SHAPING CULTURAL LANDSCAPES

Connecting Agriculture, Crafts, Construction, Transport, and Resilience Strategies

ANN BRYSBAERT, IRENE VIKATOU & JARI PAKKANEN (EDS)

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Editors' biographies

Ann Brysbaert is Professor in Ancient Technologies, Materials and Crafts, and Principal Investigator of the SETinSTONE project (ERC-CoG, grant nbr 646667) at the Faculty of Archaeology, Leiden University, and since March 2022 the director of the Netherlands Institute in Athens, Greece. Previously, she has held permanent and senior research positions at the Universities of Leicester, Glasgow, Heidelberg and Leiden. In 2014, she was Professeur Invitée at Bordeaux Montaigne University. Her main book publications to-date are: (2021) *Building BIG – Constructing Economies: from Design to Long-Term Impact of Large-Scale Building Projects. Panel 3.6.* Archaeology and Economy in the Ancient World. Proceedings of the 19th International Congress of Classical Archaeology, Cologne/Bonn 2018, vol. 10. Heidelberg: Propylaeum (with J. Pakkanen); (2018) *Constructing Monuments, Perceiving Monumentality and the Economics of Building. Theoretical and Methodological Approaches to the Built Environment.* Leiden: Sidestone Press (with V. Klinkenberg, A. Gutièrrez Garcia-M. and I. Vikatou); (2017) *Artisans versus Nobility? Multiple identities of elites and 'commoners' viewed through the lens of crafting from the Chalcolithic to the Iron Ages in Europe and the Mediterranean*. Leiden: Sidestone Press (with A. Gorgues); (2014) *Material Crossovers: Knowledge Networks and the Movement of Technological Knowledge between Craft Traditions.* London: Routledge (with K. Rebay-Salisbury and L. Foxhall); (2011) *Tracing Prehistoric Social Networks through Technology: A Diachronic Perspective on the Aegean.* London: Routledge; (2008) *Power of Technology in the Bronze Age Eastern Mediterranean. The Case of Painted Plaster*, London: Equinox.

Irene Vikatou assisted Prof. dr. Ann Brysbaert with her research on the SETinSTONE project at the Faculty of Archaeology, Leiden University until August 2020. During this time, she was also one of the co-editors of the project's second edited volume: (2018) *Constructing Monuments, Perceiving Monumentality and the Economics of Building. Theoretical and Methodological Approaches to the Built Environment*, Leiden: Sidestone Press. In September 2020 she started her PhD at the same university on the topic of ancient Greek road networks in the Greek region, during pre-Roman and Roman times. The purpose of this research is to assess the extent to which Greek roads served as predecessors to the Roman ones. She has studied Biology at the University of Athens and completed an MSc in Osteoarchaeology and Funerary Archaeology at Leiden University in 2013. In this programme, she specialized in the analysis of human skeletal remains from archaeological excavations, focusing on pathological lesions caused by external factors, such as trauma and strenuous physical activity. Her master's thesis, (2013) *Are These Clogs Made for Walking: Osteochondritis Dissecans: Evidence of Strenuous Activity and Trauma in Skeletal Elements of the Foot from a Post-Medieval Rural Society in the Netherlands*, was supervised by Dr. Andrea Waters-Rist (now Western University, Canada) and Dr. Menno Hoogland (Leiden University) and was published in the *International Journal of Palaeopathology* 19 (2017).

Jari Pakkanen is Professor of Greek Archaeology at Royal Holloway, University of London. He was the Director of the Finnish Institute at Athens in 2013-2017 and he has directed and co-directed several archaeological projects in the Greece and Sicily which have concentrated on the built environment. His main book publications to-date are as follows: J. Pakkanen and A. Brysbaert (eds., 2021) *Building BIG – Constructing Economies: from Design to Long-Term Impact of Large-Scale Building Projects. Panel 3.6.* Archaeology and Economy in the Ancient World. Proceedings of the 19th International Congress of Classical Archaeology, Cologne/Bonn 2018, vol. 10. Heidelberg: Propylaeum; J. Pakkanen (2013), *Classical Greek Architectural Design: a Quantitative Approach*, Papers and Monographs of the Finnish Institute at Athens, vol. 18, Helsinki: Foundation of the Finnish Institute at Athens; D. Blackman, B. Rankov, K. Baika, H. Gerding and J. Pakkanen (2013) *Shipsheds of the Ancient Mediterranean*, Cambridge: Cambridge University Press; J. Pakkanen (1998) *The Temple of Athena Alea at Tegea. A Reconstruction of the Peristyle Column*, Publications by the Department of Art History at the University of Helsinki 18. Helsinki: Department of Art History at the University of Helsinki and Foundation of the Finnish Institute at Athens.

List of contributors

Jørgen Bakke (jorgen.bakke@uib.no) is Associate Professor of Art History at the University of Bergen, Norway. He is a specialist on Ancient Greek and Byzantine archaeology and cultural history but has also worked with the historiography of art history, early modern European painting as well as contemporary painting in Norway.

Stuart Bedford (stuart.bedford@anu.edu.au) is a Fellow at the Australian National University and Associate with the Max Planck Institute for the Science of Human History, Jena. His research in Vanuatu covers initial colonisation 3,000 years ago to the historic period. Current projects revolve around ceremonial architecture, Post-Lapita transformations, Polynesian outliers and natural catastrophes.

Ann Brysbaert (a.n.brysbaert@arch.leidenuniv.nl) is Aegean and East Mediterranean prehistorian and Professor in Ancient Technologies, Materials and Crafts Leiden University, Faculty of Archaeology, Department of Archaeological Sciences. Currently, she is also Principal Investigator of the ERC-funded CoG SETinSTONE project (www.setinstone.eu). Since March 2022 she is the Director of the Netherlands Institute at Athens. Her research interests include ancient workshop studies, monumental architecture, economic archaeology, pyrotechnological processes, and integrating Material Culture studies into Landscape-based Studies.

Cyril Castanet (cyril.castanet@lgp.cnrs.fr), researcher of the CNRS, Associate Professor and Head of the Département de Géographie of Paris 8 University, holds a PhD in Environmental archaeology (Paris 1). He is specialized in past environments and socio-environmental interactions. He is the PI of Mayanat and HydroAgro Projects and partner of Naachtun Project.

Antoine Dorison (antoine.dorison@gmail.com) is a post-doctoral research fellow at the French research unit in Archaeology and Sciences of the Antiquity (UMR7041 ArScAn CNRS). He is trained in Archaeology, Geomorphology, Soil Science and Geomatics (LiDAR) and focuses his research on ancient Mesoamerican agriculture, impacts on landscapes and their socio-economic repercussions.

Lydie Dussol (lydie.dussol@cepam.cnrs.fr) has a PhD in Maya archaeology (Paris 1 University, 2017). Specialized in anthracology, she obtained a post-doctoral fellowship at Côte d'Azur University (Nice, France), where she is Assistant professor. Her research focusses on the fuel economy in ancient Mesoamerica and Caribbean and the human impact on tropical environments.

Kalliopi Efkleidou (kalefkleidou@hotmail.com) is an archaeologist and a Post-Doctoral Fellow at the Aristotle University of Thessaloniki, Greece, working on the stratigraphy and architecture of the Thessaloniki Toumba settlement. She specialises in Aegean Bronze Age archaeology and GIS-based spatial analysis of architectural and funerary remains in the landscape.

Paul Erdkamp (Paul.Erdkamp@vub.be) is Professor in Ancient History at Vrije Universiteit Brussels, Belgium. He teaches Ancient History, specializing in the Roman World, with a particular interest in climate change, economy, and food supply. He also works on Roman historiography, and environmental and social aspects of army and war.

James L. Flexner (james.flexner@sydney.edu.au) is Senior Lecturer in Historical Archaeology and Heritage at the University of Sydney. His primary interests are the long-term transformation of Pacific Island landscapes and archaeologies of colonial encounters in Oceania and Australia.

Manuel Antonio Franco Fernández (manuel-antonio.franco-fernandez@incipit.csic.es) is an archaeologist and topographer. He currently works as a senior GIS specialist at the ERC Starting Grant StateHorn: Pathways to Statehood: Authority, Legitimacy and Social Diversity in the Horn of Africa (11th-16th Centuries) at the Institute of Heritage Sciences at the Spanish National Research Council (Incipit-CSIC).

Alfredo González Ruibal (alfredo.gonzalez-ruibal@incipit.csic.es) is staff scientist at the Institute of Heritage Sciences at the Spanish National Research Council (Incipit-CSIC). His research focuses on the archaeology of the contemporary past and the material strategies deployed by communities who still resist modernity, globalization and the state. In 2014 he launched the Spanish Archaeological Project in Somaliland to study the participation of the Horn of Africa in Indian Ocean trade networks, and the role of indigenous communities in those networks. He is currently running projects in Ethiopia and Somaliland.

Sandrine Grouard (grouard@mnhn.fr), PhD HDR, is a researcher at the UMR 7209 MNHN-CNRS (Paris). As zooarchaeologist, she is specialized in the Caribbean and Latin America fossil Vertebrates. Her current research examines insular historic biogeography and its human impacts. She also focuses on the archaeoethnozoology of the late pre-Columbian Amerindians.

Julien Hiquet (julien.hiquet@hotmail.fr) holds a PhD by the University of Paris 1 Panthéon-Sorbonne (2020) and is now affiliated to the laboratory Archéologie des Amériques (CNRS, Paris). He is part of the Naachtun Project since 2013 working on the growth of Maya city-states during the Early Classic period and their monumental architecture.

Candela Martínez Barrio (candelamb@gmail.com) is a freelance archaeologist and specialist in physical anthropology. She is a member of the Spanish Archaeological Project in Somaliland.

Pablo Gutiérrez de León Juberías (pablo.gutierrezdeleon@incipit.csic.es) is a PhD candidate student at the Institute of Heritage Sciences at the Spanish National Research Council (Incipit-CSIC), and a member of the Spanish Archaeological Project in Somaliland. His PhD dissertation focuses on the study of nomadism in the Horn of Africa.

Stefan Müller (s.mueller89@gmx.de) participated in different field projects in the Aegean (Tiryns, Pylos, Mochlos, Iklaina, Sissi, Aigeira, Kea Survey) after having obtained a master's degree at Trier University (Classical Archaeology, Egyptology). Currently, he is working as PhD student at Heidelberg University, specialising in mortuary archaeology relating to the Aegean Bronze Age.

Philippe Nondédéo (Philippe_nondedeo@yahoo.com) is investigator of the lab Archéologie des Amériques (CNRS, Paris). Specialized in Maya archaeology, he earned his PhD at Paris 1 University. Since 2010 he has directed the Naachtun archaeological project (Guatemala). His investigations focus on settlement pattern studies, spatial analyses (LiDAR surveys), architecture, and political systems.

Gaspard Pagès (gaspard.pages@gmail.com) is researcher at the CNRS (Arscan UMR 7041) and focuses on the craft industry and the iron economy during the Antiquity and the Middle Ages, from archaeological data and archaeometrical analyses. He leads research programmes, material studies, excavations and prospections campaigns in different regions, notably in Belgium, France and Lebanon.

Jari Pakkanen (j.pakkanen@rhul.ac.uk) is Professor of Greek Archaeology at Royal Holloway, University of London. His research has concentrated on ancient built environment, quantitative methods in study of architectural design and reconstruction, development of digital 3D documentation methods and labour cost studies.

Daniel J. Pullen (dpullen@fsu.edu) is Professor of Classical Archaeology at Florida State University in Tallahassee. His research interests include the emergence of complex societies from the late Neolithic through Early Bronze Age, landscape archaeology, political economy, and the maritime Mycenaean world.

Louise Purdue (louise.purdue@cepam.cnrs.fr) is a CNRS researcher (laboratory CEPAM -UMR 7264) and the University Côte d'Azur (Nice, France). As a geoarchaeologist, she focusses on human-environment interactions and landscape dynamics. She is a specialist in ancient agriculture and water management in arid (Arabic Peninsula), temperate (France) and tropical (Central America) environments.

François Remise (fremise@yahoo.fr) is an engineer who has worked for 34 years as a manager of building companies. Since his retirement, he has been an independent researcher. He is mainly interested in the Celtic civilization, with a particular focus on labour organization.

Bence Simon (simon.bence@btk.elte.hu) received his MA degree in archaeology at the Eötvös Loránd University, Hungary in 2012. In 2013 he became a research assistant at the Institute of Archaeological Sciences of the same university, where he currently holds the same position. Bence obtained his PhD degree in 2019.

Marc Testé (marcteste.upmc@gmail.com) has a PhD in Physical Geography. He works on reconstructing paleoenvironments and society-environment interactions using bioindicators. At Naachtun, he produced a modern phytolith reference of the ecosystem to calibrate a palaeoenvironmental reconstruction. Together with fire signals, it permits to envision the evolution of Maya agrosystems and social hierarchies.

Noémie Tomadini (noemie.tomadini@gmail.com) is a research associate at the UMR 7209 MNHN-CNRS (Paris). She obtained her PhD in archaeozoology in 2018, focusing on daily life in the colonial period French West Indies. She opened her field of investigation through the study of the collection of the Maya site of Naachtun.

Francesca Tomei (f.tomei@liverpool.ac.uk) is PhD candidate at the Department of Archaeology, Classics and Egyptology at the University of Liverpool. She graduated in Classical Archaeology from the University of Pisa (MA) and the University of Padova (MSc). She has participated in archaeological projects (commercial and research) in Italy, Greece and Turkey.

Jorge de Torres (jorge.detorres-rodriguez@incipit.csic.es) is an Africanist archaeologist specialised in the Historical Horn of Africa. He currently leads the ERC Starting Grant StateHorn: Pathways to Statehood: Authority, Legitimacy and Social Diversity in the Horn of Africa (11th-16th Centuries) at the Institute of Heritage Sciences at the Spanish National Research Council (Incipit-CSIC).

Daniel Turner (drturner@crimson.ua.edu) is a Postdoctoral Researcher at the Faculty of Archaeology, Leiden University. He currently works with Anchoring Innovation, the Gravitation Grant research agenda of the Dutch National Research School in Classical Studies, OIKOS, which is financially supported by the Dutch ministry of Education, Culture and Science (NWO project number 024.003.012). For more information about the research programme and its results, see the website www.anchoringinnovation.nl.

Frédérique Valentin (frederique.valentin@cnrs.fr) is a senior researcher in Oceanic archaeology at Centre National de la Recherche Scientifique (UMR 8068, MSH Mondes, Nanterre) in France. She specialises in funerary archaeology and biological anthropology. Her work focuses on the human populations and societies of the Pacific.

Jean Vanden Broeck-Parant (Jean.Vanden.Broeck-Parant@ulb.Be) received his PhD from the Université libre de Bruxelles in 2017. From 2017 to 2019 he was a Junior Research Fellow at Wolfson College, University of Oxford. From 2020 to 2021 he was a postdoctoral researcher at the University of Utrecht. He is now a postdoctoral researcher at the Université libre de Bruxelles (F.R.S-FNRS).

Martine Van Haperen (m.c.van.haperen@arch.leidenuniv.nl) passed her PhD thesis at Leiden University on the post-depositional interventions in Merovingian burials. Presently, she is a post-doctoral researcher in the ERC Project Rural Riches in which she studies social aspects of early medieval production.

Line Van Wersch (Line.vanwersch@Uliege.be) received her PhD thesis at Liege University in archaeology and archaeometry. She is specialized in glass and ceramics from the early Middle Ages. She is currently post-doctoral researcher and Marie-Curie fellow at the CNRS (Arscan UMR 7041).

Irene Vikatou (e.vikatou@arch.leidenuniv.nl) is a bio-archaeologist and worked for the SETinSTONE project as prof. Ann Brysbaert's research assistant until August 2020. Since September 2020 she is a PhD candidate at the Faculty of Archaeology, Leiden University. She focuses on ancient road networks in the in the Greek region during -pre-Roman and Roman times.

Editors' acknowledgements

The three editors first reviewed all the papers and Ann Brysbaert did the second review with Jari Pakkanen. Stuart Heath worked as copyeditor for the entire book and also did an excellent job in proofreading several of the papers. Ann and Jari checked second proofs.

This book project started in the Spring of 2020 after the third SETinSTONE workshop was held at Leiden University, Faculty of Archaeology in November 2019. Ann and Jari organised subsequently the virtual European Association of Archaeologists session in August 2020 which replaced the large final conference of the project, due to COVID restrictions. This double session brought together a large group of papers the majority of which complete this volume. While this was an online event, we enjoyed tremendously the commitment people made to presenting from afar and across many time zones, and we thank all authors who worked tirelessly in these difficult times to submit their papers in good time.

We wish to thank Karsten Wentink, Corné van Woerdekom, Eric van den Bandt and Kayleigh Hines at Sidestone Press for their speedy and professional work on our book and enabling its publication in 2022 which was our own ambitious aim. Working with them is a returning pleasure.

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Shaping cultural landscapes through crafts, construction, infrastructure, agriculture and resilience strategies: introduction to the papers

Ann Brysbaert, Jari Pakkanen and Irene Vikatou

This edited volume has materialized out of a small workshop held at Leiden in November 2019 joint with a double session at the European Association of Archaeologists (EAA) conference at Budapest in September 2020. The differences between the two events could not have been greater. The first was designed as a small discussion session between the members of the European Research Council SETinSTONE project and several invited scholars on aspects of making and production in relation to landscapes. We were gathered at Leiden with a small but engaged audience, two people came from abroad, and the others were from the Netherlands, or even Leiden. In the EAA session, which was spread over two days, people from all around the world took part, from the US to Australia, and all over Europe. Even though attendance was restricted to participants of the EAA conference, the general audience never dropped below 75, and yet, we never met in person. Leiden in 2019 was a small student town, busy as ever, but in 2020 the place was devoid of activity and Budapest only existed on the conference website, its hosting conference platform and in our dreams, and we all wished to be there: to meet each other, to be able to discuss the topics also after the sessions, to visit the city's beautiful monuments, markets and baths. Even though everything had turned upside down, business went on 'as usual', as life went on, too. One could decide not to run sessions at conferences if they could not take place on location, and many people did so for plenty of good reasons. We decided to hold on to organising the double session online because we firmly believed that we would all gain from this by not losing the momentum. All authors of the 26 papers accepted for these two days had worked hard to be in this session: written an abstract, worked on highly informative PowerPoints, presented live or through a self-made video (how many of us knew how to do all this before COVID-19?), and more than two thirds wrote up their papers for this edited volume. An entire discussion could be opened here on how time and space are linked in producing contemporary cultural landscapes post 2019. However, what we took home from the experience is the enthusiasm that everyone demonstrated in joining and working hard throughout these two days, and it gave us energy. Despite technical hitches with the conference platform, despite the home-setting in which many of us had to find even more energy to concentrate during the conference and afterwards for writing up, the experience is imprinted in our memories.

Because of the positivity we felt throughout the process of working on this volume, we want to dedicate it to all its authors and those who were with us in person in Leiden and at virtual Budapest. Thank you all for the boundless support, willingness to go

Ann Brysbaert
Department of Archaeological Sciences
Material Culture Studies
Leiden University

Jari Pakkanen
Department of Classics
Royal Holloway, University of London

Irene Vikatou
Department of Archaeological Sciences
Material Culture Studies
Leiden University

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through every step of the review, and your warm and true collegiality in these difficult times. We will not forget this, and we hope that the reader will be as enthusiastic as we all are with the result in our hands. This is not the usual introduction to an edited volume, but these were not usual times. We think we will be forgiven!

In organizing the papers, various orders were contemplated. In a chronological order, the Bronze Age papers would have been first, followed by the Archaic, Classical and Roman ones. This, however, would have been too Eurocentric and would have left the exciting papers on Central America, Africa and the Pacific without a logical place. Using a geographical order was another thought, but how to set this up: what first, and what next? A third one would have been thematic, but this was not satisfactory as several papers touch upon several themes. In the end, the decision was to order them alphabetically by the first author. Even though this is also a western approach, at least in this group of papers we use the same alphabet.

The paper by **Jørgen Bakke** describes the life of the Marble Mountain in the southern Peloponnesian peninsula in Greece. His work integrates the material agency of human activities and processes on the Doliana Marble Mountain. This special geological formation is connected with the long history of marble quarrying: from antiquity, when it was under control of the city-state Tegea located some ten kilometres north of from the quarries, until today. His study is based on a preliminary survey of the remains of the ancient quarries and of the surrounding physical and cultural landscape. Alongside natural erosion and sedimentation processes, plant and animal life and human activities are regarded as one of many ecological agents that act together in a local micro-ecology. Through providing examples of the biographies of marble objects, buildings, and plastic works that came out of the quarries of the Marble Mountain, Bakke illustrates this ecology of marble through sculpture from the Classical period. As such, objects made from the Marble Mountain take on new forms of vivid material agency in the display of cultural identity in the sanctuary of Athena Alea.

In the Middle and Late Bronze Age Aegean mainland, tholos tombs became a typical grave type for those who could afford to build these, often monumental, structures. While the phenomenon started in the mainland in Messenia, the largest ones were constructed in the Argolid: Mycenae featuring nine in total. The paper by **Ann Brysbaert, Daniel Turner and Irene Vikatou** discusses the labour efforts in the construction of and the methodologies employed in the study of one of two tholos tombs found near Tiryns in the Argolid. This large tholos, located east of Tiryns' citadel, was excavated and published by the German Archaeological Institute in the early 20th century. Their drawings, combined with new fieldwork carried out in 2018, form the core data for this paper. In overlaying the existing drawings over the 3D model produced by photogrammetry, we compare the accuracy of modern fieldwork techniques in collecting 3D data with the hand drawings and assess whether the differences are significant to the final results. Next, we investigate, by means of architectural energetics or labour cost studies, how much effort went into the construction of this grave monument and what its potential impact on the available labour may have been. The data collected indicate that the stones employed in constructing this tomb were extracted nearby, directly from the hill in which the tomb was dug and cut. At least two main types of recognizable limestone were used while no conglomerate featured anywhere in the tomb entrance stomion, in contrast to most other nearby tholoi of the same period and the clear presence of conglomerate in the citadel. The door jambs of the stomion were embellished with plaster, possibly painted, a feature also noted on various other tombs of this period. Labour calculations cover all materials, including the plastering, and employ a relative index comparing the cost with that of other standard tomb types in southern Greece.

In the Late Bronze Age (LBA) Argolid, Greece, monumental architectural remains and some of the road remains exhibit a clear correlation between building activities and the exploitation of material, human and animal resources. The known Mycenaean highways were, however, far from the only communication ways that linked places in the region since these focus mainly on their monumental make-up and any remains alongside them. The paper by **Ann Brysbaert and Irene Vikatou** focuses on both these and the numerous lesser roads and paths that were in use, possibly for much longer periods of time. They aim to reconstruct the lesser roads and paths in the region and understand to what extent a more comprehensive road network contributed to the development of different types of settlements, only some of which turned into the dominating centres of the 13th-12th centuries BCE. Traveling and people's mobility were part and parcel of being sedentary and the perceived contrasts between these concepts are discussed through the case studies. In plotting the roads mentioned in the literature and the newly suggested ones, it became clear that the people, their animals, and their material resources were very mobile during the final centuries of the LBA in the Argolid prior to the demise of the Mycenaean societies around 1200 BCE. Many of their activities continued well after this date resulting in persistence of roads and paths, in some cases until the present day. As such, roads of any type are the grounded and materialized dynamic outcome of people's ever changing taskscapes.

Kalliopi Efkleidou's study investigates new sources of information capturing the Mycenaean territories that people identified with in the past. Previous studies have systematically missed the bottom-up approach and how the non-elites conceptualized and spontaneously enacted territory. Past research has emphasized mostly a top-down view from the palaces in the 13th century BCE when they reached the maximum territorial extent and political and economic integration. The cadastral maps in the archives of the Second Venetian Rule (1687-1715 CE) in the Peloponnese depict settlement territories as local communities communicated them to the Venetian officers. Thus, these maps form the earliest accurately measured, visually depicted and textually described evidence of common peoples' notions of territoriality. Efkleidou discusses the cadastral map of the Territorio of Argos as the only surviving such map of the wider region of the Argive Plain with its LBA Mycenaean palaces and important settlements. The insights derived from the maps' study aids in refining current models of Mycenaean territoriality and contribute to discussions of communities' land management strategies and efficiency, and demographics.

Paul Erdkamp gave the keynote address in our EAA session on Cultural Landscapes. His paper presents a critical discussion of two manifestations of approaches advocating universal truths and universally valid models: Malthusian scenarios and the Adaptive Cycle Model. These types of approaches grew historically, and this paper discusses the origins of the social sciences which lies with 18th-century investigators who strove to discover the general principles that governed the functioning of society. Approaches to the past within the social sciences reflect these roots because it seems that their interest in the past is not constructing historical narratives, but to uncover universal laws of history. Erdkamp maintains that many historians, who are also determined by their discipline's past, are weary of universal truths and tend to emphasize the uniqueness of past societies, and that archaeologists often side with the social sciences in their attempts to identify general patterns. The quest for universal truths in the past has influenced the relatively recent trends to study the impact of climate change on early societies. To him, many archaeologists and anthropologists working on early societies explain the societal impact of climate change on the basis of universal truths and universally valid models. According to Erdkamp, automatic adherence to Malthusian models steers analysis of the impact of climate change in a predetermined direction while the Adaptive Cycle Model adds little to our understanding of early societies. The latter model often just functions as a 'one size fits all' model that is used less to interpret the empirical data than to replace the data where they are missing.

James Flexner, Stuart Bedford and Frederique Valentin's many years of archaeological research in the South Pacific aims to contribute to a broader story of the ways that people have adapted to island and coastal environments in the past. Rather than separating land from sea, these environments lend themselves to the creation of 'islandscapes', integrating the terrestrial and maritime worlds as people adapted to a geographic region dominated by ocean. Over a 3000-year period, Pacific Islanders have shaped the land and seascapes of Southern Vanuatu and developed their own senses of 'historicity', the complex expressions of relationships between past and present according to local reckonings. The authors present some of the results of their work on the islands of Tanna, Futuna, and Aniwa in the south Vanuatu region. Survey and excavations have recovered evidence for Lapita and post-Lapita ceramic traditions and settlement, investment in large-scale agricultural and marine resource management strategies, and interaction with and integration of outsiders, including Polynesian settlers around 1000 CE and European Missionaries in the 1800s. Greg Dening's concept of 'encompassing' is employed to expand the archaeological narrative to account more for lived human experience on the ground and among the ocean waves.

At Naachtun in the Maya Lowlands (Guatemala), the Early Classic period represented an apex of monumental construction with temples and pyramids built on human-modified hilltops. Just after the 'Preclassic Collapse', in which an elaborate system of massive cities became abandoned, conspicuous architecture appeared again. In this context, **Julien Hiquet and co-authors** gather recent data on the human-environment dynamics during the emergence of Naachtun in order to shed light on the ecological consequences and the strategies implemented to face these. The question why Naachtun arose at the exact moment that the neighbouring cities of the Mirador region declined has been explained by overexploitation of the natural landscape. The question also arose whether the Maya behaved in a predatory way, exhausting one region before starting again. The authors combine a quantification of Early Classic monumental architecture of the Naachtun area, an estimate of the local population, and a thorough study of local resources in order to understand the long-term management of the environment in the context of the rise of Classic Maya polities. Questions of resource management in a context of growing consumption for subsistence and architecture are key issues in our understanding of the local dynamics. The local socio-ecosystem was probably the result of a very complex balance, more or less controlled by local populations.

Stefan Müller's paper examines the location of chamber tomb necropoleis, the spatial organisation of their tombs, and their distribution during the different Late Helladic phases. Furthermore, it aims to draw together evidence concerning the relationship between the necropolis and the settlement. The focus is on five locations from the Argive Plain, including both palatial and non-palatial sites: Prosymna, Tiryns, Dendra, the Berbati valley and Argos. Since the most basic requirement for digging a chamber tomb was access to usable geology, i.e., a slope of exposed bedrock, it was vital for communities to search for such places nearby the settlements. Moreover, easy access to the tombs was needed as well, perhaps in the form of paths and roads that split away from larger roads in the vicinity. Of equal importance in the spatial organization of tombs is the clustering of what seems to be family- or clan-related burials grouped together.

The paper by **Jari Pakkanen** concentrates on the temple of Athena Alea at Tegea in southern Greece and the supply of quarry stones to the fourth-century BCE building project. The main aim is to present a model of how the quarrying and transport of building materials can be quantified. Even though nearly nothing remains *in situ* of the temple above the foundations, the previous studies by the early 20th-century French team and the paper's author make possible a reliable reconstruction of the monument and the volume of stone used in its construction. Comparative labour cost analyses presented in the paper are based on rates derived from Greek building accounts and Pegoretti's 19th-century architectural handbook. The cost of quarrying marble at Doliana is estimated as circa four times as high as conglomerate. In both cases the cost of transport from the quarries to the building site was more expensive part of the building project than quarrying. With a workforce of 12 skilled and 12 unskilled labourers it would have been possible to quarry the foundation blocks in approximately one year: if the size of the quarry team was doubled, the marble for the temple could have been extracted in five to six years.

Daniel Pullen explores the social exploitation of a newly created cultural landscape of the Mycenaean harbour settlement of Kalamianos and its hinterland in the Aegean. This area was 'colonized' by people from the Argolid as they expanded their economic and political interests into the Saronic Gulf in the Late Bronze Age. Both capital and labour into infrastructure transformed a sparsely occupied territory in the Early and Middle Bronze Age into a Mycenaean cultural landscape with a walled urban settlement at Kalamianos, featuring elite style architecture, satellite settlements, and agricultural terraces. Such construction programmes suggest elite involvement commanding a range of resources. Despite large-scale terracing, there were insufficient daily food supplies for the urban population at Kalamianos. As a port, the town competed in the market system within and beyond the Saronic Gulf. Through the studies of ceramic assemblages and its architecture, Pullen suggests that people had multiple and multi-scale strategies to cope with the realities of living. Rather than producing their own, Kalamianos imported pottery from the Corinthia, Attica, and Aigina, but not from the Argolid. Architectural studies showed that workshops and storage facilities were present, but it is unknown what Kalamianos offered in exchange for the received merchandize. Markets are social strategies that operate in networks alongside and independent of centralized power and economic control by elites, such as those from the Argolid.

François Remise presents a detailed analysis of the labour and time spent to construct parts of building projects executed by the Heuneburg community in 600-540 BCE. The most appropriate labour rates are used from a large range of published values starting from raw material supply to building. The site is located in the Upper Danube valley in southwestern Germany and the upper town was protected by a mudbrick fortification and the lower town by an earth embankment. The outer settlement was divided into distinct areas by a system of banks and ditches. The types of structures built include fortifications, earthworks, dwellings and agricultural buildings. The paper takes into account maintenance, modification and rebuilding of structures, and the time spent on agricultural and artisanal activities. An estimate of the total time used for the constructions demonstrates that it was a highly impressive labour investment by the aristocracy and the whole community.

In his paper, **Bence Simon** integrates the results of a study about site hierarchy, settlement patterns and location preferences of rural Roman Pannonia into a broader methodological and theoretical narrative. He presents the role of socio-cultural conditions, physical space, and natural environmental factors in the formation and change of the settlement system and economic relations in the hinterland of Aquincum (Óbuda, Hungary) and Brigetio (Komárom-Szőny, Hungary). In this study, he questions the role of the rural settlements in the economy of Pannonia, and how the archaeological record may be able to indicate regional and local interactions between towns and their hinterland. He investigates how the hinterland's settlement patterns changed from the first to the third century CE, and why did certain places survive while others reorganized after crises. Finally, he looks into the roles played by the natural environment and the proximity of towns in these settlement pattern changes. He approaches these questions through analysing the location of the archaeological find material and using a GIS-based land evaluation model.

Francesca Tomei aims to show the cross-craft interactions between pottery production and agricultural practices, and how they influenced the locational choices of ceramic workshops in Classical-Hellenistic rural regions. She addresses these questions with the examination of two sites, Sant'Angelo Vecchio (Metapontine chora, Basilicata, Southern Italy) and Pyrgouthi (Berbati Valley, Argolid, Peloponnese) with evidence of pottery production for the presence of kilns. The palaeoenvironmental data provide information on the agricultural practices and land use in both regions. Comparison of these data with ethnoarchaeology and ancient literary sources shows that agricultural residues and wild vegetation could be resources for both pottery production and grazing. Finally, the location of pottery workshops in relation to settlements, sanctuaries and roads is analysed with the use of GIS spatial analysis tools, such as buffer analysis and least cost path analyses.

Based on more than half a decade of research of the Spanish Archaeological Mission in Somaliland, **Jorge de Torres Rodríguez and co-authors** analyse the territorial organization of central Somaliland, a region that, during the medieval period (11th-16th centuries CE), was an active trading hub in the Red Sea. Based on the archaeological evidence for this period, they explore the materiality of the different groups and stakeholders, and their interactions through time in order to understand better the different communities that inhabited the region, the evidence of international trade throughout Somaliland, and the changes of settlement patterns over time. Commerce in Somaliland was managed mostly by nomads and regulated by their seasonal movements along the Horn of Africa and the monsoons regimes, which framed the appropriate moments for trade. The medieval period in Somaliland saw some paramount changes in the history of the region, including the expansion of international trade, the arrival of Islam, the emergence of permanent settlements and the increasing involvement of states in the nomads' lives. Of great interest is that these major changes did not evolve into conflict due to the existence of the key activity of trade. For commerce to thrive, collaboration of all the involved agents was crucial and it provided a common ground for understanding of the individual players.

Line van Wersch, Martine van Haperen and Gaspard Pagès study the changes in ceramics, glass and iron during the Early Middle Ages in northwestern Europe. During this period, the places in Belgium moved from the Merovingian agglomerations to the aristocratic rural domains, the monasteries and the emporia, and these crafts saw major technical changes as well. Even though these modifications are attested in the material, the underlying factors involved are still not understood. By means of studying these materials through cross-craft interaction model, some of the triggers for innovation may be revealed, as has also been seen in many other crafting contexts. This paper approaches these crafts and their interactions, identifying potential exchanges between them, and how these may have fuelled change.

The question of profit making in the context of stone supply in Ancient Greece has not been addressed properly since the work on the building inscriptions of Epidauros by Alison Burford. **Jean Vanden Broeck-Parant** argues that labour cost estimations provide a new way to approach this issue. By comparing labour costs (converted to financial costs) with contract prices mentioned in the Epidaurian inscriptions, it becomes possible to measure the extent of the potential profits made by the entrepreneurs involved in stone supply more accurately. He discusses the arguments of Burford, who suggested that the entrepreneurs did not systematically look for profit. Through the case study of the sekos of the temple of Asklepios at Epidauros (early fourth century BCE), he estimates the amount of (human and animal) energy needed to quarry the blocks and transport them to the sanctuary of Asklepios. Where labour costs are difficult to estimate, he compares the contract prices with other known prices to perform similar tasks. The comparison of the estimated costs with the contract prices shows that the prices probably included a substantial portion of profits for the entrepreneurs who took up those contracts. The method described in this paper can contribute to our understanding of stone supply as an industry in fourth century BCE Greece.

The life of the Marble Mountain: agency and ecology in the marble quarries of ancient Tegea, Greece

Jørgen Bakke

1. Introduction

This article is an introduction to the biography of a mountain. The mountain is the northern-most tip of the Parnon Range in the Peloponnesian Peninsula of southern Greece. The Parnon Range makes up the boundary between the Eurotas Valley and ancient Sparta in the south and the Arcadian highland plains of the ancient Greek city-states Tegea, Mantinea, and Pallantion in the interior of the peninsula (Figure 1). In the literature this mountain is usually mentioned because of its marble outcrop that was quarried by Tegea in antiquity. The official name of this mountain today is *Άγιος Παντελεήμων* (Mount *Agios Panteleïmon*), and marble from the ancient quarries is usually referred to as Doliana marble after one of the mountain villages in the area. Here I will also refer to it with its traditional name *Μαρμαροβουνό* (the Marble Mountain).

Traces of ancient marble quarries on the Marble Mountain have been observed since the late 19th century (Lepsius 1890). Although observations have been made and samples collected several times since Lepsius's discovery, no systematic investigation of the quarries has ever been undertaken. Together with the Norwegian archaeologists Hege A. Bakke-Alisøy and Nils Ole Sundet and the historian Jonatan Krzywinski, I did a survey from 2009 to 2012 (*Sites in Marginal Landscapes. The Norwegian Arcadia Survey. Part II*) that also included the Marble Mountain (Figure 1). The results referred to in this article mainly stem from this survey.[1]

The first part of the article (the biography of a Mountain) introduces the theoretical approach to the life of the Marble Mountain. The second (quarries in the Marble Mountain) is a description of known marble quarries in the northern Parnon massif. Although some comments will be made about scientific methods for determining the provenience of Doliana marble, my focus will primarily be on the topography of the quarries. The third part (prehistoric and early historical landscape) situates the Marble Mountain in the local prehistoric and early historical landscape, and also discusses the most important routes of the regional communication network that facilitated access to and distribution of marble from the quarries. The fourth part (ecological agents) of the article discusses the ecological agents that influenced and were influenced by activity on the Marble Mountain, and in the fifth and final part (an ecology of Marbles), I provide some examples of the ecology of things made of marble from the Marble Mountain.

Jørgen Bakke
Department of Linguistic, Literary, and Aesthetic Studies
University of Bergen

1 The survey was undertaken under the auspecies of The Norwegian Institute at Athens, with support from The University of Bergen and The Meltzer Research Fund, and with kind support from Dr. Anna Karapanagiotou, former Ephor of Arcadia and currently Director of The National Arcaheological Museum, Athens.

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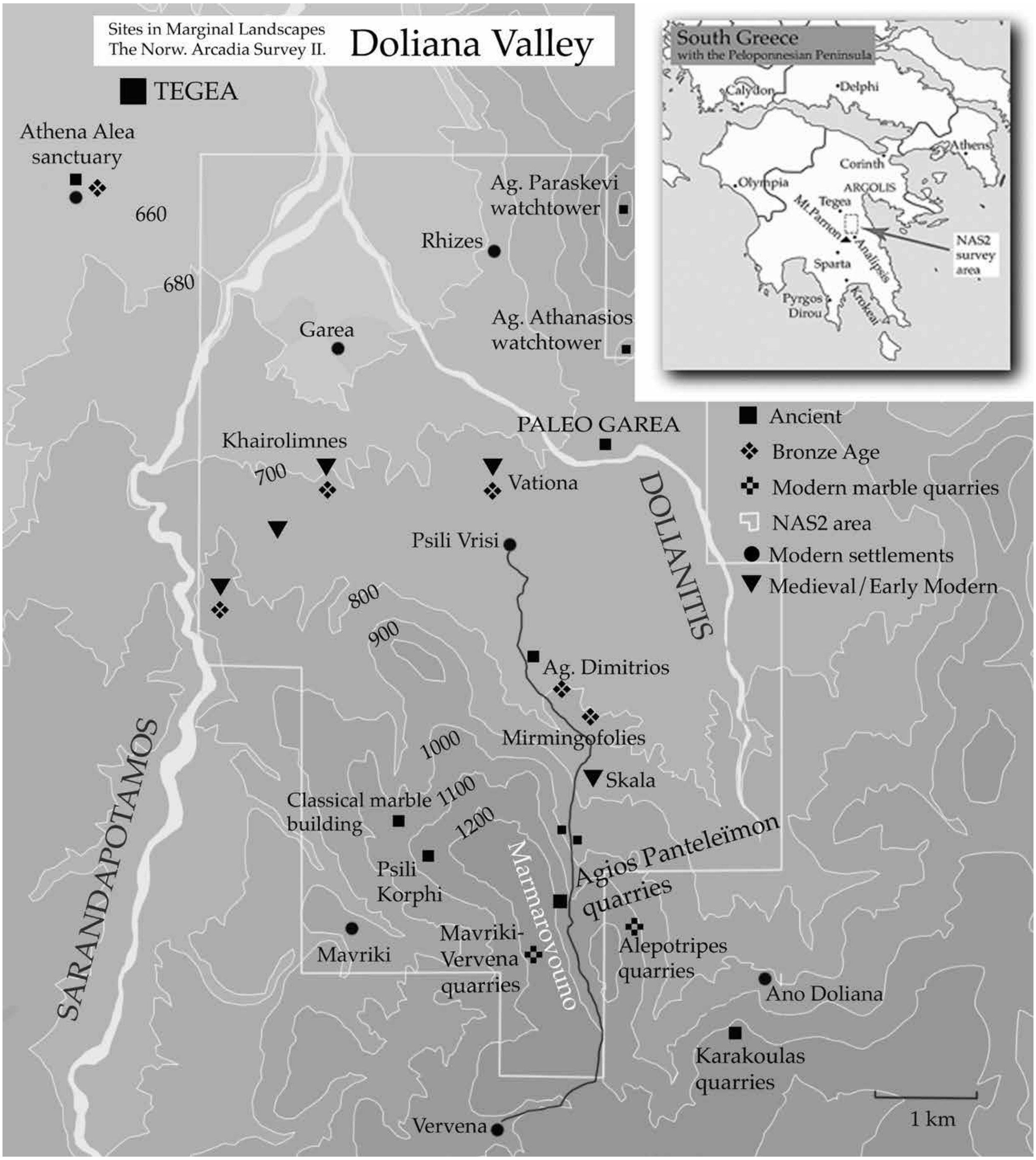

Figure 1. Map of the Doliana Valley (image produced by the author).

2. The biography of a Mountain

2.1. The life of a Mountain

The notion that non-biological things like artefacts, buildings, and tools manufactured by men have a form of agency that is analogous to human agency was first developed by anthropologists (Latour and Woolgar 1979) and has since also become commonplace in archaeology (Hodder 2012). Leaning on the anthropological tradition of object biography (Kopytoff 1986) the French ethnologist Thierry Bonnot (Bonnot 2004) has demonstrated how material artefacts like a ceramic cider bottle can be regarded as an agent in its own history. Bonnot showed how the material agency of artefacts can be described as a lifespan from the discovery of the natural resource exploited, to production, use, reuse, recycling, and discarding. Things like cider bottles and marble objects, and places like factories and mountains also have a form of agency, a form of life. Like biological life the material life of things is lived out in an ecology. In the biography of the Marble Mountain an important role is accordingly played by historical ecology. The approach termed historical ecology is first of all a recognition of the importance of the ecological element in history (Horden and Purcell 2000: 48). Long before what ecologists have recently termed the Anthropocene age (Zalasiewicz et al. 2010) when humans have an effect on the global climate, human activity has always had an impact on local ecological systems.

On the other hand, man-made things are also important agents in the ecology of modern humans. The modern human is very much a species that resides in an ecosystem of things, and the agency of those things is no less important for the life of modern humans than the agency of our natural environment. This is why I will be dealing with the ecological agency of the mountain; its cultural landscape, sedimentation processes, animal and plant life; but I will also focus on the ecology of things made of marble because they are the material agents that came out of the mountain. I have nicknamed these material agents 'the Marbles'. The paths of the Marbles in the landscape follow the path of natural erosion and sedimentation, but their ecology is also entangled (Hodder 2012) with the routes of regional communication networks from prehistory to the present. Like marbles used in children's games the Marbles are tossed about by human agents; they find their own paths and abide by the same rules as rocks and sediments do in nature, but then they may be picked up again, be shaped and transported, and act with a new material agency that take them far beyond where their geological agency would ever have taken them.

2.2. Quarries in the Marble Mountain

No secure chronological framework can be provided for any of the quarries listed here. My hypothesis is that the main periods of exploitation were in antiquity and in the late 19th and early 20th centuries when modern industrial quarrying was introduced in Greece (Warren 2012). Medieval and early modern activity is hardly commented on in the literature but is an interesting field for further exploration (Bakke and Bakke-Alisøy 2020: 44). One example of this is the abundant use of marble in post-ancient buildings in the area and the potential resource of abandoned marble quarries for local production of lime to be used in mortar and plaster. Unfortunately, there is no evidence of lime production on the quarry site. The impression of the situation, however, is that the quarries were never completely abandoned, and that abandoned blocks and waste were harvested for a long time after regular production was terminated, probably in the later phases of antiquity (Bakke and Bakke-Alisøy 2020: 45).

As we have so far been able to access, marble has been quarried from at least four different locations (Figure 1) within an area of some 4-5 km^2:

1. *Mavriki-Vervena*, also, Doliana-Mavriki (Barbin et al. 1992: 231).
2. *Alepotripes*, also, Doliana-Doliana (Barbin et al. 1992: 231).
3. *Karakulas*, (Howell 1970: 89 and 93; Pls. 40b, c).
4. *Agios Panteleïmon-Marmarovounó*. (Lepsius 1890: 31-34, 126; Bakke and Bakke-Alisøy 2020: 42-43).

The Northern Parnon marble outcrop was first described by the French military engineer and geologist Émile Le Puillon de Boblaye. Boblaye is also the first modern author to use the local name *Μαρμαροβουνό* (Boblaye and Virlet 1833: 148). The first systematic account of the marble quarries on the Marble Mountain was made by the German geologist Richard Lepsius (1890: 31-34, 126). Lepsius situated the ancient quarries on the eastern slope of *Marmarovounó,* half an hour northwest of the village *Doliana* (Lepsius 1890: 31). At a place referred to him by a local shepherd as 'Kolonna' (Lepsius 1890: 31) Lepsius identified an abandoned column drum that he measured and found to have the same proportions as the columns in the classical Doric temple from the mid fourth century BCE in the sanctuary of Athena Alea at Tegea some 10 km north of the quarries (Lepsius 1890: 126). On the quarry site Lepsius also observed traces of an ancient road where wheel-ruts with grooves 1.38 m apart were cut 5-6 cm into the bedrock. Lepsius provided a petrographic description of Doliana marble, and he also did chemical analysis of samples (Lepsius 1890: 32-34). He thus identified some of the peculiarities of Doliana marble such as its slightly bluish to grey colour (Lepsius 1890: 32), and he characterised its crystalline structure as shredded ('*zerfetzten*') due to a mixture of small and large crystals, which, in his opinion, makes it less shiny and white than the famous marble used in classical Athens from the Pentelic quarries outside the city (Lepsius 1890: 32).

Observations of ancient quarries in the vicinity of the mountain villages *Doliana*, *Mavriki* and *Vervena* (Figure 1) have also been made in more recent times (Stewart 1977: 39), but few observations were systematically recorded. In a geological map published by the British topographer W. K. Pritchett, the marble deposits are listed with different colours and crystalline structure (Pritchett 1965, figure 8). On the modern quarry site at *Mavriki-Vervena* I have myself observed a broad range of colours (white, bluish-grey, pink, and beige), marble with coarse as well as fine crystals, and coloured marbles with veins of white.

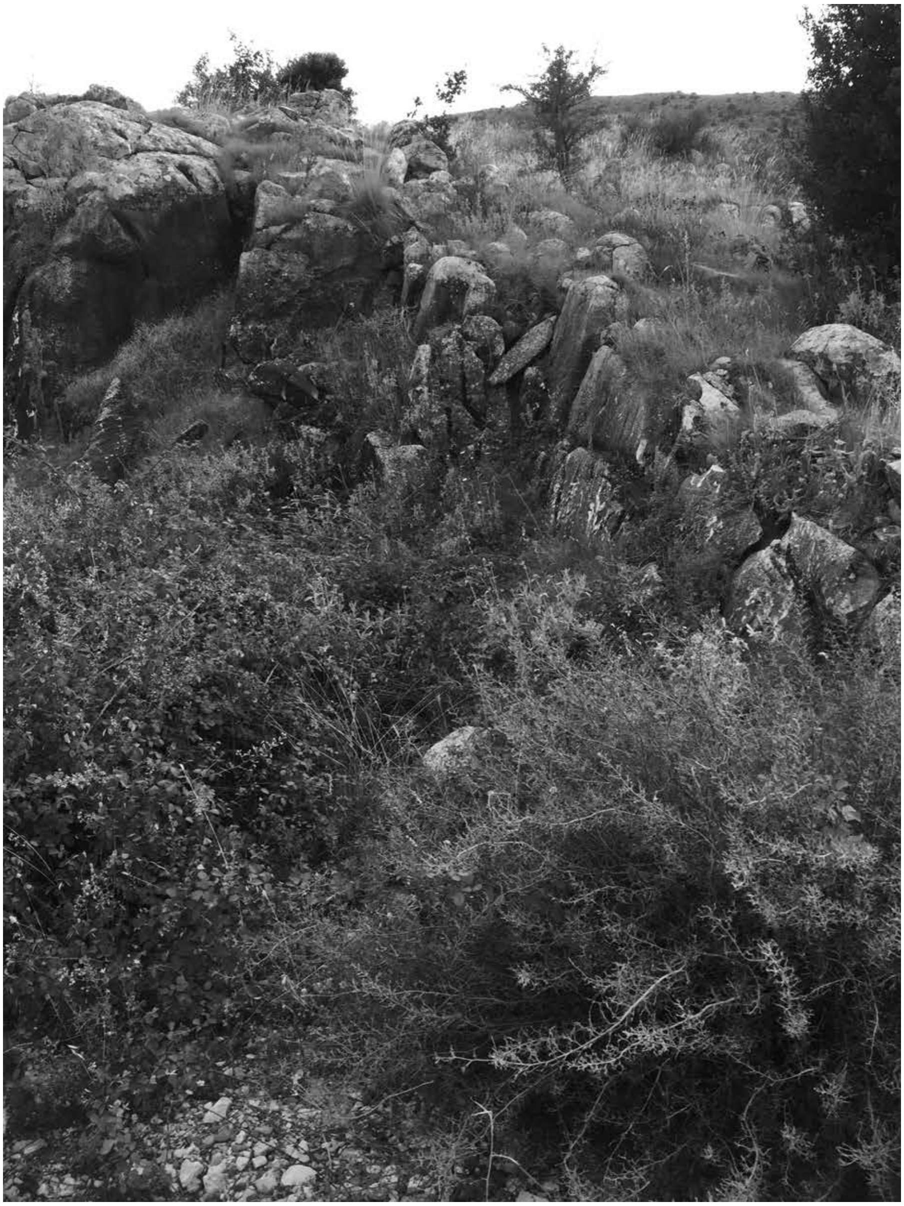

Figure 2. Traces of abandoned quarry at *Alepotripes* (photo by author).

The British prehistorian Roger Howell who did a survey of southeastern Arcadia in the 1960's recorded quarries and remains of abandoned ancient building blocks near Doliana with a couple of photographs (Howell 1970: plates 40 b and c; Bakke and Bakke-Alisøy 2020: 35-36). Howell's location is, however, clearly not identical with the location described by Lepsius. He says that the remains can be found 1 km to the southwest of *Doliana* on the slope of *Karakoula* at 1,318 m (Howell 1970: 89, 93).

Around 1990 a Swiss team directed by the geologist Vincent Barbin analysed samples taken from two locations in the area using cathodoluminescence (CL) microscopy (Barbin et al. 1992). Samples were taken from the modern industrial *Mavriki-Vervena* site referred to by Barbin et al as *Doliana-Mavriki*; and from the *Alepotripes* quarries below *Doliana* referred to by Barbin et al as *Doliana-Doliana*. Neither the *Karakoula* site documented by Howell, nor the *Agios Panteleïmon* site documented by Lepsius was sampled by Barbin's team.

Modern industrial quarrying can be found at *Mavriki-Vervena* at an altitude of 1,200 m between those two villages, and at *Alepotripes* at 900 m to the north of *Ano Doliana*. During our survey, we have made no secure confirmation of early historical activity in any of those locations. At *Mavriki-Vervena* debris from the industrial quarries appear to overlay an older layer of debris. There are also several phases of exploitation at *Alepotripes* (Figure 2). The *Karakoula* site, documented by Howell, was outside the area that was surveyed in 2012, and so we have no confirmation of it. However, the documentation provided by Howell appears to be sound.

Figure 3. *Agios Panteleïmon* quarries from highest point with view of Doliana Valley and Tegean Plain in the Background (photo by author).

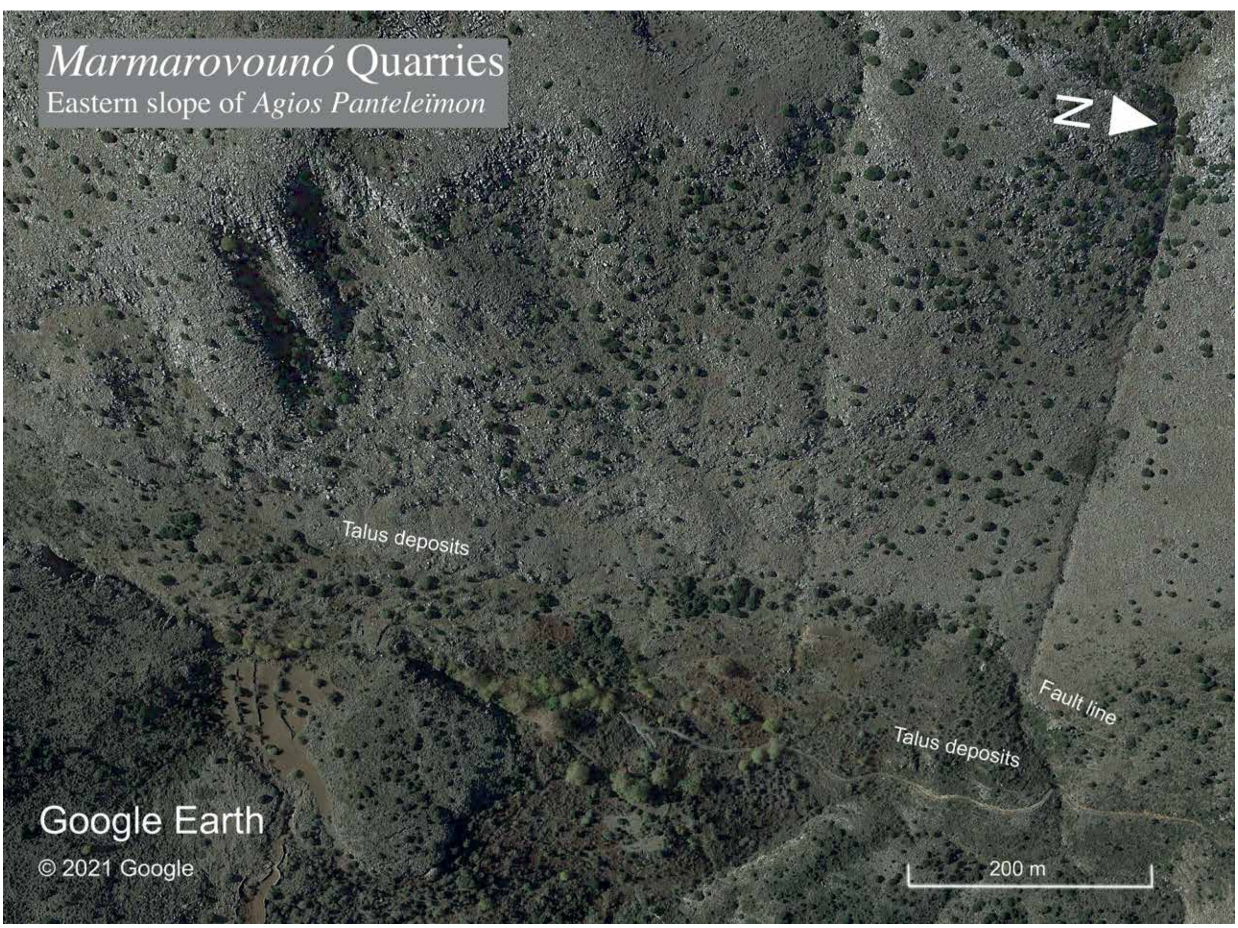

Figure 4. Google Earth image of Agios Panteleïmon quarries (modified in Adobe Photoshop CS6 by the author). ©Google, ©2022 Airbus, European Space Imaging, Maxar Technologies, Map data ©2022.

Figure 5. Abandoned attempt to split ashlar blocks in *Agios Panteleïmon* quarries (photo by author).

Figure 6. Traces of iron tools in the bedrock in *Agios Panteleïmon* quarries (photo by author).

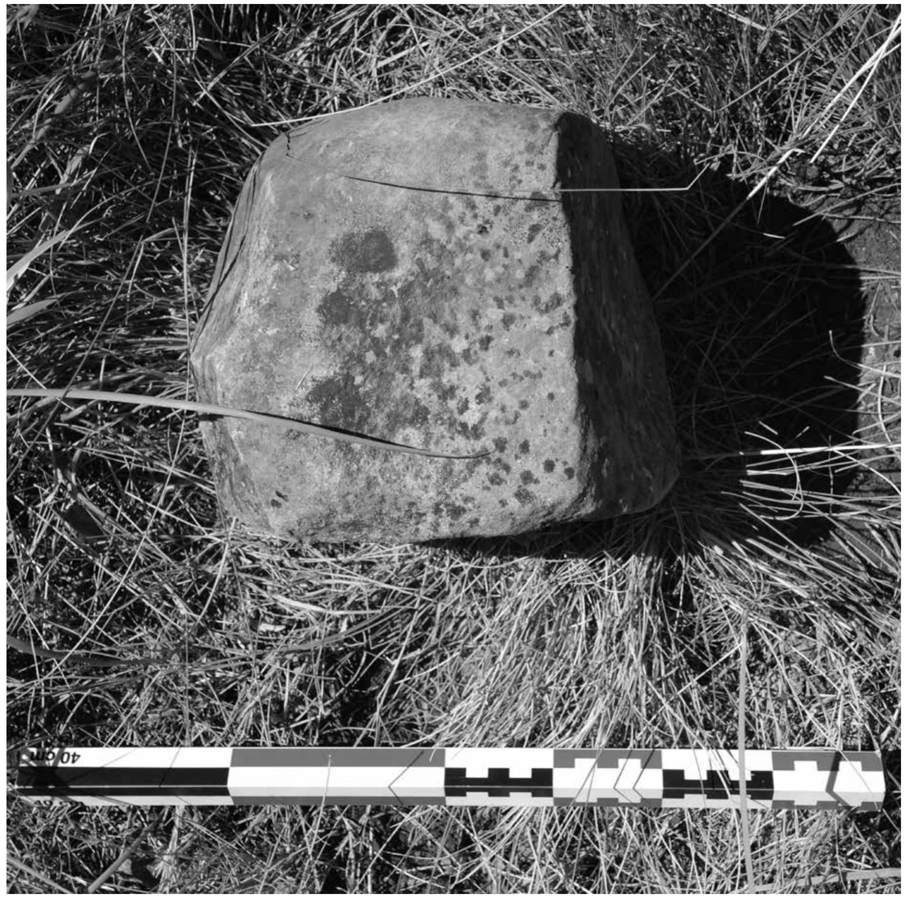

Figure 7. Block in scree below *Agios Panteleïmon* quarries with traces of iron tools (photo by author).

The main quarry remains, that we documented in 2012, is on the eastern slope of *Agios Panteleïmon*. The extent as well as the character of the remains clearly indicate that we are dealing with the location described by Lepsius. The quarries extend along a steep slope at an altitude of between 1,150 and 1,200 m stretching almost 500 m from southeast to northwest (Figures 1, 3 and 4). From a ridge at an altitude of c. 1,200 m on the eastern side of the mountain peak (1,320 m) several deep depressions have been cut into the slope. At the highest point on their western edge these depressions are defined by a vertical wall worked deep into the bedrock (Figure 3). Their lower edges are open towards the slope. The most clearly defined depression that we identified is cut deep into the steep mountain slope. It is approximately 20 m across and 120 m from the top of the ridge to where it opens up farther down the slope. This and the most immediate depression are clearly visible in the landscape from afar as two unnatural cuts in a large natural pillow of marble on the eastern ridge of the mountain (Figure 4). Everywhere in these depressions the ground is covered by large, worked marble blocks and fine to medium-sized marble chips. We also documented abandoned attempts to split ashlar blocks (Figure 5) as well as steps left in the rockslope after the quarrying of ashlar blocks. Traces of surfaces worked with iron tools are abundant (Figure 6).

The lower eastern slope of the Marble Mountain is covered by debris from the large quarries just below the ridge. The farther down the slope, the larger the fragments are. The valley bottom is littered with large boulders of marble (Figure 4). High up in the quarries the debris consists of small to medium-sized marble chips that originate in the rough adaptation of marble blocks on the production site. The blocks farther down the slope vary somewhat in size, but many have clearly worked surfaces with traces of iron tools (Figure 7). The visible surfaces of marble fragments farther down the slope are, for the most part, slightly rounded due to water erosion. Along a recent improvement of an old road up the pass to *Vervena* fragments with sharp edges not exposed to weathering can be observed. This road appears simply to have been cut into a massive scree of marble debris from the quarries (Figure 8).

No more than 5-6 m above this road where the survey team made the first observations of the marble scree there is a fault line where a wall of marble has been exposed. The wall of this fault line has, for the most part, a kind of bubbly and cracked surface that would indicate a long

Figure 8. Road cut into scree of marble debris below *Agios Panteleïmon* quarries (photo by author).

period of natural erosion. In one area the bubbles appear to have been cut away leaving an even, vertical wall up to 2-3 m high (Figure 9). Since the fault line has exposed the marble outcrop on the surface, it would have been relatively easy to quarry small slabs here. This location is at some distance from the main quarries further up the slope, and might belong to a different, perhaps earlier, phase of exploitation.

Although the most spectacular remains of ancient marble quarries are located on the eastern slope of *Agios Panteleïmon*, marble was quarried from a number of different locations before modern industrial quarries were established in the area. One documented example of this is the *Karakoula* site described by Howell (Howell 1970: 89). The quarries at *Alepotripes* may also have served building activity near the quarry site in antiquity. As I will demonstrate, the same is very likely also the case in the *Mavriki-Vervena* quarries.

2.3. Prehistoric and early historical landscape

Northeast of the main ancient quarries at *Agios Panteleïmon* is the Doliana Valley (Voyatzis 1990: 11; Bakke and Bakke-Alisøy 2020: 37-39). This is a side valley to the southeast of the plain that was the central territory of the ancient city-state Tegea (Figure 1). The Tegean plain at between 650 and 700 m with rich alluvial soil and ample water supply provided for a large population in antiquity (Forsén 2000). The early historical significance of Tegea is testified by the peri-urban sanctuary of Athena Alea. This sanctuary was a cultural contraction point in the area centuries before Tegea grew into one of the largest and most powerful city-states in the Peloponnesian Peninsula from the middle of the 6th century BCE (Ødegård 2005; and Østby 2014a). As early as around 600 BCE the Tegeans built an early Doric temple to Athena Alea partly of marble. This archaic temple is the first attested use of Doliana marble in a monumental building project. In the mid 4th century BCE this building was replaced by a large temple built entirely of marble (Pausanias 8.45.5; Østby 2014a and 2014b).

The recent survey of the Doliana Valley focused on prehistoric, mainly Bronze Age, activity (Bakke 2010; Bakke-Alisøy 2016; Bakke and Bakke-Alisøy 2020). On the eastern edge of the Tegean Plain at *Agiorgitika*, however, occupation also goes back to the later part of the early Neolithic period (Petrakis 2002: 13). No absolute dates exist for *Agiorgitika*, but comparison with other Peloponnesian locations indicate that we are in the early 6th millennium BCE (Perlès 2001: 50, table 6.1;

Figure 9. Natural fault line with highly eroded wall after quarrying below main site of *Agios Panteleïmon* quarries (photo by Hege A. Bakke-Alisøy).

105). From Howell's survey in the 1960's we knew that there were Bronze Age sites in the Doliana Valley, and one (*Mirmingofolies*) was even located along the route from *Psili Vrisi* to the *Agios Pandeleïmon* pass towards *Vervena* (Howell 1970: 93, no. 31; and Bakke-Alisøy 2016). Howell dated *Mirmingofolies* to the Early Bronze Age (third millennium BCE). Some 300 m to the northwest of *Mirmingofolies* we documented some material that dates to the Late Bronze Age (second half of second millennium BCE). The Late Bronze Age material was also recorded in close vicinity of the modern dirt road from *Psili Vrisi* to *Vervena* (Bakke-Alisøy 2016; Bakke and Bakke-Alisøy 2020: 42).

From the *Agios Panteleïmon* pass the route along the dirt road from *Psili Vrisi* to *Vervena* would easily have interconnected with the important Bronze Age site at *Analipsis* on the border between ancient Arcadia and Laconia. Finds from *Analipsis* go back to the Neolithic period (5th and 4th millennium BCE) and extend into the Medieval period, probably into the 13th century CE (Rhomaios 1902; Rhomaios 1957; Howell 1970: 95-96; Kalogeropoulos 1998; Bakke 2008: 210-228). This indicates that the route from the lower Doliana Valley through the pass of *Agios Panteleïmon* towards *Vervena* was established at a very early stage in the history of settled occupation of the inner Peloponnesian peninsula, and that its importance persisted throughout its premodern history (Bakke-Alisøy 2016). Since the Doliana deposit is one of the few Peloponnesian outcrops that provides good white marble, this also makes it a potentially interesting source for prehistoric marble objects found elsewhere in the Peloponnese. One of the few other Peloponnesian sources of white marble is in the Mani to the fare south of the peninsula (Bruno et al. 2002). A head of a marble figurine of white marble from the Late Neolithic (late 5th to early 4th millennium BCE) found in a cave at *Aleopytra* is probably made of marble from *Pyrgos Dirou* (Cooper 1988: 67-68). Another Late Neolithic figurine from Sparta, the so-called Priestess (Figure 10) is catalogued with an insecure provenance 'from the hinterland of Sparta' (Manteli 2018: 322, note 16). It is also listed as made of limestone, but no scientific investigation of the figurine appears to have been undertaken. The quality and colour of the stone indicate that it might as well be fine grained marble from the Doliana outcrop or from the Mani marble, rather than limestone. Although there is no positive documentation to indicate that the figurine was made by Doliana marble, it is an example of the kind of

Figure 10. Neolithic figurine with an insecure provenance 'from the hinterland of Sparta'. National Archaeological Museum, Athens (photo by author).

Figure 11. Reused marble blocks from *Agios Panteleïmon* quarries found in the remains of a building at *Agios Dimitrios* (photo by author).

Figure 12. Artemis Knakeatis gorgon. Tegea Archaeological Museum (photo by author).

material culture that may have come out of the Marble Mountain taking into account that the route through the *Agios Panteleïmon* pass was definitively established in the Early Bronze Age.

The route from *Psili Vrisi* to the *Agios Panteleïmon* pass is also most likely the transportation route from the Tegean plain to the quarries in antiquity. We did, however, not identify any clear remains of an ancient road with wheel-ruts cut into the bedrock as was documented by Lepsius (Lepsius 1890: 126). A modern road that cuts through deposits of waste from the ancient quarries (Figures 4 and 8) probably replaced an early modern road of which remains could be observed further down in the valley at *Skala* (Bakke and Bakke-Alisøy 2020: 42). Other candidates are made up of a series of stone walls above the modern road. Rather than following the contours of the slope as agricultural terraces typically do, they break off on a steeper ascent towards the main quarries on the slope (Figure 4). The building technique of these walls are very similar to the aligning walls of the early modern road that we identified at *Skala* further down in the valley (Bakke and Bakke-Alisøy 2020: 42). Since this is a building technique that is consistent with transport by beasts of burden rather than with wheeled transportation (Pikoulas 1999: 254-255; Forsén 2003: 71; Bakke 2008: 90-91), one should be open to the possibility that the *Agios Panteleïmon* quarries were never completely abandoned after late antiquity. This hypothesis is strengthened by finds from *Agios Dimitrios* south of *Psili Vrisi* (Figure 1). There we documented remains of a building that can be dated no earlier than the 5th or 6th century CE (Bakke and Bakke-Alisøy 2020: 41). Building material on this site include what appears to be reused ancient marble block fragments (Figure 11). I have argued elsewhere (Bakke and Bakke-Alisøy 2020: 45) that these fragments could stem from use of abandoned building blocks in the marble quarries at *Agios Pandeleïmon* rather than from an ancient building. This practice of reuse is interesting as a form of secondary material agency on the quarry site. It also attests to the resilience of the *Psili Vrisi* to *Vervena* route in the local communication network.

Claims have been made earlier (Callmer 1943: 128-131; Voyatzis 1990: 11) that the Doliana Valley was the original homeland of the Tegean tribe of the *Gareatai* mentioned by Pausanias (8.54.1). During the survey we found that a low mound situated between the villages *Psili Vrisi* and *Rhize* where the *Doliana* Valley opens up towards the main Tegean Plain is littered with ancient building remains (Figure 1). Villagers refer to this area as *Paleo Garea* (Bakke 2010: 56-57; Bakke and Bakke-Alisøy 2020: 38, note 25.). The marble blocks at *Paleo Garea* could also be recovered from the waste piles in the *Agios Panteleïmon* quarries like at *Agios Dimitrios*, but further investigations are necessary in order to decide anything about the date and function of these remains.

According to the second century CE travel description by Pausanias (8.54.4) the road from Tegea to Thyrea on the eastern shore of the Peloponnese also passed through the Doliana Valley, but no documentation has ever been provided either for this ancient route or, for that matter, for Pausanias's so-called 'direct route' from Tegea to Sparta in the Southern Peloponnese (Pausanias 8.53.11; Loring 1895: 52-53; Rhomaios 1952: 1; Pritchett 1989: 77-91). Potentially this ancient direct route to Sparta might have passed through the *Agios Panteleïmon* pass rather than through the gorge of the *Sarandapotamos* river further to the west (Figure 1). Although the *Sarandapotamos* route has been the favoured alternative of earlier scholars, documentation that ranges from the Early Bronze Age, Late Antiquity, and the Early Modern period along the *Psili Vrisi* to *Vervena* route makes the *Agios Panteleïmon* pass no less likely a candidate.

The more spectacular finds from Classical antiquity in the vicinity of the Marble Mountain, have been located on the northwestern slope of that mountain rather than down on the valley floor (Figure 1). At a place called *Psili Korphi* (the High Summit) on the northwestern slope of *Agios Panteleïmon* the Greek archaeologist Konstantinos Rhomaios excavated, in 1907, a small, and conspicuously early Doric temple built entirely of Doliana marble (Rhomaios 1952). The Norwegian archaeologist Erik Østby has argued that the temple was built as early as around 570 BCE (Østby 1995: 309, 320; see Winter 1991: 216 for alternative date). Rhomaios identified the sanctuary as that of Artemis Knakeatis mentioned by Pausanias in his description of the route between Tegea and Sparta (Pausanias 8.53.11; Rhomaios 1952). During the recent survey we also identified another ancient building complex of marble that probably dates to the Classical period further down the northeastern slope of *Agios Panteleïmon* (Bakke 2010: 54, figure 4).

What is interesting in this context with the recently identified marble buildings and the sanctuary of Artemis Knakeatis is the extensive and early use of Doliana marble in monumental architecture and in architectural sculpture such as the head of a gorgon (Figure 12) from the Artemis sanctuary. Both building sites are situated on the northwestern slope of *Agios Panteleïmon*. This places them on the opposite side of the mountain peak to the *Agios Panteleïmon* quarries. The Artemis sanctuary is also situated at a much higher altitude (c. 1,200 m) than any other documented ancient building in the area. This makes it all the more likely that the marble used in the two building complexes west of the peak was quarried from a location on the western slope of the mountain, such as the modern *Mavriki-Vervena* quarry site located further to the south and at an altitude of 1,230 m.

2.4. Ecological agents

As geological agent stone quarrying is a form of anthropogenic erosion. With their iron tools, wooden vehicles, ropes, and draft animals, small groups of modern humans have carved their way into the Marble Mountain creating deep depressions on the mountain slopes as well as debris of different shapes and sizes (Wurch-Kozelj 1988; Korres 2000). Some of this debris has been transported far away from the quarry sites and have had a remarkable life in the ecology of things as building blocks in spectacular buildings, and as plastic works with a more than human, heroic (Figure 13) and supernatural agency

Figure 13. Male head from Tegean sanctuary of Athena Alea. National Archaeological Museum, Athens (photo by author).

(Figure 12). In the *Agios Panteleïmon* quarries the results of this anthropogenic erosion can be observed both in the deep depressions on the mountain slope, but also in large amounts of debris on the slope and down on the valley floor. Even though this debris was generated by human activity, its formation processes are very similar to natural sedimentation (Skinner and Porter 1995: 230). Below the *Agios Panteleïmon* quarries large conical pillows of debris have assembled at the lowest point of the slope. A row of these pillows of debris can be observed from c. 150 m below the two deepest depressions to approximately 500 m further down the valley. At their lowest point the modern dirt road from *Psili Vrisi* to *Vervena* (Figure 8) cuts into them and thus underlines their conical contour clearly visible in the Google Earth image (Figure 4).

The deposits of waste from the *Agios Panteleïmon* quarries form a series of screes that geologist call talus deposits (Skinner and Porter 1995: 229-230). From the deep depressions high up on the slope coarse angular marble blocks have fallen (or been pushed by marble workers), slid, and rolled down the slope, thus continuously feeding the talus for as long as the marble quarries were in production. Higher up the slope the ground is covered by finer fragments. Typically, such finer fragments also find their way down to the talus where they drop into voids between coarser fragments. As in a natural talus deposit, large boulders tend to move further down the slope, and some of them have ended up down on the valley bottom, because they gain more momentum than smaller fragments as they slide and fall (Skinner and Porter 1995: 229-230).

A mix of anthropogenic agency and natural erosion processes can also be observed in a form of chemical erosion that is characteristic for calcite rocks such as marble and limestone. Acidic rainwater will react with the calcite that the marble rock is composed of, and the result will be a form of chemical erosion of exposed surfaces (Skinner and Porter 1995: 303). Surfaces that have been exposed for a long time will typically be without sharp edges and with cracks wherever an uneven surface has allowed acid rainwater to penetrate the calcite rock. Exposed remains in the *Ag. Panteleïmon* quarries (Figures 5 and 6) will typically have their sharp edges and surfaces, with marks after the use of iron tools, slightly rounded. This often leaves tool marks almost unrecognisable. A similar erosion pattern can be observed in the top layer of the talus deposits further down the slope. Notably the marble debris have more intact surfaces and sharper edges where the modern road has cut through the talus deposits (Figure 8).

Chemical erosion caused by acidic rain can also alter the visual appearance of plastic works in marble (Skinner and Porter 1995: 301). No unfinished or broken plastic works have been discovered on any of the quarry sites, but the marble head of a gorgon from the nearby site of the sanctuary of Artemis Knakeatis is a good example (Figure 12). That the facial features of the gorgon from *Psili Korphi* are almost completely wiped out by water erosion was already pointed out by its excavator (Rhomaios 1952: 18). The head of the gorgon has pierced holes for eyes, mouth, and ears. In the mythical monster that was the gorgon Medusa, eyes and mouth are especially important features because whoever meets the gaze of the gorgon will die and turn into stone. The mouth of the gorgon is important because of the terrible sound it emitted from its gnashing teeth causing fear in an opponent (Vernant 1991: 118). Because these facial features were so important, the Knakeatis gorgon probably also had inlayed eyes of bronze and possibly gemstones. The shape of the holes for mouth and eyes appears to be especially worn, perhaps because water was allowed to work more effectively there. It is with the agency of two and a half millennia of water erosion as artist that the Knakeatis gorgon has got its present ghost-like face. Even though the figure has lost the lethal gaze of its inlayed eyes, its appearance partly man-made and moulded by acidic raindrops has obtained a new form of uncanny visual agency.

Other zoological agents than humans have also contributed to the erosion of quarry remains in exposed bedrock, abandoned blocks, and debris. Most exposed surfaces are currently almost completely covered by lichens (Figures 5 and 6) that probably also contribute to surface erosion (Jacob et al. 2018). Together with debris from decomposed plant material, droppings from livestock, and wild animals these particles have left a thin layer of soil that has filled up the low trenches between blocks and debris. Since the number of sheep and goats that graze on *Agios Panteleïmon* have probably dropped significantly in recent decades this layer of soil has also allowed scattered trees of prickly oak to establish on the quarry site (Figures 3, 4, and 8). The placename *Alepotripes* (fox holes) indicate that even larger animals may have taken up residence in the cavities in piles of debris after quarrying.

Figure 14. Wild boar head fragment from Tegean sanctuary of Athena Alea. National Archaeological Museum, Athens (photo by author).

The talus deposits consist almost completely of fine white marble blocks and chips after the rough adaptation of blocks on the quarry site. To what extent they have been exploited as a resource for building material and as raw material for the production of lime to be used in mortar and plaster, is not documented. Potentially, this kind of reuse of waste represents an important afterlife of the quarries after production was probably downscaled sometime during the later phases of antiquity. Reuse of waste from the *Agios Panteleïmon* quarry site at *Agios Dimitrios*, and possibly also at *Paleo Garea*, represents a secondary form of anthropogenic erosion of the talus deposits on the foot of the Marble Mountain.

2.5. An ecology of Marble

If the material life of the Doliana Marbles was born when marble blocks were extracted from the Marble Mountain, one of its most important lifecycles in antiquity would have been to be cut, polished, and painted into classical sculptures such as a fragment of the head of a wild boar from Tegea (Figure 14). This fragment probably belonged to the beast in the Calydonian boar hunt on the eastern gable of the classical temple in the sanctuary of Athena

Alea at Tegea. We owe this identification to the ancient travel description by Pausanias (8.45.5.7). The Calydonian boar hunt took place in Calydon (Figure 1) on the Greek mainland but had a special significance to the Tegeans because the boar was first struck by the female warrior Atalanta from Tegea. It was well known in antiquity that the tusks as well as the hide of the boar were dedicated in the Tegean sanctuary of Athena Alea. Pausanias reported to have seen the sorry remains of the hide still hanging in the temple of Athena Alea in the middle of the second century CE. Its tusks he had also seen, but in the imperial gardens in Rome where they had been placed by Augustus after he raided the Athena Alea sanctuary (Pausanias 8.46.5 and 8.47.2).

Pausanias also describes cult statues and other dedications in the Athena Alea sanctuary. Among the dedications he mentions sculptures of Asclepius and Hygieia that were placed on either side of the cult statue of Athena Alea (8.46.1). The one line where he refers to these two sculptures is the only literary source from antiquity that provides us with a provenience of Marbles from the Athena Alea sanctuary. Somewhat disappointing for someone interested in the use of Doliana marble, Pausanias says that they were made of Pentelic marble, *λίθος τοῦ Πεντελησίου* (8.47.1). He also mentions that the sculptor of these works was the famous Scopas from Paros (8.47.1).

That the two sculptures inside the Athena Alea temple were made of Pentelic marble from Athens is very specific information, that Pausanias probably got from a local guide at Tegea. Perhaps his guides mentioned it to him because there was a local tradition about these sculptures being dedications from the Athenians, or, perhaps, Pausanias or his guides wanted to underline that the material of these sculptures was different than the local Doliana marble of the temple. However, if it was an observation on account of Pausanias, he might also have been mistaken. Pausanias does not mention the Tegean marble quarries, but rather defines the route that probably passed them by means of the sanctuaries situated along this route (8.53.11-54.1). It is not unheard of that Pausanias mentions industrial sites, such as the porphyry quarries at *Krokeai* (Figure 1) in Laconia (3.21.4), but sometimes he completely ignores contemporary facilities. As is often the case, Pausanias emphasises the cultural monuments, and especially religious sanctuaries, of old Greece in his description of the Tegea-Sparta route. I say this not to question the reliability of Pausanias as a source, but because Doliana marble comes in a broad range of qualities, both in terms of crystalline structure and colour that Pausanias may not have been aware of.

There are two Marbles from Tegea that have been argued to be possible candidates as fragments of the sculpture of Hygieia mentioned by Pausanias. One is the famous head of a young woman in the Athens National Museum (NM3602: Stewart 1977: 83), and the other a female torso in the Tegea Museum (Stewart 1977: 84). In his monograph on Scopas, Andrew Stewart says that the marble of NM3202 is agreed upon to be Parian rather than Pentelic. Despite his judgement that the style of the female torso from Tegea is ‘a little hard’ to be by Scopas, Stewart is open to the possibility that it could be by Scopas. He also supports his argument with an assumption that ‘the marble could also be Pentelic’ (Stewart 1977: 84).

Arguments put forward by art historical connoisseurs like Stewart, without questioning the still reigning authority on Scopas, are often taken as solid, even though they are based on nothing more than stylistic parallels of fragments and presumed copies. Stewart mentions that he collected samples of Doliana marble, but he does not provide any description of them. Like the samples collected by the Swiss team in the 1990s they probably come from one of the modern industrial quarries rather than from any of the documented ancient quarry sites.

Pausanias is also the only source of the information that the same Scopas from Paros, who made the statues of Asclepius and Hygieia, was the *ἀρχιτέκτων* of the classical Athena Alea temple (Pausanias 8.45.5; Karapanagiotou 2012). Although the ancient term *ἀρχιτέκτων* does, of course, not signify the same as the modern word architect, Stewart argues that we can be pretty sure it implied a master’s hand in the design and planning of both temple and sculptural programme (Stewart 1977: 3, 80-81). Stewart also points out that the proportions of the building indicate a careful plan for exact extraction of building blocks from the marble quarries (Stewart 1977: 81). Whether the use of proportions with exact ratios in Arcadian feet, as is suggested by Stewart, can be applied to the entire building, has been questioned by the Finnish archaeologist Jari Pakkanen (Pakkanen 1998: 76; 2013: 94-109). One of the reasons why Stewart believed that the exact measurements of blocks to be so important, was that he did not consider it to be likely that Scopas stayed on in Tegea for the perhaps as much as 15 years that it took for the construction and decoration of the temple (Stewart 1977: 80).

Whatever time the man called Scopas from Paros spent at Tegea, he probably set up a workshop on the building site of the Athena Alea temple. The activity of this workshop represents the most spectacular production of marble objects from the Marble Mountain. As with sculptural Marbles from Tegea, no form of scientific investigation has ever been undertaken on marble used in the Athena Alea temple. The mere quantity of marble that would have been required for this building project does, however, make the *Agios Panteleïmon* quarries its most likely source. It also confirms the hypothesis that Lepsius identified a column drum with the same proportions as the columns in the sanctuary of Athena Alea on the eastern slope of *Agios Panteleïmon* (Lepsius 1890: 126). Some of the other preserved marbles from the Athena

Alea sanctuary are widely held to stem from the pediment sculpture groups described by Pausanias. Although no scientific confirmation exists, most scholars agree that they are made of marble from the Doliana ore, and that they are, in fact, originals from Scopas's workshop in Tegea (Richter 1967: 276-271; Lawrence 1972: 194; Stewart 1977: 3; Karapanagiotou 2012).

Three fragments identified as belonging to the pediment sculptures were found together reused in a post-ancient wall northwest of the temple foundations (Dugas et al. 1924: 84-85, 89-92; Stewart 1977: 14). Since small and large chips have been broken off from the fragments already worn by weathering, very little of intact surfaces are preserved. One battered male head (Figure 13) still bears marks of what has become to be recognised as characteristic features of Scopas's Tegean workshop (Stewart 1977: 16-18, no. 9; Barringer 2014: 300-301). The head is turned and tilts dramatically to the left. The deep, but wide open, and large eyes give the character a strained appearance. The protruding lips made Stewart comment that he could almost feel the marble panting (Stewart 1977: 18). The cauliflowered left ear, thick neck, and muscular square shape of the head indicate the rough physique of a warrior. This 'new heroic style', as it has been termed by art historians, is characterised by more individualistic portraits and a new emphasis on emotion and the physical responses of the body (Stewart 1990: 182). Despite being badly damaged and worn the male head still touches whoever encounters it with a strong material agency, projecting the physical agony and pathos of the warrior struggling with the Calydonian boar.

Another fragment found in the same context is a piece of that very same boar from the pediment group of the Calydonian Boar hunt at Tegea (Figure 14). Although characterised as technically a sketchy piece (Dugas 1924: 84; Stewart 1977: 15) the fragment of the Calydonian Boar is really a remarkable example of Late Classical sculpture: the fragment features mainly the 'face' of the boar, where its fur is relatively thin. The snout and lower jaw of the boar is broken off, but the muscular features under the thin fur are rendered in an anatomically correct way. The beast has recognisable features of the species of wild boar that would have been familiar to the Tegeans in antiquity. There is, however, one feature that gives the boar fragment an altogether different appearance, and that is its eyes. Unlike a natural specimen that have small, well protected, almost sunken eyes, the wide-open, over-dimensioned, protruding eyes of the Tegea boar are overemphasising a similarity with the eyes of the new heroic style warriors in the Tegea pediments (Stewart 1990: 182-183). This almost gives the boar that impression of half-beast, half-man that is such a characteristic feature of other monsters from Greek mythology such as centaurs. There is, however, also a long tradition for the enhancement of eyes in portraits of monstrosity in ancient Greek visual culture (Bakke 2018: 76-81). No other example illustrates this point better than the lethal, and over-dimensioned eyes of the gorgons (Figure 12). By adopting this tradition to the Calydonian boar, the Scopaic workshop at Tegea provided the Tegeans with a new form of material agency in their encounter with mythical monstrosity. The boar is portrayed in a contemporary visual language that combines the beastly with the heroic. In the local ecology of marbles that made up the classical sanctuary of Athena Alea at Tegea, this generates a new form of animation of a mythological battle against the threatening force of a monster that was a decisive event in the cultural creation of Tegean identity. The material agency of the worn fragments of ancient sculpture from Tegea is first and foremost associated with the superb ability of ancient craftsmen and designers in the workshops of men like Scopas to portray heroic action with physical movement, agony, and pathos. The lifelikeness of Greek marble sculptures that provides them with a durable material agency is, however, also very much connected with the qualities of the raw material used to manufacture those sculptures. One example of this form of material lifelikeness is that the surface of a stone sculpture can appear and feel soft like human skin. The lifelikeness of the surface of stone objects such as the male head from Tegea (Figure 13) was engineered with ancient grinding and polishing techniques (Abbe 2020: 5-9). Neatly grinded surfaces are, however, found already in prehistoric stone sculpture from the Aegean area like the Neolithic priestess from Sparta (Figure 10). Its surface is in a much better state of preservation than the worn fragments of the Tegea Marbles. This quality of material lifelikeness does, of course, not give actual biological life to the figurine, or to the Tegean Marbles when they were in a better state of preservation. A polished marble surface is not the same as skin, but the combination of craftsmanship and the imagination of whoever encounters the Marbles generates the response of a vivid agency in them. In ancient rhetorical literature this form of vivid agency response was known as *ἐνάργεια* (Aristotle, *Poetics* 1455a). To generate that form of vivid agency (*enargeia*) in the audience was considered to be an important aim with any performative art including oratory, poetry, theatrical performances, and the visual arts (Webb 2009: 87-106).

At the same time that the grinding and polishing of the surface of Marbles are human technologies used to generate *energeia* in an audience, they mimic and refine a form of geological agency. In nature the interaction between debris of rock fragments and water can also generate a smooth, skin-like surface of evenly rounded pebbles found on beaches and riverbanks. This form of erosion is different from the chemical erosion caused when acidic rainwater hits the surface of marble. The interaction of the ecological agents, water, wind, waves, and tidal variations is a mechanical erosion process where deposits of rock fragments with uneven and sharp edges over time are shaped into even and semi-round pebbles. This was probably also the case with early stone figurines such as the early Neolithic priestess from Sparta as is suggested by Katia Manteli (Manteli 2018: 322, note 17). Possible circumstances for the discovery of marble pebbles shaped by natural erosion exist, for instance, below the fault line where a wall of marble has been exposed at the foot of *Agios Panteleïmon* (Figures 4 and 9). Since we have indications for a communication route between the Tegean plain and the Early Bronze Age site at *Analipsis* near *Vourvoura*, and from there on to Laconia, the *Agios Panteleïmon* pass would have created ideal circumstances for such discoveries.

At *Agiorgitika* on the Tegean plain occupation goes back to the early Neolithic period (Petrakis 2002: 76), and not far from the *Agios Panteleïmon* quarries at *Khairolimnes* (Figure 1) Howell found the head a of a terracotta figurine from the Early Bronze Age (Howell 1970: no. 29, 93). This does not exactly provide a parallel to the figurine from Sparta, but it does testify that there was an early prehistoric tradition in the area for the manufacture of anthropomorphic plastic works. We cannot pinpoint exactly where, and when, the first marble pebble was picked up from the eastern slope of *Agios Panteleïmon*, but when it did it would have been the beginning of the life of the Marble Mountain. It was a potential place of discovery already in the late Neolithic, from which time the Marble Mountain would have taken its first step into the ecology of Marbles that generated the classical temple in the Athena Alea sanctuary as well as lime wash used to protect the surface of village houses in the region.

3. Concluding remarks

The life of the quarries in the Marble Mountain offers an example of how monumental stone technology influenced and was influenced by its local ecology. Like agriculture, animal husbandry, and urbanisation this monumental stone technology has made its imprint on the local landscape. Over the centuries people have dug deep holes into the slopes and left piles of waste on the foot of the Marble Mountain. The activity in these quarries may have started as early as the Neolithic period and continued into the modern era, but the peak of activity appears to have been sometime between the late seventh century BCE to the sixth century CE. The most intense period would probably have been in the fourth century BCE when the Tegeans employed Scopas from Paros to design and construct the magnificent classical temple and vivid architectural sculptures in their sanctuary of Athena Alea.

The most spectacular remains of the quarries in the Marble Mountain are, no doubt, the still visible scars high up on the eastern mountain slope (Figure 4). In the local landscape context these scars and the waste below them have created micro-ecological conditions that may have diverted slightly from those of the surrounding landscape, but the long-term ecological agency of this intrusion is minimal. Screes of marble waste have ended up on the foot of the mountain in conical talus deposits as in natural screes. Deposition of small particles of eroded marble surfaces, decomposed plant material and animal droppings have slowly filled up the scars on the mountain slope allowing vegetation to establish there.

The most resilient historical agency of the quarries in the Marble Mountain is the communication route that we can extrapolate from documented finds and historical sources. A similar pattern has emerged from recent investigations of Bronze Age roads in the Argolid in the northeastern Peloponnese (Brysbaert et al. 2020). The route through the *Agios Panteleïmon* pass was probably established already in the Early Bronze Age (third millennium BCE) and persisted early modern times. The regional significance of this route is that it potentially connected the Neolithic site at *Agiorgitika* in the northeastern Tegean plain with the important Bronze Age site at *Analipsis* in the mountains on the border between Arcadia and Laconia. From this border settlement it probably connected with the prehistoric landscape of the Eurotas Valley. We cannot know to what extent the discovery of the Marble Mountain outcrop was cause or effect in the establishment of this route. In the local context we can, however, be pretty safe to say that the spectacular building activity on the western slope of the Marble Mountain that includes the sanctuary of Artemis Knakeatis at an altitude of 1,200 m would never have taken place if the marble outcrop had not been discovered.

Of the Marbles that came out of the Marble Mountain we have only looked at a couple of examples from the sanctuary of Athena Alea at Tegea and the Artemis sanctuary at *Psili Korphi*. One of the most thrilling things about the Tegea Marbles is, of course, that however fragmented and battered they may be, they are still the only possible originals that exists from the workshop of the man that we know as Scopas from Paros. Both the warrior from the Alea temple twisting his muscular body in agony in the battle with the Calydonian Boar and the ghost-like *Psili Korphi* Medusa still generates a response of vivid agency (*energeia*) in anyone who encounters them. These sculptures are the most resilient agents in the local ecology of Marbles. In pristine condition from the late 4th century BCE and probably still when Pausanias visited the sanctuary in the mid-2nd century CE they made up a most spectacular ecology of Marbles that kept Tegean cultural traditions very much alive.

One problem with the Tegea Marbles is that even though we can assume that the raw material that they were made of originated in the Marble Mountain, and more specifically from the *Agios Panteleïmon* quarries, we currently have no secure documentation to confirm this hypothesis. This unsolved question is, in fact, not the only one in the biography of the Marble Mountain. What the introduction to this biography has uncovered can be summed up in a couple of unsolved questions: First, we lack comparative scientific provenience from documented early historical quarries in the Marble Mountain and Marbles at Tegea and elsewhere. Second, even though this introduction has shown that the exploitation of marble sources was more extensive than previously believed, we still lack a good understanding of the extent and history of the Marble Mountain quarries. Only future research into both provenience and topography can provide answers to those questions. Together with Ann Brysbaert of Leiden University, Jari Pakkanen of London University, Anna Karapanagiotou of the National Museum in Athens, and Hege A. Bakke-Alisøy of the City of Bergen Cultural Heritage Agency, I am currently planning a combined field project and provenience study that will hopefully provide some of the answers in the future. It is our intention that this research program will include detailed mapping of the Marble Mountain quarries using UAV-technology and high-resolution LiDAR-scans as well as CL-microscopy and chemical analysis of identified quarry remains and of Marbles at Tegea and in the National Museum in Athens.

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Building the tholos tomb in Tiryns, Greece: comparative labour costs and field methods

Ann Brysbaert, Daniel Turner and Irene Vikatou

1. Introduction

In the Late Bronze Age Aegean mainland, tholos tombs became a typical grave type for those who could afford to construct these, often monumental, structures (Cavanagh and Mee 1998: 44-46, 63-64, figs 5.2, 6.2). While the phenomenon started in Messenia at the end of the Middle Helladic period or around 1600 BCE (on the earliest one at Koryfasion: Dickinson 1977: 62-63; Voutsaki 1998), the largest ones were constructed in the Argolid after the type reached the region around the LH IIA period if not before (e.g., Pelon 1976: 408-409, 442-453). Most were constructed before the LH III period, but some spectacular ones were built during the LH IIIA-B periods (e.g., Pelon 1976: 408-409; 1990: 171; Boyd 2015: 434, table 1). Mycenae features nine tholoi (e.g., Tsountas 1888; Wace 1949; 1955), and a total of 16 are recorded across the Argolid (e.g., Pelon 1976; Cavanagh and Mee 1998; 1999; Fitzsimons 2011) (Figure 1). These include published examples of one tholos tomb each at Prosymna (Blegen 1937), Dendra (Persson 1931), Berbati (Karo 1935: 199-200; Säflund 1965; Santillo Frizell 1984), Kazarma (Krystalli 1967: 179-180; Protonotariou-Deïlaki 1968: 237-238; 1969a: 3-6; 1969b: 104-105; Michaud 1970: 961; Dickinson 1977: 62), and Kokla (Demakopoulou 1990; Demakopoulou and Alsebrook 2018), and two at Tiryns, one published and one unpublished (Dragendorff 1913; Müller 1975; Hope Simpson and Dickinson 1979: 43; Mountjoy 1993: 161).[1] Most publications have concentrated on the tholoi at Mycenae in great length but less attention has been given to the tholoi at nearby sites.

Our paper, which is part of the SETinSTONE project, discusses the labour efforts and architectural features for the published tholos tomb at Tiryns alongside its unsolved chronology. This tholos (Figure 2), located east of Tiryns' citadel and dug into the foot of the hill of the west slope of Profitis Ilias, was excavated and published by the Deutsches Archäologisches Institut (DAI, the German Archaeological Institute) in the early 20th century (Dragendorff 1913; Müller 1975; A. Papadimitriou 2001). The tholos is also mentioned by Hope Simpson and Dickinson (1979: 43), Wells (1990: 128), and Mountjoy (1993: 161). Published drawings (in Müller 1975), combined with new fieldwork, form the core data for this paper. In overlaying the existing drawings with the 3D model produced by the detailed photogrammetry carried out in the spring of 2018, we compare, first, the accuracy of modern fieldwork techniques in collecting 3D data with

Ann Brysbaert
Daniel Turner
Irene Vikatou
Department of Archaeological Sciences
Material Culture Studies
Leiden University

1 Fitzsimons 2006: 145 refers to an additional tholos found underneath the kafenion in Midea but to our knowledge this has not been published.

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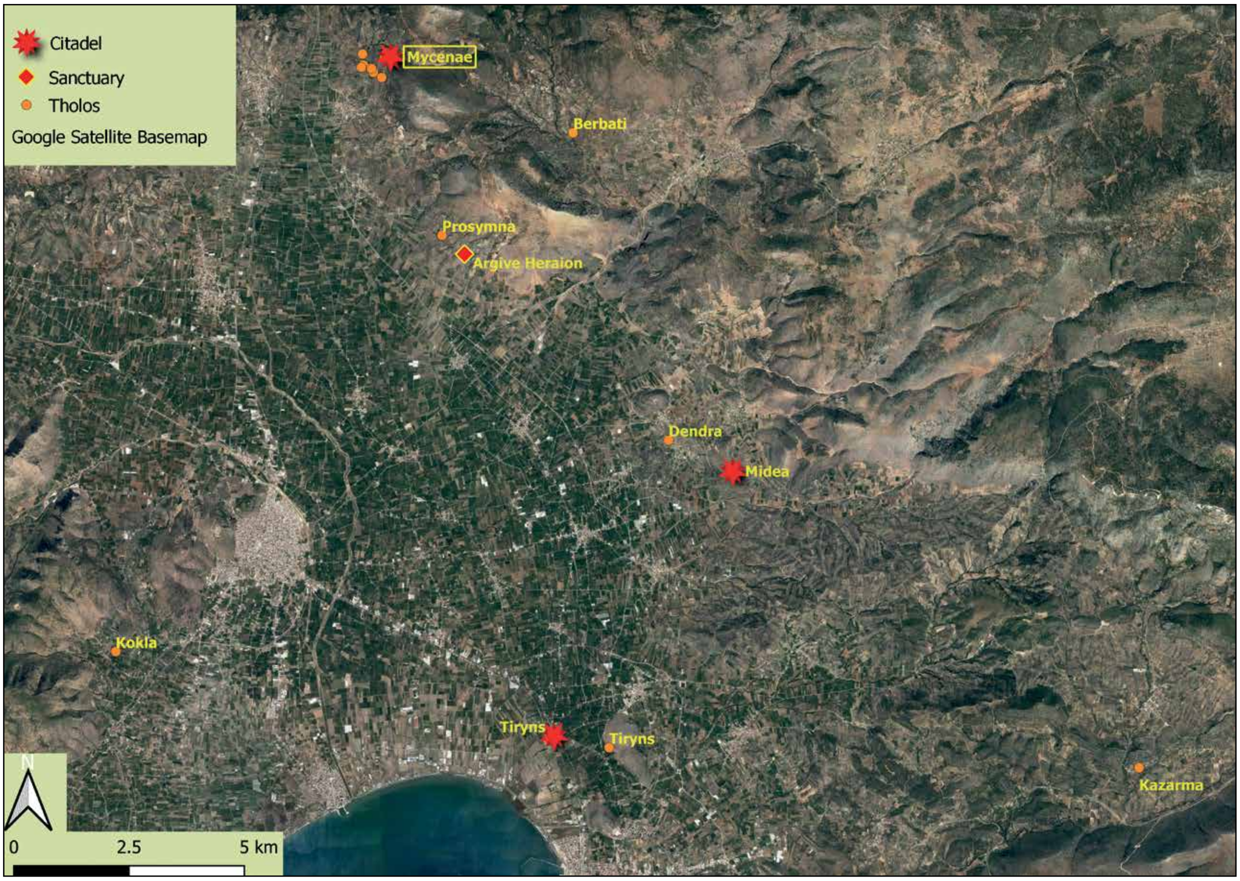

Figure 1. Map of the Argolid indicating all 16 tholos tombs (map by I. Vikatou and A. Brysbaert) Imagery ©2022 Google, TerraMetrics, Imagery ©2022 TerraMetrics, Map data ©2022.

Group	Dates by Wace (1949: 17)	Indicative dates by Pelon (1976: 409, n. 9)
I	1510-1460 BCE	1500-1440 BCE
II	1460-1400 BCE	1410-1350 BCE
III	1400-1300 BCE (= LH IIIA)	1320-1260/1250 BCE (= LH IIIA2/IIIB1)

Table 1. Wace's original grouping and dates of the tholoi at Mycenae and the re-dating of these by Pelon (1976).

much older drawings and assess whether the differences are significant to the final results. Next, we investigate by means of architectural energetics or labour cost studies (see papers in Brysbaert et al. 2018; McCurdy and Abrams 2019 for up-to-date bibliographies), how much effort went into the construction of this grave monument and what its potential impact on the available labour for other regional tasks may have been. In addition to the use of various stone types, plaster was also employed, mainly to embellish the stomion's outer façade. Since this feature is not universal to other tholoi – Wace was convinced that this feature belonged to Group II tholoi (Table 1) at Mycenae (Sgouritsa 2011: 739; it started at the second half of 15th century BCE) – we also give emphasis to the work that may have gone into this part of the construction.[2] Labour calculations thus cover most materials discernibly invested in this monument and we employ a relative index to compare the cost with that of other standard tomb types in mainland and southern Greece. Such work features largely in the ERC-funded SETinSTONE project based at Leiden University. Its monumental labour cost studies have been executed by Ann Brysbaert (Principal Investigator) with the support of I. Vikatou, Daniel Turner, Yannick Boswinkel, and Elisavet Sioumpara. One

2 Wace grouped the nine tholoi at Mycenae in three, chronologically distinct, groups of three tholoi each, based on architectural features, materials used, and style of construction. Details described per group: Wace et al. 1921-1923: 285-287, 387-393 and Wace 1949: 16-19 (with table). Group III's order changes from Atreus, Clytemnestra, Genii (Wace et al. 1921-1923: 352-353, 374, 387, 391) to Genii, Atreus, Clytemnestra (Wace 1949: 16-19). More recently, Pelon 1976, 1990 and Mason 2013 place Clytemnestra's tomb, architecturally, before Atreus Treasury. Wace's overall chronological grouping is not without discussion, see Pelon 1976; and especially also Mylonas 1957, 1966, 1973, for Mycenae itself, but even more so for tholoi outside Mycenae (e.g., Persson 1931: 24-25, 143; Santillo-Frizell 1984: 31-32; Cavanagh and Mee 1998: 44-46).

Figure 2. The Tiryns tholos tomb dug into the east flank of Profitis Ilias Hill (photograph: A. Brysbaert).

of the major aims of the project is to assess if and whether large-scale and long-term monumental construction in the Argolid during the Late Bronze Age may have affected, or even exhausted, human and other resources at play, and whether such activities may have had a role in the crises and eventual collapse of the Mycenaean societies around 1200-1190 BCE (e.g., Brysbaert 2017; Brysbaert et al. 2018). Finally, in this paper we also discuss the chronological issues surrounding the Tiryns tholos tomb.

2. Previous work and background

The first tholos tomb at Tiryns was found during a test excavation under the direction of Dragendorff and in collaboration with K. Müller (Dragendorff 1913). The second tholos is only mentioned in passing by Brommer (1939: 252), Pelon (1976: 464), Hope Simpson and Dickinson (1979: 43), and Mountjoy (1993: 161). It is located just southwest from the better-known one and sits lower down the hillslope. Overall, it is badly damaged and partially collapsed, with no easy access as it seems to sit on private

Feature	Length (m)	Width / Diameter (m)	Height / Depth (m)	Wall thickness (m)	LD (%)	WD (%)	HD (%)
3D Model							
Dromos	13.40	3.01	2.65				
Stomion	4.62	2.10	4.15				
Thalamos	8.20	8.57	7.58				
Outer façade		3.00	4.44				
Inner façade			5.99				
Relieving triangle		1.56	1.43				
Shaft grave	2.39	0.84	1.16				
Dragendorff 1913: 352-353							
Dromos	13.7	3	3.25	0.70	2.24	0.33	22.64
Stomion	4.70*	1.75-2	4.10	0.50	1.73	4.76	1.20
Thalamos		8.50	>8.50			0.82	12.14
Shaft grave	2.35	0.85	1.70*		1.67	1.19	46.55
Müller 1975: 2-4							
Dromos	12.85-13	2.84-2.97	3.25	0.70	2.98	1.33	22.64
Stomion	<-4.65*	1.70-2	4		0.65	4.76	3.61
Thalamos		8.45-8.50	7.50			0.82	1.06
Shaft grave	2.35	0.85	1.80*		1.67	1.19	55.17

* Originally listed as depth. LD, WD, and HD refer to difference with the 3D measurements.

Table 2. Comparative dimensions for the Tiryns tholos tomb, with colour coding for variation with reported length (LD), width (WD), and height (HD) measurements (green, less than 2%; yellow, 2-5%; red, greater than 5%).

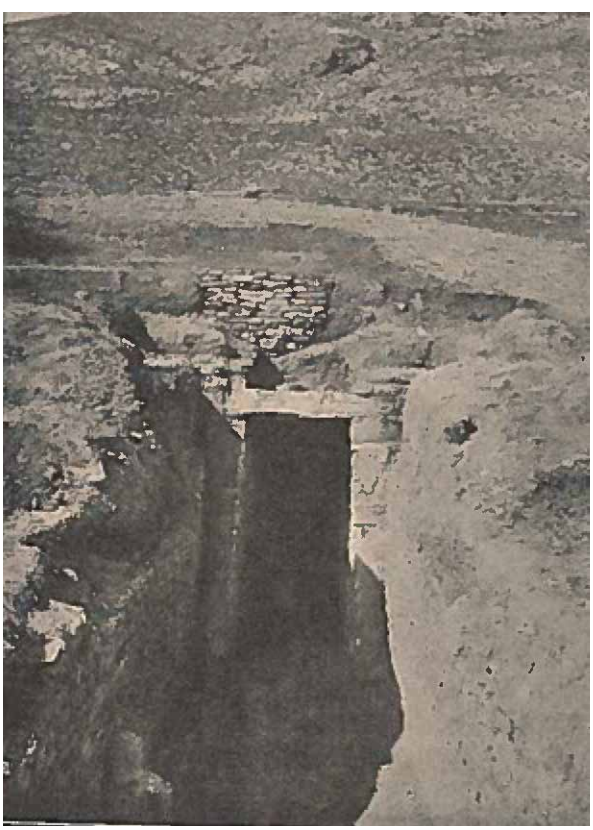

Figure 3a-b. View of the Tiryns tholos tomb taken west to east. The tomb is seated in a bare landscape in 1913 (a, reproduced from Dragendorff 1913: 348, fig. 5) while this is now in the middle of orange groves (b, photograph: A. Brysbaert).

land. Pelon (1976: 464) mentioned that the stomion has a *height* of 2.44 m, thus suggesting that this second tholos may be substantially smaller than the well-preserved one, which has a stomion height of 4 m (see Table 2). Brommer (1939: 252), however, referred to the stomion of the second tholos as having a *width* of 2.44 m rather than *height* (see Pelon 1976: 464) and suggested therefore that this second tholos was at least similarly scaled to the better-known one with a stomion width of 2 m. Stomion width, however, is admittedly among the least strongly correlated variables with other tripartite tomb dimensions, with dromos length and vault width being far stronger indicators of overall size (Turner 2020: 101-102). Whatever the case, it is quite clear that Brommer's measurement indicating the width is correct, since Pelon (1976: 464) in fact referred to Brommer (1939: 252). Brommer, furthermore, mentioned that the chamber had collapsed and massed stone rubble on location forced the postponement of its excavation. Hope Simpson and Dickinson (1979: 43) indicated that the so-called 'Tiryns Treasure' may have come from one of these tholoi, although Karo (1934: 35-36) clearly stated that the 'Tiryns Treasure' – a golden signet ring as well as bronze and amber finds – was found in a humble late Mycenaean house of unknown dimensions excavated around Christmas of 1915. Karo was convinced that the signet ring had been robbed from a royal grave. If this ring indeed originally belonged to a royal grave, its find location then indicates that looting occurred at the latest before the late Mycenaean house fell out of use, although no precise period was given here by Karo (1934: 36).

Upon the hint of their very well-trained foreman, the DAI team started excavating on the foothill of Profitis Ilias and laid bare the dromos and stomion of the well-known and published first tholos (Figure 3a-b). The closing wall of the stomion, unfortunately, had already been opened in the past. The tomb was cleared in antiquity, and its dromos and chamber were reused in Roman times. Traces of this reuse were noted in the wall that originally closed off the western dromos end, in the olive press left in the chamber, and in the pottery vessels and lamps that belong to the Roman era (Dragendorff 1913: 347-350). During the excavation of the inner space, it became clear that the robbing of the tomb was complete since not a single sherd was found. Moreover, Roman use of the tomb resulted in digging the centre of the floor of the chamber deeper so the Mycenaean floor level was destroyed (Dragendorff 1913: 353). These factors had repercussions for the dating of the tomb, but Dragendorff (1913: 352) noted that, architecturally at least, the tomb was well preserved so that its building techniques and materials would remain informative.

The dimensions of the tholos tomb vary slightly according to published finds and are therefore summarised in Table 2. We added our own measurements based on the 3D model made for this study (see Methodologies below).

In terms of size, this tholos compares well with Menidi (8.35 m diameter: Lolling et al. 1880: pl. 1; Turner 2020: 118), Vapheio (10.15-10.35 m diameter: Pelon 1976: 184) and Prosymna near the Argive Heraion (9.7 m diameter: Stamatakis 1878: 276; but 9.5 m according to Wace et al. 1921-1923: 332; Hope Simpson and Dickinson 1979: 38; Galanakis 2013: 1). Based on chamber diameter, the Tiryns tholos falls exactly in the middle of known tholoi in the Argolid (Table 3). The length of the dromos, the door width, and the length of the doorway of the Menidi, Vapheio, and Prosymna tholoi mentioned above also compare closely with the Tiryns example (Dragendorf 1913: 353).

3. Methodologies

In order to establish the labour efforts employed in the Tiryns tholos tomb AB and IV used photogrammetry to produce a high-quality three-dimensional model (Figure 4). The model was subsequently analysed by DT to derive area and volumetric data of the building materials employed and of the sizes of the individual stones where required. Since the remains of the plaster on the stomion were not well preserved, we did not record these as a separate material by means of total station. However, the dimensions of the covered surface can easily be extracted from the stomion measurements derived from the photogrammetry model and the thickness from the loose fragments found lying on the ground near the tholos. Models of this kind are sufficiently accurate in order to carry out labour cost studies on any of the architectural features of the tomb, including the plaster work. Moreover, the work carried out by Turner in a 2017 field season (see Turner 2020) on 94 chamber tombs and the tholoi of Menidi and Portes offer a substantial comparative resource with which this case study can be enriched and contextualised.

The Tiryns work started by georeferencing ground control points (GCPs) around the tomb by means of a high-accuracy differential GPS instrument (Leica GS08plus) and a reflectorless total station (Leica FlexLine TS06), work carried out by DT, Y. Boswinkel, and AB in the summer of 2017, in order to establish a site grid for the tomb integrated within the Greek grid. Unfortunately, when AB and IV returned to the site in spring 2018, the five GCP points were hardly visible, and it took a large part of the day to re-establish them even though these were marked with waterproof markers on concrete fittings around the fence posts at the site. Several of those concrete fittings had broken in the interim, destroying the point markers. It is thus advisable, whenever possible, to set the grid just prior to carrying out the other total station and photogrammetry work. Next, 41 photomarkers were placed outside and throughout the interior of the tholos tomb for the local grid, recorded to millimetre precision with a total station. All photomarkers were drawn on removable stones and an additional photomarker was

Figure 4. 3D model of the Tiryns tholos tomb, showing both the section and the plan from the inside (3D model: A. Brysbaert and J. Pakkanen).

Figure 5. Removable photo markers on field pebbles were placed at strategic points around and inside the tomb for full georeferencing (photograph: A. Brysbaert).

placed in the summit of the tholos without having been drawn (Figure 5) to ensure no trace of marking on the original monument. For the model to be as accurate as possible, vegetation had to be cleared from the edges and around the dromos walls, around the outer stomion, and along the vertical walls of the dromos. Winter growth and recent spring rains led to thriving vegetation around the tomb, which would have obscured the reading of 3D models (see Figure 6). AB and IV arrived at the end of the rainy season in April 2018, when overgrowth was at its highest point. For the photogrammetry to function and to avoid the structural problems of the dromos, south wall, AB carefully trimmed overgrowth here and along the base of both walls. In order not to dislodge stones or destabilise the walls, we carefully cut away roots from cracks between the stones, leaving a few centimetres projecting to avoid direct contact with the wall. Müller (1975: 2) had already pointed out bulging sections in the walls, an issue that needs to be addressed in the near future to keep the well-preserved monument in its current state. Since cloudy conditions are preferred to keep lighting even and avoid problematic shadows, the

Figure 6. Tiryns Tholos tomb. Growth of plants above the soil banks on either side of the dromos walls (photograph: A. Brysbaert).

tomb was photographed over the course of two days to take advantage of the rapidly changing spring weather. AB used a Nikon D7200 with 24MP sensor and, together with IV, completed the grid layout and all photography sets in only one and a half days. Post-processing of images and data on individual laptops, however, took far longer. The model was tested on the same day to check for complete coverage. This showed that additional photographs were needed in the summit of the tholos after an additional photomarker was established there. These were taken before the campaign was over to complete the model.[3] Both Agisoft PhotoScan and the more recent version, Agisoft Metashape, were used. The first author carried out the final post-processing during summer 2019 and, due to the large number of photographs, split the tomb model initially into three 'chunks'. Two of these could be processed relatively easily, although each took several days. The largest one could not be processed by a high-end laptop due to insufficient RAM, a bottleneck problem often encountered by the second author in his tomb models (Turner 2020: 97). Splitting the model into more chunks finally solved the issue, with the complete model successfully rendered in autumn 2019 (Pakkanen et al. 2020: figure 9, animation 2).

4. Construction and materials

After the introduction of the tholos tomb, this section is divided, first, in the description of the stones employed and where these were used; a separate section on the use and nature of plaster follows. Pelon (1976: 180-181, 272) mentioned that the tholos was carefully covered by a low tumulus still visible before the slope leading up to Profitis Ilias. This artificial hill was likely deliberate as a visual draw for passers-by (for tombs as route or landscape markers, e.g., Wilkie 1987: 128-129; Mee and Cavanagh 1990: 228; Mason 2007: 47-48; Galanakis 2011: 225-226; Boyd 2016). Concerning the stones used in building the tomb, the size and shape indicate methods for acquiring and processing, either quarried, gathered, reworked, or some combination thereof. This also strongly affects task rates used to calculate labour costs in acquiring, transporting, and assembling materials for the tomb's main components. Characteristics like stone shape and size can serve as chronological indicators relative to other recognised types in more securely dated tombs, especially useful for the Tiryns tholos emptied of its contents.

4.1. Stones

Data collected prior to this study indicate that the stones employed here were collected nearby, directly from the Profitis Ilias hill in which the tomb was dug. Earlier work (see Brysbaert 2015a; 2015b; 2018) showed that at least two types of limestone were present in the hill, easily recognisable by their colour. These and others were also employed in various locations throughout the Tiryns citadel complex (Müller 1930; 1975: 2; Varti-Matarangas et al. 2002). These limestones were grey/blue in colour alongside some red, both locally abundant in the surrounding hill. Figure 7 clearly shows the layering of the grey limestone above the lower-lying, inferior red limestone (see Brysbaert 2015a). Despite its noticeably poorer quality, red limestone appeared in crucial places throughout the tomb, though no specific pattern

3 We thank J. Pakkanen for helping us with testing the model when we did not have access to the full licence of Agisoft Metashape at that moment.

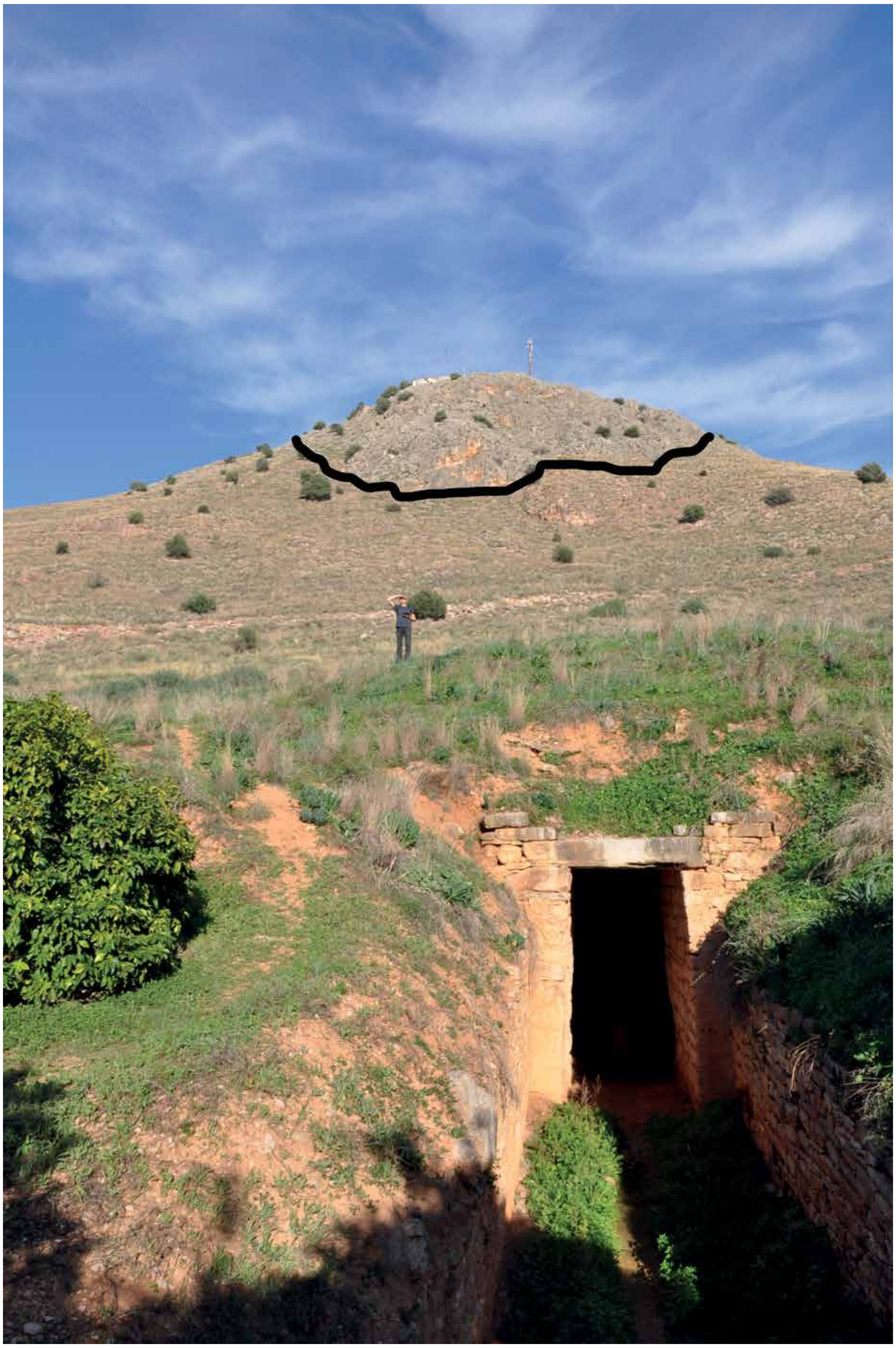

Figure 7. Tiryns. Detailed view of the hill of Profitis Ilias, c. 1 km east of the citadel, clearly illustrating two colours of stone outcrops: blue above and red stone below the black line (photograph: A. Brysbaert).

governing its use has yet been identified. The largest critical load-bearing blocks are the doorjambs and lintel stones, many times larger than most other stones used elsewhere within the tomb. Many of these, especially in the stomion, were carefully dressed blocks (Figure 8).

In contrast to several tholoi in the Argolid, the Tiryns tholos does not feature any conglomerate blocks even though limited but well-shaped conglomerate blocks were employed in the Upper Citadel, and at least one was found just east and below the Megaron area, as if it had tumbled down from above. All tholoi at Mycenae and the one at Prosymna feature conglomerate at least in the stomion (Wace et al. 1921-1923: 283-402), some also in more places (see Wace et al. 1921-1923: 357-376; Tsountas 1891b for the Clytemnestra tholos; Wace et al. 1921-1923: 378, for the Genii tholos). For the ultimate stunt in Mycenaean funerary engineering, the Treasury of Atreus was built entirely from expert conglomerate masonry with stones dressed, sawn, and polished (Wace et al. 1921-1923: 338-357; 1939), as well as further

Figure 8. Tiryns Tholos tomb. Well-dressed stonework at the stomion of the tholos and showing the right-side plaster remains (photograph: A. Brysbaert).

decoration in gold star appliqués mounted on bronze pins placed in tiny, purposely fitted holes between interior blocks (Wace et al. 1921-1923: 349; 1949: appendix, 29-31). Instead, the Tiryns tholos had other decorative elements worth noting (see 4.2. Plaster). The entire dromos, most of the beehive-shaped chamber, and large parts of the stomion were built with fieldstones worked to create flat vertical surfaces, masonry that gives the appearance of regular courses more visible inside the chamber (Dragendorff 1913; Müller 1975).

4.1.1. Dromos

The dromos was still well preserved near its base though perhaps less than half the original height survives. Its walls were shaped of stones that were broken in smooth courses to form even, vertical walls, of about 0.7 m thick. The stones were worked at least on their visible face. The dromos walls at the stomion end preserve to a height of 3.25 m. These were likely higher in their original construction as many fallen dromos building blocks indicated within the space itself, of the

Figure 9. Tiryns tholos tomb. South wall of the dromos showing some bulging (photograph: A. Brysbaert).

once sturdy walls holding back the substantial load of the hillside. Comparing our own photographs with the earlier published drawings, roughly a dozen courses are at least partially preserved. The right-hand wall when approaching the stomion shows signs of instability likely caused in part by differential settlement from the weight of the surrounding hill pushing inward. Roots from the thick overgrowth probably also play a role in shifting the stones out of place (Figures 6, 9).

4.1.2. Stomion

The unusual shape of a stomion higher than the preserved height of the dromos would not have been part of the original tomb design. Only in the Roman period were the dromos walls altered to be of consistent height that may have supported a roof (Müller 1975: 1). The door width tapers towards the top and stands at 4.10 m high. The stomion was covered with three massive lintel blocks placed next to each other over the passage: the first and largest one measured 3 m long × 2 m deep × 0.4 m

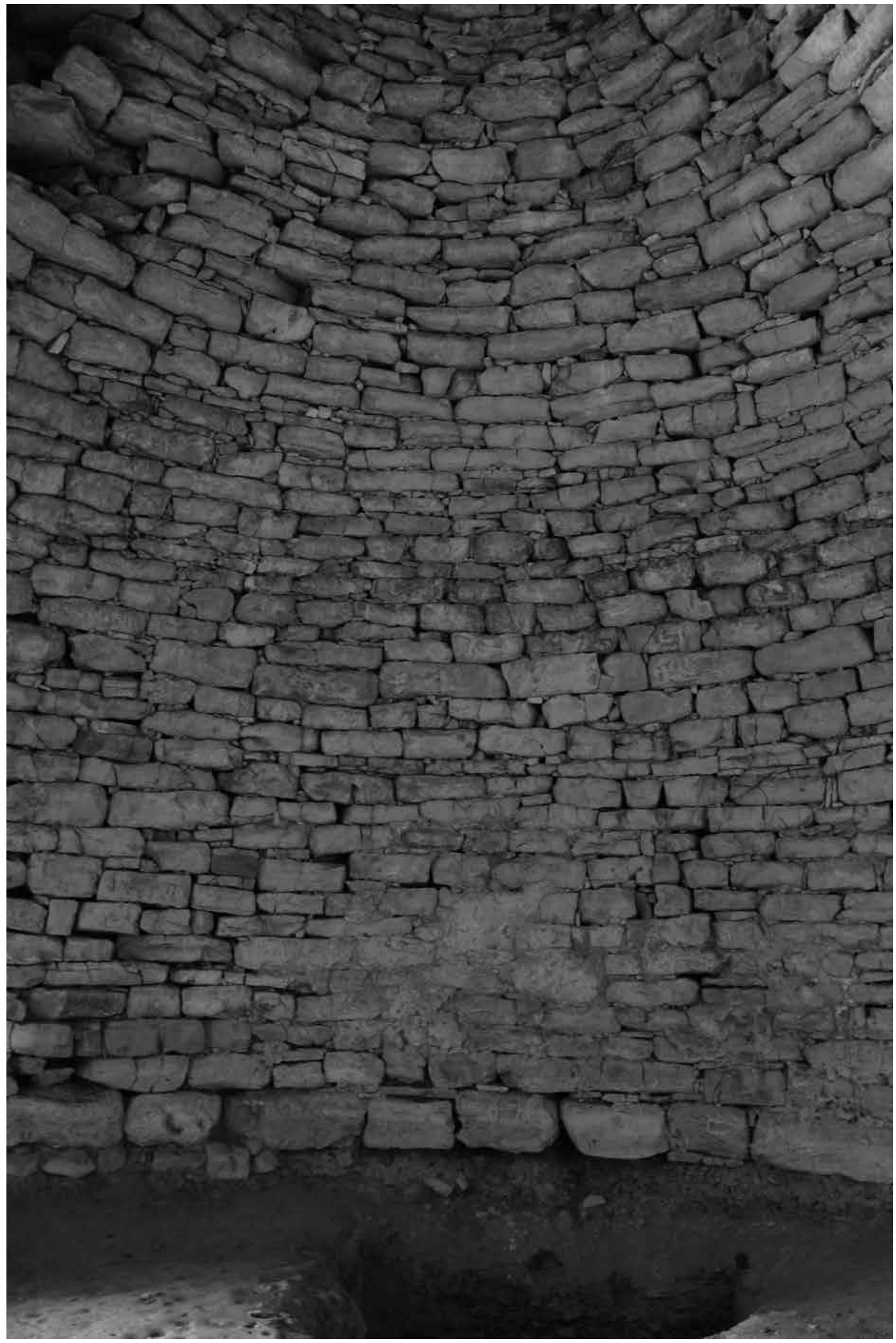

Figure 10. Flatly worked fieldstones laid out into regular courses inside the tomb chamber onto the bedrock (photograph: A. Brysbaert).

high; the other two were slightly smaller (Dragendorff 1913: 353). Pelon (1976: 181, n.1, 302) also recorded two massive blocks at the stomion's north doorjamb: facing the dromos: 1.80 m long × 0.30 m high, and towards the chamber: 2.20 m long and 0.35 m high. Both the walls of the stomion and those of the relieving triangle are curved slightly inwards (Müller 1975: 2). The plaster decoration of the stomion is described below.

4.1.3. Chamber

The actual tholos chamber is very well preserved apart from some minor damage to the relieving triangle. The lowest part of its walls comprises two rows of large squarely cut blocks placed directly on bedrock. The rest of the stones are placed in fairly regular courses, and the squarish stones were worked on the visible side. Chinking stones filled the gaps between larger stones (Walsh and MacDonald 1986: 495-497), especially in the lower two courses where the larger stones were placed neatly onto the bedrock (Figure 10). The stones elevating the chamber were better worked from the base up to the level of the lintels. Above that level, rounded fieldstones – gathered on or around the hill nearby and only lightly worked – were used in the upper courses. As the chamber walls went up, smaller stones were used, adding stability with more precise interlocking. Early excavators remarked specifically on the effect the coursing had when looking at the capstone from below, and Müller (1975: 3) saw it as a sign of very well-developed construction which was more advanced than the masonry techniques used for a stone hut. Laying stones into neat courses showed the care, forethought, and time taken by the builders to construct sturdy walls. The walls of the chamber seemed to have been constructed in such a way that they both supported and were supported by the stone packing kept in place in turn by the earthen tumulus. Cavanagh and Laxton (1981) described the stones themselves used in tholoi at Mycenae since LH II as being wedge-shaped and presenting their flat base to the inside of the chamber, forming the smooth surface in courses. The angled wedge would be stuck into the mass of the wall and held in place by the weight of the rubble fill. This also seems to apply to the Tiryns tholos construction.

In the Tiryns chamber, a shaft grave was cut into the bedrock and lined with plaster along its vertical and floor surfaces (Dragendorff 1913: 354; Müller 1975: 3). Based on the sherds found in it, the shaft grave was already emptied of its contents no later than the late Geometric or early Archaic period. The Vapheio tomb also contained such a shaft grave (Dragendorff 1913: 354). For Dragendorff, shaft graves incorporated with tholoi evoked an older group type (at least together with the Vapheio tholos) which may also push back the chronology of construction for the Tiryns tholos (cf. below on the semantics of 'shaft grave' vs. rectangular pits in chamber and tholos tombs).

4.2. Plaster

Dragendorff (1913: 352) reported that on both doorjambs along the outer façade and continuing partly into the interior stomion on the jambs, a thick plaster coat greeted the approaching visitor walking downslope toward the entrance (Figure 8). He mentioned that just a few traces indicated that the plaster was painted. Müller reinvestigated the site in 1938 (Brommer 1939: 251-252; Müller 1975: 2). He remarked that the plaster clearly covers only the outer stomion doorjambs and does not continue over the dromos walls, nor over the inner parts of the stomion. The dromos walls were apparently built after the stomion wall/façade in a risky sequence if temporary shoring was not used to stabilise the passage. The plaster was thus applied *after* the dromos walls were abutted to the stomion wall, and over the entire outer façade including the lintel block, thus providing a uniform look. The manner in which painted plaster was used here might seem singular to the Tiryns tholos, although Stamatakis (1878: 273; also, Pelon 1976: 319, n. 4) made a similar observation when he first excavated the tholos at Prosymna/Argive Heraion: traces of paint that are likely now no longer visible. Similar observations were made on the inside of the stomion (but not the façade) for Tholos 1 at Peristeria and at Vapheio (Pelon 1976: 305). Other examples of plaster-covered surfaces for Mycenaean chamber tombs are numerous but rarely uniform in application or preservation (e.g., Demakopoulou 1990: 113-115; Galanakis 2011: 223; Sgouritsa 2011; Karkanas et al. 2012: 2731; Smith and Dabney 2014: 148; see Table 3).

Demakopoulou (1990: 113), Fitzsimons (2006: 152), and Sgouritsa (2011: 741) all mention that the plastered doorjambs of the stomion were painted with (blue) spirals. Sgouritsa (2011: 742, wrongly citing Pelon 1976) also mentions the presence of red paint on the door lintel. This goes against the faint paint traces reported by Dragendorff (1913), Müller (1975: 2), and Pelon (1976: 181). Our own observations along the easily accessed lower 2 m of either doorjamb and on the detailed photographs taken illustrate that only one area still held potentially faint paint traces in grey or blue, but it is far from clear whether these coincide with the original traces noted by Dragendorff and Müller, who did not mention a specific colour. Currently, no spirals are visible macroscopically nor were they ever noted by the original excavators. If ever present, the design and the pigment traces more specifically could have been covered over time by the clay-like wash from the top of the stomion, or they simply washed away over decades of exposure to weather. Whichever the cause, only further microscopic investigation could confirm use of pigments. Unfortunately, this plaster coat is now badly degraded, and while there on fieldwork (spring 2018), we located a large loose fragment that had fallen from the base of the right doorjamb.

Painted doorjambs around the stomion and other parts of tholoi and especially chamber tombs are noted on various other tombs of this period in the Argolid and Boeotia, a popular technique there from the LH IIA onward (especially Sgouritsa 2011; Konstantinidi-Syvridi et al. 2015; Papadimitriou 2015: 94). The Lion tholos at Mycenae was described as having a calcite plaster floor on which there were still traces of red paint visible in 1892 (Pelon 1976: 165). When Pelon mentions plaster (*enduit de chaux*), this mostly relates to *floor* covers and not stomion features. He pointed out the difference between *enduit de chaux* and mud plasters, often confused by other authors. Konstantinidi-Syvridi et al. (2015) refer to such painted plaster remains (studied by first author of this paper) found in Chamber Tomb 222 at Mycenae, dated to LH IIB and in use until LH IIIA1. Table 3 includes both the tholos tombs with painted

THOLOS TOMBS			
MYCENAE			
Name/Wace's Group **Diameter**	**Date (Wace et al. 1921-1923; Pelon 1976; Iakovides et al. 2003)**	**Plaster/décor**	**Refs/details**
Aegisthus / I Over 13 m	LH I Late-LH II Early Early LH IIA LH I-mid 15th c BCE	In joints of dromos and façade	Tsountas 1892: 57; Tsountas-Manatt 1897: 124; Wace et al. 1921-1923: 296-316; Pelon 1976: 161, 408
Panagia / II 8 m	LH II / LH IIA-IIB	In joints of doorway	Tsountas 1888: 121-122; Wace et al. 1921-1923: 316-320; Pelon 1976: 163
Kato Phournos 10 m	Second half of LH II LH IIA-IIB end 15th BCE	In joints of doorway and dromos; floor with 'cement' coat	Tsountas 1893: 8; Wace et al. 1921-1923: 320-325; Pelon 1976: 164
Lion / II 14 m	LH II / LH IIA-IIB end LH II	In joints of dromos and stomion; on floor with red paint traces	Tsountas 1892: 56-57; Tsountas-Manatt 1897: 124 ff; Wace et al. 1921-1923: 325-330; Pelon 1976: 165
Genii / III 8.40 m	LH III / LH IIB-LH IIIA1	In joints of stomion and door jambs; on floor	Tsountas 1896: 29-31; Wace et al. 1921-1923: 376-387; Pelon 1976: 167
ARGOLID – OTHER			
Berbati 8 m	LH IIA/IIIA1	In joints of poros facing façade On floor	Pelon 1976: 178 Santillo Frizell 1984: 27-32
Prosymna 9.50 – 9.70 m	LH IIA	In joints of poros facing dromos; on jambs, lintel; in doorway	Stamatakis 1878: 271-286; Wace et al. 1921-1923: 330-338; Pelon 1976: 176-177, 319
Dendra 7.30 m	LH II (architecture) or LH III (finds)	On floor	Persson 1931; Pelon 1976: 181***
Kokla 5.40 m	LH IIB/IIIA1	On façade and stomion, red & blue painted disks	Demakopoulou 1990: 113
Tiryns 8.57 m (our dimension)	IIB or III Contemporary to Kokla (Sgouritsa 2011: 742-743)	On doorjambs: painted spirals(?); on lintel: red traces (?)	Dragendorff 1913: 353. Also Karo 1934: 36 Sgouritsa 2011: 743 (citing Pelon 1976: 181 wrongly and who dates to LH III)
Peristeria 12.10 m	LH IIA	In joints; over limestone	Pelon 1976: 208; Sgouritsa 2011: 738-739
Vapheio 10.15 – 10.35 m	LH IIA	In joints; clefts of jambs	Pelon 1976: 184; Sgouritsa 2011: 739
CHAMBER TOMBS (selection)			
Name, place	**Date (Sgouritsa 2011; Pelon 1976; others)**	**Plaster type / décor**	**Refs/details**
Rho, in Circle B, Mycenae	LH IIA	In joints of poros blocks of walls, façade, dromos; over plesia, painted red/black; over whole surface, entrance painted red	Mylonas 1973: 218-219; Papadimitriou, N. 2001: 26-28, 159; Sgouritsa 2011: 742
Mycenae (Panagia hill): tomb 52	LH IIIA/B	On doorjambs, painted red	Tsountas 1891a: 1-4; Sgouritsa 2011: 743
Mycenae (Panagia hill): tomb 53	LH IIIA/B	On façade, doorway, walls of interior of entrance: painted bands, triangles, rosettes	Tsountas 1891a: 4, colour plate; Tsountas and Manatt 1897: 61, fig. 16; Kontorli-Papadopoulou 1987: 152-153; Sgouritsa 2011: 743-744
Mycenae (Panagia hill): tomb 54	LH IIIA/B	On façade and doorway: decorated	Sgouritsa 2011, n. 36

Table 3. Published tholoi and selected chamber tombs with (painted) plaster decoration in the Argolid. * Blegen thought that decoration was done later than tomb construction based solely on low plaster quality (*contra* Sgouritsa 2011: n. 44). Otherwise, LH IIA would be the date for construction considering the earliest pottery. ** Keramopoulos suggested this plaster came from cover of wooden larnax (Sgouritsa 2011: n. 54). *** Pelon 1976: 181 refers to Wace (1949: 18) who dates Tiryns in Group III alongside Dendra. Dates given by specific authors are mentioned underneath this date in column 2 of this table.

THOLOS TOMBS			
Mycenae (Panagia hill): tomb 81, 3rd km cemetery	LH II (Tsountas and Manatt 1897)	Painted bands on jambs with capitals and bases, incised and painted disks above lintel; on ceiling of doorway; on 1.35 m of wall above rock-cut bench, painted in multi-coloured bands	Tsountas and Manatt 1897: 133, figs 49-50; Kontorli-Papadopoulou 1987: 152-153; Wace 1949: 33; Sgouritsa 2011: 744, (ref. Tsountas' notebooks)
Mycenae: Chamber tomb, near Circle B	LH IIIA	On façade and doorway: painted multi-coloured bands	Papadimitriou 1952: 468-470; Sgouritsa 2011: 744-745
Mycenae, S of Cyclopean tholos	LH? unknown date	On façade and in chamber: decorated	Xenaki-Sakellariou 1985: 320, n. 39; Sgouritsa 2011: 745
Prosymna: tomb II	LH IIA-IIIA2 (pottery)*	On jambs and lintel: multi-coloured running spirals and bands	Blegen 1937: 174, 238, plan 39; Sgouritsa 2011: 745; Kontorli-Papadopoulou 1987: 152-153 Persson 1942: 155-156 Steinmann 2020: 381-383
Prosymna, tomb III	DATE? LH II	On façade: decorated	Blegen 1937: 181, 238-239; Persson 1942: 157-158; Sgouritsa 2011: 745
Argos-Deiras, tomb V	LH IIIA-B (Kontorli-Papadopoulou 1987: 153)	On façade: painted with floral/palm tree multi-coloured	(Kontorli-Papadopoulou 1987: 153); Vollgraff 1904: 368-370; Sgouritsa 2011: 745
Argos-Deiras, tomb VI	LH IIA (pottery); in use 15th-12th c. BCE	On façade: painted red	Vollgraff 1904: 375-387, fig. 2; Sgouritsa 2011: 745
Argos-Deiras, tomb XII	LH IIIA2	On façade and doorway: painted	Deshayes 1966: 33, 238-239, 337; Sgouritsa 2011: 745
Asine, tomb 2	LH IIA-LH IIIC middle	On façade and chamber (roof)	Frödin and Persson 1938: 162-163; Sgouritsa 2011: 745-746
Dendra, tomb 16	LH IIIA	In chamber	Protonotariou-Deïlaki 1990: 91; site text panel
Thebes (Kolonaki), tomb 15	LH III A2-LH IIIC early/middle	On jambs, walls of doorway: painted (wood imitation)	Keramopoulos 1917: 159-160; Kontorli-Papadopoulou 1987: 152-153; Sgouritsa 2011: 746;
Thebes (Kolonaki), tomb 24	LH III A2-LH IIIC early/middle	On walls and chamber floor**	Keramopoulos 1917: 185-187
Thebes (Megalo Kastelli), tomb I	Initial construction in LH III A2. Expanded in mid-LH III B	On façade (red), bench, entrance: painted with bands, flowers, female figures, disks, spirals, palanquin, landscape	Spyropoulos 1971: 163; 1972: 310-311; 1973: 255; Cavanagh and Mee 1998: 68

Table 3. (continued).

plaster doorjambs and their dates, but also as many chamber tombs as we could find in the literature with (painted) plaster decoration (Wace 1931: 140-141; Wace 1949: 33; Pelon 1976: 319-323; Kontorli-Papadopoulou 1987: 152-153; Cavanagh and Mee 1998: 46; Gallou 2005: 67-70, 123-124; Sgouritsa 2011).

Chamber tombs with painted designs were not limited to the Argolid and Boeotia as the stomion at Voudeni tomb 75 in Achaea illustrates. There, the paint seems to have been applied directly to the wall without plaster, as such a coat is not mentioned in the brief publication. This tomb was likely constructed in LH IIIA and remained in use until the sub-Mycenaean period (1425-1050 BCE; Kolonas 1998; 2009: 28-29). The LH IIIA2 Prosilio chamber tomb 2 near Orchomenos also showed signs of painted and clay-coated surfaces, apparently with additional coatings reapplied at least once ahead of the tomb's lone funeral (Bennet 2017; Yannis Galanakis, personal communication 2020).

5. Cost rates for plaster

Before a general discussion of labour costs (see 6.2. Labour costs.), closer analysis of the cost rates of plaster is in place: this material has not been discussed in detail in previous publications anywhere. Important here are the efforts that have gone into plastering and painting the doorjambs at Tiryns tholos. In order to cover the entire *chaîne opératoire* of plaster-making, we do not have all the required data to calculate the labour cost for each step. Collecting and calcining the raw materials, slaking quicklime, ripening slaked lime in pits, and transporting it to the site (at one of the steps), are all part of this process. We miss evidence of the quarrying and calcining location(s), likely in the same place, but we do not know where lime was extracted for the plaster. We may assume that limestone from the actual hill itself qualified (other options, see Varti-Matarangas et al. 2002; Brysbaert 2015b). Equally unclear is where the quicklime is slaked. This did not take place at the tomb but perhaps at the quarry, or elsewhere. Quicklime is half the weight of slaked lime, and some form of transport will have been needed. Sand had to be brought from about 2 km away (LBA coastline to the tholos tomb area) to mix the slaked lime with, and DeLaine (1997: 180) uses a rate of 0.7 pd per m^3 for mixing mortar by hand. DeLaine (1997: 181) mentions the lime to sand ratio as 1:3. The process is described in detail in Brysbaert (2008); here we cover the major steps. Devolder (2013: 38) discusses very briefly the mortar used between different types of stonework and gives standard costs for those. Clear evidence for mortar between the stones in the Tiryns tholos has not been recorded, although several tombs at Mycenae have been described with a coat of *plesia* clay along their façade. The total cost of a plaster coating on the doorjambs at the Tiryns tholos cannot be assessed using Devolder's standard rates, and no other such rates have been discussed for the Aegean Bronze Age. She did discuss, however, the time needed for supplying and mixing such mortar and determined that about 1 person-hour (ph) is needed to mix the ingredients for 0.23 m^3 of mortar and that 0.8 m^3 mortar per ph could be supplied (Fathy 1970; Devolder 2013: 38, 43, 46) although these rates seem very low and perhaps the 0.8 m^3 figure should have been 0.8 m^2. In the context of the research carried out on Bronze Age painted plaster from 17 sites in the Aegean and East Mediterranean, Brysbaert (2008: 107, 170-171) received data from modern plasterers about how long it takes to cover the interior walls three metres high in a residence of 50 m^2 surface area with four rooms, five doorways and five windows, with a maximum of two coats. This would have taken two experienced plasterers, with the ready plaster in hand, a minimum of eight full working days, each of eight hours. Modern plasterwork is comparable in places to its counterparts in the past. Trowels and floats are still standard tools for applying plaster, only the tool materials have changed and the plaster itself comes in ready-mixed buckets from wholesale dealers. So, the cost and efforts of *producing* the plaster are not discussed in detail here. Elsam (1825: 136-142) dedicated a full section on the cost of plastering different parts of a structure expressed in salaries, and he also referred to painting jobs (Elsam 1825: 148-153) although these tend to refer to uniformly painting surfaces rather than elaborate motifs. Fletcher (1888: 98ff, 113ff, 2018) also dedicated sections to plastering and painting. We know, however, that both *al fresco* and *al secco* painting can be done in a day or less if the plaster covered a surface area of 50 m^2. If *al fresco* had been intended at Tiryns (not possible to investigate here considering the faint traces), this would have had to be done in a day (Brysbaert 2008: 171).

Comparing other work rates for plastering and painting helps to narrow our labour models for these tasks. According to Bologna (2016; 2022), working on Pompeiian painted plaster and its plaster and painter workshops, 2.9 h/m^2 is required for plastering (accounting for mixing but not drying times; cf. Devolder 2013: 38, here above), and 0.21 m^2 can be painted in one hour (4.76 ph/m^2). Bologna also derived painting costs based on average times observed through experimental and restoration tasks. Compiling rates from several pre-industrial building manuals (e.g., Pegoretti 1863; Rea 1902; Hurst 1905, among others), Bologna (2022: table 1) uses average rates for plastering a 1 cm thick coat across 1 m^2, with tasks such as rendering (0.18 ph), floating (0.5 ph), setting (0.54 ph), and fine setting with putty (0.73 ph), drying times not included. Her average totals came to 0.35-0.46 ph for two men to carry out the work (0.70-0.92 ph/m^2). For Pompeian houses, she envisions minimum work crews of 4-6 people.

Since plastering time further depends on the number and the thickness of each layer, it is important to note that the layers with which Bologna worked are substantially thicker than what was noted for the Tiryns tholos. While Vitruvius mentioned seven layers in Roman contexts, this was only executed in specific high-status houses. Work carried out on Bronze Age painted plaster indicates that a maximum of three plaster coats were applied to any surface of inhabited places (Brysbaert 2008: 122, table 6.2). Thus far, however, painted plaster remnants from tomb contexts, have only been studied macroscopically from Mycenae. For this project we did not hold a permit to conduct any work on the plaster remains and only one fragment which we found loose on the ground at Tiryns could be briefly examined. This confirms, at least macroscopically, the findings/observations from the Mycenae material.

Pigment prices, at least in Roman times, varied widely (Pliny, *HN*, 33.27, 39, 40, 57, 34.18, 35.20, 35.28; also, Bologna 2022), as is clear from the Egyptian blue price difference between Pliny's figure and Diocletian's Price Edict (details: Bologna 2022). While we have no prices for these materials in the Bronze Age, it has been postulated that the man-made Egyptian blue pigment was much more costly than other ones (Philippakis et al. 1976), and thus used more sparingly.

6. Results

The results section is divided into three parts with a clear link. We discuss the methods used to provide us with the results, we next lay out our labour cost figures for both the construction of the tomb and its plastering efforts, and finally we touch on the various aspects of the dating of the Tiryns tholos.

6.1. Methods

We first compared the existing drawings with the detailed photogrammetric model produced based on the spring 2018 fieldwork. Given the centimetre-precision available to photogrammetric and total station modelling, we wanted to compare the accuracy of modern fieldwork techniques with the much older traditional drawings. This would suggest the relative reliability of traditional methods

Feature	Dig labour (ph)[1]	Wall labour (ph)[2]	Skilled labour (ph)[3]	Total labour (ph)[4]	Area (m^2)	Volume (m^3)
Tiryns tholos						
Dromos	1,285	4,558		6,427	151.93	107.10
Stomion	476	2,179	726	3,719	72.62	39.70
Thalamos	3,371	8,827		13,418	294.24	280.91
Grave	28		101	141	10.05	2.33
Total	5,160	15,564	827	23,706	518.79	427.71

[1] Volume-derived excavation costs (12 ph/m^3). [2] Area-derived cutting, transport, and assembly costs for stone walls (30 ph/m^2). [3] Painting and plaster-related costs (10 ph/m^2). [4] Manual labour plus 10% planning/supervision.

Table 4. Detailed labour costs for the Tiryns tholos tomb, where ph represents person-hour.

alongside the pitfalls (if any) to discrepancies in the final labour calculations for the Tiryns tholos. At least on a case-by-case basis, comparisons between measurements can alleviate concerns over misrepresenting econometric estimates where access to newer data sets might be limited (e.g., the travel restrictions attendant to the 2020 pandemic). Of course, the 3D model provides more than scale comparisons and can be employed for detailed stone-by-stone description if needed, including colour, preservation state, and overall stability, useful to the local Ephorates for repair, restoration, and anastylosis projects.

Table 2 compares dimensions derived from the 3D model with those from earlier publications. Most differences in length and width measurements were less than 2% of the measured values from the 3D model. Height or depth, however, is more susceptible to catastrophic changes from deterioration of the tomb, and large differences (more than 20%) could be attributed to loss of shape, publication error, an incorrect reading of the measuring tape during initial fieldwork, or a misreading of where the measurements were taken. This could include debris filling the bottom of the shaft grave preventing an easy height measurement from the 3D model. In the case of the dromos and stomion, DT split measurements for the inner threshold (stomion) versus the outer façade. The remnant depth of the dromos is considerably less than the outer façade, which is also missing its full height. Neither measurement from the 3D model corresponds well with the measured height of the dromos from earlier publications. Since the labour estimates reference only the remaining surface area and volume of the tomb, discrepancies in linear measurements have little to no effect on the labour models presented here. Attempting solid geometry calculations for a workable volume from published measurements, however, does have its issues in exaggerating volume over the actual shape (Lacquement 2009; 2019). While important to note, this has been shown to have less of an impact than the far more speculative use of arbitrary labour rates, particularly with architectural features that have already lost much of their original shape (Turner 2012; 2018). With care, linear measurements from published drawings can be reliably converted into volume and area estimates for labour cost models, with differences in the few percentiles range not noticeable in large-scale comparisons (Turner 2020: 97-99, 120).

6.2. Labour costs

Next, by means of labour cost studies, we investigated how much effort went into the construction of this grave monument and what effect this may have had on available labour. At least 2-3 stone types were recognised macroscopically, but a more in-depth geological study based on microscopic samples might confirm additional differences in composition despite superficial likeness (e.g., Varti-Matarangas et al. 2002). With stone types traced to their quarried beds, more could be gleaned from the logistical challenge of transporting these stones to the building site. In that sense, it is worth noting that the tholoi at Tiryns are located near the M4 highway (Brysbaert 2021; Brysbaert et al. 2020), and while the monumentalisation of that road into a highway may well have been executed only in the 13th century BCE (the tholos may be older, see below), there is enough evidence that a substantial road between Tiryns and Mycenae was in use before M4 became a highway. For now, minimalistic labour rates assuming stones from local sources suffice for a first step in detailed labour costs (Table 4). Beyond different stone sources, calcite plaster mainly embellished the stomion of the tomb. Since this feature is not known from all tholoi, we calculated the efforts necessary for plastering and painting exposed surfaces of the stomion in its current state of preservation. The surface area used (c. 73 m^2) is thus a placeholder estimate meant to reconcile the lost area of the upper façade. Simplifying the cumulative rate to 10 ph/m^2, derived from the work of DeLaine (1997) and Bologna (2022) (1.25 ph/m^2 for supplying; 2.9 ph/m^2 for mixing; 0.92 ph/m^2 for rendering, floating, and setting; and 4.76 ph/m^2 for painting; see above), plastering and painting roughly 73 m^2 of exposed surfaces in the stomion would have required 726 ph, or about a week for a team of 10 working 10-hour days. However, space may not have allowed for 10 people working together, and if, instead,

Feature	Aggregate Labour (ph)[1]	Workers	Days	Volume (m^3)	Scale TREX	Labour TREX
Menidi tholos (MT)						
MT Combined	12,360	150	83	618.00	22.27	37.12
MT Dromos	6,980	84	84	349.00	25.85	43.09
MT Stomion	283	4	71	14.17	18.90	31.49
MT Thalamos	5,097	62	83	254.83	18.88	31.46
Tiryns tholos (TT)						
TT Combined	8,554	150	58	427.71	15.41	25.69
TT Dromos	2,142	37	58	107.10	7.93	13.22
TT Stomion	794	14	57	39.70	52.93	88.22
TT Thalamos	5,618	99	57	280.91	20.81	34.68
Treasury of Atreus[2] (AT)						
AT Combined	267,570	500	536	3,500	126.13	803.51
Standard Chamber Tomb AA01[3] (AA)						
AA Combined	333	11	31	27.75	1.00	1.00
AA Dromos	162	5	33	13.50	1.00	1.00
AA Stomion	9	1	9	0.75	1.00	1.00
AA Thalamos	162	5	33	13.50	1.00	1.00

[1] Comparative aggregate rate (20 ph/m^3) for the majority of replicable excavation/ extraction, transportation, and assembly tasks. [2] Based on Cavanagh and Mee (1999: 95) and Harper (2016: 421-428), aggregate rate (17.32 ph/m^3) calculated from total volume of building materials (15,450 m^3). [3] Excavation rate (12 ph/m^3), based on Turner 2020.

Table 5. Tomb Relative Index (TREX) for comparing tholoi with a standard Achaean chamber tomb, based on Turner 2020: 100-101, Table 4.3.

four people worked together, it would have taken two and a half weeks to complete. Unlike the heavy labour of stone cutting, transport, and assembly that requires effectively shorter work times to limit fatigue, plastering and painting could accommodate longer working days.

Finally, we compared relative costs and dimensions for the Tiryns tholos versus similar Mycenaean multi-use tombs (Tables 5 and 6). Rather than attempt detailed costs for each, susceptible as these are to technical minutiae that obscure the comparative utility of energetics, aggregate labour rates allow for rapid comparison of major construction tasks. Further to that comparative spirit, a relative index based on scale (volume) and labour (respecting the differences in logistical challenges between stone-built and rock-cut monuments, for instance), shows the awe-inspiring disparity among the largest funerary monuments Mycenaean engineers could muster. Similar work by Fitzsimons (2014, with earlier references) compared the technical challenges presented by the lintel stones for seven of the nine tholoi at Mycenae, excluding the Treasury of Atreus and the Tomb of Clytemnestra for their vast difference in scale to the others. As a proxy for factional power springing partly from differential access to labour, Fitzsimons (2014: 97) surmised that snapshots of construction (like moving the multi-tonne lintels) were better suited than full-cost analyses to rapidly comparing tombs. From the work of Turner (2020: 99-101, Table 4.3) comparing chamber tombs in Achaea, a Tomb Relative Index (TREX) highlights important differences in scale and effort, which can be interpreted in a number of ways, including as a form of costly signalling from influential families commissioning tombs (for costly signalling with architecture, e.g., Glatz and Plourde 2011; Gittins and Pettitt 2017; see discussion in Turner 2020: 47-50, with references). Economically at least, larger, more technically challenging tombs like Tiryns and Menidi reflected better mobilisation of available labour. Socially, those tombs reflected a tolerance for standing out, potentially a risky enterprise in the arena of mortuary behaviour. Ritually, spiritually, or otherwise, death and its eschatological demands could breed a host of reasons why these super-tomb types appeared where and when they did.

For Tiryns in particular, digging the tomb and constructing its walls with skilled and unskilled labour could be imagined as a group of 10 people working 10-hour days for a total of 236 days, or close to eight full months of uninterrupted work (see Table 4). This fits closely with preindustrial ideas of a working calendar year (for a concise summary, see Turner 2020: 68-69, with references; similarly, Brysbaert 2020; 2022), deliberately scheduled during opportune times (e.g., limiting conflicts with work-intensive planting and harvesting seasons or avoiding the frequent thundershowers of early spring and late autumn). Stone, by nature of its laborious transport even from nearby sources, would especially demand dry weather to avoid complications from muddy slopes (e.g., broken axles, reduced traction and risk to valuable oxen). As modelled in Table 4, the combined cost of erecting the

Feature	Length (m)	Width (m)	Height (m)	LREX	WREX	HREX
Menidi tholos (MT)						
MT Dromos	27.00	2.90	6.74	4.50	1.93	2.25
MT Stomion	2.74	1.70	3.02	2.74	2.27	3.02
MT Thalamos	8.25	8.35	8.51	2.75	2.78	3.40
Tiryns tholos (TT)						
TT Dromos	13.40	3.01	2.65	2.23	2.01	0.88
TT Stomion	4.62	2.10	4.15	4.62	2.80	4.15
TT Thalamos	8.20	8.57	7.58	2.73	2.86	3.03
Treasury of Atreus[1] (AT)						
AT Dromos	36.00	6.00	10.50	6.00	4.00	3.50
AT Stomion	5.40	2.70	5.40	5.40	3.60	5.40
AT Thalamos	14.60	14.60	13.39	4.87	4.87	5.36
AA01 Standard (AA)						
AA Dromos	6.00	1.50	3.00	1.00	1.00	1.00
AA Stomion	1.00	0.75	1.00	1.00	1.00	1.00
AA Thalamos	3.00	3.00	2.50	1.00	1.00	1.00
[1] Based on Harper (2016: 348, Figure A.25)						

Table 6. Linear dimension comparison of tholoi using the Tomb Relative Index (TREX), based on Turner 2020: 99-101, Table 4.3, and including relative index comparisons for length (LREX), width (WREX), and height (HREX). Yellow colour coding indicates a potential discrepancy with measurements reported as equal.

Tiryns tholos's stone walls (15,564 ph, or roughly one month for 50 workers and 5 oxen pairs) more than triples the projected cost of digging the tomb's footprint (5,160 ph, or 26 days for 20 workers, with 10 excavators and 10 carriers alternating to limit fatigue). Despite exaggerating the plasterwork to include the exposed sections of the stomion (with the hope that this aligns better with the original dimensions of the outer façade) and the lining of the shaft grave inside, its share of the total labour costs projected for the tomb is only around 3%. This could change, of course, in the event that expensive pigments or elaborately drawn paintings were included, which must await further investigation.

6.3. The dating issue

Most scholars (e.g., Alden 2000: 13; Fitzsimons 2006: 107; see below) have followed Wace's groupings of tholoi at Mycenae in terms of dating these and sometimes also to date the other tholoi in the vicinity (but see n. 1, this paper). While the architectural developments on which these groupings were based may be useful for Mycenae's tholoi, not all criteria may be applicable to tholoi elsewhere as Wiesner (1938: 77) and even Wace himself (1921-1923: 284-285) already pointed out early on. To Wiesner, the tholoi of Tiryns and Dendra belonged to Wace's Group II architecturally, but not chronologically. He failed, however, to explain why that is. Equally, the use and frequency in use of conglomerate that helped to define Group II is not useful for several non-Mycenae-based tholoi since all tholoi in Mycenae feature conglomerate, and the Tiryns tholos has none.

Some sources refer to the Tiryns tholos tomb belonging to an early phase of the tomb-type development (Dragendorff 1913: 354), or to the LH IIB period or Wace's Group II (Fitzsimons 2006: 152-153; 2011) on the basis of comparing it to other tholoi in the region with similar architectural features and materials. There, on the basis of specific rubble stonework used for the dromos, combined with an exterior blocking wall and the cutting of the lintel blocks to fit the horizontal and vertical curvature of the thalamos, the Tiryns tholos would have fit well in Wace's Group II. Others (e.g., Wace et al. 1921-1923: 394; Müller 1930: 218; 1975: 4; Karo 1934: 36; Pelon 1976; Hope Simpson and Dickinson 1979: 43; Cavanagh and Mee: 1998: 64, 81) date it to the LH III period. Most of these authors refer to each other and the earlier work of Wace's groupings at Mycenae. Some of the defenders of the LH IIIB date (Cavanagh and Mee 1998: 64) also emphasize the uncertainty of that date. Also, against Wace's groupings is the statement by Dickinson (1977: 62) who dates the construction of the first six tholoi at Mycenae all to the same LH IIA period, based on palatial pottery typology (Dickinson 1977: n. 24).

Wace's groupings did not exist at the time of Dragendorff's publication (see below). Alongside small differences in measurements, it is in the dating of the Tiryns tholos tomb that Müller's account and arguments, published only in 1975, diverged mostly from Dragendorff's earlier publication. He used the style of the tholos, specifically the curved lines of the stomion's lintel and the relieving triangle, the peculiar construction of the beehive and its specific stone use as strong arguments for a late date (Müller 1975: 3-4). He also compared the presence of the early shaft grave feature to those in later tombs such as Mycenae's Genii and the Dendra tholos, which he assigned both to Wace's Group III, although Persson (1931: 23) placed the Dendra tholos in Group II. Müller stated that Tiryns does not fit in Wace's grouping since Tiryns' features and stone materials, both at the tomb and palace structures, are too far removed from Mycenae to benefit from its stone sources employed in ample amounts (conglomerate and poros). However, conglomerate was used at the Tiryns citadel. The locking system to seal the inner threshold in Wace's Group III is also visible both in Tiryns and in the Lion's tomb (which belongs to Group II). It must be said, however, that Müller also presented no strong arguments for his statements without the support of diagnostic finds from within the tomb.

Of interest is that several authors use its architecture and features for either an early *or* a late date (e.g., Dragendorff 1913; Fitzsimons 2006 versus Wace et al. 1921-1923; Müller 1975; Pelon 1976). Brysbaert (2018) followed Fitzsimons (2006) in dating this tomb to LH IIB based on the architectural features which Fitzsimons placed in LH IIB, based on Dragendorff. Dragendorff (1913: 351-353) compared the design, stone, construction technique, and dimensions of the Tiryns tholos to those properties from the Prosymna and Menidi tholoi. Karo (1934: 36) also compared Tiryns with Menidi, whose finds likely date to the LH IIIA2-B1 period (Arena 2015: 5; Younger 1995: 527). Turner (2020: 116, with references) expressed doubts about the Tiryns-Menidi architectural connection when 3D modelling the Menidi tholos, mostly due to its use of flat schist slabs and an experimental stacked-slab relieving system. The most striking similarity between the two tholoi are their similarly scaled burial chambers and thresholds, the Tiryns entrance passage and façade being too damaged to link conclusively to Menidi's well-preserved and partially reconstructed counterparts (Turner 2020: 116). The discrepancies in style cast doubt over using Menidi to support a late date for Tiryns, but their remarkable similarity in scale leaves room for some exchange of construction ideas, not necessarily requiring their initial construction to coincide. In any case, the debate over the construction date of the Tiryns tholos may prove impossible to settle, despite our suggestions for supporting evidence indicating an earlier date in this paper (see discussion).

7. Discussion

Related to the chronological debate, we offer some tentative arguments below for an earlier date of the Tiryns tholos tomb based on both architectural features and the way the tomb was used over time. Boyd (2015: 440), for example, suggests that the shift from shaft graves to chamber tombs at Mycenae may have taken place during the LH IIA period, when the last shafts in Grave Circle A were dug while the new chamber tomb phenomenon rapidly developed. In that light, elites at Mycenae stopped using shaft graves as they fell out of fashion, and perhaps this trend influenced Tiryns as well. To construct a shaft grave *within* the Tiryns tholos, which was very likely the grave for the local ruler, therefore seems an odd choice. Either Boyd's findings could be used to date the Tiryns tholos as an earlier, rather than later, tholos, or, perhaps more usefully, we could draw a clearer distinction between rectangular pits in chamber and tholos tombs (as at Tiryns) and their standalone shaft grave counterparts. Deep rectangular pits within many chamber tombs in Achaea and Kephalonia have been linked to the LH IIIA period and appear alongside floor burials or burials atop thin clay layers (Papadopoulos 1979: 60-61; Kolonas 2009: 13; 1995: 203; Turner 2020: 124). Linking the rectangular pit within the Tiryns tholos to an earlier date is less certain in light of the choices available to burials throughout the LH II-III periods elsewhere in southern Greece.

Perhaps the diameter is an indicator for an earlier tomb. The tholos at Tiryns has a diameter of c. 8.5 m, and while this is similar to the LH IIIA2-B1 Menidi tholos and much smaller than the diameters of the LH IIIA/B Treasury of Atreus and the Tholos of Clytemnestra, these numbers do not say much in themselves. However, if these diameters are connected to the number of people that can comfortably enter the tomb for ceremonies, it could hold more meaning. Boyd (2016: 75) allows 12-25 people into a space with a diameter of 8 m (c. 50 m^2 of floor space) and 55-110 for 12 m (c. 113 m^2). Both Atreus and Clytemnestra are beyond 12 m and may have easily accommodated between 60-120 people, *if* there were no exclusionary criteria of social ranking, for instance, for those *allowed* to enter. The Tiryns tholos, if assigned to its ruler, certainly would be expected to allow more people in than a mere few dozen if he truly was the influential lord of Tiryns during the LH IIIB period. Far more participants could observe rites outside the tomb, especially along the line of procession, but the expansion of floor space to accommodate more entrants does seem to be a late concern in the chronology of tholos tombs (Boyd 2016: 64-70).

In terms of scale and relative labour investment in tombs, there is an important caveat to tomb comparisons with diameter alone. Diameter on its own has been found to be a very weak reference point for comparing tomb scale (Turner 2020: 118). Volume is far more indicative of relative cost, superseded only by a full labour cost assessment. Voudeni chamber tomb 75, for instance, would be 92% the size of the Menidi tholos if comparing diameter/width of chamber alone, yet it is less than 42% the volume and potentially only 13-25% the cost depending on the stone source for Menidi (Turner 2020: 118). The length of the dromos (only for well-preserved tombs) would be the next best measurement comparison absent volume or labour and would also be an excellent means of comparing the number of participants allowed within the tomb at any one time (Papadimitriou 2015; Boyd 2016). Looking at Table 5, the Tiryns tholos is still more than 15 times larger and more than 25 times as costly as a standard (Achaean) chamber tomb, well on par with the organisational capabilities of the lords of southern Greece. However, when comparing this with the absurdly rich megalomaniac(s) that built Atreus' Treasury (126 times larger and 803 times the cost of that same tomb standard), hyperbole comes easier to anomalously large tombs and Cyclopean walls (Turner et al. forthcoming). In that sense, Mycenae's Atreus and Clytemnestra tholoi and the Treasury of Minyas at Orchomenos are best discussed separately from other Mycenaean tombs (Fitzsimons 2014).

A firmer argument in favour of an earlier date for the Tiryns tholos can be found in the material choices and the decorative scheme, especially the (painted) plaster feature at the stomion of the tomb. This phenomenon seems to have started in LH IIA and was frequently used in LH IIB (see Table 3), as is seen in chamber tomb 222 at Mycenae (Konstantinidi-Syvridi et al. 2015: 413, 416), and in the LH IIIA1 chamber tomb 75 at Voudeni, where at least red pigment was noted at the stomion (Kolonas 2009: 29; Turner 2020: 204). More relevant is the painted plaster design on the stomion of the Kokla tholos (Demakopoulou 1990: 113, fig. 4) and plaster/clay mentioned at the Kazarma tholos, both dating to the LH IIB-IIIA1 period.[4] White clay near the stomion (Kazarma), mortaring in white clay or stucco of the doorway/stomion blocks (Mycenae Group II: Panagia, Kato Phournos; Genii in Group III; Prosymna tholos), and plaster on the floor (Dendra and Berbati) still appear (Table 3). The employment of plaster became less prevalent in later periods when the material seemed replaced by relief decoration in the two latest tholoi at Mycenae and Minyas Tomb at Orchomenos (Wace 1931; Pelon 1976; Sgouritsa 2011; Papadimitriou 2015: 94). Plastering and painting in chamber tombs was known from LH IIA onwards and became even more elaborate later on (e.g., the Theban tombs at Kastelli, Table 3). This emphasis can be explained as the 'Versailles Effect' of what was known from the tholoi before LH III (after Wiener 1984). Owners of chamber tombs emulating the rich and mighty commissioners of tholoi can also be substantiated by the fact that most embellished chamber tombs were all of superb quality, well-cut in comparison with the rest of the cemetery and featuring additional benches as well as extremely rich finds (Sgouritsa 2011: 747).

The use of painted plaster seems especially informative on the stomion (threshold) of the tomb, long recognised as the liminal locale through which one moves from the world of the living to that of the dead (e.g., Boyd 2002: 83; Gallou 2005: 67; Dakouri-Hild 2016: 20). It is clear that the decorative elements focused and highlighted the opening to the 'other world'. Emphasis here is reinforced by additional efforts to enhance the outer façade. Mycenae showcases several instances of elaborate doorways: 1) decorative bands carved in hard stones (e.g., the Tomb of the Genii and the Tholos of Clytemnestra); 2) rounded half-pilasters carved from exotic materials brought in from far away (e.g., Treasury of Atreus); 3) the embellishment of the entrance by contrasting stonework (e.g., Tomb of Aegisthus, Panagia tholos, Kato Phournos tholos, Berbati [Karo 1935: 199]); 4) and enormous, complex lintel systems (Treasury of Atreus and Lion Tholos). Another expression of tomb liminality was noted by Kolonas (1998; 2009: 16, fig. 16 section of Tomb 4), who saw a connection between houses for the living and the dead, particularly where vault cuttings in the ceilings of several chamber tombs at Voudeni imitated the gabled shape of a house roof (see also Galanakis 2016: 159 for similar argument; Turner 2020: 158). There is of course also the argument that plastering, and painting may not have taken place at the time of constructing the tomb but at the time of interment (e.g., Papadimitriou 1952; Xenaki-Sakellariou 1985: 166; French 2002: 44), but this is not agreed on by all (Mylonas 1973: 219 on tomb Rho). We would also need to consider which interment if tombs were used multiple times.

Furthermore, conglomerate was employed in all Mycenaean tholoi from LH I-II onwards. At Tiryns, conglomerate was present since LH IIIA/B onwards in *specific liminal* spaces atop the citadel (Maran 2006). We wonder, then, if the tholos was indeed built in LH IIIA, why would a construction with an explicit liminal sphere and function at the stomion not employ this material *par excellence*? The absence of conglomerate ashlar in its construction anywhere, even though the material was also used in both Prosymna and Berbati (the latter also not near a source), could be seen in favour of a date earlier than those suggested for Prosymna and Dendra (see Fitzsimons 2006: 153). Finally, the Kato Phournos tholos was dated by Wace to the end of the 15th century BCE and later than the tholos of Panagia. Both are similar and in Group II, and each have a relieving triangle comparable to Tiryns (Pelon 1976: 163-164).

8. Conclusion

This paper concludes that, methodologically, it is useful to carry out photogrammetric recording of the monuments, especially if no further detailed drawings exist, to aid labour cost studies. Comparing the traditional drawings with the 3D model, in the case of this tholos, indicated that the differences were often unremarkable but need assessing on a case-by-case basis. In terms of the chronological debate, we contributed to the discussion by having brought together all data on the matter for the first time. How the Tiryns tholos fits – on the edge of the (living) world yet embedded within the thriving Argolid – depends partly on its unresolved construction

4 Kokla: LH IIB-LH IIIA1: Demakopoulou 1990: 113; the most recent date given for Kazarma tholos was LH IIA-B by Keramidas et al. (2021).

date and how the contemporary populace perceived the investment. General funerary trends for the Argolid (and southern Greece apart from tholoi-dense Messenia) show that the small-to-medium-sized tholoi of the LH II period gave way to the far more numerous LH III chamber tombs and the exceptional few mega-tholoi. All the while elites negotiated their roles, including those as patrons and labour organisers, partly through mortuary display (e.g., Wright 1987; Dabney and Wright 1990; Voutsaki 1995; 1997; 2001). Whether its construction began in the LH IIB or LH IIIA based on regional tomb developments, the Tiryns tholos would have been familiar to observers in scale, form, and message. For its scale, more than 15 times larger and greater than 25 times the cost of a standard Achaean chamber tomb (Turner 2020: 100; see Table 5, this paper), the statement is one seemingly made by a regional power on par with those who built the Menidi tholos near Athens (Tables 5 and 6). Though admittedly an incomplete picture, from their tholoi alone both Menidi and Tiryns fall far short of the might wielded by the lords of Mycenae and Orchomenos at their apogee. This could speak to an LH IIB Tiryns not yet in its prime, long before the final building of its mighty walls. Alternatively, LH IIIA-B Tiryns could have prioritised other communal projects, such as its walls and earthen dam. Little indeed could be spared if all monumental construction in the area coincided, still a candidate scenario for the pressure felt near the catastrophic end of the palatial centres (Brysbaert 2013; 2015a; 2020; 2022). As far as the plastered stomion is concerned, only careful surface cleaning, microscopic examination for any pigment traces, and instrumental analysis on cross sections will tell us more on the potential décor of this liminal feature of the tomb. Until then, we can no longer maintain that blue painted spirals greeted visitors of this magnificent tomb.

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Mobility as a drive to shape cultural landscapes: prehistoric route-use in the Argolid and surroundings, Greece

Ann Brysbaert and Irene Vikatou

1. Introduction

Starting on a journey provides an opportunity for communication and change, and the act of leaving a place makes people realise how mutable people's lives become. People have, for ever, taken to the road and to exploration, and have engaged in intercultural contacts for plenty of good and not so good reasons. The movement of people, their animals and posessions, the movement of people's ideas, thoughts, skills and knowledge, are a constant factor which relies on the purpose of the travel and who travels, when and where, and it can be one- or multi-directional. People's mobility also depends on the available infrastructure facilitating movement and travel. For example, path and road surfaces with packed earth are more difficult to negotiate in rainy seasons than ones built of hardier materials, and, if not well-maintained, soon become precarious. However, safe, well-scouted and -trodden routes, especially in mountainous areas with continuous, but perhaps dynamic, inhabitation patterns may illustrate very persistent features when they serve co-dependent features in the landscape: crop fields, villages, farms, marketplaces, larger administrative towns, ritual and memorial spaces, and (other) infrastructure. Ethnographic, historical, and archaeological research on mobility and landscape modifications indicate that older roads may be in use for centuries or millennia (Via Egnatia albeit with 20-21st century modifications) or may be given a new life to fit current needs (*e.g.* Via Appia Project: de Kleijn et al. 2016).

People's mobility was part of even their daily sedentary existence, and motivation for moving between places was easy to find: visiting kin; going to work; herding animals; collecting and selling produce; scouting for, extracting, transporting a range of resources; going to war; fleeing. This list is not unlike what we encounter today. Even the bodies of people, but also animals and plants in themselves are in constant motion as they grow, decay, get hurt, die, and refertilize new life (*e.g.* turtles coming back to their place of birth to lay eggs forms a good example). As narratives of past migrations across wide areas of the planet are now substantiated by ancient DNA studies, the more local or regional day-to-day movement of people, animals and many other resources seem somewhat less considered. This is especially the case for how people themselves experienced these daily movements and how they tried to achieve these.

In the context of the late Middle until the end of the Late Bronze Age in the Argolid (northeast Peloponnese, Greece) and surrounding regions (c. 1600-1100 BCE; hereafter MBA, LBA), people's mobility patterns took on a different level in contrast to earlier periods as veritable building programmes took place especially in the 13th century BCE

Ann Brysbaert
Irene Vikatou
Department of Archaeological Sciences
Material Culture Studies
Leiden University

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and resulted in awe-evoking citadels, burial monuments, waterworks, roads, and bridges (*e.g.* Maran 2010; Simpson and Hagel 2006). Many expressed that these building programmes must have mobilized substantial labour forces over sustained periods of time. But these construction works were far from the only reason why people exerted coordinated efforts and moved around on a day-to-day basis. As a wide range of different craft production processes took place, agriculture and animal husbandry were the predominant subsistence strategies for most people in the Greek LBA. Also, these types of production and consumption processes required a great deal of movement and effort (Brysbaert 2020; 2021; 2022a).

The aim of this paper is to discuss and reconstruct a fuller picture of the mobility patterns of multiple human, animal, material and immaterial resources and their interactions which shaped, and were shaped, by both the material and immaterial elements of mobility in the LBA Argolid region and its surroundings. The topic of movement and mobility, and specifically how this could have been achieved locally, regionally, and interregionally is investigated. As will be shown, people and their resources employed a substantial Mycenaean road network in the topographically varied landscape of the Argolid and surroundings prior to the demise of the Mycenaean societies in around 1200 BCE.

2. Mobility, movement, travel, and transport

Mobility is totally interwoven with energy expenditure. Contra sedentarist theories in which staying put and being stable in one place is the norm, the 'mobility turn' allows for movement to be considered as normal for being a sedentary human, and it also stresses the importance of networked places (Sheller and Urry 2006: 208-209). Social entities comprising of people, animals, technologies, and information in systems of movement are not free from space and place. Terrains are no longer seen as objective and spatially fixed geographical containers for social processes: we make our way *through* a world-in-formation (cf. Ingold and Vergunst 2008: 2). Consequently, maintaining both sedentary and mobile lifestyles result in embedded and immobile infrastructures, such as roads and ports, and costs can be measured in terms of energy spent and materials processed. Mobility is thus materialized and grounded, just as much as the traveller is (Ingold and Vergunst 2008). The 'mobility turn' studies physical movement (walking, climbing), movement enhanced by technologies (vehicles), movement of images and information at various scales, and movement of skills, knowledge, ideologies, and beliefs. It also investigates immobile infrastructures for transport and its borders, and gates that stop, channel, or facilitate movement. Many of these are connected and fluidly interdependent. As such, the 'mobility turn' questions and studies patterns of concentration that create zones of connectivity, centrality, and empowerment, on the one hand, and disconnection, social exclusion and inaudibility, on the other (Graham and Marvin 2001: 87-88, 308, 383-385). People's mobility is thus certainly one of the many aspects that are part of Ingold's taskscape (1993: 162) which he defines as 'a pattern of activities collapsed into an array of features'. These can include areas of production and spaces in which ideas are transferred.

Sheller and Urry (2006: 211-213) point out that the mobility turn does not reflect one single network but, instead, it has complex intersections of endless regimes of flow which move at different speeds and scales. This is because walking, vehicular transportation, movement of images, information and ideas, and movement – enhanced by roads, and bridges – influence each other. This way of looking at mobility resounds very closely the meshwork of lines of life (Ingold 2011). Nowadays, when we move in a known or unknown territory we often think in several dimensions (latitude and longitude, next to height, time, and our perceptions and experiences), certainly when we employ GPSs on phones or in cars. Ingold (2011: 149-150), moreover, distinguishes between lineal movement along a path of travel and lateral movement across a surface. On the one hand, he sees the wayfarer as being continually on the move, in an ongoing process of growing, development and self-renewal for as long as life goes on, and in which they are sustained from within. A wayfarer moves along a path, laying out a trail while crossing other such trails. As such, they inhabit the earth through embodied experiences of moving through, around, to and from places and from one place to another (applied example in Koussoulakou et al. 2015). On the other hand, he sees that transport takes place when people move across a surface, along specific latitudes and longitudes, while Bakke (2007: 95) believes that people in the past would never have thought about it in this geometric way. Human existence thus seems *place-binding*, not place-bound, as it unfolds, not in places, but along paths (Tilley 1994: 25). The concept of transport, to Ingold, is destination-oriented, during which people and goods carry across from location to location. At a first glance, Ingold does not see the transporter as a mover within himself but rather as *being moved* (as if a passive entity) by the means of transport, until the destination is reached, and *being sustained* by his/her supplies (water, food).

According to Kirby (2009a: 4) too many scholarly analyses have taken it as a given how the axes of space were extended and were overlaid on top of existing notions of relations, proximities, and affect. This was done by replotting alternative social mappings in x, y and z co-ordinates, and facilitating proliferation of a certain culturally anchored set of political relations. Kirby (2009a: 11-16) sees movement more as an essential component of the effervescence and improvisation of social life, or of the inevitability of movement across, or along, spatio-political structures or boundaries intended to restrict movement. He asserts, however, that boundaries do not always disappear simply because of an increase of mobility, just as relations are not necessarily severed because of the presence of boundaries. Movement is life and through movement (in a foreign world) researchers could become more sensitive to the spatial, cultural, and political dimensions of social life. In this light, movement is seen as a vehicle in analysing social experience of surroundings (Kirby 2009a: 15).

3. Moving in a topographically varied landscape

When travelling in mountainous regions, horizontal movement combined with height and slope and road gradients need to be negotiated since these affect wayfinding within a varied topography. When a destination is set, a direction of travel may suggest itself. Depending on the purpose for travel and the load taken, speed, time, means of movement, and the amount of exertion required, all become important parameters and, depending on the goal, some will take priority over others. Even when walking for recreation, we may want to be back before dark, for example. In conjunction with all these factors, we need to determine how to get there: what are the means (pedestrian, vehicle type) and route options, and what are our priorities: speed, ease of terrain and route, or specific resting places?

If we journey somewhere for the first time, we encounter unknown places that bring along attractors (rest places, water holes) and deterrents (seasonally inaccessible roads, dangerous ravines). Such journeys are aided by (inter)visibility and navigational indicators, especially in a topographically varied landscape, as surprises and danger may lurk behind every turn. Our knowledge of such navigational indicators on chosen roads strongly influences whether those roads will facilitate or restrict our movements. Further facilitation or restriction of movement occur when roads are controlled by specific groups, or travel *has* to go via specific roads (e.g., tolls). The crucial navigation markers, then, are both physically real, and in the traveller's mind who then uses them to make decisions about a direction. These markers are included in mental maps (see Ingold 2011) on which real distances are less important than perceived ones, and in which value ascription is not purely cost-based but is experientially obtained. The value and meaning given to trajectories may be as important for the traveller as the distance covered. This perceptive quality of movement lies in another dimension of movement: time. A traveller cannot be in two places simultaneously and, therefore, cannot be the same person upon arrival somewhere as they were before they left. It takes time to get there (Ingold 2011: 152).

A landscape, too, carries meaning through how it is perceived, experienced and contextualized (Knapp and Ashmore 1999: 1). Places with sacred geographic features such as ritual stopping points (e.g., wells or shrines), or perhaps places that indicate connections to ancestors (tombs), or quarries (see red and blue stones at Tiryns, Brysbaert 2015) can, therefore, be or become important landmarks or even navigational indicators. People's perception of the landscape is tied up with movement and their (repeated) experiences in this environment (Kirby 2009b; Ingold 2011: 11). Social knowledge of, and movement through, a social milieu is topo-mnemonic in character, memory is always influenced by spatial practice and spatial cues, and engagement in surroundings flows from embodied mnemonic interplay with characteristics of place in a community (Kirby 2009a: 16). As such, places lived in are not indifferent (Bachelard 1994: xxxvi), it cannot be. Places are defined by movement. Repeated experiences in a landscape may be linked together (e.g., traffic between home and place of work), but they also include memories, in themselves linked to past activities/ events (funerals, processions). The persistence of routes is an outcome of these experiences and associated processes. Experiences and memories lead to a better grasp of that route along which we move. So, the route's meaning and use can influence or can be influenced by its trajectory, its beginning and end. All along, the presence of older meaningful places or navigation markers, were important. This, in turn, can lead to persistent places (Tuan 1977), but also to a world which embraces its inhabitants in its own renewal through the seasonal cycles. For example, seasonal torrential rains can easily destroy an earthen road along a mountain slope.

An understanding of the role of navigational indicators cannot be complete without considering aspects of visibility, especially in a topographically varied landscape. Visibility studies relating to mobility and navigation are well established in archaeological landscape studies more generally. For the Mycenaean Argolid, however, there are very few, although statements on visibility and intervisibility have been made throughout architectural studies (e.g., Müller 1930; Maran 2006). Studies on sea-based navigation are well known from Aegean islands archaeology (e.g., Broodbank 2000; Jarriel 2018) and Brughmans (et al. 2018: 479-483) provides an overview for the Caribbean. Another type of visibility study which helps to explain site locations (after Brughmans et al. 2018: 480) is exemplified by Mason's (2007) paper on the visibility of the location of the Treasury of Atreus from various vantage points as a political statement, as much as the tholos construction and size itself. Finally, Tartaron et al. (2011: 615) show the importance of site intervisibility in higher upland areas since this seems to be systematically important in the region around Kalamianos for their choices of settlement locations. Being visible is 'saying something' after all, and intended visibility markers, whether natural or constructed, are part of strong and effective communication strategies as long as the sender and receiver understood the message. They may form a level of control and inherent safety as well.

Moving in any territory, reliance on the senses plays a crucial role, especially if the unknown unfolds in front of the traveller. The better someone knows an area through repeated encounters with it, the finer tuned their perception of it is (Ingold 2011; Slayton 2017: 27): after having walked the same route for several years, we may still see something which we had not noticed before. Trying to understand how people's perception of their surroundings and movement within, how they articulated social engagement, and how they enacted relationships with each other through movement is hard, especially the further you look back. But certain types of informants may aid in getting another perspective on this matter. The ethnographic work by anthropologists with nomads (e.g., Gooch 2008), professional travellers or ordinary people who move a lot, all contribute to better understandings of these topics as new studies show the changing character of people's roots, identity and affiliation in a modern world of porous borders and novel connections. But while this reflects current situations, there is no reason to believe that such matters were very different in the past. As Kirby (2009a: 15) states: 'The liaison between bodies and environs brings endless adaptions and growth, with the land influencing denizens and travellers as much as the reverse. Movement is central to this engagement between being and surroundings'. In seeing movement in this light, any Cartesian perspective of movement in the vessel that the landscape is considered to be, has been enmeshed with the sensory experience of being in and with the land.

The timing and repetition of each trajectory, leading to new and accumulated experiences, are essential to form a mental map that would enable us to return along the same route after our business is done. The active process of remembering navigation markers, whether in our mind or physically present, must have been an intergenerational practice, and must have resulted from well-bonded social groups with integrated knowledge of their surroundings (Ingold 2011: 161). Less-experienced travellers could be initiated in unknown trajectories and its difficulties by experienced travellers, as is also the case nowadays. Based on negotiating their emerging capacities with the affordances and restrictions of the environment in which they are, and in doing this together, communities of practice are created (Lave and Wenger 1991; Wenger 1998: 77; Ingold 2011: 161), as there are in any production activity. Alternatively, a fleeting acknowledgement of knowledge transfer between travellers is the untraceable outcome.

Covering trajectories together creates joint experiences and so does facilitating such trajectories because the roads need to be built, repaired, and maintained. Passing on such accumulated expertise allows the continuation of knowledgeable and comfortable journeying as a skill and, as such, it brings along inherent prestige, resulting in, among other things, rewarding storytelling. It is in the movement from place to place – or from topic to topic – that knowledge is integrated' (Ingold 2011: 161). Landscape features, such as roads and bridges are thus, both physically grounded entities, and simultaneously, the products of social relationships through the physical and social labour of trained and skilled people, over generations. People construct, repair, and maintain the physical nature and function of each of these interlinked features for further use in that dynamic landscape. The landscape in which past actors habited, lived, worked, and travelled could, therefore, never have been a static backdrop but needed constant attention, production, action and interaction. It is alive too, considering the seasonal affordances and restrictions that force and forge these interactions.

4. Types of roads in the Argolid and surroundings, and their purposes

According to most writers (especially Jansen 2002) there are various types of roads, paths and even highways in the Mycenaean Argolid and the surroundings. The differences between these types sit in their construction techniques, materials, along with their trajectories. The difference in construction of Mycenaean Highways and lesser roads are noted especially in the scale of effort required to build, and their width. The Highways follow the same contour throughout their trajectory (low gradient), even if this is high up on a slope. They are often well-constructed in the cut-and-terrace technique and their surface constructed using several layers. Their width varies between 2.20 and c. 5 m. They allow the passage of Heavy Good Vehicles (HGVs) for large cargoes. Lesser roads are archaeologically difficult or impossible to recognize as they consist of mostly trodden earth and can be of any width. They follow a more direct trajectory and may, therefore, cross higher slope gradients and entire mountain ranges.

The Mycenaean heartland of the Argolid has eight Highways, the so-called M-highways (see esp. Lavery 1995). These have been described in detail elsewhere (Brysbaert et al. 2020) but a short overview is illustrated in Table 1. Provisional labour cost figures for the building of the M-highways are revealing. For a total length of 175 km of Mycenaean Highways, some are on flat land and some are cut into the surrounding hill slopes. It would have taken roughly 5.1 years (minimum) of construction to complete. This would have required 100 workers, working 10 hours/day for 365 days/year (details in Brysbaert 2022a). To

Nbr	From	To	Via	Joining
M1	Mycenae Lion Gate	Tenea (Corinth)	Stefani, Agionori, Klenia, Chiliomodi (Tenea), Solomos	M3 (near Solomos) M2 (at Kastraki)
M2	Mycenae Lion Gate	Zygouries-Kleonai (Corinth)	Ag. Vasileios, Kephalari plateau	M3 (at Kleonai) M1 (1.5 km from Lion Gate at Kastraki)
M3 M3W	Mycenae Lion gate	Corinth	Nemea-Tzoungiza, Kleonai	M1, M2
M4	Mycenae conglomerate quarries	Tiryns	Monastiraki, Heraion	m5 (at Tiryns), M6 (Ag. Georgios bridge), M7
M4E	Mycenae	Heraion	West of Zara	
M4W	Mycenae	Heraion	Chavos/Chonia ravine	M4 (Ag. Georghios bridge)
m5*	M1	Tiryns	Berbati, Mastos, Dendra-Midea-Kastro	M4 (at Tiryns)
M6*	Aidonia	Heraion	Phlious, Ag. Georghios bridge	M4, M7
M7*	Mycenae Lion Gate	Argos (and Lerna)	Epano Pigadi, Chania, Vathyrema W	M4
M8*	Mycenae Lion Gate	Fychtia	-	M7 (at start point)

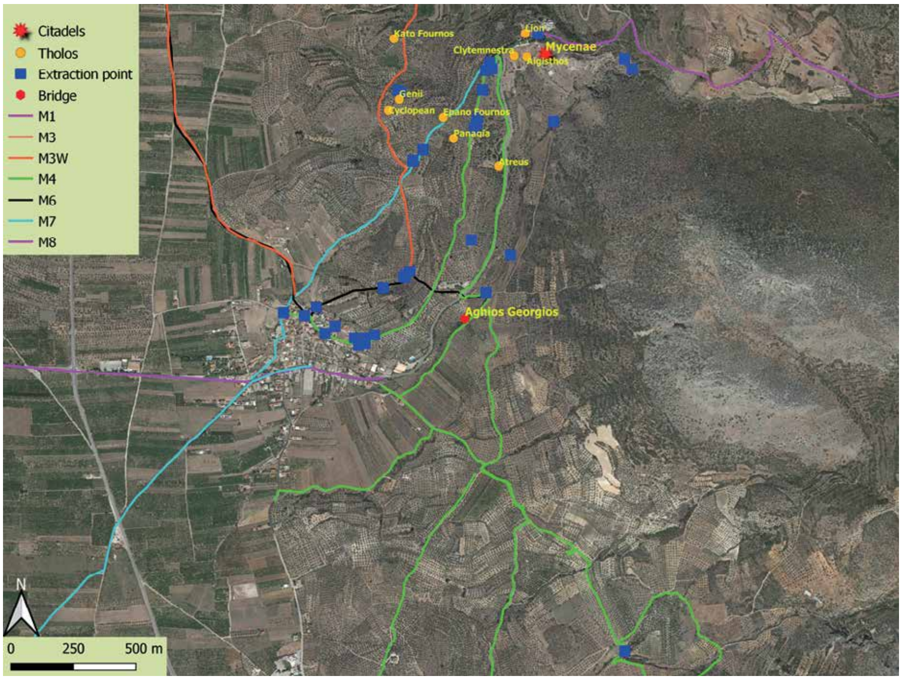
Table 1. Known Mycenaean M-highways and m-roads reported by various sources (Tsountas 1888; Wace and Stubbings 1962; Mylonas 1966; Lavery 1990; 1995; Jansen 1997; 2002; Iakovidis et al. 2003; Simpson and Hagel 2006). *New roads according to Lavery (1995): he also considers m5 a highway.

compare, the citadels of Tiryns and Mycenae in their entirety would have taken approximately 6 or 7.5 py for 100 people respectively (Brysbaert 2020). It would, therefore, have made more sense to construct the highways over a much longer period. This agrees with Schallin (1996) and Lavery's (1990) pre-13th century BCE dates for M1 and M2. Who was involved in constructing these M-highways, or any roads in Mycenaean Greece, is unclear. There were likely people of similar status as those who were engaged in the construction of the fortified citadels known at Mycenae, Tiryns, Midea, Gla (Boeotia), Athens (Attica) and Teichos Dymaion (Achaia), who used similar construction techniques and knowledge. Many have suggested that slaves must have been conscripted, but it is hard to find convincing evidence to support this, apart, perhaps, from diachronical suggestions. Bakke (2007: 104, n. 320) seems convinced that slaves were doing the hard work on road building (and quarrying) throughout the Graeco-Roman world. He also refers to Roman army troops who set to build roads in peace time. A similar picture is known from Versailles where soldiers in peace time were converted into builders of the palace extensions (Duindam 2003).

Finally, Pikoulas (1995) describes many sections of roads dating to later Classical and Hellenistic periods illustrated by wheel ruts. Several of the Mycenaean M-highways seem, despite the chronological differences, to correspond with these roads. For example, the section from Corinth to Kleonai via Longopotamos corresponds to parts of M3 where wheel ruts were located. Wheel ruts were also found at Spathovouni, Mapsos (Corinth-Tenea road: Pikoulas 1995: 32-39), along the route from Kleonai to Nemea (Pikoulas 1995: 46-49), and at Dervenakia and Fichtia along the route from Kleonai to Argos (Pikoulas 1995: 56-61). Along our M1 wheel ruts (now destroyed) were reported at Agionori (route Tenea to Argolid). Along M2 between Kleonai and Mycenae, potential but unconfirmed ruts were noted (Pikoulas 1995: 50-53). Finally, Pikoulas (1995: 64-69) also recorded *kalderimia* (stone-paved roads) along the route from Phlious to Mycenae and Argos. The latter corresponds to the trajectory of M6.

We recently (Brysbaert et al. 2020) raised the likelihood for the existence of a myriad of smaller roads and paths in the Argolid linking various places, via which people went about their daily businesses, as well as facilitating the construction of monumental tombs and citadels. In order to understand where such other roads and paths ran, we collected, for example, data on the constituent construction materials of the nine tholos tombs and the citadel of Mycenae. We focused on the limestone and conglomerate quarries, and plesia clay, used as a sealant on tholoi facades and citadel walls. The blue dots in Figure 1a-b indicate extraction places for these materials. We next observed how the extraction points and monuments related to each other, to the lesser roads, and to the known M-highways. We were fully aware that most tholoi were constructed before 1300 BCE, the century in which most M-highways are said to have been constructed (but see Lavery 1995; Schallin 1996; Brysbaert et al. 2020 for a chronological discussion). We ran Least Cost Paths (LCPs; details in Vikatou and Brysbaert, forthcoming) from these resources to all nine tholoi and the citadel. In comparing the LCPs with real trajectories (Figure 1a-b), only the archaeologically detected and confirmed trajectories could have been employed in transporting building materials to the construction sites. This has now been confirmed by Müller's work (2022) on the road vicinity to various tomb clusters, and additional

A



B

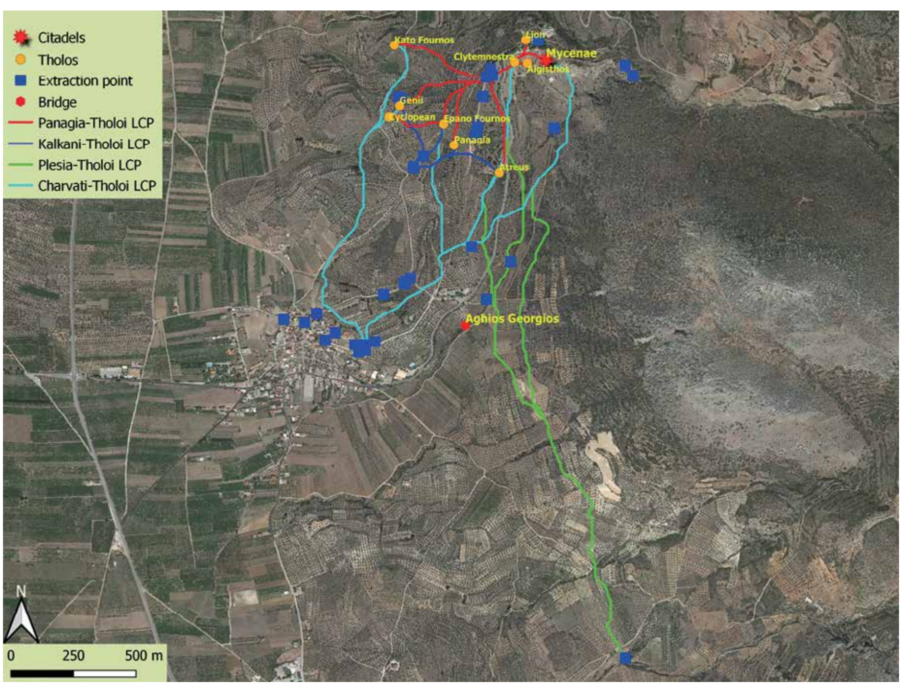


Figure 1a. Mycenaean highways nearby Mycenae's extraction points for stone and clay sources; 1b. Least Cost Paths near Mycenae's extraction points for stone and clays (maps by I. Vikatou and A. Brysbaert). Figure 1a and 1b: Imagery ©2022 Google, Imagery ©2022 CNES / Airbus, Maxar Technologies, Map data ©2022.

roads leading from M-highways to tombs. An earlier paper by Efkleidou (2019) showed a clear trend for non-highway roads connected to certain cemeteries in and near Mycenae. Since most tombs were built before the M-highways were in place, we believe (Brysbaert et al. 2020) that these M-highways were preceded by earlier earthen roads until they became monumentalized during the 13th century BCE. This monumentalisation, combined with the multiple uses that roads experienced, for example, access to the sanctuary of Apollo Maleatas, has now also been asserted by Keramidas et al. (2021), for the road from Nafplio/Tiryns to Epidauros. Such evidence exists in an earlier stretch of M4, just below the citadel, which may have functioned for defensive purposes because it had a great command over the surrounding land below. Since also the tholoi were likely meant to be seen and remembered, it is, therefore, no coincidence that these M-highways ran along all nine tholoi (Brysbaert et al. 2020).

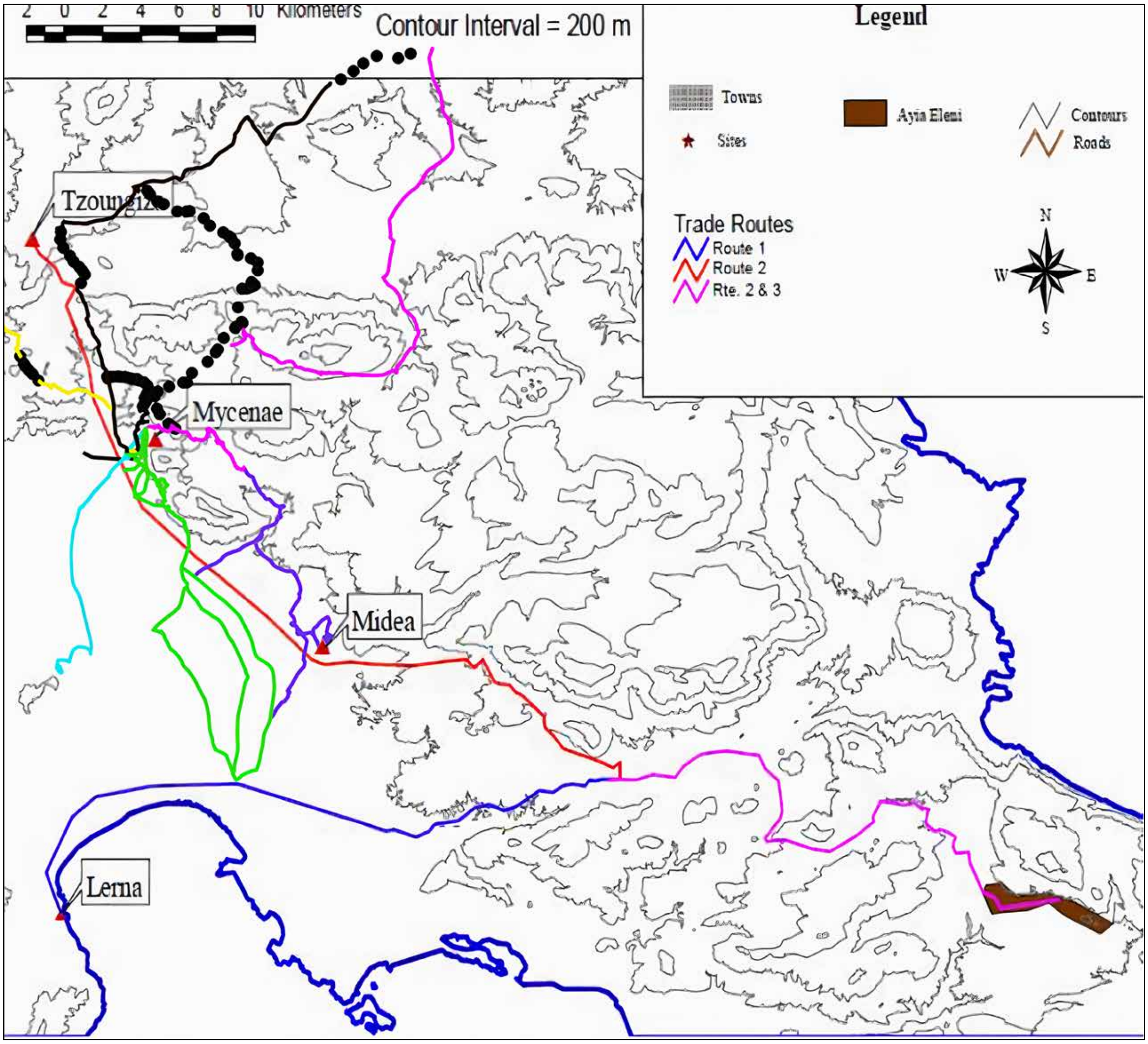


Figure 2. Map based on Newhard 2003, figure 7.1. and overlaid with our suggested Mycenaean M-highway network (see also Figure 3) in order to show the vicinity of his Route 1 (colour blue) and Route 2 (colour red) nearby the M-highways and linked to the Agia Eleni outcrop of chert (image by I. Vikatou and A. Brysbaert).

In addition to the eight Mycenaean Highways in the heartland of the Argolid, another well-known substantial road runs from Tiryns/Nauplion to Epidauros and passes by the tholos tomb of Kazarma. The trajectory of this road (Kritsas 1973: 94), possibly constructed before LH IIIB (see Keramidas et al. 2021) is partly visible from the modern road and includes two well preserved bridges and remains of two other ones (Piteros 1997; 2006). In relation to this road, Newhard (2003) provides information on a chert outcrop in the modern village of Ayia Eleni, located near Epidauros and c. 5 km southeast from the Asklepeion sanctuary. Yellow-reddish chert material is known from sites such as Mycenae, Tzoungiza and Midea, and, to a lesser extent from Lerna. It has also been attested at Tiryns and it corresponds closely to the description of the sampling bed G 04 next to Ayia Eleni and to the description reported by Newhard (2003: 75-76. For chert objects at Tiryns from LH IIIB to LH IIIC, see Brysbaert and Vetters 2010; 2013; 2015; Brysbaert 2013). Newhard (2003) proposes several routes by which this material might have been transported from the Ayia Eleni outcrop to the sites mentioned. Figure 2 shows how close his route 1 passes by Tiryns and may have connected there with M-highway 4 coming from Mycenae, or, if the material was already traded in earlier periods than the latter part of LH III, a forerunner of the M4 highway (as we suggested: Brysbaert et al. 2020). Newhard

Site name	Route 1	Route 2
Mycenae	53.04	50.14
Tiryns	37.48	43.91
Midea	43.08	36.86
Lerna	50.81	54.76
Tzoungiza	62.25	59.36

Table 2. The distance in km from the Agia Eleni chert outcrop to the sites where chert was found (after Newhard 2003, table 7.1).

(2003: 112, 121) provides the necessary support for trade in Saronic Gulf pottery and millstones between the Argive Plain and the Saronic Gulf settlements during the Early and Middle Bronze Age (e.g., Kolonna on Aigina and Ayios Konstantinos on Methana), and he believes that the chert could have been one of these traded goods embedded in the trade of these other materials between both regions from then onwards, a point we also expressed on several occasions for the use of the Mycenaean highway network (Brysbaert et al. 2020). Newhard's route 2 (Figure 2) would provide for the sites of Midea. It ran its own route from Ayia Eleni, but from Midea onwards, it roughly follows the M4 to Mycenae and from there, it skirts alongside the M2 to Tzoungiza. Table 2 shows the distances that Newhard (2003: table 7.1) calculated between the Agia Eleni quarry outcrop and the sites where chert was found (although he did not study Tiryns' chert material).

The road from Nauplion/Tiryns to Epidauros is perhaps the first *known* route that travels from Mycenae/Tiryns to the east shore of the Argolid, but others have been outlined too. Tartaron et al. (2011: 614-615, 628) and Pullen (2022) mention the access that Mycenae had to the Saronic coastline and Gulf through Kalamianos which was likely built under control of Mycenae. They describe a Bronze Age upland route being indicated by several fortified enclosures (Tartaron et al. 2011: fig. 40) along the fault line that connects the small basins in the southeastern Corinthia. This upland road would connect to Kalamianos via the dry streambed downhill for about 4 km (Tartaron et al. 2011: 615). The described trajectory serves as the main route between the Korphos area and the Corinthia and Argolid inland regions. This is based on ethnographic accounts they retrieved about an overland passage from Mycenae via the small basins and mountain passes of Sofiko, Angelokastro to Limnes and Berbati.

According to Pullen (2022), another possibly well-constructed road with bridges (but of unknown date) could have connected Kalamianos with upland Stiri (major EH occupation) via Sarakina. This allowed goods to follow this route, possibly on wheel-based transport. It would have run further north from the Nauplion/Tiryns-Epidauros road. Kalamianos and Stiri were inhabited in the EBA and had trade contacts beyond their immediate vicinity, indicating the need for routes, at least overseas (obsidian from Melos, andesite from Aigina and other sources in the Saronic Gulf: Runnels and Murray 1983: 63). Kolonna on Aigina however, was the site best connected to the mainland for their exports of pottery, especially from the shaft grave period onwards (MH III and peaking in LH I-II; Tartaron et al. 2011: 628).

Closely linked to the upland road linking the region of Kalamianos to Mycenae via Limnes, it is possible that, at the point of Angelokastro, a road heading south and then westwards towards the (modern) village of Arachnaion, as the modern road still does. A little south of this village, remains of a Mycenaean shrine on the hill of Profitis Ilias were found among later material (Psychoyos and Karatzikos 2015: 269-270). This shrine, situated on a dominant hill and visible from Tiryns and Midea, was only 16 km away from Tiryns, 11 km from Midea, and 20 km from Mycenae, potentially serving all of the large citadels of the Mycenaean heartland. Another road heading south from the village of Arachnaion possibly linked to the Nauplion/Tiryns to Epidauros road at the crossing near Chani Mercouri or Ligourio.

Other potential roads from within the Argolid linked to the surrounding regions. One possible road connected Lerna with Sparta, crossing over the Helikon mountains (Pritchett 1980: 140; Krigas 1987), while Krigas (1987: 81) also mentions another road that would have gone through Anthana and Neris to connect both Lerna and Sparta. This has not been elaborated on further though (see Mason 2007: 36, fig. 1). Bakke (2007: 102)[1] is not convinced that there would have been a network of Mycenaean roads in Arcadia as suggested by Krigas (1987). Bakke (2007: map 3) may be correct that there were no engineered roads in Arcadia apart from the small section at Khoma, and a few others. In following Jansen (2002) he sees the M-highways around Mycenae for local purposes only, i.e., transportation of agricultural and pastoral produce to the centres 'by means of beasts of burden rather than by wheeled carriages' (Bakke 2007: 103). We, however, believe that the M-highways functioned well beyond the local network (Brysbaert et al. 2020). The problem is that the wheeled carriages seem to be understood mainly as chariots while much heavier vehicles were mentioned in the literature (discussed in Lavery 1995; Brysbaert et al. 2020) for the transport of large cargoes, building stones and wood logs. In a detailed description of roads in Arcadia, Bakke-Alisøy

1 Jørgen Bakke and Hege Bakke-Alisøy have been carrying out survey work in the region of Doliana and Tegea for many years and published recently a new interdisciplinary methodology to recognize roads as part of their surveying work, see Bakke and Bakke-Alisøy 2020 for details.

(2016: 6) follows Bakke (2007) in expressing a steep road gradient for carriage roads while roads/paths for foot passengers with beasts of burden would follow contours up and down the mountains. There seems to have been confusion between road and slope gradient, though. The road gradient for any type of carriage, especially when pulled by oxen or other animals with a heavy load cannot be steep because the animals would not be able to cope with the pressure of their load downhill (Brysbaert et al. 2020; see also Efkleidou 2019: table 1). This is one of our arguments in favour of the gentle *road* gradient we noted in several M-highways. While these ran often on high *slope* contours, they did so consistently, allowing the transport of heavy cargoes, such as building materials in stone and/or wood (Brysbaert et al. 2020; Brysbaert 2022a). In Mycenaean contexts at least, beasts of burden (oxen) and four-wheeled wagons are combined. Bakke (2007: 112ff) also discusses road use as a function of large-scale stone transport of Doliana marble (see below).

That not all large roads were constructed as highways is clear but there nevertheless must have been larger roads, perhaps widened paths, for the transport of cargoes to other regions. For example, Bakke's (2007: 125-126) Peloponnese Highway which he sees crossing the Peloponnese north-south from the Isthmos to Megalopolis, seems remarkably like the road which ran from the Isthmos to Sparta and passed by Lerna (Bakke-Alisøy 2016: 12-13), and possibly via Argos, as Krigas (1987) pointed out. Wheel ruts indicate their use from the Classical period onwards when this technique was introduced and copied into Greece from the Persians (Bakke-Alisøy 2016). Both Bakke (2007) and Forsén (2003: 83) believe that this Highway dated to the Bronze Age, or even earlier, and Forsén talks about a Highway going through Asea, passing other settlements of the valley. Bakke-Alisøy (2016) even sees the possibility that the use of this Peloponnesian Highway may be datable to the EH period, connecting Tegea to the Gulf of Argos, the Plain of Asea, and the Plain of Mantineia. Bakke-Alisøy (2016) describes other local networks in addition to those described by Bakke a decade earlier. From this, it seems that several local neworks, i.e., in every direction in-and-out of Tegea, around the Doliana valley, and through several other regions. All eventually link to larger roads, such as the Peloponnesian Highway. The latter thus connected Sparta with Argos, and a major crossroad at Stous Phonemenous that also fed roads leading to Analipsis on the plain of Karyai. Bakke-Alisøy (2016: 10) calls Analipsis a highland node in an ancient network, where roads east-west and north-south crossed, possibly existing in prehistoric times (Forsén 2003: 64, 67).

In relation to building materials, specifically to marble stone transportation, Bakke (2022) refers to a road, in use from potentially the Bronze Age to the Medieval times. In fact, he goes as far as suggesting that the road was built in order to bring the Doliana marble (in the north Parnon) to Tegea in the Archaic period so both building projects (temple and road) coincided. He also notes that there were Late Bronze Age settlements (e.g., Mirmingofolies) in the Doliana valley:

'The Late Bronze Age material was also recorded in close vicinity of the modern dirt road from Psili Vrisi to Vervena (Bakke-Alisøy 2016; Bakke and Bakke-Alisøy 2020: 42). From the *Agios Panteleïmon* pass the route along the dirt road from *Psili Vrisi* to *Vervena* would easily have interconnected with the important Bronze Age site at *Analipsis* on the border between ancient Arcadia and Laconia. Finds from *Analipsis* go back to the Neolithic period (5th and 4th millennium BCE) and extend into the Medieval period, probably into the 13th century CE [...]. This indicates that the route from the lower Doliana Valley through the pass of *Agios Panteleïmon* towards *Vervena* was established at a very early stage in the history of settled occupation of the inner Peloponnesian peninsula, and that its importance persisted throughout its premodern history[...]'.

Later, Bakke (2022, see also Bakke and Bakke-Alisøy 2020) notes: 'The route from Psili Vrisi to the Agios Panteleïmon pass is also most likely the transportation route from the Tegean plain to the quarries in antiquity'.

A final route may be extracted from a recent paper (Buckley et al. in press) which brings together evidence of the use of charcoal in the Late Bronze Age East Mediterranean, based on the recognition of lignite in dental calculus analysis. Evidence of lignite at Tiryns suggests that wood from the region of Olympia was used. While bringing the wood itself to Tiryns from Olympia is not suggested here, at least the charcoal, probably produced closer to the wood source to avoid long-distance heavy transport, must have travelled from Olympia to Tiryns during the LBA. This likely was carried out taking the road form Olympia in the direction of Tripoli or Mantinaia towards Lerna and Argos, and, as such, tying into the network again described by Bakke (2007) and Bakke-Alisøy (2016).

Finally, hidden in her publication on Arcadia, Salavoura's (PhD 2006, published in 2015) work somewhat cuts off the Argolid from her map in which a wide network of roads is indicated for Arcadia and beyond. Her research into Arcadia ran simultaneously with the work by Bakke (PhD 2007). In appendix 2, she describes the Mycenaean roads in Messennia, Attica, and Boeotia, and gives a summary of known data on four of the eight M-highways in the Argolid, known as M1-M4, and the Nauplion-Epidauros road. Roads m5, M6-8 are not mentioned in her work despite their description in Lavery (1995). As we did, Salavoura mentioned the difficulty in dating roads directly without thorough excavations. However, indirectly, several strands of information are

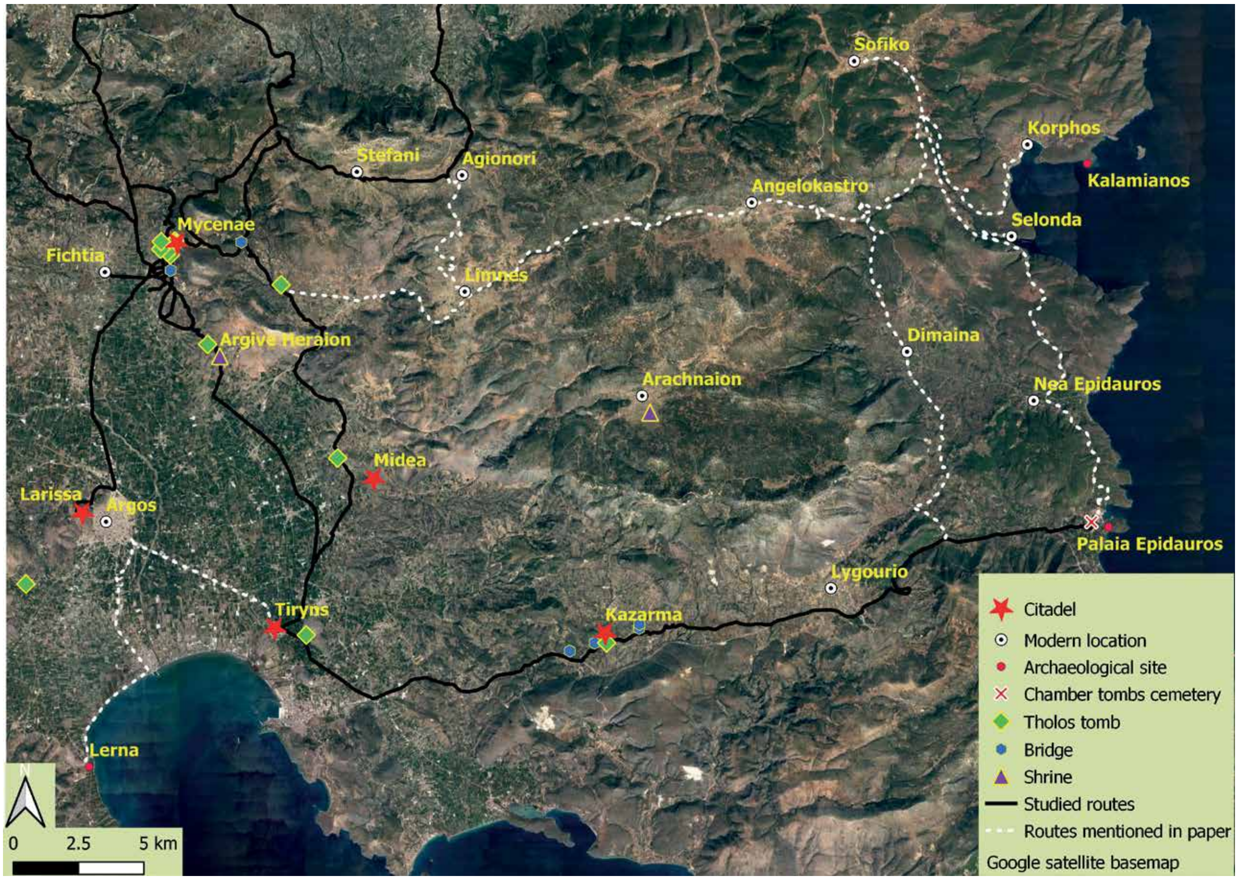


Figure 3. Map of the northeast Peloponnese indicating Mycenaean highways and other roads mentioned in the text (map by I. Vikatou and A. Brysbaert). Imagery ©2022 Google, Data SIO, NOAA, U.S. Navy, NGA, GEBCO, Imagery ©2022 TerraMetrics, Map data ©2022.

useful, such as the construction materials and techniques (massive Cyclopean blocks for bridges, curbs, and culverts, not known after the end of LH IIIB), and the fact that they link places of Mycenaean interest and material culture, as Bakke (2007), Bakke-Alisøy (2016), Pullen (2022), and our paper (Brysbaert et al. 2020) have amply indicated.

5. Discussion

While already over 30 years old, the paper by Sanders and Whitbread (1990) on graph theory and early Network Analysis of (1) the Peutingeriana map, (2) written accounts of ancient travellers, and (3) 19th-century travellers and their writings on the Greek roads they travelled following Pausanias, shows that many routes in the varied landscape of the Peloponnese have not changed much since antiquity. These routes seem very persistent but are not static features. Where the routes did divert, though, the few kilometre shifts, noted by them, are explained by changes in the concentration of settlements. Courses of rivers were followed and crossed at ancient bridging points and fords, and trajectories followed, where possible, coastal plains to avoid the difficult mountainous interior. Beyond the shift of some routes, the importance of the nodes themselves changed in response to the development of settlements over time and their importance (Sanders and Whitbread 1990: 345), an entirely logical observation. Some of their useful results were that, in general: (1) the road system alone was not indicative of relative centrality; (2) distance in terms of travel time was not a direct constraint on accessibility; and (3) a specific place may have little significance in a small area but may be far more important within a larger network (Sanders and Whitbread 1990: 349). These points are discussed below in relation to the Mycenaean road data.

In the northern part of the Peloponnese, several central nodes were recognised on the basis of roads leaving from, arriving at and passing through Mycenae, Argos (Figure 3), but also Analipsis (see Bakke-Alisøy 2016). What each of these nodes and central places indicate is that a very interconnected road network criss-crossed larger parts of the Peloponnese in Mycenaean LBA times, and perhaps even earlier for many different reasons. The (eight)

Figure 4. Captured image based on Google Earth showing a dense network of paths leading from the Korphos region towards Epidauros on the mountain slope, nearby the modern Selonda Bay (image by A. Brysbaert). Bilder ©2022 Google, Bilder ©2022 CNES / Airbus, European Space Imaging, Maxar Technologies, Kartdata ©2022.

Mycenaean Highways in the Argolid were certainly part and parcel of this road network during the LBA. Many goods and people had to be transported from and to the Argolid centre of Mycenae and other nearby citadels. These M-highways and other roads were not just there for a single purpose, as many have amply demonstrated (Pullen 2022; Bakke 2007; Bakke-Alisøy 2016; Brysbaert et al. 2020). Both Bakke and Bakke-Alisøy, and Pullen (2022) clearly discussed the existence of roads in terms of establishing connections between settlements and other places. The site of Analipsis was an important node, just as the invisible marketplaces were (Pullen 2013). In doing so, they also took environmental factors into account: people avoided marshy land (Mantineian Plain), made good use of vantage points (intervisible sites upland from Kalamianos), dealt with natural erosion (through road maintenance during winter periods), looked for waterways, and various other natural aspects of relevance to travel. Such natural factors cannot be seen separate from the reasons for and how to travel, and from movement over a criss-cross network of tied-in roads, paths, and the M-highways. For example, the road, described by Tartaron et al. (2011) and Pullen (2022), out of Stiri near Korphos heading westwards, could have linked with the Mycenaean Highways a little south from the M1 at Limnes, from which a small zigzag road ran north to Agionori, and then on west towards Berbati. Pullen (2022) also mentions an extensive network of paths and routes in the inland interior of the Korphos region well above the coastline. Along the same vein, Google maps show an equally dense network of paths leading from the Korphos region towards Epidauros close to (modern) Selonda Bay (Figure 4). All these may have served terraced agricultural land. It seems very likely that there was also a good road between Kalamianos and Epidauros following the coast, possibly not far from the modern road from Epidauros to Isthmos, crossing the riverbed just west from Selonda bay, to then link up, via the dense network of paths, with the older Korphos road. Pullen (2022) has suggested another road, further inland, running more or less parallel, between Korphos and Epidauros via Dimaina.

Some of these roads may have taken the traveller faster to their destination than others as is clear, for example, from Newhard's distance calculations when comparing his routes 1 and 2 (Table 2). However, the distance, in a mountainous region, is not necessarily an indicator for speed and, as previously mentioned, people travelled on specific roads for specific reasons, whether that reason was economic or not. Moreover, travel time should not be seen as 'dead' time. Instead, embedded activities and learning about places and people are central to the success of the journey. Taking time allows people (at different scales and speeds) to gather information and goods, to work (network), connect, socialise, learn, share and exchange, and enjoy and anticipate while journeying (Brysbaert et al. 2020). These cross-over activities, the meeting of others, and looking after each other while going about daily tasks are central themes of this paper. For example, Newhard (2003) pointed out that travelling just to distribute chert to various sites would not warrant the effort. Instead, the likelihood that other very durable materials, such as andesite and Aiginitan pottery, were also brought on these trips is high. Less durable materials may have travelled too or may have even been the prime reason for these journeys. Two separate roads, heading inland and eastwards from the two harbours (Kalamianos and Epidauros) where Aiginitan goods would first arrive onland, would facilitate their distribution onwards, and also Pullen (2022) mentions andesite as possibly being used as ballast for ships arriving at Kalamianos. Aiginitan pottery only declined around 1400 BCE when Mycenae's pottery took over, thus highlighting the then dominant settlement in the region with its expanding and developing road network. Kalamianos was of enough importance to Mycenae around 1300 BCE to have its port town architecturally planned and built in one go (Tartaron et al. 2011: 630-631; Pullen 2022). This reflects an interest in the coastal settlement by Mycenae prior to 1300 BCE, thus confirming the existence of a road between them prior to 1300 BCE. In a similar vein, the road from Nauplion/Tiryns crossed over to the Saronic coastline bringing and receiving goods from there. Aigina could thus ship its pottery to both Epidauros and Kalamianos for overland distribution into the depth of the Argolid, and on from there. It could thus reduce and spread the risk of losing access (or a cargo underway) by dividing its transport through two different harbour points.

Travelling, when done by experienced voyagers, is a knowledgeable form of performing, through which people and places connect, as they also do through building (Brysbaert 2018). Building materials, as previously discussed, likely travelled along the same routes as other cargoes that travelled between Tiryns and Mycenae, and Bakke (2007; 2022) comes to similar conclusions concerning the Doliana marble material. Therefore, several intersecting levels of mobile people and their belongings can be traced, illustrating the complexities of human interactions with non-human beings and materials whilst on the move (see Sheller and Urry 2006: 208-213). In our modern perception, embedded activities may perhaps save time, but the actual trajectories taken may have made the journey longer, and for good reasons. Travel time, therefore, was likely not the most determinant issue in choosing the road taken, rather travel comfort *for all parties* (human, animal, and breakable produce) seemed to have been the priority until the arrival of motor-driven vehicles forcing changes in the road type, construction techniques, and materials. Any beast of burden, whether ox or donkey, was an asset not to be wasted as livelihoods would have depended on them. These animals, furthermore, set the rhythm and speed of the journey, thus also its duration (see Gooch 2008). And that, again, depended on the road type taken.

Mycenaean Highways were hardly the common road type in the Argolid, as outlined above. Only a handful of constructed roads have been recognized: eight M-highways around Mycenae, the road between Tiryns/Nauplion to Epidauros, a small section near/on the Dam (Khoma) in Arcadia (Bakke 2007) and some traces near Kalamianos (Pullen 2022). Only the M-highways followed the same contours along hill slopes but smaller roads and paths took higher road- and slope gradients into their thread. These smaller roads and paths could easily take people and smaller pack animals (donkeys, mules) and were comfortably accessible for travellers on foot. It is, therefore, not a surprise that the road from Epidauros heading inland crossed at least three bridges. It likely thus formed another constructed M-highway as some cargoes using it must have been substantial enough to warrant a wider (constructed) road and beasts of burden to take them to their destination. One would expect a similar road leading from Kalamianos to Mycenae but the topography in between is more challenging than that between Nauplion to Epidauros. Having said this, as Pullen also pointed out here, there is much more in the region that still needs exploration.

Beyond people's mobility in their taskscape where people produce while looking after each other (Ingold 1993), knowledge of roads is important to get about and (inter)visibility is instrumental in achieving this knowledge. Mason (2007: 39-40) argues that the location of the Treasury of Atreus was based on the local topography of Mycenae and that the tomb was visible for anyone coming from the southeast or southwest along certain M-highways, but also from the northeast, and from within the citadel itself.[2] Especially the link with the surrounding (landscape) features, such as the gorge of the Charadros river (Mason 2007, 46-47, 49, fig. 11) is convincing, and as such, he links the natural and built environment. The same visibility was noted for the citadel from various viewpoints along roads leading to Mycenae while Efkleidou (2018) noted intentional *invisibility* of the Lion Gate from all roads surrounding Mycenae. Our work on Mycenaean roads in the region has taken visibility and especially points of intervisibility of both sites and natural features (hilltops) into account while being aware that visibility may alter seasonally and over longer periods of time due to erosion, changing vegetation patterns and landuse, along with changing coastlines (known from Tiryns: Zangger 1993). For example, mount Arachnaion as the location of a Mycenaean shrine is clearly visible

2 Contra Efkleidou (2017) who argues that this is not possible due to the height of its walls, and that the Atreus Treasury is only visible from the court in front of the megaron.

from Tiryns and Midea and all along the route from Argos to Mycenae until Fichtia. At this point, Arachnaion disappears behind Mount Zara, and Mycenae (with its own shrine/sanctuary) becomes clearly visible.

Visibility was not just useful to find and reach a destination; navigational landmarks could fulfil other purposes too. Even if a trajectory is considered to be located through a well-trodden region (e.g., between Tiryns and Mycenae), so that no landmarks would have been needed for wayfinding, it might still be useful to realise what people could see as landmarks. Argos, already an important settlement in the MH period (Papadimitriou et al. 2015), and marked by the Aspis and Larissa hills, was always in view and so were the Palamidi and Acronafplion hills. Next to Mycenae and Tiryns many locations were well-established places over time and, in different ways, each indicating an accumulation of different routes and road types in their respective surroundings which showed their connection to each other and many other places in the well-trodden region. Tiryns, for example, interlocked both sea and land travel, and Mycenae formed a perfectly protected locale with a dense node of routes in and out of its valley.

Beyond their visibility, landmarks helped people's memories on how to reach a destination, but such persistent places in the landscape could also form nodes in people's social memory, whether based on natural features or built ones, such as the Arachnaion shrine mentioned above. Gosden and Lock (1998) refer to sites being constantly reworked, and a very useful example is the site of the Tiryns LBA citadel, remodeled and revisited repeatedly since its first monumental construction in EH II-III in the shape of the Rundbau (Maran 2016 and Brysbaert 2018). That genealogical memory could stretch back over extended periods (oral transmission alone can reach back two centuries: Bradley 2002: 8; Whittle et al. 2011: 3), is also attested in EBA-LBA Britain (Gosden and Lock 1998: 8). Another clear example are the roads: when not maintained and looked after throughout the seasons by people who knew what they were doing and what that meant for the overall benefit of society – thus creating bonds between them – the routes would never have afforded the megalithic blocks that they allowed to be transported from Mycenae to Tiryns. One could even go as far as to say that these megalithic block cargoes are the proof of close social ties of communities at work in the region, and the importance they gave to the work they did for the community. Santillo Frizell (1997-1998) has illustrated well what such transport may bring about in people's social memory. This is where the people involved in transportation would actively interact with their environment (see also Slayton 2017, but contra Ingold 2011: 149-150) and with each other, while having, and because of having, a specific destination in mind for their cargoes. The need to transport these cargoes, especially when large and heavy, would have requested specific negotiations with the surroundings: the least slope gradient to traverse (see M1, M4 and M6: Brysbaert 2022b), where possible the shortest route, water holes and resting places for the animals along the route (M4). And perhaps there would even be an obligatory stop imposed by others: for 'live performance' purposes near some of the magnificent tholoi (after Santillo Frizell 1997-1998), to honour their ancestors (e.g., Galou 2005), or to attend and participate in rituals at the hilltop shrine (on Mount Arachnaion).

As physical entities such as roads and bridges are the grounded products of the physical and social labour relationships of generations of skilled workers and their apprentices, forming a taskscape. As much as people and their relations are dynamic, so are the landscapes these people transform, since the roads needed constant attention and maintenance, and people change with them each time they traverse these roads. Equally, the physicality of stone quarries change shape as they are being reduced in size and volume, and once abandoned, they may overgrow. This physical change was clearly visible at the conglomerate quarry sites at Mycenae (Brysbaert et al. 2020). Also, agricultural surroundings, such as terraced fields, are alive as hinted by their seasonal opportunities and restrictions that are part of human-environment interactions. While people and their animals are the most obvious actors, we cannot underestimate the agency of their surroundings, built or not.

On a more regional and diachronical level, it is fair to say that the constant or recurrent labour input of route maintenance and construction, combined with their constant or recurrent usage over time, makes roads persistent features, right up until modern times. In this context, the M-highways around Mycenae may have become more of a burden to later generations of elites over the following centuries, especially in being able to mobilise the needed labour to access materials in order to maintain these roads. When left unattended, such maintenance costs would quickly accumulate and therefore not warrant keeping these roads in use. In contrast, the smaller roads and paths, employed on a daily basis, once the palatial elites were no longer in charge after 1200 BCE, were easier to maintain; they have always been. This ties in nicely with the observations made by Sanders and Whitbread (1990: 345) in which roads may shift a few kilometres over time in relation to a site of importance. Once Mycenae lost its importance, the M-highways may have been, temporarily, out of regular use at least by the elite members of society. Lavery, however, did mention some continuity until Mycenae was conquered by Argos, and these roads were likely used for several non-palatial purposes, as they were before. Road shifts are thus recognised here, and an

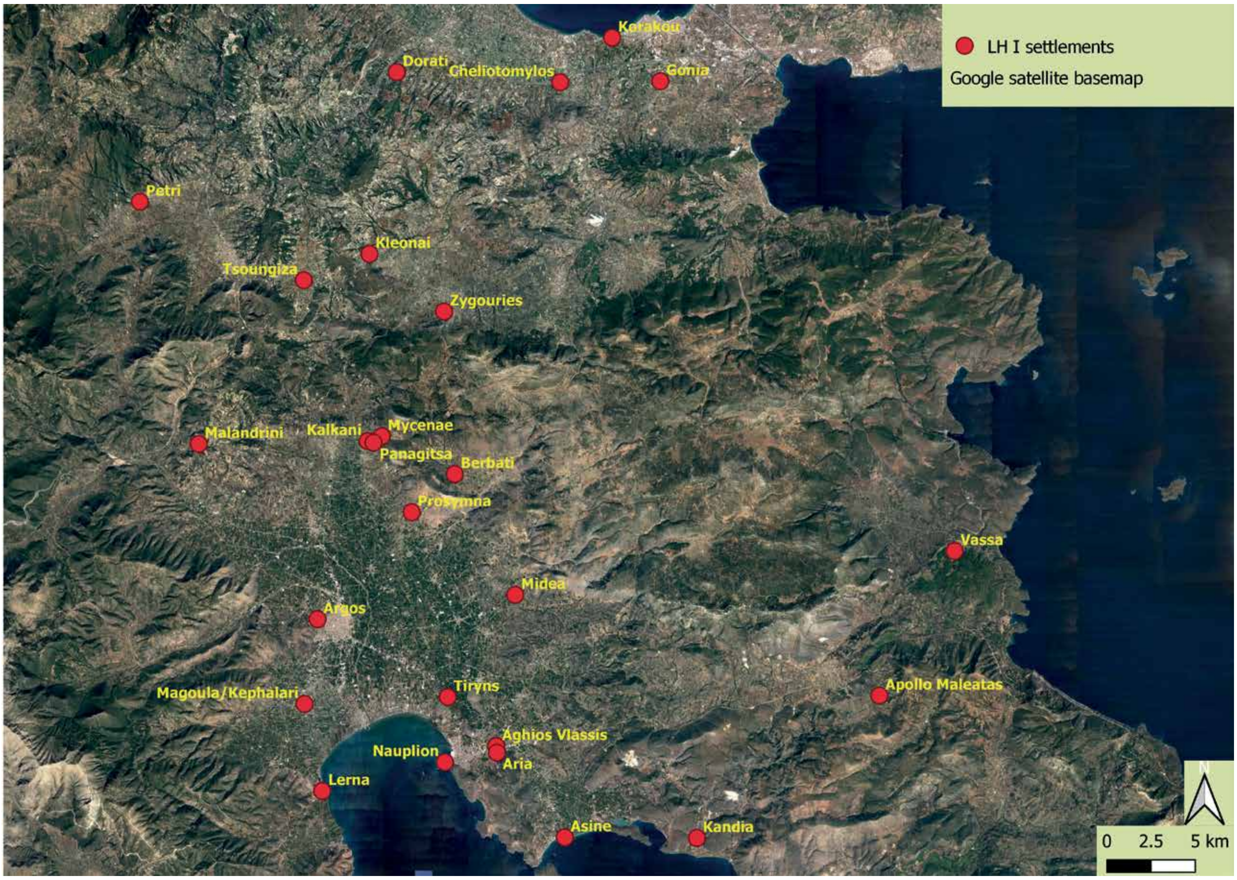


Figure 5. Map indicating the non-exhaustive spread of settlements, cemeteries and various other site types for the period of LH I (map by I. Vikatou and A. Brysbaert, based on data from Bintliff 1977; Davis 2004; Jameson et al. 1994; Nakassis 1916; Schallin 1996; Simpson and Dickinson 1979; Sjöberg 2004; Tetford et al. 2018; Wright 2004; and many reports in Archaiologikon Deltion). Imagery ©2022 Data SIO, NOAA, U.S. Navy, NGA, GEBCO, Google, Imagery ©2022 TerraMetrics, Map data ©2022.

important road from Argos to Lerna and towards Sparta (Krigas 1987; Bakke 2007) seems to confirm this shift of site importance from Mycenae to Argos after palatial times.

Kirby (2009a: 8) states that socio-political topologies of hierarchy (and exclusion through elite control, level of visibility and surprise-awe factors), are helped and encouraged by control over infrastructure in empires since roads and paths are connectors: they facilitate access and cross boundaries, if allowed. Simultaneously, roads and paths can also restrict because forming such paths/roads, especially under elite sponsorship, can impact the landscape with its resources and people, for the purpose of domestic stability and geographical advantage. Inter-visibility plays a key role in the impact that routes have on people's use and circulation in the landscape. We referred to this, following Jansen (2002), as a clear indication that Mycenae must have played a more dominant role in the northeast LBA Argolid as so many of the constructed roads led to and from there, when compared to those from and to Tiryns and Midea respectively. In this sense, perhaps the Mycenaean shrine at Arachnaion was not to compete with the one at Mycenae, despite its most prominently high location. As mentioned above, the shrine was likely accessible via Angelokastro travelling south, and then west to modern Arachnaion, or when following M1 and descending south from Agionori towards Limnes and south from there towards a still existing track which connects Arachnaion with Midea. People from Tiryns could also reach it from there, or they could travel along the route to Epidauros and then head north up from there at the height of the Acropolis of Kazarma or further east (between modern Chani Merkouri and Ligourio) – although from there, they would have to cross the Arachnaion range at a height of c. 850 m to reach their destination. Near the shrine area, one could easily imagine processions and larger groups of people using these roads to travel there on appropriate days. All roads considered, several larger and smaller ones, seem to circulate the shrine locale making it a central and very visible place, and could be relatively easily reached from each corner of the northeast Peloponnese

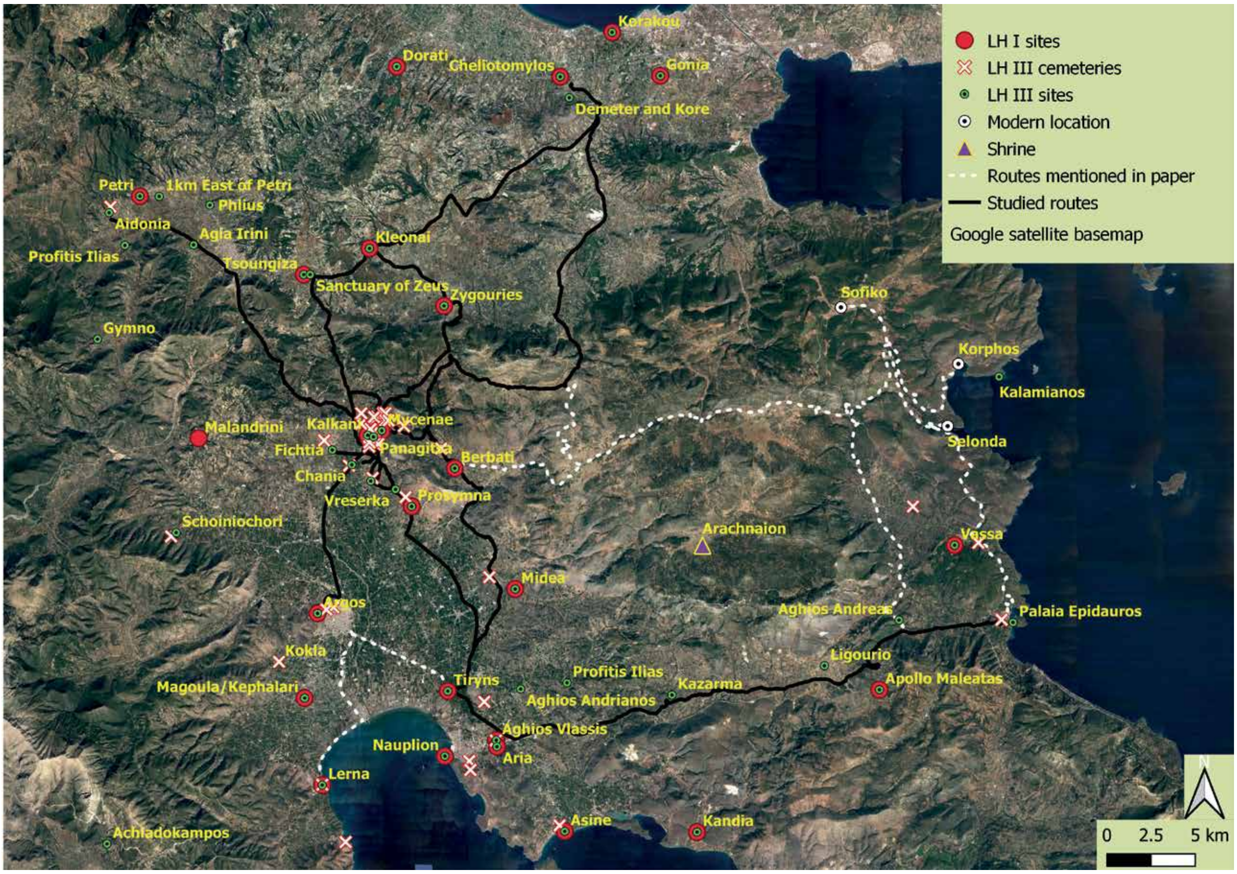


Figure 6. Map indicating the non-exhaustive spread of settlements, cemeteries and various other site types for the period of LH III in relation to the plotted M-highways along their currently known trajectories (map by I. Vikatou and A. Brysbaert, based on data from based on data from Bintliff 1977; Davis 2004; Jameson et al. 1994; Nakassis 1916; Schallin 1996; Simpson and Dickinson 1979; Sjöberg 2004; Tetford et al. 2018; Wright 2004; and many reports in Archaiologikon Deltion). Imagery ©2022 Data SIO, NOAA, U.S. Navy, NGA, GEBCO, Google, Imagery ©2022 TerraMetrics, Map data ©2022.

by using the existing road network. As such, mount Arachnaion could not be an indifferent place (Bachelard 1994: xxxvi), or a passive backdrop for activities, as any place is defined by movement. The repeated experience of passing by the Arachnaion mountain in this landscape was linked together with traffic between home and work, trade and commerce, and, as such must have included specific memories; triggered by seeing the shrine landmark on one's mental map. Activities in the shrine may have linked themselves to past activities/events (funerals, processions), and the persistence of routes encirculating the mountain may be an outcome of these processes.

The existence and use of the lesser roads is linked to the chronological discussion of the Mycenaean Highways (details, see Brysbaert et al. 2020). Not everyone agrees that all M-highways were constructed in the 2nd half of the 13th century BCE. Especially Schallin (1996) already opted for an LH IIIA date for M1 and Lavery (1995) maintained that M2 was even older. Also, M4 seemed to have existed before 1300 BCE. The spread of settlements, cemeteries, and various other site types for the periods of LH I versus LH III is revealing in relation to the plotted M-highways along their currently known trajectories (Figures 5-6). In order to reach and connect these places, lesser roads had always been crucial since harvest collection and the trade and transport of material resources were certainly present in the region before the M-highways were in existence. Also, burial rites and transporting bodies to the tombs was a regular affair which needed proper access between the settlements and tombs, these existed well before the M-highways were constructed (Efkleidou 2019 on reaching the chamber tombs at Mycenae; Brysbaert et al. 2020 especially on the tholoi; see also Müller 2022). As expressed before, we believe that the M-highways must have been based on pre-existing roads that were both widened and monumentalised from 1400 BCE onwards, perhaps starting with M2 and M4, and followed by M1, in order to allow for Heavy Goods Vehicles which needed wider road surfaces for their cargoes, next to their continuous use for other activities. This trend was continued once monumental building was restarted in the

Archaic period when quarries, roads and building sites were closely linked (Pakkanen 2021: personal communication). Bakke's work on the Doliana marble also confirms such observations for Arcadia.

6. Conclusions

This paper aims to construct a fuller picture of multiple human – animal – material/immaterial resources, mobility patterns which shaped and were shaped by both the road types in existance, on the one hand, and other more immaterial infrastructure (mental maps based on intervisible landmarks) on the other, in the LBA Argolid region and its surroundings. People there went to work (building, agriculture, crafts), and were involved in trade and commerce (e.g., Pullen 2013 on markets). People carried out military operations (coast guarding, food transport protection), used roads in rites of possession and division, and took part in socio-religious activities (buried relatives, visited shrines). The purpose of the journey, combined with the natural environment dictated how and when people moved, and the time they took for travel. The relationship between the four main Mycenaean highways (M1-M4) and agricultural activities such as collecting and transporting harvests to Mycenae's citadel has been mentioned by Jansen (2002), Lavery (1990; 1995) and others. Lavery's (1995) expansion from four to the eight M-highways was not excessive considering the number of roads, highways or otherwise, described here, that were accessed in the LBA, or well before that, in the Argolid and surrounding regions.

Studying the multiple overlaying networks of Mycenaean roads and paths of the past (and more recent ones) in the landscape can highlight several aspects of human economic, political, ritual and social activities. The nodes through which several of these roads may have led, may give indications about the importance of such nodes. The more roads that go through a place, i.e., Argos, Mycenae, the more connected it will be and this will reflect in its overall importance to the surrounding places situated along these roads. In political-geographic-terms, the Mycenaean Highways together show the extent of the potential connections, and influences that the three major citadels had together, either under Mycenae, or each in their own way as competitive entities. The costs in their construction indicate efforts well beyond the local community level in terms of coordination, execution and sponsoring. They also highlight those who benefited most when they were in use: the grandeur of the roads and what they claimed alongside: far-reaching territories, power visible in their monumental character and scale, access and perhaps control over labour forces that could also be used for military efforts when needed. But when combined with the entire Mycenaean road network, the full extent of people's daily activities came into view and eventually led to the concentration of Mycenae's might, at least temporarily during LH IIIA-B. Choosing to spread such construction efforts over time, or using more people to finish the job at hand may have had very different effects on managing many other large-scale projects, while other tasks such as house building, agricultural activities, and multiple craft productions still needed to be carried out too. If the M1-2-3 were potentially also employed (and even partly constructed) for stone transport and other heavy cargoes, they would have been multifunctional too, and the stone transport from Skaloma to Mycenae seems to suggest that this was the case (see Brysbaert 2022a).

Smaller roads would have to have been connected to these M-highways or their predecessors to reach every corner of the agricultural land and connect it to Mycenae as its final destination. Other substantial cargoes could also be transported along them, such as pottery and other goods. Finally, the intervisibility of landscape markers, which would have facilitated people's travel, as we noted on our walks, was crucial. While walking, the mountains surrounding Mycenae along the M6 only disappeared from view when those near the Kelossa pass became visible. These led the travellers clearly on to their final destination. A similar pattern was noted in relation to the intervisibility between mount Arachnaion and two of the three major citadels in the Argolid. The most static of things in our minds, a place, is defined by its opposite, movement, and necessarily so. This goes to show that the environment in which past actors habited, lived, worked, and travelled, could never have been a static backdrop but needed constant attention, production, repair, action, and interaction. Such a taskscape is fully alive, as already hinted at by its seasonal affordances and restrictions that force and forge many of its interactions.

In plotting the numerous roads mentioned in the literature, along with newly suggested ones (Figure 5), it became clear that the people in the Argolid and surroundings, their animals, and their material resources were very mobile indeed in the final centuries prior to the demise of the Mycenaean societies around 1200 BCE. Many of their activities continued well after 1200 BCE and the persistence of these led to the longevity of the roads, paths, and other places; in some cases until the present day. The long-term use of some of the roads discussed here are the grounded and materialised dynamic outcome of people's ever changing taskscapes, of multi-generational work, physically on the roads themselves, as well as the execution of many other jobs that required access to these roads via wayfinding, based on mental maps of navigational landmarks.

It is a skill to be able to read the road, to navigate it well, and to be sure of where it will end, if that is the purpose of the journey. Passing on these skills while travelling created worthwhile experiences and these, in turn, drove the transfer of skills over the generations. When people pass on their accumulated expertise, they also allow the continuation of knowledgeable and comfortable journeying – as a skill. Experienced journeying, for whichever purpose, may bring prestige and may also result, if you are good at it, in rewarding storytelling. 'It is in the movement from place to place – or from topic to topic – that knowledge is integrated' (Ingold 2011: 161). As understood in repeated practices when mastering any craft, persistence is the message. This message was and is carved in the physical and mental road map of the Mycenaean landscape of the Peloponnese.

7. Acknowledgements

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Tracing the Mycenaean hinterlands. Refining the models of Mycenaean territoriality with insights from the cadastral maps of the Second Venetian Rule in the Peloponnese, Greece

Kalliopi Efkleidou

1. Introduction

Mycenaean notions of territoriality have attracted a lot of interest, but very few attempts have been made to systematically discuss and model them. Almost all attempts in the past discuss the territories of Mycenaean states at the peak of their development, that is during the 13th century BCE when palaces are thought to have reached maximum territorial extent and political and economic integration. These theoretical approaches have followed a variety of lines of evidence (textual, excavation and survey data, demographic and land use models) and methodologies (statistical, computational models). They all have, however, one thing in common: they are driven by a top-down approach, that is from the view of the palace as the political, economic and administrative centre of these states.

What we are systematically missing is the view of the common people and how they conceptualized and spontaneously enacted territory. Considering the very selective involvement and control of the palaces in the economy and administration of their territories, it is possible that the common people, beyond the eye and reach of the palace, had a very different conceptualization of the territory with which they identified.

In the present paper, I suggest we turn to other sources of information that depict or describe the territories common people identified with in the past. This is a bottom-up approach to territoriality that could extend and enrich previous approaches in the field. The earliest and most complete dataset of this kind is found in the archives of the Second Venetian Rule in the Peloponnese (1687-1715 CE). The archives consist of the cadastral books and maps for various regions in the Peloponnese, reports of administrators to the metropolis of Venice, and population censuses conducted during the same period. The cadastral maps, in particular, indicate settlement territories as local communities communicated them to cadastral officers. Consequently, the maps constitute the earliest accurately measured, visually depicted, and textually described evidence of common peoples' notions of territoriality available for the Peloponnese. I suggest that through the study of this material one can get a clearer idea of Venetian-times territoriality notions and extrapolate to Mycenaean times.

Kalliopi Efkleidou
Department of History and Archaeology
Aristotle University, Thessaloniki

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2. The need for a new paradigm

During the 14th and the 13th century BCE, a series of large building projects (massive fortification walls, palace complexes, a regional road network, waterworks systems) were undertaken at several Mycenaean settlements (Mycenae, Tiryns or Midea) in the Argolid, Southern Greece. A key issue to understanding the impact of these construction works to the economy and political setup of respective communities has to do with the different types of costs related to the mobilisation of the necessary workforce, tools, and raw materials. Most of these costs are proportional, that is they are directly related to the size of the workforce that was 'employed' to the construction.

The massive size of monumental building projects has led scholars to assume also massive mobilisation of workers for their construction, but the exact size of this workforce has been a matter of debate. Egyptian and Assyrian images of hundreds of workmen pulling massive building blocks or statues, such as the wall painting in the tomb of Djehutihotep, the Egyptian nomarch who lived during the 12th Dynasty (c. 1900 BCE) or the bas-relief fragments from the South-West Palace of Nineveh (Davison 1961; Harper 2016: 137-139) have been considered instructive. Recent studies, however, working on labour force estimates have started to shed doubt and propose lower numbers of workers involved (Loader 1998; Brysbaert 2013; 2015; 2017; Cook 2014; Harper 2016).

While the main question behind it all is how and by whom these monumental building projects were financed, there is also the issue of whether the carrying capacity of respective settlements' hinterland could sustain their populations increased by the size of the workforce (men, their families and animals) mobilized from other areas for the needs of the construction projects (see discussion in Bintliff 2020: 16-23; Brysbaert 2020). Inherent to this discussion is the question of the size of the exploitation territory (as Higgs and Vita-Finzi (1972) defined the area around settlements habitually used for their daily subsistence needs) and of crop yield available to Bronze Age communities.

Several studies on Aegean Bronze Age states and their territories have appeared over the past 50 years based on different types of data (e.g., pottery styles), information (e.g., Linear B administrative texts) and methodologies such as the rank-size rule or Central Place theory (see Chadwick 1972; Renfrew 1975: 15, fig.3; Bintliff 1977: 667-702). Minoan states gradually attracted most attention (e.g., Knappett 1999; Adams 2006; Bevan 2010), but the work of Bennet on the expansion of the Pylos state in Messenia over time and space (Bennet 1995; 1999; 2007; 2011) has been of great importance to understanding that states were not monolithic structures but evolved through time and space. Their results, however, are static representations of territories driven from a top-down approach (Foxhall 2014), that is of how palatial or elite authorities understood the extent of their political and administrative territory. There is textual evidence, further, indicating that palaces had a limited and specialised interaction and control over local communities in their states (Nakassis 2020). It is plausible, therefore, that the myriads of farmers and craftsmen in the Mycenaean states might have had different notions of territoriality related closer to their everyday activities and interactions than their relationship to the palaces. Concepts such as the 'site exploitation territory' devised by Vita-Finzi et al. (1970) and further developed later by Flannery (1976) to refer to the entire set of resources available to site inhabitants, or the 'sacred' lands of native Americans (i.e., lands integrated as such through the senses, experiences, beliefs and narratives of the indigenous people; Makes Marks 2008) could be indicative of how common people might have enacted territoriality in the past (bottom-up approach to modelling territoriality).

This bottom-up vantage is preserved, however, and depicted on the cadastral maps compiled by Venetian authorities during the Second Venetian Rule in the Peloponnese (1690-1715 CE). These Venetian cadastral maps indicate settlements and their hinterland or 'territory' as clearly bounded areas of various sizes and shapes. The value of this material is increased by the fact that they are the earliest reliable, clear, and scientifically accurately measured testimonies of settlement territories available to scholars from the region of the Peloponnese (Katsiardi-Herring 2018; Liata 2018; on the topographic quality of the maps, see Livieratos 2018). They are even more important because the limits of the settlement territories were indicated to the authorities by local communities themselves and show their own conceptualisation and enactment of territory (Stouraiti 2012). The Venetian archive also includes population censuses and textual and tabular descriptions of land uses and their spatial extent (Liata 2003), which complement our understanding of communities' interaction with their landscape, their responses and strategies to secure their subsistence.

While I do not advocate directly reading Mycenaean notions of territoriality from the Venetian-period data, the study of the latter could offer an alternative vantage over significant issues that pertain to Mycenaean-period settlement territories, such as their relevance to population size, topography, land use management strategies and efficiency, and yield performance.

3. The *disegni* of the Second Venetian Rule of the Peloponnese (1687-1715 CE)

Subsequent to the war against the Ottoman Empire, Venice acquired in 1687 the Peloponnese, in southern Greece. The Venetian rule lasted only 30 years, until 1715 CE when the region was recaptured by the Ottomans.

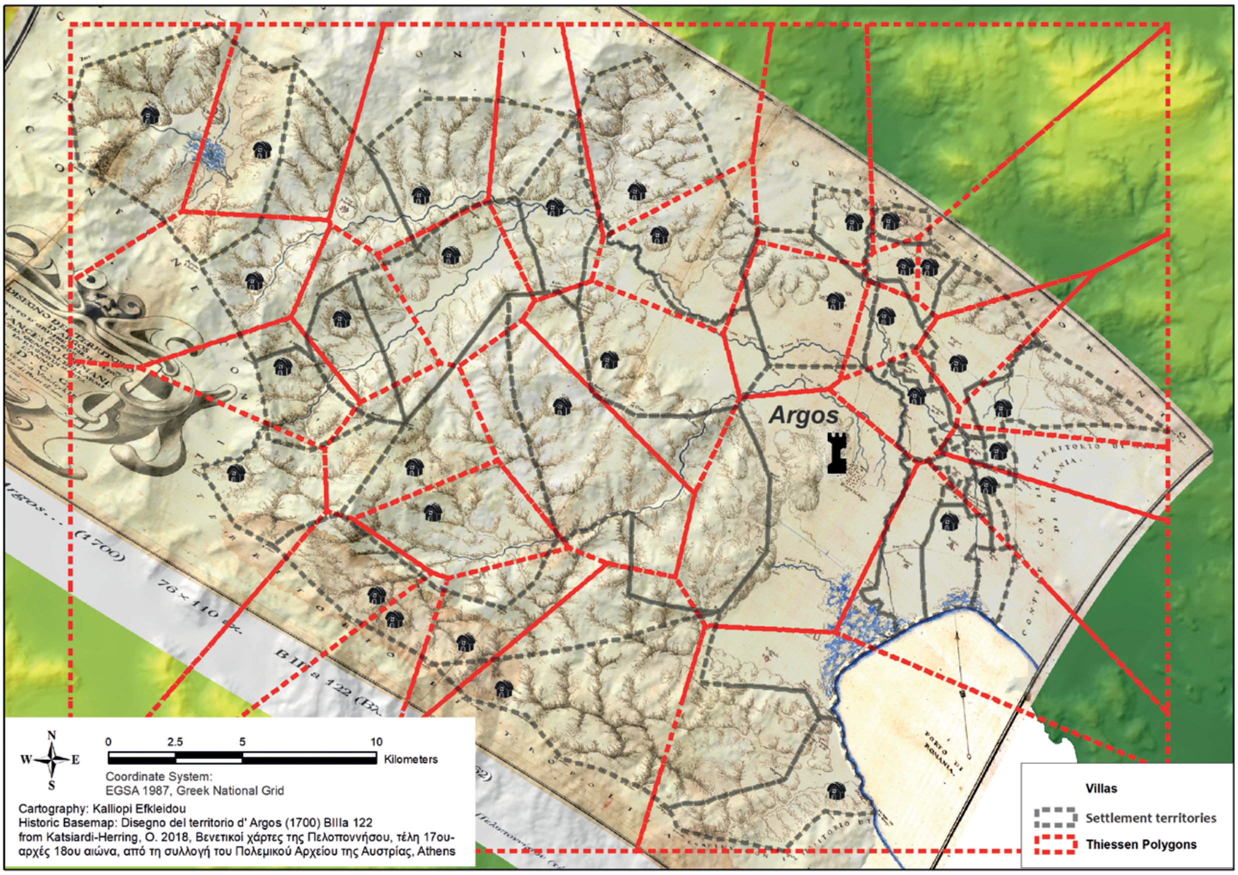


Figure 1. Comparative map of Venetian-period settlement sub-territories and territories constructed with the Thiessen polygons method (K. Efkleidou).

The Venetians were immediately determined to achieve maximum gain from their newly conquered lands, which meant also maximising agricultural production and land management efficiency (Panopoulou 2017; Tselikas 2018). First, however, they needed to understand the economic structure of these lands and estimate their yield relative to local population needs and capacity. To this aim, Venice sent over three magistrates (Marin Michiel, Giacomo Renier, and Domenico Gritti) known as *Sindici Catasticatori* with the mission to set up an administrative scheme, conduct a census and a cadastral survey, and design a taxation policy. The Peloponnese was divided into four Provinces (*Provincie di Romania, Achaia, Laconia, Messenia*) and subdivided into 25 territories (*Territorii*) (Dokos and Panagopoulos 1993: XXIV-XXIX).

According to the Venetian censorial and cadastral practice, a topographical map (*disegno*) for each *territorio* was drafted and accompanied by a cadastral book (*catastico*), which was either brief (*ordinario*) or analytical (*particolare*). The *disegno* depicted the limits of the *territorio* as a whole; the settlements (villages (*villa*) and estates (*zevgolatio*)) with their territory ('sub-territories' from here on); and a limited number and type of natural or man-made features (i.e., churches, bridges) on those lands (Liata 2018: 264-265). The cadastral books provided detailed textual descriptions of territorial boundaries, of settlements and their population, of land uses and their spatial extent, and, in some cases, of individual plots of land and their ownership status (Dokos and Panagopoulos 1993: XLIV-XLV). Unfortunately, the entire set (*quinternetto*) comprising of the cadastral map and book did not always survive. Of the surviving few cases is that of the *territorio d'Argos*, of which both the brief cadastral book (Liata 2003) and the cadastral maps have been found (Katsiardi-Herring 1993) and published (Katsiardi-Herring 2018; Liata 2018).

For the present paper, I will focus on the *Disegno del Territorio d'Argos* drawn in 1700-1701 CE by Francesco Vandeyk (Liata 2018: 264), since it integrated parts of the area that we are interested in for the Mycenaean period (the northern and western parts of the Argive plain). The rest of the Argive plain belonged to the *Territorio di Napoli di Romania* (modern Nauplion), the cadastral maps of which have not survived or remain elusive (Liata 2002).

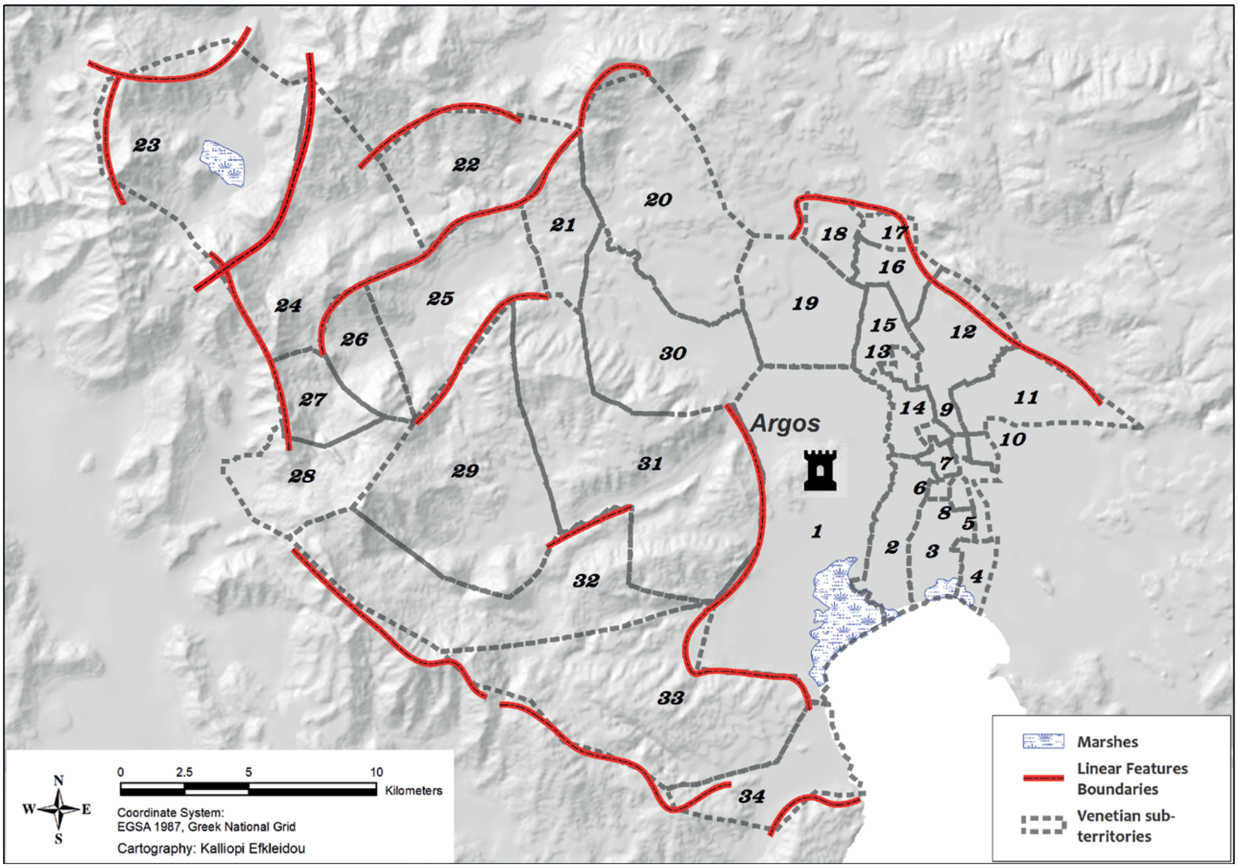


Figure 2. The boundaries of the Venetian-period settlement sub-territories at the Territorio d'Argos. Red lines indicate boundary lines that follow prominent linear features of the natural topography in the area (K. Efkleidou).

4. Settlement territories as depicted on the *Disegno del Territorio d'Argos*

The analysis of the *Disegno del Territorio d'Argos* was carried out in ArcGIS. The georeferencing process based on control points was highly successful because the majority of the settlements depicted on the map still exists today. There are discrepancies, however, at the edges of the map, especially at the eastern and western-most settlement territories (numbered 11, 12, 16, 17, and 23) where control points were either not enough or of inadequate accuracy.

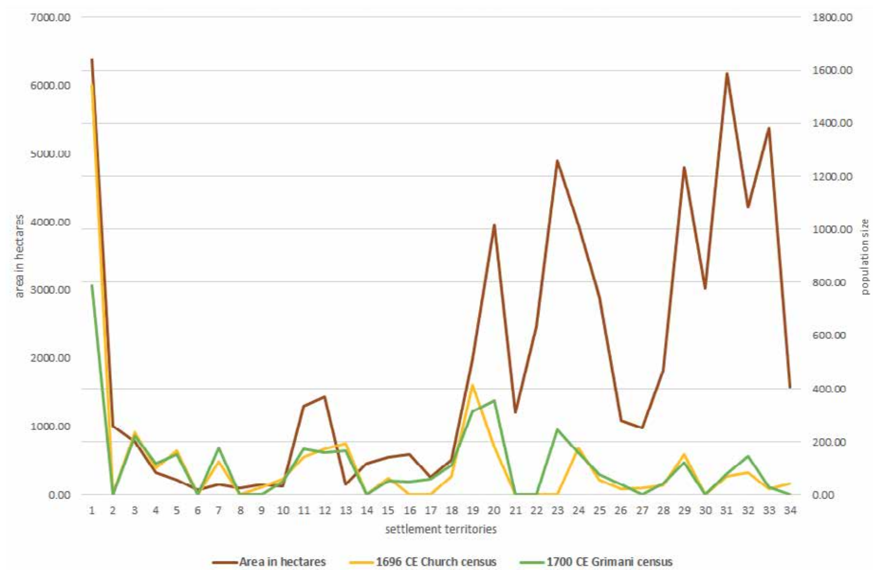
The Digital Elevation Model of 20-metre resolution was produced from manually digitised point-heights and contours at 20-metre intervals on 1:50,000 Greek Army maps. Contemporary land-cover data derive from the Corine 2000 Land Cover Inventory made freely available at geodata.gov.gr (Greek License Creative Commons Attribution 3.0).

At first glance of the *disegno* (Figure 1), we are struck by the variability in the shape and size of settlements' sub-territories. They are neither circular nor regularly shaped as theoretical territorial models tend to produce (for example the hexagonal service areas of Central Place Theory (Christaller and Baskin 1966)) nor do they show any fit with the irregular polygons of the Thiessen polygons method (Timothy 2008).

The area of the *Territorio d'Argos* can be distinguished into two general areas: the fertile part of the Argos plain to the east of Argos (ca 30% of the *territorio's* total area) and the mountainous area to the west of Argos. Argos itself was a fortress town but by the time of the Second Venetian Rule it had been reduced to a dependency of the neighbouring port-town of Nauplion and considered of minor importance (Andrews 2006: 107). It is important to note, however, that the fertile lands of the Argive plain had been equally divided between the two largest towns (Argos and Nauplion) of the area (Liata 2003: 27).

The fertile part was divided mostly into small-sized sub-territories (numbered 2 to 9 and 13 on the maps). These sub-territories are associated mostly with *zevgolatia*, i.e., large estates on fertile lands that had been granted during the previous Ottoman occupation by the central administration to Ottoman citizens

Figure 3. Population sizes at the Territorio d'Argos according to the 1696 CE and the 1700 CE census vis-à-vis settlement sub-territory area (K. Efkleidou).



Sub-territory id	Topographic profile	1696 CE Church census	1700 CE Grimani census	Area in hectares	Population density (persons per hectare)
1	lowland	1,544.00	**787.00**	6,381.29	**0.12**
2	lowland			1,007.27	
3	lowland	236.00	**222.00**	778.06	**0.29**
4	lowland	99.00	**119.00**	321.38	**0.37**
5	lowland	165.00	**153.00**	219.66	**0.70**
6	lowland			67.82	
7	lowland	124.00	**175.00**	147.88	**1.18**
8	lowland			94.74	
9	lowland	27.00		145.69	
10	lowland	61.00	**50.00**	119.07	**0.42**
11	mixed	143.00	**173.00**	1303.36	**0.13**
12	mixed	172.00	**159.00**	1437.14	**0.11**
13	lowland	193.00	**165.00**	153.12	**1.08**
14	lowland			459.55	
15	mixed	64.00	**54.00**	549.07	**0.10**
16	mixed		**50.00**	591.17	**0.08**
17	lowland		**59.00**	257.61	**0.23**
18	mixed	69.00	**111.00**	510.32	**0.22**
19	lowland	413.00	**315.00**	1986.12	**0.16**
20	mountainous	179.00	**355.00**	3964.85	**0.09**
21	mountainous			1203.15	
22	mountainous			2,463.75	
23	mountainous		**246.00**	4,890.32	**0.05**
24	mountainous	176.00	**159.00**	3,953.60	**0.04**
25	mountainous	55.00	**75.00**	2,902.92	**0.03**
26	mixed	21.00	**40.00**	1,090.01	**0.04**
27	mountainous	25.00		977.68	
28	mountainous	35.00	**41.00**	1,826.52	**0.02**
29	mountainous	151.00	**120.00**	4,794.42	**0.03**
30	mixed			3,017.60	
31	mountainous	70.00	**81.00**	6,173.03	**0.01**
32	mountainous	82.00	**144.00**	4,217.35	**0.03**
33	mountainous	20.00	**27.00**	5,371.28	**0.01**
34	mountainous	42.00		1,584.16	

Table 1. Population size and density per hectare according to the Grimani census at the sub-territories of the Territorio d'Argos. The area of the sub-territories was calculated in ArcGIS as conversion of Venetian land measurements to modern ones remains unresolved (K. Efkleidou, based on data in Liata 2003: table 1).

(*çiftlik*). These estates occasionally included entire villages, attached to the land and its exploitation (Dokos and Panagopoulos 1993: lxxxix). After the Venetian conquest, Ottoman populations fled, and the Venetian state took possession of their lands. The mountainous areas, however, had never attracted the attention of the Ottomans (Dokos and Panagopoulos 1993: xc) and the larger-sized settlement sub-territories in those areas may be considered to truly represent the area that was considered by local communities as their 'natural' hinterland to exploit.

Returning to the variable shape and size of these mountainous sub-territories, one can also observe that several boundary lines were drawn on the map along linear features (mountain ridges and foothills) or water bodies (rivers and streams) of the natural topography (Figure 2). This is perhaps consistent with the way information was collected by Venetian surveyors, who relied on oral declarations of boundary delineations from village elders, notables, priests, and captains (Stouraiti 2012). These oral testimonials commonly made reference to prominent natural features, such as rock outcrops, trees, and other distinctive formations that allowed them to orientate themselves in space and make boundary declarations.

5. Possible factors contributing to the size and shape of the villages' hinterland

Considering that not all boundaries followed linear features in the landscape, other factors might also have played into the construction of settlement territories. Possible factors could be population size, land use efficiency and yield performance, or walking time distance between settlements and fields. In what follows, I will discuss these factors in detail.

5.1. Population size

Most sub-territories at the *Territorio d'Argos* included only one settlement or a settlement and a *zevgolatio* within their limits. Exception to this rule were sub-territories 16, 20, 23, 29, and 32, which included two or three villages. One might wonder, therefore, whether the size of a sub-territory was related to the size of its population.

Useful population data for the period when the cadastral maps were drawn derive from two sources: the 1696 census conducted by the church and the 1700 census conducted by the Venetians under the direction of the *Proveditor* (Governor-General) F. Grimani (Liata 2003: 38-40, table 1). Both censuses present population sizes, village by village, even though some areas are missing completely in either or both. The 1696 CE church census gives a total of 4166 persons for the entire *Territorio d'Argos*, but its demographic value is limited as priests recorded members of their church parish and not necessarily persons living at any one settlement (Liata 2003: 40). The 1700 CE Grimani census, which is widely considered as the most reliable demographic source for the period, reports 3880 persons for the entire *territorio*.

A closer look at the table compiled by Liata (2003: table 1) demonstrates that population size and settlement sub-territories' area are not necessarily associated. Population size does not present variability and does not appear increased in the larger-sized mountainous settlement territories. The density of the population, however, is inversely proportional to settlement territories' spatial extent: density is low on all mountainous sub-territories irrespective of the number of settlements sharing the same territory, whereas it is high at the sub-territories of the fertile plain (Figure 3 and Table 1). This phenomenon can be easily explained by the attraction that high crop yields expected in the lowlands posed to people.

5.2. Topography and land-management efficiency

Another possible factor contributing to the size of settlement sub-territories could have been related to their topography and the types of land use communities relied upon. As mentioned already, some territories are completely lowland, and others are mountainous or mixed (combining lowland and mountainous lands). The data reported in the Venetian cadastre of the *Territorio d'Argos* and compiled in tabular form by Liata (2003: table 2) show that respective communities had adapted their subsistence economy to suit the topography of their hinterland.

Specifically, the Venetians monitored five main types of land use: cultivated lands, meadows, marshes, mountain pastures, and unusable lands. One further type was devised for those lands that could be given over to cultivation, the 'cultivable' lands. This last type of land is related to the Venetians' eagerness to maximise crop yields because when they arrived at the Morea, they found that farming was not intensive enough with large areas remaining uncultivated (Tselikas 2018: 155). Greek farmers until then did not practice intensive forms of agricultural exploitation, such as manuring (Dokos 2018: 167), and followed the two-field system, with one field sown and the second left fallow (Tselikas 2018: 156). The *sindicus catasticatori* Domenico Gritti suggested to the metropolis the introduction of manuring and the three-field system, already common in western Europe, with one field sown with prime cereals for human consumption, such as wheat, barley, oat or rye, the second with lower quality cereals for feeding animals, such as millet or corn, and the third left fallow (Tselikas 2018: 156).

Figure 4 shows that except for a few lowland sub-territories, where only farming was practised (#5-10, 13-14), all other sub-territories integrated lands for farming and livestock pasturage (meadows or mountain

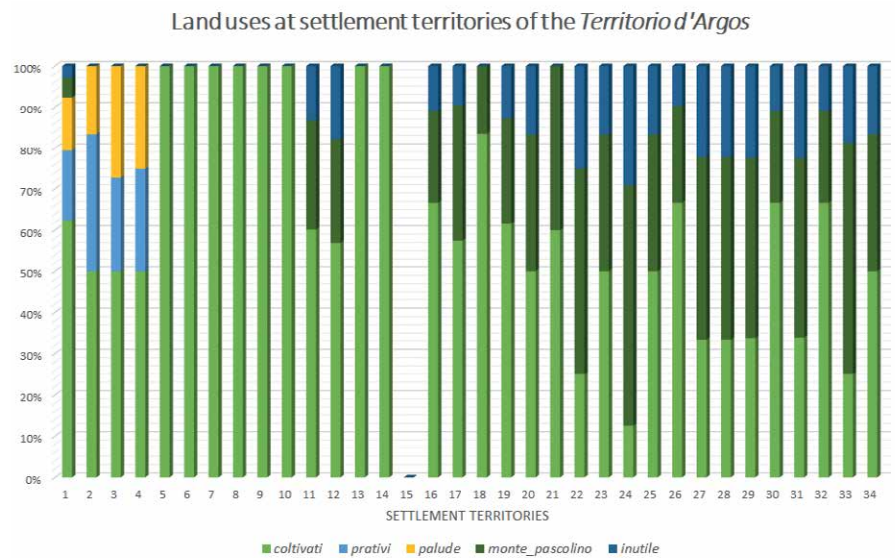


Figure 4. Land uses at the Territorio d'Argos. Coltivati = cultivated lands; Prativi = meadows; Palude = marshlands; Monte pascolino = mountain pastures; Inutile = useless lands (K. Efkleidou, based on data in Liata 2003: table 2).

pasture). It should be noted that, contrary to modern-day deep (iron) ploughs which function best on the heavy soils of the valleys, pre-mechanised (wooden) ploughs could be used for ploughing the lighter soils on slopes of up to even 15° inclination, an ability that allowed increasing the spatial footprint of agricultural lands on the mountainous areas (Kreuz and Friedrich 2008; Halstead 2014: 35). Beyond this angle of inclination, lands needed to be converted to terraces to allow cultivation.

Grimani considered the locals idle and observed that they cultivated only as much land as was necessary for their subsistence (Topping 1976: 95). Yet they kept flocks of animals, which they largely considered a cash-producing activity (Forbes 2000a: 55-64). Their flocks included, as a rule, goats and sheep, smaller numbers of cattle (used either for traction or their meat and hide). Horses were rarely kept, while most households owned a minimum of one donkey, the standard pack animal at the time (Forbes 2000a: 57-59).

At the mountainous sub-territories (#20-34), finally, a substantial part of the land was considered 'useless'. These lands were unsuitable for cultivation or pasture, and probably involved rock outcrops and extremely steep areas. It is unlikely, however, that they also included woodlands, which are conspicuously missing from the cadastral records, and are difficult to integrate into the cultivable or pasture lands, because of the importance that wood had for the Venetians. Woods in the area were rich in oak and pine trees, whose wood is especially suited to construction purposes and for building ships (Tselikas 2018: 156).

Presumably mountainous sub-territories (with their sloping topography more susceptible to erosion) would have had lower yield performance than lowland ones. This could only be overcome by integrating more cultivable lands within their territory, or by building terraces to transform lands unsuitable for farming into cultivable ones. Still, the quality of soil and yield performance was not as high as those of the lowlands, and farming demanded more labour input (Halstead 2014: 35). Consequently, land management efficiency could have been one reason for which mountain villages had larger territories.

5.3. Distance between settlements and farming plots

The distance and cost of transportation to different resources (such as dairy farming, forests, crop and livestock farming lands) from the settlements form the basis of von Thünen's (1966) concentric circles around a central market community. Since then, most territorial or land use studies based on cost-benefit ratios similarly delineate territorial limits based on distance from settlements. Chisholm (1962: 53) and Bintliff (1999; 2002; 2020) have argued that settlements in antiquity had an agricultural catchment area with on average 2.5-km radius around them. If measured in travelling time, that would be approximately a 30-minute walk on level ground. Livestock farming, on the other hand, necessitated a 5-km radius catchment area or approximately a one-hour walking distance. Considering that these time-distance zones were calculated on level ground (Euclidean Distance buffer zones), the actual spatial extent of the 30-minute and the one-hour walking distance catchments at the mountainous territories of the *Territorio d'Argos* would be smaller due to retardation of walking on sloping ground.

To assess how far the limits of territories lay from settlements, walking time-distance buffer zones were calculated in ArcGIS using the Path-Distance tool and implementing Naismith's rule of thumb (Naismith 1893; with adjustments by Langmuir 1984). Naismith's rule accepts that pedestrian movement speed is dependent on the steepness of slope (for a detailed description see Efkleidou 2019). This distance analysis has shown that the limits of the territories on the plain could be reached within half an hour's walking distance. Walking-time distance increased as we move towards the hills or in the mountainous territories. The hilly territories on the edges of the plain needed one hour's walk for a person to reach the limits of the settlement's territory. In the mountainous area to the west of Argos, however, there were several settlement territories where people needed to walk up to two hours, and in one case longer, to reach their territory's limits (see Figure 6 for a sample of the *Territorio's* area with walking-time distance buffer zones from respective settlements).

Differences in the distance of settlements to sub-territorial boundaries could be indicative of communities' efforts to exploit more extensive land parcels to compensate for the larger crop yields that the spatially limited territories on the plain had. Distance alone, however, does not explain the inner workings of how lands were divided among communities and territories.

Chisholm (1962: 53) also noted the existence of exceptionally large territories in antiquity and argued that 'the most widespread single cause of large distances (*note by author*: between villages and farming plots) is the fragmentation of holdings'. Forbes (2000b; 2007: 202) observed during his ethnographic study at Methana, Southern Argolis, that this fragmentation had emerged over a long period and as a result of the rules of dowry and inheritance followed in the area.

A second reason for fragmentation could be related to the actual spatial footprint of different types of land in relation to the villages. Settlements did not always have uniform access to lands suitable for farming. Farmers might choose to keep fields in different micro-climates, on different soil types, and at variable distances from the settlement to sow with different types of crops as a failed crops risk-buffering strategy. However, the spatial extent and distribution of different land uses are not indicated on the Venetian cadastral maps, and one cannot immediately assess the validity of this hypothesis from the maps.

To evaluate this assumption, it is necessary to map the spatial footprint of cultivable, pasture, and useless lands, calculate their distance from settlements and evaluate their yield production to ascertain whether immediately available lands produced enough to sustain local communities. If so, the construction of larger than necessary territories could mean that these communities were oriented to producing surplus yield that they could use to trade and produce cash.

I determined the spatial footprint of cultivable lands based on slope suitability and soil erosion hazards (Kreuz and Friedrich 2008; Sobolewska-Mikulska et al. 2014;

Farming Suitability criteria		
Slope		**Description**
Degrees	**Class**	
0-5	6	Near level-very gentle.
5-10	5	Gentle.
10-15	4	Moderate.
15-25	3	Moderately steep. Plough use impossible unless terracing (Kreuz and Friedrich 2008)
25-35	1	Steep. Plough use impossible unless terracing (Kreuz and Friedrich 2008)
>35	0	Very steep.
Soil Erosion Hazard (according to Sobolewska-Mikulska et al. 2014)		
0- 3	6	Weak
3-6	5	Moderate
6-10	4	Average
10-15	3	High
15-35	2	Very high

Table 2. The criteria used for modelling farming-land suitability classes (K. Efkleidou).

Farming Suitability Class	**Description**
Degree Slope	
0-3	Very high suitability for farming
3-5	High suitability for farming
5-6	Average suitability for farming
6-10	Moderate suitability for farming
10-15	Low suitability for farming
15-25	Unsuitable-Terrace building necessary
25-35	Unsuitable-Terrace building necessary
>35	Unsuitable lands

Table 3. Farming-land suitability classes after fuzzy-overlaying slope and soil erosion hazard raster sets (K. Efkleidou).

Shukurov et al. 2015) (Table 2). The two criteria were fuzzy-overlayed, and the resulting raster dataset was divided into agricultural-farming suitability classes (Table 3). Climatic and soil data have not yet been computed into the model, but they are expected to provide important refinement to the model and, especially, to yield performances, which are now considered uniform in all cultivable lands. Pasture lands were determined based on the Corine 2000 Land Cover data and slope suitability (Forbes 1994; Ditsch et al. 2006; Gkoltsiou 2011) (Table 4). All slopes above 35° angle or 60 % grade are considered too steep and useless for any kind of activity.

A striking result that immediately emerged from the analysis was that settlements were not necessarily located at the centre of their territory, and, especially in the mountainous area to the west of Argos, they had been founded on lands of low or marginal suitability for farming (i.e., lands that could be used for farming only if terraces were built). This could be interpreted as an effort by communities to not waste good quality farming-lands.

To test the validity of this land use model, however, it is necessary to compare the spatial extent of different land uses with the area of the same reported in the Venetian cadastres. However, as there is no consensus yet on the conversion of Venetian areal measures to modern ones (Forbes 2000c: 323-324; Davies 2004), we can only rely on a comparison of the relative percentages of land uses reported in the cadastres with those produced in the model.

The validity test was performed on a sample of the *territorio*, specifically, on sub-territory 32, chosen for its topographic profile (a mountainous territory) and the combination of land uses it integrated (agriculture, pasture, and useless lands). According to the Venetian cadastre, 66.7% of its total land was devoted to farming, 22.2% to pasturage and 11.1% was considered useless. According to our model of sub-territory 32 (Table 5), whose total area measures 4220 ha, lands highly to moderately suitable for farming constitute only 19.8%. Lands, on the other hand, suitable for pasture (slopes of 6% to 50% grade) constituted 62.4%. These percentages directly contrast the percentages reported in the cadastres, unless one takes into consideration those steep and very steep sloping lands that can be cultivated only if they are converted into terraces. In this case, cultivable lands drastically increase to fit the percentage reported in the cadastre (Figure 5). It proves, further, that Venetian-period farmers made maximum use of their landscape resources, using almost all lands available, with slopes of up to 25° angle and the construction of terraces on the steep slopes, while they left aside for pasturage only the very steep sloping lands with an angle above 15° (Table 6). Consequently, it can be argued that settlements in sub-territory 32 were located on marginal lands that could still be cultivated or otherwise exploited only if terraces were constructed. These terraces could be used for orchards and gardens for vegetables and legumes, as is also reported in the texts of the cadaster (Liata 2003).

Taking into consideration the results of the validity test and the refinement of the land use model for the entire *territorio*, walking-time distance analysis was again performed on a sample of five mountainous sub-territories (25, 29, 30, 31, and 32) to evaluate the average distance of cultivable lands from settlements. The analysis showed that all settlements had access to enough cultivable lands within a one-hour walking distance. The quality of these lands, however, varied. Except for Cato Belessi in sub-territory 25, which had good quality

Pasture Suitability Criteria	Description
Slope Percent (according to Gkoltsiou 2011)	
6%-12%	Moderately sloping
12%-18%	Strongly sloping
18%-35%	Steep
35%-50%	Very steep
>50%	Unsuitable
Corine 2000 land cover class	
2.3.1	Pastures, meadows and other permanent grasslands under agricultural use
3.2.1	Natural grassland
3.2.2	Moors and heathland
3.2.3	Sclerophyllous vegetation (maquis)
3.2.4	Transitional woodland/shrub

Table 4. The criteria used for modelling pasture-land suitability classes (K. Efkleidou).

Suitability Class		Elevation/Slope Data		Slope/Corine 2000 Data	
		Cultivable Areas		Pasture Overlapping Cultivable	
	Slope	Hectares	%	Hectares	%
Terracing	25°-35°	859.04	20.37	852.8	20.22
	15°-25°	1,591.24	37.73	1,404.12	33.3
Low	10°-15°	694.76	16.48	573.12	13.59
Moderate	6°-10°	371.8	8.82	302.28	7.17
Average	5°-6°	83.24	1.97	64	1.52
High	3°-5°	167.32	3.97	131.96	3.13
Very High	0°-3°	210.72	5	155.56	3.69
Useless	>35°	238.84		237.76	

Table 5. Statistical characteristics of the spatial extent and distribution of lands suitable for agriculture and pasture in settlement sub-territory 32 according to our model (Source: Kalliopi Efkleidou).

Suitability Class		Cultivation		Pasture		Useless	
	Slope	Hectares	%	Hectares	%	Hectares	%
Terracing	25°-35°	0	0	852.8	20.22	6.24	0.15
	15°-25°	1,300	30.83	104.12	2.47	187.12	4.44
Low	10°-15°	694.76	16.48				
Moderate	6°-10°	371.8	8.82				
Average	5°-6°	83.24	1.97				
High	3°-5°	167.32	3.97				
Very High	0°-3°	210.72	5				
Useless	>35°					238.84	5.66

Table 6. Estimated statistical characteristics of the spatial distribution of agricultural, pasture and useless lands in settlement sub-territory 32 after adapting the model to conform to the Venetian cadastral data (Source: Kalliopi Efkleidou).

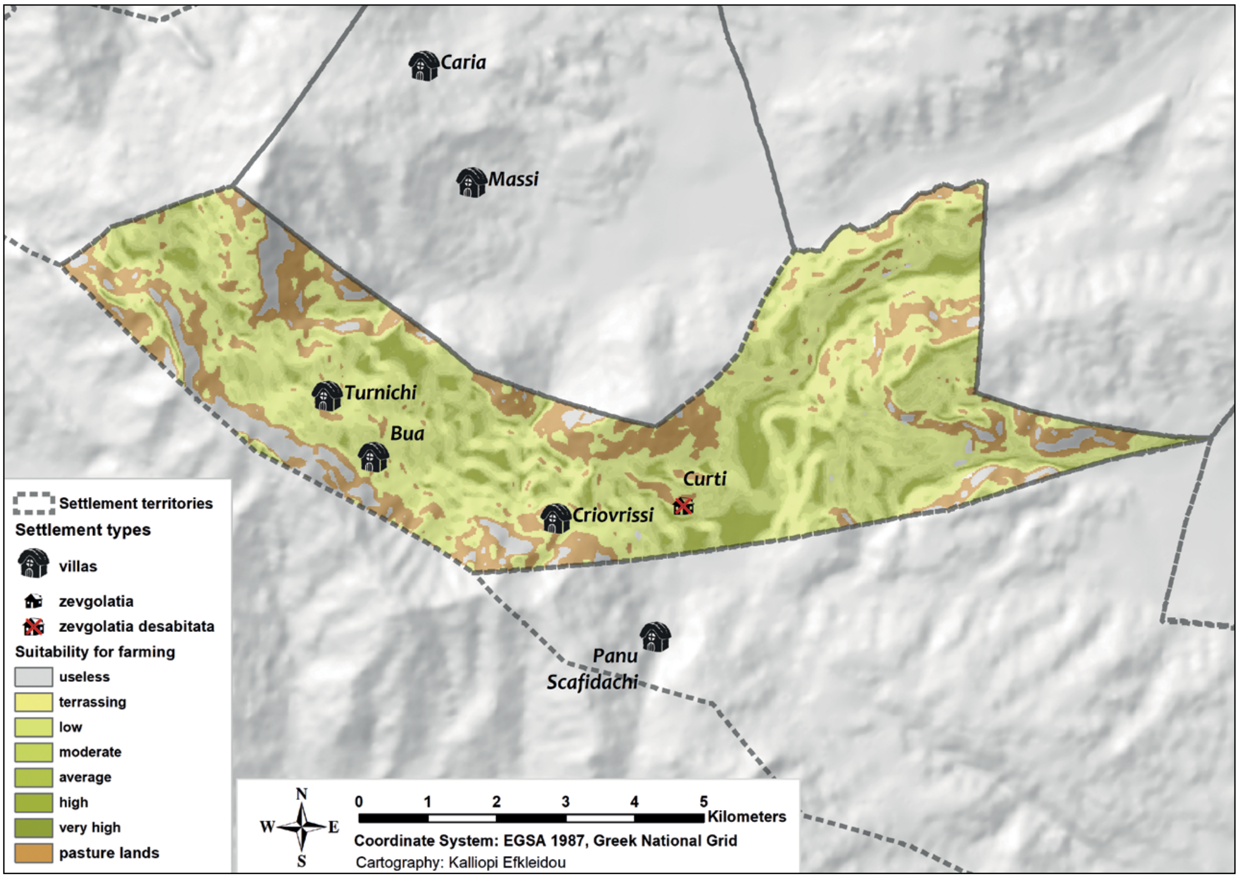


Figure 5. Land use map of settlement sub-territory 32 after testing the model results and adapting them to agree with the areal figures reported in the Venetian cadastres (K. Efkleidou).

farming land and access to water in its immediate vicinity, all other settlements had an immediate exploitation zone of 15 to 30-minute walking distance radius that could be characterized as of very low quality, unless terraces were built. Even then, expected yields from the terraces would be lower and more labour intensive than from corresponding lands on the plain. Ethnographic evidence (Forbes 2007) has shown, further, that villagers avoided letting their animals graze on these terraces where several households might hold farming plots as it was difficult to keep animals separated and away from accidentally grazing on other households' plots. This practice seems to confirm why Venetian-period farmers did not use manuring or other intensive agricultural practices (Forbes 1994; Dokos 2018: 167). As a result, moderate to high-quality lands could be reached from settlements at a walking distance of half to one hour and 15 minutes (Figure 6).

Following Kreuz and Friedrich's (2008) model for estimating the sustainable population by expected cereal crop yields, we can ascertain land use management efficiency. Kreuz and Friedrich's model proposes that 30%-50% of the potentially arable land was left as pasture/fallow ground. Up to the Venetian period, farmers followed the two-field system, which means that 50% of the land was left fallow. Low yield estimates assume a crop production of 1,000 kg per hectare a year, while high yield estimates assume a crop of 1,500 kg per hectare a year. 10% of the crop yield was reserved for the following year's sowing needs. Weiberg et al. (2019) also add a degree of loss or waste estimated at 10% of the crop yield. Finally, it is assumed that a person needed a pound (450 gr) of grain per day.

If we leave aside the 15-minute zone around the settlements where terraces were necessary and were probably used for vegetables and pulses, and we assume that all cultivable lands were used for cereal crops, it can be deduced that the cultivable lands lying between a 15-minute and one-hour walk exceeded by far the nutritional needs of the local communities (Table 7). This seeming overproduction was important to the communities as they had to secure their self-sufficiency and make allowances for failed crops, for failed labour input (such as accidents, illness, deaths, warfare) and for storage of surplus that could be used to trade with market products. Finally, local populations were also

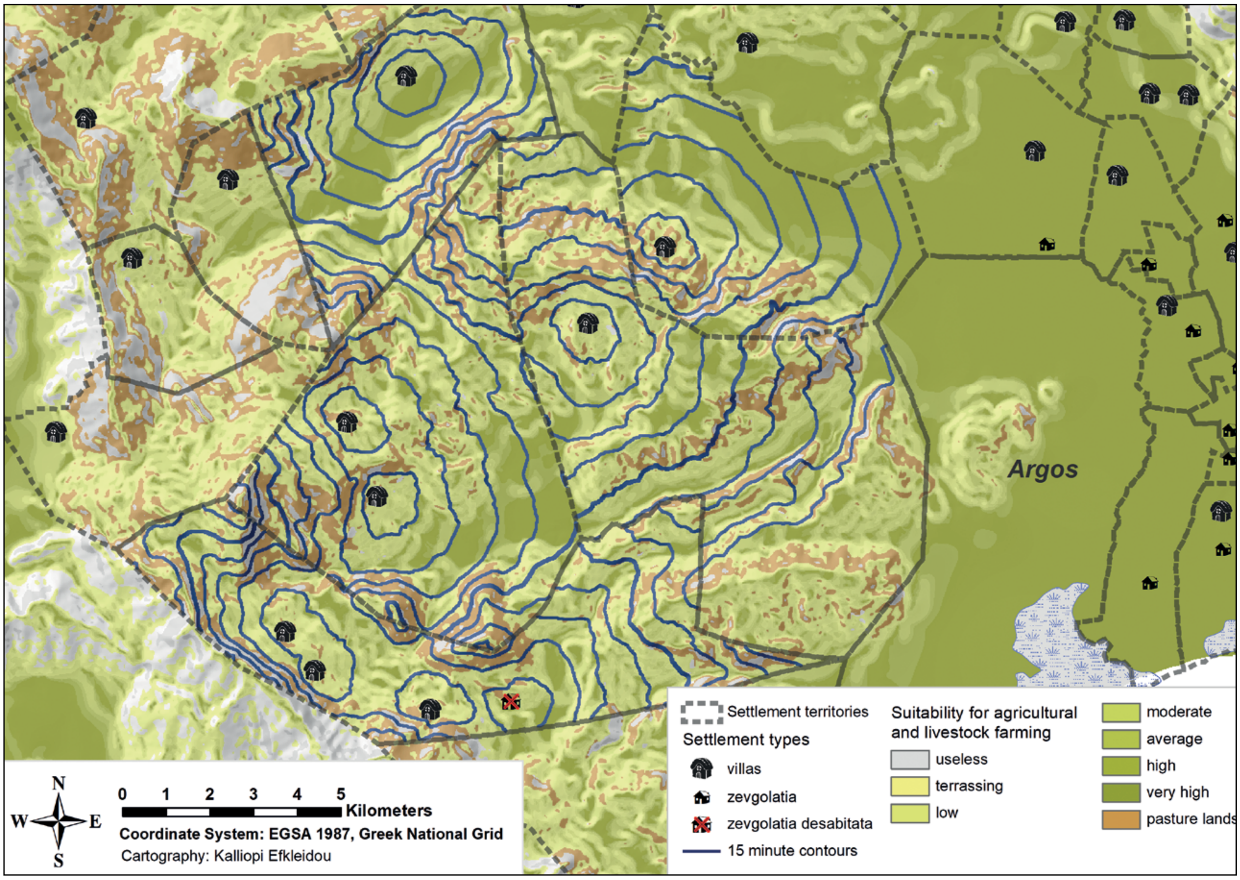


Figure 6. Land use map of a sample area at the Territorio d'Argos indicating the suitability of land for agricultural and livestock farming and 15-minute walking-time distance zones from settlements (K. Efkleidou).

Table 7. Estimated population size that could be fed from the potentially arable lands in a sample of settlement territories according to walking-distance zone and depending on low or high crop yields (K. Efkleidou).

Territory	25		29		30		31		32	
Crop Yield	Low	High	Low	High	Low	High	Low	High	Low	High
Walking distance	Persons/year		Persons/year		Persons/year		Persons/year		Persons/year	
0-15 min.	-	-	-	-	-	-	-	-	-	-
15-30 min.	194	291	385	578	214	321	222	332	465	698
30-45 min.	259	389	485	728	341	511	285	428	245	368
45-60 min.	390	585	597	895	504	756	506	759	208	313
Sustainable persons	**843**	**1,264**	**1,468**	**2,201**	**1,059**	**1,589**	**1,013**	**1,519**	**919**	**1,378**
1700 CE population census	**75**	**75**	**120**	**120**	-	-	**81**	**81**	**144**	**144**

obliged to pay taxes (the 'tithe'), the value of which was estimated upon the expected harvest, before the reaping of the crops, and was due partly in kind (grain) and partly in cash. This surplus has been estimated by ethnographic studies as 25% of normal yields (Forbes 1989; Halstead 1990; Forbes and Foxhall 1995; Halstead 2014; Forbes 2017). Considering all these, our model may still seem over-optimistic, as it is founded on the assumption of cereal monoculture when we know from the Venetian archives that people cultivated a variety of grain crops, tree crops (fruit and olives), and vines. Yet, Venetians believed that Greek farmers under-exploited their resources producing enough to secure their subsistence and only in cases of monasteries or estates did they find intensive livestock farming as a cash-producing enterprise (Forbes 2000a). If so, the results of this model should be treated only as maximum figures of sustainable populations.

5.4. A possible scenario for the construction of settlement territories during the Second Venetian Rule

The cadastral archives of the Second Venetian Rule in the Peloponnese describe and graphically depict on maps settlement territories. While there are no explicit references to how these territories were empirically constructed or enacted, they seem to represent common people's intuitive notions of settlement territoriality, because it was the people themselves who proclaimed their boundaries to the Venetian cadastral officers.

The previous section was aimed at determining those factors that weighted in the construction of settlement territories. The discussion was, by no means, exhaustive, but it became evident that settlement territories had been structured on the cumulative and entangled effect of community size, topography and ecology, distance between settlements and lands suitable for various land uses, especially agriculture, as well as social practices related to the operation of kinship (Forbes 2007).

Lowland territories, however, systematically had a smaller size than mountainous ones. This was largely due to the quality of soils on the plain, which were highly fertile and produced equal or higher crop yields on smaller areas than soils at the mountain territories. It was also observed in the analysis that settlements at the mountain territories were systematically located on moderate or bad quality lands, which could only be transformed into cultivable land if terraces were built. In most cases, these terraces needed to be built within a buffer zone of 15-minute walking distance radius around settlements. Consequently, farmers at the mountain territories needed to walk further away from their settlements to reach arable lands than farmers on the plain.

The correlation of land uses with walking distance from settlements showed that farmers needed to walk between half and one hour to reach sufficiently large areas of high or very high farming quality, that might have been reserved for more high-risk or high-status crops. Lands near the settlements were also exploited for agriculture, but their quality was lower, and one may conjecture that farmers cultivated there low-risk and, perhaps, more labour-intensive crops.

Demographic statistics seem to support the above observations. The inverse relationship between population density and territorial size is closely associated with the topographic profile of the settlements' hinterland and yield production. While the actual population size among communities does not vary significantly, lowland settlement territories show high population density, because the same number and more people in the lowlands could be sustained by the yields of even a very small hinterland. The opposite was true for the mountainous territories.

6. An analogy between the Second Venetian Rule and the Mycenaean period

Our knowledge of the agrarian economy at the *Territorio d'Argos* derives mainly from reports of the Venetian Governors-General (*proveditori*), especially during the early years of the Venetian Rule, from the cadastre, and from the surviving tax records. It proves that during at least the early years of the Venetian conquest, subsistence economy was based mainly on pre-mechanised agriculture and livestock rearing. The basic economic unit at the time was the household, which followed a mixed agropastoral system: households held plots of land cultivated by household members themselves and a moderate number of animals (mainly goats and sheep).

The Argos plain was also known during the Venetian period for its vegetable gardens irrigated from relatively low-depth wells (Liata 2003: 57), while the wider Argive plain was exploited for the cultivation of cereals (mainly wheat and barley), rice (near the coastal marshlands), pulses, cotton, tobacco, corn, vines, and olive trees (Liata 2003: 57-64). The extensively cultivated orange trees that one sees everywhere nowadays in the Argive plain were not introduced in the area until the early 20th century CE. Olive oil production was moderate up to the Venetian rule, but the number of olive trees in some favourable areas in the Argolid increased significantly only between the years 1700 and 1704 CE due to a policy enforced by the Venetians to satisfy the increased demands of the textile and soap making industries (Panopoulou 2017: 360). The same happened with viticulture, which was also encouraged by the Venetians to minimise wine imports from the Cyclades (Panopoulou 2017: 361).

Stock-raising involved primarily sheep and goats, as well as small numbers of bovines, mules, donkeys and horses, which could also be used as draft animals. The enterprise was closely integrated with agricultural practices. Livestock grazed in uncultivated (fallow ground) or uncultivable lands, which bordered settlement locations and arable lands, as well as on agricultural residues (straws, chaff, leaves, and weeds) that could not be consumed by humans (Forbes 1994: 190). The high relative percentage of pasture lands reported in the cadastres is indicative of the importance of stock-raising to the communities in the mountainous village territories. Stock-raising was more than a subsistence strategy. In fact, it could become a wealth creating enterprise via the exchange of animal by-products, such as food (meat and milk), hides, wool, hair, and manure (Forbes 1994: 190-196). Villagers would move their flocks over short distances within their territory's limits during the summer and, as reported by D. Gritti (Tselikas 2018: 155), over longer distances down to the Argive plain during the winter, where they would graze on fallow lands and increase soil fertility with manure. Larger flocks of animals were kept only by monasteries mostly as a cash-producing enterprise (Forbes 1994; 2000a). Most of all, households needed to be primarily self-sufficient in cereals for human (mainly wheat) and animal (mainly barley and oats) consumption and only secondarily on other products.

Turning to the Late Bronze Age, the agrarian economy was based on a largely similar mixed agropastoral system. The basic unit of production was the household which sought to secure its subsistence by practising small-scale dry agriculture and herding strategies of modest numbers of livestock for domestic consumption (Halstead 1992; 2000: 116-117; Nakassis 2020). The intensity of households' practices remains a question with variable responses as individual communities responded differently to climatic and soil conditions and other external pressures through time (Halstead 2000; Weiberg et al. 2016; cf. Nitsch et al. 2017).

Grains made up a major component of people's diet at the time. Field crops included standard species (barley, emmer, and einkorn), but during the 14th century BCE new species were introduced, such as bread wheat, spelt, and millet. Viticulture, fruit orchards, and olive cultivation were also developed during this period (Halstead 1992; Weiberg et al. 2019: 9-14, fig. 4-5). Among livestock species, apart from pig, cattle, and sheep/goats, we also find oxen, horses, and the introduction of mules as traction animals (Weiberg et al. 2019: 9-14, figs 4-5). The Mycenaean diet was complemented further by the consumption of wild animal species, such as deer, boars, fish, reptiles, and birds (Halstead 1998-1999).

Agricultural practices during the Late Bronze Age had adapted to a period of dry climate (3700-2550 BP; 1750-600 BCE) and especially to the extra dry conditions that occurred between 3650 and 3200 BP (1700-1250 BCE). Risk-reducing farming strategies included the growing of cereals along with labour-intensive pulses, the fragmentation and dynamic adaptation of plot sizes (Halstead 2014: 119; Brysbaert 2020: 66, 71-72), and the rearing of a moderate number of animals for consumption of their meat and by-products and as indirect storage (Flannery 1969; Halstead 2014). A successful strategy, further, for increasing the spatial extent of lands suitable for agriculture was the construction of terraces (Kvapil 2012; Fallu 2017).

With the emergence of the Mycenaean palaces (14th century BCE), we also have the first indications for extensive and specialised agricultural and livestock farming. The palaces invested in the directed production of wheat and barley to sustain their operations (mainly in the form of ration compensations for their personnel) by conceding lands to local communities ('da-mo' in Linear B, δῆμος) and oxen to help with the tillage while communities probably provided the necessary labour force (a form of sharecropping). Direct production of cereals for the palace, however, did not take place in large estates owned and operated by the palace, but complementarily to other types of field crops on the lands of the various communities within palatial polities (Halstead 1992; Foxhall 1995; Killen 1998; Halstead 1998-1999; 1999a; 1999b; Nakassis 2020). As a result, palaces pushed communities for increased cereal yields of which it collected the normal surplus or the entire yield (Killen 1998; Halstead 2000; 2001).

Palaces were also involved in animal husbandry practices, even though they do not appear to have owned their own flocks of animals, but rights over a set number of animals. Palatial interest was chiefly placed in the rearing of large numbers of sheep for their wool (some 30-40% of the total sheep population) (Foxhall 1995; 2014; Dickinson 2006; Nakassis 2020). Apart from sheep, the palace owned herds of horses, goats, pigs, and cattle which were managed by named herders (Halstead 1998-1999; 2001). These herders, according to Halstead (2001), kept palatial animals along with their own herds, following a system that allowed for herders to 'exchange' animals between palatial and non-palatial flocks enabling the unhindered re-stocking of both.

Beyond the level of direct palatial involvement in the Mycenaean agrarian economy, the palaces also interacted with local communities as consumers of an array of products that were not systematically monitored and recorded but are present in the archaeological record as remains of food consumption. Consequently, one can assume that the palaces procured staple goods via some form of 'transaction' from the normal surplus that small-scale farmers in local communities produced (Halstead 1999a; 2014).

The operation of the palaces within this economic system had some impact on agrarian economies. Yet, their highly selective involvement in specific sectors of agricultural and animal husbandry practices suggests that no dramatic changes occurred in the fundamental subsistence practices at the level of local communities and individual subsistence farming households.

It is at this basic level of the subsistence agrarian economy (the land uses, the agricultural and livestock farming practices, the topography, the ecology and biodiversity of plants, and the climate) that the analogy between the Venetian and the Mycenaean period becomes appropriate for scholars to use. Each period's farming practices were, of course, linked to their unique historical context and cannot be equated or directly compared. Nevertheless, the Venetian-period data offer a unique opportunity to historians and archaeologists to explore how small communities interacted with their landscape and spontaneously constructed notions of territoriality.

7. A shift of paradigm and where do we go from there

During the Second Venetian Rule in the Peloponnese, communities identified each with an area of bounded space, i.e., their settlement territory. While borders were not institutionalised or demarcated in any rigid form, communities had a clear notion of territoriality that they could convey to the Venetian cadastral officers. These notions of boundedness had not emerged *in vacuo* or been externally imposed on local communities. They had accumulated historically and in response to different internal or external stimuli or pressures.

Returning to the discussion of Mycenaean notions of territoriality, I do not suggest that Venetian-period settlement territories should be applied *per se* to the settlements of the Mycenaean period. Instead, I argue that we should use the set of factors (i.e., topography, soil quality, plant and animal ecology, climate, and diet among others) and the range of human responses (i.e., farming practices and intensity, tools, transportation means, organisation of labour) contributing to the enactment of settlement territories during the Venetian period as a toolkit for building heuristic models of Mycenaean settlement territories.

Such a paradigm shift would produce models of territorial notions that were meaningful to the common people beyond the administrative and political control of the palaces. Furthermore, it should give us an idea of land use management efficiency and a measure for assessing the level of self-sufficiency for local communities in pre-modern pre-industrial times. This measure could subsequently be compared to the increased needs communities were faced with at the onset of the monumental building projects with the mobilisation of a sizable construction workforce and, possibly, their families, and increased pressure was put on available resources and land use management strategies.

A key parameter in evaluating land use management efficiency, finally, is the size of a settlement's population. Occasionally, researchers have attempted to assess settlements' population from the spatial extent of settlements, domestic floor space, and level of urbanisation of settlements based on excavation and survey data, but there is a general reluctance among scholars to undertake such analytical exercises. In their seminal studies, Bintliff (1977; 1989; 2016; 2020) and Whitelaw (2001; 2004; 2019) largely agree on an average urban population density of 200-225 persons per hectare for major Minoan (e.g., Knossos) and Mycenaean (e.g., Mycenae, Tiryns) towns, and of 100-125 persons per hectare for smaller settlements/villages (e.g., Prosymna, Argos). According to Bintliff (2016; 2020), then, Mycenae would have a population of 6,000, Tiryns of 3,600, Argos of 2,000 and Prosymna and Nauplion of 600 each. The wider region of the Argive plain, from Nemea to Asine and from Argos to Berbati, would have a population density of 12 persons per km^2 (Bintliff 2020: 21-22). This figure, further, is close to the 9 persons per km^2 estimated for the entire Pylos kingdom (Bintliff 2020: 18).

Here again, pre- and early modern archival data going back to the Second Venetian Rule in the Peloponnese (1687-1715 CE) can be informative. Settlement populations recorded in the 1700 CE census, conducted by the Governor-General F. Grimani, present a picture of severe depopulation for the Peloponnese. Following a century of warfare, the great plague pandemic, climate deterioration between 1645 and 1715 CE (part of the 'Little Ice Age'; Zerefos et al. 2011), and famine, it is conceivable that mean population density in the entire Peloponnese reached a low of 8.4 persons per km^2 (Panayiotopoulos 1985: 170). Even so, the population of the entire peninsula (43,366 families) was not so much different from that reported in the Ottoman archives of the 16th century CE (50,941 families). In subsequent years, the population density of the Peloponnese increased rapidly, reaching even 34 persons per km^2 in 1879 CE (Panayiotopoulos 1985: 173, table 20).

Territorio d'Argos, in particular, in 1700 CE had a mean density of 7.2 persons per km^2 (Panayiotopoulos 1985: 176, table 21). However, it integrated a large mountainous area (ca 443 km^2) with very low population density (a mean of 3.4 persons per km2) and a smaller lowland area (ca 206 km^2) with substantially higher population density (34.8 persons per km^2; figures worked out by the author from data reported in Liata 2003).

Compared to the figures estimated by Bintliff (2020) for the kingdom of Pylos and for the Argive Plain, the Venetian-period mean population density figures present a more complicated image. Considering that the Venetian-period mean density for the *Territorio d'Argos* was reached after a century of events that depleted the population of the Peloponnese, Bintliff's (2020) estimates of 9 to 12 persons per km^2 during the period of the Mycenaean states' culmination seem initially to be verified (if not considered a little underestimating). The detail of the Venetian-period data, however, could prove particularly useful in refining Bintliff's estimates by allowing closer consideration of the topography of the Mycenaean states and differential treatment of mountainous areas and settlements from lowland ones.

Finally, the present carrying capacity analysis of the Venetian-period *Territorio d'Argos* indicates that the population densities reported for both Venetian and Mycenaean times could be sustained from their unique hinterlands. This comes in contrast to Bintliff's (2016: 42) argument that only the smaller communities in the wider Argive plain region could sustain themselves from their hinterland, whereas the large palatial centres of Mycenae and Tiryns had to rely on the mobilization of resources from a wider regional network of supply.

To sum up, Venetian cadastral maps provide us with clues and a challenge to go beyond the normative, typological, or evolutionary statements that form the core of territorial analyses in archaeology. Aegean archaeologists can find in the boundary lines of the Venetian cadastral maps those elements of the landscape, of everyday struggle for subsistence, and of responses to internal and external pressures, that cumulatively shaped settlement territories in the Venetian period. They can then use that knowledge to construct informed models of Mycenaean notions of territoriality that were meaningful to the common people.

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Climate, carrying capacity and society: the quest for universal truths

Paul Erdkamp

1. Universal truths

In the early 1950s, the famous science fiction writer Isaac Asimov published his *Foundation*-trilogy, which is set in the distant future, after the fall of the Galactic Empire. The book introduces a theory of history – psychohistory, Asimov calls it – that is based on sociological and statistical principles, and which is able to predict societal processes in the future. Hence, the fictional creator of this theory is able to foretell the fall of the Galactic Empire, but also to take measures to alleviate the impact of its fall. The *Foundation*-trilogy shows the confidence of the 1950s in progress, including the idea that at some point in the future social science would be able to identify the laws that govern societal processes. It is revealing that Asimov, who was a professor of biochemistry, sees the future of historical science not with historians, but with sociologists, psychologists and statisticians.

Several points can be taken from Asimov's *Foundation*-trilogy that are directly relevant for my paper. To begin with, the decline and fall of the Galactic Empire clearly refers to the Roman Empire, the fall of which ushered in the Dark Ages. This link is not a figment of a Roman historian's imagination. In his foreword to a later edition, Asimov noted that the idea for the *Foundation*-trilogy came after reading Edward Gibbon's *Decline and Fall of the Roman Empire* (1776-1789), reading it not once, but twice. Gibbon saw Christianity's impact on the Roman mindset as a fundamental cause of the fall of the empire, so against this background the role of mentality and attitude in Asimov's *Foundation*-trilogy is not surprising.

More importantly, Asimov's source of inspiration, Edward Gibbon wrote in an age that wanted to understand the fundamentals of nature and society. Gibbon did not simply want to tell a story, but he wanted to understand why history took the course it did. At about the same time, Adam Smith published his *Enquiry into the Nature and Causes of the Wealth of Nations* (1776); John Millar studied the general principles of rank and authority in human societies (1771); and Thomas Malthus wrote his *Essay on the Principle of Population* (1798). Gibbon and his contemporaries were influenced by scientific discoveries, such as Isaac Newton's Laws of Physics, so they searched for universal laws in society. Social sciences – economics, sociology – developed from these roots: 19th-century social science was indeed interested in the past, but not for its narrative. Despite their differences, scholars like Comte and Marx have in common that they studied the past to understand the laws governing society. It was these laws, which they identified primarily as social and economic factors that were beyond the control of individuals, that gave meaning to the past.

The development of history as an academic discipline in the 19th century took a different path. One of its basic principles was that all societies were unique and had to be understood

Paul Erdkamp
Department of History
Roman Society Research Center
Vrije Universiteit Brussel

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by themselves. All societies were different, all events unique. There were no laws of history – no universal truths. History as a discipline has changed significantly since the 19th century, but it is still very much rooted in the same soil. In a sense, history has shifted towards social science, often putting social and economic factors at the heart of the narrative and assigning an important role to the environment, including climate, but many historians are still very much wary of universal truths in the past and of 'Grand Narratives' that reduce myriad events to a few big ideas.

The sociologist Johan Galtung (1997: 2-4) calls for macrohistorians to look for 'recurring patterns' and 'mechanisms underlying them'. Many archaeologists tend to side with social science on this issue and 'aim at describing and hopefully explaining repeating patterns in the course of history from a truly *longue-durée* perspective' (Peters and Zimmermann 2017: 50). It is revealing that anthropology is often seen as archaeology's natural partner, not history (e.g., Middleton 2017). Processual archaeology was very much influenced by social science, and hence, two of its fundamental characteristics were the search for underlying principles and the emphasis on environmental factors in human society (O'Brien 2017: 296; Weber 2017: 27). There was, in other words, a penchant for environmentally inclined 'Grand Narratives'. Fundamental causes of societal change were seen in the link between environment and population, and thus, environmental change, population growth, carrying capacity and societal collapse were key themes in this approach to the past. However, the criticism that processual archaeology understated the role of human agency has been taken to heart, with postprocessual archaeologists, like most historians, rejecting environmental determinism. Hence, society-oriented concepts like 'resilience' and 'transformation' are more central in postprocessual research. (On the concepts of 'collapse' and 'resilience' in archaeological research in past decades, see Heitz et al. 2021: 130-144. For a nuanced approach to the resilience of past societies in the face of climate change, see Degroot et al. 2021.)

This paper aims to critically discuss two elements in recent studies of the impact of climate on early societies that are related to 'universal truths' and 'general principles'. First, 'general laws' are invoked in various forms in such studies. It is often claimed, for example, that temperature and population were positively linked, with population levels rising when average temperature rose and going down when temperature fell (Galloway 1986; Malanima 2013: 72-73; Kennett and Marwan 2015: 2; Lee et al. 2016; Bevan et al. 2018). Some even go so far as to causally link sunspot activity and population (Wiener 2018: 17). To give another example, one finds statements like 'stable climate conditions favour the formation of agrarian states, while persistently volatile climatic conditions can contribute to the episodic collapse of these complex societies' (Kennett and Marwan 2015: 1, who base this statement on pre-Columbian American states). Less general, but still quite sweeping is the following variation: 'Beginning around 2050 BCE, a period of generally good climate lasting almost a millennium enabled the rise of powerful and prosperous states from Egypt to Assyria to Anatolia to Crete and later mainland Greece' (Wiener 2018: 8). The underlying principle of such narratives is that stable states are formed in times of good climate, while they fall due to bad climate, although one could just as well argue that larger states, controlling a larger and more diverse territory in terms of climate and agricultural conditions, would be more successful in coping with increasing harvest volatility than smaller states.

A second element to be discussed is that the use of some models is based on the fundamental comparability of different societies and events. Stripping historical processes to their essence, such theories identify causal links that are valid for all societies (or at least those with certain broad characteristics) and that thus can be applied to a particular case even if the data are missing to establish such links empirically. The Malthusian model is a case in point. The Malthusian model causally links population, material resources and living standards, viewing the limited growth of material resources (basically: land) as a limiting factor. More broadly speaking, one might call it 'carrying capacity', although the term was never used by Malthus. Concisely put, his theory states that population tends to grow faster than material resources. When living standards in a society increased, due to technological or economic progress or as a result of mortality crises, fertility would increase and mortality decrease, causing population growth. However, the rise in mouths to feed would inevitably eat up the gains in total material resources. While in the long run material resources (i.e., carrying capacity) and population levels may move upwards in cycles of increasing and decreasing pressure, to staunch Malthusians only a very limited rise in living standards was possible in pre-modern times. A general application of Malthusian theory, for example, underlies many approaches in processual archaeology to the demography and economy of early societies (e.g., 'boom and bust' cycles). A more postprocessual interpretation of such models, stemming from Resilience Theory, consists of the Adaptive Cycle Model, which imposes a fixed cycle on a society's response to external forces. The postprocessual emphasis on the particularity of societies generates some tension with the assumed general applicability of such cycles. Hence, the Adaptive Cycle Model is not unanimously embraced by archaeologists, let alone historians.

The discussion of generalized models and universal laws not only touches upon our fundamental notions regarding the nature and driving forces of human history, but also questions the assumptions underlying some of the arguments made in the debate on climatic impacts.

2. Time and scale

It has been pointed out that on the scale of the entire Holocene, there seems to be no correlation between climate and society. Until the onset of Global Warming in modern times, the long-term climatic trend in Eurasia was one of decreasing temperature and humidity. Despite fluctuations within this trend in terms of temperature and humidity, which were limited compared to the current and predicted effects of Global Warming, temperature and precipitation saw a declining trend over the millennia. At the same time, however, population levels, societal complexity and life expectancy increased significantly in Eurasia (Roberts et al. 2019: 937). Both climatic and societal trends were not linear, as there were fluctuations and geographic variations in these trends, but it is clear that these conditions did not constrain the development of humankind quantitatively or qualitatively. Nobody would want to conclude that humans fare better in colder and drier conditions, so the conclusion must be that humankind was resilient. In the long run, humankind did well, despite overall adverse climatic trends.

However, from a different perspective the image reverses. For example, the deadliest famine in Scotland in historical times occurred in the 1690s, one of the coldest decades in the second millennium in western Eurasia. Severely cold weather catastrophically affected livestock and arable farming in the later 1690s, causing approximately 100,000 people to die in Scotland (10-15% of the entire population). Finland suffered from a catastrophic famine at the same time, losing about one quarter of its population (Huhtamaa and Helama 2017: 9). Finland and Scotland suffered far more than England or France, which shows that not only temperature was at play in this mortality crisis (D'Arrigo et al. 2020). Large segments of the population in the most affected countries proved less resilient and more vulnerable than in surrounding countries. Nevertheless, despite differing degrees of vulnerability, societies clearly were susceptible to weather extremes (including flooding, the most severe of which were as deadly as famines).

However, also the demographic impact of this extreme weather event is a matter of scale, as Scotland's and Finland's population recovered fairly quickly. In the long run, this cold spell had little impact on northern Europe's demography, although the catastrophic experience may have seriously affected these societies in other ways. Demographic studies of societies that offer sufficient empirical data (i.e., societies in the past millennium) have shown that famines by themselves had little impact on population levels in the long run (Watkins and Menken 1985; Nielsen 2017). Major demographic downswings were caused by epidemics, not famines. Most studies on prehistoric societies focus on food availability as the link between climate and population, but surprisingly few (if any) point to epidemics. Probably the main reasons for this disregard of the demographically more forceful epidemics are, first, that epidemics only recently have become archaeologically visible and, second, the general idea that connectivity was too low to spread infectious diseases.

The main point is that climate seems not to have obstructed demographic and economic growth on a millennial scale, but that adverse weather conditions potentially were catastrophic on an annual scale. What about the decadal or centennial scale?

2.1. Climate, carrying capacity and population: an early-modern excursus

To answer that question, we will first focus on western Europe in the early-modern period. There are two reasons for this geographic and chronological focus. First, paleoclimate proxies indicate that the early-modern Little Ice Age (LIA) constitutes the most severe cold period in the northern hemisphere over the last millennia, roughly to be dated between 1400 and 1800, although its chronological boundaries are hard to define due to geographical variations. In contrast to other climate eras, which are often hardly visible in wide-ranging and long-term northern hemisphere timeseries of speleothem data, the LIA is detectable in these data (Lechleitner et al. 2018: 18). Second, in order to establish the impact of climate change empirically, we need time series of data on population and economy, which are available for western Europe from the later Middle Ages onwards, but for few societies beyond these temporal and spatial boundaries.

The purpose of the exercise is to see whether the LIA constrained demographic and economic growth, as is predicted by the 'universal law' that a colder climate caused population levels to drop. More broadly formulated, a long-term trend towards lower temperatures is assumed to have lowered the carrying-capacity of the land. Following a Malthusian reasoning, a decline in carrying-capacity would inevitably increase population pressure on the land and depress living standards, ultimately causing a decline in population. From a Malthusian viewpoint, carrying capacity (≈ agricultural production) is a determining factor of population. The general validity of such a Malthusian scenario is disputed, as Esther Boserup offered a contrasting model, in which population is a determining factor of agricultural production. Boserup argued that if population increased pressure on the land, this would trigger a change in agricultural system, leading to a rise in agricultural production. In her view, agricultural production never reached a ceiling of maximum capacity, thereby allowing growth when the need arose. An ecologically defined 'carrying capacity' is of limited use in the study of complex societies, because agricultural production is not only determined by such ecological factors as soil, yields and weather, but also by the structure of landholding, the extent of (under) employment, of specialization and of market integration. In other words, societal factors act as constraints on the utilization of natural resources. Consequently, societies never make optimal use of natural resources (Erdkamp 2021b). This means that the concept of 'carrying capacity' as it is often used in archaeological studies, i.e., as an ecologically fixed maximum of agricultural production, does not make sense. (For a criticism of the concept of 'carrying capacity' from a geographer's perspective, see Sayre 2008: 132, who rejects the idea of 'environmental limits in abstraction from time and history').

Production increase was sometimes based on generally higher, but more volatile outputs, but an equally important point is that production increase always was at a cost, as inevitably some input factor had to be raised. In preindustrial times, the most adaptable input factor for most farmers was labour. In other words, when the need arose, farmers would adapt their production strategies and work harder (e.g., from slash and burn to continuous cultivation; from fallow to crop rotation and manuring). A change in crops or the investment of capital also played a role in adaptive strategies, but this role depended very much on the social-economic conditions of agriculture (i.e., who controlled land, capital and labour).

As the importance of past climate change had not been recognized at their time, Malthus and Boserup did not include climate change in their models, but climate may be seen as an additional factor that (in a Malthusian model) increased or lowered carrying capacity, or (in a Boserupian model) lowered or increased pressure on the food supply, thereby triggering a response irrespective of population levels.

Recurring waves of the plague in most of Europe in the later 14th and 15th centuries caused a dramatic decline in population just when the generally warmer conditions of the Middle Ages started to give way to the Little Ice Age. Recent paleoclimate research shows that climate change did not occur in uniform centuries-long eras but was characterized by much more chronological and geographic variation than previously recognized (Psomiadis et al 2018). Nevertheless, all regions saw periods of significantly lower temperatures between 1400 and 1800 (Esper et al. 2018). In most countries we see a decline in agricultural production concomitant with the fall in population in the wake of the Black Death. In combination with the onset of a long-term cooling trend this may at first sight seem to point to a widespread climate-induced 'carrying capacity' crisis, and this is exactly what some studies conclude. It has been claimed, moreover, that 'social mechanisms that might mitigate the impact of climate change were not significantly effective during the study period'. Such a scenario is proposed for the entire Eurasian continent between 1400 and 1900 by Zhang et al. (2007: 19214): 'Long-term climate change has significant direct effects on land-carrying capacity (as measured by agricultural production). Fluctuation of the carrying capacity in turn affects the food supply per capita. A shortage of food resources in populated areas increases the likelihood of armed conflicts, famines, and epidemics, events that thus reduce population size' (cf. Lee et al. 2015). If correct, societies had been more or less helpless against environmentally caused carrying capacity crises, with little scope for Boserupian solutions. Many historians reject such an approach, which 'reduces the economy to little more than a direct physical relationship between weather and harvest results, but seventeenth-century economies in most of Eurasia were not so simple. Technology, markets, institutions could, and did, buffer the effects of climate on food production and distribution' (De Vries 2014: 375).

Interestingly, in the wake of the Black Death (itself an exogenous factor, or at least not an endogenous one in the Malthusian sense), the Netherlands, Britain and Portugal do indeed show a Malthusian response (although one that does not contradict Boserup), as living standards and per capita GDP rose.

In response to medieval population growth and urbanization, agricultural production methods had improved, which allowed the lowering of labour input and abandonment of marginal lands in the 15th century. In most of western Europe, life was better for those who survived, as per capita productivity rose. Finland and Spain were different, though, as the Black Death passed Finland by and post-Reconquista Spain already had plenty of land in relation to its small population even before the Black Death. In the 16th century, various countries did indeed feel increasing pressure between population and agricultural production, but in all cases, it was demographic growth (not a falling carrying capacity) that brought about an increase in agricultural production. In those countries where land was scarcer than labour (the Netherlands, Britain, Portugal), growth was achieved by means of innovation and intensification of agricultural practices; in Finland and Spain this was realized through the expansion of arable farming, making more efficient use of available land.

Despite the Little Ice Age, the increase in agricultural production kept outpacing demographic growth in the Netherlands and England, while living standards (defined as GDP per capita) rose in Spain and Portugal until the 18th century. Subsequent decline in Portugal, Spain and Italy was not a consequence of a lowering carrying capacity, but of demographic growth outpacing agricultural productivity, aggravated by adverse changes in international trade relations. In sum, in accordance with Boserup's model, population was a determining factor in early-modern western Europe, not a dependent variable, as in a Malthusian carrying capacity model. The Little Ice Age did neither prevent population levels from rising nor agricultural production from growing. In fact, northern European countries, which should have been more vulnerable to a long-term drop in temperature, fared better from the 18th century onwards than southern European countries. One is tempted to speculate that the LIA stimulated rather than impeded economic performance.

We may conclude that, on a decadal and centennial scale, western European countries showed themselves resilient against the potential negative impact of adverse climate trends. (cf. Degroot et al. 2021). While extreme weather events were costly in terms of human lives and material damage, their effects were short-lived. Famines caused short-term peaks in mortality levels and lows in fertility levels, but below-average mortality and above-average fertility in their wake soon made up for the temporary loss in population. With the exception of flooding, material damage of extreme weather did not last long either. While Malthusian scenarios did occur in some places and at some periods, a Boserupian response was more common in western Europe in this period.

The purpose of the exercise was not to arbitrarily project the findings regarding early-modern Europe onto Neolithic or ancient societies. A valid question is, therefore, to what extent these periods are comparable. To begin with, these are all agrarian societies based on a similar range of crops. Neither the diet nor agricultural systems were significantly different. Cereals and pulses offered most of the nutrients and calories to most of the population in western Eurasia from the onset of agriculture, while human and animal labour provided the main sources of energy in their production. A general intensification of the use of land and labour from the Neolithic onwards constitutes the main development over this period, but this already occurred in the early states of the Near East and Mediterranean, while slash and burn farming was still practiced in early-modern Finland. While technical innovations in agriculture, food processing and transport are undeniable, the question is whether these prohibit comparisons between both periods. More significant than technical advances may have been differences in economic structure and complexity, i.e., the scale and extent of market integration, specialization and urbanization. However, in this regard we must differentiate between, on the one hand, Neolithic societies with no long-distance trade in staple foods and, on the other, ancient empires whose trade networks and command channels moved large volumes of staple foods across long distances. Surely, the difference in economic terms between the Mediterranean in the Roman imperial period and in the 16th century is one of degree rather than essence. Hence, I would argue that technical and economic differences are not of such a degree as to make the drawing of comparisons between early and ancient societies on the one hand and the much better documented societies of early-modern Europe on the other impossible.

So, the points to take away from this excursion into the early-modern period, based on much better empirical data than available for the prehistoric and ancient world, are:

It is not a universal law that population and temperature are directly linked;

Carrying capacity as an ecologically determined fixed maximum of agricultural production is not a valid concept;

Malthusian scenarios in which agricultural production determines population are a possibility, but so are also Boserupian scenarios in which population determines agricultural production;

Early modern societies, characterized by relatively high rates of urbanization and complex socio-economic relations, were resilient to adverse climate change, in the sense that adverse climate trends did not prevent demographic and economic growth and increasing urbanization.

2.2. Climate, carrying capacity and population in prehistory and antiquity

That said, it is still entirely likely that societies as diverse as Neolithic farming communities, the Roman Empire or 17th-century Britain differed significantly in the potential impact of climate change, even apart from the nature and extent of the climate change itself. So, we may still see a different situation regarding the link between climate and population in prehistoric or ancient times. It must be stressed, though, that our demographic or economic data for early societies are not comparable to those for early modern Europe. Population trends for ancient societies are generally based on estimates of settlement size and number, while those for prehistory are derived from trends in radiocarbon dating (Shennan et al. 2013; Lillios et al. 2016; Gronenborn et al. 2017; Capuzzo et al. 2018; Bevan et al. 2018; 2019; Palmisano et al. 2019). When discussing population levels in relation to climate, one has to keep in mind that the results have a wide margin of uncertainty and that our proxies only offer relative trends, not absolute numbers, whose spatial and temporal resolution moreover are quite low (Erdkamp 2021a).

Recent studies regarding prehistoric Europe generally give a nuanced picture of the possible impact of climate change on demographic trends. A long-term study of the Mediterranean from the beginning of the Neolithic until Classical Antiquity observes demographic 'boom and bust' cycles, but most significantly, these fluctuations were not synchronous between the various regions, which is argued to indicate that there was no common external cause and that the dynamics behind these fluctuations were predominantly internal (Roberts et al. 2019: 928).

However, while temperature changes congruously over wide regions, precipitation does not. So, in theory, fluctuations in demographic trends that are not regionally synchronous is not incompatible with climatic impacts. Indeed, Roberts et al. (2019: 16) point out that, while there are no significant relationships between moisture availability and human population in some regions (e.g., central Italy), such an impact is likely in southern Greece between 5000 and 2000 BCE and in north-central Italy between 4000 and 1000 BCE. Similarly, Capuzzo et al. (2018) observe no convincing long-term correlation between population and climate in Bronze Age central and southern Europe in general. However, adverse climate change seems to affect population negatively in particular cases, such as the Massif Central during a particularly cold and wet phase (1700-1500 BCE) or the Swiss Plateau during a severe cold period.

In other cases, the demographic trend is contrary to what one would expect in view of the climate trend. Across the Iberian Peninsula, for example, human activity increased during the fourth and third millennia BCE, despite a general trend towards a more arid climate over the same period (Lillios et al. 2016, 144). In southern Anatolia, the peak in population occurred at the end of an overall drying trend that lasted from 3000 BCE to 500 CE, while population started to decline rapidly just when the drying trend reversed in the mid-first millennium CE (Woodbridge et al. 2019). In spite of a drying trend in the Levant between about 2000 BCE and 350 CE, anthropogenic pollen (reflecting human intervention in the landscape) increased (Palmisano et al. 2019). Referring to the same drying trend in the eastern Mediterranean (with slightly different dates), Allcock (2017: 73) points out that 'minimum precipitation levels therefore coincided with a time when centralized urban living, regional trade and crop agriculture were increasing'.

We may conclude that from prehistoric times onwards, climate did not universally determine population levels, but that in some cases there appears to be a causal link between climate and population. However, the difficulty here is when to conclude that correlation reflects causality, and when the absence of correlation is evidence of the absence of causality. The low temporal resolution of both societal and paleoclimate proxies certainly makes it more difficult to establish causality purely on the basis of coincidence (Weiberg and Finné 2018: 2; Karakaya and Riehl 2019-2020: 137).

Various scenarios throughout history are suggested in recent studies: (1.) the demographic trend changes at about the same time as paleoclimate proxies indicate a significant change in climate. This is generally seen as a causal link, the more so if population responds in the manner a priori expected, e.g., a fall in population coinciding with a drying trend in an area susceptible to drought; (2.) changes in population and climate can be linked with a time-lag, e.g., population responding a few generations after the turn in climate trend, which is explained as the build-up of climate-related pressure and the failure of societal resilience (e.g., Gronenborn et al. 2017: 54); (3.) in those cases that paleoclimate trend breaks are not concomitant with societal change, the conclusion may be either that climate was irrelevant or that society was resilient. The point is that certainty cannot solely be based on synchronicity. Even Kaniewski et al. (2019: 8) in a study of the 3.2 Ka BP event – a period of severely lower precipitation visible in various paleoclimate proxies – concludes that 'the aridification and downturn in agricultural activities are chronologically correlated and are *probably* interrelated' [my italics]. One should indeed be wary of automatically assuming that a period of lower precipitation than before or after had a detrimental effect on agriculture. It is certainly misleading automatically to speak – as many publications do – in terms of 'drought' or even 'aridification' in such cases.

One further note: expansion during beneficial circumstances does not logically imply contraction during unfavourable conditions since societies were not passive subjects of their environment. It might have been precisely catastrophic experiences as a result of weather extremes and the challenges posed by worsening conditions that stimulated societies to adapt and develop institutions and mechanisms that increased their resilience. Hence, it is entirely possible that favourable climate conditions stimulated demographic growth more often than that an adverse climate change caused demographic decline. The main point is that without good and chronologically precise data series on population and society, it is difficult to disentangle the causal links between all the variables involved. There are no 'universal truths' here.

3. Resilience Theory

To give structure to their construction of causal relationships between environmental and societal factors, archaeologists have looked for models outside their own discipline, as the archaeological data do not offer such a structure themselves. Many studies on the impact of climate change on past societies have adopted Resilience Theory to guide their analysis. Resilience Theory was a response to deterministic and monocausal views that treated societies as passive subjects to environmental forces and tended to emphasize collapse. At the same time, Resilience Theory's aim to analyse societal strategies and adaptations within their environmental setting also answered the critique aimed at processual archaeology of disregarding human agency (Gronenborn et al. 2017: 56; Rogers 2017; Heitz et al. 2021: 134-135).

A key feature of Resilience Theory is the Adaptive Cycle model, which identifies four phases in a fixed cyclical pattern in societal processes. These phases are *growth/exploitation* (r), *conservation* (K), *release* (Ω) and *reorganization* (α). The cyclical pattern may be described as follows. During the *expansion* phase, a society (or entity) expands its resources and features. At some point this phase passes into the *conservation* phase, which revolves around retaining of what has been achieved, leading to rigidity and vulnerability. Increasing pressure then leads to the *release* phase, in which things fall apart, which opens up opportunities for *reorganization* in the final phase, which then passes over in the *growth/exploitation* phase of the next cycle. Each phase is characterized by a different balance between *connectedness* and *potential*, leading to different degrees of resilience. 'The classic adaptive cycle model is defined by potential and connectedness in particular; with the conservation phase exhibiting a high degree of coherence (lots of connection between entities) and high potential (lots of capital)' (Freeman et al. 2017: 84).

The phase-structure of the model invites scholars to see climate shifts as the drivers behind the cycles. See, for example, the following general statement on climate impacts from an Adaptive Cycle perspective: 'Periods of good environmental conditions (e.g., mild temperatures/ high precipitations) cause high resource availability resulting in population increase. It is only under these conditions that the demographic threshold leading to lowered resilience at the end of the K-domain could have been passed, finally leading to a regime shift during a subsequent climatic downshift' (Bradtmöller et al. 2017: 12). In other words, the authors (archaeologists and an anthropologist) see beneficial climate conditions as driving the r-phase (*growth/exploitation*), inevitably leading to increasing vulnerability in the K-phase (*conservation*), with a climatic downshift ushering in the Ω-phase (*release*). One of the key-elements in the argument refers back to the concept of carrying capacity, as growth is seen as leading to overstretch and greater vulnerability. Presenting climate as the sole driver of the process, the Adaptive Cycle model as applied here is in danger of returning to environmental determinism.

There is no agreement that the Adaptive Cycle model is a valuable contribution to the debate, nor that it has been employed in a useful way. To begin with, the Adaptive Cycle model has been criticized for its simplification and overgeneralization. It is a curious mix of rigidity in its fixed cyclical pattern and vagueness in its parameters. The concept of resilience is applied to entities varying from villages of peasants or fishermen to city states and empires. In the study of prehistory and antiquity it has been applied to processes varying from less than a few centuries to several millennia, but regarding the recent past it has been applied to much shorter timeframes (Bradtmöller et al. 2017: 5). Since the model lacks clear definitions, O'Brien (2017: 298) points out, 'it is possible to

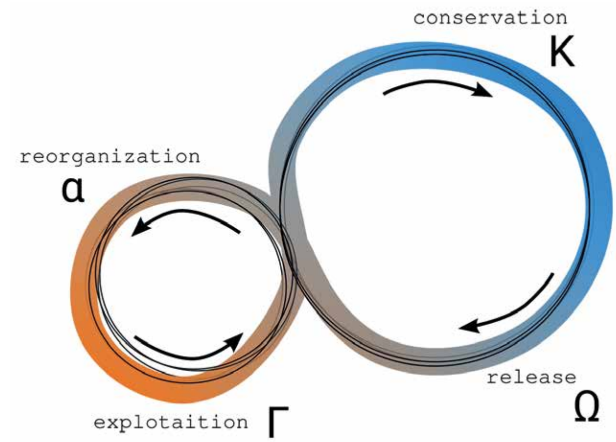

Figure 1. The Adaptive Cycle (by Hernán De Angelis. Source: Wikimedia Commons).

construct a cycle simply by marking in 'front loops' and 'back loops' at the appropriate point in the timeline'. The vagueness of the model is reflected in the way it is utilised. Rather than using it as an analytical tool, most studies draw analogies between existing periodizations and the model's phases. The Adaptive Cycle model, Freeman et al. (2017: 92) note, is too general to be falsified in a Popperian sense. The key elements remain imprecise and open to any scholar's individual interpretation. Most studies offer no clear distinction between *connectedness* and *potential* but merge these concepts into the concept of *complexity* (on which more below), which encompasses such broad issues as subsistence, demography, social differentiation and innovation. Subsistence is treated as the main element, which means that the archaeological analysis focuses on agricultural systems, diversity of food, food storage, trading and redistribution networks (Bradtmöller et al. 2017: 5). This is not surprising, seen against the background of processual archaeology's emphasis on demography and economy, and the fact that archaeological finds are most useful on material aspects of early societies.

While the model in theory combines variables representing various aspects of societies and their environment, in practice these have to be translated into proxies visible in archaeological research. Heitz et al. (2021: 143) observe: 'The identification of suitable archaeological indicators or proxies causes a major problem, as parameters and factors in the cyclical models deriving from non-archaeological disciplines cannot really be matched. It seems rather that culture-historic information and thus the rhythms in material culture change – first and foremost pottery styles that were used for periodization – as well as general knowledge of archaeological events, are used instead of measurable proxies.' At least in the eyes of a historian, this sometimes leads to a complex societal cycle in practice based on an extremely limited bandwidth of data. A good example of such a study is that of Gronenborn et al. (2017) analysing Linearbandkeramik (LBK) populations in the early Neolithic in southwestern central Europe. Their study uses diversity in ceramic styles as proxy for the concept of *complexity*, which is then combined with population and paleoclimate trends to impose the Adaptive Cycle model's cycle on the development of LBK populations. The conclusion of this study is that severe climate excursions shaped the location of tipping points in the social system (identified by shifts in ceramic styles), which after a few generations cause shifts in the population trend. In this application of the model, climate is the driver of the Adaptive Cycles, but its impact on the demographic trend is mediated by social systems. Studying tipping points in the social systems of early-modern Europe would certainly lead to endless debates, despite a relative mass of data, so I wonder how one can draw robust conclusions on such a complex issue solely on the basis of shifts in ceramic styles.

Since it is so very vague and general, with undefined concepts and unclear timeframes, the danger of the Adaptive Cycle model is that it becomes a 'one size fits all' model that is used not so much to interpret the empirical data, but to replace the data where they are missing. In other words, not the data, but the model leads the interpretation. Too much is based on simplifications and inapplicable generalizations in order to confirm preconceived ideas about environmental impacts and existing periodizations. Two particular weaknesses of the Adaptive Cycle model, as it has been applied in recent studies, pertain to their footing in the Malthusian paradigm and the assumption that societal complexity leads to a reduction in resilience.

3.1. Adaptive Cycles in Neolithic and Ancient Cappadocia

Expansion of agricultural production is often seen as inevitably linked to increasing pressure on resources, causing degradation of environments and thus leading to increased vulnerability. Such a scenario is, for example, postulated for the Peloponnese during the 2nd millennium BCE by Weiberg and Finné (2021: 224-228) on the basis of empirical evidence for the expansion of settlement and increasing levels of anthropogenic pollen indicators (API). However, these data are not sufficient as evidence either of degradation of the environment or of increased vulnerability. So, there is a danger that the latter are assumed because the Adaptive Cycle model requires so, rather than that the data independently point in that direction.

In a recent article titled 'Long-term socio-environmental dynamics and adaptive cycles in Cappadocia, Turkey during the Holocene', Samantha Allcock (2017) concludes 'at no point throughout the Holocene can climate be seen as the sole driver of societal change'. To me that is a perfectly acceptable conclusion, but can we agree entirely on the argument leading to that conclusion, and in particular on the role that Adaptive Cycles play in that argument? We will not address the paleoclimate reconstruction, as it is the model and the underlying societal assumptions that concern us most. Let us first summarize some key findings in Allcock's study.

The growth of the early Neolithic system under beneficial climate conditions is seen as the r-phase of the first cycle that Allcock identifies. The 7th millennium BCE saw a drying trend, and as moisture availability decreased, the flexibility in exploitation and subsistence strategies from the early period lessened. Expansion of cultivation and grazing increased the fragility of the landscape. 'The increase in landscape instability, pronounced local resource exploitation and lack of major and new settlement expansions during the Ceramic Neolithic are consistent with a 'K' phase in the Adaptive Cycle' (Allcock 2017: 76). The drying trend culminated in the '8.2 Ka BP' event – a period of dry and cool climate – but this did not cause much disruption, let alone collapse, as Neolithic culture proved robust and resilient. A drying trend in the 5th millennium BCE, however, triggered or at least exacerbated declines in settlement number. 'Reduced economic organisation and the increasing impact of drought on a system heavily involved in agro-pastoralism, possibly from the start of the Middle Chalcolithic, thus played a large factor in causing lower levels of growth, settlement abandonment and declining prosperity. This has resulted in the Middle Chalcolithic being a 'release' phase (Ω-phase) because of the overall degradation of social systems that hastened a decline in resilience levels' (Allcock 2017: 77).

A new, second, cycle begins in the Early Bronze Age, despite increasing aridity, with demographic growth and greater complexity continuing well into the 2nd millennium. This time degrading climatic conditions are seen as a stimulus to society, showing the social ingenuity of the time. During the Middle Bronze Age, however, the lifestyles of the Early Bronze Age were becoming harder to sustain, indicating the conservation 'K' phase in the Adaptive Cycle. Evidence of attempts to mitigate the effects of drier conditions and associated harvest failures are seen in the food distribution strategies and greater administrative control of this period. Collapse (Ω-phase) comes with the Late Bronze Age, 'the driest period of the Holocene', which hit society when resilience levels were at their lowest.

The following, third, cycle consists of the Hellenistic/Roman period, with a similar development as in the previous ones. 'The increased number of people in the area and an associated higher demand on the rural environment created a new phase of landscape vulnerability, which in turn would have put pressures on agricultural productivity and economic growth, forcing greater investment in maintaining capital.' In other words, resilience decreased during the Roman period. 'Sustained intensification and landscape alteration are features of the 'K' phase and reflect a long-period of lifestyle conservation and social investment in economic systems that created specific anthropogenic landscapes.' 'Increasing landscape degradation and an over-reliance on agrarian economies likely had negative consequences on socioecological fragility, and may have contributed to another 'release phase' (Ω-phase) in the Adaptive Cycle from the mid-seventh century CE' (Allcock 2017: 78).

In short, the early history of Cappadocia consists of subsequent cycles – a Neolithic, Bronze Age and Hellenistic/Roman cycle – in which the *growth*-phase inevitably and tragically incorporates the roots of the subsequent decline. According to the model's logic, the *conservation*-phase is perceived in terms of over-exploitation and socioecological fragility linked to intensification of agriculture, heavy involvement in agro-pastoralism, landscape degradation and inflexible food distribution systems. The weakened and less resilient system was unable to withstand subsequent periods of drought'. Climate is not treated as an all-determining factor, though, as the Neolithic K-phase withstood the drying trend of the 7th millennium BCE, including the '8.2 Ka BP' event, but not the decline in precipitation in the 5th, while a similar trend in the Early Bronze Age actually stimulated the expansion of that era. As far as I see, the model does not really explain why society is 'robust' in the early Neolithic K-phase, fell in the 5th millennium, and why only the Early Bronze Age-society is stimulated by drought, resulting in its r-phase. Neither is the over-exploitation argument very convincing, as the supposed fragility of the landscape due to the expansion of cultivation and grazing did not prevent Neolithic culture from prospering over several millennia. Moreover, a recent pollen study argues that it is uncertain whether the Neolithic communities were large enough to have any significant impact on the natural vegetation of the landscape (Woodbridge et al. 2019).

Let us look a bit closer at Allcock's argumentation concerning the Roman period. 'Classical communities may have built socioeconomic systems that exacerbated rather than mitigated potential hazards through the over-exploitation of the landscape around them, principally for farming use; as Cappadocia was the 'bread bin' of the Roman empire and relied heavily on its cereal crops. The growing focus on wheat cultivation therefore, and to some extent olive and other fruit-bearing trees, led to unsustainable politically-influenced landscape behaviours that would have partially diminished resilience levels because of both social and environmental instability.' None of this is actually substantiated. Part of it simply rephrases the claim of overexploitation. Cappadocia's suggestive role as 'bread bin' of the Roman Empire never existed – the reference actually pertains to the Byzantine era. There is no reason to see the 'landscape behaviours' of the Roman period as either politically driven or unsustainable. A significant rise in cultivated trees is visible in the pollen data already around 3000 BCE. The Beyşehir Occupation Phase (BOP), which refers to a system of land exploitation based on pasture, cereals and fruit trees such as olives and walnut, became characteristic of the Anatolian region in the course of the 2nd millennium BCE and lasted for more than two millennia (Haldon 2014: 132). A recent study of the region of Sagalassos concludes that the onset of the BOP created the circumstances for local populations to live in a sustainable and resilient way, creating a set of stable environments that served as niches of habitation and provided for all local needs in energy and resources (Daems et al. 2021: 606-607). Another study points out that cereal cultivation in central Anatolia increased during the 4th and 5th centuries CE and that the agricultural output of the region only meaningfully decreased in the later 7th century (Maranzana 2021: 566; likewise, Chavarría et al. 2019: 322-325). When intensive cereal cultivation and the BOP declined in the mid-7th century CE, they possibly did so as a result of the devastating Arab-Byzantine wars, which caused a drastic drop in population, removing any need for intensive exploitation of the land (Woodbridge et al. 2019; cf. Maranzana 2021).

In short, the ecological discourse of over-exploitation and fragility seems to stem more from the logic of the model than from what we know about the environmental and societal development of the region. The most valuable observations made in the article are those that are based on solid evidence, not on the Adaptive Cycle model.

3.2. Adaptive Cycles and complexity

Governmental control and commercial links play a negative role in Allcock's analysis, and this is another key-assumption of the model. 'While resilience is increasing from the r-to K-domain, it declines as the system becomes too rigid and specialised. In this case, the system can reach a threshold after which it is unable to self-organize if confronted with external or internal changes. As a result, the cycle proceeds into the Ω-domain (i.e., release), a crisis that leads to parts of the system breaking down and the subsequent reordering of numerous functional structures and networks' (Bradtmöller et al. 2017: 10). *Connectedness* is treated as synonymous with rigidity, which is a sign of stagnation, not a positive thing (Gronenborn et al. 2017: 57; Peters and Zimmermann 2017: 43; Solich and Bradtmöller 2017). The Roman Empire serves as a case in point, as its 'regimented economy' is seen as the main reason for low system resilience (Marston 2015: 595-596; Bradtmöller et al. 2017: 9).

Applying this central idea of the Adaptive Cycle model to Bronze Age Greece, recent studies (Weiberg and Finné 2018; 2021) suggest *complexity* as the major factor explaining the collapse at the end of the Late Bronze Age. Socio-political cycles in the Peloponnese are identified, based on the variations in population density, investments in infrastructure (settlements, roads) and in administrative control (hierarchies and tax systems). These in turn are seen as indicators of varying pressures on resources and of the vulnerability of the socio-political structures. On the basis of recent paleoclimate data, Weiberg and Finné observe that the LH II period (1600-1440 BCE) was considerably drier than the preceding period and, in particular, drier than the wet and stable conditions of the subsequent LH IIIA period. Despite these drier conditions, they note, the LH II period showed slow but steady societal expansion. Mycenaean society's resilience in the face of adverse climate during this period is ascribed to the more loosely organized patterns of life and lower population density, while scale and composition of land use was still very much the same as in the previous period (Weiberg and Finné 2018: 9; 2021: 231-232). However, the palatial economies became more strongly interconnected and increasingly rigid – the 'recipe for disaster' in Adaptive Cycle thinking. 'Societal connectedness – the interdependence between different actors and between aspects of society – increases in parallel with growing societal complexity. Following the perspective of resilience thinking, such interdependencies may in the long run lead to over connectedness and a growing rigidity within the system that increase the likelihood that a 'stability threshold' will be transgressed, moving the system into a vulnerable state. […] Increased vulnerability can develop when resource management becomes too fixed to hinder adaptation, creating a form of path dependency and lock-in effects' (Weiberg and Finné 2018: 11; similar 2021: 233). However, little evidence is given to show that socio-political and economic structures became not just more complex, but 'over-connected' and, therefore, more rigid and less able to respond to adverse conditions. This is not to advocate the environmental deterministic emphasis on climate change, nor to deny the potential validity of the claim that internal processes caused the decline and fall of Mycenaean palace-states. However, there is a danger that, in the absence of clear empirical data that would allow us to unravel the causality of societal processes, we seek solutions in unsubstantiated 'universal truths' that are used to fill in the gaps in our evidence.

Where does the idea come from that complexity is inversely related to resilience? Much of it, it seems, originates in studies in different contexts, whose results are treated as universally applicable and thus projected on as widely differing societies as Neolithic communities and ancient empires. One study that is referred to, for example, analysed how ancient groups in Central America coped with volcanic eruptions (Sheets 2012). It is concluded that societies with a centralized scheme of decision making and redistributive systems were less resilient than those in which coping strategies were made at the household level and in subsistence contexts (cf. Fitzhugh 2012; Riede 2014; criticism of the argument in Torrence 2019: 260-261). However, the impact of such short-term and localized events as volcanic eruptions is fundamentally different from that of climate change, which is by definition a long-term phenomenon that allows much more complex responses by wide segments of society than the immediate survival of the ones most directly affected. Responses to volcanic eruptions do not support the general assumption that complexity reduced societal resilience.

There is, moreover, no consensus among historians and archaeologists that the complexity of early states made them more vulnerable. To the contrary, Roberts et al. (2019) notes that the connection between climate and demography was closest in early farming communities and lessened with the emergence of complex stratified societies and trading networks from the later Bronze Age onwards. A recent long-term study of the Levant during the Holocene concludes that the region became less vulnerable to worsening climate conditions during the Babylonian and Persian periods, owing to the emerging trade networks and to the institutional and physical infrastructure created by larger states, which made it possible to transfer surplus to where harvests had failed (Palmisano et al. 2019).

To a Roman historian it is surprising that the Roman Empire is seen as a typical case of state-induced rigidity leading to low levels of resilience. Population levels, which began to rise in the Iron Age, reached a peak in the eastern Mediterranean during the Later Roman Empire, with prosperous cities and villages and high levels of commercial connectivity in many parts of the eastern part of the empire continuing up to the 6th century CE. In spite of climatic ups and downs in that region in the previous millennium, the system's supposed lack of resilience never caused a general decline. Of course, the socio-political make-up of the Roman East changed over time, but transformation is not the same as decline. Palmisano et al. (2019) point out that 'the Roman hegemony of the Mediterranean integrated the farming systems of the Levant into a large economic and political superstructure that mitigated the impact of climatic hazards'. In fact, it has been argued that the relatively greater stability of the food supply throughout the Roman Empire stimulated its unquestionable economic growth (Erdkamp 2016). Likewise, Roberts et al. (2019) point out that the all-time peak in population levels until modernity occurred during Roman imperial rule, seeing Mediterranean-wide production and exchange systems as the main cause.

Finally, early modern countries in western Europe proved to be resilient, despite the fact that their governments had become more centralized, international relations more interwoven, and their economies increasingly interconnected and interdependent. One may even suggest that these countries were resilient precisely because they were complex and connected.

4. Concluding remarks

'In complex adaptive systems [...] the behavior of the whole is much more complex than the behavior of the parts' (Holland 1998: 2). Modelling complex systems seems a contradiction in terms, as models by definition are simplifications whose purpose is to reduce reality to comprehensible levels. As part of that reduction, models select variables that are regarded as relevant, disregarding those that are not. This is inevitably based on a priori assumptions that ideally are based on hypotheses that are empirically confirmed. History is no exception.

Two observations, however. First, applying general models to past societies is based on the comparability of these societies, and this adds a complication that is not present in, for example, physics or biology. We are simplifying past and current reality by using labels to phenomena that are only the same to a certain extent. A king is a 'king', whether in the Hittite Empire or early modern France, in so far as they both have certain common characteristics, but we all realize that the comparability only goes so far. This is even more the case with such constructions as cities, trade, tax systems, or states. Hence, applying models is at all times finding a balance between simplification and complexity, between the uniqueness of past phenomena and their comparability. It is part of this balance to hypothesize patterns that can be proven or disproven, but one should avoid universal truths, as these would either be gross simplifications or so very general as to be meaningless.

Second, complex models work well if they are used to make sense of a myriad of data, as they offer tools to make sense of an otherwise meaningless mass of observations. They are wrought with difficulty, though, in an opposite context, if they are used to overcome a lack of data. Unfortunately, the study of prehistoric and early societies often finds itself with too many questions to ask and too few data to answer them. It is indeed valid to limit the range of possible interpretations by employing general theories to the data at hand, but one should not succumb to the temptation of filling in the gaps with universal truths.

The debates on climate and society of the past decades have provided many important insights, not only in the form of paleoclimate data that give us a much more detailed perception of past climate change than before, but also in terms of archaeological data and interpretations. The most important realization might be that societal processes in the past were indeed the result of the complex interplay of numerous environmental and human factors. Moreover, societies were not uniform entities that strove *en bloc* to be resilient. Societies were the result of the continuous struggle and collaboration of numerous individuals, each with their own experiences, considerations, and goals. To say that the processes involved are complex is an understatement, but most importantly, no configuration of forces occurred in exactly the same way twice. As observed above, the past can only be understood in terms of simplified and hypothesized patterns that are ideally checked empirically, and that is where the shoe pinches. We have made tremendous progress in understanding the natural environment of the past, but it is the shortcomings of our data on prehistorical and ancient societies that make it questionable whether we will ever be able to answer all questions regarding the impact of climate change on past societies.

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Encompassing islandscapes in southern Vanuatu

James L. Flexner, Stuart Bedford, and Frederique Valentin

1. Encompassing islandscapes in southern Vanuatu

1.1. Introduction

Islands, particularly in the Pacific region, have long served as metaphorical or actual models for microcosms of human ecologies and societies (Kirch 1997; 2007; Broodbank 2000; Thomas 2021). Dening (2004: 16) uses the term 'encompassing' to explain the process of tracing boundaries and connections across vast areas of ocean and scatterings of islands through time and space. The vision of island space constructed by Western cartographic traditions is to some extent inadequate to understand the lived experiences of islanders themselves. As Broodbank (2000: 23) notes, 'Maps are hard to avoid using, but they do not inform us of the raking, sea-level views that made up the islanders' own perception of islandscapes, and which must have heavily influenced how they put these together.' The process of *encompassing* can provide a middle step to shift from the abstract and distanced cartographic perspective to lives lived on the ocean waves, across sandy beaches and rocky shores, to the low dunes of atolls and the high mountain ridges of volcanic islands.

Dening (2004: 14-15) uses the migratory pattern of the yolla (*Puffinus tenuirostris*, mutton-bird) as a metaphor for the process of encompassing. The yolla migration begins in Aotearoa (New Zealand), next passing through southeastern Australia. From there, the migration turns northward, passing through the western Pacific islands of Fiji and the Solomon Islands. The yolla continue north from there, all the way to the Behring Sea. As the weather turns cold, they return south to the atolls of Polynesia and past the Tuamotus. Their route continues via the coast of South America and returns westward via subantarctic waters. Over the year, the birds have completed a circuit of over 25,000km of linear distance. The vast area within this circuit, criss-crossed by the routes of migratory birds, whales, sea turtles, and human navigators, is Oceania.

The narrative we construct below offers an attempt to craft a slightly different archaeological narrative that somewhat eschews orthodox approaches to temporality in archaeology (Ingold 1993). While we have attempted to provide enough information to offer a general sense of cultural history, the temporality of the narrative is non-linear in places (Ingold 2016). The idea is to represent these islandscapes in terms of the way they might be experienced in place, since features from ancient and recent histories co-occur. We hang the narrative off the history of Cook's initial impressions of three islands in Vanuatu: Tanna, Erromango, and Aniwa (see Figure 3 below), then expand

James L. Flexner
University of Sydney
(Corresponding author)

Stuart Bedford
College of Asia-Pacific
The Australian National University and
Max Planck Institute for the Science of Human History

Frederique Valentin
Centre National de la Recherche Scientifique de France (UMR 8068)
MSH Mondes à Nanterre

In: Brysbaert, A., Vikatou, I. and Pakkanen, J. (eds) 2022. *Shaping Cultural Landscapes. Connecting Agriculture, Crafts, Construction, Transport, and Resilience Strategies*. Leiden: Sidestone Press, pp. 117-132.

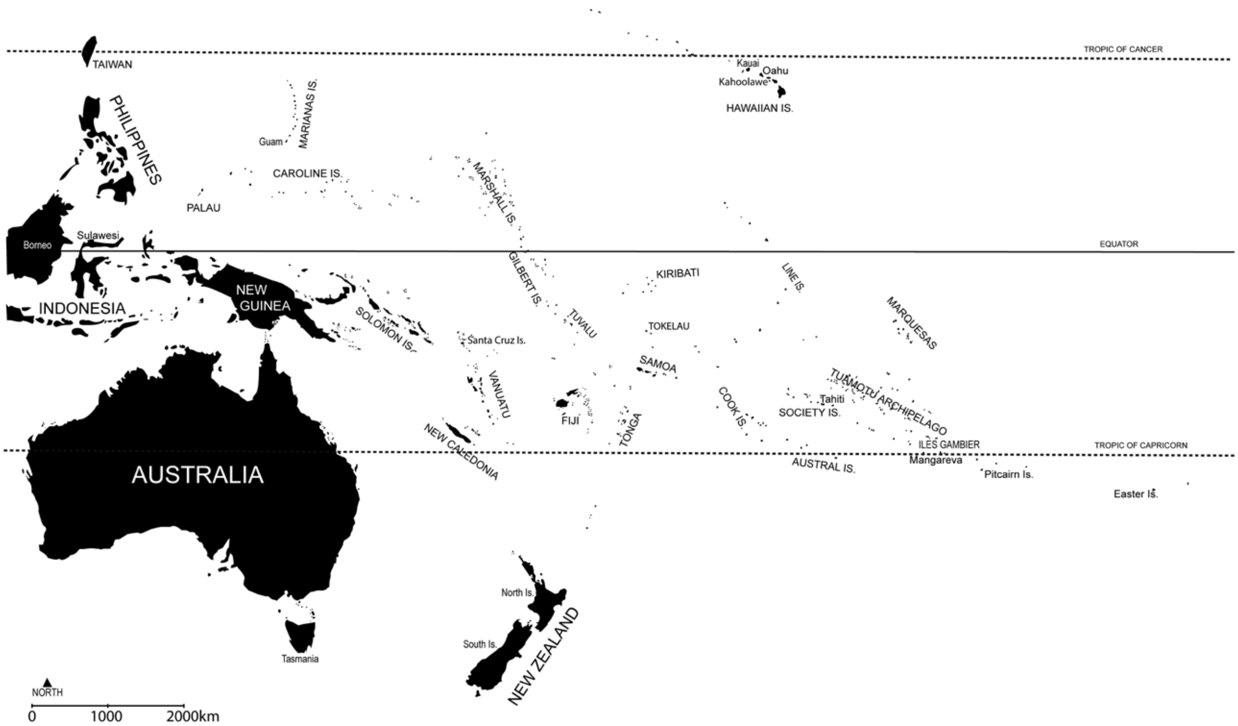

Figure 1. Map of Oceania, featuring the names of major island groups (image source: Flexner).

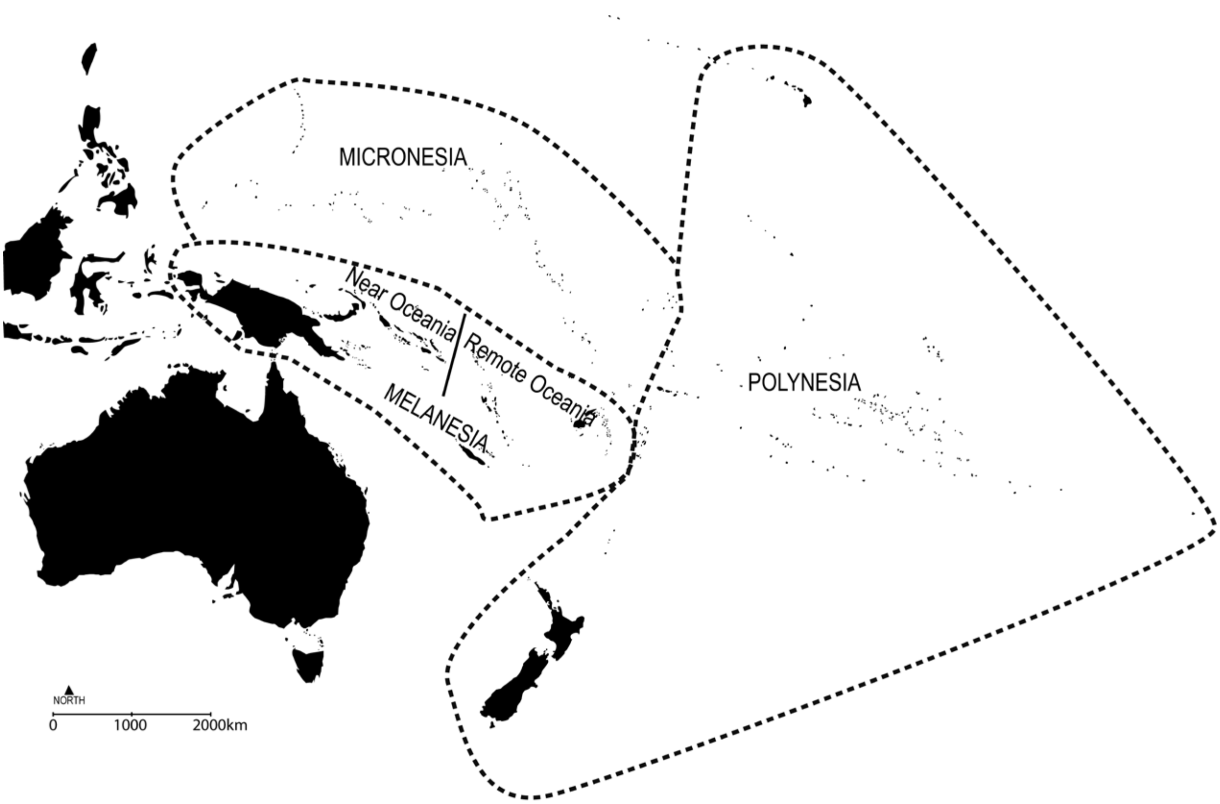

Figure 2. Dumont D'Urville's 19th century tripartite division of subregions in Oceania (image source: Flexner).

across time and space to encompass information from history, ethnography, and archaeology. We collected the archaeological evidence during surveys of these islands from 2016-2019 (note much of the radiocarbon chronology is currently unpublished, though see Flexner et al. 2018a). While we are representing a place that is not 'home' for us, it is a place we have inhabited for longer and shorter periods of time over a span of years. Though we write as outsiders, our archaeological experience offers a nonetheless distinctive perspective on the deep history of this cluster of small islands lying in the immense blue of the Pacific Ocean.

1.2. Defining Oceania

The Western tradition of Pacific geography owes much to the British navigator James Cook. Cook's third and final voyage (1776-1780) ended with his death and sacrifice on the *heiau* (temple) in Kealakekua Bay where he had been so warmly welcomed only weeks before (Sahlins 1985: 104-135). After the completion of this circumnavigation the cartographic view of Oceania was reasonably complete. Aided by advances in navigation techniques and equipment, not least the chronometer that allowed for accurate tracking of longitudinal locations (Sobel 1995), Cook and the navigators who preceded and followed him (Beaglehole 1966; Rigby et al. 2005) charted the locations of the thousands of islands spread across roughly one third of the Earth's surface (Figure 1).

Not content to simply know the locations of islands and their inhabitants, Europeans subsequently imposed boundaries and divisions for the purposes of knowledge, religious conversion, and political rivalry. One of the key boundary-making acts was the creation of the geographic spaces of Polynesia, Micronesia, and Melanesia proposed by the French naturalist and navigator Dumont D'Urville in 1832 in 'Sur les îles du Grand Océan', published in the *Bulletin de la Société de Géographie* (Figure 2; see Clark 2003). Subsequent scholarship has problematised the boundaries and definitions imposed by Dumont D'Urville, and yet these lines across vast swathes of ocean remain remarkably persistent (e.g., Flexner and Leclerc 2019: 1-2).

Polynesia, the sea of many islands, has been shown to hold together reasonably well, representing a 'phyletic unit' of related peoples and cultures (Kirch and Green 1987; 2001). Micronesia, the sea of little lands, makes sense to some extent geographically. It is largely composed of low-lying atolls and islands with very small surface areas. However, the lumping together of Micronesia's small islands results in a flattening of deep history and cultural diversity (Rainbird 2004). Melanesia is the most problematic of the three, as Dumont D'Urville characterised the 'dark islands' by the skin colour and, following the racist logic of the time, 'savagery' of their inhabitants. While the term is still used as a geographical heuristic, it is generally agreed that the original definition not only needs to be rejected, but masks what is in reality one of the world's most remarkable concentrations of cultural and linguistic diversity (Flexner and Leclerc 2019). Adding another layer of complication to these spatial definitions are the Polynesian Outliers: those islands located outside of the great triangle comprising Polynesia, with Hawaii, Rapa Nui (Easter Island), and Aotearoa (New Zealand) at the vertices, but speaking languages from the same family (Kirch 1984; Feinberg and Scaglion 2012).

Much has been written about Western cartography's 'god trick' (Haraway 1988), providing the illusion of simultaneous and apparently objective views from everywhere and nowhere. The map of the Pacific, an apparently straightforward representation of the scattering of small lands in an enormous ocean, usually represented as empty space, lacks the textures of millennia of human and non-human movements, interactions, beliefs, practices, and stories scattered through and across the waves (Hau'ofa 1993). To accept this image uncritically is to ignore the relatively recent politics of the Western cartographic representation of Oceanic space (Douglas 2018; Hanlon 2018).

What we seek to do here is to descend to a much smaller stretch of islands and sea, focusing on the islands and adjacent seascapes of Tanna, Futuna, and Aniwa in Southern Vanuatu, but also making reference to the intervisible islands of Erromango to the north and Aneityum to the south (for the location of Vanuatu see Figure 1, and Figure 3 below for the detailed map of the southern islands). Over a period of three millennia, spanning the first exploration and colonisation, through to the present, people and other non-human actors created and re-forged the islandscapes of this area to suit their biological, social, and spiritual purposes.

Pacific archaeology has a rich narrative tradition of synthesising sea, land, and time that has deepened our understanding of island life across millenia (e.g., Golson 1972; Gosden and Webb 1994; Kirch and Green 2001; Erlandson and Fitzpatrick 2006; Carson and Athens 2007; Urwin 2019). To encompass the islandscapes of Southern Vanuatu, we draw on the existing ethnographic and historical records, as well as decades of archaeological research that tracks the material traces of island life through space and time (Shutler et al. 2002; Flexner et al. 2018a). We of course do not and cannot claim an insider's perspective on such a life, though we do draw on our own experiences working and living in these island worlds. The narrative that follows is a move towards expressing archaeological knowledge through what Ballard (2014) has called 'Oceanic historicities', those parts of island connections between past and present not easily translated into Western academic rhetoric. We are visitors to rather than inhabitants of these islands, yet as Dening's

(1980; 1988; 2004) historical and anthropological work has shown, this kind of liminality can provide a critical space for allowing new narratives about islands to emerge. The metaphorical and actual space of the beach, ever-shifting, always in motion, an ambiguous place of comings and goings of many sorts, is an especially productive place in this regard. 'From a beach, it is possible to see beyond one's horizons. Beaches breed expansiveness' (Dening 2004: 19). Beaches promote thinking that encompasses and moves beyond received discourses to think across culture, space, and time in ways that expands the realm of possibility for the islands we study, and often, for the continents from which we view them.

1.3. 3,000 years of settlement and interaction in Southern Vanuatu

Southern Vanuatu is comprised of five islands located in the 'southern Melanesia' interaction sphere (see Spriggs 1986; Sand 1999), featuring close connections with both Polynesia to the east and New Caledonia to the west (Figure 3). The region of southern Vanuatu was initially settled approximately 3,000 years ago by Oceanic navigators from the Lapita Cultural Complex (see Green 1991). Lapita people and their Oceanic descendants were master navigators and sailors who moved between the islands of the Pacific systematically and persistently. We do not know exactly what a Lapita canoe looked like. The descendant forms include outrigger or double-hulled canoes with lateen or sprit sails documented historically (Haddon and Hornell 1938), which provides a sense of the ancestral form (Doran 1981). Polynesian linguistics allow us to reconstruct a vocabulary of terms for canoe parts and cordage, as well as Oceanic navigation involving use of stars, currents, and weather patterns (Kirch and Green 2001: 106-107, 196-198).

Lapita people made a distinctive dentate-stamped pottery, which is named after the place on the Koné peninsula in New Caledonia where the pottery was first formally defined and dated in the 1950s (Sand and Kirch 2002). Decorated Lapita vessels as well as contemporaneous plain sherds are found throughout Vanuatu. Evidence for interisland trade is found in temper that shows some vessels were made with sediments from other islands, including those in New Caledonia some 400 km distant (Bedford 2006; Dickinson et al. 2013). Colonisation in Vanuatu was followed by rapid regionalisation. By 2600 BP, this process can be identified in the pottery sequences found in midden mounds in Southern Vanuatu where distinctive fingernail decorated vessels have been found (Bedford 2006: 32-39, 85-104). Several centuries later, by about 2000 BP in the region, pottery was abandoned altogether (Flexner et al. 2018a: 260). Presumably this was followed by an elaboration of other forms of material culture, though with a few exceptions to be seen below, much of this would have been made of organic materials in wood, leaves, bark, and fibre that does not preserve archaeologically.

Microscopic evidence in the form of pollen, starch grains, phytoliths (the silicate fossils of plant cell walls), and even sponge spicules and diatoms speak to the transformation of island environments in Southern Vanuatu by human settlers and their commensals throughout 3,000 years of human occupation (Horrocks 2020). Evidence speaks to widespread burning to maintain patchwork landscapes of rotating garden plots that were cleared, planted, harvested, then left fallow to restore their fertility (see Bonnemaison 1991). Below we go into greater depth regarding the ways that each island nonetheless followed its own pathway to agricultural productivity. From the first moments of occupation people have harvested the resources of deep sea, reef, and shoreline, gathering fish and shellfish as sources of protein alongside their chickens and pigs. Over time, the human population increased, and this is reflected by an apparent intensification of landscape management roughly 1,000 years ago.

Along with the population boom within a few centuries of this period beginning 1,000 years ago, a new wave of visitors sailed to Southern Vanuatu over the sea from the east. The incursion of these people who we now call Polynesians, most likely from what is today Tonga, Samoa, or nearby islands such as Wallis and Futuna (note the Western Polynesian toponym duplicated in southern Vanuatu), brought new languages, material culture, and ideas to the region. These contacts resulted in the formation of the Polynesian Outliers of Futuna and Aniwa, but they also had reverberations in the larger neighbouring islands (Lynch 1996; Flexner et al. 2019a; Zinger et al. 2020).

With the arrival of Europeans beginning in the 18th century, and perhaps earlier (there may have been indirect contacts resulting from a Spanish incursion further north to Espiritu Santo in the 1600s; Flexner et al. 2016a), island populations collapsed with the introduction of foreign pathogens (Spriggs 2007). Islands that were once almost entirely cultivated reverted to tropical rainforest, and the remaining populations concentrated into a smaller number of settlements, often along the coast, and often with missionary encouragement. This settlement pattern largely persists until the present, though populations are rapidly expanding again. Gardens long left abandoned are re-opened. Kava drinking grounds not used in over a century on Tanna, and on the neighbouring islands, are once again places where the chiefly brew made from the root of the *Piper methysticum* plant is consumed as society dissolves and is reassembled each night (Brunton 1979; see below).

The first Europeans to visit southern Vanuatu sailed with Cook in 1774. Sandalwooders were the next group of visitors who came from many parts of the globe exploiting

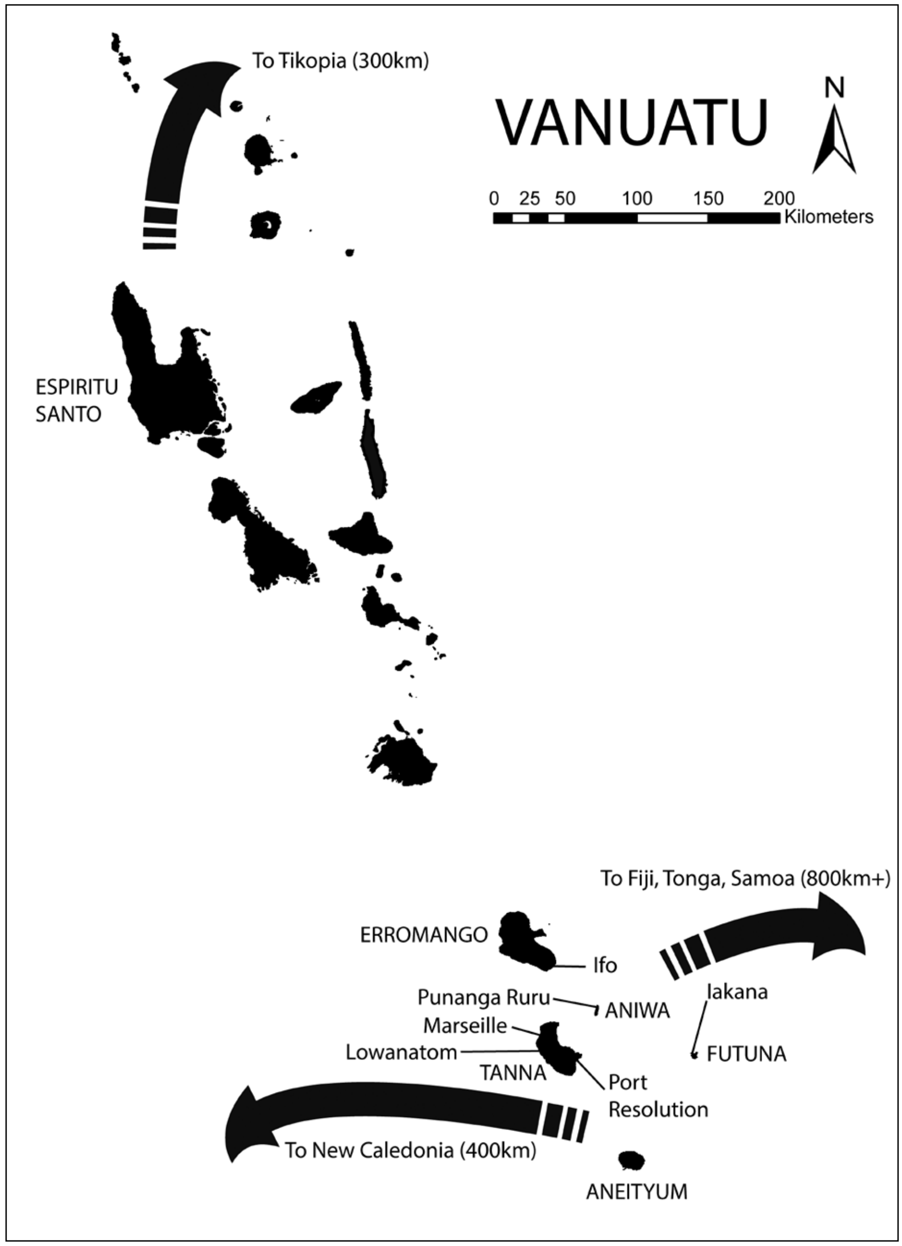

Figure 3. Map of Vanuatu highlighting key islands and locations mentioned in the text (image source: Vanuatu Department of Lands adapted by Flexner).

the islands' resources from the 1820s through to the 1840s. It was a period fraught with misunderstanding, conflict and introduced diseases (Shineberg 1967). By the 1840s the islands were hosting Presbyterian missionaries, themselves descendants of maritime ancestors from Scotland and Lower British North America (today Canada's Maritime Provinces), along with the Polynesian catechists who often preceded them (Flexner 2016; Zubrzycka et al. 2018). These encounters with outsiders were always marked by cultural misunderstanding on both sides of the beach, and sometimes ended in violence (see Adams 1984).

By the end of the 19th century, missionary presence was waning as Church matters could increasingly be left in indigenous hands. The missionary shadow colours much of subsequent ethnographic knowledge about southern Vanuatu, since the islands became heavily Christianised and many accounts draw heavily on missionary ethnohistory. These sources are essential to understanding a region that has changed immensely in the last 150 years but must also be read critically (Douglas 2001). The 20th century was nonetheless a continuous period of local people negotiating, accommodating, and adapting to various outsiders and their notions of modernity. The first archaeologists visited Southern Vanuatu in the 1960s. Our own beach crossings into Southern Vanuatu officially begin in 2016, though all of us have done fieldwork in the region for years or even decades before that.

As part of our narrative from the beach, we approach each island from a single entry in Cook's diary account of his 1774 navigation through the islands of Southern Vanuatu (Beaglehole 1969: 474-530) before expanding the narrative to encompass the fullness of island histories in Tanna, Aniwa, and Futuna. Cook is always a tricky figure in Pacific history. He is widely recognised as a genius for his navigational skills, cartographic efficacy, and scientific observations. Simultaneously he can be cast as villain because of his seeming inability to exercise restraint with firearms when events on the beach got out of hand (for various perspectives see, e.g., Beaglehole 1966: 229-315; Obeyesekere 1992; Sahlins 1995; Salmond 2003). Here we take Cook from his own words, spiralling outwards to how his ships might have appeared to the Tannese and their neighbours and take this as a starting point for understanding everything that came before and everything that came after, including our own archaeological investigations over 240 years after Cook and crew departed over the horizon.

Following an encounter on Erromango on 4 August 1774 that ended in violence, with Cook's sailors firing upon and killing several islanders, the *Resolution* and *Adventure* sailed to the south. During the night and early morning of the 5th of August 1774, Cook sighted the three islands that are the core places in this narrative, providing the quotations from his diary that open our discussion of each island below (Beaglehole 1969: 481). Cook's notes on Futuna and Aniwa are limited and cursory, the islands were small and hardly worth a detour. Some centuries before, though, they had almost certainly hosted some of the most profound and dramatic cross-cultural contacts with sailors from Polynesia. On Tanna, Cook and crew spent several weeks based in the calm harbour at Port Resolution. Their encounters began peacefully, establishing trade and friendships with the local people. However, Cook and crew were forced to depart after increasing proximity with the islanders destabilised relationships, order, and discipline among the sailors, one of whom shot and killed a Tannese man, apparently unprovoked (Beaglehole 1969: 480-500). During this time the navigators certainly met some of the Futunese and Aniwans whose islands they had ignored along the way. These moments across the ship's gunwales and on the beach provide an entry point to the island worlds of Southern Vanuatu, with their ever-shifting rivalries, magical gardens and fisheries, and temporalities that fold past and future in on themselves in ways that defy European understandings.

2. The islands of southern Vanuatu

2.1. Tanna

> '…we now found that what we had taken for a common fire in the Night was a Volcano which threw up vast quantities of fire and smoak [sic.]' (Beaglehole 1969: 481).

Tanna (Figure 3) is an island of magic and spirits. The greatest ancestral spirits inhabit the highest mountain peaks, one of which is the active volcano, Iasur. Tannese people today still leave a quiet offering, or younger people might chant a cheeky message as they pass the volcano. Cook and crew, drawn by scientific curiosity following the enlightenment mindset of their time, sought on several occasions to climb the ancestral peak while *Resolution* and *Adventure* lay in the harbour that now bears the name of the former ship. The navigators would proceed inland following local guides only to find themselves led in circles through the bush. It was too dangerous to allow the as-yet unidentified strangers, who might have been ancestors, ghosts, or devils, near such an important enspirited place (Flexner et al. 2018b: 259-260). Indeed, when Cook's crew were first allowed ashore in 1774 (Beaglehole 1969: 462), they were probably greeted as *ierehma*, ancestral spirits propitiated with an offering of food and hemmed in by a traditional fence of *ning* (wild cane).

The Tannese refer to the far future and distant past by the same term: *kwumwesin* (Lindstrom 2011: 146). When missionaries first began translating the bible into Tannese languages beginning in the 1860s, they settled upon *kwumwesin* as the term for God (Flexner 2016: 63) but it is probably more accurately translated as 'infinity' or 'expanse'. This is not to say the Tannese do not recognise historical change. People remember Cook's visit, which is encompassed in place names, stories, and songs (Flexner et al. 2016a: 214-215). The name Tanna itself is an artefact of encounter, coming from a literal response to Johann Forster's gestured query of what people called the ground they stand on rather than, as Forster assumed, the name of the island (Flexner 2016: 60). People remember when the first missionaries arrived beginning in the 1840s, and the native converts who preceded them (Flexner 2014: 12-20). They remember when the demigod Mwatiktiki came over the seas long before any Europeans visited the islands to capture the neighbouring islands in his net (Flexner 2022). Tannese people nonetheless believe their island is the centre of the world, the origin point of all things and the place where all things come back eventually. Echoes of this can be seen in the contemporary John Frum 'cargo cult', a syncretic tradition that uses a combination of traditional dance, spirits, and invented military ritual to attempt to bring the world's wealth back to the island after it was 'discovered' by the Tannese during World War II (see Lindstrom 1993).

Tanna's enspirited cultural islandscape is organised through a network of kava drinking and dancing grounds, called *imawarim* in the Nafé language of the south of the island and *yimwayim* in the West Tanna language area. These sacred spaces consist of large open areas framed by enormous, and in many cases ancient, *nepuk* (banyan trees). The roots of the trees can be woven together to form hammock-like structures and enclosures to cordon off particular areas. These can form private spaces for young mens' circumcision ceremonies, for example. During particular times of year, such as the *Nekowiar* dance ceremony, or the *Nieri* pig exchanges, these are public spaces, gathering places for men, women, and children to express and perform their sense of community (see Brunton 1989; Bonnemaison 1994).

For most of the year, though, the *imwarim* are men's spaces, primarily used during the evenings for the consumption of kava. Each afternoon as the sun sets, men who are related via ties of kinship, place, or society gather to drink extremely strong doses of kava prepared by chewing the root, spitting the masticated pulp onto a leaf, and straining with water through a palm husk. The brew is served in sometimes massive coconut shells, with the goal of providing a dizzying intoxication followed by a deep sleep. The work of kava is to open people to the voices of ancestors and spirits, who guide people to the right pathways for life on the island. Brunton (1979) observed that this dissolution of consciousness matches the 'dissolution of society' as male obligations and alliances shifted constantly through the social space of the *imwarim* and its links to familial hamlets and magical gardens.

Indigenous accounts of Tanna's past, like all knowledge claims, are contested and political, as authority will rest with the senior person who is agreed to know the 'real' or 'best' version of the story (Lindstrom 1990).

To encompass our understanding of Tanna, we draw briefly on outsider accounts (Guiart 1956; Bonnemaison 1994: 105-182; Lindstrom 2020), as well as stories whispered over shells of kava on the *imwarim*. Like all ethnographic knowledge these stories, as we express them, sit within that liminal and hard to define space between emic and etic, but should give a sense of local historicity (Ballard 2014). Early in Tanna's history in the time of *kwumwesin*, when the island was bare, stones (*kapiel*) were deposited on the island. At first, the stones rolled across and around the island, leaving behind some of the more prominent geographical features. Eventually, these stones settled down, creating a sacred geography that concentrated power in particular places. Once the stones settled, the first men arrived on the island. They were later joined by the first women, a mythical structure that makes sense since marriage arrangements are normally patrilocal in Tanna and elsewhere in southern Vanuatu, even if lineages and land titles are often passed through the matriline via the father's sister (Capell 1958: 8).

Over time, people divided into territorial groups connected by kinship and history. The Tannese land divisions are labelled 'canoes', *neteta* in the Nafé language and *niko* in the west Tanna languages, reflecting the inherently maritime identities of islanders even though some of these divisions are landlocked and dozens of kilometers from the beach. Each district had hereditary chiefs as well as leaders who gained their titles through accomplishment of great acts. Chiefly titles follow the pattern of the 'Heroic I', that is to inherit or achieve a title is also to inherit and achieve the great deeds of all previous holders of that title (Lindstrom 2011). Types of chief abounded: the *yeremanu* who had the right to wear the ornament of *kweriya* (hawk) feathers; the *yeni neteta* who was the leader of the district (literally 'the chief who steers the canoe'); the *yeni en dete* who spoke for the district, and many others. Yet no chief's authority reached above the level of the land canoe, and even within a district no one person had anything approaching absolute power. Tanna was fractious, reflected in the approximately 120 land divisions on the large island (the number fluctuates because territorial boundaries are still disputed) as opposed to six or seven on the other large islands in Southern Vanuatu. Contributing to the complexity of this situation, the men of each district were divided into two moieties: *Numrukuen*, consisting of clever and subtle magicians, and *Koyometa*, aggressive warriors. The links between *imwarim* representing each moiety overlay and further expanded the territorial meshwork of Tannese chiefly rivalries and political competition (Bonnemaison 1994).

Chiefly authority paralleled and sometimes overlapped with magical efficacy. The *Tupunas*, powerful and wise sorcerers with the power to control magic stones, made the crops grow and encouraged fish to gather and spawn at particular times of year. But they could also control stones whose power was of a darker nature, causing illness and death, and even summoning devastating cyclones to ruin the crops of rivals and enemies. Nor did the spirits of the dead, *ierehma*, always depart their island world, adding another level of hazard and a need for propitiation and management carried out by yet another class of magical specialists (Humphreys 1926; Guiart 1956; Bonnemaison 1994).

It has been suggested that Tanna's arts lay less in the material world, more in dance, speech, and song (Lindstrom 1996), which might be cause for pessimism as an archaeological islandscape. As it turns out, Tanna's archaeology is abundant, and something we are only beginning to uncover. The earliest archaeological sites found so far are in the north and northwestern part

Figure 4. a) The *yimwayim* of Loukanuo (top; image source: Flexner); b) some of the beads recovered from the site (bottom; image source: Flexner).

of the island, an area of uplifted coral limestone full of rockshelters, cliffs, and crevices. In the north, Lowanpakel, a site of magical significance associated with a local origin story, revealed pottery now dated to almost 2,800 cal BP (Flexner et al. 2018a: 258-259). Another site with a series of midden mounds is located close to the sea at Marseille, northwest Tanna. It resembles sites at Ifo and Ponamla on the southeast and north coast, respectively, of intervisible Erromango Island (see Bedford 2006: 32-39). The mounded site at Marseille dates to c. 2600-2800 cal BP. Pottery from the sites includes the distinctive fingernail impressed pottery representing an identical decoration to the pottery from Ifo and Ponamla.

Archaeologists would identify an origin over the seas for Tanna's first people, the Lapita migrants, who left the Bismarck archipelago some 3,200 years ago and navigated through the Solomon Islands and on to Vanuatu (see Bedford and Spriggs 2019). This is at odds with origin stories that point to a local beginning for human history. Yet the *kapiel* rolled not only around the island, but some sailed over the waves as well. A mobile beginning is thus not exclusive to one kind of history for Tanna: archaeological or indigenous.

In April 2015, during the devastating winds and rain of Tropical Cyclone Pam, a *nepuk* (banyan tree) was overturned at a *yimwayim* (kava drinking ground) called

Loukanuo at Lowanatom (Figure 4a). After the storm cleared, the village children noticed strange-looking shells in the root ball of the tree. Over time, as the tree rotted and was eventually burned as a safety hazard, the sediment from the root ball and the associated artefacts fell to the ground. We travelled to Lowanatom to excavate the site in 2019 following contact from a local schoolteacher who was curious about the finds. During our time on site, there happened to be a marriage exchange taking place on the *yimwayim*. On the surface and in the upper 10-20 cm of sediment, excavations recovered thousands of shell beads made from the spiral tops of *Conus* shells (Figure 4b). The beads are in various stages of manufacture from rough blanks to polished discs. Radiocarbon dating of two of the bead blanks returned basically identical ages of 1250 cal BP. Excavation down to over a meter below the surface eventually revealed tin cans and crisp wrappers: the modern detritus of snacks eaten to wash the bad taste of kava from the mouth after drinking. In a sense this is a classic case of 'reverse stratigraphy', a straightforward taphonomic process resulting from a dramatic weather event in a specific place. But this is not just any place, it is Tanna, an island where the upside-down temporality intersects with the sacred space of the *yimwayim* and the everlasting return to *kwumwesin*.

2.2. Futuna

> 'At daybreak we discover'd a high table land bearing EBS…' (Beaglehole 1969: 481).

Futuna (Figure 3) is a steep extinct volcanic cone draped in the fossil remains of ancient coral reefs. Sometimes precipitious slopes raise an island only 5 km in diameter over 650 m above sea level. The island has a small and uneven living reef, then a narrow coastal plain called the *romara*, the steep slopes now covered by agricultural terracing called *ropae*, and the high central plateau or *tatafu*. The island is divided into eight wedge-shaped districts radiating from *tatafu* to the sea. The Futunese, like their neighbours, used the term for canoe (*vaka*) to refer to community, but unlike on Tanna, Erromango, or Aneityum, the two canoes on Futuna correspond not to territorial divisions, but to the two moieties. *Kaviameta* and *Namruken* were present in each of the land divisions, with each village having separate *marae* (sacred space) for each of the *vaka* (Keller and Kuautonga 2007: 45-47, 61).

Futunese society can be encompassed around two metaphors. The first is the distinction between *hkano*, the essence of a thing, and *ata*, its shadow or reflection in the world. '*Ata* are gifts of the supernatural offering magical connections to living *hkano*' (Keller and Kuautonga 2007: 5). The other is *ta uka*, the braided lines connecting the knowledge needed to manage weather, wind, sea, trees, crops, pigs, sorcery, sickness, health, marine life, people, and the island itself (Keller and Kuautonga 2007: 61-63). Despite using Polynesian naming conventions, the chiefly system that carries out the day-to-day work of *ta uka* quite closely resembles the Tannese system. District chiefs are called *teriki*, village headmen *tagata sore* (literally 'big man'). In addition to *teriki*, there were the *tanata tapu*, the magical specialists who could tap into the relevant *ata* to control the various elements of *ta uka*. At times the authority of the *tanata tapu* would usurp that of *teriki* (Capell 1958: 3-5). The open spaces for dancing and drinking kava are *marae*, but these Polynesian terms for leadership, authority, and sacred space are combined with an adherence to the moiety system of *Kaviameta* and *Namruken* of neighbouring Tanna.

Futunese people have their body, which is *hkano* and the spirit *ata. Ata* can be disembodied temporarily during sleep or unconsciousness. The latter state can be inflicted by dangerous *tagata tapu* with the relevant knowledge. At death, the link between *hkano* and *ata* was severed permanently. The *ata* would hang around the mortal plane for a short period before passing on to the place of the ancestors, an underworld called *'i o atua*. Like the *ierehma*, wandering *ata* were a cause for anxiety and were to be avoided if possible and propitiated if necessary (Capell 1958: 35-37). Besides spirits, the demigod Majihjiki (the Aniwa-Futuna language variation on Mwatiktiki) and sea snake deity Tagaro represent the foremost of the ancestral beings, *atua* (Capell 1958: 39). Majihjiki is an especially prominent culture hero. He saved the island from catastrophe by defeating a dangerous man-eating monster. It is also through Majihjiki that the Futunese draw explicit links to Tonga, where the demigod travelled in pursuit of his Tongan wife who had been confined to, then escaped from Futuna. Majihjiki's sister had a daughter, Sina, who lived in Futuna in convent-like seclusion, in privilege and comfort. Majihjiki's youngest son, Jiverau, was able to pass through the concentric fences that protected Sina. Like Majihjiki and his wives, the young couple disappeared over the ocean waves to Tongatapu (Keller and Kuautonga 2007: 98-186).

Tales of Majihjiki involve magic and supernatural happenings of all sorts, but they also may provide hints at some of the historical events that resulted in the formation of a less hierarchical society in the Polynesian Outlier. It has been suggested that Outlier islands like Tikopia represent the expansion of the Tongan Maritime Empire, with the installation of high chiefly lineages in new island frontiers (Firth 1961; Kirch and Yen 1982: 341-343; McCoy et al. 2020). In Futunese tales, the Tongan lineage is never fully established. Majihjihki sails over the waves in search of his bride who had chafed at being confined to the small island. Sina travels with Jiverau, and with her the royal lineage disappears from Futuna. It is possible that the

Figure 5. Mapping the irrigated terraces on the steep slopes of Iakana (image source: Flexner).

geographic remoteness and small size of Futuna, combined with the assertiveness of the neighbouring Tannese, meant that the latter island was a more direct influence on local politics and communities than the distant chiefs of Tonga (see Flexner 2021: 209-210).

Archaeological remains add a distinctive thread to Futuna's ethnogeography, encompassing space and time from a distinctive, albeit decidedly etic, perspective (Flexner et al. 2018a: 250-252, 256-257). The evidence for initial occupation on Futuna is very limited, but the island was at least visited by pottery producers by about 2,800 BP. Most of the evidence recovered so far dates to the last 1,000 years, however. As a raised limestone island Futuna features numerous rockshelters, caves, and crevasses. The Futunese buried their dead in these spaces beginning at least 1,000 years ago (Shutler et al. 2002: 196-200; Valentin et al. 2011: 58-59), perhaps as a way of containing wayward *ata*. Roughly 300-200 years ago, possibly as the population suffered the first effects of mass deaths from introduced European diseases, bodies were deposited on the shelter surfaces and sometimes fenced in with stone walls and cairns (Valentin et al. 2022).

The Futunese were master builders in dry-stacked stone. They covered the island in terraces, canals, roads, and walls that encompassed garden plots, village spaces, and *marae*. The terraces focus on rainfed agriculture on the leeward (dry) north and west of the island, with irrigated systems focused on producing taro in the windward (wet) south and east (Flexner et al. 2018a: 251). Agricultural expansion and intensification began roughly 1000 BP when the earliest terraces were constructed in the lower part of the island's steep slopes (Figure 5). By roughly 400 BP, the entire outside of the island was covered in terraces, right up to the highest points over 600m above the sea.

The Tannese generally eschewed construction in stone, with the exception of one site on the far south of the island (see Bedford 2019; Flexner et al. 2016b). The island of Aneityum did see a similar history of building massive systems of canals and irrigated terraces, primarily for the growing of crops (Spriggs 1981; 1986). The expansion of these systems and subsequent need to manage and control water and soils has been interpreted as a causal factor in the emergence of a more hierarchical, territorial chiefly system on Aneityum (Earle and Spriggs 2015: 523). Futuna's history and society do not follow the trajectories of neighbouring islands in straightforward ways. The Futunese invested in massive infrastructure to develop the agricultural system of the island. But this did not lead to an increase in hierarchy on the island. Quite the opposite, the island retained its horizontal social organisation. It is possible that the story of Majijihiki and the monster (see above) is in fact an allegory for managing the aspirations of self-aggrandising chiefs against needing to maintain a balance in the social order.

One reason for the unique nature of Futunese history might relate to the specific context of Futuna being relatively geographically remote. Not only is the island more distant from its neighbours than they are from each other, but it is also separated by a deep-water trench (Neef and McCullough 2001: 805-807). The Futuna Trench features unpredictable and dangerous currents, and canoes sailing between Futuna and other southern Vanuatu islands were liable to be blown off course, often with disastrous consequences. Though the Futunese mastered these waters they could be more challenging for those from the neighbouring, less isolated islands. While island geographies do not entirely determine the courses of island histories, the setting of Futuna and its rugged, steep topography contribute to the structure of life on this small island through time, often self-deprecatingly and ironically referred to by its inhabitants as 'Fatuana' ('just a rock'; Keller and Kuautonga 2007: 41). The phrase was apparently uttered to Forster as he misnamed yet another Southern Vanuatu island during Cook's voyage and has remained since then.

2.3. Aniwa

> '…and a smal [sic.] low isle bearing NNE which we had passed in the night without seeing it' (Beaglehole 1969: 481).

Aniwa (Figure 3) is a spit of uplifted coral, approximately 7.5 km long from north to south and less than 1.5 km across, with a high point only 42 m above sea level. As a result, it would be easy to sail past, even from a relatively small distance. Even in the 1960s anthropologists lamented over how little was known about the island's culture (Guiart 1961). The first archaeological excavations seeking to understand a deeper past were not carried out until 2016 (Flexner et al. 2018a: 253-256). Yet it is doubtful that Cook's ships went unremarked by the Aniwans as they sailed past. Not only would they have been visible if even small lights were lit during the night passage, but Aniwans would likely have sailed quickly to their Tannese neighbours upon receiving news of the strange arrivals. Aniwa is located less than 30 km from the much larger island of Tanna, so it is not surprising that the two islands are closely connected by ties of kinship and exchange. This is true in spite of the marked linguistic difference between the Polynesian Outlier dialect of Aniwa and the completely unrelated languages from Tanna. Multi-lingualism was likely to have been a key adaptive strategy in the past and remains so today with most Aniwans being able to speak a Tannese language.

Regardless of its small stature, Aniwa was nonetheless a central island for its inhabitants, who believed Majihjiki was in the midst of drawing in the larger neighbouring islands to help Aniwa grow when the sennet cords to his net snapped, leaving the small atoll stranded. Standing on Aniwa in a place where his footprint can still be seen, Majihjiki had thrown his net over Lowanpakel, currently the site of earliest known occupation on Tanna. Majihjiki was apparently a force for connection to neighbouring islands, striking a volcano, then located on Aniwa and called Tasoata, so hard that it retreated to Tanna where it became Iasur. The lack of perennial running water sources on Aniwa is explained by Majihjiki stopping up a water hole while drinking kava, diverting the flow to Aneityum (Guiart 1961: 50). Majihjiki was not the only one who forged such connections. Two magic stones, Faturere and Iuwip were arguing over who got the best seat in Futuna's plateau. Iuwip tricked Faturere into flying to Aniwa, where the stone remains on a high promontory overlooking the sea and longing for its home today (Flexner et al. 2018a: 250).

Spirits and ancestors abound in places on Aniwa as on its neighbours. There was a kind of 'totemism' in Aniwa, with the sea snake, emblem of the Polynesian deity Tagaro, appearing as one of the main ancestral beings (Capell 1958: 52). Another totem is *ruru*, an owl. *Ruru* belongs to one of our main collaborators in Aniwa. At a cave on Aniwa's west coast called *Punanga Ruru*, excavation of a small test pit recovered the remains of over 600 years of owl meals, hinting at some antiquity for the activities of the birds both as organisms and as totems. In the fine mesh sieve, we recovered thousands of bones from one of the main Polynesian commensals, *Rattus exulans*, the Pacific rat. In the upper levels there were a few bones from *Rattus norvegicus*, an 18th or 19th century introduction. Ongoing waves of colonisation brought not only people but their sometimes-unintended commensals to the island.

Aniwa is divided into two primary land divisions: Sura (or Surama) to the north, and Iafatu (or Iefotuma) to the south (see Capell 1958: 1 for alternative names). As on Futuna and Aniwa, the Tannese moiety system was present as a structuring element of chiefly society. As a likely reflection of this, villages were laid out as a dual structure with open space dividing groups of houses. In contemporary Aniwa, this duality is less marked, and currently social divisions are more visible between fervent converts to Tanna's John Frum cult (the 'cargo cult' that uses traditional dance, song, and syncretic rituals to call on the wealth of the outside world; see above) and those who follow the more 'traditional' Christian churches (increasingly the founding Presbyterian Church finds itself competing with various evangelical rivals).

As a low-lying island with a limestone substrate and no perennial running water, Aniwa has a relatively limited agricultural potential. Gardens were still productive, enough that a surplus allowed Aniwan chiefs to raise pigs for various exchanges, but they were nowhere near the productivity found on neighbouring islands. Crop shortages occurred periodically (Capell 1958: 20-21). Like many Pacific Islanders in such situations, the Aniwans turned to the bounty of the sea to provide nourishment and resources. Fish and shellfish featured heavily in Aniwan diets. After hearing of our discovery of a pearl shell fishhook from a deep stratigraphic layer in one of our test pits, over 2 m below the surface and by stratigraphic association at least 2,000 years old, a village priest remarked, '*fis hemi mit blong mifala*' ('fish is our meat'). Aniwa features a large and productive northern lagoon, which is used as a base for seasonal campsites (Figure 6). Most of the year the lagoon is *tabu* and not to be harvested,

Figure 6. View over the Aniwa lagoon (image source: Flexner).

but at the appointed time people congregate to feast on fish, shellfish, and crustaceans during a period of up to several months depending on the bounty of the season. Excavations at Punanga Imanu ('bird cave'), adjacent to the lagoon, revealed that this pattern of seasonal feasting has been consistent for a period of at least 800 years.

Garden soils were augmented to some degree by the volcanic ash fall from the Iasur volcano on Tanna. Standing on the west coast of Aniwa, the active volcano is clearly visible on most days, and the roar of the eruption can often be heard above the crash of the ocean waves. Besides providing for the agricultural productivity of the island, Iasur is also contributing to the expanding size of Aniwa itself. Because of a process called lithospheric flexure, the weight of Iasur, as it grows, pushes Tanna so it tilts downwards to the south and east. This pressure on the seabed raises the neighbouring areas. Analysis of ancient coral terraces which have been dated using the uranium-thorium method suggests Aniwa has been rising at a rate of 10 cm per century since long before human arrival in south Vanuatu.

Lacking volcanic stone, the Aniwans were also forced to rely on neighbouring islands for basalt adzes and the oven stones that are critical to the local earth oven cuisine. Adzes could be produced using giant clam (*Tridacna* sp.) shells. The Aniwans made a facsimile of the throwing club known as *kawas* on Tanna and usually made of polished basalt, out of the fossil coral abundant on the island (see Flexner et al. 2019b: 416-417). As a marker of exchange, we have also recovered fragments of basalt *kawas* from excavations in Aniwa. There are certain things that simply cannot be replaced, and in those cases Aniwans drew on their relationships with neighbours. They strengthened these bonds through exchanges of crops, marine resources, mats, and via marriages and other alliances. Trade after all is not simply about obtaining necessities, it is also a basis for sociality and interconnection with the neighbouring islands in southern Vanuatu's microcosmic sea of islands.

3. Encompassing islandscapes

Over 20 years ago, island archaeologists expressed concerns that in spite of decades of significant research, their interests were perceived as marginal to the discipline as a whole, or at the least were not well understood by continent-centric scholarship (Broodbank 2000: 6-7). Island and coastal settlement were mistakenly seen as a relatively recent phenomenon, and one that contributed little to the 'important' discussions of human resource use, social complexity, and settled life from the point of view of archaeologies of the mainland (Erlandson and Fitzpatrick 2006). Currently, this perspective is changing. Facing a millennium where human experience will be shaped by environmental change not seen since the end of the last Ice Age, the idea of islands as critical to understanding the human past as well as its present and future has re-emerged in predominant narratives from within and outside the discipline (e.g., Chandler and Pugh 2018). Islands are now central for understanding everything from early human dispersals in the Pleistocene (e.g., Kealy et al. 2016) to the emergence of different forms of political economy (e.g., Kirch 2010; Earle and Spriggs 2015).

Yet the abstracted view from afar remains common in island archaeologies. Spriggs (2018) has noted that the kinds of maps and accompanying narratives produced to represent island colonisation and networks in Oceanic and Island Southeast Asian contexts is reminiscent of those presented by the early 20th century 'hyper-diffusionists' that many archaeologists claim to have relinquished to the history of the discipline. As a corrective to this kind of approach, we recommend the view from afar be supplemented with the view from either side of the beach, as well as the beach itself. This is not entirely a rejection of the cartographic viewpoint. Some kinds of distances and spatial relationships are most effectively represented in the form of the plan. But, the plan should not be confused with the phenomena it claims to represent. Rather, both perspectives can help to provide the complex and multi-varied experiences of place (Rodman 1992) as they were experienced and encompassed among island societies, past, present, and future.

In many ways, the process of encompassing appears to offer an atemporal kind of archaeological narrative, drifting as it does in and out of the present and across many time periods. It does not follow the conventional 'first, then next, and so on' approach to writing archaeology. While we agree there is a place for more orthodox narratives, we also perceive some value in occasionally trying something different (see also David et al. 2012; Bloch 2019; Urwin 2019). The kind of drifting narrative offered here is closer to the first-hand experience of Southern Vanuatu's islandscapes, where walking and sailing through island space in the present is also an evocation of recent and deeper histories, which themselves can collapse and fold into each other (see Bonnemaison 1994: 113; Flexner 2014). It is an encompassing of time and place, a forging of connections across land and sea that is an integral part of island life and all its attendant joys, pleasures, trials, and challenges. For archaeologists, this kind of narrative takes us away from the comfortable and conventional, but also allows for the expansiveness that Dening (2004: 19) identified as one of the great potentials of the perspective from the beach.

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After the Preclassic Collapse. A socio-environmental contextualization of the rise of Naachtun (Guatemala)

Julien Hiquet, Cyril Castanet, Lydie Dussol, Philippe Nondédéo, Marc Testé, Louise Purdue, Noémie Tomadini, Sandrine Grouard and Antoine Dorison

Julien Hiquet
UMR CNRS 8096 ArchAm

Cyril Castanet
UMR CNRS 8591 LGP

Lydie Dussol
UMR CNRS 7264 CEPAM

Philippe Nondédéo
UMR CNRS 8096 ArchAm

Marc Testé
UMR CNRS 8591 LGP

Louise Purdue
UMR CNRS 7264 CEPAM

Noémie Tomadini
UMR CNRS 7209 AASPE

Sandrine Grouard
UMR CNRS 7209 AASPE

Antoine Dorison
UMR CNRS 8096 ArchAm

1. Introduction

The Maya history of southern Mesoamerica's tropical lowlands is often used as a cautionary tale about the contemporaneous concern of societal collapse due to overuse of local resources (see, e.g., the concluding sentence in Hansen 1994: 323; Lentz and Hockaday 2009: 1350; Turner and Sabloff 2012: 13913; the Maya case is also used by Diamond in his 2005 best-seller on collapse). Many of the city-states of this brilliant, scientifically advanced civilization suffered at least two 'collapses', and there is a strong temptation to link those events to environmental changes at least partly induced by the overexploitation of natural resources for agriculture and cities. This is why many studies on Maya history have focused on the moment of collapse, or the decades that immediately preceded it (Abrams and Rue 1988; Seligson 2019).

This chapter focuses on a different stage of the developmental cycle of societies and explores the environmental impact of the growth of Naachtun, a Classic Lowland Maya city-state which emerged after the demise of the regional polities at the end of the Preclassic period (2000 BCE-150 CE). Our case study questions the existence of a conscious will to manage the environmental resources, linked to the memory of human-induced environmental crises. Did the Maya adapt their behaviour and maintained a balance between the necessary preservation of resources and the pressing need to gather numerous inhabitants in a monumental city to gain economic and political power? In other words, was the preservation of their environment a priority to the Maya, to the point they would avoid conspicuous and environmentally costly undertakings? We place a special emphasis on the monumental architecture at Naachtun and its induced construction effort, clearly at its heyday during the Early Classic period (150-550 CE). Public architecture growth is a key topic for the understanding of this particular moment of Maya history. Preclassic cities such as El Mirador and Nakbe were characterized by their monumental buildings, and some scholars have assumed that the overwhelming demand for natural and human resources it implied had been a major factor leading to their collapse. Not so far from these centres (15-20 km), the almost simultaneous rise of Naachtun at the beginning of the Classic period shed new lights on the circumstances and consequences of both rapid urbanization and population growth in a regional context of supposed resources exhaustion.

In: Brysbaert, A., Vikatou, I. and Pakkanen, J. (eds) 2022. *Shaping Cultural Landscapes. Connecting Agriculture, Crafts, Construction, Transport, and Resilience Strategies*. Leiden: Sidestone Press, pp. 133-152.

The first author's doctoral dissertation (Hiquet 2020) provided comprehensive estimates of the energetic cost of Early Classic monumental architecture at Naachtun as well as an estimate of its population across time and space. Together with paleoenvironment specialists, we compare the sequences obtained to assess the question of the impact of Naachtun's monumental development on the local environment and human and natural resource availability. One can ask whether any stress on the resource supply can be detected and how the Maya of Naachtun adapted their procurement strategy to meet these possible changes. To answer these questions, it is necessary to envision the situation at the scale of the whole Naachtun territory of subsistence, including its hinterland. In 2016, the Naachtun Archaeological Project obtained images and additional data from a LiDAR survey of 135 km² around Naachtun, provided by the Pacunam Lidar Initiative, which enabled us to identify not only secondary centres and residential areas, but also hydraulic features, quarries, terraces, fields, etc (Castanet et al. 2019; Nondédéo et al. in press). All these features are spread throughout the landscape, yet the question of their dating remains, and ground-truthing is necessary. Fieldworks were initiated in 2019 and need to be continued during the upcoming field seasons.

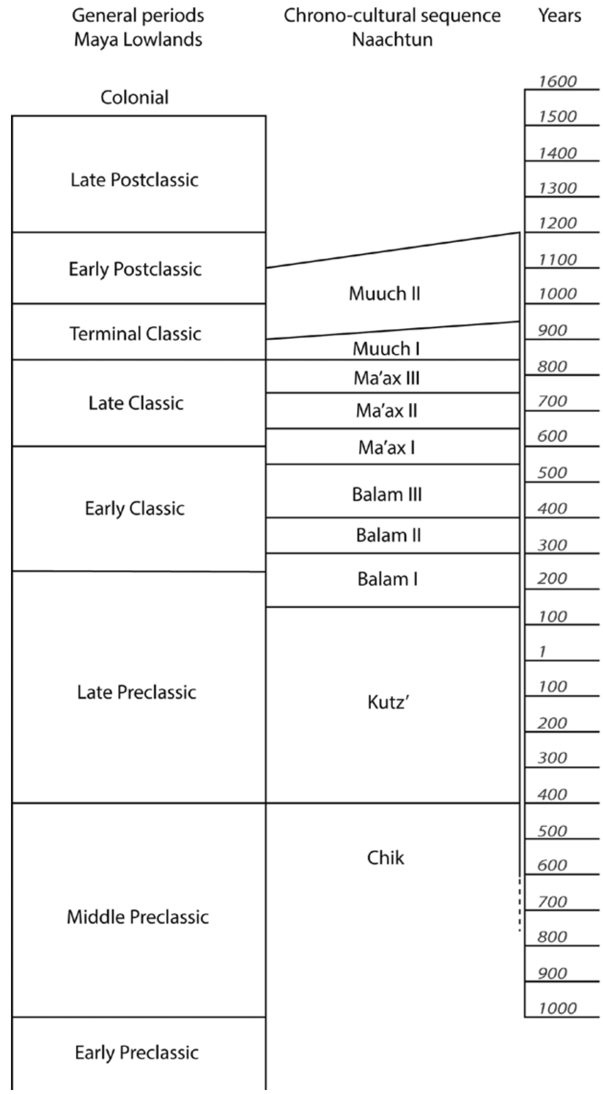


Figure 1. Chrono-cultural sequence of the Maya Lowlands and of Naachtun. The sub-phases of the Naachtun sequence are mainly based on ceramic analysis by Patiño-Contreras (2016) and Perla and Sion (2018).

1.1. The Late Preclassic context: a first Maya 'collapse'

The growth of Naachtun is particularly interesting because it started just after the so-called 'Preclassic collapse', a dramatic trend of regional upheaval in the heart of the central Maya Lowlands at the transition between the Late Preclassic and Early Classic periods (c. 150 CE, Figure 1). During the Middle and Late Preclassic periods, a system of huge, monumental cities had covered part of the Maya Lowlands. The best known of them is El Mirador, the giant capital at the hub of a network of long-distance causeways connecting those early cities across swamps, fields, and forests. Around 150 CE, this system collapsed and various Preclassic centres along with their hinterland were abandoned for a few centuries, both within and beyond the Mirador region (Hansen 1990: 216-221; 1994: 315; 2013: 260; Arnauld et al. 2004; Walker 2005; Wahl et al. 2007; Dunning et al. 2013; 2014). One of the aspects that best characterized the Late Preclassic period in the Mirador region was the monumentality of its buildings, on average well above the volumes and heights reached during the following periods. That is why some researchers have attributed the collapse to the environmental and human cost of this building programme (Hansen 1994; 2013; Hansen et al. 2002; Diamond 2005: 169). In their view, the carrying capacity of the local environment would have been overwhelmed, in particular by the ecological cost of lime production ubiquitous in this architecture, and the large demand on green woods for the pyres (Hansen et al. 2002; Schreiner 2002). This hypothesis remains controversial since others argue that lime production could be sustainable (Russel and Dahlin 2007; Wernecke 2008; Seligson 2019). This criticism focuses in particular on the will to stress the Maya's resilience and their undeniably fine knowledge of their environment, instead of insisting on their failure. Nevertheless, all these theories are based on case studies of a much smaller monumental scale than the Mirador region. It is likely, as Seligson et al. (2017: 133) recognize, that each region had its own experience of stress on resources.

The pertinence of the use of the term 'collapse' has been discussed, because not all the Maya cities suffered at this time (Dunning et al. 2014: 125). What is more, the overexploitation of resources remained putative and

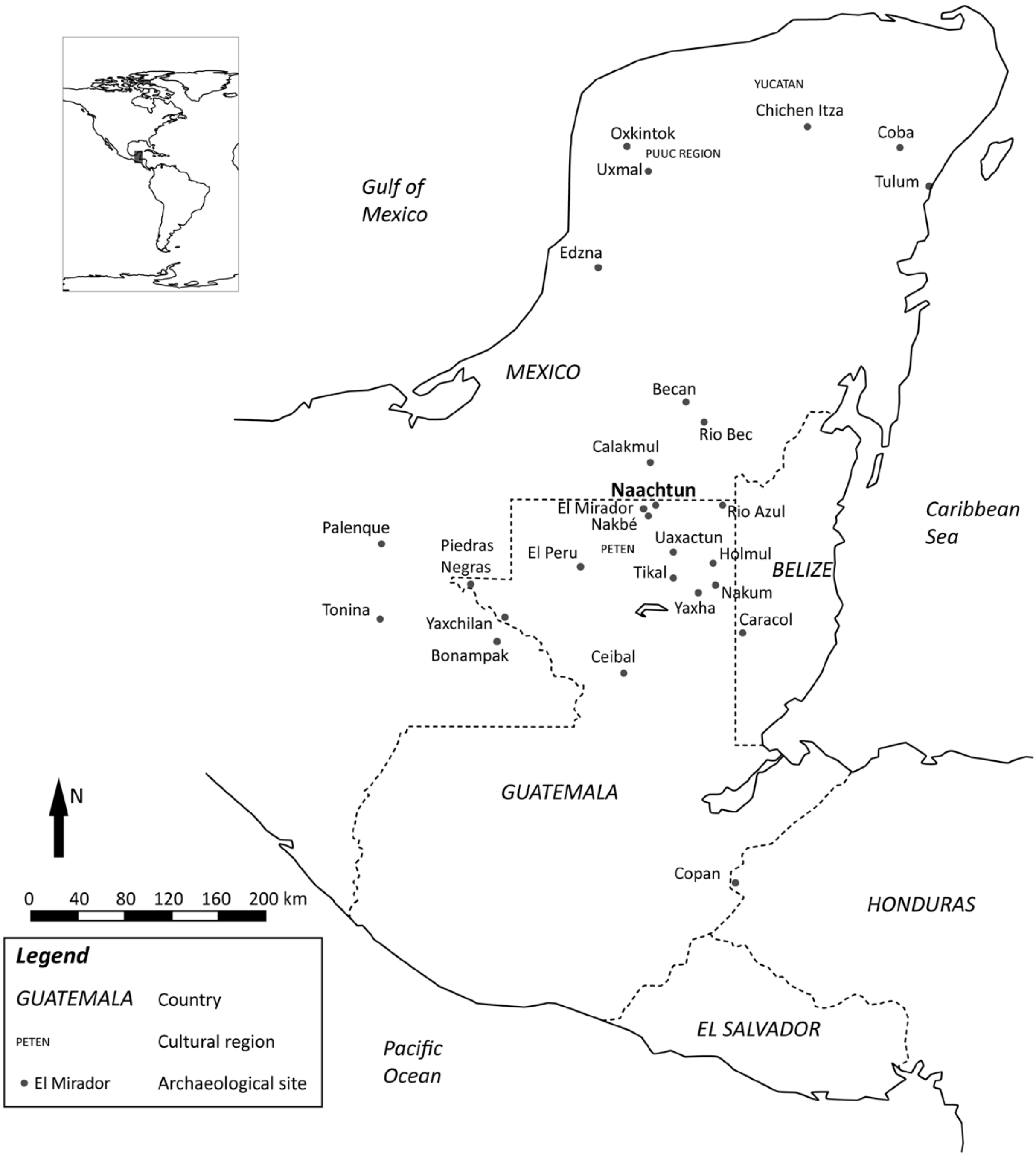


Figure 2. Localization of Naachtun in the Maya Area (map by J. Hiquet).

represented only one among many factors in a complex array of intermingled trends that may have led to a crisis (Hansen 2013). Nevertheless, one aspect is now known beyond doubt: the Maya Lowlands suffered a series of major droughts at the end of the Preclassic period, between 150 and 250 CE (Gill 2000; Haug et al. 2003; Kennett et al. 2012; Carrillo-Bastos et al. 2013; Wahl et al. 2014; Douglas et al. 2016, Ebert et al. 2017). They must have played a significant role in the Preclassic situation, forcing the Maya to adapt their mode of subsistence and maybe impacting other activities such as construction. It is at least certain that the environmental conditions were less favourable at the end of the Late Preclassic period than before, a climatic change that cannot be linked to human activities: it is best explained instead by Intertropical Convergence Zone (ITCZ) migration, changes in the frequency of El Niño (Kennett

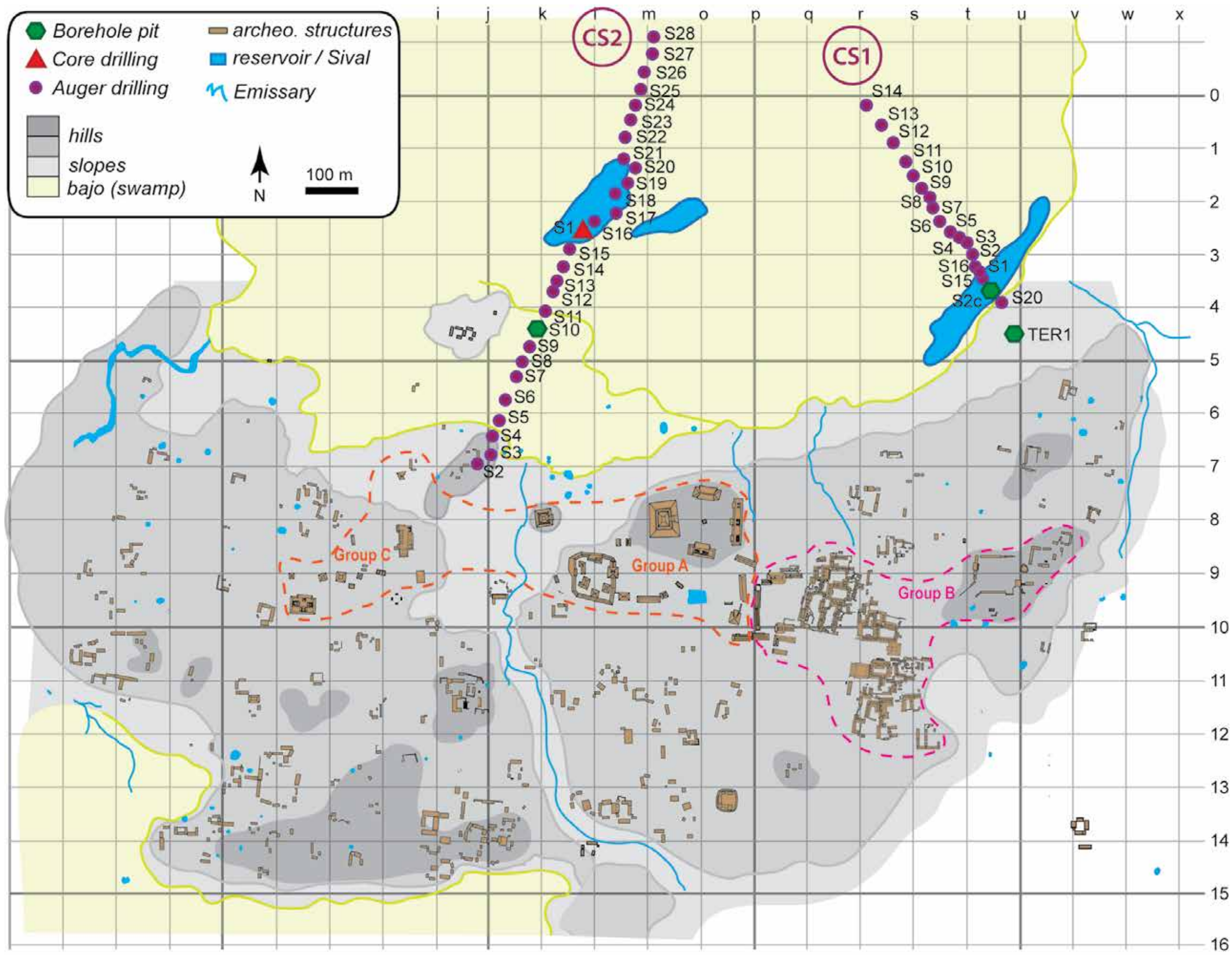


Figure 3. Test-pit transects in *Bajo* El Infierno (map by M. Testé).

et al. 2012: 789) and by other non-anthropogenic induced factors (see also Ford and Nigh 2013: 95).

In sum, reducing the events that affected different areas of the Maya Lowlands only to the overexploitation of the environment, whatever echo this may have in our current emergency context, is far-fetched (Heckbert 2013). It is true, on the one hand, that the scale of the construction programme in the Mirador region during the Late Preclassic was unique and must have affected the local availability of resources (Dunning et al. 2013). On the other hand, it is also true that drought episodes affected both population and landscape. That is why most archaeologists coincide on the idea that environmental degradation must have played a part in the crisis of the Late Preclassic period (Dunning et al. 2002: 276, 278; 2014: 115-117; Douglas et al. 2016: 636).

1.2. Naachtun: localization and Preclassic history

Located in northern Guatemala, Naachtun lies close to some of the largest Preclassic cities (Figure 2). During the Preclassic period, Naachtun was nothing more than a small village. Only a few scattered early dwellings have been identified in the area later covered by the city core area, suggesting a total population amounting to fewer than 300 inhabitants at the end of the Late Preclassic period around 150 CE (Hiquet 2020). Even if the LiDAR image has enabled identification of some additional Preclassic dwellings in the core zone, compared to the ground survey and excavations, no Preclassic public and monumental architecture existed at Naachtun, and certainly not at the scale of the giant neighbouring cities.

Evidence of occupation have been identified since 1600 BCE (Nondédéo et al 2020). From the beginning, the early settlers of Naachtun probably chose this upland location for its proximity to a seasonal swamp, at this time a permanent lake. In the Maya area, seasonally flooded wooded marshes, actually karstic *poljes* called *bajos*, cover between c. 25 and 60% of the territory, depending on the area considered. In the Naachtun hinterland, for example, 103.5 km^2 of the 135 km^2 LiDAR survey pertain to hilly uplands, which is an upland/*bajo* ratio of 77:23 (Nondédéo et al. in press). A 71:29 ratio is found around the great capital of Tikal, located 50 km south of Naachtun (Lentz et al. 2014). As they are environments

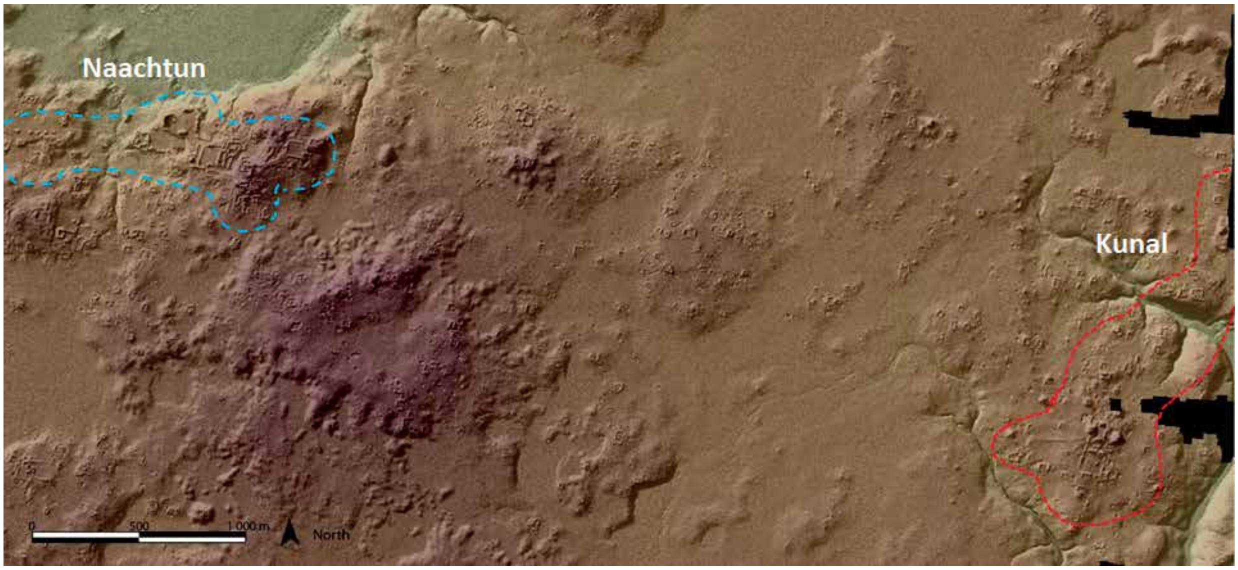


Figure 4. Locations of Naachtun and Kunal. LiDAR DEM Pacunam Lidar Initiative (modified by J. Hiquet).

offering a range of resources, the *bajos* undoubtedly played a major role in the installation of the earliest Maya Preclassic communities, seeds of the first cities to come: indeed, most of the important centres are located directly next to those low-lying areas (Harrison 1977; Dunning et al. 2002). *Bajos* contain vast lands suitable for agriculture (see discussion of this controversial topic in Dunning et al. 2002: 271, also Lentz et al 2014), provide abundant wood and other vegetal products from roots to fruits, and are home to wildlife (mammals, birds, reptiles, amphibians, molluscs), highly prized for food and crafts. Also, at Naachtun, the closest marsh (Figure 3), called *Bajo* El Infierno, presents favourable limnological characteristics since it houses today three seasonal wet areas (called *civales*), the remnants of the ancient lake (Castanet et al. 2016). The *bajo* and its paleo-lake attracted settlers since they offered good access to water for human consumption and land for agriculture, in a context of markedly different seasonal precipitations. In addition to the key role the *bajos* played in the population's subsistence, the trapped sediments still present a very good record of the variations in local ecological conditions. In the frame of the Naachtun Project, 49 core drilling pits and five control test-pits were excavated along two transects across *Bajo* El Infierno (Figure 3). They open a window onto millennia of Naachtun's environmental history.

When the history of Naachtun as a city began at the very beginning of the Early Classic period (around 150 CE), the area was in no way an untouched forest. Paleoenvironmental data indicate that forest clearance and soil erosion had begun earlier during the Preclassic times, probably because of agricultural practices and initial land use (Dussol 2017; Nondédéo et al. 2020: 101). No cultural artefacts dating to this period (probably an aceramic occupation) could be found during Naachtun excavations. Early and Middle Preclassic clearances were probably quite limited in area, while Late Preclassic activities probably led to a wider deforestation of the *bajos* (Testé 2020).

2. Demographic trends

At Naachtun, the onset of the Early Classic period was marked by an unnatural demographic rise: the population of the city around 300 CE, estimated at c. 580-1,050 people, is far too high to result only from the natural growth of the local Preclassic population (Hiquet 2020: 452). Short-distance immigration may explain this nucleation, in the context of the regional reorganization that followed the crisis of 150 CE. Population may have come from Kunal, a recently discovered major Preclassic centre located only 4 km east of Naachtun (Figure 4). The sequence of occupation at Kunal is complementary to that of Naachtun, that is to say, nearly without Early Classic features. This suggests possible effects of 'communicating vessels' between the two cities (Nondédéo et al. in press), something also observed in the same period in other sites of the Central Lowlands such as San Bartolo and Xultun (Garrison and Dunning 2009), and El Palmar and El Zotz (Garrison et al. 2019). Later during the Early Classic period, Naachtun may have hosted between 1,100 and 1,300 inhabitants (Hiquet 2020: 454-461), with a slow growth between 300 and 550 CE. Later, at its demographic peak during the eighth century (end of the Late Classic period), the city would reach twice the Early Classic total, i.e., around 2,500 inhabitants in the core area. Regarding

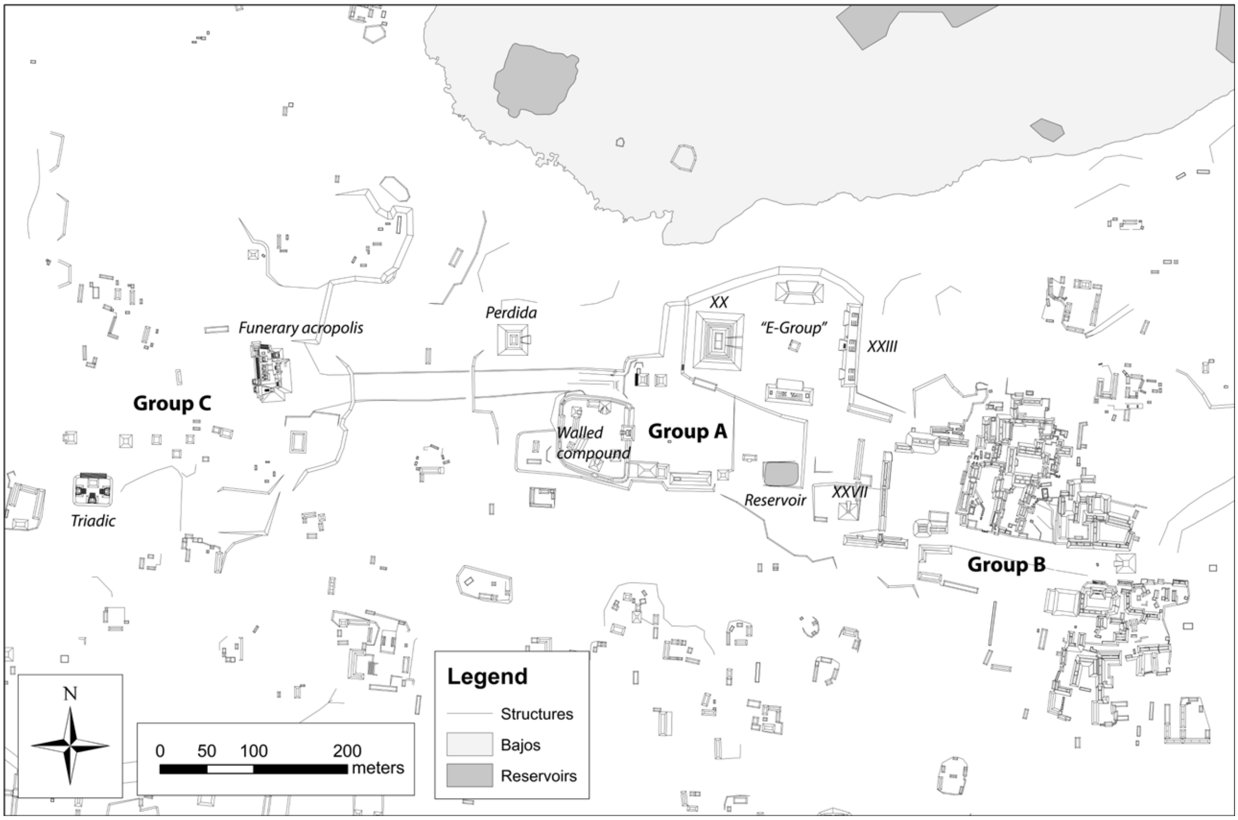


Figure 5. Map of the central area of Naachtun.

the population in the Hinterland, we have only rough estimates at present, based on the LiDAR survey. Many issues arise when analysing the Digital Elevation Model for a population estimate. The main one is the question of contemporaneity of occupation. Naachtun's landscape is among the densest in architectural remains in the Petén region (Canuto et al. 2018: 5), but those structures span more than two millennia of occupation and were not necessarily contemporaneous. Thorough corrections are indispensable to consider contemporaneity, invisibility, structure use, and occupation period, even more so in the case of the Early Classic period which has less visible residential remains as they are covered by later occupation. Conversely, the coverage cannot be considered to encompass exhaustively the territory submitted to Naachtun: no clear limit of occupation could be identified, and the long-distance causeway network structured with Naachtun at the centre extends far beyond the limits of the survey (Nondédéo et al. in press). In any case, we currently assume that the 135 km² area was inhabited by thousands of persons, perhaps around 8,000 in 300 CE, and 13,500 in 550 CE. These figures were obtained by applying the method exposed by Hiquet (2020: 496) to an actualized count of Late Classic inhabitants (Hiquet 2021: 18-19).

3. The Early Classic architectural growth of Naachtun

One of the most visible features of the rise of Naachtun is its monumental architecture. From the second century CE on (sub-phase Balam I), Naachtun started its growth to become a major centre with pyramids, plazas, monumental platforms, causeways, temples, and palaces. Monumentality started with the terracing of two natural hills, one of the heaviest architectural investments in Naachtun's history. This was done at an energetic expense that is difficult to quantify, as most of the original shape of the landscape remains unknown. Ceremonial and political structures were soon built on those terraced hills, giving birth to Groups A and C of the monumental core (Figure 5). Group B is much later since it was mainly built during the Late Classic period and is not assessed here. In Group A, which would soon become the central place, a standardized complex for public and ceremonial rituals, dubbed 'E-Group' in Maya archaeology, was built in three stages. This E-Group is designed to mark the sunrise and sunset at key moments of the agricultural-ritual and solar year through an east-west building alignment (Šprajc 2021). It comprised the largest pyramid ever built at Naachtun, Pyramid XX, west of a large plaza. The pyramid measures 60 m at its base and reaches 32 m in height in its final version. It is associated, to the east, with a north-south

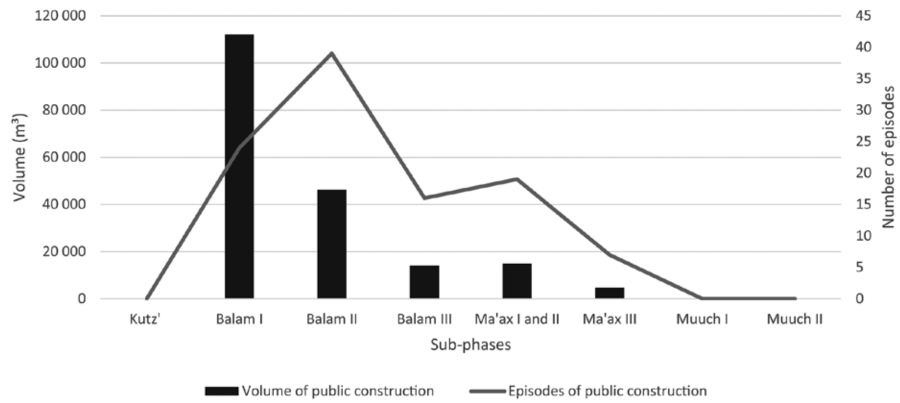


Figure 6. Volume of monumental public architecture built during each sub-phase at Naachtun.

platform at least 80 m long by 4 m high. In Group C, on another hilly area to the west, early royal funerary chambers show that some elites already ruled the city, probably before the official founding of the local dynasty at c. 325 CE, as registered on a retrospective Late Classic inscriptions (Nondédéo et al. 2018: 346). These early tombs were soon covered by pyramidal temples and platforms, as a process of ancestralization of the dead rulers.

Construction continued at an intense pace during the following fourth century (sub-phase Balam II), but with new characteristics. What is striking during this period is the quantity and ubiquity of construction stages in Groups A and C. Most, or all, buildings showed some activities from Balam II sub-phase in their sequence. While Balam II is the shortest of the three Early Classic sub-phases, it has more construction episodes (39) than Balam I (24) and Balam III (16). Yet, generally, public architectural projects tended to be smaller than during Balam I. Some buildings, like the pyramid called *La Perdida* or the politically oriented 'Triadic complex', still stand out due to their size, but the median volume of construction episodes remains much higher in Balam I (1,864 m^3) than during Balam II (194 m^3). As a consequence, the total volume of building in Balam II is much lower than during Balam I (Figure 6).

The trend of dynamic construction slowed during the fifth and sixth centuries CE (sub-phase Balam III), with a manifest setback in monumental construction. As shown in Figure 6, the total volume of building continued its decrease. Fewer projects were carried out at this time, and the most significant of them seem to have concerned restricted areas, political in nature, emphasizing the differentiation between the ruling elite and the rest of the population. This is best illustrated by the construction of a wall circumscribing a sacred and palatial compound, the Walled Compound (Figure 5), and probably of another wall limiting access to a funerary complex (Structure XXVII). This trend to enclose specific areas clearly indicates changes in political conceptions or illustrates political difficulties suffered by the dynasty, but much work remains to be done to fully understand this moment.

To sum up, a calculation of the volume of construction per sub-phase shows a very clear apex in monumental construction during the Early Classic period, and particularly the first two-thirds of it, between 150 and 400 CE. At no moment after this first peak could the investment in public architecture reach such a construction effort.

What does this case study tell us about the management of resources for a growing city in a post-collapse context? How did the trends described above affect the local environment and resources, and how did the inhabitants adapt to the impact of their activities on the landscape?

4. Management of the human resources

Apart from the volumetric estimate, Hiquet (2020; Hiquet et al. in press) has calculated the energetic cost of public construction during the whole history of Naachtun. The estimate follows the method of architectural energetics developed by Abrams (1994) and the process of analysis was accelerated due to programming of software specifically designed by Hiquet in collaboration with Emmanuel Froustey (Froustey and Hiquet 2019). Together with the population estimates, this software enabled the comparison of the available workforce with the manpower needed to carry out the architectural programme, and to assess the weight of taxation of the families living in Naachtun through their participation in the construction effort. We consider that the workforce for monumental construction was mobilized through a system of *corvée*, managed by administrators charged to recruit workers among the families dwelling in the residential areas around the centre, as a fiscal obligation. It must be remembered that the prehispanic Maya had no beasts of burden nor wheeled transportation devices, so human energy was a central resource in moving materials. According to epigraphy and ethnology, the annual architectural work season may have coincided with the low season in the agricultural calendar, and lasted probably around two to three months, starting preferably at the beginning of the dry season (e.g., for epigraphy, see Kettunen 2014: 102; Houston 2019; for ethnology: Abrams 1994: 42, 103; Becquelin et al. 2001: 206). On this basis, we estimate that the initial earthworks to create artificial platforms in Groups C and A, along with the building of the massive Pyramid XX, represented an energetic cost too high to be performed only by the inhabitants of the urban core. Manpower had to be drawn from the surrounding areas (hinterland) for a few seasons, an experience that might have encouraged some of the workers to settle in this dynamic capital. After this initial investment and according to models slightly modified from Hiquet (2020: 633-639), we consider that during the remainder of the Balam I and Balam II sub-phases, an inhabitant of Naachtun may have had to contribute by participating in, at most, a whole season of construction every three to five years, depending on the length of the season, and assuming that only the population of the city itself contributed, without the help of the hinterland inhabitants. In Balam III, a moment without strong pressure on manpower, an individual would have to participate in a two to three-month season every 11 to 18 years. If workers were also recruited from the hinterland, a larger rotation was possible, allowing one person to have to contribute only once in his lifetime (mean age at death among adults has been calculated between 35 and 42 years for a sample of well-excavated Classic period Maya communities; Hernández-Espinoza and Márquez-Morfín 2015; Ortega-Muñoz et al 2020).

The strong initial investment in monumental construction recalls the one calculated by Carrelli (2004) for the reigns of the first two kings of Copan, a large capital city on the southeast fringe of the Maya Lowlands. According to her, each man living in the Copan Valley would have had to contribute between 30 and 45 days annually to monumental construction during the 20 years following the founding of the dynasty. In research building on this Copan example, Wingard (2013) showed that this early mobilization for monumental construction did not prevent the Maya from carrying on with their proper daily activities, starting with cultivation. Monumental construction does not seem to have been a burden for the population and may have even been seen as an attractive factor for people to settle in the cities, with the social and economic opportunities it created and encouraged.

5. Forest management

With the growth of Naachtun in terms of population and monumentality, and hence the increase of human demand for staple food and for building materials, questions logically arise concerning the impact of urbanization on woodlands. The long-abandoned region is nowadays an endless forested area, but the situation was much more contrasted in the past.

5.1. A managed resource

Everyday life, along with public and private architectural needs in terms of material, certainly created a high demand for wood (Abrams and Rue, 1988; Russel and Dahlin 2007; Wernecke 2008: 202; Turner and Sabloff 2012: 13910; Lentz et al 2014: 18514). Each household arguably had at least one hearth permanently fuelled. In any case, it is what has been constantly observed by ethnographers during the 20th century (Redfield and Villa Rojas 1934; Soustelle 1937: 21, 67; Wisdom 1940; Vogt 1969). Additionally, some craft productions such as pottery also required frequent firings. As far as architecture is concerned, in addition to the timber used in construction, almost all surfaces were covered by lime plaster. Consequently, large areas of forests had to be cleared, either because of the setting of plastered-floor plazas, or because of the lime production process (both reasons could intermingle). However, the urban growth of Naachtun apparently did not dramatically impact the availability of forest resources. Palaeoecological data from archaeological charcoal studies show that despite probable initial forest clearance starting from the Preclassic period, the condition of woodlands around Naachtun remained fairly stable during the following period (Dussol 2017). Dussol (2020) and Dussol et al. (2021) observe a consistent use of firewood in domestic activities over at least six centuries (150-750 CE). A wide array of wood types was gathered in diverse, semi-open woodlands, both from the uplands and from the marshes. This stability suggests that the local agroforest system was managed to maintain itself, perhaps through rotating cycles of cultivation and fallow lands. Hence, forest resources remained widely accessible during the Early Classic urban expansion of Naachtun. It must be clearly stated, as a contribution to the debate upon the impact of lime production on the forest, that the production involved in the apex of monumental architecture at Naachtun did not lead to a disappearance of the forest. This issue is to be assessed on a case-by-case basis.

5.2. Archaeozoological clues on forest management

According to Tomadini and Grouard (2021), it seems that whatever the period considered, the inhabitants of Naachtun managed the conservation of wildlife, and in particular the white-tailed deer (*Odocoileus virginianus*). This species, which is the best represented within the archaeological contexts, lives in forested areas and, therefore, its presence is another proxy suggesting the permanence of woodlands. Moreover, when slaughter age is considered (Tomadini and Grouard 2021), only a few remains of juveniles were found on the site, indicating a natural renewal of the herds but also the absence of

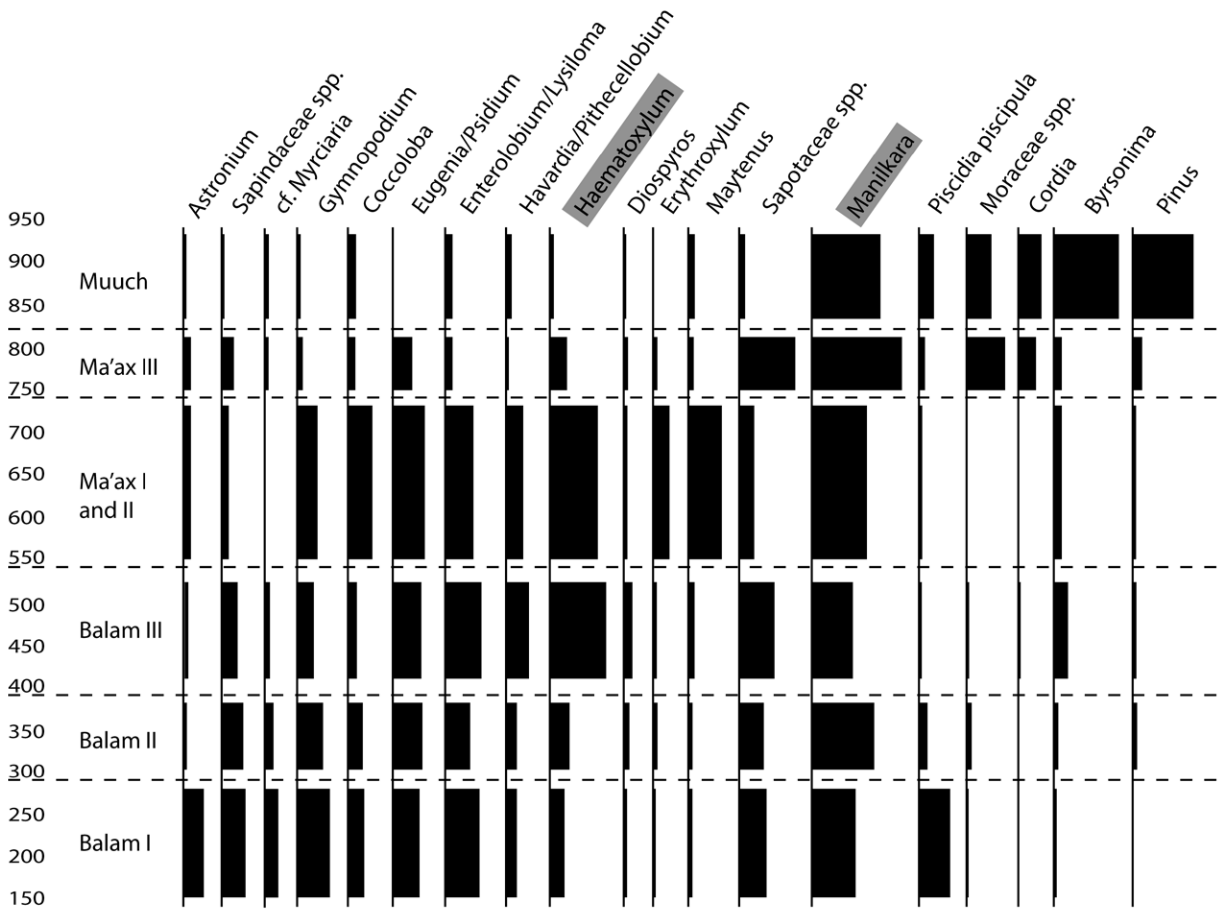


Figure 7. Charcoal fragments of wood taxa (chart by L. Dussol and J. Hiquet).

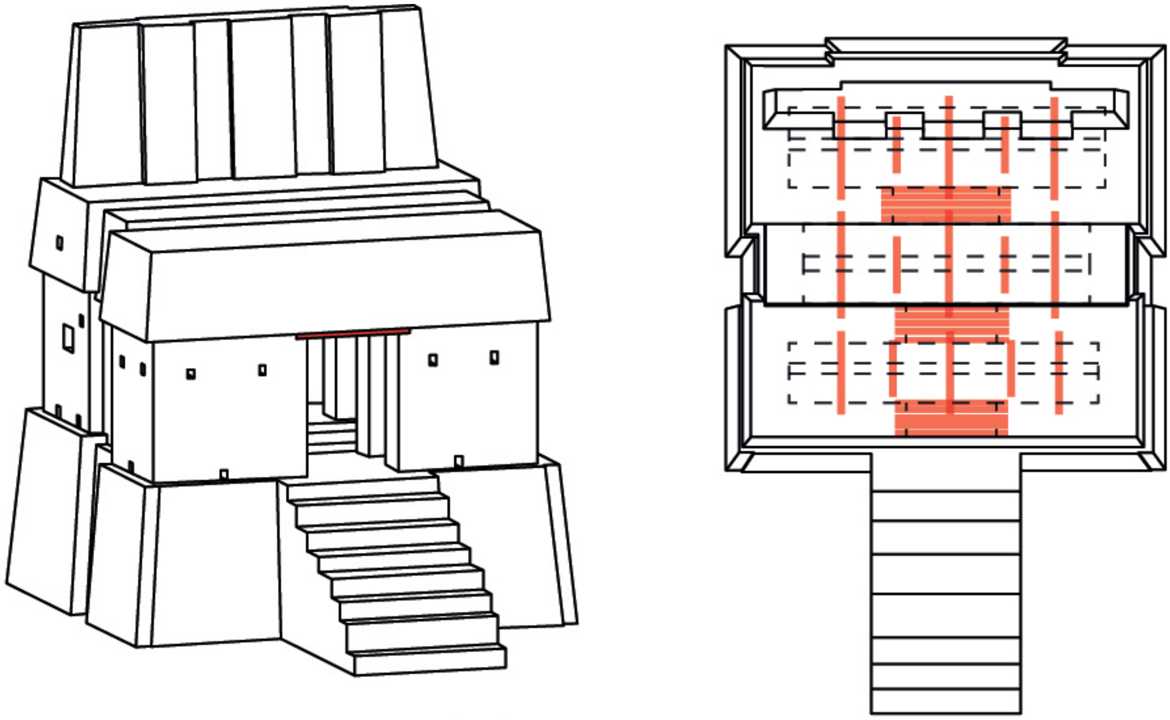
stress in hunting activities as shown in the selection of the individuals.

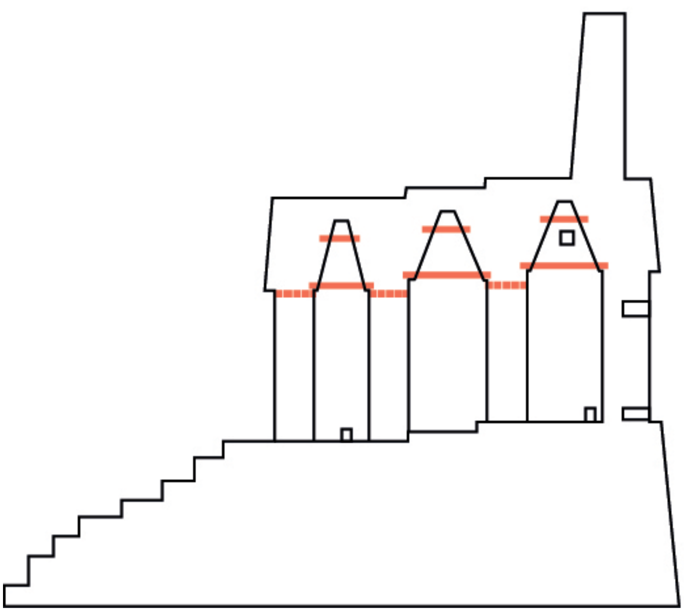
5.3. The particular case of Manilkara zapota

Despite this general panorama, there are nevertheless some insights that specific types of wood might have been lacking at some point in the city's development, and interestingly this correlates with the period of clear architectural slowdown of the last tier of the Early Classic period. In Balam III, after the demographic and architectural boom of Balam I and Balam II, there was a certain change in domestic firewood acquisition, as indicated by the analysis of charcoal from domestic dumps. The dense woods of big and slow-growing *Manilkara zapota* trees (locally called *chicozapote*) that were the most commonly used since the Preclassic period were replaced by another hardwood, *Haematoxylum campechianum*, locally known as *palo tinto* (Figure 7). The latter is a legume tree that naturally grows in the marshes. Interestingly, researchers working on preserved beams and lintels of the monumental buildings of Tikal identified a similar replacement of *Manilkara zapota* by *Haematoxylum campechianum* after a period of massive architectural investment (Lentz and Hockaday 2009, fig. 8). They interpreted this change as the result of a shortage in *Manilkara zapota* wood following its previous heavy use in construction:

> 'Perhaps the best explanation for this shift away from sapodilla to the extraction of logwood is that the Tikal Maya had exhausted the supply of large sapodilla trees and turned to a forested area that had not yet been heavily exploited, namely, the *bajos*' (Lentz and Hockaday 2009, 1350).

However, it is worth noting that at Naachtun at least, the situation is slightly more complex than this proposed scenario. Indeed, the *Bajo* El Infierno had been exploited and deforested for various centuries at this time (Testé 2020: 285) and was no longer a 'forested area that had not yet been heavily exploited'. Significantly, phytolith analysis in the *bajo* showed that during the Classic period,





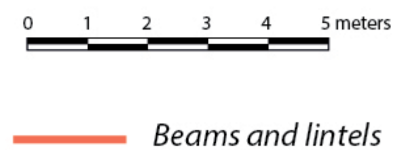


Figure 8. Idealized isometric view, plan and vertical section of the three-roomed Temple Va, one of the best-preserved Early Classic superstructures at Naachtun, showing in red the possible locations of wooden beams and lintels. The holes on all façades are for scaffolding (drawings by J. Hiquet).

some areas, for example at the foot of the southern slope, were re-forested (after the Preclassic deforestation) probably as an attempt to provide easy access to wooden resources for fuel.

At Naachtun, we thus have possible evidence – though indirect for the moment, for no wooden piece of monumental architecture has been preserved – that public monumental programmes indirectly affected the subsistence economy by exhausting certain preferred resources, in this case *Manilkara zapota* woods. For a while, people had to reduce the domestic use of the long-favoured *Manilkara zapota* and switch to the thorny *Haematoxylum.* However, this change was temporary and the use of *Manilkara zapota* increased again during the following period, to achieve its peak during the Late Classic period. This suggests that the Naachtun inhabitants implemented successful conservation strategies of local wood resources, perhaps through active silvicultural practices (Dussol et al. 2017a; 2021), as would be indicated by the *bajo* phytolith data. An alternative would be the extraction of woods from other more or less distant areas. Potentially favourable supply areas exist within a range of a few hectometres to various kilometres around Naachtun. Fieldworks are planned in this hinterland and should allow us to identify in a near future the areas of the surroundings of the city left empty of construction and agriculture during the Early Classic period.

One could ask how exactly the investment in monumental architecture during the Early Classic period would have endangered *Manilkara zapota* availability for domestic purposes. Indeed, plazas, pyramids, and temples did not imply heavy use of this wood. These constructions are mainly masonry platforms that required mainly mineral materials. The superstructures topping the aforementioned platforms were generally small and narrow. Only the beams, occasionally crossing the narrow vaults (Gilabert Sansalvador 2018: 186-196), and the lintels of the doorways (these buildings had no windows) were made of hardwood (Figure 8). It is hardly feasible for now to compute the volume of wood and number of adult trees needed for this use, yet one aspect must be underlined: the large lintels were cut from mature trees. Other construction-linked uses may be considered. As already stated, the floors of public spaces were plastered, a useful technique to catch rainwater and guide the water flows towards the network of reservoirs spread over the territory and which assured access to water during the months of the dry season. Consequently, the setting of Naachtun's centre between 150 and 400 CE, with its dozens of hectares of plastered plazas, necessarily implied the deforesting of a good part of the uplands, the preferred place of growth of *Manilkara zapota*. In addition, the residential units, with their plastered courtyards scattered amidst infield parcels and orchards, progressively occupied an area of more than 170 hectares all around the monumental core, sharply affecting the possibility of tree growth in these upland areas (Castanet et al. 2016; Purdue and Goudiaby 2016; Testé 2020: 291; Nondédéo et al. in press).

We must add that ethnologists consider that *Manilkara zapota* is unsuitable for traditional lime production: Schreiner (2002: 44) reports that this species is deliberately avoided because it produces too much charcoal that would contaminate the final product, a strict requirement confirmed by the informants of Russel and Dahlin (2007: 412). Note, also, the absence of *Manilkara zapota* in Seligson and colleagues' (2017: 135-137) informed experiments. Experimentation led by Dussol at Naachtun enabled the quantification of the important charcoal production induced by the combustion of *Manilkara zapota* (Dussol et al. 2017b: 484-486). Consequently, lime production, a task otherwise extremely costly in wood,[1] is unlikely to be held responsible for a *Manilkara zapota* scarcity.

Another possibility to explain the stress in wood resource is the scaffolding needed in construction. In some cases, large trunks may have been used to support ladders like those that seem to appear on Tikal graffiti depicting monumental construction (Nielsen 2012). Although we could not figure out which species were used, the very dense *Manilkara zapota* (its density is higher than 1000 kg per m^3) would have been a poor candidate as the trunks are extremely heavy and hard to manipulate (although undeniably strong). Lighter materials such as bamboo are more likely to have been used, as suggested by Houston and colleagues (2017).

Another option, more elusive, would be the existence of royal early Early Classic palace mainly built of wood. At present, no residential palace can be identified at Naachtun for the royal elites of Balam I (the architecture of potential candidates for the rest of the Early Classic, Structures VIII sub and XXV sub, is anyway poorly known). If a building made entirely, or mostly, of fine, durable, and dense wood was to be considered, it would have represented a larger demand in *Manilkara zapota* timber than the relatively few lintels and beams that complemented otherwise stone-built narrow rooms. The hypothesis still has to be tested, however.

In sum, at Tikal and Naachtun, extensive episodes of monumental construction appear to have been concomitant with some stress upon the favoured, dense wood of *Manilkara zapota*. Because of that chronological correlation, it is tempting to suggest that the construction of the buildings of these cities was stressful, but no causality can be firmly established. Finally, an alternative explanation, not tied to architecture, would

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1 The exact rate of efficiency of Classic period Maya lime kilns has been a matter of discussion for almost a century among archaeologists. Morris et al. (1931: 220), having restored the Temple of the Warriors at Chichen Itza, started the controversy, observing that open air pyres, considered "traditional" and extrapolated as being a direct heritage of prehispanic technologies, had a low fuel efficiency. Other milestones in this long scientific debate are Redfield and Villa Rojas' (1934) observations and Erasmus' (1965) paper on costs of construction task. Schreiner (2002) led various experiments in the context of the hypothesis of a responsibility of lime production in the collapse of El Mirador. Russel and Dahlin (2007) made their own observations in Yucatan. Wernecke (2008) proposed to reassess widely accepted old assertions lacking scientific support concerning pyres and kilns yields. More recently, Seligson (2017) led new experiments with more efficient, closed kilns. Interestingly, many intents (all but Schreiner's) took place in the Northern Lowlands, where the use of kilns is archaeologically established. This is not the case in the Central Lowlands where Naachtun or El Mirador stand. There, it is possible that open-air pyres were preferred. The experiments mentioned gave ratios of fuel weight / lime weight ranging between 1.7:1 and 10:1, but the most trustable experiments range between 3:1 and 5:1.

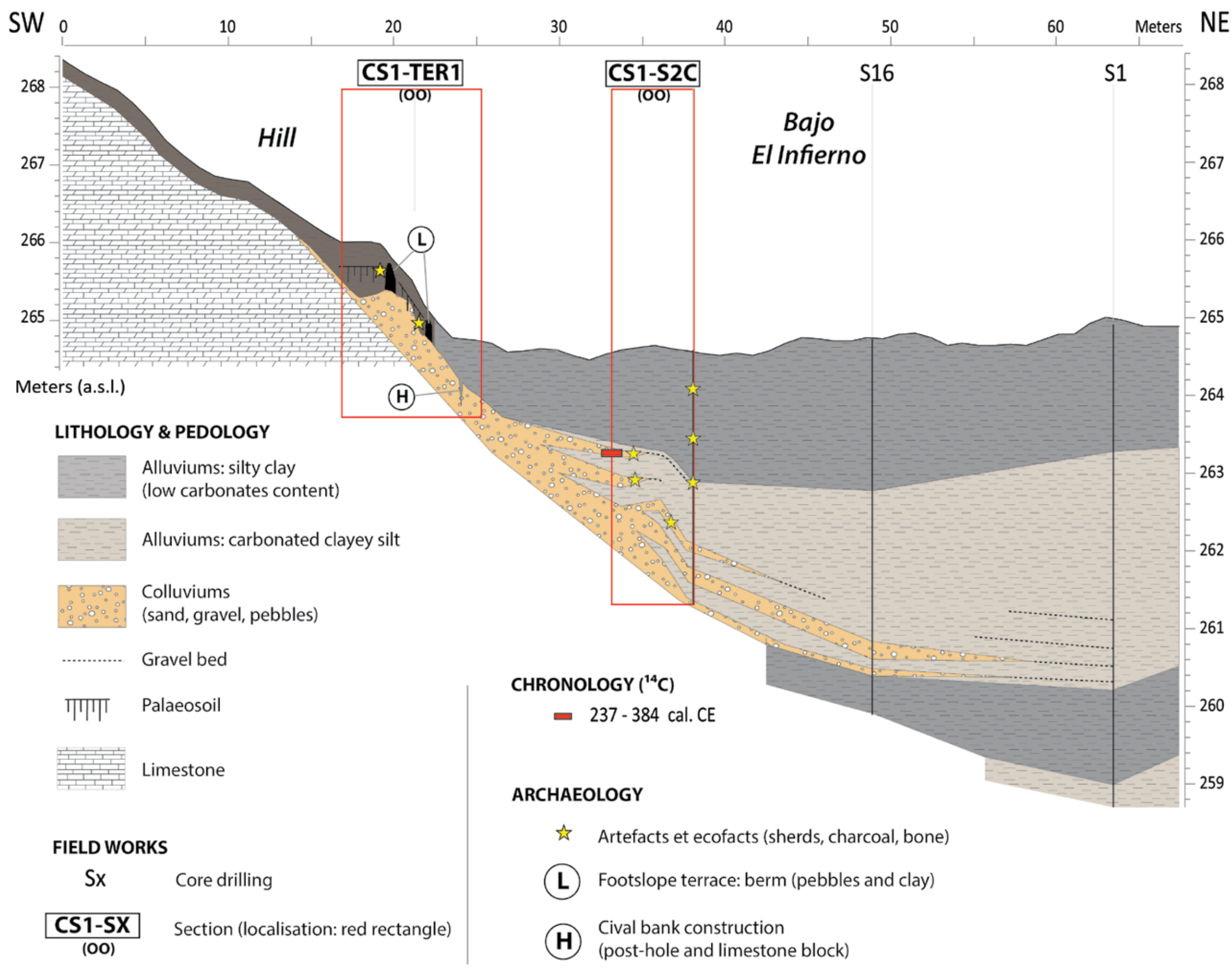

Figure 9. Stratigraphy of the cival and footslope deposits of the Bajo El Infierno, extrapolated from data collected in boreholes TER1, S2C (both framed in red) and auger drillings S16 and S1 of eastern transect CS1 (see Fig. 3). Observe the Early Classic colluvial deposits (drawing by C. Castanet).

be to link the identified pattern with domestic use in a context of demographic growth, since the qualities of *Manilkara zapota* are also required for domestic fuel. Significantly, Abrams and Rue (1988) calculated that wood acquisition for domestic fuel was responsible for the main stress on wood resource, far above lime production and house building (see also Lentz et al 2014). Yet their calculations only encompassed domestic productions, needs for monumental construction were left aside. Besides, the fact that Naachtun's inhabitants switched back to the use of *Manilkara zapota* during the Late Classic clear demographic apex encourages us to keep exploring a relationship between public construction and the scarcity of *Manilkara zapota*. A calculation of both the carrying capacity of the area in *Manilkara zapota* and the exact architectural need are required for the future. A question remains: is the strong diminution we observe at Naachtun in monumental construction from Balam III onwards linked to a possible stress on resources? At present, political reasons are privileged (such as a weakening of the rulers due to the setback of Teotihuacan and Tikal of the Mesoamerican geopolitical landscape), but maybe they should be contrasted with environmental data. The fifth and sixth century were also marked by drought episodes: Prufer and Kennett (2020: 31) link the ceasing of public construction at Uxbenka, Belize, to this climatic change. At the same moment, the cataclysmic eruption of the Ilopango volcano had worldwide effects on crop yields. As elsewhere, crises were probably the result of a mix of environmental, social, economic, and political factors.

6. The marshes: resources for the Maya, records for the archaeologist

The vast *Bajo* El Infierno bordering the city was of major importance in Naachtun's subsistence. As already stated, wood was extracted there, but this wetland area was also cultivated due to different techniques taking advantage of the varying conditions of moisture (Castanet et al. 2019).

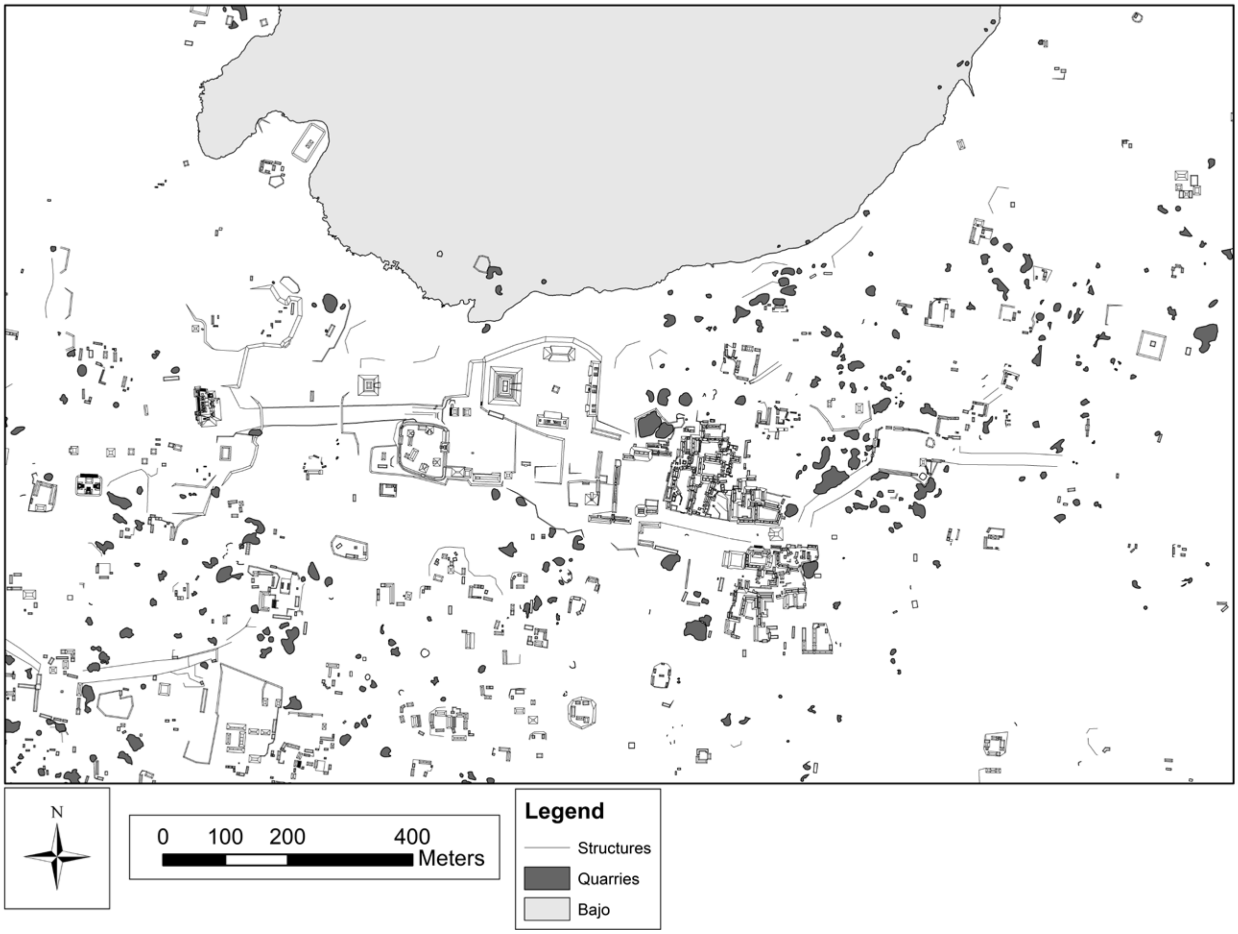

Figure 10. Map of Naachtun urban core scattered with quarries.

It also includes natural shallow lakes and depressions converted into artificial reservoirs providing water all year long, in a region otherwise almost devoid of permanent streams and rivers. A permanent or intermittent lake depending on the periods had existed on the south side of the *bajo* throughout Naachtun's history (Figures 3 and 5). Nevertheless, its level, extension, and limits fluctuated markedly during the Preclassic and Classic periods, a variation that may have been partly caused by human activities in addition to natural factors (Castanet et al. 2021). Human activities may include deforestation (producing erosion), direct water withdrawal for consumption, architecture, and other craftwork, construction of upstream reservoirs, and modification of the deeper parts of the lake to create shallow basins and reservoirs. An age-depth model established from the drilling programme along the transects (Figure 3) suggests that the lake had a higher water level during the Early Classic Balam I and II sub-phases than at the drier end of the Late Preclassic period. This difference could be linked to a global climatic change at the start of the Early Classic period towards more precipitation, as well as, in part, to human activities. Later, from Balam III on, the lake grew slightly shallower (Castanet et al. 2021).

During the Late Preclassic period, before 150 CE, few colluvial and alluvial deposits are found in the sedimentary record of the *bajo*. This is interpreted as a diminution of sedimentary connectivity between uplands and the *bajo*, because of the building of terraces, canals, and reservoirs (Castanet et al. 2021). Later, during the whole Classic period, a high alluvium rate in the *bajo* indicates upland deforestation and the multiplication of plastered and cultivated areas at a wider spatial scale, namely that of the whole watershed.

During Early Classic Balam I and II sub-phases, sedimentary records of the lake and *bajo* margins conserve the trace of an episode of coarse colluvium infilling (calcareous gravel and boulders) (Figure 9: indicated in light brown). Unlike the alluviums, this episode corresponds to local landscape modifications. It is dated between 250 and 400 CE, pending more absolute dating. Materials inside colluvium layers, likely mixed, are not particularly conducive to obtaining a good dating. Nevertheless, such a temporality would perfectly fit with the landscape modifications linked with the building of the monumental core of Naachtun, the subsequent deforesting, and the exploitation of open-air limestone quarries on the hills overlooking the marshes (Figure 10). The Maya exploited limestone by cutting blocks from outcrops of the bedrock, mostly horizontally. As the material was abundant in the uplands, numerous quarries were opened, generally as close as possible to the edifices to be built. The Triadic complex, the westernmost monumental platform at Naachtun, perfectly exemplifies that tendency, with the 0.25-hectare quarries located a few metres all around. In a few instances, blocks were even extracted from the exact location of the construction, and then the quarries were covered by the fills of the new building. It is complicated to evaluate the exact amount of material extracted from a quarry, yet the exploitable bank was relatively thin, driving the Mayas to open large areas to obtain enough material. Another aspect to consider is the spatial growth of the city, with its vast plastered plazas and vacant spaces for fields. These spaces were not re-opened to access the bedrock, and limestone had to be extracted farther away. As early as the Balam I sub-phase, most of the centre was covered by structures or plastered floors, and the Maya had to get access to free terrain to exploit the bedrock. This is why the area that would later be Group B was probably already under exploitation for public architecture during the Early Classic period, which could explain the colluvium episode downward from those hills. The fact that this phenomenon seems limited only to the Early Classic period is maybe a sign of a landscape stabilized by earthworks at the end of this period.

To sum up, the Early Classic colluvium layer could be a visible effect on the landscape of the massive programme of monumental building, a phenomenon whose dating would independently validate the clear trends identified in the architectural sequence.

7. Water storage

At present, the construction or modification of the many reservoirs identified all around Naachtun urban core is complicated to date. They were indeed prone to processes incompatible with the establishment of a stratigraphic sequence useful for dating: alluvium and dredging mixed the archaeological materials. LiDAR-derived data and ground survey identified fourteen large-scale reservoirs inside the 1-km radius around the city (Castanet 2018; 2020; Castanet et al. 2019). Some of them, particularly in the *Bajo* El Infierno, have a very large capacity and could satisfy the needs of thousands of inhabitants during a whole dry season, even when accounting for evapotranspiration (Castanet 2018). Even if dating can be improved, Early Classic sherds were found in test-pits and in berm fills, and the rise of the population during the Early Classic likely required the development of several of these reservoirs.

Beyond the questions of carrying capacity, water storage strategies are relevant because it has been suggested that in the post-drought context of the Early Classic period, greater control of water storage facilities played a key role in the establishment of local dynasties, headed by sacred kings capable of guaranteeing water and agricultural supply (Dunning et al. 2002: 271; 2013; Lucero 2002; Garrison and Dunning 2009: 540, 545; Douglas et al. 2016: 636). Reservoirs would have been a tool enabling the successful new elites to gain their legitimacy, compared to the Preclassic elites of some sites who had failed in providing water. In that perspective, the multiplication of reservoirs and water-storage infrastructures during the Early Classic period could be further evidence of the rise of Naachtun as a political centre. The idea of a traumatic memory of the Terminal Preclassic droughts was pursued by Bonnafoux (2011) to explain the omnipresence of watery iconography that characterizes the elite ceramic production of the Early Classic period.

To date, the reservoir with the best-controlled sequence is a man-made square basin found in Group A of the monumental core, close to the monumental buildings (Figure 5). Excavations there suggest that it resulted from a modification of a natural pond in use since the Late Preclassic period and Balam I sub-phase. Its bottom was apparently levelled during Balam I (if not before), and berms were subsequently erected in Balam II, and later modified in Balam III when its storage area was apparently reduced. It was modified again during the Late Classic period. The permanent attention given to this feature perhaps indicates its symbolic importance for the dynasty as well as its role in water consumption for the elite. As for the consumption of the rest of Naachtun's population, it probably relied on the huge *bajo* reservoirs, and the much smaller ponds located close to the residences which were sufficient for domestic needs.

8. Agricultural practices

As far as agricultural practices are concerned, our temporal resolution is not precise enough to place the events at the chronological scale of the periods of sub-phases (Balam I, II, III). It seems, nevertheless, that the Early Classic period was a period of diversification of agricultural practices to cope with the increase of population around Naachtun and the normal soil degradation following centuries of land use (Nondédéo et al. in press). One can observe (Figure 10) the existence of large portions of vacant spaces between the residential units, most of them dedicated to agriculture, and established at the start of the Early Classic period (Castanet et al. 2016; Purdue and Goudiaby 2016).

In parallel, remote sensing of the hinterland showed that the agricultural features spatially associated with

Preclassic residences severely impacted the landscape, notably through the implementation of stepped terraces. In contrast, agricultural features associated with Classic groups seem to have had less impact on landforms. Typical Classic period terraces are encountered on the upper edge of low hills with very little modification of the natural slope. Although this does not necessarily indicate fewer destructive agricultural practices during the Classic period, it does indicate that changes occurred in slope management and, probably, in overall farming strategies.

The only agricultural practice that could be precisely dated corresponds to the setting of large areas of dark organic soils, clearly artificial, deposited on top of the upland bedrock during Balam I, in sectors directly adjacent to the monumental core (Purdue 2014; Castanet et al. 2016; Nondédéo et al. in press). In the past, researchers have interpreted similar contexts of dark organic layers dating to the Preclassic period as rich in organic matter sediments transported from the bajos (Hansen et al. 2002). But the question of the origin of theses dark organic soils remains open in Naachtun as some of them clearly come from the bajo and others clearly not. Regarding the soil amendment, one hypothesis is the use of cut herbaceous material, while the other considers the use of human excrement as fertilizer, a plausible explanation as no latrines could be identified in ancient Maya residential groups. Also, ethnologists have documented such a fertilization practice (Sanders 1981; Chase and Chase 2014: 11). This long-held practice was abandoned after Balam I and the aforementioned areas of dark organic soils were covered by the fills of plazas or residential units. The reason for this change is partly due to the need of new spaces as the city was growing, but we must admit that the inhabitants of Naachtun also turned to other techniques (such as terraces, infield orchards, raised fields, and slash-and-burn), maybe to respond to a growing population and the arrival of new settlers. The range of agricultural practices was wide and the Early Classic inhabitants of Naachtun somehow succeeded in feeding the city, facing demographic growth, pressure on lands, and soil depletion.

9. Discussion

Many archaeological studies, cited hereafter, have focused on pre-collapse periods (i.e., the Late Preclassic and the Terminal Classic periods) to identify clues to the sustainable strategies developed by the Maya to face shortages of raw materials for building construction. A proxy widely used in this field concerns the thickness and composition of plastered floors. It appears in various cases that from the end of the Preclassic period on, builders reduced the proportion of lime in plaster layers (even totally replacing it by clay), and/or applied thinner layers of mortar (5-6 cm versus 15 cm), mixing it with fine gravel layers, probably in a strategy to face environmental degradation and resource exhaustion. This has been identified at El Mirador (Hansen 1994; Schreiner 2002: 126-127) and San Bartolo (Garrison and Dunning 2009: 539-540) before the Late Preclassic collapse, and at El Pilar (Wernecke 2008: 205), Calakmul, Palenque (Villaseñor and Aimers 2009: 39-40), and Copan (Schreiner 2002) before the Terminal Classic collapse. To Wernecke (2008), these data are misinterpreted as circular evidence of supposed stress on resources, while it can also indicate a mere evolution of construction practices towards a more effective optimisation of resource use. Yet, Hansen (1994: 321) notes that the earliest plastered floors during the Middle Preclassic period did not contain processed lime, and it is only later, with the development of cultural and economic complexity during the first half of the Late Preclassic, that thicker, lime mortars, were introduced, a contradiction of Wernecke's argument.

Our study focuses on another moment of Maya history, the onset of urban growth, after a moment of crisis. If we accept the fact that consumption of resources for the extraordinary Preclassic architecture contributed, at least partly, to environmental degradation and the demise of important cities at the end of this period, we must also raise the question of the historical memory of past socio-environmental events and of a more sustainable exploitation of local resources in cities, like Naachtun, that thrived in the aftermath of the crisis. To Seligson (2019: 13) and his colleagues (Seligson et al. 2017: 131, 139), the Late and Terminal Classic lime makers of the Puuc Region northwest of Yucatan could have implemented more fuel-efficient kilns than those probably used earlier in the Central Lowlands, to avoid overexploitation of wood and limestone for lime production destined for the thriving urban centres. We are to understand that the Maya had the will to avoid reproducing the errors of the past (Seligson 2019: 9, see also Lucero 2018: 350).

However, it seems that the growth of Naachtun from the beginning of the Early Classic period had a clear impact on the landscape, hardly avoidable, despite the indisputably deep knowledge those populations had of their local environment. Those repercussions are visible in the sedimentary record of lakes and *bajos*, in phytolith studies, as well as in archaeological remains (charcoal). The inhabitants of Early Classic Naachtun do not appear to have been initially concerned by a sustainable use of their resources, and this complex society, with its political and economic elites, somehow appreciated a certain conspicuous use of its resources. That is why initial cases of stress on environmental resources (wood, water, probably soils) were followed by new strategies offering alternatives to overcome the situation. Sometimes, they were efficient: such was the case at Early Classic Naachtun, with the temporal shift from *Manilkara zapota* to *Haematoxylum campechianum* use during Balam III. This shift was enabled either by the setting of patches of forest in the adjacent *bajo*, or by the use of resources from a more remote area, which, in turn, enabled the re-use of the former wood species during the following centuries.

Yet we observe that monumental construction never again reached the levels of the beginning of the Early Classic period, nor even came close. Why would the Late Classic inhabitants of Naachtun build much fewer, and smaller, pyramids than their Early Classic ancestors? It has often been noted that the general trend along the history of a site was of a progressive decrease in the monumentality of public architecture (e.g., Drennan and Kolb 2019), because of political and economic reasons. The main of them is a lesser need for well-installed political authorities to seek legitimacy through impressive buildings, often leading to a focus on administrative buildings instead of massive tombs and temples (Murakami 2015). Like many other Maya cities, Naachtun knew violent political shifts and dynastic overthrows, possibly leading to periodic surges of public construction activity, but they had a much smaller scale than the initial investment. Meanwhile, the population was greater than during the Early Classic period, facilitating the recruitment of manpower. The Early Classic case demonstrated that the Maya were successful in avoiding resource shortage. This is why we interpret the Late Classic architectural investment slowdown as a shift in political communication strategies more than as an effect of resources scarcity. At the end of the Early Classic period, however, the possible return of droughts as well as a possible alert on hardwood availability might have played a part in the sobriety of the public architectural programmes.

10. Conclusion

In palaeoenvironmental records, although incomplete and not always easy to interpret, it is possible to identify phenomena that may indicate a certain pressure on the environment during the Early Classic period at Naachtun. It is an independent confirmation of the impact of the public building programme between 150 and 400 CE, and of the population attraction and nucleation from the hinterland (maybe partly displaced from the Preclassic centre of Kunal). Architectural, demographic and environmental results form a coherent array of data pointing towards a dynamic Early Classic period.

The arrival of new inhabitants and the construction campaigns launched during the first half of the Early Classic period impacted the local environment, particularly the forest, but not to an irretrievable extent. Even if the ex-nihilo creation of a capital city with a rapid agglomeration of inhabitants somehow destabilized the local balance, the Early Classic population of Naachtun seems to have been aware of the risks of shortage of key resources, such as water, wood timber, and fuel. As in other areas of the Lowlands, they implemented strategies of conservation of resources and managed to maintain a certain stability during centuries, sometimes approaching the edge of local carrying capacity. The Early Classic monumental construction had an impact not only on the environment but also, on occasion, on the population's everyday life. At the beginning of Balam I sub-phase, the population certainly had to contribute by repeated participation as workers in construction projects during maybe a few decades before the pressure gradually decreased. Later, in Balam III, people had to adapt their strategies of resource procurement by temporarily turning to other sources of supply not impacted by the consequences of the previous monumental construction programme.

The available data offer a good example of strategic planning and historical memory inherited from the Preclassic turmoils: on the one hand, evidence shows that the inhabitants of Naachtun did not particularly spare their natural environment after the collapse of 150 CE. Very soon, they built a large capital on terraced hills. On the other hand, when a possible resource shortage occurred, they have demonstrated a strong ability to bring forward alternative solutions (regarding wood, water or landuse). Expected additional results on the chronology of these alternative strategies in the management of resources will help us to distinguish ad hoc adaptation from long-planned approaches.

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Placing the houses of the dead: the spatial setting of Late Helladic necropoleis in the Argive Plain, Greece

Stefan Müller

1. Introduction

As one of the major centres of occupation in Late Helladic times (c. 1600-1075 BCE, all dates of the different phases in this paper based on the chronology provided in Deger-Jalkotzy and Hertel 2018: 20; hereafter: LH), investigations in the Argive Plain have not only brought to light important palatial centres, but many non-palatial sites of variable size. In addition to these, many related necropoleis and tomb monuments have been found. This study aims to draw together published results concerning the location of chamber tomb necropoleis, their spatial setting in respect to their related tombs, their distribution from phase to phase (LH I-IIIC), and the relationship between settlements and necropoleis. Though various forms of tomb architecture are attested in the area, this paper concentrates specifically on chamber tombs, since it is probable that the bulk of the LH population (at least from LH IIA-IIIC, c. 1525-1075 BCE) was buried in tombs of this type. Five well-known locations have accordingly been chosen for examination here: Prosymna, Tiryns, Dendra/Midea, Argos and the Berbati valley. The paper is divided into two main sections: the first examines the location, orientation and the spatial setting of tombs and necropoleis from phase to phase, while the second investigates the relationship between settlement and necropolis.

2. Tomb and necropolis distribution

2.1. Prosymna

2.1.1. Context

At Prosymna, 55 chamber tombs have been discovered to date (Waldstein 1902: 45, 79-80; Waldstein 1905: 42 (Nr. 269), 91-95; Blegen 1937a; 1937b; Protonotariou-Deïlaki 1960: 124-135; Verdelis 1970: 156), of which 53 are examined in this paper: for Chamber Tomb 23 and Chamber Tomb 'W2', information on their contents is lacking (cf. Shelton 1996: 303). The tombs are situated north and northwest of the settlement and were separated by Blegen into 12 separate groups or necropoleis (Shelton 1996: 303). They are distributed over four major locations (Figure 1): the East Yerogalaro Ridge (seven groups), the West Yerogalaro Ridge (two groups), the Asprochoma Ridge (two groups) and the east slope of the Kephalari Hill (one group). Of the eleven groups which are located northeast of the LH road, leading from Mycenae via Monastiraki and Prosymna to Tiryns, only the group on the Kephalari Hill and the single tholos

Stefan Müller
Institute of Pre- and Protohistory
University of Heidelberg

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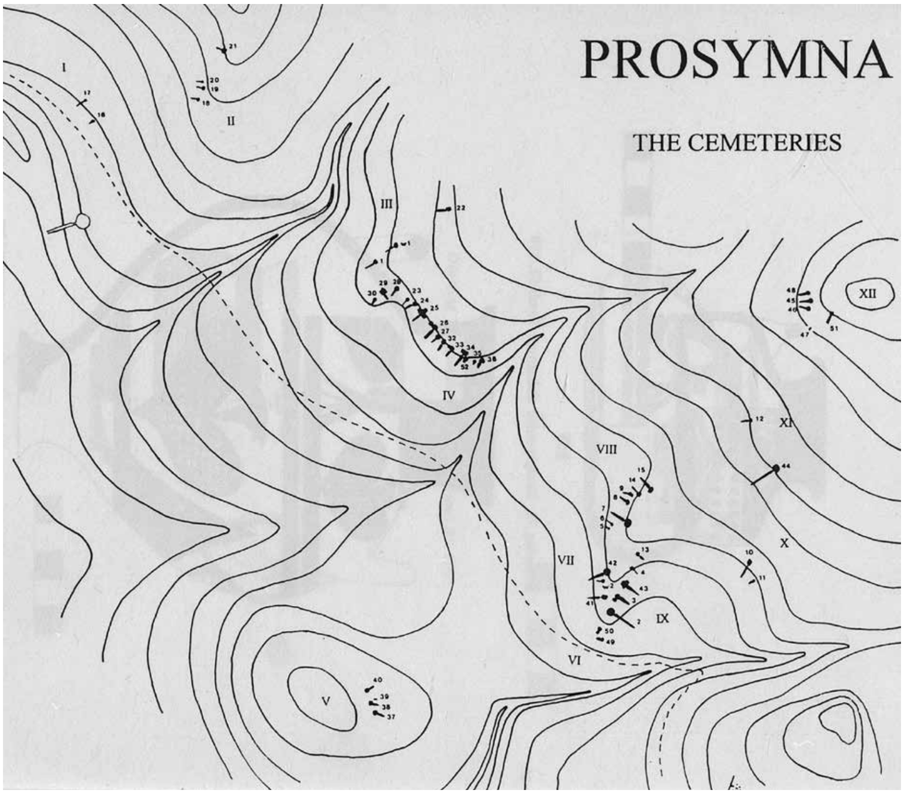

Figure 1. Prosymna, Late Helladic burial groups (overview) (after Shelton 1996, map 1).

tomb on the Asprochoma Ridge are located southwest and south of the road. In more recent research, this road is known as 'M4' (cf. Brysbaert et al. 2020: 37, table 1). The orientation of the tombs (roughly) follows the natural gradient of the slopes.

According to Shelton (2020: 51; 1996: 303-315), this division of the tombs into different groups was likely underpinned by cultural reasons and does not demonstrate a chronological division, since all groups contain tombs of different periods and run partly in parallel. In fact, during LH IIIA2 (c. 1360-1300 BCE) and LH IIIB1 (c. 1300-1250 BCE) all 12 groups had at least one tomb in use. These divisions must have been based on familial or tribal subdivision within the community of Prosymna. Therefore, the creation of a new tomb group perhaps indicated the arrival of a new group of people or the establishment of a new family within the community (Shelton 1996: 303-306). An important observation is that by LH IIIA1 (c. 1400-1360 BCE) all tomb groups had been established (although no burial activity of this phase was associated with Tomb Group XI, the use of which recommenced in LH IIIA2). This could indicate that no new group arrived at Prosymna after LH IIIA1 during the Late Bronze Age. It is also an interesting point in support of the suggestion that the site reached its peak population in LH IIIA2, as has been argued from the contents of the tombs (cf. Shelton 1996: 303-306).

2.1.2. Data (cf. Figure 2)

The dating of all single tombs as well as tomb groups throughout all relevant periods for this site (LH I-IIIB2) is based on the work of K. Shelton, who re-examined the pottery of the chamber tombs of Prosymna, cf. Shelton 1996: 303-315. Initially, the chronology of the tombs and tomb groups had been established in an early version by C. Blegen (1937a: 51-232). The first chamber tombs (Chamber Tombs 25, 26 and 52) were all cut during LH I, in the West Yerogalaro Ridge. These are relatively close together (Figure. 2), and all belong to Tomb Group IV. It is most likely that these three tombs represent one wide familial network. In LH IIA, the picture changed significantly (Figure 4). Four new tombs were built in Tomb Group IV (Chamber Tombs 28, 30, 32 and 34) as well as one more (Chamber Tomb 1) in the West Yerogalaro Ridge (marking the earliest of Tomb Group III). Eight new tombs were constructed in the lower slopes of the East Yerogalaro Ridge (belonging to Tomb Group VII, VIII, IX and X: Chamber Tombs 42, 6, 7, 14, 2, 3, 13 and 11). Two tombs were also carved in the upper slopes of the East Yerogalaro Ridge (Chamber Tombs 44 and 46, belonging to Tomb Group XI and XII). Finally, two isolated chamber tombs were established in the Asprochoma Ridge (Chamber Tombs 17 and 18, belonging to Tomb Group I and II), and a tholos tomb to the southwest.

The establishment of new graves and tomb groups demonstrate both a growing population and an increased diversity within the community (Shelton 1996: 306). It

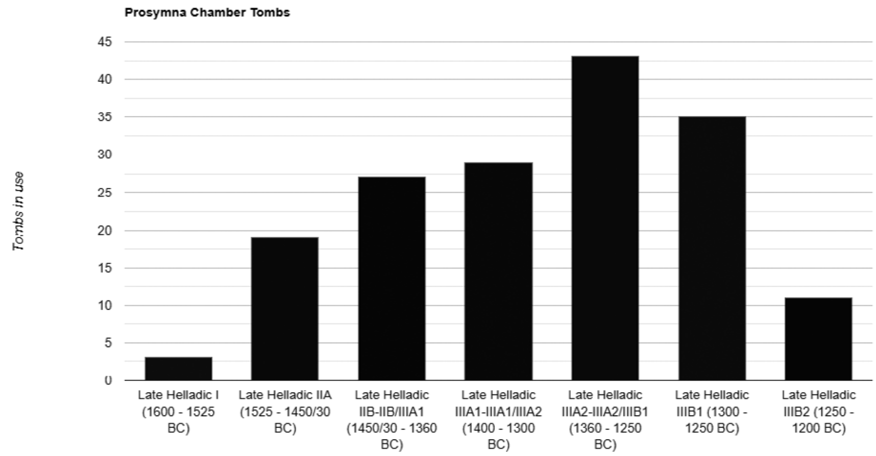

Figure 3. Prosymna, tombs in use during LH I (after Shelton 1996, map 2).

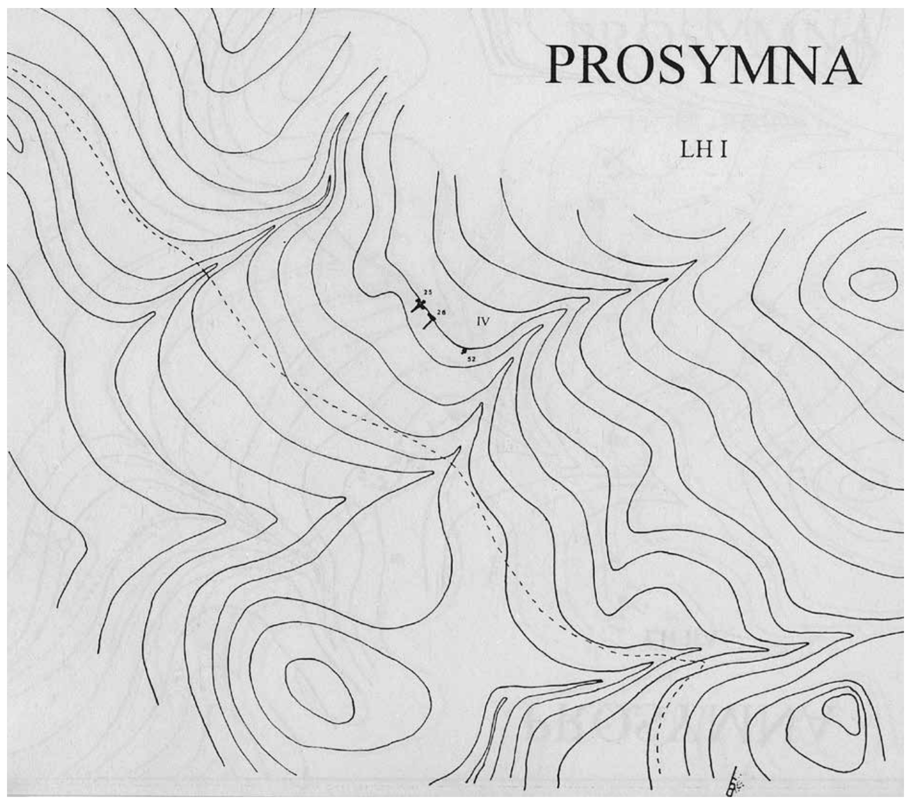

Figure 2. Prosymna. Tombs in use per sub-phase (S. Müller; dating based on Shelton 1996: 303-305).

can thus be inferred that new families were established through new settlers as well as a ruling family. In case of the families, there seems to have been at least three larger family groups and up to nine groups in total (if we accept distinct geographical groups and single tombs as indicators for different families). There is no evidence of a royal tomb earlier than LH IIA. According to Shelton (1996: 306), it is important to note that the tholos tomb, which is dated to LH II (Wace et al. 1921-1923: 332; Pélon 1976: 177) had been built as an isolated monument far from the settlement (c. 1 km, Wace et al. 1921-1923: 330), at a distinct distance (exact distance not published, but cf. the certain distance visible in Figure 1) from the original LH I necropolis and southwest of the road leading from Prosymna to Mycenae. According to Shelton (1996: 306), it could be that its location suggests that the king of Mycenae might have recognized the importance of the settlement. It is, therefore, possible that he had sent a part of the royal family, for which the tholos tomb was built later on, to that settlement to establish itself there. Mycenae is not far away and represents most likely the palatial settlement of origin (rather than Midea or Tiryns). Furthermore, the establishment of a ruling family at Prosymna may have encouraged the arrival of new settlers and led to population growth during LH IIA (cf. Shelton 1996: 306).

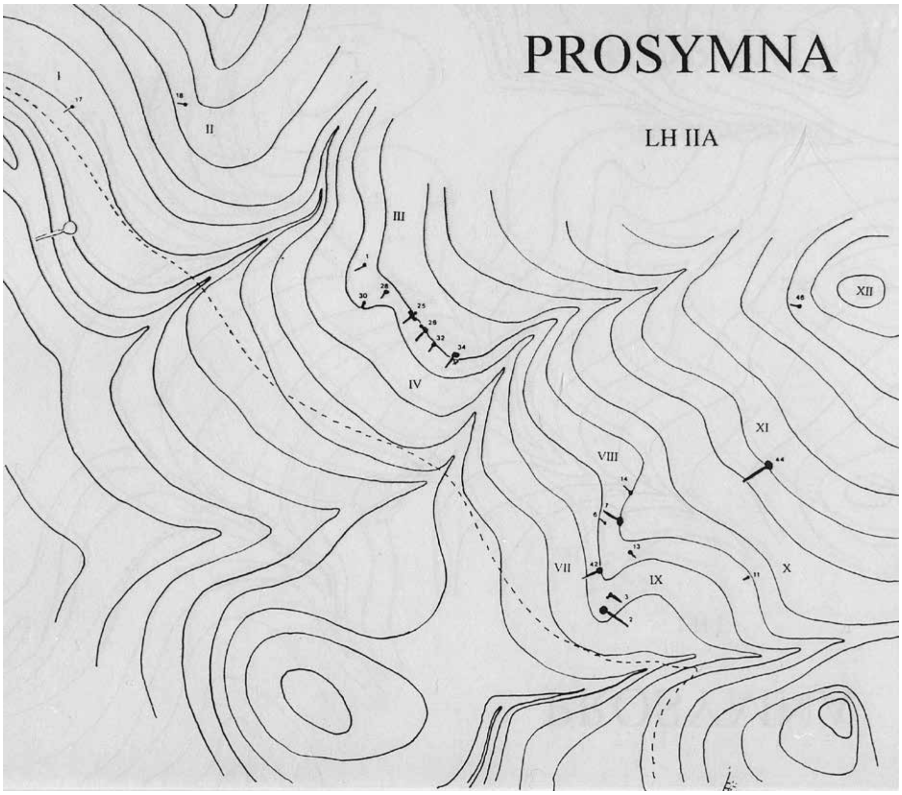

Figure 4. Prosymna, tombs in use during LH IIA (after Shelton 1996, map 3).

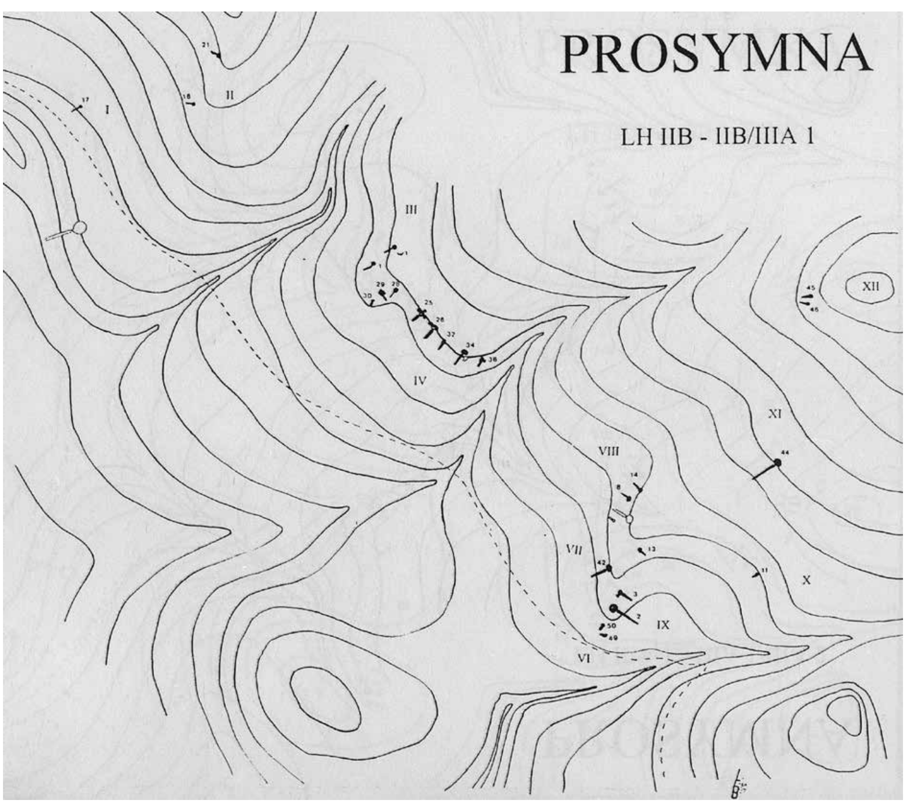

Figure 5. Prosymna, tombs in use during LH IIB-IIB/IIIA1 (after Shelton 1996, map 4).

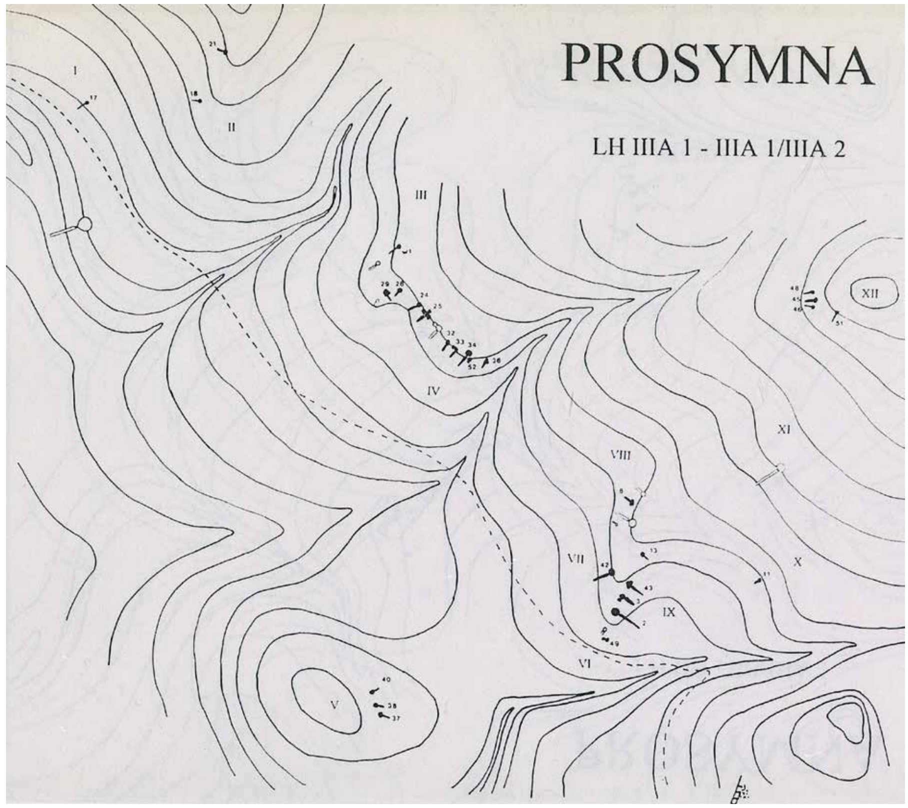

Figure 6. Prosymna, tombs in use during LH IIIA1-IIIA1/IIIA2 (after Shelton 1996, map 5).

During LH IIB (Figure 5) no new necropolis was established, but several new chamber tombs were carved, especially within the smaller necropoleis: three tombs were created in the lower slopes of the East Yerogalaro Ridge, and two in the upper slopes (Chamber Tombs 49, 8, 50, 45 as well as Tomb 'P-D';[1] this last tomb is not shown in Figure 1). Three more tombs were carved into the Western Yerogalaro Ridge (Chamber Tombs 36, 29, W1) and one into the Asprochoma Ridge (Chamber Tomb 21). All in all, it seems that there was no major change in the constitution of the society during this period, but there was probably a growth in the size of families (evidenced by new tombs in existing necropoleis). In addition, one new group of people might have arrived since one of the new tombs was carved in a rather isolated position (Chamber Tomb 21; cf. Shelton 1996: 306).

In LH IIIA1 (Figure 6), the picture does not change much. Additions were made to only three of the tomb groups: one tomb in the oldest necropolis in the West Yerogalaro Ridge (Chamber Tomb 33), one in the lower slopes of the East Yerogalaro (Chamber Tomb 43, Tomb Group IX), and two near its summit (Chamber Tombs 48 and 51). Beyond that, a new geographical group (Tomb Group V) was established in the east slope of the Kephalari Hill to the west of the settlement. In this period, three chamber tombs were carved there (Chamber Tombs 37, 38 and 40). Thus, all twelve tomb groups were established by LH IIIA1, whereas Tomb Group XI does not seem to have been in use during that phase.

It is important to note that, apart from the tholos tomb, Tomb Group V is the only tomb group to have been established south of the LH road ('M4') to Mycenae (cf. Figure 1). According to Shelton (1996: 307), it is quite certain that their creation marks the arrival of a new group of people at Prosymna.

During LH IIIA2 (Figure 7), a major growth of the population is indicated through the construction of many new chamber tombs, all within the already existing tomb groups. This suggests that no new groups were established at Prosymna from that period onwards, but that the existing families and groups grew: Chamber Tombs 16 and 19 in the Asprochoma Ridge, Chamber Tombs 22, 27 and 35 in the West Yerogalaro Ridge, Chamber Tombs 41, 15, 10, 12, 47, 4 and Tomb 'Verdelis' (this last tomb is not mentioned in Figure 1) in the upper and lower slopes of the East Yerogalaro Ridge, and Chamber Tomb 39 in the east slope of the Kephalari Hill. Additionally, the growth of population is also indicated through a number of older tombs that were reused after a period of abandonment. This might have been influenced by economic reasons, as people, whether from existing families or new immigrant

1 Following Shelton (1996: 306), this tomb is named after its excavator: Protonotariou-Deïlaki 1960: 124-135.

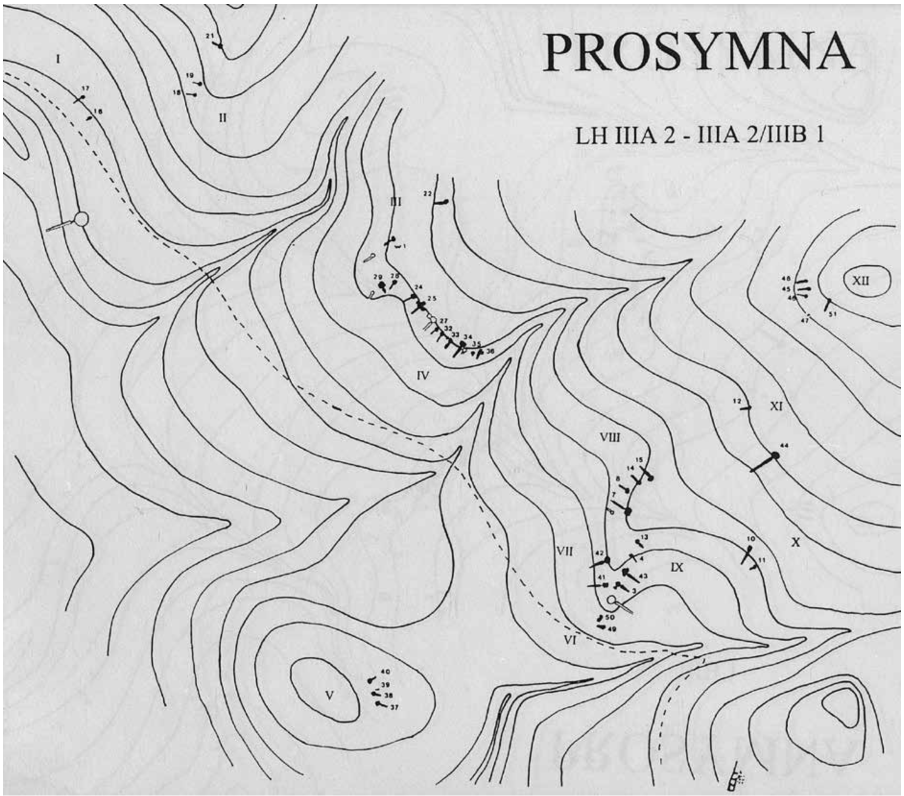

Figure 7. Prosymna, tombs in use during LH IIIA2-IIIA2/IIIB1 (after Shelton 1996, map 6).

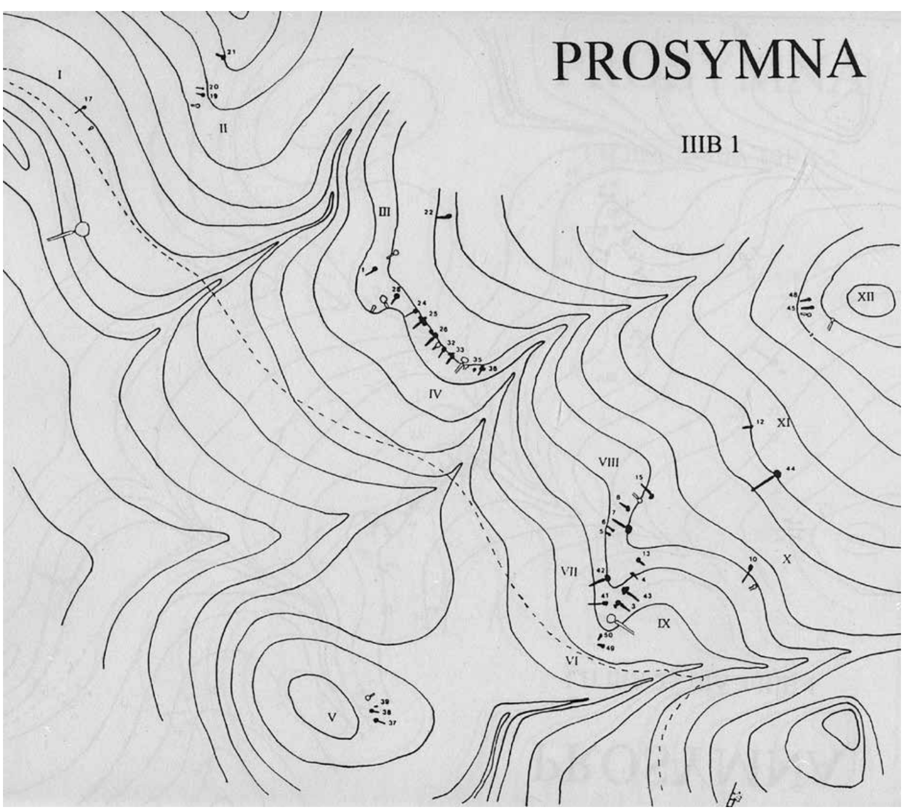

Figure 8. Prosymna, tombs in use during LH IIIB1 (after Shelton 1996, map 7).

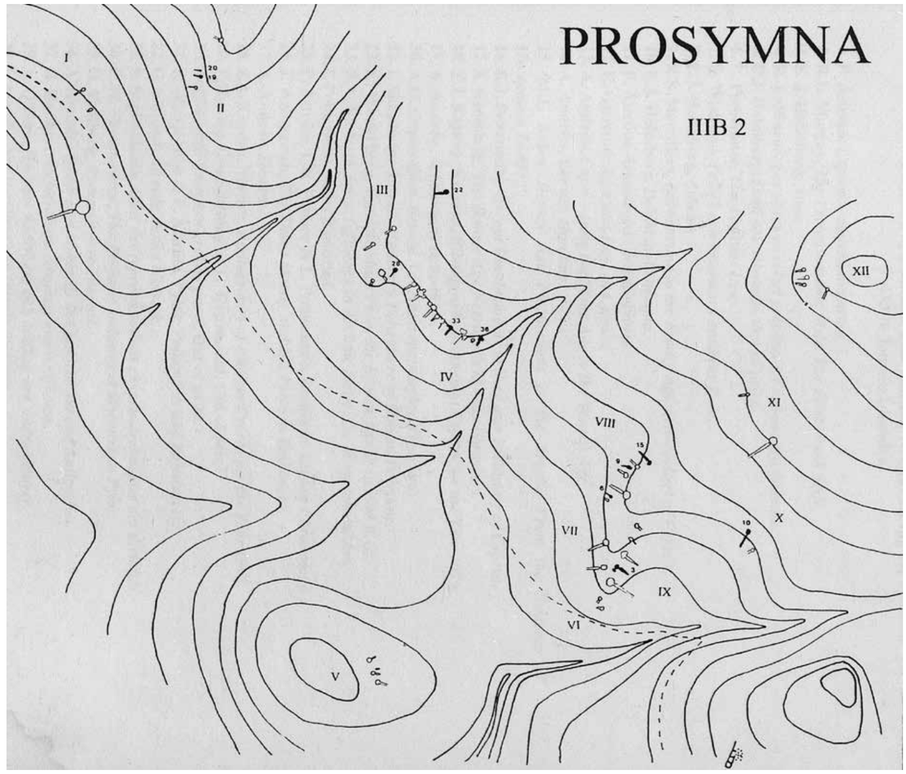

Figure 9. Prosymna, tombs in use during LH IIIB2 (after Shelton 1996, map 8).

groups, sought to utilise existing resources in order to avoid carving new tombs or tomb groups. Shelton (1996: 307) argues that such growth could have happened without new immigrants. According to her argument, it is also likely that the majority of overall population increase happened within the families and groups already living at Prosymna, which would explain why tombs in established groups were selected for reuse.

In LH IIIB1 (Figure 8), only one or two new tombs were established: Chamber Tomb 20 in the Asprochoma Ridge (its earliest use is unclear, occurring in either IIIB1 or IIIB2) and Chamber Tomb 5 in the East Yerogalaro Ridge. In addition, many tombs across various tomb groups were abandoned, perhaps due to population decrease.

In LH IIIB2 (Figure 9) the decrease apparently continued: five tomb groups went out of use. It seems that only one or perhaps two tombs were cut during this period. These are Chamber Tomb 9 in the East Yerogalaro Ridge, which had been disturbed prior to excavation, and possibly Chamber Tomb 20 in the Asprochoma Ridge (which, as noted above, may not have been constructed in the preceding period). According to Shelton (1996: 307), if one or both tombs were cut in this period, the reason for their creation might not have been due to the arrival of new families, but rather due to damage in other tombs. During this period, most of the tomb groups had just one to three tombs still in use. Interestingly, one of them is the oldest tomb group along the West Yerogalaro Ridge. The entire population in LH IIIB2 seems to have consisted of just six to seven different larger family groups, as indicated by the tomb remains. By LH IIIC Early, the settlement seems to have shrunk to just one family: one interment in Chamber Tomb 20 in the Asprochoma Ridge (cf. Shelton 1996: 307).

2.1.3. Discussion

As regards the transition from Middle Helladic to Late Helladic times, Shelton (2020: 51) has observed that a 'juxtaposition of chamber tombs built in the Early Mycenaean period and Middle Helladic cist graves suggests that an ancestral cemetery was being maintained, despite the change of tomb type'.

Given the chronology of the tomb groups and the single tombs, some general thoughts can be made. In my view, it is tempting to accept the idea that different geographical positions of tombs and tomb groups are indicators for different non-native population groups, but due to the lack of written sources (Blegen 1937a; Shelton 1996), we cannot be certain and should avoid stating any firm conclusions on such matters. Therefore, many different scenarios are possible. In my opinion, the creation of each new tomb group may not indicate the arrival of a new group: it could also mark a splitting of a pre-existing family group or clan and/or a mixing of two different clans or families. Furthermore, without additional evidence, the reasons behind such events cannot currently be determined. Such developments at a site might have been initiated through new relationships but could also have been based on the division of groups due to internal conflicts. During LH times in general, the only distinct ways to trace the arrival of a new group, not related to the indigenous population, are the comparison of grave offerings between tombs and tomb groups as well as DNA analyses of the preserved individuals. Detecting offerings (and arrangements) in certain tombs at a site, which are distinctly different from those observed in other tombs (and might be situated at a certain distance from others), yields a certain hint to different population groups. This idea relies on the assumption that a new group of people bring (at least some) different products, techniques and traditions with them.

2.2. Tiryns

2.2.1. Context

The Prophitis Ilias hill is located to the east of Tiryns; on its western side two tholos tombs have been found, while a chamber tomb necropolis is located on its eastern side. One of the tholos tombs has been excavated and published (Müller 1975; see now a new examination: Brysbaert et al. 2022, the other has only been partly excavated (Papadimitriou 2001: 71). Although the hill is at a distance of around 1 km from Tiryns, and the chamber tomb necropolis itself approximately 1.5 km as the crow flies (Figure 10; Brysbaert et al. 2020: 56), the tombs should nevertheless be associated with the site of Tiryns since the hill is the nearest point in the vicinity to be suitable for chamber tombs. The hill mostly consists of limestone that is too hard for bronze tools, but on its eastern side there is a covering of softer serpentine in which the tombs are carved. In the necropolis area, approx. 50 chamber tombs have been located, 20 of them investigated in full, and four just partly investigated (Figure 11), while two of them were found robbed (Rudolph 1973).[2] The orientation of the tombs (roughly) follows the natural decline of the slope. Due to the hiatus between the tomb's excavation (in 1927, by a team under the direction of G. Karo, cf. Rudolph 1973: 23.) and their publication, the provision of some contextual details is inexact. Sometimes, even the precise find spot of some of particular finds is unknown. Beyond this, we face the problem that some graves were found in such disorder that individual vessels could not be associated with specific corresponding burials, so the chronological sequence of burials could not be reconstructed. The number of excavated and partly excavated chamber tombs thus represents just a sample of the total number of tombs in this necropolis (cf. Alden 1981: 230-231). In my view, the representativeness of this sample is limited because it equates to just a third of the known necropolis.

2 The following tombs have been fully excavated: Chamber Tombs I, III, IV, V, VI, VII, VIII, XIV, XV, XVI, XVII, XVIII, XIX, XX. The following tombs have just been partly excavated (only the dromos): Chamber Tombs II, XI, XIII, XXII, XXV, XXXVI.

2.2.2. Data (cf. Figure 12)

Since we only have reliable data for around a third of all the known tombs, any subsequent conclusions regarding the development of the community's size can only be tentative. Due to the fact that only the dromoi (but not the chambers) of Chamber Tombs II, XXII, and XXV have been excavated to date, these tombs are omitted from the following discussion of the development of the known section of the necropolis.

Of the excavated chamber tombs at Tiryns, none seem to date to LH I (the dating of the chamber tombs of Tiryns follows the dates provided in their full publication: Rudolph, 1973). The few isolated LH I vessels which have been found might have accompanied later burials (Alden 1981: 234). In LH IIA (Figure 11), six tombs came into use: Chamber Tombs IV, XVI-XX, indicating rich families or family groups. In LH IIB one of these tombs fell out of use (Chamber Tomb XX), while the other five continued to receive burials. Furthermore, Chamber Tombs III, VII, and VIII came into use for the first time during this phase. The LH IIB material from Chamber Tombs III, IV, and VIII was relatively minimal, probably indicating that corresponding burial activity commenced later in that sub-phase (Rudolph 1973: 124). Taken together, the material from these tombs seems to indicate the growth of the Tiryns community over the course of LH II. In LH IIIA1, the settlement's size seems to have remained similar (with a small increase), but with some changes concerning which tombs were in use. Excluding Chamber Tomb XI, from which the evidence is scant and interrupted, Chamber Tombs I, III, IV, VI-VIII, XVI and XIX were in use throughout LH IIIA1, while the use of Chamber Tombs III and VII probably ceased prior to the end of the phase. In LH IIIA2, the settlement evidently grew further, since three new tombs were created (Chamber Tombs V, XIV, XV; the use of V began later in the phase). Burials in Chamber Tombs III and VII, however, ceased (as early as the later part of LH IIIA1), and subsequently ceased in Chamber Tomb I during LH IIIA2; evidence for the ongoing use of Chamber Tomb XI during this phase remains limited. Over the course of LH IIIB1, a decrease in the number of tombs in use is apparent. Chamber Tombs VIII and XIX went out of use early in the phase, as did IV and V shortly after the middle of the phase; VI, XIV-XVI stayed in use for the whole phase, while XVIII was in use towards the phase's beginning. This obvious drop in the size of the community during LH IIIB1 clearly does not mirror the palatial reality and splendour of Tiryns at this time (e.g., Maran 2015). From my point of view, the reason for this discrepancy must be sought mainly in the fact that just less than a third of all detected tombs has been excavated (cf. above). In the following phase – LH IIIB2 – the number of tombs

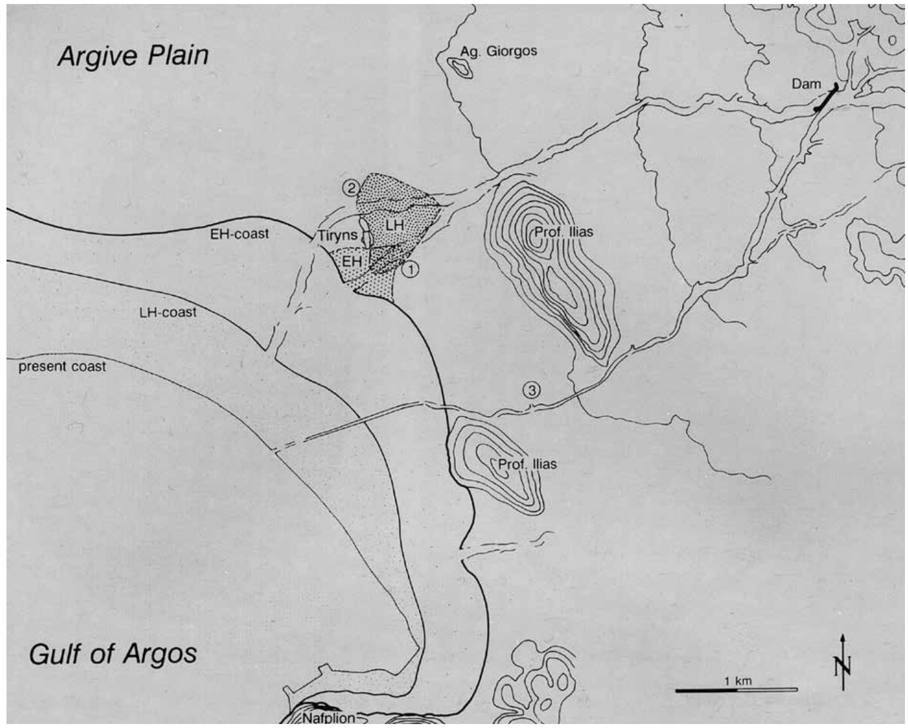

Figure 10. Tiryns and surroundings during the Bronze Age (after Papadimitriou 2001, Abb. 1).

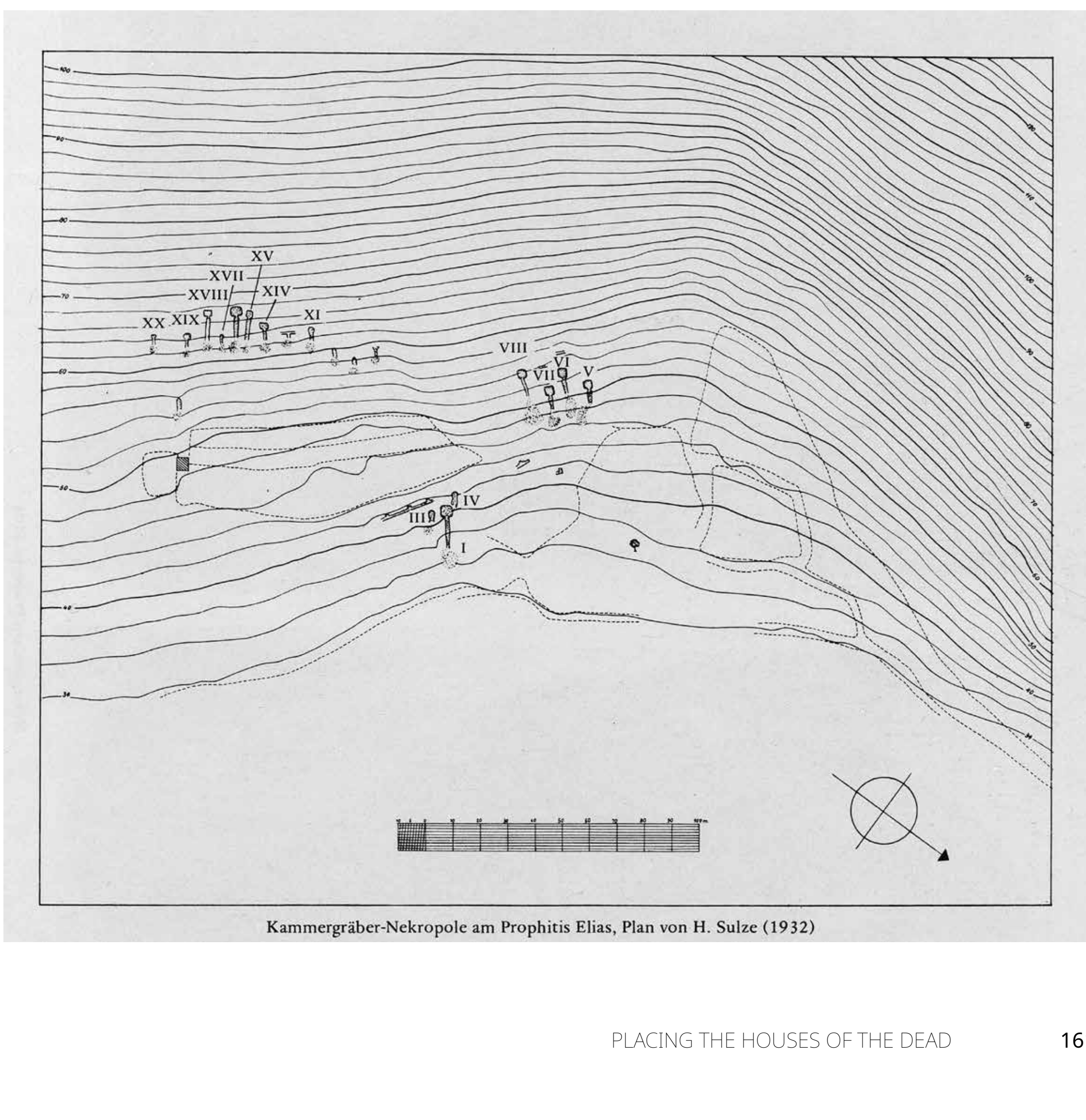

Figure 11. Prophitis Ilias Hill (east of Tiryns): chamber tomb necropolis (after Rudolph 1973, Tafel 9).

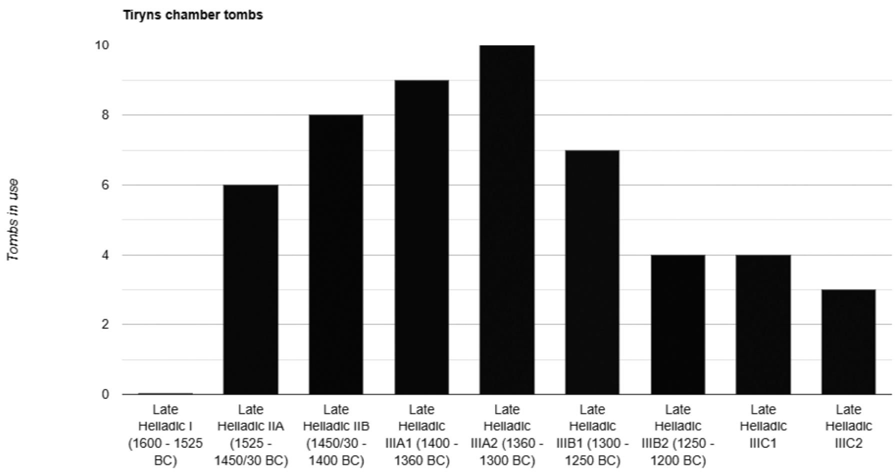

Figure 12. Tiryns. Tombs in use per sub-phase (S. Müller; dating based on Rudolph 1973: 124).

in use shrank even further: Chamber Tombs XIV, XVI and XVIII fell out of use in the later part of the phase. Only Chamber Tombs VI and XV remained in continual use. However, Tombs V and VII came into use again towards the end of the phase, following a temporary hiatus in new burial activity. That the community might have shrunk at the end of the phase is certainly connected with the collapse of the Late Helladic palaces. In the earlier part of LH IIIC1, four tombs were in use (Chamber Tombs V-VII, XV), whereas in the later part of the phase, this number changes to three (Chamber Tombs VI, VIII and XVI). In LH IIIC2, these three final tombs stayed in use until roughly the middle of the phase and ceased to be used for new burials after that point (Rudolph 1973: 124), perhaps reflecting the reality of post-palatial decline at Tiryns.

The overall picture gained by examining the excavated tombs is a rather poor one. For the most part, only pottery vessels have been found, which might indicate that the graves had been looted at some point in time (Sjöberg 2004: 112).

2.2.3. Discussion

According to Rudolph (1973: 87), the division of the excavated tombs into three groups (Figure 11) might be coincidental: due to the geological settings, which also finds confirmation through the distribution of the other known, but not excavated tombs (locations not included in Figure 10). A more compelling proof for this claim is lacking in Rudolph's publication (Rudolph 1973: 87). I find Rudolph's statement questionable, especially in relation to a very significant palatial site like Tiryns, where many different families, family groups, and clans should be expected. Furthermore, since there are not many locations in the vicinity of Tiryns suitable for chamber tomb necropoleis, it is very likely that the necropolis on the eastern slope of the Prophitis Ilias hill is divided according to different familial groups. Beyond that, the space for the approximately 50 known tombs seems to be rather limited, which could also suggest that a division into geographically separated familial groups might not always have been possible. A full excavation of all known tombs is needed. The only visible spatial division which might be identified with relative confidence is the placement of royal burials on the west side of the Prophitis Ilias Hill, where the two known, and perhaps more as yet unknown, tholoi are situated.

2.3. Dendra

2.3.1. Context

The Late Helladic necropolis of Dendra is located about 2 km northwest of the citadel of Midea (Figure 1), to which it can most likely be attributed. The main publications relating to this necropolis (Figure 13) are Persson (1931; 1942), Åström (1977), and Protonotariou-Deïlaki (1990). Chamber Tombs 4 and 5, excavated by N. Bertos in 1927, have never been fully published. There are, however, three photographs of Chamber Tomb 4 from 1927 (showing the dromos, with intact stomion wall and a niche in the right dromos wall, containing a skeleton); a sketch of the same tomb was also produced. In 1962, Chamber Tomb 4 was cleaned, resulting in the discovery of two probable niches in the chamber, each containing a few finds (Åström 1983: 6, figs. 5-7).

Chamber Tombs 15 and 16 have seen a very brief publication (Protonotariou-Deïlaki 1990: 95, figs. 4, 8, 10). A plan of the whole necropolis has been published in different versions, but none of them depicts all 17 LH tombs together: 15 LH tombs are included in Figure 13, but Chamber Tombs 15 and 16 are only depicted in Figure 14, a map showing a section of the whole necropolis. The LH necropolis of Dendra contains 16 chamber tombs and one tholos tomb. No comparable necropolis has been discovered nearer to the citadel itself.

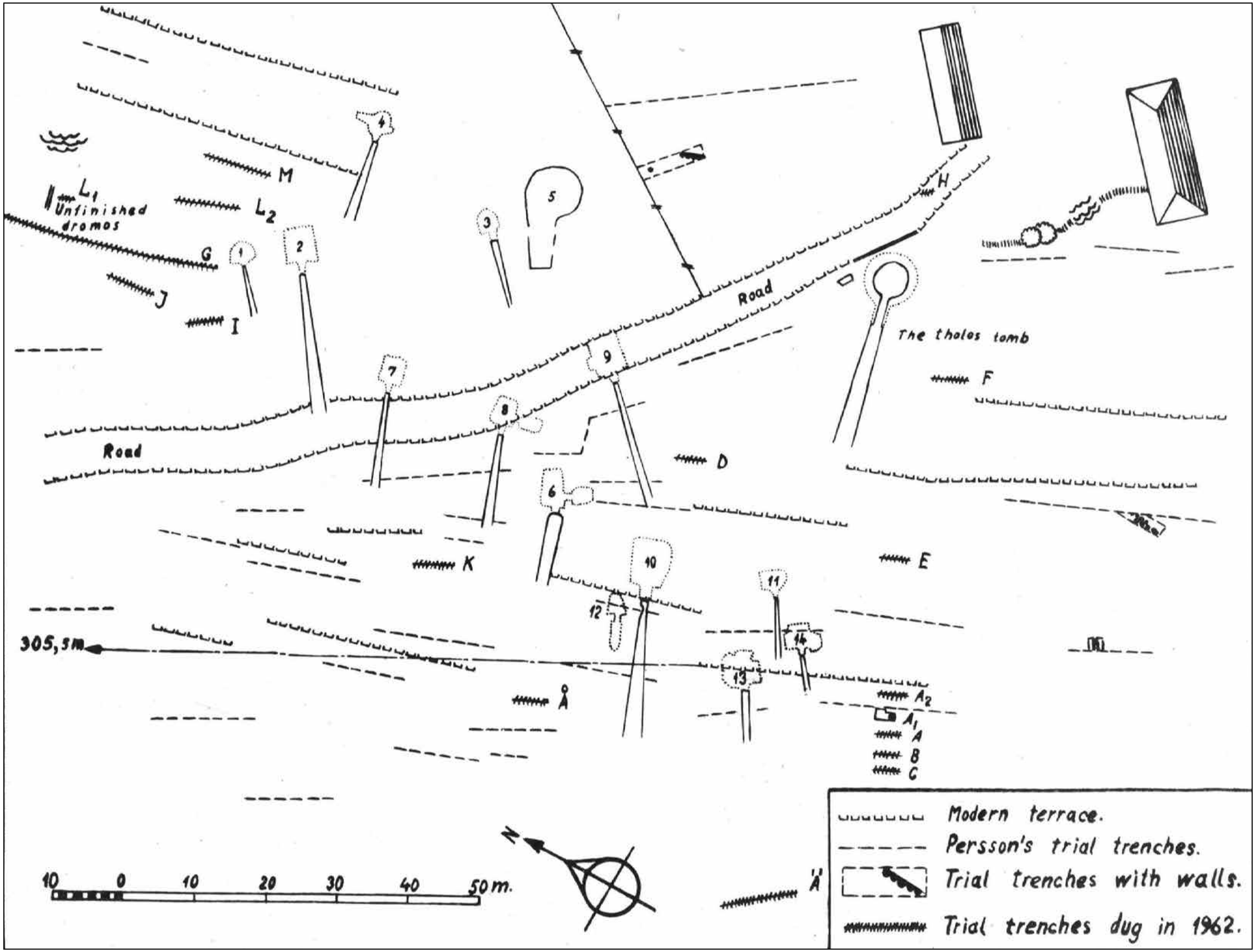

Figure 13. Dendra, general plan (after Åström 1977, fig. 1).

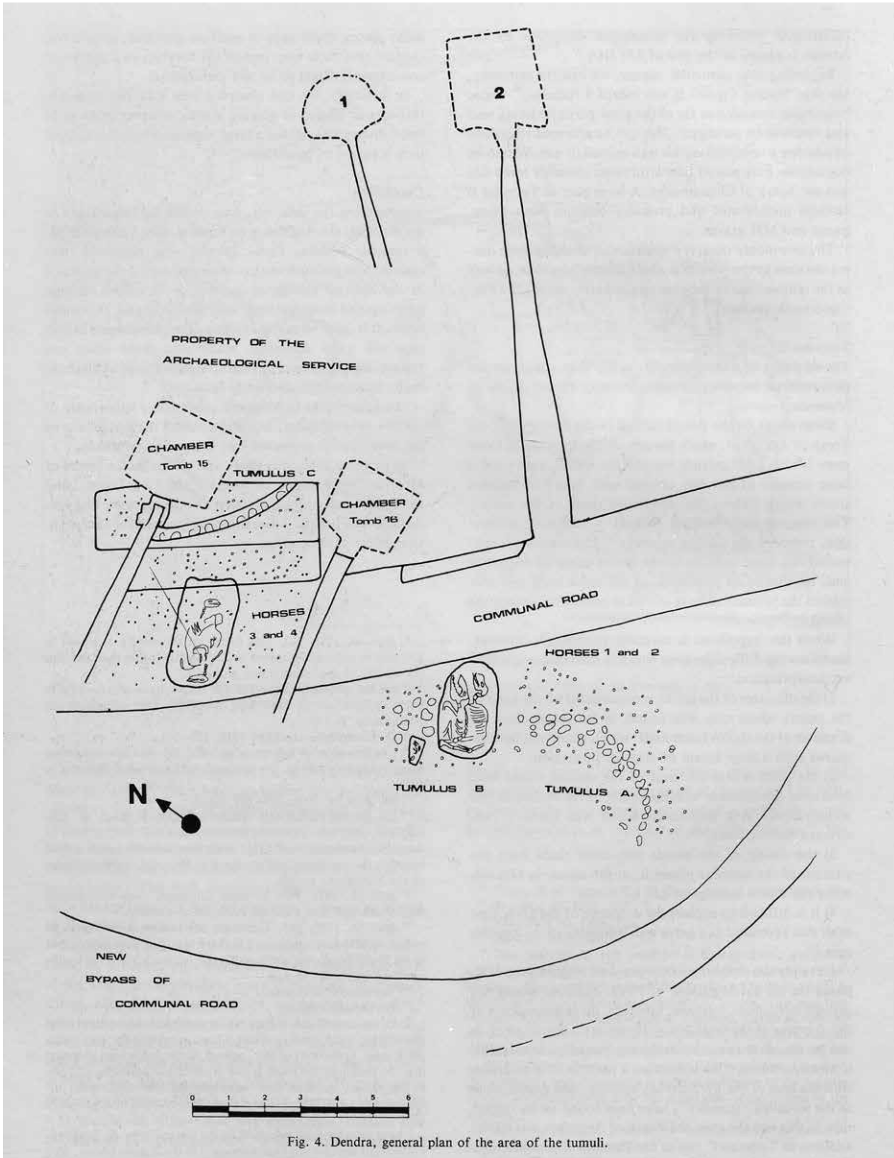

Figure 14. Dendra, area of the tumuli (after Protonotariou-Deïlaki 1990, fig. 4).

The tombs were carved into a gentle terraced slope south of the modern road through Dendra (Figure 13). The tombs are roughly oriented according to the direction of the slope. There is no clear grouping to be observed like that at Prosymna, except for the tholos tomb which is spatially differentiated from all of the chamber tombs (Figure 13), the latter being situated to their south/southeast/east. Thus, 14 chamber tombs, excluding the unpublished Chamber Tombs 4 and 5 (see Astrom 1983: 6) are considered in this section.

2.3.2. Data (cf. Figure 15)

As regards the dating of the chamber tombs and the tholos tomb, their chronology is mainly based on the overview of research in Sjöberg (2004: 111, 114-115) for Chamber Tombs 1-3, 6-14 and the tholos tomb, but for Chamber Tombs 15-16, the initial publication (Protonotariou-Deïlaki 1990) needs to be used, since they are not included in Sjöberg's work. Only in LH IIA do the first four tombs appear: Chamber Tombs 6, 8, 10, and 13. In the following phase (LH IIB), the number of tombs in use increases to six: three new tombs were dug, Chamber Tombs 7, 11 and 12, while Chamber Tombs 8, 10, and 13 were reused. The use of Chamber Tomb 6 probably ceased altogether. During LH IIIA1, seven tombs were in use (Chamber Tombs 10-13, 15-16 and the tholos tomb; Chamber Tombs 7-8 falling out of use). A further change is observed in LH IIIA2, at which time the use of Chamber Tombs 1 and 2 was ceased. At this time, Chamber Tomb 12 and the tholos tomb went out of use, while five (Chamber Tombs 10, 11, 13, 15 as well as 16) continued to receive burials. In the following

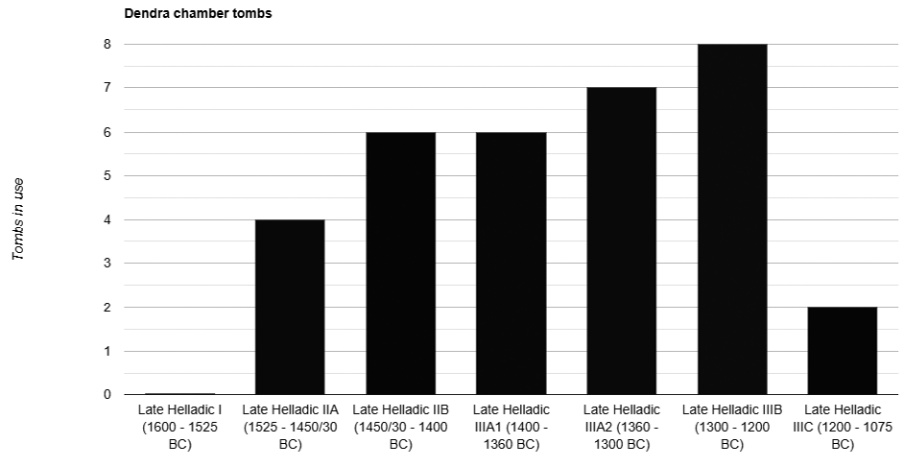

Figure 15. Dendra. Tombs in use per sub-phase (S. Müller; dating based on Sjöberg 2004: 111).

phase LH IIIB, an increase in the number of tombs is attested, a total of eight were occupied: Chamber Tombs 1, 2, 11, and 13 saw ongoing use, while Chamber Tombs 3, 9, and 14 were newly carved. Chamber Tomb 7 was reused after a temporary hiatus, probably two successive phases in length; Chamber Tombs 10, 15, and 16 went out of use altogether. A great decrease in tombs has been noted as regards LH IIIC: just Chamber Tombs 7 and 11 stayed in use.

2.3.3. Discussion

In comparison to other necropoleis of the Argive Plain (like Prosymna or Argos), the necropolis at Dendra shows a more homogenous picture of wealth during LH IIA-IIIC. In particular, this observation is evidenced by the copious deposition of metal objects. It is important to emphasise that by LH II, many of the object types attested at Dendra must have arrived through trade (such as items of lead and silver, materials which were not mined in the region of the Argive Plain). Such finds testify to a considerable wealth known to the social groups of that period (Sjöberg 2004: 114-115).

2.4. Berbati valley

2.4.1. Context

In the Berbati valley, three chamber tomb necropoleis have been found, but only one of them, the 'Western Necropolis', has been partly excavated (Alden 1981: 279). This necropolis is located 1.2 km to the northwest of the Mastos Hill (Figure 16), which must have been the acropolis of the area during the Bronze Age (Säflund 1965: 15). Twelve tombs have been found, distributed over four terraces. Of these, eight have been excavated (Chamber Tomb I-III, VI, VIII, X-XII), while Tomb VI has been identified as an empty pit. Unfortunately, no plan of this necropolis has yet been published (and no map shows the exact location of the other two necropoleis). As such, we only have the plans and sketches of the seven single tombs (Säflund 1965), and the location of the necropolis on published maps of the Berbati valley (Figure 16). The tombs are roughly oriented according to the course of the slope. One further chamber tomb has been excavated to the northeast of the acropolis (Holmberg 1983), as well as one tholos tomb to the northwest of the acropolis (Santillo Frizell 1984).

2.4.2. Data (cf. Figure 17)

The seven chamber tombs of the Western Necropolis were mainly in use during LH IIIA1 until IIIB as the site's excavators did not subdivide this last phase. The chronology of the tombs is based on Säflund (1965) for Chamber Tombs I-III, VIII, X-XII, on Holmberg (1983) for the single chamber tomb, and on Santillo Frizell (1984) for tholos tomb. It seems that an earliest chamber tomb (Chamber Tomb I) was in use between LH IIA and IIB (Sjöberg 2004: 121-122), until new tombs appeared in conjunction with an increase in population during LH IIIA1, when four chamber tombs of the Western Necropolis were in use: Chamber Tombs II, X-XII. In the following phase, LH IIIA2, the growth of the population was intensified: all seven tombs of the Western Necropolis (I-III, VIII, X-XII) as well as the single chamber tomb to the northeast of the Mastos Hill were in use. In LH IIIB, a decrease of population is observable, with only three tombs continuing to receive burials. Chamber Tombs II, III, VIII, XI, and XII went out of use, with only the three others remaining in use, while for LH IIIC there is no indication of ongoing tomb use at all.

2.4.3. Discussion

Of course, the available evidence is rather scant, since two whole necropoleis as well as four remaining tombs of the Western Necropolis have not yet been excavated. Future excavations could therefore change this current picture radically. Beyond that, it is also important to take into

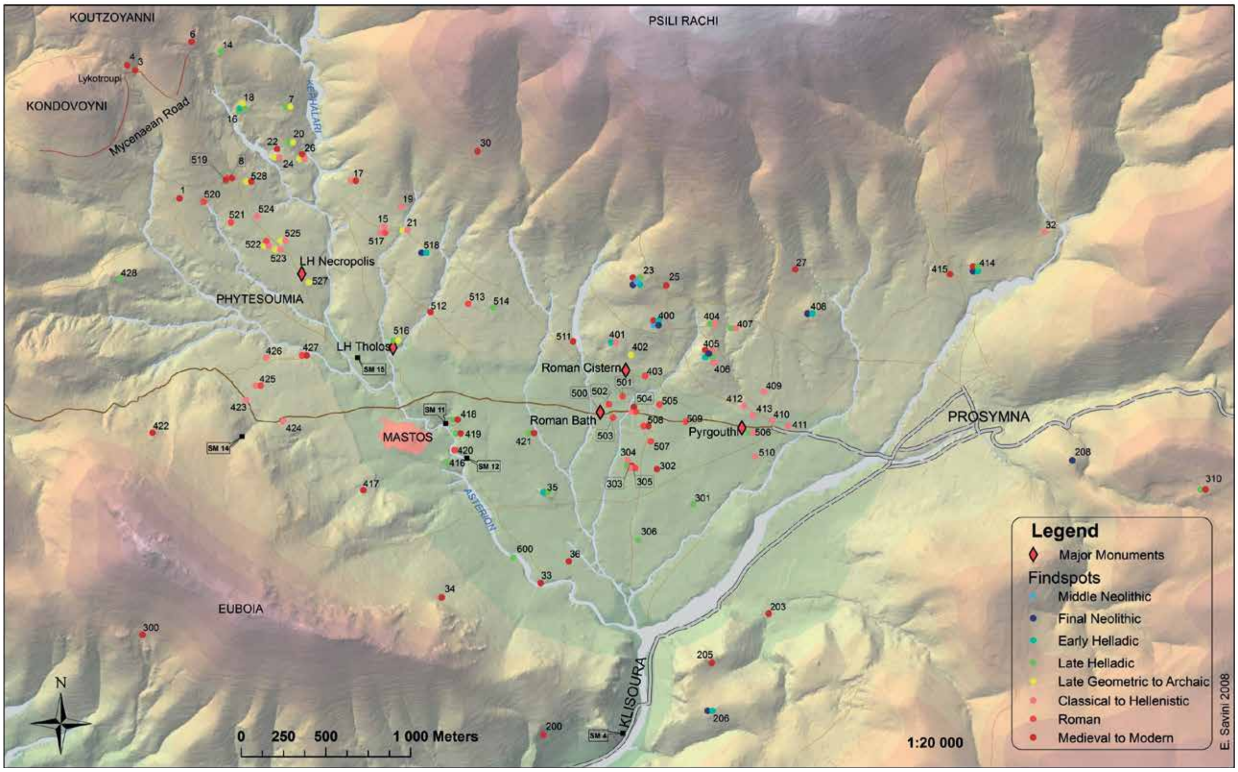

Figure 16. Berbati valley, general map depicting several archaeological sites (after Wells and Lindblom 2011, fold-out 1; drawn by E. Savini).

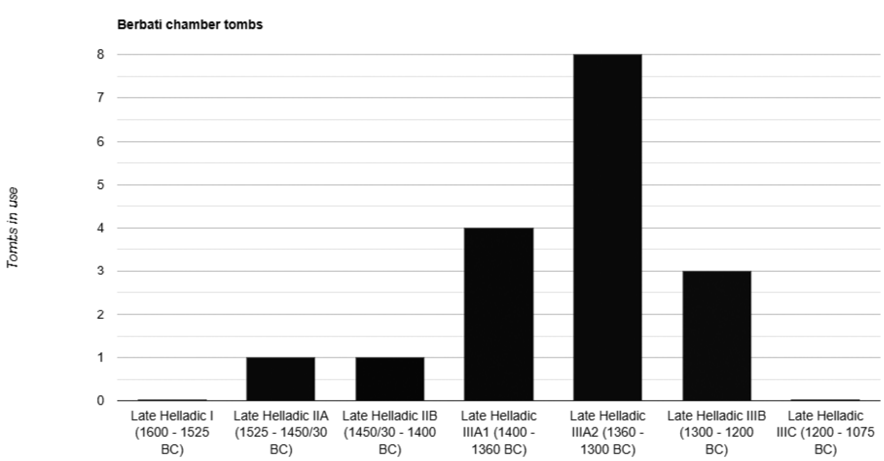

Figure 17. Berbati valley. Tombs in use per sub-phase (S. Müller; dating based on Sjöberg 2004: 122).

account that one out of the seven excavated chamber tombs of the Western Necropolis might have been (mostly) robbed (Chamber Tomb III, Säflund 1965: 35-42). Furthermore, all the seven tombs had been disturbed due to their collapsed roofs, but six (Chamber Tombs I, II, VIII, X-XII) still contained burials (some even *in situ*) as well as grave goods (Säflund 1965).

Compared to Dendra in particular, but also other necropoleis in the region, the seven tombs of the Berbati valley's Western Necropolis are characterised by much less ostentatious burial assemblages, and perhaps create a picture of a somewhat poorer community. The only current exception is the single chamber tomb to the northeast of the Mastos Hill, which contained not only many pottery vessels but also a larger range of object types (Holmberg 1983). Even here, the available evidence is quite limited in quantity.

2.5. Argos

2.5.1. Context

Argos has a dense group of tombs in the Deiras ravine between the Larisa hill and the Aspis hill (Figure 18), where approximately 40 chamber tombs and 30 pit and

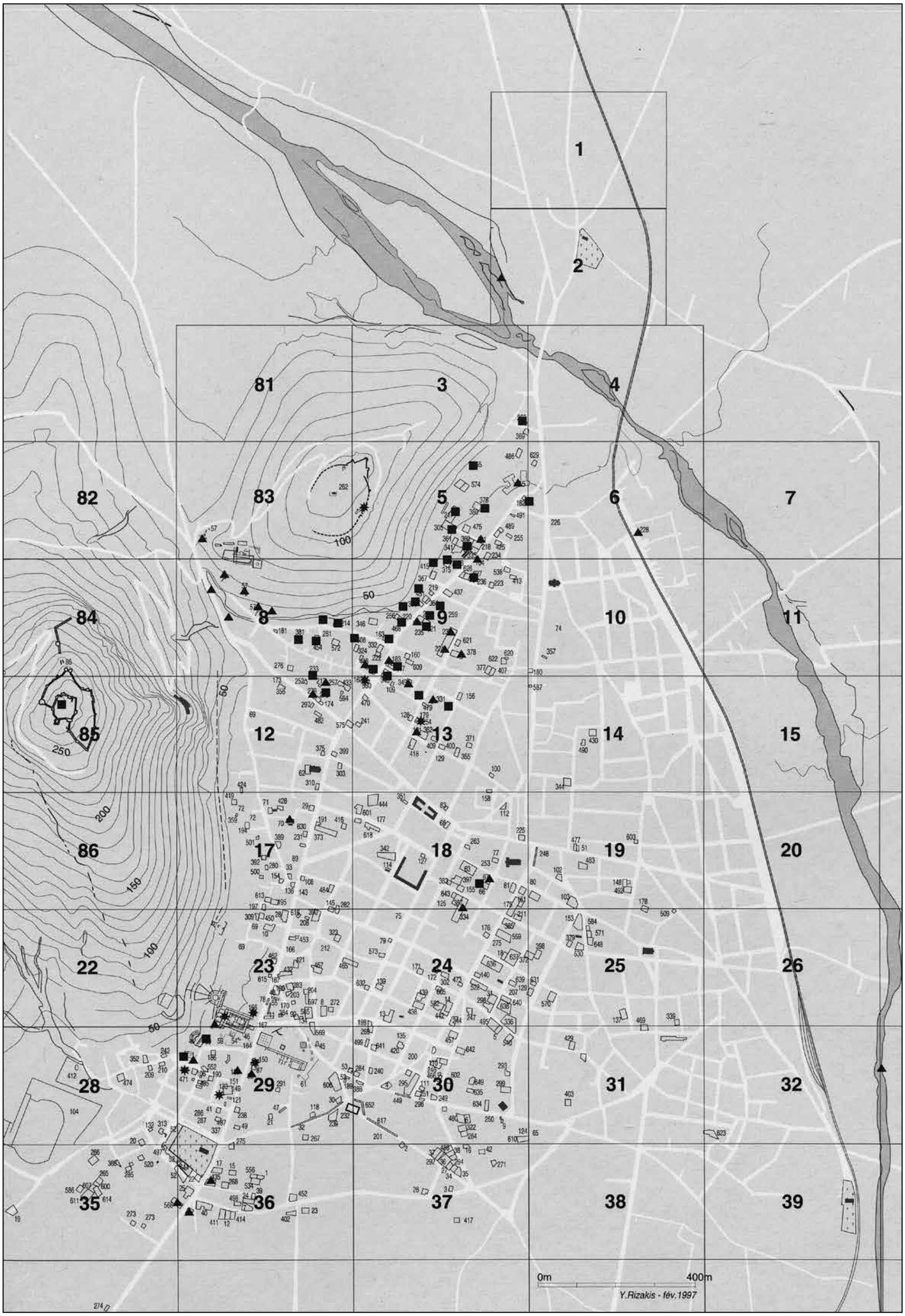

Figure 18. Argos in LH times (after Pariente and Touchais 1998, pl. 8).

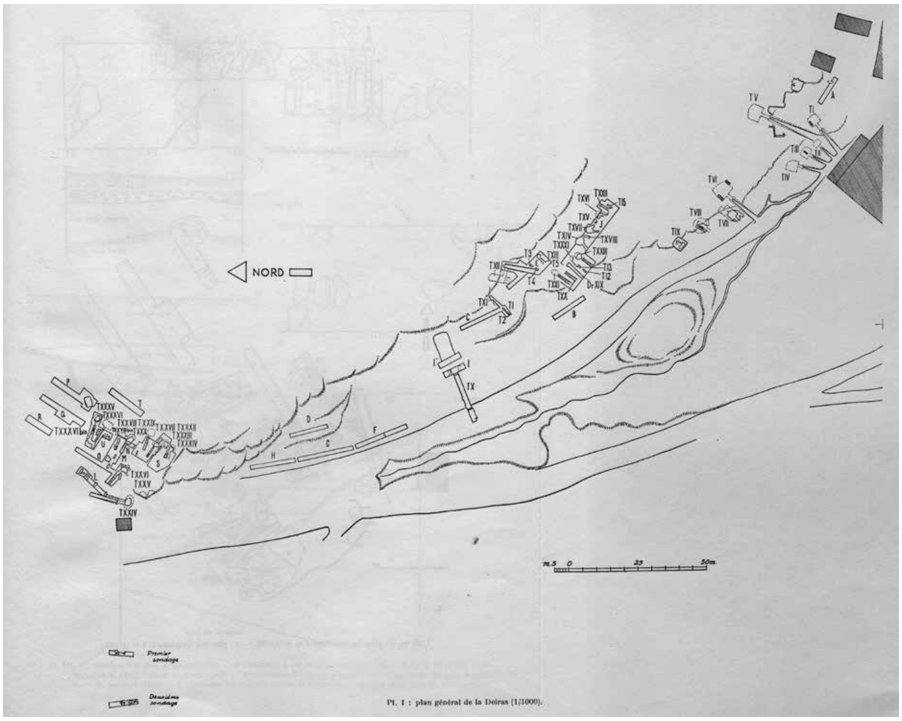

Figure 19. Argos, Deiras necropolis (after Deshayes 1966, pl. 1).

cist graves are located (Figure 19).[3] As such, it is one of the largest Late Helladic necropoleis in the Argive Plain. Asine and Prosymna each have a similar number of tombs (Alden 1981) and Nauplion contains even more (Piteros 2015), but Mycenae remains the largest by far, containing at least around 250 chamber tombs (cf. Shelton 2003).

The tombs in the Deiras ravine are divisible into three geographic groups, which are located along the western foot of the Aspis Hill: the southern, the central and the northern sector (for a list of key publications, cf. Papadimitriou et al. 2020: 61). The tombs are roughly oriented according to the course of the slope (Figure 19).

2.5.2. Data (cf. Figure 20)

Concerning the construction dates of the chamber tombs as well as pit and cist graves, a recent re-examination of the pottery has been published (Papadimitriou et al. 2020, table 4.1). These results are included in and connected with the published data, allowing a more precise dating of some of the tombs and their subsequent reuse. The earliest attested establishment and use of chamber tombs is to be found in the southern sector and on the opposite side of the ravine: in LH IIA, Chamber Tomb VIII was carved, as was Chamber Tomb 'Larissa 2'. LH IIB saw the construction of three tombs (Chamber Tombs VI, VII, IX, situated in the southern sector), while Chamber Tomb VIII continued to stay in use. In LH IIIA1, Chamber Tombs I, III and V were built in the southern sector, while XXIV, XXVI, XXX, and XXXIII appeared in the northern sector; in addition, Chamber Tombs VI-IX remained in use. During LH IIIA2, Chamber Tombs II and IV in the southern sector, XI-XIII, XVI, and XXI in the central sector, and XXVII, XXVIIIbis, XXIX, XXXII, XXXIV, and XXXIV in the northern sector were built. Also, during LH IIIA2, Chamber Tombs II-IV (in the case of Chamber Tomb III, only during the early part of this phase), VI-IX (and possibly also V) in the southern sector, as well as XXIV, XXVI, XXX, and XXXIII in the northern sector remained in continual use. In LH IIIB (no further subdivision into LH IIIB1 and IIIB2 has been published so far, except in the cases of Chamber Tombs I-IX), Chamber Tomb 'Larissa 1' was carved in the southern sector, XIV, XV, XVII, and XXIII in the central sector, and XXV, XXVIII, and XXXVI in the northern sector. Tombs remaining in continual use throughout LH IIIB include Chamber Tombs II, IV, VIII, and IX (IV and VIII only in LH IIIB1) in the southern sector, XII, XVI, XIX, and XXI in the central sector, and XXVI, XXVII, XXIX, XXX and XXXV in the northern sector. In LH IIIC, Chamber Tombs XVIII, XX, XXII, and XXXI were built in the central sector, but no new tombs were constructed in either of the other two sectors. Chamber Tomb II in the southern sector contained some LH IIIC1 evidence. Otherwise, no tombs

3 Two chamber tombs are situated on the opposite site of the ravine to the main concentration of tombs. These are called 'Larissa 1' and 'Larissa 2', and are not visible on the plan included in this study – no overall plan including the location of these two sepulchres has yet been published.

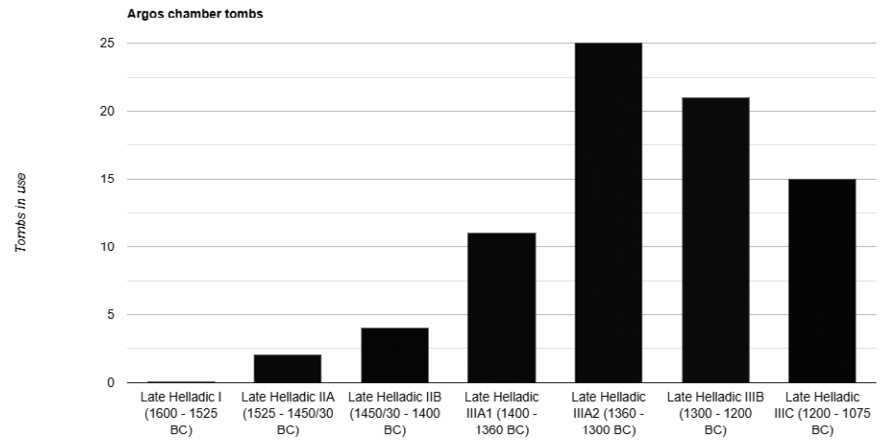

Figure 20. Argos. Tombs in use per sub-phase (S. Müller; dating based on Sjöberg 2004: 116 and Papadimitriou et al. 2020, table 4.1).

at Argos yielding LH IIIC material have been further categorised in accordance with Early, Middle, or Late sub-phases (LH IIIC1, IIIC2, and IIIC3 respectively) in any studies published to date, except for Chamber Tombs I-IX. In the central sector, XIV, XVI-XVIII, XX, XXII, and XXXI stayed in use into LH IIIC, as did XXIX, XXX, and XXXIII in the northern sector. With regard to the tombs in these last two sectors, information about the duration of tomb use during LH IIIC, based itself on an investigation of their contents, has thus far not been published.

2.5.3. Discussion

In comparing the data of the three different sectors, the southern sector is clearly the earliest (with burial activity commencing in LH IIA), followed by both the northern and the central sector in LH IIIA1. The latter sector does not seem to have had a chamber tomb in that phase, but just one or possible two pit/cist graves. It is important to note that several tombs have been found disturbed or robbed, which indicates that we may not have all the necessary data needed to identify the phase(s) in which all tombs were in use (Sjöberg 2004: 116; Philippa-Touchais and Papadimitriou 2015: 453; Papadimitriou et al. 2020: 61-64).

In contrast to other necropoleis in the Argive Plain, the LH tombs of Argos contained considerably fewer precious objects such as those made of materials coming from exotic regions. This suggests that the level of exchange with other settlements was not as significant at Argos as it was between other sites, something that might be explained by the relatively weak economic status of the social groups associated with these tombs (Sjöberg 2004: 117). Significantly, several tombs have been robbed, which might partly obscure relevant evidence since the general picture gained by the tomb material does not suggests neither a very prosperous community (compared to Mycenae or Asine), nor a thoroughly poor one.

3. The relationship between the necropolis and the settlement

3.1. Prosymna

The chamber tomb necropoleis are situated to the north and northwest of the settlement, of which only a few walls and remains are known[4] due to the later building activities in historical times that covered the earlier remains (Sjöberg 2004: 71). Since 55 chamber tombs have been found and some further surveys were carried out by Blegen (1937a: 1-10), it might be assumed that at least to the north and northwest of the settlement, most tombs have already been detected. All chamber tomb necropoleis (except for one, together with the tholos tomb) are situated to the north/northeast of the LH road ('M4'), leading from Mycenae via Monastiraki and Prosymna to Tiryns (Brysbaert et al. 2020: 37 Table 1); only group V lies in the east slope of the Kephalari Hill (Figure 1).

In my view and based on the evidence described above, the following acts of a burial process are very likely. It can be expected that a form of *ekphora*[5] was conducted via the LH road 'M4', probably beginning at the house of the deceased and ending at the relevant grave, which

4 Sjöberg 2004: 71-73 with further references. Walls attributable to seven houses have been found; all of them have been dated to LH IIIB. Beyond these, walls of further Mycenaean houses have been reported, but apparently without any specfied dating. Finally, sherds of LH II and LH IIIA times have been mentioned.

5 In general, the archaeological evidence we have deriving from tomb contexts, which would enable us to reconstruct burial rituals during Late Helladic times, is scant. We are primarily limited to small finds like needles and any kind of grave good suggestive of some kind of ritual practice (e.g., vessels for ointments), the iconographic depictions of the larnakes from Tanagra and some other sarcophagi, as well as some Linear B texts. Nevertheless, with the supplementary consideration of depictions from later objects (like pottery vessels depicting a *prothesis* or an *ekphora*), some more interpretations or even probabilities can be added. For a description of different ritual activities cf. Müller 2018 (with references).

had either been dug shortly beforehand or re-opened and prepared for the ceremony. As most of the tomb groups are not situated far from the road (except for the groups higher up the East Yerogalaro Ridge), the *ekphora* was almost able to reach the tomb via this route. In agreement with Brysbaert et al. (2020: 68), the funeral procession or tomb visitors in general might have followed some smaller dirt roads or paths ('m-roads') to the relevant tomb, moving there in a straight line or in a winding shape depending on the steepness of the slope. On the higher slope of the East Yerogalaro Ridge and the Asprochoma Ridge in particular, such a route would have been quite sensible (cf. Figure 1).

3.2. Tiryns

Regarding Tiryns and its chamber tomb necropolis on the east slope and the tholos tombs on the west slope of the Prophitis Elias Hill, I emphasize that the tholos tombs are situated near the 'M4' highway which leads to the Tiryns citadel (Brysbaert et al. 2020: 56; Brysbaert et a. 2022). In my view, there must have been at least one dirt road (m-road) which led to the tholos tombs and continued until the chamber tomb necropolis on the eastern slope, most probably via the saddle of the hill, and probably following a similar winding pattern as the modern route today. In this manner, the participants of a funeral ceremony or the tomb visitors could have started in or near the citadel (in the lower town) of Tiryns, following the 'M4' highway and finally the m-road described above to the relevant tomb. Otherwise, it is also imaginable that processions led around the hill, either along its northern or the southern end.

An important factor to consider at this point is the creation of the dam of Tiryns to the northeast of the Prophitis Ilias hill (see Brysbaert et al. 2020; Maran 2010; Hope Simpson and Hagel 2006: 182-184; Knauss 1995 and Balcer 1974 for examinations and discussions). This large-scale technical operation most probably was necessitated by periodic floods in the 13th century BCE, caused by the river Manesi, which obviously led to an abandonment of at least certain parts of the Lower Town of Tiryns in LH IIIB2 (Maran 2010: 728). Therefore, the course of the river had to be changed. This dam must have been built in LH IIIB2 (Maran 2010: 728), directing the water from Manesi into an artificial canal which ran in southwestern direction and to the south of Prophitis Ilias hill (cf. Figure 10). This canal then led the water to another riverbed, called Ramandani (Papadimitriou 2001: 6, 71).

3.3. Dendra

Near Dendra, road 'm5' has been uncovered, leading down the acropolis of Midea and connecting the citadel with the sea (Brysbaert et al. 2020: 48-50). In my view, another small road must have split from it in order to reach the Dendra necropolis, which is approximately 2 km from the citadel itself (Schallin 2016: 76, 90). Since the slopes of the hill are steep, it is probable that the upper section of the road was winding until reaching the foot of the hill.

From other areas of habitation, for example a possible lower town between the hill of Midea and Dendra (Schallin 2016: 88), there might also have been some connecting roads, which probably intersected with the 'm5' at some point (cf. also Brysbaert et al. 2020: 56). Taking these possibilities into account, it is conceivable that the deceased would have been carried down the hill on foot or very probably by a horse-driven chariot (cf. the burials of paired horses in the Dendra necropolis, Pappi and Isaakidou 2015: 476). As such, an *ekphora* would have started from the citadel itself, or from a certain spot in the lower town before moving towards the intended tomb.

3.4. Berbati valley

The tholos tomb north of the Mastos hill lies close to two main roads: M1, which begins at Mycenae and an arm of which terminates in this area, and m5, which starts here and runs via the Mastos, through the Kleisoura gorge and via Dendra/Midea (cf. above) to Tiryns (Brysbaert et al. 2020: 37 Table 1, 45 Fig. 2, 56). Thus, there must have been another small road starting from M1 and leading to the Western Necropolis as well as to the other two, unexcavated necropoleis, which is situated a bit further northwest from the tholos, and another small road leading from m5 to the single chamber tomb to the northeast of the Mastos (cf. Figure 16). Due to the fact, that m5 runs via the Mastos hill, it is obvious that funeral processions must have started here and guided in northern direction before either leaving this road to the single chamber tomb to the northeast of the Mastos or to the tholos tomb in the north – or continuing on M1 until hitting the small road to one of the three necropoleis to the northwest of the Mastos hill.

3.5. Argos

The town of Argos has witnessed uninterrupted settlement since its inception (Piérart and Touchais 1996). As a result, many ancient remains are sealed today, and can only be accessed in the event of rescue excavations. Fortunately, many monuments of considerable size, especially from Roman times, could have been preserved in the southwestern-most area of the modern town (Piérart and Touchais 1996). The most extensive remains surviving from the Bronze Age include the excavated Deiras necropolis (cf. above), the MH settlement on the Aspis Hill, and the Cyclopean wall remains on top of the Larisa hill (the obvious acropolis in the LH period, cf. Piérart and Touchais 1996: 13-20). Beyond these locations, many rescue excavations have yielded numerous settlement patches spread over a large part of the modern town; cf. Figure 18).

Thus, some kind of relationship can be drawn between the gained picture of the Late Helladic settlement, which has mainly been visible in the north/northwestern part and southwestern part of Argos (cf. Figure 18), and the Deiras necropolis containing the known chamber tombs. It is certain that there must have been some road infrastructure within the settlement, and indeed one main road, M7, is known to date, running from Mycenae to the top of the Larisa (Brysbaert et al. 2020: 37 table 1, 45 fig. 2). Splitting from this road at a certain point, a smaller road must have led to the Deiras necropolis (and further to the settlement, cf. Figure 19), which primarily consists of a single stretch of tombs on the north side of the ravine, plus two additional chamber tombs on the south side. Given the possibility that a road ran roughly through the middle of the ravine, it would have been near to all the tombs (in some almost in direct proximity, and in others at a distance of some meters away). In my view, this setting would have been quite suitable for processions, leading from a certain point in the settlement to the necropolis. Having reached the point nearest to the relevant tomb, the participants might have taken a path from there, leading directly to the dromos of the relevant tomb.

4. Conclusions

It is obvious that the most basic requirement to dig a chamber tomb must be seen in the physical shape of the surrounding area of a site: a slope with a certain, but not too steep a gradient is needed. In a recent work, several tools from different contexts have been compiled in order present their use and stamina (Turner 2020: 62, 277-282). Thus, it was necessary for communities to search for the nearest viable site. In some cases (Prosymna, Argos) these are situated in close proximity, but at a greater distance in others (especially Tiryns).

Furthermore, it has been observed that other reasons likely underpinned the choice to construct a tomb at a given location. At three locations in particular, Prosymna, Tiryns, and the Berbati valley (but also at Argos), distinct groups of tombs are to be found, quite probably representing different families, family groups, or clans. At Prosymna, most of the groups were placed relatively near to the LH main road 'M4', perhaps informed by practical reasons (ease of access for funeral processions).

As regards the relationship between settlement and necropolis, the evidence for a direct link, i.e., a road or pathway leading from the former to the latter, there are traces of at least main roads/highways, also at the other three sites (Dendʀa/Midea, Tiryns and Argos) and the Berbati valley. While none of these highways leads immediately to the necropoleis or specific tombs but at least near to them, there must have been smaller roads splitting from the main road and leading to the relevant tombs. Thus, funeral processions having started at the settlement and having terminated at a certain tomb would have been possible via these road systems, but future excavation efforts might yield more conclusive answers in this regard.

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Marble in the mountains – econometrics of quarrying and transporting building stones for the temple of Athena Alea at Tegea, Greece

Jari Pakkanen

1. Introduction

Very little of the Late-Classical temple of Athena Alea at Tegea is preserved *in situ* above the level of the conglomerate foundations. However, hundreds of marble blocks from the building lie scattered around the archaeological site allowing for a reliable reconstruction of the monument (Dugas et al. 1924; Pakkanen 1998; 2013a: 94-109; 2014a; 2014b). The ancient traveller Pausanias visited the imposing temple in the second century CE and he recounts that its architect was Skopas of Paros, one of the most famous sculptors of the fourth century BCE (Paus. 8.45.4-5). First exploratory trenches at the site were excavated in 1879; full-scale excavations were carried out in 1900-1902 by the French School and in 1909, the final private property on top of the foundations was purchased and excavated. The next phase of major further work at the sanctuary was conducted by the Norwegian Institute at Athens in 1990-1994 (Dugas et al. 1924: x-xii; Østby 2014a; 2014b). Based on the new fieldwork at the site, the Classical temple can now securely be dated to 350-325 BCE (Østby 2014c: 341-346). The latest field documentation campaigns at the site in 2016 and 2019 have employed photogrammetry and three-dimensional intensive reflectorless total station drawing (Pakkanen 2021a: 116-117). An orthorectified and georeferenced mosaic image of the foundations and the archaeological site based on drone photography is presented in Figure 1.

Greek monumental architecture of the Classical and Hellenistic periods is characterised by the employment of durable materials. Therefore, for most buildings it is possible to present a relatively accurate reconstruction which can be used in econometric estimates of the construction *chaîne opératoire* (Pakkanen 2013b: 56-72; forthcoming; cf. also Salmon 2001: 195). The value of the preserved building accounts from Attica, Delphi, Epidauros, Delos and Didyma has been demonstrated in a series of economic studies on monumental architecture (see, e.g., Haussoullier 1926: 127-138; Stanier 1953; Rehm 1958: 62-64; Burford 1969; Haselberger 1985; Clark 1993; Davies 2001; Pakkanen 2013b) but their potential is still underutilised (Pakkanen forthcoming). The example of Janet DeLaine's pioneering monograph *The Baths of Caracalla* (1997) has been followed also in the domain of Greek building in the historical periods: these studies incorporate comparative data and labour rates from a range of different contexts to give an idea of the potential econometric impact

Jari Pakkanen
Department of Classics
Royal Holloway, University of London

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Figure 1. Georeferenced orthomosaic of the archaeological site and foundations of the temple of Athena Alea at Tegea (J. Pakkanen).

of building projects (see e.g., Pakkanen 2013b; 2021b; forthcoming; Lancaster 2019). The most extensive demonstration of the utility of labour cost analyses in understanding the economic importance of building in the Greek world is Ann Brysbaert's SETinSTONE project concentrating on the Late Bronze Age (for most recent summaries with extensive bibliographies, see Brysbaert et al. 2018; 2022; Brysbaert 2020; 2021. For individual projects part of SETinSTONE: Turner 2020; Boswinkel 2021).

DeLaine (1997: 105-106) has argued that it is prudent to base econometric estimates on the principle of minimum costs since the exact date and length of building projects is in most cases unknown. Difficulties in sourcing and transport of materials and project finance did cause delays in monumental construction. However, Classical and Hellenistic building accounts indicate the contract prices and costs of monumental building. When these figures are analysed in conjunction with the preserved architectural elements, it is possible to derive actual labour rates rather than minimum ones (Pakkanen forthcoming). 19th-century architectural handbooks are also valuable sources for estimating how much work is needed to quarry and carve different types of stone. For example, Giovanni Pegoretti's volumes have been made very good use of in analyses of ancient Roman building (Pegoretti 1863-1864; see DeLaine 1997; Russell 2013; for an extensive discussion, see Barker et al. forthcoming). In a separate paper, I have analysed how Pegoretti's labour constants compare with Greek architectural and inscriptional data from the Classical and Hellenistic periods (Pakkanen forthcoming). These rates are the basis of the calculations presented in this chapter for the cost of quarrying and transport of building stones for the fourth-century temple of Athena Alea at Tegea. The sites and quarries discussed in the text are indicated in Figure 2. For architectural terms used in the text, see Figure 7.

The aim of this chapter is to present a model of how the quarry volume, supply and transport of building stones of a large-scale Classical construction project in the middle of Arcadia at Tegea can be quantified. Comparative labour rate studies can be used to gain an understanding of the size of required workforces and the timeframe of the project, the role of stone quarries

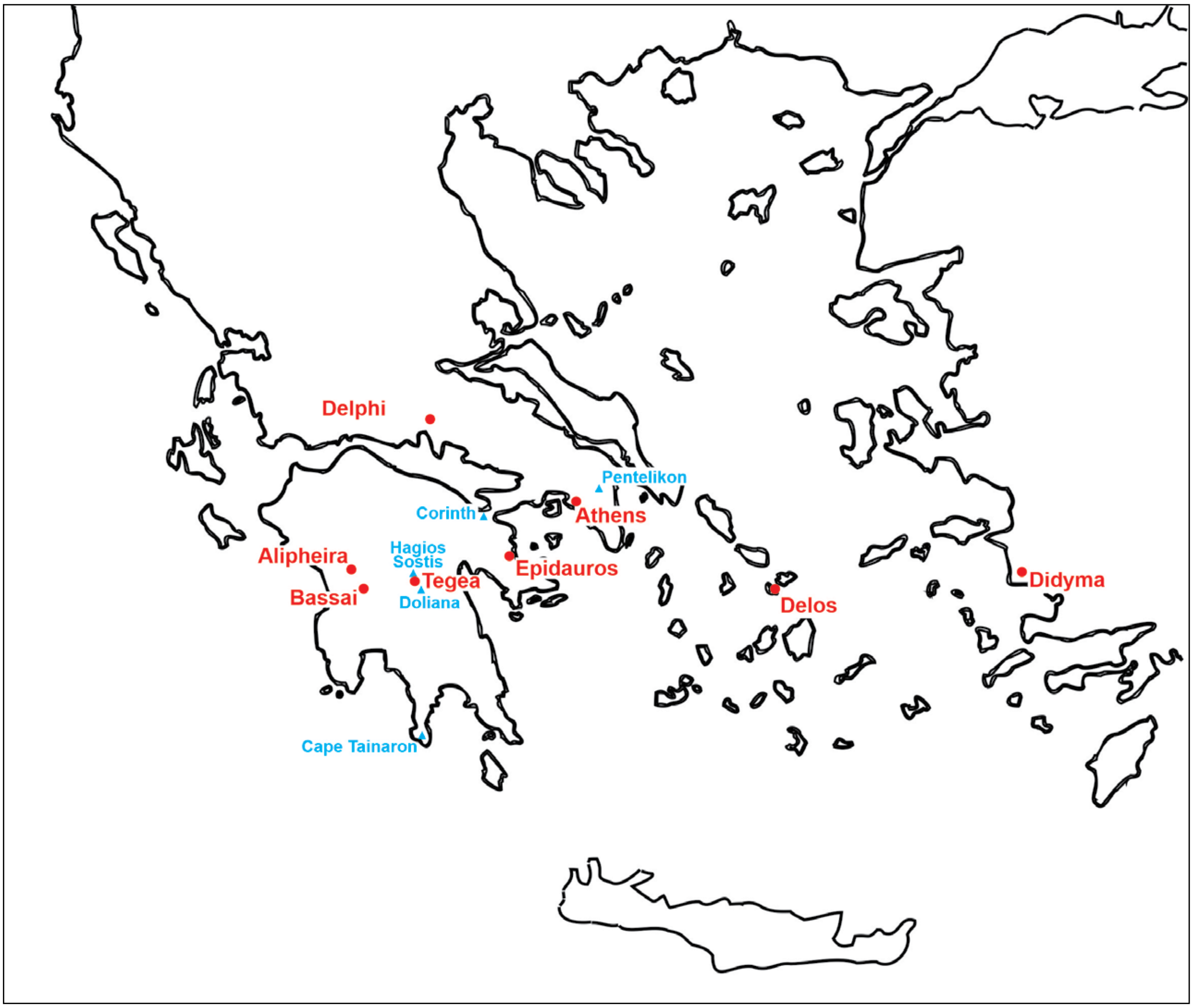

Figure 2. Map of principal sites (red circles) and quarries (blue triangles) mentioned in the text (J. Pakkanen).

and monumental construction in the economy of the city-state and the overall cost of temple building.

2. Cost of quarrying and transport of local conglomerate

The foundations of the temple of Athena Alea were built large ashlar blocks of conglomerate. The clasts of the sedimentary rock are well-rounded pebbles as is typical of conglomerates formed in coastal and fluvial environments. The nearest outcrop of this type of stone is at Hagios Sostis, c. 3.0 km north of the temple (Mendel 1901: 246; Dugas et al. 1924: 9). The hardness of conglomerates varies depending on the cement and the composition of clasts (Himus et al. 1972: 169-170). The temple builders at Tegea considered this the best locally available material for the foundations.

The horizontal dimensions of the foundations based on the 1996 fieldwork are presented in Figure 3 (Pakkanen 2013a: 102-103). The depth of the outer ring foundations supporting the exterior peristyle order of the temple varied: in the northeast corner, they comprise nine courses and have a depth of c. 3.1 m; in the southeast corner the five courses are c. 1.5 m deep; on the south side, the depth is c. 1.3 m, the west c. 1.6 m and on the north c. 1.9 m. The depth of the east ramp and north platform foundations is c. 1.1 m. The depth of the inner ring is c. 1.5 m and the foundations supporting the east and west walls of the cella are slightly shallower with a depth of c. 1.2 m (Dugas et al. 1924: 10). In the corners of the temple, the courses were stepped. However, some marble blocks from the Archaic predecessor were also recycled into the Classical foundations (Østby 1986: 91-92), so these two factors largely cancel each other in the calculation of the total volume of conglomerate needed for the temple foundations. The volume of stone for the outer ring can be estimated as 771 m^3 and

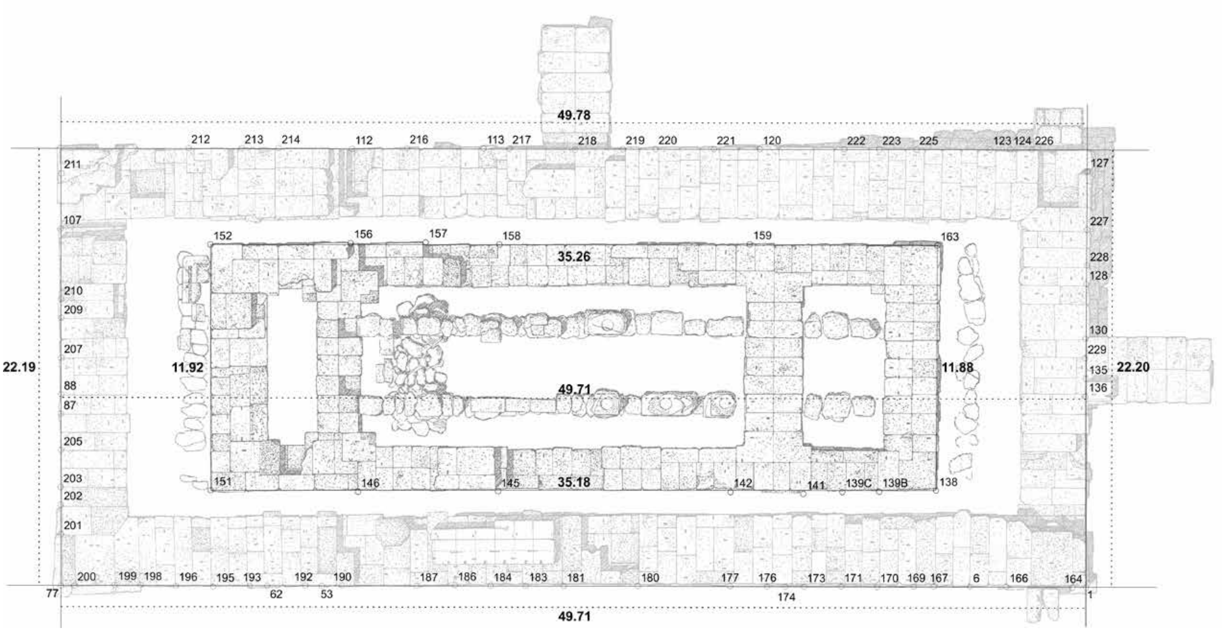

Figure 3. Foundation dimensions of the temple of Athena Alea and locations of new measurements taken in 1996 (J. Pakkanen; foundation drawing based on Dugas et al. 1924, pls. 3-5).

the inner ring as 325 m^3. The volumes are based on a combination of previously published figures and new fieldwork.[1]

Table 1 presents a summary of limestone quarry, transport and construction costs based on the contracts recorded in the building inscriptions of the early fourth-century BCE temple of Asklepios at Epidauros (*Inscriptiones Gracae* IV^2 102; Pakkanen forthcoming). The table corrects the labour rates presented by Alison Burford (1969: 248-250). The contract prices are adjusted on the basis of Sebastian Prignitz's reinterpretations and the stone volumes based on Georges Roux's architectural monograph (Prignitz 2014: 18-85; Roux 1961: 83-130). The function and general characteristics of the local soft limestone recorded in the first two contracts are comparable to the conglomerate at Tegea, and the combined quarry, transport and construction costs give a baseline for the cost estimates of the temple of Athena Alea. The location of the local Epidaurian quarries is not known, but the foundation stone would have been sourced close to the sanctuary keeping the transport costs as low as possible. The rates for Corinthian stone in Table 1 include both land and sea transport, but in another instance the cost of oxen cart transport for Pentelic marble coffers from the harbour to the sanctuary can be calculated as 2.3 Aiginetan drachmas per cubic metre and kilometre (Burford 1969: 186; Pakkanen forthcoming). I have also estimated that based on Pegoretti's figures and taking the length of a working day as 10 hours, the rate for quarry costs, including rough shaping, of good-quality limestone column drum blocks at Corinth can be calculated as 6.8-18.3 Aiginetan drachmas per cubic metre, and most likely towards the lower end of this range. The large range based on Pegoretti is primarily the result of different types of limestones he takes into consideration. The daily wage of a skilled craftsman at Epidauros can with quite high degree of certainty be taken as one Aiginetan drachma a day, so conversion of Epidaurian rates into skilled person-day rates is very straightforward (Pakkanen forthcoming). In order not to complicate matters in the following, I will keep expressing the costs in terms of Aiginetan drachmas. Comparison between the Epidaurian contracts and Pegoretti's rates shows that the Corinthian limestone quarry entrepreneurs made, in most cases, a healthy profit by getting at least twice the price of daily wages they would have needed to pay for the extraction of the blocks.

The two first contracts, 1 and 2 in Table 1, show that the rate for quarrying soft local limestone was considerably less expensive than Corinthian stone, so the quarry costs for the conglomerate at Tegea were also likely below the range established based on Pegoretti's limestone rates: 5 Aiginetan drachmas per cubic metre seems a reasonable estimate. Therefore, to quarry and roughly cut into shape the c. 1,100 m^3 of conglomerate needed for the foundations

1 West outer ring (width × length × depth): 3.40 m × 14.44 m × 1.6 m. North: 3.40 m × 49.78 m × 1.9 m. South: 3.35 m × 49.71 m × 1.3 m. East: 3.40 m × 14.45 m × 2.3 m. East ramp: 3.20 m × 6.10 m × 1.1 m. North platform: 5.83 m × 3.03 × 1.1 m. Opisthodomos foundations of the inner ring: 2.75 m × 7.82 m × 1.5 m. West cella wall: 2.15 m × 7.82 m × 1.2 m. East cella wall: 2.65 m × 7.82 m × 1.2 m. Pronaos: 2.65 m × 7.82 m × 1.5 m. North: 35.26 m × 2.05 m × 1.5 m. South: 35.26 × 2.05 m × 1.5 m.

Table 1. Temple of Asklepios at Epidauros. Cost rates based on contract prices in the inscriptions and reconstructed stone volume (probable day wage of a skilled craftsman: 1 Aiginetan drachma per day; c. 6.1 g of silver per drachma).

Construction task and quantity	Q, T & C	Q & T	Quarry (Q)	Transport (T)	Construction (C)
1. Local limestone for foundations of peristasis, 176 m^3	4,068 dr. 23.1 dr./m^3				
2. Local limestone for foundations of cella, 96 m^3	1,385 dr. 14.4 dr./m^3				
3. Corinthian stone for peristasis from steps to pediments, 258.7 m^3		5,700 dr. 22.0 dr./m^3			
4. Construction of visible steps & stylobate, 66.9 m^3					888 dr. 13.3 dr./m^3
5. Construction of colonnade & entablature, 191.8 m^3					3,068 dr. 16.0 dr./m^3
6. Corinthian stone for cella (half), 135.1 m^3		6,167 dr. 45.6 dr./m^3			
7. Corinthian stone for cella (other half), 135.1 m^3			4,437-4,455 dr. 32.8-33.0 dr./m^3	1,712-1,730 dr. 12.7-12.8 dr./m^3	
8. Construction of the cella, 270.2 m^3					3,209-3,500 dr. 11.9-13.0 dr./m^3
9. Fluting of exterior and interior columns, 574.5 m^2					1,336 dr. 2.3 dr./m^2

would have cost c. 5,500 Aiginetan drachmas. Possibly half of the quarry workers would have been unskilled labourers paid half the wage of a skilled craftsman (cf. DeLaine 1997: 209-210), so a group of 12 skilled and 12 unskilled quarrymen would have been needed to produce this volume of stone in c. 300 days.[2] Even though the quarries were very close to the temple, the cost of oxen transport of the blocks at c. 7,600 Aiginetan drachmas was very likely more expensive than quarrying the stone.[3] Conglomerate and marble were already used for the Archaic temple (Østby 1986: 79), so the road network between the quarries and the sanctuary must have already been developed in late seventh century BCE.[4]

3. Cost of quarrying and transport of marble

The marble for the superstructure of the temple was quarried at Doliana, c. 12 km southeast of the site (for an extensive discussion of the Doliana quarries, see Bakke 2022 in this volume). The quarries are located c. 1,100 m above the sea level and the route in the beginning descended steeply to the Tegea Plain (c. 650 masl). The few euthynteria blocks on the south flank are the only *in-situ* pieces of marble of the Late-Classical temple (Figure 4), but more than 800 blocks from the temple have been documented at the site (Figure 1; Pakkanen 2014b).

The marble from the temple has not been scientifically studied and the different strata at Doliana have not been documented in detail, so in this chapter I have taken the cautious approach that all marble used in the building could originate from these nearby quarries. The material of the temple sculptures is discussed in some detail by Charles Dugas and Jules Berchmans, and they conclude that there is no specific reason to suggest that the marble would have been imported to Tegea from further away (Dugas et al. 1924: 78-80). However, the possibility of imports cannot entirely be excluded for the Tegea temple. For example, the marble, which was used for the rooftiles, coffers and sculpture in the temple of Apollo at Bassai, could have been an option. The Cape Tainaron quarries are located at the south end of the Mani peninsula (Cooper 1996: 108-111), so the material would have needed first sea transport along the west coast of the Peloponnese and then more than 40 km on a winding road to Bassai up to a height of 1100 masl. The route to Tegea would have been similar but along the east coast to modern Astros and then over the mountains. Translucent marble allows sunlight to filter inside the building, so the temple builders did not shy away from transporting large quantities of stone to the mountains for specific purposes. Similar marble is used more widely to the west and north of Bassai, for example in the Late-Archaic temple at Alipheira (Orlandos 1967-1968: 79-89; Cooper 1996: 107-108).

Table 2 summarises the rates for quarrying, transport and construction of marble blocks based on the building accounts of the Hellenistic temple of Apollo at Didyma (Rehm 1958: 40-64; Pakkanen forthcoming).

2 $1{,}096\ m^3 \times 5$ dr./ m^3 = 5,480 dr. With 12 skilled and 12 unskilled, 5,480 dr. / (12 dr./pd + 0.5 × 12 dr./pd) ≈ 304 pd. For the argument that the physically arduous tasks of quarrying and construction would have been carried out by a workforce consisting of mostly men and not women and children, see DeLaine 1997, 106.

3 2.3 dr./(m^3×km) × 1096 m^3 × 3.0 km ≈ 7,562 dr.

4 Pikoulas (1999, 306-309) discusses the dating of the road network in Arcadia: he dates the beginning of a systematic cart-road construction to the seventh century BCE based on political and military factors. Forsén 2003, 70 discusses the late sixth century temples of Vigla and Agios Elias at Asea and connecting these construction sites with cart roads from Doliana. On the complexity of dating and establishing the road network between Doliana quarries and the Tegea Plain, see Bakke and Bakke-Alisøy 2020.

Figure 4. Detail of the south flank of the temple of Athena Alea. The marble euthynteria is on top of the foundation conglomerate blocks, and the column drum is not *in situ*. The red lines are part of the 3D total station drawing (J. Pakkanen).

The currency and day wage are different than at Epidauros, so in order to convert the rates into person-days of a skilled craftsman they need to be divided by two. The land transport rate per cubic metre and kilometre at Didyma is strikingly high, approximately four times more than at Epidauros. This could partially be explained by the colossal scale of the temple and the very large marble blocks which were difficult to handle. Since the unfinished column drums at Didyma record the ordered sizes of blocks and it is possible to measure their actual sizes with the extra mantle of stone, the building accounts make possible differentiating between the ordered and delivered rates: the volume of delivered stone is greater than what was ordered, and in many cases the drums are placed lower in the shaft than originally intended making good use of the extra delivered material. The two different rates for quarry stone take into account the stratification of marble in the quarries: blocks with a height of less than 0.5 m were easier to find and extract, and taller blocks could only have been quarried from specific places.

The quarry rates based on the building accounts at Didyma, 131.8-192.4 dr./m^3, can be compared with the range based on Pegoretti's data. I have calculated that using Pegoretti's time and volume estimates and the same day wage of two Alexandrian drachmas as at Didyma, the range is only 35.8-43.7 dr./m^3 (Pakkanen forthcoming). The colossal size of the temple, difficult handling of the very large blocks, and high degree of quarry wastage are likely the largest factors behind the differences between the rates. Therefore, Pegoretti's range is used in the following as the rate for the cost of quarry stone at Tegea. However, it should be kept in mind that Pegoretti gives potentially a low baseline for marble quarrying: in the 19th century, extraction of marble in the main Italian quarries was a highly professional operation aimed also at export market. When the range is converted into fourth century Epidaurian day wages and the Aiginetan currency used in the previous section, the range becomes 17.9-21.9 dr./m^3, which is 3.6-4.4 times higher than the conglomerate rate used in this chapter.

Table 2. Temple of Apollo at Didyma. Cost rates as outlined in the inscriptions and based on ordered sizes and actually delivered blocks (likely day wage of a skilled craftsman: 2 Alexandrian/Attic drachmas per day; *c.* 4.3 g of silver per drachma).

1. Task	2. Rate	3. Rate ordered	4. Rate delivered
Quarry stone (H < 0.5 m)	4 dr./ft^3	153.6 dr./m^3	131.8 dr./m^3
Quarry stone (H ≥ 0.5 m)	5 3/6 dr./ft^3	211.2 dr./m^3	192.4 dr./m^3
Land transport		19.2 dr./(km × m^3)	17.4 dr./(km × m^3)
Loading to ship	1/6 dr./ft^3	6.4 dr./m^3	5.8 dr./m^3
Sea transport		1.6 dr./(km × m^3)	1.4 dr./(km × m^3)
Unloading from ship	1/6 + 6/72 dr./ft^3	9.6 dr./m^3	8.7 dr./m^3
Lifting & positioning	1 dr./ft^3	38.4 dr./m^3	38.0 dr./m^3
Fine dressing	2 dr./ft^2	22.8 dr./m^2	21.6 dr./m^2
Fluting	2 dr./ft^2	22.8 dr./m^2	22.2 dr./m^2
Carving Ionic capital	5 dr./ft^2	56.9 dr./m^2	54.5 dr./m^2

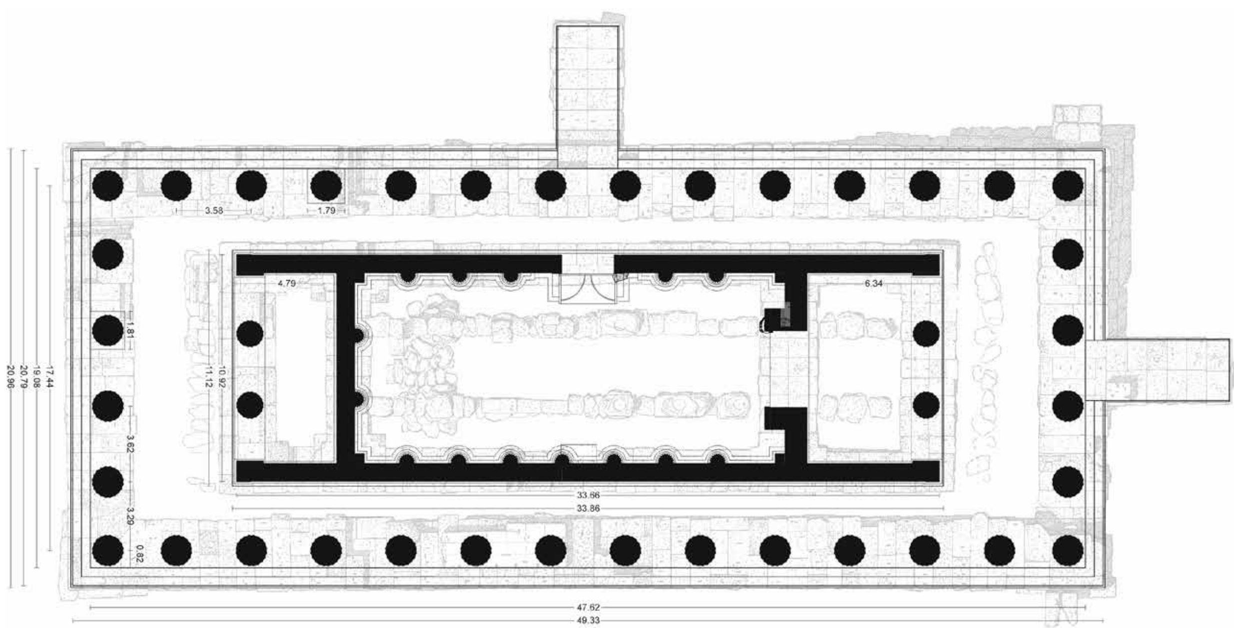

Figure 5. Reconstructed plan of the temple of Athena Alea superimposed on the foundations (J. Pakkanen).

The calculation of the volumes of Doliana marble used in the temple of Athena Alea is based on fieldwork and reconstructions presented in Figures 5-7 (for further dimensions of the different elements, see Dugas et al. 1924; Pakkanen 1998; 2013a: 94-109; 2014a). The volume of marble in the euthynteria and the three steps of the krepis is c. 449 m^3, the exterior order columns c. 549 m^3 and the entablature[5] c. 455 m^3. The exact layout of the cella interior is still a work in progress, but the minimum volume of Doliana marble for the cella can be estimated as 1,095 m^3. The coffers and their supporting beams of the ceilings had a volume of c. 252 m^3, and, finally, the marble roof c. 148 m^3.

To sum up, the minimum total volume of Doliana marble used in the temple is c. 2,950 m^3. Using the range calculated on the basis of Pegoretti's figures, the quarry cost of this volume is c. 53,000-65,000 Aiginetan drachmas. With 24 skilled quarrymen and 24 unskilled labourers working at the marble quarries, they would have been able to quarry the stone in five to six years.[6] Halving the size of the quarry workforce would have doubled the length of this part of the building project. If funds for temple construction at sanctuary of Athena Alea were limited, this

5 The total volume of the entablature includes the architraves (178.4 m^3), the frieze course (163.4 m^3), the horizontal geisa (91.7 m^3), the tympana (14.7 m^3) and the raking geisa (7.2 m^3).

6 2,948 m^3 × 17.9 dr./ m^3 ≈ 52,770 dr; 2,948 m^3 × 21.9 dr./m^3 ≈ 64,560 dr. With 24 skilled and 24 unskilled, 52,770 dr. / (24 dr./pd + 0.5 × 24 dr./pd) ≈ 1,470 pd; 64,560 dr. / (24 dr./pd + 0.5 × 24 dr./pd) ≈ 1,790 pd. The calculation of years assumes that a working year comprised a maximum of 300 workdays.

Figure 6. Reconstruction of the east façade of the temple of Athena Alea (J. Pakkanen).

might have been the preferred option.[7] As in the case with the conglomerate, the cost of carting the stone from the quarries to the building site was larger than extraction: the sum can be estimated as 81,000 drachmas.[8]

4. Conclusions

The econometric analysis presented in this chapter is just one step towards understanding the role stone quarries and monumental construction had at ancient Tegea. Craftsmen from Tegea are recorded in the building accounts from Delphi and Epidauros (Burford 1969: 199 n. 2; on construction in Arcadia, see Roy 1999: 336-338) but further work on the volume of stone extracted from Doliana is required to get a more thorough picture of how important the quarries were (cf. Bakke 2022 in this volume).

The 1,100 m^3 of foundation conglomerate could have been extracted by a team of 12 skilled craftsmen and 12 unskilled labourers in about a year, but even though the quarries were only 3 km from the sanctuary, the cost of land transport was more expensive than quarrying. Extracting marble is more time-consuming than conglomerate, but because of the further distance of the quarries from the sanctuary, the cost of carting the blocks was again more expensive than sourcing the stone. The minimum volume of marble used in the temple is nearly 3,000 m^3. With twice as many people working at the quarries at Doliana, it would have taken five to six years of work to quarry the necessary volume of stone. If the building funds were limited, the work in the quarries could have extended over a much longer period and with fewer craftsmen.

One of the most significant economic decisions the temple commissioners and Skopas as the architect had to make was choosing the different types of material and scale of the monumental building project. At Epidauros, the temple builders decided to use Corinthian limestone for most parts of their rather modest monumental structures at the sanctuary of Asklepios. At Didyma, even though the temple of Apollo could be built using

7 According to the preserved building inscriptions, the relatively small limestone temple of Asklepios at Epidauros took 4 years, 9 months and 12 or 13 days to build; the larger Tholos did not proceed as promptly, and the project took 25-40 years to complete; see Prignitz 2014: 248-249. On the costs at Epidauros, see also Burford 1969: 81-85.

8 $2.3\ \text{dr.}/(\text{m}^3\times\text{km}) \times 2948\ \text{m}^3 \times 12.0\ \text{km} \approx 81{,}360\ \text{dr.}$

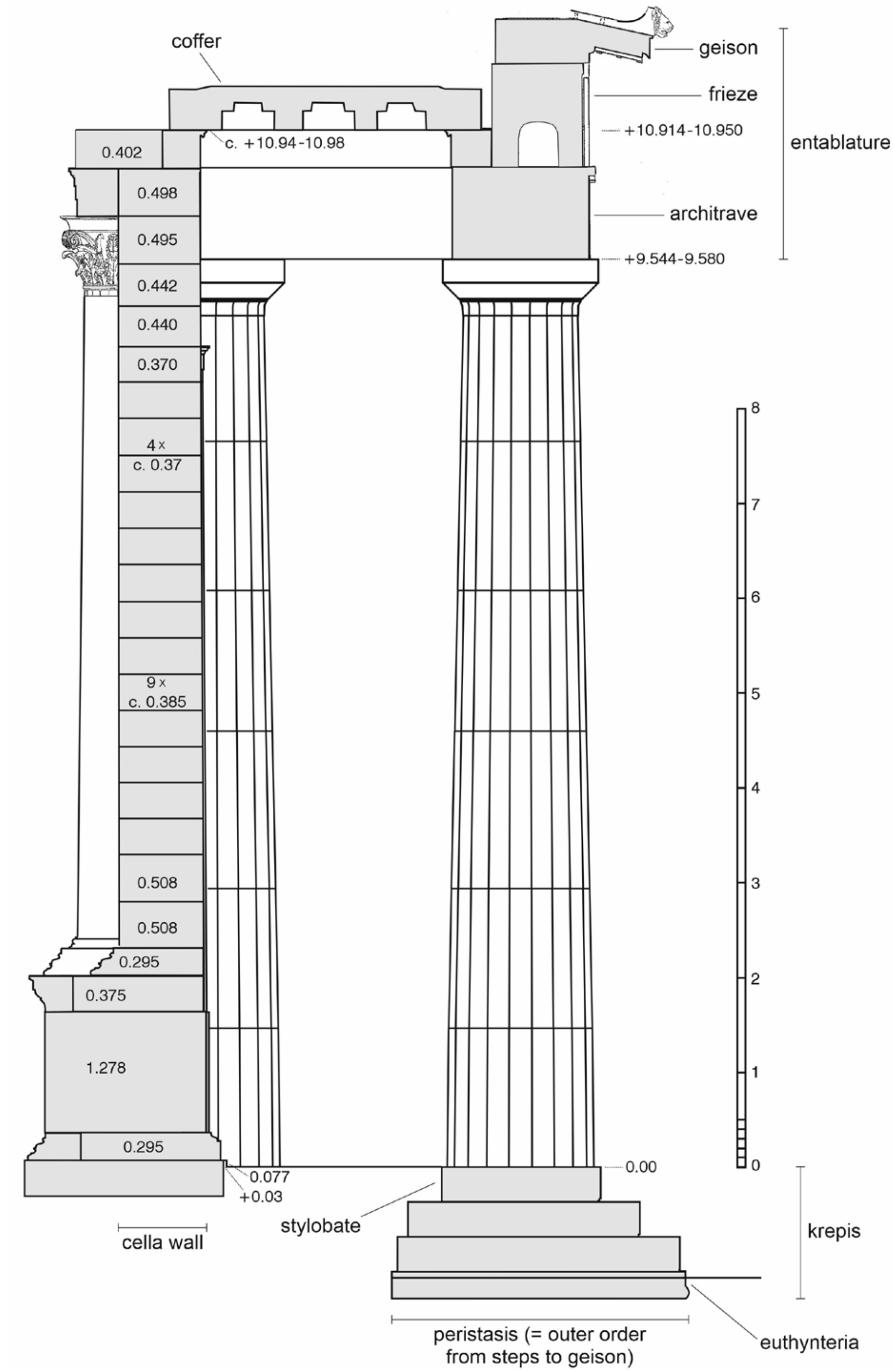

Figure 7. Section of the flank order of the temple of Athena Alea with architectural terminology indicated (J. Pakkanen).

locally sourced marble, the colossal scale resulted in very high costs. I have calculated that the choice of material and scale resulted in more than four times as high expenses at Didyma than at Epidauros per cubic metre of stone (Pakkanen forthcoming). At Tegea, the builders opted to use the most prestigious stone, marble, for the temple of Athena Alea. However, it was also a local stone from quarries with a long history of exploitation, so it was an economically rational choice: the commissioners could trust that the supply was constant and not coming from too far away.

5. Acknowledgements

The latest documentation campaigns at the temple of Athena Alea at Tegea were carried out in 2016 and 2019 with the permission of the Ephorate of Antiquities of Arkadia. Special thanks are due to its director, Dr Anna Vasiliki Karapanagiotou, and the staff of the Tegea Museum. The fieldwork in 2016 was financed by the Foundation of the Finnish Institute at Athens.

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Shaping a Mycenaean cultural landscape at Kalamianos, Greece

Daniel J. Pullen

1. Introduction

Nearly a century ago, in a modest pamphlet, the American geographer Carl O. Sauer formulated a simple definition of the cultural landscape as one 'fashioned from a natural landscape by a culture group. Culture is the agent, the natural area is the medium, the cultural landscape the result' (Sauer 1925: 46). That statement has had lasting impact in its argument for the primacy of human culture and against environmental determinism that was such a dominant force in the fields of geography and anthropology at that time (see Denevan and Mathewson 2009). I would argue that we should also consider the 'social landscape' in order to recognise the individuals and institutions involved in the 'fashioning' of the cultural landscape. In this paper I examine the Mycenaean (Late Bronze Age Aegean) harbour settlement of Kalamianos and its hinterlands along the Saronic Gulf coast of the Corinthia, taking into account the natural landscape that formed the 'medium' as well as the social landscape of the actors and institutions involved in creating the distinctive Mycenaean cultural landscape of Kalamianos (Figure 1). The region of Kalamianos is particularly well suited for exploring the nature of a Mycenaean cultural landscape, for the port town was founded near the end of the Late Helladic (LH) IIIA2 period, c. 1390-1330 BCE, at the height of the Mycenaean palatial period, on the Saronic Gulf, apparently as an outpost of the elites at palatial centres in the Argolid, and that ceased to exist when the palatial system was destroyed at the end of the LH IIIB period, c. 1190/1180 BCE.

2. SHARP and Kalamianos

The Saronic Harbors Archaeological Research Project (SHARP), co-directed by Thomas F. Tartaron (University of Pennsylvania) and Daniel J. Pullen (Florida State University), was founded to explore interactions in the 'small world' of the Saronic Gulf in the southwestern Aegean. Of particular interest for us was the expansion during the Late Bronze Age of the land-based power centres of the Argolid into the Saronic Gulf, at a time of increasing competition among newly emerging economic centres in the Saronic that coincides with the demise of the long-dominant centre of Kolonna on Aigina (Pullen and Tartaron 2007). We suggest that the elites at Mycenae and other Argolid centres (e.g., Midea and Tiryns, among others), whether palatial or not, optimised their opportunities for trade by exploiting ports on all three major bodies of water surrounding the Argolid/Corinthia, including the Saronic Gulf. The Saronic coast of the Corinthia was a contested periphery between Kolonna and the Argolid centres, and we hypothesise that the harbour settlement at Kalamianos was established by elites from the Argolid to be their strategic outpost to counter the maritime power of Kolonna.

Daniel J. Pullen
Department of Classics
Florida State University

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Figure 1. Map of the Saronic Gulf and Northeast Peloponnese, Greece, with location of Kalamianos (author).

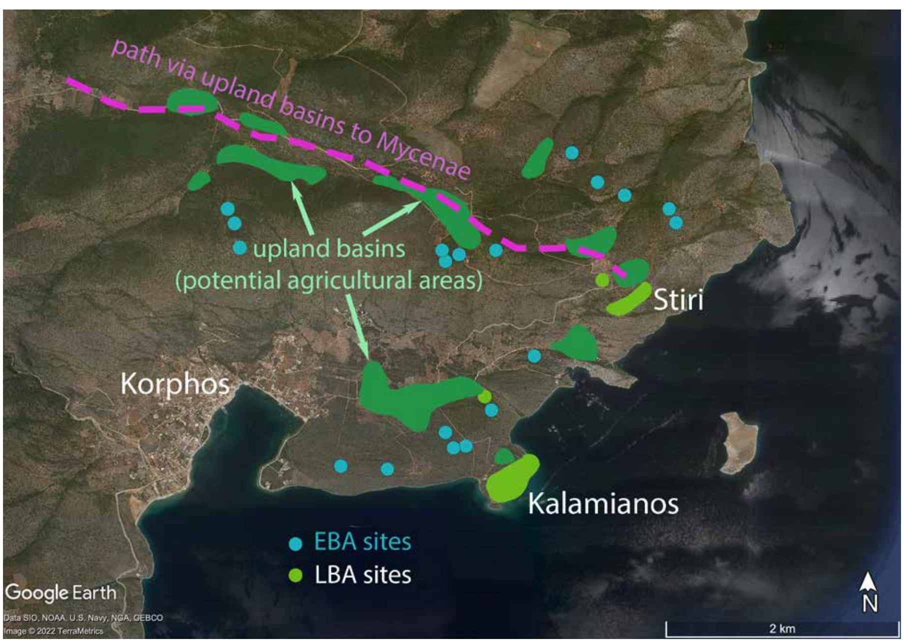


Figure 2. Satellite image of the Korphos region, showing the locations of Kalamianos, Stiri, and other sites discovered by SHARP. Dashed line is historically attested path to the Argolid and Corinthia. Irregular green areas are basins of potential agricultural usage (image Google Earth, Data SIO, NOAA, U.S. Navy, NGA, GEBCO, Image © 2022 TerraMetrics).

From 2007 through 2010, SHARP conducted fieldwork to explore the harbour settlement at Kalamianos and its surrounding region. The fieldwork comprised intensive archaeological surface survey at the site of Kalamianos, extensive survey and architectural study throughout the surrounding region, underwater exploration of the harbour, and geomorphological and anthropological research (Tartaron et al. 2011; Pullen 2013a; Tartaron 2015). We discovered large quantities of ancient architecture, particularly dating to the Mycenaean period, including dozens of large and small structures at Kalamianos, extensive terracing, and additional complexes uphill and inland from the coast on the hill of Stiri (less than 2 km northeast of Kalamianos) and elsewhere in the region (Figure 2). No excavations could be conducted during the fieldwork and all our data have been collected solely through above ground techniques. The geological history and the lack of any substantial intervention at Kalamianos after the Late Bronze Age has resulted in an unusually extensive exposure of building remains on the surface.

Our architectural documentation program has succeeded in generating a detailed plan of the enclosed Mycenaean (LH IIIB) town, with its circuit walls, buildings, and streets, as well as detailed plans and descriptions

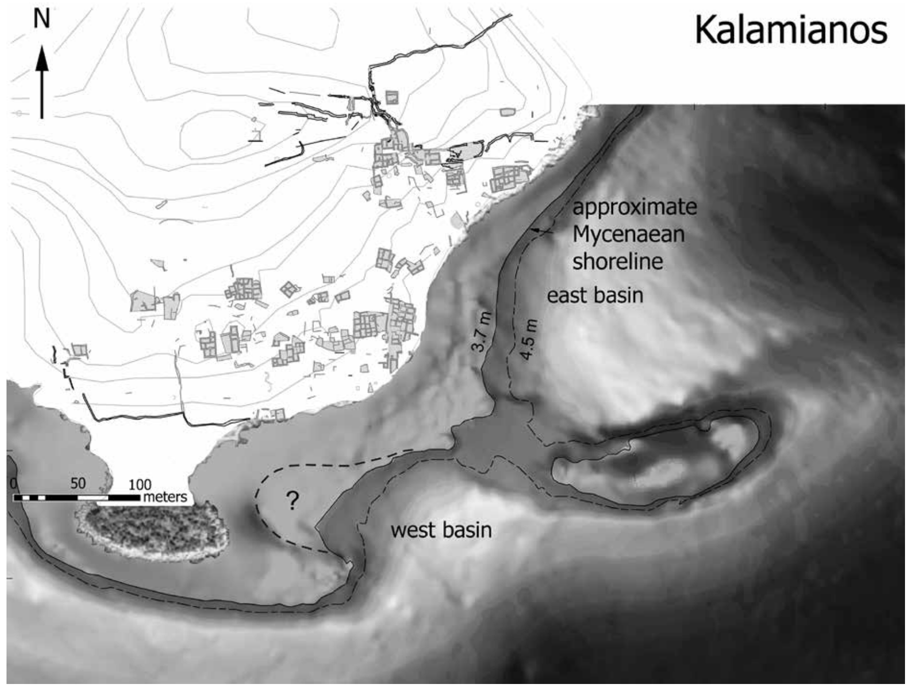
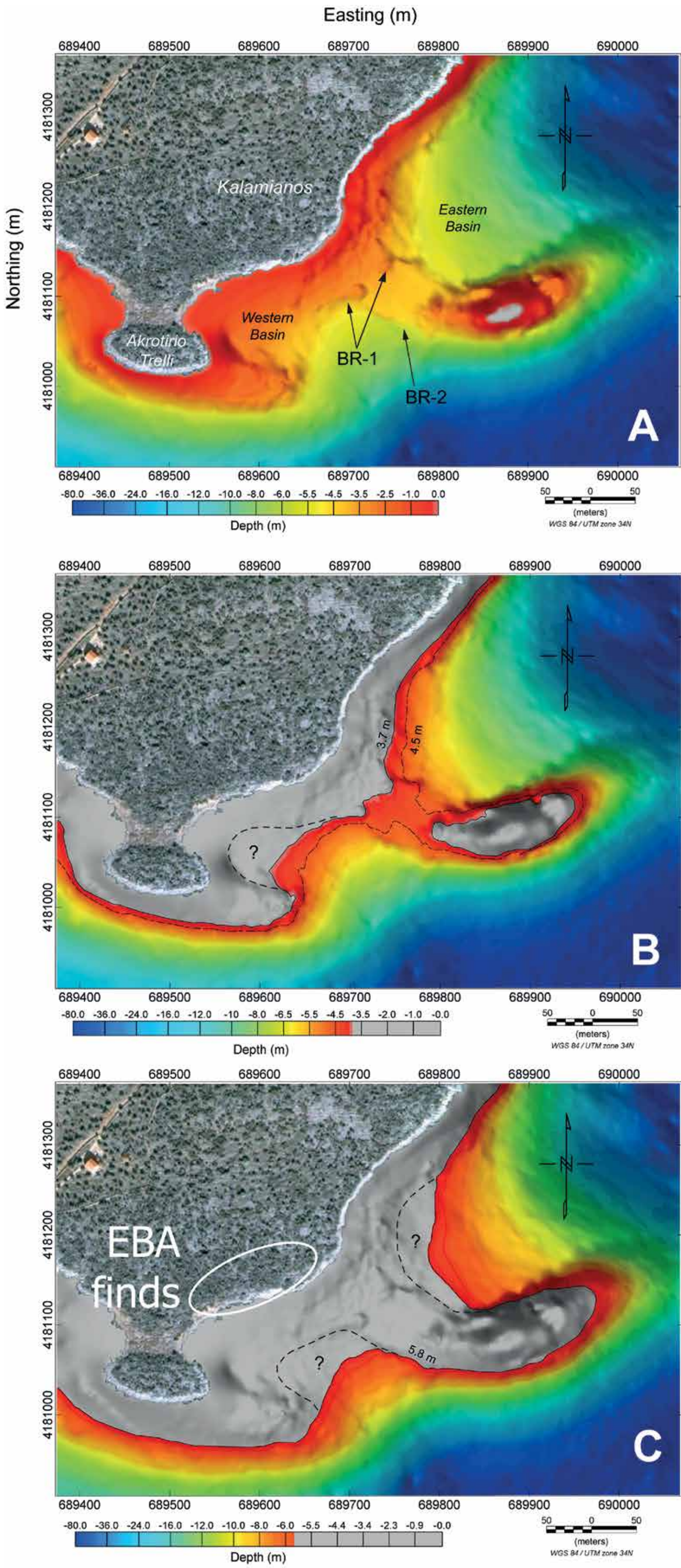


Figure 3. Map of Kalamianos town and harbour. Approximate shoreline during the Late Bronze Age at -3.7 masl (SHARP).

of many of the structures contained within the walls (Figure 3). By the end of the 2010 season, we had mapped about 50 buildings with 120 measurable rooms, over two dozen additional structures and features, and over 500 metres of the circuit walls at Kalamianos (Tartaron et al. 2011; Pullen 2015). We were also able to map a dozen or so complexes and structures at Stiri dating to the LBA. Though we lack excavated levels associated with the buildings at Kalamianos, we are confident in our assignment of them to the Mycenaean period (c. 1700-1200 BCE). The Kalamianos structures are consistent in their masonry style with Mycenaean structures elsewhere (see Darcque 2005). Our systematic survey of the site succeeded in retrieving ceramics from within the walls of buildings, from the rooms, and from outside of the buildings. The overwhelming period represented was that of the Mycenaean, especially Late Helladic III, c. 1420/1410-1200/1190 BCE (63% of diagnostic material), though material from other periods was present (see Tartaron et al. 2011: 607-611 for more details of the ceramics). Material of the Early Bronze Age, c. 3100-2100/2050 BCE (6% of diagnostic material) was identified in parts of the site, especially along the coast in the southwest near where many examples of EBA pottery were also found underwater (e.g., Tartaron et al. 2011: 573 fig. 10c). We have very little evidence for occupation at Kalamianos after Early Helladic (EH) II until the palatial Mycenaean period (late in LH IIIA). At Stiri a few pieces of ceramics have been identified as belonging to Aeginetan matt-painted wares and cooking pots, all dating to the late Middle Helladic (MH)-early LH period (LH II), and there may be a couple of sherds of similar date at Kalamianos. No ceramics of the post-palatial LHIIIC period were identified, and it seems likely that the site was abandoned at the end of the palatial (LH IIIB) period. Late Roman material was identified in a few areas, including a small kiln found built into the corner of a Mycenaean structure. The scanty remains of architecture found above structures in a few places probably date to the Late Roman period, but these later structures do not seem to have substantially altered the underlying buildings.

Given the sparse evidence for settlement in the region in the centuries after the EH II period and the large quantity of buildings within a circuit wall, extensive terracing, and satellite sites – all of Mycenaean date, we believe that the Kalamianos region was settled rather rapidly, in what we might (anachronistically perhaps) call a colonialist enterprise. This situation provides us with a good case study for identifying essential features of Mycenaean culture that would have been brought to the area, and not dependent upon a pre-existing history. There are several features of the natural landscape which most likely were beneficial to settlement in the Kalamianos region: the usable harbour or anchorage; land routes connecting the higher elevations with the Argive plain and other portions of the Argolid-Corinthia; access to drinking water at Kalamianos through the system of bedrock faults; agricultural lands; and plentiful limestone suitable for building material, especially at Kalamianos. Each of these features of the natural landscape will be examined through the lens of how the Mycenaeans interacted with them and how distinctly Mycenaean cultural and social landscapes might have been formed from them.



3. The harbour

Marine geophysical work conducted as a component of SHARP and related projects has confirmed the presence of a harbour at Kalamianos in the Late Helladic period. While there are a few instances of built harbours and installations in Bronze Age Crete, such as at Kommos (Shaw 1985) or Gournia (Watrous 2012) among others, no such constructions have been identified so far elsewhere in the Aegean during the Bronze Age (Shaw 2019). Instead, Kalamianos follows a common Aegean location of a settlement on or adjacent to a promontory or offshore island forming two harbour basins, such as Ayia Irini on Kea, Manika on Euboia, or Kolonna on Aigina (Shaw 1990: 423; also, Chryssoulaki 2005; Pullen 2013a). One of the main issues with studying natural harbours is that the coastline in the tectonically active Aegean has changed much even in the last few thousand years; a change in sea level vis-à-vis the adjacent land of only a metre or two can render a harbour unusable or create a new one. In the Aegean we have not only eustatic sea level rise but also shifting of the land through subsidence, tilting, and uplift associated with tectonic activity, sometimes on a very local scale (Rothaus et al. 2003). For instance, overall, the Corinthia has undergone tilting such that the Corinthian Gulf has experienced uplifting while the Saronic Gulf has experienced subsidence, but there can be great variation in the local effects of these geomorphological and tectonic forces, especially in shallow and low-lying coastal waters.

Kalamianos is located 2.5 km east of the modern village of Korphos, along the southeastern coast of the 'bulge' of the Corinthia into the Saronic Gulf. Whereas today Korphos is on a natural harbour in a small bay, in the Bronze Age Korphos Bay was probably mostly a wetland or other

Figure 4. Map of coastline and bathymetry at Kalamianos: A: modern shoreline with submerged beachrock BR-1 and BR-2; B: reconstructed shoreline during the Late Bronze Age; C: reconstructed shoreline during the Early Bronze Age, with major area of EBA finds on land indicated (J. Boyce and SHARP).

unsuitable anchorage (Rothaus et al. 2003; Nixon et al. 2009) and the harbour was at Kalamianos. The harbour at Kalamianos was first identified through geological and coastal studies associated with the Eastern Korinthia Archaeological Survey (Rothaus et al. 2003; Tartaron et al. 2003; Tartaron et al. 2006a). These studies indicated that there had been great geomorphological changes since the Bronze Age.

In 2009 as part of SHARP a Greek-Canadian team (directed by Despina Koutsoumba and Joseph Boyce) conducted a marine geophysical and underwater survey of some 10 km^2 of sea off the shore of Korphos and Kalamianos, including bathymetry, side-scan, subbottom seismic and magnetic surveys. The results confirmed that the area of Kalamianos was much more suited to being a harbour in the Bronze Age than was the Korphos Bay (Dao 2011; Tartaron et al. 2011: 570-575). The Digital Bathymetric Model constructed from the data and confirmed by an extensive underwater diving survey revealed submerged beachrock platforms at -3.5-3.7 m (BR-1) and at -5.8-5.9 m (BR-2) below the water's surface (Figure 4A). BR-2 had plentiful Early Bronze Age ceramics. The upper beachrock platform BR-1 had massive quantities of Late Helladic pottery (estimated at 30-50% of the volume of the beachrock) and yielded a radiocarbon date of c. 1616-1437 BCE (Beta 278839, 2-sigma calibration); that date unfortunately is older than most of the pottery retrieved from the adjacent land site, but the sample may have been affected by being submerged. We were not able to extract any of the submerged ceramic material.

The resulting reconstructed shorelines show how much the coastline has changed over the last 5,000 years. In the Early Bronze Age, the small islet currently about 200 m offshore was connected by a narrow isthmus, forming two natural harbour basins (Figure 4C). Archaeological survey has found a large quantity of water-worn ceramic material dating to the Early Helladic period along the shore to the north and west of the western basin; indeed, this is the principal portion of the Kalamianos site that has yielded pottery of this date. Along with the pottery a large quantity of water-worn obsidian was found, much of it large flakes with cortex adhering, indicating that these were probably decortication flakes marking the initial reduction of chunks of imported cobbles of obsidian into workable cores. Most likely this obsidian also dates to the Early Bronze Age. In addition to the decortication flakes, several cores were found at this location, but relatively few blades.[1] Kalamianos thus is one of an increasing number of known EBA obsidian processing centres, mostly coastal, such as Manika (Euboia), Lithares (Boiotia), Fournoi (southern Argolid), Lerna, and Romanou (Messenia) that receive the raw material from Melos, process the obsidian into cores and other forms such as blades, and then export these products to neighbouring sites and areas, especially inland (Kardulias and Runnels 1995; Hartenberger and Runnels 2001: 274-277; Parkinson and Cherry 2010; Karabatsoli 2011: 686-691). At Stiri and other locations identified in the regional survey conducted by SHARP, only finished products such as blades were found.

By the Late Bronze Age, perhaps less than 1,000 years later, the relative sea level was 1.5 m higher, flooding the neck of the peninsula and forming a much larger version of the present-day islet (Figure 4B). The two basins were still present, separated by the submerged promontory. A few of the many magnetic anomalies discovered by the underwater work throughout the western and eastern basins were investigated by divers, and were found to be piles of volcanic stone and ceramics, surely ballast piles, though they remain unexcavated. One of the ballast piles in the western basin was very large, c. 4-5 m in diameter, with Late Helladic ceramics in it (Tartaron et al. 2011: 573 fig. 10: f); this mound may represent an accumulation over a period of time and thus a favoured anchorage spot. The volcanic stone in these ballast piles is mostly andesite and undoubtedly originated on the nearby island of Aigina in the centre of the Saronic Gulf.

A substantial amount of land has been lost to the rising sea level; for the LBA we estimate the shoreline to have been 50 to 100 m further out, and for the EBA even more. Mycenaean buildings extend right to the edge of the modern shoreline, and many seem to have continued beyond, indicating a continuation of settlement into those now lost areas. Unfortunately, the geophysical methods employed were not able to penetrate the silty floor of the shallows. Perhaps the majority of the EBA settlement is now underwater.

A question arising from our study is why the harbour (and settlement) seemingly was abandoned after the EBA and not resettled until the middle of the LBA, roughly eight centuries later. The physical setting of the harbour would have changed somewhat during that time (perhaps in a series of tectonic events, though also through gradual geological changes), but it was still a viable location for anchoring boats.

Now we must invoke the cultural and social landscape of the Saronic Gulf and how the harbour at Kalamianos area fits into that small world. We have suggested several times (Pullen 2007; Pullen and Tartaron 2007; Tartaron et al. 2011: 628-631; Tartaron 2013) that the emergence of Kolonna on Aigina in the late EBA (Rutter 1993: 776-780; Gauss 2019; 2021) as the dominant centre of the Saronic Gulf greatly affected developments in the coastal zones until Kolonna was eclipsed by multiple emerging centres around the Saronic in the LBA. Kolonna had extensive contacts with Crete, leading to such developments as the

1 William Parkinson, in preparation. My thanks to Parkinson for allowing me to mention this.

importation of Minoan ceramics and technology, and the initial phase of construction of the Large Building Complex with ashlar masonry (Gauss and Smetana 2010). Similar developments are not attested elsewhere in the Saronic Gulf during the MH period, though Lerna in the Argolic Gulf displays some of the same developments in ceramics and other material culture. Sailing technology reaches Crete by the end of the EBA (Broodbank 2000: 341-347), and it is likely that sail-powered boats allowed Minoans to expand their networks of contacts to Kolonna and other places such as Lerna and Ayia Irini on Kea. When sailing technology was adopted by mainland groups is not clear (Tartaron 2013: 48-89), for rarely are sailing vessels depicted in art until the LBA, but two MH II matt-painted pithos or barrel jars from Kolonna depict vessels, one with armed figures on an oared vessel (Siedentopf 1991, no. 162, pl. 38) and one with two manned vessels with perhaps masts in lieu of oars (Siedentopf 1991, no. 158, frontispiece, pl. 37), giving a clear indication that Kolonna was familiar with naval power (Rutter 1993: 778-780).

4. Land connections

At first look, the Saronic coast of the Corinthia appears to be very foreboding, with steep mountains rising directly from the sea and few places to access the interior (or vice versa). But while the quantity of suitable anchorages such as Kalamianos is quite limited (Rothaus et al. 2003), there is an extensive network of paths and routes in the inland interior, much of it at higher elevations than the coast. Overland paths and routes connect the Korphos region to the rest of the Corinthia and Argolid via upland valleys and passes (Figure 2), and eventually the road system around Mycenae (see Brysbaert et al. 2020 for the uses of such roads and paths). One such route runs from the site of Stiri, just 2 km northeast of Kalamianos and part of the Mycenaean 'colonisation' of this area, west to Mycenae, via the towns of Sophiko, Angelokastro, and Limnes, a distance of c. 50 km.[2] Branches off this route lead southwest to Midea and Kazarma, south to Vassa/Dhimaina and Epidauros, and northwest to Athikia and Ancient Corinth; many of these paths are documented through oral reports (Tartaron et al. 2011: 614-615). Unfortunately, little of this rugged area between the Argolid Plain and the Saronic Gulf, dominated by Mount Arachnaion (+1,197 masl), has been systematically explored, and so we do not know how extensively it might have been settled or utilized in prehistory (see Psychoyos and Karatzikos 2015 for the Mycenaean shrine on Mount Arachnaion). SHARP crew members attempting to find a shortcut leading from Kalamianos directly west to Angelokastro (and bypassing Sophiko) discovered an unknown Mycenaean structure that was strategically located to take advantage of vistas and routes leading from Angelokastro to Dhimaina/Vassa and Ligourio/Epidauros; undoubtedly there are more such sites not yet discovered. Constructed Mycenaean roads have been documented only in the area east of Mycenae and south near Kazarma (at least several bridges on a route from the Argolid east to Epidauros) for wheeled traffic (Hope Simpson 1998; Jansen 2002), but other modes of transporting goods such as via donkey or humans might not need such infrastructure if the traffic were lighter and settlements less dense than nearer Mycenae and other Argive centres.

The only constructed pre-Modern road identified in the Kalamianos region is one that leads from the small valley above Sarakina (a small inlet east of Kalamianos) up the slope to Stiri. This road was cut into bedrock in places and made use of small bridges in its zigzag path up the steep slope; it could possibly have accommodated wheeled traffic (Tartaron et al. 2011: 617). The date of this road has not been determined; it was in use by villagers from Korphos to reach the Byzantine chapel of the Panayia at Stiri before the late 20th-century road was bulldozed through, but probably was in existence much earlier. Given the extensive investment in construction of buildings and terrace walls at Stiri and Kalamianos (see below), a road between these two spots would be a sensible addition to the landscape and would follow the Mycenaean pattern of road systems connecting smaller sites with larger ones. Such a road would also connect the upland interior routes with the maritime routes emanating from the Kalamianos harbour. Jansen (2002) has suggested that many of the roads around Mycenae were for local circulation, connecting areas of agricultural production with urban centres (contra, e.g., Hope Simpson 1998), and Sjöberg (2004: 49) argues that roads facilitate horizontal integration of communities beyond local neighbours, such as through periodic markets. The construction of facilities for exchange (marketplaces) or, more pertinent to the Aegean situation given the lack of physical marketplaces, to facilitate exchange, such as harbours and roads, is one characteristic of market systems (Pullen 2013b). There is a growing awareness of the importance of markets for Mycenaean societies as the severely hierarchical palatial-centric models of Mycenaean society and economy are challenged (Pullen 2020 and see below).

5. Food and water

I have argued elsewhere (Pullen 2019a; 2019b) that expansion of settlement in the Kalamianos region in the palatial Mycenaean period was intended to be self-sufficient in terms of subsistence, as large-scale redistribution of foodstuffs or outright supplying of food to a large community would be impractical in the long-term and is not elsewhere documented in the LBA mainland.

2 The travel time from Stiri to Mycenae on foot varies from 10 to 13 hours, as attested by SHARP crew members.

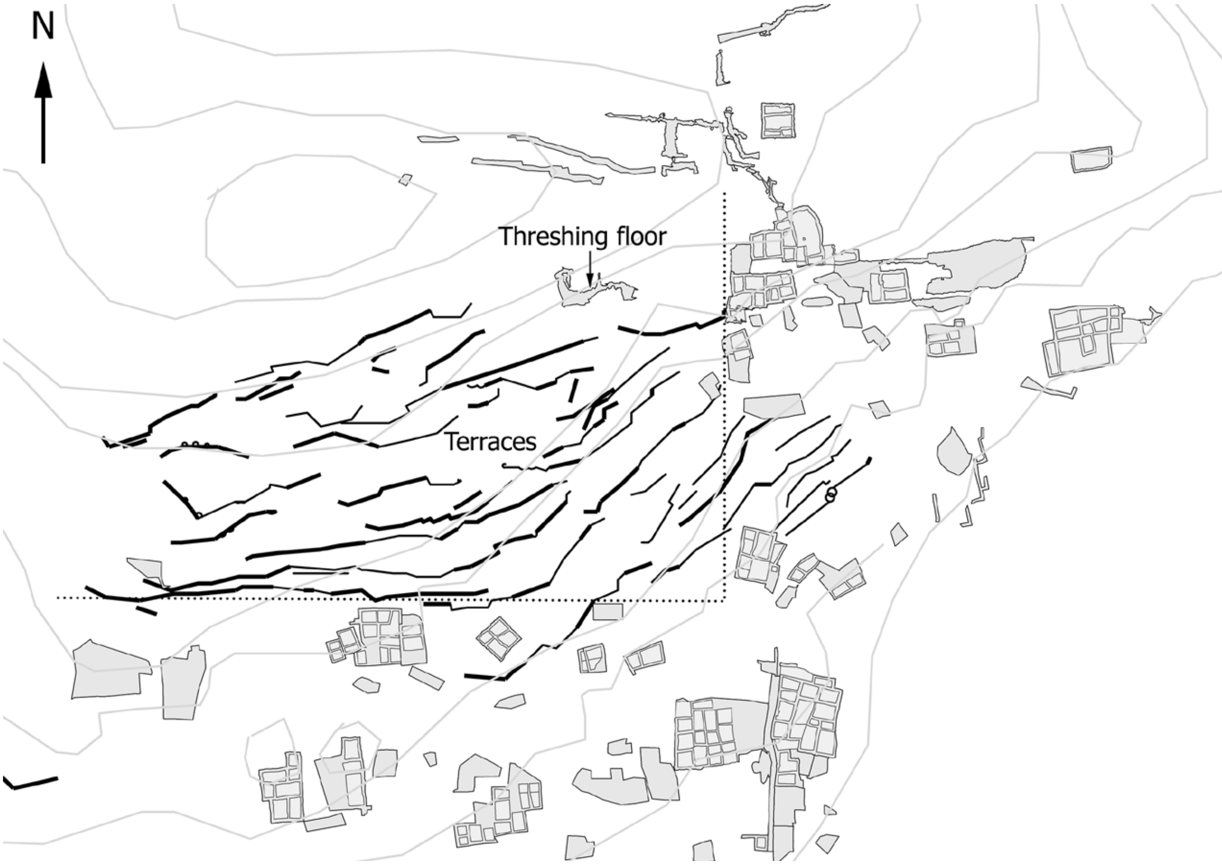


Figure 5. Plan of Kalamianos architecture and quadrant of intramural agricultural terraces. Thicker black lines indicate terraces of Mycenaean date; thinner black lines are currently undated terraces (SHARP).

Massive quantities of food and drink for large-scale feasts are mobilised by the palatial elites (Bendall 2008; Nakassis 2012), and thus short-term supply of subsistence needs would be theoretically possible, say, for the initial establishment of 'colonists' sent out to Kalamianos by palatial authorities, if that reconstruction is correct. This suggestion that the Kalamianos region was intended to be self-sufficient for subsistence is supported by the presence of several hectares of terrace walls in several areas: within the walls of Kalamianos, immediately outside the wall, and on the slopes around the hilltop of Stiri (Tartaron et al. 2011: 624-625). Lynne Kvapil has studied the terrace walls in the Korphos region and has been able to identify those that are, or most likely are, of Mycenaean date by their construction, masonry, and location (Kvapil 2012). There are several small basins and low-lying areas suitable for agriculture between Kalamianos and Korphos, and more are located in the uplands west and north of Stiri (Tartaron et al. 2011: 563-565), but these may have been thought to be insufficient for the agricultural needs of Kalamianos and Stiri (Figure 2), and thus 15 hectares or more of land near Kalamianos and Stiri are estimated to have been terraced in the Mycenaean period. Some of the terrace walls on the steep slopes of the hill of Stiri utilize very large blocks in a manner similar to the construction of buildings at Kalamianos; one wonders whether those almost monumentalised terrace walls also served as symbols for those below, whether on land or arriving by sea, much in the way that the 'cyclopean' masonry of the Mycenaean citadel fortification walls conveyed power and strength (Pullen and Sapirstein 2020).

Of particular note is the quadrant of terraces within the circuit wall of Kalamianos – an area of c. 1.4 ha of land within the circuit wall was covered with shallow agricultural terraces and no structures (Figure 5). Additional terraces bring the total of area of terraces within the circuit walls to 2.0 ha. The presence of a threshing floor, tentatively dated to the Mycenaean period by its construction methods, adjacent to these terraces might suggest grains. However, a more likely scenario is that these terraces within the wall were used for garden crops or, as Kvapil (2012: 226-230) has suggested, for high-value crops such as herbs or other plants for production of perfumed olive oil (e.g., cumin, sesame, coriander). This terraced quadrant need not have been under the control of a single individual, for plots as small as 120 m^2 are record in the Linear B tablets (Palaima 2015: 628-629).

Figure 6. Artificially modified surface opening of a water-bearing fissure (SHARP).

The 15 to 20 ha of terraces documented throughout the region would not have been sufficient to supply a town of the size of Kalamianos. Using very gross estimates based on the identification of at least 50 structures (not all of them residential, nor necessarily single-family occupied) and a standard five-person household, an estimated population of 250 people might need the harvest from c. 75 ha, based on minimal cereal production with some ox-plowed fields (Halstead 2014: 247-248; Pullen 2019b). There are other areas of arable land, such as the upland basins, that would not need terracing in order to be exploited; we were not able to conduct geomorphological studies to reconstruct how extensive these would have been in Mycenaean times (Figure 2).

In addition to food, water is an essential component of life. Throughout the Korphos region are found what we colloquially call 'fissures,' fractures in the limestone bedrock that have been enlarged through groundwater movement (Tartaron et al. 2011: 566). These fractures also produce freshwater springs beneath the sea all throughout the coastal zone, and in the same manner many of these on land contain water, though access from the surface is most often not possible. At several locations at Kalamianos, however, these surface openings have been artificially enlarged to allow ready access to the fresh water (water tested from two fissures meets all standards for drinking water in the USA) (Figure 6). Buildings seem to cluster around these augmented openings (Figure 7), though which came first

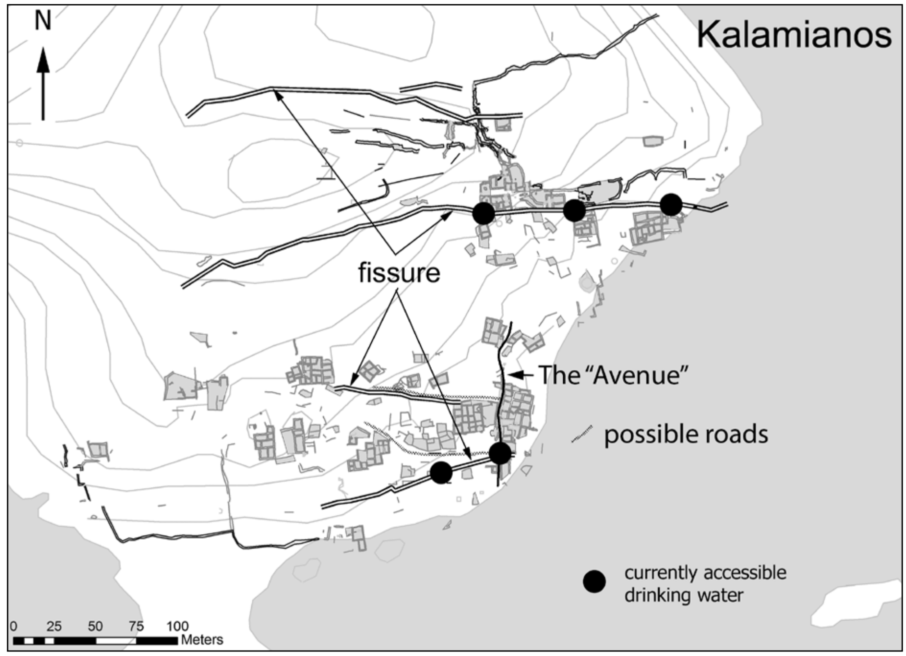


Figure 7. Plan of Kalamianos architecture with water-bearing fissures, the 'Avenue', and possible roads indicated (SHARP).

is not always possible to tell (Pullen 2015: 381 fig. 4). It is worth noting that pottery of the EBA period is not found clustered around these fissure openings, but there may well have been additional fissures and openings in those parts of Kalamianos now lying beneath the modern sea level. Access to some of these openings is controlled by walls, but whether for ownership, to prevent accidents, or just to keep the water sources clean is unknown. The identification of potential water-bearing fissures would suggest a knowledge of hydrology in a karstic landscape; the Mycenaeans are, of course, well known for their hydrologic engineering, including the digging of cisterns to tap underground springs such as at Mycenae, Tiryns, and Athens.

6. Building and construction

The last category of the natural landscape of importance for Mycenaean Kalamianos to be considered here is the plentiful limestone available for construction. The system of faults and fractures in the bedrock discussed above in the context of water has an overall east-west orientation, with other fractures running perpendicular to the main set. Throughout the site of Kalamianos the bedrock is exposed on the surface, sometimes to a metre in height today (Figure 8). Though we cannot yet firmly reconstruct the ground surface in Mycenaean times, and some evidence suggests a loss of soil of up to 0.50 m in parts of the site, nevertheless the presence of limestone exposed at levels above the socles of buildings suggests that much bedrock would have been exposed back then. Bedrock outcroppings were often used directly in construction. The exposed bedrock splits naturally into large rectangular blocks, sometimes up to a metre or more in length. Given the proliferation of exposed bedrock across the site, no portion of Kalamianos is more than 50 metres or so from outcrops suitable for construction material, and several buildings seem to have been built of blocks removed to make way for the actual structure. Unfortunately, the exposure of the site since the Mycenaean period has meant that weathering has erased direct signs of quarrying. The use of the predominately east-west orientated bedrock in construction has led to a deceptively grid-like appearance of the plan of the site, but some internal planning is indicated throughout the site (below). Likewise, the natural fracturing of the bedrock into large rectangular blocks was exploited by the builders for practical purposes of construction but also sometimes to give a certain monumentality to a structure (Pullen and Sapirstein 2020).

The settlement is surrounded by a wall that encloses c. 7.2 hectares (plus whatever might have been lost to the rising sea level). We call it a 'circuit wall' as it is not very wide (usually c. 1.10 m in width) nor is it preserved very high; in most documented stretches (c. 500 m are preserved) there is insufficient stone found adjacent to reconstruct a wall much taller than 1.0 m in height. This raises the questions whether the Circuit Wall was ever completed (perhaps with mudbrick upper portions?) and indeed what the purpose of the wall might have been (defence? demarcation of the urban territory?). Internal 'boundary' walls mark off parts of the space inside the walls, though these walls never completely enclose space. Only 3.5 hectares of the space enclosed by the Circuit Wall has buildings and hypothetical surrounding 'yards' (defined as space within 20 m of a structure); including the

Figure 8. Aerial view of Complex 7-I/III/X showing state of remains on surface (center) and exposed bedrock (left and right). Note the 1-meter square drawing frame in lower center for scale (photo by K. Xenikakis and S. Gesafides for SHARP).

quadrant with terraces at 1.4 hectares and an additional 0.6 ha of terraces throughout the settlement, there is still 1.7 hectares of 'unused' space within the Circuit Wall. Other walled Mycenaean sites also have little of the enclosed space occupied by structures, such as Krisa (2 of c. 23.5 hectares), Eutresis (3.5 of 21.3 hectares), and Gla (5 of 20 hectares) (Pullen 2019b: 144-145). We have identified two phases to the wall, an earlier one encircling the eastern hill and a later one that extended around the entire settlement, partially incorporating the earlier wall, partially supplanting it. We do not know if the seaward side was walled or not, due to the loss of that part of the site to rising sea levels.

Some planning was involved in the establishment and layout of Kalamianos (none is evident at Stiri). As discussed above, the overall east-west orientation of the bedrock fracturing and exposed bedrock lends some guidance to the organization of the structures. One quadrant of the enclosed area was set aside for the shallow agricultural terraces. But beyond that there are instances where the walls of buildings align with walls in nearby buildings – thus in Buildings 7-I, 7-II, 7-III, and 7-X both east-west and north-south walls align (Pullen 2019b: 220 fig. 10.4) over a distance of 50-60 m. A major organizing principle was proximity of buildings to fissure openings and access to water. We have two long east-west lines of structures that follow two of the main fissures. Parts of (unpaved?) roads have been documented along these lines of structures, leading to intersections with the north-south 'Avenue' (Figure 7). This paved road was lined with walls and buildings and was traced for over 60 m before being lost at the shoreline. Structures along the Avenue seem to be much denser than along the two east-west lines of buildings, with little space for yards or outdoor courtyards. While an orthogonal grid is often thought to be the principal organizing schema for the planning of urban settlements from ancient times throughout the world, several scholars have demonstrated that many other types of planning schemes are apparent in ancient societies (Kostof 1991; Smith 2007; Creekmore 2010). In the Mycenaean world there is not a lot of evidence for planning of settlements, in large part because of the lack of study of the 'lower towns,' but sites such as Dimini show urban areas arranged orthogonally along a large roadway (Adrymi-Sismani 2016: 42), or Gla with its series of large structures axially arranged within a walled area (Iakovidis 2001).

Several smaller buildings are roughly square, c. 10 m on a side, and several larger, multi-roomed buildings seem to have a core of a square c. 10 m on a side (Pullen and Sapirstein 2020: 378-382). The largest compounds do not appear to have been the result of gradual expansion and agglomeration around a core of centrally positioned structures, but rather a set of homogenous units set out along a grid, as if each complex had been allotted a territory and the builders selected the most convenient site within each plot for structures. Thus, we have spacing between structures or groups of structures of 10 to 25 m, allowing for yards or other outdoor spaces along the two east-west lines of buildings. Nonetheless, while some centralised planning is implied by this pattern, there is little evidence for strong hierarchy among the building plots themselves. The sizes of the structures and of the individual rooms, despite the use of large blocks and generally thicker walls than at many other Mycenaean sites, do closely follow the measurements of Mycenaean buildings elsewhere (Tartaron et al. 2011: 588-591, tables 1-3, and fig. 21; Darcque 2005).

Even though orthostates and other special construction elements and its location distinguish Complex 7-I/III/X, the blocks utilised do not greatly exceed the scale of the largest blocks in other areas of the site nor do the *methods* of construction differ greatly, as if the occupants of this monumental complex did not advertise an exclusive claim to power. We have discussed Complex 7-I/III/X in detail elsewhere (Tartaron et al. 2011: 595-598; Pullen 2015: 386-388; Pullen and Sapirstein 2020: 372-377), so I will only touch upon those features that we consider 'Mycenaean.' What started as three separate buildings (7-I, 7-III, and 7-X) were eventually united into a larger complex with walled courts and other spaces, encompassing over 925 m^2 of usable space stretching over 50 metres from east to west. Building 7-I, apparently the most important of the elements, incorporates most of the architectural features we have identified as 'palatial,' such as the use of orthostates especially around corners and entrances, free-standing piers or pillars, and a gridded internal support system that utilises the piers, door jambs, antae, and other large stones. Large stones, often extending the full thickness of a wall (i.e., 0.70-0.85 m in dimension) are used extensively throughout Kalamianos on the exteriors of buildings, generally at the corners, wall abutments, or adjacent to doorways; in Building 7-I a large number of these large stones are also found on the interior. There is both a south and a north entrance into the structure, one feature that led Donna Nagle in her space syntax study of Mycenaean architecture to conclude that Building 7-I may have had more of a public function, with little indication of domestic activities (Nagle 2015: 442-443). By size and features Complex 7-I/III/X falls into Darcque's category of Intermediate Buildings (Darcque 2005: 339-340, 357-366), along with buildings at Gla, Sparta (the Menelaion), and palatial sites (e.g., Northeast Building at Pylos); most of these seem to have some 'public' function.

In addition to Complex 7-I/III/X, the large Building 5-VIII (27.50 × 17.40 m) stands out for its unusual form of an 'insula' of four (and perhaps as many as six) units, each with three to four rooms arranged in a line. The finds suggest some kind of industrial function, with many examples of coarse and cooking pot wares and very few fine ware examples; one volcanic handstone converted into an anvil; and a large number of shells, a large majority of them murex.[3] Nagle concluded from her spatial analysis of this structure that it most likely was used for workshops and storage, not domestic purposes (Nagle 2015: 446-447).

7. The Mycenaean cultural and social landscapes of Kalamianos

In this paper I have tried to show the particular Mycenaean approach to constructing a cultural and social landscape from the natural landscape. The Kalamianos situation is particularly useful in an attempt to isolate what it means to be 'Mycenaean' (if we can use that term in a general sense, and not invoke fraught notions of identity), in that there was little pre-existing settlement or occupation that had to be accommodated in the construction of the LBA settlement there. In this concluding section I wish to briefly consider the cultural and social landscapes that contributed to the establishment of Kalamianos and to its role in the large Late Bronze Age Aegean world.

The large investment in infrastructure at Kalamianos points directly to one of the major issues in Mycenaean scholarship – the degree of palatial control over the economy. Who might have been responsible for this investment, and why? How does the situation at Kalamianos compare to that at other ports, such as Korakou or Tiryns?

The question of 'why Kalamianos?' is perhaps easier to answer: the harbour was undoubtedly the draw for settlement here. On the long Saronic Gulf coast of the Corinthia and Argolid, there are very few suitable harbours (Rothaus et al. 2003), and fewer with additional resources to allow substantial settlement (such as discussed above); only Kalamianos between Isthmia/Kenchreai in the north and Palaia Epidauros in the south would fit those criteria.[4] Most likely the rugged mountains separating the Corinthian coastal zone from areas to the west was a hindrance, and perhaps a contributing factor to sparse settlement here between the EH II and LH III periods.

Harbours and maritime activity were very important to Mycenaean groups (Tartaron 2013), and the ports on

3 Amy Dill, who is publishing the finds from Kalamianos, suggests the manufacture of purple dye from murex.

4 But see Tartaron et al. 2003; Tartaron et al. 2006b for EBA use of anchorage at Vayia.

the Argolic, Corinthian, and Saronic Gulfs were important nodes for the Argive centres to participate in trade, both long-distance and shorter. Tiryns was a major (but not the only) port on the Argolic Gulf, with extensive connections throughout the Mediterranean as documented by the large quantity of imported objects (Burns 2010: 36-40) and the presence of Transport Stirrup Jars, usually found only at palatial sites on the mainland (Haskell et al. 2011). As Kardamaki et al. (2016: 157-158) argue, Transport Stirrup Jars represent 'literate, planned administration of taxes/tribute to the palaces' or at least 'the establishment of an administrative relationship between the Mycenaean Palaces and Crete during [LH IIIB]' (Kardamaki et al. 2016: 160-161). Thus, it seems that at least some activities at the port of Tiryns can be directly tied to the palatial elites and their interests.

On the Corinthian Gulf, Korakou has long been identified as a major site in the LBA, in part due to a harbour located at the shore there or to the west at the nearby site of Lechaion. Recent work around Ancient Corinth, however, shows a significant Mycenaean centre just north of Ancient Corinth, with an extensive cemetery, settlement, and tholos tomb (Kassimi 2015; Tzonou-Herbst 2015). Previously we addressed the question of why no Mycenaean palace had been found in the Corinthia, in the context of the emergence of Mycenaean states in the Peloponnese and Saronic Gulf (Pullen and Tartaron 2007; see also Tartaron 2010: 166-172), and the historical trajectory of relationships among the several Corinthian Mycenaean sites remains to be established. The situation of long-term social and economic stability of settlements in the northern Corinthian plain was not favourable for the emergence of a complex hierarchical polity through the domination by one site over others, we argued, and the northern Corinthia was peripheral to the competitive states of Mycenae and Kolonna in the earlier Mycenaean period. In other words, the northern Corinthia was beyond the direct control of either state. We argued that Kolonna's position as the centre of the Saronic Gulf hampered the emergence of competing economic centres and expansion of the Argive centres into the coastal zones of the Saronic, thus affecting the Corinthia, at least until the decline of Kolonna in the later Mycenaean period.

Kalamianos, then, was established in large part to take part in the increasing maritime interactions and other economic activity in the Saronic Gulf now possible with the relative decline of Kolonna on Aegina and growth of sites such as Megali Magoula (Troizenia), Kanakia (Salamis), Eleusis (Attica), and Kontopigado Alimos (Attica) (Pullen 2020). Trade was also now easier over the Isthmus with the removal of the Kolonna 'bottleneck,' and Korakou and Ancient Corinth, connected by sea through the Corinthian Gulf with the Adriatic and Central Mediterranean and by land with central Greece, prospered.

Turning to the question of who might have been behind the establishment of the settlement at Kalamianos, we must avoid the fallacy of assuming a full 'palatial' founding, in a hierarchical, top-down directed enterprise. The model of top-down dominance of the palaces in all matters of economic and social (political) organization has hampered the exploration of the actual variability among the various Mycenaean polities in these and other aspects of culture (Parkinson et al. 2013: 414-415). There is growing recognition that Mycenaean economies were not palatially-controlled, or perhaps not even palatially dominated, with significant non-palatial sectors in agriculture and craft production (Halstead 1992; Parkinson and Galaty 2007; Nakassis et al. 2010; Pullen 2010; Bennet and Halstead 2014), and a greater consideration of the multiplicity of exchange modes in Mycenaean economies, including market exchange, redistribution, gift exchange, and reciprocity (Nakassis et al. 2011; Parkinson et al. 2013; Pullen 2020). Nakassis (2012; 2013) has also shown that many of the individuals in the Linear B tablets played multiple roles related to palatial interests, some kingdom-wide and some at local levels. These individuals would have multiple loyalties and allegiances and would be involved in multiple exchange relationships with people at many different levels of the political and economic spectrum, from local to kingdom levels, both within and outside the interests of the palace (Pullen 2019a; Pullen 2020).

I have put forth arguments for some involvement by elites from the Argolid in the establishment of Kalamianos (Pullen 2019a; 2019b; 2020), and will just summarise some of the main points of those. The planning and layout of the settlement, that is the allotment of separate lots for structures, setting aside a specific area within the walls for agricultural terraces, alignment of structures, etc., all indicate some organisation beyond the individual family unit. The (relative) rapidity of construction, the skills needed to cut and manipulate the building blocks, and the great similarity in construction protocols among structures (Pullen and Sapirstein 2020) suggest the involvement of skilled workers such as are indicated in some of the limited Linear B tablets (Nakassis 2013: 275-279; 2015; Pullen 2019a: 227-228). Likewise, pairs of oxen can be allocated by palatial authorities for agricultural purposes, including for the purpose of bringing land into cultivation (Palaima 2015: 626-635) and perhaps also for construction projects such as Kalamianos (Brysbaert 2013; Pullen 2019a: 228). And the mobilisation of large quantities of foodstuffs for feasts, though periodic and not daily, indicates that palatial centres could have sustained a project like the 'colonisation' of the Kalamianos region with its walled harbour settlement of several dozens of buildings, hectares of agricultural terraces, and subsidiary sites. Harper concludes from his study of architectural production at Kalamianos that 'the volume of staple payments monitored by the palace at Pylos for perhaps a month well exceeds the equivalent daily rations that would be consumed during any of the architectural projects [at Kalamianos]; from the perspective of staple finance, architectural production may not have been especially burdensome' (Harper 2016: 311). Thus, it is theoretically quite possible for one of the Argolid palatial centres to be fully behind the establishment – provided that the Argolid palace(s) operated in a manner similar to the palace at Pylos, something that is not assured at all given the great variability in Mycenaean polities.

But in contrast to the possible Argive elite involvement in the establishment of Kalamianos, the ceramic evidence presents a picture of connections not with the Argolid, but rather with other sites in the Saronic (Pullen 2020). There is as yet no evidence for local production of pottery at Kalamianos. Like other sites around the Saronic Gulf, all of the cooking pots analysed from the Kalamianos region were produced on Aegina (Trusty 2016; Trusty and Gilstrap in press). Fineware vessels found at Kalamianos and Stiri were produced in the Corinth area, Kontopigado Alimos (Attica), and Aegina (Gilstrap 2015); none of the fineware samples analysed from Kalamianos and Stiri could be associated with the Argolid. Thus, consumption of pottery at Kalamianos is supplied by multiple production centres throughout the Saronic to the exclusion of the Argolid. This situation is a good example of the need to consider short-distance maritime trade and modes of exchange besides palatially centred redistribution or administered trade (Gilstrap et al. 2016). I would suggest that market exchange is the primary mode operating for distribution of ceramics in the Saronic, as palatial redistribution models have been shown to be woefully inadequate and highly impractical to supply the ceramic vessel needs of any significant population (Pullen 2013b; Pullen 2020).

As discussed above, the multiple roles of elite individuals in the Linear B texts have been well established by Nakassis (2013). I would suggest that local elites, interacting occasionally with the palace centres (with those interactions recorded in the Linear B tablets), also interacted with individuals and institutions in their own communities (with those interactions *not* recorded); in economic interactions, this would have involved market exchange, and not just at the local level: the tablets themselves even refer to wages and a few texts record 'purchases' (the *o-no* tablets) of materials from named individuals (Bennet and Halstead 2014: 275-278; Nakassis 2021). I would go further and suggest that one of the roles these elite individuals played was that of merchant, facilitating trade and exchange not only on the regional level within a Late Bronze Age kingdom but also at larger scales, such as with the Saronic Gulf 'small world' or such as the Aegean merchants referred to in the Ugaritic texts (Knapp and Cherry 1994: 123-155; Pullen 2020). The presence of sets of weights in wealthy tombs (e.g., the lead weights found in the Vapheio tholos tomb, Schon 2015) could be seen to corroborate this suggestion of elite involvement in trade and exchange. Scholars working in the Levant and Mesopotamia are increasingly recognizing the importance of merchants in those societies, even when as in the case of Ugarit the palatial officials are also involved in trade and exchange (McGeough 2007; Monroe 2009). At Ugarit, for example, there is a wide range in types of arrangements for trading activities, with the long-distance trade perhaps having greater involvement of palatial officials and individuals associated with the palaces. A similar wide range of types of economic arrangements is increasingly being recognised for Mycenaean polities (Nakassis 2021), and what we might conceive of as a single type of transaction, say the mobilisation of textiles by the palatial centre, actually consists of different types of activities that range from direct production by palace-controlled workshops to purchases from textile specialists (Nakassis 2021: 110).

Within this context of complex and multiple economic arrangements, we should perhaps not search for a single institution or individual who might be responsible for the establishment of Kalamianos. The palatial centre would not be concerned with the operation of Kalamianos *per se*, but rather what it might be able to obtain through agricultural and craft production or trading enterprises, the economic areas for which we imagine Kalamianos to be established. So perhaps a palatial centre might be interested in the production of aromatics and other ingredients for perfumed oil, or in the production of purple dye from murex for the textile industry; the production of these commodities would not by 'controlled' by a palatial centre, but rather would have been 'taxed' through quotas on the community (Nakassis 2021). Palatial investment in infrastructure is not documented in the Linear B tablets, but archaeologically we know that there is extensive infrastructure constructed throughout the Mycenaean world beyond the citadels and palaces themselves, such as the dam to prevent flooding at Tiryns, the draining of the Kopais basin, the construction of roads, or perhaps even a port near the palace at Pylos. We might envision a palatial allotment of some specialists and work teams to lay out the settlement and initiate construction, but these would not necessarily be under the command of the palace but rather under some elite individual.

Ultimately, though, the significance of Kalamianos is that it was established as a Mycenaean port settlement, bringing Mycenaean cultural and social landscapes to this part of the Saronic Gulf. Kalamianos did not continue into the post-palatial period, in part because tectonic forces rendered the natural landscape of the harbour unusable, but also because the social landscape of its palatial connections was altered by the destruction of the palace centres. Without the natural and social landscapes, the Mycenaean cultural landscape of Kalamianos could not endure.

8. Acknowledgements

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Time spent at the Heuneburg, Germany, between 600 and 540 BCE to build all their constructions

François Remise

1. The Heuneburg

The Heuneburg is located on the Upper Danube in southwestern Germany. It is one of the key sites of the European Iron Age spread over several km². The upper town is on a rocky hilltop on the left bank of the Danube. The site was inhabited in the Middle and Late Bronze Age (1600 to 1100 BCE), and after having been abandoned for several centuries, was again settled and fortified at the end of the 7th century BCE. Around 600 BCE, the upper town was surrounded by a mudbrick fortification, unique north of the Alps, replacing a more traditional rampart in wood and earth. This upper town was only a small part of a settlement spread over nearly 100 hectares with a lower town and an exterior settlement. In the 6th century BCE, with an estimated population of 5,000 inhabitants (Kurz 2012: 19-20; Schumann 2019: 171-179; Krausse et al. 2019: 180-189), the Heuneburg was one of the most important urban settlements of Western Europe. Finally, what makes it an exceptional site is the concentration of burial mounds in this area, including the Hohmichele (~ 30,000 m³), and the hilltop settlements of Ennetacher Berg, Alte Burg, Groβe Heuneburg and Bussen within a radius of 15 km. All these places were likely part of a settlement system. After a prosperous period, the importance of the site decreased in the second half of the 6th century BCE and the mudbrick fortification was violently burnt around 540 BCE. The site was finally abandoned around 450 BCE and only resettled in the Middle Ages.

2. The historical context

2.1. The 'princely seats'

The Hallstatt culture was the predominant Western and Central European culture between the Late Bronze Age and the Early Iron Age (1200 to 450 BCE). It is traditionally linked to the genesis of Celtic cultures. From the 9th century BCE, this culture is characterised by burial mounds containing rich graves of warriors, often with their bronze and then iron weapons, four-wheeled carts, and then around the 8th century BCE accompanied by luxury Mediterranean imports. The first wheeled cart remains were found in 1846 by Bourée when excavating the *Tumulus des Mousselots* at Sainte-Colombe (Prudhomme 2020). Paulus, after having excavated four burial mounds near the Heuneburg, spoke of *Fürstengräber* (princely burials) (Fischer 1995: 34). The term *Fürstensitz* (princely seat) was first introduced by Bittel and Rieth in the subtitle of their book *Die Heuneburg an der oberen Donau: ein frühkeltischer Fürstensitz* (Bittel and Riett 1951).

François Remise
Independent Researcher

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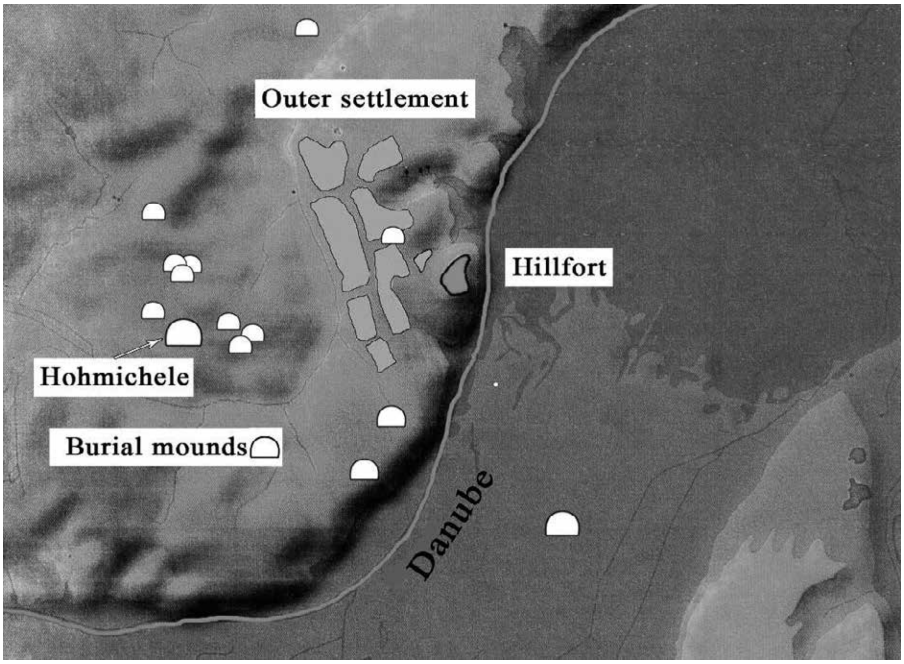

Figure 1. The Heuneburg site.

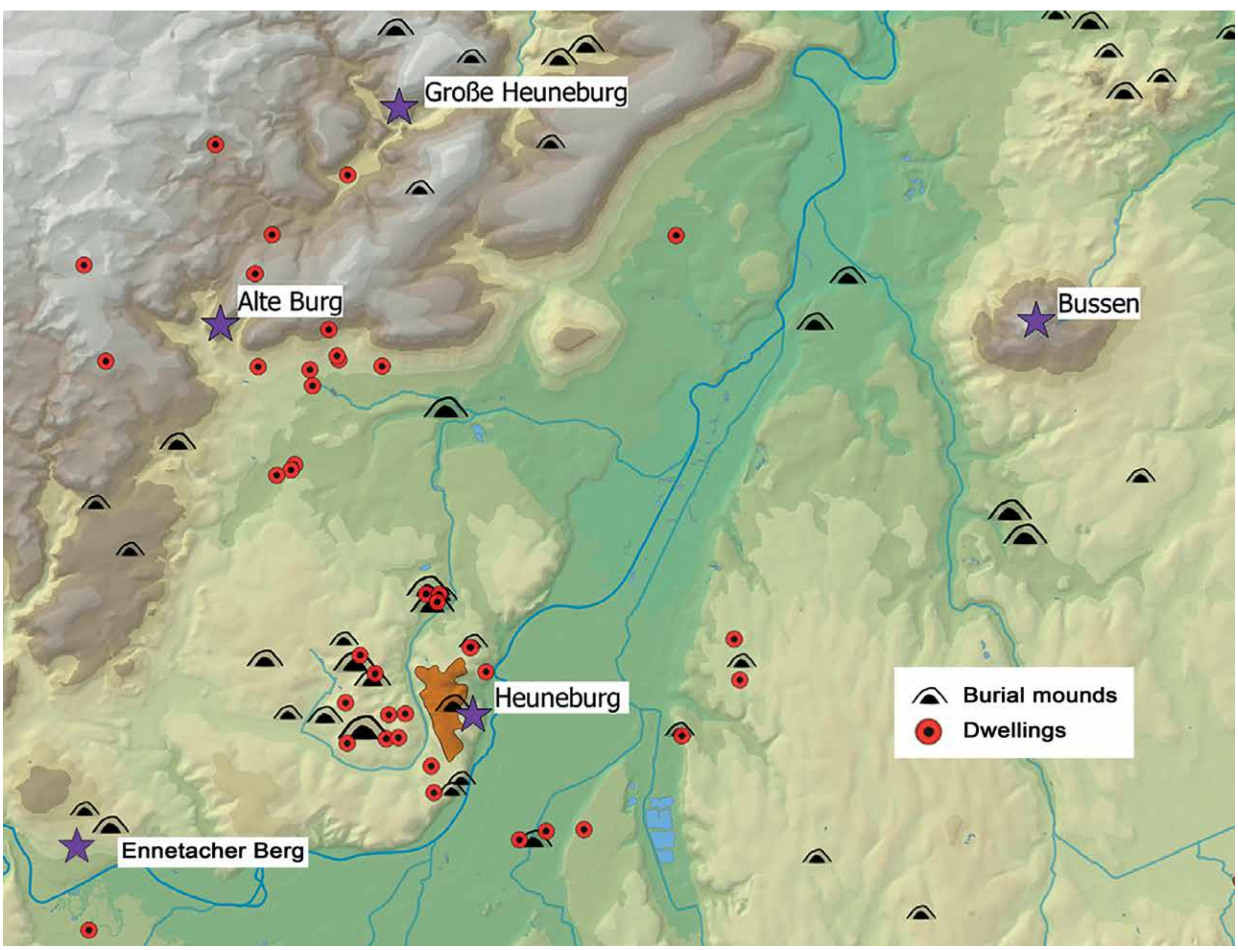

Figure 2. The environs of the Heuneburg.

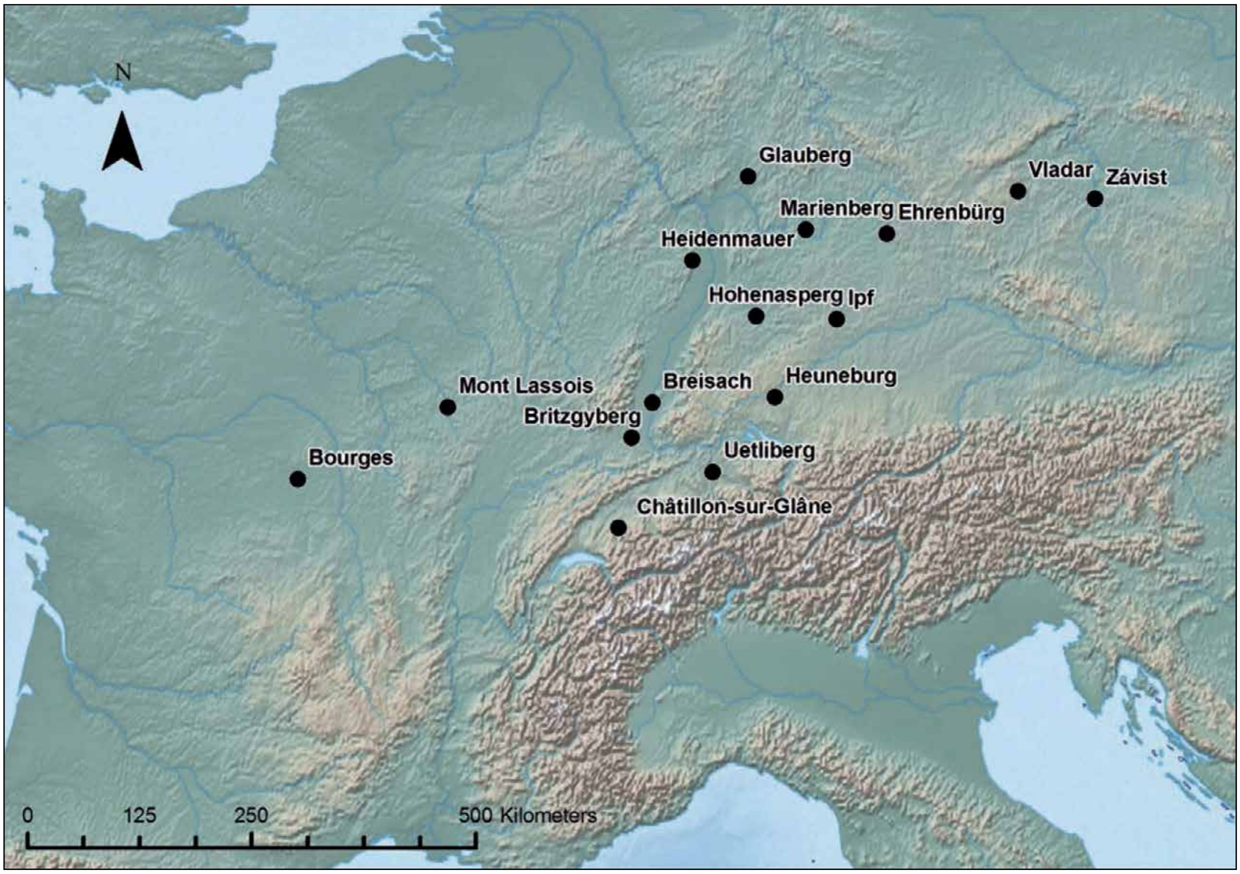

Figure 3. Princely seats north of the Alps (after Fernández-Götz / Ralston).

After excavating the Heuneburg, Kimmig regarded these princely seats as fortified settlements organized by the Hallstattian aristocracy and linked to burial mounds containing their graves. He defined a model of princely seats meeting three criteria (Kimmig 1969: 95-113): a location which allowed control of communications, often a fortified hilltop; rich burial around the settlement; and luxury Mediterranean imports in the dwellings. In 1987, Brun suggested that these seats could have controlled an area within a radius of 30 to 40 km, thus being economic and politic centres for a network of territories, each one being ruled by the fortification of a subordinate chief (Brun 1987: 80). Again, it is the Heuneburg site, with its rich burial graves of the Hohmichele, but also these at Buchheim, Ebingen, Winterlingen, Vilsigen and Grossengstigen sites, which allowed him to outline this definition (Brun 1987: 107). In 1991, Pare (1991: 188-191) criticized the almost unanimously adopted model which claimed that the cause for the formation of these princely seats was the foundation of Massalia in 600 BCE and the trade relations with the Mediterranean world. He took into account the numerous fortified settlements linked to rich graves in Southwestern Germany as soon as Ha D1, even Ha C[1], and considered that the emergence of the princely culture of Hallstatt D was mainly due to internal development.

Since 2005, many archaeologists have agreed on the fact that these princely seats were power centres, and that some of these may be considered as towns (The Heuneburg, Vix, Bourges etc.) controlling a wide territory. But they also point out differences between all the considered sites: fortified or not fortified settlements, respective sizes of the main settlement and the outer settlement, distances between the settlement and the burial mounds etc. (Chaume 2007: 40-43; Milcent 2012: 109-110; Fernández-Götz 2015: 73-75). Among all these sites, the Heuneburg, certainly the most thoroughly investigated, has been called «the first town north of the Alps» (Fernández-Götz and Krausse 2012).

1 Ha C: 800-620 BCE; Ha D1: 620-530 BCE.

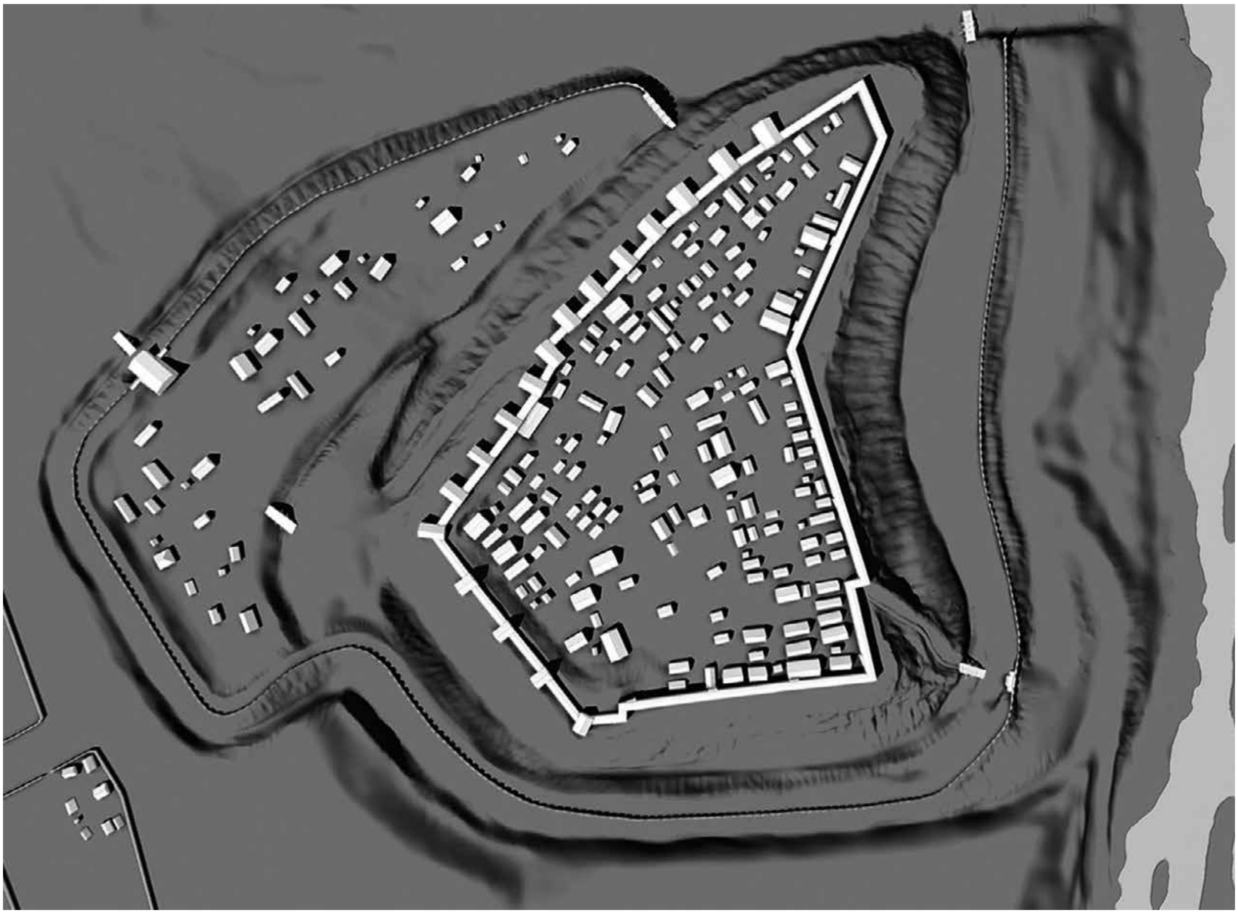

Figure 4. The mudbrick fortification of the upper town.

2.2 The history of the Heuneburg

It has been possible to identify 23 structural phases at the Heuneburg, from the Middle Bronze Age to the Middle Ages, 14 of which date from 650 to 450 BCE. The first settlement on the plateau, which lasted from 1600 to 1100 BCE, was surrounded by a fortification made of timber blocks filled with earth whose large volume suggests that the settlement was already considerable. The site was deserted around 1100 BCE and the centre of power seems to have moved to Bussen for several centuries where rich burials have recently been excavated (Hansen et al. 2021: 21). The Heuneburg was resettled around 620 BCE when groups of farmsteads were built on the plateau, surrounded by a fortification made of timber blocks filled with earth, identical to that of the Bronze Age, but more massive. The numerous excavations made around the site lead one to think that the development of agriculture and social elites, associated with population growth, were responsible for this revival. For instance, the rich goods of the burial mounds 17 and 18, constructed around 650 BCE near the Hohmichele, show that social elites were already developed before the rise of the princely seat (Fernández-Götz and Arnold 2017: 190). Around 600 BCE, the Heuneburg was completely restructured and a mudbrick fortification, likely of Mediterranean origin, was constructed on a stone base around the plateau (Krausse et al. 2016: 49–56). The wall, 3 m wide and 3-4 m high, was surmounted by a wooden parapet. The defence of the upper town was reinforced by 17 bastion-like towers on the west side, opposite the Danube.

On the plateau, all the buildings were reconstructed with a higher density and according to a regular plan. All these buildings, dwellings, stores and workshops (metal-working – iron, bronze and gold – textile, bone, amber, glass) (Krausse et al. 2016: 49–61) were reconstructed four times between 600 and 540 BCE (Gersbach 1995: 108–223). The lower town consists of buildings constructed on the slopes of the plateau. From 600 BCE, it was surrounded by a massive fortification mainly made with earth, to separate the lower town from the outer settlement. The fortification was controlled by a monumental gateway made of a mudbrick structure on a stone base, 16 m wide and 10 m long. The excavations made after 1990 revealed a large outer settlement covering 100 hectares west of the

Figure 5. The upper town, the lower town and the outer settlement.

plateau. This outer settlement was composed of scattered farmsteads ranging from 1 to 1.5 hectares, separated by ditches, banks and palisades, all constructed according to a regular plan. These rich dwellings were likely inhabited by aristocratic families and the quasi-uniformity of their constructions reveals that it was planned by the ruling elite (Baray 2016: 50–51).

The Heuneburg is surrounded by several cemeteries including large burial mounds dating from the Hallstatt period. A large group of 36 burial mounds is located in the Speckau woods, 2 km west of the town. The larger one is the Hohmichele, with a diameter of 80 m and a height of 13 m. The central chamber was robbed in ancient times, but it probably contained a man, a woman and a wagon. Many amber and glass beads were discovered. Among all the graves excavated in 1937–1938, one was undisturbed, containing the remains of a man and a woman, a four-wheeled chariot, a knife, a quiver, rich amber and glass beads, and bronze articles (Krausse et al. 2016: 117). Around 540/530 BCE, the town was destroyed by fire likely due to an attack. The mudbrick fortification was replaced by a more traditional fortification made of timber and earth. The density of buildings decreased in the upper town, but new large buildings were constructed (up to 400 m^2). On the contrary, the density of the lower town was intensified, and the outer settlement was deserted (Krausse et al. 2016: 91–99). Just after the fire, four burial mounds were constructed only 350 m away from the town. We can think that they contained remains of members of one clan which took power over the others (Baray 2016: 53–54). Around 450 BCE, the site was finally abandoned and was only reoccupied in the Middle Ages.

3. The labour cost of the constructions

3.1 The scope of the study

The most likely balance of labour and time that the community of the Heuneburg expended in constructing the building and earthworks between 600 BCE and 540 BCE has been estimated on the basis of the following data:

- the mudbrick fortifications on a stone base of the upper town with its wooden parapet and its 17 towers (800 m long, 3 m wide and 3 m high)
- the earth fortifications of the lower town with its monumental mudbrick and the outer ditch (2,200 m long)
- all the buildings of the whole settlement (upper and lower towns and outer settlement) including ditches, banks, and palisades
- burial mounds: the calculated estimation for the Hohmichele was extrapolated to all burial mounds proportionate with their volumes
- My estimations outlined below include the first constructions but also their maintenance during the whole period.

3.2. Estimation method

The stages of the study are as follows:

- The raw materials were identified, their volumes calculated, thanks to excavations reports (Gersbach 1995; Riek 1962), each volume being estimated using geometric formulas of comparable solids.
- Each task of the construction process was identified.
- For each task, I chose the most likely labour rate, taking worksite conditions into account.
- Labour rates are applied to the volumes to obtain the labour cost of each task, which when summed up, give the total labour cost.

Labour costs are expressed in person-day (pd) or person-hour (ph).

3.3. Choice of labour rates

In most previous labour cost studies, volumes are quantified as precisely as possible. By contrast, the choice of labour rates is rough, as authors often consider one value found in the literature (more than 50% of the 210 studies I reviewed), or between one and three, and use a reasoned interpolation of them (more than 30% of the 210 studies). We know that due to many uncertainties in these studies, we can only obtain an order of magnitude of building construction costs, but when one closely considers the labour rates values options of each task, this uncertainty is significantly reduced. Labour rates depend on many factors linked to raw materials (physical characteristics), tools and working methods used, shape and dimensions of the construction work, workers (gender, experience, fitness, training), type and organisation of the work (corvée labour, hourly paid, piecework, work feast, with or without supervision), daily hours worked, size of the production site, climate, project specification given to the construction manager (quality, sustainability, completion date) among others. All labour rates drawn from the literature must then be considered with their linked factors. Due to these numerous factors, labour rates can reach an infinite number of values, between a minimum near 0 and a maximum corresponding to a sporting feat. Each of these values was reached during works whose factors, mentioned above, were precisely defined, but which we cannot know. To be able to choose a labour rate within this continuum of values, we only have labour rates drawn from the literature, and values that we can obtain through discussions with knowledgeable people about the topic. To choose the most adequate labour rates for each task, the method I use consists of: first, defining the most likely working conditions under which the building studied was built, and then assuming the linked factors of each task; second, looking for the maximum labour rate values in the literature with their linked factors and trying to find the key factors which explain the scattering of the values, and third, estimating the most adequate labour rate, which, *a priori,* has nearly no chance of corresponding to one of the values drawn from the literature because the set of the linked factors drawn from the literature has nearly no chance to be the same as the studied building one.

Theoretically, we can find labour rates in eight types of sources. I consider ancient texts and inscriptions, general literature on construction, and ethnographic observations difficult to use, as tasks and linked factors are often too roughly outlined. The reasons for this are as follows: first, I am not aware of any ancient text or inscription providing sufficient information on the linked factors of a labour rate that allow them to be used safely. Second, I am not convinced that selling prices form a useful source to draw labour rates from, since the final price paid by the customer is most often different from the initial selling price. Details of these statements will be developed elsewhere (Remise forthcoming). Fourth, experimental archaeology reports are useful. Tools, methods, and worker profiles are often clearly defined. The most significant shortcomings are too short experiment times and the use of unexperienced workers. Mainly American archaeologists use these reports. Fifth, labour manuals of the 19th or beginning of the 20th century are interesting. Apparently, Startin (1976; 1982; Startin and Bradley 1981) is the first one to have used them (see also Startin et al. 1981), considering labour rates drawn from Hurst (1886), Rea (1913) or Rankine (1865). DeLaine (1992) used values drawn from Hurst (1865) and Rea (1902) in her thesis, but in her later book, one of the key publications of our field of study (DeLaine 1997), she mainly uses Pegoretti (1869). From then on, many studies especially carried out by European archaeologists used the same values as DeLaine (1997). Also, Barker and Russel (2012) discuss the great interest and the failings of these manuals in relation to stone working. In these older labour manuals, tasks are often only roughly outlined, except in specialized manuals (e.g., handbooks of earth excavation – see de Gayffier 1844; Pontzen 1891; or Gillette

1920). The linked factors are quite precise but labour rates correspond to specific values of these factors which I could define as estimations by the author (or assumed by the author), at a certain date, of a safe average labour rate – to be used by unexperienced cost estimators – for an average (experience / fitness / motivation) 19th century male worker, using 19th century professional tools, working 10 h/day six days a week, working in organised companies with supervision, in a temperate climate, hourly paid (not at task-work), for a small or medium work.

Construction site reports, as a sixth resource, may be useful when they are sufficiently outlined, as labour rates take into account actual worked hours and site conditions: walking distances, interactions between the different trade workers, professional workers. There are few, but three of these must be indicated: *Men Who Love Mountains* (International Labour Office [ILO] 1963) for earthmoving, Fathy (1989) and Seeher (2007) for mudbrick. Some earth excavation manuals contain interesting construction site reports (see e.g., Etienne et al 1910 and Gillette 1920).

Seventh, previous time-labour studies are interesting when their authors analyse several labour rates: among the 210 studies I analysed, Hammerstedt (2005) may be mentioned for tree-felling, Bessac and Nehmé (2007) and Barker and Russel (2012) for stone working, Korobeinikov (2005) and Turner (2018) for soil digging and shovelling. Eigthth, discussions with knowledgeable people when done directly with them are certainly the best sources, but the results are difficult to transpose to other cases.

It is impossible to know how many hours workers laboured at the Heuneburg. In previous studies, authors most often stated the number of working hours indicated in their employed labour cost sources. Authors using Erasmus' (1965) labour rates consider a 5-hour working day (Clark 1998 among more than 35 authors), those using Abrams's labour rates a 5 or 8-hour working day depending on the tasks (Murakami 2010 among more than 20 authors), and those using DeLaine's labour rates a 10-hour working day (Snyder 2020 among more than 25 authors). Most others use an 8-hour working day which I followed for this study. It should be pointed out, however, that a labour rate only makes sense if it is associated with the corresponding number of worked hours: a labour rate obtained for a 5-hour working day should not be used as it is for a higher number of worked hours. Similarly, a labour rate obtained for a 10-hour working day should be increased for a day with lower number of worked hours.

In any case, using a longer working day decreases the total number of worked days, but increases the total number of worked hours. Erasmus' (1965: 284-285) experiment carried out in Sonora can be taken as an example. This earth carrying experiment lasted six hours. Two carriers transported earth, the first one making 50 m trips, the second one making 100 m trips. The results are shown in Table 1:

Erasmus Sonora (1965: 284-285)					
Nb h/d	1 h	4 h	5 h	6 h	
50 m	44	168	206	234	Total number of trips
	44	**42**	**41.2**	**39**	Number of trips/hour
100 m	26	96	116	134	Total number of trips
	26	**24**	**23**	**22**	Number of trips/hour

Table 1. Results of Erasmus' experiment in Sonora.

Number of hours for: 10,000 trips					Number of days for: 10,000 trips				
Nb h/d	1 h	4 h	5 h	6 h	Nb h/d	1 h	4 h	5 h	6 h
50 m	227	238	243	256	50 m	227	60	49	43
100 m	385	417	431	448	100 m	385	104	86	75

Table 2. Erasmus' experiment in Sonora: Interpretation.

For each carrier, the number of trips decreases with the number of worked hours, due to fatigue. For unexperienced workers, the first hour could be less productive, due to the learning curve, and for very experienced workers, the number of trips could be steady. Let us assume that each worker should have to make a total of 10,000 trips. The two sections of table 2 show that when the number of daily worked hours increases, the total number of hours increases but the total number of days decreases.

I do not agree with the authors who write that labour rates in person-days must be avoided in favour of labour rates in person-hours (see Harper 2016: 51-52; Munson 2020: 45). Both methods are equivalent under the express condition that hourly or daily labour rates are given with their linked number of daily worked hours, because they depend on them.

To illustrate my own method as outlined in section 3.2. and employing an 8-hour working day expressed in person-days, I take two basic tasks, earth excavating and carrying light loads as examples, and I explain my choice of labour rates for the studied works at the Heuneburg.

3.3.1. Example of earth digging

The labour rate for digging earth is needed to estimate several tasks among the studied constructions, including the removal of the previous fortifications made of earth and timber, the mudbrick manufacture, the digging of the surrounding ditch and quarters' ditches, and the construction of the Hohmichele. These tasks are not identical, and their linked factors (see below) are also assumed different.

For the removal of the previous fortifications and ditch digging, I consider loosening the soil and shovelling. For mudbrick manufacture, the soil is only loosened before its tempering with water and chaff takes place.

For the surrounding ditch digging, I take its depth (6 m) into account. For the construction of the Hohmichele, I consider digging and filling baskets. These tasks being different, their labour rates will be as well. Moreover, the factors linked to these tasks are not assumed identical:

- Soils are different in each case: an already loosened earth for the removal of the previous fortifications and for the quarters' ditches, wet clay for mudbrick manufacture, rocky soil for the surrounding ditch and earth with roots for the construction of the Hohmichele.
- Shapes and sizes are obviously different.
- I assume that the workforce is composed of experienced workers for the hard tasks: removal of the fortifications, digging of the surrounding ditch and loosening of the clay for mudbricks. I assume that a less experienced work force with a less physical strength is needed for the quarters' digging (family work) and for the construction of the Hohmichele (clan and perhaps ritual work).
- The work is organized differently: with a time constraint for the removal of the fortifications, supervised for the digging of the surrounding ditch, less supervised and with less time constraints for the three other tasks.
- I generally suppose an 8-hour working day but I assume that the construction of the Hohmichele may have been done during periods of several hours which were interrupted by rituals.
- Digging ditches and filling baskets require greater care than the other tasks: nearly all labour manuals give different labour rates for digging ditches (e.g., Pegoretti 1869), and the deeper one digs, the harder the work (see also Atkinson 1961).

Since these tasks and their assumed linked factors are different, the labour rates are likely different as well. However, how do I choose the different labour rates? From more than 500 labour rate values for digging earth I kept 39 labour rates corresponding to digging experiments with non-metal tools (Toussaint 2009: 61–68; Milner et al. 2010: 105–109; Kuehn 2014: 56–57; and Morgan et al. 2018: 67–72; see Table 3). The other labour rates with metal tools were used to estimate the effect of some additional factors such as the influence of the climate, special works, experience or motivation of the workers, and the number of worked hours per day.

To do this type of analysis, it is essential to consider all labour rates obtained during these experiments (which can be named reference values) and not only the average. It is the gap analysis between these reference values which allows one to estimate the influence of the various factors. These analyses have in fact already been done by some of the authors of these experiments (see e.g., Toussaint 2009: 67–68; Milner et al. 2010: 108; Morgan et al. 2018: 74–75). To try to improve these analyses, I asked the authors specific questions and obtained some answers. In spite of all these reference values, it is impossible to build a precise model which could allow one to predict the labour rates corresponding to the various factors. This is due to too small a number of experiments, the great number of factors to be taken into account, and to the subjectivity of their assessment. In fact, while tools, work dimensions and workers' experiences are correctly outlined, the soil characteristics are very inaccurately described (neither penetration measurements nor stone percentages). Reference values range from 0.06 m^3/h to 0.69 m^3/h. Logically, the lowest labour rates correspond to hard soils and the highest ones to light soils. The 0.52 m^3/h labour rate deserves a comment as it is the most often used labour rate in the studies I analysed.

This value was obtained by Erasmus (1965) at Las Bocas (Mexico). Erasmus employed two workers to excavate earth, one with a digging stick, the other with a metal shovel. The earth was put into containers and their volumes were measured. The labour rates were so high that Erasmus, who had accepted to pay the workers piecework, stopped the experiment after 30 minutes. As Erasmus rightly doubted, they could not have maintained the same speed during a whole day, so he reduced the labour rates by 33% for the labour rate obtained with the digging stick and 25% for the labour rate obtained with the shovel. Thus, he considered that a 5-hour day of digging would produce 2.6 m^3/h with a digging stick and 7.2 m^3/h with a metal shovel. However, he does not indicate what type of soil was dug (*a priori* a sandy earth). The volume of earth has been measured without taking the swell into account (10 to 15% for a sandy soil). The reduction coefficients are difficult to justify. Finally, the piecework payment, which can increase the labour rate up to 30% to 50% is not the most common work condition. In spite of these uncertain and rare work conditions, this labour rate of 2.6 m^3/h was still chosen as the labour rate with non-metal tools in 90% of the cases, often for different soils than sandy soil (in nearly 50 studies). This example shows that all the factors linked to an experiment must be carefully analysed. However, this experiment is still interesting as it allows one to estimate a maximum labour rate, and a ratio between metal and non-metal tools in the same conditions.

Let us return to our 39 reference values. From the reference values, we can deduct the following ranges of labour rates:

- hard soils with stones: 0.06 to 0.20 m^3/h
- light soils with stones: 0.12 to 0.25 m^3/h
- wet or hard clay: 0.20 to 0.30 m^3/h
- light soils: 0.30 to 0.50 m^3/h

Reference		Labour rate (m3/h)	Soil	Tool	Exp. Time (h)	Motiv.	Shape	Exper.
Ashbee 1998: 491	Experiment	0.24	Chalk	Antler pick	1.00			
	Estate	0.14		Antler pick	8.00		Great	Great
Coles 1973: 74	Experiment	0.24	Chalk	Antler pick	1.00			
Erasmus 1965: 285	Experiment	0.69	Sandy	Digging stick	.50	Very high	Great	Great
	Estate	0.52		Digging stick	5.00	Average	Great	Great
Erickson 2010: 631	Experiment	0.25						
Hammerstedt 2005: 46	Experiment	0.29	Silty loam	Chert hoe	7.00			Average
Kuehn 2014: 57	Experiment	0.24	Silty sand	Digging stick and wooden shovel	1.25			
	Experiment	0.16	Wet sand and gravel		2.67			
	Experiment	0.10	Sand, hard pan, pebbles		1.75			
	Experiment	0.10	Wet sand and hard pan		0.75			
Mathewson 1987: 326	Experiment	0.13	Indurated clay	Digging stick	6.00			Average
Milner 2010: 109	Experiment	0.37	Compact silt to clay loam	Chert hoe	1.00	High	Great	Poor
	Experiment	0.37			1.00	High	Great	Poor
	Experiment	0.25			1.00	High	Great	Poor
	Experiment	0.15			4.05	Average	Average	Poor
	Experiment	0.20	Compact silt to clay loam + stones		0.42	High	Great	Poor
	Experiment	0.17			1.00	High	Great	Poor
	Experiment	0.11			1.78	Average	Average	Poor
	Experiment	0.19			0.68	Average	Average	Poor
Morgan 2018: 68	Experiment	0.16	Sand and pebbles	Digging stick	1.10		Great	Great
	Experiment	0.16	Sand, clayey sand, pebbles		1.45		Great	Great
	Experiment	0.21	Sand and hard pan		2.25		Great	Great
	Experiment	0.22	Clay, pebbles, roots		3.67		Great	Great
	Experiment	0.06	Clay and roots		0.32		Great	Great
	Experiment	0.17	Clay and roots		0.25		Great	Great
	Experiment	0.16	Clay and roots		0.37		Great	Great
Toussaint 2009: 63	Experiment	0.14	Silt	Antlers and wooden tools	0.50			Great
	Experiment	0.06			1.00			Great
	Experiment	0.11			1.00			Average
	Experiment	0.15			4.00			Top
	Experiment	0.13			4.00			Great
	Experiment	0.25			0.75			Average
	Experiment	0.10			3.00			Average
	Experiment	0.12			4.42			Top
	Experiment	0.07			4.42			Poor
	Experiment	0.10			3.50			Top
	Experiment	0.20			2.00			Great

Table 3. Labour rates with non-metal tools.

For our five different tasks mentioned above, I chose the following labour rates, taking into account the wet climate pointing towards starting from the lowest values of the ranges, and the influences of the other factors:

- removal of the previous fortifications: for an already loosened soil, the throwing of earth onto the slope and with experienced and supervised workers, I propose a labour rate of 0.35 m^3/h
- shallow quarters ditches: for an already loosened soil, throwing earth nearby, with moderately experienced workers, I propose a labour rate of 0.30 m^3/h
- loosening clay for mudbricks: for wet clay and loosening without throwing earth, I propose a labour rate of 0.40 m^3/h (however, some additional time has been considered for tempering the earth)
- digging the surrounding ditch: for a deep ditch to be dug in a stony soil, with experienced and supervised workers, I propose a labour rate of 0.10 m^3/h
- construction of the Hohmichele: for a silty soil with roots, with moderately experienced workers and filling baskets, I propose a labour rate of 0.25 m^3/h.

This method to choose labour rates may seem unscientific, empirical and subjective. The choice of a labour rate, however, cannot be based only on reading tables of labour constants or charts. What I present here is very similar to the method used by a modern cost estimator who never looks at a manual but has hundreds of values in mind, each one corresponding to a particular project. To choose a labour rate, this cost estimator (see Appendix) will make a subjective judgment which integrates all his available data. The advantage of the cost estimator over the archaeologist is that he takes many more values into account in much more known conditions. My suggested method for choosing labour rates is, therefore, a similar approach.

3.3.2. Example of carrying light loads

The method to choose a carrying labour rate is often poorly understood. While for all other tasks a labour rate is the capacity to work a certain amount of material, in volume or weight, the carrying labour rate is the capacity to carry a certain amount of material at a certain velocity. The labour rate, therefore, depends on two interconnected variables, expressed in m^3 × km/h (or kg × km/h). Similarly, a daily carrying capacity should be expressed in m^3 × km (or kg × km) (see Cotterell and Kamminga 1990: 194; Rankine 1865: 252). The two suitable methods to calculate a carrying time are to either take a carrying labour rate linked to the number of hours worked in m^3 × km/h or kg × km/h (which has never been done in the previous analysed studies), or to choose consistent loads and carrying velocities, a method which has often been used. A formula cannot be *a priori* rejected (see DeLaine 1997: 268 mentioning Pegoretti), provided the way it was obtained is known.

Let us first consider the transport method. We do not know how the workers were carrying their loads at the Heuneburg, whether they were carried on their shoulders, on their heads, or if they used the tumpline method[2] (the wheelbarrow had not yet been invented). However, the more efficient method consists of carrying on the head and using a relay method (see ILO 1963: 28–29; ECAFE 1957: 40) for a distance of around 30 m (30 m to 50 m according to ECAFE 1957). Taking this assumption into account, we have the double advantage of minimizing the carrying time and not to consider the carrying distance when choosing the labour rate.

If L is the lead and Vm the average velocity for the run, the time of the round-trip $t = 2L/Vm$. If q is the average load for each trip, the daily output for H worked hours is $Qd = H \times q \times Vm/2L$. This simplified formula is called the ECAFE formula since Aaberg and Bonsignore (1978) drew it from an ECAFE publication (ECAFE 1957: 22). The full formula considers the loading and unloading times as well as time for rest. These additional times are often included in experiment results. They can be neglected for distances higher than 200 m (less than 5% of the carrying time).

If Q is the total transported quantity and T the total transport time, the equivalent formula is:

- $Q = T \times q \times Vm/2L$.

Now, the previously defined labour rate is:

- $C = q \times Vm$.

Then,

- $Q = T \times C/2L$, or
- $T = Q \times 2L/C$.

In selecting the labour rate C and the carrying distance L it is possible to obtain the total time T. The discomfort or misunderstanding of the authors of several previous studies is manifested in many ways:

- The ECAFE formula, as described the first time by Aaberg and Bonsignore (1975: 46) is nearly always mistaken for an empirical formula gained through experience. This is due to an ambiguous wording from the authors also relayed by Abrams (1994: 160).
- The velocities indicated by Aaberg and Bonsignore, 3 km/h for loading and 5 km/h for unloading are not justified. The authors took three assumptions for the loads, 15 kg, 22 kg and 40 kg (Aaberg and Bonsignore 1975 55). It is obvious that the velocities should depend on the loads. That has not prevented more than 20 authors from choosing these velocities and one of these loads: most often 22 kg. However, Devolder (2013: 31), for instance, takes 40 kg and Clark (1998: 172) writes that the formula is applicable for any load, even if these authors' reasoning clearly shows that their load values are not related to their velocities. Authors most often independently choose loads and velocities, which is not logical.
- More than 20 authors have used labour rates obtained by Erasmus, who has carried out two experiments on carrying loads. In the first experiment, two workers carried earth with leads of 50 m and 100 m for a period of five hours. He obtained labour rates of respectively 83 kg × km/h and 93 kg × km/h (Erasmus 1965: 285). In the second experiment, four workers carried stones for distances of 250, 500, 750 and 1,000 m for the same period of five hours. He obtained labour rates of respectively 95 kg × km/h, 100 kg × km/h, 155 kg × km/h and 100 kg × km/h (Erasmus 1965: 287). If we analyse these results, it is clear that the workers employed by Erasmus had the capacity to carry loads with a labour rate in the range of 80 kg × km/h to 100 kg × km/h for

2 The tumpline method consists of using a strap which goes around the body, either across the forehead or the shoulders.

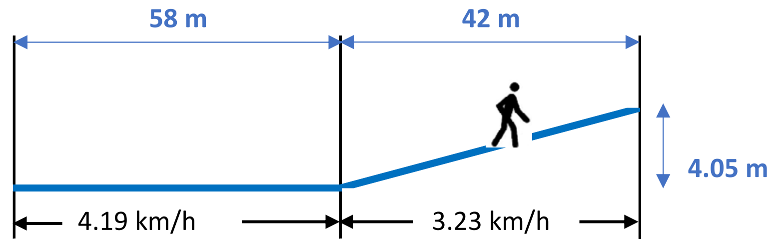

Figure 6. Average leads and velocities.

five hours except one worker who had a labour rate of 155 kg × km/h. This latter performance can only be explained by the fitness of this worker, and certainly not by the distance for which he had to carry the load. Many authors chose the labour rate corresponding to the distance they had to take into account or to the type of material (which is not important, only the load is important). Topic (1991: 160) looks for a labour rate corresponding to a distance of 750 m and he uses the labour rate obtained by Erasmus for 750 m (155 kg × km/h) which is abnormally high.

- Two books in which tables of labour rates are presented do not indicate labour rates for transport, but only the ECAFE formula (Devolder 2013: 43, 45-47; McCurdy and Abrams 2019: 7). DeLaine (1997: 107-108, 110-11, 268) indicates separately (like in Pegoretti: 1869) values of loads and velocities, which could then be independent from one another. Turner (2018: 200-201) argues about the trip back (which is not a problem) and renounces any attempt to analyse transport labour rates.

In my study, I consider the reference values for human transport included in the construction report ILO (1963) which offers a wide range of data. During a dam construction in India, eight civil engineers collected more than 45,000 measures. They observed 6,500 men, women, and teenagers carrying earth during a one-month period. The earth was carried on top of each porter's head and loads were transported using a relay method. These measures allow one to quantify the influence of the lengths of the leads and of the various slopes, up and down. Workers were mainly paid by the hour.

Let us take transport of earth to construct the Hohmichele as an example. Considering moderately experienced workers and a humid climate, I take into account a load of 20 kg, which is the maximum load which can be regularly lifted unaided, and an average velocity on flat ground of 4.2 km/h, 10% less (educated guess) than the experienced professional workers (ILO 1963: 147). I obtain a carrying labour rate on flat ground C_1 of 84 kg × km/h.

I calculate the carrying time considering that earth has been transported from the centre of gravity of the excavated earth to the centre of gravity of the mound (on this approximate method see Gillespie 1847: 124; Etienne and Masson 1850: 26; Korobeinikov 2005: 127). This method does not give the minimal time but certainly gives a safe realistic one, considering that some earth has been excavated far from the mound (Arnold 2010: 106). For the sloping section of the pathway, on the mound, I consider the average velocity for the corresponding slope drawn from ILO (1963: 157-158).

The volume of the Hohmichele is estimated at 30,000 m^3. It is composed of earth which has been excavated nearby. For a wet silty earth, I consider a density of 1,900 kg/m^3 and a swell coefficient of 20%. Therefore, an average load of 20 kg corresponds to a volume of 0.0125 m^3.

The sloping section corresponds to a slope of 10%. Velocities are 3.37 km/h loaded going up and 4.35 km/h empty going down. I reduce these velocities by 10% for non-professional workers and by 5% for a loose ground. This gives an average velocity of 3.23 km/h and a labour rate on a sloping pathway of 65 kg × km/h. Average leads and velocities are indicated in Figure 6.

Using the formula $T = Q \times 2L/C$, I obtain the following carrying times:

- $T_1 = Q \times 2L/C_1 = 30{,}000{,}000 \times 1.6 \times 2 \times 0.058/84 =$ 66,286 hours (flat ground)
- $T_2 = Q \times 2L/C_2 = 30{,}000{,}000 \times 1.6 \times 2 \times 0.042/65 =$ 62,430 hours (sloping ground)

The total time for the round trips is 128,716 hours. If the workers were working six hours a day (taking into account hours for rituals), it would correspond to 21,450 person-days.

4. Time spent at the Heuneburg between 600 and 540 BCE to build all the constructions

All the buildings and earthworks pointed out in Section 2.1 have been studied using the method as described above. The detailed analysis of these works (Remise forthcoming) includes 95 basic tasks of which 41 tasks are for the upper town, 25 tasks for the lower town, six tasks for the burial mounds and 23 tasks for the buildings (see Table 4). The raw materials and products considered are as follows: earth, stone, wood, mudbricks, mortar, plaster and chaff. When I assumed it was needed, some supervision (5% or

Number of Tasks Quantified	Design	Preparation	Timber removal	Earthdigging	Stone excavation	Transport by carts	Straw procurement	Production	Carrying	Tree felling	Delimbing	Squaring	Assembly	Shingle cutting	Installation	Compaction	Supervision	Number of tasks
Upper Town	1	1															1	**41**
Fortification removal			1	1		1												
Stone substrate					1	1		1							1			
Mudbrick wall				1			1	3							1			
Mortar / coating				1			1	1							1			
Parapet						2		3	1	1	1	1		1	5			
Miscellaneous															2			
Cleaning															1			
Maintenance															1			
Lower Town	1	1															1	**25**
Earth rampart				1					1						1	1		
Door (stone/mudbrick)				1	1	1		1	1						1			
Mortar/coating				1			1	1	1						1			
Ditch				1														
Bridge						1		1		1	1	1			1			
Burial mounds																	1	**6**
Hohmichele		1		1					1							1		
Other mounds															1			
Buildings																		**23**
Buildings		1				2			3	1	1	3	1		6			
Ditches				1														
Palisades								1			1	1			1			

Table 4. Number of tasks quantified.

		First Construction	Maintenance and reconstruction	Total
Community	Upper town fortification	100,000	120,000	310,000
	Lower town fortification	60,000	30,000	
Clans	Burial mounds	150,000		150,000
Families	Private buildings	40,000	100,000	140,000
Total (times in p-d)		**350,000**	**250,000**	**600,000**

Table 5. Time spent at the Heuneburg between 600 and 540 BCE to build construction and earthworks.

10%) has been included. The final rounded results are presented in Table 5.

As explained above, I have calculated these estimated labour costs looking for the most probable ones. Obviously, despite the care taken in choosing the most appropriate labour rates, many uncertainties remain about the actual work organisation and labour costs. However, I reckon that the estimated labour costs are lower than the actual ones due to costs I have not taken into account relating to, e.g., the tools' production and maintenance, delays of production, faults during production or installation, and food preparation for the workers. I also estimate that the labour costs obtained are rather consistent as the same method has been used to calculate them all. Therefore, looking at the proportions between the figures obtained, we can see that 75% of the total work has been done by groups of people larger than single families, *a priori* instructed by the ruling elite. This ruling elite was likely living in the outer settlement, the only part of the Heuneburg where large dwellings of this period have been found. Now, if we add the time to construct the outer settlement buildings to the time to build the fortifications and burial mounds, we see that 90% of the labour investment

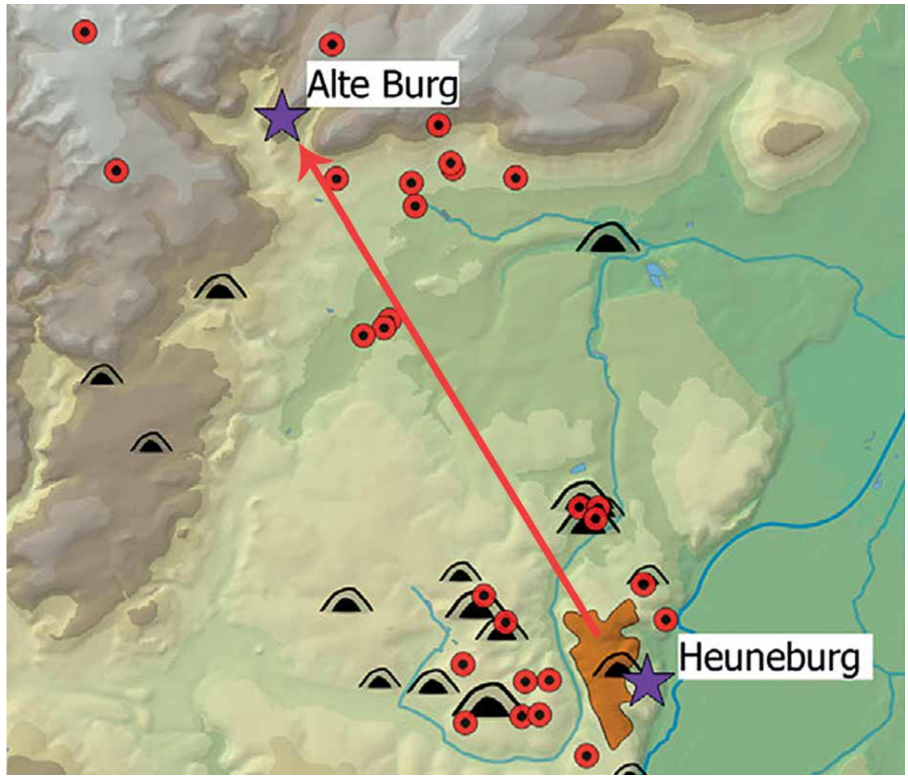

Figure 7. Alte Burg seen from the upper town.

was ordered by the aristocracy and for its satisfaction and was also meant to impress persons from the outside.

Around 540 BCE, a violent fire destroyed the impressive upper town fortification. The settlement was thoroughly restructured, and the outer settlement abandoned. Shortly after, large buildings were constructed in the upper town, one of them had a floor area of 400 m^2, and four monumental burial mounds were built close to the upper town, one of them exactly on the location of a large dwelling of the previous period. The explanation of this event is not clear, but as it has been suggested (Verger 2008: 534), it probably means that new clans took power, now inhabiting in the upper town, and constructed the family burial mounds close to their dwellings. Moreover, Alte Burg, a likely huge meeting place for the whole district, could be seen from the upper town along the same axis with the burial mounds.

The monumentality of the Heuneburg lies in the fortifications, burial mounds and large dwellings. The location from which it could be seen was transferred from the outer settlement to the upper town, from the previous living location of the aristocracy to the new one.

5. Appendix. How does a cost estimator choose the labour rates?

Having been a building company manager for 34 years, I provide below a brief *chaîne opératoire* of how cost estimators work in contemporary building contexts. Having worked with them and experienced their processes firsthand has provided me with very useful insights which inform the figures and thoughts of this paper.

5.1. Specification

The cost estimator estimates quantities of products taking into account the specifications and the drawings of the project. Let us assume that the cost estimator works on a large project and that products are standard (the uncertainty and subjectivity are more important for non-standard products).

5.2. Prices of products

The cost estimator has price lists from all the suppliers, but he negotiates a reduced price (that he will always obtain; prices are only 'references values' for small and medium quantities). He knows that if he gets the job he will then have a better price, but he cannot estimate the reduction he will obtain. Very often, he decides to quote another product, instead of the specified one, hoping he will succeed in convincing the customer to accept it.

5.3. Labour costs

The cost estimator has to assume whether the job will be carried out by company workers or if it will be subcontracted (he cannot be sure of the choice). The labour rates that he will choose depend on the products, the size of the job, the access to the building, the economic situation, the season, the planning, perhaps even the climate at the job location. In order to choose the labour rates, he evaluates all the linked factors and, taking into account all the values he has in mind, decides a value. He may also discuss this with other cost estimators or works supervisors.

Labour manuals still exist and somewhat resemble the 19th century labour manuals. In these manuals, you can today find prices or labour rates for all kinds of trades and products. In my 34 working years in building companies, I have never seen a cost estimator looking for a price or a labour rate in a labour manual: they have a far much better knowledge of these prices and labour rates and have in mind several hundreds more values than those we can find in these manuals. These manuals could be used to find prices or labour rates for a trade they are not familiar with, but a cost estimator will always prefer asking somebody who knows.

The cost estimator decides to take a certain percentage of losses and hazards. He is now able to estimate the final costs. Note that none of his decisions are based on certainties and on written 'tables'. Everything is subjective. Each company has its standards or reference values.

5.4. Selling price

The selling price is usually decided by a salesman (or a sales manager), deciding the gross margin to be applied, depending on the market, the customer, the competitors (if they are known), the order book, and the motivation to take the job. In order for the contractor to get the job, this selling price will certainly be decreased after negotiations with the customer. The selling price written on the contract is only the tip of the iceberg, because, first, there are non-written counterparts, second, there will be additional work and/or non-performed or partly performed work, and finally, there will be negotiations about delays and planning changes. The final price paid by the customer (only known to the customer and the building company) generally differs from the initial selling price.

If I had to give order of magnitude between initial and final figures, I would say that the differences are most often between:

- -30% and +100% for the selling price
- -20% and +100% for the final cost
- -200% and +50% for the gross margin (-200% means that you had foreseen a gross margin of 1,000 and had finally a gross margin of -2,000)

5.5. Differences between the processes of a modern cost estimator and a labour cost study

The modern cost estimator has a far better knowledge of all the information, but he does not know the final cost. This final cost is only known by the building company. The archaeologist who performs a labour cost study has many uncertainties about the labour rates but has often a better knowledge of what has been finally built.

6. Acknowledgements

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The agricultural hinterland of Aquincum and Brigetio, Hungary. Landscape, rural settlements, towns and their interactions

Bence Simon

1. Introduction

In archaeology, the concept of 'hinterland' was introduced probably thanks to British archaeology, in conjunction with the Boeotia Survey Project, which began in 1978 and focused on mapping the archaeological surface debris in the rural countryside of ancient cities (Bintliff et al. 2007). Although the notion of 'hinterland' has not been defined, hinterland studies have always concentrated on the interaction between the urban and rural spheres, and especially on the evolution of settlement patterns. In this sense, this paper is also a hinterland study, which examines two cities and the rural settlements in their hinterland.

Aquincum (Óbuda, Hungary) and *Brigetio* (Komárom-Szőny, Hungary) were two prominent cities in Pannonia, on the frontier of the Roman Empire (Figure 1). Both settlement complexes consisted of a legionary fortress with a military and a civil town, thus housing a heterogenous urban population in the 1-4th century CE. Although complex research into towns, legionary fortresses, and auxiliary camps goes back more than a century (*Brigetio*: Számadó 1997; Borhy 2014; *Aquincum*: Kuzsinszky 1934; Zsidi 2003), little was known about the interactions between the Pannonian *limes* and its agricultural hinterland. The aim of my doctoral dissertation (Simon 2019a) was, therefore, to collect previous research data and to study the hinterland of the *limes* in a novel, primarily landscape-regional approach. My research focuses on how the complex rural sphere was functioning, how it was affected by the economic system, the society and the physical natural environment, and what answers archaeology can give by analysing the location and scatter of the archaeological sites, and the find material, including the epigraphic monuments studied with GIS methods. The details of the previous results have been published in several articles in recent years (Simon 2015; 2016; 2017; 2019b). These show that *limes* hinterland under study was mostly populated by smallholders living in villages located along ideal paths crossing the heterogenous landscape, and whose neighbourhood was mostly suitable for crop cultivation. The purpose of this article is twofold: first, to outline the theoretical framework of the relationship between the rural countryside and cities and the army, focusing on the economic connections reflected in the archaeological record, and second, to provide new data on the impact of natural resource exploitation on the settlement system and its resilience.

Bence Simon
Institute of Archaeological Sciences
Eötvös Loránd University

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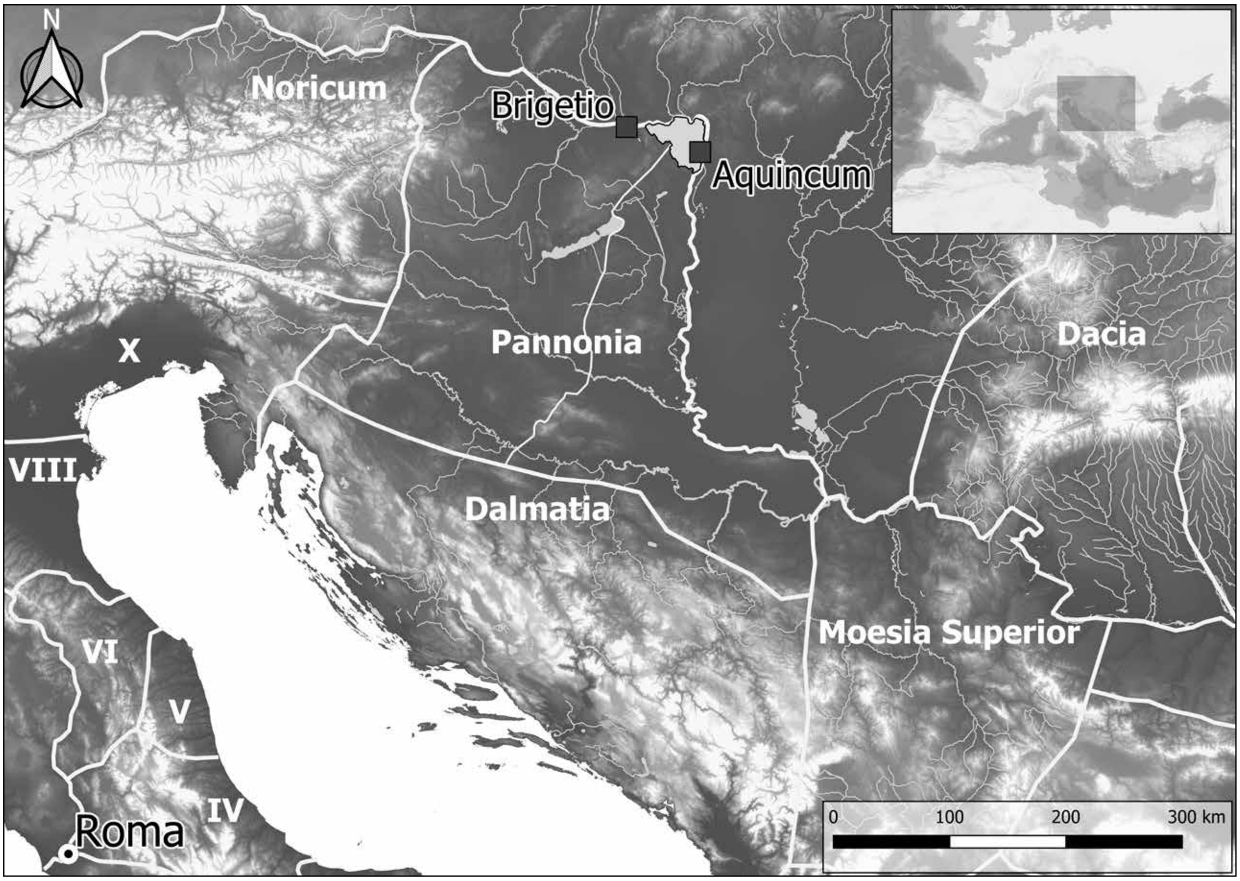

Figure 1. The location of the agricultural hinterland of Aquincum and Brigetio (author).

1.1. Frontier economy and food-supply

The description of the Roman frontier economy in the 1st-3rd centuries CE generally revolves around the relationship between the rural and the urban/military spheres and the question of transaction mechanisms. These themes also dominate the debate on the nature of the Roman economy as a whole. A detailed discussion of this is beyond the scope of this chapter, but a few issues need to be examined in order to present our view of the provincial economic system and its impact on the settlement history of the region.

The prospects of an economy are determined by the ecology of the individuals and communities, demography, laws and economic institutions, and technology as set out in the first part of the Cambridge Economic History of the Greco-Roman World (Scheidel et al. 2007). Laws and institutions were the most easily described of all the determinants before the huge increase in the archaeological study of regional landscapes. Especially the socio-political functions of the cities, which were essentially the backbone of the economic environment (Frier and Kehoe 2007: 113) in each province, were best studied. Moreover, cities were the foci of the different levels of the economy.

In the western provinces (e.g., Britannia, Germaniae, Pannoniae) cities were the creation of socio-political centralization, therefore, their economic functionality was always subordinated to their administrative and fiscal role (Bintliff 2002: 242). However, thanks to their central role, they also, with few exceptions, became economic centres (Bekker-Nielsen 2020). The city as an autonomous unit thus represented the local level of the frontier economy, which was controlled by the local administrative and fiscal authorities, i.e., the local elite (Parkins 2005: 81-108). They were responsible for making and introducing local, and implementing universal, imperial laws (Czajkowski and Eckhardt 2020; Eck 2020) and had the power to assess taxes, which were imposed on the municipality (Scheidel 2015: 178).

Three levels of economies can be distinguished that involve the Roman cities in the two Pannoniae: local, provincial, or regional, and imperial. The issue of market integration between local, i.e., urban, economies of the Roman Empire is part of recent opposing conceptual models and, although there is disagreement on its degree, there is agreement that cities played a key role in it (Bang 2008; Temin 2013). At a second, provincial level, the intermediaries between local markets were private entrepreneurs and traders (Evers 2011: 45), who relied on the social connections of local communities and institutions that disseminated commercial information (Temin 2013: 29-52; Brughmans and Poblome 2016). The highest level of the economy is the imperial economy (Evers 2011: 45), which refers to the flow of commodities through the borders of custom districts or provinces. The recipients of the shipments – olive oil, wine, fish sauce, etc. in *amphorae* – were first and foremost the members of the military (Remesal Rodríguez 2002), but in case of various types of tableware (e.g., *terra sigillata*), urban residents and, mainly through the city market, the rural population also had access to imported goods (van Oyen 2015).

In light of the above, cities were nodes in the Roman frontier economy, channelling commodities towards the rural settlements and providing services to them in return for agricultural goods (Erdkamp 2001; Bintliff 2002: 215-216). How the cities and the military, the two net consumers of the frontier economy, obtained the necessary provisions is still not entirely clear, but it is certain that redistributive and market transactions were simultaneously active (Evers 2011), and relied heavily on local resources (Erdkamp 2005).

This was also true for peacetime military supply, which did not necessarily require long-distance corn supply (contra: Whittaker 2004). As recent landscape archaeological studies have shown (Kooistra et al. 2013; van Dinter et al. 2014), the food demand of the military could be partially met even in extreme conditions. Therefore, there is no reason to doubt that provinces with better natural conditions, such as the two Pannoniae, were able to feed the cities and the military from local sources (cf. Cod. Theod. 8,4,6). Nor do the epigraphic sources attest to any centralized military corn-supply; only the logistics of war seem to have been orchestrated from Rome (Bérard 1984; Roth 1999). Moreover, military communities and the settlements beside the auxiliary fortifications did not normally function as local or regional markets; rather necessities were procured through redistributive mechanisms or civilian market centres, i.e., towns (Weaverdyck 2016; 2019). This also confirms the economic importance of towns in the local and regional frontier economy.

2. The framework of political and economic connections along the limes

The agricultural hinterland of the *limes* in Pannonia, which is under investigation (cf. Simon 2017: 261), is a diverse landscape, which was inhabited by two Celtic tribes, the *Eravisci* and *Azali*, before the Roman military occupation which took place in the first half of the 1st century CE. A large part of this indigenous population lived into the Roman period, and thus shaped many aspects of provincial life in the first two centuries CE. Their influence can also be observed in case of the rural settlements, the subject of my paper. In addition to the less significant Roman-style villas, the common rural settlement type of the 1st-3rd centuries CE was the Roman civilian village, the *vicus* (Bíró 2017). *Vici* in Pannonia were generally not as extensive and Romanized as in the western provinces, as they were loosely structured, unplanned settlements with mostly semi-subterranean pit-houses and only a few Roman-style buildings.

After the Roman military occupation and the political establishment of the province, enormous economic pressure was put on the local indigenous population. Since the Emperor was the sole proprietor of land in the western provinces (cf. Gaius *inst.* 2,7; Castillo Pascual 2011: 70-75), communal property became private possessions (*possessio*), and a land-tax was imposed on them to cover the expenses of the state (Wolters 2007: 413-418), the beneficiaries of which were mainly the provincial military. Around the turn of the 1st-2nd century CE, land tax in Pannonia was expressed in money according to the assessed value of the land (Hyg. *lim. grom.* 205 L) and, as the case of other militarized provinces testify, it was also collected in money (Duncan-Jones 1990: 44; France 2001: 372-373; Evers 2011). This does not necessarily mean that the rural sector was heavily monetized, but this mode of collection certainly encouraged greater interaction with the military and the cities, who had money at their disposal.

In addition to paying the economically stimulating taxes, the rural population had to produce a surplus to supply the military locally. This was probably not an easy task, as the nominal strength of the military steadily increased on the studied *limes* section from 41 CE to the end of 2nd century CE (Figure 2). The number of men significantly upsurged when the legions arrived in 89 CE consisting mainly of infantry, but also more and more horses were kept in the military units reaching a peak around 119 CE. Although the nominal strength of the forces did not necessarily correspond to reality (e.g., Evers 2011: 26), the increase in nominal numbers was accompanied by a trend in increased demand for wheat (Figure 3). Interestingly, it only decreased after suspected economic tensions, such as the arrival of the legions (89 CE) and the devastating Marcomannic Wars (168-180 CE).

The rural landscape, which was the source of taxes and the food-supply, was always part of an autonomous, self-governing *territorium*. Until the time of Hadrian, the northern region of the research area was governed by the *civitas Azaliorum*, the southern by the *civitas Eraviscorum*. From the reign of Hadrian (117-138 CE) onwards, two towns inherited these *territoria* (Kovács 2013). Both territories were presided over by the descendants of a native local Romanized elite, who constituted the members of the city council (Mócsy 1959: 70-71). Thus, they played an important role in the organization of the rural sphere and

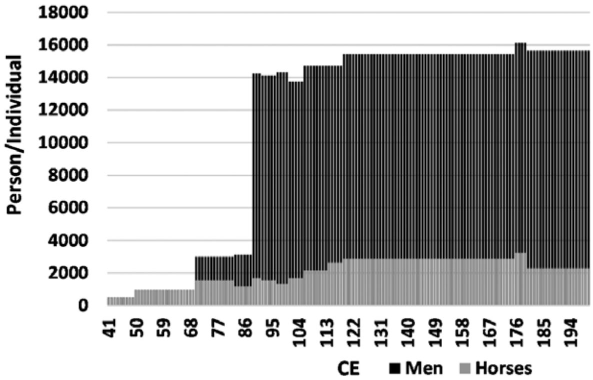

Figure 2. Nominal strength of the stationed military along the limes section between Brigetio and Campona (41-200 CE). The reconstruction of troop history and nominal strength based on Lőrincz 2001.

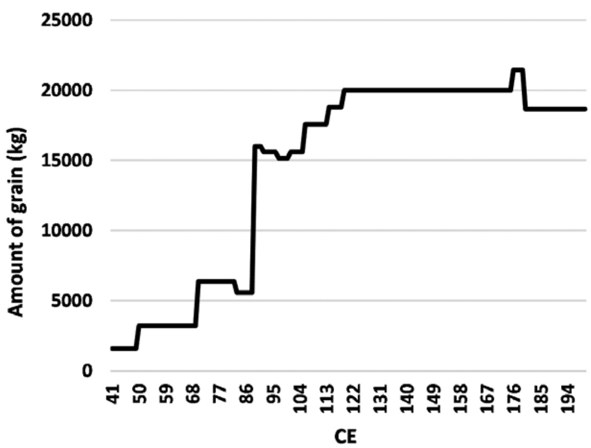

Figure 3. Wheat demand of the stationed military along the limes section between Brigetio and Campona (41-200 CE). The reconstruction of troop history, nominal strength and wheat demand were based on Erdkamp 1998: 28; Roth 1999: 61-67; Lőrincz 2001.

integration of local settlements into the Empire in order to meet state and military needs.

In the research area wagon- and horse-burials also attest to the presence of these prestigious Romanized indigenous families in the rural landscape (Mráv 2013a; 2016; Figure 4). In some cases, these graves contained archaeological material, which proves that some of the family members had served in the military and probably subsequently obtained citizenship. Auxiliary soldiers and veterans are also attested by *militaria* finds (official documents, i.e., *diplomata*, horse-gear etc.) and weapon graves, especially in the northeastern part of Pannonia (Mráv 2013b: 88-91). This evidence suggests that rural settlements were led by two, sometimes intertwined social groups, the Romanized local elite, and soldiers.

However, epigraphic and archaeological material suggest that these groups maintained tighter ties with different regions within the territory of *Aquincum* (Óbuda, Hungary). Based on the find-sites of the votive altars and gravestones of wealthier military individuals ranked above the *immunes* (minor position held by soldiers in the legion: Dig. 50.6.7), the military was more closely linked to the northwestern area of the territory of *Aquincum*, which was crossed by the important *via publica*, the Diagonal Road (Figure 4; On the numbered monuments see: Simon 2019a: Függelék B = Appendix B, EKat ID). In contrast, the 1st-2nd centuries CE elite burials and the 3rd century CE epigraphic material of the urban upper-class are located in the southeastern and southern region. This can be explained by the possibility that the powerful families, who were mostly descendants of native Celts, uninterruptedly possessed lands from the beginning of the Roman age to the end of the 2nd century CE in this area and gradually gained economic and political leadership in *Aquincum*.

Apart from the immediate territory of the military fortifications, only the *legio II Adiutrix* had a closer connection with the rural landscape, as it was almost the only unit which was mentioned on stone monuments further away from the Danube (Simon 2019a: fig. 12). This could be explained by wealth, higher literacy, or the number of soldiers, but the fact, that inscribed monuments were found in great numbers (cf. Barkóczi and Soproni 1981: 210-273, N. 864-932) next to the auxiliary camps, only makes this doubtful in the latter case.

One of the best indicators of regional economic transactions is the Pannonian stamped grey pottery, which was scattered throughout the whole rural landscape and was also carried beyond the Roman frontiers. Although its production is closely connected to the cities with a legionary presence, such as *Aquincum* (most recently Nagy 2017) and *Brigetio* (Delbó 2019: 124-137), the development of the type cannot be attributed solely to military influence. Unlike the 'legionary pottery' (Vámos 2012), Pannonian stamped ware was a genuine mass-produced good, present in the find material of military garrisons, as well as urban and rural civilian settlements. Moreover, its distribution was independent of the legions, since one of the biggest deposits of the Eastern Pannonian stamped pottery was *Gorsium*, a major civilian settlement south of *Aquincum* (Nagy 2017). Therefore, it seems reasonable to conclude that there is currently no evidence to support the idea that the military maintained a stable and archaeologically visible economic relationship with the rural sphere.

Therefore, it seems reasonable to conclude, and also the scatter of epigraphic material and regional pottery supports it, that just as along the *limes* of

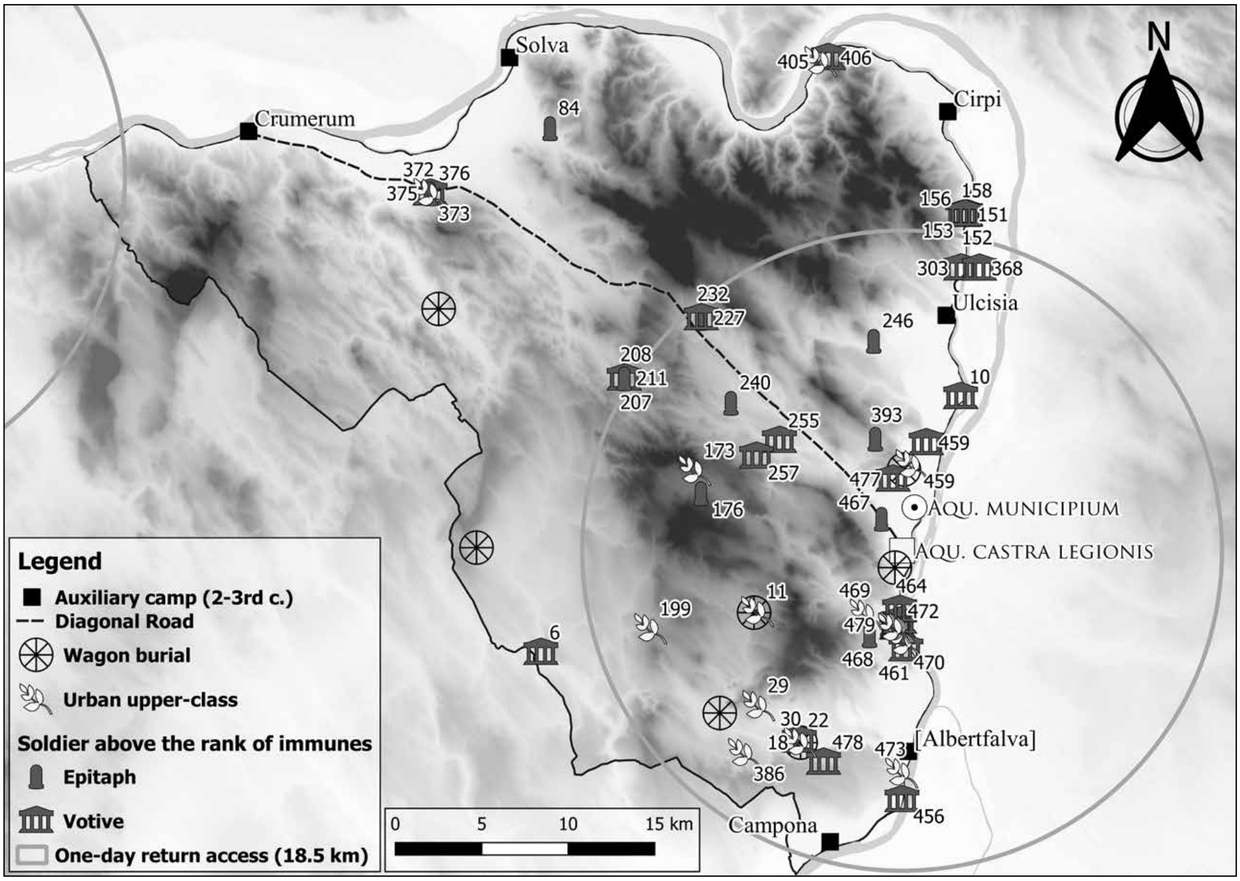

Figure 4. The spread of wagon burials and inscribed stone monuments in the hinterland of the limes section (author).

Moesia and *Germania Inferior* (Weaverdyck 2016; 2019), the military forts and their associated civilian settlements in the hinterland of *Aquincum* and *Brigetio* (Komárom-Szőny, Hungary) probably did not function as regional markets for the rural countryside and did not have a visible, far-flung direct social network after the early 2nd century AD. This assumption may change in the future, if the number of micro-regional studies focusing on the mapping of military equipment increases.

Although a direct economic connection with the military forts is doubtful, the interaction between cities and rural settlements can be best illustrated by the poem *Moretum*, recently interpreted by Crawford (2017). The main character of the poem is a landowner with two steers, who sells his agricultural produce, mainly fresh vegetables, in town every week, from where he returns with heavy (copper) money. The source also reveals that he rarely buys the goods (*merx*) of the *macellum*. It is not known exactly what the author meant by *merx*, but it may have referred to some commodity that he could only find in the urban market, e.g., *terra sigillata* or Pannonian stamped vessels.

3. Marketing, cultivation and rural settlement patterns

In the past years I have developed and published a topographic mapping method to determine the location of the Roman villages in the hinterland of the Pannonian *limes* (Simon 2015; 2017). The primary basis for this definition was the regional and imported pottery from the archaeological sites, as well as traces of Roman-style buildings. This approach is rooted in the afore-mentioned assumption that villages, that functioned as rural centres, were to some extent integrated (on Roman rural integration see: de Haas and Tol 2017) into the regional and interprovincial market through cities (cf. van Oyen 2015). The stronger the social and economic ties with the cities, the more likely they had extensive marketing networks and Roman-style buildings.

As recently pointed out by Witcher (2017), the degree of integration was influenced by the social connectedness of rural settlements, as described above, and by the distance from regional marketing centres (e.g., *Aquincum* and *Brigetio*) and from major roads. Witcher's approach to the rural countryside is not unfamiliar to scholars investigating the role of space-time costs, i.e., the time and energy consuming activity of moving in the physical world (cf. Bekker-Nielsen 2020: 82-83), in the development of settlement networks and ancient markets. The link between marketing and the development of settlement network was first studied by economic geographers, whose ideas also shaped ancient historians' view of the rural landscape. After the model of 'The isolated State' of J. Heinrich von Thünen and the consumer city of M. Weber, Christaller (1933) formulated the Central Place Theory in the first half of the 20th century (cf. Bekker-Nielsen 2020). Central Place Theory is based on exploring how the goal for maximizing profit with least effort is linked to the spatial dimensions of the economy, the settlement hierarchy, and the structure of settlement patterns (Knitter and Nakoinz 2018: 2-3; Vionis and Papantoniou 2019: 4). Christaller distinguished three different drivers behind settlement hierarchies based on their spatial distribution: the market principle, the transportation and administration principle (Bekker-Nielsen 2020: 85-86).

The novelty of Christaller's view was that he interpreted the relationship between cities and the countryside as a mutual co-dependency, in which both are producers and consumers at the same time. More importantly, the central idea of his model was that there is a difference between the value and the spatial distribution of the assets: certain goods and services are centred in the cities, while agricultural products are dispersed in the countryside. The value of these assets is based on the spacio-temporal cost of accessing them – for example an urban market and its luxury goods will be more attractive to visitors from a greater distance than a weekly market in a village. This difference creates a hierarchy of settlements, in which a strong tendency for regularity of spacing will emerge between settlements on the same levels (cf. Bintliff 2002: 215-216).

Christaller (1933) also suggested that the different patterns into which these central places clustered, would attest to the ordering law behind the urban locations. On this basis he distinguished between the marketing principle (*Versorgungsprinzip*), the transport principle (*Verkehrsprinzip*) and the administrative principle (*Absonderungsprinzip*). The different patterns predicted by the Central Place Theory have been confirmed in practice by many economic historians, as well as the regularity of historical urban systems. Bintliff (2002) in his fundamental paper on ancient marketing summarized these studies and stressed that urban systems structured along the marketing principle have a certain reoccurring distancing. According to this view, the peasantry had a limited access radius within which they could reach a regional market-town to sell their agricultural products, which also limited the hinterland of a town for direct exploitation. In such urban systems, regional towns are located about a day's walk (c. 30-40 km) from each other, with minor centres evenly surrounding them. This network serves the basic needs of urban dwellers through small-scale trade, orchestrated through minor centres around the regional centre (Bintliff 2002: 229).

Before the Roman conquest, however, settlement nuclei in regions such as Pannonia were far less developed than in the Central and Eastern Mediterranean. In these provinces, the tribal centres and their territories were preserved and legally elevated to urban status (Kovács 2013), which was a socio-political process, rather than a product of economic forces. Therefore, it is not surprising, that the city of *Aquincum* had an enormous territory under its control, which extended as far as the Lake Balaton, c. 100 km away (Figure 5; based on: Mócsy 1959: 59). Such an extensive area could only be exploited indirectly by centrally imposed taxes, not by market transactions. But even in such sparse urban networks, in prosperous economic and demographic conditions, new regional, secondary centres could emerge to 'fill the gaps' in the rural landscape (Bintliff 2002: 240). It was probably this 'economic vacuum' which allowed the uninterrupted development of *Gorsium* to be one of the most important settlements in Pannonia, without a known legal status (Alföldy 1997; Fishwick 2000; Bíró 2017: 299, 303-304).

In his monograph, Bekker-Nielsen (1989: 66) studied the spatial network of Roman cities and identified five different urban systems, which he distinguished on the basis of their theoretical hinterland. Since there was insufficient information regarding the actual boundaries of the cities, Bekker-Nielsen used Thiessen polygons or Voronoi diagrams to delineate their territories (Bekker-Nielsen 1989: 11; for methods currently in use see: Ducke and Kroefges 2008). This method is based on the law of minimum effort, resulting in a demarcation line equidistant from both centres. The Pannonian urban system under study, thus can be classified as Bekker-Nielsen's type 'C', which has an average distance between cities of around 50-75 km, with a theoretical hinterland of 25-37.5 km in radius. Despite the long distances between such central places, in Pannonia one-day return access still influenced marketing and economic connections around regional towns. As mentioned above, the directly exploitable hinterland extended up to around 20 km radius from the city. This seems to be confirmed by the epigraphic material, which is concentrated within this range in the studied area of *Aquincum* (Figure 4), and the same kind of rule seems to hold for other Pannonian towns as well (Tóth 2006: 100-105). The case of *Aquincum* suggests, that the elite, literate and wealthy enough to erect these stone monuments, maintained closer social and economic connections with the rural countryside, which could meet the city's daily needs.

Outside this immediate hinterland, and even within it, the rural landscape was packed with Roman settlements,

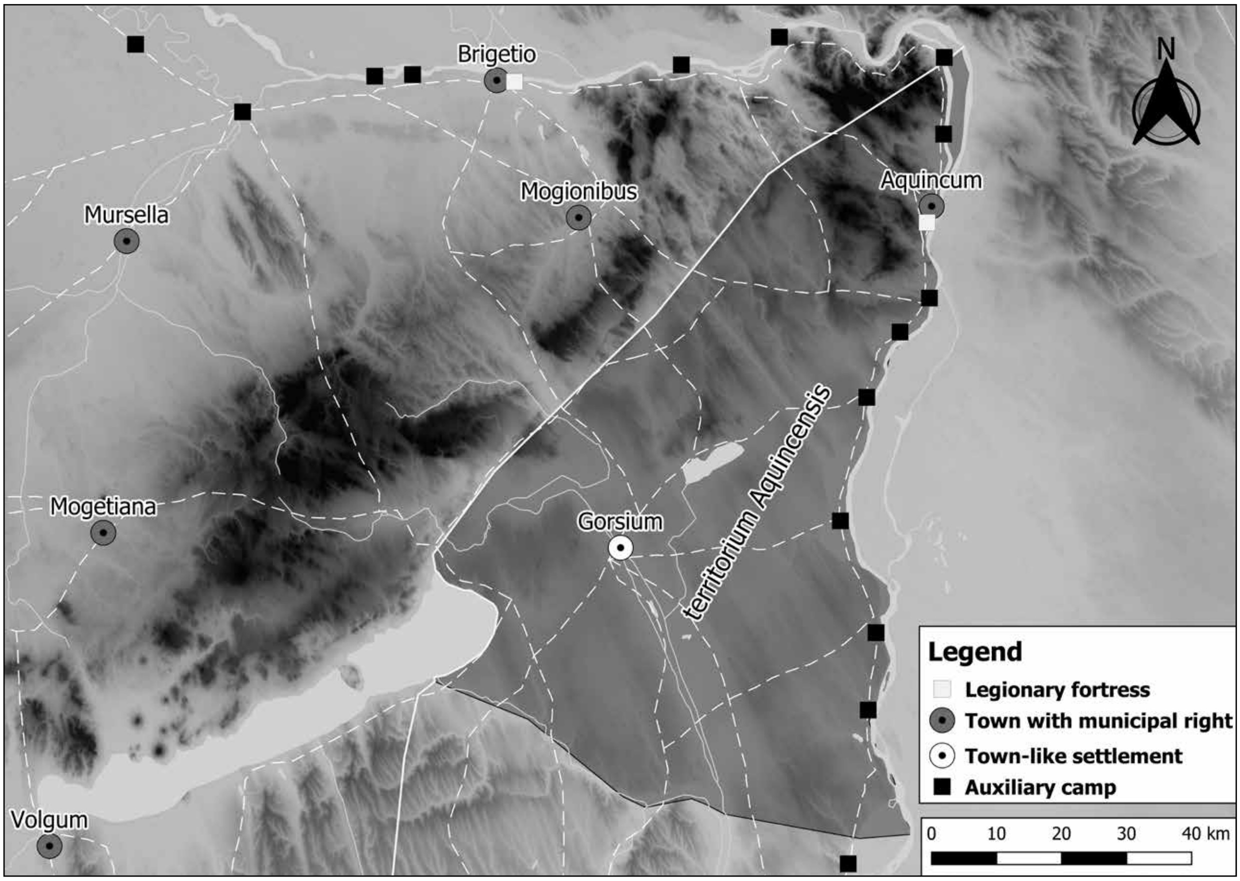

Figure 5. The administrative territory of Aquincum and the location of Gorsium (author).

of which villages functioned as lowest or second lowest rank centres (cf. Bekker-Nielsen 1989, table 2.1), forming the economic backbone of the countryside (Figure 6). Despite their structure, the lately identified 58 villages of the studied hinterland (Simon 2017, on the settlement sites see: Simon 2019a, Függelék A = Appendix A), were probably socially and economically independent entities, which had access to regional and imported commodities through the economic or social mechanisms described above. The observed Euclidean average distance between the nearest neighbouring villages was around 3.2 km (Simon 2019b: 215) and they arranged into a regular settlement pattern that incorporated the city and the legionary fortress of *Aquincum*, as well as the military camps along the Danube. The latter can be explained by the claims of the Central Place Theory, which stresses the strong tendency for regularity of spacing (as cited above), but the former also needs to be explained.

As movement in the landscape consumed energy, this not only affected the accessibility of cities, but also the daily life of the farming population (Simon 2019b: 207-208). In permanently settled societies, the distance between the cultivated land and the dwellings was limited by the rationality of the smallholders. The rural countryside and the villages were mostly populated by such inhabitants, who had fewer economic opportunities than wealthier landowners, leading mainly to labour-intensive agricultural production. According to Chisholm's (1979) ethnographic study smallholders were able to profitably farm plots that were 1-2 km from their place of residence, with a maximum distance of 3-4 km, where the labour cost sufficiently and harmfully exceeded the return (Chisholm 1979: 54-59, 73). Numerous archaeological examples demonstrate that access to land significantly influenced the development of rural settlement patterns and their territorial boundaries (Simon 2019b; more generally see: Bintliff 2002).

Again, along with many other scholars, Bintliff (1994) has argued that in the earliest stages of rural occupation, numerous nucleated settlements develop to control and directly exploit cells of 2-3 km radius. His examples of Classical Greece are comparable to the results of ethnographers, and it is also not a coincidence that the same regular settlement pattern was observed in the hinterland of *Aquincum* and *Brigetio*. Moreover,

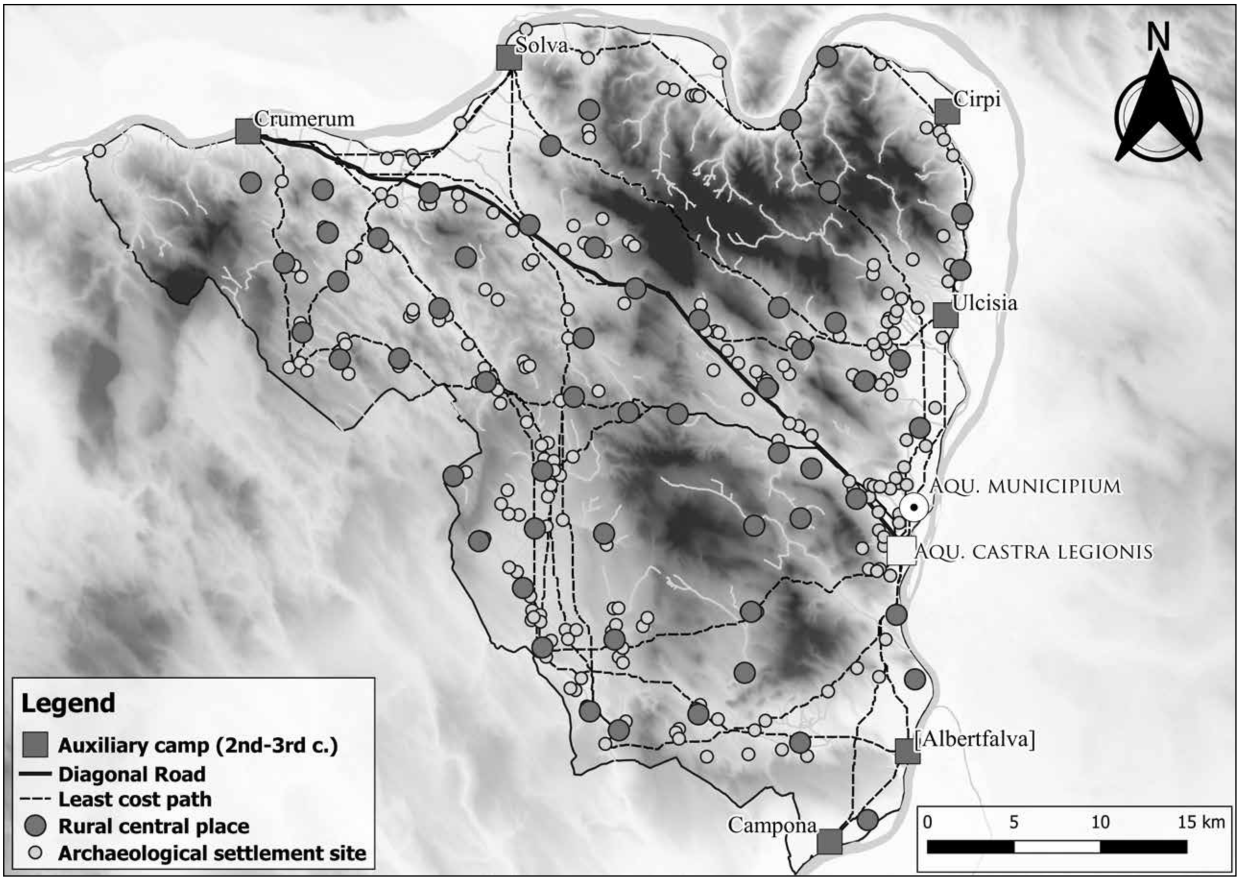

Figure 6. Distribution map of rural central places, settlement sites with least cost paths and the Diagonal Road (author).

as the number of regional landscape studies of Roman Pannonia increases, similar results can be expected for other areas of the province. More recently, Doneus and colleagues (2018: 163-171) have recognized that in the northwestern part of *Pannonia Superior* rural settlements dominated the landscape in a regular manner, controlling areas of 1.5-2 km in radius. Although the distance between the settlements there was slightly less than in the hinterland of the studied *limes*, the same pattern prevailed. The regular village pattern was not specific to the Roman period, as it was also characteristic of Medieval Ages (Simon 2019b), suggesting that travel constraints may have generated a similar universal pattern in all historical periods until the industrial revolution.

The *limes* hinterland of *Aquincum* and *Brigetio* was populated by villages in the manner described above, but the direction of this was determined by the physical landscape. Earlier on, I have attempted to identify the other possible axes of transportation and communication in other areas of the studied Roman countryside by developing a least cost path (LCP) model that closely resembles the only, archaeologically, documented Diagonal Road (cf. Figure 6; Simon 2015). These models are based on cost surfaces calculated from digital elevation models to determine the path that requires the least energy to travel between two points (Conolly and Lake 2006: 252-256). In my study the cost surface was a reclassified slope map derived from a 10x10 m resolution digital elevation model (DEM), which was prepared for my PhD thesis in two steps: 1) by digitizing the main contour lines of the Hungarian national topographic maps and 2) by using the interpolation algorithm of a GIS software (Simon 2019a: 151). Once the least cost routes have been calculated from the cost surface, I concluded that the identified villages were more or less aligned to the least cost paths that followed or ran perpendicular to river valleys. Since these were generated from the slope map of the research area, it must be concluded that the physical topography of the region played a key role in determining the Roman-era routes and hence the evolution of the rural settlement patterns.

4. Access to resources, roads, and urban markets – a key for resilience

4.1. Land evaluation model

In the above-quoted studies of Classical Greece and *Pannonia Superior*, the apparently unoccupied areas raised the question of whether they were the result of a bias in the archaeological record or of historical reality. In a number of studies that have managed to escape the pitfalls of natural determinism, predictive modelling proved to be a useful tool for assessing such problems (Verhagen and Whitley 2020). As data-driven archaeological predictive modelling mostly revolve around the issue of identifying the most attractive landscape or cultural environmental features for settlement or land-use, results represent the most suitable locations for such an exploitation (e.g., Goodchild 2007: 121-176; Jeneson 2013: 160-222; Weaverdyck 2016: 130-161; Casarotto 2017). In contrast, theory-driven predictive modelling examines how archaeological site locations fit into the distribution of various landscape characteristics or socio-cultural factors that have been predicted based on general human behaviour (e.g., Goodchild 2007: 180-328; Farinetti 2009; Casarotto 2018: 43-67).

Although my theory-based approach is presented above, and results of location analyses examining settlement preferences for different physical landscape features – elevation, slope, soil, aspect, direct sunlight duration and slope position – have also been published (Simon 2017; 2019a), their synthesis and their role in assessing settlement resilience is the subject of the present paper. The knowledge gained was considered suitable for the creation of a land evaluation model that not only addresses the problem of unoccupied areas, but also provides a useful tool for assessing the prospects of identified villages and their resilience to political and economic crises.

Archaeological land evaluation (Kamermans 1993) has been successfully applied to the rural landscapes of the Roman Tiber Valley and Classical Boeotia (Goodchild 2007; Farinetti 2009), as the authors avoided the direct application of the archaeological sites' location data. Verhagen and Whitley (2020), citing D. Wheatley, have stressed that such a practice can lead to circular reasoning, however. Since my previously published location analyses focused not only on the archaeological sites themselves, but also on the 1.5 km radius of the villages, their ideal agricultural hinterland, they were directly applicable (on the methods and database see: Simon 2017: 261-264). The advantage of this, in my opinion, was that the assessment of the ancient land-use was sufficiently independent of the interfering noise of modern agriculture, therefore the Roman landscape perception could be effectively reconstructed.

The evaluation was based on the results of statistical analyses performed on the above-cited physical landscape features. As there are minor differences between the results which were published in Simon (2017) and my PhD dissertation (Simon 2019a), these will be briefly presented. The main difference is that the number of places involved in the analyses has increased to 217 in the dissertation. Furthermore, the zonal distribution of soil categories has changed, as the spatial distribution of soil types has been extrapolated to currently habited areas (Simon 2019a: 130-132). The flat areas were missing from the dissertation, as the aspect map was derived from a new, self-made 10x10 resolution digital elevation model (DEM), as mentioned above. In my dissertation the statistical results only changed for the slope gradient, as the areas between 25-60% were avoided (Simon 2019a: 193).

In addition, the preference for slope position was only examined in my dissertation (Simon 2019a: 190-191). This landscape feature expresses where a certain slope is located within the local topography, whether it is a valley, a flat, a lower, a middle, or upper slope, or a ridge. This map was produced in two steps: 1) by calculating a topographic position index (TPI) for all cells of the mentioned DEM and 2) by thresholding the TPI values of the cells. The method is the same as the one developed by Weiss (2001), which calculates the topographic position index (TPI) for each cell, expressing the deviation of elevation from the mean of the neighbourhood under study. In this case, the neighbourhood of each cell was investigated within a radius of 70 m, which was visually and statistically the best choice for generating the slope position map (Figure 7; Simon 2019a: 191). The map reflects local topographic conditions, which can be used for landscape archaeological purposes, but it is no longer suitable for defining large geographical regions. The analysis on slope position showed that valleys, lower and flat slopes were preferred, middle and upper slopes were neutral, while ridges were avoided.

The essentially deductive evaluation model was thus constructed by grouping the categories of the different landscape features – elevation, slope, soil, aspect, direct sunlight duration, and slope position – into three classes, ideal, suitable and unsuitable (Table 1-2; Soil types were grouped according to the DKSIS database: Pásztor et al. 2012). These classes were defined using the results of previous inductive analysis published in an article and in my dissertation (Simon 2017; 2019a) reflecting a statistically confirmed preference for them. In the publications when a certain landscape feature was preferable, it was marked green, when it was avoided, it was marked red, while neutral was not marked at all. According to previous results, for example, the elevation map was reclassified into

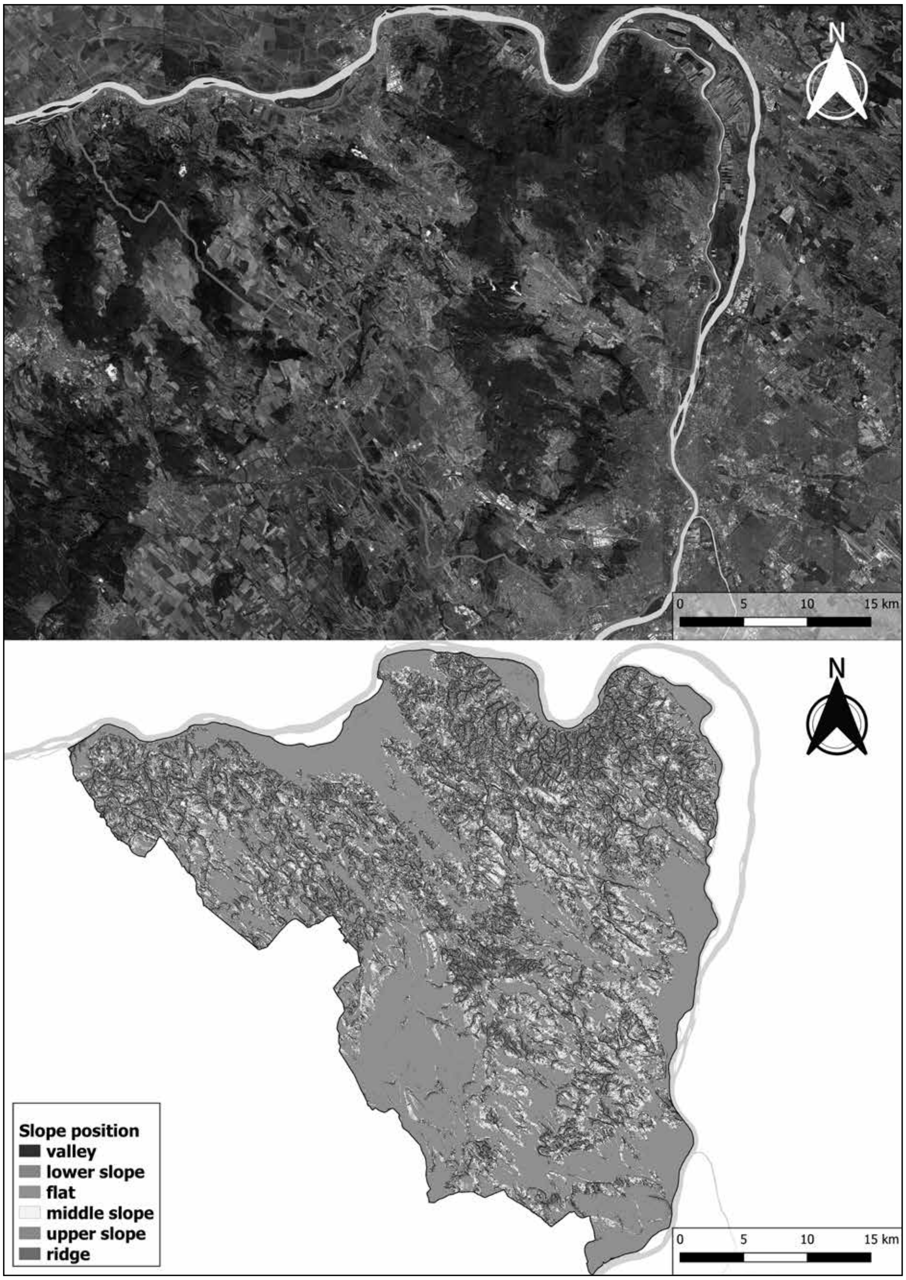

Figure 7. Above: The research area on Google Earth satellite imagery (map data ©2021 Google). Below: Slope position map of the research area (author). Imagery ©2022 Maxar Technologies, CNES / Airbus, Google, Maxar Technologies, Imagery ©2022 TerraMetrics, Map data ©2022.

three categories, corresponding to certain values. A preferable (ideal) area between 0 to 250 m was assigned a value of 1, a neutral (suitable) area between 250 and 300 m was assigned a value of 2, and an avoidable (unsuitable) area above 300 m was assigned a value of 3 (cf. Simon 2017: 275, tab.13; 2019a: 192, tab. 21). In case of aspect, the northeast, east and southeast directions were considered 'ideal', the north, and south directions 'suitable', and the southwest, west, northwest directions 'unsuitable', which is supported by the need for protection against the prevailing northwesterly winds in the area and the results of the statistical analysis (cf. Simon 2017: 276, tab. 16; 2019a: 192-193, tab. 24). After reclassifying the six landscape feature maps, the raster values were combined into a single map. Finally, the derived raster values of the map were classified into five categories: ideal, ideal-suitable, suitable, suitable-unsuitable, unsuitable, using the Jenks natural breaks optimization method (Conolly and Lake 2006: 142). Thus, based on the results of the previous analyses (Figure 8), the values of the archaeological land evaluation map between ideal and unsuitable express how a certain area might have been perceived by the rural population in the Roman period.

Table 1. Classification of soil types, used in the archaeological land evaluation model.

Ideal	Neutral or slightly alkaline consistent sand
	Neutral or slightly alkaline clayey and silty soils
	Acidic soils with poor water conductivity, more consistent than loam
Suitable	Acidic, more consistent sand
	Neutral or slightly alkaline loose sand
	Acidic, highly consistent soil
Unsuitable	Root development inhibiting level near the surface
	Soils with shallow topsoils, the subsoil of which is unsuitable for crop production
	Periodically waterlogged, waterlogged areas
	Lakes, reeds and rivers
No data	Forests

Table 2. Classification of landscape features, used in the archaeological land evaluation model.

	Ideal (1)	**Suitable (2)**	**Unsuitable (3)**
Elevation	0-250 m asl.	250-300 m asl.	> 300 m asl.
Slope	0-12 %	17-25 %	> 25 %
Aspect	from N to SE	N and S	from SW to NW
Direct sunlight duration	> 13 h	12-13 h	< 12 h
Slope position	valley, lower slope, flat slope	middle slope, upper slope	ridge

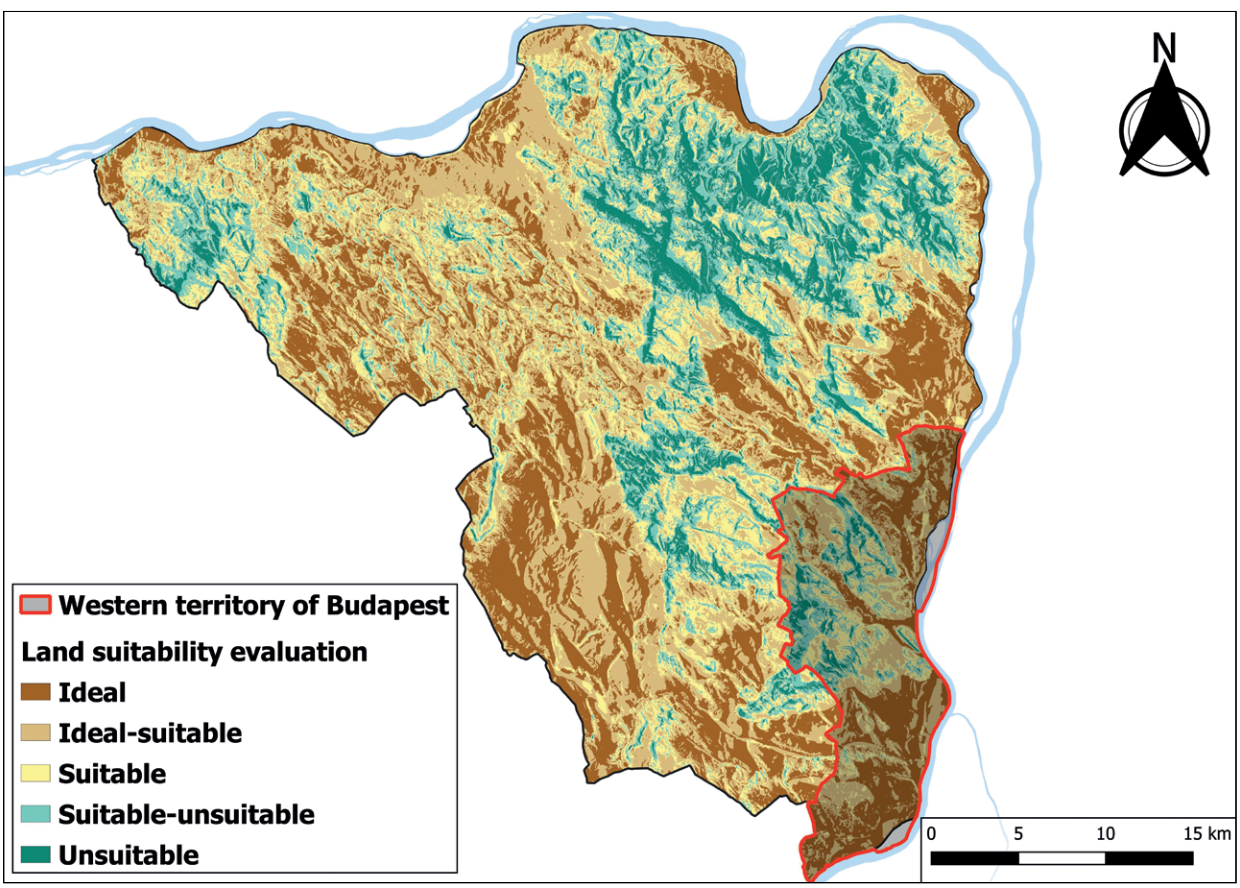

Figure 8. Visual result of the deductive archaeological land evaluation model (author).

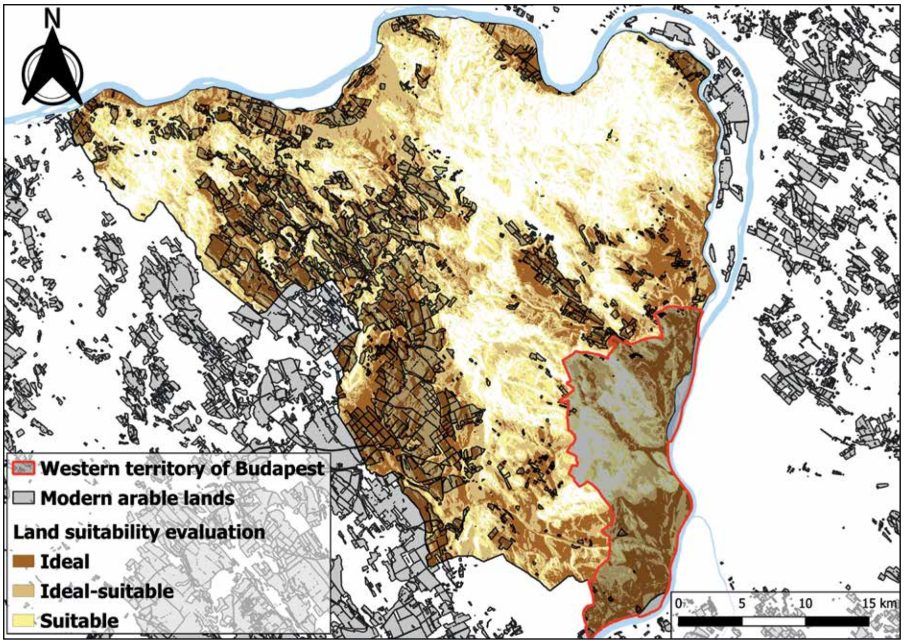

Figure 9. Correlation between the land evaluation model and the location of modern arable lands (author).

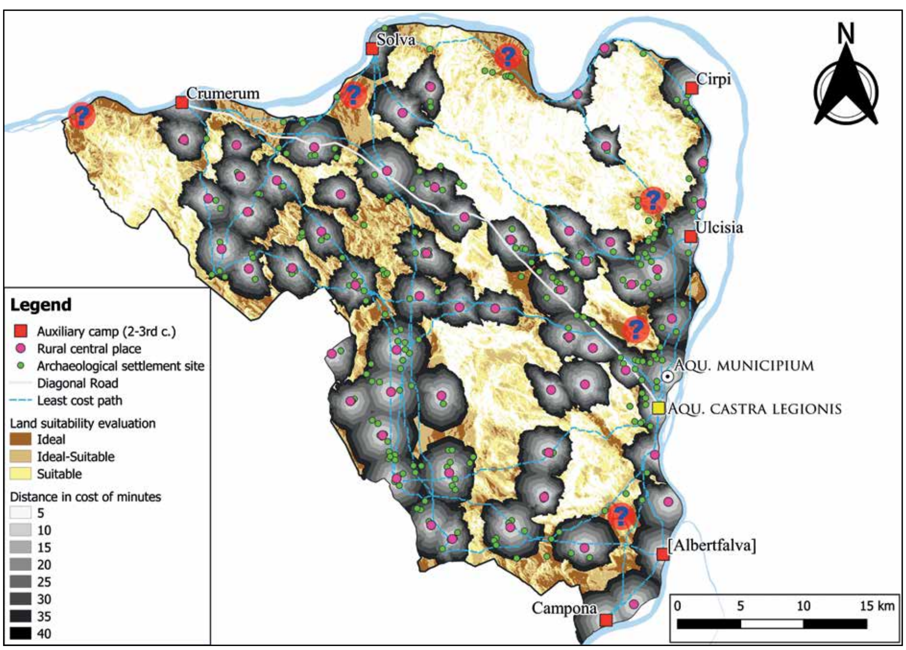

Figure 10. Assessment map to determine the completeness of the archaeological data and the rural infill using the archaeological land evaluation model (author).

4.2. Agricultural economic prospect in the limes hinterland

Since the data of the evaluation method were taken from a statistical analysis of the optimal Roman agricultural zones (1.5 km radius), it was expected that the map would correspond to the extent of arable lands today. To examine this correlation, I vectorised ploughlands from the Ecosystem Map of Hungary (Agrárminisztérium 2019) and overlaid them on the three best categories of the land evaluation map (Figure 9). The results were visually compelling, especially in the western areas where current land-use is still mainly agricultural. Naturally, this type of exploitation is missing in the east, where the city of Budapest is located. It is worth noting that, according to the evaluation map, the immediate neighbourhood of the Roman settlements were carefully chosen by the inhabitants with a view to the needs of intensive crop cultivation, and given the drawbacks of archaeological topography, such as lack of information (Simon 2019a: 144-147), their perception of the landscape was probably little different from our own.

Ideal and suitable areas for labour-intensive cultivation were limited in the rural countryside. Therefore, since the landscape was dominated by 58 villages acting as

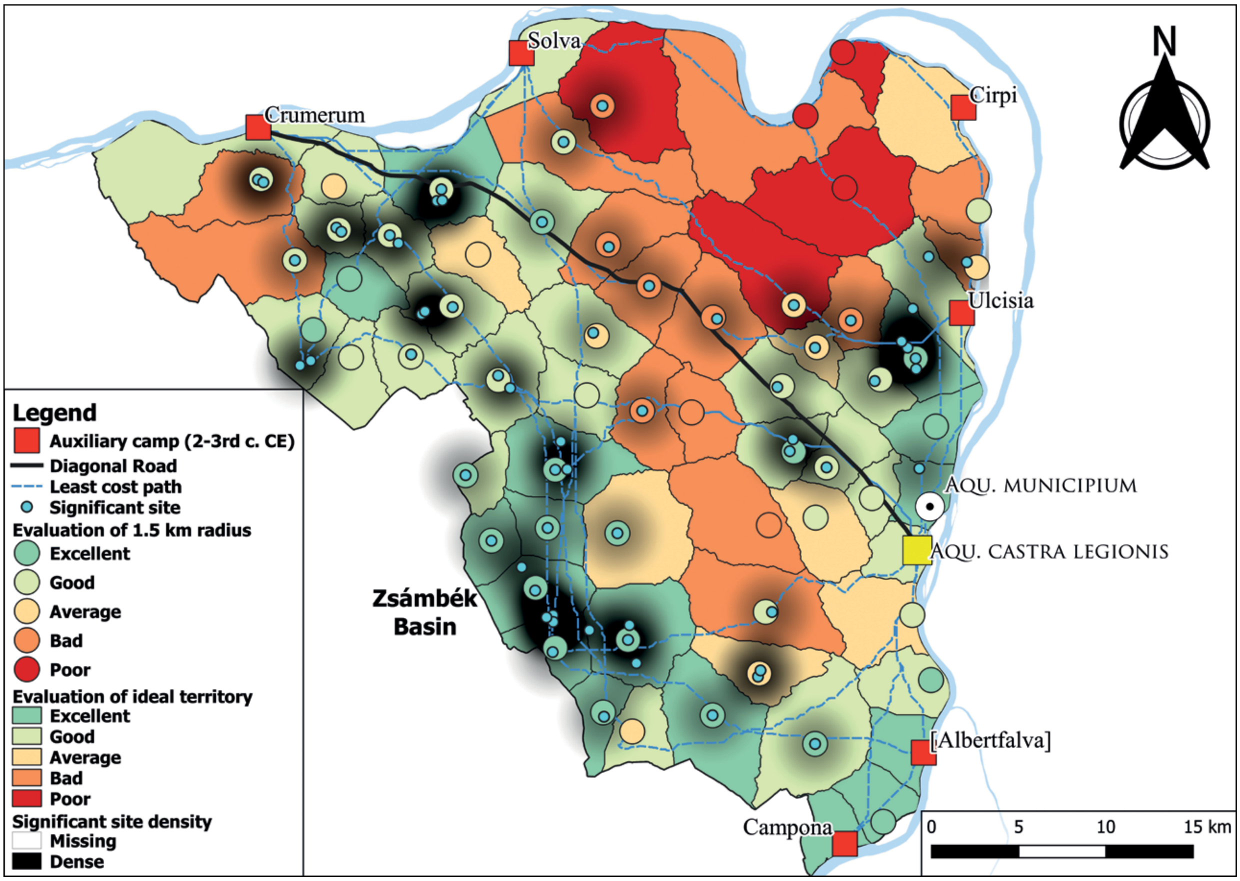

Figure 11. The result of the zonal queries on the data of the land evaluation model compared to the density of 'significant' sites (author).

micro-regional central places, the incompleteness of rural infill or archaeological data can both be detected when their regular settlement pattern and action radius (on the methods see: Simon 2015: 116-121; 2017: 279; 2019b: 217) is projected onto the evaluation map. Figure 10 shows, that the area within a 40-minute walking distance to the villages, i.e., 3.2 km (cf. Simon 2019b) covers almost the entire rural landscape which could have been ideal for ploughland. If the accessibility is also taken into consideration, there are only a few places, where further villages would be expected (marked with a '?'). But already based on our present knowledge, rural infill could have been nearly complete in the Pannonian *limes* hinterland. Only within the 500 m radius of the identified 58 rural central places did settlement pattern change (Simon 2017: 263, 278), therefore it is conceivable that until the mid-3rd century CE the exploitation of the natural resources by village communities was highly efficient. However, it is still subject of further investigation and debate whether the essentially deductive evaluation map will not change significantly when new data on the forested hills become available.

I found that, on average, the proportion of landscape features considered ideal was higher within 1.5 km of the villages compared to other Roman places (Simon 2017: 276-281, tables 18-21; Simon 2019a: 198). Thus, it seems reasonable to assume that their better access to resources was key to their economic prosperity and the reason why they became central places. However, resource distribution was not equal, so even villages had different economic opportunities. In order to assess their agricultural prospects, the territories of the villages were classified into five categories from excellent to poor with the Jenks natural breaks optimisation method (Conolly and Lake 2006: 142), based on their share of the 'ideal' and 'ideal-suitable' categories defined by the landscape evaluation model. The zonal query used as a basis for the grouping was carried out at two levels, firstly using a 1.5 km radius of the villages, as in my previous study (Simon 2017), and secondly, using the ideal boundaries of the settlements. As the ideal territories proved useful in mapping the actual historic settlement boundaries in parts of the research area (Simon 2019b: 217), I created them in a similar way for the present study. They were generated with the 'Path Distance Allocation' tool of ArcGIS 10.3 based on the reclassified slope map used to model the least cost paths. This time the analysis was not based on the

	All places	Surviving places	Percent of all places to survive
1st-2nd century	86	[redacted]	34.88 %
2nd-3rd century	112	30	27.60 %
3rd-4th century	67	31	[redacted]

Table 3. Correlation between all Roman places and surviving places.

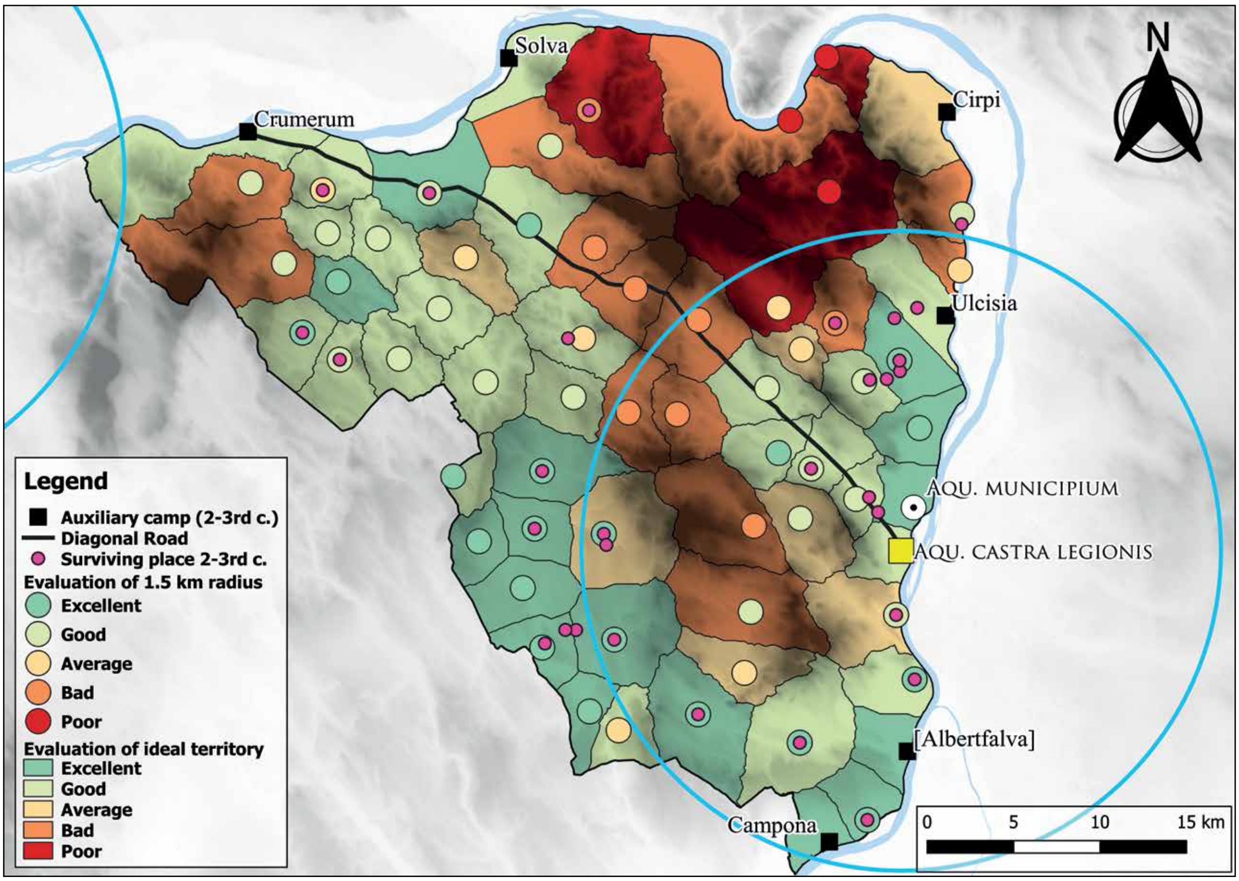

Figure 12. Distribution of surviving 2nd-3rd centuries CE places in the socio-cultural and natural environment of the limes hinterland (author).

actual area, but on the percentage of the top two categories relative to all others.

Thanks to the classification based on two levels of zonal statistics, a similar result in terms of distribution was obtained as for the archaeological sites with finds indicative of regional or interprovincial economic connections (Figure 11; cf. Simon 2016: fig. 2). The so-called 'significant' sites, denoting the latter, are scattered mainly in the Zsámbék Basin, southwest of *Aquincum*, and north of the city. These same areas are also the areas with the best agricultural prospects according to the landscape evaluation model, showing the correlation between the collected archaeological material and the ideal placement of Roman rural settlements.

The study also showed that there are differences between the 1.5 km radius environment and ideal territories. In only five cases was it observed that the agricultural prospects calculated according to the ideal territory were better than those calculated for the 1.5 km radius zone of the villages. In contrast, in 17 cases the immediate surroundings of the village had better conditions than the ideal territory as a whole. This seems to suggest that the villages also owed their economic strength mainly to the land in their immediate neighbourhood and not to their overall micro-regional hinterland.

4.3. Settlement resilience, economic prospect, and cultural factors

Since rural settlements were loosely structured in Roman times, archaeological sites do not necessarily reflect the reality of the past. Therefore, instead of settlement sites, I identified and used settlement places

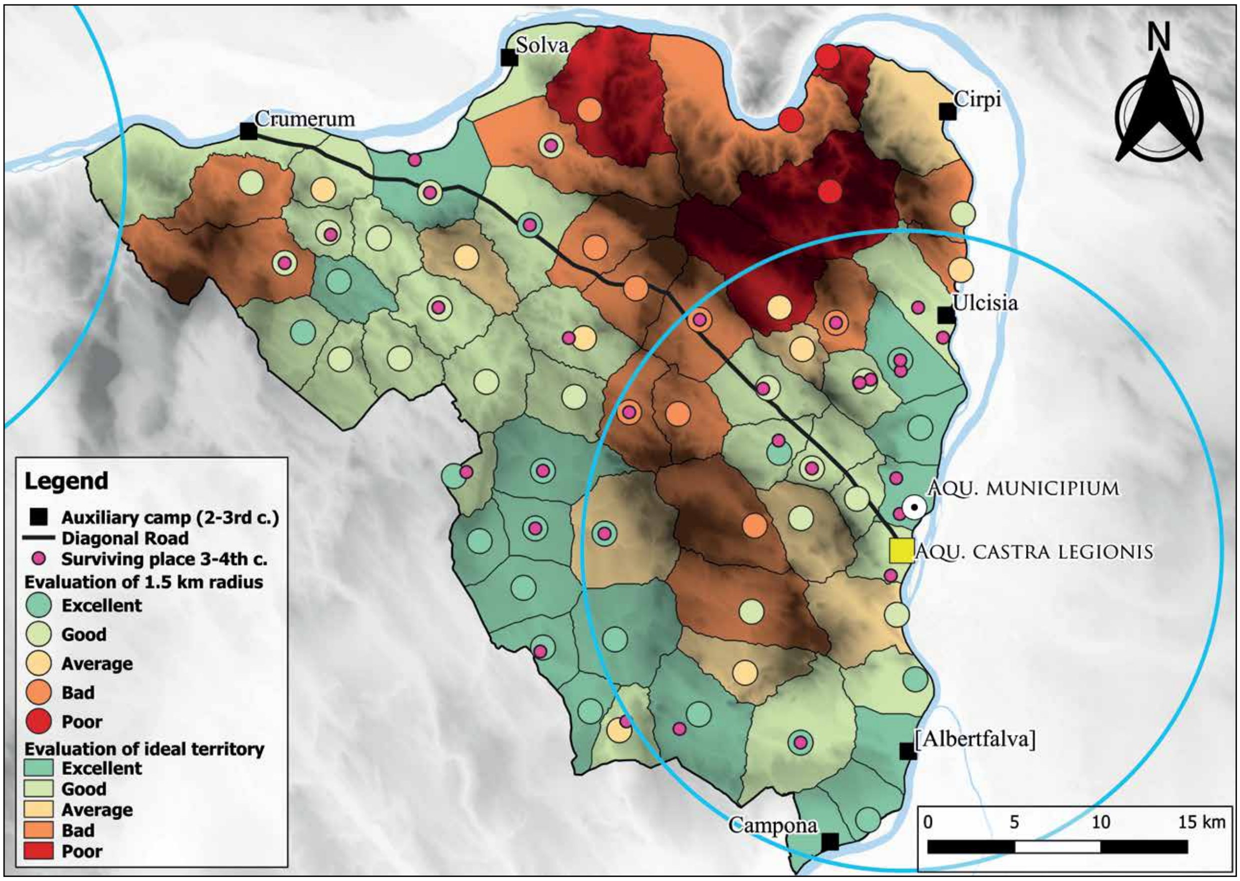

Figure 13. Distribution of surviving 3rd-4th centuries CE places in the socio-cultural and natural environment of the limes hinterland (author).

for the analysis, the methodology of which I have previously described (Simon 2017: 263). These places were defined by grouping archaeological sites from the same period within 500 m of each other. This allowed me to investigate the survival of whole complexes of sites rather than just a single site. Accordingly, I used a simple query to compare sites from successive periods to find those that survived in an unchanged pattern. This means that within a certain place, the occupation of the sites was uninterrupted, and without any spatial rearrangement. Following the military crisis of the Marcomannic Wars at the end of the 2nd century CE, 30 settlement places survived into the 3rd century CE (Table 3). The majority of the remaining settlements, 17, were located in the immediate hinterland of *Aquincum*, while another three were near the two main roads, the *Limes* Road along the Danube and the Diagonal Road (The course of the former is not precisely known, Figure 12). Of the surviving settlement places, only nine were located further inland. This suggests that cultural factors must have played a key role in the survival of the settlements and made village communities resilient in times of economic crisis. This did not change significantly in the late Roman period, when 21 of the 31 surviving places were located in the marketing range of *Aquincum* or along one of the main roads (Figure 13). Only 10 of the remaining sites were located deep in the countryside.

As shown above, in addition to cultural factors, such as the access to roads and markets, these places benefited from advantageous environmental conditions, which gave them greater resilience in recovering from crises. When the surviving places are projected onto the landscape assessment map, it seems clear that environmental factors may have played a major role in the survival of the places without direct access to major roads or urban markets (Figures 12-13). All but one of the surviving places were, or were near, a village, which received at least an average rating based on the agricultural prospects of their 1.5 km radius. The only exception is the village southeast of the *Solva* camp, which may indicate different local conditions. This is confirmed by the fact that not one, but three of the surviving villages with direct access to urban markets and main roads had 'bad' environmental conditions.

Obviously, the study of rural settlement resilience is based on too little data, but it seems as if cultural factors played a greater role in settlement survival than environmental ones, since after each of the political and economic crises mentioned above, only one third of the surviving places were outside the direct access to major roads or the city of *Aquincum*. While cultural and environmental factors may have been both important, it should be emphasized, that only one third of the former economic places remained unchanged in the post-crisis periods (Table 3). This demonstrates that the other two thirds of the places were resilient in other ways. Since the position of the central rural places was mainly determined by the intersection of long-standing (1st-3rd century) significant sites and settlement sites of the 1st-2nd and 2nd-3rd centuries CE (Simon 2017: 278), where no surviving places were found, there was only a rearrangement in the settlement pattern, but the occupation of the micro-region did not change. In summary, it seems certain that nearly one third of the settlements remained in place, mainly due to cultural and environmental advantages, while in the remaining micro-regions new settlements were established around the economically central locations. For the latter, the abandonment of previous settlement locations may have been a consequence of the destruction caused by the wars, rapid population change, or ruined dwellings.

5. Conclusions

Aquincum and *Brigetio* became important economic centres of the Pannonian frontier with two heterogenous urban populations as they consisted of a civil and military town and a legionary fortress. This population had to be supplied with food by the hinterland, which determined the economic relations in the region. Cities were first and foremost socio-political central places, who controlled and exploited their hinterlands through different kinds of economic transactions. Therefore, at the intersection of the different levels of the Roman economy there were settlement complexes such as *Aquincum* and *Brigetio*, and it was mainly through the social network of these towns that the rural settlements were integrated into local, regional and provincial economies.

As the careers of the indigenous elite have shown, there was an interconnectedness of the civil and military spheres in both rural and urban life. This overlap was particularly necessary, as rural resources could be claimed by both groups in the city. The scattering of epigraphic material has made it possible to identify two spatially distinct areas in the hinterland of *Aquincum* to which these groups were linked. This system of contacts provided the framework for political and economic relations in the area, along which trade information could have been transmitted.

However, the network of contacts was spatially limited, as the stone monuments were within the one-day return radius of *Aquincum*. This pointed to the phenomenon, discussed in several studies, that physical space, and thus market access, determined the evolution of urban-rural relations. According to this, an ancient city could only directly exploit its hinterland within its marketing range, which in the case of *Aquincum* meant a radius of 18.5 km.

Not only the immediate hinterland, but also the extent of villages' territories was determined by the physical environment, as farmers sought to minimize the energy required to reach the land in their daily agricultural work. This has resulted in a regular settlement pattern, typical of intensive farming communities, with villages more or less 5 km or an hour's walk apart. The rural settlement pattern was also in conjunction with the modelled least cost paths and incorporated the urban and military settlements along the *limes*. This part of the study demonstrated that the determined settlement network could be reconciled with the predictions of Central Place Theory, and that the environment and socio-cultural influences were intertwined in creating the rural settlement network.

In the second part of the study, I highlighted that socio-cultural and environmental conditions have played a significant role not only in the development of the settlement network, but also in its changes. The results showed that, according to my archaeological landscape evaluation system, the Roman villages occupied areas with better agricultural potential, which justified their central function. However, a different picture emerged when I studied the location of the surviving economic places from the 2nd-3rd centuries and 3rd-4th centuries CE. I concluded that, although only a third of the economic places preserved their former settlement pattern after the serious war events of the 2nd and 3rd centuries CE, the majority of those that survived probably owed their resilience to the proximity of the Diagonal Road and *Aquincum*.

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Classical and Hellenistic pottery kilns from Greek rural areas in their natural and human landscape

Francesca Tomei

1. Introduction

This contribution, which is inspired by my ongoing PhD research, aims to investigate how pottery production and the cultural landscape were connected in ancient Greek rural areas. It aims also to show the cross-craft interactions (Brysbaert 2007) between pottery production and agricultural practices and how they influenced the locational choices of ceramics workshops in Classical-Hellenistic rural regions. The analysis will focus on two regions of the Greek world, the *chora* of Metaponto in Basilicata, southern Italy, and the Berbati Valley in the Argolid, between the Classical and Hellenistic periods. Both regions are strongly marked by an agricultural economy still nowadays, and pastoralism and transhumance of flocks between lowlands and uplands were practised until recent times. In particular, I will analyse two sites, Sant'Angelo Vecchio and Pyrgouthi, that share some characteristics: evidence of pottery production (kilns, wasters) and agro-pastoral activities on-site or off-site in the immediate surroundings. The study aims to understand how the landscape of activities influenced the locational choice of the pottery workshops and what was the role of the roads and pathways in connecting the production sites with households or worship places in the Greek and Southern Italian countryside.

From a methodological point, the palaeoenvironmental studies (archaeobotany and zooarchaeology) provide information on the botanical landscape, crops and livestock breeding (Costantini and Pica 2016; Florenzano 2016; Mylona 2005; Sarpaki 2005), and ethnoarchaeology (Forbes 2007; Forbes 1996) helps to reconstruct how these economic activities crossed with pottery production. Furthermore, QGIS spatial analysis tools, specifically buffer- and least-cost path analysis, enable me to model the land use in connection with agriculture and pottery production, and postulate better pathways connecting the workshops with other settlements and the raw material sources. The Least Cost Path is a spatial analysis technique that allows the calculation of the most cost-effective route between two points and GIS software generates it evaluating the smallest sum of raster cell values between the two points (ESRI 2013). It is based on a cost surface raster whose values are defined by the user and it can be, for example, the terrain slope, the time and the land use, etc. Thus, it reflects the patterns of movement through the landscape (Seaman and Thomas 2020: 554). The QGIS Least Cost Path Plug-in used to calculate the least-cost path in this contribution uses the terrain slope to calculate the effort to travel and generate the least cost trajectories.

Furthermore, I apply the cross-craft interactions concept to pottery production and agriculture in two Greek rural contexts. The cross-craft interactions methodology explores how technical knowledge and technologies move and interact in societies and shows how

Francesca Tomei
Department of Archaeology, Classics and Egyptology
University of Liverpool

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Figure 1. Maps showing the location of the sites analysed: a) Sant'Angelo Vecchio in the *chora* of Metaponto, Basilicata, Southern Italy; b) Pyrgouthi in the Berbati Valley, Argolid, Greece.

materials, objects and technologies are interconnected with a social meaning (Rebay-Salisbury et al. 2014: 2). Technology enables people to interact with other people and with the environment, therefore it is embedded with the socio-economic context (Rebay-Salisbury et al. 2014: 2). Cross-craft interactions, then, happen when artisans work in proximity and they can exchange tools, space and knowledge, or when craftspeople travel through long- or short- distance networks of trade and exchange (Brysbaert 2007: 333-334). Agriculture is a craft itself because it involves working raw materials to make new products and the employment of specific artificial tools, techniques and knowledge (McGovern 1989: 2; Brysbaert 2020: 61). In a rural context, agriculture is the primary source of subsistence, but people were also engaged with other crafts to produce commodities, such as pottery. The cross-craft interactions, then, allow me to demonstrate that pottery production and agriculture influenced each other and that the proximity of farmsteads affected the choice of location of pottery workshops in the land.

In the following sections, the rural pottery workshops from the *chora* of Metaponto (Sant'Angelo Vecchio) and the Berbati Valley (Pyrgouthi) will be analysed as case studies (Figure 1).

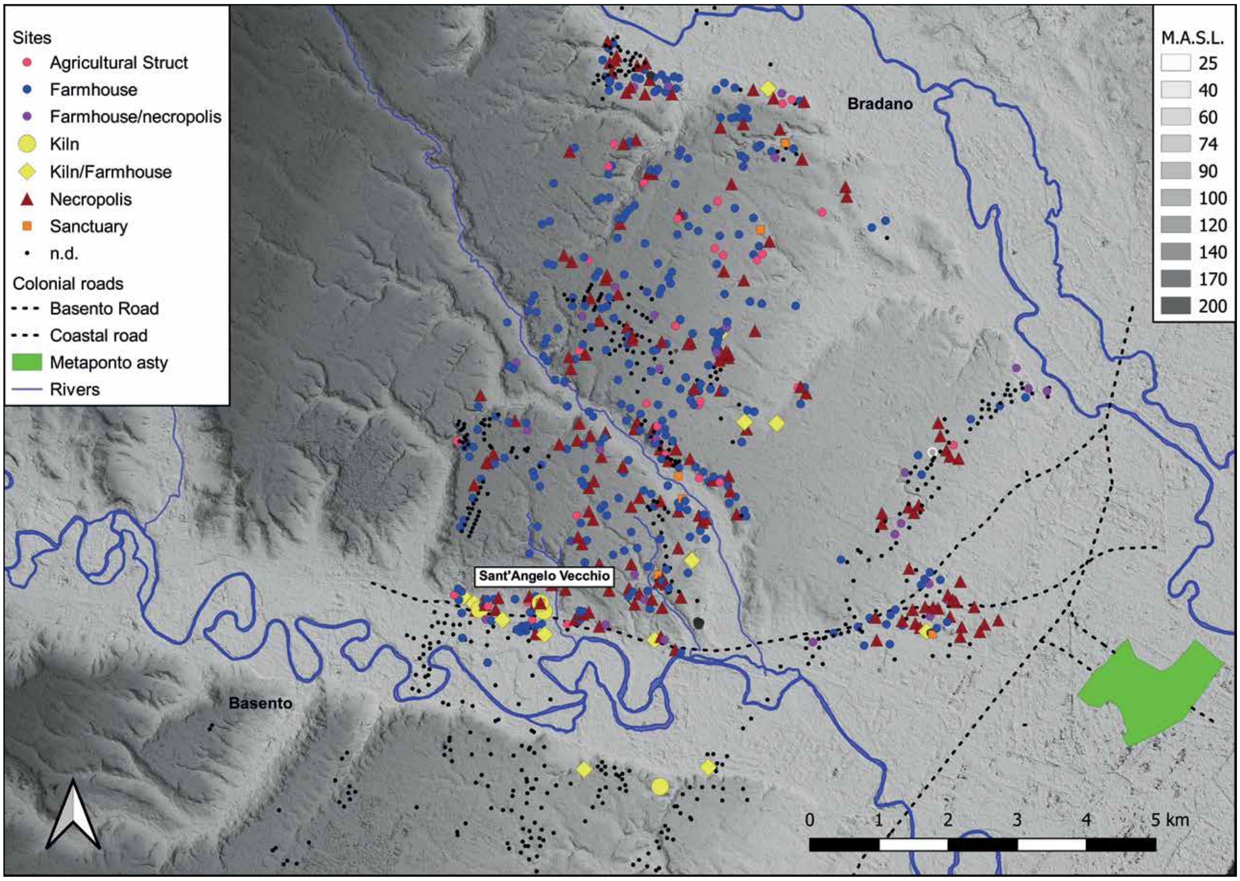

Figure 2. Map of the section of the *chora* of Metaponto between the rivers Bradano and Basento, showing the distribution of Archaic to Hellenistic kiln sites (yellow symbols) in relation with the other sites.

2. The *Chora* of Metaponto

The territory of Metaponto, an Achaean colony founded around the mid or late 7th century BCE, stretched for 25 km from the coastal plain (SE), where the city is located, up to the lower Lucanian mountains (NW) and it is crossed by three main rivers: Bradano, Basento and Cavone. Bradano in the north and Cavone in the south were also the natural boundaries of the *chora*[1] (Carter 2006: 118).

In 1974, the Institute of Classical Archaeology of the University of Texas at Austin, led by Joseph Coleman Carter, started systematic and intensive surface surveys (Carter 2008: 18) together with the excavation of Greek rural sites, such as Fattoria Fabrizio (Lanza Catti and Swift 2014), Sant'Angelo Vecchio (Silvestrelli and Edlund-Berry 2016), and Pantanello (Carter and Swift 2018). First, they investigated the 'Bradano-Basento Transect' which was later extended up to the Cavone stream, surveying a total area of 80 km². The survey campaigns allowed to identify around 600 sites from the prehistoric to the modern eras, although the majority of them belong to the Greek period (Archaic-Hellenistic; Carter 2008: 22). In the Bradano-Basento transect, investigated in 1980-1982 (Carter and Prieto 2011), 15 kiln sites of Archaic to Late Hellenistic period have been identified, but only a few of them have been fully excavated. Based on the map of site distribution, it is clear that kilns are located preferentially close to farmsteads or rural households, tombs, and main roads or pathways (Figure 2). To understand how these kiln sites were connected with the other sites, especially farmsteads or farmhouses and roads, I analyse in detail the site of Sant'Angelo Vecchio (Silvestrelli and Edlund-Berry 2016).

2.1. Sant'Angelo Vecchio: a multiphase and multipurpose site

The archaeological site of Sant'Angelo Vecchio has been investigated from 1974 to 1981. It is located 8.2 km west of the *asty* of Metaponto, in the central part of the *chora*, on a marine terrace overlooking the Basento river

1 In the Greek world, the *polis* or state was composed of the *asty* or the city (e.g., Athens, Metaponto, etc.) and the *chora*, which was the city's territory. The *asty* always had a strong connection with its countryside, where the majority of the population lived in villages and farmsteads and dedicated to agriculture (Fachard 2021: 21).

Pottery production at Sant'Angelo Vecchio- Early Hellenistic phase	
Kiln supports	Wedge-shaped (Types 1 and 2) Pyramidal (Type 3) Parallelepiped bar (Type 5)
Loom weights	Oscilla
Figurine moulds	Seated female votive plaque; Eros loom weight; palmette antefix; Artemis Bendis antefix; male head antefix; Medusa rosette; standing female votive plaque
Plain and coarse wares	21 overfired non- diagnostic pieces

Table 1. Wasters and kiln supports from the deposits associated with the Early Hellenistic workshop. The presence of terracotta figure moulds and over-fired pieces of plain and coarse wares suggests that the figurines and household wares were fired in the kilns (from Silvestrelli 2016d: 566-573; Edlund-Berry 2016: 448).

Pottery production at Sant'Angelo Vecchio- Late Hellenistic/Early Roman phase	
Kiln supports	Parallelepiped bar (Type 5)
Loom weights	Pyramidal
Cooking wares	Pan (over fired) *Klibanos* (over fired)
Grey Ware	Non-diagnostic overfired piece

Table 2. Wasters and kiln supports from the deposits associated with the Late Hellenistic/Early Roman workshop. The overfired pieces and the typology of kiln supports indicate that Grey Ware and cooking wares were produced at the workshop (from Silvestrelli 2016d: 575-578).

(Silvestrelli 2016a: 3). The site is characterized by short and discontinuous occupation phases (Foxhall 2020: 8). The hill was first occupied by a domestic settlement or farmhouse, called 'House on the Hill', which dates to the second half of the 6th century BCE until the mid-5th century BCE, according to the pottery evidence (Silvestrelli et al. 2016: 63-65). Contemporary to the farmhouse, a sacred area at the foothill was connected with a natural spring, and it is marked by a boundary stone bearing an inscription in the Late Archaic alphabet. A few kiln wasters, including terracotta figurine moulds, have been found suggesting the presence of a workshop probably connected with the sanctuary (Silvestrelli et al. 2016: 67; Foxhall 2020: 6). After a period of abandonment, from the 5th to late 4th century BCE, when the area was used as a rural necropolis without evidence of dwelling (Becker et al. 2016: 85-87; Foxhall 2020: 7), a pottery workshop was built on the southern slope next to the spring. The workshop consists of remains of wall foundations, identified as a potter's shed, and a firing area located 20 m southeast of the shed, with two poorly preserved kilns (Silvestrelli et al. 2016: 71-73).

The kiln wasters and the deposits associated with the firing area suggest that the kilns mainly fired terracotta plaques, as they are present in big quantities, together with plain and cooking wares (Edlund-Berry 2016: 453; Silvestrelli 2016b: 132). The mould typology of the terracotta plaques, the tiles used for the shed's roof and the pottery from kilns levels indicate that the workshop was active between the late 4th and 3rd centuries BCE (Edlund-Berry 2016: 448; Silvestrelli 2016c: 34). Besides pottery and votive terracottas, a good quantity of disc-shaped loom weights (*oscilla*) has been found in the shed and firing areas, so it is possible that they, too, were manufactured at Sant'Angelo Vecchio. However, some pieces from the kilns' deposits are heavily overfired and, therefore, it cannot be excluded that some of them were re-used also as kiln spacers (Foxhall and Quercia 2016: 455).

From the mid-3rd until the late 2nd century BCE, there is no evidence of production or occupation of the site. In the late 2nd century BCE, however, a new workshop was built right above the previous one, with a new shed and three kilns (Silvestrelli 2016b: 133). The firing area, named the 'Kiln Complex', consists of three well-preserved kilns of 2.5 m in diameter, surrounded by four walls that form an enclosed space of 92 m^2 (Silvestrelli et al. 2016: 80).

Although the second phase workshop is better preserved than the first one, no specific discard area has been documented on-site. Therefore, the identification of the ceramics produced there can be based on the scattered misfired sherds from the 'Kiln Complex' assemblages. It seems, thus, that mainly Grey Ware and cooking wares were manufactured and fired, possibly to supply the closest farmhouses with vessels for everyday use (Quercia 2016: 533; Silvestrelli 2016b: 133). The workshop was active until the end of 1st century BCE, when the site was abandoned again without any evidence of further activity.

2.2. Agricultural activities at Sant'Angelo Vecchio and their relation with pottery production

The archaeobotanical analysis on pollen samples (Figure 3) from stratigraphic sequences (6th to 1st century BCE) from the workshop area allowed the reconstruction of the botanical landscape surrounding the site as well as the agricultural practices of the region (Florenzano 2016: 159-162). The landscape was dominated by herbaceous plants (49%) typical of pasture, such as *Cichoriae* (herbaceous perennial plants or shrubs) and flax-leaved daphne, and by Mediterranean shrubs (42%) such as holm, juniper, and myrtle. Amongst the cultivated wooden plants, there is evidence of olive tree (*Olea europaea*, 2.1%), walnut (*Juglans*, 0.3%) and grapes (*Vitis*, 0.8%), whose low percentages probably indicate that they were not grown immediately close to the Sant'Angelo Vecchio site (Florenzano 2016: 164). Cereals are also represented in the pollen samples, especially oat/wheat (*Avena/Triticum*), but its low rate, 0.7%, means that they were cultivated at a distance from the site and not processed on-site, but used

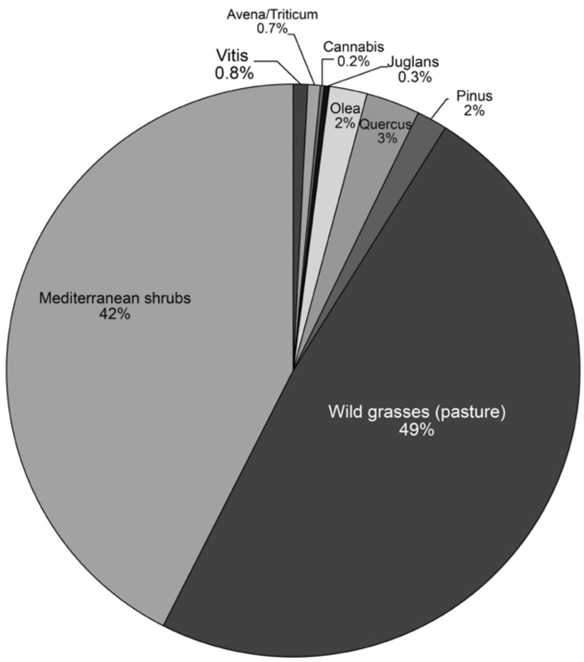

Figure 3. Pie chart showing the percentages of pollen from Sant'Angelo Vecchio.

in some ways locally (Foxhall 2020: 8). In fact, during the 1979 archaeological campaign, the recovered fired clay fragments from the 'Kiln Complex' carried impressions of cereal straws and chaff. In particular, it was possible to identify emmer wheat (*Triticum dicoccum*), wheat (*Triticum durum*), barley (*Hordeum distichum/ vulgare*), chickpea (*Cicer arietinum*), pea (*Pisum sativum*) and bitter vetch (*Vicia ervilia*). There is no evidence of structures for cereal processing in Sant'Angelo Vecchio in the Hellenistic and Early Roman periods, so the charred-fired clay fragments indicate that chaff and straws were used as temper for kilns' mudbricks (Costantini and Pica 2016: 173-175; Foxhall 2020: 8). In addition, chaff and straws could be a source of fodder for animals, such as sheep, goats and mules or donkeys, and bitter vetch is still used nowadays to feed ruminants (Forbes 2012: 166; Costantini and Pica 2016: 180; Foxhall 2020: 9).

Pastoral/breeding activities on-site are indicated by several factors: the abundance of weeds typical of pastures, such as the flax-leaved daphne, and the presence of coprophilous fungi, such as *Sordaria* and *Sporormiella*, and the parasite eggs of *Dicrocoelium* as Non-Pollen Palynomorphs (NPPs) in soil samples. These records are evidence of dung of animals, in particular ruminants, grazing at Sant'Angelo Vecchio (Florenzano 2016: 162; Foxhall 2020: 8). The faunal remains do not help in the identification of the animals that grazed on-site as the sample consisted of only very few bone fragments. Although it has been possible to distinguish cattle, pigs, dogs, horse/donkey/mule and ovine bones, the material is so fragmented and composite that they were more likely in secondary deposition (Biller 2016: 195-196). However, we may assume that donkeys or mules might have been present at the workshop because they can be heavily loaded with pottery and/or wood, as documented amongst traditional potters in Greece until recent times (Matson 1972: 220).

Cereals' by-products and waste were not only used as fodder for animals but could also be added to the fire in the kiln during the firing process. For example, Plutarch (*Mor.* 658d) reported that the goldsmiths used chaff because it develops heat rapidly. The agricultural residues, indeed, are commonly used as an affordable and easy-to-get fuel source for potters, especially for those who live and work in rural communities (Arnold 1985: 35). In the Mediterranean area, the olive tree branches and vine pruning are the most popular because both plants are widely grown: olive was considered the best fuel for its 'oily texture' (Theophr. *Hist.* pl. 9.4.6), and vine sticks are preferred as they burn well without making too much charcoal in the combustion chamber (Theophr. *Hist*. pl. 9.4.6; Matson 1972: 219; Foxhall 1998: 37). Besides the account of ancient authors and the ethnoarchaeological evidence, there are also some (rare) archaeological samples of burnt olive stones found in deposits associated with kilns or inside the stoking pit, as in the case of Pyrgouthi (see below) and the Hellenistic amphora workshop at Kounophia on Thasos island (Brunet 1986: 809).

Finally, another agricultural by-product, frequently used for pottery firing and employed in the pre-industrial but contemporary workshops of Thrapsano in Crete, is the olive oil pressing waste, or pomace. It is particularly appreciated because it burns at high and constant temperatures for up to 10 hours, and it is easy to obtain in regions where oil is regularly produced (Rowan 2015: 467). The use of crushed olive stones as fuel in the pottery industry is documented in archaeology in considerable quantities of burnt stones, and there is such evidence in pre-Roman and Roman sites throughout the Mediterranean (Rowan 2015: 468-469). Olive trees and vineyards were present in the Sant'Angelo Vecchio area and I can reasonably argue that the waste from the seasonal trimming of those plants, as well as olive oil pomace, could have been used by the potters to feed their kilns during firing. Moreover, the land was covered by Mediterranean wild shrubs and trees that needed to be pruned regularly to allow pasture, so that branches and sticks could be added to the fire in the kiln (Matson 1972: 219; Forbes 1996: 73).

The agricultural and pastoral works in the proximities of Sant'Angelo Vecchio created favourable conditions for the development of local-scale pottery production,

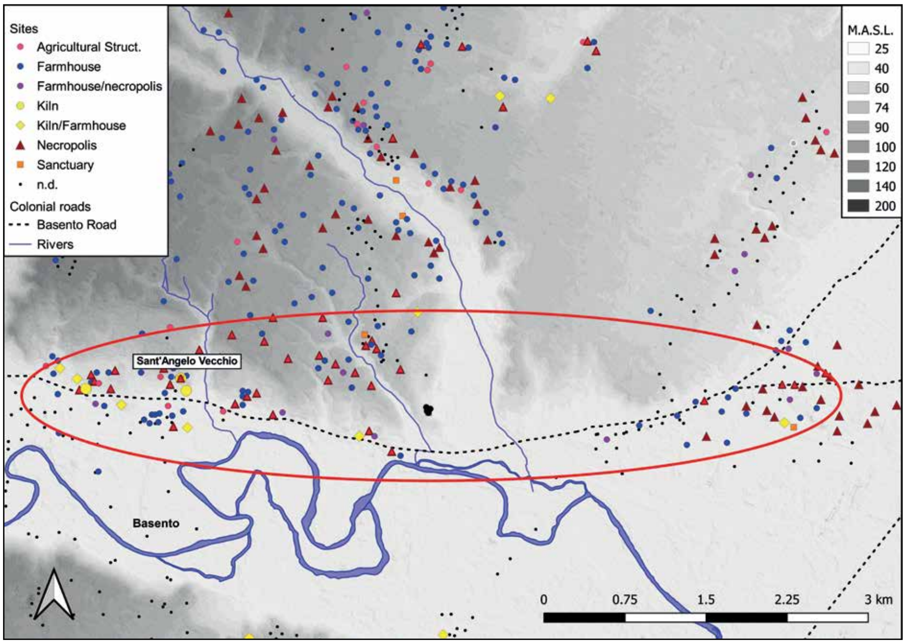

Figure 4. The distribution of Archaic to Roman kiln sites along the Basento road connecting Metaponto with the lower Lucanian mountains.

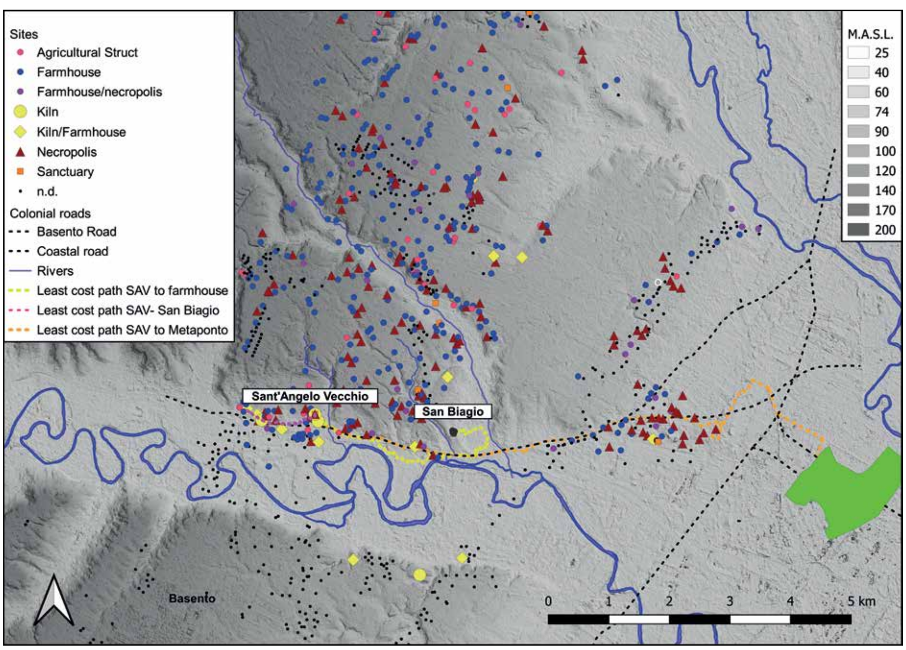

Figure 5. Map showing the least-cost path elaborations confirming the feasibility of the Basento road from Sant'Angelo Vecchio (SAV) to reach other settlements. Green path: from SAV to a Hellenistic farmhouse; yellow path: from SAV to San Biagio Sanctuary; orange path: from SAV to the *asty*.

both in the late 4th and in the 2nd centuries BCE, since potters could take advantage of scraps as a fuel source to fire their pots. In addition, a perennial spring – still used also nowadays – provided water for clay processing, pot shaping, and to prevent the risk of accidental fires. A possible clay pit has been identified at the foot of the hill, 60 m northwest of the workshop (Montanari et al. 2016: 158). Sant'Angelo Vecchio workshop was in an advantageous position also to the Basento road, an important route leading from the *asty* to the Lucanian mountains: the site, indeed, was located only 188 m far from this road. As shown in Figure 4, most of the Classical-Hellenistic kilns in the *chora* are placed along the road, meaning that it was the most feasible route for the movement of raw materials, people and ceramic products, and it was possibly accessible with carts. The least-cost path tool on QGIS (Figure 5) confirms that the Basento road allowed the movement to the nearby contemporary farmhouses, to the *asty*, and to the sanctuary of San Biagio, where terracotta plaques made from the same moulds found at Sant'Angelo Vecchio have been recognised (Tempesta 2016: 434).

Figure 6. View of Pyrgouthi with the remains of the Hellenistic tower and the surrounding landscape (photo by F. Tomei 2020).

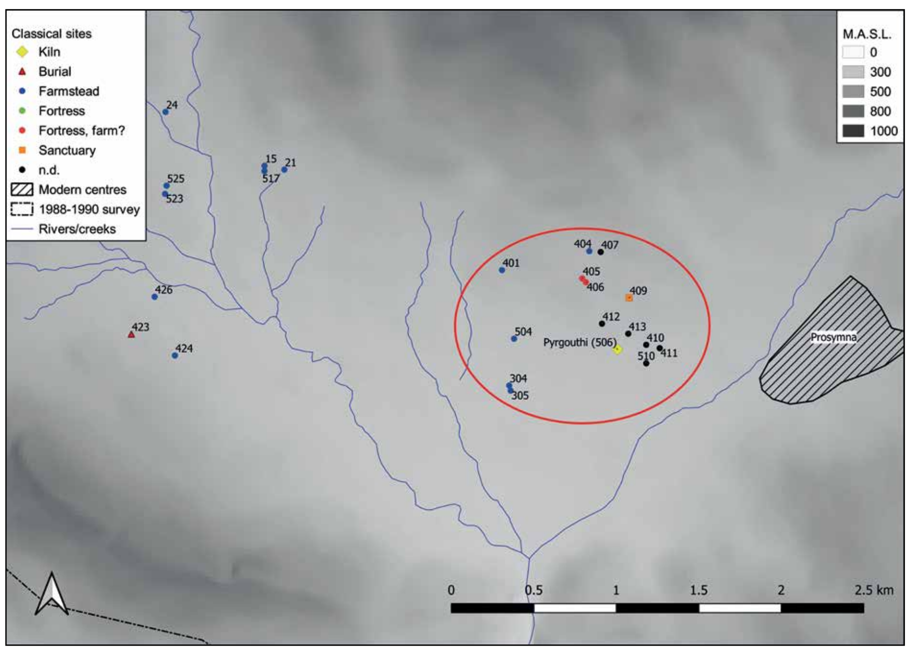

Figure 7. Map of the Classical sites identified with the 1988-1990 survey by the Swedish Institute at Athens in the Berbati Valley. In the red circle, Pyrgouthi and the nearby farmsteads and agricultural sites.

3. The Berbati Valley in Argolid (Greece)

The Berbati Valley is located within the mountains of the northeastern Argolid on the border with Corinthia (Figure 1b). It is separated from the Argive plain by the Euboia range, and northwest of Berbati there are Mycenae and the upland region. The valley is crossed by several torrents which have seasonally been full of water until recent times (Penttinen 2005: 96-97). The Berbati Valley and the Limnes uplands were intensively surveyed from 1988 to 1990 by the Swedish Institute at Athens (Wells and Runnels 1996; Wells, Runnels and Zangger 1996). Their main objective was to investigate the agrarian economy of the valley during the Neolithic, the Mycenaean and the Classical-Hellenistic periods (Wells 1996: 15; Wells 2005: 7). In 1999, a further survey on Mastos Hill led to the identification of a total of 600 sites from the Neolithic to the modern periods (Lindblom and Wells 2011).

3.1. Pyrgouthi: a Classical pottery workshop

The site of Pyrgouthi, whose toponym means 'tower' since the Hellenistic tower has always been a striking feature of the landscape, was excavated in 1995 and 1997 by a team of the Swedish Institute at Athens (Figure 6). The multiphase and multipurpose site lies on an outcrop of the bedrock

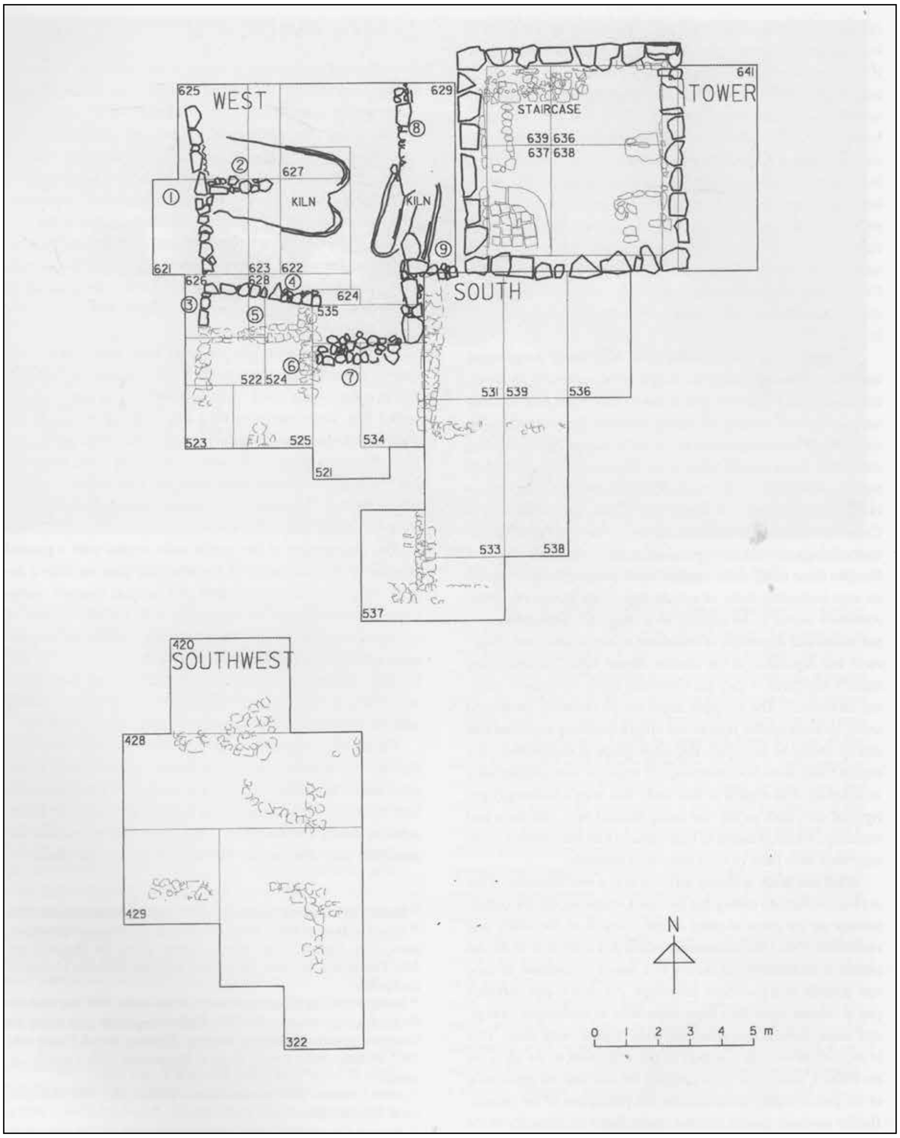

Figure 8. Plan of Pyrgouthi with the Hellenistic tower and the Classical kilns in the western trench. The westernmost is Kiln 1, which is better preserved and bigger than Kiln 2, partially cut by the Hellenistic tower's wall. They are both double shaft kilns (Penttinen 2005: 16, fig, 3). Courtesy of the Swedish Institute at Athens.

and it is surrounded by other farmsteads and agricultural sites of the Classical and Hellenistic period (Figure 7) (Foxhall 2020: 4). Before the excavation, an intensive survey around the site was carried out identifying its agricultural use during the Hellenistic period, but also in Late Antiquity (Wells 2005: 8-9).

The excavation campaigns confirm that the site was occupied for short and discontinuous phases of different activities and site uses (Foxhall 2020: 5). The first evidence of occupation at Pyrgouthi dates to the Early Iron Age. Although the ceramic material is sporadic, this small assemblage, which lacks large storage vessels, has been interpreted as evidence of the use of Pyrgouthi as a seasonal settlement by mobile pastoralists (Penttinen 2005: 91).

In 5th century BCE a pottery workshop with two kilns (Figure 8) marks the main activity at the site. It occupies the western area and part of it has been covered by the Hellenistic tower. Evidence of clay processing and a pot forming area has not been found nearby, although the second kiln was possibly abandoned at some point and used as a clay basin because there is plenty of unburned clay in the intentional filling of the combustion chamber (Penttinen 2005: 21). Kiln 1 is the best-preserved one with a length of 4.1 m and an interior width of 2.5 m. The combustion chamber and the double shafts are excavated in the bedrock and their interior is lined with pale yellowish or greyish plaster. Kiln 2 is partly cut by the late tower's wall and it is slightly smaller than the other one, with a preserved length of 2.75 m and internal width of 1.5 m. Like Kiln 1, it has two shafts excavated in the bedrock lined with plaster (Penttinen 2005: 21-22).

The ceramic material in the kilns' fillings (Classical phase: Strata 3, 3b and 4) provides information on the

Pottery production at Pyrgouthi- Classical phase	
Roof tiles	Corinthian pan tiles
Kiln supports	Wedge-shaped
Cooking wares	*Lekane*; *chytra*; *louterion*; *lopas*
Plain wares	*Hydria*; basin; mortar; table amphora; bowl
Fine wares	*Kotyle*

Table 3. The kiln supports and the overfired pieces from the kilns deposits indicate that Corinthian pan tiles were the main production of the Classical workshop at Pyrgouthi, but also a cooking, plain and fine wares were fired (from Penntinen 2005: 29-35).

workshop's production: the large quantity of discarded misfired Corinthian tiles and the presence of wedge-shaped kiln supports indicate that the kilns mainly fired tiles. The rectangular shape of the combustion chambers and their large dimensions also confirm this assumption (Hasaki 2002: 166), although also utilitarian coarse wares were fired, such as *lekanai*, *hydriai*, mortars, small *pithoi* and beehives. All the ceramics finds belong to 5th century BCE (Penttinen 2005: 29-30, 35, 92). Moreover, in the area of the kilns, some miniature vessels have been found and described as part of the apotropaic gesture by the potters to prevent accidents during firing (Hasaki 2002: 33; Penttinen 2005: 92). However, it cannot be excluded that they were made for the nearby site 409 (Figure 7) which was an active sanctuary in the Classical-Hellenistic period (Penttinen 1996: 254-256).

3.2. Agriculture and pastoralism

The archaeobotanical analyses on seeds from the Classical phase samples enable the reconstruction of the land use and the agricultural practices around Pyrgouthi (Figure 9). The main cultivated plants were the olive trees (41%), although a small number of almond seeds (*Prunus amydgalus*) may indicate the presence of this cultivar nearby. Overall, weeds and wild grasses were common (28%), suggesting that the land was mostly uncultivated (Sarpaki 2005: 318, 336, table 4). Grape is completely absent from the Classical levels, reflecting either the absence of cultivation in the area or a problem of preservation. There is also evidence of cereals (wheat and barley: 12%) and legume crops (15%; Sarpaki 2005: 318-319). The over-representation of olive stones may reveal that the olive branches or, more likely, the olive oil pomace was used as fuel, as I assumed for Sant'Angelo Vecchio, since the exposition to fire charred them and enhanced their preservation in the soil (Sarpaki 2005: 319). Almond tree branches could also have been collected for firing after the seasonal pruning. According to Hesiod's account (Hes. *Op.* 384, 414-617), pruning of fruit trees usually took place between October and November (cf. Fitzjohn 2013: 628, table 1; Foxhall 2007: 127, fig. 5.4).

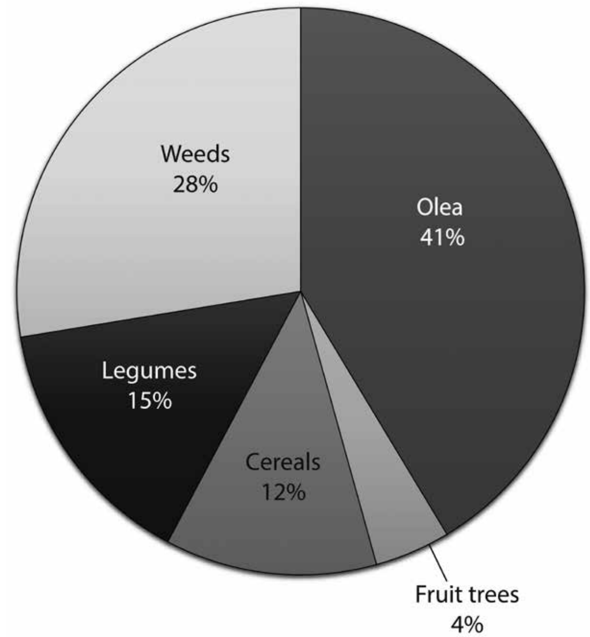

Figure 9. Pie chart showing the percentages of pollen from Pyrgouthi.

The uncultivated land was an important resource at Pyrgouthi and the Berbati Valley because branches from wild vegetation could be used as firewood (Forbes 1996: 87), roots and herbs could be gathered for food, and leaves and grasses as fodder for animals (Penttinen 2005: 97). Animal husbandry for manure, wool and milk mixed with agriculture as a form of subsistence is still practised in some parts of rural Greece and it was certainly more common in the 20th century. This type of pastoralism involves a form of transhumance, with the movement of flocks to upland pastures in the summer and to the lowlands in winter. Some pastoralist structures, such as animal folds, have been found on the western slopes of the Euboia mountain range. Although they are very difficult to date for the lack of ceramic materials, they are signs of pastoralism in the mountainous areas of the Berbati Valley in the past (Penttinen 2005: 99-100). Moreover, the scattered Classical and Hellenistic small farmsteads, located 200-500 m apart from each other, may have been suitable for subsistence cultivation and for breeding small flocks (Forbes 1995: 334-336; Penttinen 1996: 279; Penttinen 2005: 111). At 5th century BCE Pyrgouthi, there are bones of sheep/goats, pigs, and cattle that may belong to the site itself or the closest contemporary sites (Mylona 2005: 301, table 1). In any case, animals contributed to the maintenance of the uncultivated land, and at the same time, they provided manure for crops.

The workshop at Pyrgouthi was located in a favourable position for the proximity to farms, agricultural sites and water and clay sources. Indeed, the Classical pottery and

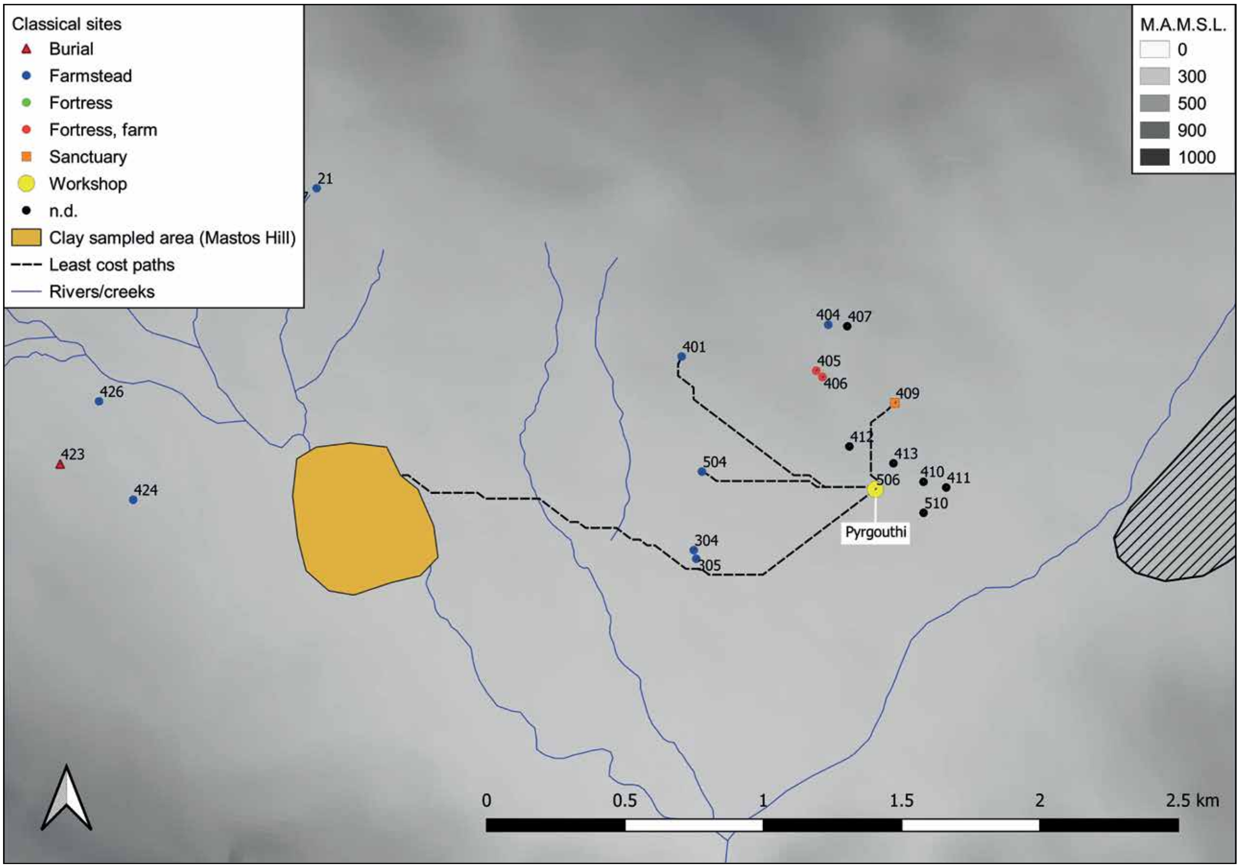

Figure 10. Map showing the least-cost path calculated in GIS, connecting Pyrgouthi with nearby farmsteads, clay deposit, and sanctuary at site 409.

the Corinthian tiles produced on-site are all made with the same yellow refired fabric sampled in local clay deposits in the area of the Mastos Hill (Whitbread et al. 2007: 179, 185). Although there is no archaeological evidence of roads passing nearby Pyrgouthi, I calculated with QGIS Least Cost Path plug-in the possible pathways connecting it with other closer farmsteads, the clay deposit and the sanctuary (site 409). The sites located north of Pyrgouthi lay on steeper slopes, which may have been accessible only by pack animals loaded with ceramic products; however, the land where site 409 and the source of clay are located is flatter, so that routes may have been accessible also with carts (Figure 10).

4. Conclusions

The study of Sant'Angelo Vecchio and Pyrgouthi demonstrates the cross-craft interaction between pottery production and agriculture in the ancient Greek countryside. The proximity of farmsteads and pottery workshops allowed the interactions between the two crafts with the exchange of raw materials, in particular the agricultural waste and by-products, that had an important value for pottery production. The olive tree branches and vine pruning, indeed, were the most appreciated and common fuel sources, as confirmed by archaeological remains, literary sources and ethnoarchaeology, and they were grown almost everywhere in the Mediterranean area. Fruit tree pruning and cereal chaff and straws were also used, especially to set fire, but also as temper for bricks, as we have seen in Sant'Angelo Vecchio. At the same time, the agricultural waste, particularly from cereals and legumes, chaff and fruit tree leaves, was also used as fodder for animals, especially sheep and goats, whose presence has been recorded on both sites. The uncultivated land occupying the majority of the land both in the Metapontine *chora* and the Berbati Valley had many resources both for grazing animals, in the form of herbs and small bushes, and for kiln firing in the form of branches and sticks from Mediterranean brushes. Figure 11 illustrates the cross-craft interactions between agriculture, grazing and pottery production in rural workshops.

As shown in Figure 11, grazing, therefore, contributes indirectly to pottery production. The cross-craft interactions between agriculture and pottery production also influenced the locational choice of the workshops. The proximity to farms was convenient for potters since they could take advantage

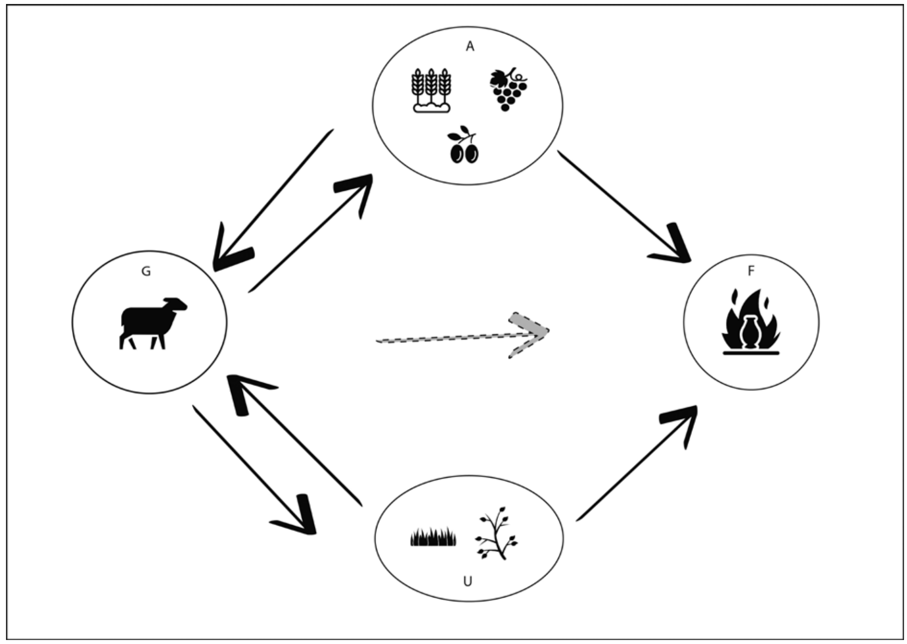

Figure 11. Agricultural residues (A) grants fuel for kilns (F) and fodder for animals (G). Husbandry (G), at the same time, provides manure for crops and keeps the uncultivated land (U) clean which is used as pasture. Wild vegetation (U) is also a source of fuel for kilns with branches and pruning.

of agricultural waste as fuel and as temper for bricks. At the same time, people living in the close farmhouses could get the plain and cooking wares for everyday life or tiles for building or renovating their houses. Therefore, placing pottery kilns near farmsteads/farmhouses was economically convenient for people working and living in the countryside. Roads and pathways played an important role too in the interaction between agriculture and pottery production and in the locational choice of pottery workshops, as they allowed the movement of raw material and products through the territory. Sant'Angelo Vecchio and many other kiln sites in the *chora* are placed along the main Basento road, certainly accessible by wheeled carts. At Pyrgouthi, QGIS can be used to reconstruct a net of paths that connected the workshop with farmsteads and raw material source places. In the Greek and Southern Italian countryside, where people lived, worked the land, grazed their livestock, made and fired ceramic products and produced metal objects, cross-craft interactions were everywhere.

5. Acknowledgements

I warmly thank Prof. Joseph Coleman Carter and the University of Texas at Austin Institute of Classical Archaeology team for kindly providing the GIS materials that allowed me to perform my landscape research on the *chora* of Metaponto. Moreover, I thank the Swedish Institute at Athens for providing useful information on Pyrgouthi's excavation. Lastly, I thank my PhD supervisors, Prof. Lin Foxhall, Dr Matthew Fitzjohn from the University of Liverpool and Dr Ina Berg from the University of Manchester for strongly supporting me and my research. I also thank the AHRC-NWCDTP for funding my PhD research at the University of Liverpool.

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Towns in a sea of nomads: territory and trade in Central Somaliland during the Medieval period

Jorge de Torres Rodríguez*,
Alfredo González-Ruibal, Manuel Antonio Franco Fernández, Candela Martínez Barrio, Pablo Gutiérrez de León Juberías

1. Introduction

In 1518 CE, a Portuguese fleet commanded by Antonio de Saldanha attacked and destroyed the coastal village of Berbera, in current central Somaliland. Although the Portuguese had some intelligence about the settlement and they knew that it was involved in intense trade with Persia and Arabia, when they arrived, they found it completely empty of people and goods. After resupplying, the fleet left for the Arabian coast. This brief reference included in the *Description of Africa* by Luis del Mármol Carvajal (1599) could be just one reference of the many raids that the Portuguese conducted along the Red Sea coasts in their struggle – ultimately unsuccessful – to control of the region. As we will see, this attack was one of the first of a series of episodes that provoked the demise of a dynamic and successful trade system that had connected the Horn of Africa with the rest of the world for centuries. The study of this trade system will be the focus of this paper.

The paper approaches the organization of trade in central Somaliland (Figure 1) from a dual perspective. On the one hand, it looks at the role that trade played organizing the territory. On the other hand, it explores the interactions between the local communities and the other actors participating in this activity. Between the 11th and the 16th centuries, the Somaliland region went through some deep transformations which included the arrival and expansion of Islam, a surge in the international trade, the emergence and consolidation of a network of permanent settlements inland and the increasing influence of Muslim states in the region. The result of these historical processes was the progressive modification of the social, cultural and economic fabric of the local groups that inhabited central Somaliland. From a relatively simple structure based on seasonal interactions along the coast between the nomadic groups and foreign traders, the trade system grew in complexity with the emergence of permanent settlements along the main trade routes, and the increasing influence among these activities of the Muslim sultanates of Ifat (1285-1415) and Adal (1415-1577). The spread of Islam inland from the 13th century onwards had also an impact upon the organization of the nomadic communities, as it can be attested from the disappearance or resignification of pre-Islamic meeting places which previously had helped in structuring the territory.

Jorge de Torres Rodríguez
Institute of Heritage Sciences, Spanish National research Council (Incipit-CSIC), Santiago de Compostela, Spain (corresponding author)

Alfredo González-Ruibal
Manuel Antonio Franco Fernández
Candela Martínez Barrio
Pablo Gutiérrez de León Juberías
Institute of Heritage Sciences, Spanish National research Council (Incipit-CSIC), Santiago de Compostela, Spain

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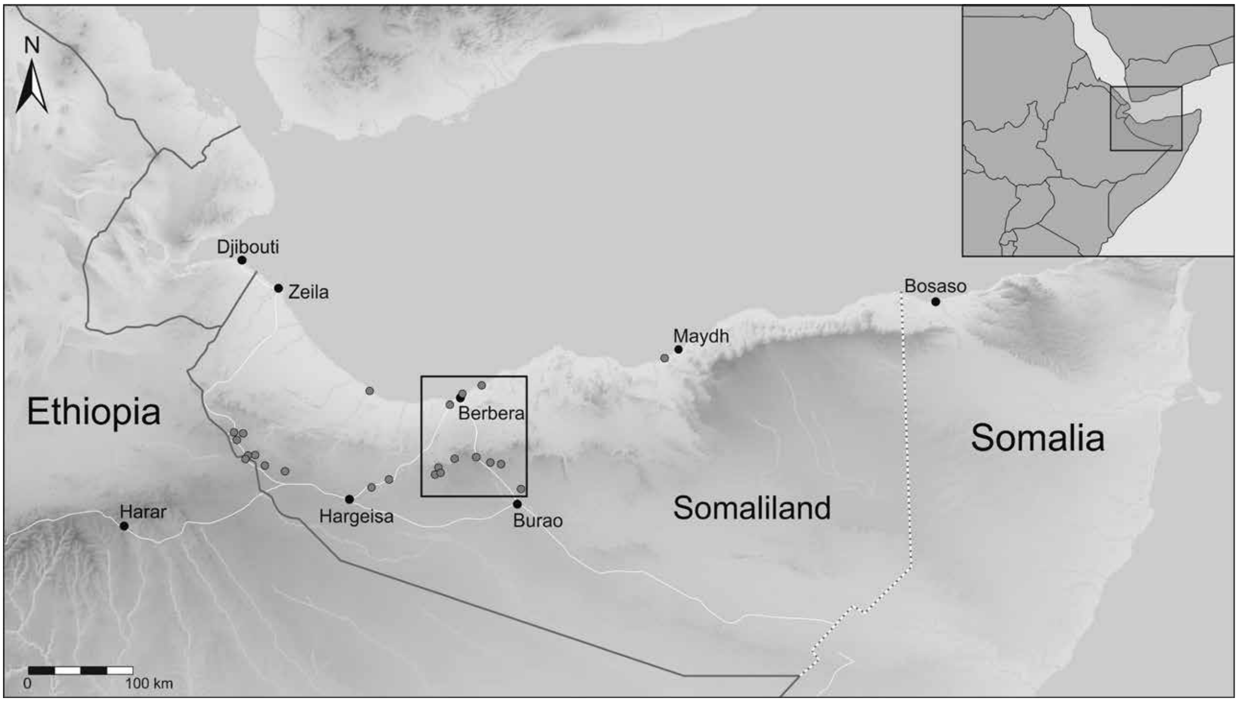

Figure 1. Map of Somaliland showing the area of study and the sites documented by the Spanish Archaeological project.

The paper presents data from eleven archaeological sites studied between 2015 and 2020. It examines the material evidence of the different communities that inhabited the region, as well as the archaeological record of their interactions and the changes they went through during the medieval period. The paper explores the ways these communities reacted and adapted to the expansion of trade, and how their interaction with the territory was affected by these changes. A major hypothesis of the study is that – somehow paradoxically – trade was at the same time a factor of change and the activity that helped to stabilize the region during a period of increasing complexity.

2. Trade in the Medieval Horn: the case of Central Somaliland

The integration of the Horn of Africa in the Red Sea and Indian Ocean trade networks during the medieval period has long been discussed in the historical literature (Pankhurst 1961). Yet, the materiality of this trade has only very recently began to be studied (González-Ruibal et al. 2017; González-Ruibal and de Torres 2018; González-Ruibal et al. 2021). Contemporary European and Arab writers such as Thomas Pires (1944: 11) or Al-Idrisi (1866: 30-31) refer to different types of products being traded in the area and identify the town of Zeila as the main regional trade hub. Besides Zeila, only two other coastal settlements, Berbera and Mette (current Maydh), are cited in the Portuguese accounts (Barbosa 1865: 15). Besides these scant references, there is no precise information about the conditions under which trade was conducted, or about the organisation of trade beyond the shoreline and further inland. Such a lack of information is understandable in the case of Portuguese texts, as their interaction with the region was limited to occasional raids or resupply stops, but it is harder to understand in the case of the Arab writers who must have enjoyed a better access to the interior, and who described in detail the trade mechanisms in other areas of the Horn of Africa coast such as Mogadishu (Abderahman 1977: 152).

The geographical and climatic conditions that characterize the Horn of Africa are fundamental to understand the social and economic dynamics of Somaliland. The region is directly affected by the monsoon regime, which regulates both the seasonal movements of the nomads and the navigation in the Red Sea (Figure 2). The main rainy season starts in April, with rain falling mostly in the mountains and the interior plains (the Haud) and the nomad groups moving south to take advantage of the pastures there. During the summer the Guban or semi-desert coastal plain of Somaliland remains almost empty, suffering from very high temperatures and strong winds that render sailing difficult and make life very uncomfortable. As the grazing areas to the south get progressively dry and water becomes scarcer, the nomads begin their return to the north, putting pressure on those groups that had occupied the mountains. By September-October, most of the groups have returned to their original

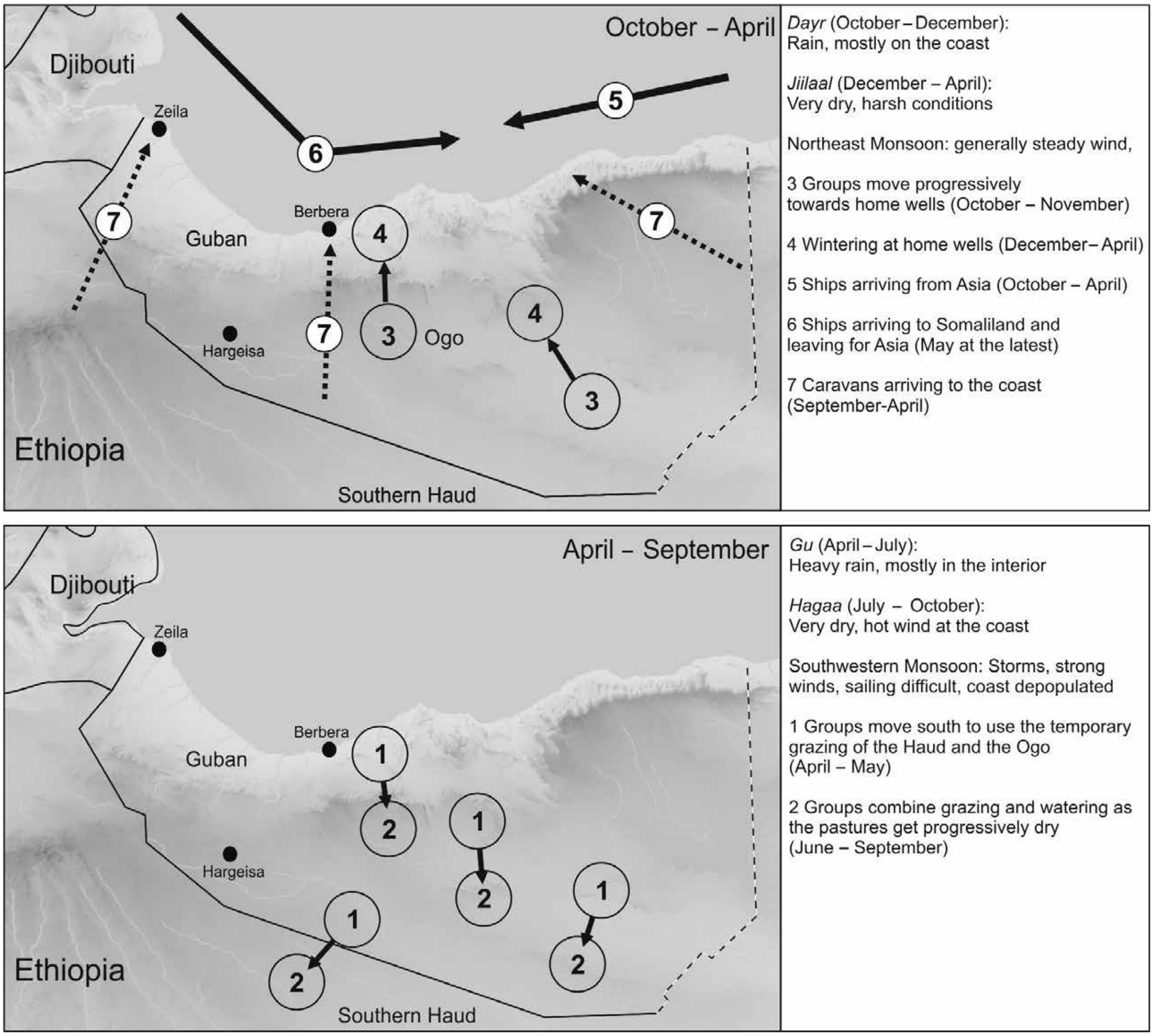

Figure 2. Seasonal movements of nomads and ships according to the monsoon regime.

territories and the coast is again populated around those few wells that have permanent water. During this season the winds change and the northeast monsoon allows an easy access to the coast.

This confluence of easier navigation and population concentrated in the coastal settlements has historically framed the trading season in Somaliland between October and April (Hornby 1907: 87). This situation has traditionally led to significant population shifts in the coastal trade hubs depending on the season, as described by early travelers like Burton (1894) or Cruttenden (1849); and such shifts may explain why a town like Berbera was completely empty during the Portuguese attack in 1518.

Thus, far from being just an economic activity, commerce in Somaliland was directly related to the management of the territory, through the integration of commercial routes with the seasonal movements of the nomadic communities. Both activities were closely interrelated and often overlapped, and in many aspects, they contributed to structure the territory, combining the most efficient routes with the most reliable wells, pre-established coastal trading points and traditional nomadic meeting sites. Trading meetings were more than just spaces for economical exchanges: they acted as places for social and political interactions, and in many aspects helped to organize the temporality and spatiality of nomadic communities through their recurrence (González-Ruibal and de Torres 2018). This pattern seems to have existed at least from the first centuries CE, as it has been recently documented during the excavations at the site of Xiis (Fernández et al. in press). However, in the medieval and early modern periods the previous model,

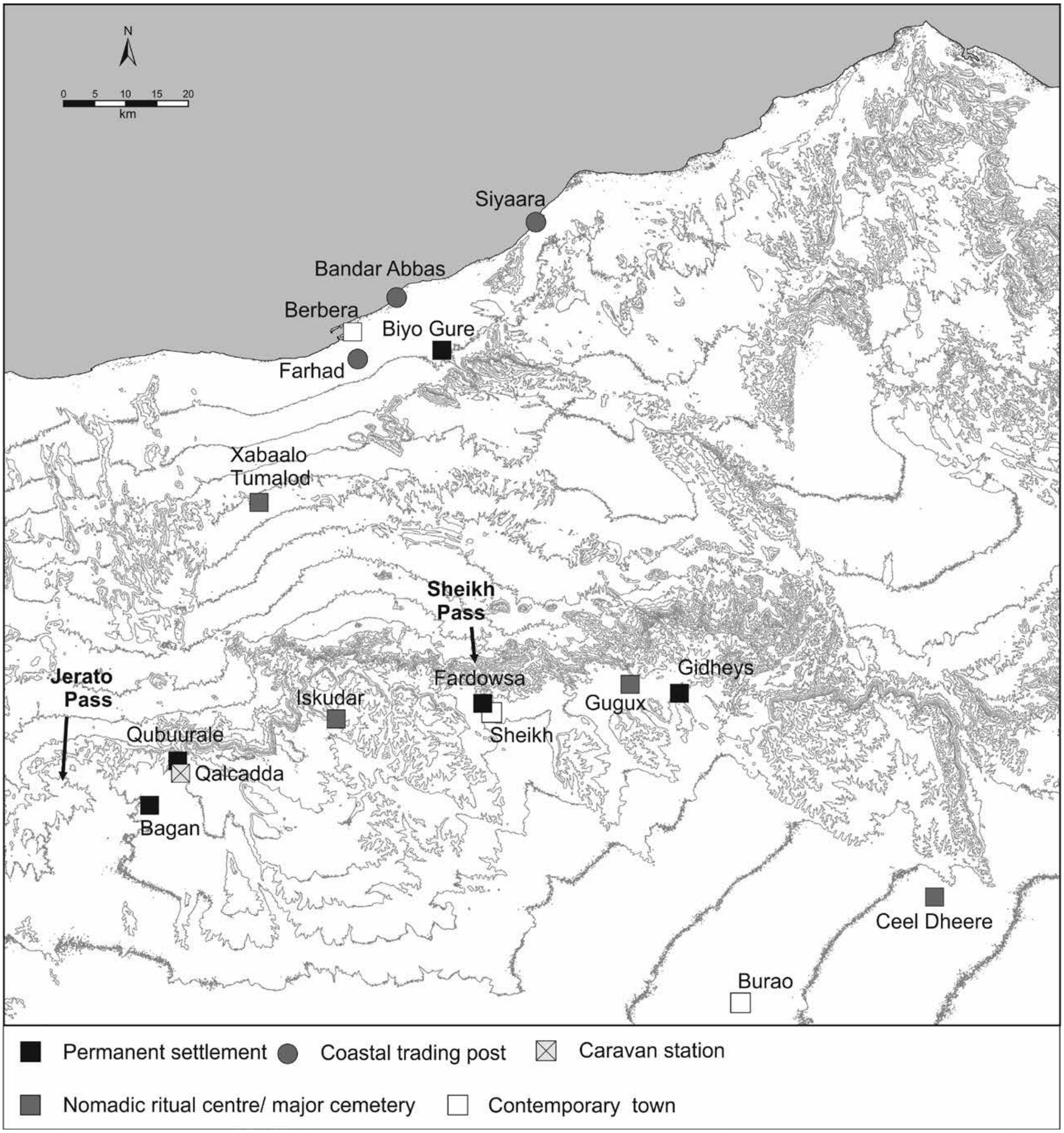

Figure 3. Medieval archaeological sites of central Somaliland.

based on direct exchanges between nomads and foreign traders, grew in complexity with the emergence of a network of permanent settlements throughout the region, some of them having developed into proper trading towns, and the increasing presence of states which vied for the control of the lucrative trade routes.

This increasing complexity has been particularly well-recorded for central Somaliland. Since 2015 and with the help of archaeological research, many of the different agents involved in trade activities have been identified and a significant number of sites has been located. The current case study (Figure 3) focuses on the region around the axis defined by the towns of Berbera and Burao, with the village of Sheikh situated approximately in the middle. This territory covers the three main geographical regions of Somaliland (The Guban or desert-plain-coast, the Ogo mountains, and the Haud plains), and it includes two of the main mountain passes of central Somaliland (Jerato to the west and Sheikh to the east). The selection of such a large area allows to analyze the impact of both seasonal

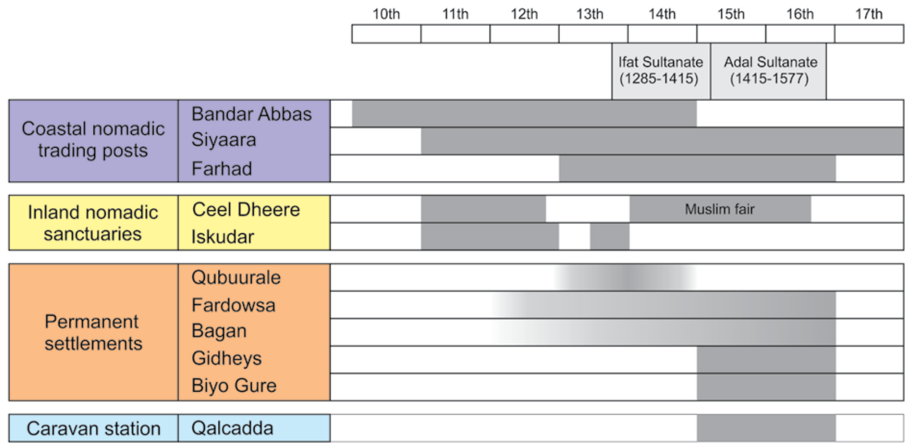

Figure 4. Chronologies of the medieval sites of central Somaliland.

movements and trade exchanges in different contexts, from the coastal trading hubs to the grazing plains to the south.

The region has been relatively well-surveyed in the last years, and as a result thirteen medieval sites have been documented with some detail and eleven of them have been dated with some accuracy (Figure 4). The area was briefly visited in 2015 and it was more extensively surveyed in 2016, when a group of sites were documented following the escarpment of the Ogo Mountains from the Jerato to the Sheikh passes (González-Ruibal et al. 2017). In the same year, several test pits were excavated at the sites of Qalcadda, Quuburale, Iskudar and Fardowsa. In 2017, the important sites of Siyaara and Farhad were documented (González-Ruibal and de Torres 2018), and in 2020, a full excavation campaign was conducted in Fardowsa, near Sheikh (de Torres et al. 2020), combined with surveys in the coastal region around Berbera and short visits to the Burao area. These campaigns have been complemented with remote sensing surveys, which have so far identified 1904 cairns, clusters of cairns, and other structures throughout the region. Although far from comprehensive, this data makes the present case study the best-recorded region in Somaliland from an archaeological perspective. Moreover, the variety and importance of the documented sites allows to elaborate a first overview of the territorial dynamics that took place in the region during the medieval period.

The archaeological information compensates to some extent the silence of the historical record, which for the region under study is almost non-existent. The Portuguese chroniclers mention Berbera relatively often (de Barros 1777: 279, 298) and the Spaniard Luis de Mármol Carvajal (1599: 50) lists several towns in the interior, none of which have been identified archaeologically. Arab sources are even more elusive, since there has not been found yet a single text referring to this region. Therefore, the historical knowledge about this region is very scant. Thus, for instance, it cannot be established conclusively whether the region was populated uniquely by Somali populations, by other ethnic groups or tribes, or by both of them at the same time. We do not know either whether the region was controlled by the medieval sultanates of Ifat and Adal, which ruled over most of southern Ethiopia and western Somaliland between the 13th and 16th centuries. However, there are some hints indicating that this region was under the influence, if not the control, of these states at least during the period of dominion of the Sultanate of Adal (1415-1577 CE): the targeting of Berbera as a military objective by the Portuguese, the existence of a network of permanent settlements, or the fact that the references to the 'land of the Somali' place it further away, in the region of Maydh, some 200 km to the east (Faqih 2003: 27-28).

There is a similar lack of information regarding the process by which the nomads inhabiting Somaliland became islamicized, especially for the central and easternmost regions. Recent research would suggest that the consolidation of Islam in the Horn of Africa was a much longer process than it is generally assumed, and that this process occurred along a primary route that run north-southwards, from the Dahlak Islands (Eritrea) to Shoa (Ethiopia), following the escarpment of the Ethiopian Highlands (Fauvelle-Aymar and Hirsch 2011b: 39-40). Only in the 14th century did Islam progress into western Somaliland through the routes that connected the important cities of Zeila and Harar (Fauvelle-Aymar and Hirsch 2011b: 42). Further to the east, Islam seems to have been restricted to the coastal areas, although locals were considered only thinly islamicized by the travellers who visited the region (Abderahman 1977: 118-120). From the 12th century onwards, there is evidence of proselytizing activities by Muslim missionaries in the coast of Somaliland. Some of these missionaries, such as Sheikh Ishaq ibn Ahmed and Sharif Yusuf Aw Barkhadle, will later become the great figures of the Somali Islam, and their resting places evolved into important pilgrimage centres up to the present (Abderahman 1977: 120-125).

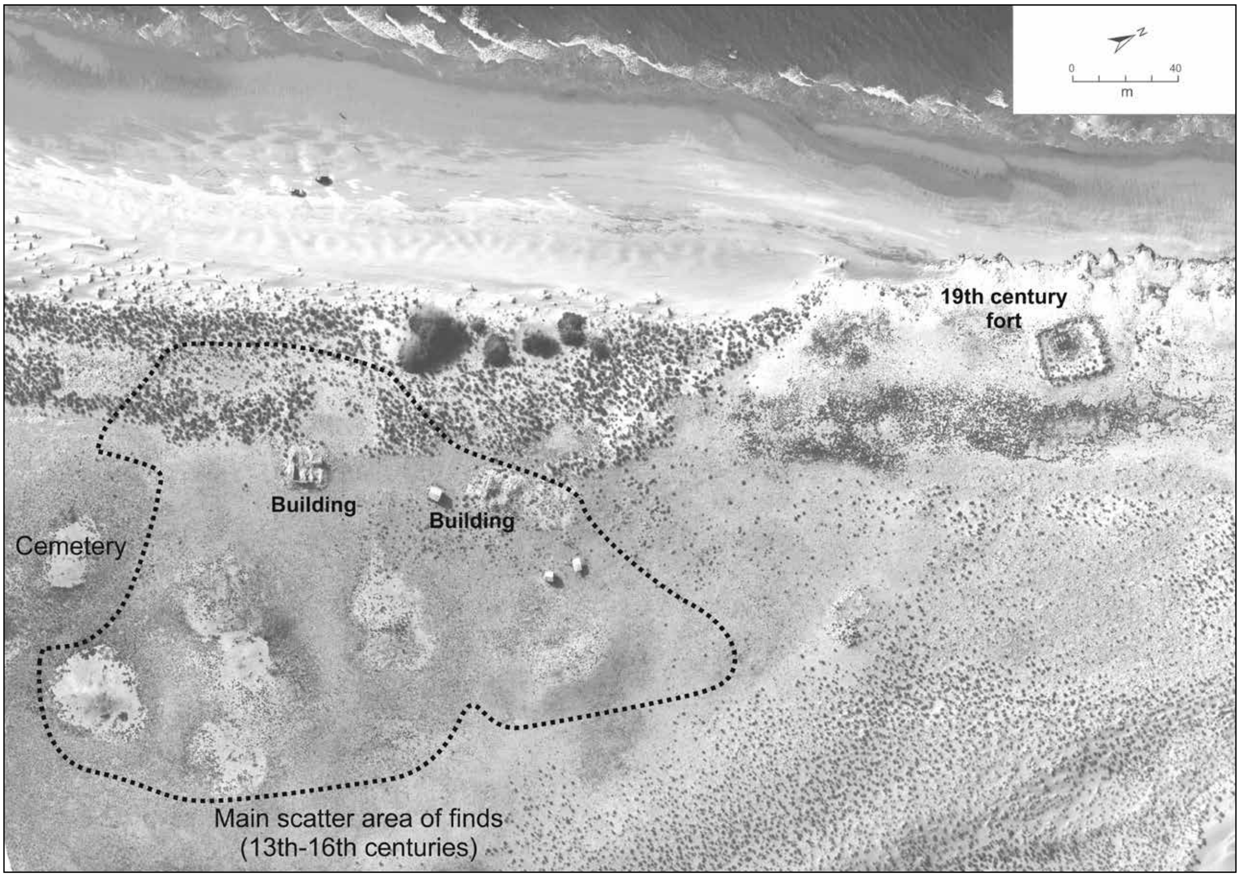

Figure 5. Orthophoto of the central area of Siyaara.

3. The archaeological evidence

3.1. Places for meeting: the nomadic archaeology of Somaliland

In a previous article (González-Ruibal and de Torres 2018) we argued that the nomadic landscape in Somaliland was structured around nodes of contact in the form of gathering places where social, economic and political activities took place recurrently. This repeated activities in a permanent place helped to provide a spatial, temporal and social framework for the pastoral communities that moved throughout the territory. We called these nodes of contact interfaces and made a distinction between those that articulated relations between communities with the same cultural background (internal), and those that regulated interactions between nomads and other groups with different cultural parameters − interfaces of exteriority (González-Ruibal and de Torres 2018: 24-25). These two types of interfaces have cultural but also natural expressions, being placed in liminal areas such as coasts or mountain passes that favor connections. The types of interactions conducted around them were manifold and often overlapped, merging economic, social and religious activities.

The most obvious interfaces of exteriority in the region were the coastal fairs where exchanges took place during the trading season. Activities in these sites represented a recurrent episode in the life of the nomads who met seasonally with foreign traders on agreed upon places, often over centuries. Two of these medieval coastal sites (Siyaara and Farhad) have been documented in the region, in places with poor harbouring qualities but with availability of water. A third coastal site – Bandar Abbas – seems to have combined a trading with a religious purpose.

Of the coastal sites identified in the region of Berbera, Siyaara is the one with a longest history spanning from the 11th to the 19th centuries. Documented in 2017 (González-Ruibal and de Torres 2018) and visited again in 2020, the site (Figure 5) is located around 30 km east of Berbera, covering an area of around 8 ha and occupying a long, sandy plain next to the beach. The ground of Siyaara is densely covered by large concentrations of imported objects such as glass, pottery, stone and organic materials (charcoals, bones and ashes). However, there are few structures on the site: two square stone buildings, a score of cairns and several Muslim cemeteries with thousands of tombs. A detailed study of the concentrations and chronologies of

Figure 6. Imported materials from Siyaara. 1–2. Blue and white porcelain (16th century); 3. Sgraffiato (12th–13th centuries); 4. Yellow Yemeni ware (13th–14th century); 5. Timaha ware (13th–15th centuries); 6. Probable Yemeni imitations of blue and white porcelain (15th–16th centuries); 7. Yellow glaze ware; 8. Green underglaze painted; 9. Green and blue underglaze painted; 10. Green monochrome glaze.

the materials has documented a progressive displacement of the site occupation from south to north between the early and middle second millennium CE (González-Ruibal et al. 2021). According to this study, the oldest period of trade in Siyaara seems to have taken place in a ritual context, given the accumulations of local incense burners, bones, and charcoal that have been found around a large cairn to the south. These materials were mixed with imported pottery dated in the 11th to the 13th centuries (Figure 6). Trade went through a clear expansion during the 15th and 16th centuries, which seems directly related to the heyday of the Sultanate of Adal (1415-1577 CE). Although the site seems to have declined sharply after the collapse of the Adal sultanate by the end of the 16th century, trade was still conducted in the site at least until the 19th century (González-Ruibal et al. 2021: 6).

Located inland, 3.5 km south of Berbera, Farhad extends along the slope of a rocky hill and the immediate plain. The outcrop is very prominent in the landscape and it was probably a landmark for sailors and locals alike. The site consists of an area of 5 ha littered with thousands of scattered materials including imported wares, glass, stone vessels, animal bones, and seashells. The main concentration of materials is located on the slope of the hill and no structures were documented during the two campaigns carried out in 2017 (González-Ruibal and de Torres 2018: 29-30) and 2020 (González-Ruibal et al. 2021: 17). Imported wares are very abundant and their study suggests a chronology coincident with the Adal sultanate period (15th-16th centuries), although its use in previous centuries is well attested by well-known types such as the Yemeni Yellow or the Molded wares (González-Ruibal et al. 2021: 17). Farhad was probably one of the fairs that existed around Berbera during the medieval period. Unlike Siyaara, the occupation of the site does not seem to go beyond the 16th century, although it is difficult to know whether the abandonment was related to the end of the Sultanate of Adal, to the disturbance of the trade routes caused by the Portuguese, or, more simply, to the move of the activities to another nearby site.

The third coastal site is Bandar Abbas, located just 8 km east of Berbera, very close to the mouth of the Biyo Gure river and extending along a consolidated dune of approximately 2 ha. The site was surveyed in 2016, when a rectangular structure of stone and brick, later identified as a mosque, was found. The structure was surrounded by abundant imported pottery and remains of domestic animals. The site was then interpreted as a trading post used by foreign merchants (González-Ruibal et al. 2017: 143-145), but research conducted in 2020 has revealed a far more complex picture. The 2,000 m^2 studied in 2020 (around 10% of the site) have yielded several hearths, scatterings of pottery, glass and bones, buried pots in stone-lined pits, and the remains of a rectangular structure made with camel bones. All were related to a small cairn in a prominent position (González-Ruibal et al. 2021: 3). The study of the imported materials produced a chronology between the 11th and 14th centuries CE, although the main occupation of the site seems to have taken place during the 12th century (González-Ruibal et al. 2021: 5).

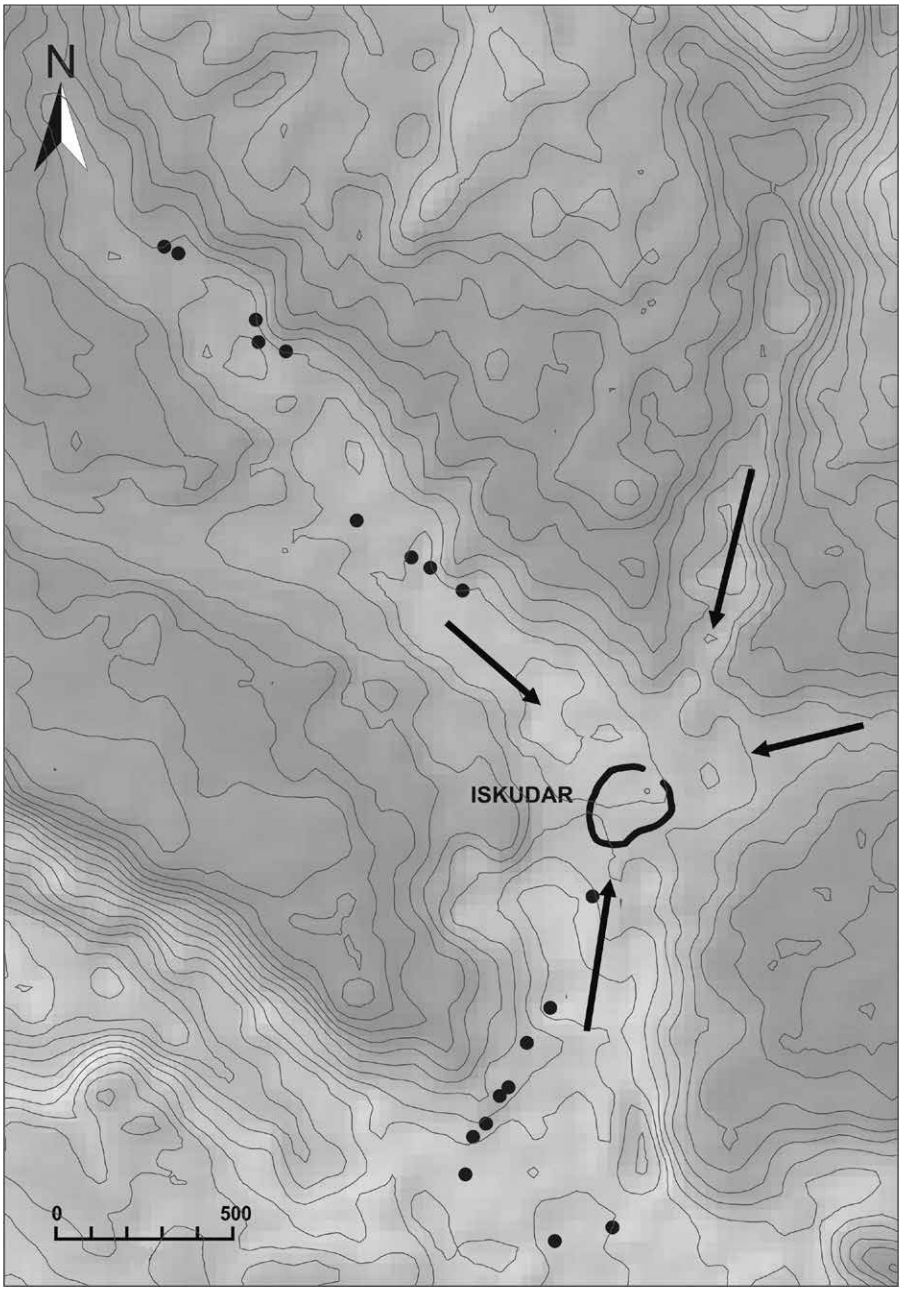

Figure 7. Location of Iskudar, showing the main accesses to the site.

Despite the presence of imported pottery, especially Yemeni and Indian wares but also Late Sgraffiatos, Celadon, and Martaban wares (González-Ruibal et al. 2021: 4), there is evidence that Bender Abbas was not a trading site *stricto sensu*, but a meeting site associated to religious and intercultural celebrations. These celebrations included recurrent feasting as indicated by the high numbers of domestic animals slaughtered, the presence of abundant hearths and of common pottery. The presence of camel remains is especially remarkable, as it is an animal which was not consumed on a daily basis but was typically reserved for important occasions. The local nomads and likely also people from Yemen –as suggested by the large amount of pottery from that region- would have used the site as a gathering place, to celebrate feasts and religious worship (González-Ruibal et al. 2021: 5).

These religiously motivated cyclical meetings, usually connected with the veneration of Muslim saints, are deeply ingrained into the Sufi roots of Somali Islam and are still practiced today (Lewis 1956: 151), often following traditions that can be tracked back to the medieval period. Moreover, everything indicates that they are built on older, pre-Islamic traditions of ancestral worship, as it has been documented for the nearby non-Islamic groups such as the

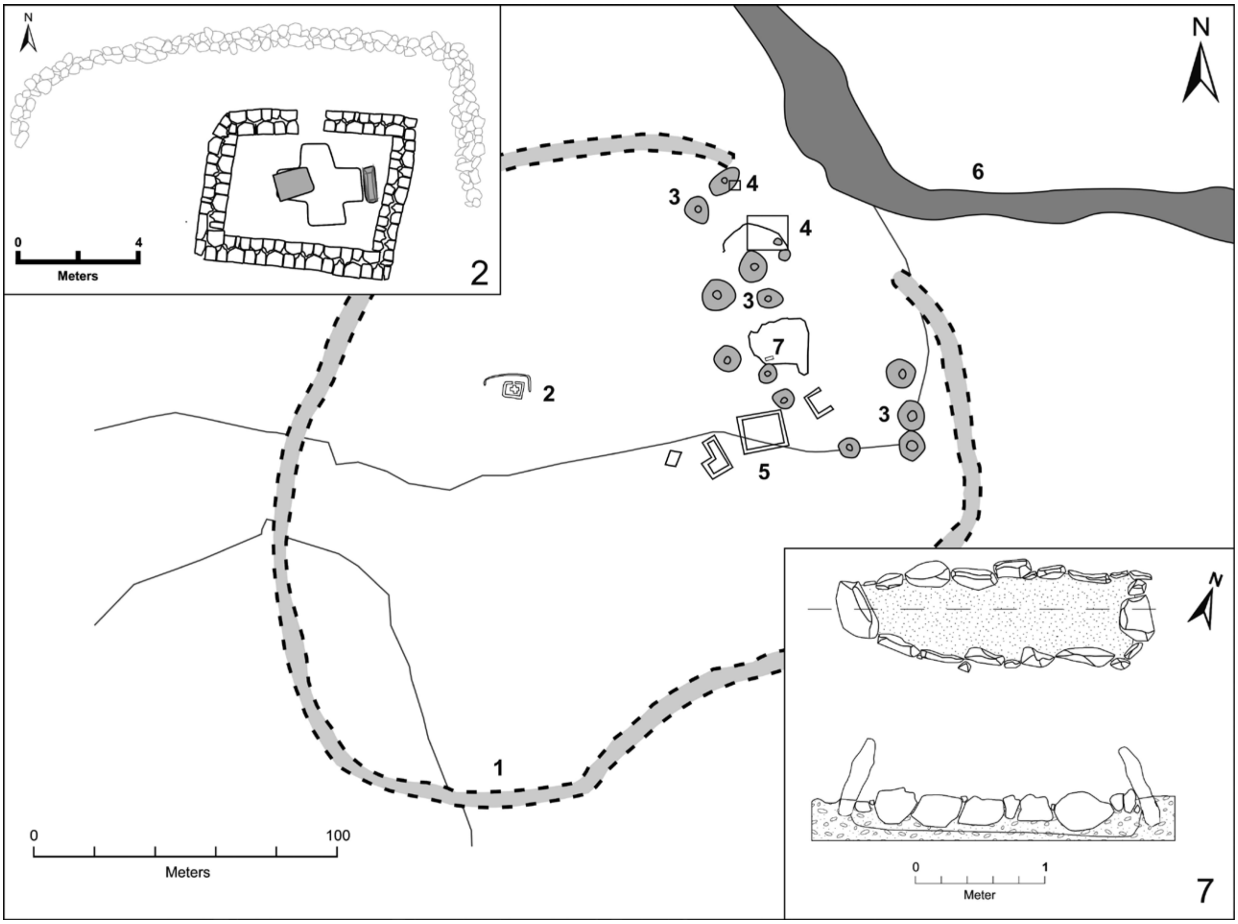

Figure 8: Plan of Iskudar. 1. Ritual fence; 2. Cruciform tomb; 3. Cairns surrounded by a ring of stones; 4. Excavation areas; 5. Buildings; 6. River; 7. Tomb.

Afar (Thesiger 1996: 74). In the case of the studied area in Somaliland, archaeological evidence for this pre-Islamic practice has been identified on sites such as Iskudar.

Iskudar was documented in 2016 by the Incipit archaeological team and it was interpreted as an aggregation centre for nomadic populations, as its name indicates: Iskudar in Somali means 'aggregation', 'mixing' or 'combination' (González-Ruibal and de Torres 2018: 34). The site is located in the escarpment that marks the divide between the inner Ogo Mountains and the coastal plains, thus being a physical interface located at the crossroads of several mountain passes. The site stands at the junction of three streams, with two of its accesses flanked with cairns which can be interpreted as ceremonial markers (Figure 7). The main site is an enclosure of around 3 ha surrounded by a perimeter low wall made of parallel slabs stuck vertically. Inside the wall, which clearly had a symbolic purpose, a significant number of structures have been documented, including large cairns, stone rings with small cairns or cists inside, cruciform tombs, and clusters of cists. All of these features are probably pre-Islamic with the exception of a group of 20th century tombs oriented following the Muslim precepts (González-Ruibal and de Torres 2018: 35).

The excavation of several test pits in an area of cairns enclosed by stone rings exposed a layer of bones, charcoal, cowries, and some hand-made pottery sherds belonging to a incense burner (Figure 8). The latter were lying on an original floor of compacted sand. This evidence has been interpreted as the remains of feasting activities related to ancestors' cults by groups of nomads who would meet recurrently at the site. Interestingly, the dating of two charcoal samples of these layers has provided two different chronologies of the mid-12th century and the late 14th century CE, proving not only the long persistence of these gatherings for several generations, but the reluctance to abandon pre-Islamic traditions in a period when Islam was rapidly spreading throughout Somaliland (González-Ruibal and de Torres 2018: 36-37). The Sufi traditions that prevailed in East Africa were especially receptive to the incorporation of these practices into the new religious framework. The tombs of ancestors were substituted by tombs linked with saints, and these became important pilgrimage sites, such as the well-known

Figure 9. Pre-Islamic cairn at Ceel Dheere.

cases of Maydh and Aw-Barkhadle (Lewis 1998) and likely Bandar Abbas in our region.

Iskudar can be considered principally, if not fully, non-Islamic, although its people were undoubtedly in contact with Muslim communities (González-Ruibal and de Torres 2018: 37). The site of Ceel Dheere, on the contrary, was also used after the Islamization process, probably as both a trading and religious place. Located 37 km northeast of the town of Burao, the site is situated in the Haud plains which are still used as a grazing area for the nomads. It consists of two different areas separated about one kilometre from each other. The first one is a cemetery of several stone rings with cairns and tombs made of slabs; some have stelae at their sides (Figure 9). Although the chronology of this site is uncertain, it is undoubtedly pre-Islamic, with the tombs marked with slabs maybe dating to the early second millennium CE based on parallels from Iskudar. The second site is situated 900 m to the northeast and consists of a mosque, a small Muslim cemetery and several square structures delimited by one row of stones. Two complete pots, buried in the floor, were found close to one of these structures, while on the surface a number of green glass shards from perfume bottles and Yemeni White Cream pottery provide a tentative chronology between the 13th and 16th centuries. This second site has been interpreted as a meeting point for Muslim nomads which would also act as a fair and is a good example of how pre-Islamic meeting centres were resignified and adapted to the new religion.

Although fairs and sanctuaries were fundamental in the structuring of the nomadic lifestyle, they were by no means the only elements in the landscape. Throughout the territory, thousands of burial monuments (cairns and other kinds of tombs) dot the landscape either isolated, in small clusters or in extensive necropolis. They usually appear along the wadis that connect the interior with the coast, or at important natural crossroads such as mountain passes or fords. The variety of tombs that has been documented in Somaliland (Chittick 1992) has likely chronological and maybe also social, ethnic, or geographical readings, but unfortunately extensive research is still needed to understand their role in Somaliland's history. In our region, around 2,000 of these tombs have been documented so far through both field and remote sensing surveys. Most of the tombs appear isolated or clustered, but there are several major concentrations that seem to correspond to proper cemeteries, such as Xabaalo Tumalod (González-Ruibal et al. 2017: 164) or Gugux. Unfortunately, studies in our region are still very scarce (Mire 2015; Cros et al. 2017) and chronologies have not been established yet, although many of the tombs are evidently pre-Islamic (González-Ruibal et al. 2017: 162-163). A proper classification and chronological ascription of the different types of nomadic funerary structures is still a pending task in the archaeology of Somaliland.

3.2. The settlements

So far, six permanent settlements have been located in our region, of which only Fardowsa can be considered a proper town while Biyo Gure, Gidheys, and Bagan are all villages of medium or small size. Of the two remaining sites, Qalcadda has been interpreted as a caravan station (González-Ruibal et al. 2017: 149-152), while the last one, Qubuurale, has a much more complex interpretation (González-Ruibal et al. 2017: 160-161). All of them present a very similar material culture and architectural style and were occupied during a similar period that spans from the 15th to the 16th centuries, with Fardowsa, the biggest one, probably reaching back into the 12th century. They share similar features such as the lack of protective walls and urban planning, the houses being square or rectangular structures built with flat stones and bound with mud. Although all the sites have yielded imported materials, only Fardowsa, Biyo Gure, and Qalcadda seem to have been involved in large-scale trading activities.

Fardowsa is the most important medieval site in the interior of central Somaliland. A major town covering around 35 ha, the city is located at the outskirts of the contemporary village of Sheikh, 60 km south of Berbera. The city is located in the proximity of the escarpment that divides the Ogo Mountains and the desert coastal plain, at the exit of one of the principal mountain passes connecting Berbera's hinterland and the Haud plains (Figure 3). The area has good availability of water and pastures, and the city most likely acted as a resupply stop for the caravans before or after facing the desert coastal plains. The site is covered by dense vegetation to the west and by contemporary constructions to the south, which have severely damaged many of its medieval buildings. The northern and eastern areas are better preserved, and throughout the site large heaps of stone mark the presence of the archaeological remains. Two graveyard areas have been located so far, one to the north and a second one to the south, although the southern one has almost disappeared under the recent urban sprawl of modern Sheikh. Both local and imported archaeological materials are very abundant throughout the site, providing a chronology in the 14th-16th centuries.

Unlike medieval cities in western Somaliland, which were studied as early as the 1930s (Curle 1937), Fardowsa appears in archaeological reports only since 2011, when the site was briefly visited by Fauvelle-Aymar and Hirsch (2011a: 41-42). In 2015, the Spanish Archaeological Project did a preliminary survey of the site and, in 2016, it excavated two tests to the north and the south which documented stone structures and abundant layers of ashes and animal bones (González-Ruibal et al. 2017: 157-159). In 2020, a much larger excavation was launched on the site, clearing around 600 m^2 and documenting two large, rectangular houses with an identical layout (Figure 10; de Torres et al. 2020). These two houses and another rectangular building defined a courtyard whose northwestern side was delimited by a fence. The whole area was interpreted as a compound for an extended, wealthy family. This interpretation is confirmed by the materials documented on the site which include numerous imported pottery and glass from China, Southeast Asia, Persia, Yemen, and Middle East. The quantity and quality of the pieces found so far suggest a close engagement of the owners of the houses in commerce, and also point to the existence of privileged groups in the settlements, something not documented before in the medieval archaeology of Somaliland (de Torres et al. 2020: 34). In the case of Fardowsa, this interpretation is supported not only by the imported objects (Figure 11), but by the large size of the houses (double than the average building on site) and the quantity of bones of camel – an expensive and economically valuable animal -found in refuse pits in the courtyard.

Although more research needs to be done in Fardowsa, the results of the 2016 and 2020 excavations point to the town having served as a trading hub, profiting from its strategic location to provide both supplies and rest for the caravans moving towards or from the coast. Unlike other major towns in Somaliland which have rendered surprisingly few imported materials and where trade just simply passed through (de Torres et al. 2018), Fardowsa seems to have actively participated in this trade, although its exact role has still to be determined. The recent publication of a workshop dedicated to the processing of cowries in Harla, Ethiopia (Insoll 2021), shows that not all the trade goods imported into the Horn of Africa were fully finished, and some products were prepared in intermediate stations. The strong connection between this site and the international trade networks might also explain why Fardowsa was abandoned towards the end of the 16th century, a time that witnessed the collapse of the Sultanate of Adal and the coming to the Red Sea of the Portuguese. Although some buildings continued to be used after the town was abandoned, the almost total lack of 17th-century imported materials seems to indicate beyond doubt that the international network which had existed for centuries was no longer active.

A more dramatic fate seems to have been endured by the village of Biyo Gure. The site was first documented in 1984 (Dualeh 1996: 39) and it was studied in some depth by the Incipit Archaeological project in 2020 (González-Ruibal et al. 2021: 21-24). Biyo Gure is a permanent settlement composed of about 30 structures, located at a rocky spur on the left bank of the Biyo Gure wadi and in one of the natural

Figure 10. One of the two large houses excavated in Fardowsa in 2020.

Figure 11. Imported pottery from Fardowsa. 1, 7. Chinese celadon; 3, 4. Yellow Yemenite ware; 5. Blue and White Chinese porcelain; 6. Martaban; 8-10. Speckled ware.

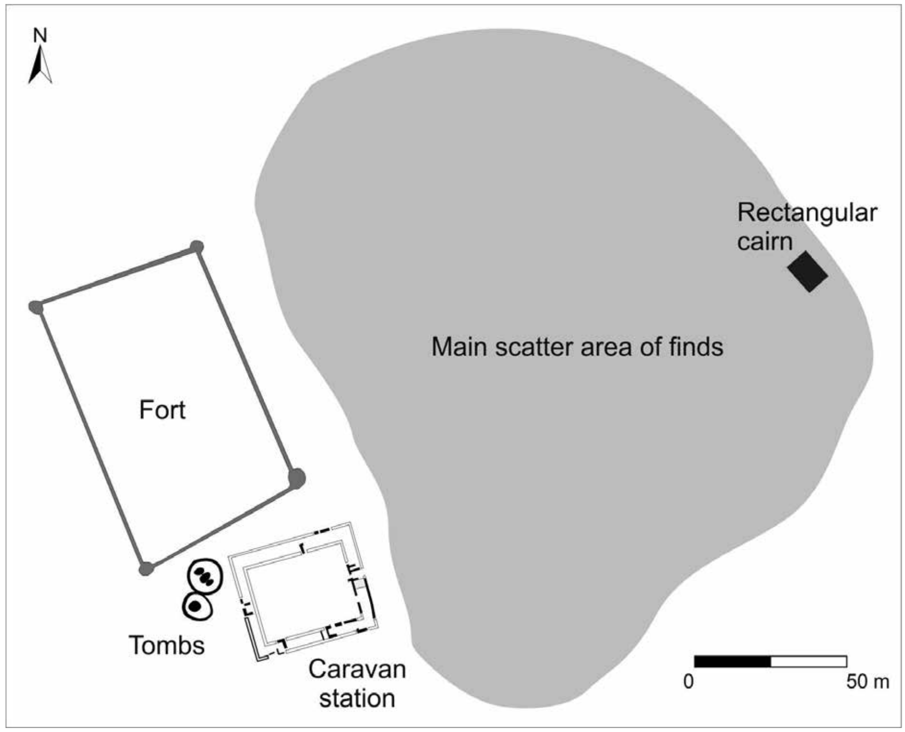

Figure 12. Plan of Qalcadda.

routes to the Ogo mountains. It is the only hitherto known permanent settlement situated in the coastal desert plain; its proximity to a major course, it is to be noted, allowed access to drinkable water and some cultivation, which is practiced still today. The site is narrow, extending about 150 m on an east-west axis and covering an area of about 7,000 m². In contrast with its small size, imported materials were very abundant, consisting mainly of Chinese porcelain and Southeast Asian Martaban and Celadon wares, Yemeni Tihama wares and Speckled glaze pottery, all of them offering a consistent chronology between the 15th and the 16th centuries CE (González-Ruibal et al. 2021: 22-23). The number of imports (significantly superior to the other surveyed villages in the interior) suggests that the site combined agricultural with trading activities, using its privileged position to provide food and water for the caravans which headed to or from the coast (González-Ruibal et al. 2021: 23). The abandonment of Biyo Gure can be inferred from the widespread evidence of destruction by fire in the structures which points to an attack, although the context in which it occurred, and its perpetrators (perhaps nomadic raids, Portuguese soldiers, or locals) are unknown. Whatever the case, the destruction of the village was another chapter in the process that saw the demise of the trade networks that flourished in the area during the 15th and 16th centuries.

The third trade-related site found in the region is Qalcadda, a caravanserai or caravan station. The site was located during the 2016 campaign close to the Ogo mountains escarpment and the Jerato Pass, the main route connecting Berbera and Hargeisa. Qalcadda (Figure 12) got its name (Qalāt is 'fortified place' in Arabic) from the rectangular fort with round bastions at the corners, which lies nearby, a large square building with a central courtyard and rooms distributed around it. As such, it follows the characteristic plan of a Middle East caravanserai. These caravan stations were particularly popular between the 12th and 16th centuries (Onge 2007; Tavernari 2009), offering their services to merchants who used the premises to pass the night and store their merchandises safely. The location of Qalcadda close to the escarpment was, as happened with Fardowsa, of strategic value: it was the first settlement in this region at which a caravan would find shelter, pasture, and reliable sources of water after the hot coastal desert. To the east of these two buildings, an artefact scatter of around 0.8 ha has been interpreted as a trading area, where animals could be unloaded, and exchanges could take place. The survey yielded imports such as Chinese celadon and porcelain, Speckled and other glazed wares, tortoise shells and cowries, while local pottery consists mostly of jars and containers (González-Ruibal et al. 2017: 151). These materials provide a chronology in line with the 15th-16th centuries and which corresponds to the heyday of the Sultanate of Adal (1415-1577 CE).

This chronology has been confirmed by radiocarbon dating at a test pit excavated in 2016 at the east side of the caravanserai, next to the entrance to the building. The same test pit documented the existence of four consecutive floors made of lime, each of them with an occupation layer

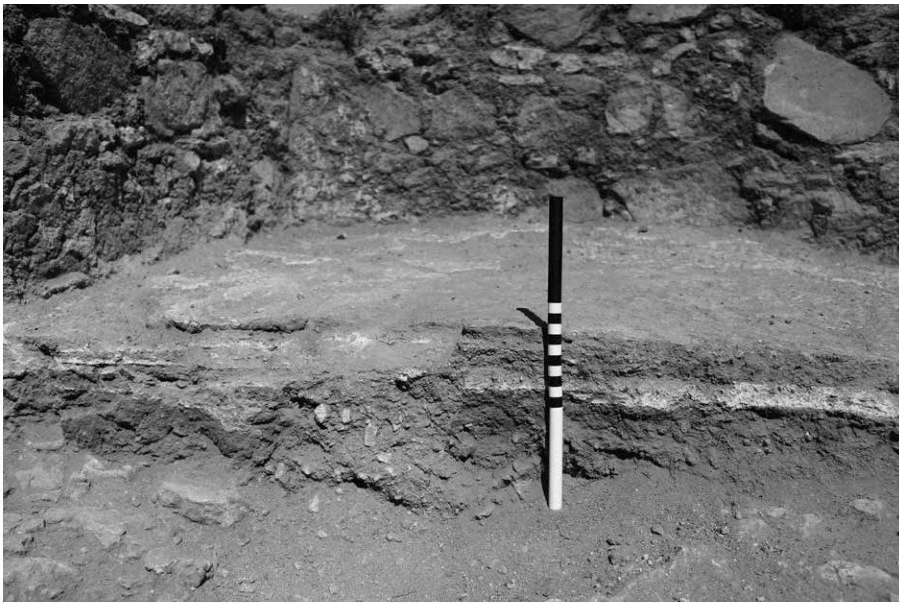

Figure 13. Photograph of test pit at Qalcadda, showing the different plaster floor levels.

(Figure 13). The penultimate of these occupation layers was dated to 318 ± 28 BP (D-AMS-015989, CAIS 24947; calibrated to 1486-1646 CE) placing the most likely use of the room around the 16th century. Besides this date, the evidence of recurrent repairs of the floor shows an investment of resources which indicates a well-maintained site. The effort that was required to construct and maintain the different buildings and to upkeep a garrison seems to rule out that Qalcadda was simply a private enterprise. More probably, the caravan station emerged as a state initiative and should be seen as a manifestation of the increasing control that medieval states exerted over long-distance trade, especially during the period of the Adal Sultanate (González-Ruibal et al. 2017: 152).

It must be noted that not all the sites in the region show evidence of trading activities. Bagan and Gidheys (González-Ruibal et al. 2017: 154-156), for instance, are small or middle-sized villages characteristic of the 15th-16th centuries in Somaliland. These villages consist of small square or rectangular houses arranged in loose clusters, without any trace of urbanism. Bagan (Figure 14) is much bigger than Gidheys (6 ha against 2 ha) and it is organized in groups of houses that could be interpreted as compounds of extended families (González-Ruibal et al. 2017: 154), while Gidheys is more packed. Otherwise, the material culture and general appearance of the sites are basically the same. Regarding the chronology, the lack of datable imports offers a sharp contrast with the materials found at Fardowsa, Biyo Gure, and Qalcadda. Only three imported objects were found at Bagan, offering a general chronology between the 12th and 16th centuries (González-Ruibal et al. 2017: 155), while at Gidheys imports are even scantier and consisted of a fragment of a blue glass bracelet of the same wide chronological range. The same can be said for the site of Quuburale, although, in this case, it is not even clear if the place was a settlement. It consists of several groups of structures, some of them with monumental features, but others consist only in rectangular rooms forming long structures (González-Ruibal et al. 2017: 160). Imported materials were also very scarce, consisting of a Yellow Yemenite ware sherd and one fragment of blue glass which suggest a chronology of the 13th-14th centuries. Although two test pits were excavated at the site, none of them helped in determining its function.

4. Discussion: territory, trade and identities in medieval Somaliland

The sites described in this paper attest of the richness and complexity of medieval life in central Somaliland, and the multiple facets of human interactions and landscape transformations that took place during a period of about half a millennium. However, this same variety can complicate our comprehension of the historical dynamics, their actors, rhythms, and strategies that took place in the region. In order to understand these historical processes and their material expressions we need to consider, on the one hand, the chronological changes in the territory and landscape that took place from the 11th to the 16th centuries, and on the other, the ways these changes were negotiated and implemented by the communities that occupied the region.

By the 11th century, central Somaliland was most probably a world of nomads (Figure 15, sites marked in red). Besides some recent data from the Berbera's hinterland (Gonzalez-Ruibal and de Torres 2018: 25), our knowledge of the archaeology of the first millennium CE is scarce. Only Xiis, an extensive cairn field at the east

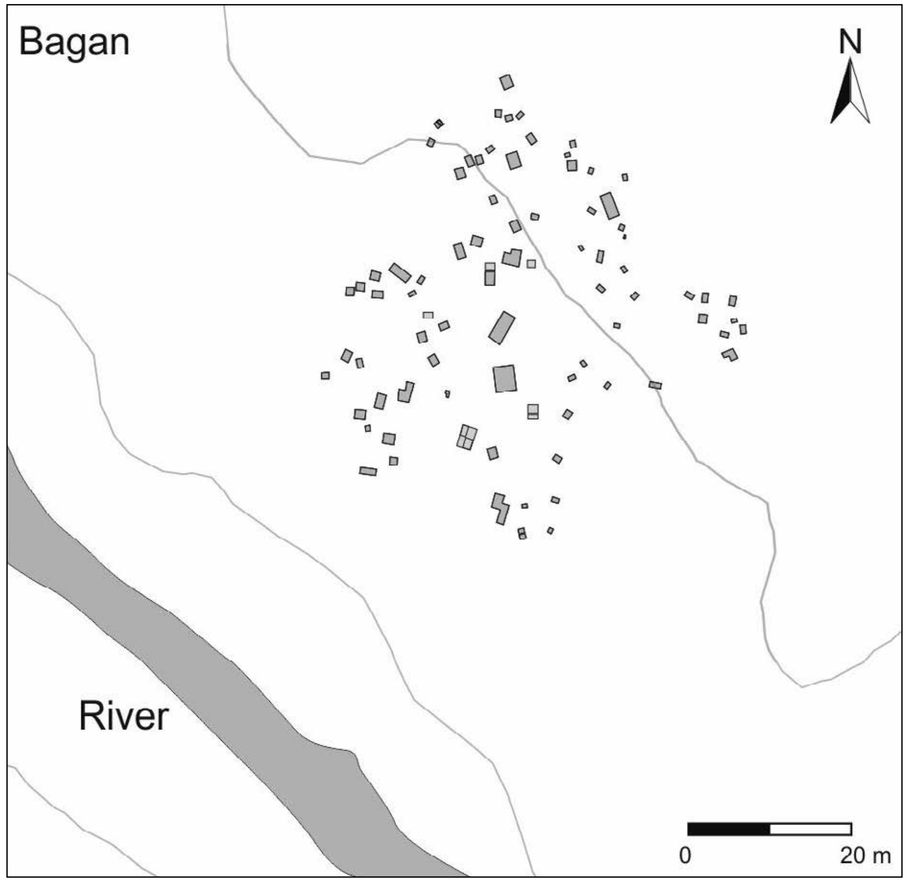

Figure 14. Plan of Bagan.

Somaliland's coast has been systematically researched (de Torres et al. 2019; Fernández et al. in press). Its study attests to the existence of trade with Middle East, the Mediterranean Sea, and India between the 1st and 3rd centuries CE. Therefore, medieval coastal trading places such as Siyaara should be considered later examples of a centuries-old tradition of commerce between nomads and foreign traders. Inland, sanctuaries such as Iskudar or Ceel Dheere would have played a similar role to that of the coastal fairs, helping the nomads to structure their spatiality and temporality, providing safe environments for interactions and facilitating relationships with other groups (González-Ruibal and de Torres 2018: 24-25). Sanctuaries would also favour the connection between nomads and their ancestors, acting as 'contact' surface between this life and the afterworld. It is in this world where, at an undetermined moment during the early second millennium CE, the process of islamisation probably started.

Did Islam actually represent a radical and traumatic change for the nomads of the 13th and 14th centuries? Although more research is needed, it seems that the adoption of Sufism, the type of Islam practiced predominantly in Somaliland until today, eased significantly the tensions derived from religious change, and it was perfectly suitable for nomadic life. The importance given to saints and holy men, the role of pilgrimage sites, and the more individualistic practice of Islam, which are all Sufi traits, seem to have been key in the adoption of Islam by the nomadic societies. Yet, conversion might not have implied complete assimilation, as Sufism incorporated many pre-Islamic beliefs, traditions, and sites which are visible even today (Lewis 1956). As in many other historical cases, conversion involved a significant amount of negotiation, resistance, and syncretism. The fact that Iskudar endured as a pre-Islamic pilgrimage centre during the 13th century proves that Islamisation was not a univocal and welcomed process everywhere (González-Ruibal and de Torres 2018: 36-37).

This manifold situation is what we can find in the early medieval sites of Bandar Abbas, Siyaara, Iskudar or Ceel Dheere, that show the multiple ways in which Islam was negotiated and incorporated into the nomads' lives. Thus, the oldest medieval site we know so far (Bandar Abbas, 10th century) shows already Muslim influences, and has been interpreted as a gathering place for locals and Yemeni groups around an Islamic context which includes a mosque (González-Ruibal et al. 2021: 6). However, this situation does not seem widespread at all: the oldest occupation of Siyaara (11th-12th centuries) gravitated around a large cairn, with rituals undertaken

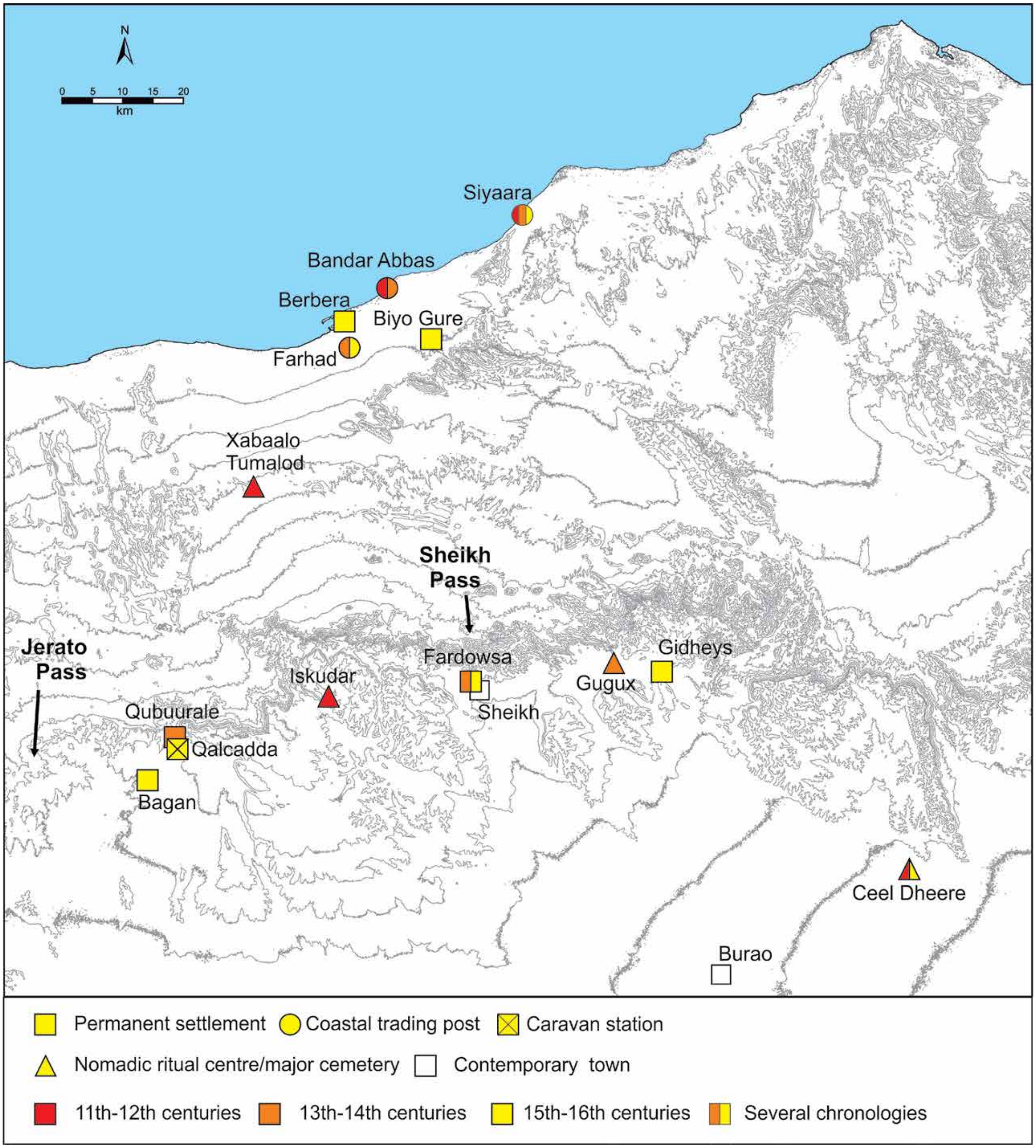

Figure 15. Sites in use in central Somaliland between the 10th to the 16th centuries.

in the traditional pre-Islamic mode. The shallow presence of Islamic influence is even more evident at inland sites like Iskudar or Ceel Dheere, where the occupation around the 11th-12th centuries does not show any evidence of Muslim presence. The territorial, social and identity parameters in the region would be essentially the same as in the first millennium CE, with the main changes taking place around coastal trading posts.

The 13th-14th centuries, on the contrary, seems to have contemplated some deep changes in the region: the expansion of trade perceptible at the coast; the end of some local, indigenous sanctuaries, and the appearance of the first permanent settlements in the interior (Figure 15, sites in orange). Regarding trade, Bandar Abbas continued acting as a gathering centre with a religious and to a less extent commercial role, while Siyaara seems to have evolved into a conventional fair (González-Ruibal et al. 2021: 15), and the fair of Farhad started to function. The increase of commerce is visible in the quantitative growth of fairs and imports and in the increasingly diverse origin of the archaeological recordand, as well as in the appearance of imported materials in inland sites such as Iskudar (González-Ruibal et al. 2017: 166). Although more evidence is still needed, trade may also have been behind the appearance of the first permanent settlements in the region. That is the case of Fardowsa, located at the most strategic position in the region, which could have been established during an earlier period (González-Ruibal et al. 2021: 26). Despite of its difficult interpretation, Quuburale has provided materials from a 13th -14th century chronology (González-Ruibal et al. 2017: 160). The third relevant change is the abandonment of some nomadic ritual centres located in Iskudar and at the oldest phase at Ceel Dheere, which seem to have been abandoned towards the 13th century.

The reasons for these changes are still unclear, but they are probably related to the consolidation and expansion of the Sultanate of Ifat (1285-1415) and to the intense activity of Muslim missionaries which took place during the 13th and 14th centuries. Although it is unlikely that the Ifat Sultanate controlled central Somaliland, it probably played a beneficial role by creating the conditions for the development of stable trading activities, increasing the demand of imports, and, to some extent, favouring relations with other Muslim regions. Indeed, Islam could have created extremely useful conditions for trade: a shared feeling of belonging to the same community, improving safety during travel, and a common materiality expressed in religious structures such as mosques or cemeteries. Both features would enhance trust based on similar values and mindsets, facilitating agreements and deals.

By the beginning of the 15th century, the trends already observed in previous centuries seem to accelerate in central Somaliland (Figure 15, sites in yellow). The amounts of imports grow substantially, with some of the fairs who were active in previous periods now reaching their maximum expansion. Bandar Abbas, on the contrary, will be abandoned, maybe due to the growth of nearby Berbera which, at this moment, according to the historical record, becomes one of the most important ports in the Somaliland coast. Although no medieval materials have been found in Berbera, 16th-century documents and maps are consistent in qualifying that town as one of the three permanent sites along the Somali coast, hence being the target of Portuguese attacks. In the interior, fairs were established in previously used sites such as Ceel Dheere, where a trading area grew around a mosque and several other buildings, just one kilometre away from the large tombs from the 11th-12th centuries.

The expansion of commerce had an impact not only upon the nomadic populations. Permanent settlements grew both in number and extension, and engaged actively in trade, usually providing supplies and safe spaces to rest and trade. Thus, Fardowsa reached its heyday as the most important inland town in central Somaliland, while other places like Biyo Gure are and Qalcadda were founded *ex novo*, most probably with the main purpose of supporting trade routes. However, it would be misleading or at least simplistic to explain the rise of permanent settlements just as consequence of the increase of trade. Some sites like Gidheys and Bagan have yielded extremely low rates of imported materials and seem to be oriented towards agriculture; a feature shared by other sites deeply involved in trade such as Biyo Gure. At the same time, some sites like Qalcadda seem to have been under the tutelage and protection of the Sultanate of Adal (1415-1573 CE) and served to keep peace and safety in what had become a key sector of its economy. Unfortunately, we have almost no information about the territory controlled by the Sultanate of Adal in what is now Somaliland. From the scarce references available, we can infer that western Somaliland was fully integrated in this kingdom, while the territory to the east was home to Somali tribes who only nominally obeyed the Sultans and who had to be military pressed into supporting the state (Faqih 2003: 28). Based on the above, it can be speculated that central Somaliland was somehow in a liminal position, somehow under the influence or the sparse control of the Sultanate of Adal, either directly or through proxies. The development of permanent settlements would parallel that of western Somaliland and Ethiopia, in which trade centres were combined with smaller peasant villages (de Torres et al. 2018).

For the first time, the implementation of a network of permanent settlements challenged the materiality and the landscape of central Somaliland. So far, changes had involved the transformation of pre-Islamic ancestors into Muslim holy men, the re-signification of pilgrimage sites, or a quantitative increase in commerce. Permanent settlements, on the contrary, represented a completely alternative approach to the control upon the territory, with very different economic bases and involving the construction of a radically different materiality. The existence of the permanent settlements was not only alien to the nomadic perception of the world: it also challenged the parameters of social and political equality that characterize Somali society even today. The wealthy households identified in Fardowsa show a radically different approach to prestige than could be expected from pastoralist groups, and they constitute another expression of the depth of the social changes that took place in the region during the 15th and the 16th centuries.

Considering all these economical, religious, cultural, and political changes, it is difficult not to think about the

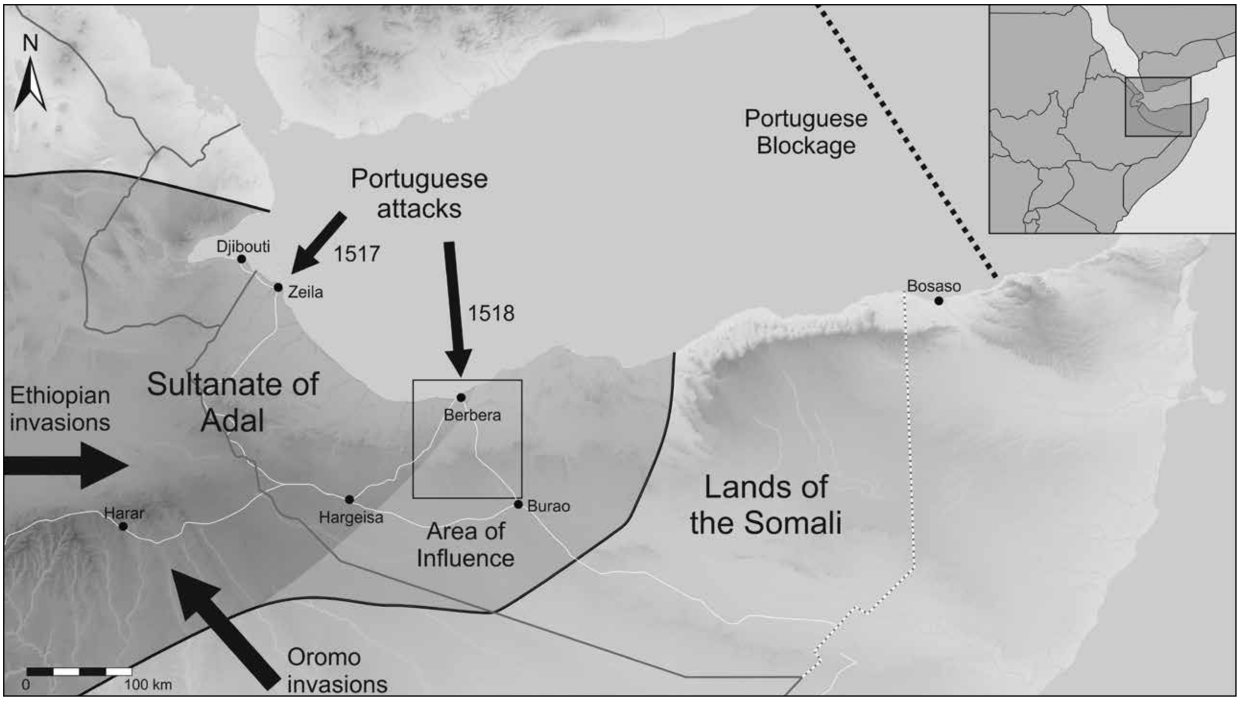

Figure 16. Political situation and the end of the trade networks in Somaliland in the 16th century.

possible social and political tensions or even open conflict that they might have provoked. Yet, there are many indications that suggest this was not the case. Although far from idyllic – the fort of Qalcadda shows that protection was sometimes necessary –, there is strong evidence that the region enjoyed remarkable stability during this period. Significantly, not a single settlement of central and western Somaliland was walled, contrary to what happened at the border region between the Sultanate of Adal and the Christian kingdom of Ethiopia (Fauvelle-Aymar and Hirsch 2011b: 33-34). There is no evidence of trade disturbance until the 16th century, and written texts do not make any references to unrest or conflict in the region. This apparent lack of conflict needs an explanation. In our opinion, conflict was avoided by the development of what we have called 'spheres of interest' (de Torres 2020: 188): key activities or endeavours around which communities with very different backgrounds could get involved in collaborative projects.

In the area studied, two of these 'spheres' were especially important during the medieval period. The first one was trade, the longest and widest collaborative project in Somaliland. The proper running of trade routes and fairs required a close coordination and collaboration between the different stakeholders involved. This coordination seems to have been kept for centuries while the trading system became more complex, moving from simple direct exchanges between nomads and foreign merchants to an elaborate system that involved nomads, traders, permanent settlements and state-run caravan stations. In fact, it is likely that the involvement of nomadic societies in this activity increased through time, as they were the only dynamic agents which connected the geographically scattered nods of the trade network, from coastal trading posts to towns and caravanserai. The second sphere of interest of relevance for central Somaliland was, as it was noted above, Islam, which provided a shared identity around which these groups could interact and collaborate. Moreover, Sufi Islam probably built a bridge between the nomadic pre-Islamic beliefs and the Muslim predominant world of the 15th and 16th centuries, thus facilitating a transition which was probably complex and contested. These and other spheres of interest (de Torres 2020: 183-187) helped to develop remarkable conditions of stability in the region that may have lasted for centuries.

Such a fluid but highly adaptive system started to be challenged towards the beginning of the 16th century (Figure 16), when the Portuguese presence in the Red Sea severely disturbed international trade. Some decades later, the Muslim defeats against the Ethiopians and the immediate Oromo invasions provoked the collapse of the Sultanate of Adal. The disappearance of trade and state structures had an immediate effect on the network of permanent settlements in central Somaliland: none of the sites seems to have continued their activities beyond the 16th century and along the coast only Berbera and

Siyaara seem to have endured, although 17th century imports in Siyaara are negligible (González-Ruibal et al. 2021: 15). Whilst more information is needed from archaeological and historical research on Somaliland during the 17th-19th centuries, the hitherto know evidence indicates that the settlement dwellers embraced nomadic life, and, although some trade still took place occasionally, pastoralism became the main way of life until today.

5. Conclusions

In this paper, we argue that trade in central Somaliland represented not just an important economic activity, but it also played a paramount role in structuring large territories, and it became a fundamental tool to ease tensions between communities with very different cultural backgrounds, or between these communities and the state. Indeed, trade provided stability through processes of religious conversion, state building and territorial reorganization. Against the backdrop of these transformations, the nomads were not only able to endure but to thrive, adapting and incorporating new groups to the system in an increasingly sophisticated model that was to endure several centuries. The fact that this system finally disappeared, and that trade networks and permanent settlements were abandoned should not lead us to think of the history of trade in Somaliland as a collapse, or as an aborted process by which a society that was becoming more and more complex, returned to nomadism. That approach would not only be misleading, but it would also be inaccurate and deterministic, assuming that increasing complexity, statehood and urbanism are always logical and desirable. International trade disappeared, but the Somali society did not collapse: it adapted to the historical context as it had done many times before, and it did so with enduring efficiency, so much so that nomadic culture has ultimately been identified as the traditional lifestyle of the Somali people until today.

6. Acknowledgements

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A cross-craft approach to ceramic, glass and iron in the Early Middle Ages. The resources of workshops from southern Belgium

Line Van Wersch, Martine van Haperen and Gaspard Pagès

1. Introduction

The Early Middle Ages are a period of strong political and social mobility. This period truly marks the end of the Roman as well as the beginning of medieval society and economy (Wickham 2000). With the fall of the Western Roman Empire, in its northwestern part, the power goes first to the Merovingian kings and at the end of the 7th century CE, they are replaced by the Carolingians. Under their rule, the aristocracy becomes more powerful and changes the rural world by organizing manorial complexes[1] (Verhulst 2002; Devroey 2003). This period also sees the growing supremacy of the Christian faith that goes along with the intensifying foundations of churches and abbeys who possesses large estates and hosts craft activities (Lebecq 2000; Henning 2007). Next to them, emporia emerge on the coasts of the North Sea. These ports have a clear commercial orientation and appear as economically dynamic agglomerations (Tys and Loveluck 2006; McCormick 2007). Some historians view the transition from the Merovingian to the Carolingian period as a time of demographic and productive growth due to the rural reorganization in which the North Sea is a zone of active exchanges (Wickham 2000; Verhulst 2002; Devroye 2003). Others however believe the new organisation of the rural world can just as well lead to the ruin of productivity and to the inhibition of efficiency and innovation due to the strong paralyzing domination of the elites (Henning 2007). Nonetheless the early medieval elites are regarded as leading the economy and as responsible for cultural change (Wickham 2008).

With the ERC Advanced project 'Rural Riches' (2017-2022) Theuws questioned that point of view and considered the role of the rural population in the economic development in northern Gaul after the collapse of the Roman Empire. In his opinion the mass of objects found in the graves, especially those of the 6th century CE, show that rural dwellers had access to local, regional, and global exchange networks and that they could have triggered economic growth. In order to substantiate this hypothesis, a large amount of data has been collected from sites, their material culture, and burial rites in northern Gaul, allowing the analysis of the distribution patterns by means of GIS and the contextual analysis of finds. The 'Rural Riches' project also employs instrumental

Line Van Wersch
Université de Liège – CNRS, ArScAn UMR 7041

Martine van Haperen
Leiden University

Gaspard Pagès
CNRS, ArScAn UMR 7041

1 The lords possessed and ruled rural estates exploited by labourers supporting themselves and their lords who had to protect them in return.

In: Brysbaert, A., Vikatou, I. and Pakkanen, J. (eds) 2022. *Shaping Cultural Landscapes. Connecting Agriculture, Crafts, Construction, Transport, and Resilience Strategies*. Leiden: Sidestone Press, pp. 275-277.

analyses on various categories of objects as well as the study of ancient DNA and isotopes. Thanks to these new data, Theuws and his team aim at formulating new models on structural and dynamic aspects of the early medieval economy. In these, they will consider the links between ritual, production, and exchange, as well as the nature of demand, material culture, and the relations between production and the imaginary world.

In a Marie Skłodowska-Curie project, called EMPyr (2021-2025), the artisans are considered as the starting point of technical changes that precipitated into wider changes and transitions in the Early Middle Ages, more specifically at the 8th century CE, the fringe between the Merovingian and Carolingian periods. Indeed, for this period, the scholars have traditionally favoured demand, while disregarding the realm of production (Moreland 2000; Wickham 2000; Theuws 2007) and, up until now, the studied production lines were mainly of the agrarian type (e.g., Dierkens et al. 2017). Craft production has long been neglected as it left almost no written traces. Until Henning's work published in 2007, there was no global inventory of the archaeological traces of craft activities in the Frankish territory. Henning (2007) presents an overview of Merovingian, Carolingian, and Ottonian archaeological sites (6th – 11th centuries CE) between the Loire and eastern border of Bavaria, with evidence for non-alimentary production surpassing the household level. This includes glass working, ferrous and non-ferrous metal processing and pottery production.

From the Roman to the Merovingian period, there is a significant shift in the location of production from ancient agglomerations to single workshops in small rural settlements and rural craft centres with multiple workshops. There is still some artisanal activity in the old Roman towns, but this is dwarfed by the evidence from the countryside. Production took place on a smaller scale, but nevertheless still had substantial yields, as evidenced by the lavish funerary record from this period. The predominance of rural production in single workshops and craft centres persists into Carolingian times. Production in old Roman towns seems to decline somewhat further in this period. Monastic sites however, which show almost no artisanal activity in the Merovingian period (476-751 CE), take on a noticeable role during the Carolingian period (751-987 CE). Finally, there is an increase of production in the so-called proto-urban trading sites or emporia. These modifications in the location of craft production must have reflected, and also introduced substantial changes in the social structure of early medieval society.

At the same time, the pyrotechnologies, especially ceramic, glass, and iron underwent profound technical changes. The most emblematic is certainly that of glass production, changing the fluxing agent from soda to potash glass, at the end of the 8th century CE (Wedepohl et al. 1997; Van Wersch et al. 2016). By using material available in northwestern Europe, glassmakers first put an end to the dependency on oriental primary productions with natron, only available in the eastern Mediterranean (Foy et al. 2003). Secondly, in the 8th century CE, between the Loire and the Rhine, the Merovingian ceramic characterised by biconical dark pots or red bowls (Siegmund 1998; Châtelet 2002; Van Wersch 2011) was replaced by white products with a more limited morphological repertory (Gross 1991; Châtelet 2002). If the first had a regional diffusion, the second were spread from centralised production centres over greater distances (Verhaeghe 2003). Finally, Carolingian documents reflect a new start in iron production at that time (Sprandel 1969) with the existence of large rural iron workshops and villages of blacksmiths (Verhulst 2002). This period also witnessed significant modifications in forging. Damascene blades obtained by pattern welding, the most common during the 6th and 7th centuries CE (Rogalla von Bieberstien and Dillmann 2011: 196), seem to decrease during the 8th century CE (Coupland 1990), almost certainly as a direct consequence of the development of improved forging techniques that produced blades of higher quality steel. All these modifications imply changes in the material resources used that might explain or be due to the relocation of the workshops.

In order to tackle this phenomenon, the present paper examines the locations of production activities and tries to evaluate how the geological resources may have influenced the settlement process. Our approach starts from the raw material used by craftspeople, especially because its procurement is essential for the production. We therefore focus on a limited area holding the resources used to make glass, ceramic and iron: the south of current Belgium, Wallonia. The region is crossed by the Meuse river which was a major communication axis along which several settlements are attested (Plumiers and Regnard 2005). Both recent and older excavations delivered a reasonable amount of archaeological data regarding artisans' productions in both rural contexts and agglomerations (Van Wersch et al. in press). In addition, this region is at the heart of the Loire-Rhine area that had both unusually rich landowners and widely available artisanal productions during the Early Middle Ages (Wickham 2000). The Carolingian family has its roots in this specific territory (Close et al. 2017) and some of the places under their influence developed to become wealthy monasteries or bishopric seats.

In order to fully understand these productions and their changes, we consider, in addition to the natural factors, cross-craft interactions because one production process could have triggered innovation in others. This approach provides a framework to study one craft at a time as well as considering several crafts comparatively

Site	Production	Start date	End date	Remarks
Macquenoise (?)	Glass (?)	540	610	uncertain identification
Stavelot	Glass	650	900	
Huy – aux-Ruelles	Glass	475	525	
Huy – Sous-le-Château	Glass, Iron	575	700	general date 400-700, glass production dated end 6th-end 7th century CE
Huy – place Saint-Séverin	Glass, Iron	550	700	glass production dated second half of the 6th-beginning of the 7th century CE
Namur – Grognon	Iron, Pottery	450	700	iron working debris deposited in the final phase
Huy – quartier de l'hôpital	Iron			no specific date
Huy – Saint-Hilaire	Iron			no specific date
Huy – Avenue des Ardennes	Pottery	500	700	
Huy – rue du vieux-pont	Pottery	500	700	
Huy – Saint-Jacques	Pottery	550	650	
Huy – Batta	Pottery	600	700	kilns dated to 700
Huy – Parc Struvay/rue Godelet	Pottery	675	800	dated from the end of the 7th-8th century CE by Willems (?) – uncertain dates
Marilles – Mossembais	Pottery	650	750	
Quévy-le-Grand – Rue des Soeurs	Pottery	650	800	

Table 1. early medieval workshops for production of glass, pottery and iron excavated on the current territory of Wallonia.

(McGovern 1989; Costin 2005; Miller 2007; Brysbaert 2007; Brysbaert and Vetters 2010). The concept of cross-craft interaction has never been applied to the Early Middle Ages so far. The actual division of the work and specialisation lead researchers to consider glass, ceramic, and iron as separate, and these pyrotechnologies have usually been studied independently. However, as for other periods (Brysbaert 2007: 333), in the Middle Ages, the same person may have mastered several skills and practiced different arts, such as the monk Theophilus who wrote about recipes and techniques of paintings, glass and metals (Bontemps 1876). The juxtaposition of the different pyrotechnologies in artisanal quarters may also have facilitated sharing and exchange of goods, materials, tools, technical knowledge, and ideas (Van Wersch et al. in press). For example, the supply in raw material might be shared by more than one craft (Brysbaert 2007: 330, 347). The co-location of these craftspeople could also promote reciprocal emulation and acquisition of skills that could lead to innovation, especially when they worked in the same building, for the same people or in the same network.

2. The location of the workshops, a new assessment

Within the ERC Rural Riches project, we are creating an updated inventory of all archaeological data from pyrotechnological activities from the Merovingian period in the area between the Seine and the Rhine. For this purpose, we have meticulously sifted through numerous regional overview publications and excavation reports, and we have also consulted Henning, who kindly allowed us access to the data he gathered for his 2007 article. This has resulted in a comprehensive overview of workshop sites in the research area. Unfortunately, many finds from production sites have still not been studied or published in detail. It is often unclear for how long workshops were in use and at what scale production took place. Add to that the problems of taphonomy and preservation that archaeologists always struggle with, and it is clear that we are working with an imperfect and limited sample. Nevertheless, some very interesting details have come to light in this study, offering useful insights into the early medieval economy and the modus operandi of early medieval artisans.

For the period running from the 6th to the 8th century CE, 45 ceramic workshops, 20 glass working sites and 76 places with traces of iron metallurgy are recorded between the Loire and the Rhine. Of these, eight pottery production sites, four glass workshops and five iron smelting and smithing sites were located in Wallonia (Table 1 and Figure 1).

Most of the workshops were found in two Merovingian agglomerations: Namur and Huy. The site 'le Grognon' in Namur, delivered iron slags from the 7th century CE, together with crucibles fragments for copper alloy working (Plumier et al. 2005: 223). Two other kilns for ceramic production were also discovered more recently on neighbouring sites in the same city (Van Mechelen et al. pers. comm.). In Huy, Willems and Witvrouw (2005) recorded that nine Merovingian pottery kilns were uncovered, and that production wasters were attested in two additional locations. Glass production took place in at

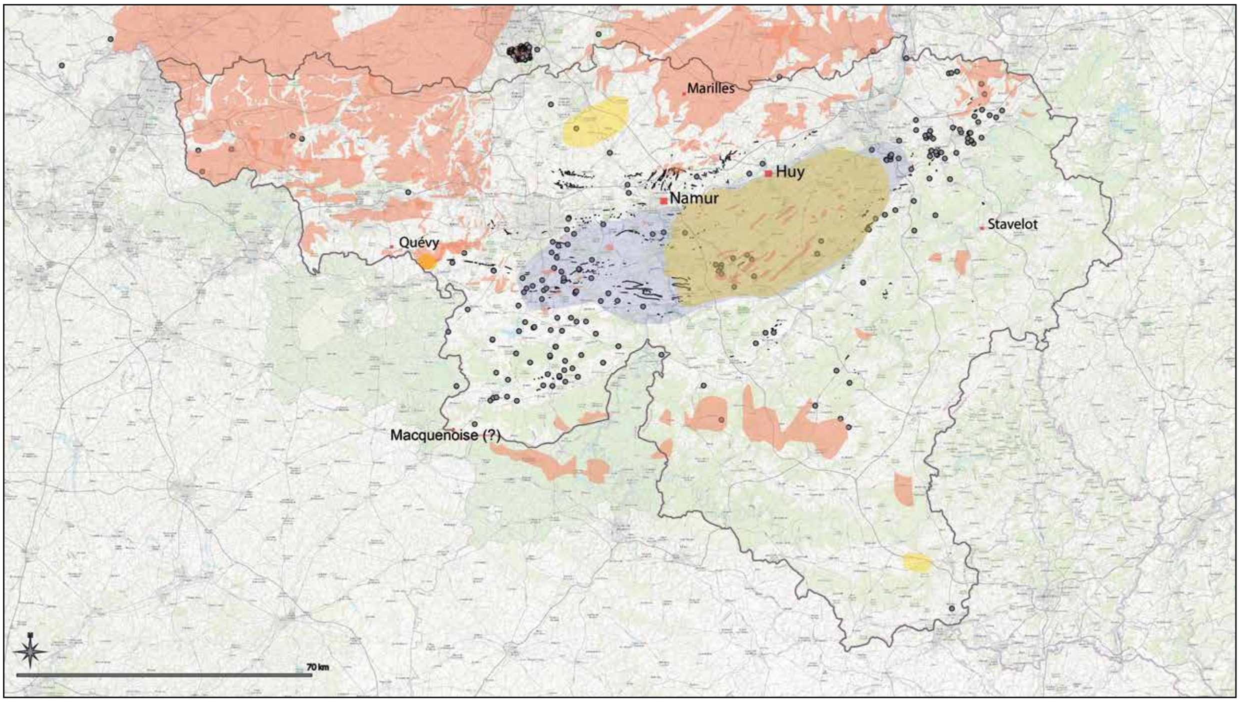

Figure 1. Map with the location of the workshops mentioned in the paper and the raw resources. Clay resources in orange (from Rekk 2104); zones with white sands in yellow; location of iron ores in black and smelting sites corresponding to grey dots. The blueish area corresponds to the Condroz region (map created with Qsig 3.22).

least three sites from the 5th to the 7th century CE. Still in Huy, wasters and two kilns were found on the site called 'aux Ruelles' (Péters and de Bernardy 2016) and iron slags are attested at different places (Péters and de Bernardy 2016). Next to the remains of ceramic, glass and iron, related traces of bronze production also exist in the same places as well as the remains of antler working (Péters and de Bernardy 2016).

Ceramic productions could be located in rural areas outside these Merovingians centres. One pottery kiln was discovered in Marilles (Mercenier 1962) and another in Quévy (Danesse et al. 2016: 127). While the latter can be dated between the end of the 7th and the end of the 8th century CE, the production of the former is typical for the Merovingian period and should be situated in the 6-7th centuries CE. From this period, there is also indirect evidence for ceramic production at several other locations. One can be situated in the Condroz region, a karst (limestone) plateau located between the Meuse river and the Ardennes massif (Figure 1), stretching 130 km from east to west, because the potters used a clay characteristic of that region (Van Wersch et al. 2020). Next to this, the numerous wares found in the cemeteries show technical and material peculiarities indicating that several productions existed and that settlements had access to multiple suppliers, but the exact locations of their workshops remain unknown (Van Wersch 2011).

Regarding glass craft in Wallonia, only secondary production occurs. It relied both on recycling and on imports of raw glass transported over long distances. In addition to the workshops from Huy and certainly Namur, an additional one has been reported in Macquenoise (Chambon and Arbman 1952). Even though, it was proved that an important number of glass objects were counterfeit by Chambon (Fontaine-Hodiamont and Wouters 2012). A recent study of the remains leads us now to doubt the identification of this site as a glassworkshop. One more glass production site was found at the abbey of Stavelot, in contexts dating between the end of the 7th and the end of the 9th century CE (Figure 1). The fragments of crucibles, glass wasters and pieces of kilns at this site could be related to the manufacture of architectural glass, most certainly tesserae, that was meant to decorate the church(es) and buildings of the monastery founded by saint Remacle at the end of the 7th century CE (Neuray et al. 2019).

Traces of iron metallurgy dating to the Early Middle Ages are only reported in Huy and Namur (Table 1 and Figure 1). These sites, from which the artefacts still have to be studied, are most certainly related to forges and not to ore treatment. In addition to these places and thanks to the discovery of slags, 172 smelting sites (direct iron process) have been inventoried, by Serneels (in the 1970s), Houbrechts and Petit (2003) and Pagès (Pagès et al. forthcoming). So far, the reported locations could date from Protohistory to the middle of the Middle Ages, including the Early Middle Ages. Only some of the smelting sites can be identified as clearly Roman, especially in the Entre-Sambre-et-Meuse region, but the others cannot be accurately dated. Still, this inventory allows us to identify clear concentrations of these traces in certain zones and the total lack of them in others (Figure 1).

Considering these data from a limited territory, the Merovingian artisans practising pyrotechnologies seem to have settled preferentially in the agglomerations, although they were present in rural contexts as well, specifically pottery and iron. Parallels can be drawn with the rural settlements discovered in the north of France where, if iron metallurgy is rather common, ceramic production is rare and glass craft is not attested at all (Peytremann 1995: 12-14). After the 7th century CE, there is a clear lack of archaeological evidence for craft production in the agglomerations. This already lead Theuws (2007: 162) to wonder where the artisans of the 8th century CE were located. In the considered territory, the potters' workshop of Quévy for ceramic production and the glassmakers of Stavelot are the only ones dating after the Merovingian period. This matches with the conclusions of Henning who noticed a continuous decline of production in old Roman centres and an increase at monastic sites during the Carolingian period (Henning 2007). Still, more traces should be sought out, especially in areas where potential sources of raw materials were located.

3. The sources of raw materials

Based on the work of geologists, especially that of Rekk (2014), clay is a quite common material in the south of current Belgium. Large deposits are available in the area (Figure 1). To these deposits, the river clays can be added. Still, the clays that will give white pottery are more limited to the Condroz region. White clay is also attested south of the Meuse river and to the east of the territory, close to the German border (Goemaere 2010; Rekk 2014). From the map, it appears that some areas, especially in the Ardennes, seemed quite poor in clay material.

Before the end of the 8th century CE, the material necessary for glass production was imported from other regions. Then with the change of fluxes to wood ash glass, the glassmakers would have had to find the right sand for glass production. Wedepohl et al. (2011: 89) assume that the glass workshops were established in the woods. The glassmakers avoided the rivers sands and preferred to use tertiary sands available in a nearby area. In Wallonia, sands are numerous and varied, but geologists paid them limited attention (Macar et al. 1947: 125). At the moment, there is no general inventory of sands, and the only mapped deposits are limited to potential places for current sand extraction (Poty and Chevalier 2002). The tertiary sands are a discontinuous cover lying on older deposits. At the northern reaches of the Meuse river, they are distributed without connection with the substratum. They become more continuous and deeper to the north of Belgium, in Flanders under the loess deposits (Macar et al. 1947: 125). Quite substantial deposits were exploited at the southern end of the Meuse river in the karstic depressions lying in the Condroz region. In the karstic traps, these sands were associated with gravel, clay (sometimes white clay) and lignite (Goemaere 2010: 409). Among these deposits, some were used in 19th century CE glass production such the famous crystal of the Val Saint-Lambert (Macar et al. 1947: 139). In the Walloon Brabant, white quartz sands are also attested and could be very deep. These are also present in the northwestern part of the present province of Namur and in the northeastern part of the Hainaut. Around Mont-Saint-Guibert et Chaumont-Gistoux, they were exploited for the glass industry, such as the sands at the eastern border of Wallonia (Macar et al. 1947: 140). Finally, white fine sands were used for the glass industry west of Arlon, in the south of Wallonia (Macar et al. 1947: 146). Even if these deposits cannot be mapped properly, at least some zones that could have been more interesting to find materials for craft activities are pointed out (Figure 1). In that regard, the Condroz is of particular interest.

This region also contained large quantities of iron ore, in the form of limonite, extracted from clay-sand karst filling as well as seams of ore derived from sulphide oxidation. All deposits date to the Dinantian (-358,9 ± 0,4 to -330,9 ± 0,2 millions of years) or the Famennian (-372,2 to -358,9 millions of years) Paleozoic Ages (Denayer et al. 2011). The iron ores from Wallonia were listed and geolocalised by Denayer et al. (2011). In addition to the Condroz resources, this work points out additional concentrations of smelting sites which illustrates the existence of iron ores nearby, along the Meuse river (Figure 1). The Entre-Sambre-et-Meuse area can be distinguished by the number and the concentration of iron smelting sites and of the iron ore deposits (92 smelting sites, including 36 from the Roman period). The Soignes Forest, close to Brussels, the current capital of Belgium, also yields abundant evidence of smelting practices.

Next to the raw materials that will be transformed (clay, sand and ores), the crafts of ceramic, glass and iron also required water and wood. The quantities of wood vary depending on the craft, but this material is found more or less everywhere in the territory, and it was probably not a constraining element for the location of workshops. Finally, clay was needed by the three crafts in order to build the kilns and the furnaces. As this was a common material as well, it probably did not constitute a limiting factor for the placement of a workshop.

4. Discussion: a first crossing of the data

It appears that the Merovingian artisans settled at first in the agglomerations, along the river Meuse. Natural resources are also attested in and around these places. Clay was easily accessible and proven to be used by the potters. The petrography and the chemical studies of their productions showed that they worked with local resources even if those were not the most suitable (Van Wersch et al. 2015). Outside the settlements, iron ores are at hand around Namur. In smaller amounts, some are also located near Huy (Figure 1). The glass production of that period rested on imported and recycled materials. Those were probably more easily accessible in the agglomerations, especially close to a communication axis like the Meuse. The river and its affluents joining it in Namur and Huy also provided water. Wood was abundant in the vicinity. All the materials required were therefore present. Moreover, in these places, the existence of living quarters as well as churches (Péters and Fontaine-Hodiamont 2005; Plumiers et al. 2005) reflected the presence of a community of potential customers for artisanal products. In addition to the demand from the agglomerations' regular inhabitants and travelling people, these places may have seen additional seasonal activity, for instance at the time of religious festivals or administrative assemblies when inhabitants from the surrounding rural area would have gathered here (Theuws 2001: 203-204), taking advantage of the opportunity to acquire goods from the local artisans. This might have constituted an added motivation for the artisans to set up their workshops here.

Along with the access to the materials and consumers, the presence of other artisans could have influenced the choice of some craftspeople to settle in these places. Indeed, in a recent paper, Croix et al. (2019) defined 'operating networks' at early medieval emporia of Ribe (Denmark) where specialist bronzers set up alongside other craftspeople working with copper alloys. They suggest that the interdependence of crafts and the resulting self-organization of craft workers may have been a catalyst in the emergence of an urban community at Ribe. This offers an interesting alternative to the established thought that organization of crafts and the development of an urban community requires elite involvement. Within the framework of the Merovingian pyrotechnologies, we have evidence of the existence of similar networks of artisans, which may also have played a role in the organisation and development of the local communities. The sharing of certain materials, resources, tools and techniques could have formed the basis for cooperative relations between artisans. In that regard, some crafts were probably more dependent on these relations than others.

Glassmakers were especially reliant on other crafts. Even if not discovered in their workshops, their iron tools – canes, pincers, scissors – were certainly made by smiths. They also needed the potters for the production of their crucibles. During the Merovingian period, the known crucibles were wheel-thrown pots, quite similar in shape to common cooking pots (Péters and Fontaine-Hodiamont 2005). Those found in Huy were made with a particular type of inclusions that were not attested in common pottery, but the clay matrix is very similar, indicating that they were probably made for this specific purpose by the potters. Moreover, the colouring materials of glass are often metallic elements such as particles of copper or iron (Peake and Freestone 2012). It can be concluded that glassmakers had to have at least sporadic exchanges with the potters and blacksmiths. These exchanges could also have been a determining element in the location of their workshops.

Regarding the other crafts, their dependence upon material coming from other productions is weaker. Blacksmiths could use additions of clay or sand as refining elements during forging, but these do not need to come directly from other artisans. For this particular craft, the metallurgy of iron, we have to keep in mind that its *chaîne opératoire* is divided in two main steps: the first to obtain a raw material, the second to shape it. The extraction, the preparation of the ore, and its reduction usually take place close to the deposits while refining and forging took place elsewhere (Pagès and L'Héritier 2021). In this case, as reported in Table 1 and Figure 1, forging was practiced in the agglomerations and, even if they cannot be dated, the remains of extractive metallurgy are found outside the centres, close to the ores' deposits.

Potters also used clay and sand but, in the same way, they did not require specific collaboration with other artisans in order to practice their craft. Nevertheless, a common supply of wood, perhaps even clay, could be considered for several pyrotechnologies. This would suppose an organization of craftspeople, and this would also imply access to these materials. Access to raw clay is attested at the location of the Merovingian potters' workshops outside Huy and Namur, in Marilles (Figure 1). At the end of the Merovingian period, workshops disappear from the agglomerations. In the same period, a specific white clay was also selected but this particular material cannot be found everywhere. Such white kaolinitic clay from the Condroz, called 'derle', was already sporadically used before the 8th century CE and had a growing success later. The workshop from Haillot, dated to the 10th century CE, was situated in the region of these specific deposits (Van Wersch et al. 2019). Around the 8th century, the need of a white clay might explain the relocation of pottery production, most certainly close to kaolinitic beds and maybe in the Condroz.

Still in the Condroz, white sands are also attested (Macar et al. 1947: 139). Those were suitable for the glass industry and could have been used by medieval glassmakers. As for iron metallurgy, the *chaîne opératoire* of glass was divided in two steps: the production of the raw material and the shaping of objects. With the introduction of woodash glass these could have occurred at the same place but, up until now, there is no evidence for that. The only workshop dating after the 7th century CE is the one of Stavelot, where architectural glass was produced. All production-related evidence from this site points to natron glass (Neuray et al. 2019). On this same site, fragments of windows made of woodash glass were found in a context dated from before the end of the 9th century (Van Wersch et al. 2014), but no indications for woodash glass production were found on the site and this material might originate from another location. In a near futures, strontium (Sr) isotopes analyses could answer some of the questions about glass production on this site (Van Ham-Meert et al. 2021). Next to the sand sources from the Condroz, suitable sands for glass productions are also attested in the south of the territory as well as in Walloon Brabant, in the northwestern part of the province of Namur, and in the northeastern part of the Hainaut region. Close to Walloon Brabant, a high concentration of remains of metallurgical activity is noticed in the Soignes forest. These certainly date to the Early Middle Ages, contrary to those in the Entre-Sambre-et-Meuse region that date mostly to the Roman period. In the Soignes forest, another type of ores is exploited than in the Entre-Sambre-et-Meuse. Therefore, during the Early Middle Ages, the ores as well as the exploited areas were much more diversified.

In the three pyrotechnologies of ceramic, glass and iron, the innovations of techniques all demonstrate a better comprehension of the materials used in the manufacture, and led to the production of artefacts with new, sometimes better, qualities. Artisans increased their knowledge of their environment and made more efficient use of the raw materials available in their region. The more advanced mastering of local resources led to a higher or more efficient production. If one was looking for places of production linked to pyrotechnologies at the fringe of Merovingian and Carolingian periods, areas surrounding the deposits of raw materials should be targeted specifically.

The areas containing simultaneously clay, sand and ores, such as the Condroz, could be particularly interesting regarding the cross-craft interactions because the exploitations of these resources could be mutualized. If workshops are not found, the petrographic and chemical analyses of the tools, such as crucibles and kilns, as well as the one of the productions could identify the materials and their origins. This could also give insight into the sharing of innovations. For example, the white kaolinitic clays shaped by the potters could have been used for the production of crucibles and benefited to the glassmakers. It could also be added as refining agent in forging. Still, this remains to prove by further studies.

Finally, the access to raw material might also shed light on the implication of the elite in craft organisation and innovation, especially when these activities are concentrated in one place. Being at the origin of the technical changes or not, if the elites controlled the land and its resources, they had to guarantee, or at least allow their exploitation by the artisans. This aspect also must be searched and we will build models for the social organization of the crafts and their interactions with varying levels of elite involvement. Those could be related to an historical study of the aristocratic domains placed on these territories since the use of these resources could have become a determining factor for the development of these domains. The stranglehold on some supplies may have favoured certain owners or guardians of the land whose access to specific resources allowed them to develop specific artisanal activities that other could not.

5. Conclusion

The elites are generally considered as the main actors of changes during the Early Middle Ages, but scholars have decided to take a closer look at the role of the rural population as well as the artisans considering them and their potential interactions as trigger for innovation linked to social and economic changes. In that frame, this paper specifically questions the relocation of the production activities and the contemporary innovations in pyrotechnologies between the Merovingian and the Carolingian period. Therefore, it considers the location of the workshops and the raw resources on the current territory of Wallonia.

For the Merovingian period, the inventory of these activities underlines the geographical proximity of the artisans linked to glass, ceramic and iron production inside the agglomerations along the Meuse river. Established close by one another, they certainly had contacts and exchanged goods and ideas. For some artisans such as the glassmakers that needed tools from other craftspeople, their presence could have influenced the choice to settle in one place. In these agglomerations, they also had access to material and customers. After the end of the 7th century CE, the clues of these activities became scarce and they disappear from these centres. Still, they are sporadically testified in the rural area and in one monastery, as already observed previously by Henning (2007). This change in the settlement choices also corresponds to technical modifications in the three pyrotechnologies, especially ones in the raw material used by these craft.

Looking at the raw materials available in the considered territory (Figure 1), if some places are totally lacking them others have rich resources such as the Condroz and the Brabant regions where it is attested that clay, sand and ores where gathered. These geographical areas containing several raw materials would undoubtedly have been of interest to the artisans, even more so if they were crossed by major communication routes such as waterways. Moreover, from the 8th century, as the artisans were using specific clay, sands and ores, their location in the environment could have influenced their relocation. These areas also offer opportunities for the sharing of resources and for the organisation of a common supply. In the near future, a detailed examination of the materials used and made by the artisans might highlights these cross-craft interactions.

Finally, a link could be drawn to other crafts and production activities such as architecture that also demonstrated a renewal at the beginning of the Carolingian period. In this domain, the shared exploitation of a common material with multiple crafts is already proven on one site where kaolinite such as iron was identified in some mortars (Demelenne et al. 2016: 18-19). These domains that have barely been studied could give us a better idea on the craft organization that certainly contributed to the so-called 'Carolingian Renaissance ', the roots of which might be found in the creativity of craftspeople.

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Did ancient building contractors work for free? Stone supply in fourth-century BCE Epidauros, Greece

Jean Vanden Broeck-Parant

1. Introduction

Profit is the difference between what is earned and what is paid in production and selling costs. That some individuals were able to make profit in antiquity has never really been in doubt, or a matter of debate among scholars. Indeed, there is plenty of literary evidence showing that in various activities of production and trade, people did look for profit (e.g., Xen. *Por*. 4.5-6; *Lac*. 7.1-3; Arist. *Eth. Nic*. 8.9.4-6 [1160a]; *Pol*. 1.1257b 23-25; Pl. *Ap*. 30b). Not even Finley, a substantivist, would have denied this (Finley 1973: 21). What has been debated, rather, is whether there was a widespread desire to *maximize* profit (if at all), notably by means of capital investment and innovation. Today, the ability and desire of individuals in ancient Greece to seek and maximize profits is no longer in question. This shift can be explained in great part by the new attention paid to archaeological data and quantitative approaches, which have considerably changed our understanding of various aspects of production and trade (de Callataÿ 2014; Raepsaet 2014). However, with regard to the issue of profitability, there is one sector of the ancient Greek economy that has been left somewhat behind, namely, the production and trade of building stone and, in particular, of limestone (for the profitability of Roman marble quarries as an industry, see recently Long 2017).

With her seminal book *The Greek Temple Builders at Epidauros* (Burford 1969), Alison Burford is still, to this day, one of the only scholars who have addressed frontally the question of the profit made by the entrepreneurs who produced and transported materials for Greek construction projects. She did so on the basis of the corpus of Epidaurian building accounts, dating from the Late Classical and Early Hellenistic period (early 4th-early 3rd century BCE). These accounts contain invaluable information about the construction of various buildings, including financial details such as contract prices. In this respect, they represent an ideal source material to study the revenues of the entrepreneurs involved in construction programmes. Burford acknowledged the influence of Finley on her work; in fact, the study of this corpus was suggested to her by him (Burford 1969: 10). Burford's view on the contractors' profits is best summarized by a quote from herself: 'Both the nature of the work and the evidence of the accounts suggest that contractors for temple building were not all motivated solely or even primarily by expectations of profit from their contract; this is not to say that *no* contractors, either entrepreneurs or professional craftsmen, ever considered the possibility of positive material benefit from contracts for public works, but simply that the evidence shows that in many cases where big profits might have been expected such a thing was hopeless' (Burford 1969: 149).

Jean Vanden Broeck-Parant
F.R.S-FNRS, Université libre de Bruxelles

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The statement is quite nuanced, but Burford's opinion is clear: contractors could have made some profit, but they may as well have not. The implication of such a view is that contractors (or, at least, some of them) might have provided their services 'free of charge' or at a loss.

In this paper I want to address the issue of the profit made by contractors involved in monumental construction from a different perspective. I will do so by comparing contract prices found in the Epidaurian building accounts with labour cost estimations based on the architectural remains and reconstructions of the monuments. Labour cost estimations have been used sporadically since the middle of the 20th century, notably by Stanier (1953) and Burford herself (1969) but have regained interest since the publication of the study of the Baths of Caracalla by DeLaine (1997), as one of the new ways to approach the ancient economy. The method consists in measuring the quantity (volume, weight, units) of materials used in monumental constructions, and then, in estimating the amount of human or animal energy necessary to extract, transport and set into place those materials. The estimation of the amount of energy needed is obtained by measuring rates observed in 'ethnographic' contexts to perform these actions on similar materials, and is usually expressed in person-days or, in the case of oxen-pulled materials, in yoke-days. Labour cost estimations are not and should not be a goal in themselves. Instead, they are a tool that helps us compare processes that would not otherwise be comparable. In this sense, the figures do not claim to be more than estimates, and truthfulness is more important than accuracy.

In the context of Late Classical-Early Hellenistic Greece, labour cost estimations can be converted into financial costs since we have a relatively accurate idea of the average daily wage at the time. In turn, these financial costs can be compared with contract prices, which can give a better idea of the margin (that is, the profit) made by the contractors. Russell (2020: 258) applied this principle to the production of marble sculpture in the Roman period and roughly estimated that a carver probably made a profit of around 10-20% of the price of the statue that he had been commissioned to make. I will take the temple of Asklepios (early 4th century BCE) as a case study, as it presents two important qualities for labour cost estimations: its architectural features can be measured quite accurately, and contract prices are recorded for its construction. More specifically, I will focus on the quarrying and the transporting of the blocks of the interior part of the temple (the pronaos and the cella), which is referred to in the building inscription as the *sekos*; what this word exactly entailed from an architectural perspective will be discussed below. Before doing so, I want to address Burford's arguments for the supposed 'unselfishness' of (some of) the entrepreneurs involved in the Epidaurian building programmes. I follow her line of argumentation closely, as she paved the way for a reflexion on this topic.

2. Burford's line of thought

Burford was cautious not to make monolithic statements about the status and motives of the entrepreneurs involved in construction programmes, as she acknowledged that there must have been a variety of situations. Yet her analysis insists, in various places, on the 'landowning status' of the entrepreneurs and the 'diplomatic flair' necessary for 'organizing the resources of others'. These features can hardly be disputed, but in a Finleyan perspective, they are characteristics of wealthy individuals more interested in status than in money-making. This view underlines her idea that profit was not a prime motivation for the entrepreneurs to take up contracts. On the same line, the entrepreneurs, Burford argued, were bonded to the city by an obligation of the sort that was induced by liturgies (Burford 1969: 149). However, this comparison does not seem appropriate, since a significant number, if not most of the contractors working at Epidauros, were foreigners (mostly from Argos, Corinth, and Athens). In fact, if we understand liturgies as civic duties in the context of the construction of the temple of Asklepios at Epidauros, guarantorship would better qualify as a liturgy. This is supported by the fact that the guarantors were all recruited among the wealthy Epidaurian citizens, and they could hardly hope for any material benefits.

Two specific arguments are presented by Burford to claim that entrepreneurs could not hope to make profit and, therefore, were not necessarily interested in making any. The first argument is that some contractors were fined enormous amounts for delays or defaulting works. In the Thymele accounts, the entrepreneur Megakleidas received 1,040 drachmae in fines out of a contract price of 1,775 drachmae (*IG* IV^2 103 = Prignitz 2014, inscr.2, lines 198-199, 230-231), and Molossos, another entrepreneur, paid a huge fine of 4,320 drachmae (lines 207-208), which must have, according to Burford (1969: 152), 'cancelled out a large part of his contract price too', even though the contract price is not known in the latter case. Megakleidas, she says, 'lost over sixty per cent of his contract price in a fine for delay, which rather suggests that he took the job on for its interest, not as a business proposition' (Burford 1969: 149). This amounts to saying that Megakleidas expected to be fined when he took on the contract and that he did not care too much about it, which is purely conjectural (Schaps 1996: 86, n. 32 has a similar reservation). All that can be safely deduced from Megakleidas' and Molossos' cases, in fact, is that fines could be quite substantial, but nothing excludes *a priori* that the entrepreneurs could have spread these costs over several projects. The same Molossos, for example, was paid the considerable sum of two talents (12,000 drachmae) for supplying sima[1] blocks to Delphi in 341 BCE (*CID* II 32,

1 The sima is the outer edge of the roof, acting as a gutter. It is usually decorated with mouldings and paintings.

Table 1. Figures of quantities, prices and costs for the quarrying and transport of stone for the *sekos* of the temple of Asklepios at Epidauros. All figures are estimates, except the prices in italics, which are directly deduced from *IG* IV[2] 102 = Prignitz 2014, inscr. 1.

FIGURES OF STONE QUARRYING AND TRANSPORT FOR THE SEKOS OF THE TEMPLE OF ASKLEPIOS AT EPIDAUROS
Quantity of stone
Volume of stone extracted: 271.2 m^3
Volume of stone in building: 244.1 m^3
Weight of the stone transported: 488.2 T
Prices and costs of quarrying
Total contract price for quarrying: 8800 dr.
Price for quarrying per m^3: 32.5 dr.
Total cost for quarrying: 1084.4 person-days = 1084.4 dr.
Cost for quarrying per m^3: 4 person-days = 4 dr.
Prices and costs of transport
Total contract price for transport (including land and sea transport): 3400 dr.
Price for transport per T: 7 dr.
Total costs for transporting the stone on land:
From the quarries to the harbour of Kenchreai: 162.75 yoke-days = 325.5 dr.
From the harbour of Epidauros to the sanctuary of Asklepios: 488.2 yoke-days = 976.4 dr.
Total: 651 yoke-days = 1302 dr.
Cost for transporting on land per T: 1 yoke-day = 2 dr.
Total price for sea transport: 1547 dr.?
Price for sea transport per T: 3.2 dr.?

lines 10-11). Arguably, such large contracts, if taken up by Molossos on a regular basis, would have easily absorbed fines of several thousands of drachmae.

Burford's second argument, which is more assumptive, is that an interest for the cult of Asklepios could have prompted entrepreneurs to take up contracts. This may well be true, but religious interest is not incompatible with business and profit making. Furthermore, the evidence that she invoked is quite meagre; it is the case of Hermon of Thespiae, who 'took out' (ἀφεῖλε) six drachmae of the 220 that he was supposed to receive for supplying reed for the temple of Apollo at Delphi (*CID* II 56 A, l. 10-20). This discount was interpreted by Bourguet (1905: 156) and then Bousquet (1989: 105) as an 'offering' to Apollo. However, it is also possible that Hermon made this cut in order to be more competitive and to increase his chances of winning the contract, as was already suggested by Feyel (2006: 486-489) who sees further possible examples of discounts in the prices of Delian contracts. The *naopoioi*[2] eventually withheld a tenth of 214 drachmae (not 220), presumably because Hermon's delivery was late. Knowing that, another possibility is that he made a discount with the idea that it could grant him the leniency of the *naopoioi* and that he could avoid a 22-drachma penalty. The interpretation as an 'offering' is, therefore, far from obvious. Perhaps more importantly, a discount on a salary is, in fact, in contradiction with the very principle of an offering, which is to *give* something to a deity.

The question of the profitability of building contracts, therefore, remains open. Labour cost estimations, I argue, provide a new angle to explore this issue, by comparing those costs with the prices of the contract to which they pertain.

3. A case study: the sekos of the Temple of Asklepios at Epidauros

The Temple of Asklepios at Epidauros was built in the first half of the 4th century BCE. It is traditionally dated around 370, although Prignitz (2014: 248-249) has recently suggested a much earlier dating around 400-390 BCE. While the remains of the temple are rather scarce, its construction is well known thanks to an inscribed stele recording the building expenses (*IG* IV[2] 102 = Prignitz 2014, inscr. 1). The inscription is almost completely preserved, allowing us to know the duration of the works (about five years), the overall cost of the temple (around 23 talents), and a number of details about the construction process. Large chunks of the works were let out as single contracts, some of which comprised not just one, but two or three steps of the construction, such as quarrying, transporting and placing the blocks. Usually, a single entrepreneur took up a whole contract and was, therefore, in charge of a significant portion of the temple. The text of the inscription rarely specifies what the total price of each contract corresponded to, or how it was calculated. Therefore, it is impossible, on the sole basis of the text, to determine individual costs included in the contract prices, let alone whether the contractors were making any profit. Labour cost estimations arguably provide a way to measure the actual costs of specific tasks, as opposed to contract prices, which can comprise a whole range of costs in addition to the ones pertaining specifically to the said tasks. Since we have a pretty good idea of the average daily wage at the time of the construction of the temple of Asklepios, it is possible to convert labour costs into financial costs and, in turn, to compare those costs with the contract prices. Table 1 shows a summary of the price and cost estimations discussed in this paper.

The *sekos* of the temple, which comprises the pronaos and the cella, is a good case study for the estimation of labour costs of quarrying and transporting stone. It combines three important qualities. First, we know relatively well what the '*sekos*' of the inscription corresponded to in reality, an issue often encountered when attempting to match the inscriptions with the physical remains. Second, despite the poor state of preservation of the building, it is possible to reconstruct the architecture of the *sekos* with relative accuracy, and therefore, to estimate the total volume of stone that was needed. Finally, the quarrying and transporting of the stone blocks for the *sekos* were the objects of separate contracts that allow us to easily determine the total price of this specific operation.

2 The *naopoioi* were an international board of officials in charge of the construction of the temple of Apollo at Delphi.

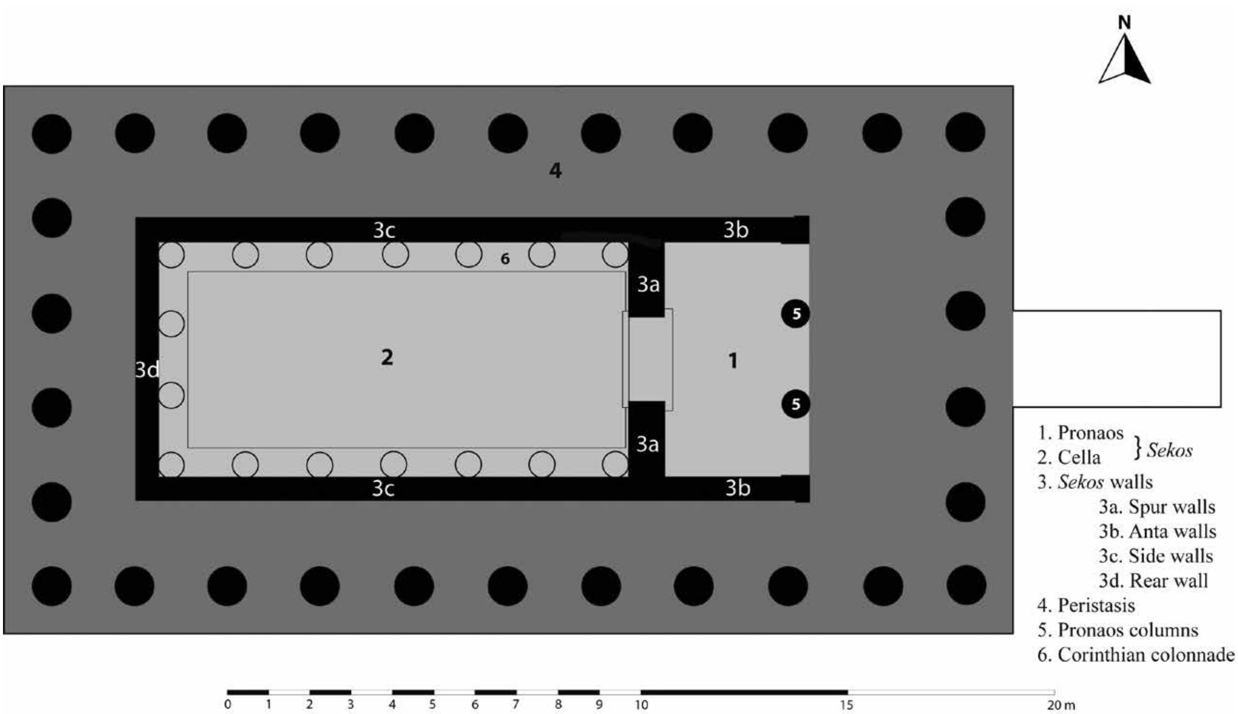

Figure 1. Plan of the temple of Asklepios, with the architectural elements mentioned in the text. After Roux 1961: pl. 28.

The accounts of the temple record that Euterpidas of Corinth took up the quarrying and transporting of half of the *sekos* for 6,167 drachmae (Prignitz 2014, inscr. 1, lines 12-14); that Archikles of Corinth took up the quarrying of half of the *sekos* for 4,400 drachmae (lines 14-16) or perhaps a bit more (some letters are missing); and that Lykios of Corinth took up the transport of half of the *sekos* for 1,700 drachmae (lines 16-18) or perhaps a bit more (here too, some letters are missing). From these prices it is clear that the total prices for quarrying and transporting the blocks of the *sekos* were, respectively, about 8,800 drachmae and 3,400 drachmae. It could have been slightly more but, in any case, the difference would be negligible for our calculation.

In order to estimate the labour cost that corresponded to these prices, one needs, first, to assess the total volume of stone of the *sekos*, which implies to determine what the word *sekos* exactly stands for from an architectural perspective (see Figures 1 and 2). It certainly included the side and rear walls, the anta walls of the pronaos, and the spur walls separating the cella from the pronaos. Roux did not find any fragment of the crowning of the walls, but the inscription refers to a ὑποδόκιον, possibly a course of stone blocks supporting the beams, as the name indicates (Roux 1961: 115; Prignitz 2014, inscr. 1, lines 57-58; 230-231). One of the passages mentioning the ὑποδόκιον also mentions a κυμάτιον, which Prignitz (2014: 53) interprets as a decorative course below the ὑποδόκιον. In any event, the reconstruction of the upper parts of the walls remains conjectural. A generous estimation of their total volume, based on Roux's drawings, amounts to 60.9 m^3. The ceiling itself was made of wood (Roux 1961: 123) and must be, therefore, excluded from our calculation.

Should the two front columns of the pronaos be included in our contract? Baunack (1890: 69-70) suggested that they could have been the object of a separate contract mentioned on lines 18-19. These lines are very badly preserved; the only letters that make sense on line 19 inform us that two individuals were paid 230 drachmae and 300 drachmae (or more) respectively, for jobs that had been already completed when the account was written (this is evident from the fact that their names are in the dative form; see Thür 2015). Baunack's suggestion finds support in the fact that the second craftsman, Kallidikos, appears elsewhere for 'stone quarrying' ('λατομία', line 296). However, he was most likely an Epidaurian, since no ethnic is mentioned, which means that the stone he quarried probably came from the Epidauria. Since the local limestone was unlikely to be finer than the Corinthian limestone, one would have to assume that the pronaos columns, which were probably the object of particular care, were made of a coarser stone than the one used for the rest of the *sekos*. In any case, it is possible that Kallidikos performed a job other than stone quarrying mentioned on lines 18-19. Therefore, I chose to include the two front columns in my estimation of the total volume of the *sekos*. Future works will have to take into account that the lines 18-19 could have referred to the quarrying of stone for some element of the temple. At this stage, it is impossible to tell.

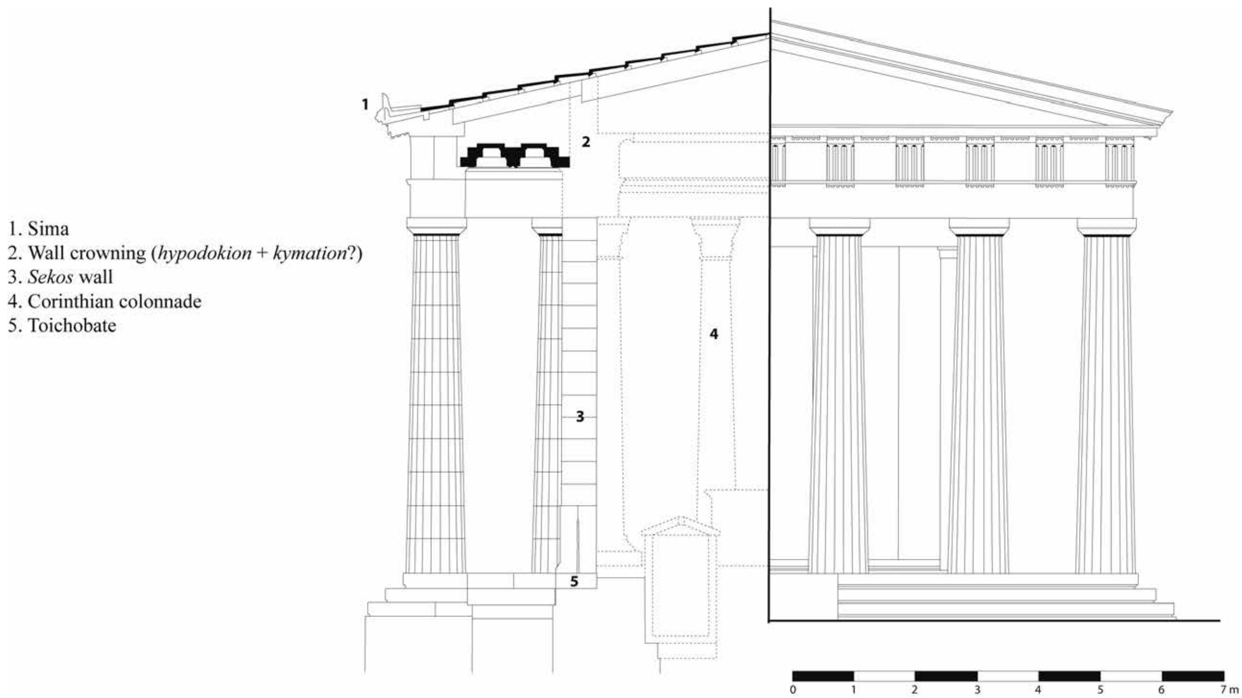

Figure 2. Section (left) and facade (right) of the temple of Asklepios seen from the front, with the architectural elements mentioned in the text. After Roux 1961: 125 fig. 28.

The foundations of the *sekos* were part of a different contract that was taken up by Antimachos of Argos (lines 9-10), so they should be excluded. So was the paving of the temple (lines 38-40), which must have included the *sekos* since no distinction is made in the inscription between the different paved areas. What is more, the pavement was made of a finer limestone than the one used for the elevation. I include the toichobate[3] course in my estimation, since it makes more sense for it to have been included in the quarrying of the *sekos* than in the quarrying of the foundations or of the peristasis[4]. In any case, it represents a relatively small percentage of the total volume of the *sekos* and its absence would not significantly change the results of the estimation. A more problematic issue is the supposed interior colonnade of the *sekos* running along the side and rear walls. Roux (1961: 112-114) could not find any fragment belonging to this colonnade but he nonetheless hypothesized its existence on the grounds that several wall blocks show a recess comparable to the ones that can be observed in the Tholos at Delphi, where there was an interior colonnade. Furthermore, the contractor Marsyas is said to have polished the columns 'τᾶν ἔχθοι καὶ τᾶν ἔνδοι', the ones outside and the ones inside (lines 66-67), where the 'inside' columns could refer to an interior colonnade. I chose to include this hypothetical, yet plausible, interior colonnade in the contracts for quarrying of the *sekos*. The columns appear on Roux's drawing of the plan of the temple, but he does not discuss their number (16 columns appear in his drawing) and diameter (about 0.65 m). My estimation of the volume of the colonnade is based on this drawing. I assume that the height is the same as that of the *sekos* walls (about 5.7 m), as restored by Roux (1961: 125, fig. 28). The total volume of the supposed interior colonnade is about 30 m^3, which represents about 17% of the total amount of stone that was quarried for the *sekos*.

Overall, the volume of stone used for the construction of the *sekos* was about 244.1 m^3. However, this figure does not exactly account for the volume of stone that was extracted. One needs to take into account the material that was 'lost' in digging the excavation trenches and in scantling the blocks, which could have amounted between 7 and 11% according to Bessac (1996: 311); he suggests an approximate 10% for labour cost estimations. Adding another 1% accounting for the surface material that was removed in order to access the exploitable stone, we get a figure of 271.2 m^3. Even taking into account the hypothetical interior colonnade and the 'lost' material, it is still significantly less than what Stanier had estimated for the front and for the back and side walls of the cella alone, 345m^3 (Stanier 1953: 74; the same figure is used by Burford 1969: 248). This discrepancy comes in large part from

3 The toichobate is a row of blocks integrated to the crepis (the substruction courses of a temple), which supports a wall.

4 The peristasis is a four-sided colonnaded porch around the cella of a temple.

the fact that Stanier based his estimation on the figures given by Dinsmoor and Cavvadias (1891), where the walls appeared to be much thicker than they actually were: 1.55 m for the rear wall and 1.48 m for the side walls. This is almost three times the measurements given by Roux.

4. The costs of quarrying

No experimental work has been done so far that could help us determine the time needed for extracting the specific limestone used in the temple of Asklepios or, more generally, the oolitic limestone that is found abundantly in the Corinthia. Hayward (2013: 68) estimated that it would take about 25 hours for quarrying 1.4 m^3 of Corinthian oolitic limestone, on the basis, first, of an experiment by Kozelj (1988: 36-39), who extracted a Thasian marble block of 0.125 m^3 in 22.5 hours, and, second, the assumption (originally collected by Stanier 1953 from Oxonian stonemasons and then repeated by Burford 1969), that marble takes about five times longer to quarry than softer stones. Hayward does not specify how many workmen are implied in his figure; it must be two, for a simple arithmetic calculation based on Stanier's ratio and Kozelj's experiment gives not 25, but 50 hours, for quarrying 1.4 m^3 of Corinthian oolitic limestone. Therefore, it must have taken one person about 36 hours for extracting one cubic metre. This is slightly more than what Bessac estimated for quarrying the same amount of stone in the Pielles quarry, in southeastern France (31 hours and 10 minutes), in the context of a quarry with Hellenistic traditions and techniques. The stone from les Pielles is 'slightly firmer' than the local oolitic strain, and it is surprising that it would take longer to quarry the soft Corinthian limestone. This tends to confirm Bessac's (1996: 309, n. 1) friendly criticism of Kozelj's experiment, namely that the productivity can vary dramatically between a one-off experiment and a professional, routine activity. Strict comparisons, however, are deceptive and can also be misleading. Therefore, I follow Hayward's estimation, in lack of more accurate estimations.

The average length of a working day in antiquity cannot be ascertained. It must have depended on the various activities; some being more wearing than others. The maximum limit, of course, must have been determined by the available daylight. In Athens, the time of daylight ranges from about nine hours and 30 minutes per day in the winter to about 14 hours and 45 minutes in the summer. Some, like Bessac (1996: 309), have proposed an average of 10 hours of work per day, others, eight hours (Hayward 2013: 68, n. 24). There is little doubt that there must have been important variations according to the place and time. Here I take an average of nine hours of effective work per day. Therefore, it must have taken roughly two days (18 hours) for a team of two quarrymen – or 4 person-days – to extract 1 m^3 of Corinthian oolitic limestone. This is significantly less than Burford's figure, who estimated that it took 6.5 person-days for extracting 1 m^3 of limestone (Burford 1969: 248).

In the Erechtheion accounts, the daily wages of workmen comprised between five obols and one drachma (or six obols), and that of the architect is one drachma (Randall 1953). These are Attic drachmae, not Aiginetan as in Epidauros. However, the architect of the temple of Asklepios, Theodotos, also had a salary corresponding to one drachma a day (Prignitz 2014, inscr. 1, lines 7, 29-30, 52), and I assume that the ratio between his salary and the wages of the skilled workers was the same as in the Erechtheion accounts. Since 1 m^3 of stone required two skilled quarrymen to work for two days, it can be estimated that its extraction cost four (Aiginetan) drachmae. This cost can be compared to the cost of limestone blocks from the Akte Peninsula mentioned in an Eleusinian inscription dating from 329/8 BCE (*IG* II^2 1672, lines 131-132). Pakkanen (2013: 64-65) calculated that the price of 1 m^3 was about 4.9 (Attic) drachmae and suggested, on the basis of ethnographic comparisons, that this price only accounted for the actual labour costs of quarrying. At that time, the daily wage of the workers was two drachmae, as attested in the same inscription, meaning that the extraction required 2.5 person-days, to be compared with the 4 person-days required for extracting one cubic metre of Corinthian oolitic limestone. This comparison, combined with Bessac's criticism mentioned above, suggests that the estimation of 4 person-days is perhaps too generous. In any case, a lower estimate would only reinforce the discrepancy between the actual quarrying costs and the contract price for quarrying. Indeed, according to my estimation, the price of 1 m^3 of stone (32.4 drachmae) was about eight times higher than its actual quarrying cost (4 drachmae).

How can we explain this difference? The stone itself, as a material, probably did not cost anything, contrary to gold or silver, for example. The question of the intrinsic value of stone has been a long-lasting debate which has still not reached a consensus. However, it might be, as Carusi called it, a 'false problem', since stone, she writes, 'does not exist in the abstract without quarrying' (Carusi 2019: 67). The Eleusinian inscription *IG* IV^2 1672, as Ampolo (1982: 255 n. 31) has shown, seems to point in that direction, since the price (τιμή) of the stone corresponds exactly to the cost of its extraction (τομή).

There were, of course, a lot of costs for a contractor in addition to the extraction of a block. The exploitation of the quarries was probably subjected to a fee, in one form or another. Little is known about the ownership of the quarries in Greece, and in the Corinthia specifically there is a complete dearth of evidence. A column drum found in a quarry bears the two-letter mark ΔA which, according to Lolos (2002), is the abbreviation of δαμόσιον. In fact, ΔA could equally have been the abbreviation of a name, as was noted by Sève (*BE* 2003: 575, n. 92). Even if the two letters did refer to the 'public' or 'state' sphere, it would not necessarily mean that the quarry itself was state-owned. Since then, new inscriptions have been discovered on quarry faces near Kenchreai, the eastern harbour of Corinth, but they date from the 1st or 2nd century CE and do not inform us on the ownership of the quarries (Hayward and Pitt 2017). Therefore, one must, as is often the case, turn to the Attic sources. They are not abundant and might not be completely relevant to the exploitation of quarries in the Corinthia, but they can at least give us an idea about the different regimes that could have existed. There is evidence in Attica of quarries owned by gods and administrated by the city or the demes. For example, an Eleusinian inscription bearing two decrees dealing with the quarry of Herakles in Akris attests that this quarry was leased out, at the deme level, to the highest bidder (*SEG* 28, 103). The existence of privately owned quarries in Attica is debated. Recent scholarship, however, has demonstrated the high probability that private quarries existed alongside public quarries, and that the state received taxes on the exploitation of such quarries (Flament 2015 and Carusi 2019, with earlier bibliography). The Attic evidence is scarce but tends to suggest that whatever regime they were subjected to, the contractors had to pay for the right to exploit quarries. Unfortunately, it is impossible, in the state of our documentation, to measure the weight of these financial burdens. All we can say is that it did not apparently deter entrepreneurs from investing in quarries.

In addition to these 'exploitation fees', stone quarrying, especially for monumental buildings, incurred a series of costs related either to the additional tasks required when extracting a block or, more generally, to the logistics of a quarrying site. First, stripping was necessary to access the stone bed. Then, a quarry face had to be opened. These preliminary steps generated a considerable amount of waste that had to be discarded. The quarrying operations themselves generated more waste in the form of stone chips and dust which also had to be regularly removed. These tasks which did not pertain directly to the extraction of stone blocks were probably performed by day labourers. A block, once extracted, needed more or less extensive scantling. It was then moved to a storage platform or directly to the loading area, which also required some handling. Possibly, an individual (or more) was assigned to the loading of the blocks on the carts. According to Kozelj (1988, 31), the 'basic' arrangement of a quarry also included, in addition to the infrastructure that we already mentioned, hoisting machines, a small sanctuary, a guard tower, accommodation for the workers, and a workshop for repairing the tools. This equipment needed maintenance, which generated further expenses. It is, however, difficult to determine the extent of these facilities, or whether they existed at all in the quarries that produced the stone for the temple of Asklepios, as we do not have the slightest idea as to how the production was organized. If the production was relatively constant in time and space, it would make sense that the quarrymen and their family had settled in nearby villages. In such case, on-site accommodation would not have been necessary. The guard tower was likely a recurring feature of large-scale quarrying sites, but it is doubtful that it would have been necessary on smaller sites. As for the sacred areas, they did not necessarily take the form of imposing structures and could have consisted of small shrines (Kokkorou-Alewras et al. 2010: 66-67). There was, in any case, a need for metal workers and equipment for the maintenance of the tools. *Ostraka* of the Mons Claudianus in the Eastern Desert of Egypt, which date from the early 2nd century CE, provide lists of workers employed on the quarry site. For four stoneworkers, about one metal worker was required, a high ratio related to the exceptional hardness of the granodiorite that was extracted here. Russell (2019) gives the approximate ratio of 1:12 for the Dokimeion quarries, where softer marble was excavated, and it is likely that this ratio was even lower in the Corinthian limestone quarries.

We still know too little about the organization of stone exploitation in the Corinthia (despite the enormous progress made thanks to the work of Hayward 1996; 2013) or in Greece in general at that period, to draw realistic assumptions about the costs incurred by the running of a quarry, notably in terms of its infrastructure and the wages paid. However, the evidence does exist, in direct or indirect forms. The ancient quarries themselves arguably provide the best source material if one interprets them in light of the ancient texts but also, more importantly perhaps, the ethnographic surveys play a major role. Such work, which combines all the various sources that we possess, remains to be done, especially for Classical and Hellenistic Greece.

5. Land and sea transport: costs and price parallels

The total price for the transport of the stone blocks of the temple of Asklepios, as we have seen, was about 3,400 drachmae. This comprised at least sea transport from Kenchreai to the harbour of Epidauros, roughly 43 km by sea, and land transport from the harbour of Epidauros to the sanctuary of Asklepios. The easiest route, especially for heavy transport, must have been the one corresponding to the modern national road EO70 that goes from the modern town of Epidauros towards Nauplion. The ancient road thus probably went along the north side of the Myrona and Profitis Ilias mountains, and then went south after the latter, to the sanctuary (see Figure 1). Following this route, the distance from the harbour to the sanctuary was about 11.3 km, on a relatively flat terrain.

As for the land transport from the quarry to the port of Kenchreai, there are two issues. The first problem is that we do not know exactly where the stone of the *sekos* was

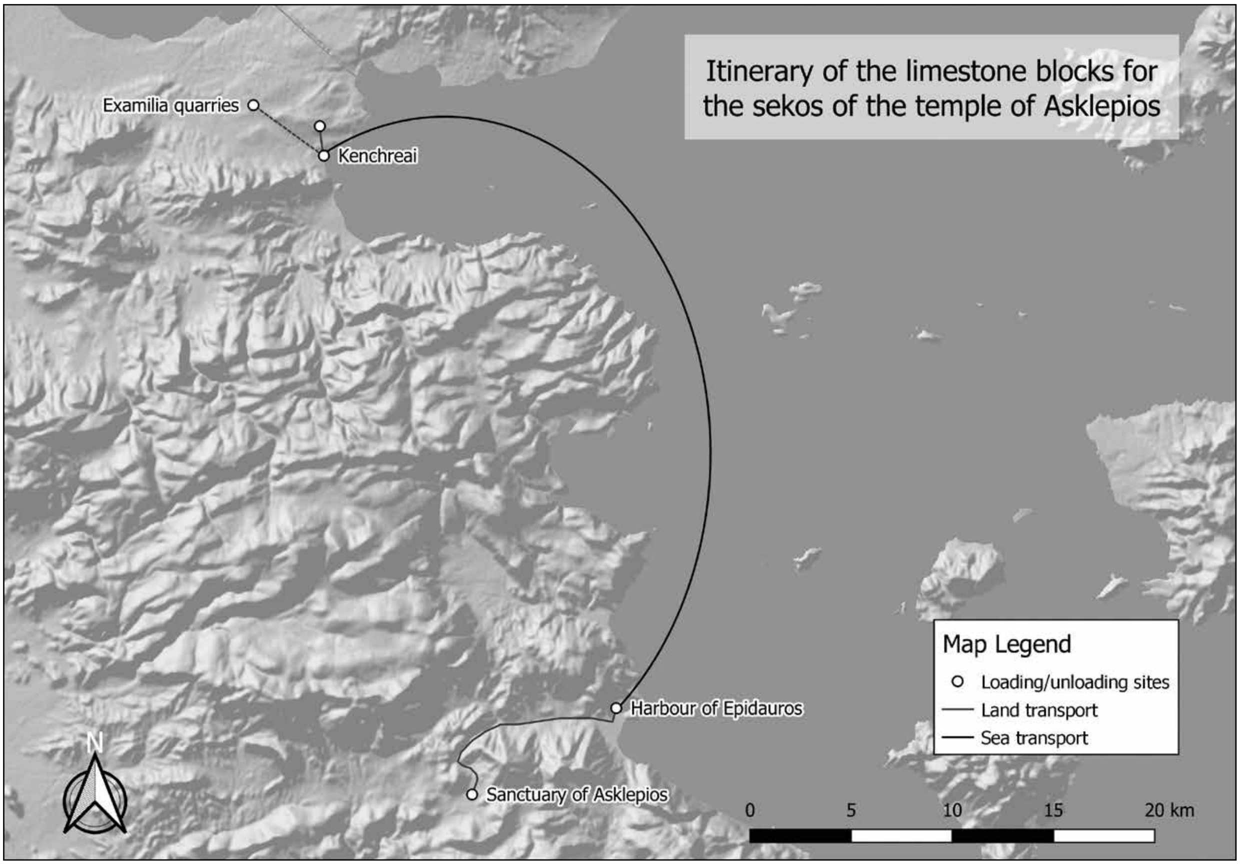

Figure 3. Map with the itinerary of the limestone blocks for the *sekos* of the temple of Asklepios.

quarried, or whether it was quarried in only one place. The exact provenance is difficult to establish because of the rather uniform appearance, at a macroscopic level, of most of the oolitic limestone of the Corinthia. According to Hayward (1996: 219), extensive quarries situated about 1.5-2 km away from Kenchreai must be considered as 'strong candidates' for the supply of oolitic limestone to Epidauros. The Examilia quarries could also have provided the limestone of the temple of Asklepios but are a bit more distant (about 4.5 km). This dilemma can only be solved by high-accuracy provenance determination of the stone used in the temple of Asklepios, which remains to be done. Arguably, however, a two-kilometre difference did not have a big impact on the transport costs. The second issue is that it is not certain whether the land transport from the quarry site to the harbour was comprised in the 'quarry contract' or in the 'transport contract'. After all, the contract titles as they appear in the inscription are rather concise and vague; furthermore, it would have made sense for the contractor in charge of the quarrying to arrange the transport of the blocks out of the quarry, as the logistics of the two were intrinsically linked – one thinks, for example, of storage and space management within the quarry site. I follow here the most straightforward interpretation, which is that the transport from the quarry to Kenchreai was comprised in the 'transport contract'.

The volume of transported stone was not equal to the volume extracted. As we have seen, an average of 10% of the extracted stone was 'lost' in scantling works in the quarry. The objective of this operation was, precisely, to reduce the transportation costs. Of course, some finishing work on the construction site would have further reduced the total volume of the blocks, but only by a negligible degree. Therefore, the figure used in the following calculation is that of the estimated total volume of the *sekos*, i.e., 244.1 m^3. The main variable to take into account in our case is not the volume, but the weight. Indeed, the blocks used for the construction of the *sekos* were of a medium size and could be fitted easily on a small cart. The standard elevation blocks, for example, measured 0.565 × 0.355 × 1.132 m (Roux 1961). According to Hayward, the density of the Corinthian oolitic limestone is approximately 1.9-2.1 tonnes per cubic metre (Hayward 2013). Taking the average of 2 tonnes per cubic metre, we get a total weight, for the *sekos* of the temple, of 488.2 tonnes. This is considerably less than the 948 tonnes estimated by Stanier. In addition to the difference in volume estimates, this huge discrepancy is also due to the fact that Stanier assumed a density of about 2.7 tonnes per cubic metre, which is closer to the average density of marble stones. As a result, the transport price per ton was about 7 drachmae.

Let us now see how this price compares with the figures that we obtain with labour cost estimations. I will start with the cost of land transport, which lends itself more easily to labour cost estimations than sea transport. The most common means of heavy transportation in ancient Greece was a wagon with two or four wheels pulled by oxen. For large blocks of several tonnes, special platforms or reinforced wagons would have been needed, as well as several pairs of oxen. However, the blocks of the *sekos*, the weight of which was comprised (roughly) between 400 kg and a ton each, could have been easily transported by a pair of oxen, which could pull a charge of a tonne in normal conditions. That carts could transport a charge of a ton or more is evidenced by the Epidaurian accounts themselves, as Burford has shown (1969: 187-188) and was confirmed by Raepsaet on the basis of ethnographic sources (Raepsaet 2019: 81-82). The distance from the harbour of Epidauros to the sanctuary, as we have seen, is about 11.3 km. I assume that the road was relatively flat, as it is today, and that it was made of battered earth. The average slope between the departure and arrival points is of less than 3%. In these conditions, which can be considered 'normal', a pair of oxen pulls, on average, a weight of one ton, at a speed of about 2.5 km per hour (Raepsaet 1984). On the basis of these factors, it can be estimated that it took about four hours and a half for a pair of oxen carrying about one ton of material to get to the sanctuary. We also know from ethnographic sources that a pair of oxen can work about six hours a day when subjected to an intense effort (Raepsaet 2019: 52). Considering that some time must have been needed for loading and unloading the blocks (see Brysbaert 2015: 96-97 for the loading and unloading of blocks in a prehistoric context), and that the pairs of oxen had to make the return travel (with an empty wagon), it is unlikely that a carriage could have made more than one delivery per day. Therefore, we must consider that, on average, one pair of oxen could deliver one ton of stone at the sanctuary per day.

The oxen were probably hired, along with carts, from local peasants. Costs for hiring pairs of oxen for one day are found in the Eleusinian inscription from around 330 BCE which contains accounts of the construction of the Porch of the Telesterion and deals in particular with the transportation of column drums (*IG* II^2 1672). The situation with which the transporters of the Telesterion blocks had to deal with was significantly more complicated than that of the blocks of the temple of Asklepios: the blocks weighed about 7.5 tonnes and required a specific type of wagon, as well as up to 11 pairs of oxen pulling together over 35 km for up to three days and a half. The cost of hiring a pair of oxen was four drachmae a day, 'according to a decision of the people that Lycurgus had put to the vote', the inscription records (*IG* II^2 1673, line 65). The figure makes sense, considering that a normal daily wage at the time was two drachmae, as already mentioned; the four drachmae covered the peasant's salary as well as maintenance fees and, perhaps, a compensation for the inconvenience of the requisition. As we have seen, the daily wage in early 4th century Epidauros was not two drachmae, but one; therefore, we can reasonably assume that the hiring of a pair of oxen cost two drachmae a day at the time. The cost for transporting the blocks of the *sekos* to the sanctuary, therefore, can be estimated to 976.4 drachmae. Applying the same reasoning for the land transport from the quarry site to Kenchreai, and assuming that the latter was about 2 km away from the former, it can be estimated that a single pair of oxen was able to make three deliveries a day, for a transport cost of about 325.5 drachmae. In total, the land transport costs would have amounted to about 1,302 drachmae, or 38% of the contract price. Of course, this estimation does not take into account the loading and unloading of the blocks, which required several workers and cranes or ramps (Korres 2003: 36-37). As already mentioned, it is also possible that the transport cost from the quarry to Kenchreai (estimated at 325.5 drachmae) was included in the 'quarry contract' rather than the 'transport contract'. However, the difference would not be high enough as to change the observations made above.

Interestingly, the Thymele accounts contain a reference to a contract for transporting stones specifically from the harbour of Epidauros to the sanctuary of Asklepios: Megakleidas (an entrepreneur already mentioned above) transported 71 blocks of Pentelic marble for a total price of 1,775 drachmae, or 25 drachmae a piece (Prignitz 2014, inscr. 2, lines 198-199). There is little doubt that the price was calculated per individual block. According to Roux (1961: 175), the 71 blocks must have constituted the totality of the marble blocks necessary for the completion of the *sekos* walls of the Thymele, with the exception of the exterior orthostates. This would amount to approximately 50 tonnes, meaning a price of around 35.5 drachmae per tonne to transport the stones from the harbour to the sanctuary. The difference with the price recorded for the blocks of the *sekos* – 7 drachmae per tonne for the whole trip, including sea transport – is huge but not extremely surprising: the blocks of the Tholos were made of a heavier, but also finer, marble and, more importantly, their curved and slender shapes, which made them more susceptible to breakage, implied a completely different set of logistics.

With regard to sea transport, the actual costs are difficult to estimate because we lack sufficient direct parallels but also, more crucially, because too little is known of the infrastructure that was used, such as the types of cranes (and the number of men that were required to operate them), and the harbour facilities in place to load and unload the blocks. One might expect that Kenchreai had developed efficient infrastructure by the early 4th century, but that was not necessarily the case at the harbour of Epidauros at the time. More importantly perhaps, we are at sea regarding the type of ships that were used and their cargo capacity. At the time of the construction of the temple of Asklepios, the cargo capacity of transport ships could already exceed 100 tonnes (see Bresson 2016: 86-87; Raepsaet and Pomey 2020: 34-37). In theory, therefore, five journeys or less would have been enough to transport the blocks of the *sekos*. In reality, smaller ships, such as those of the type of the Kızılburun wreck (late 2nd-1st century BCE; see Carlson 2009), could have been used to transport stone. The size of the ship and of the space available for cargo also determined the number of rowers on board, who probably helped with the loading and unloading of the blocks. Since too many details elude us, it is impossible, at this stage, to estimate the costs of sea transport in terms of wages.

There are, however, a number of parallels with regard to prices for sea transport, notably for Delphi at about the same period and, in the Hellenistic period, for Epidauros and Didyma, but, as we will see, none of the ratios given in these passages can be safely replicated in our case study. Loading and unloading the blocks were arguably burdensome steps: Haussoulier (1926) calculated that column drums for the Didymaion, about seven tonnes each, were loaded and unloaded at a cost of roughly 80 drachmae each (40 drachmae for each step); at a time when the daily wage was about 2 or 3 drachmae a day (Raepsaet and Pomey 2020: 45). Assuming an average daily wage of one drachma in Epidauros, and applying this rate to our case, the total cost just to load and unload the blocks would be unrealistically high (about 1,860 drachmae at the very least). For the loading and unloading operations, the size of the blocks mattered a lot. An Epidaurian inscription from about 300 BCE mentions the lifting of blocks 'from the sea', thus probably following a wreckage that happened close to the shoreline, for 5 drachmae a piece (Kritzas and Prignitz 2016). However, this rescue operation can hardly be compared with a normal (un)loading operation.

Relatively close in time to the construction of the temple of Asklepios, around 338 BCE, a series of replacement limestone blocks (angle triglyphs and *epignapheia*[5]) were shipped from the Corinthian harbour of Lechaion, on the Corinthian Gulf, to Khirra, the harbour of Delphi (*CID* II 59, lines 50-69). Hansen (in Amandry and Hansen 2010: 473, fig. 19.3) gives the measurements of these blocks, which allows estimating their volume and weight. In turn, the price per tonne for shipping can be calculated as about 41.2 drachmae. At such a rate, and even if we assume an inflation ratio, the price to transport the blocks of the *sekos* of Asklepios would have skyrocketed. This high price can be explained by the fact that these blocks were an emergency order, and that the commissioners evidently did not proceed to an auction, as was normally the case (Bommelaer 2008: 234). The risk factor may also have had an impact. Risk is, of course, extremely difficult to assess, but crossing the Gulf of Corinth is arguably riskier than following the coastline from Kenchreai to Epidauros; it could also have been a bad season for sailing when the emergency order was placed.

The Epidaurian inscription mentioned above also gives rates for the transport of blocks overseas (Kritzas and Prignitz 2016, lines 94-114, 128-138). The configuration of the stone supply resembles ours in many aspects, with small, ashlar ('four-feet') limestone blocks being shipped from Corinth across the sea to the harbour of Epidauros. The inscription does not specify where the blocks were delivered, but the mention 'across the sea' makes it likely that the land transport from the harbour of Epidauros to the sanctuary was the object of a separate contract. Lakon, the entrepreneur who took up the contract, received 9 drachmae per 'four-feet' block. Four feet makes about 1.20 m, which corresponded to one of the dimensions of the block, but the other dimensions are not specified. Kritzas and Prignitz (2016: 22-23) argue that the blocks mentioned in the inscription were probably intended for the upper parts of the Propylon of the Gymnasium, meaning that each of them would have had a volume of either about 0.28 m^3 or about 0.56 m^3. The limestone foundations of the temple of Artemis in Epidauros are paid by the tetrapodia, and standard blocks of these foundations have been measured as 1.28 x 0.78 x 0.29 m (Roux 1961, Pakkanen 2013). This gives a volume of about 0.29 m^3 per block, a figure very close to the volume of some of the blocks of the Propylon for the Gymnasium. If the four-feet blocks transported by Lakon had a volume of about 0.28 m^3, the rate would have amounted to 32.1 drachmae per cubic metre, or 16 drachmae per tonne; a volume of 0.56 m^3 per block would halve this rate, thus 8 drachmae per tonne. Applying such rates to the *sekos* of the temple of Asklepios, and taking into account the inflation, we obtain, respectively, figures of about 3,904 drachmae, which exceeds the total contract price (3,400 drachmae), and 1,547 drachmae. Even though the latter figure seems more realistic in relation to the contract price, we lack evidence that could help us to decide between the two rates, as many other factors could have influenced the prices and explain the rate difference between c. 390 and c. 300 BCE. One of these factors is the level of competition between contractors. The example from Delphi cited above gives an idea of what the prices could be when there was no auction, and the prices were fixed.

6. Conclusions

The preliminary results presented in this paper allow some comments regarding the profitability of the contracts taken up by the entrepreneurs at Epidauros. The case study of the *sekos* of the temple of Asklepios shows that the costs in wages for quarrymen represent only a small portion of the prices of quarrying contracts. This suggests

5 The word *epignapheion* is a hapax and probably refers to angle cornice blocks.

that there was room, in the contract price, for substantial profits. The exact size of these profits in proportion to the contract price, however, remains to be determined. A number of additional costs, which might have represented, together, a more substantial amount than the quarrying itself, are still largely eluding us. A better understanding of the management of quarries in the Corinthia in the 4th century BCE should help answer that question. With regard to transport, the combination of costs for hiring pairs of oxen and of a tentative shipping *price* (which may itself have included a margin!) still leave about 550 drachmae. This sum might include costs that I was not yet able to estimate precisely, such as the maintenance of the machines and wagons, or the loading and unloading of the blocks at the quarry site and at the sanctuary, but also, arguably, a margin for the entrepreneurs.

In this investigation, I have insisted on the uncertainties and issues that one is facing when attempting to estimate the costs and prices of quarrying and transporting construction stone. Small 'leaps of faith' are often required, and a substantial amount of data is still missing to obtain figures that can be firmly trusted. At the same time, I hope to have shown in this case study that labour cost estimations are a useful method to explore the question of the profits made by entrepreneurs in Classical and Hellenistic Greece, in particular in the production and trade of construction stone. However, further work is necessary, which will require the combination of various kinds of sources, each demanding specific sets of skills for approaching them. Interdisciplinarity, a trendy word in archaeology and history, is, in this case, an absolute necessity: architectural scholarship, geology (for provenance determination), experimental archaeology, ethnography, and epigraphy must work together.

Ultimately, the question of the profitability can only be useful and meaningful if it is placed in the wider context of stone production and trade as an industry, taking into account dynamics of supply and demand. Once believed to be an occasional activity in Classical Greece, the supply of construction stone for monumental buildings is now regarded as a more constant business, in the same way as other economic sectors. In this framework, the profitability (or non-profitability) of stone supply is a major factor in our understanding of the economy of monumental construction and, more generally, of the economy of the Classical poleis.

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8. Bibliography

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CID = *Corpus des inscriptions de Delphes*
IG = *Inscriptiones Graecae*

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SHAPING CULTURAL LANDSCAPES

Any activity requires the expenditure of energy, and the larger the scale of the undertakings, the more careful and strategic planning in advance is required. In focusing on labouring by humans and other animals, the papers in this volume investigate through a wide range of contexts how past people achieved their multiple daily tasks while remaining resilient in anticipation of adverse events and periods.

Each paper investigates the resource requirements of combined activities, from conducting agriculture or trade, over many different crafts, constructing houses and monumental buildings, and how the available resources were employed successfully. Multilayered data sets are employed to illuminate the many interconnected networks of humans and resources that impacted on people's day-to-day activities, but also to discuss the economic, cultural and socio-political relationships over time in different regions.

Each of us aimed to discuss novel perspectives in which the landscape in its widest sense is connected to interdisciplinary architectural and/or crafting perspectives. Rural landscapes and their populace formed the backbone of pre-industrial societies. Analyses of the rural 'hinterland', the foci of cities and other central places (often with monumental architecture) and the communication between these are essential for the papers of this volume. These different agents and phenomena and their connections are crucial to our understanding how political units functioned at several socially interconnected levels.

Bottom-up approaches can dissolve "monolithic" understandings of societies, the elite-labour/farmer and the centre/rural dichotomies, because the many social groups co-depended on each other, albeit perhaps in unequal measure depending on the given context.

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