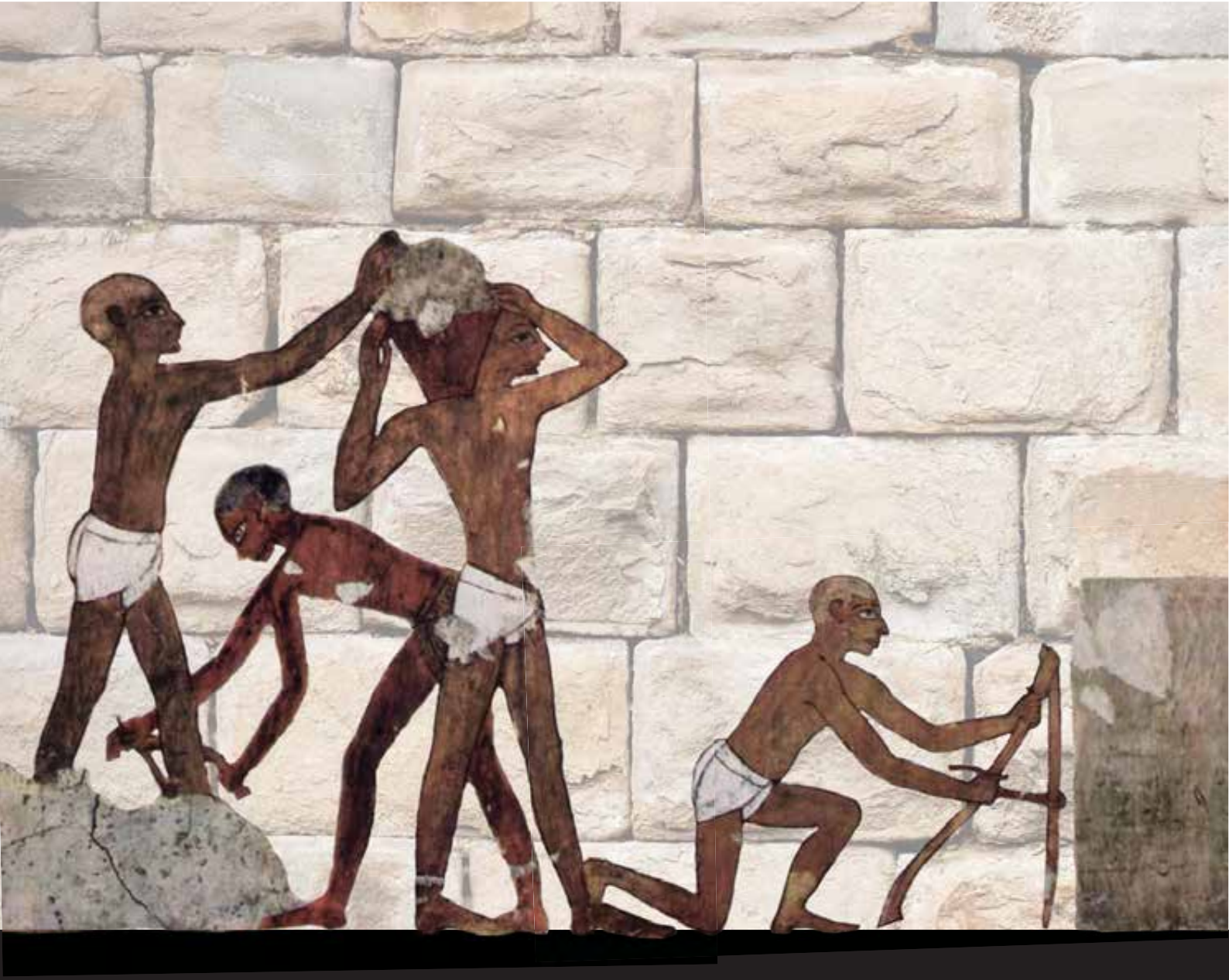

CONSTRUCTING MONUMENTS, PERCEIVING MONUMENTALITY & THE ECONOMICS OF BUILDING

THEORETICAL AND METHODOLOGICAL APPROACHES TO THE BUILT ENVIRONMENT

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

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Victor Klinkenberg received his PhD in Near Eastern Archaeology at Leiden University in 2017. His research interests include digital archaeology, spatial analysis, and household archaeology. Currently a post-doc at Leiden University, he works as project manager in the 'SETinSTONE' project and as field director at the excavations of a Chalcolithic settlement at Palloures, Cyprus. Key publications: Düring, B.S., V. Klinkenberg, C. Paraskeva & E. Souter (2018) Metal Artefacts in Chalcolithic Cyprus: New data from Western Cyprus. *Mediterranean Archaeology and Archaeometry* 18; Klinkenberg V. (2016) *Reading Rubbish: using object assemblages to reconstruct activities, modes of deposition and abandonment at the Late Bronze Age Dunnu of Tell Sabi Abyad, Syria.* Leiden: Nederlands Instituut voor het Nabije Oosten. PIHANS Volume 129; Klinkenberg, V. (2015) Are we there yet?! 3D GIS in archaeological research, the case of Tell Sabi Abyad, Syria. In: Kamermans, H., de Neef, W., Piccoli, C., Posluschny, A.G. and Scopigno, R. (eds.): *The Three Dimensions of Archaeology. Proceedings of the XVII World Congress of UISPP*. Archaeopress, Oxford.

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List of abbreviations

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

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

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

Part One

Theoretical and practical considerations on monumentality

7

Set in stone at the Mycenaean Acropolis of Athens

Documentation with 3D integrated methodologies

Elisavet P. Sioumpara

7.1 Introduction

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

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

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

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

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

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

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

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

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

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

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

304 On the geology of Acropolis, Athens and Attica, see Judeich 1931, 43-49; Andronopoulos and Koukis 1976; Higgins and Higgins 1996, 26-30.
305 Hurwit 1999, 4.
306 Regarding the several phases of destruction of the Acropolis circuit wall, see Korres 2015, 177-185.
307 Kavvadias and Kawerau 1906.

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

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

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

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

310 Kavvadias and Kawerau, 1906, plate A.

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

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

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

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

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

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

317 Iakovides 1962.

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

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

320 Mark 1993.

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

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

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

322 Wright 1996.
323 Mylonas-Shear 1999.
324 Iakovides 1983.
325 Küpper 1996.
326 Loader 1998.
327 Maran 2006.
328 Mountjoy 1995, 14 proposes an alternative date in LH II, perhaps LH IIA, for this room.
329 Regarding the excavation of this room, see Kavvadias and Kawerau 1906, plate 6, no. 36 and Holland 1924, 151-156, figure 12. Holland (1924, 151, footnote 1) dated the room is based on ceramics found above and below its floor, dated by Wace and Blegen, as Holland 1924, 151 footnote 1 says, which is now lost. For a full description, see Iakovides 1962, 69-70; Iakovides 1983, 75; Hurwit 1999, 71; Iakovides 2006, 73-75.
330 Mountjoy 1995, 22-24 sees a possible date of LH IIIA, without excluding a date of LH IIIB for the terraces. If she is right, then the terraces and a possible palace on them would be simultaneous with the palaces at Mycenae and Tiryns, and not later, following the standard interpretation.
331 Iakovides 1962, 71-105; Iakovides 2006, 76-114. The walls of the terraces are of large unworked stones; only their outer face is regular, while the inner face was uneven and adapted to the shape of the rock. Also, the borders of the terraces established based on cuttings in the bedrock, are not universally accepted: compare Hurwit 1999, 72-73 and 337, footnote 29 with earlier bibliography.
332 Travlos 1971, figure 67 reconstructs another large terrace further south, part of the space where the later Parthenon was erected. He believes that the whole palace complex must have occupied the area of the later temples and shrines. Iakovides 1983, 112-113 footnote 21, underlines that this assumption does not rely on excavation findings. If one looks carefully at the plan, it is obvious that this sixth terrace to the south, according to Travlos, practically occupies the rest of the space of the highest and widest natural terrain of the rock, according to the altitude contour lines. Its borders practically surround the contour lines. This plan has not been reproduced in the bibliography.
333 Iakovides 1962, 97-101; Iakovides 2006, 105-111.
334 Iakovides 2006, 190-196. The well-known base of hard limestone and the two steps made of Poros stone were once located northeast of the *Erechtheion.* These blocks were removed by the Membra Disiecta project of the Acropolis Restoration Service in the Old Acropolis Museum in June 2017, in order to prevent further erosion. The service will also perform conservation measures.
335 Iakovides 1962, 173-178; Iakovides 2006, 190-196.

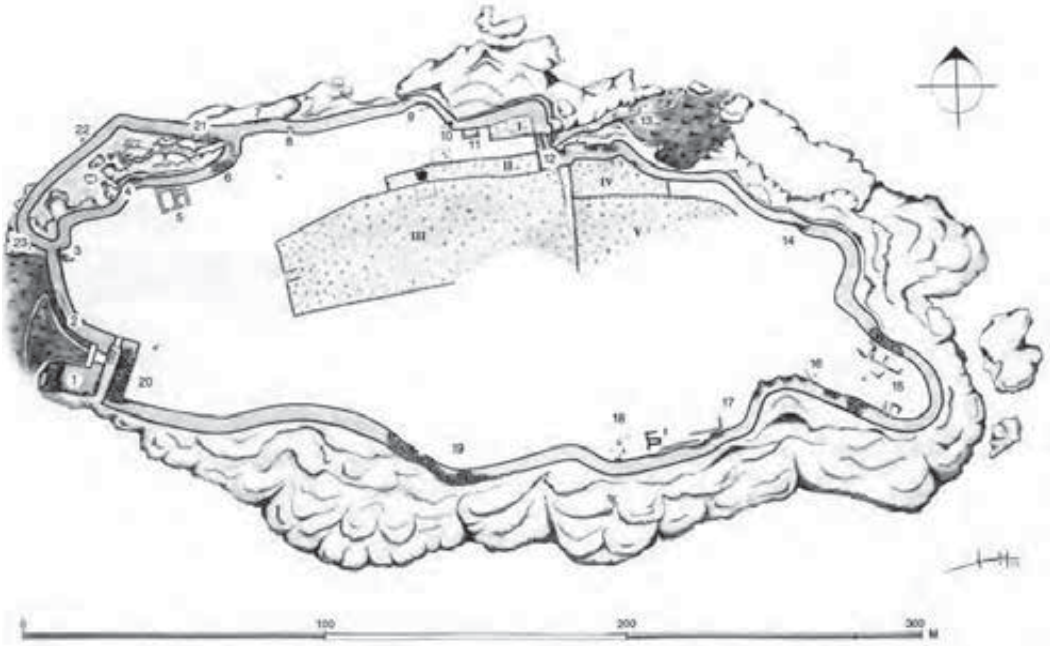

Figure 7.1: Plan of the Mycenaean Fortification Wall at Acropolis (after Iakovides 1973, plan 13).

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

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

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

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

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

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

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

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

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

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

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

344 Bohn 1880, 311-312.

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

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

347 Balanos 1956, 789-790.

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

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

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

351 Mark 1993, 20-30.

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

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

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

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

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

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

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

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

355 Iakovides 2006, 123-128 with plan 19.

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

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

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

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

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

361 Iakovides 2006, 129-136.

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

363 Iakovides 1962, 123; Iakovides 2006, 135.

364 Kavvadias and Kawerau 1906, Tafel 1.

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

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

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

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

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

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365 Iakovides 1962, 122; Iakovides 2006, 135.

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

367 Iakovides 1962, 131-132 with drawing 25.

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

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

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

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

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

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

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

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

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

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

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

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

382 Compare Dinsmoor Jr. 1980, plate 10.

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

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

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

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

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

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

389 See Tanoulas 1997, 222-224.

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

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

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

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

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

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

394 Hurwit 1999; Iakovides 2006, 235.

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

396 Wycherley 1978, 269.

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

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

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

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

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398 Especially Iakovides 2006, 234-239.

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

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

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

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

403 Kolbe 1936, 12; Heberdey 1919, 233.

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

405 Bundgaard 1976, 20.

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

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

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

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

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

406 Iakovides 1962, 205-206.

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

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

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

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

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

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

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

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

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

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

414 I refer to the remains mostly at the south section of the wall: No. 16, No. 17, and No. 18.
415 Kavvadias and Kawerau 1906, plate A with details at the other plates.
416 See the restored plans in Bundgaard 1976, plates A-G.
417 The bastion on the south-west has still today the best documentation, based mostly on the plans, archival material, and photos published by Balanos 1956; see also Mark 1993 and Wright 1994.
418 Iakovides 2006, plans 21, 22, 23, and 24.
419 During 2008 the whole rock under the Classical wall of the Acropolis was cleaned of vegetation, a task performed by professional climbers, compare Ioannidou 2008.
420 Bohn 1882, plate X, at a scale of 1:75.
421 Regarding the 'fountain', see especially Broneer 1939; Broneer 1956, 9-18.

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

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

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

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

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

422 See above.

423 See also Brysbaert *et al.* 2018.

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

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

424 Pakkanen 2009; Pakkanen 2013.

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

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

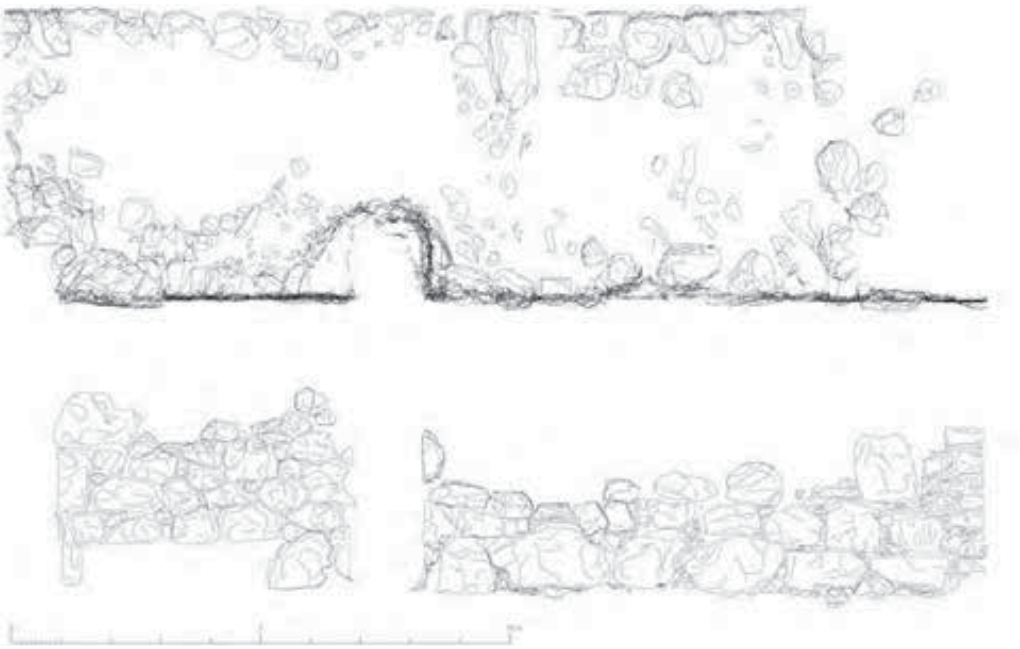

Figure 7.2: New plan and west elevation of the remains at southwest corner of the Mycenaean Fortification Wall at Acropolis (3D line-models in AutoCAD with reflectorless laser total station, without processing, E. P. Sioumpara).

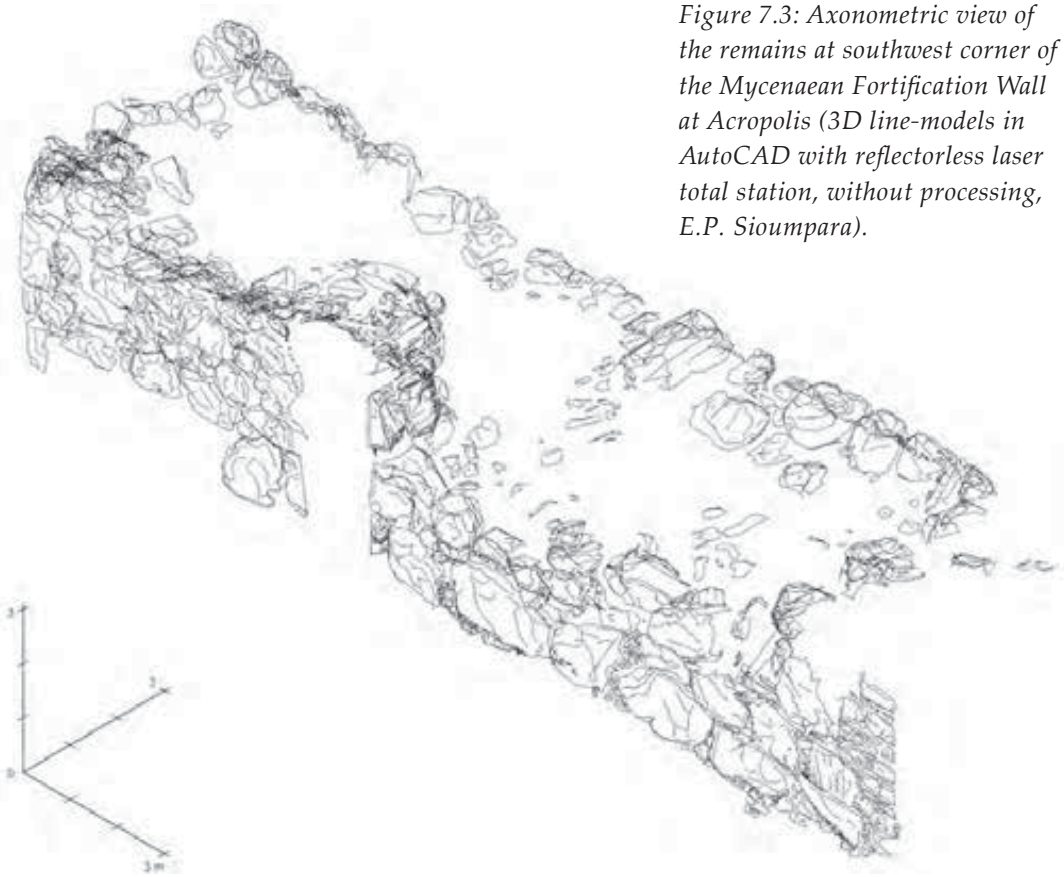

Figure 7.3: Axonometric view of the remains at southwest corner of the Mycenaean Fortification Wall at Acropolis (3D line-models in AutoCAD with reflectorless laser total station, without processing, E.P. Sioumpara).

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

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

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

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

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

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

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

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

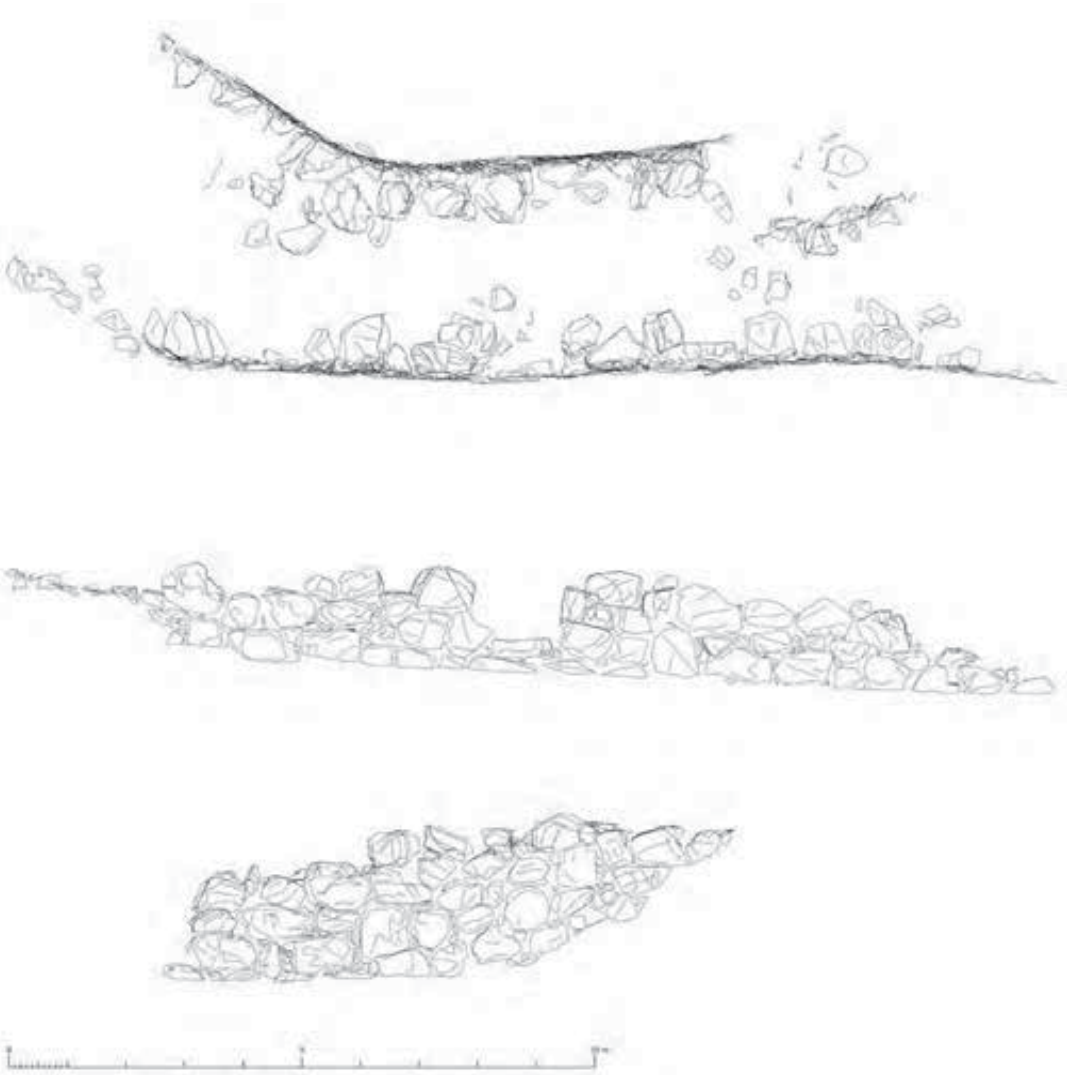

Figure 7.5: New plan, west elevation and southeast elevation of the remains at southeast corner of the Mycenaean Fortification Wall at Acropolis (3D line-models in AutoCAD with reflectorless laser total station, without processing, E. P. Sioumpara).

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

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

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

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

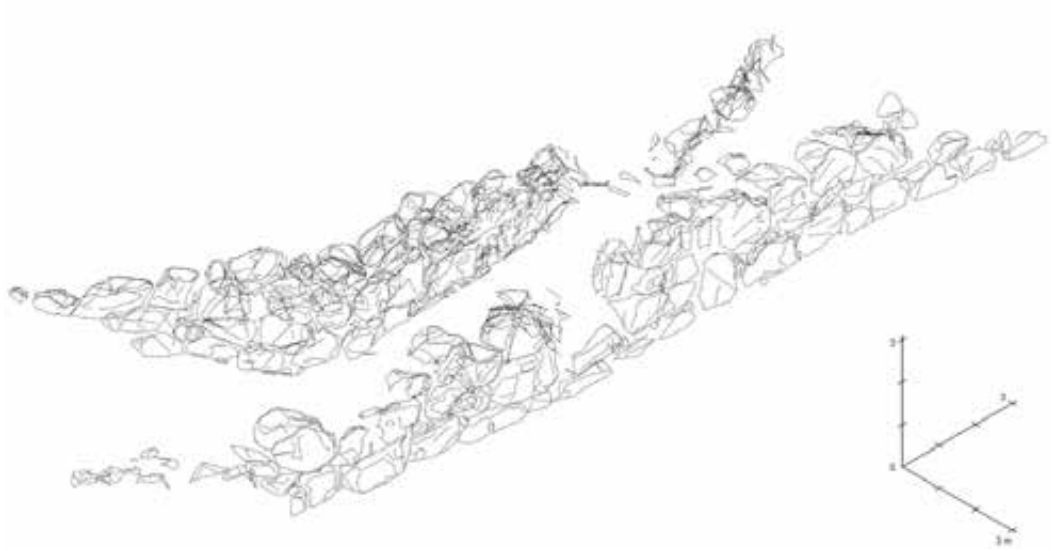

Figure 7.6: Axonometric view of the remains at southeast corner of the Mycenaean Fortification Wall at Acropolis (3D line-models in AutoCAD with reflectorless laser total station, without processing, E. P. Sioumpara).

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

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

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

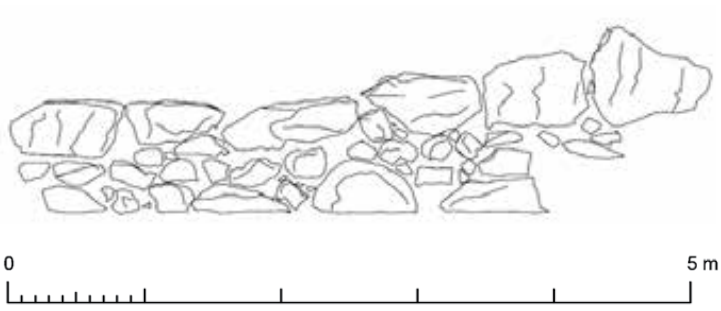

Figure 7.8: Elevation of the remains at east corner of the south section of the Mycenaean Fortification Wall at Acropolis (3D line-models in AutoCAD with reflectorless laser total station, without processing, E.P. Sioumpara).

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

7.5 Summary and preliminary results of the work

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

i. Regarding the construction, we found that the size of the boulders of native limestone used in the wall can vary. The reinforcement of the corners of the construction using large boulders is therefore confirmed. The biggest boulders were found in the lowest course of the south part of southwest section. They range in size from 1.50 m × 0.56 m up to 2.08 m × 1.30 m with a calculated average depth around 1 m, and a volume of around 0.84 to 2.74 m^3. This confirmed that the construction of the outer corners needed the largest boulders for stability reasons, and that these were built directly on the rock.
ii. The average size of the boulders is around 0.70 m to 1.50 m × 0.50 m to 0.80 m with a depth around 0.75 m. They are found in the outer and inner faces of the wall, as seen in the southeast section of the wall. Therefore, they correspond to the sizes known from other LBA fortification walls with Cyclopean masonry.[433]
iii. Smaller stones were used to fill the gaps between the boulders, but not in all cases. In the north part of the wall section, only small stones are used, without big boulders. The boulders could also be cut in such a way as to fit to each other with minimal or no gaps at all. In this case, small stones were used only to fill in the space between the outer and inner faces of the wall.
iv. At the southeastern section, the north part of the east front was fitted perfectly onto the rock and its slope; the wall here uses large and small boulders, and small stones to fill the gaps. It is the only place where we can follow exactly how the line of the wall changes direction. Also, the difference in the depth of the north and south section is discernible here.

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

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

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

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

435 Kavadias-Kawerau 1906, 129.

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

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