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DO MYCENAEAN THOLOS TOMBS ENCODE ASTRONOMICAL ALIGNMENTS?

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ABSTRACT

Beginning in 1998, Victor Reijs (Reijs, 1998) made numerous observations of the sun's passage into the Treasury of Atreus through the relieving triangle near the times of the equinoxes. He suggested that this solar orientation was intentional in the design of the tomb and that the relieving triangle was, at least for a time, open to provide observations of these events. This paper takes a different approach regarding the orientation of these Mycenaean Tholoi, based on architectural and topographic considerations. Como (2009) and others describe in detail the construction methodology used in Mycenaean Tholoi and in particular that of the Treasury of Atreus. Numerous researchers have analyzed and discussed the complex forces involved in this structure, which explain the stability of the monument. As an alternative to tholoi orientations based on astronomical considerations, we argue that topographical characteristics of these sites dictate the orientation and to a large extent the construction of the tomb (Maravelia, 2002). The methods of archaeoastronomy must include all aspects of the site: its topology, the architectural practice of the period, artistic expression, and the cultural aspects of the monument, not just the correlations of the site with respect to astronomical phenomena. The nine tholoi in the general area of Mycenae are examined with respect to their topological siting and relative to possible astronomical phenomena. We find that none of the tomb entrances was intentionally built to observe astronomical events such as the equinoxes.

KEYWORDS: archaeoastronomy, GIS, mapping, topography, solar, lunar

1. INTRODUCTION

The purpose of this paper is to examine the proposition that the Treasury of Atreus was intentionally aligned for observation of the spring and autumn equinoxes, as proposed by Reijs (1998), and to determine if such alignments exist for any of the other tholoi. The Treasury of Atreus is one of nine tholos tombs located near the Citadel of Mycenae, under the supervision of Fourth Ephoreia of Prehistoric and Classical Antiquities at Nafplion (The Archaeological Society at Athens, 2003). This group of tholos tombs represents a unique collection of tombs concentrated in one area covering a period of time dating from 1510 B.C.E. to about 1220 B.C.E. (Mylonas, 1999). The earliest known account of the area is credited to Pausanias, the geographer and traveler of the second century C.E. Pausanias, in his *Description of Greece*, translated by Frazer (1898), recounts observations of the Mycenaean ruins and mentions that "…parts of the circuit wall are still left, including the gate, which is surmounted by lions." and "…underground buildings of Atreus and his children where their treasures were kept." One might suppose that the second excerpt is perhaps to the Treasury of Atreus. A long list of early travelers to Mycenae can be found in the *Archaeological Atlas of Mycenae*, with visits recorded beginning in the 1660s (The Archaeological Society at Athens, 2003).

The archaeological literature for Mycenae begins in the 1830s with the authorization of the Greek Archaeological service by King Otto in 1834. The literature of Mycenae is expansive and covers more than a century and a half (Schlieman, 1878; Wace, 1920-1923; Wace, 1926; Evans, 1929; Wace, 1940; Wace *et al*, 1955; Wace, 1956; Mylonas, 1966; Wace et al., 1980; Dirlik, 2012). In the early twenties of the last century, a spirited debate developed between Evans and Wace over Evans' perceived Minoan influence on Mycenae. Evans maintained that the early phases of development at Mycenae and Mainland Greece in general "represented the result of actual conquest and 'the abrupt wholesale displacement of a lower by an incomparably higher form of culture'", see Galanakis (2007). This could be seen in particular in the development of the Mycenaean tholoi. Evans (1929) argued that the Atreus and Clytemnestra tombs were best explained as products of the highest peak of the Minoan culture. In this scenario, the tombs of Atreus and Clytemnestra represented the earliest and highest order of architectural development. The other tombs, later in his sequence, represented decline. The formulation by Wace (1921-1923) of a scheme that established the chronological sequence of the tholos tombs at Mycenae was designed not only as a rejoinder to Evans but as a view based on solid evidence. As a result of careful field work, Wace established the basis for the current chronology we use today (Galanakis, 2007). Table (1) is a modern assessment of this chronology by Fitzsimons (2006).

Table 1. Tholos chronology (Fitzsimons, 2006).

Group 1	Group 2	Group 3
1 Cyclopean, LH IIA	4 Panagia, LH IIB-IIIA:1	7 Genii, LH IIB-IIIA:1
2 Epano Phournos, LH IIA	5 Kato Phournos, LH IIA-B	8 Clytemnestra, LH IIIA:2-IIIB:1
3 Aegisthus, LH IIA	6 Lion, LH IIA-B	9 Atreus, LH IIIA:2-IIIB:1

1.1 Design and Structural Considerations

A great deal of work has been reported on the construction of tholos tombs (Cavanagh and Laxton, 1981; Frizell and Santillo, 1984; Lazar *et al.*, 2004; Como, 2009). Cavanagh and Laxton explore the architectural and structural design of tholoi from an engineering and mathematical perspective. They examine the stability of the corbelled horizontal rings and discuss the gaps in these structures at the stomion and relieving triangle. (The use of the relieving triangle is a structural concept utilized in modern architectural design to relieve the load on a structural element, such as a lintel, and was apparently recognized by these Mycenaean builders in the later tholoi such as the Treasury of Atreus and the Tomb of Clytemnestra. {Tholoi 8 and 9

Appendix A}) Frizell and Santillo (1984) provide a detailed analysis of the function of the relieving triangle in their discussion of the method of construction of corbelled tholoi. Como (2009) examines the conditions of equilibrium for the Treasury of Atreus, based on a careful survey of the monument, and also proposes a scenario for construction of this tomb. Of interest to us is the prevalence of the relieving triangle in those tombs reported in Wace's groups two and three, in that if we are to consider the use of this architectural feature as playing a part in astronomical observations it would be of interest to know when it became a regular feature. The Tomb of Aegisthus, a member of the first group, is of particular interest. Wace placed this tomb chronologically in group one among the earliest Mycenaean tholoi due to the nature of construction, including material and architectural finish. A feature of the first group was the lack of a relieving triangle. The fact that early investigations of the Tomb of Aegisthus did not report the existence of a relieving triangle, along with other architectural features, placed it early in the chronology. Our recent observations noted what appeared to be such a feature, and on careful review of a number of research papers discovered that more recent archaeological research (e.g., Galanakis, 2007) did establish that this tomb had a relieving triangle (Tholos 3 Appendix A). One might suspect that if relieving triangles had an astronomical function, that practice might date back to the earliest tombs. Due to the poor state of preservation, it has not been conclusively established that the earlier tholoi were deficient in this feature.

2. METHODS

The data utilized in this project were obtained from three main sources. First, direct measurements were taken at each tomb using a fluxgate compass and GPS unit. See Appendix A. Second, high resolution satellite imagery was employed to verify ground measurements taken by the senior author and other researchers (Maravelia, 2002; Reijs, 1998; Table 2). Lastly, a Digital Elevation Model (DEM) was created for the Mycenae environs to model locational aspects of each tomb and to model the horizon altitude, as seen from each tomb entrance. The above three datasets are discussed in detail below.

2.1 Ground Measurements

A Nikon AW100 camera which included an internal GPS and Fluxgate compass was used to obtain photos at each tomb. These images of dromoi, visible horizon, and tomb details (Appendix A) were used to validate data obtained by others mentioned above. A Garmin GPS was also used as backup of geo-coordinates. GPS measurements were taken at dromos entrances allowing maximum access to available satellites.

2.2 Remotely Sensed Imagery

The satellite imagery used in this project consisted of 0.41m pixel resolution panchromatic color images taken by the GeoEye-1 satellite and distributed by DigitalGlobe. The imagery is projected in the WGS 1984 system, allowing for precise estimates of tomb dromos alignments to within 0.5 degrees azimuth from True North. Nine tomb alignments were estimated in this manner, using an angle measurement function in QGIS, a Geographic Information System software package. The results are presented in Table (2) and compare favorably to measurements taken onsite by the senior author and by Maravelia (2002) and Reijs (1998). The azimuth data collected by this method were then used in conjunction with the DEM to estimate the altitude of the horizon, as seen from each tomb entrance.

2.3 Digital Elevation Model

The DEM was produced from two main data sources for a variety of analytical reasons, but most importantly for estimating the horizon altitude as seen from each tomb entrance in order to determine the rise times for various astronomical events. The primary data utilized for the DEM were obtained from the topographic maps published in the *Archaeological Atlas of Mycenae* (The Archaeological Society at Athens Library 2003). The Atlas maps were generated in part from 1:5000 scale Hellenic Military Geographical Services topographic mapping. Elevation contours from the Atlas maps were hand-digitized to vector lines using ArcMap 10.2 software. The vector dataset was then converted to a raster or grid DEM with a 9m cell size (each cell represents the elevation over a given 9m x 9m area of terrain). Unfortunately, the Atlas maps did not cover the entire area of interest and the area outside of the Atlas coverage was modeled using ASTER satellite data, which provides for elevations at a 30m cell size for the surrounding terrain at an approximate scale of 1:25000 (NASA, 2013). The resolution of the ASTER data was satisfactory for this project as the astronomical event horizons for all of the tombs except for Atreus were 17-30km away. The horizon, as seen from the Treasury of Atreus, was modeled using the highly accurate 1:5000 Atlas data described above. The DEM dataset derived from the Mycenae Atlas data was also used for a variety of local measurements at each tomb. These measurements included estimates of elevation, slope, and facing aspect of the terrain taken at the stomion entrance to each tomb (Table 2) using the Spatial Analyst toolkit in ArcMap 10.2. Terrain elevation in meters above mean sea level was measured for each slope from a point directly at (above) the entrance to each tholos tomb. The slope value was generated from the DEM using the derived slope function, returning a slope gradient value in degrees. Finally, the facing aspect of the hillside for each tomb was generated by using the Facing Aspect function. Facing aspect is an azimuth value in degrees for the associated grid cell of the DEM at each tomb's entrance. The facing aspect value is an azimuth measurement calculated perpendicular to the cell's gradient.

3. DISCUSSION

Michael Hoskin (2001) has extensively surveyed the orientations of upwards of 3,000 prehistoric sanctuaries and communal tombs across the western and central Mediterranean. This corpus of data has implications for the connections between sky and cultural practices. In many instances, there are clear preferences for orientation that correlate with both solar and lunar horizon events. Can these preferences be shown to exist in Mycenaean tombs? Of course, this project was to some extent inspired by the observations of Reijs at Mycenae and our skepticism of an intentional solar orientation for the Treasury of Atreus specifically and the cluster of tholoi at Mycenae in general. We have used several tools at our disposal including GIS mapping, on-the-ground observations of the tombs, and astronomical software. A review of Mycenaean archaeological literature pertaining to the tholoi provides insight into construction and cultural use of these tombs. Figure (1) maps the locations of the nine tholoi, the focus of our study.

Table 2. Azimuth of tomb dromos from north, corresponding azimuth of the perpendicular to the slope (aspect), horizon altitude and tholos elevation. [1]Mickelson 2013, [2]Maravelia 2002, [3]Reijs 1998.

ID	Name	Az.[1] (°)	Az.[2] (°)	Az.[3] (°)	Aspect[1] (°)	Aspect[2] (°)	Slope [1] (°)	Alt.[1] (°)	Ele. (m)
1	Cyclopean	280.0	282.5	277.3	285.8	280.5	7.2	4.0	174.6
2	Epano Phournos	186.0	185.0	185.5	245.8	210.5/182.5	3.4	1.3	202.6
3	Aegisthus	194.0	198.0	198.9	216.4	196.5	11.2	0.0	225.7
4	Panagia	248.0	255.0	254.4	256.7	253.5	13.7	3.2	193.3
5	Kato Phournos	273.5	274.0	272.9	298.2	273.5	2.6	2.5	163.5
6	Lion	335.0	334.5	325.8	333.1	335.5	11.0	0.8	221.1
7	Genii	301.0	301.0	302.0	347.7	301.5	12.4	2.0	175.2
8	Atreus	102.2	102.0	102.5	91.6	99.5	5.2	18.0	215.2
9	Clytemnestra	169.9	168.0	167.8	186.4	169.5	6.1	0.0	221.1

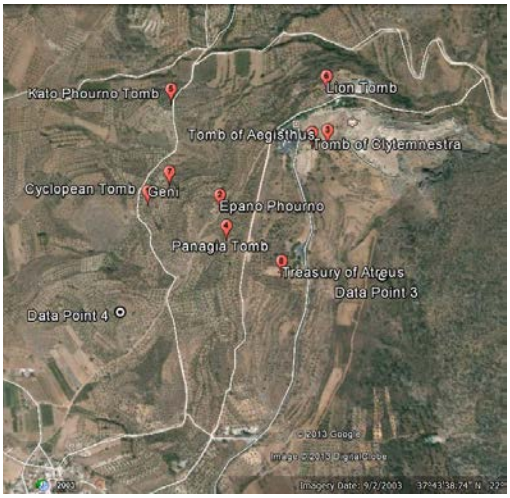


Figure 1. Google Earth Map showing the locations of the nine tholos tombs.

The paper by Maravelia (2002) investigated the orientations of the nine tholoi at Mycenae and their relationship to the topography of the site. The manner of constructing a tholos appears to require cutting a passageway or dromos into a hillside perpendicular to the slope of the landform. The dromos then determines the orientation of the structure. Maravelia, using a magnetic compass corrected for the magnetic declination of the area around Mycenae, determined the azimuthal orientation of each of the dromoi, averaging several measurements along the sides of the dromos. She also estimated the azimuth of the perpendicular to the slope of the hillside denoted as "Aspect" in Table (2). We also have similar values for the orientations of the dromoi from Reijs and have confirmed these ourselves using the aerial mapping methods discussed above.

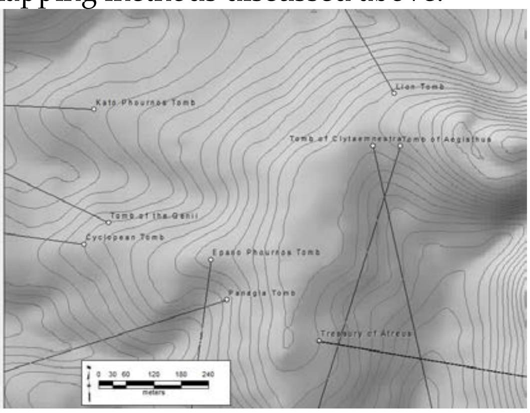


Figure 2. Topographic map with orientations of tholoi superimposed relative to the terrain.

Figure 2 shows the orientations of the tholoi superimposed onto a topographic map of the area. As can be seen from Figure 2 and Table 2, the azimuths of each tholos appear nominally perpendicular to the contour lines. Thus, the orientations of the tholoi are highly correlated with topographic placement and are therefore a result of the method of construction.

3.1 Astronomical Considerations

Tables 3 and 4 present the azimuths of the rising and setting points for an unobstructed horizon for the sun and moon. These data were determined for Mycenae using the JPL Horizons Ephemeris and the United States Naval Observatory Multiyear Interactive Computer Almanac (MICA). In Table 3, there is a noticeable difference in the azimuths of the solstices for the two eras, which is due to a difference in the obliquity of the equinoxes. The obliquity is about 23° 51′ in 1350 B.C.E. and currently about 23° 26′. The azimuths of the equinox rise and set points will not be affected by the variation in the obliquity, but the azimuths of the solstices change by around a half a degree over the epoch cited in Table (3). This is negligible for our purposes and within the error limits of the determinations of the azimuths of the tholoi. In the Armenoi section of the appendix to *Tombs, Temples and their Orientations* (Hoskin, 2001) the author describes the measurements he and Marie Papathanassiou made of the orientations of 224 tombs in this region of Crete which date from the Late Minoan II-IIIB era (1450-1190 B.C.E.). The dromoi of these tombs are in such a good state of preservation that azimuthal orientations could be determined to better than one degree. The range of these azimuths defined an eastern arc whose end points are the extreme lunar standstills, with the preponderance of the orientations correlating with solar azimuths over the course of the year. The question to consider is whether this cultural practice might have influenced the orientations of the Mycenaean tholoi. Might we see solar or lunar encoding in Mycenaean monuments if they occur in

Minoan tombs? Table (4) shows the approximate azimuths of the extreme lunar standstills for the 2006 cycle that would have been observable at Mycenae. The cycle repeats with an 18.61 year period.

Table 3. Solar horizon azimuths.

Event	1350 B.C.E. Azimuth / proleptic Julian Calendar Date	2013 C.E. Azimuth / Gregorian Calendar Date
Spring Equinox Rise	90.26°/ 01.04.1350	90.12°/ 19.03.2013
Spring Equinox Set	270.17°	270.28°
Summer Solstice Rise	58.55° / 04.07.1350	59.09° / 23.06.2013
Summer Solstice Set	301.54°	301.04°
Autumn Equinox Rise	90.27° / 07.10.1350	90.09° / 24.09.2013
Autumn Equinox Set	270.11°	270.33 °
Winter Solstice Rise	120.01°/ 28.12.1350	119.59° / 22.12.2013
Winter Solstice Set	240.23	240.59

Table 4. Approximate rise and set azimuths for the moon at the latitude of Mycenae during the 2006 period of extreme northern and southern excursions.

Event	Extreme North	Extreme South
Lunar Rise	52.8°	127.4°
Lunar Set	307.1°	232.5°

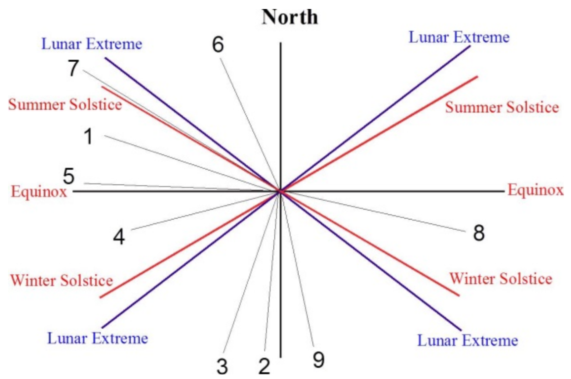


Figure 3. The orientations of the nine tholoi with superposed Lunar and Solar alignments.

Figure (3) shows the orientations of the nine tholoi and the azimuths of the solar and lunar events from Tables (3) and (4). Three of the tholos tombs have an orientation which could be aligned with solar events. Reijs has called our attention to the Treasury of Atreus (Tholos 8 Appendix A). Note that the azimuth of the Treasury of Atreus in Table (2) is 12 degrees greater than the normal horizon equinox sunrise. A large difference at first glance; however, the horizon is obstructed by Mount Sarra to the east at an altitude of from 18 to 22 degrees, depending upon where on the slope the sun appears and where the positions of observation are made in the tomb. As the sun rises its azimuth increases, allowing the sun to be observed through the relieving triangle on a number of days around the equinox. Calculations (MICA) of the azimuth and altitude of the sun as a function of time predict the observations. The Kato Phournos Tomb has an azimuth of 274° and a horizon elevation of about 2.5 degrees (Tholos 5 Appendix A). The equinox sunset occurs at an azimuth of about 270.1° in 1350 B.C.E. thus an apparent correlation. However, no evidence of a relieving triangle is extant for this tomb. With such a low horizon, the sun could enter the open stomion. Finally, the tomb of the Genii has an orientation of 301°, which is near the summer solstice sunset in 1350 B.C.E. and does have a relieving triangle (Tholos 7 Appendix A). The horizon elevation is 2°, which is of no consequence due to the fact that the sun must have an elevation on the order of 22-18 degrees, assuming tholos dimensions similar to Atreus in order to pass through the relieving triangle. Again, using MICA to calculate the azimuth for a solar altitude corresponding to 22-18 degrees yields azimuth values from 17° to 14°, too far to the south for this tholos to function as observed at the Treasury of Atreus. Thus, the possibility that Kato Phournos could function as a solar observatory is indeterminate due to the lack of evidence of an observing aperture, and the Tomb of the Genii, although having a relieving triangle, is orientated too far to the north to allow the sun to pass through the relieving triangle.

3.2 Reijs' Observations

Beginning in April of 1998, Victor Reijs (1998, 2009) began a series of solar observations at the Treasury of Atreus. He supposed that the equinoctial sun would penetrate the tholos via the relieving triangle, and through observations made over a period of more than a decade he demonstrated the phenomenon. A number of photographs and videos are posted at the URLs referenced. Figure (4) shows an image from the March 31st 1999 observations. Subsequently, a video produced in September 2009 displays the observation as a function of time.

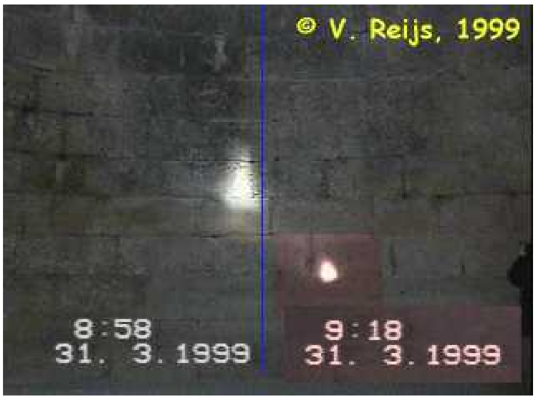


Figure 4. Reijs' March 1999 solar image on the west wall of the interior of the tholos.

Arguments in support of the proposition that the Treasury of Atreus could intentionally be aligned to the equinoctial sun rises include the following three points. First, the sun does in fact enter through the relieving triangle on dates around the equinoxes. However, there is a wide range of dates around the equinox when the phenomena are observed. The window is not precise or narrow, as one might expect if the design were to pinpoint the precise date. Second, it is also argued that the relieving triangle was not necessary to relieve the load on the lintel and thus it could have been designed for observation. Architectural engineers have long known this principle and they practice it in buildings where the loading on lintels over windows and doors is large. Third, he suggests the Treasury of Atreus might be compared with the likes of Newgrange if the relieving triangle were not closed; however, he admits that it might have been. Although he admits the archaeological evidence for the existence of blocking walls and a façade closing the relieving triangle, he proposes that the tholos could have been used to observe the sun prior to filling and blocking the dromos, which we find unlikely given burial practices and the need to protect the tomb's contents. Mylonas (1966) mentions that blocking walls were in evidence both at the Treasury of Atreus and for the Tomb of Clytemnestra. "After each burial, as was the case with chamber tombs, the stomion of the grave and its doorway were blocked by a wall and the dromos was filled with earth. Such a formidable blocking wall was found intact in the stomion and in front of the entrance of the tholos tomb at Dendra… The fact that remnants of a blocking wall survived to the days of Schlieman in the doorway of the so-called Tomb of Klytemnestra would indicate that even in the more elaborate and ornate tombs the practice was followed." Mylonas (1966) goes on to say that this practice has been observed in a number of other tholoi "indicating that the dromoi were filled after burials." It would appear that an astronomical observing function for these monuments is highly improbable. Figure (5) presents a reconstruction of the façade presumed to be at the entrance of the Treasury of Atreus (Mylonas, 1966). It is based on carved fragments of red and green marble from the façade preserved in the British Museum, the National Museum in Athens, and at Berlin, Munich, and Karlsruhe (Higgins *et al.* 1968). Finally, the attributions of the Treasury of Atreus, and the tombs of Clytemnestra and Aegisthus to those mythical personages are without foundation. However, Reijs finds a passage linking Atreus to the sun in Graves' *The Greek Myths: Complete Edition* (1955). There is no denying that Reijs has passionately followed an idea and fully demonstrated the "sun in the tomb" concept.

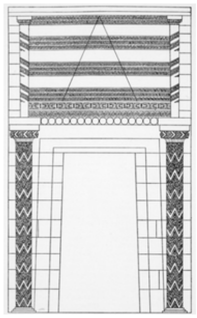


Figure 5. The Façade of the Treasury of Atreus. After Mylonas (1966).

CONCLUSIONS

The orientations of the tombs are highly correlated with topography and to the method of construction and not to any confirmable inclination toward astronomical events on the part of their designers. We reach this conclusion based on the lack of any corroborating evidence of astronomical orientations for any of the other tholoi. There is very convincing archaeological evidence that the relieving triangle would have been closed by a façade and the dromos filled with a blocking wall and filled with soil. Recent evidence for the Tomb of Aegistus confirms the existence of a relieving triangle although it is placed by Wace in group one. This raises two questions. If it is a member of Wace's group one tholoi, does it suggest that the other members of the group had such features? Could Aegistus be transitional between groups 1 and 2? Of the tholoi known to have relieving triangles, we have demonstrated that only Atreus could in principle function as a solar observatory. If the Mycenaean culture constructed tholoi and other burials such that a connection with the sky through alignments was intended, we would expect to see significant evidence of the kind that Hoskin demonstrates in the Armenoi Cemetry.

We therefore conclude that Mycenaean tholoi in general did not encode astronomical alignments and were not used as solar observatories; in particular the Treasury of Atreus was not intentionally aligned to the solar equinox sunrise.

ACKNOWLEDGEMENTS

We are grateful to Professors Jim Wright and Kim Shelton, who provided useful information on the locations of the less accessible Mycenaean tholos tombs, and Randy Piersall, a practicing architectural engineer who shared his insights on the modern use of the relieving triangle and a suggestion as to why the lintel at Atreus was so massive. We would like to thank Victor Reijs for the use of Figure 4 and John Fischer, who over the years, has been friend and councelor on things Greek. Finally, thanks to Diana Mickelson, who has supported our archeological and archaeoastronomical projects over the years throughout Greece.

APPENDIX A: PHOTOS AND GEO DATA FOR MYCENAEAN THOLOI

Table A. Geographical coordinates and azimuths of the nine Mycenaean tholoi.

ID	Name	Latitude	Longitude	Azimuth[1] (°)	Std. Dev. (°)
1	Cyclopean Tomb	37° 43′ 43.4″	22° 44′ 57.2″	280.9	2.6
2	Epano Phournos Tomb	37° 43′ 41.6	22° 44′ 06.6	185.5	0.5
3	Aegisthus Tomb	37° 43′ 49.3	22° 44′ 19.8	197.0	2.6
4	Panagia Tomb	37° 43′ 39.4	22° 44′ 07.8	252.5	3.9
5	Kato Phournos Tomb	37° 43′ 52.8″	22° 44′ 57.8	273.5	0.6
6	Lion Tomb	37° 43′ 54.6	22° 45′19.3	331.8	5.2
7	Tomb of the Genii	37° 43′ 45.2	22° 44′ 58.8	301.3	0.6
8	Tomb of Clytaemnestra	37° 43′ 49.3	22° 44′ 18.6	102.2	1.2
9	Treaury of Atreus	37° 43′ 36.2	22° 44′ 15.9	168.6	0.3

[1]Average of azimuths reported in Table 2.

Cyclopean Tomb [Tholos 1]

Dromos Entrance

Horizon Toward the West

Epano Phournos [Tholos 2]

Dromos Entrance

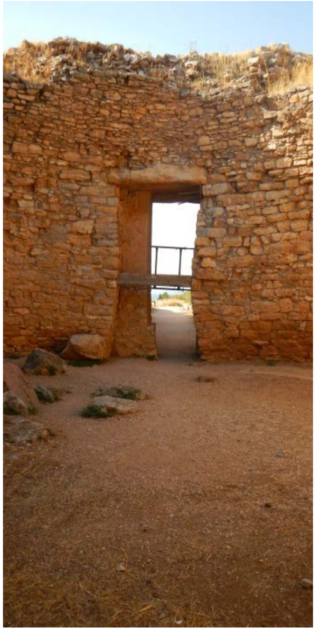
Interior from above rear of tomb

Horizon to South

Tomb of Aegistos [Tholos 3]

Entrance to Dromos toward Stomion (note Relieving Triangle)

Horizon View from Stomion



View of Stomion from Interior (note Relieving Triangle)

Panagia [Tholos 4]

Dromos Entrance toward Stomion

Horizon to S.W.

Stomion from Interior of Tholos

Kato Phournos [Tholos 5]

Entrance to the Dromos toward the Stomion

Interior toward Stomion from above and view of the horizon to the West

Lion Tomb [Tholos 6]

Entrance to Dromos

Horizon from Stomion

Stomion from inside Tholos

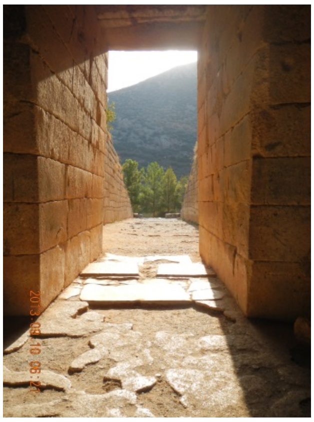
Tomb of the Genii [Tholos 7]

Entrance to Dromos

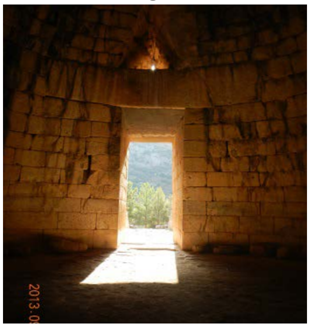
Horizon from the Stomion

Treasury of Atreus [Tholos 8]

Entrance to Dromos



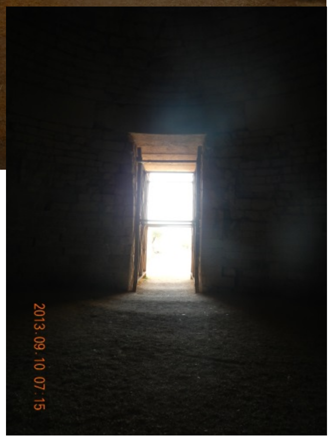
View through Stomion



Relieving Triangle

Tomb of Clytemnestra [Tholos 9]

Entrance to Dromos



Horizon view from the Stomion through the Dromos (Upper Right)

Note that from the interior of the Tholos the Relieving Triangle is closed. (Lower Right)

REFERENCES

The Archaeological Society at Athens, (2003) *Archaeological Atlas of Mycenae*, Archaeological Society at Athens Library No. 229, Athens, Greece.

Cavanagh, W. G. and Laxton, R.R. (1981) The structural mechanics of the Mycenaean tholos tomb, *The Annual of the British School at Athens*, Vol. 76, pp. 109-140.

Como, M.T. (2009) The construction of Mycenaean Tholoi, *Proceedings of the Third International Congress on Construction History*, Cottbus, May 2009, pp. 385-391.

Dirlik, N. (2012) *The Tholos Tombs of Mycenaean Greece*, Master's thesis in Classical Archaeology and Ancient History, Uppsala University, Sweden.

Evans, Sir A. (1929) *The Shaft Graves and Bee-Hive Tombs of Mycenae and their Interrelation*, MacMillan and Co., LTD, London, UK.

Fitzsimons, R.D. (2006) *Monuments of Power and the Power of Monuments: The Evolution of Elite Architectural Styles at Bronze Age Mycenae*, unpublished Ph.D. Dissertation, University of Cincinnati, OH, USA.

Frazer, J.G. (1898) *Pausanias' Description of Greece, Translated with Commentary*, vol. 1, MacMillan and Co., London, UK, pp. 94-95.

Frizell, B.S. and Santillo, R. (1984) The construction and structural behavior of the Mycenaean tholos tomb, *Opuscula Atheniensia Journal,* vol. 15, pp. 45-52.

Galanakis, Y. (2007) The construction of the Aegisthus Tholos Tomb at Mycenae and the 'Helladic Heresy', *The Annual of the British School at Athens*, vol. 102, pp. 239-256.

Graves. R. (1955) *Greek Myths: Complete Edition,* Penguin Books, London, UK.

Higgins, R.A., Ellis, S.E., Simpson, R.H., and Higgins, R.H. (1968) The Façade of the Treasury of Atreus at Mycenae, *The Annual of the British School at Athens*, vol. 63, pp. 331-336.

Hood, M.S.F. (1960) Tholos Tombs of the Aegean, *Antiquity*, vol. *XXX*IV, no. 34, pp. 166-176.
Hoskin, M. (2001) *Tombs, Temples and their Orientations*, Information Press, Oxford, UK.
Lazar, N.A., Kadane, J.B., Chen, F., Cavanagh, W.G., and Litton, C.D. (2004) Corbelled domes in two and three dimensions: the Treasury of Atreus, *International Statistical Review / Revue Internationale de Statistique*, vol. 72, no. 2, pp. 239-255.
Maravelia, A. (2002) The orientations of the nine tholos tombs at Mycenae, *Archaeoastronomy*, no. 27 (JHA, xxxiii), pp. S64-S66.
Mylonas, G.E. (1966) *Mycenae and the Mycenaean Age*, Princeton University Press, Princeton, NJ, USA.
NASA, (National Aeronautics and Space Administration) (2013) *Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) dataset*. http://asterweb.jpl.nasa.gov/, viewed October 2013.
Reijs,V. (1998-2009) *Possible alignments at Mycenae, Greece*, http://www.iol.ie/~geniet/eng/atreus.htm, viewed November 2013.
Reijs, V., (2009), *Treasury of Atreus, sunrises of Sept. 17/18*, http://www.youtube.com/watch?v=T-Prwb93Ad0, viewed November 2013.
Schliemann, H., (1878), *Mycenae*, London, UK.
Wace, A.J.B. (1920-1923) The report of the school excavations at Mycenae, *The British School at Athens*, vol. 25, pp. 283-396.
Wace, A.J.B. (1926) The date of the Treasury of Atreus, *The Journal of Hellenic Studies*, vol. 46, part 1, pp. 110-120.
Wace, A.J.B. (1940) The Treasury of Atreus, *Antiquity, A Quarterly Review of Archaeology*, vol. XIV No. 55, pp. 233-249.
Wace, A.J.B., Hood, M.S.F. and Cook, J.M. (1953) Mycenae, 1939-1952: Part IV. The Epano Phournos Tholos Tomb, *The Annual of the British School at Athens*, vol. 48, pp. 69-83.
Wace, A.J.B. (1955) Mycenae 1939-1954: Part III. Notes on the construction of the 'Tomb of Clytemnestra', *The Annual of the British School at Athens*, vol. 50, pp. 194-198.
Wace, A.J.B. (1956) Mycenae 1939-1955: Part I. Preliminary report on the excavations of 1955, *The Annual of the British School at Athens*, vol. 51, pp. 103-104, 105-120, 121-122.
Wace, A.J.B., Desborough, V.R.d'A. (1980) Excavations at Mycenae 1939-1955, *The British School at Athens. Supplementary Volumes*, no. 12, pp. 101-131.
Wace, A.J.B., Holland, M., Hood, M.S.F., Woodhead, A.G., and Cook, J.M. (1980) Excavations at Mycenae 1939-1955, *The British School at Athens. Supplementary Volumes*, no. 12, pp. 1-93.