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# M I S C E L L A N E A

## Petsophas and the summer solstice*

by

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In our earlier archaeoastronomical study of the peak sanctuary on Petsophas (H. 255 m) in eastern Crete (*Fig. 1*),[1] we proposed that the site on the summit for the small structure had been deliberately chosen and its walls so oriented that the following relationships were established with major celestial events.[2]

(1) The long axis of the area QRST was oriented towards the rising sun at the summer solstice. In order to achieve this orientation it was necessary to build at an angle of about 45° to the sloping terrain. It would have been more natural to place the long axis at a right angle to the slope.

(2) The building was placed on the mountain so that the sun would be observed to set behind the conical peak of Modi (H. 539 m) on the day of the equinoxes by anyone within 30 metres of the building. It is significant here that Modi is a very prominent and quite isolated landmark to the west of Petsophas. The site, which is not at all the most suitable on the summit for a building, seems to have been chosen for the sake of this alignment, as the distance to Modi is only about seven kilometres. The structure was not built at the highest place, which would have been a better lookout point and from which the town below would have been visible.[3]

(3) The walls AA' and AB were oriented to the heliacal risings and settings, the acronychal risings, and the cosmical settings of the bright star Arcturus. Due to the precession of the earth's axis, it is possible to date these walls from their orientations to 1876 ± 47 BC (*Table 1*). Because of the slow rate of precession however—a change in azimuth of 1° per 112 years in the present case—these orientations would have served the purposes which we ascribed to them for most of the Middle Bronze Age (*c.* 2000-1600 BC) .[4] Thus

* *Acknowledgements* – In this addendum to our article 'Evidence for Minoan astronomical observations from the peak sanctuaries on Petsophas and Traostalos', *OpAth* 21, 1996, 99-114, we would like to thank again the members of the boards of the following foundations for their support of our research: the Swedish Council for Research in the Humanities and Social Sciences, the Gunvor & Josef Anér Foundation, the Axel & Margaret Axelsson Johnson Foundation, the Magn. Bergvall Foundation and the Helge Axelsson Johnson Foundation. We are also grateful to the Greek Archaeological Service for permission to study Petsophas. We would like to thank as well Costis Davaras, former ephor, and Nikolas Papadakis, present ephor of antiquities at Ayios Nikolaos, Berit Wells and Bodil Nordström of the Swedish Institute at Athens, all of whom have helped us in the pursuit of our investigations. We remain indebted to the members of the graduate seminar in Classical Archaeology and Ancient History at Uppsala University for their continuing interest in our research and for their helpful criticisms. We are also grateful to Åke Johansson for his help with our computer needs. We owe special thanks to Peter Blomberg who helped us carry all equipment up the mountain and also helped with the measurements and photography.

[1] G. Henriksson & Mary Blomberg, 'Evidence for Minoan astronomical observations from the peak sanctuaries on Petsophas and Traostalos', *OpAth* 21, 1996, 99-114. The measurements of the walls of the structure on Petsophas were made with the laser theodolite SOKKIA SET 4C on two occasions. All orientations of the co-ordinate systems were obtained from observations of the sun, which are accurate to < 0.01°. With such exact measurements we can be confident that we have not introduced any significant errors of measurement.

[2] In archaeoastronomy only orientations and alignments to major celestial events are considered significant. These are sunrise and sunset at the solstices and equinoxes, moonrise and moonset at the standstills, the heliacal risings and settings, the acronychal risings and the cosmical settings of bright stars and prominent constellations. Even in the case of major celestial events, the possibility of chance should be ruled out. This can only be done on the basis of studies of several sites, unless there are orientations to multiple major events at the same site, as we find at Petsophas, or a number of unique relationships concerning one event, as at Knossos (publication in preparation). In the case of Petsophas it is significant that the orientations to Arcturus are duplicated at Traostalos. Other factors, such as the choice of location for a building and of foresights, should also be evaluated. On the specialised use of the terms *orientation* and *alignment* in archaeoastronomical studies see E.W. MacKie, 'Maeshowe and the winter solstice: ceremonial aspects of the Orkney Grooved Ware culture,' *Antiquity* 71, 1997, 340f. These specialised meanings cannot be strictly applied to Minoan sites. *Alignment,* however, is used here only where a distant foresight is part of the arrangement.

[3] Compare A. Peatfield, 'Minoan peak sanctuaries: history and society', *OpAth* 18, 1990, 119f.

[4] Henriksson & Blomberg (supra n. 1), 111-114. The parameters for calculating the visibility of Arcturus have been based on the results of A. Bemporad, 'Zur Theorie der Extinktion des Lichtes in der Erdatmosphäre', *Mitteilungen Grossh. Sternwarte zu Heidelberg* 4, 1904, 1-78; H. Siedentopf, 'Neue Messungen der visuellen

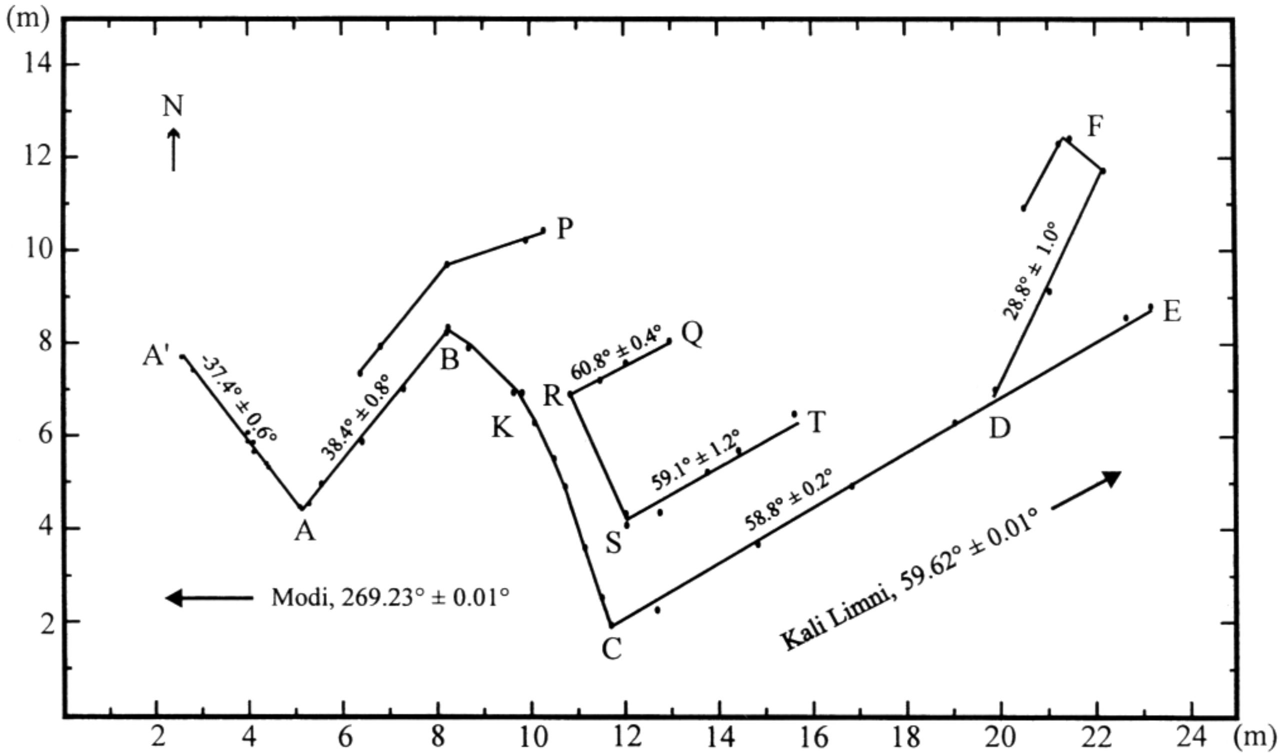


Fig. 1. Ground plan of the structure on Petsophas (H. 255 m) with orientations.

Table 1. Summary of the measured azimuths of the orientations from the peak sanctuary on Petsophas (H. 255 m).

| Object | Azimuth | Mean error | Number of points measured | Comments |
|---|---|---|---|---|
| AA' | 322.6° (-37.4°) | ± 0.6° | 10 | Arcturus' cosmical and/or heliacal settings, optimal for 1925 BC ± 60 years |
| AB | 38.4° | ± 0.8° | 6 | Arcturus' acronychal and/or heliacal risings, optimal for 1812 BC ± 57 years |
| DF | 28.8° | ± 1.0° | 9 | later wall according to Myres |
| CE | 58.8° | ± 0.2° | 8 | close to sunrise at the summer solstice *c*. 2000 BC, valid for many centuries |
| ST | 59.1° | ± 1.2° | 4 | see CE |
| RQ | 60.8° | ± 0.4° | 8 | see CE |
| Axis of QRST | 60.4 | ± 1.0° | 12 | see CE |
| to sunrise at the summer solstice | 59.86° | | | upper limb visible above Karpathos, t = +20°, computed for 2000 BC |
| to Kali Limni (H. 1215 m) | 59.62° | ± 0.01° | | just north of sunrise at the summer solstice *c*. 2000 BC. Valid for many centuries |
| to Modi (H. 539 m) | 269.23° (-90.77°) | ± 0.01° | | close to sunset at the spring and autumn equinoxes *c*. 2000 BC, valid still today |

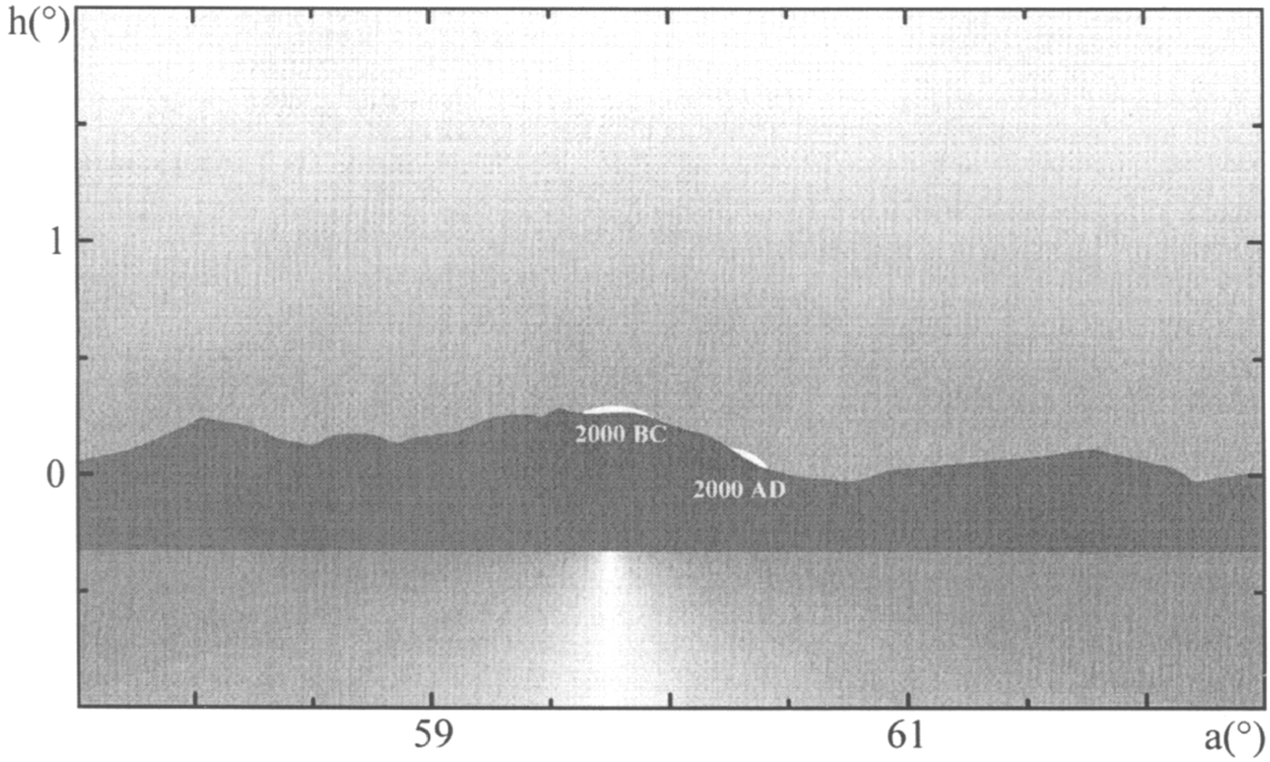


Fig. 2. Theoretically calculated position of sunrise at the summer solstice above Kali Limni, Karpathos' highest peak (1215 m), 23 June 2000 BC, 04.39.35 o'clock local mean solar time (sun on the left), as it would have been observed from the peak sanctuary on Petsophas (H. 255 m). The sanctuary's axis of symmetry has the orientation 60.4° ± 1.0°, which in view of the margin of error coincides with the orientation to sunrise at the summer solstice (59.86°) when the sanctuary was built. Karpathos' profile has been digitised from a photograph that was calibrated with theodolite measurements. The figure shows the sun 10 seconds after the time when, according to the calculations, the first rays of the sun would have been visible above Karpathos, which is *c.* 90 km away.

The sun on the right shows sunrise 21 June 2000 AD, 05.01.38 o'clock Greek standard time. Refraction calculated for + 20° C and atmospheric pressure 760 mm Hg.

they agree well with the time span for the use of the site as indicated by the archaeological evidence.[5]

We have recently been able to determine more precisely the relationship between the orientation of the axis of symmetry of the area QRST, the highest peak of Karpathos, Kali Limni (H. 1215 m), and sunrise at the summer solstice.[6] The alignment of the long axis of QRST is 60.4° ± 1.0° and the azimuth of Kali Limni is 59.62°. The azimuth of the upper limb of the sun at sunrise at the summer solstice was 59.86° (*Table 1*). The first rays of the sun would have been visible in clear weather just south of Kali Limni in the centuries around 2000 BC from Petsophas (*Figs. 2, 3*). This means that the highest peak of Karpathos, when visible, would have been an excellent foresight for sunrise

Kontrastschwelle', *Astronomische Nachrichten* 271, 1941, 193-203; A. Ljunghall, 'The intensity of twilight and its connection with the density of the atmosphere', *Meddelanden från Lunds astronomiska observatorium,* ser. 2, vol. 13, no. 125, 1949; J.F. Schmidt, 'Ober die Dämmerung', *Astronomische Nachrichten* 63, 1865, article no. 1495. It is important to use Schmidt's visibility calibration for Athens from *c.* 1850 our era as his observations were made before modem air pollution. We are very grateful to Professor Lennart Bondesson, Department of statistical mathematics at Uppsala University for his help with the statistical evaluation of the orientations of the walls AA' and AB. He calculated the orientations by orthogonal regression and used Student's T-test with pooled variance to test the probabilities.

5 J.L. Myres, `Excavations at Palaikastro. II. The sanctuary-site of Petsofà', *BSA* 9, 1902-1903, 356-387: we surmise from Myres' comments the time span MM I to LM I; C. Davaras, 'Πετσοφάς', *ArchDelt* 27, B:2 (Chronika), 1972, 652: MM I–LM I; B. Rutkowski, *Petsophas. A Cretan peak sanctuary* (Studies and monographs in Mediterranean archaeology and civilization, 1), Warsaw 1991, 15-20: MM I to LM I; J.A. MacGillivray & Jan Driessen, 'Minoan settlement at Palaikastro', in *L' habitat égéen préhistorique,* ed. P. Darque & R. Treuil (BCH, Suppl. 19), Paris 1990, 401 and 412: MM 1B/IIA to MM IIIB/LM IA.

6 We would like to thank Col. Kostakis Grammenos and Col. Ioannis Spanditheas of the Hellenic Military Geographical Service for providing us with maps and the necessary co-ordinates. The profile of the mountain was measured from a photograph and calibrated by theodolite measurements.

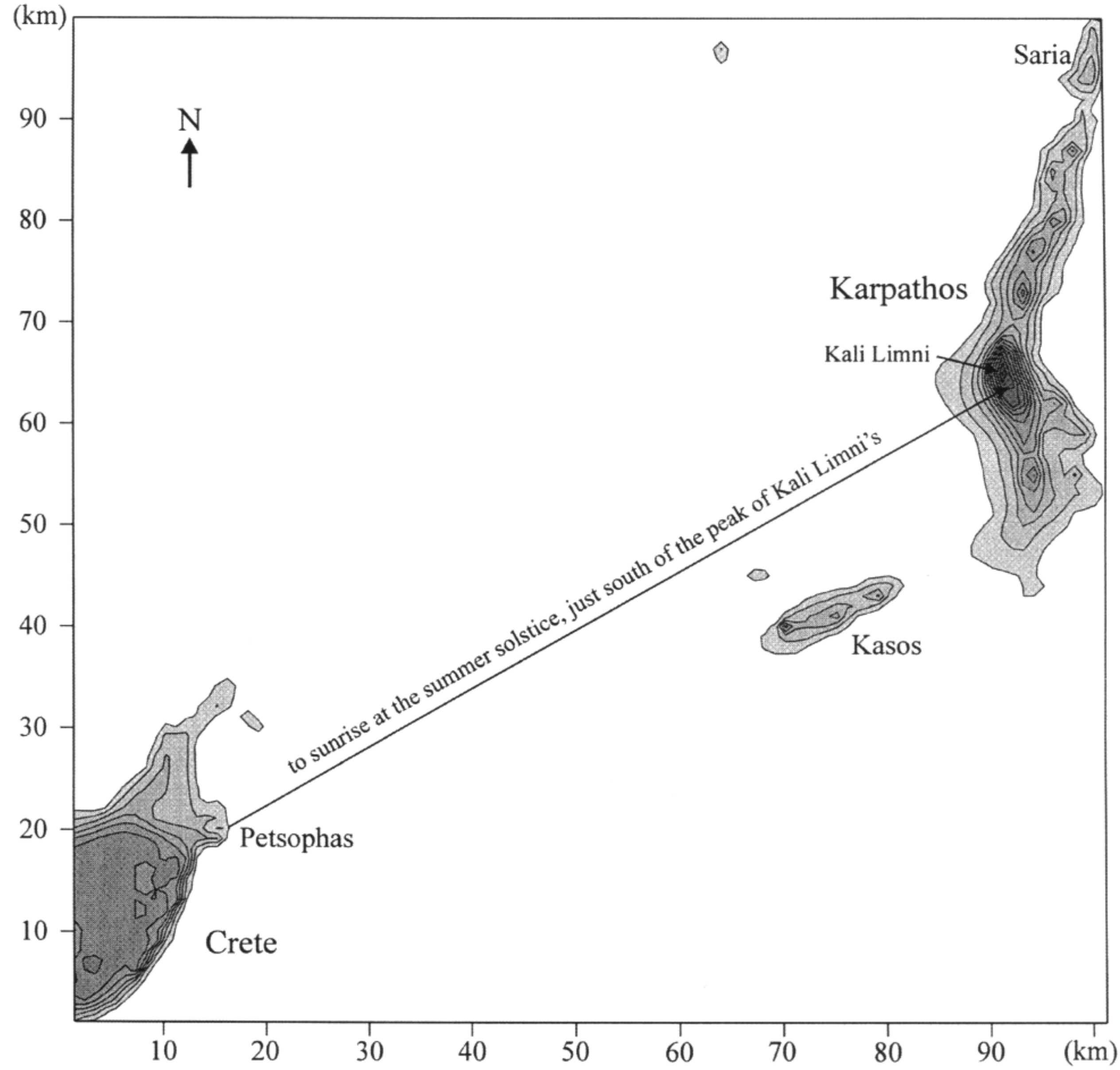


Fig. 3. North-eastern Crete and Karpathos. Orientation of the axis of symmetry for the area QRST = 60.4° ± 1.0°; alignment to Kali Limni 59.62°; distance to Karpathos *c.* 90 km. Contour lines at 100-metre intervals above sea level.

on the morning of the summer solstice to observers sitting on the benches along the three sides of the area QRST.[7] In the event of poor visibility on the morning of the solstice, the orientation of the walls QR, ST and CE would have been useful for pointing to the place for sunrise so that the first appearance of the sun would not be missed.

The discovery of this possibility of using Kali Limni as an accurate foresight for sunrise at the summer solstice strengthens our earlier arguments for the deliberate and careful placement of the small sanctuary building on Petsophas. Only in its present position at the edge of the broad plateau would the structure have had an imposing natural feature in the east and another in the west that would have served well as foresights for key calendrical positions of the sun in its annual cycle: sunrise at the summer solstice and sunset at the equinoxes. The orientation to Modi in the west, however, is far more sensitive because the distance is only about seven kilometres. There is a similar relationship at Zakros involving the palace, a prominent natural feature and a major celestial event. The cliff to the southwest would have served well as foresight for moonrise at the southern major standstill with respect to the northern-most corridor of the west wing.[8]

[7] It is relevant here to point out that the thick and extensive layer of ashes which Myres (supra n. 5, 357f., 360) found west of the wall DF indicates that the area QRST had no roof in the Middle Minoan Period.

[8] Publication in preparation. See also J.W. Shaw, 'The orientation of the Minoan palaces', *AntCr* 1, 1977, 59.

It now seems very probable that celestial events of major calendrical importance account for all contemporary parts of the small sanctuary building on Petsophas, except for the curved wall BC,[9] but including the oblique walls AA' and AB: sunrise at the summer solstice, sunset at the equinoxes, the heliacal risings and settings, the acronychal risings and the cosmical settings of the bright star Arcturus. Arcturus, as we pointed out in our earlier article, is well known as a calendrical star from our earliest Greek texts, and it continued to be used as such down into late Roman times.[10]

The discovery of the possibility of using Kali Limni as a foresight for sunrise at the summer solstice supports our earlier conclusions that the purpose of the site was both practical and religious—practical in that it was used for systematic observations of the heavenly bodies for the sake of keeping a lunisolar calendar and learning the positions of the stars for navigation, religious in that it seems likely that the Minoan gods and goddesses were in some way associated with the heavenly bodies and that their feasts had to occur on the correct dates.[11]

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[9] According to Myres (supra n. 5, 357), the wall DF is "later"; presumably he meant later than the walls BC and CE.

[10] Henriksson & Blomberg (supra n. 1), 107f. See also J.N. Coldstream & G.L. Huxley, 'An astronomical graffito from Pithekoussai', *PP* 288, 1996, 221-224.11

[11] See further Henriksson & Blomberg (supra n. 1); M. Blomberg & G. Henriksson, '*Minos enneoros.* Archaeoastronomical light on the priestly role of the king in Crete', in *Religion and power in the ancient Greek world. Proceedings of the Uppsala symposium 1993* (Boreas. Uppsala Studies in Ancient Mediterranean and Near Eastern Civilizations, 24), Uppsala 1996, 27-39.