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ASTRONOMICAL ORIENTATIONS OF ANCIENT TEMPLES AT RHODES AND ATTICA WITH A TENTATIVE INTERPRETATION

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ABSTRACT

Archaeoastronomical orientations of twelve temples and sacred places from Attica and the island of Rhodes, Greece, are presented. Azimuths, angular altitude of skyline, star declinations, star attribution and solar season are produced from field measurements and home made software. The sites include Rhodes (Aphrodite, Athena of Kamiros, Athena Polias at Ialyssos, Nymphaeon, and two unknown temples at Lindos and Kamiros), Attica (two temples of Nemesis at Ramnous, and in Eleusis the Telesterion, Ploutonion, Artemis Propylaea, and a Mycenean megaron B). For six of them a tentative interpretation is made. The solar equinoxes and winter solstice, the Antares (alpha of Scorpion), the delta of Centauri and the Orion seem to be related to the measured orientations.

KEYWORDS: archaeoastronomy, temples, azimuths, declinations, stars, Greece, Rhodes, Attica

INTRODUCTION

Surely, it is difficult for most of us to imagine our life without the electric lights. Habitants of large cities in the modern world rarely, if ever, get the chance to see a real dark night sky. Most of us have lost contact with the sky; and yet our ancestors have lived with this celestial environment, moment-by-moment, day-by-day and season-by-season. Past people became intimately familiar with the heavenly bodies and their movements: the sky was indeed a sine qua non part of their living world (Ruggles 1999). It is quite well known the astronomical significance of Stonehenge and Mayan Temples alignments to midsummer sunrise. In another case, around the shortest day each year (winter solstice, 21st of December), just after dawn, a shaft of sunlight suddenly penetrates deep into the interior of the five thousands year old passage grave at Newgrange, Co. Meath. The phenomenon lasts only for a few minutes and it is dependent upon the weather, yet each year hundreds of people clamor to see it at first hand. Only a privileged few actually get to do so. The waiting list is several years long, and the queue can be jumped only by dignitaries such as government ministers (Ruggles 1999; Aveni 1989).

These and many more widely known examples confirm, the general idea that there is a connection between ancient stone monuments, or at least the best ones, and astronomy, which is firmly engrained in the popular culture. Popular legends have long attributed protection or healing properties to ancient standing stones in association with the sun, and were worshippers of a deity associated with the monumental construction, in turn connected (by alignment) with a celestial body. What did this mean for their stonemasons? Were such megalithic structures some sort of observing instrument or did the alignment symbolize something? Were special ceremonies held there as the sun shone in along the axis or entrance corridor? Could anyone join in or were they the preserve of a privileged few?

To address questions such as these is the scope of archaeoastronomy. Archaeoastronomy is the scientific study of the beliefs and practices concerning astronomy that existed in ancient and prehistoric civilizations. The study of archaeoastronomy pertaining to the classical world and to the eastern Mediterranean basin in particular has undergone considerable rejuvenation in the past two decades, as a number of articles which summarize the status of these investigations has attested. (Henriksson and Blomberg 1996; Aveni and Romano 2000).

Since prehistoric times, people observed with particular interest the starry sky and the celestial phenomena, either for religious or worship purposes, or for calendrical reasons, which they should use to cultivate their land or for navigation. Many prehistoric and historic monuments seem to have been undoubtedly orientated towards the sunrise during the date of construction, during the four solar stands (two solstices and two equinoxes), or other very significant celebrity dates of the year. We should pay particular attention to the early work of Dinsmoor (1939), who pioneered the study of the possible astronomical orientations of Aegean Temples, and Nissen (1869), Lockyer (1891), Petrie (1883, 1930), Penrose (1892), Shaw (1977), all of which focused on Greek temples, British megaliths and Egyptian monuments. From these early attempts most Greek temples seem to lie out to face the sunrise on the actual day of their foundations, presumably the festival day of the divinity.

Figure 1 shows a frequency chart of ancient Greek Temple orientations based on their azimuths by Nissen (1906-10). Nissen's data cover most Greek Temples. The orientations in Fig.1 sway a tendency towards eastern targets with a spread of $\pm 45^0$ around east, and several exceptions pinpointing south, north and scattered between S-W-N. Quite clearly, if enough

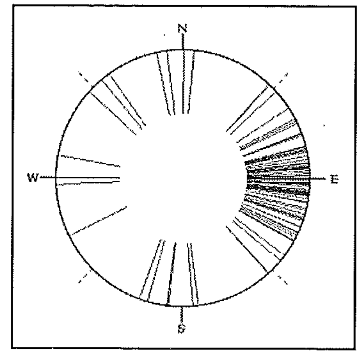

Figure 1. Frequency chart of Greek Temples orientations from azimuths mentioned by Nissen (1869)

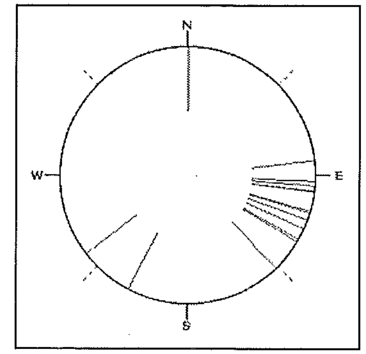

Figure 2. Frequency chart of Greek Temples orientations from azimuths measured in this study, but including other temples of Athena (Lindos, Rhodes); Apollo Pythios and Erethymios (Rhodes); Zeus Atavyrios (Rhodes); Demeter, (Rhodes) (Liritzis and Vassiliou, 2002) .

is known about ancient society's astronomy, it helps to resolve the questions of orientation. For Greeks, it is known they were experienced sailors and have had a practical knowledge of certain star positions (see, Orphic fragments, Homer's Iliad and Odyssey, classical writers, representations of sailing in prehistoric ceramics and walls-paintings, navigation since early neolithic times evidenced from acquisition of Melean obsidian found in mainland Greece, to mention a few examples).

The reported study here deals precisely with this issue. That Greek temples aligned to the east with a few exceptions is furthermore reinforced. It is based in part on statements from classical literature indicating that the gods, i.e. the cultic statues placed within temple sanctuaries, were required to face the rising sun in the proper season.

For example, Aeschylus (Agamemnon, 519-20) implies that the statues are "gods who face the rising sun...with gleaming eyes".

From this passage (custom) we may derive our word 'orientation', which means "to face the sunrise on the actual day of foundation (of the temple presumably the festival day of the divinity" (Lucian in De Domo, 6; Shaw 1977).

However, other later accounts place the statue to face the west, or follow environmental factors, "so that those who enter to sacrifice or to make offerings, may have their faces to the east, as well as to the statue in the temple...hence all altars of the gods should be placed towards the east...but if the nature of the place do not permit this, the temple is to be turned as much as possible so that the greater part of the city may be seen from it. Moreover, if temples be built on the banks of a river, as those in Egypt on the Nile, they should face the river. So also if temples of the gods be erected on the road side, they should be placed in such a manner that those passing by may look towards them, and make their obeisance" (Vitruvius, De Architectura, IV.5). Entering the temple with the back to the rising sun and then facing round due east is also reported by Plutarch (Numa Pompilius 14:4).

Other accounts include historian Diodorus of Sicily in the 1st century BC, who quotes passages attributed to Hecateus of Abdera (c.330 BC), about moon "...they say also that the moon, as viewed from this island, appears to be but a little distance from the earth...the god visits the island every 19 years, the period in which the return of the stars to the same place in the heavens is accomplished". This period is the Metonic cycle marking the time after which the moon returns to the same phase on any given day in the year (though doubts are expressed to the reliability of this ancient historian).

Orphic hymns from relevant fragments quote in a mostly symbolic manner celestial bodies, for example for the sun, the four solar stands ("...dancing with four feet...father of time, ...", hymn to Helios, VIII), for the moon ("...taurus horned mene...male and female...mother of time...", Hymn to the Moon, IX), for the chthonean Nymphs, "...friends of the spring...come with joyful mood to the respectable holy ceremonies, pouring salubrious running water to the wealth given epochs", Nymphs incense, LI).

Apart from the sunrise foresight, other particularly bright stars have been involved in the alignment and in star/moon rising or setting. The choice of a particular star of a constellation for such an alignment is rather related to an associated myth in which a deity related with the temple is involved. In Greek mythology deities, demigods, and/or heroes, after the will of father god Zeus, were becoming stars or constellations named after them (Burkert 1977, 1987; Decharme 1884; Dicks 1970; Graves 1986[2]; Grimal 1951; Kerenyi 1966; Nilsson 1961; Theodosiou and Danezis 1998). Thus, there was a relation between sacred structures with astronomy. Therefore, there may exist an association between orientation of sacred places and those celestial bodies. Our present study aims exactly at this; to investigate if any such alignment is a fact or not, examining both directions of the elongated temple.

Nevertheless, perceptions of the sky are culture-specific. The above modes of explanation apply to the Greek and eastern Mediterranean traditions, in other cultures key importance is attached to different points (e.g. dim stars, dark patches in the Milky Way, etc (Ruggles 1987; Urton 1981). The above discussion offers the basic rationale for undertaking archaeoastronomical orientation work and introduce the reader to the new prospective in archaeological research with due caution.

PRESENT DATA AND ERROR EVALUATION

We have measured twelve temples from Rhodes and Attica, six of which are fully interpreted (Table 1) (Gruben 2000; Jacobich 1982; Rocco 1993; Liritzis and Vassiliou 2002). The following presentation gives an in depth account of the procedures, errors and formulae used.

In each case, for the horizon survey and data reduction techniques the following parameters were measured: azimuth (angle between magnetic or true north and main axis of building, e.g. side walls, entrance corridor, etc), the angular altitude of the horizon by a magnetic (prismatic) compass combined with an attached inclinometer (MERIDIAN type), and the determination of geographical latitude by a pocket-sized global positioning system (GPS) receiver (GARMIN GPSIII type) with uncertainties 3-6

meters depending upon satellite coverage. The statistical (=random and systematic) errors in azimuths and angular altitudes of the skyline transmitted to star declination were taken into account in the star attribution. Corrections were applied for the magnetic rate of change (declination) in each site regarding azimuths (map data kindly provided by the Greek Geographical Army Service, GYS, Athens, and from useful communication with Dr D. Barraclough, Edinburgh), and for the atmospheric refraction which makes stars to rise higher in the horizon. These were taken into account in the star declination and consequently the star attribution.

Star attribution followed the Smithsonian star catalogue (Hawkins and Rosenthal 1967; Liritzis 1998, 2001), through a home made software (FINDSTAR), which provides the dates within a century and the names of all possible stars in the past millennia of the calculated corrected declinations with associated error bars which reflect error in measurements and applied corrections. A subroutine of this program concerns the division of the solar year; it is the subprogram SUNDAY, which gives the exact day of the year of sunrise. The appropriate software corresponds to the formula that expresses the sun's declination:

$$\text{Sin}\delta = \sin\varepsilon \cos [0.9856n + 2.07\sin(0.9856(n-n_p)]$$

Where δ is sun's declination, ε is the obliquity of the ecliptic, which has a value of 23.4^0 at present (slightly varies over time), n_p is the time of perihelion, the point when the earth is closest to the sun, measured in days forward from the June solstice (21st of June), n is the number of days that have elapsed since the June solstice, and all angles are expressed in degrees. The 0.9856 is computed from 260/365.25 the number of degrees in the circle divided by the number of days in a year (tropical year), and the coefficient 2.07 comes from $2e\text{x}180/\pi$, where e=0.0181 the mean ellipticity of earth's orbit round the sun. This varies slightly with time and its present time value is 0.017 that makes the coefficient equal to 1.948.

In fact, orientation is carried by locating principal axis of single conspicuous sidewalls and the entrance corridor. Along these lines the azimuth and altitude of the horizon are measured.

The computation of declinations was made with a simple software (STARDEC) based on the formula:

$$\text{Sin}\delta = \sin\lambda \sinh + \cos\lambda \cosh \cos A,$$

where, A=azimuth, h= angular altitude of the skyline (AAS), δ=declination, λ=geographical latitude of the site. The atmospheric refraction is accounted for the respective AAS. Use of the program GETDEC, which assumes a mean refraction correction, was also made (see, C. Ruggles, internet site) for comparison especially concerning refraction correction.

Fig.2 shows the azimuths measured in the present study for Greek temples presented in a circular horizon perspective (see also, Liritzis and Vassiliou, 2002). It is observed an eastern but with some trend due south, and three exceptions, one northern and two southwestern directions. In general, the distributions follow Nissen's orientations (Fig.1). Errors in azimuth were 0.2 to 0.5 degrees. Any better precision does not offer any more useful information regarding orientation (precision = the degree of refinement of a measurement, that is the size of units in which it is quoted, to the nearest minute of arc, to the nearest half-degree, etc.).

We believe that, a) the disturbed archi-

TABLE 1: The studied Greek temples, along with their date of construction, the azimuths with associated errors and star declinations. Declinations include refraction correction according to AAS. All azimuths refer to foresights on entering the temples, whereas in the Telesterion refer to both, the long E-W walls, and along the entrance. Similar for Athena Polias Temple (Measurements by Penrose (1893) include a) Telesterion, Eleusis, Az=296° 51′, western alignment; b) Artemis Propylaea, Eleusis, NW direction Az=133° 43′ 13″ reporting Arcturus and Capella, and for SE direction Az=313° 43′ 13″, no suitable star reported, c) Nemessis, Themis, Az=268° 30′ 14″, Spica rising, d) Nemessis Rhamnous, Az=271° 24′ 50″, Spica rising).

TEMPLE	LATITUDE	AAS	AZIMUTH DIRECTION	AZIMUTH	DECLINATION	POSSIBLE STAR	POSSIBLE DATES
Nymphaeon 3d - 2nd centuries BC, Monte Smith, Rhodes	36°26′37.1″	0°±0.2	Eastern	96.8° (±0,5°)	-6° 4′ 33,3″	Ori ζ	Oct., 8-9-10 Mar., 3-4-5
Ploutonion 6th century BC, Eleusis, Attica	38°2′30″	3,5° (± 0,2°)	Eastern	106° (± 0,2°)	-10° 31′ 58″	Ori ι	Oct., 21-22 Feb., 19-20
Telesterion, Palace Peisistratian phase 550 - 510, BC, Eleusis, Attica	38°2′27.4″	3,5° (± 0,1°)	Eastern Southern	119.5° (± 0,2°) 29.5° (± 0,2°)	-20° 35′ 55″ 45° 58′ 46,7″	Cma b Cas β	Nov., 26-27 Jan., 14-15
Mycenaean Megaron Bca 1300-1100 BC, Eleusis, Attica	38°2′27.4″	3,5° (± 0,1°)	Eastern	110° (± 0,5°)	-13° 35′ 40,8″	Ori ι Sco α	Oct., 31 Feb., 10
Athena Polias, Zeus Polieus end of 6th century BC, Rhodes, Ialysos	36°23′56.5″	0°±0.2	Northern Southern	8.23° (± 0,5°) 188,23°	52° 11′ 51,5′ -53° 19"	Cvn α Car α- Car ε	
Athena 3d 2nd century BC, Kamiros, Rhodes	36°20′13.6″	1°±0.2	Northern	0.7° (±0,2°)	54° 11′ 45,6″	Cep α	
Unknown Dedication Hellenistic period Kamiros, Rhodes	36°20′20.3″	0°	Eastern	83.2° (±0,5°)	4° 51′47″	Aql α	Sep., 10,11,12 Mar., 31 Apr., 1-2
Unknown Dedication Roman period Lindos, Rhodes	36°5′28.4″	0°	Eastern	107° (±0,5°)	-14° 16′ 33,3″	Cet o Sco δ	Oct., 3 1/Nov.,1-2 Feb., 8-9-10
Artemis Propylaia, Poseidon Pater, 160-180 BC, Eleusis, Attica	38°2′32.1″	6°	North western	135.99° (±0,2°)	30° 4′ 29,8″	Cet β	
Aphrodite 3d - 2nd cen. BC, Rhodes	36°26′45.5″	0°	Eastern	97.05° (±0,2°)	-6° 16′48,3″	Ori ζ	Oct., 9-10 Mar., 3-4
Nemesis - Themis 5th cen. BC, Rhamnous, Attica	38°13′03.4″	5°	North eastern	92.52° (±0,5)	0° 56′36,1″	Peg ε	Sep., 20-21-22 Mar., 21-22-23
Nemesis ca 450 BC, Rhamnous, Attica	38°13′03.4″	5°	North eastern	94.52° (±0,5)	-0° 37′ 8,6″	Peg ε Ori γ	Sep., 22,26 Mar., 17,20-21

tectural remains (human, tectonic activities), b) the ancient observers healthy status of sighting, and c) the approximate alignments drawn using early practical orientation tools, do not provide the intended astronomical orientation, if uniquely measured with highly sophisticated topographical tools (accurate to the second of a degree), instead of more conventional portable instruments (a magnetic compass and a clinometer). Atkinson (1956) has noticed the latter in his comment, "it must be remembered that Lockyer's observations [of midsummer sunrise at Stonehenge] were made with instruments of the highest precision, whereas instruments used by the original builders were confined to their own naked eyes and, at the most, a number of straight sticks cut from the nearest hazel-thicket".

However, in finding a target's position in a horizon, further effects add to complications when insisting at highest precision in such marking targets at past, a purely astronomical problem. These include, a) the gradual decrease in obliquity of the ecliptic (ε), b) the sinusoidal variation in the parallax, c) differences in the mean refraction corrections owing to the fact that particular events can only be observed at particular times of year and day, and the fact that the magnitude of day-to-day variations in refraction (= the bending downwards rays of light reaching an observer from a distant object), owing to the daily changes in weather conditions (air temperature and pressure, dust).

The smalest effect of refraction occurs at high angular altitudes of the horizon (AAS). For star declination evaluation the main errors rise from atmospheric refraction and extinction. For sun the declinations over the past few millennia have not changed noticeably. For example, since 2000 BC it has changed by about 0.5°, roughly equal to the width of the solar or lunar disc. Today the sun's declination at zero AAS varies between +23.45° (midsummer, 21 June) to -23.45° (midwinter, 21 December), whereas for moon it varies between +27.7° to -29.5° respectively (in fact in 4000 B.C. dec=24.11°, 3500 BC dec.=24.07°, 3000 BC dec.=24.03°, 2500 BC dec.=23.98°, 2000 BC dec.=23.93°, 1500 BC dec.=23.87°, 1000 BC dec.=23.81°, today dec.=23.45°). Note that solar declinations are calculated from the center of sun. It is the declination of upper limb of the sun or moon that is considered, as suggested also by Thom (1954) at Ballochroy and Kintraw. That is, the first seen part at sunrise or moonrise, when the tip of the sun just gleams behind the distant horizon. Thus, one should add or subtract 16' (=s=sun's semidiameter) from the computed solar declinations (which refer to the center of solar disc), for the Summer (+(ε+s)) or Winter (-(ε-s)) Solstice respectively. For lower limb, during sunset, subtract 16' (see, Ruggles 1999, astronomy box3).

Surely the accuracy (= how well the measurement of an attribute conforms to its true value) depends on the accuracy of how well aligned the ancients made the temple. Present measurements get better with repeated readings, and with care to avoid in situ systematic errors e.g. a magnetic environment, which deviate magnetic needle from the true north, and accounting for the magnetic declination. Thus, the orientations are not meaningful to any better accuracy than the 0.2 to 0.5 degrees, obtained by conventional ways instead of applying sophisticated astronomy and measuring instruments.

Herewith the orientation of twelve Greek temples is presented. Based on available archaeological evidence and ancient literature textural information, it was possible to cautionary discuss six of them. The work of archaeoastronomical orientation of Greek temples is ongoing. (Liritzis and Vassiliou 2002).

PRELIMINARY EVALUATION ON SOME OF THE PRESENT DATA

1) Temple (Telesterion=ceremonial hall of Eleusinian mysteries) of Demeter at Eleusis (510-550 BC) (Guide to Eleusis 1997; Foucard 1914). The straight long walls of the inner hall (vertical to the entrance corridor), directed towards broad eastern sight are aligned to the sunrise in the winter solstice, 22nd December, the shortest day of the year. A symbolic day for Demeter and Kore, Persephone. Her daughter was kept by Pluto in underworld, during the four winter months, returning back to earth for eight months. Pluto represents darkness identified with the smallest duration of daylight occurring in the winter solstice. The returning to earth implies back to the light. Certainly the seemingly end of the world - longest length of night- represents death, and the associated Eleusinian cult may be related to the initiation of life after death (Buckert 1977, 1987; Grimal 1951; Kerenyi 1966; Nilsson 1961).

2) Temple of Nemesis, Ramnous, Attica, 550-490 BC (Archaeological Guide to Ramnous 1991; Petrakos 1991; Kokkorou-Alevra 1991; Mastrapas 1994).This is the oldest of two adjacent temples in Ramnous. The entrance has an eastern foresight aligned to the rising sun in the autumnal equinox, around 20-22 of September or vernal equinox (21-23 March). Perhaps, it relates to the Nemesia, a celebrity of Athenians to honor the dead - birthday of the dead- which took place in the fifth day of boedromion i.e. 20th of September.

3) Another temple of Nemesis, at Ramnous, just beside the earlier, build after 450 BC aligns with the sunrise at vernal equinox (21st of March) or the autumnal equinox (22-26 September). Nemesis at Ramnous was celebrated as an agricultural goddess who cares about the equal distribution of grazing (pasturable land) and of the balance and preservation of agricultural order. This relates her attributes to the beginning of spring, when fertilized land sprouts and nature blossoms. On the same foundations, an earlier temple was founded at c.6th century BC, when Nemesis was an agricultural deity of order and preservation. The above imply a similar religious tradition of Nemesis, preserved by locals in the later rebuilt temple at the site of Ramnous

4) Mycenean temple at the foundations of Telesterion, Eleusis (c. 1100-1400 BC) (Archaeological Guide to Eleusis 1997; Kokkorou-Alevra 1991; Mastrapas 1994; Gruben 2000). The orientation differs from that of Telesterion. The orientation was made along the survived wall in the foundations of the hall inside Telesterion, towards the eastern side. Admittedly, no clear view of any entrance was apparent, thus, it was decided to follow the broad eastern direction in a similar mode to the orientation to the overlaid classical hall.

For solar alignment the calculated solar declination pinpoints sunrise at around 10 February or 31st of October. For star alignment, given the uncertainty in the dating and the possible declination range, foresights the well known bright star of alpha of Scorpion (α-Sco), the so-called Antares, i.e. across the planet Ares (the Mars), and/or the bright star of the Orion constellation of ι-Orion. Bearing in mind the war-god Ares in the early Olympian pantheon, the Mycenean world religious system, and the war atmosphere during late Mycenean times (Decharme 1884; Kerenyi 1966; Burkert 1977; Foucard 1914; Grimal 1951; Nilsson 1961), invasions, migrations, colorizations, etc (Vermeule 1983), a possible connection may be suggested between bright Antares and this early temple.

5) Nymphaeon (cult place of Nymphs), Rhodes, 200-300 BC (Carousos 1973; Konstantinopoulos 1986). Its narrow long entrance corridor when extrapolated towards back sight it aligns with the sunrise during autumn. It reminds the reported special festivities taken place during the autumnal equinox (21st September) by the Neriedes Nymphs. The report derives from an Orphic fragment 'Hymn to the Neriedes', who have exposed the ceremonies to Banchus and Persephone but Apollo too, during autumnal equinox.

6) Temple of Aphrodite, Rhodes (200-300 BC) (Carousos 1973). The alignment of its foresight entrance points to the rising of the star zeta-Orionis of the Orion constellation. Orion was lover of Aphrodite, according to the related myth (Grimal 1951; Kerenyi 1966; Burkert 1977; Decharme 1884).

7) Three of the measured adjacent monuments in Rhodes of the same date, i.e. the temple of Pythios Apollo (Liritzis and Vassiliou 2002), Aphrodite's temple and Nymphaeon, in Monte Smith, have the same azimuth and declination.

CONCLUSION

Our aim to investigate possible connection of alignments in ancient Greek temples with astronomical targets is of preliminary nature (Papathanassiou 1994). We do believe such a project requires much more meticulous work, both on a statistical basis (many more cases), as well as on interpretation. Today it is a customary to question the reality of such evidence, arguing that a knowledge of astronomy goes beyond the likely capacity of the contemporary population. But this view is largely a measure of ignorance. On the other hand overemphasis of the intentional draw of astronomical orientation as uniqueness, betrays an ethnocentric or biased attitude to the question. By disregarding prehistoric astronomy altogether is being as guilty, of projecting our own prejudices into the past, as if retreating it in our own image.

Our paper promotes the middle route that follows neither of these. Instead, we strongly suggest such works must be based entirely on, a) current archaeological (both excavation and artifact remains), and ancient literature evidence, b) the inevitably introduced errors in alignment due to seismo-tectonic, theological activities, and climatological conditions, c) the human intervention. Nevertheless, one must not over- or under-estimates the abilities of prehistoric cultures. We let the facts speak of themselves attempting extrapolations with due caution.

In the present preliminary investigation certain dates of the year, correlated with deities and / or mythology, seem to relate to rising sun stands (December, October, March, September), and certain rising stars (δ-Centauri, α-Scorpion, ζ-Orionis) positions. Our work is ongoing.

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