

# Astronomy, topography and landscape at Akragas' Valley of the Temples

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The issue of the orientation of Greek Temples has been the subject of much debate since the end of the 19th century. In fact, although a general tendency to orientation within the arc of the rising sun is undeniable, specific patterns and the true meaning remain obscure. With the aim of shedding light on this problem we present here a new, complete, high-precision survey of the temples of Akragas, the so-called Valley of the Temples UNESCO site. Our results include all temples – one of which was essentially still unpublished – and show that very different reasons influenced the choices of orientation – some symbolic, but others much more practical – beyond the general rule of orienting 'to the rising sun'. In particular, the temples of the central terrace – including the world famous temple of Jupiter – were oriented in accordance with the town's grid, while a rigorous orientation to the cardinal points is evidenced for the Aesculapius sanctuary. Finally, for two temples having 'anomalous' orientations, a stellar and a lunar proposal respectively are made.

*Keywords:* Greek temples, Sicily, Agrigento/Akragas, Cardinal orientation, Stellar orientation, Lunar orientation

## 1. Introduction

The ancient Greeks built hundreds of magnificent temples over the course of several centuries, from the 7th century BC onward [1]. Leaving aside regional and chronological distinctions in the layout and in the column orders, these sacred buildings were always based on the same conception: an imposing rectangular construction adorned with columns on the façade. Although in many cases the presence of columned porticoes on all sides made the view of the structure enjoyable from all directions, the main principle always remained the same: a Greek temple was meant to occupy a natural place with an obviously man-made feature, and it was to be admired from the outside only.

Admission was reserved to priests and to the privileged few, and public rites were celebrated outside, in front of the temple, which in many cases was equipped with an altar and a *plateia* (religious occasions included festivals, processions and long rituals). The interior of the temple was, strictly speaking, the home of the god. The god's domestic welfare (hence, the beauty and decorum of the building, correct insertion in the landscape, regular giving of offerings) was

fundamental to assure benevolence and protection to the community. The cult image, located in the central place of the temple, was in many cases an out-and-out masterpiece, like the famous ivory-and-gold statues of Zeus at Olympia and of Athena in the Parthenon in Athens.

The positioning of Greek temples has been the subject of interesting scholarly research. For instance, a connection between the terrain on which the temple is erected and a related deity has been suggested by Retallak [2]. The relationship with the landscape as a whole was first suggested by Scully [3]. His work pioneered research on the Archaeology of the Landscape, pursuing the idea that landscape and temples formed an architectural unit that was characterized in accordance with the specific god worshipped. Occasionally, the choice of the terrain and/or of the landscape was exploited to achieve a specific orientation, while in other cases the temple architecture in itself created the sacred landscape [4]. In any case, the matter of understanding the specific orientation of the Greek temples deserves to be dealt with on its own.

The orientation of a Greek temple is preferably defined as the direction of the main axis from inside looking out, which is the direction in which the statue of the god was in principle looking, as well as being the direction along which the sun would illuminate the façade, which, as we have seen, was the scene for rites and celebrations taking place outside the temple. The majority of these monuments face the eastern horizon, mostly within the arc of the

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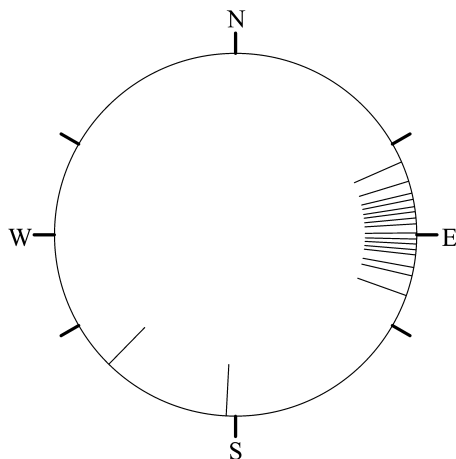
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rising sun [5–8]. Recent research, however, has shown that eastern orientation is not the universal key to Greek temples, as was previously believed [9–13].

What appears to be a simpler situation occurs in the case of the Greek temples of Sicily. The orientation of the temples of Sicily demonstrates indeed a very clear pattern [14,15]. It has been determined that 38 out of 41 measured temples are oriented within the arc of the rising sun (Fig. 1). This sample is virtually exhaustive for all but one (studied in this paper) of the existing monuments, and clearly we have no need of any statistical analysis to conclude that orientation within the arc of the rising sun was intentional. However, in a way, we are only at the beginning. As it happens, there is no specific concentration of data, for instance, around the solstices or the equinoxes, or other dates for that matter – so how was the alignment chosen? Was it the day of foundation of the temple, or the day of the feast of the god, or what? Perhaps there was a tradition passed down from the original town of provenance? So far, attempts to gain more insight into this problem – for instance, by investigating possible groupings for patron deities – have not been successful. Matters are complicated by the fact that the calendars in use in Greek towns were luni-solar, so that alignments based on feast days would not have been calendrically effective in relation to the timing of the rituals carried out annually in front of the temple (presumably at dawn).

The orientation also appears somewhat unusual when one looks at comparable families of monuments, for instance the Italic temples (temples of the peoples inhabiting continental Italy before the Roman conquest, like the Samnites) which are oriented to the sun ascending in the sky, and the Etruscan temples, which are mostly oriented to the sun ascending or descending in the sky, that is, between the winter solstice sunrise and the winter solstice sunset [16,17]. Gonzalez-Garcia and Belmonte [18] have argued that while Greek temples in the same region may differ among themselves with regard to orientation, nonetheless the orientations as a whole correlate better with those of temples from other, culturally related regions, e.g. the temples in Sicily compared with those of South Italy.

Finally, it should also be noted that solar orientations cannot be distinguished from – eventually – stellar orientations occurring at the same declination. Thus all Greek temples oriented to the rising sun also happen to be broadly oriented towards the constellations in which the sun was rising at the epoch of construction, and can on occasion be accurately oriented to specific stars of such constellations as well as to other stars that had the same declination.



**Fig. 1.** Orientation of the Greek temples of Sicily.

Based on data by Aveni and Romano [14].

A possible, specific interest by the builders in this kind of stellar target must be investigated separately case by case (see e.g. [10]).

Motivated by such a variety of open questions, we decided to approach the problem by performing a complete survey and analysis of a homogeneous and particularly significant set of temples: the world famous UNESCO site of the Valley of the Temples of Agrigento, ancient Akragas. Our results are actually quite unexpected and show that a variety of factors, not all of them astronomical, influenced the Akragantine architects.

## 2. The Valley of the Temples

*Akragas* – today’s Agrigento – was one of the most important Greek colonies in Sicily, founded in 582 BC by settlers from the nearby Gela and from Rhodes. The site lies on a huge plateau, naturally protected from the north by the Athena Rock and the Girgenti Hills, and from the south by a long rib-hill, bounded on either side by the rivers Akragas and Hypsas, confluent to the south in a single water’s course, at the mouth of which the port was constructed.

From the very beginning, under the tyranny of Phalaris (570–554 BC), the city was characterized by a regular urban layout, dominated by the Acropolis on the Athena Rock and bordered by the rib-hill which started to house monumental sanctuaries; in the central area were dwellings and public buildings in accordance with an orthogonal grid layout; the necropolis was located outside the city walls. In the last decades of the sixth century BC, Akragas was surrounded by massive walls 12 km long, with 9 gates. The colony reached fame and power under the tyrant Theron (488–471 BC), who defeated the Carthaginians at Himera in 480 BC, and during the years of the democracy (471–406 BC) established by the philosopher Empedocles. It is in this period that the extraordinary series of Doric temples, today comprised in the UNESCO archaeological site called the Valley of the Temples, was built.

There are as many as ten temples in the complex. We list them in the following using the traditional names [19] which are of current use in all publications on the site; it is however *fundamental* to recall that only the temples of Heracles, Jupiter and Demeter (and the sanctuary of Aesculapius, which is *extra moenia*) really belong to these deities:

- temple of Olympic Jupiter (Fig. 2): this is the largest Doric temple in the western Mediterranean. The temple was, however, left unfinished and later collapsed, perhaps due to an earthquake. It is built on a huge stand (56.30 × 113.45 meters) and was reached through a crepidoma of five steps. The most relevant architectural peculiarity comprises the stone giants (the *Telamones*), which were probably placed in each intercolumniation. The temple was



**Fig. 2.** Akragas, Valley of the Temples. The area of the Temple of Olympic Jupiter, with one of the huge *Telamones* in the foreground.



Fig. 3. Akragas, Valley of the Temples. Temple of the Dioscurides.

founded to commemorate the Battle of Himera (480 BC), won by Akragas and Syracuse against the Carthaginians, and it is mentioned by both Diodorus and Polybius;

- temple of the Dioscurides (Fig. 3): the Doric temple was hexastyle with 13 columns on the long sides ( $13.40 \times 31$  meters); today only a reconstructed corner can be seen. The attribution is completely unknown;
- temple L (Fig. 4): adjacent to the temple of the Dioscurides, it was left unfinished but the foundations excavated in the rock are clearly visible, together with blocks at the northeast corner, and



Fig. 4. Akragas, Valley of the Temples. The ruins of Temple L.



Fig. 5. Akragas, Valley of the Temples. Temple of Concordia.

numerous drums of columns scattered in the building area. The attribution is completely unknown;

- temple of Concordia (Fig. 5): this is the best preserved temple in Agrigento. The temple stands on a pedestal with a crawl space inside that corrects the natural inclination of the ground. It is hexastyle with a peristyle of  $6 \times 13$  columns on a stylobate of  $39.42 \times 16.92$  meters, which is accessed by a crepidoma of four steps. Exceptionally preserved are the architraves with frieze of triglyphs and metopes, the *geison*, and, on the facades, the *tympanum*. Probably almost contemporary with the temple of Juno, with which it shares many characteristics, its attribution is completely unknown;
- temple of Heracles (Fig. 6): this is probably the oldest of the Doric temples of Akragas, dating to the end of the 6th century BC. It stands on a mighty pedestal, has a peristyle of  $6 \times 15$  columns (stylobate of  $67.04 \times 25.28$  meters), which is accessed by three steps. The attribution is based on a passage by Cicero who mentions a temple dedicated to the hero and placed not far from the agora, which should likely be in this area;



Fig. 6. Akragas, Valley of the Temples. Temple of Heracles.



Fig. 9. Akragas, Valley of the Temples. Temple of Juno.



Fig. 7. Akragas, Valley of the Temples. Temple of Aesculapius.

- temple of Vulcan (Fig. 8): the temple is peripteral, Doric, hexastyle, with 13 columns on the long sides. Few remnants are preserved of the building: two stretches of crepidoma with four steps and two columns. The temple was built extending an archaic precinct. The attribution is completely unknown;
- temple of Juno (Fig. 9): this temple is located at the eastern end of the hill on a high base. Probably dating to the middle of the 5th century BC, it is hexastyle with a peristyle of  $6 \times 13$  columns; the stylobate measures  $38.15 \times 16.90$  meters while the crepidoma is of four steps. The attribution to Juno (Hera) is purely hypothetical;
- temple of Demeter and Persephone (Fig. 10): the temple building was incorporated in the Middle Ages into the Norman church of San Biagio. It was a Doric temple with the cella preceded by a portico *in antis*. Attribution is firmly based on archaeological material.

- temple of Aesculapius (Fig. 7): this temple is located outside the city walls, south of the Hill of the Temples, on a substrate of sedimentation clay. The Doric temple has a portico *in antis* (with two columns between the doors), and size of  $21.70 \times 10.70$  meters. It was comprised in a vast sanctuary easily accessible from the sea. A sanctuary to Aesculapius is mentioned by Polybius who placed it outside the walls of the city, so the attribution looks certain;

At least two further temples existed in Akragas, but not in the Valley. They were located on the Acropolis, which corresponds to the centre of the modern town. One, the so-called Temple of Athena, is buried and partly visible below the Church of St. Mary of the Greeks. The remains of the second lie almost certainly below the medieval Cathedral nearby.



Fig. 8. Akragas, Valley of the Temples. Temple of Vulcan.



Fig. 10. Akragas, Valley of the Temples. Temple of Demeter and Persephone.

**Table 1**

Astronomical data for temples in the Valley of the Temples, Agragas.

Temple	Az (°)	Hor (°)	Dec (°)	Coordinates	Solar Dates	Stars
Jupiter	78° 30'	2° 08'	+10° 15'	37° 17' 26" N 13° 35' 04" E	April 16	Hamal (Alpha Arietis)
Discourides	82° 54'	2° 30'	+7°	37° 17' 29" N 13° 35' 54" E	April 7	Epsilon Delphini
L	77° 54'	2° 48'	+11° 09'	37° 17' 30" N 13° 35' 55" E	April 19	Hamal (Alpha Arietis)
Concordia	89° 36'	1° 08'	+0° 46'	37° 17' 02" N 13° 35' 32" E	March 22	Bellatrix (Epsilon Orionis)
Heracles	90° 30'	1° 55'	+0° 34'	37° 17' 25" N 13° 35' 11" E	March 22	Bellatrix (Epsilon Orionis)
Aesculapius	89° 57'	3° 36'	+2° 05'	37° 17' 57" N 13° 35' 18" E	March 26	Spica (Alpha Virginis)
Vulcan	87° 05'	2° 22'	+3° 35'	37° 17' 35" N 13° 35' 43" E	March 29	Betelgeuse (Alpha Orionis)
Juno	82° 24'	1° 42'	+6° 52'	37° 17' 19" N 13° 35' 60" E	April 7	Epsilon Delphini
Demeter (front)	125°	0°	-27° 32' (Lunar -26° 53')	37° 17' 57" N 13° 36' 12" E	-	Adhara (Epsilon Canis Majoris)
Demeter (back)	305°	2° 38'	+28° 45' (Lunar +29° 22')		-	

### 3. The orientations of the temples: survey methods and results

The orientations of the Agragas temples are dealt with in [5] and, more recently, in [13,14]. As we shall see, however, not all the published data are reliable, and not all the temples have been considered (further details below). We have, therefore, re-measured all the temples with a high-precision optical theodolite during field-work which lasted one week, from 1 to 8 August 2015 (Table 1).

The geology of Agrigento is quite complex [20], and the upper town is subject to submergence and landslides, largely due to modern man-made factors. The geological situation of the Valley appears to be more stable, but in any case long-term geological activity (which might affect orientations) is not expected to have occurred, although dramatic events, such as earthquakes, cannot be excluded [21]. Agrigento belongs to an active seismic area, which was nonetheless – as far as we can know on the basis of historical records – only marginally affected by the great earthquakes registered in Sicily; the alleged earthquake sometimes invoked as the cause of the collapse of the temple of Jupiter is not historically proven. So we tend to exclude that the present orientation of the temples might have been affected by intervening natural causes.

Almost all temples have been visited and measured twice on different days. North was calibrated at each measure using a long-distance GPS measure from the theodolite station to a recognizable feature (a corner of a skyscraper) of the modern town of Agrigento (at distances of about 2.5 km).

The nominal accuracy of the transit instrument that we used is optimal, below 1'. However, this accuracy refers to the direction, which is being measured. Errors can arise because one has to be sure that the direction measured really is the azimuth of the temple, and in some cases the corners cannot be individuated precisely, while in others the sides are partly covered by huge amounts of sand and/or trees. In all measures we always used one or two poles set in the far corner and in the middle of the side, optically aligned with the instrument (Fig. 11). Allowing ~20 cm of error in the choice of the measured direction, we actually estimate that the error of our measures can be reasonably assumed to be ±15'. This value is anyhow below the error that the builders might reasonably have committed in tracing their alignments, especially if they used the sun.

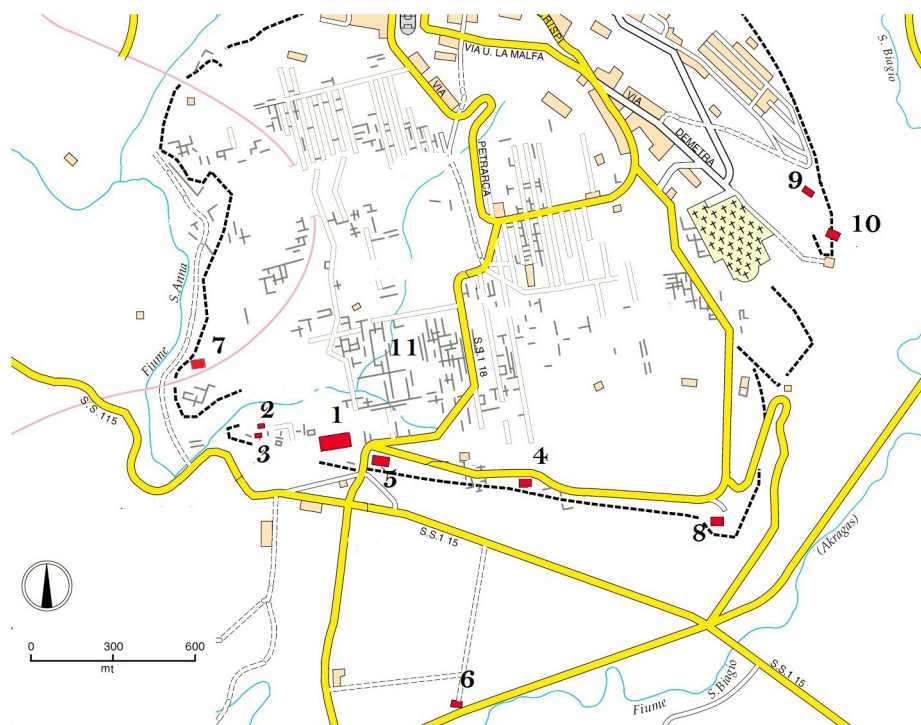
Of course we also accurately measured the visible horizon – defined as the visible height from the centre of the entrance to the temple – for each temple. Again, the nominal accuracy is below 1', but it should be noted that in the case of the temples located on the

central terrace the measure was possible only with great difficulty, owing to intervening modern features, so that the calculated declinations for such temples are only approximate. However, as we shall see, it also appears that these temples were not astronomically oriented anyway (Section 4).

The consistency of all measures was cross-checked with the readings of a professional SUUNTO compass-clinometer; the compass readings were corrected for magnetic declination using the calculator kindly provided by NOAA (<http://www.ngdc.noaa.gov/geomag-web/#declination>) (magnetic anomalies are not to be



Fig. 11. Agragas, Valley of the Temples, measuring the north side of the Temple of Concordia.



**Fig. 12.** Plan of ancient Akragas (town's wall in black). (1) Temple of Jupiter, (2) Temple of Dioscurides, (3) Temple L, (4) Temple of Concordia, (5) Temple of Heracles, (6) Temple of Aesculapius, (7) Temple of Vulcan, (8) Temple of Juno, (9) Temple of Demeter, (10) 'Fountain Sanctuary', (11) Agora.

expected at Akragas). Our corrected compass readings are fully consistent with transit readings, as the latter all fall within the nominal error band of the corresponding compass readings ( $\pm 1/2^\circ$ ).

Finally, we performed a cross check of the data also using Google Earth. The compass overlay tool of the program was used for azimuths and the elevation profile tool was used for horizon readings; again, all the data are consistent within  $\pm 1/2^\circ$ .

The results of the campaign are given in Table 1. As a comparison with the literature, it can be noticed that our results differ, in some cases considerably, from those of Salt obtained with a magnetic compass. It is difficult to explain this discrepancy since – as mentioned – we also performed compass readings, and they turned out to be consistent with our transit data. However, Salt mentions the presence of steel fences, which obliged him to perform some of his measures on maps. There are fences in Akragas, encircling many of the temples and restricting access to the public; of course they have no effect on transit readings but they disturb magnetic readings if taken from outside. Our magnetic readings do not suffer from this problem because we were granted full access to the inside perimeter and cellas of all the temples.

Another set of published data is that by Aveni and Romano who worked with a theodolite. In this case it can be noticed that our results in azimuths agree relatively closely. On the other hand, our results in declinations differ considerably. We calculated declinations using the program GETDEC kindly provided by Clive Ruggles, which takes into account atmospheric effects, but this is not enough to explain the difference with the Aveni and Romano data. It is unfortunately impossible to fully compare the results because these two authors did not give horizon heights; however, a few trials that we have made with their data seem to show that they simply assumed a flat horizon for all temples, something that is definitively untrue.

For each temple, we report azimuth, horizon, declination, GPS position, the first solar dates and the bright stars, which eventually correspond to such declination in the century of construction.

## 4. Discussion

### 4.1. The temples of the central terrace: Jupiter, Dioscurides, Temple L

Akragas was planned on the basis on an orthogonal street grid plan in the Greek style, with 'meridian' roads (*plateai*) crossed at right angles by longitudinal streets (*stenopoi*) (Fig. 12). We have accurately measured the street grid plan; our result is that the grid is orthogonal with a very good accuracy, and the *stenopoi* are oriented at  $78^\circ 15'$ . This orientation is probably topographical as it is roughly orthogonal to the slope of the Akragas hill. In particular, a *stenopos* crossed the hill longitudinally heading towards the central sacred area, which houses the circular sanctuary of the chthonic deities, the temple of the Dioscurides, temple L and, to the left of the road, the temple of Jupiter. There is therefore little (if any) doubt that one of the largest temples of the Greek world, the Akragas temple of Jupiter – azimuth  $78^\circ 30'$  – was orientated *topographically* in accordance with the street grid (curiously, the declination associated to the temple is compatible with the star Alpha Arietis, but Aries was possibly related to Jupiter only much later, and with the identification with the Egyptian God Amun).

The same topographical criterion holds for Temple L – azimuth  $77^\circ 54'$  – which fronted the road directly, occupying the horizon of any person descending the hill. This did not occur for the nearby temple of the Dioscurides, which formed instead a sort of scenography for the space fronting Temple L. It is probably for this reason that the Dioscurides temple was skewed clockwise, with an azimuth of  $82^\circ 54'$ . However, this temple shares the same declination as the Juno temple, whose orientation certainly has nothing to do with the topography of the town (see discussion below). It may therefore be that both orientations have the same origin (for a comparison with the topography of nearby Selinunte see [22]).



**Fig. 13.** Akragas, Valley of the Temples, Concordia Temple, the sun rising in alignment with the axis of the temple on 24 March 2015.

#### 4.2. Equinoctially oriented temples: Concordia and Heracles

Among the three temples located on the Akragas 'rib', the two westernmost ones, Concordia and Heracles, are oriented cardinally, with the front to due east, with *very good* precision ( $\frac{1}{2}^\circ$  within our accuracy of  $15'$ , so the maximal error committed by the builders certainly did not exceed  $\frac{3}{4}^\circ$ ).

It is of course tempting to think that these temples might have been orientated to the rising sun at the equinoxes. A non-trivial horizon raises the declination (from zero) for each one of them, but for Concordia and Heracles this deviation is very small (declinations respectively  $0^\circ 46'$ ,  $0^\circ 34'$ ) giving dates very close to the equinoxes, as we also verified directly on site with the rising of the sun in alignment with the temple on 24 March 2015 (Fig. 13).

#### 4.3. The sanctuary of Aesculapius

The sanctuary of Aesculapius, located right below the rib outside the city walls, is oriented to the cardinal points with an astonishing precision: our measure furnishes  $89^\circ 57'$ . The temple is definitively not, however, oriented to the rising sun on the days of the equinoxes, since the non-trivial horizon raises the declination to  $2^\circ 25'$  and the solar dates are later than the spring equinox (and correspondingly earlier than the autumn equinox). On the other hand, the temple orientation to the cardinal points is so accurate that it leads us to believe that the main aim of the orientation was *not* to orient towards the rising sun on specific days of the years. We propose here instead the idea that it was deliberately oriented *cardinally*. Astronomy was there, of course, in the determination of true east (or, more likely, of true north) and symbolism was certainly there as well, with the choice of orienting a square sacred

building with the sides along the cardinal directions. However, the builders – who were of course aware that the sun rises at true east on the equinoxes only if the horizon is flat – were not interested in this last phenomenon.

#### 4.4. The temple of Vulcan

The Temple of Vulcan (azimuth  $87^\circ 05'$ ), in spite of its relatively large deviation from true east, is probably to be ascribed to the family of temples orientated along this direction. In fact the topographical setting of the temple is quite special: the temple sits on a separate hill with the narrow Colimbeta valley passing behind. The temple contains – and is built over – an archaic building oriented along the line of maximal slope of the hill  $\sim 80^\circ$ , while the project of the enlarged monument was skewed towards the cardinal directions as much as possible with respect to the existing topographical constraint.

#### 4.5. The Temple of Juno

This magnificent temple sits at the easternmost end of the rib, and is sustained by an enormous artificial terrace. The attribution to Juno is only traditional, as no archaeological material supporting any attribution has ever been found there.

To begin the study of this temple, we verified accurately and without any possible doubt the following fact: placing the very same building with a cardinal orientation was possible without any geological or topographical obstruction and over the very same terrace.

Therefore there must be a different reason why this temple is not oriented equinoctially, as the two which follow along the rib – forming an internationally renowned, spectacular sequence – instead are, as discussed above. The azimuth of the temple is  $82^\circ 24'$ . We propose here the possibility that this temple was oriented to the stars.

In the 5th century BC, the front of the temple very neatly faces the region of the sky where a relatively faint constellation Delphinus (the Dolphin) was rising (its brightest star is of magnitude 3.8). As is obvious, it is impossible to speak about the azimuth of rising of an entire constellation, so this assertion needs a detailed explanation. Delphinus occupies a small portion of the sky, which can be individuated by a small 'quadrilateral' of four stars. Due to their high magnitude, we must of course consider these stars at their minimal visible height due to extinction, which according to Thom's rule (visible height = magnitude in degrees) is not less than about  $4^\circ$ . In the Akragas sky of, say, 450 BC these four stars were visible in the region of azimuths between  $80^\circ 45'$  and  $83^\circ 15'$ , with the unique other relevant star of the constellation, Epsilon, at  $86^\circ$ . We have therefore a very good match with the Juno temple in the century of its construction.

Owing to the lack of archaeological material, the attribution of the temple is completely unknown. The orientation to Delphinus that we are *tentatively* proposing could make sense especially if a dedication to Apollo – a god who is currently absent from any other temple in Akragas – could be suggested by future research or excavations. Delphinus is indeed one of the constellations connected to Apollonian mythology. According to a recent proposal, it was even used as a marker for the season of the pilgrimage to Delphi [11], although the faintness of the constellation casts doubts on its practical calendrical use [4] and other, brighter constellations, Lyra and Cygnus, were more tightly connected with this God [11].

#### 4.6. The Temple of Demeter and Persephone (San Biagio)

The temple is of Doric style, and belongs to the final phase of the Archaic period (480–470 BC). It is very well preserved because

in the Middle Ages the building was transformed into a church dedicated to San Biagio. The facade of the church points to the north-west, but it is very likely that the facade was obtained by opening an entrance in the back wall of the cella of the temple, which was therefore originally fronting south-east. However, of the portico with two columns that the Greek temple should have had, only the (so-called honeycomb) foundation sections can be seen. The stone foundation platform of the whole building and a part of the original stone walls are preserved, accurately built in isodomic masonry of huge rectangular blocks. Inside the church, excavations have revealed a cistern belonging to the Greek phase, located close to the north-west corner and therefore inside the cella of the temple, a quite unusual feature.

There is no available space for an altar in front of the temple, since the terrain slopes down abruptly on to the escarpment of the city walls. A relatively large esplanade is instead present on the back (that is, in front of the church). This esplanade is contemporary with the temple and was obtained artificially through the construction of huge retaining walls on the south side and an accurate excavation and leveling of the rock on the north side. The area was accessed from the town through a large road partly excavated in the rock as well, which is still perfectly visible today.

During the excavations of 1925 a votive deposit was found, formed by a large amount of objects. In particular, there were many fragments of two female busts of terracotta, one of which could be reconstructed in its integrity and was identified as Persephone. As a result of this discovery, the temple is attributed to the Eleusinian divinities. The attribution to Demeter and Persephone is also confirmed by the presence of two small circular altars: one, with a diameter of 2.53 meters, is filled in and the other, with a diameter of 2.70 meters, has a central well (*bothros*), which was found filled with ritual offerings, i.e. broken *keranoi*, or ritual vessels of Demeter. These altars are located in the 'corridor' formed between the rock cut to the north and the side of the temple.

The front of the temple could be accessed directly by a stairway, which crosses the town's walls through a postern and leads to a strange building located outside the walls. It is a protohellenic (7th century BC) sanctuary probably dedicated to chthonic deities, whose architectural elements are integrated with the natural features of the site, as is often found in the holy shrines of the gods of the earth (for example at Eleusis, in Lykosoura or in Enna). The sanctuary consists of a rectangular building up on the cliff (below the temple of Demeter and Persephone), on which there are two communicating hypogea, which were filled with votive offerings. A third gallery was used as an aqueduct to supply water collected from a nearby source in the basin of the building, which was therefore a sort of fountain-sanctuary.

The temple of Demeter and Persephone was measured by Nissen [5]; for reasons we do not know, it has passed unnoticed in more recent works. Nissen was a very conscientious scholar and his data are usually reliable, but not in this case. In fact, we discovered that the azimuth given by Nissen, which is close to that of the rising sun at the winter solstice, is in defect by as much as 4 degrees. As a consequence, the azimuth of the temple *falls below the arc of the rising sun*. To our surprise, then, we discovered that the temple is the only one in the Valley whose declination ( $-27^{\circ} 32'$ ) is not in the solar range,<sup>1</sup> and adds to the very few Sicilian temples whose declination has this property.

It can be noticed that the building could have been built in the same place but skewed some 4 degrees towards the east, in order to align with winter solstice sunrise, without any practical problem.

<sup>1</sup> In fact it is the unique non-solar temple in the whole of Akragas, since we managed to measure the azimuth of the basement of the Athena temple on the Acropolis to be  $\sim 110^{\circ}$  (a solar azimuth). The horizon there is not measurable.

Even more, although the horizon in front of the temple is flat, a rock curtain located immediately to the left (east) looking from the entrance was left *in situ* (the huge excavation of the terrace ends just nearby), and this curtain even obscures the midwinter sun at rising. Perhaps the fact that the temple is not aligned with the rising sun was actually discovered by Nissen, but seemed so unnatural to him that he decided the measurements were wrong? We shall probably never know. In any case, the – clearly deliberate – orientation of the temple cries out for an explanation.

The first thing to be noticed is that the declination of the temple is enclosed between the declinations of the sun at winter solstice and that of the moon at the major southern standstill, and fits the Venus minimal declination. We were therefore at first intrigued by the idea that the temple could be aligned to Venus. However, although Venus can attain – in principle – its maximal and minimal declinations both as the morning and as the evening star, the morning star has *never* had a declination significantly greater than that of the sun at the solstices in the last four millennia or so. This fact is already well known from studies on Venus alignments in the Mayan world [23], but in any case we verified it independently – using the software StarryNight Pro 7 – in all the 8-year Venus cycles of the 5th century BC.

We then re-analysed the orientation taking into account the possibility of a lunar alignment. Lunar declinations are affected by parallax by about  $\frac{1}{2}^{\circ}$  (see e.g. Ruggles [24]): the front of the temple – again using the program GETDEC – yields a lunar declination  $-26^{\circ} 56'$ . This value looks too far from the major lunar standstill (at  $\sim -29^{\circ}$ ) to be considered significant *per se*, although—as is well known—lunar standstills are very difficult to be determined precisely and, as we shall now see, we do propose that the temple was oriented to the Moon. The reason stems from the fact that it is very likely that processional rites were carried out in this place. The rites involved both the fountain-sanctuary and the temple uphill, and we can imagine nocturnal processions coming up from the sanctuary and reaching the temple, in front of which, however, there is not – and there never has been – enough space to house worshippers. It is therefore conceivable that the people, after the ascent, crossed the corridor between the north side of the temple and the hill (perhaps throwing votive offerings in the *bothros*) and gathered in the vast esplanade located at the *back* of the temple (recall that this esplanade has been constructed artificially, and with huge effort, at the same time as the building). So motivated, we visited the temple again and measured accurately the horizon to the north-west from the facade of the medieval church and therefore from the back side of the temple. This horizon is very striking, since it is occupied by the hill where the acropolis of Akragas once stood. In particular, the tower of the medieval cathedral, almost certainly built over the main temple on the acropolis, is clearly visible directly in front of the temple. Measuring the horizon we took into account an estimated average for the height of the modern buildings, and the results in declination are  $+28^{\circ} 44'$  uncorrected by parallax, with a lunar declination  $+29^{\circ} 22'$ . This result is impressively close to the maximal lunar declination which in the 5th century BC (due to the slight variation of the obliquity) was around  $28^{\circ} 50'$ .

As mentioned above, precise lunar extremes azimuths are very difficult to individuate. However, the full moon near to the winter solstice in the years close to the standstill attains an azimuth which is always very close to the maximal one [24]. All in all, then, we propose a lunar connection for the complex of San Biagio, a fact which would fit well with the religious connections of the water cult in the Mediterranean basin.

## 5. Conclusions

Our results show that the orientation of the Greek temples of Sicily could be affected by different considerations, so that there



is no 'golden rule' to explain it. In particular, the long sought 'day=god' rule appears to be rather a superimposed idea which is probably due to a misleading parallel with (some) Christian churches. At least in the case of the temples of Akragas, a variety of different reasons played a role.

First of all, the pre-existing urban layout influenced the orientation of the temples of the central terrace, including the huge project of the temple of Jupiter, which has the same azimuth of the *stenopos* leading to the central terrace. The resulting declination also points to the stars of the constellation Aries, but a relation of this asterism with Jupiter may occur only later; actually, practically all the temples do point also to relevant stars at the time of their construction, but a stellar explanation seems to be (tentatively) feasible only for the Juno temple, which was intentionally skewed to the north of east with respect to the easterly, equinoctial orientation of the other two temples of the same hill, the magnificent Concordia Temple and the Temple of Heracles.

Secondly, morphological aspects of the terrain could be as important as symbolical ones, as very probably occurred for the temple of Vulcan. On the other hand, symbolic reasons could be more difficult to incorporate than expected: in particular, our data clearly show that the sanctuary of Aesculapius was deliberately oriented to the cardinal points – with the front to true east – irrespectively of the horizon and therefore independently from the date when the sun would have risen in alignment with it.

Finally, there are cases in which orientation was clearly and deliberately sought in spite of any topographical difficulty: besides the above-mentioned temple of Juno, this holds for the temple of Demeter. The orientation of the latter – which was essentially unpublished before the present study – appears to be understandable if framed in a setting of other buildings: the 'sacred fountain' located outside the city walls but connected through a postern, and the huge artificial esplanade to the back of the temple. Considering the 'anomalous' (non-solar) orientation of the temple within its (natural and human-built) landscape allowed us to propose a lunar explanation for it.

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