

DOES SUNRISE DAY CORRELATE WITH EASTERN ORIENTATION
OF BYZANTINE CHURCHES
ON SIGNIFICANT SOLAR DATES AND SAINT'S DAYS?
A PRELIMINARY STUDY

IOANNIS LIRITZIS AND HELEN VASSILIOU/RHODOS

With illustrations on tables XXXIV–XXXVI

Introduction

Archaeoastronomical research has shown that in planning sites and building structures, traditional historic and prehistoric cultures around the world have incorporated astronomical alignments of calendrical or sacred ritual importance. Alignments to the solstices, the equinoxes, and to the major standstills of the moon and bright planets have been demonstrated or suggested, while stellar alignments have also been shown to have been important for some societies.

It is very well known that most ancient civilizations were interested in the celestial bodies and phenomena such as the periodic cycles of sun, moon and planets in order to determine the time to plant, harvest or plough, appropriate days to sail (navigation), to fix the ritual celebration of seminal seasonal events, of the first rain, and as a result of sky-watching and counting the days the first calendars were made.

As most reliable evidence for the ancient practice of astronomy comes from written records and unwritten oral stories, evidence from archaeological excavations, artefacts, iconography, planning and orientation of buildings, the further investigation of the possible relation of orientation of buildings to heavenly bodies has become a significant alternative methodology in the study of early societies, in particular their anthropological, sociological and cult aspects.

During the last two decades many scholars have published articles related to archaeoastronomical matters. Characteristic pieces of work can be found in the proceedings volumes of SEAC (European Society for Astronomy in Culture), regarding SEAC's Conferences since 1993, focussing mainly on the European and Mediterranean region (<http://www.archaeoastronomy.org>); in the proceedings of the 2nd Oxford International Conference on Archaeoastronomy¹; and the cited references. A rather detailed work concerning basics in astronomy useful in archaeoastronomy and a complete study of megalithic structures and their astronomical significance in Great Britain and Ireland has been made by Clive Ruggles.²

We thank the Ephors of Antiquities, of the Hellenic Ministry of Culture, at Dodecanese, Phokis, Ioannina, and Laconia, for permission to carry out orientation measurements, and Dr. E. Kollias, Prof. N. Gioles and Prof. P. Themelis, for useful discussions. IL thanks Ministry of the Aegean for partial funding of this project.

¹ A. F. AVENI (ed.), *World Archaeoastronomy. Selected papers from the 2nd Oxford International Conference on Archaeoastronomy Held At Merida, Yucatan, Mexico 13–17 January 1986*, Cambridge 1989.

² C. RUGGLES, *Astronomy in Prehistoric Britain and Ireland*. New Haven/London 1999.

Until now few orientation measurements on Byzantine churches have been performed in Greece,³ concerning mainly the astronomical dating of churches located at the Hagion Oros (Mount Athos) and Meteora monastic areas, and deriving results from the sunlight entering the church from the sanctuary or the dome's windows during the "third hour" or the middle of the morning, according to the liturgical calendar of churches.

We know that natural horizon features have been used by various ancient skywatchers to pinpoint the position of the sun, and perhaps other celestial objects.

The aim of the present paper is to investigate whether the day of sunrise coincides with the deity's name day in several Byzantine churches from Greece. The idea is to monitor the passage of time in terms of the shifting position of sunrise across the details of the mountainous horizon. The positive case implies that the architectural drawing of the church was intentionally constructed towards the particular horizon point where the sun rises at the celebration day of the saint of the church. Other orientations due east which are not related with sunrise at the saint's name-day, but with equinoxes and summer solstice, will be discussed.

Measured Monuments

Our work concerns the possible astronomical alignments of twelve Byzantine churches: Saint Anastasia, c. 5–6; Saint John of the Order of Saint John; Knight Templars, Rhodes, c. 14; Saint Triad, Rhodes, c. 14; Saint Sophia, Mani, Peloponnese, c. 16; Saint Demetrios, Laconia, c. 12; Saint John (Desfina) near Delphi, c. 13; Assumption of the Blessed Virgin, Ioannina, c. 12; Red Church, Arta, c. 13; Annunciation of the Blessed Virgin, Arta, c. 13; Saints Asomatoi, Taenaro, Laconia, c. 10; Saints Taxiarchai near Delphi, c. 18 and Saint Artemios, Rhodes, c. 14–15.

Measurements and Methods

In all occasions, orientation measurements included azimuth (Az) and angular altitude of the skyline (AAS) and were made with a magnetic compass (Meridian, MG-3101) with attached clinometer. The geographical latitude and elevation were measured by a portable GPS (Garmin GPS III). The magnetic declination correction was determined from magnetic variation maps of the Military Geographical Service (Athens) for the year 2000. No attempt was made to check for local magnetic anomalies, but according to geological maps, the local environments were of limestone.

The astronomical declination (δ) of a horizon point and the corresponding day of the year of sunrise were calculated using specially developed software (STARDEC and

³ I. POTAMIANOS, *Light into architecture, evocative aspects of natural light as related to liturgy in Byzantine churches*. PhD Thesis, University of Michigan 1996; G. PANTAZIS/M. PAPATHANASSIOU, *On the date of the Katholikon of Daphni Monastery. A new approach based on its orientation. Mediterranean Archaeology and Archaeometry* 5 (2005) 63–72.

SUNDAY) based upon appropriate formulas.⁴ Magnetic correction due to present day geomagnetic declination at the sites is around +2° to +3°.

Alignment was carried out along external walls, and the main nave walls or the main apse are considered adequate to yield azimuth directions.

Concerning the azimuth values, errors involved in compass were at the level of ±0.5 degrees with a subtracted systematic error of 3°, while for AAS angles they were at ±0.5°. Altitude of sun for given azimuths was calculated with software SkyMap Pro Version 10.

Astronomical orientation of Byzantine Churches

Astronomical orientation of medieval churches has been reported since very early times.⁵

Over 800 churches have been investigated for their orientation in Europe: the results suggest that a) the rising sun shines through the longitudinal axis of the church on days of equinoxes, b) solstitial orientation though accepted is not found so often, and c) the orientation of numerous churches was carried out on the feast day of the patron saint, on the day of the laying of the foundation of the church or on the day the building actually begun.⁶

In Christianity a cycle of four feasts celebrating Christ's birth and conception (Christmas, 25th December, and the Annunciation, 25th March respectively) and Saint John's birth and conception (24th June and 24th September respectively) became the solstitial and equinoctial points in the Christian calendar with theological and cosmological symbolism. Augustine in his *Sermones* makes clear the contrast between the pagan worship of the visible Sun and the Christian creator of the sun, Jesus Christ, the Sun of Justice.⁷

On the other hand, as far as English churches are concerned there is a lack of coincidence with specific feasts.

For churches demolished by fire, war or natural catastrophes, when rebuilt the axis of reconstruction often deviated from former axis due to inconsistency between the old Julian calendar and the tropical year (Gregorian Calendar).

Early Christian communities followed the ancient tradition considering the orientation towards the east as sacred – known from literature of Origenes, Clemence of Alexandria and Tertullianus. Indeed in 400–450 AD Pope Leo the Great (440–461 AD) issued

⁴ G. S. HAWKINS/S. K. ROSENTHAL, 5,000 and 10,000-year star catalogs. *Smithsonian Contributions to Astrophysics* 10/2 (1967) 141–179; A. THOM, *Megalithic Sites in Britain*. Oxford 1967; RUGGLES, *Astronomy in Prehistoric Britain and Ireland* (see above fn. 2) 285 formulas A2.1, A5.1; I. LIRITZIS/H. VASSILIOU, *Astronomical orientation of ancient temples at Rhodes and Attica with a tentative interpretation. Mediterranean Archaeology & Archaeometry* 2/1 (2002) 69–79.

⁵ A. THIJM, *The holy line*. Amsterdam 1958; Carl CHARLIER, *On the orientation of early Christian Churches. Vierteljahresschrift d. A.G.* 37 (1902) 229–231.

⁶ K. BARLAI, *Some archaeoastronomical problems in East-Western Europe*, in: Anthony F. AVENI (ed.), *World Archaeoastronomy*, 2nd Oxford International Conference on Archaeoastronomy. Cambridge 1989, 436–440.

⁷ S. McCLUSKEY, *Astronomies and Cultures in Early Medieval Europe*. Cambridge 2000, 25–27.

a decree against the veneration of the rising sun, which shows that the sun only had to be taken as a symbol of the Christ entering his church and not as a deity itself.⁸ On the other hand Pope Vigilius (537–555 AD) confirmed the eastern orientation of churches put forward by Bishop Athanasios during the first Synod of Nicea (325 AD) when it was ordered that a priest specifically had to turn eastward during prayer in church (as specified in the *Rationale Divinorum Officiorum* V.2.57).⁹

In fact, Saint Athanasios writes about orientation in the fourth century: "... the location of the churches was generally such that the faithful, in praying, with their faces toward the altar, would be looking toward the rising sun, the symbol of Christ, who is the sun of justice and the light of the universe".

This direction was still considered sacred by tradition during the Renaissance, as can be seen from the figure given in Apianus' *Astronomicum Caesareum* printed in 1540, depicting four professions related to the cardinal directions: a priest to the east, a cosmographer to the north, the poet to the west and the astronomer to the south.¹⁰

Though early churches show this eastern orientation in two ways – either the altar is positioned in the eastern main apse while the entrance door points to the west, or the door might be in the east so that the rising sun beams illuminate the altar then positioned in the west – only few churches actually point in the cardinal directions.¹¹ Early Christian churches followed the earlier practice from pre-existing cultures, such as Mithraic and Jewish worship meeting places in Rome and Jerusalem,¹² and Classical and Hellenistic practices in Greece,¹³ where the temples and the position of deity's statue within the temple related to the illumination by the first rays of the rising sun (e. g. Aeschylus, *Agamemnon* 519–520: "gods who face the rising sun... with gleaming eyes").

⁸ M. FIRNEIS/H. LADENBAUER, Studien zur Orientierung der Kirchen von St. Ulrich in Wieselburg und St. Ruprecht in Wien. *Forschungsberichte zur Ur- und Frühgeschichte* 10 (1978) 124–126.

⁹ T. GUZSIK, Sol aequinoctialis: Zur Frage der aquinoktialen Ostung im Mittelalter. *Periodica Polytechnica* 22 (1978) 191–213.

¹⁰ P. APIANUS, *Astronomicum Caesareum*. Ingolstadt 1540, FIIIv.

¹¹ M. G. FIRNEIS/C. KOBERL, Further studies on the astronomical orientation of Medieval churches in Austria, in: AVENI (ed.), *World Archaeoastronomy* (see above fn. 6) 430–435.

¹² L. M. WHITE, *Domus Ecclesiae – Domus Dei: Adaption and development in the setting for early Christian assembly*. New Haven 1982, 27.

¹³ e.g. see F. C. PENROSE, On the results of an examination on the orientation of a number of Greek Temples, with a view to connect these angles with the amplitudes of certain stars at the time these temples were founded, and an endeavour to derive therefrom the dates of their foundation by consideration of the changes produced upon the right ascension and declination of the stars by the precession of the equinoxes. *Philosophical Transactions of the Royal Society of London* (A) 184 (1893) 805–834; idem, On the orientation of certain Greek temples and the dates of their foundation derived from astronomical considerations. *Philosophical Transactions of the Royal Society of London* (A) 190 (1893) 43–65; idem, Some additional notes on the orientation of Greek temples, being the result of a journey to Greece and Sicily in April and May 1900. *Proceedings of the Royal Society of London* LXVIII (1901) 112–114; I. LIRITZIS/H. VASSILIOU, Archaeoastronomical orientation of seven significant ancient Hellenic temples. *Archaeoastronomy* XVII (2003) 94–100; iidem, Highlighting New Archaeoastronomical Results From Greece (prehistoric, classical and byzantine temples), in: *Proceedings of 13th SEAC, Sardinia, June 28–July 3, 2005*; idem, Lights and Shadows in Cultural Astronomy (in press, to appear in 2006); idem, Were Greek Temples Oriented Towards Aurorae? *Astronomy & Geophysics* 47 (2006) 14–18.

Surely, regarding astronomical alignments of churches, written records *ordering* axis orientation are most vital. They can be traced in old writings, e. g. in monastic orders such as the Franciscans and the Cistercians, who have had definitive rules according to which churches had to be oriented toward solar positions on data related to the life of their monastic founders.

However, it is not known whether the Christian churches built during later centuries (throughout the Byzantine period) continued to keep or ignored this building rules of orientation, or whether the clash between eastern and western world cultures, some pagan sighting practices, and even practical reasons arising from the architectural structure of crowded settlements in villages and capitals, influenced the actual orientation of new churches when building them.

In our project early Christian and Byzantine churches were measured for their orientation towards the rising sun on certain and 'particular' days of the year. Here we present a part of our project, considered as a significant link between history, archaeoastronomy and Christian religious practices.

In the determination of the position of the sun, the switch from the Julian to the Gregorian calendar has been taken into account. In fact, during the year 1545 AD, the date of the vernal equinox had regressed from the 21st March (date of vernal equinox at the time of the Council of Nicaea, 325 AD) to March 11th (10 days earlier), and in 1582 a papal decree had been published in order to return the equinox to its proper date.¹⁴ Therefore the 5th October 1582 was followed by October 15th, just to compensate for the error of the 10 days accumulated during the past 11 centuries, because of the incomplete calculations of the Julian calendar.¹⁵ In Greece, the Gregorian Calendar has been accepted since 1924, when 5th March was followed by March 18th.¹⁶

Thus dates after the year 1582 must be corrected as follows: from 1582 to 1699 we must add 10 days, from 1700 to 1799 we must add 11 days, from 1800 to 1899 we must add 12 days and from 1900 to 1924 we must add 13 days.¹⁷

For centuries earlier than 1582, we applied appropriate days, in certain Byzantine churches, bearing in mind the change of 0.78 days per century starting from 325 AD, the date of fixing Greek Christian Easter.

Our software provides Gregorian dates, thus for comparison with Julian calendar a subtraction of some days is applied to the computed dates and the present saint's day celebration.

¹⁴ V. GRUMEL, *Traité d'Études Byzantines I: La Chronologie*. Paris 1958, 175; August ZIGGELAAR, The Papal Bull of 1582 Promulgating a Reform of the Calendar, in: G.V. COYNE/M.A. HOSKIN/O. PEDERSEN (eds.), *Gregorian Reform of the Calendar. Proceedings of the Vatican Conference to Commemorate its 400th Anniversary 1582–1982*. Specola Vaticana 1983, 201–239, here 201–202; Anthony F. AVENI, *Empires of Time: Calendars, Clocks and Cultures*. Revised Edition, Colorado 2002, 101–102.

¹⁵ AVENI, *Empires of time* (see above fn. 14) 102; ZIGGELAAR, The Papal Bull of 1582 (see above fn. 14) 201–202.

¹⁶ O. GINGERICH, The Civil Reception of the Gregorian Calendar, in: COYNE/HOSKIN/PEDERSEN (eds.), *Gregorian Reform of the Calendar* (see above fn. 14) 265–279, here 276–277; I. POTAMIANOS, *Το φως στη Βυζαντινή εκκλησία* (The light in the Byzantine church). Thessaloniki 2000, 156.

¹⁷ F. PARISE, *The Book of Calendars*. New York 1982.

The Angular Altitude of Skyline (AAS) was considered in two cases, a) emergence from the perceptible horizon, the intersection between extrapolated axis of the altar towards the east, and b) variable angular altitudes along the vertical projection of the sun onto the intersected point of the horizon.

Results and Discussion

(Abbreviations used: Lat. for geographical latitude, Long. for longitude, Az_E for the azimuth, i. e. the angle between the eastern main axis of the church and magnetic north. Angular altitude of skyline (AAS) is the angle between the horizontal plane and the height of horizon at the point of intersection between the extrapolated axis of the church and the horizon line.)

1) *Saint Anastasia, Karpathos island (c. 5th–6th AD):*

(Lat.= 35° 28' 30.5" N, Long.= 27° 6' 47.2" E, $Az_E=90^\circ \pm 2^\circ$, AAS=14° ±1°)

In the area of Arkasa on the island of Karpathos, under the foundation of the later chapel of Saint Sophia, the excavations of the Italian Archaeological School in Athens discovered the foundations of a large Early Christian Basilica dedicated to Saint Anastasia. Only the mosaic floor of the prodomos and a part of the floor of the narthex are visible, which are decorated with geometrical forms (Fig. 1). The dedication to Saint Anastasia is confirmed by an inscription found in the mosaic floor in front of the Great Door of the Church.¹⁸

The dates that derived from the eastern direction were found to be around the equinoxes and specifically 5th to 14th September or March 29th to April 7th (Gregorian calendar).

As the commemoration day for martyr Saint Anastasia is the 22nd October, the above dates certainly are not related to the saint's day, because even if we subtract one or two days respectively for the 5th and 6th centuries, we get 3rd to 13th September. Regarding the alternative dates in March, we get 27th March to 6th April, very close to the vernal equinox. The results fit mostly to the common practice of the four feasts referred to above and especially to the vernal equinox.

However, for an AAS within the errors of the measurement (–0°49'54" ca. 6:30 am) the day of 22nd October is met, but with adjustable azimuth to 104.5°, which certainly is an unacceptable case.

We must add that later in the North-eastern edge of the great church a chapel of Saint Sophia was built which has the same orientation. The day of celebration of Saint Sophia is 17th September according to the Eastern Orthodox Church calendar.

2) *Saint John of the Hospitaller Knights of the Order of Saint John, Rhodes (c. 14th):*

(Lat.= 36° 26' 41" N, Long.= 28° 13' 27.6" E, $Az_E=87^\circ \pm 0.5^\circ$, AAS=0° ±0.5°)

The Church of Saint John of the Collachium, as it is called, was the largest and finest church that belonged to the Western European architectural types, located at the Medi-

¹⁸ M. G. MICHAELIDES NOUAROS, *Καρπαθιακά Μνημεία Γ'. Ίστορία της νήσου Καρπάθου* (Monuments of Karpathos III. History of Karpathos Island). Athens 1940–1949, 59–60.

eval city of Rhodes Island, south of the Grand Master's Palace. Today only the foundations and part of the floor are visible, as it was totally destroyed when it was blown up in 1856. Medieval accounts and the descriptions and woodcuts left by travelers in the last century, as well as the excavation carried out by the Italian architect P. Lojacocono in 1934, help us to obtain a rough reconstruction of the building, which was a three-aisled basilica with a transept and a sanctuary with a rectangular plan. The aisles had timber roofs, the central one being a barrel vault and the side ones single pitched. The transept and sanctuary had ribbed cross-vaulting. The church was 48 or 50 m long and 15 or 17 m wide, and the transept about 25 m long.¹⁹

The foundations of the Church probably were laid immediately after the Knights came to Rhodes in 1309, and were finished in the time of Grand Master de Villeneuve.

The dates derived from the eastern direction of the church were found to be 24th to 26th September or 8th to 11th March (Gregorian calendar).

Regarding the dates of September, if we subtract approximately eight days to meet the Julian calendar, we reach 16th–18th September, which is very close to the feast of the Conception of John the Baptist, but also the date of the autumnal equinox. If we apply the subtraction of eight days to the alternative dates of March, we reach the beginning of March (1st to 3rd) when there is no feast of the patron saint.

3) *Saint Triad, Rhodes (c. 14th):*

(*Lat.*= 36° 26' 41" N, *Long.*= 28° 13' 17.6" E, $Az_E=93.5^\circ \pm 0.5^\circ$, $AAS=0^\circ \pm 0.5^\circ$)

The Church of Saint Triad or Holy Trinity of the Collachium is located on the South-eastern edge of the Grand Master's Palace in the Medieval City of Rhodes. It is a very small three-aisled building of the 14th century, built in the type of the great Church of Saint John.²⁰

The dates derived from the eastern direction are 6th to 10th October or 3rd to 7th March (Gregorian calendar).

As the commemoration day of the Holy Trinity is the first Sunday after Pentecost (50 days after the Easter Sunday), the building was not oriented to face the sunrise during that certain date; with the subtraction of eight days we reach on 28th of September to October 2 (very close to the important feast of Michelmas on September 29, and just five to eight days after the autumnal equinox), or of February 24th to 28th respectively. There is of course the possibility that the orientation was not by intention and made randomly. However, all churches of Rhodes, except the two of Saint John and Panagia (Mother Mary) of the Castle, have changed the original, but yet unknown saints' names.²¹ The initial attribution of a saint's name has been forgotten during the later Ottoman occupation and the transformation to a mosque. This matter requires further investigation.

4) *Saint Sophia, Ghournitsa-Kardamyle, Mani, Peloponnese (c. 16th):*

(*Lat.*= 36° 53' 30" N, *Long.*= 22° 30' 14" E, $Az_E=75^\circ \pm 0.5^\circ$, $AAS=24^\circ \pm 0.5^\circ$)

The church of Saint Sophia is located on a hill named Ghournitsa, a settlement of Kardamyle, in Messenian Mani, Peloponnese (Fig. 2) According to inscriptions it was built

¹⁹ E. KOLLIAS, *The Medieval City of Rhodes and the Palace of the Grand Master*. Athens 1998², 100–101.

²⁰ *Ibid.*

²¹ Dr. E. Kollias, personal communication.

about 1604–1630, and the murals were completed circa 1700. It was made of local sandstone. The church building forms a cross, which is evident from the inside under the dome: its spine is reaching forward from the church entrance to the altar and sanctum, its two arms extending left and right. Two marble columns, of different shape, support the dome which is said to be exceptional: it has twelve panels, each with carved arches of alternating Byzantine and Ottoman designs. There is a small window above each arch to admit light into the church.²²

The measurements to the eastern direction give dates from the 6th to 12th June or 30th June to 5th July (Gregorian calendar).

The orientation of the building is certainly not related to the commemoration day of Saint Sophia which is the 17th September; with the subtraction of ten days on 5th July to 30th June, we reach June 20th to 25th respectively, a date very close to the summer solstice, or for Christians, to the commemoration day of the birth of Saint John the Baptist.

We must add that St Sophia's feast day is met at an altitude of $0^{\circ} 11' 13''$ (early dawn), but on a different azimuth of 86.5° , which certainly is an unacceptable case.

5) *Saint Demetrios, Laconia (c. 12th)*

(*Lat.*= $36^{\circ} 30' 30''$ N, *Long.*= $22^{\circ} 30' 21''$ E, $Az_E=60^{\circ} \pm 1^{\circ}$, $AAS=4^{\circ} \pm 1^{\circ}$)

This small single-aisled church preserves Byzantine sculptures in secondary use. Among these pieces are a part of an arched *proskynetarion* on the outside wall, above the south window, a rounded marble plaque in front of the door and a cornice above the built templum screen. Around the small church, which is said to be dedicated to Saint Paraskeve, a newer and larger half-finished building dedicated to Saint Demetrios has been erected.²³

The dates derived from the eastern direction are 6th July or 6th June (Gregorian calendar). The orientation of the church may not be related to the commemoration day of Saint Demetrios (26th October), but with the subtraction of (approximately) seven days from the 6th July in order to meet the Julian date, we reach 30th June, eight days after 22nd June, which date coincides with summer solstice.

On the other hand, for an altitude $-0^{\circ} 50' 9''$ and $0^{\circ} 38' 27''$ (ca 5:30 to 7:00 am) the feast days of St Demetrios and St Paraskeve, respectively are met, but with different and unacceptable azimuths ($107^{\circ} 40' 38''$ and $66^{\circ} 38' 57''$ respectively).

6) *Saint John, Desfina, near Delphi (c. 13th) rebuilt during 18th century (1760).*

(*Lat.*= $38^{\circ} 22' 54''$ N, *Long.*= $22^{\circ} 31' 33''$ E, $Az_E=98^{\circ} \pm 0.5^{\circ}$, $AAS=30.5^{\circ} \pm 0.5^{\circ}$)

The church of Saint John the Forerunner (Prodromos) is located in Desfina, a small town of Phokis near Delphi. It was built, according to inscription, in 1760, over the foundation of an older church of the 13th century, which was the *katholikon* of the Monastery of Saint John. The church is dedicated to the Beheading of Saint John, but the main feast is on 14th September, the commemoration day of the Holy Cross (Fig. 3). The dates derived from the eastern orientation are 24th to 29th August or 15th to 18th April.

²² M. MICHAILIDIS/A. CHRISTOFIDOU, Monasteries from the region of Kardamyli, the Capetanate of the Troupakides-Mourtzinoi, in: Churches in Greece after the Halosis, Vol. 3, Athens 1989, 189–227, here 193–197, 210; F. O. GEARING/M. ATHANASEA-GEORGOTA, From the Edge of Greek Space Exo Mani. Athens 2002, 77.

²³ N. DRANDAKIS, Byzantine Sculptures of Mani. Athens 2002, 260.

The 29th August is an ideal result, because it is the commemoration day of the Beheading of Saint John, but taking into account the subtraction of the days to meet the Julian calendar, we reach between the 13th and 16th August, which is about 15 days earlier than the patron saint's day, but very close to the commemoration day of the Assumption of the Virgin Mary.

However, the 29th August, the patron saint's feast day, is met at an altitude of 25 degrees for the same azimuth, which reinforces the orientation to the Patron's day.

7) *Annunciation of the Blessed Virgin Parigoritissa (the Consoling), Arta (c. 13th):*
(*Lat.*= 39° 9' 31.7" N, *Long.*= 20° 59' 1.15" E, $Az_E=67^\circ \pm 0.5^\circ$, $AAS=5^\circ \pm 0.5^\circ$)

The church of the Panayia Parigoritissa, as it is called, dedicated to the Annunciation, was built at the end of the 13th century, by the despot of Epirus Nikephoros Komnenos Doukas and his wife Anna Palaiologina. It was formerly the *katholikon* of a large monastery, of which 16 cells and the refectory are also preserved. The *katholikon* has dimensions of 20.30 × 22 m and was built following a fairly original model. On the ground floor its plan is similar to that of Greek-cross octagon churches, while at first-floor it follows the type of the cross-in-square church. The nave is square and has no internal supports. The distinctive feature of the church is the manner in which the dome is supported, which does not seem to have been used in other Byzantine monuments. The dome rests on eight pilasters, on which stand three rows of columns leaving the interior space undisturbed. The walls of the Parigoritissa are adorned with wall-paintings dating from a variety of periods.²⁴

The dates that are derived from the eastern direction are July 30th to August 1st, or 11th to 15th May (Gregorian calendar).

Taking into account the difference between the Gregorian and Julian dates, if we subtract seven days (approximately), we get 23rd to 25th July or 4th to 8th May. These dates do not coincide with the commemoration day of the Annunciation, which falls on 25th March. On the other hand, about 20 days later, on 15th August, there is another important day: the commemoration of the Assumption of the Blessed Virgin. We may suppose that the constructors intended to dedicate the church to the Blessed Virgin, and set the foundation stone close to the day of Assumption.

The date of Annunciation on 25th March is met at an altitude of $-0^\circ 50'$ (ca 6:30 am), but with a different azimuth of 83.5 degrees, which is an unacceptable case. On the other hand, the 15th August is acceptably met at an altitude of about $0^\circ 30'$ (ca 6:00 am), when illuminated rays apparently emerge above the perceptible horizon.

8) *Red Church (Birth of the Virgin Mary) Arta (c. 13th):*
(*Lat.*= 39° 21' 17" N, *Long.*= 21° 11' 9" E, $Az_E=105^\circ \pm 0.5^\circ$, $AAS=20^\circ \pm 1^\circ$)

The church of the Birth of the Virgin Mary was built around the 13th century in the highlands of the Area of Arta, surrounded by mountains. It was made of red bricks, and thus is called the Red Church. It has the form of a two-column cross building with a

²⁴ L. THEIS, *Die Architektur der Kirche der Panagia Parēgorētissa in Arta/Epirus*, Amsterdam 1991; N. K. MOUTSOPOULOS, *Οι βυζαντινές εκκλησίες της Άρτας* (Byzantine Churches of Arta). Thessalonike 2002, 91–96.

dome, of which only the basement exists today. It was decorated with murals, but only few parts exist.²⁵

The measurements to the eastern direction give dates from 22th to 26th September or from 16th to 20th March (Gregorian calendar).

If we apply the subtraction of approximately 7 days, we get 15th to 19th September, which dates are around eight to eleven days after the commemoration day of the Birth of the Virgin Mary, which is celebrated by the Eastern Orthodox Church on 8th September. Concerning the dates of March, a subtraction of approximately seven days reaches 9th to 13th March, which is 12 to 16 days before the other important feast of the Annunciation. On the other hand, these dates are very close to the autumnal equinox. However, the 8th September is rightly met at an altitude of 27.5° ca 9:30 am.

9) *Birth or Assumption of the Blessed Virgin, Hellenikon (Tsouka) Ioannina (c. 12th, rebuilt in 17th century):*

(*Lat.*= $39^\circ 33' 19''$ N, *Long.*= $20^\circ 58' 19,3''$ E, $Az_E=119^\circ \pm 0.5^\circ$, $AAS=9^\circ \pm 1^\circ$)

The Monastery of the Blessed Virgin (Tsouka Panayia) is located at the edge of a precipitous hill, named Tsouka, which means “peak of the hill”, near Hellenikon village at Ioannina. According to the tradition, it was built in 1190 by the Byzantine Emperor Isaakios Angelos. The Katholikon of the monastery is a small single-aisled church with three apses. Its inside is completely covered by wall-paintings. The church was dedicated, according to the tradition, to the Assumption or the Birth of the Virgin Mary, but it is celebrated on 8th September (Birth of the Virgin Mary).²⁶

Measurements to the East-Northeast direction of the church gave us dates from 10th to 16th November or from 25th to 31st January (Gregorian calendar).

If we apply the subtraction of approximately six days, we get 3rd to 9th November, or 18th to 24th January respectively.

The building is certainly not aligned to the sunrise on the commemoration day of the Birth of the Virgin Mary, on 8th September, or the Assumption, which is on 15th August. The closest important feast (about 12 to 18 days later than the dates in November), dedicated to Virgin Mary is on the 21st November, when the Eastern Orthodox Church commemorates the Presentation of the Virgin Mary to the Temple. It could be possible that the church was oriented to meet the sunrise around this feast.

However, the dates of the Assumption and Birth of the Virgin Mary are successfully met towards the same azimuth at altitudes of 48° and 35° respectively. Thus, in spite the unclear original dedication, the orientation is related to the celebrated days of Blessed Mary.

10) *Saints Asomatoi (Michelmas), Tainaro, Laconia (c. 10th):*

(*Lat.*= $36^\circ 24' 6.3''$ N, *Long.*= $22^\circ 12' 29''$ E, $Az_E=79^\circ \pm 0.5^\circ$, $AAS=6^\circ \pm 1^\circ$)

The chapel of Saints Asomatoi at the southern edge of Peloponnese, at Cape Tainaron, was built above the foundation of an ancient temple of Poseidon, approximately in the

²⁵ B. PAPAĐOPOULOU, *Monuments of Byzantine Art*, Athens 2002, 121.

²⁶ P. NOUTSOS, *Chronography of the Tsouka Monastery*. Athens 1968, 15; L. POLITES, *Tó καθολικό τῆς μονῆς Τσιούκας στὰ Κατσανοχώρια (The Katholikon of the Tsiouka Monastery)*, in: *Ἐκκλησιές στὴν Ἑλλάδα μετὰ τὴν Ἄλωση (Churches in Greece after the Halosis)*, vol. 4, Athens 1993, 75–86, here 86.

tenth century (there is no secure information about the chronology, because there is no evidence for dating). It is a single-aisled building and now almost destroyed (Fig. 4). Only the north wall and parts of the roof remain in place.²⁷

The dates derived from the eastern orientation are 25th to 29th August or 13th to 17th April (Gregorian calendar).

The building is not aligned to the sunrise on the commemoration day of the Archangels, which is on 8th November. It is more probable that the chapel followed the orientation of the pre-existing building.

The feast day of patron saint is met at an altitude date of $0^{\circ} 3' 4''$ circa 6:20 am, but with a different azimuth of $112^{\circ} 16' 41''$, which is an unacceptable case.

11) *Saints Taxiarchai, Desfina near Delphi (1314±19)*

(*Lat.*= $38^{\circ} 25' 5''$ N, *Long.*= $22^{\circ} 31' 54.6''$ E, $Az_E = 99.5^{\circ} \pm 0.5$, $AAS = 12^{\circ} \pm 0.5^{\circ}$)

The little chapel of Saint Taxiarchon belongs to the type of the single-aisled vaulted basilica. It is very characteristic that it only has a small narrow window at the eastern apse of the sanctuary and the entrance door at the west side. Inside the chapel important mural paintings are preserved.²⁸ The dates derived from eastern orientation are 27th to 30th September or 13th March (Gregorian calendar). The building is not aligned to the sunrise on the commemoration day of the Archangels, which is on 8th November. However, in Julian calendar the church aligns to sunrise on 19th to 22nd September or 5th to 7th March, pointing to the autumnal equinox.

The feast day of the patron saint is met at an altitude date of $0^{\circ} 3' 57''$ circa 7:15 am, but with a different azimuth of $113^{\circ} 42' 5''$, which is an unacceptable case.

12) *Saint Artemios, Rhodes (14–15th c.)*

(*Lat.*= $36^{\circ} 26' 35''$ N, *Long.*= $28^{\circ} 13' 32''$ E, $Az_E = 90^{\circ} \pm 0.5^{\circ}$, $AAS = 0^{\circ} \pm 0.5^{\circ}$)

The church of Saint Artemios was possibly built before the arrival of the knights at Rhodes Island, but rebuilt during the 14th or early 15th century. It belongs to the type of aisleless barrel-vaulted churches.²⁹

The commemoration day of Saint Artemios is on 20th October and the sunrise is aligned to the eastern orientation of the church from 30th September to 2nd October, or from 10th to 13th March, which in Julian calendar corresponds to 21st to 24th September or to 1st to 5th March. In Julian calendar the name day of Saint Artemios is on 10th October. That is, the day of sunrise along the church's eastern axis is midway between the saint's name day and autumnal equinox.

The feast day of the patron saint is met at an altitude date of $-0^{\circ} 36' 9''$ circa 6:30 am, but with different azimuth of $105^{\circ} 55' 36''$, which is an unacceptable case.

²⁷ N. D. PAPACHATZIS, Pausanias' description of Greece, vols. 2, 4, 5. Athens 2004, vol. 2, 440.2

²⁸ M. G. SOTERIOU, Αἱ τοιχογραφίαι τοῦ βυζαντινοῦ ναυδρίου τῶν Ταξιαρχῶν Δεσφίνης (Frescoes of the Byzantine Chapel of St Taxiarchon at Desfina). *Δελτίον τῆς Χριστιανικῆς Ἀρχαιολογικῆς Ἐταιρείας* 3 (1964) 175–200.

²⁹ A. GABRIEL, La cité de Rhodes, MCCCX–MDXXII: architecture civile et religieuse. Paris 1923; KOLLIAS, The Medieval City (see above fn. 19) 99.

In all cases above, we have taken into account the possible sunrise target not at the first emerging sunrays; a little later when sun has risen, it gives a southern/northern shift in Az_E . While one should account a) for possible inaccuracies during the setting of foundations, and b) unknown changes of patron not recorded by later literature. Regarding the former a deviation of around 10–15 days may be due to an azimuthal shift of $\pm 3^\circ$. In cases where churches were built over the foundations of classical temples they conveniently followed the ancient temple's eastern direction.

Conclusions

From this preliminary orientation investigation of twelve Greek Byzantine churches sunrise alignment was either a) during Equinoxes for most of them, b) a week around summer solstice, c) on the name day of a saint, or d) in no obvious predetermined direction.

It is worth mentioning that in the early Christian era the celebrations of Jesus's and Saint John's conception were set a few days after the vernal and autumnal equinoxes, respectively.

Similarly, two or three days past the winter and summer solstices the celebrations of Jesus's and Saint John's birth, respectively, were established. Correlation of alignments with the temple's deity was based on archaeological, textural and religious data. Certainly, a greater number of churches would provide a sounder statistical basis for their orientation, an ongoing project led by the first author.

Abstract

A preliminary investigation into the orientation of twelve Greek Byzantine churches towards the east is made in relation to the day of sunrise. Measurements were carried out using magnetic compass with inclinometer and GPS (azimuth, latitude, angular altitude of horizon) while declination corrections included a) local magnetic declination and b) refraction. The position of sunrise in the horizon as well as during morning hours was computed with in-house software. Accounting for the differences between Gregorian and Julian calendars, orientation of the nave towards spring and/or autumn, i. e. around the two equinoxes, was found for most churches. Orientations toward the summer solstice and the name day of the saint were also found.