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# ASTRONOMICAL AND MATHEMATICAL KNOWLEDGE AND CALENDARS DURING THE EARLY HELLADIC ERA IN AEGEAN "FRYING PAN" VESSELS

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**ABSTRACT**

Analysis of the symbols engraved on prehistoric unknown use terracotae, the so called frying pan vessels (Teganoschema), reveal a symbolic writing that depicts astronomical phenomena, that are complex calendars based on the Sun and the Moon and all then known planets. The frying pan vessels are mainly found in Cyclades, and around the Aegean, Crete, Attica, and Thessaly. They are artifacts of the Cycladic civilization of the Early Helladic Era. They have been found mainly in graves and settlements. The first findings came to light during the late nineteenth century in the islands of Cyclades and their possible use is still causing strong scientific interest, as it is unknown. Until now, archaeologists could not determine their use and the meaning of their representations. It was believed that these vessels were used in funeral rituals, therefore depicted patterns like the sun and the sea may be associated with beliefs about the afterlife. We have studied the morphology and the representations of the Cycladic frying pan vessels that are found in museums and in literature dating from the middle of the 4th millennium.

In this paper we argue that the Cycladic frying pan contain calendars that are not only based on the periodicities of the Sun and Moon, but in a very advanced knowledge of the movements of the planets, their periodicities in relation to the Earth and the phases of Venus, which is used as calendar, as well as pregnancy and birth predictor calculator..

**KEYWORDS:** calendars, prehistoric astronomy, prehistoric mathematics, ancient astronomy, ancient mathematics, frying pan vessels, pregnancy calculator, prehistoric Greece, prehistoric Europe, Aegean, Cyclades.

## 1. INTRODUCTION

The role of astronomy is crucial in all societies from the dawn of humanity. Societies from prehistoric times realize that their lives depend upon climate and seasons which they realize change with the changes of the sunrise position on the horizon. Gatherers relate collection of food, fruits and hunters and fishermen organize fishing and hunting, with seasons and the phases of the Moon. Eventually they realize that using astronomy and appropriate mathematics enables humans to know when to act properly in agriculture, to cultivate, to seed etc. Ancient civilizations governed their lives influenced by natural phenomena, especially with the movement of the Moon (Liritzis and Kosmatos, 2005).

In this article new evidence based on the interpretation of marks and decorations on prehistoric terracotae (4400 to 2000 BCE) named frying pan vessels (from their shape) indicates that during the Early Helladic Era humans in the Aegean probably record astronomical phenomena with the aim to predict the position of the planets based on their periodicities.

The study indicates that humans at prehistoric times in Greece have knowledge of astronomy, they understand and use successfully causality with accurate mathematics that they have developed to describe and use the "laws of nature" they discover, i.e. the periodicities and periods of planets and probably the phases of the planet Venus (Hannah, 2015).

This study of the symbols on these terracotae indicates that they have developed some "advanced" mathematics that enable them to use various symbols that enable them to use large numbers (hundreds of days, expressed with symbols each representing a number, unity, the number 7 or 14 or 28, using multiples of them and more rarely another number sometimes expressed with the number of rays of star like central image that probably represents the Sun.

The numbers and their multiples are expressed with symbols, multiplications and summations. The symbols vary with time and region in the Greek seas.

Frequently terracotae that have the period of Venus have an eight rayed star like the Macedonian star, which naturally is related with the eight year period of Venus, while one of them has a five rayed star which represents the 5 synodic periods of Venus in 8 solar years, which is one of the symbols of Pythagoreans. Thus, one can say that there was some sort of Pythagoreans before Pythagoras (Belen Castro, 2015).

## 2. PERHISTORIC ASTRONOMY AND FRYING PAN VESSELS

At this point some simple astronomical knowledge is presented to understand better the astronomical finds on frying pan vessels. The Sun is the centre of the solar system and the planets move in ellipses around the Sun. As humans observe the sky every night they see the stars rotate around the axis of the Earth, or axis of the Cosmos, at a rate of 15 degrees per hour. Observing the sky for long they realize that some astronomical bodies some of the brighter ones, move with respect to the fixed stars. These are the planets, the wanderers, as their name implies, that move with variable speeds, but with certain periodicities.

On these terracotae the astronomical phenomena are recorded with their periods, the periods of the planets as seen from the Earth, as a human living on Earth sees them, in the Geocentric system. These numbers are very characteristic and unique and every planet has a distinct number of days which give the identity of the celestial body, the particular planet.

The most important periodicity of a planet (or the Moon) is the synodic period, which is the time period the planet takes to reappear in the same position with respect to the Sun, as seen from Earth.

It can be measured from syzygy, i.e. when the planet and Earth are approximately on the same line with the Sun to the next syzygy. In particular we call the conjunction for the outer planets (Mars, Jupi-

ter, Saturn) when the planet is behind the Sun, when the Earth the Sun and the planet are in approximately the same line. We call opposition when the Earth is right in the middle between the Sun and the planet, again in almost a straight line. For the inner planets, Mecrury and Venus, we call inferior conjunction when the planet is between the Sun and the Earth and superior conjunction, when the planet is behind the Sun. For the inner planets we name largest Eastern (or Western) elongation from the Sun, the largest angular distance from the Sun as seen in the morning or evening.

Inner planets are the planets with orbits inside the orbit of the Earth, i.e. Venus and Mercury, which some ancient Greek authors call solar planets. Superior planets, those having orbits larger than the Earth's, can have only superior conjunctions with the Sun.

Synodic period is the time required for a celestial body within the solar system to return to the same or approximately the same position in its orbit relative to the Earth and Sun. For example, it can be the time between two conjunctions, oppositions, etc. In this paper we will use the term synodic period for denoting the time interval between two successive conjunctions of a planet with the Sun.

Venus appears in the sky before the sunrise for 263 days and then after the sunset for 263 more days. The 263 days correspond to approximately nine lunar months (265 days). The fact that Venus orbits the Sun in 224.65 days and the Earth at 365.256 days, it can be determined the synodic period from the following relationship:

Synodic period=
1/(1/224 .65 - 1/365.25)=583.91days

The synodic or conjunction period of Venus is a period of 584 days. Naturally it is the same for inferior or superior conjunction. After the superior conjunction Venus becomes invisible for a period of about 50 to 53 days, while after the inferior conjunction becomes invisible for a period of 8 to 9 days. This is the result of the very strong light of the Sun that makes planets invisible, when they are at a small angular distance from the Sun.

All planets move around the Sun in the same sense, the direct or prograde motion. The planets as seen from Earth that moves too around the Sun perform a backward motion for a period of time as seen from Earth. This backward motion is called retrograde motion.

Venus performs a retrograde motion for 20 to 21 days before and after the inferior conjunction, and reaches the highest apparent brightness approximately 35 to 37 days before the inferior conjunction as well. When the maximum apparent brightness is reached, Venus is found on the east of the horizon at approximately 47 degrees. Afterwards until the inferior conjunction, its brightness and height respectively to the horizon is reduced.

After the inferior conjunction, Venus is observed in the West with increasing brightness and within the following 35 days reaches its maximum brightness, while this angular distance from the Sun is again the 47 degrees. For the following 228 days, the brightness decreases while Venus goes around the Sun. After these 228 days (9 lunar months), Venus becomes invisible due to its passage behind the Sun, and then reappears in the East. During moonless nights, when Venus has maximum brightness (at 47 degrees from the Sun), its light creates soft shadows on the ground seen by good observers, as described by ancient astronomers.

From our analysis of the symbols on the frying pan vessels, it is possible that some prehistoric people that probably already knew well the motions and the periodicities of the Sun and the Moon, all the planets were a high interest too, based on our interpretations of the records on frying pan vessels. On the frying pan vessels we read the synodic periods of all the planets, Jupiter, Saturn, Mercury and Mars. Jupiter synodic period is 399 days, Saturn 378 days, Mercury 116 days and Mars 780 days.

It is very natural for humans to relate the solar altitude at noon which varies during

the year with seasons and climate. In fact the term climate means inclination of the Sun in Greek. The word ΚΛΙΜΑ means inclination, slope with respect the horizontal plane, and ΕΓΚΛΙΜΑ ΤΟΥ ΚΟΣΜΟΥ according to Hipparchus means terrestrial latitude.

Generalizing the dependence of weather with the season and the position of the Sun, humans conclude wrongly that the stars affect their lives and the climate. It is interesting to note that humans relate planets with weather conditions. The first reference for the Venus is found on a Babylonian plate (K160 in the British Museum) of the 16th century B.C. called the Venus tablet of Ammisaduqa (mid-seventeenth century BCE). It is recorded in the cuneiform inscription of King Ammisaduqa 21 times of appearance and disappearance of Venus in relation to weather. The phrase "when Venus disappears to the east for two months and three days" is characteristic. However the record about the disappearances of Venus in the Babylonian text is not associated with the use of a calendar like the one that occurs many centuries later to the Mayans, who had knowledge of the 584 days of the synodic period.

## 3. FRYING PAN VESSELS

The frying pan vessels appear first in Cycladic I time period and they are more widely spread during the Early Cycladic II period. Their current name is given due to their characteristic shape and not their use, which until our days remains enigmatic. They have either a forked or a quadrilateral shaped handle, while the "base" has usually inscribable decoration of concentric circles, or simple spirals, radial patterns, and sometimes illustrations of rowing boats.

Cyclades are a beautiful group of islands in the Greek sea that have been extremely important at prehistoric time, as they are isolated, very safe places, as there were no big wild animals. It is characteristic that in Greek islands there are dwarf hippopotamuses, dwarf elephants, dwarf horses (smaller than ponies), some of them still in Skyros, as large ones could not survive.

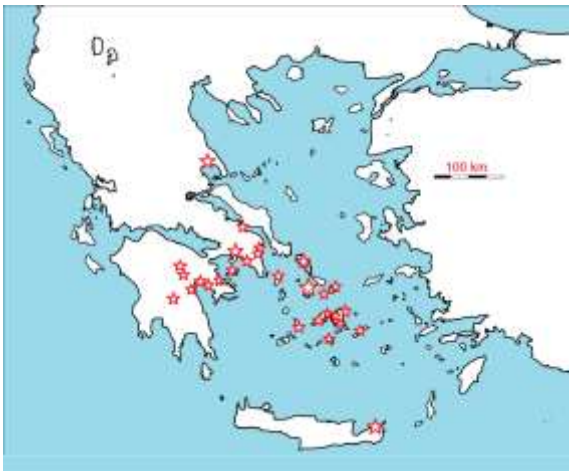


**Figure 1 Archaeological sites of the Early Bronze Age in the Aegean where "frying pans" have been found, based on Coleman, 1995.**

Cyclades have been very important in antiquity, before the bronze era as they have good quality obsidian suitable for blades. Cyclades have an advanced and high tech industry of the blades of obsidian, unique and very important for the societies of that era and these islands become rich with important and impressive civilization. Torrence (1979), Carter (1998) and Liritzis (2010) present the technological importance of Cycladic blade industries in prehistoric societies. People in the Late Pleistocene and Early Holocene are good in seafaring, which was common in the Aegean where craft and cultural contact are widespread during the 3rd millennium BCE (Liritzis, 1988), while migrant farmers is necessity as the small island do not produce sufficient cereals for a large and prosperous population and travel becomes necessary for food too (Broodbank and Strasser, 1991). All these require a good knowledge of astronomy for navigation as Protocycladic colonization of Crete (Broodbank, 1993).

The difficulties to sail and trade without sails at long distance require knowledge that eventually gives power in the early Cyclades. All this travelling and agriculture needs good knowledge of astronomy for many reasons.

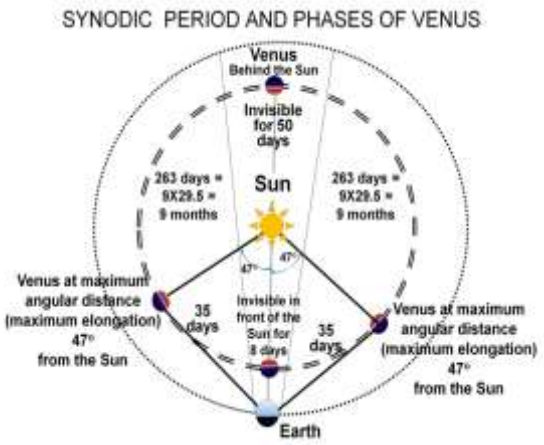


**Figure 2 Venus conjunctions and periodicities. Notice the 9 month period which very naturally makes humans to associate this planet with women, the goddess of fertility and love, Aphrodite or Venus..**

## 3. ASTRONOMY ON TERRACOTAE

The frying pan vessels are probably records of astronomical knowledge, some kind of astronomical manual, expressed in art and it seems that the Neolithic people used it to associate activities like agricultural and social events, festivities to them related to the movements of the planets and especially with the movement of the Venus, as this planet happens to be very bright and at the same time to have two distinct long periods that by coincidence are equal to the pregnancy period and humans very naturally relate the planet with women and reproduction, and hence the planet signifies the fertility goddess, Aphrodite - Venus - Ishtar.

The periodicity of planet Venus is very common in frying pan vessels. It is very characteristic that almost all frying pan vessels that have the periodicities of planet Venus. More than half of all vessels that we have studied display symbols that have to do with female genitalia and have a number of etchings that possibly correspond to the number of days of pregnancy and the period of planet Venus.

**Figure 3 Venus holding a mirror and a Cycladic frying pan. National Archaeological Museum of Athens.**

Frying pan vessels are quite spread in the Greek seas. The archaeological sites of the Early Bronze Age in the Aegean where "frying pans" have been found in various places are Pefkakia, Manesi, Manika, Litharres, Eutresis, several places around Athens, like Marathon, Palaia Kokkinia, Raphina, Ayios Kosmas, Markopoulo, Aegina and Corinth, Perachora, Nemea, Berbati,. Tiryns, Lerna, Asine, Epidauros, Asea in Pleoponnese, Keos, Ayia Irini, Andros, Syros, Chalandriani, Mykonos, Siphnos, Akrotiraki, Despotikon, Paros, Kampos, Naxos, Grotta and Aplomata, Naxos, Ayioi Anargyroi, Louros;, Ano Kouphonisi, Amorgos, Kato Akroterion, Sikinos in Cyclades and in Crete, Agia Photia (see Tsountas, 1898, 1899, Papavasileiou, 1910, Zervos, 1957, Mylonas and Angel, 1959 and mainly Davaras, 1972, 1976 and Coleman, 1995, who classifies them).

## 4. THE FRYING PAN VESSELS AND THEIR ORIGIN

The first findings came to light during the late nineteenth century in the islands of Cyclades and their possible use is still causing strong scientific interest.

For the study of frying pan vessels see Tsountas (1898, 1899), Mylonas and Angel (1959), Davaras (1972, 1976), Davaras and Betancourt (2004), Coleman (1985) who makes an excellent classification of these vessels.

Davaras (private communication, 2014) is in fact the first to conceive the possible relation of time and astronomy with the frying pan vessels.

Astronomy has been and still is important for travelling at sea. People had to use the sea to travel, as the roads of the sea were the only one available in antiquity. Agouridis (1997) and Sampson (1998) present the importance of sea travelling and sea routes and means for navigation in the Greek seas. Liritzis and Kosmatos (1995) discuss the importance of solar changes and climatic cycles (using tree-ring record from the Parthenon) which force people to realize that they need astronomy to keep their societies.

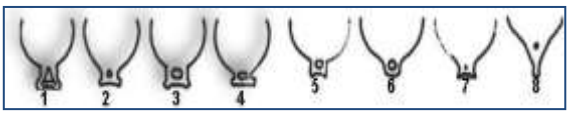

**Figure 4 Frying pan vessels with female pubic symbols**

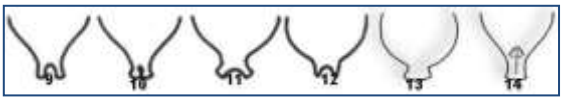

**Figure 5 Frying pans vessels with two-pronged handles**

The most recent study concerning the morphology of their construction and their possible use was published by John E. Coleman and in the map (Fig. 3) the sites where the frying pan vessels have been found is shown. Based on their construction form, the frying pan vessels can be classified into categories according to the astronomical information they contain. (Fig.4, 5).

We observe that the frying pan vessels with two-pronged handles Fig.5 (shapes 9, 10, 11, 12) as well as those with the female pubic symbols and the cavity Fig.4 (shapes 1, 2, 3, 4, 5) make references to the 584 synodic days of Venus.

On the other hand, those who have a different handle (as seen in the shapes 13, 14, 7, 8, Fig. 4, 5) portray the synodic days of planets with masculine names (Mercury, Mars, Jupiter and Saturn).

Out of the 120 different frying pan vessels that are known, the best 31 which are the most complete ones, without important parts missing, have been examined and five of the most characteristic frying pan vessels are presented in this study.

The frying pan vessels that bear the pubic mark are shown in the Fig. 6 (shapes 1, 2, 3, 4, 5, 6, 7, 8, 9). The only exception in the symbolism is the shape 10 in Fig. 6 which represents the male organ. In this frying pan vessel from Chalandriani in the island of Syros, Greece (Fig. 8) we measured a total of 780 impressed symbols at the bottom surface, which correspond to the Synodic periods of planet Mars measured in days.

## 5. FRYING PAN VESSELS AS MIRRORS AND POSSIBLY AS INSTRUMENTS TO OBSERVE THE SUN INDIRECTLY

Tsountas (1898, 1899) has introduced the theory that the frying pan vessels were probably functioning as mirrors by pouring water inside them since they were glazed in the interior, us implies that mirrors were made of vessels with water, as esoptron means looking inside. The quality of frying pans as mirrors has been examined thoroughly experimentally by Papathanassoglou and Georgouli (2009) and they conclude that they really are excellent mirrors if filled up with water or other liquids, as their bottom has a dark colour that makes them very reflective. The same concept of frying-pan shaped copper made mirrors with a rim that permits to fill with water to make a better mirror have been in use for millennia.

The handles seem to prevail 2,500 years later, and even today. On the other face of these copper made mirrors there are representations of the goddess Venus, and similar representations of Aphrodite holding a mirror as on the Attic vase of the 5th century BCE. (Fig. 3).

Frying pans can possibly be used to observe the Sun too. Many ancient authors refer to reflections of the Sun and even the

myth of Medusa really implies exactly this observation of the Sun using reflection.

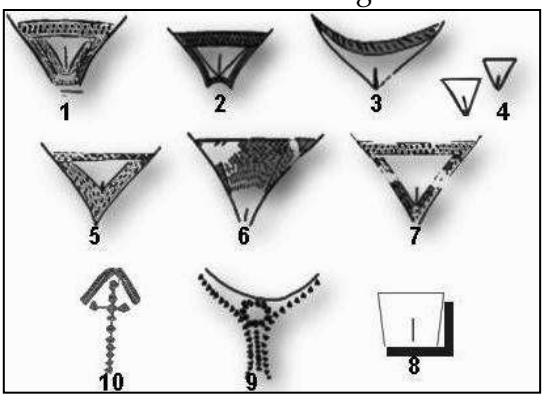


**Figure 6 Forms of handles of frying pan vessels, mainly with female genitalia on the handle of the vessel, from Chalandriani, Syros, Greece. Modified from Coleman, 1995.**

Many ancient texts inform us that we can only see the Sun through reflection with a mirror. For example in Scholia in Euclidis data et catoptrica we read "... ΤΟΥ ΗΛΙΟΥ ΦΛΟΓΩΔΕΣ ΕΛΛΑΜΠΟΝΤΟΣ ΥΔΩΡ ΤΙΣ ΕΝ ΠΙΝΑΚΙΣΚΩ ΒΑΛΩΝ ΕΙΤΙΟΝ ΑΥΤΟ ΘΗ ΤΟΙΧΟΥ ΤΙΝΟΣ, ...", i.e. if we fill a plate with water we can observe the shiny burning image of the Sun using a dish that contains water and observing the reflected and projected image on a wall.

Another passage shows that it was common to observe the Sun with a mirror as Gregorius Nyssenus in *Canticum canticorum* inform us referred to Jesus "...ΚΑΘΑΠΕΡ ΕΝ ΚΑΤΟΠΤΡΩ ΒΛΕΠΕΙ ΤΟΝ ΗΛΙΟΝ, i.e. we see [Jesus] as we see the Sun by reflection in a mirror, and again "ΤΩ ΗΜΕΤΕΡΩ ΚΑΤΟΠΤΡΩ ΕΝΖΩΓΡΑΦΟΥΣΑΙ ΤΟΝ ΗΛΙΟΝ"; and he continues "... ΟΥΤΩ ΚΑΚΕΙΝΟΙ ΩΣ ΕΝ ΚΑΤΟΠΤΡΩ ΚΑΘΑΡΩ ΤΗ ΕΚΚΛΗΣΙΑ ΤΟΝ ΤΗΣ ΔΙΚΑΙΟΣΥΝΗΣ ΗΛΙΟΝ ΒΛΕΠΟΥΣΙ", i.e. we see [the invisible Jesus] as they see the Sun using a clean mirror.

## 6. FRYING PAN VESSELS FROM CHALANDRIANI IN SYROS, 2800 TO 2300 BCE

Syros has most of findings from the Early Cycladic II period, when the Cycladic civilization flourished and navigation in the Aegean has developed. The findings in Chalandriani come from 600 family graves. The characteristic offerings are clay frying pan vessels usually with forked handles, which have incised decorations on the exterior. Most of them have incised pubic triangle just above the two-pronged handle. These pubic triangles vividly resemble the genitalia of the marble female figurines and statues; this detail that allows hypothetical correlations between the elements of nature and the female fertility.

Frying pan vessels are not very frequent. The fast that only a small number of frying pan vessels are found in 600 family tombs, probably means that very few people could have the wealth to afford to have them, or had the knowledge to use them. These were probably the wise people that could predict phenomena and mainly keep the calendar for agriculture. Presumably the frying pan vessels were status symbols too. These terracotae possibly gave the power of knowledge to predict astronomical phenomena based on the periodicities of the planets and even to foretell the position of a planet with respect to the Sun for an observer at the Earth, when Venus will reappear in the morning before sunrise after disappearing in the evening after sunset, etc.

Even though frying-pan vessels are mainly found inside graves, there are many samples that come from settlements. Until now, archaeologists could not determine their use or the meaning of their representations. It is believed that since these vessels were used in funerary rituals, patterns like the sun and the sea may be associated with beliefs about the afterlife.

The offerings of the Early Cycladic I and II period found in cemeteries of Naxos (3200-2300 BCE) are very interesting, since they are evidence of rich societies with prestigious luxury goods. Among the findings were statuettes made of the best marble from the Island of Paros and metal jewels that accompanied the dead. Vessels of this type were primarily found in tombs; however, the samples from settlements suggest that they were also used in the everyday life. Alongside the frying pan vessels

there were also small pots, some of them made of semiprecious stones, containing red and blue dye. These dyes perhaps were used to underline a mark on the frying pan vessel, to know the "date", the phase of the planet and to predict the motion of the planet in the sky, perhaps the distance from the Sun.

### *6.1 Venus Calendar, Syros, 4971*

The artefact marked 4971 in the National Archaeological Museum of Athens is from Chalandriani, Syros Island, Greece. On this item we observe an eight-pointed star in the centre of which there is a circle with 164 imprinted menisci. By adding up the 164 points with the 19 points located at the bottom left of the vessel results to 183 days. It is exactly the number of days between the winter and the Summer solstice. Therefore, it is probable that the ancients were watching the solar calendar alongside the synodic calendar of Venus and the synodic lunar months.

On this finding, we observe a clear recording of the synodic period of Venus. More specifically, if we add up the imprinted menisci located outside the eight-pointed star, we realize they are 584 (=60+59+67+72+81+89+78+78), a number that corresponds to the synodic period of planet Venus. This artefact correlates and supports the monitoring of two calendars: a Solar of 365 days, and the synodic Venus calendar of 584 days.

Humans use Venus as together with Jupiter are the brightest planets. Venus in particular moves much faster than Jupiter and it is very easy to follow the motion of Venus, night by night and week by week. At the same time the "observer" can move the mark painted with a dye from one mark to the next. Till few years back many Greek peasants, sailors knew very well the phases and the appearance of Venus. The eight year period was extremely important too, as it is a period that it is divided by an integer number of lunar months and hence is a period easy to keep.

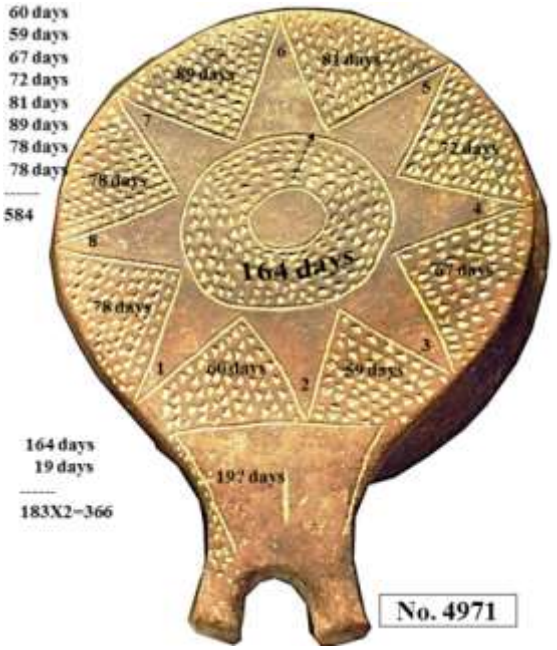


**Figure 7 Frying Pan no. 4971 from Chalandriani, Syros. National Archaeological Museum of Athens. Notice the pubic symbol near the handle, the eight rayed star that is the eight year period planet Venus takes to return to the same distance from the Sun, which is equal to 99 lunar months or tow Olympiad periods, one of 49 months and the next of 50 months.**

### *6.2 Mars Calendar, Syros Island, Chalandriani*

The frying pan vessel marked 5012 is the largest one in the National Archaeological Museum in Athens comes from Chalandriani, Syros.

This artefact has a diameter of about 35 cm and it is reasonable to be larger than the other frying pan vessels, since, as it will become evident, it has 780 imprints of small triangles corresponding to the synodic period of the planet Mars.

If we observe Fig. 8, we will notice 142 points in the inner circle. At the bottom of the frying-pan and near the handle, we notice an imprint cyclic mark and a cross of imprinted triangles (see Fig. 8). Both of them together, it seems to represent a phallic symbol made of a Λ shaped symbol /\ with a cross (†) inside. These symbols consist of 17 (Λ) and 24 (†) imprinted triangles respectively. Adding the points mentioned above (142+17+24) we take a sum of 183 imprinted triangles, which corresponds to

the period between the winter and summer Solstice.

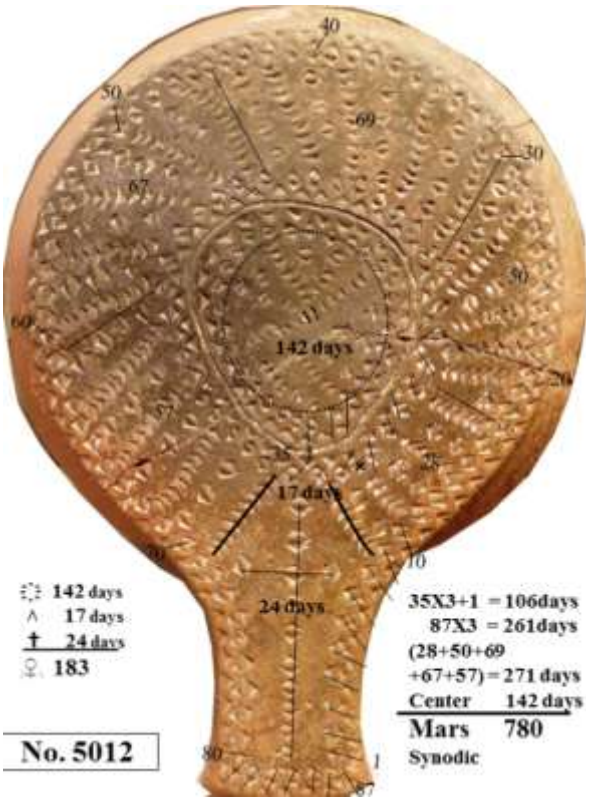


**Figure 8. The frying pan from Chalandriani in Syros. No. 5012 at the National Archaeological Museum in Athens. Notice the Λ shaped symbol /\ with a cross († made of 24 dots) inside it in the handle. The number 183 is possibly half a year.**

If we count all the imprinted triangles (Fig. 8) located in the frying pan outside the area with the phallic symbol, we reach 780 imprinted symbols.

If we consider that the sum of 780 imprinted triangles represents days, then we should accept that the Cycladic people have recorded the synodic period of Mars on this artefact.

This observation, in connection with the frying pan vessels that will be presented later on this paper, indicates that the proto-Cycladic People of the 3rd millennium BCE had astronomical knowledge and had recorded the observed synodic movements of the known planets in our solar system with great accuracy, using large numbers, up to a few hundreds.

### *6.3 Human gestation Calculator, Syros*

The frying pan vessel (artefact marked 5153) in the Archaeological Museum of Athens comes from Chalandriani, Island of Syros, Greece.

We observe the characteristic circle with the 32 imprinted menisci forming the symbolic pubic triangle, and a circle at the bottom that bears a vertical line with 10 imprinted symbols.

The construction topology of the frying pan vessel shows three regions on its back:

a) In the centre there is an eight-pointed star. In the centre of the star there are two concentric circles with two rows of 18 and 13 imprinted menisci. This set of points adds up to 62 (31x2). The rays of the eight-pointed star have 41 imprinted points. The sum of all the points is 103 (62+41).

b) The sum of the imprinted points between the radii and the outer circle is 247 (=17+27+36+32+31+35+37+34).

c) Between the inner circle of the star and the outer region of the frying pan there are three rows of imprinted meniscus that give us a total of 234 (=86+74+74).

The total sum of all the imprinted menisci is 584 (=103+247+234).

A possible way of use of the above vessel from a woman could have been to follow her menstrual cycle on a daily basis. If her menstruation did not appear within 32 days, she would continue to mark the outer circle with the 234 imprinted menisci, as can be seen in Figure 9.

As a result, when the cycle was completed there would have passed (32+234)=264 days, or 9 lunar months, which coincides with the pregnancy period of women. At the end of those 264 days the day of the child's birth would have arrived.

Apart from its function as a human gestation calculator, the frying pan vessel in Figure 9 also functioned as a calendar based on the synodic period of Venus in the following way:


**Figure 9: The frying pan no. 5153 from Chalandriani, Syros Island. National Archaeological Museum in Athens. Notice again the eight rayed star in the middle which probably represents the eight year period which corresponds to five synodic periods of Venus or 99 lunar months, two Olympiads.**

Consider that the centre of the star with the two cycles of the 62 imprinted triangles corresponds to the number of days when Venus vanishes behind the Sun (superior conjunction). Since there are 41 imprinted triangles on the rays of the star, we assume that they signify the number of days when Venus was in retrograde motion, before the inferior conjunction, where she vanishes in front of the Sun for about 9 days. These nine days can be observed at the bottom with the description "Dark days". The most likely entry would be 20 days before the inferior conjunction, starting at the edge of the star where the radius is open. We have marked that point in Figure 5 with the word "start". The woman would mark six points, then she would mark another 7 in the next radius and she would complete the marking on the last radius with 7 points. After that, she would mark the 9 dark days of the inferior conjunction and she would complete the marking at the next rays of the star, which we have marked as 5, 6, 4, 3, 3, thus recording for 21 days the retrograde movement that would follow. Then she would mark the area with the 17 points where Venus would reach her maximum apparent brightness. She would then continue by marking the areas 27, 26, 32, 31, 33, 37 and 34, i.e. a total of 247 imprinted menisci. After that she would mark the 53 points in the centre, which correspond to the dark days of the superior conjunction. Finally, she would complete the record by marking the outer circle with the 234 imprinted menisci.


**Figure 10: Frying Pan vessel from Syros**

Another frying pan (Fig. 10) comes from Syros and it is similar in function to the previous one. In the centre there is a spiral with five helices and it has 17 impressed triangles around it. If we multiply 17X5 = 85 and if we add the 31 points of the inner circle we get a total sum of 85+31 = 116 days. This number can be associated with the synodic period of the planet Mercury. The next circular area contains 266 impressed dashes that correspond to the 9 lunar months observed in a circle around the area. Finally, the outer zone contains 143 impressed triangles.

The basis of the frying pan has two feet, each one decorated with the symbol of the spiral. Those symbols correspond to two lunar months of 59 days. The supporting base has 32 impressed points. If we add up all the points from the centre to the periphery we get: 116+266+143+59 = 584, which

corresponds to the synodic period of Venus.

### *6.4 Calendar and Human gestation Calculator from Louvre*

In the following, a Cycladic frying pan, dated around 2700 BCE is presented. It comes from Syros and it is now in the Louvre Museum in Paris. Its dimensions are approx. 20.3x22cm and its thickness is close to 4 cm. As shown in Figure 4, it has an incised decoration of triangles and dashes, organized in four circles. The number of markings is certainly not accidental. As we observe, the inner circle has a seven-pointed star in its centre and 9 triangles around it, while the next circle has 34. Overall there are 9+34 = 43 imprinted triangles, and if we assume that the 7 interior points are the key for the 7 days, then the inner circle corresponds to 43X7=301 days.

Between the two concentric circles there are 77 parts with three dashes each, resulting in a total of 231 dashes. Then we notice 8 incised running spirals, which correspond to Venus, just like in the other artefacts. The outer circle shows 128 imprinted double triangles, which add up to a total of 256. The whole disk is based on two legs, decorated with 27 and 25 vertical dashes respectively (a total of 52). The whole construction is based on a flat base with 32 imprinted triangles. If we add up these imprinted triangles with the engravings (9+34+231+256+52) they give us a total of 582, which corresponds to the number of days that Venus needs in order to come into conjunction. Another interesting approach emerges if we consider the 7 days in the centre as a key; then we have 43x7 = 301 days, then in the next cycle 77x3 = 231 days and finally 52 days at the base. The sum of these days is a total of 301+231+52 = 584 days, which is exactly the synodic period of Venus.

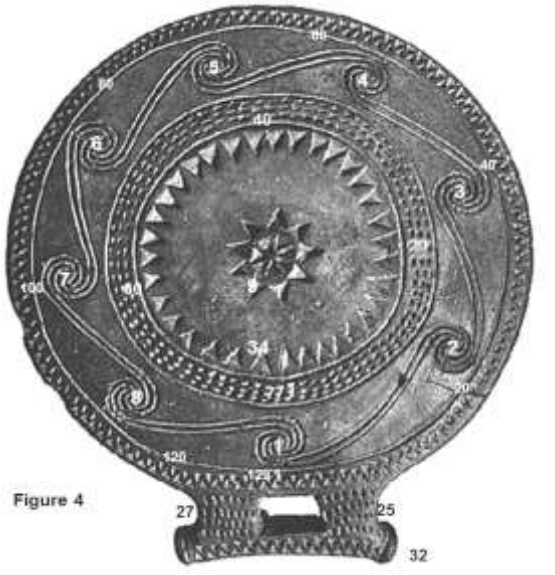


**Figure 11: Cycladic frying pan that has a calendar based on Venus synodic period and the period of pregnancy of 9 months, dated around 2700 BCE, it comes from Syros Island, Greece, and it is now in the Louvre in Paris. The eight spiral decorative probably represents the *oktaetiris*, a period of 8 years, which is 99 lunar months or 5 Venusian synodic periods.**

Almost all Venus based calendars, which are the majority (more than half of the total) have a 8 ray star, the so called Macedonia star, depicted in the middle, and sometimes several motifs that come in 8, like the 8 spirals of the Cycladic fynig pan in Figure 10, which is the 8 year period later called Oktaetiris (or oktaetiris). Oktaetiris, described by Cleostratus, is the period of 8 solar years (more correct tropical years) equal to 2921.9375 days, which is equal to 99 synodic Lunar months (2923.5282), or 107 Sidereal lunar months (lunar month with respect to the stars) and equal to 5 Venusian synodic periods or 13 Venusian sidereal periods and of course two Olympiad periods that were very important for the Greeks. An oktaetiris was the period of reign of many heads of state in antiquity (and today as a matter of fact). Oktaetiris was in use in Scandinavia till the 12 century AD, celebrated every eight year with human sacrifices; following in practice the ancient Greek myth of Minotaur of 2000 BCE, which proves that this was a Pan-

European tradition and a continuity for at least three millennia.

We see on one occasion of a frying pan a 5 ray star, which is what is commonly called *pentalpha*, and which becomes later one of the symbols of Pythagoreans and of course represents the oktaetiris. This symbol was called in antiquity pentemychos as in the cosmogony of Pherecydes of Syros and the "five corners" are where the seeds of Chronos (Time) and the Pythagoreans call it Hugieia Pentagram used by Neoplatonists as symbol of recognition by the Pythagoreans,

## 7. POSSIBLE WAYS TO USE A FRYING PAN VESSEL AS CALENDAR

Let us suppose that the islanders of the Cyclades used a thin charcoal or paint in order to mark each day, then the 9 imprinted triangles in the centre would correspond to the days that Venus disappears while moving in front of the Sun in the inferior conjunction. Then they would mark the next cycle with the triangles corresponding to 34 days, which would show Venus in the East with a half-crescent form while its brightest appearance would be on the 35th day. In the next circle they would colour 231 dashes, which correspond to the days that Venus needs in order to complete the Eastern appearance, before she disappears in the superior conjunction. Overall it would have been 274 (265+9) days and Venus would have entered the dark period. Then the Cycladic islanders would begin to mark the legs of the frying pan, which have 52 vertical lines and correspond approximately to the number of days that Venus remains hidden behind the Sun. After that, 256 days would follow during which Venus would move to the West, to complete a synodic period of 582 days (274+52+256).

During these movements Venus would approach the Sun like "touching" each other twice, at the sunrise immediately after the inferior conjunction and shortly before the superior conjunction. Similarly, Venus would approach the Sun two times during the sunset. Assuming that the Cycladic islanders considered those contacts of the two celestial bodies important in their religious belief, we might assume that they would mark them at the base of the frying-pan with the 32 imprinted triangles. Thus, in a period of 8 solar years, they would record the 32 contacts or conjunctions of the Sun with Venus.

**Figure 12: Blue and red pigments to colour body and face or even to mark on frying pan vessels?**

A possible alternative use of the frying pan vessels, compatible with its use as a calendar, would be the monitoring and estimation of the date that a woman would give birth to a child, in the following way: On a daily basis, each Cycladic woman, would mark her menstrual cycle with colour at the base with the 32 imprinted triangles. Within 32 days she would know that she was pregnant if her menstruation was late. We believe that the nine-pointed central star indicates the nine lunar months 9X29.5, corresponding to 265 days, and the amount of human gestation days. Since the two inner circles give a sum of 34+77 X3 = 34+231 = 265 days, we conclude that the

Cycladic woman would first mark her menstrual cycle at the base with the 32 triangles, and then she would move into the inner circle of the 34 points where she would mark how many days she was late. When all 231 points of the next cycle were coloured, she would have predicted the day she would give birth.

It is therefore possible that this vessel was not only used as a calendar based on the conjunctions of Venus, but it also functioned as a human gestation calculator for women. The Cycladic woman would mark on that vessel each passing day from the conception date until the 265th day, when she would give birth to her child.

## 8. DISCUSSION

Analysis of symbols on all Frying Pan Vessels of the 4th and 3rd millennium BCE give indications that these teracottae probably contain complex accurate calendars, which are based not only on the periodicities of the Sun and Moon, as in several other nations. See for example Aveni (1990), Broodbank and Strasser (1991), Coleman (1985),

Davaras (1972) and Hodges (1998) and Liritzis and Kosmatos (1995) for the importance of cli-mate for the ancient people.

The decipherment of the frying pan vessel decorations shows an advanced knowledge of astronomy and mathematics, of the notion of causality and a pre-Pythagorean tradition that is similar to the original one of Pythagoras or Orpheus. From the present study it is very probable that humans perhaps back at the 5th millennium BC have an understanding of the movements of the five planets, of their periodicities with respect to the Earth and especially of the phases of Venus (on more than half of the frying pan vessels), which are used as calendars pregnancy, for predicting the date of birth of an expected child.

The results show an advanced knowledge of mathematics, beyond the expectations and beliefs we have for prehistoric people.

The dots and lines, and other symbols that often appear in frying pans, such as helices (spirals) usually represent a number of days, such as a period of seven days or a period of months, as well as other periods, which sometimes are based on a number of rays depicted around the centre of frying pan.

From the total of 31 frying pans, we studied, 19 frying pans show the synodic period of Venus. This forms a rate of 60%. In half of them, the synodic periods of Venus and Jupiter are drawn together. The most important of these periodicities is the oktaetiris, a period of 8 solar years equal to 99 lunar months or equal to 5 conjunctions of Venus as seen from the Earth.

In 9 out of 31 frying pans, the synodic period of planet Mercury (Hermes) is presented, while in 1/3 of the frying pan vessels (10 out of 31) the synodic period of Mars along with synodic period of Saturn are represented by imprinted symbols. In 6 out of 31, along with the synodic periods of the pre mentioned planets, the solar calendar of 365 days is drawn.

In 4 frying pans, 59 etchings are drawn possibly corresponding to the 59 days required for a two lunar months cycle. Finally a clay frying pan exhibited in Cycladic Art Museum in Athens (no. 99) of the Early Cycladic I-II period of the Kampos phase (2800-2700 BCE) includes imprinted symbols which possibly corresponds to the synodic periods of all the five then known planets (Mercury, Venus, Mars, Jupiter, Saturn).

It seems that another very important periodicity is the period of nine months, when Venus is appeared in the East or in the West. Since the length of this period corresponds with the period of women's pregnancy, it was possibly associated with the fertility and hence the planet associated with the goddess of fertility Aphrodite (Venus). Often the synodic periods of Venus and Jupiter are presented together in the frying pans, possibly because these two planets have the same apparent brightness and colour to an extent.

Another pair with the same apparent brightness is the pair of planets Saturn and Mercury. Also the synodic periods of these planets are presented together in the frying pans. The synodic period of planet Mars appears rarely.

The frying pans that have periodicities of the planet Venus have very schematically illustrated the mons pubis, external female genitalia. Some frying pans of Venus presents an eight-pointed star, while the frying pans of Jupiter presents a twelve-pointed star that corresponds to the period of 12 solar years, when the Jupiter appears to the same position of ecliptic.

**The existence of the clay pot colour found together with frying pans may be interpreted that the dead could make use of them in his after death life. The monitoring of the planet movement, because of their steady move on the ecliptic, seems to be part of a divine worship. Plato in Cratylus (397d) connects the word "God" with the notion of "running", since the old gods were celestial bodies in the sky running in the old days before the time of Plato.**

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**REFERENCES**

Agouridis, C. (1997) Sea routes and navigation in the third millennium Aegean. *Oxford Journal of Archaeology*, *16*(1), 1-24.

Aveni, AF 1990, *Empires Of Time*: *Calendars, Clocks And Cultures* / Anthony F. Aveni, n.p.: London : Tauris, [1990], ©1990., University of Edinburgh's Library Catalogue, EBSCOhost, 3 June 2014.

Broodbank, C. and Strasser, T.F. (1991) Migrant farmers and the Neolithic colonization of Crete, *Antiquity*, vol. 65, No 247, 233-245.

Broodbank, Cyprian. (1993) Ulysses without sails: trade, distance, knowledge and power in the early Cyclades, *World Archaeology* 24.3 315-331.

Belen Castro Martin (2015**)** A historical review of the Egyptian calendars: the development of time measurement in ancient Egypt from Nabta Playa to the Ptolemies. *SCIENTIFIC CULTURE, Vol. 1, No 3, pp. 15-27*

Carter, T. B. (1998) *Through a glass darkly: Obsidian and society in the southern Aegean Early Bronze Age* (Doctoral dissertation, University of London).

Coleman, J. (1985) "Frying Pans" of the Early Bronze Age Aegean, American Journal of Archaeology, Vol. 89, No. 2, pp. 191-219

Davaras, C. (1972) Archaeotites kai Mnemeia Anatolikes Kritis, *Deltion* 27 649.

Davaras, C. (1976), *Guide to Cretan Antiquities*. Park Ridge, New Jersey: Noyes Press,

Davaras, C., & Betancourt, P. P. (2004). *The Hagia Photia Cemetery I: the tomb groups and architecture* (Vol. 1). Institute for Aegean Prehistory.

Dean, M. and Ferrari, B. (ed.) (1992) *Archaeology Underwater* (The NAS guide to principles and practice), *Nautical Archaeology Society*, Great Britain.

Hannah, R (2015) The roles of observational astronomy in ancient Greece. *SCIENTIFIC CULTURE, Vol. 1, No 2, pp. 47-56*

Hodges, H. (1998) *Artifacts An introduction to early materials and technology*, 3rd edition, Duckworth, Great Britain.

Liritzis, I. (2010) Strofilas (Andros Island, Greece): new evidence for the cycladic final neolithic period through novel dating methods using luminescence and obsidian hydration. *Journal of Archaeological Science*, *37*(6), 1367-1377.

Liritzis, I. and Kosmatos, D. (1995) Solar-climatic cycles in the tree-ring record from Parthenon. *In Holocene Cycles (climate, sea levels and sedimentation)*, C.W. Finkl (ed.), *Journal of Coastal Research*, CERF, Florida.

Liritzis, V. M. (1988) Seafaring, craft and cultural contact in the Aegean during the 3rd millennium BC. *International Journal of Nautical Archaeology*, *17*(3), 237-256.

Mylonas, G. E., & Angel, J. L. (1959). *Aghios Kosmas: An Early Bronze Age Settlement and Cemetery in Attica.* Princeton University Press.

Papathanassoglou, D. A., and Georgouli, Ch. A., (2009) The 'frying pans'of the early bronze age aegean: an experimental approach to their possible use as liquid mirrors, *Archaeometry* 51.4 658-671.

Papavasileiou, G.A. (1910) *About Manika in Euboea*: HEp "About the archaeological tombs of Euboea", Athens.

Sampson, A. (1998). The Neolithic and Mesolithic occupation of the Cave of Cyclope, Youra, Alonnessos, Greece. *The Annual of the British School at Athens*, *93*, 1-22.

Soles, J.S. and C. Davaras, (1994), Excavations at Mochlos 1990-1991, *Hesperia* 63: 391-436.

Tsountas, CH., (1898), *Cycladic I*, *ArchEph*, 137-212.,

Tsountas, Ch., (1899) *Cycladic II, ArchEph*, 73-134.

Torrence, R. (1979), A technological approach to Cycladic blade industries. *Papers in Cycladic prehistory*, 66-86.

Zacharias, N., Beltsios, K., Oikonomou, Ar., Karydas, A.G. and Bassiakos, Y. (2008) Thermally and optically stimulated luminescence properties of an archaeological glass collection from Thebes, Greece, *Journal of Non Crystalline Solids*, vol. 354, 761-767.

Zervos, Ch ., (1957) *L'art des Cyclades*, Paris.