ANDESITE SUN IN CARPATHIAN MOUNTAINS - ROMANIA

IN MEMORIAM MARIA COMŞA

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Abstract. Sarmizegetusa Regia (III-I B.C.) was the most significant Dacian religious, military and political centre. On the plateau from Sarmizegetusa Regia (near Hunedoara) is the sacred zone, which contains several circular and rectangular sanctuaries and the Andesite Sun. The Andesite Sun from Sarmizegetusa Regia and our results about the ten solar radiuses on the top of the Sun altar from an astronomical point of view are presented.

Key words: History of Astronomy – Archaeoastronomy – Alignments – Sarmizegetusa Regia – Romania.

1. DACIAN KINGDOM

"Here stood one who studied the waxing and waning of the moon, while still another regarded the labours of the sun and observed how those bodies which were hastening to go toward the east are whirled around and borne back to the west by the rotation of the heavens" (Iordanes, 2014).

About the year 3000 B.C., legends mention the existence of a great empire, ruled by the priestess of the Uranian Sun, Dacia "Dochia", which was located in the area of the Ceahlău Mountain. She was simultaneously the supreme judge and military leader. Five hundred years later, Hestia (Vesta), queen and high priestess of the sacred fire, led the same empire based upon the code of fair laws - Belagine. Hestia was later on deified by the Thracians.

Around 1400 B.C., traditions mention the name of Zamolxe (Zamolxis, Zalmoxis), high priest, physician and king, likewise deified, who presumably received the Belagine code of laws, directly from the goddess Hestia.

As it appears today, in the Zamolxean schools, which lasted for hundreds of years, philosophy, logic, mathematics, and medicine were taught, while the spells and names of medicinal herbs have been handed over to us, through folklore (Szücs-

Csillik *et al.*, 2010b). Sarmizegetusa Regia (Geographical latitude: $45°37'36''$ N, Geographical longitude: $23°18'62''$ E, Altitude: 990 m), located in the sacred Orăştie Mountain in Romania, consists of the remains of a Fortified City and Sacred Area (Bărbosu et al., 2004).

The city dates from 82 B.C. to 107 A.D., being raised during the reign of Decebal, the last of the Dacian kings. It was the most important Dacian religious, military and politically centre of Dacia during this period. The archaeological ruins clearly illustrate the importance of geometry in designing the city. Rectangular and polygonal structures were common along with circular sacred spaces.

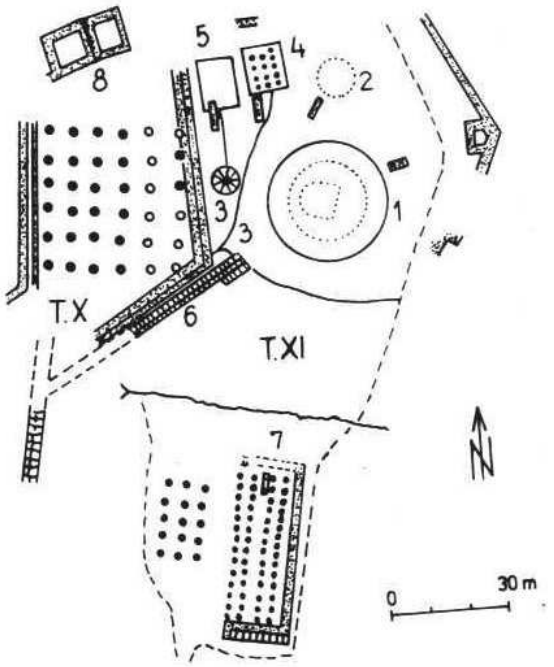

Fig. 1 – The map of the sacred area of Sarmizegetusa Regia (1. The great round sanctuary; 2. The small round sanctuary; 3. The Andesite Sun; 4. The eastern rectangular sanctuary; 5. The western rectangular sanctuary; 6. The sacred way; 7. The southern old sanctuary; 8. The western new sanctuary).

On the Grădiştea hill rise the ancient Sarmizegetusa, the biggest Dacian fortress known. The fortress covers 3 hectares between its walls with an irregular plane (Figure 1). But Sarmizegetusa didn't have primary strategic importance; unlike the other fortresses that dominate the surrounding places. Sarmizegetusa Regia is at 1000 m

elevation and it is dominated the highest places around. But, most impressive by their stateliness and by their enigmatic nature are Geto-Dacian's religious constructions, their sanctuaries (Daicoviciu, 1961; Glodariu, 1995; Iaroslavschi, 1994; Csillik *et al.*, 2001; Szücs-Csillik *et al.*, 2010b; Ionescu and Dumitrache, 2012; Stănescu, 2015).

The ruin complex that was named The Sacred Precincts were 100 m away from the Eastern Gate of the Sarmizegetusa fortress. Towards that place, we are guided by a large road, paved with limestone slabs, delimited by a short stone wall. The road led us to a paved little square, that is bordered by water branches, collected from a nearby spring. The two branches fall into the nearest precipice.

In the sacred area 7 sanctuaries had been unearthed, numbered from 1 to 7 and corresponding to the following gods (Ionescu and Dumitrache, 2012):

- Sanctuary 1 was dedicated to Mars. With a rectangular shape, it had the same orientation (10° NE) like the other temples. Based upon some of the objects found and upon the writings of the historians Iordanes and Dio Cassius, who mentioned the fact that Trajan had found weapons and war machines in the Dacian mountains, we could say that the Getae-Dacians worshipped Mars by offerings, the revenging rituals of Mars being known to all neighbouring people to the Dacians.

- Sanctuary 2 was dedicated to Saturn. It had a rectangular shape and the orientation of the temple is also of 10° NE.

- Sanctuary 3 was dedicated to Jupiter and Triads. It was the largest sanctuary in this sacred precinct and had a rectangular shape.

- Sanctuary 4 was dedicated to Mercury. The Thracian and Dacian kings considered themselves also descendants of Hermes/Mercury; according to the opinion of Herodotus expressed in his Histories, Hermes was a mediator between the two worlds: of the gods and of the common people. This temple had been almost completely destroyed by the Romans, specifically because Decebal was a descendant of the god Mercury and the temple was dedicated to the mentioned divinity.

- Sanctuary 5 was dedicated to Venus. The rites were connected with the attributes of the goddess acting together with the Sun in regulating the balance between the drought and rainfall. These practices in the Dacian time are to be found today in the Romanian customs of Caloian and Paparude.

- Sanctuary 6 was dedicated to the Moon. It had a rounded shape, with a diameter of 12.6 m and the temple was made of andesite pillars.

- Sanctuary 7 or Dacian Pantheon is the large, rounded sanctuary, the place where all divinities had been gathered, rendering, at the same time, the organizing of the Cosmos. Its structure and dimensions are evidence for the knowledge and use by the Dacian constructors of the golden section, of the golden number. This temple is a replica in stone and wood of the Universe Structure, as perceived by the Dacians in the antiquity. By the shape of the abside, some conclusions could be inferred, regarding the cosmogony of the Dacian religion, which is somehow similar to the religion of many neighbouring people and refers to the egg of the world, out of which the Universe had emerged.

The number 7 is often considered lucky, and it has a definite mystique, perhaps because it is a prime number that is, it cannot be obtained by multiplying two smaller numbers together.

There are seven days of the week, named after various ancient gods and planets, the phases of the Moon last approximately seven days. Many cultures recognized seven planets (Sun, Moon, Mercury, Venus, Mars, Jupiter, and Saturn).

Today the landscape is impressive. In the middle of the secular forest, the eye-spots the monumental traces of Dacian sanctuaries located on two terraces (MacKendrick, 2000).

2. ANDESITE SUN

Fig. 2 – Andesite stone and the great round sanctuary.

Near the great round sanctuary is to be found one of the most interesting mon-

uments of The Sacred Precincts: a pavement of andesite slabs arranged like rays around one round slab, made of the same stone (Figure 2).

Because of this shape, this round pavement that has 7 m diameter was named The Andesite Sun* - this huge circular construction, divided into ten slices, having approximately 36 degrees each, comes tangentially to the Great Calendar Temple and points to several Dacian buildings (Daicoviciu, 1961; Comşa, 1991; Stănescu, 2015). This pavement has a foundation made of limestone blocks. It has one long radius,

Fig. 3 – Andesite Sun (GPS measurements).

which points exactly to North and an inner circle that has 1.52 m in diameter (Figure 3). The thickness of the disc is 30 cm.

In nature, we find patterns, structures from the microscopic particles to the larger cosmos. These follow geometrical archetypes, which underlying the relationship of the part to the whole. As above so below.

This principle of inseparability and union provides us with a continuous reminder of our relationship to the whole. The Dacian used this idea in their sacred architecture, when they elaborated the sanctuaries from Sarmizegetusa Regia (Szücs-Csillik *et al.*, 2010a). As we know, among the most common petroglyphs are those typically interpreted as images of the sun (Ruggles, 2005).

*Maria Comşa (1928-2002) was one of C. Daicoviciu's students in Cluj-Napoca, with whom she had done her student practice, one the sites where she worked in this capacity being Sarmizegetusa Regia. Later on, she became an important Romanian archaeologist, dealing with the first millenium A.D. During her activity, she had also made and published studies about the Geto-Dacians, including some referring to the Andezite Sun.

The 10 radiuses traced on the surface of the Andesite stone, measures 2.76 m in lengths (Comşa, 1991). As we can see below, the numbers of dimensions of the Andesite Sun are similar:

$$\alpha = \frac{\pi}{5},\ a = 2.163,\ R = 3.5,\ r = 0.76,\ r/R = 0.22,\ A = 5 \cdot R^2 \cdot \sin\alpha = 36, \quad (1)$$

where α is the angle between two consecutive radii, a is the decagon side lenght, r and R are the radius of the inner and outher circle, and A is the area of the decagon. In other terms, the Dacian used the so-called pyramidal numbers ($1+3+6+10+15 = 35$), and the number 10 was the base of the decimal number system as for other ancient civilizations. Ten is a Pythagorean symbol of perfection. For example, humans have ten fingers and ten toes (Smith, 1958; Flegg, 2002). The Dacians were inter-

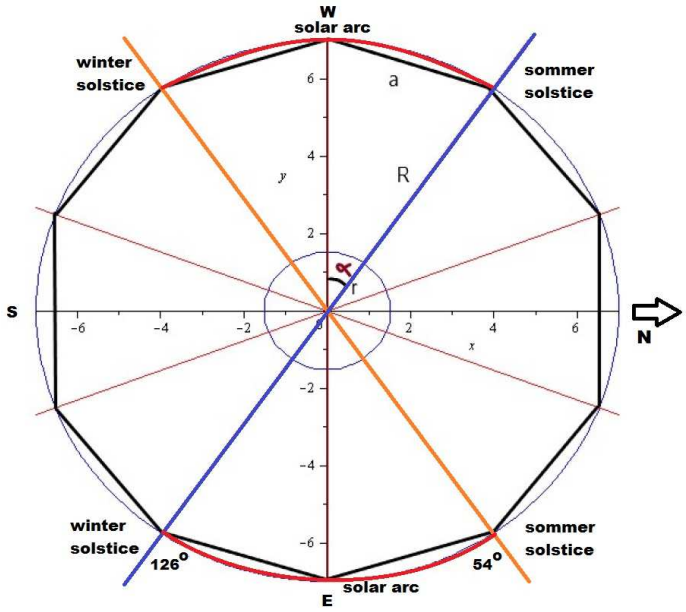

Fig. 4 – Andesite Sun's dimensions.

ested in numbers (arithmetic) which are connected with geometric forms and which, therefore, received the name of figurative numbers (Sloane and Plouffe, 1995).

The sacred Andesite Sun have divine proportions, due to the decagonal form. A symbol of unity, the circle holds a decagon. These divine proportions given by the golden number, $\varphi = \frac{1+\sqrt{5}}{2} = 1.618$, and the silver number, $\Phi = \varphi - 1 = \frac{1-\sqrt{5}}{2} = 0.618$ have been utilized by numerous artists since (and probably before) the construction of the Great Pyramid, in Egypt. The golden and the silver ratios are irregular numbers, defined as the whole is the longer part plus the shorter part, and the

whole is to the longer part as the longer part is to the shorter part (Biederman, 1994). If we note the whole with n and the longer part with m, then the second statement above becomes

$$\frac{n}{m} = \frac{m}{n-m}. \tag{2}$$

The golden and the silver numbers are present in the Andesite Sun, in the concentric circle and also in each of the 10 mentioned isosceles triangles of the regulate decagon (Figure 4).

We determined the divine proportions mathematically used by the Dacian builders, as presented below:

$$\begin{aligned} \frac{R}{a} &= \frac{a}{R-a} = \varphi, \\ \varphi &= 2 \cdot \cos\left(\frac{\pi}{5}\right), \\ r &= \frac{R \cdot (R-a) \cdot \varphi}{10}. \end{aligned} \tag{3}$$

The engraved stone was inscribed very carefully. Depiction of the inner circle was not randomly, as we can observe from the inferential equations. These relations clearly prove that the Andesite Sun is not just a religious altar, it is a very accuratelly calculated, well placed and well thought construction. Moreover, because the main axis is orientated exactly to the north direction, we can conclude that the Andesite Sun was a divine astronomical instrument to place Sarmizegetusa Regia in time.

The monument of the compact andesite disk with 10 rays incrusted upon its surface is placed right as an extension of the large axis of the Large Rounded Sanctuary abside, with an orientation to 30 degrees.

The supporting basis of the disk is very solid and this led to the conclusion that upon the disk there were practised offerings of large animals (horses, bulls etc.), a hypothesis supported by a big dish of limestone placed beneath the disk, with a leaking perforation towards the collecting channel of the sacred precinct.

According to Sîrbu, one of the most important Romanian specialists who had studied for decades the Dacian spiritual life, the andesite sun was a sundial, an astronomical observatory, a place where the festive days were calculated and, also, where (human and animal) sacrifices were performed, all of these functionalities being valid, at the same time (Sîrbu, 1997).

The symbol of the solar disk is to be found upon many Dacian fragments of pottery discovered during the excavations. The andesite sun was named sun, because it has the appearance of the sun and, therefore, it was assumed that it rendered that specific star. The distinct four, six, eight, ten, twelve, or sixteen rayed figures were solar symbols in ancient times. The Andesite Sun has ten rays and it is incorporated into a big circle. The decagonal shape is obvious. We mention two well-known ex-

amples from ancient Roman architecture for decagonal form: the dome of Temple of Minerva Medica from Rome, and the Roman Catholic church Saint Gereon Basilica in Cologne.

Many ideas had arisen concerning the nature of the andesite stone use. In the following lines, we will present a few possible uses of this assembly.

For a better orientation in space can use the following instruments:

- The sundial is a device that tells the time of day when there is sunlight. In the northern hemisphere, the shadow-casting edge is normally oriented so that it points to North and is parallel to the rotation axis of the Earth. There were usually used in former times for observing the altitude of the Sun, especially when it is on the meridian. The style is the part of the gnomon that casts the shadow. This can change, as the Sun moves. For example, the upper west edge of the gnomon might be the style in the morning and the upper east edge might be the style in the afternoon (Stănescu, 1996, 1999). The Andesite Sun could be a horizontal sundial because the plane that receives the shadow is aligned horizontally. The style, the time-telling edge of the gnomon is aligned with the Earth's rotational axis, the style points true North and its angle with the horizontal equals is the sundial's geographical latitude.

- The gnomon is the shadow-casting object, the part of a sundial that casts the shadow. The gnomon was used in ancient time in order to determine the changes in seasons, orientation, and geographical latitude. For example, the vertical gnomons were usually used in former times for observing the altitude of the Sun, when it is on the meridian.

- The astrolabe is used by classical astronomers, navigators, and astrologers. Its many uses include locating and predicting the positions of the Sun, Moon, planets, and stars; determining local time given local latitude and vice-versa; surveying; and triangulation.

- The compass is a navigational instrument for determining direction relative to the Earth's magnetic poles. An astrocompass is a navigational tool for determining the direction of the North, through the positions of various astronomical bodies.

For determining the measurement units: Solar cycle (11 years) is the main source of periodic solar variation, activity, driving variations in space weather. The cycle varies in both amplitude and duration (Usokin *et al.*, 2007; Yang *et al.*., 2000). The cycle is observed by counting the frequency and placement of sunspots visible on the

Sun. The largest spots group can be visible with the naked eye when the Sun's glare was filtered.

Sunspots had some importance in the debate over the nature of the solar system. They showed that the Sun rotated, and their comings and goings showed that the Sun changed (Figure 5). In the Dacian period can be present a 10 years solar cycle, which was represented on the top of the solar altar, namely the ten radiuses.

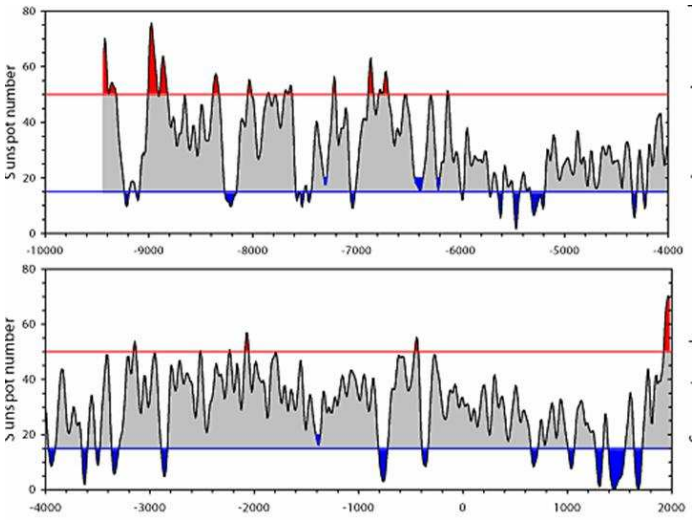

Fig. 5 – Sunspot numbers between 4000 B.C. and 2000 A.D.

For determining the measurement units:

- The number 10 appeared many times in the Dacian numerology. The Sun activity period can be observed in nature (weather, flora and fauna, human health and behaviour, economy, etc.).

- In geometry, a decagon is any polygon with ten sides and ten angles, and usually refers to a regular decagon, having all sides of equal length and all internal angles equal to $144°$.

- A decagon is a divine, or sacred geometric form because it has divine proportions. This golden number (1.6180339..) is the key to understanding fractality, and the nature of reality. Perhaps, Leonardo da Vinci was the one, who recognized that the octagon, the decagon, and the dodecagon are those that appear to face in all directions and also have a relationship of four face tangency with the square (Reynolds, 2008).

- We can make a regular decagon using a regular pentagon; extend a line from each corner of the pentagon through the centre of the circle. A regular pentagon is constructible using a compass and straightedge, either by inscribing one in a given circle or constructing one on a given edge. This process was described by Euclid in his Elements circa 300 B.C., Euclid proved that the diagonals of the regular pentagon cut each other in extreme and mean ratio, now more commonly known as the golden ratio.
- The Divine Proportion, or Golden Section, φ, is one of those mysterious natural numbers like π that seem to arise out of the basic structure of the universe.

For orientation in a plan: The Andesite Sun's solar rays are pointed to the peaks of surrounding Mountains (Peţan, 2018):

1. Plăvaia Peak (1230 m) and Faţa Bătrână Peak (1174 m);
2. Frasânu Peak (1440 m) and Năii Peak (1119 m);
3. Cioaca Ulmului (1242 m) and Groapa Peak (1284 m);
4. Gârbava Peak (910 m) and Sub Cunună Peak (961 m);
5. Grădiţei Peak (1071 m) and Paltinului Peak (1202 m);
6. Leucuş Peak (1295 m) and Jigorul Mare Peak (1699 m);
7. Tâmpu Peak (1493 m) and Titianu Peak (1721 m);
8. Steaua Mică Peak (1675 m), Steaua Mare Peak (1780 m) and Şureanu (2069m);
9. Cocoşului Peak (1490 m) and Şipcia Peak (1510 m);
10. Zebru Peak (1404 m) and Lupşea Peak (1487 m).

For religious ceremonies (Sun-Altar of the God): In the Dacian classical period, the cult of the Sun has been proved specifically by the temple dedicated to the Sun, the Andesite Sun (Mateescu, 2012). Specialists who have studied this sanctuary had rightly considered that temple as being a cult site for worshipping the Sun, a star which played a decisive role in the life and activity of agriculturists, shepherds, manufacturers and even in the day-by-day life of people. The Sun-cult was massively disseminated on the entire surface of the Earth, in different cultures (Ionescu and Dumitrache, 2012).

Between the first archaeological evidence about the Sun worshipping are petroglyphs, rock arts, engraved megalithic stones symbols (Eliade, 1961; Szücs-Csillik, 2017).

For example, the Sun worshipping was important in Egypt where, in the 14th century B.C., the pharaoh Akhenaten had reformed the Egyptian religion. He had resumed the cult of the antique divinity Re-Horakhte, under the name of Aton, an older denomination given to the solar disk. This was the first form of monotheism known in the history, yet, that lasted for a short time because the priests of the old temples had raised the population against the pharaoh Akhenaten, who was killed and all the Aton temples were destroyed (Redford, 1987).

All populations who venerated the Sun had similar features: the existence of some towns and belief in the sacred nature of the king.

Sun was the leader of both, the upper and the lower worlds, which he had visited daily, during its movement on the celestial vault, being rendered by the eye that sees everything. It was also a warrant of justice and source of wisdom (Szücs-Csillik and Comşa, 2017).

Evidences for the Sun-cult of the Getae-Dacians: The Andesite Sun from Sarmizegetuza, with a diameter of 7 m, worked out of andesite plaques and having in the centre a disc with a diameter of 1.5 m. The encrusted arrow pointed to the North; this was the altar where the offerings were brought and animal maybe human sacrifices were being done; the missing roof at the Dacian temples, in order to prevent the hiding of the Sun; the arrangement of the pillars and slabs of the rounded sanctuary from Sarmizegetuza proofs the knowledge about the 365 days calendar and of the Sun movement along the year; the use of the sacred fire and practice of cremation proofs the veneration to the Sun (Peţan, 2018).

The Sun-cult is tightly connected with the rounded sanctuaries like the one from Sarmizegetuza, or for example, the older one in England at Stonehenge. The notion of a sacred circle had expanded further to all magical practices, as a protection form of the space where a ritual takes place. The probable denomination given by the Dacians to the Sun was Dzio. From this denomination are coming the recent words of ziua (day) and zeu (god), that has still a close form in the Italian word dio (Ionescu and Dumitrache, 2012).

A piece of evidence for the Sun-cult is the stones' alignment north-south, east-west and to the solstice sun (Comşa and Szücs-Csillik, 2018). In other words, the main directions and solstice marker (solar arc) visible present in the sacred area made it clear the astronomical using of these sanctuaries.

Accurate measurements of the horizon, the precise North direction are important to determining the accurate solar arc, which is described by the points of sunrise (sunset) during a year on a horizon, and it is limited by the winter and summer solstice. We calculate the azimuth of the Sun (the angles are measured from the North to East) at the latitude of Sarmizegetusa for the summer and winter solstice, for 3000 B.C. (Szücs-Csillik and Comşa, 2017).

Using the solar arc methodology introduced in the reference article (Szücs-Csillik and Comşa, 2017) we calculated that the azimuth of sunrise for summer solstice is $54^{\circ}.36$, and the azimuth of sunrise for winter solstice is $125^{\circ}.63$. These two data are the same as the first and fourth radii on the Andesite Sun (turning right from the big stone arrow, which marks the North direction). Similarly, turning left from the big stone arrow we obtain the azimuth of the sunset for summer and winter solstices as the first and the fourth radii (see Figure 4). This fact seems to be not a coincidence. Rather, the "invisible" solar arcs marked correctly of the Andesite Sun is another proof of the greatness of the Dacian calculations, and its use for astronomical purposes. Using the solar arc methodology we established that the Dacian people had practised the Sun-cult.

3. CONCLUSIONS

We presented Sarmizegetusa Regia, the legendary Dacian Stonehenge of Romania pointed on the Andesite Sun round altar. The 10 number is used in the Dacian mathematic. The 10 rays on the surface of the Andesite Sun pose a lot of questions. Why 10 rays? Why two concentric circles? Why pointed to North? What were the Dacians used for?

We could say just that the Andesite Sun from the Carpathian Mountains is, from many points of view (astronomic, geographic, mathematic, religious, cultural, political, philosophical, etc.), the revealing symbol of this sacred place. The complex solar sign was represented by two concentric circles joined through ten solar rays.

We calculated a relation for the calculation of the inner circle's radius using the pyramidal numbers and the divine proportions. These relations prove that the Andesite Sun is not operated just as a religious altar, it is a very accurately calculated, well placed and mathematically well-thought construction. Moreover, because the main axis is orientated exactly to the north direction, and the solar arc is represented by four well-chosen radii, we can conclude that the Andesite Sun was a divine astronomical instrument to place Sarmizegetusa Regia in time and space.

The results suggest that the Dacians possibly made astronomical observations and calculations in Sarmizegetusa Regia, and the sacred place was a platform for astronomical observations.

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