

Archeologia e Calcolatori
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CASE STUDIES OF ARCHAEOASTRONOMY IN ROMANIA

1. INTRODUCTION

Archaeoastronomy is the discipline that studies celestial phenomena, looking from our ancestors' viewpoint (how they understood and used celestial phenomena and what role the sky played in their cultures). Archaeoastronomy uses different methods coming from archaeology, anthropology, astronomy, statistics, and probability theory, in order to determine the thoughts of the ancient civilizations: Neolithic people, for example, made sky observations and used sky phenomena in their culture, in their daily and yearly concerns. Because these methods are heterogeneous and use data from different sources, their collecting and processing is a long lasting process.

With its roots in the Stonehenge discoveries in the 1960s, archaeoastronomy and ethnoastronomy (the study of contemporary native astronomies) have blossomed into active interdisciplinary fields, which provide new perspectives for the history of our species' interaction with the cosmos. In Central and Southeastern Europe there are a lot of archaeological finds with archaeoastronomical significance (necropolises, aligned structures, etc.). The formation of these monuments represents the ideology of the Neolithic man. By the use of astronomy (mathematics) we can perform a closer examination of this Neolithic world (what they saw in the night sky and how they used this knowledge in their culture). In the Neolithic era, for example, the orientation of the deceased on the day of burial was towards the sunrise, or sunset (MAXIM *et al.* 2002).

At the Annual Meeting of the UISPP 4th Commission 2009 Data Management and Mathematical Methods in Archaeology we presented two well-known archaeological sites from Romania: the Cernica Neolithic necropolis and Sarmizegetusa Regia, the most important Dacian religious, military and political center. These two sites have been studied here mostly from the astronomical point of view.

For scientific purposes, we first created our detailed databank – a process which is not so easy from many points of view – and then we elaborated a mathematical-astronomical numerical program, written in MATLAB, for the solar arc calculation at Cernica Neolithic necropolis. Using these results, we plotted the most important consequences.

We also presented Sarmizegetusa Regia, the legendary Dacian “Stonehenge” of Romania, focusing on the Andesite Sun round altar. The presence of ten rays on the surface of the Andesite Sun poses a lot of questions. Why ten rays? Why two concentric circles? Why pointed to the North? From

many points of view (astronomic, geographic, mathematic, religious, cultural, political, philosophical, etcetera), we can say that the Andesite Sun from the Carpathian Mountains is the revealing symbol of this sacred place. The complex solar sign was represented by two concentric joined circles by means of ten solar rays. The arc of the circle had a symbolic meaning, which indicated periods when the solar cults took place, or when the Sun phenomena occurred (solar-cycle). The arcs of the circle have different measurements; the reason for this might be an irregular phenomenon of the Sun.

2. CERNICA

An important historical moment for the Cernica area was the discovery of the Neolithic necropolis, about 20 km Southeast of Bucharest (geographical latitude: 44°25'25.8"; geographical longitude: 26°16'06.5"; elevation: 59 m). Up to date, this is the largest necropolis on the Muntenian territory, dating back to the Neolithic period. It was discovered and investigated by Gheorghe Cantacuzino (CANTACUZINO, MORITZ 1963; CANTACUZINO 1969). The monograph regarding the Cernica Neolithic necropolis (378 graves) was published by Eugen Comşa and Gheorghe Cantacuzino (COMŞA, CANTACUZINO 2001).

This necropolis was found accidentally in 1961, on the occasion of the systematic excavations in the Căldăraru village, on the western bank of the Cernica Lake. Between 1961 and 1974, 374 burials were discovered. The earliest interments of the Cernica necropolis belong to the Dudeşti Culture and the subsequent ones to the Boian Culture. The burials of both cultures consist of simple pits, with rectangular or oval shapes. The position of the corpses was extended or flexed. In the last case, the lower and upper extremities were bound together. It is believed that the flexed position can indicate the fetus' position in the uterus or the most common position in sleep, which gives death the meaning of extensive sleep. The funerary inventories – on or under the corpses – are very poor, compared to the Eneolithic period: a dish, a flint blade, a stone ax, a bead or pendant, a bracelet made of *Spondylus*, a meat offering, ochre (dust or clump). In one of the burials from Cernica a bead made of copper ore was found, the oldest one from Romania and Europe.

The archaeologists identified three types of funerary inventories: food offerings and pots filled with water – Neolithic people believed in “afterlife” or a “life after death” and offered food and drink to the dead person to have them on the way to the afterworld; different tools from smooth stone, flint and bone, which partly reflect the householder's tools used during his lifetime; the “jewels”: pins – near 8 skeletons; the M101 skeleton had a pin that featured a nude woman – pendants, beads, bracelets, the valve of a shell – near the M43, M47, M48, M14 skeletons – a ring of bone) (Fig. 1).

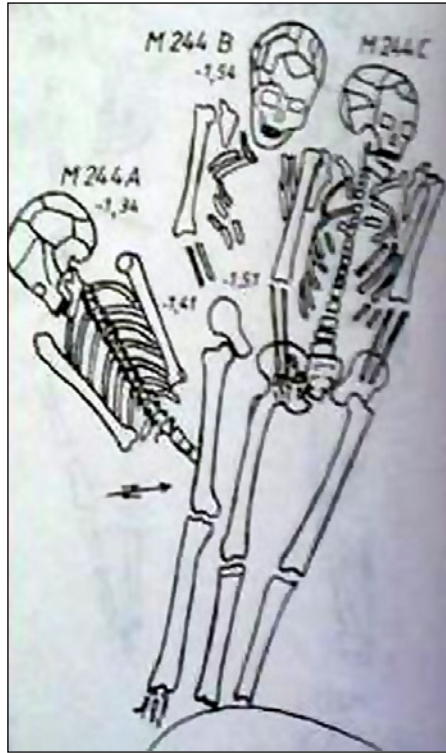


Fig. 1 – A grave (M244) from Cernica with three skeletons.

The low number of graves from the Neolithic time is discordant with the demographic estimates; for this reason, some researchers advanced the hypothesis that just a part of the population was selected for burial (SÂNGEORZAN 1981). The East-West orientation in the Cernica Neolithic necropolis is evident. On the map of the cemetery, two accumulations of burials can be distinguished, one in the North and the other one in the South (Fig. 2). Between these two groups, there is a central row of about 10 burials. Some of them are far from the main groups. The reason might be that in the neighborhood of the necropolis traces of all three phases of the Boian culture can be detected (Giulești, Vidra, Bolintineanu).

In Fig. 2 we can see that many skeletons, whose orientation is out of the solar arc, are grouped along a line, at the border of the Northern and the Southern agglomerations. The reason may be due to a miscalculation, or an exception made by the community.

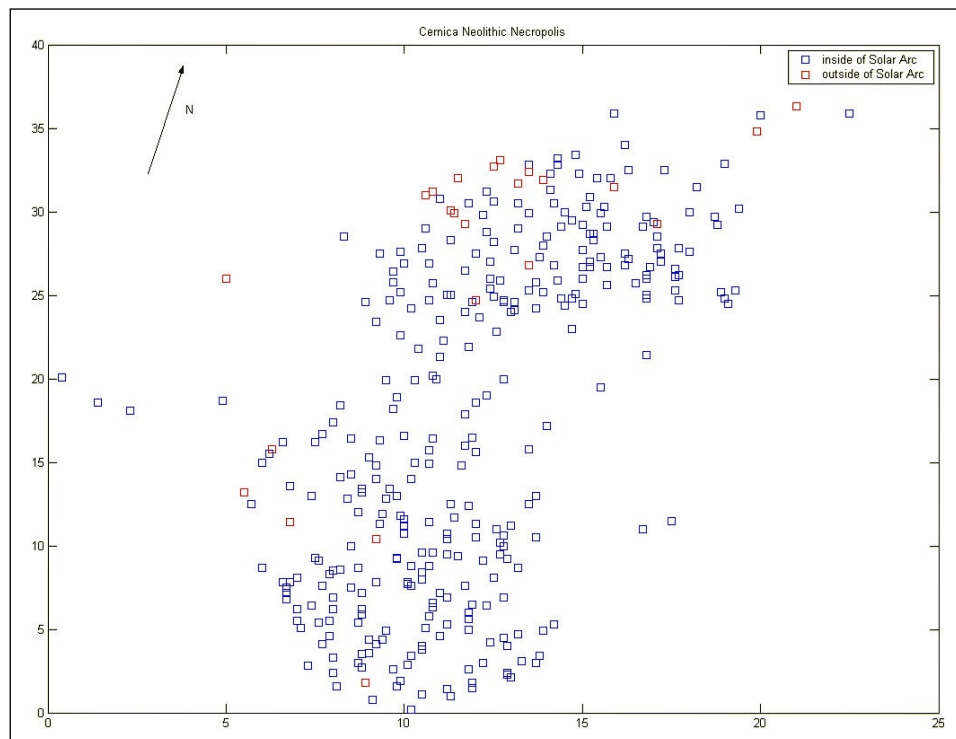


Fig. 2 – Digital overview map of the Cernica Neolithic necropolis.

For the analysis of this necropolis, characterized by large amounts of data, we constructed a database. This database includes many fields containing topics like: burial number, in the discovery order; interesting and particular graves (for example pregnant women, skeletons facing down, and so on); x-axis of the graves (measured on the map); y-axis of the graves (measured on the map); azimuth (measured in degrees from the North, data taken from the monograph); azimuth (measured in degrees from the North, data taken from the monograph map); azimuth (cardinal points); state of the skeleton; age of the skeleton; sex of the skeleton; height of the skeleton; depth of the grave; position of the skeleton in the grave; head position; head orientation (cardinal points); head orientation (code); extended or flexed; hand position; hand under the skeleton; leg position; burials with inventory; place of funerary inventories; funerary inventory (description); funerary inventory (object); pottery; tools; jewelry; anthropological data; year of discovery; trench; culture; phase; burial outline; burial rite.

Using this huge database, we could draw a lot of conclusions about the life of Neolithic man in the Cernica range. For the processing of our database we used MATLAB and Maple programs (GARVAN 2001; MOLER 2004). Our numerical programs are conceived for the case study of the Cernica necropolis, but they can be very useful for other types of research as well. In the future, we plan to use them for a study regarding other Neolithic necropolises in the Carpathian Basin.

We will briefly present the mathematical and astronomical method used for the Neolithic necropolis of Cernica. We know that the points of sunrise and sunset differ from the years 4600-4200 BC, the period to which the Cernica necropolis has been dated. During the year, the points of sunrise (sunset) follow a solar arc, which is delimited by the winter and summer solstice (MAXIM *et al.* 2002).

First, we calculated the azimuth of the Sun (the angles are measured from North to East with a compass) at the summer solstice (A_1) and winter solstice (A_2) for the geographical latitude of $\varphi = 44^\circ 25' = 44.416$ (Cernica necropolis).

Using Wittmann's theory (WITTMANN 1979) and the formula from MAXIM *et al.* 2002, we found that:

4200 BC	Summer solstice	Winter solstice
Sunrise azimuth	$A_1 = 55^\circ 04' 38''$	$A_2 = 124^\circ 55' 22''$
Sunset azimuth	$A_3 = 304^\circ 55' 22''$	$A_4 = 235^\circ 04' 38''$
4400 BC	Summer solstice	Winter solstice
Sunrise azimuth	$A_1 = 55^\circ 01' 35''$	$A_2 = 124^\circ 58' 25''$
Sunset azimuth	$A_3 = 304^\circ 58' 25''$	$A_4 = 235^\circ 01' 35''$
4600 BC	Summer solstice	Winter solstice
Sunrise azimuth	$A_1 = 55^\circ 00' 07''$	$A_2 = 124^\circ 59' 53''$
Sunset azimuth	$A_3 = 304^\circ 59' 53''$	$A_4 = 235^\circ 00' 07''$

One can see from the calculation results that the sunset follows a solar arc in one year from 235° (Winter Solstice) to 304° (Summer Solstice) for 4600-4200 BC (Fig. 3). Using these mathematical results we can say that, in this period, a form of solar cult was practiced in Cernica: sunrise and sunset were observed as part of a burial ritual. The Gaussian distribution of the skeletons from Cernica necropolis shows a West-East orientation, with an apex at spring-autumn (Fig. 4).

Concerning the main results, especially those which are derived from comparisons regarding orientation, one can note that, out of 378 burials, 41% of the skeletons were facing to the left (North) and 46% to the right (South). Perhaps the view was in the direction of the ancestral land or the house of the deceased.

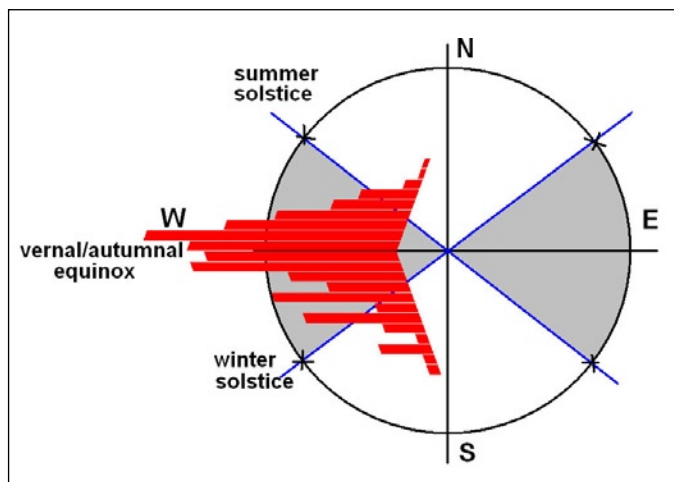


Fig. 3 – Orientation of skeletons in Cernica Neolithic necropolis.

The positions of skeletons were 91% extended and 8% flexed. The archaeologists arrived at an important historical conclusion: the graves which contain extended skeletons were earlier than those containing flexed skeletons, because, as already stated, they belonged to different material cultures (Dudeşti and Boian).

In Cernica a form of solar cult was practiced: sunrise or sunset were observed within the limits of a burial ritual (COMŞA 2006). Among the aligned skeletons 92.11% were also comprised in the western area of annual oscillation of the Sun in azimuth. 26 skeletons are out of the solar arc, but they are close to the winter and summer solstice point. The Gaussian distribution of the skeletons from Cernica necropolis shows a West-East orientation with an apex at spring-autumn. This fact shows that the mortality rate grows in spring and autumn. This death rate can be connected to epidemics (influenza, hepatitis, encephalitis), or lack of food (the end of winter).

Looking at the skeletons from Cernica, it is possible to deduce that each one of them was meant to express something that had characterized the dead person. The skeletons were put in the graves in a specific manner. For example, in the skeletons which are outside of the solar arc, the hand position is correlated with the direction in which the head is facing. Using this body language (PEASE 1981), we can deduce the following: the Neolithic people from Cernica belonged to the Sun culture. This is revealed by the burials inside and outside the solar arc; the position of hands and legs of pregnant women's skeletons; the unnatural position of corpses; different positions of grave goods along the corpses in the three different phases of the Boian culture.

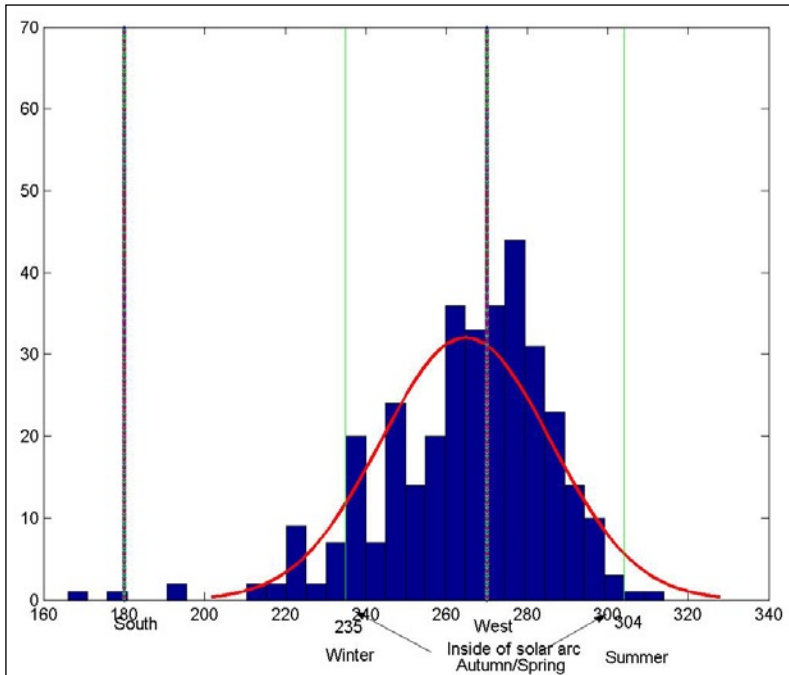


Fig. 4 – Histogram of aligned skeletons.

The hand positions show the same apex (at the Western point) and we obtain the same result if we take into account the sex of the skeletons (Fig. 5). But the head position and the hand position seem to be well correlated. The legs are extended, bended or crossed.

Four skeletons of pregnant women [M158 (242°), M251 (264°), M256 (280°), M303 (284°)] were found in the Cernica cemetery. Each skeleton is inside the solar arc and is not isolated in the cemetery. M158 was buried in January or December, M251 in October or March, M256 in September or April and M303 in May or August. Three skeletons positioned face down [M149 (258°), M237A (260°), M318 (260°)] were also discovered in the Cernica necropolis. Each skeleton is inside the solar arc and is not isolated in the necropolis. It is very interesting that none of the skeletons had a funerary inventory. The Neolithic people buried the dead person face down to immobilize its spirit in the pit, and to prevent it from disturbing the living.

As we have already pointed out, the large inhumation cemetery at Cernica is one of the chief sites of the Boian Culture. The anthropological studies made on the Cernica necropolis showed that the small-statured Mediterranean anthropological type was mostly frequent within the Neolithic population,

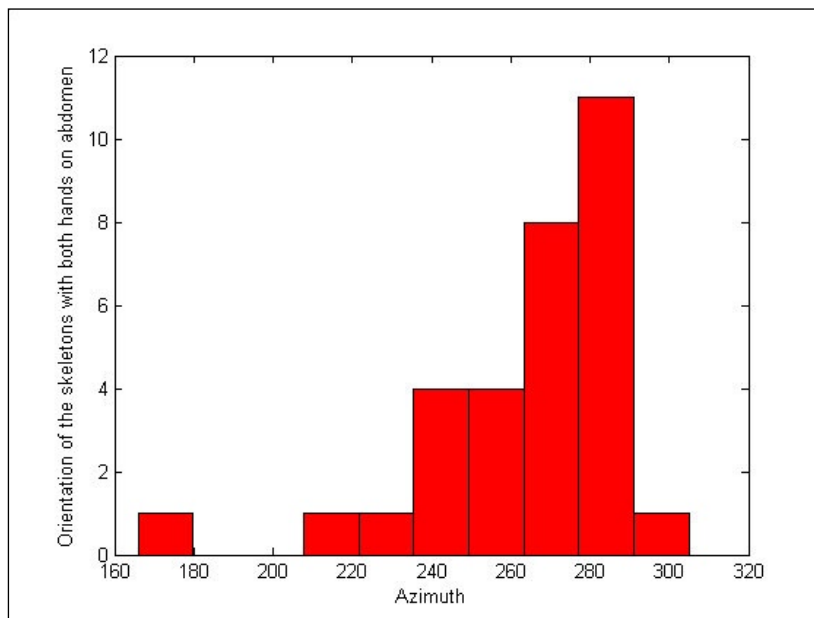


Fig. 5 – Orientation of skeletons with both hands on the abdomen versus azimuth.

followed by the Protoeuropid, the Alpine and Nordic ones (NECRASOV *et al.* 1990).

The Cernica necropolis yielded valuable evidence on burial practices and on the use of personal ornaments (pendants, bracelets, beads) of Mediterranean origin and made of shells. This indicates that extensive intertribal trading existed between the Boian culture in Romania and the Mediterranean region. The skill of the Boian potters is reflected in the footed cylindrical vases, the open dishes, and the cups which have straight sides sloping slightly outward from the base.

3. SARMIZEGETUSA REGIA

Legends mention, about the year 3000 BC, 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 BC, 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 uses and names of medicinal herbs have been handed over to us through folklore.

Sarmizegetusa Regia (geographical latitude: 45°37'36" N; geographical longitude: 23°18'62" E; altitude: 990 m), located in the sacred Orăștie Mountains in Romania, comprises the remains of a fortified city and sacred area (BĂRBOSU *et al.* 2004). The city dates from 82 BC to 107 AD, during the reign of Decebal, the last of the Dacian kings. Sarmizegetusa Regia was the most important religious, military and political center of Dacia during this period (Fig. 6). The archaeological ruins clearly illustrate the importance of geometry in designing the city; rectangular and polygonal structures were common, along with circular sacred spaces.

Ancient Sarmizegetusa, the biggest known Dacian fortress, rises on the Grădiștea hill. The fortress covers 3 hectares within its walls with an irregular plan. But Sarmizegetusa did not have a primary strategic importance, unlike the other fortresses that dominate the surrounding areas. Sarmizegetusa Regia is at 1000 m elevation and it dominates the highest places around. Because of their stateliness and their enigmatic nature, the most impressive features are the sanctuaries, Getae-Dacian religious constructions (GLODARIU 1995).

Near the great round sanctuary there is one of the most interesting monuments of "The Sacred Precincts": a pavement of Andesite slabs arranged like rays around one round slab, made of the same stone (Fig. 7). Because of this shape, this round pavement with a 7 m diameter was named "The Andesite Sun" – this huge circular construction, divided into ten sections, having approximately 36 degrees each, comes tangentially to the Great Calendar Temple and points to several Dacian buildings. This pavement has a foundation made of limestone blocks. It has a long radius, which points to North and an inner circle that has 1,54 m in diameter. The 10 radiuses traced on the surface of the Andesite stone measure 2,76 m in length (COMȘA 1991).

The monument of the compact Andesite disk, with 10 rays incrustated upon its surface, is placed on the right as an extension of the large axis of the Large Rounded Sanctuary apse, with an orientation to 30 degrees. The golden number is present in the concentric circle and also in each of the 10 isosceles triangles of the regular decagon. The supporting basis of the disk is very solid and this led to the conclusion that offerings of large animals (horses, bulls, etc.) were practiced upon the disk, a hypothesis supported by a big limestone dish placed beneath the disk, with a drainage hole over the collecting channel of the sacred precinct.

The symbol of the solar disk is to be found upon many Dacian fragments of pottery discovered during the excavations. The Andesite sun has

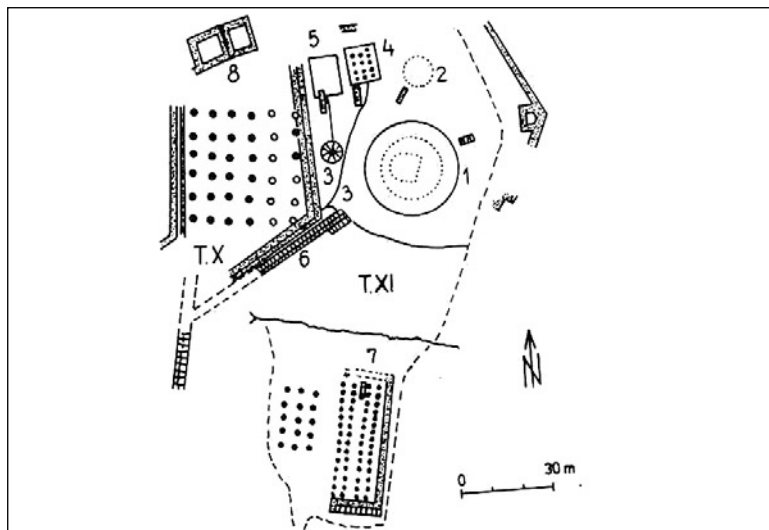


Fig. 6 – The map of the sacred area of Sarmizegetusa Regia: 1. The great round sanctuary; 2. The small round sanctuary; 3. The Andesite Sun; 4. The eastern rectangular sanctuary; 5. The western rectangular sanctuary; 6. The sacred way; 7. The southern old sanctuary; 8. The western new sanctuary.



Fig. 7 – Andesite stone and the great round sanctuary.

this name because it displays the Sun. Many ideas had arisen concerning the nature of the Andesite stone use. In the following lines, we will present few possible uses of this assembly: for a better orientation in space (the sundial, the gnomon, the astrolabe, the compass), for determining the measurement units (decagon, pentagon, golden number), for orientation in a plan (radiuses pointing to the peaks of surrounded Mountains), and for religious ceremonies (the Sun Altar of the God).

There is much evidence for the solar cult of the Getae-Dacians: the Andesite Sun from Sarmizegetusa, with a diameter of 7,1 m, worked out of Andesite plaques and having in the center a disk with a diameter of 1,5 m; the incrustrated arrow pointed to the North: this was the altar where the offerings were brought and sacrifices were made; the missing roof on the Dacian temples, in order to prevent the Sun from being hidden; the arrangement of the pillars and slabs of the rounded sanctuary from Sarmizegetusa, which proves their knowledge about the 365 day calendar and the Sun movement during the year; the use of the sacred fire and the practice of cremation.

The solar cult is closely connected with the rounded sanctuaries like the one from Sarmizegetusa, or the one in England, at Stonehenge. The notion of the sacred circle had expanded further to all magical practices, as a form of protection for the space where a ritual takes place. The probable denomination given by the Dacians to the Sun was “Dzio”. From this word are derived the recent words of “ziua” (day) and “zeu” (god), that still have a close form in the Italian: “dio”.

In our astronomical investigation we used the sun view from the Sun altar. Sunspots are seen as “small” dark spots on the surface of the Sun. They are easy to observe and count if the sunlight is strongly filtered. They were first noticed (in Western record) in the year 325 BC by Theophrastus, a Hellenic scientist, and they have been counted on a regular basis since the middle of the 17th century. They come and go in cycles which average about 11 years. Solar cycle is the main source of periodic solar variation and activity, causing variations in space weather. The cycle varies in both amplitude and duration. The cycle is observed by counting the frequency and placement of sunspots visible on the Sun. The largest group of spots become visible to the naked eye, when the Sun’s glare is filtered (Chinese, BC). 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. In the Dacian period a 10 year solar cycle may have been present, which was represented on the top of the solar altar, namely the ten radiuses. Analyzing numerically the data from the Dacian period of Sarmizegetusa Regia, we can say that the 10 year solar cycle hypothesis could be the reason for the Sun altar’s appearance. So, we can bring evidence for the hypothesis that at Sarmizegetusa Regia the Dacians had used their astronomical knowledge.

4. CONCLUSIONS

In the burials from Cernica, the dead person had his legs towards the sunrise direction. So, we can admit the existence of a special cult, which consisted in the orientation of the dead person towards the sunrise. The purpose of this practice can be a last, desperate attempt to resurrect the dead person to “life”, the light of the Sun feeding him with energy during the “resurrection” moment (SZÜCS-CSILLIK, MAXIM 2008). The main occupations of all Dudeşti and Boian communities were agriculture and animal husbandry, suitable to the geographical environment of the plain, so that they could easily develop a solar calendar. This Solar cult, which subsequently appeared and was also used for the burials, was created by a systematic observation of the Sun. Another important conclusion is that Neolithic people had possibly made a social differentiation concerning the dead location in the cemetery (in the middle was the rich, healthy, protected person), and in the orientation of the skeletons (probably derived from another population, not native but foreign).

In the case of the Sarmizegetusa Regia, the so-called Romanian Stonehenge, the complex solar sign was represented by two concentric circles joined by means of ten solar rays. The arc of the circle had a symbolic meaning, that indicated periods when the solar cults took place, or when the Sun phenomena occurred (solar cycle). The arcs of the circle had different measurements, and the reason for this might be an irregular phenomenon of the Sun.

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ABSTRACT

Archaeoastronomy is the discipline which studies celestial phenomena looking from the viewpoint of our ancestors (how they understood and used celestial phenomena and what role the sky played in their cultures). Archaeoastronomy uses different methods, derived from archaeology, anthropology, astronomy, statistics, and probability, in order to determine the thoughts of the ancient civilizations. Because these methods are heterogeneous and use data coming from different sources, the collecting and processing require considerable time. In this article two archaeoastronomical case studies in Romania are presented. First, we show a mathematical method used in order to study the astronomical orientation of the skeletons from the Neolithic necropolis of Cernica. We created a detailed data bank for the Cernica necropolis and, using our program written in MATLAB, we obtained interesting results, mostly from an astronomical point of view. Secondly, we provide an astronomical explanation about the ten radiuses on the top of the Andesite Stone from Sarmizegetusa Regia.

