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MEGALITHIC OBSERVATORY KOKINO

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Abstract. In 2001, on the footpath of a mountain peak, near the village of Kokino, archeologist Jovica Stankovski discovered an archeological site from The Bronze Age. The site occupies a large area and is scaled in two levels. Several stone seats (thrones) are dominant in this site and they are pointing towards the east horizon.

The high concentration of the movable archeological material found on the upper platform probably indicates its use in a function containing still unknown cult activities.

Due to precise measurements and a detailed archaeoastronomical analysis of the site performed in the past three years by Gjore Cenev, physicist from the Planetarium in Skopje, it was shown that the site has characteristics of a sacred site, but also of a Megalithic Observatory.

The markers found in this observatory point on the summer and winter solstices and spring and autumn equinoxes. It can be seen that on both sides of the solstice markers, that there are markers for establishing Moon's positions. The markers are crafted in such a way that for example on days when special rites were performed (harvest rites for example) the Sun filled a narrow space of the marker and special ray lighted the man sitting on only one of the thrones, which of course had a special meaning. According to the positions of the markers that are used for Sun marking, especially on the solstice days, it was calculated that this observatory dates from 1800 B.C.

1. INTRODUCTION

Archeoastronomy is a scientific field of recent interest. Studying myths and religious views of ancient cultures related to the sky, as well as recognizing their real knowledge related to the movements of the celestial objects, positioning their places of rising and setting along the horizon, making and usage of calendars are just among the themes that belong to the field of interests of archeoastronomers. Thus they usually say that they are rather dealing with anthropology of astronomy to make difference with the existing history of astronomy.

In 2001 archeologist Jovica Stankovski from the National Museum from Kumanovo-Republic of Macedonia, discovered a huge site with terracotta from the Bronze Age near the village of Kokino (Stankovski, 2002). According to the dimensions and the type, this site is distinct from all archeological sites seen until then. The site covers an area of 5000 sq m, scale like established in two platforms right beneath

the mountaintop of Taticev Kamen with an altitude of 1013 meters. At first glance the stone seats called thrones crafted into the rock and positioned in the north-south direction are dominant on this site (Fig. 1). In such a way a person seated on one of the thrones is turned towards the east horizon so that, among archeologists, arose an idea of existence for a possibility that celestial objects can be observed in such a way.

Figure 1:

In 2002 physicist Gjore Cenev from the Planetarium at MKC in Skopje got involved in the researche of the site and made the first more comprehensive archeo-astronomical analysis (Cenev, 2002). In the site, the central position was located for observation of celestial objects as well as existence of seven markers made in vertical rocks used for marking the positions of rising for the Sun and the Moon.

2. RESULTS AN DISCUSSION

According to the analysis of geologist N. Djoredjević (Djoredjević, 2003) the entire archeological site is placed on the top of a neo-volcanic plate made of andenzite rocks. The inhabitants from that period used the natural disposition of the andenzite to dig in vertical and horizontal directions and in a relatively easy way they could craft the four thrones as well as the stone markers.

The main idea of the archeoastronomical analysis was to measure the horizontal coordinates of the stone markers observed from the central position, and then using the formula for the transformation of the equatorial coordinates to reach a conclusion

concerning the nature of the celestial object which rises on the eastern horizon. For that purpose the following formula was used:

$$\sin\delta = \cos A \cos\varphi \cos h + \sin\varphi \sin h$$

where δ is the declination of the celestial object, A is the azimuth, measured from the northern horizon point, h is the elevation over the horizon, and φ is the latitude of the site. This archeological site has the following geographical coordinates: latitude $\varphi = 42^\circ\ 15'\ 47''$ and longitude $\lambda = 21^\circ\ 57'\ 32''$.

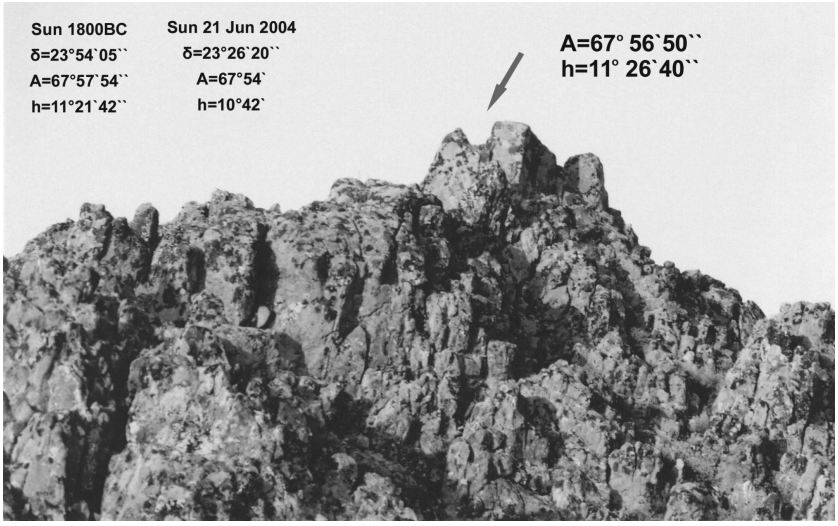

Figure 2:

These measurements were performed with the assistance of geodesist Chedomir Arsovski, and the instrument used was Total Station Lica 307 with laser, that enables us to obtain results with great precision (Cenev, 2002). As an illustration of the measurements and analysis preformed we shall present the following example of the marker used for marking the position of the sunrise on the day of the summer solstice. The measurements of the horizon coordinates of the marker have provided the following values: $A = 67^\circ\ 56'\ 50''$ and elevation $h = 11^\circ\ 26'\ 40''$ (Fig. 2). The calculations have anticipated a mistake that is due to the refraction impact ($\rho = 3.1'$). Using the given values we can calculate that the declination of the celestial objects whose rise was marked with the stone marker of a declination of $\delta = 23.9^\circ$. This is the declination value of the Sun on the day of the summer solstice in 1800 B.C., meaning that the stone marker was crafted 3800 years ago and used for marking the sunrise on the horizon observed from the central position of the site.

Due to the precession impact the current value of the Sun declination on the day of the summer solstice has a different value (Fig. 2), which means that nowadays the Sun over the stone marker will rise lower and more on the left than 3800 years ago.

That can be nicely seen in the photo of the sunrise over the stone marker taken on 21^{st} of June 2003 or on the day of the summer solstice (Fig. 3). Using the similar methods measurements and analyzes of the other markers were performed. It was concluded that observed from the site's central position the 7 stone markers could be easily recognized. Three of them are marking the places of the sunrise on the days of the summer solstice, winter solstice as well as on the days of the vernal and autumn equinoxes. Four markers are marking places of the moonrise above the horizon when the Moon has maximum and minimum values of the declination in the summer and in the winter period. These values are given in Table 1, where for comparison purposes values of the markers of the famous Stonehenge in Great Britain according to the measurements and calculations of G. Hawkins are also provided (Hawkins, 1963), as well as the theoretical values of the declination for the objects in 1800 B.C.

Table 1:

	STONEHENGE	KOKINO	2000 BC
Sun summer solstice	23.9^0	23.9^0	23.9^0
Sun winter solstice	-23.9^0	-23.9^0	-23.9^0
Moon winter major standstill	29.0^0	28.2^0	28.2^0
Moon winter minor standstill	18.7^0	20.4^0	17.9^0
Moon summer major standstill	-29.0^0	-30.2^0	-30.0^0
Moon summer minor standstill	-18.7^0	-18.6^0	-19.6^0

Several conclusions could be drawn from the performed measurements and analyzes. In the archeological site we can clearly recognize the central position for observing the celestial objects, as well as existence of seven stone markers used for marking the places of the rising of the Sun and the Moon on the horizon observed from the central position that using the astronomical terms has the role of a top center for observation of the movements of the celestial objects. All stone markers are providing information for the same time of crafting, and that is 1800 $\pm$ 50 years B.C. In astronomy it is a very well known fact that places for of the moonrise repeat in a period of 18.6 years, and to understand that this is really a periodical event there should have been observations of the moonrise at least every forty years. That leads us to the fact that before the stone markers were crafted in the ancient past, there had been some people observing dedicatedly on a daily basis the sky and movements of the Sun and the Moon. Establishing the stone markers they had a possibility to make also a calendar used for the organization of life in the community, i.e. in practice they

could determine days for the beginning and ending of the agricultural activities and activities related to the cattle breeding, as well as for the determination of the days for performing of rites.

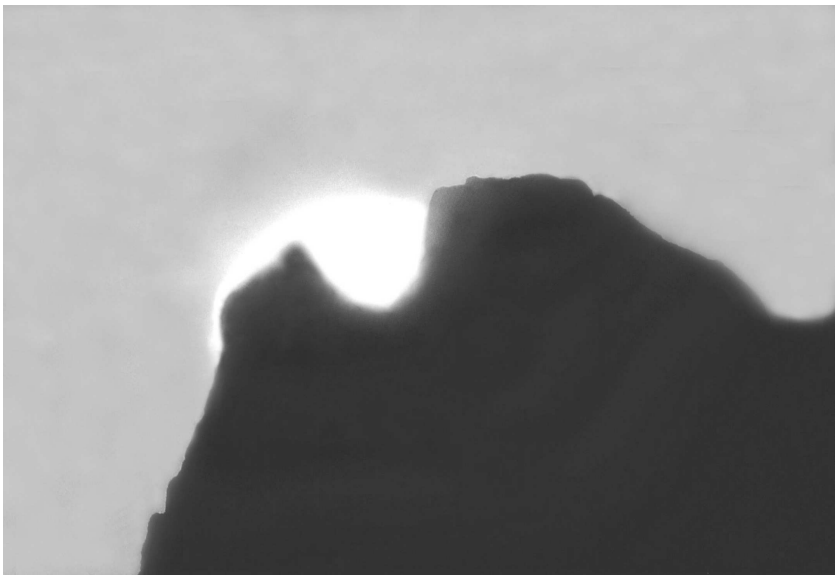

Figure 3:

In an archeoastronomical analysis it is of crucial importance to have the same time of archeological findings and the time of stone markers crafting. In the first attempt with regard to the terracotta an age of around 3400 years was anticipated, but the most recent excavations from 2005 made by archeologist Jovica Stankovski have shown that on the east side of the site there are some burrows with objects the age of which is anticipated to be around 3800-4000 years, that is in excellent agreements with the time of stone markers crafting according to the archeoastronomical analysis.

Everything presented above leads us to conclude that this archeological site beside the role of a mountain sanctuary 38 centuries ago had also a role of a prehistoric observatory. In accordance with the time and culture known for that period, this site was called Megalithic Observatory of Kokino.

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