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Stellar Astronomy of the Bronze Age Sanctuaries in North Khakassia

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Abstract

This publication presents the results of two studies of astroarchaeological monuments in North Khakassia confirming the existence of Siberia stellar astronomy in the Bronze age (andronovo culture, Khakassia, mid-II millennium BC). It is proved that in the study area ("Sunduki") Arcturus - the brightest star in the northern sky - was purposefully observed in conjunction with the stars of the Orion constellation (in particular Betelgeuse - the brightest star of the constellation). In both investigated monuments of the Bronze Age were found man-made objects specifying astronomically important areas - a kind of tools to monitor these stars. Because there is no any written source the observed stars and epoch of observation were identified by geodetic measurements and astronomical calculations. This era is XIV-XIII centuries BC which corresponds to the archaeological dating of these objects defined in terms of style and semantics of petroglyphic images marking astronomically significant azimuths.

The work confirms the hypothesis of tracking the heliacal and acronycal passages of Arcturus by andronov priests (the first in the morning and the last in the night) in predetermined directions. Arcturus was observed by priests to determine the winter solstice, the middle of the spring and summer seasons. This revealed the specifications of observing of the heliacal and acronychal passages of stars with a naked eye such as a weakening of the apparent brightness of stars near the horizon at dusk and full moon, as well as the loss of light depending on the angular distance from the sun. Because of these features the first and the last star passages of the year through a given direction can be observed in the time interval up to ten days.

The conclusion about the features of the observation of Arcturus by andronovo culture priests confirms and explains the perfection and precision of their lunar-solar calendar systems revised in such a way from the observations of the stars. No less important was the fact that figuring out a direct connection of different types of okunev and andronovo anthropomorphic petroglyphs with astronomically significant directions. This allows us to judge more reliably the semantics of certain images of okunev and andronovo cultures. Due to the fact that until recently Arcturus took a very important place in the astral mythology of indigenous peoples of Siberia the problem of reconstruction of stellar components of andronovo mythology in Khakassia becomes more perspective to solve.

The obtained results allow us to consider the whole astronomical dating from observations of stars as a reliable and highly accurate (± 50 years) instrument of ancient man-made structures' dating which was used with different cultures in the cult practice of astronomical observations.

Keywords: okunev culture, andronovo culture, heliacal passages of stars, solstice, equinox, Arcturus, Betelgeuse.

Introduction

Astronomy of Bronze age widely and commonly presents observations of the Moon and the Sun held to fix important astronomical events associated with the seasons changing and the calendar regulating cult practice of the Bronze age societies [1]. There are not many facts proving purposeful observations of stars at the same period (star archaeoastronomy); most of them belong to the written sources of ancient civilizations of Sumer, Babylon and Egypt, Ancient Greece and Ancient China [2]. In the absence of written sources or rock carvings, paintings depicting the starry sky it's much more difficult to find any evidence of purposeful observations of stars by ancient people than the observation of the Sun and Moon. This is due mainly to precession when the declination of stars is changing rather quickly over time compared to the change in the declination of the Sun solstice. In this case if the monumentally fixed solar astronomical directions function with minor amendments for thousands of years the precession motion in 50.3" a year changes direction to the star to 1.40^0 in just one century. Therefore, the observation of one and the same star using durable construction cannot be used.

At the same time, if the study of ancient cult construction reveals some objects arranged to observe a star, the astronomical dating of that archaeological landmark by declination of the star is highly accurate (several decades) opposing to the dating by the Sun (five hundred years and more).

Despite the fact that over the millennia of precession a variety of bright stars can decline the same value when a stellar candidate for intended observation is selected the additional archaeological information about the age of functioning of the cultural monument can always be obtained. This information except the correct selection of the star lets to determine the presence or absence of the very fact of observational astronomy of stars in religious practice of a particular ancient society. Such a carrier of information in the absence of written language can be specific to a particular culture petroglyphs marking object designed for star observing.

A characteristic feature of star observations which astroarcheological specialist should focus on is the fact that unlike the sun the stars even the brightest (and even in dark moonless night) are hardly visible on the horizon because of the atmosphere. Only from a height of 2 degrees above the horizon the brightest stars become visible [3]. Traditional methods of horizon astronomy such as calculating on the dawns and sunsets of bright star do not apply here. Therefore when you study the religious constructions which are thought to be objects of stars observing at fixed direction you should pay attention to the natural or artificially designed "windows" that are above the horizon relative to the observer. If these supposed objects are man-made archaeological structures marked with semantically legible petroglyphic symbols these religious constructions are the most likely candidates as objects for "star observatory" of ancient cultures.

The mithologem and theologem semantics as well as cult practices figure the problem of reasons for stars observations in a given place at a given time. Fascinating picturesque sky with shining stars, incomprehensibility, inaccessibility and "immortality" of stars were a rich natural source for myth-making among all peoples. Seasonal changes of the sky view enriched the

mythology. But the constellations can be seen without effort and any special tool. Therefore the directed observation of specific brightest stars had other practical meaningful purpose and meaning, for example from the standpoint of religious and sacred calendar practices. Therefore the events to observe by the ancient astronomers are heliacal (acronych, space) [4] passages of stars across the horizon for the first time after their invisibility or conversely for the last time in the season. Observations of such events for keeping and clarification of the sacred calendar which regulates the ritual practices of ancient peoples are described in the astronomical texts of all the above ancient civilizations [5].

Currently existing astronomical computer programs allow modeling the sky view at different epochs and on different dates and calculate such star passages. There are several factors that determine the date of the first or last occurrence of stars in the twilight sky:

– weakening of the star brightness on the horizon;

– transparency of the atmosphere (currently the transparency of the atmosphere significantly decreased compared to the Bronze age);

– refraction;

– angular distance of the star from the Sun;

– the moon phase;

– visual acuity of the observer.

Figure 1. The First Sunduk sanctuary (all photos by S.A. Parshikov).

You can conclude from the above that facts of existing of stellar astronomy in ancient cultures in every region and especially in andronovo era in Khakassia confirmed by archaeological finds, geodetic measurements and astronomical calculations are fundamentally important for the understanding of the spiritual culture of the ancient society.

This publication presents the results of two studies of astroarchaeological monuments in the North Khakassia confirming that there was stellar astronomy in Siberia in the Bronze age (andronovo culture of Khakassia) and shows the connection between the observations of heliacal stars passages with fixing of the equinoxes and solstices.

The discussed astroarchaeological monuments are located in the North Khakassia near the village Yus among the mountain range "Sunduki". For more than three decades there were astroarchaeological comprehensive studies under the guidance of Doctor of History V.E. Larichev (Institute of Archaeology and Ethnography). During this period was found a large number of astroarchaeological monuments which are evidences of active surveillance of the Sun and the Moon by bearers of ancient cultures, special reverence of solstices and equinoxes by priests. A lot of this kind of objects were discovered within the boundaries of the First Sunduk sanctuary ($89^0$42' e.long.$54^0$41' n.lat.) (Fig. 1) so that the natural and cultural object is perceived by us as "Astronomical Observatory" which is unique to Siberia and neighboring regions of Asia [6].

Observations of the Arcturus star in the monument of First Sunduk

In 2002-2003 during an integrated complex astronomical and geodetic expedition of the Institute of Archaeology and Ethnography of the Academy of Sciences and the Siberian State Academy of Geodesy in the monument of First Sunduk an observation platform was discovered, later it was named as "Arcturus slab".

Figure 2. The Pipe for Arcturus observation" on the slope of a rocky ridge of the First Sunduk. Bottom view.

Figure 3. The Pipe for Arcturus observation on the slope of a rocky ridge of the First Sunduk. Top view.

The slab was located in front of a hole deliberately issued on the slopes of the rocky ridge a "pipe" in a length of about 2.5 meters formed by a massive slab №1 (Fig. 2) backed by another less massive slab №2 (Fig. 3) [7]. According to preliminary assumptions the observation platform could be a starting point for taking a sight of a priest-observer at the starry sky through the "pipe" hole.

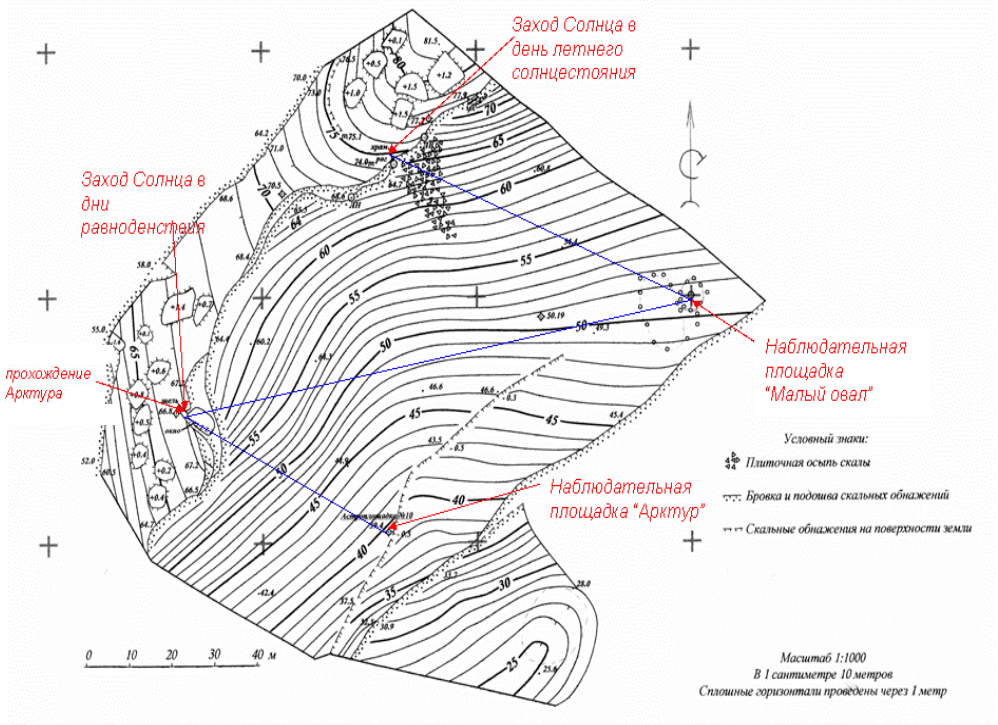

Figure 4. Plan of the astroarchaeological sites on the slope of the First Sunduk. Compiled by V.N. Komissarov.

Since the "pipe" was not designed to observe the Sun and the Moon there was an idea to check the possibility of bright stars' observations.

$35^0\ 58.7' \leq \delta_{star} \leq 37^0\ 18.5'$.

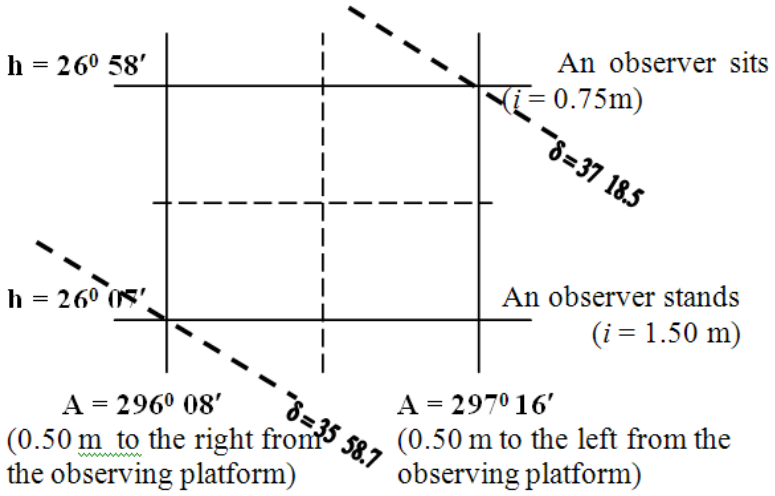

Figure 5. Scheme of horizontal coordinates limit values and declinations of star depending on the observer position.

The "Arcturus slab" or "pipe" is in a complex with other astroarchaeological nearby object (an "Oval" platform observation [8]) which was a point for monitoring the sunsets at the equinoxes and the summer solstice (Fig. 4) in the sanctuary of First Sunduk. Hole of the "pipe" (Fig. 2) could be seen from a limited area below along the azimuth (from $296{,}1^0$- to $297{,}2^0$) at a height of $26{,}5^0$ from the horizon of the discovered observation platform "Arcturus slab" and according to calculations it was not designed for observations of the Sun and the Moon. In addition the observed angular dimensions of the "pipe" seen from the "Arcturus slab" were less than apparent diameters of these stars.

Table 1. Declines of Arcturus at different epoches sand the dates of solstices and equinoxes.

Epoch	Arcturus declination	Spring equinox	Summer solstice	Autumn equinox	Winter solstice
900 BC.	$35^0\ 59'$	29-30 March	1-2 July	1-2 October	29-30 December
1100 BC	$37^0\ 19'$	31-1 April	3-4 July	3-4 October	30-31 December
1300 BC	$38^0\ 47'$	2-3 April	5-6 July	4-5 October	31 December - 1 January
1350 BC	$38^049'$	2-3 April	5-6 July	5-6 October	1-2 January
1500 BC	$39^0\ 42'$	3-4 April	6-7 July	5-6 October	1-2 January
Notes to Table 1. In the calculations in astronomy computer programs the dates of solstices and equinoxes in ancient times were determined from the characteristic values of the right ascension of the Sun (0, 6, 12 and 18 hours).					

The REDSHIFT astronomical program revealed that among possible bright northern stars (Arcturus, Vega, Capella) Arcturus is the most suitable candidate for the era of 1-2 millennium BC.

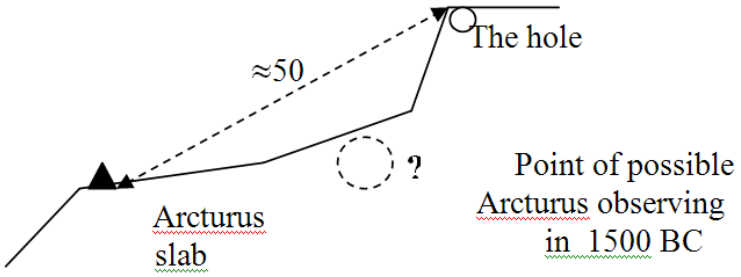

Figure 6. Croquis of land profile in the studied object location.

Although the decline of this star is currently away from the calculated one (+19^0 11) a successful combination of its own influence of the motion and precession for the long period of time make Arcturus the only appropriate bright star of all others.

The results of astronomical and geodetic measurements helped to calculate the limit values of daily parallels' declinations of the stars observed in the "pipe" hole considering the lack of precise knowledge of the position of the priest-observer (step to the left or right from the center of the site, sitting or standing (Fig. 5).

In the Table 1 there are calculations of Arcturus declination and dates of solstices and equinoxes at different epoches.

The era of 1100-900 years BC of possible observation of Arcturus obtained and presented in Table 1 corresponds to received declines of Arcturus is obviously different from the archaeological dating of cultural objects of First Sunduk sanctuary (mid-II millennium BC).

Since the direction of the azimuth on the "pipe" is almost fixed (the hole is not visible from the other direction) it was assumed that the more ancient epoch Arcturus observations could be made at the other star's height above the horizon and from the other site located above the slope.

Figure 7. Matted stone scree of the rocky ridge slope of the First Sunduk on azimuth given by "Arcturus pipe observations". Bottom view of the "observation pipe".

Calculations showed that in the era of 1300-1500 BC declinations of Arcturus in the direction specified by "observation tube of Arcturus" (Figure 2) correspond to the altitude of the stars above the horizon which is in the range of $29{,}0^0$ to $30{,}5^0$. Calculated height allowed us to determine the place and the possible location of the observer's site on the slope of the First Sunduk ridge (Fig. 6). Currently there is a thick layer of crumbled stones (Fig. 7). Massive slab named by us as "Arcturus slab" is located below the stone debris near the edge of the canyon and possibly it was a reference direction pointer to the true place of the Arcturus observation in Andronovo era of Khakassia in XVIII-XIV centuries BC. Hypothetically "Arcturus slab" could be the platform for Arcturus sight with the "observation tube" in the era of the Khakassia's karasuk culture in XI-IX centuries BC [9]. This time interval of possible observation of Arcturus from the "Arcturus slab" has not been validated due to the fact that up to the present moment we have not found any other astroarchaeological objects testifying of fact that there was a stellar astronomy in the karasuk culture of Khakassia.

Table 2. Arcturus heliacal passages through a given direction.

Epoch BC	**The first in a year morning passage**			**The last in a tear evening passage**		
	Date	Time, hour-min.	Sunrise, hour-min.	Date	Time, hour-min.	Sunset hour-min.
900	**24 May** (56 day. After SE, 37 days before SS)	4-55	5-51	**5 September** - 10 September (22-27 days before AE)	22-04	21-07
1100	**20 May** (50 days after SE, 43 days Before SS)	5-02	6-01	**30 August** (35 days before AE)	22-19	21-25
1300	**11 May** - 15 May (39-46 after SE, 54-47 days before SS – Out of season)	5-28	6-24	**17 August** 21 August (43-47 before AE, 44-48 days after SS – Out of season)	22-58	21-57
1500	**2 May** - 6 May (30-34 days after SW)	5-53	6-49	**10 August** -14 August (35-39 after SS)	23-17	22-12

Notes to Table 2. The calculated data are given for the following conditions:
Observation point: $89^042'$ e.long., $54^041'$ n.lat;
Time difference with GMT +8 hours;
Azimuth: $296{,}1^0 – 297{,}3^0$;
The height of the sun -70 and below.
Abbreviations: SE, AE - spring and autumn equinox, WS, SS - winter and summer solstice, respectively.

Due to the fact that in another sanctuary the astroarchaeological objects for star observations were found and dated to the era of Andronovo culture of Khakassia including the Arcturus declination (Table 1) it was assumed that the time interval of 1300-1500 BC (relating to the andronovo era) is also the most likely time of Arcturus observations for the First Sunduk sanctuary.

In the era from 1500 to 900 BC Arcturus was a circumpolar star at the latitude of the observation $54^0$41' and therefore the heliacal rising and setting of the star on the horizon are not relevant. However it is worth attention the appearance of the star in a preferred direction given by an ancient man: the first morning (heliacal) before sunrise and last night (acronyc) after sunset. We will call both of these phenomena heliacal passages through man- given direction.

StarCalc an astronomical program modeled the Arcturus heliacal passage through the direction given by" Arcturus observation tube ". Also the date and time of these events were calculated (see. Table. 2). In the calculations it was assumed that Arcturus becomes visible to the naked eye from the beginning of astronomical twilight at the height of the sun minus 7 degrees or less. As the star was quite high above the horizon ($26,5^0$) the weakening of its luster in the atmosphere was slight to 0.32 of star magnitude (according to [10]). Arcturus had the smallest distance from the Sun (about 41^0) at last evening passage which is not enough to loosen the star's brightness.

Table 2 shows the extreme dates and related timings. Since the heliacal passage occur under different atmospheric conditions and the different phases of the Moon the phenomenon can be observed with the naked eye in the time range 2 days minus 5 days plus from the date of calculated moment.

As can be seen from the table 2 the era of 1300 BC is the most prominent period of time for the calculated heliacal passages when the first and last appearance of Arcturus in the "observation tube" marked the offseason - a balance between the summer solstice and equinox. Actually the summer solstice and equinox were captured on a nearby site an "Oval" [11].

Thus makes clear the logic of the creators of the "Arcturus observation tube". A sacred complex of points for observation and fixing of solstices and equinoxes [4, 6] allowed to determine the off-season relying on the observations of the brightest stars in the northern sky. That can lead us to the conclusion that the complex use of equipped with "Oval" and "Arcturus" areas in the sanctuary of First Sunduk allowed the priests of andronovo culture creating an accurate calendar system relying on the observations of the Sun (solstices and equinoxes) and track Arcturus (off season – mid of Spring and Summer).

Seraphim Stone Sanctuary

A decade after Arcturus' observation in the sanctuary of First Sunduk was evidently proved, in the same area another evidence of purposeful tracking of stars in the Late Bronze Age was found in the sanctuary of the Seraphim Stone [12]. This monument is located on the left bank of river Chernaya south to Solbon town. Here was found the ring formation of Okunev sanctuary having 20-30 m. in diameter (Fig. 8). From the northeast the ring is formed with a "gateway" of two sandstone slabs (Fig. 9). There are two Okunev petroglyphic images on the slabs of the ring:

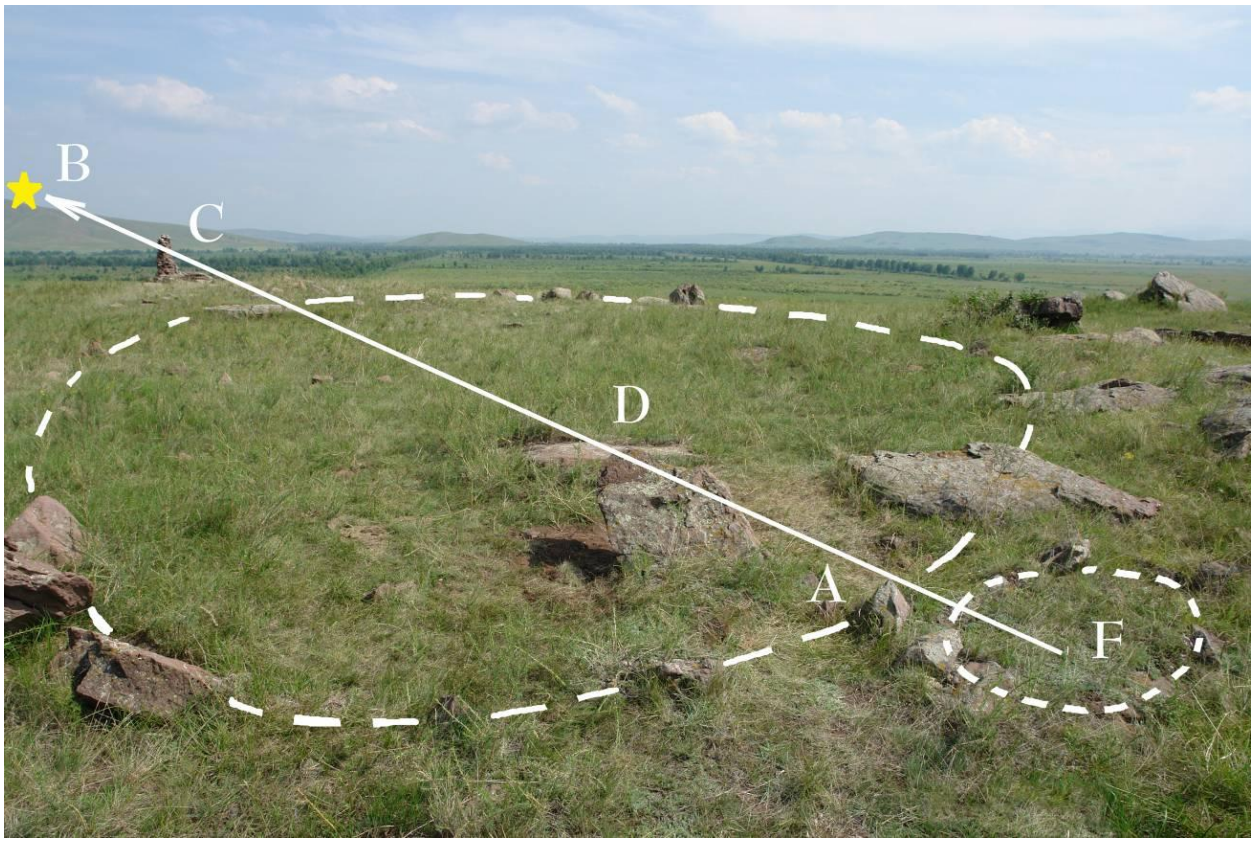

Figure 8. Round formation of the Seraphim Stone sanctuary.
F-B the direction of Betelgeuse observation. **D** – a buried plate with a chtonic deities (fig. 10B), **C** a plate with a bearded image (fig. 12B)

1) The first image (Fig. 10, A) is depicted on the left plate of the north-eastern "gates" orienting the gaze of the observer to the top of the First Sunduk (Fig. 9) and defining the direction to the sunrise from its peak in the summer solstice. Taking into account the accompanying astronomical phenomenon it is clear that this image symbolizes a good solar deity;

2) The second image (Fig. 10, B) is depicted on the another single slab in the western part of the ring (Fig. 8). It is obvious that the second image symbolizes a negative Chthonic deity. Another evidence of it is the direction to the image from the center of the formation setting the azimuth at the sunset during the summer solstice. Moreover the image was initially, in situ, buried by the creators to a depth completely hiding the face of the deity. Only a few centimeters of an "antenna" crowning the deity's head were above the ground.

We believe that the position of the "antenna" (perhaps symbolizing the snake) (Fig. 10, B) above the ground was not accidental and from a theologem position provided connection between the Earth life and underworld. Snake as an Earth and underworld (chthonic) at the same time an "eternal" (due to the skin shedding in the process of molting) creature could symbolize eternal life after death.

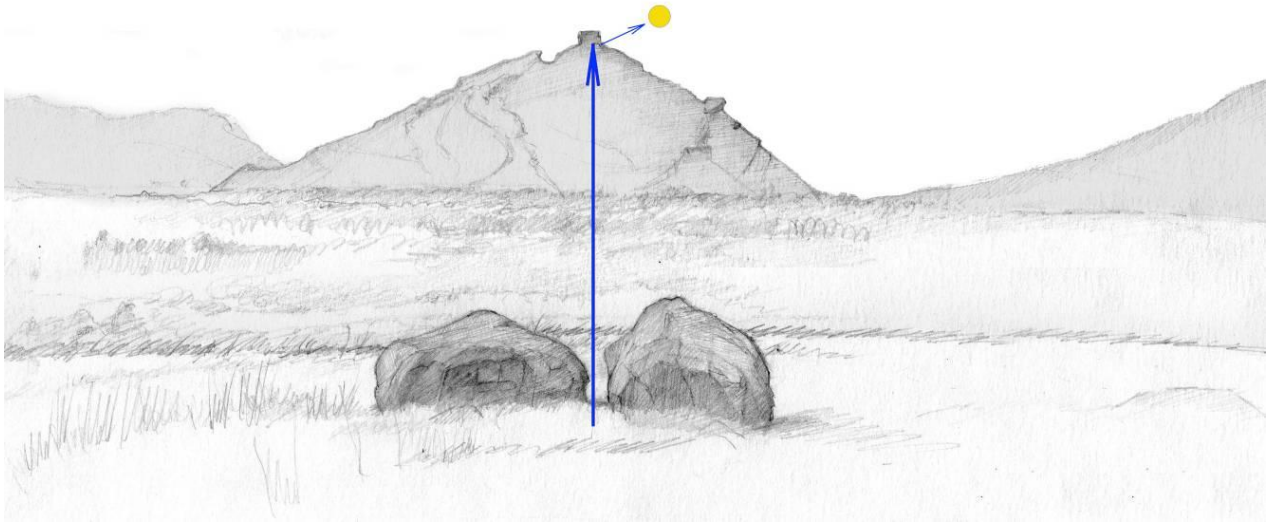

Figure 9. The North-eastern "gate" of the Seraphim Stone sanctuary.

It should be noted that stylistically the picture of three-eyed deity is not quite typical for okunev culture because of the indistinctive shape of the lines attached to the deity's mouth. It is possible that these stylistic features are specified by the nature of the chthonic deities. In addition to these structures in the culturally adjusted space of the sanctuary there is a man-made structure formed by rounded masonry of 1.5 m in diameter and massive blocks of sandstone. In this case several pairs of sandstone boulders form a series of "gates" extending to the south down the hill for about 200 meters and ending with megalithic size boulder of grayish-pink sandstone called by natives Seraphim Stone (in honor of St. Seraphim of Sarov) (Fig. 11). On one side of Seraphim Stone facing the West is depicted an image (Fig. 12, A). Stylistically image of the deity is not quite typical for okunev culture because of indistinctive shape of the line closing the contour of the deity's chin.

Astroarchaeological studies revealed that the location of the formations and the boulders "gates" as well as many other megalithic sites of Seraphim stone sanctuary are focused on the sunrise and sunset at the summer solstice [8].

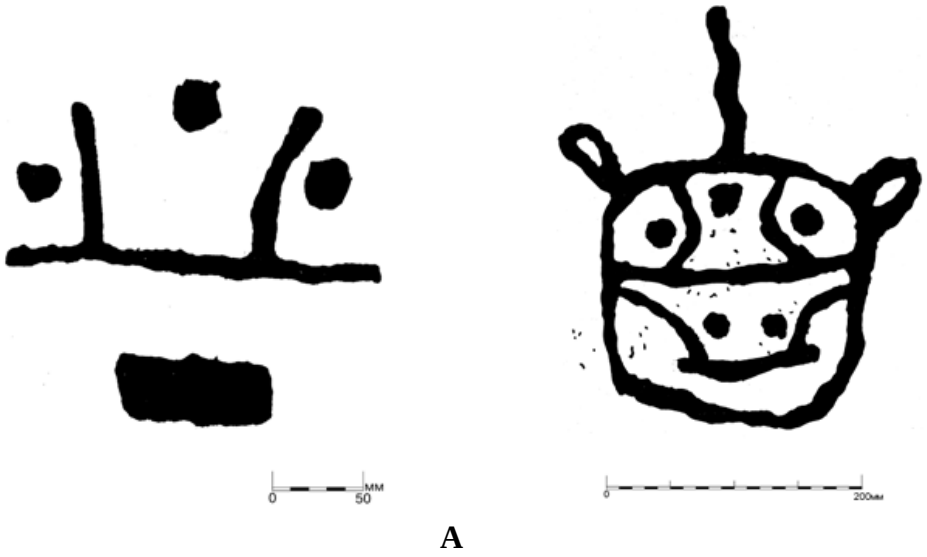

Figure 10. Images depicted on a circular structure of the Seraphim Stone sanctuary.
A – Solar deity, **B** – Chthonic deity.

Figure 11. Seraphim Stone.

The results of measurement helped to discover an astronomical connection between the First Sunduk and Seraphim stone marking another place of sunrise at the summer solstice viewed from the top Seraphim stone [13]. Thus confirmed the idea that okunevo bearers percept the First Sunduk sanctuary as the World mountains [14].

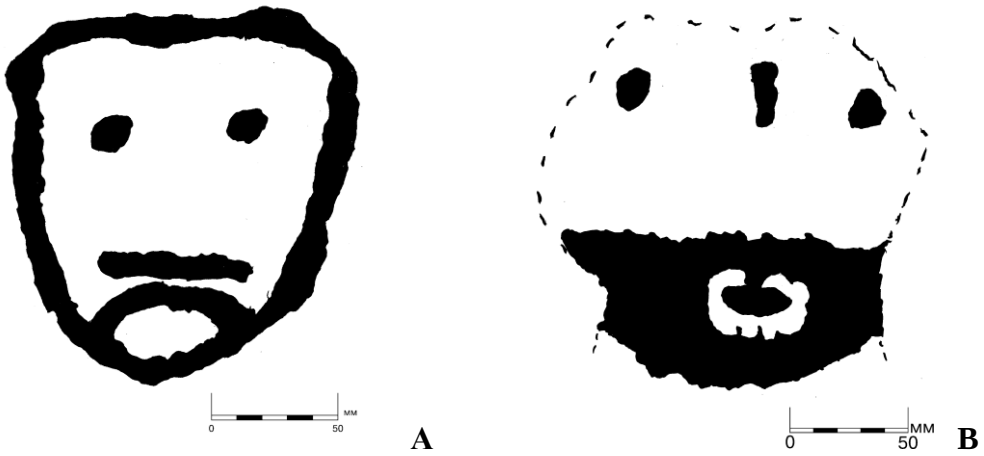

Figure 12. Images of the Seraphim stone sanctuary.

Besides fixed "solar directions" other structures were discovered in the sanctuary suggesting the stellar astronomy at this object. 15 meters to the east of the ring structure (Fig. 8) on the edge

of the slope there is a huge boulder in a length of 2.8 m (Fig. 13) which has on its top badly preserved "bearded" image looking to the zenith (Fig.12 B). This image is not typical for images of okunev archaeological culture. Lips of the image are made in the relief and the beard in counter-relief. Uncharacteristic appearance of both images (Figure 12, A, B) may indicate the creation of these images at the final stage of the okunev culture or that they were created by andronovo culture bearers in Khakassia.

There are two large plates leaned against a boulder forming a kind of "telescope" (Fig. 13). From the local observation platform located below the hill on the line of sight of the "telescope" a limited part of the sky (12-15 minutes of arc, less visible solar radius) can be seen through it. The shape of one of the sandstone blocks (designated by us as "targeting sight") located in the alignment the "telescope" - "observation platform" is surprisingly close to the shape of the field of view of the "observation tube". It should be noted that the arrangement of "supervisory complex" shaped with "observation tube" and the observation platform (Figure 13,14) is similar to the complex for Arcturus observation in the sanctuary of the First Sunduk (Figure 2).

According to astronomical calculations (see Table 3) through the "telescope" of the Seraphim stone sanctuary the Arcturus sunset could be seen in 1350 BC ± 50 years. This dating corresponds to the final era of the existence of the fedorovo culture of Khakassia which was relative to andronovo cultural-historical community and chronologically synchronized to the same object Arcturus observation in the sanctuary of the First Sunduk.

Figure 13. Visual " Arcturus observation tube. Tour of sandstone slabs is modern and made by shepherds grazing cattle in the vicinity of the sanctuary.

The first direction is defined by a ridge of large blocks of sandstone (60-70 meters long) which limits the monument from the south-southwest and ends at Seraphim stone; the azimuth of the ridge defined by a GPS-navigator is 102-105 degrees.

The second direction is set by several structures that limit the monument from the north. Their location from west to east: a small stone formation (a burial), a slab with a circular structure with the image (Figure 10 B), diametrically opposite to it a large (1.5-2 m) horizontally placed slab (possibly the altar), a large rounded burial, the "Arcturus observation tube" with the image of a bearded deity (Fig. 12 B).

The five (!) man-made objects are located on the same line with an error in a few minutes of arc. The azimuth of the direction is defined to the Sun to within 1 ' is 102^0 5.5′. According to calculations made with the StarCalc program that direction in 103^0 was chosen due to the dawning-place of the Orion constellation (precisely its brightest star Betelgeuse) in the period of Arcturus observation in the sanctuary in 1350 BC ± 50 years. It was calculated that Arcturus appeared in the location of the "Arthur pipe observation" for a brief moment in 8 - 10 minutes after Betelgeuse passage through 103^0 azimuth given by the above-described man-made directions. To confirm the calendar importance of purposed star tracking dates and times of heliacal Arcturus passages through the field of view of the " Arcturus observation tube " and Betelgeuse passages in the selected man-made structures direction have been calculated (Table 4).

Since measured altitudes of the stars in the preferred direction are small - $5,1^0$ for Arcturus and $9,8^0$ for Betelgeuse - the weakening of their luster in the lower atmosphere was taken into account. At an altitude of 5^0 star looks dimmer on $1,67^m$ in average, at 10 degrees - on 0.98^m [15]. Thus in this case Arcturus was observed with apparent magnitude of 1.63^m, Betelgeize with the magnitude of $1,48^m$.

Figure14. Visual "Arcturus observation tube".

At dusk the stars of such apparent magnitude most likely can be seen at the sun altitude of minus 10 degrees [16] but after adjusting for the greater purity of the atmosphere in ancient times, there is a possibility of observing these stars with the beginning of astronomical twilight (at the sun altitude of minus 70). In the evening passage the angular distance from the sun to azimuth was about 100^0 for and Arcturus and about 135^0 for Betelgeuse. Morning passage also satisfies the observations conditions at the distance from the Sun: 55^0 for Arcturus and 70^0 to Betelgeuse. The modeling of heliacal passages let us think that constructions were designed for both stars' observation. The modeling showed that the last appearance of Arcturus with Betelgeuse meant anticipation of the winter solstice. The first morning appearance of Arcturus happened about a month after the onset of the summer solstice.

Table 3. Calculation of the Arcturus sunset observation.

Direction	Azimuth	Altitude	Declination	Event
Platform - «sight» - «telescope center»	$344^0 57{,}9'$	$5^0 06{,}05'$	$38^0 49{,}1'$	Arcturus sunset in 1350 BC ± 50 years.

The fact that the astronomically important areas on the monument marked with okunevo and andronovo petroglyphic images confirms purposeful observation of the stars and the Sun by representatives of both cultures. That proves that there was a solar and stellar observational astronomy in Siberia in the middle of the II millennium BC on okunevo-andronovo sanctuaries.

Table 4. Heliacal Arcturus passage (**A**) and Betelgeuse (**B)** in a given direction in 1350 BC.

Sun altitude	**First in the year morning passage**			**Last in the year evening passage**		
degrees	Date	Time Hour-minutes	Sunrise Hour-minutes	Дата	Time Hour-minutes	Sunset Hour-minutes
-7^0	01-02 August (27 SS)	B: 04-27 A:04-36	05-40	24-25 December, (a week before the WS)	B: 18-54 A: 19-03	17-40
-10^0	04-05 August (30 days after SS)	B: 04-19 A:04-20	05-45	13-14 December, (18 days before WS)	B: 19-37 A:19-46	17-45
Abbreviations: SE, AE - spring and autumn equinox, SS, WS - winter and summer solstice, A - Arcturus B - Betelgeuse						

Judging by the stylistic accessories of petroglyphic images of the Seraphim stone sanctuary the astronomical binding of okunevo images indicates a solar character of the sacred content of sanctuary for the okunevo bearers in the era of XXV-XIX centuries BC. Observation of Arcturus in both sanctuaries described in a determined by us chronological interval is in turn indicates that there was the stellar observational astronomy in andronovo of Khakassia. In this case most likely that the fixation by andropov's of heliacal, the last evening of the year, passages of Arcturus and Betelgeuse in a given direction helped them to predict the date of the winter solstice for the week and a half before the event. Thus the observation of the evening passages Arcturus and Betelgeuse preceded the date of the winter solstice. In their ritual practice determined by the astronomical phenomena the priests could not afford to make a mistake in the date of the astronomical

phenomenon such as solstice, equinox, or the off-season due to weather conditions. This required equipping of astrosanctures in the way to precede the date of significant astronomical phenomena.

The structures of the sanctuary, the location of petroglyphs and astronomically significant directions are shown in Figure 15.

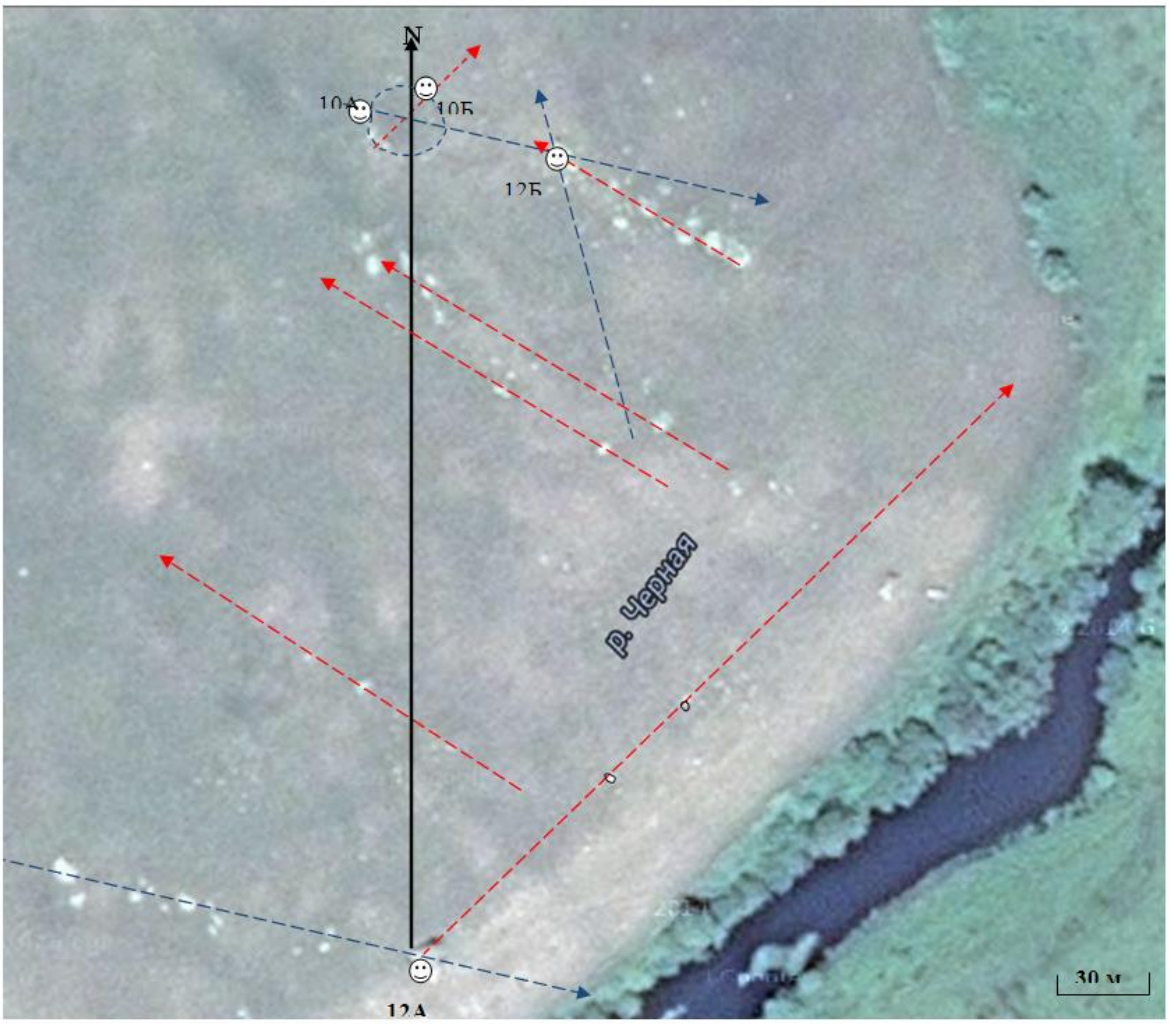

Figure 15. Arrangement of the structures and astronomical directions of Seraphim stone's sanctuary. Satellite image: Google maps

Scheme legeng:

→	The direction of the astronomical meridian
- - - →	The direction to the sunrise and sunset during the summer solstice. 1 Sunrise over a white plate mounted on the southern slope of the first sunduk [8] 2 - sunrise from the top of the first sunduk
- - - →	The direction to the stars: A - Arcturus B - Betelgeuse (Orion constellation)
☺	Images quantities, 10A, etc.. - Numbers of corresponding figures in the article.

The fact that heliacal star observations were practiced for at least two millennia indicates a poem "Works and Days" by Hesiod (VIII-VII centuries BC). In the poem we found a reference to fixation of calendar seasons on the heliacal Arcturus observations. For example, in one of the fragments of the poem says [17]:

> Observe all
> this until the year is ended and you have nights and days of
> equal length, and Earth, the mother of all, bears again her
> various fruit.
>
> When Zeus has finished sixty wintry days after the
> solstice, then the star Arcturus (25) leaves the holy stream of
> Ocean and first rises brilliant at dusk. After him the shrilly
> wailing daughter of Pandion, the swallow, appears to men when
> spring is just beginning. Before she comes, prune the vines, for
> it is best so.
>
> (Hesiod)

The very fact of labeling by priests the astronomically significant areas with petroglyphic images indicates non accidental characteristics both the images and astronomical directions labeled by them. This statement is under a base that in the sanctuaries of Seraphim Stone and the First Sunduk all detected petroglyph images mark astronomically significant areas (!). The same can be said about the images in the sanctuary Saratsky Sunduk [18]) which is not concerned in this publication. Thus the sacred astronomy of two studied periods is marked with petroglyphic images of two cultures of Khakassia - okunevo (XXV-XIX centuries BC) and andronovo (XVIII-XIV centuries BC) participated in the astronomical arrangement of sacred space of sanctuaries First Sunduk , Seraphim Stone and Saratsky Sunduk. The fact that a number of astronomically significant areas of the First Sunduk sanctuary are not labeled with petroglyphs can be explained by the fact that the petroglyphic images were not saved due to antiquity and sharp continental climate of Khakassia with typical temperatures ranging from -40^0 Celsius in winter to $+ 40^0$ in summer. Due to the fact that petroglyphic images we found are on the not weatherproof rock surfaces of Devonian sandstone and are subject to the damaging effects of extreme temperatures, wind and freezing winter waters (destroying the porous surface of the sandstone) the preservation of the petroglyphs is directly dependent on climatic conditions of Siberia. The most preliminate statistical studies of petroglyphs of tagar culture of Khakassia (VIII-III centuries BC) we have done showed that no more than 22-26% of the original number of petroglyphs survived in open weather and investigated by us tagar arheocomplexes. Devonian sandstone which depicts the petroglyphs of Khakassia was destroyed by water and temperature changes, by peeling surface "skin" which is a result of patination ("desert varnish") of sandstone surface in the Sun. Due to the fact that the petroglyphs of Andronovo culture of Khakassia for a thousand years and Okunevo culture for two thousand years older than the petroglyphs of tagar culture the percentage of their preservation in the open-aired, not weatherproof archaeological complex is even less. This factor can be explained by the fact that not all astronomically selected areas of the sanctuary First Sunduk were marked with petroglyphic images. In favor of this argument is the fact that all preserved petroglyphic images of the First Sunduk and Seraphimov Stone sanctuaries fix astronomically significant areas.

Overview of archaeological sources confirming the astronomical dating

We consider it necessary to argue our position particularly on correct attribution First Sunduk and Seraphim Stone to Okunev and Andronovo cultures of Khakassia

As was convincingly shown by the studies of Khakassia University archeological laboratory under the direction of A. Gotlib [19], D. A. Kirillova and M.A. Podol`skaya publications [20,21], sanctuaries of the same kind in Khakassia existed during different periods of the Bronze Age – from Afanas`ev to Karasuk culture. Okunev ceramics were discovered on four sve (Khakassia term meaning «stronghold on a mountain») examined by these authors.

On Chebaki sve that is located 30 km south-west from the described objects A. I. Gottlieb discovered Okunev and Karasuk ceramics.

D. A. Kirillova and M.A. Podol`skaya studied sve Kyzul hai, located on the right bank of Black Ius river between s. Ustinkino and s. Podkamen`, 25 km north-west from the objects described in the article. Okunev, Karasuk and Andronivo ceramics were discovered in the Kyzul hai sve.

Structures such as system of swells, marking and isolating inner space and the «wall» made of dry masonry of sandstone slabs [22] similar to the objects described in the mentioned sources were discovered on the First Sundu territory. Based on that as well as on the object`s chronology in accordance to the observations of Arkturus on the First Sunduk we came to the conclusion that the First Sunduk is the monument of Okunev and Andronovo cultures. We are also sure that should archeological excavations be conducted Okunev, Karasuk, Andronovo and Afanas`ev ceramics are found.

Seraphim Stone was attributed to the Okunev culture because of two images placed in situ on the Stone that are certainly attributed to the Okunev culture. Judging by the Arcturus and Betelgeuse observation, we can attribute Seraphim Stone to the Okunev-Andronovo culture. The presence of the two atypical images that define astronomically significant directions and cannot be attributed to any other known culture of Khakassia allow us to assume that these images may have created by Andronovo culture bearers in Khakassia

After studying the sves, A. I. Gotlib, D. A. Kirillova and M.A. Podol`skaya came to the conclusion that these building were the places of seasonal residence and periodical ritual actions, not of permanent residence. At the same time, a clear stratigraphy of cultural layers in the studied objects could not be detected. The researchers proved that monumental swell structures of sandstone slabs can be unambiguously attributed to the Okunev culture.

Resume

Among variety of astroarchaeological objects found in the area of the "Sunduki" sanctuary (North Khakassia)the most valuable are monuments confirming that andronovo bearers Khakassia had the stellar astronomy (Arcturus and Orion observation). Any evidences of the intended observations of stars are very valuable for modern scholars because the data would provide a tool for the precise dating of archaeological sites. Even if the direction of the star is measured or known to an accuracy of 1 degree the error in dating will be about 60 years. "Solar" astroarchaeological directions widely represented in many regions due to the very slow change of the declination of the Sun give an error at best a few hundred years and often does not allow to date it at all. On the other hand the Sun declination slow changing let us directly observe its sunrises and sunsets with minor amendments in the same circumstances as in ancient times. During the "star directions" search the recommendations given in the introduction on fixing

features of "star" directions, the attenuation of light in the Earth's atmosphere, the heliacal star passages and observing them at dusk, as well as observations of stars due to calendar dates will be useful.

In addition to the remarkable fact confirming the existence of the stellar astronomy in Siberia in the Bronze age (andronovo culture of Khakassia XVIII- XIV BC) there are several equally important factors:

1). The above astroarchaeological sites allow us confidently set (with astronomical and archaeological methods) time of especially intense functioning of the First Sunduk as great astronomical center of southern Siberia in the bronze age. It should be mentioned that this monument was functioning synchronously with the famous Stonehenge, though no objects that can confidently assert that the priests were engaged in intentional observations of the stars were discovered for now.

2). The organizers of the First Sunduk and Seraphim Stone sanctuaries deliberately chose and witty fixed the directions for the heliacal passages of the Arcturus nonsetting bright star in conjunction with the Betelgeuse star at certain times of the year. That indicates a high level of astronomical knowledge of andronovo in Khakassia;

3). The conclusions of the observation of the heliacal passages Arcturus and Betelgeuse by andronovo priests confirm and explain the perfection and accuracy of their calendar systems (see. [23]);

4). Since Arcturus until recently held an especially prominent place in the astral mythology of indigenous peoples of Siberia (see details. [24]) there is a promising solution to the problem of reconstruction of the andronovo stellar mythology within Zurvan-Mazdean theologem [25]) fixed in the composition of the petroglyphs of the Saratsky Sunduk sanctuary and in the symbolism of the constellations' images fixed in the petroglyphic compositions of andronovo sanctuary "Temple of the universe creation" [26, 27]);

5). The establishment of a direct connection of different types of okunev and andronovo petroglyphs with astronomically significant directions allows to confidently judge the solar and chthonic dichotomy of the semantics of both cultures images.

In light of the above a conclusion of a remarkable historian of astronomy of XVIII century Jean-Sylvain Bailly (see. [28]) who claimed that the origins of astronomy were located in Biblical times at the east of Siberia. At the moment we as the researchers of Bronze age cultural objects in Khakassia cannot reasonably confirm or refute the views of Jean-Sylvain Bailly. Despite there are cultural monuments in Siberia having astronomical structures and (or) artifacts of astronomical and calendar content from the Paleolithic era to the Bronze age, these monuments chronologically asynchronous. At the moment other monuments synchronous to already discovered has not found yet so we cannot assert that there were cultural sites of observational astronomy in Khakassia older than the II millennium BC. Nevertheless we believe that such astronomical structures sooner or later will be discovered. The objects of observational astronomy synchronous at least to the era of the «Belaya Loshad» («White Horse») sanctuary (16 thousand years [29]) are most likely to be found. Our confidence is supported by the discovering in Khakassia the most ancient image of the person (Maininskaya discovery [30]) made of baked clay which indicates a high level of culture bearers created this sculptural artifact. It is important that chronologically "Maininskaya

discovery" is synchronous to "Belaya Loshad" astrosancture (16 thousand years). The distance between the "Belaya Loshad" sanctuary and location the "Maininskaya discovery" is about 400 kilometers. The fact let us to assume that the creators of Maininskaya sculpture and the "Belaya Loshad" sanctuary could belong to the circle of the same culture bearers.

There is only slight opportunity that due to the greater antiquity there will be detected objects for observational astronomy of era which is synchronous to the Malaya Syya settlement [31]). At the same time we believe that sooner or later at least arthefacts' material confirming that there was an observational and calendar astronomy in this era and will be found on another chronologically synchronous to Malaya Syya settlement archaeological sites.

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