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Ancient Astronomical Knowledge: the Unity of Diversity

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Abstract. Peculiarities and cultural projection of ancient astronomical knowledge are described. Substances of ancient astronomy including megalithic constructions, symbolism, and manuscripts are considered. Results of investigations of astromegaliths and written materials of Georgia are presented.

1. From Relicts to Enlightenment

Cultures of the ancient nations keep the initial views of the ancients about the universe, the world of stars and planets. These initial imaginations—grains of the primary knowledge, are scattered and irregular, however, they pervade practically all layers and segments of the ancient cultures. Since the pre-historic times, from epoch to epoch, these relict imaginations have been expanding and modernizing steadily. Megaliths and their structures, ancient stony structures spread so widely in different geographical regions throughout the world, are often aligned on the astronomically important points on the horizon, determining constructively both the observational and religious significance of a given complex or monument. The ancients prayed to their gods when watching the rise of bright luminaries: the Sun, the Moon, and stars. Quite often, just the brightest stars in the sky were for an ancient man his gods endowed with almighty power, light, and heat. When appearing above the horizon with ineluctable accuracy and regularity, the bright luminaries-gods were by view of an ancient man determining his daily life, the nearest and distant future. The ancient people gradually learned to divide and use the time for short periods and long seasons.

The megalithic structures transformed from the observational and ceremonial points into the fixators and keepers of time. With accumulating new views and filling the "baggage" of empiric knowledge, the ancient people started to apply more and more widely their constructional complexes for different purposes—to fix the rise of stars, to worship the gods, to define the warm and cold seasons. The time came when these complexes acquired multifunctional significance. The development of civilization, transformation of a human from contemplation and accumulation to construction and creation, as well as invention of new technologies by mankind, have predetermined occurrence and development of new elements of cultures, which included in themselves different crafts, primary architecture and applied arts of the different sub-types and directions. On a stone processed by a man, smelted metal, glass, appeared fragments of the amazing starry sky, wandering luminaries—pictures of the cosmographic nature. Ornaments and engraved images of the scenes of human's "communication" with the heavenly bodies began to decorate the surfaces of dishes of the colored and precious metals, decorations

of various types. The obvious progress being accompanied by origination of the scientific fields like mathematics and astronomy, invention of writing, alphabets of different types and forms have further developed mankind's understanding of the surrounding environment and the universe. A man started to reflect the seen and understood on the sheets of parchment together with the empiric data of interpretation of what he has seen, explanations of what he has understood, and the results of what he has analyzed. The sets of the observational data, pictures and drawings, extensive descriptive material have become the basis for the ancient and medieval scientific treatises, dedicated to various astronomical phenomena, the starry sky, wandering luminaries, and of course, the universe in general. The development of different sciences and invention of the exact mechanical and optical instruments in the intellectual environment of the Renaissance and Enlightenment have expanded human knowledge of the same world of stars and planets. Ancient megaliths, the cosmographic ornaments, multilingual manuscripts and books are diverse in their unity, reflecting different paths of uniform "movement" of mankind towards the truth. This unity of diversity is composed of mutually supplementary components that are absolutely unified in spite of differences in their nature. Uniformity of the cosmological imaginations of the ancients and the astronomical knowledge of the periods of Renaissance and Enlightenment have been achieved by different ways and methods. Unity of the worldview in the diversity of its manifestations, as well as the generality of the differences in mankind's understanding of his role in the universe are based on:

1. observation by a man of the near and far orders of the surrounding landscape, relief, and numerous stars in the sky;

2. build-up of the megalithic structures with coordination to the local landscape and alignment with the astronomically significant points of the horizon;

3. observations and worship of the Sun, the Moon, and bright stars;

4. dividing the time into the short periods and long seasons, for daily, religious, and agricultural purposes;

5. reflection of the bright phenomena observed in the sky on stone, glass, metal handicrafts, household items, and decorations;

6. invention of the alphabets and other forms of recording with their further application for description of the celestial phenomena;

7. integration of the visible luminaries and strictly recurring celestial phenomena into the unified world system, with their further description in a form of the schemes, tables, and texts; and

8. the scientific analysis of the earlier collected, preserved, and systematized empirical data by means of the already developed theoretical and experimental research methods.

The principles specified above can be reformulated in detail; however, the unity of diversity of the ancient views and concepts of the universe are visible in the efficiency of the path of development of knowledge from astro-megaliths to orbital telescopes.

2. Solar Stations

The daily life of the ancient people was largely determined by the environment of their habitation. The surrounding natural landscape, having the shape of hills, forest slopes, extensive lowlands, rivers, and lakes) has stimulated the ancient people using these natural features. Their homes and settlements could be located on the lowlands near the water ponds, while the buildings and structures of special purpose could be placed on the heights, peaks of the hills and mountains. These special structures could have defensive, observation, and of course, the religious nature. After completion of a working cycle (a week, as per the modern sense), which had been established by traditions, views, and habits of relevant tribes, the ancient people could devote their free time to various activities, including observation of the celestial luminaries and phenomena.

As a result of the centuries-old accumulation of empirical information, the ancient people learned to "interact" with the sky and align their constructions with the astronomically important points of the horizon. Of course, there existed stricter cycles of vital activity of the ancient people. These cycles were linked to occurrence of certain luminaries (the brightest ones, primarily) in the sky, which, by view of the ancients, were the higher powers—gods. These two aspects were often interpreted uniformly by the ancients: the rising of the bright star as the return of the god of their tribe. Periodic strictly recurring celestial phenomena determined the observational experience and the religious commitment of ancient man. The long-awaited rise of a bright planet or a group of stars once again convinced the ancients in the correctness of their worldview and the necessity of their unwavering submission to the higher powers. Contemplation of the ascending luminaries and the simultaneous carrying out of various ceremonies and sacrifices were an organic part of the actual content of these strict cycles. The phenomena seen once and understood originally passed from generation to generation and acquired new features, details, and elements. Only the widest observational experience could link together a justification for waiting for a celestial phenomenon, correctness of the alignment of the construction, and features of the relevant ceremonies.

Inevitably strict recurrence of the rising and setting of bright celestial bodies allowed the ancient people to understand the intervals and periods of time seeing their virtual ties with climatic conditions, warm and cold seasons, the freezing of ponds, and floods of rivers. The ancients understood time in nature as well, namely, in themselves and the surrounding environment of flora and fauna. The rising of the bright luminaries, as viewed by the ancients, could indicate the approach of the rainy or hot season, or the time of harvesting. Special buildings acquired extremely critical importance. From these stony structures, the ancients observed the starry sky, worshiped the gods, and kept time. In these strange stony complexes built on the peaks of hills, they were storing all their most valuable things: knowledge, faith, and time.

It is not difficult to imagine how valuable these stones were for the ancient people and how they could protect them. Considering that the surrounding landscape determined the location of their houses and their special use buildings, the features of the visual horizon dicated the precise orientation of the elements of these buildings and divided the world of ancient man into the near-range and far-range orders—including the world of the uncountable stars. A particular elevation or depression of the visible horizon could be precisely aligned to the relevant elements of a megalithic structure: entrances, windows, menhirs, and their rows. Just above these hills, at an appropriate time of year, the long-awaited luminaries appeared, permeating with their light the corridors of the megalithic labyrinths. While observing, worshiping, and applying the

acquired knowledge, the ancient people moved to the path of understanding their role in the near-range and far-range orders of the universe, as a whole. We are still moving in the initial section of this long path as we expand the knowledge and experience of our ancient predecessors.

The Sun played a special role in the daily life of ancient man, his views on the universe and in the entire progress and development of mankind. For the ancient people, the Sun was the main source of light and heat, indicator of time, and object of special worship. The Sun provided light and heat, transferred life-giving energy to the plants and cultivated crops, cured with its heat, lit the mountainous paths with dazzling light, and marked the approach of the warm and cold seasons with a perfect accuracy. The ancient people noticed regularly recurring movement of the rise and set points of the Sun on the horizon and understood the possibility of using this phenomenon for time keeping, fixing short intervals of time and indicating of the long-range seasons like winter and summer. Regularly recurring solar phenomena and the special power of the Sun's light and heat transformed the brightest celestial luminary into the main deity of the ancients, into the object of their particular worship. They were waiting for its occurrence, worshiping before its rising face and bright golden rays, arranging various ceremonies. The appearance of their god (the Sun) at various points of the horizon (such as the solstices) testified to the ancients about its great power and unequivocally pointed them to the beginning of the new season.

The ancient people devoted to their great deity, the Sun, special complexes of buildings. These megalithic constructions were built on special sites, peaks of mountains and hills, which were too difficult to climb every day even for physically strong men. On specially established days of observations and ceremonies, people climbed (or, were permitted to climb) to their megalithic complexes for observing the sunrise, meeting their god of light and heat, and arranging different ceremonies dedicated to these phenomena, which, in the view of the ancients, established a human's role in the boundless heavenly world. By their understanding, their role was minimal, symbolically expressed in small torches and bonfires, comprising elements of the worship ceremony. Structures of these megalithic complexes were aligned by the ancients according to the sunrise and sunset points in such a manner that the rays of the Sun could penetrate into the particular structural elements: entrances, corridors, and rows of menhirs. Constructional features of these megalithic complexes are uniquely associated with the peculiarities of the movement of the Sun over the sky, its shift along the horizon, and its influence on the consciousness of ancient men.

These ancient megalithic structures have become the first observation sites, fixators and keepers of time, temples for worship to the Sun. The multifunctional nature of these megalithic complexes is obvious. We call these multifunctional complexes "solar stations" (Simonia 2011). At the solar stations the people observed the sunrises and sunsets, fixed the time, and worshiped their god, the Sun. Later on, a level of multifunctionality of these stations increased with expansion of the empirical knowledge of the ancient people, who saw and understood that appearance and movement of the other less bright luminaries (the Moon, stars, and planets) could testify of other facts and phenomena and commemorate the beginning and completion of shorter time intervals. Expressed figuratively, the Sun became the hour hand of the virtual clock, while the stars and planets the minute hand. The increase in the level of multi-functionalism of the solar stations was accompanied by constructional complexity: extension of the new corridors and the menhir systems, mounting of new columns, and creation of new open-

ings in various directions for additional windows. It would not be difficult to imagine how the ancients were observing sunrises through the main entrances to these buildings and observing the rising and setting of other stars from the additional areas of these buildings or through the specially arranged small windows.

The progress of the ancients in their cosmological imagination was positively reflected in their skill in constructing more and more complex buildings. We consider that the invention of solar stations cannot be exclusive to this or that particular ancient culture. Based upon the principle of the unity of diversity as formulated above, we conclude that solar stations could be spread over different regions of the world, at various latitudes, in conditions of different landscapes and climates.

Good examples of solar stations can be found in Georgia. Georgia is an ancient country located at the eastern edge of Europe. High mountains, forests, numerous rivers and lakes, and the coast of the Black Sea are all elements of the landscape of Georgia. During the past millennia, the Georgians formed and developed their own original culture, language, alphabet, literature, applied arts, music, architecture, folklore, and agriculture. One of the most important elements of the Georgian cultural heritage is the development of sciences, especially the exact ones, including mathematics and astronomy. Ancient Georgians' interest in celestial phenomena was manifested during various stages of the pre-historic epochs, including the megalithic era.

Figure 1. Abuli solar station in Georgia.

In Georgia, south of the capital city Tbilisi, in the municipality of Ninotsminda, lies a megalithic complex known as Abuli. The complex is located at 41°22′22″ N, 43°41′06″ E, elevation 2,637 m. The construction of the Abuli complex is characterized by rectangular and spherical forms. The spherical part of the complex is aligned to the southeast. An archaeoastronomical investigation conducted in 2011 and 2012 (Simonia & Jijelava 2012) showed that the eastern part of the horizon is open, and in

the northeast direction the visible horizon has negative altitude, that is, it lies below the horizontal. In fact, the Abuli complex is a rounded structure on different levels with a central rectangular-spherical construction. A set of small, stone rooms, symmetrically located, are connected with one another and provide passage from one level to another. The central construction is supported by six columns marking the north, northeast, east, southeast, west, and northwest directions. The narrow corridor divides the building into component parts, north and south. In the northeast direction, there is an architrave entrance into the central edifice. This entrance faces the visible horizon and is oriented with azimuth 59°43′. There are two windows in a spherical part of the central building which, as viewed from the interior, are supplied with small niches. These are oriented with azimuths of 97°50′ and 166°54′. Both windows face the sky; to be more exact, only the mathematical (level) horizon is seen through them. This could undoubtedly have enabled ancient observers to see rising heavenly bodies near the horizon. At the times of the solstices, the rays of the rising sun were seen to penetrate through the architrave entrance. The Abuli complex possesses five or six points (or constructed elements) from which ancient people could have observed astronomical objects and events such as Polaris, the heliacal and acronychal rising of bright stars, and the rising of the Sun and Moon. If people lived around Abuli, then the complex could have been used for religious ceremonies and observations of the heavenly bodies with the aim of determining and preserving time (Fig. 1). If so, then the Abuli complex was indeed is an ancient solar station, or in other words, a multifunctional site for rituals and observation (Simonia & Jijelava 2015).

Near Paravani Lake in the Shaori Mountains of Georgia can be found a large megalithic complex. The Shaori complex consists of two parts: the large Shaori on the highest summit and the small one on the other mountain. The large Shaori building is located at 41°29′2″ N, 43°44′57″ E, elevation 2739 m. The architectural space of the large Shaori comprises an envelope-like shape with the remains of a small column at its center. The inner side of the complex wall contain numerous dolmens. The large Shaori building has a central opening with a door facing southeast. The large Shaori building is connected to the bottom of the mountain by a ceremonial road several meters wide and stepped with recumbent menhirs. These Bronze Age buildings had a dual significance both as a cult center and an observational place (Fig. 2). Religious ceremonies held in Shaori buildings could have included the observations of heavenly bodies. The central opening or door of the large Shaori building faces a true azimuth of 121°40′ as determined by a survey carried out by Ilia State University in 2011. The azimuth of the rising sun at the winter solstice is 121°, so that observers standing near the central column would have seen the rising winter solstice sun through the door. In view of what we know of ancient Georgians' religious beliefs, it is possible that the Shaori complex was not only a ceremonial center with buildings in which diverse rituals were performed, but also an observational site, a type of ancient solar station in which people worshiped their gods and watched the rising of diverse heavenly bodies—the Sun, Moon, and stars—in order to maintain their orientation in time (Simonia et al. 2015). Similar megalithic constructions are located in other parts of Georgia.

3. Ethno-Cosmological Symbolism

The continuous accumulation of new knowledge and practical experience by the antient people led to the development of new technologies, traditions, and methods. Humans

Figure 2. Shaori solar station in Georgia.

learned to smelt metal and glass, and prepare from these materials different items, tools, and ornaments of complex and delicate construction. The daily life and outlook of the ancient people also developed. It was not enough to only remember the objects they saw in the sky, but to reflect them in stone, metal, and glass. The bright, rare phenomena a person could see in the sky, while gradually acquiring more and more systematic understanding, started to be "reflected" on the surfaces of various material objects: dishes, tools, weapons, ornaments, and other items. They could be reflected as a conditionally straight projection (images of stars and planets) or in a form of relative virtual projection (correct geometric shapes, recurring ornaments). Of course, these astronomical projections were formed in line with the religious beliefs of the ancients, reflected in the additional visual and symbolic features of the pictures. Thus, the Sun, Moon, and stars, as well as their symbols, were set in precious stones and with different ornaments and decorations.

In Georgia, archeological artefacts of metal, glass, and ceramic are not infrequently decorated with the images of luminaries, or with pictures and ornaments of a cosmological nature. The ancient Georgians represented on the surfaces of different items, including the items of daily and ritual use, the luminaries they saw in the sky. The religious views of the ancient Georgians also had a certain impact on the straight and symbolic images of luminaries and on the general picture of the world as the ancients understood it. The strictly recurring circular ornaments and closed curves could symbolize rotation of the sky, the steadily recurring return of the luminaries, and a spherical shape of the world in the understanding of the ancients. In the middle of the last century, in Trialeti, in the eastern region of Georgia, a golden goblet decorated

with semi-precious stones was discovered (Fig. 3). The goblet dates from the 17th–15th centuries BC and is considered an item of the material culture of Trialeti (National Museum of Georgia, inventory number 9-63/981) (Jorjikashvili & Gogadze 1974). The gold as well as the semi-precious stones of the ornament could symbolize the Sun, especially since the minerals of chalcedony (also known as karneol or sardonyx) are named in number of cultures as the sun-stones, while turquoise minerals are known as the heavenly-stones. Thus, a common, conditionally cosmological picture is formed where the Sun is the basic element of the recurring celestial phenomena and the rotating world of stars. Considering that the cultural traditions of viticulture and winemaking were developing in Georgia during those millennia, we may gain some insight into the common philosophical-cosmological ideas of the ancient Georgians and "find" in the Trialetian golden goblet a material embodiment of the boundless space, of the steady ticking of time, and the extensive harvest of the grapes that depends so strongly on the warm sunbeams.

Another example of the ethno-cosmological symbolism was discovered in the 1970s. A silver bowl with the orderly sequenced pictures of animals and recurring ornaments was found in the Colchis lowland in the western part of Georgia (Fig. 4). The animals depicted on the bown were shown as if running around one center in the counterclockwise direction. The bowl dates to the 2nd century BC (Herzfeld 1947). In the eastern toreutics, the bowls with the images of lotus, a symbol of the Sun, were spread widely. However, in case of the Colchis bowl, the images of animals are placed instead of the lotus, which is undoubtedly associated with the cosmological imaginations of the ancients. The eight-petalled star between the first and the fourth animals can be considered an additional indicator of the cosmological nature of the pictures on the bowl. The Lion, lynx, boar, and deer depicted on the bowl had a special place in the Colchis pantheon. This silver bowl, decorated with the images of animals and regular ornaments, is an example of the ancient Colchis art that demonstrates the views of the ancient Georgians about the world of stars (Simonia & Simonia 2005). The ancient people saw that the large and small groups of stars are easily combined into familiar faces and outlines of animals, which they placed on objects of daily use. Could the pictures of animals on the Colchis bowl be an attempt of the ancient people to see the terrestrial world in the sky, with outlinines of the constellations in the darkness of night? Most likely, the polar region of the sky is reflected on the bowl by its ancient artisan. Is it possible to link the number of animals depicted on the bowl with different seasons of a year, with periods of warm, cold, and moderate weather? Answers to these questions are found in the comparative analysis of the Colchis ornament; one thing is clear: on the silver surface of this sample of ancient art, one sees that space, time, and the rotations stars demonstrated.

The examples of the ethno-cosmological symbolism above testify to the diversity of unity of worldviews of ancient peoples who tried to describe by different methods and symbols the heavenly bodies they were observing in the sky and reflect them as certain referenes in a dynamical world.

4. Letters and Numbers in the Unity of Parchment

As time passed, development of mankind continued as people permanently acquired new knowledge and skills, transforming their outlook and their ways of thinking and acting. New cultural layers were created, technologies were modernized, and instead of

Figure 3. Cosmological symbolism of the Trialeti golden goblet.

passive contemplation of the surrounding world, the more exact analyses of constructivism and representativeness appeared. It was no longer enough just to see, depict, or simply describe. A clear necessity emerged to understand more deeply what was seen, to describe it exactly in detail, and to predict tomorrow's events and circumstances. The ancients recognized the necessity of development of methods for inter-cultural communication, a universal description of the surrounding environment, and to share of knowledge. Invention of scripts of different types was a precondition for a qualitative leap in development of the ancient cultures by enabling a new level of "dialog" between a humanity and the nature. The possibility of a numerical description of the countless stars, and expression of the observed celestial phenomena by the series of letters and numbers, became a unique "instrument" for accumulation, storage, and analysis of the empirical knowledge about the Universe. Written language opened the way to the theoretical description of the world of stars and planets. Thus, in this way the layers of handwritten materials, textual complexes, tables and figures describing movement of planets, constellations, eclipses of the Sun and the Moon were formed.

In different languages, using different alphabets and forms, with their peculiarities, the same celestial phenomena were described, complementing each other and generalizing a common picture of the Universe. Perfection of the systems of accounting and deepening the traditions of written language played important roles in the formation of the exact sciences of mathematics and astronomy. As a result, philosophers and schol-

Figure 4. Projection of the Universe in the Colchis silver bowl.

ars of the ancient era received the precise virtual instruments for studying the universe, a certain initial laboratory of its understanding, which was "based" on the parchment sheet. The heritage in the variety of written materials of different cultures reflects the unity of interest of the ancient scholars to both the process of understanding the creation of the world and the very nature of the celestial phenomena. When considering small details, individual celestial phenomena, or some specific object, the ancient scholars were on the path to the creation of a common model of the Universe and understanding of the world.

Creation of an original alphabet by the ancient Georgians was a precondition to the formation of their written heritage. A key element of this heritage are the manuscripts of astronomical and cosmological nature. More than 300 such manuscripts written using the letters of the ancient Georgian alphabets—Asomtavruli, Nnuskhuri, and later on Mkhedruli—are kept in the libraries and archives of Georgia and other European and Asian countries. Figure 5 shows a fragment of the old Georgian astronomical manuscript (Star Book) describing different interpretations of the celestial phenomena, and mentioning the names of the same luminaries in different languages, reflecting the common Ptolemaic model of the Universe (Simonia 2001). Today, in the epoch of nanotechnology and space missions, representatives of different cultures, scientific schools, and traditions, return again to the common goal of understanding the micro-

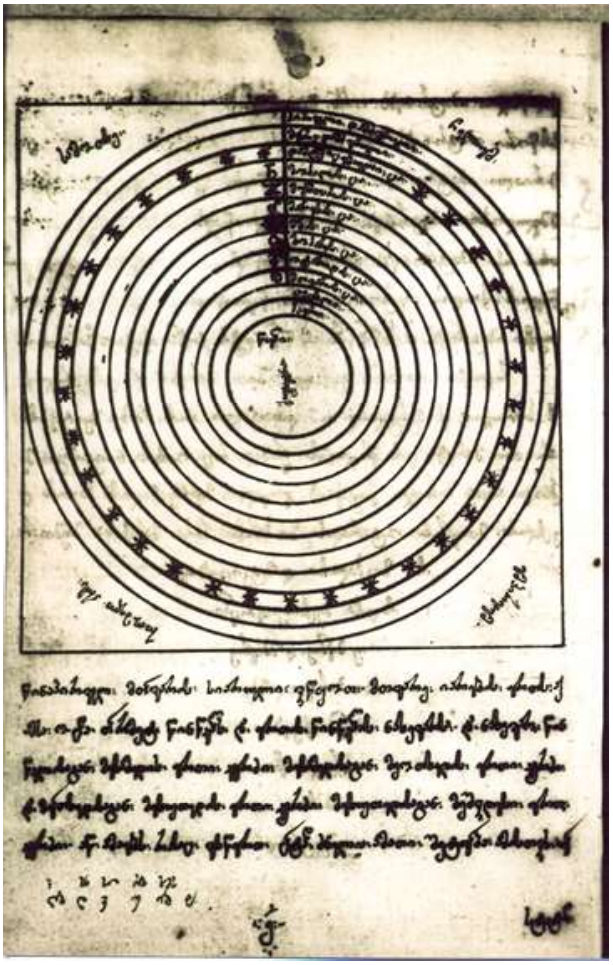

Figure 5. Old Georgian manuscript Star Book.

and macro world. They integrate into the unified complex the cultural variety and erect a "bridge" between the past and the future.

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Astronomy in the Ancient Caucasus

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Irakli Simonia and Badri Jijelava

Contents

Abstract

This chapter discusses the role of recurrent heavenly phenomena in the formation of ancient cultural traditions. Artifacts bearing witness to astronomical and calendrical practices in the ancient Caucasus are described and we analyze the significance of the "boats of the sun" petroglyphs at Gobustan in Azerbaijan, the solar station at Abuli in Georgia, and the "sky dial" at Carahunge in Armenia. Similarities and differences between the ancient cultures of the region are discussed. Finally, we present the results of the latest field research and new facts and hypotheses.

Introduction

The starry sky played a special role in the lives of ancient humans. The risings and settings of the bright heavenly bodies, the precisely repeating movements of

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numerous stars, and rare celestial phenomena created a relationship between ancient humans and the firmament. It became the main instrument by which they oriented themselves in time and space, the world of gods and supreme powers, and a multicolored landscape both by day and by night.

The sun and the moon, as the brightest heavenly bodies in all their observed manifestations (risings, settings, eclipses, and phases), were the main focus of regular observations and were worshipped in many ways. Bright and dim stars, conceptually united into figures and ornaments and observed in a single framework together with the planets, were another instrument used by ancient people to determine time. Stars rising at dawn or dusk became markers of relevant periods of time; they were a special symbol or a sign from the heavens, according to the convictions of ancient people.

The day and night sky, filled with luminaries differing in brightness and color, continually disappearing but always returning, was ancient peoples' universe, the object of enormous interest and worship. In order to fix the rising and setting times of the heavenly bodies, to establish periods of time, and to conduct ritual ceremonies, ancient people built both simple and complex constructions in stone, accurately orientating them to distinctive features in the surrounding landscape. Empirical knowledge of heavenly phenomena, their own understanding of what they had seen, and emotions about what they observed were reflected by ancient people in material objects (e.g., drawings on stone and ornamentations on metal) and were incorporated into folklore (e.g., narratives and legends).

Relics of Astronomical Practices in the Ancient Caucasus

Evidence of ancient humans' "interaction" with the heavenly bodies incorporated in stone constructions, graphic symbols, and folklore can be found throughout the world in ancient ruins, on artifacts, and in oral traditions. Such is the case in the South Caucasus. Surrounded by the mountain ridges of the Greater and Lesser Caucasus and bordered by the Caspian and Black Seas, this geographical region of the world is rich in ancient cultures. The astronomical practices and cosmological ideas among the ancient peoples of the South Caucasus are both similar to and different from one another; a clear example of the unity and diversity of knowledge held by ancient humans.

Azerbaijan

In Azerbaijan, the archaeological reserve called Gobustan (translated as "the territory of ravines") is located south of the capital city, Baku, in the Karadag and Apsheron regions. This reserve, which is described as a rock art cultural landscape, covers more than 3,000 ha located between the southeast slope of the Greater Caucasus Ridge and the Caspian Sea. The cultural heritage of Gobustan falls into two categories: ancient petroglyphs (rock drawings) and ancient sites. The latter

include monuments such as the remnants of a prehistoric cromlech. Research on Gobustan began in the 1930s, when numerous petroglyphs, symbols, openings in rocks, and other evidence of cultural activity of ancient people were discovered (Jaffarzade 1958).

In the mountains of Beyuk-dash, Kichik-dash, and Kyanizadag, researchers discovered petroglyphs that were carved and scratched on rocks. Images were also discovered on pieces of rock and in local caves. The drawings reflected ancient people's everyday lives. Figures of men and women are represented, with scenes of dancing, hunting, and land cultivation, along with various animals, symbols, and signs. Taking into consideration the graphic evolution of the drawings, expressed in the transformation of geometrical forms and symbols in different series of drawings, they are dated, on the whole, to the Upper Paleolithic and Middle Bronze Age. On the rocks of Gobustan there are images of boats of different forms and methods of construction; many of their bows are decorated with representations of the sun.

The petroglyphs of Gobustan may well reflect cosmological ideas. The rising and setting of heavenly bodies, the constant motion of the stars, and a dynamically changing world could be represented by the movement expressed in geometric figures, people dancing, and animals running. The drawings of Gobustan abound in such themes. Considering the geographical peculiarities of the area, it has been suggested that the rising of the sun, moon, and other bright heavenly bodies came to form the basis of cosmological ideas for the local tribes. Bright rising heavenly bodies were not only their gods but also their landmarks in space and time. Watching the rising of heavenly bodies, the ancient people accumulated comprehensive empirical knowledge that they used for everyday purposes. At the summer and winter solstices, they could travel by their boats to the sea to meet the sun, approaching it by the solar path. The first rays of the brightest luminary personified for them the appearance of a major deity and the start of a new period of time. The numerous petroglyphs of the "boats of the sun" support this argument.

The remains of a cromlech, mentioned above, suggest that Age this location functioned as a temple during the Bronze Age. Whether it was aligned in the direction of the solstices may be determinable archaeoastronomically by field measurements and/or analysis of satellite images of the locality.

Rustamov (2009, 2011), who considers the symbolic significance of the "boats of the sun" (Fig. 126.1), also analyzes the spatial orientation of the ancient drawings with respect to the horizon. In addition, he shows that some natural rock structures and large stones at Gobustan are aligned to astronomically important points on the horizon, and in particular to sunrise at winter solstice. These aligned structures quite often abound with impact marks and other traces of artificial elaboration. This may mean that ancient people, relying on their observational experience, created precise markers of time on the stony surfaces, pointing to the rising points of heavenly bodies at different times in the year. Rustamov considers various stones in the complex both in their observational and religious contexts, including the astronomical alignment of clear-cut plain surfaces that he interprets as altars of sun worshipers. He concludes that the complex of Gobustan was an ancient solar observatory.

Fig. 126.1 Two "boats of the sun" at Gobustan, Azerbaijan (Photograph: A. Rustamov)

Further archaeoastronomical research is needed at the Gobustan complex, including the accurate field measurement of azimuths of landscape features. For the present, we can state that people living here during the Bronze Age "interacted" with the heavenly bodies, expressed in stone what they had seen, and measured time by the sun and the stars.

Georgia

In Georgia, south of the capital city, Tbilisi, in the municipality of Ninotsminda, lies a megalithic complex known as Abuli. The complex is located at $\varphi = 41^\circ\ 22'\ 22''$ N, $\lambda = 43^\circ\ 41'\ 06''$ E, elevation 2,637 m, to the southeast of Paravani Lake, on the slopes of the mountain Little Abuli. This mountain is formed of andesite-dacite lavas of Pliocene age, and is, in fact, a volcanic cone. The mountain slopes of Little Abuli are covered with alpine and subalpine meadows, and are also characterized by numerous stony boulders from desiccated rocks.

Narimanishvili (2009) notes that the Cyclopean Abuli complex is a dry-stone construction made of basalt blocks. It consists of a central fortification and a surrounding settlement, concentrated mostly in the eastern direction. The central fortification is encircled by two stone walls, which are set against a large construction on the north side. There are several entrances from the east and west (Fig. 126. 2). Its walls are strengthened by columns, mostly at the entrances. The central complex is divided into two parts by a narrow passage connecting the east and west entrances. In its interior are several two- and three-storey tower-like constructions. To the south of the complex there is a closed-off site. Berdzenishvili (2002) indicates that preliminary archaeological investigations at the Abuli complex have not revealed any small artifacts, which would provide evidence that people resided at the site. Consequently, in his opinion, the extant complex was purely of a ritual character. It is attributed to the Bronze Age.

Fig. 126.2 Ancient solar station at Abuli, Georgia (Photograph: B. Jijelava)

Simonia (2011) considers the astronomical significance of the Gokhnari megalithic complex, near the Manglisi settlement, in the same region of Georgia. The ruins of this Cyclopean construction are characterized by rectangular and spherical geometry. It is believed to have been a "solar station" – a multifunctional complex serving as a centers of residence, for sun worship, and for the determination of time.

The construction of the Abuli complex is also characterized by rectangular-spherical forms. The spherical part of the complex is aligned to the southeast. A field archaeoastronomical investigation conducted in 2011 and 2012 (Simonia and Jijelava 2012) showed that the eastern part of the horizon is open, and in the northeast direction the visible horizon has negative altitude, that is, it lies below the horizontal.

In fact, the Abuli complex is a rounded structure on different levels with a central rectangular-spherical construction. A set of small, stone rooms, symmetrically located, are connected with one another and provide passage from one level to another. The central construction is supported by six columns marking the north, northeast, east, southeast, west, and northwest directions. The narrow corridor divides the construction into component parts, north and south. In the northeast direction, there is an architrave entrance into the central construction. This entrance faces the visible horizon and is oriented with azimuth 59° 43′.

There are two windows in a spherical part of the central construction which, as viewed from the interior side of the construction, are supplied with small niches. These are oriented with azimuths of 97° 50′ and 166° 54′. Both windows face the sky; to be more exact, only the mathematical (level) horizon is seen through them. This could undoubtedly have enabled ancient observers to see rising heavenly bodies near the horizon. On June 22, 2011, the rays of the rising sun were seen to penetrate through the architrave entrance (Fig. 126. 3).

The Abuli complex possesses five or six points (or constructed elements) from which ancient people could have observed astronomical objects and events such as Polaris, the heliacal and acronychal rising of bright stars, and the rising of the sun and moon. If people could have lived around Abuli, then the complex itself could have been used by them for religious ceremonies and observations of the heavenly bodies with the aim of determining and preserving time. If so, then the Abuli

Fig. 126.3 The first rays of the rising sun penetrating the northeast entrance of the Abuli complex, Georgia, June 22, 2011 (Photograph: B. Jijelava)

complex was indeed is an ancient solar station, or in other words, a multifunctional site for ritual and observation.

Armenia

In Armenia, approximately 150 km from the capital city, Yerevan, near the city of Sisian (in the southeast region of the country), is the megalithic monument Carahunge (Zorats Karer). This monument is located at $\varphi = 39°33' 06'' \text{ N}$, $\lambda = 46°01' 44'' \text{ E}$, on the eastern slope of the ridge Zangezur at 1,770 m above sea level. Nearby flows the mountainous river Vorotan, which means "rattling". The average daily temperature of the area fluctuates from +18 °C in July to −6 °C in January.

A mountainous landscape surrounds the monument, but there are open views in the southern direction, and in the other directions the altitude of the surrounding hills does not exceed 7°. The horizon altitude affects the azimuth where horizon astronomical events such as sunrise at summer or winter solstice are observed to occur (see ▶ Chap. 30, "Basic Concepts of Positional Astronomy").

Carahunge consists of more than 150 standing stones (menhirs) (Fig. 126.4), oriented in definite directions with a symmetry that is clearly visible. The extent of the complex is about 250 m. Scores of stones have already fallen down, but the main part of the complex has been well preserved. The height of the menhirs varies from 1 to 3 m. The monument comprises a central dolmen surrounded by a slightly distorted circle of standing stones and additional constructions in the form of rows running northward and southward, and an avenue running out toward the northeast.

The specific geometry of the complex probably points to it being of astronomical significance (but see also ▶ Chap. 127, "Carahunge - A Critical Assessment" for a different view). Carahunge has been interpreted as a megalithic observatory (Herouni 1998; Bochkarev and Bochkarev 2005). It is curious that about 80 of the menhirs have round holes (cylindrical openings passing right through the stone) of different diameters located in their upper parts. The stones

Fig. 126.4 The megalithic monument of Carahunge in Armenia (Photograph: D. Lisittsian) (see also Figs. ▶ 9.7, ▶ 127.1)

with such holes are aligned in various directions, including the east, but dispersed over practically the entire horizon. Some of the openings are inclined to the horizontal by as much as 15°. While some of the holes could have been used to sight upon the rising of the sun, moon, or bright stars, the origin has not been determined and it is difficult to exclude the possibility that they may be later additions (Ruggles 2005).

In 2010, a joint expedition of Oxford University and the Royal Geographical Society was arranged with the aim of undertaking a comprehensive study of the monument (Vardanyan 2010).

The expedition supported the idea that Carahunge had an astronomical significance, concluding that the monument is aligned to rising points of the sun, moon, and several bright stars. However, Carahunge may have had a dual purpose, both as a pantheon of some kind (a burial vault of an important person) and as an observational ritual site – a "sky dial" as mentioned above. The complexity but at the same time the simplicity of the monument's construction, with the geometry of disposition of the standing stones and other component elements, points to such an explanation. Its central dolmen, the row of standing stones extending from the south to the north, and the avenue of standing stones to the northeast, opposite an entrance from the southwest, suggests that this monument had a ritual-astronomical significance.

In the Bronze Age, the burial of an important person may well have been conducted in accordance with relevant traditions and protocols that were also connected with the orientation of the person concerned in time. After the burial, the construction acquired a practical purpose. It is quite possible that at corresponding times, for example at midsummer or midwinter, cult ceremonies were arranged accompanied by the appearance of bright heavenly bodies (such as the sun or moon) which served to fix the time. The northeast avenue could have served to indicate sunrise at the summer solstice, while the southwest entrance could have been used to observe sunset at the winter solstice. The rows of standing stones could have been aligned to the risings and settings of bright stars, each

concrete direction being marked by a single stone or a row of stones. This would be consistent with division of time into warm and cold seasons, dictated by the needs of everyday life and subsistence, including the peculiarities of land cultivation. Carahunge still contains many uncertainties, and archaeoastronomical research at this monument should continue.

Cultural Context: Similarities and Differences

The cultures of the ancient peoples of Azerbaijan, Georgia, and Armenia are varied, differing in many ways. They have produced distinctive traditions of folklore, and material, oral, and written heritage. Their languages, architecture, scientific traditions, and modes of everyday life were very different. Their ethnocosmology, reflected in legends, myths, and sayings, architectural constructions, drawings and graphic images, and literary works are diverse and do not carry obvious common traits. However, there are things that unite them.

Firstly, they share the Caucasian region in common, with its characteristic climate and landscape. Secondly, empirical aspects of ancient astronomical practice are manifested in common expressions of what was seen in the sky. Simple stone instruments were built and oriented on the basis of what was seen in the bright and regularly repeated heavenly order.

The brightest heavenly body – the sun – united the ancient peoples of the Caucasus. Images of the "boats of the sun" in the mountains of Azerbaijan, "solar stations" on the mountain summits of Georgia, and the "sky dial" in the mountains of Armenia indicate that, in the Neolithic and Bronze Age, the ancient Caucasians worshipped the sun, met and celebrated the solstices, and oriented themselves in time by repeated solar events. In other words, there was much that was different but also much in common, and this unity through diversity is evident as regards the astronomical traditions of the ancient cultures of peoples of Azerbaijan, Georgia, and Armenia. We have described here only a few constructions, but there are many more Caucasian artifacts of interest to archaeoastronomers.

Cross-References

► Basic Concepts of Positional Astronomy
► Carahunge - A Critical Assessment

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Digital Projection of Ancient Astronomical Heritage

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Abstract. This paper discusses the problem of cataloging and preserving old astronomical heritage manuscripts. Examples of old astronomical materials and new initiatives are presented.

1. Particles of Knowledge

Astronomy, as a representative of exact sciences and as a cultural phenomenon, played an important role in development of the mankind. The ancients observed, fixed, remembered, predicted, and, "grain by grain," collected "particles of knowledge" about the Universe. The repetitiveness and regularity of the celestial phenomena had great influence on ancient people, making them return to contemplation of the world of the stars from night to night. Walking on the path of accumulating the knowledge, ancient man tried to understand his role in the Universe. This comprehension was formed over millennia, having passed the distance from primitive megalithic buildings constructed in the context of the heavens to multi-volume star catalogs and atlases. From contemplation to observation, from passive fixation to interactive communication, from watching to measuring—is an evolutionary process on the way to understanding the Universe. "Communication" of ancient man with the world of stars was accompanied by the following basic processes:

1. accumulation of empirical knowledge;
2. formation and development of instrumentation;
3. formation and development of centers of observation, observatories, and research institutes;
4. accumulation of observational experience, relevant skills, and abilities; and
5. invention and development of methods for registration and storage of information.

These synchronous and complementary processes, along with parallel development in other spheres of knowledge and mathematics, led to the regulation of a general process of cognition and formation of the fundamental bases for scientific ideology. Observed phenomena demanded general description, systematization, and formation of

fundamental theories. These complicated processes of evolution in scientific ideology demanded great effort and time.

Now, in the 21st century, mankind's path of development is far more evident. However, many problems remain, including the issues of development of relevant fundamental theories on spreading regular knowledge, including astronomical knowledge. Cultural heritage of different kinds and forms, written and printed materials, other relicts of scientific findings can shed new light on the development of the ancient science of astronomy and mathematics. Ancient astronomical treatises, texts, schemes, and tables, are not only carriers of the scientific information proper, but also "reflectors" of the ways for transmission and distribution of knowledge from culture to culture, from continent to continent, from the past to future. Not many of these ways are studied and, sometimes, are even forgotten. Digital data storage technology is also a very important aspect of the astronomical heritage protection problem.

2. Astronomical Manuscripts in Georgia—an Electronic Book

Georgia is an ancient country in the far east of Europe dating from the 7th century BC. The original language and alphabet, literature, music, architecture, applied arts, and oral folklore are just a few of the important parts of the ancient Georgian culture. An organic part of Georgian cultural heritage is ancient philosophical and cosmological theories, material relicts—a witness of the ancient process of comprehending the surrounding world. An important part of ancient Georgian cultural heritage is direct and indirect indicators of the astronomical science, artifacts—material incarnations of the process of evolution in astronomical knowledge. Relying on this conceptual view and gathering together the facts, documents, theories, and hypotheses, we conclude that ancient Georgians followed the traditional path of development of astronomical ideas. This way involved accumulation of empirical knowledge, development of instrumentation, foundation of institutional centers of science, accumulation of observational experience, registration and storage of information, etc. In other words, the development of astronomical ideas in Georgia went in a traditional way from megalithic constructions to optical telescopes.

The territory of Georgia is rich in diverse artifacts that demonstrate the relationship ancient people had with the celestial bodies. The ancient people built and used different stone buildings to observe celestial objects. They reflected the observed phenomena in primitive schemes and ornate pictures cut or carved on stone surfaces. Oral Georgian folklore, legends, and tales reflect ethno-astronomical ideas of ancient Georgians (Simonia et al. 2008). This material is quite scattered, and much of it is lost or poorly studied.

Along with the development of universal human ideas and the formation of ethno-cosmological ideas and accumulation of empirical knowledge, a gradual transformation of the "interaction" of ancient man with the world of stars was taking place. In ancient Georgia, this process was stimulated by the formation of an original alphabet and the appearance of a tradition of written documentation. Ancient Georgians started to write down observed celestial phenomena on skins and later on paper. This became the basis for the formation of a unique layer of ancient Georgian written materials on astronomical and cosmological topics. Original Georgian astronomical treatises, cosmological models, descriptions of instruments and observations, and calendars of different types began to appear. Today all these manuscripts and volumes are in various states of

preservation. Classical Persian and Arabic astronomical treatises, works of theoretical and practical significance were translated into the Georgian language (Fig. 2). The earlier Middle Ages were also marked by the appearance of Georgian translations of philosophical-cosmological and calendar-chronological works of Basil the Great, Gregory of Nyssa, John of Damascus and other brilliant representatives of Byzantine culture.

Digital reproduction and storage of ancient astronomical texts and artifacts has high importance. More than 15,000 manuscripts in the Georgian, Persian, Arabic, Greek and other languages are preserved in different universities, libraries, and scientific centers of Georgia. Georgian manuscripts embrace the period of the 5^{th} to 19^{th} centuries and contain original Georgian texts and foreign materials translated into the Georgian language. These manuscripts are quite extensive in their content. The collections preserved in the centers mentioned above contain religious, scientific, literary, and mixed works. The manuscript materials also involve different chronicles, historical notes, descriptions of different events, and instruction material, maps, tables, diagrams and pictures. Among the scientific materials we encounter astronomical, astrological, mathematical, geographical and other works and their fragments. The manuscript materials of astronomical character are in the form of completed treatises and works, or in fragments in the form of separate chapters or parts of chapters. The mixed manuscripts often contain astronomical and astrological fragments. Astronomical material, preserved in the scientific centers, includes from 300 to 400 manuscripts, including original works or translations into Georgian language; approximately 60 Persian and Arabian astronomical materials are in the form of treatises, manuscript books and their fragments. Assessments of the number of manuscripts are approximate and can change with time.

The physical condition of materials is diverse. There are manuscripts preserved in good condition, but a significant fraction of the manuscripts have been damaged by time, and demand restoration and conservation. Taking into consideration the fact that Georgian manuscripts are preserved in the scientific centers and libraries of other countries, including Greece, Egypt, Great Britain, France, Germany, Russia, etc., it should be stressed that: (1) Georgian astronomical manuscripts, scattered in the different centers, were never subject to systematic registration; and (2) the astronomical content of these manuscripts has not been studied in detail; these manuscripts were only subject to general philological and historical analysis. The methods of analysis of ancient astronomy and mathematics have not been used in regard to them yet, with the exception of several astronomical works of the 13^{th}–18^{th} centuries (Abuladze 1990).

With the purposes of virtual organization of scattered manuscript materials, rapid analysis of unknown astronomical works, formation of short descriptions of unknown manuscripts, and simplification of access to the materials for scholars of different countries, we initiated a special project called "Astronomical Manuscripts in Georgia." The main result of this project was formation of the interactive database/electronic book of unknown or insufficiently studied astronomical manuscripts preserved in the scientific centers of Georgia. The key goals of this project were: (1) investigation of unknown or insufficiently studied Georgian, Persian, and Arabic astronomical manuscripts to reveal their scientific significance; and (2) preparation of catalogues of manuscript materials for the electronic book (interactive database) as a reference source, which, in turn, will stimulate further study of these unknown manuscripts. The results of this project are:

1. description and explanation of the content of unstudied and insufficiently studied Georgian, Persian, and Arabic astronomical manuscripts;
2. revealing of scientific data, viewpoints, methods, facts and names important for ancient astronomy in the studied manuscripts;
3. revealing of hitherto unknown astronomical manuscripts; and
4. formation of reference sources for further research (electronic book, website, and printed publications).

The electronic book/database by I. Simonia et al. (2015) "Astronomical Manuscripts in Georgia" was published by Ilia State University Press (Tbilisi, 2015). It was published on DVD discs in the Georgian and English languages. This edition contains descriptions, bulletins, images, fragments, and full texts of little studied and unknown Georgian, Persian, and Arabic astronomical manuscripts of the 9th through 19th centuries. It was the first edition of its kind based on digital technology.

3. Well-known and Little-known Astronomical Heritage Manuscripts

We analyzed more than 400 astronomical, cosmographic, and mixed Georgian, Persian and Arabic manuscripts. More than 300 Georgian and about 60 Persian and Arabian astronomical manuscripts are preserved in the Tbilisi National Center of Manuscripts, in the State Archives, museums, and libraries of Tbilisi, Gori, Kutaisi, Akhaltsikhe, and other cities. These astronomical treatises embrace the period of the 9th through 19th centuries and are written in the ancient Georgian language, late medieval Georgian, and in the Persian and Arabic languages. The material, on the whole, is scattered and involves both theoretical works and complex observational data. These manuscripts in particular are dedicated to descriptions of cosmogony theories, elements of spherical astronomy, various systems of calendars, astronomical instruments, star catalogs, etc. These manuscripts give detailed descriptions of different celestial phenomena, both of regular character and also rare phenomena, including eclipses and appearances of comets. These materials list bright and dim stars, groups of stars, and constellations.

Astronomical manuscripts, surely, are often accompanied by astrological material with different predictions and prognoses. The greater part of the Georgian astronomical manuscripts are anonymous, i.e., authors, translators, or scribes are not specified. However, we also encounter materials by known authors. In the Georgian manuscripts the geocentric views, church calendars, and practical instructions on observation of celestial bodies are common. Many Georgian astronomical manuscripts are included in more general papers and works, primarily of religious nature. Besides these, purely astronomical works, treatises, descriptions, and tables are most common. There are many original Georgian materials and translations. The Persian and Arabic astronomical manuscripts, preserved in the scientific centers of Georgia, are of later period, and describe the issues of cosmogony, practical astronomy, and chronology. All of these have been insufficiently studied, but the centers and archives of Georgia also preserve quite well-known works, including the treatise of 13th century Georgian philosopher and astronomer Abuserisdze Tbileli, and the treatise of 11th century Arabian astronomer Al Sufi, the "Book of Fixed Stars."

Modern digital technologies have great potential for preserving and distributing astronomical heritage records, copies of manuscripts, and images of artifacts. The data

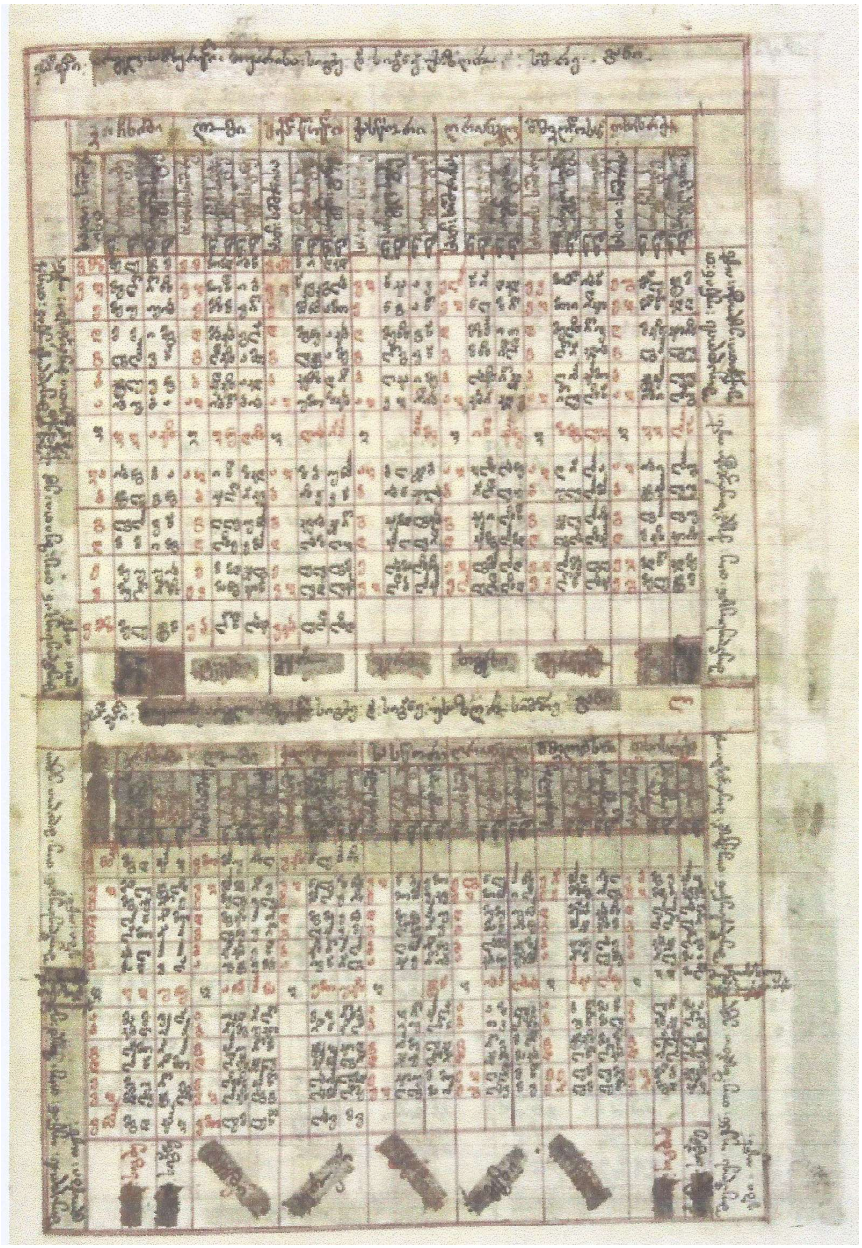

Figure 1. Ulughbeg, Star catalog. It was translated into Georgian by the king of Georgia Vakhtang VI Bagrationi in the 18th century.

storage platforms must be widely accessible, large in capacity, and simple to navigate. Websites, FTP servers, and DVD discs are the best platforms for astronomical heritage data storage. On this basis, we also suggest creating a special electronic visual atlas "On the Meridian of Ancient Astronomy." It must be a large electronic database of unknown or little-studied astronomical heritage materials, including cosmographic images on material artifacts (metal, glass, jewelery), archeological artifacts (stones), and

manuscripts with old astronomical drawings and schemes. The main principles of visual data regulation will be: (1) one entry per item—one file with images, brief textual descriptions, and references; and (2) all data ordered by their geographic features (the meridian of data origin). Such an electronic atlas will be a valuable source of data for researchers and students for teaching and research.

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DVD Database Astronomical Manuscripts in Georgia

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Abstract. Little known and unknown Georgian, Persian, and Arabic astronomical manuscripts of IX-XIX centuries are kept in the centers, archives, and libraries of Georgia. These manuscripts has a form of treaties, handbooks, texts, tables, fragments, and comprises various theories, cosmological models, star catalogs, calendars, methods of observations. We investigated this large material and published DVD database Astronomical Manuscripts in Georgia. This unique database contains information about astronomical manuscripts as original works. It contains also descriptions of Georgian translations of Byzantine, Arabic and other sources. The present paper is dedicated to description of obtained results and DVD database. Copies of published DVD database are kept in collections of the libraries of: Ilia State University, Georgia; Royal Observatory, Edinburgh, UK; Congress of the USA, and in other centers.

1. Introduction

Astronomical manuscripts usually involved wide textual descriptions, numerous tables detailed images and schems. Manuscripts reflected progress of the astronomical knowledge, new discoveries and theories, information on modern instruments. Numerous astronomical manuscripts preserved in universities, libraries and archives, which present to us old systems of universe, theories on movements of luminaries, stellar catalogues, calendars, constructions of astronomical instruments. The works of Hipparchus, Ptolemy, Al-Biruni, As-Sufi, Nassir Al-din Tusi, Regiomantanus, Copernicus, Tycho Brahe, Kepler, Galileo Galilei, William Herschel and others, which today are still the object of public interest and comprehensive research, have become known just through the manuscripts and their dissemination. Astronomy and mathematics since time immemorial have developed in Georgia as well. The Georgian manuscripts containing astronomical and astrological information have reached us in the form of separate manuscript books, collections, documents and fragments of various contents and volumes. The material of astronomical content, both original and translated represents extended texts, tables, drawings and their complexes, which are written in different Georgian alphabet – Asomtavruli, Nuskha-Khutsuri and Mkhedruli. Especially should be noted the manuscripts containing some Georgian works: the paschalistic work (X c) of Ioanne-Zosime on Byzantine and Georgian calendar systems, which is involved the Sinai collection; the Treatise of Abuseridze Tbeli (or Abuserisdze) dated by 1233 "Complete Choronikon" (Figure 1); astronomical comments (XII c) of Ephrem Mtsire

supplied to his translation of Gregory the Theologian's work "Sitkvani"; and others. This large massive of scientific information is preserved in different scientific centers and antiques depositories in Georgia and other countries. Hundreds of Georgian astronomical manuscripts are still unknown or unstudied from the scientific viewpoint. In corresponding descriptions, in frequent cases, are pointed only names of the works and the list of evidences, their incomplete or non-exact annotations. These manuscripts (astronomical, cosmological, chronological), which probably involve unique data, facts, fundamental works, have not been analyzed by the specialists of astronomy history. The Georgian astronomical manuscripts often are of mixed character and involve some mixture of astronomy and astrology. Majority of these manuscripts are not deciphered, their astronomical importance has not been studied. They are unknown for a wide community of researchers. It should be mentioned here that the Georgian manuscripts of this type are preserved abroad, namely, in Greece, France, Great Britain, Egypt, Russia, and in eastern countries as well. More than 60 Arabic and Persian astronomical manuscripts (XV-XIX cc) are preserved in the National Center of Manuscripts. They involve the works of medieval classics: Nassir Al-Din Tusi, Ulugh Beg, Ali Qushji, Al-Balkhi, Al-Andalusi, Al-Birjandi, Al-Rumi and others in Arabic and Persian languages. Many translations from the oriental sources are presented in the Georgian antiques depositories.

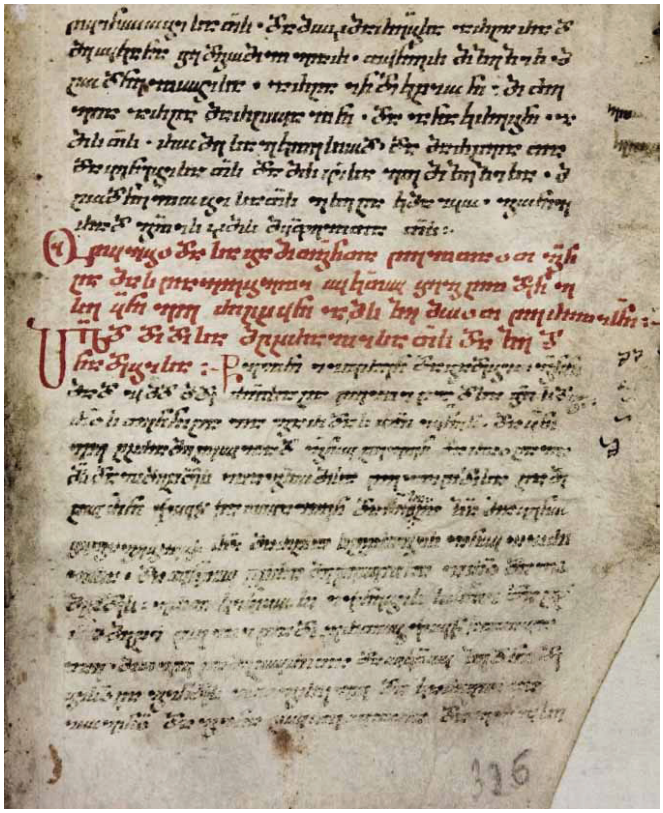

Figure 1. The fragment of "Complete Choronikon" treaties of Georgian astronomer and writer Abuseridze Tbeli, XIII century (GAM 5).

2. The Project "Astronomical Manuscripts in Georgia"

Manuscripts of different content, history and periods are preserved in scientific centers, libraries, archives and museums of Georgia. The manuscripts of scientific, religious, socio-political and other content mostly belong to Late Antiquity, the Middle Ages, Renaissance and Enlightenment. The manuscript materials preserved in the centers and libraries differ with their volume and quality of protection and are written on parchment and paper. The structure of this material can be characterized by two main elements, namely, textual, and graphical-illustrative materials. These two elements often are organically merged in the manuscripts and fill each other – the texts are equipped with illustrations, drawings and schemes of different type, which are supplied to the textual explanations. Quite an important part of the manuscripts preserved in the depositories of antiquity of Georgia are manuscripts of the scientific content. This segment is widely presented with the exact sciences, geography, and medicine. A great number of manuscripts involves mixed material and is complex in its character – within one book, work or supplement we can, probably, come across religious, literary, scientific, political texts, materials on everyday life. The mentioned manuscript material reached us both in the original form and of late copies, in the process of formation of which a certain part of original forms and texts were either lost or enriched. The works or other material preserved in the manuscripts, in frequent cases, are anonymous. They are studied well from the codicological-philological viewpoint. Their subject research as of the monuments containing scientific material was not done as it was necessary. On the whole, study of manuscripts, apprehension of their importance, was mostly done from philological, linguistic history. Therefore in most cases, rich manuscript heritage is not comprehended from the viewpoint of exact sciences. It should be specially mentioned that the texts are published at high professional level and represent the most important step for their further comprehensive research. The depositories of antiquity of Georgia also preserve manuscripts in Persian, Arabic, Greek and other languages. This material is characterized with complex and diverse structure, involves both religious and secular works, material involving scientific information, historical documents, notes, comments, etc. On the basis of analysis of the general picture and the results of astronomical science development, we came to the conclusion that special attention should be concentrated on astronomical manuscripts as the monuments containing scientific information and unique data. We apprehended and established the main tasks and prepared the scientific project "Astronomical Manuscripts in Georgia". The project was implemented in 2012-2015 years. We shall list main scientific centers and depositories of Georgia, in which are kept astronomical manuscripts of different period, different content: National Center of Manuscripts (Tbilisi), National Archives of the Ministry of Justice (Tbilisi), Library of Parliament of Georgia (Tbilisi), Historical-Ethnographic Museum (Kutaisi), depositories of antiquity in Gori, Akhaltsikhe, Zugdidi, Telavi, Batumi. In parallel with astronomical manuscripts in the centers mentioned above are also preserved the manuscripts of allied branches, physics and mathematics.On the whole, we described the Georgian astronomical manuscripts in general, without detailed analysis, explanations and interpretation; we looked through almost 3,000 originals. All this cultural layers and each separate manuscript (except some of them) demands deep scientific analysis. The Persian and Arabic astronomical manuscripts preserved in the depositories of antiquity of Georgia did not become the subject of historical-scientific study, which is also quite topical and urgent. Proceeding from the factors cited above, the main purposes of our project were outlined:

1. Research, systematization of the astronomical manuscripts preserved in Georgia, involvement of the data into scientific circulation, publication of the interactive database; research of unstudied or partially studied Georgian, Persian and Arabic manuscripts and determination of their scientific significance;

2. Study of unknown astronomical manuscripts revealed in the process of research;

3. Catalogization of the material, which will form the basis, reference-source, for their further deep and comprehensive study.

We expect to reach the following main results:

1. Primary general systematization of the Georgian, Persian, and Arabic astronomical manuscripts preserved in the centers of Georgia;

2. Primary scientific description of this material;

3. Discovery of unknown astronomical manuscripts and their scientific description.

4. Publication of the interactive database on DVD disc, which involve a complex of the material and textual, graphical documents, bulletins, images, information, etc.

It should be mentioned that the sphere of our interests involved also the material of allied sciences (especially, physics), which contain astronomical information. We elaborated special methods for their express-analysis and systematization, outlined and worked out main structure of the planned database, with the detailed components and integral parts. All this was theoretically substantiated, apprehended and described. In the very beginning of the project implementation we distinctly felt well-known difference between theory and practice, namely, we came across much more complicated, irregular, scattered and, certainly, less studied material. A technical side of realization of the set tasks appeared beyond expectations. In other words, the degree of complexity of set tasks turned to be much higher than it was expected. Within three years we conducted express-analysis of more than 300 Georgian and more than 60 Persian and Arabic astronomical manuscripts from the several centers. Within the project interest we did not study the material of Telavi, Batumi and Zugdidi museums for the reasons independent of us. It should be mentioned neither the private collections appeared in the area of our research. Private libraries and archives, collections of documents and manuscripts were also unavailable for us. According to the published data, the Georgian astronomical manuscripts are also preserved beyond the borders of Georgia in the libraries, archives and museums of different countries. Unfortunately, with rare exceptions, our possibilities failed to include the material preserved in mentioned countries into the present project. Let us pass to description of some important Georgian, Persian and Arabic astronomical manuscripts, which we analyzed and catalogued. The substance Georgian astronomical manuscripts is quite wide and irregular. Georgian manuscriptsare written in Asomtavruli, Nushka-Khutsuri, and Mkhedruli letters. The Georgian alphabet passed three stages of development: Asomtavruli (rounded) is the oldest type, in which epigraphic and manuscript texts are done in V-IX centuries; Nuskha-Khutsuri (angled) – was used in parallel of Asomtavruli from X century; these two types of alphabet are mostly used in religious manuscripts; according

to the manuscript tradition, Mkhedruli, i.e. modern Georgian alphabet is in X-XI centuries and, mostly, was used for secular texts. To separate some definite places in the manuscript text (from IX century) was used red writing paint – singur (HgS), mixture of mercury and sulfur. Singur was used signs designating the text beginning and the end, titles and upper letters were written in singur, in some cases, also paragraphs, and great part of the text, colophons and postscripts, comments and explanations, etc. Under Georgian astronomical manuscripts we mean: Manuscripts of purely astronomical content; Expanded and short astronomical fragments, included into religious, secular and mixed type manuscripts; Separate extracts or scattered pages of astronomical content, which have no beginning page of any authorized note; Collections of different, often of mixed, type, which involve astronomical section or completed astronomical work; Astronomical and astrological works, in which astronomical content prevails. The most voluminous are manuscripts of second category. Material of this type is most frequently met in separate works, also collections of religious character. In such manuscripts, logical succession of religious or religious-philosophical chapters quite often breaks unexpectedly with astronomical supplements or additions – in the form of a separate chapter, short text or, even, a table or picture. The manuscripts of this type are numerous in out depositories. We considered them as regular astronomical works, though pointed that they belonged to broader context. The added to them a catalogue number and implied the whole work entire expanded manuscript. Respectively, quite a great amount of religious manuscripts are placed in the catalogue, only fragments of which or some pages are purely astronomical material. Majority of astronomical manuscripts are not authorized. It seems that in the Middle Ages in frequent cases such tradition existed – not to mention author or translator, often neither the copyists. However, it is clear that there are such Georgian astronomical treatises, textbooks, observation instructions, etc, authors or translators of which are unknown. To old Georgian astronomical material belong the works of cosmological character, treatises in practical astronomy, also the material, which presents description of celestial sphere and movement of luminaries, instructions for observations and notes for preparing the astronomical instruments, calendar-chronological treatises, different religious calendars, description of rare astronomical phenomena, almanacs, etc. Georgian astronomical manuscripts can be grouped as follows:

1. purely astronomical researches, descriptions;
2. notes on use of special methods, instruments, results;
3. textbooks and instruction material;
4. general educational texts.

Many Georgian astronomical manuscripts are translated from Greek, Persian, Arabic and other sources. We have Georgian original astronomical manuscripts as well – treatises, descriptions, tables and textbooks. The degree of their preservation differs. We placed into the catalogue 300 Georgian astronomical manuscripts. However, the certain part of the manuscripts, are not in the catalogue due to of the certain reasons, some of them were not available, some others were a full copy of the old material; origin, text content, etc of some manuscripts, was uncertain. We can say the same about the Georgian astronomical manuscripts preserved in Gori and Kutaisi depositories of antiquity. In frequent cases we used digital copies and microfilms of the

manuscripts preserved beyond the borders of Georgia. Scientific profile of the Georgian astronomical manuscripts can be determined thus: majority of them, more or less, directly or indirectly are connected with old cosmological ideas, theories and models, calendar-chronological systems, educational-practical means of spherical astronomy. In old times, till late Middle Ages in general comprehension of the world Georgians give preference to geocentric system, Calendar-chronological systems, methods and theories are, mostly, concentrated on religious interests and are connected with strengthening of the Orthodox church rule, customs and traditions by means of time recording, chronology. We should mention in regard to this, as it seems, purely Georgian phenomenon from the group of Georgian manuscripts, which are called "Jhamni". In these collections distinctly elaborated calendar system determines strict, legalized in time succession of Orthodox ceremonies, dates of Christian holidays and other important events connected with the church life. At the same time, these collections involve practical astronomical material, dates of rise and set of luminaries, names of stars and their location, characterization of rare astronomical phenomena. A clear example of teaching-practical textbook is the Textbook of Astronomy, compiled by Vakhtang VI Bagrationi, King of Georgia (Abuladze 1990). The present course concerns wholeness of the world, methods of astronomical observations, evidences on luminaries, etc. In some Georgian astronomical manuscripts we come across elements of ethnoastronomy, which contain legends and narrations on the sky, folk names of bright stars, sayings and stories connected with rare astronomical phenomena. From this viewpoint specially mentioned should be the information reflecting ethnoastronomical knowledge proved in "The Knight in the Panther's Skin" of Shota Rustaveli, medieval Georgian poet and thinker (Tevzadze 1979). Georgian astronomical manuscripts of XVII-XVIII century differ with more scientific depth, there appear, namely, more exact theories, descriptions and data, more modern scientific interpretation of phenomena, which corresponds to general contemporary scientific achievements in the world; also appear translations of textbooks in physics, in which astronomical and cosmological elements are presented in abundance. Of special interest is the X-XIII century old Georgian astronomical manuscripts. To this unique material we should attribute the translations of cosmological sections in the works of Basil the Great, Gregory of Nyssa, John of Damascus, done by Giorgi Mtatsmideli, Ephrem Mtsire, Arsen of Ikalto; also calendar-paschal work of Ioanne Zosime, calendar-chronological work of Abuseridze Tbeli "Choronikoni Sruli Misita Sautsqeblita Gangebita". To the study of old Georgian astronomical materials were dedicated the works of Tskhakaia (1959), Kharadze (1958), Giorgobiani (1965, 1971), Chagunava (1986), Abuladze (2009), Simonia (2001, 2004). The study of Georgian manuscript heritage we conducted showed quite complicated and, in some cases, contradictory picture: the Georgian manuscript heritage involves interesting and, at the same time, practically unstudied astronomical material. It is mentioned in the work of Jones (1996) that Byzantine astronomy, to a certain extent, was astronomy of manuscripts. In our opinion, the same can be said about old Georgian astronomy. On the basis of results of our studies we prepared and published the interactive database – "Astronomical Manuscripts in Georgia" (Simonia et al. 2015). This database contains rich textual and graphical information, catalogues, tables, instructions, full texts, and etc. Georgian astronomical manuscripts contain a main part of the database and have the index GAM – Georgian Astronomical Manuscripts. The following Georgian astronomical manuscripts require special attention:

GAM 3 – "Gardamotsema" of John of Damascus;

GAM 6 – mixed collection;

GAM 11 – collection: Sulkhan-Saba Orbeliani – "Teaching Described by Explanation", Khelta, church and indiction evidences, calendar in verse;

GAM 13 – Davitni/Book of Psalms, "Mtsketa Manuscript", is supplied with calendar-paschal fragments;

GAM 17 – "Katighoria Simetne", translated by Cathalicos Anton I;

GAM 22 – Concise Physics, translated by Cathalicos Anton I;

GAM 24 – Sulkhan-Saba Orbeliani "Sikvis Kona" ("Bunch of Words");

GAM 30 – Georgian translation of Nasir ad-din Tusi "Teaching Book of Astrolabe";

GAM 32 – Synaxarium;

GAM 39 – "Dialectics" of John of Damascus and commentator works of Amonius Ermia;

GAM 42 – Synaxarium;

GAM 51 – Astrological-astronomical collection;

GAM 53 – Baumeister's Physics, translated by Cathalicos Anton I;

GAM 58 – Ulugh Beg, "Ziji – Star Catalogue", translated by Vakhtang VI;

GAM 61 – Collection;

GAM 66 – Vakhtang VI, Kvinklos;

GAM 67 – Collection;

GAM 72 – "Hydayat Al-Nujumi Ű Book of Stars", translated by Vakhtang VI;

GAM 83 – "Sakme metsniereba mzisa da mtovaris shetqueba (shetqoba)";

GAM 96 – the Moon Cycle;

GAM 98 – Short narrations about life of old philosophers;

GAM 102 – Menaion;

GAM 106 – Gulani of Svetitskhoveli;

GAM 140 – Horologion;

GAM 167 – Mtvaris Msrboloba (The Moon Movement);

GAM 170 – Astronomical-astrological treatise "For Passover";

GAM 172 – Physics of David Batonishvili (Prince David);

GAM 178 – Astronomy;

GAM 207 – Calendar-liturgical and dogmatic collection;

GAM 222 – Epimerte or Astronomy;

GAM 224 – Horologion;

GAM 242 – Church calendar;

GAM 252 – Concise Physics, translation of Chr. Wolf's "Physics" by Anton I;

GAM 266 – Sin 34, Liturgical collection;

GAM 296 – Collection: Basil the Great, Gregory of Nyssa, Gregory the Theologian, Athanasius of Alexandria, etc.

We enlisted here almost 12% of those Georgian astronomical manuscripts, which are in the catalogue. We consider that this old material can appear to be most interesting for the research of medieval astronomy of East Europe, Near and Far East. These old manuscripts should add a new layer to the history of Georgia-Byzantium, Georgia-Persia cultural and scientific relations. We separated the above-listed manuscripts by out subjective criteria as well. Taking into consideration inhomogeneous character of the manuscript heritage we recommend the scholars working on these topics to familiarize with complete content of the catalogue of Georgian astronomical manuscripts. The collections of National Center of Manuscripts preserve also Persian and Arabic astronomical manuscripts. Within the present project we analyzed the Persian and Arabic astronomical manuscripts of different content, volume and level of protection. It is interesting material, which is also unstudied from the viewpoint of history of astronomy. Majority of these manuscripts is later copies of the classical works of Oriental astronomers and mathematicians. We come across unknown authors and anonymous works as well. The astronomical manuscripts written in the Persian and Arabic languages concern the issues of cosmology, spherical astronomy, descriptions of planets and stars, calendar and chronology, angle-measuring astronomical instruments, etc. Widely presented are star catalogues and tables. The degree of protection of these manuscripts is different – from good to the very damaged. Their part was being copied directly in Georgia. In our depositories are preserved the works of such renowned astronomers, as: Nasir Al-Din Tusi, Ali Qushji, As-Sufi, Al-Rumi, etc. This astronomical heritage is also little studied. They could have special importance for research of Oriental astronomy, cultural and scientific relations of Georgia and Oriental countries. According to the results of our research we prepared a second catalogue of astronomical manuscripts, which involves the Persian and Arabic astronomical materials. This catalogue is also presented in the database. These manuscripts received the catalogue index AM – Astronomical Manuscripts. We will enlist some of them, which are of interest:

AM 2 – Ulugh Beg's "Zij"/"Star Catalogue";

AM 10 – Persian calendar;

AM 11 – "Sufficient Teaching of Astrological Science";

AM 17 – Astronomical-astrological work;

AM 19 – Astronomical-astrological work;

AM 22 – Astronomical collection;

AM 28 – Collection of works of Nasir Al-Din Tussi;

AM 34 – Astronomical work of Abd Ar-Rahman As-Sufi: "Book of Constellation Images";

AM 38 – Extracts from astronomical treatise;

AM 47 – Explanation of the celestial spheres. Author – Baha Al-Din Muhamed Al-'Amili;

AM 53 – Issues on celestial spheres, tables, etc.

We cited here 18% of the Persian and Arabic astronomical manuscripts preserved in Georgia. They are selected by our criteria. We recommend the specialists in old Oriental astronomy to familiarize with the complete version of the catalogue. We should mention here that we consider as "unstudied manuscript" the concrete copies, variants and units. The database contains Georgian translations of Armenian and Russian astronomical sources. We conducted laborious work from the viewpoint of catalogization and study of the astronomical manuscripts preserved in Georgia. The results obtained, surely, demand expansion and further deepened research which, we hope, will be realized in the future. We consider the obtained results as the primary analysis of astronomical manuscript heritage preserved in Georgia and efforts to determine from the right course in boundless world of old books and manuscripts dedicated to the stellar universe.

3. The Structure of DVD database

Interactive database "Astronomical Manuscripts in Georgia" involves vast textual and graphical material with relevant descriptions and instructions. The database is supplied with the References, which consists of fragments of the manuscripts in the form of textual quotations and images. The database is equipped with the system of indexes, designated for search of the documents arranged according to the search words. After the "Introduction" and the "tasks and results" is given an instruction about receiving the image of some, especially interesting, important manuscript. Each image is supplied with explanatory inscription. Here are presented the Georgian, Persian and Arabic manuscripts. In the database is given an instruction on the catalogue of Georgian astronomical manuscripts. The catalogue, in its turn, is equipped with short information on a concrete manuscript and a detailed bulletin (for each manuscript). Each bulletin is a text with description of the manuscript and a graphical fragment of the manuscript. The bulletin involves general data of the manuscript and its astronomical description. It also presents to us bibliographical information and relevant index GAM (Georgian Astronomical Manuscripts) or AM (Astronomical Manuscripts). Each bulletin is a PDF file. Then instruction follows on the Persian and Arabic astronomical manuscripts and, also on the additional catalogues (the catalogue of those manuscripts, which are not introduced into the database in the form of informational bulletins). Our interactive database presents full copy (in the JPEG format) of some Georgian, Persian and Arabic manuscripts. These copies are designated for research and non-reproductive purposes. Then the interactive database gives a link on short dictionary of Georgian astronomical terms, in which is given relevant English equivalent of the main term. In the link "Additional Material" one can search for mixed information of different kind. The database presents a short list of internet-resources required for research. The database "Astronomical Manuscripts in Georgia" is published by Ilia State University Press in the form of DVD discs.

4. Conclusion

It is clear that the old Georgian, Persian and Arabic astronomical manuscripts, preserved in the Georgian antiques depositories and yet unstudied, demand deep research

and stage by stage publication. This is multi-aspect issue, which implies interdisciplinary (astronomy, codicology-textology, etc) continuous research. This can be settled only by inter-connected and inter-filling steps, by using the latest modern scientific methods and technologies. With the aim of forming the reliable grounds for settlement of the above-mentioned problem, we have prepared and implemented a special scientific project, the purpose of which was analysis and systematization of the Georgian, Persian and Arabic astronomical manuscripts, preserved in the antiques depositories and scientific centers of Georgia. We have published the database, involving an important source of scientific information for the specialists studying old astronomy; the scientists studying manuscript heritage, lost and unknown scientific data. For the university professors, researchers of different institutes and laboratories, employees of libraries and archives, students of relevant specialties the present database will perform the function of a navigator in the sphere of little studied astronomical heritage. We express hope that the present database will be for you a valuable source of information, which will promote preparation and publication of new scientific works. Researchers can find copies of DVD discs in Libraries of: Ilia State University, Georgia; Byurakan Astrophysical Observatory, Armenia; Royal Observatory, Edinburgh, UK; University of Cambridge, UK; University of Hamburg, Germany; also in libraries of Alexandria, Egypt; Congress of the USA and in other centers.

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Substances of the Ancient Cosmology

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Abstract. Influence of celestial phenomena on the ancient man is described. Processes of creation and development of ancient cosmological notions are considered. Main substances, elements of ancient cosmology are explained.

The surrounding world, its multi-complex and multi-coloured assumption demanded its understanding, comprehension and description. Each element of this complicated picture, each fragment of this endless mosaic have become construction blocks of the process of creation of cosmological notions of the ancient people. Instruments of this process, probably, were observations and permanently growing and strengthening memory. It was necessary only to see and remember. Further on, to these natural functions there will be added registration of what was seen, in the form of primitive pictures, pictograms, hieroglyphs, but this will be later, while in the beginning they only watched, remembered and regulated.

For the ancient people the world, undoubtedly, was complicated, changeable and often hostile. But having seen more attentively, it was possible to recognise its fundamental elements, forms, substances. For the ancient people the earthly firmness was a basis of life, here they were born and died, hunted, gathered fruit, communicated with one another. This firm surface, this endless world of forests and mountains seemed to be ancient immense space. But this firm infinity displayed its bounders in the form of the inaccessible horizon cutting the Earth and the sky surrounding the man always and from all sides. Just this flat firmness has become the first fundamental substance of cosmological system of the ancient people.

For them a flat surface of the Earth has become the centre of the universe, and the ancient people, correspondingly, were component parts of this centre. Many year long experience of contemplation of the surrounding world simply assured the ancient man in that the dark blue dome, the blue cupola, covering the flat Earth everywhere, is a second substance, the most important element of the universe. Now being transparently dark blue, blue, then infinitely black, this dome attracted special attention of the ancient people, as just inside it there appeared and disappeared tiny small, large and enormous sparkles and fires subject to unusually strict and incomprehensible order. And thus the sky became for the ancient people second substance of the universe. They lived on the flat Earth, and were covered above by mysterious azure of the sky. And to see, to be surprised or frightened, always and everywhere, in any point of the flat Earth a man had to look upwards. The flat Earth under the feet and the amazingly complicated sky above

became two basic substances, two media, and categories of cosmological systems of the ancient people.

Visible, but sometime inaccessible border of these media is the horizon, now marine, smoothly spherical, then mountainous, cut by complicated relief. For them, living thousands of years ago, this was evident assumption, here behind the horizon there ended the Earth and started the infinite sky. Here are two important substances of the ancient cosmology, two component elements of cosmological notions of our ancestors– the Earth and the sky. They were born, lived and died, brought up children, developed economy, created, fought, became friends and enemies on the Earth, and were surrounded by the infinite, deep, mysterious sky, regularly changing its colour from blue to black. These two media, firmness under the feet and air transparency above the head, became basic component elements of the world awareness of the ancient people. These elements, certainly, consisted of definite localities or sub-elements, for example, details of the landscape, forest areas, crooked rivers, or clouds smoothly moving in the heavenly ocean. However, these were only details, while main, determined by fundamental substances of the world outlook, world perception, was firm Earth and infinite air dome over it.

Simplicity of the nature is in its complexity. It was clear for the ancient people that the world is far more complicated, apprehension of it resulted from their many year long experience, passive contemplation, active watch and observance over the celestial bodies. They saw and attentively watched the rise and set of the bright celestial bodies: the Sun, the Moon, and the stars. They noticed and remembered recurrent travels in the heavenly blackness of wandering celestial bodies the planets. They were amazed by beauty of thousands of the stars and pointed with surprise, or maybe with horror, to their endlessly recurring names.

Regular recurrence of the heavenly phenomena, strict accuracy of starry performances roused enormous interest in the celestial bodies, the wish to apprehend them, to approach them at least in mind. These multi-coloured discs and spots of various sizes and forms, strikingly bright or dying dim, became the objects of exclusive interest, inspiration and worship of the ancient men. There exists no doubt that multi-faced world of the celestial bodies–the stars and the planets–became the third important substance of the ancient cosmology. It was multi-complicated, diverse, mysterious substance, organically added into the world of the Earth and the sky creating, forming an organic picture of the infinite universe. Thus, three substances, three elements: the earth, the sky, the celestial bodies became three components of cosmological notions of the ancient people, supplementing, enriching, and complicating one another. An ancient man lived in the complex world, as the Earth–a firm basis of his being, was so enormous, now friendly, and then hostile; and the infinite sky turned to be filled with a multiplicity of incomprehensible details, and finally the world of the stars in the sky was so multifaced and innumerable. A man still has to apprehend this world. Intangibly close Earth, fields of stars lacking colours were not understood, studied, described yet. Only general division into media or spheres, into substances or their manifestations dominated in consciousness of the ancient people. The world has still been waiting or had already waited for its description. The ability to remember what was seen; inclination to comparison, thinking with analogies assisted the ancient man in making the first steps along the long way to understand the universe.

He could compare what he saw on the Earth with the heavenly experience. Is not remote light on the horizon a star on the horizon, is not sea azure like the heavenly

veil, and is movement in the sea waters like crossing of the heavenly ocean. They also floated, these heavenly lights, floated in the black ocean of the universe. Burning heat of the nearby bonfire, its bright yellow-orange fire, is not it like the Sun in the sky?

There are a great number of examples of analogies, with only some specification: in the scale of unaware naivety, measured, let us say, from zero to hundred, an ancient man was in the very end at the mark of hundred. At the same time, a rhetoric question arises, where the contemporary mankind is now, at which mark of this scale. Nevertheless, naïve simplicity or simply primitiveness largely contributed to the development of the process of world awareness by an ancient man. Increasing life experience opened more and more potentials to the ancient people, including ability of orientation in space and time, evaluations of distances of closeness and remoteness of events and much more. Mad flame of the bonfire, big and bright, is a close fire, and small light at the horizon is the same bonfire, but far away. Here it is, Earth distance, method of its visual evaluation based on simple life experience. Using his comparative capacities, inclination to analogies an ancient man could conclude that the Sun was a source of light and warmth, it is a close bonfire, and the stars, twinkling in the remote blackness, are far-off bonfires. And one more step was made by the ancient men, to be more exact, a small step, but already to physics of phenomena. It is physical-chemical process we deal with both in the first and in the second cases. As we see, to general division into spheres and media there are added their characteristics, first of all, distances.

World of the stars steadily demanded its classification according to the traits and properties, complexities and simplicities of the phenomena. Here an ancient man faces the question, which would follow him persistently thousands of years after, the question–how to divide! And in this case the ancient people could rely only upon their experience of observation. Day by day, night by night they saw in the sky diversity of the world of celestial bodies, differing from one another by brightness, colour, form, size. In the heavenly depth of the night something blazed and faded, twinkled or piercingly shone, forming a complicated pattern or regular recurrence. There were too many bright and dim stars, let us say, of yellow and red colour. There were also many different discs, smoothly moving in the background of the stars, something was rounded, something prolonged, unexpectedly falling, crossing the dome of heaven. In a word, there were many colours, forms and moves. All this multiplicity of colour was subject to strictness of recurrence, appearance and disappearance, ascending and descending, change of form. Groups, classes should be separated from this complex diversity of colours and relevant places should be attached to them on the stairs of the heavenly order. Complexity of the task could have seen insurmountable for the ancient people, but most likely till the moment when the ancient people did not notice an essential fact. Along with the Sun and the Moon, bright representatives of the heavenly population, in regular performances there participated thousands of other celestial bodies, differing by their brightness!

Consequently, it was possible to divide the entire starry diversity into bright, average and dim celestial bodies. Further on, in each of these classes, there might be formed subclasses, dividing the stars and the planets into rather strict groups according to brightness. Using life experience, transferring it into world of the stars, the ancient people concluded: bright were closer, dim were farther. And here, a scale might be formed of heavenly distances or spheres, implying distancing of objects by their brightness. The brightest heavenly bodies, the closest, hung just directly over the head, average were farther, and the weakly twinkling stars were at big distances, as well as

the far-off bonfire at the horizon. Thus, brightness of the heavenly bodies could become a main instrument in formation of spatial cosmological notions of the ancient people. Bodies–bright and close, the stars–dim and remote–were also substances of the ancient cosmology and were subject to definite hierarchical distribution according to brightness.

Complex regular recurrence of heavenly events was still beyond the point of understanding over the horizon of awareness. But the stars and the planets have already occupied definite places and distances, designated for them by the mind of the ancient man. Thus, the universe could consist of the following substances: hard and flat Earth; the sky, covering the Earth; celestial bodies. In their turn, these celestial bodies were regulated according to their brightness–distances. The picture of starry distribution–heavenly order in the simplest, elementary manifestation–could have the character of distribution of celestial bodies into three main spheres (layers): 1) lower sphere–sphere of the Sun; 2) next sphere over it–sphere of the Moon; 3) next sphere over the Moon–sphere of the planets and the stars. Consequently, the nearest sphere was that of the Sun, where it existed lived, but the most remote was sphere of the twinkling stars, so feeble and inaccessible. Nearby bonfire–the bright Sun shedding light and warmth to the Earth; silvery light of the Moon, higher and more remote, reminded the ancient people to orientate in the enigma of the night; dim light of far-off stars and planets could only remind of complexity of the world and long way and weak bonfires at the horizon.

Any climatic phenomena: rain, snow, hurricane, mute movement of clouds only complicated the picture of the world setting for the ancient people new, difficult to settle, tasks: explanations and apprehension of what was seen. Substances of the ancient cosmology, cosmological categories of the ancient men's thinking have come to us through the millennia, in peculiar forms and types, have reached us on the bearers of relict information: in ancient pictures, ornaments, simplest articles, folklore (Simonia & Simonia 2005; Brandt et al. 2008).

Being transferred from generation to generation, acquiring details, being enriched with experience, they have reached us carrying inside themselves a kernel of relict information on cosmological ideas of the ancient people, on their world awareness and their own role in this infinite world of stars and planets. Development of religions of various forms and types played an important role in the cosmological ideas of the ancient people. In fact the ideas of the ancient people on the world and their religions were bound into a single context, complex cultural alloy of belief, knowledge and experience. Bright celestial bodies and twinkling stars, complexities of heavenly events have become symbols of different deities, which, from the viewpoint of the ancient men, ruled the destinies of individual persons and whole peoples. The ancient men worshipped their gods–mysterious celestial bodies: the Sun, the Moon, and the stars. They watched rise and set of the celestial bodies, and the inexorable accuracy and recurrence of the heavenly events witnessed force, power of these bright discs and dots. Cult ceremonies and observations over heavenly events were bound into a knot of everyday reality of special feasts, being packed into single religiously cosmological order of the ancient people (Simonia et al. 2009).

However, these have not yet been apprehended observations of the starry sky aiming at watching over the behaviour of the celestial bodies, but it was more the passive contemplation of the heavenly events by people, impressed and charmed by the sky, fearing the depth of vast universe. Awareness will come later, just in the moment, when the ancient people will understand that a strict order and recurrence of bright heavenly

events does not only witness force, but essential instrument, natural chance, which can be used for the well being of the mankind. Only one step was before this awareness, the step into the millennium. But as the Earth steadily encircles around the arc of its orbit year after year, century after century, the same with time–this alloy of fancy and reality inexorably moves in mysterious infinity. It is evident from this that this very moment has come; time has come of awareness and interaction. The first step of a man from the past into the future was made.

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Astronomical Significance of Ancient Monuments

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Abstract. Astronomical significance of Gokhnari megalithic monument (eastern Georgia) is considered. Possible connection of Amirani ancient legend with Gokhnari monument is discussed. Concepts of starry practicality and solar stations are proposed.

The bright yellow-orange Sun, as inexhaustible source of light and warmth, played a special role in everyday life of the ancient people. This fiery ball, going up over the horizon, lighted the mountains and valleys with golden light, gave boundless warmth of its wealth to men, animals and plants. Day after day, year after year, century after century, watching the sunrises and the sunsets behind the Sun's smooth movement in the blue of the heavenly ocean, the ancient people noticed inexorable regularity and recurrence in the movement of the Sun. The Sun always rose there over those mountains, but set, surely, behind the remote mark of the water surface, in the opposite direction. It was also noticed that days were different, but now brightly long, then pale short. And the Sun, kept heaving now over this mountain, then over that one. And these transformations and conversions kept repeating and repeating. Experience of the ancient people gradually expanded and deepened, embracing climatic phenomena as well. In particular, they found out, remembered and apprehended that the sunrise in a certain point of the horizon is a herald of long warm days, light and rain. And the sunrise over another point witnessed the beginning of dusk and cold. Ascribing what they saw to divine powers, believing in power of light–the God of the Sun, the ancient people, nevertheless, started thinking how to practically use inexorable regularity and accuracy of movement of the celestial bodies and, certainly, to use this for the benefit of the men. Moreover, already by that time there was behind their back some construction experience of erecting the rough stone constructions and all kinds of their complexes, what we call today megaliths.

Once one ancient morning, I will not be mistaken if I mention–one ancient evening, a man decided to entrap a sunbeam into the trap of his intellect. Talk maybe like this, we shall build here something, it will rise and will be caught into our stone nets, and it will unintentionally tell us what is there in front. It is hard today to evaluate and even more, to prove the details of the initial "interactions" of an ancient man and celestial bodies. In addition to this, multiplicity of megalithic constructions, oriented at significant astronomical points of the horizon, were scattered around the world and this fact is inexorable. Many of these constructions have already been studied within the interests of archaeoastronomy, while many others are not. Now let us discuss just these ones. Not quite far and not quite near, in South Caucasus, the territory of Georgia is rich in archaeological artifacts–stone monuments of different forms and constructions.

Many of them are well studied archaeologically, but are not studied at all by the methods of archaeoastronomy (Simonia 2001). This witnesses that expected astronomical importance of megaliths, complex constructions of the Bronze Age and antique temples of Georgia, has not been studied. This omission should be filled up as soon as possible. An ancient layer of possible astronomical heritage can be organically added to the single circle of the ancient cultures. For example, according to Zukhbaia (1975, p. 32):

> From ruins of fortresses and cities, first of all, Gokhnari megalithic monument should be mentioned in the river Algeti ravine, in 10 km distance from Manglisi, the so-called Yellow mountain slope. The monument occupies 0.25 square kilometre area. To the east of the dwelling there is bank of stones with clefts and tunnels, to the west–ruins of a city and to the west from these ruins–ruins of a fortress. In the centre of the square of buildings there is erected big pillar-like monolith. To the east of the ruins of fortress there is natural rock used as a fence: here we come across four shelters, five dolmens and many clefts and tunnels. The thickness of walls is average 3 metres.

Here should be pointed that the settlement Manglisi is located southwards from Tbilisi in approximately 30 kilometre distance.

According to L. Melikset-beg (1938):

> This dwelling, being one of the biggest city and fortress ruins preserved in Georgia up to now, is located opposite Manglisi, on the other bank of the river Algeti, in the distance of 18 km by the road and 10 km by short way (through Mariamjvari or Sakrisi) from Manglisi, and in 1 km distance from Gokhnari, between the so-called Yellow mountain slope and small water, on the hill, which can be reached only from the north-west. This dwelling of the megalith culture consists of mostly quite big monument, which occupies 1/4 square kilometres and in the centre of which there is seen from all sides an enormous pillar-like monolith. The dwelling consists of 3 main parts, one of which represents a heap of stones with clefts and tunnels eastwards from the centre; second, westwards from this centre–the ruins of a city proper; and third, westwards from the ruins of a city–the ruins of a fortress built on the plan of the irregular quadrangle. The fence eastwards is especially grandiose, by the way, because natural rocks are used for its construction, one of which is similar to two faceted (three-angled in its foundation) counterforts, being just in the centre. Southern fence of the ruined fortress is also interesting with its cylindrical towers, which come down like amphitheatre southwards to the water. In all the three parts of the dwelling there are scattered shelters (about four), dolmens (about five), clefts and tunnels (plenty), pillar-like monoliths in vertical condition.

Small water passes by the ruins of city and fortress to the south-western direction. It is inaccessible from every part, except north-western side, from which the road seems to have been laid towards water and Mariamjvari, on the so-called Yellow Mountain. That is why it is quite understandable that in the legend of Amirani, where the talk is about the tower of Algeti mountain, which, in our opinion, should be just that ruin of city and fortress. By the way, why it is said:

> In an unknown mountain a tower they saw
> Built of crystal stone,

Brothers walked around
Failing to find the door of its.

With a variant:

There was one tower there
Built of steep rock,
Walked we around it three days and nights,
Failing to find the door of its

Or:

On an unknown mountain saw they a tower
Built of crystal stone,
Passed it around indifferently
Failing to see the door of its.

As it was mentioned above, the entire megalith dwelling occupies about 1/4 square km area, and ruins of a fortress hold the following area: length of the northern wall inside is 17 metres, of the southern wall, also inside, 32 metres, by length–average (also inside) 45 metres. The wall width is average 3 metres. Despite poor quality of printing technique of the 1930s, we reproduce here photograph published in the cited work. This is essential as this graphical material reflects the condition of the present monument in the first half of last century.

This megalithic monument is located in the mountains, in difficult to access locality. The monument is structured and consists of the site of an ancient town, fortress, monoliths, dolmens (Figure 1), shelters, cylindrical towers and other elements. In our opinion, this witnesses multifunction character of this megalithic complex. In the Bronze Age there was, probably, located a separate settlement, autonomic and self-sufficient. Here may have lived people of common principles, cultural traditions, cosmological notions, and religions, united by concrete social form. They were born and died, brought up their children, built and destroyed, sowed and reaped, fought for their future. All this kept repeating year after year, century after century. Within this endless order of events, sometimes very much similar to one another as rings of the same chain, cultural notions of these ancient people were being polished and enriched, their knowledge on the sky were being deepened. The construction itself of this megalithic monument, more exactly, its ruins, talk about complex functional peculiarities, importance of each element of the construction. Today, it is too difficult to precisely evaluate, apprehend or feel deeply practical significance of this megalithic constructivism, but probably it may have been this way as well: they lived in different constructions, they buried their dead in dolmens and burial mounds, they buried their riches and ritual articles behind the high and thick fortress walls, and sometimes saved their lives from enemy raids. But pillar-like monoliths, shelters and labyrinths, and other spatial elements of the construction might have served to rather important objectives, namely, to cult and astronomical ones.

The very complexity of this megalith construction, inter-location of monoliths, fences, shelters and other elements witnesses that the ancient inhabitants do not only contemplate the celestial bodies, but masterfully and accurately "caught" the light of far-off celestial bodies. In particular, monoliths and eastern fence are located so that in

Figure 1. Dolmen in Gokhnari (Melikset-beg 1938).

the day of solstices the Sun could rise just behind one of the monoliths (or other elements), and the sunrays of the rising Sun could for definite time penetrate into the fence through the openings into the counterforts. Thus, the ancient people conducted accurate fixation of time. A year or, to be exactly, full time could be divided by them into seasons, warmth and cold, such important stages of their everyday life. A marker of the beginning of this or that season was appearance of the Sun or any other celestial body over or behind definite constructive elements of the complex. In the orientated openings or small windows the ancient people could see, as minimum once a year, light of the remote star or the bright Sun. To make the rays of the celestial bodies penetrate into, designated for this, constructive details of openings, hollows, cuts, accuracy of placing the elements of the constructions of fences, columns, labyrinths should have been quite high. This could have been reached only on the basis of knowing all the precise details of annual motion of the heavenly bodies and, surely by means of preliminary planning, of spatial location of all the elements of the construction. Practical implementation of all these tasks were not impeded either by mountainous relief or weight of cyclopic stones, just on the contrary, the principle–the more the more precise–has worked unmistakably

Thus, this was not simple contemplation. Their knowledge was accurate and regular enough, based on long-term experience of observation, probably, being transferred from generation to generation. These ancient people were not investigators, but they were observers and time keepers of the Bronze. The life itself–fight for existence–forced them to "relations" with the heavenly bodies. Their main and natural device was an eye, and additional instrument was enormous and heavy stone masterfully placed just on the required top of that remote mountain. Here is a starry practicality laying

the way for the ancient people through fiery centuries of merciless history. It could have been naïve simplification to discuss cosmological notions of the ancient people, their astronomical experience out of touch with their religious views. Bright and dim celestial bodies were for them not only guests of the dome of heaven pointing to the way in time, but they, first of all, were different gods, objects of unrestrained worship and respect. It is not difficult to suppose that the most powerful, the strongest and the most important could have been god of the Sun–the brightest from the brightest celestial bodies, gifting light, warmth and hope to the ancient people. Seeing the rising Sun, pricking rays of which penetrated once a year through the cherished opening, the ancient people conducted cult ceremonies and started counting off the time, season of warmth or cold. This infinite sky was the object of their worship and knowledge, the source of their spiritual calmness and human happiness. Their belief and knowledge were bound into the single context of indefinable and much incomprehensible, but exceptionally exact heavenly order. The very essence of the natural landscape created additional preferences forming "fruitful ground" for developing their religious views and astronomical knowledge.

Quite important is the southern side of the monument characterised by existence of cylindrical towers located on the slope and directed to water. Unfortunately, photographs published in the above mentioned work do not give exact information on the form and spatial location of these southern towers. It is too difficult now to judge the functional designation of these elements of the construction. They could have everyday cult or astronomical meaning.

The ancient people left for us stone evidences of their everyday life, belief, knowledge. Was it done unintentionally? Did they or did not they want to leave for us their stone wills?

And though megalithic constructivism clearly witnesses its own self, it, meanwhile, cannot talk. However, folklore have brought to us ancient Georgian legend on Amirani, loudly speaking in the words of thousands of people living in far-off Bronze Age and Antiquity, in the Middle Ages and living now. Amirani, as the ancient people apprehended him, is the son of the Sun. It is considered that the epic was formed in the middle of the second millennium BC (Georgian Encyclopedia 1975, p. 396). What is kept in silence by stone is said loudly by the folk legend. Melikset-beg (1938) turned his attention to this in the 30s of last century. But now, however paradoxical it is, we have also paid our attention to this independently of him. There exists a chance that, thousands of years later, something concealed will still be formed in the evident.

Legend on Amirani has many different variants. Different narrators, reciters, interpreters cite various variations of this ancient epic. On the pages of the above mentioned work there are published small fragments of two variants. Two circumstances attract attention; firstly, the lines of the legend mention the word *broli*, literally meaning "crystal" in modern Georgian. Explanatory dictionary of the Georgian language, compiled by philosopher S. S. Orbeliani (1991, p. 115), defines the word *broli* as "natural white stone". Secondly, in different variants of the epic it was talked that walking around the tower no entrance was found to it. Proceeding from the said above, we suppose that through millennia in the lines of the folk epic there has come to us the information on how an enormous monument laid in white stone was towering above in the mountains in the south of Georgia. Now we see material in the form of archaeological artifact and virtual in the form of poly-syllabic folk epic and one is added to the other. We will try

to expand, enrich our ideas on this monument. We use one more variant of this legend for this (Tsiklauri 2006, p. 27) it is said in particular that:

> In the unknown place they have seen a tower, built of crystal stone,
>
> Walking around it, failed they to find door of its,
> Wherever the Sun shed its light–Amirani with his knee of wolf,
> There a tower opened its door, there was the door of its,
> In the tower a lion was lying, wounded by giants,
> There was a horse at the head, digging ground with its feet,
> To the left a spear stood, its tip cutting the sky,
> To the right a sword stood, its blade being of diamond,
> In one corner–gold and silver, gathered,
> Beside there stood a wife–shedding tears into the sea,
> Having a book of paper, between fingers and fingers.

On the same page it is also said that the brothers came up to the mountains of Algeti and discovered this tower. Analysis of this fragment of the epic, in our opinion, witnesses that this folk substance of the ancient knowledge, being rhythmically united into the single whole, experienced temporal transformation passing through the Antiquity and the Middle Ages, Enrichment of the legend with the knowledge of corresponding epochs witnesses the materials enlisted in these ancient lines, including paper. However, root information, the basis of description itself, is most interesting. Where the sunray fell, there Amirani passed through the open door. This, as minimum, means that in circular construction there was one opening for the sunray. And farther, in the tower, a wounded lion lay, to the left there was a spear, which pierced the sky, and to the right–a sword with a diamond blade. The lion and his armour are symbolic form, indirect instrument of delivering the real knowledge and religious views. This megalithic monument near the settlement of Manglisi was in those far-off times a place where the ancient people lived, a sanctuary, and a site of astronomical observations. Proceeding from the said above, it may be supposed that the ancient people living in this crystal tower worshipped the Sun, measuring the time by the motion of the heavenly bodies and, first of all, by the Sun. Taking into account isolation of this megalithic stand, its mountainous location and taking into consideration chronological notions of its inhabitants, we suggest naming such a monument (and others like it) a solar station. High in the mountains, surrounded by the sky and the horizon, thousands of years ago, there lived people, who worshipped the Sun and counted their time by the Sun, Certainly, there will be found arguments in favour and against, but one thing is obvious, that the solar stations, as the vital territory, as the cult place and the site for astronomical observations could have existed not only in Georgia, but in any other mountainous region of the world, where people believed and lived, watched, opened the pages of a mysterious book of the universe one page after another. To prove or disprove the hypotheses, expressed by us, to clarify astronomical importance of the crystal tower of the Algeti mountains of Georgia, it is necessary to conduct regular archaeoastronomical research of the discussed site.

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РОССИЙСКАЯ АКАДЕМИЯ НАУК

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им. С. И. ВАВИЛОВА

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Сборник содержит ряд статей по проблемам истории отечественной и мировой астрономии и астрофизики. В числе наиболее интересных тем публикаций: история открытия гравитационных волн; история открытия темной энергии; история планетной космогонии и связанные с ней нерешенные проблемы; астрофизические исследования знаменитого российского физика П. Н. Лебедева; история создания величайшего российского телескопа с диаметром зеркала 6 м, введенного в строй в 1976 г. в Специальной астрофизической обсерватории РАН; астрономо-геодезические работы, проводившиеся русским морским штурманом Н. Г. Рубцовым во время первой русской экспедиции в Бразилию в 1821–29 гг. Часть публикаций посвящена жизнеописаниям российских ученых-астрономов в XX в., их исследованиям и порой трагическим судьбам.

Для научных работников, любителей и преподавателей астрономии и читателей, интересующихся историей науки.

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АСТРОНОМИЧЕСКИЕ РУКОПИСИ ГРУЗИИ – МАЛОИЗУЧЕННЫЕ СТРАНИЦЫ СРЕДНЕВЕКОВОЙ НАУКИ

Введение

Звёздное небо оказало огромное влияние на развитие человеческой мысли, на повседневную жизнь и культуру. Наблюдения древними ярких светил, регулярно повторяющихся небесных явлений, редких астрономических явлений во многом сформировало представления людей о пространстве и времени. Накопленный наблюдательный опыт, «багаж» эмпирических знаний обусловили зарождение науки, исследовательской деятельности человека.

Мегалитические конструкции стали первыми площадками для наблюдений небесных явлений. Эти огромные каменные комплексы имели наблюдательное, религиозное и практическое значение. Здесь древние наблюдали восходы светил, поклонялись астральным божествам и отсчитывали время, фиксируя начало сезонов тепла и холода. Освоение человеком новых технологий, изобретение письменности, а также различных механизмов и инструментов ускорили развитие астрономической науки.

Развитие культур древних народов как уникального сплава увиденного, отображенного и изобретенного шло различными путями. Эти оригинальные комплексы человеческих знаний, умений и творчества, столь многообразные в своих проявлениях, оставались едиными в стремлении отразить роль человека

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во Вселенной. Поэтому представление человека о мире звёзд столь едино в своём многообразии. Это хорошо видно при изучении истории астрономической науки. На протяжении многих веков представители различных народов, культур и традиций исследовали каждый по-своему бесконечное мироздание, отражая на своих языках, своими методами увиденное и понятое. Этот разноязычный мультикультурный комплекс знаний един и универсален, он свидетельствует о нашем стремлении к пониманию Вселенной. И тем не менее есть в нем малоизученные страницы, неизвестные древние данные, требующие внимания, систематизации и сравнения с широко известными принципами, понятиями и величинами.

На крайнем востоке Европы находится древняя страна Грузия, расположенная в горах Кавказа у Черного моря. Земледельческий уклад, оседлый образ жизни в немалой степени определили интерес древних грузин к звёздному небу, регулярно повторяющимся небесным явлениям, светилам, освещающим долины и горные тропы. И в данном случае пути развития астрономических знаний древних пролегали от астромегалитов до современных обсерваторий [Simonia, 2011; Simonia et al., 2015a].

В X–XIII вв. в столичных городах Тбилиси и Кутаиси функционировали обсерватории [Simonia, 2001]. Именно к этому периоду относятся наиболее древние известные грузинские астрономические трактаты, труды календарно-хронологического характера. Сегодня нам известны сотни оригинальных и переводных грузинских астрономических манускриптов. Эти средневековые астрономические и космографические труды мало изучены и мало известны научному сообществу. С целью исправления ситуации мы подготовили и издали электронную книгу, или базу данных «Астрономические рукописи Грузии», содержащую сведения об этих манускриптах [Simonia et al., 2015b].

Астрономия манускриптов

В своей работе А. Джоунс [Jones, 1996] отмечает, что астрономия Византии во многом базировалась на рукописной традиции — сохранении и переписывании рукописей, посвящённых различным аспектам астрономической науки. В целом та-

кой подход был распространен и в грузинской астрономии средних веков и Возрождения.

В настоящее время в научных центрах, библиотеках и архивах Грузии хранятся не менее 300 грузинских астрономических работ, датируемых IX–XIX вв. Эти манускрипты в основном анонимные, они являются как оригинальными, так и переводными и посвящены описанию звёздного неба, движению планет, календарю и хронологии, конструированию и описанию угломерных астрономических инструментов. Особое внимание в них уделяется общим моделям Вселенной. Геоцентрическая система мира Птолемея описывается почти в каждом грузинском астрономическом труде вплоть до XIX в.

Астрономические знания, по-видимому, имели особое значение в древней Грузии. Грузинские астрономические труды дошли до нас не только в виде отдельных манускриптов, но и в виде фрагментов, включённых в манускрипты религиозного, литературного и другого характера. Такого рода фрагменты разнятся по объёму и содержанию. Наиболее часто встречающиеся фрагменты имеют календарно-хронологическое и космологическое значение. В грузинских астрономических рукописях имеются также описания созвездий, видимого движения Солнца, Луны и планет, редких астрономических явлений, включая солнечные и лунные затмения, появления комет, и др. Календарно-хронологические системы, лунные и солнечные циклы, точное датирование религиозных праздников рассматриваются почти в каждой из такого рода рукописей. Отдельные их главы содержат различные календари и их фрагменты, пасхальные таблицы, сводки дат, используемых для религиозных и повседневных целей.

Уделялось внимание и астрономическим инструментам, в частности конструкции и технологии изготовления астролябий, методам наблюдений угломерными инструментами. Немало грузинских астрономических манускриптов содержат переводы с греческого, арабского, персидского и других языков. Эти переводы в основном относятся к IX–XVIII вв. В XIX в. были переведены с русского языка труды по астрономии и физике; с греческого — труды Василия Великого (IV в.), Иоанна Дамаскина (VIII в.), и других богословов и философов, содержащие в том числе элементы космологии. С арабского и персидского языков были переведены труды

Насир ад-Дина ат-Туси (1201–1274) и Улугбека (1394–1449), а с русского — работы физика Петра Гиляревского (XVIII–XIX в.) [17].

Помимо чисто астрономических манускриптов, библиотеки и архивы Грузии хранят астрологические сочинения и тексты смешанного содержания, посвященные описанию судеб человека и мира, предсказаниям различного характера и выявлению «корреляции» общественно-социальных событий с астрономическими явлениями. Степень сохранности грузинских астрономических манускриптов очень различна — от весьма повреждённых, с трудом поддающихся восстановлению и консервации, до достаточно хорошо сохранившихся пергаментов. Астрономическое содержание этого письменного наследия изучалось мало и нерегулярно. Работали в основном, специалисты по филологии и общей истории, занимавшиеся лингвистическими и историографическими аспектами проблемы. Можно сказать, что историко-астрономическое содержание этих материалов изучено недостаточно и лишь ожидает глубокого научного анализа.

Происхождение астрономического культурного наследия Грузии вполне очевидно, оно обусловлено функционированием церковных и общих школ, астрономических обсерваторий и библиотек как центров создания, перевода и копирования научных и просветительских трудов [Simonia, 2004]. Международный обмен, взаимообогащение астрономическими знаниями и данными, легко прослеживаются по «путям движения» грузинских астрономических рукописей. В библиотеках и архивах Греции, Румынии, Франции, Великобритании и стран Востока хранятся грузинские астрономические рукописи, также не подвергавшиеся серьёзному научному изучению. Заметное количество астрономических рукописей на грузинском языке содержится в научных институтах и библиотеках России,

[17] Так воспроизводится это имя в грузинской историко-научной литературе. В русской литературе это Петр Иванович Гиларовский (конец XVIII — начало XIX вв.) — преподаватель математики, физики и языков — русского, латинского и греческого — в различных учебных заведениях Санкт-Петербурга. В 1793 году вышел в свет его труд «Руководство к физике, сочиненное Петром Гиларовским, учителем математики и физики в учительской гимназии, Физики в обществе благородных девиц, Российскаго слога и латинскаго языка в благородном Пажеском Корпусе», который включал классические разделы физики, химии, а также астрономию. Перевод на грузинский язык появился ок. 1812–1814 гг. (прим. отв. ред.)

в том числе в библиотеках М. Е. Салтыкова-Щедрина и Института востоковедения РАН Санкт-Петербурга.

Многие грузинские астрономические труды не содержат сведений об авторах или переводчиках, хотя, имена переписчиков или заказчиков копий нередко встречаются на заключительных страницах рукописей. Вместе с тем есть случаи, когда имена авторов известны: к примеру, хорошо известен трактат «Полный Хроникон» грузинского философа и астронома Абусеридзе Тбели (1190–1240) [Кавтария и др., 1998]. Лучше обстоит дело со знанием имён переводчиков и интерпретаторов классических иностранных трудов астрономического, космологического и религиозно-философского характера. Грузинские монахи и философы Георгий Мтацминдели (1009–1065) и Ефрем Мцире (XI в.) перевели классические труды Василия Великого, Григория Нисского (IV в.) и других богословов и философов, отразив основные элементы византийской космологии. Грузинский царь и просветитель Вахтанг VI Багратиони (1675–1737) перевёл на грузинский язык труды классиков средневековой восточной астрономии [Абуладзе, 1990], передав представления о Вселенной в целом, о движении планет, положении звёзд и о методах создания и применения угломерных астрономических инструментов [Георгобиани, 1971], [Харадзе и др. 1958]. Католикос и просветитель Антоний I (1720–1788) перевёл с латинского и русского языков экспериментальную физику Христиана Вольфа (1679–1754) и труды его последователя Фридриха Христиана Баумайстера (1708–1785).

Научные центры, библиотеки и архивы Грузии хранят также оригинальные астрономические рукописи на персидском и арабском языках XIV–XVIII вв. Насчитывается не менее 60 персидских и арабских астрономических рукописей. Часть из них написана или скопирована в Грузии. Среди астрономических трудов присутствуют и классические сочинения Насир ад-Дина ат-Туси, ас-Суфи (903–986), ал-Бирджанди (XVI в.). На страницах этих древних манускриптов рассматриваются звёздные каталоги, движения планет, календари и угломерные инструменты, содержатся космологические описания Вселенной.

Значительная часть этих астрономических манускриптов анонимна, их историко-астрономическое содержание до настоящего времени не исследовано. Первая попытка каталогизации древнего грузинского письменного астрономического наследия относится к середине прошлого века. В частности, Г. Кеваниш-

вили [1951] составил первый каталог (или список) грузинских астрономических манускриптов, хранящихся в различных научных центрах Тбилиси и Ленинграда (ныне Санкт-Петербург). Этот каталог не был опубликован и находится в настоящее время в частных и университетских архивах.

В целом рукописный компонент древнегрузинского астрономического наследия многообразен, достаточно интересен, но весьма разрознен и мало изучен. Древние астрономические манускрипты требуют серьёзного анализа, систематизации и последующей публикации.

Цифровая проекция письменного астрономического наследия Грузии

В университетах, библиотеках и архивах Грузии хранится обширное собрание средневековых рукописей, имеющих астрономическое содержание. Этот уникальный научный материал малоизвестен современным исследователям и в настоящее время труднодоступен. Сама специфика астрономических манускриптов, их форма, разрозненность и нередко интегрированность с другими текстами усложняли доступ к материалу и его полноценный научный анализ. С целью исправления сложившейся ситуации и решения вышеуказанных проблем, объединённая группа исследователей из Государственного университета Ильи и Национального центра рукописей Грузии подготовила и осуществила в 2012–2015 гг. специальный научный проект «Астрономические рукописи Грузии». Он был реализован при поддержке национального научного фонда Грузии — Фонда Руставели. Основными целями проекта были: 1) исследование и систематизация астрономических рукописей, хранящихся в научных центрах и библиотеках Грузии; неизученных грузинских, персидских, арабских астрономических трудов и определение их научного значения; 2) подготовка и издание электронной книги (интерактивной базы данных), содержащей всеобъемлющую информацию о письменном астрономическом наследии Грузии; 3) выявление ранее неизвестных астрономических рукописей с их последующим исследованием; 4) каталогизация рукописного материала для формирования базисной информации для будущих исследований.

В результате осуществления проекта ожидалась: 1) первичная систематизация грузинских, персидских и арабских астрономических манускриптов; 2) первичное научное описание этого письменного наследия; 3) описание неизвестных астрономических материалов и последующая их публикация; 4) публикация электронной книги (базы данных) в виде DVD-диска, содержащего текстовую и графическую информации. В проект предполагалось включить не только астрономические труды, но и работы по космографии и физике. Рукописи астрологического характера, хотя и оставались в «поле зрения» проекта (за счет их астрономического сегмента), но не подвергались изучению и систематизации.

Под исследованием (изучением) манускриптов подразумевался экспресс-анализ древних материалов — общий обзор каждой рукописи и более глубокий анализ наиболее важных ее фрагментов. Из многих тысяч грузинских рукописей, хранящихся в различных научных центрах, библиотеках, музеях и архивах городов Грузии, необходимо было выбрать рукописные материалы астрономического и смежного характера. Таким образом, были изучены более 300 грузинских и более 60 персидских и арабских астрономических рукописей IX–XIX вв.

Проект определил ряд основополагающих принципов формирования структуры DVD-диска. В частности, под астрономической рукописью понимался отдельный авторизованный или анонимный труд астрономического содержания (тексты, таблицы, рисунки), либо фрагмент, включенный в рукопись религиозного или светского характера.

В рамках проекта были изучены рукописные коллекции различных центров, главных библиотек, музеев и архивов городов Тбилиси, Кутаиси, Гори и Ахалцихе. К сожалению, по техническим причинам коллекции музеев Телави, Зугдиди и Батуми, а также архива Кутаиси, не были проанализированы. Эти хранилища письменного и печатного наследия могут содержать древние астрономические материалы. Уже в начале реализации проекта обнаружилось, что структура письменного астрономического наследия Грузии сложнее, чем предполагалось изначально. В связи с этим проект претерпел некоторые изменения и модернизацию. Не все из поставленных задач были решены или развёрнуты. Однако основные цели проекта достигнуты.

Летом 2015 г. издательство государственного университета Ильи выпустило DVD-диск под названием «Астрономические рукописи Грузии» [Simonia et al. 2015b]. Это электронное издание, содержащее материалы на грузинском и английском языках, предлагает детальное описание выполненного проекта и результаты научного анализа астрономических манускриптов: бюллетени, фрагменты и полные тексты манускриптов, каталоги рукописей, таблицы, словарь, галерею избранных изображений, интернет-ресурсы и обширную библиографию. DVD-диск снабжён поисковой системой по ключевым словам, астрономическим терминам и именам. Необходимо отметить, что полные тексты астрономических рукописей опубликованы в виде электронных копий подлинников (JPEG-файлов).

Важным информационным наполнением электронного издания являются 360 бюллетеней (формат файлов .pdf), каждый из которых посвящён одной конкретной астрономической рукописи. Бюллетень обычно состоит из 2–3 страниц описательного текста, изображения одной страницы соответствующей рукописи и библиографии. В бюллетене приводятся характеристики манускрипта, степень его сохранности и кратко его астрономическое содержание. 300 бюллетеней посвящены грузинским астрономическим манускриптам, а 60 — персидским и арабским. Бюллетени грузинских астрономических манускриптов имеют индекс GAM, тогда как бюллетени персидских и арабских астрономических манускриптов — индекс AM.

Важным элементом этого издания является словарь древних грузинских астрономических и смежных терминов. При этом для каждого термина приводится его английский эквивалент. Некоторые слова, имена и термины проникли в грузинский из греческого, арабского и других языков. Данная специфика прослеживается в терминологическом наполнении словаря. DVD-диск содержит также обширные каталоги астрономических рукописей, вошедших и не вошедших в издание. Это электронное издание представляет собой интерактивную базу данных, рассчитанную для работы в новейших версиях операционной системы Windows, её составных компонентах и стандартных аппликациях.

Помимо DVD-диска, были изданы три сопутствующие одноимённые брошюры, посвящённые этапам реализации проекта, полученным результатам и каталогам соответственно. Экземпляры DVD-диска и брошюр были разосланы в научные

центры и библиотеки разных стран, включая университеты Кембриджа, Гамбурга, Геттингена, Праги, Гарварда и др. В России экземпляры DVD-диска имеются в библиотеках Института истории естествознания и техники им. С. И. Вавилова РАН, в библиотеке Института востоковедения РАН (Москва), в Российской национальной библиотеке им. М. Е. Салтыкова-Щедрина (Санкт-Петербург).

Электронные страницы древних пергаментов

С учетом степени сохранности древних манускриптов и с соблюдением всех технических стандартов, был полностью или частично просканирован ряд грузинских, персидских и арабских астрономических манускриптов. Эти электронные материалы составили графическое наполнение DVD-диска. В частности, диск содержит полный текст хронологического труда грузинского монаха и просветителя Иоанна Зосиме (X в.). Рукопись написана грузинским алфавитом асомтаврули и содержит пасхальные таблицы для периода 781–1312 гг. , а также таблицы грузинского хроникона. На странице 141v — таблицы с комментариями для расчета солнечного и лунного циклов (Рис. 1). Полностью опубликован также грузинский перевод философско-религиозных сочинений Василия Великого и Григория Нисского. Перевод был выполнен Георгием Мтацминдели. Рукопись написана грузинским алфавитом нусхури и содержит описание всеобщего (суточного) движения планет и звёзд; солнечные и лунные годы; летоисчисление; положение и размеры Солнца и др. На диске приведен полный текст поздней версии (XVIII в.) астрономического труда ас-Суфи «Книги фигур созвездий» («Китаб сувар ал-кавакиб») на арабском языке. Манускрипт изобилует описаниями созвездий и содержит многочисленные таблицы (Рис. 2).

На диске представлен грузинский перевод курса физики Христиана Вольфа выполненный католикосом Антонием I. 117-страничная рукопись написана грузинским алфавитом мхедрули и состоит из пяти частей и нескольких глав. Она содержит астрономические фрагменты, включая описание Солнца, Луны, планет и неподвижных звёзд. Рассматриваются также редкие астрономические явления, в частности, затмения. В Тбилисской семинарии Антоний I преподавал физику по пере-

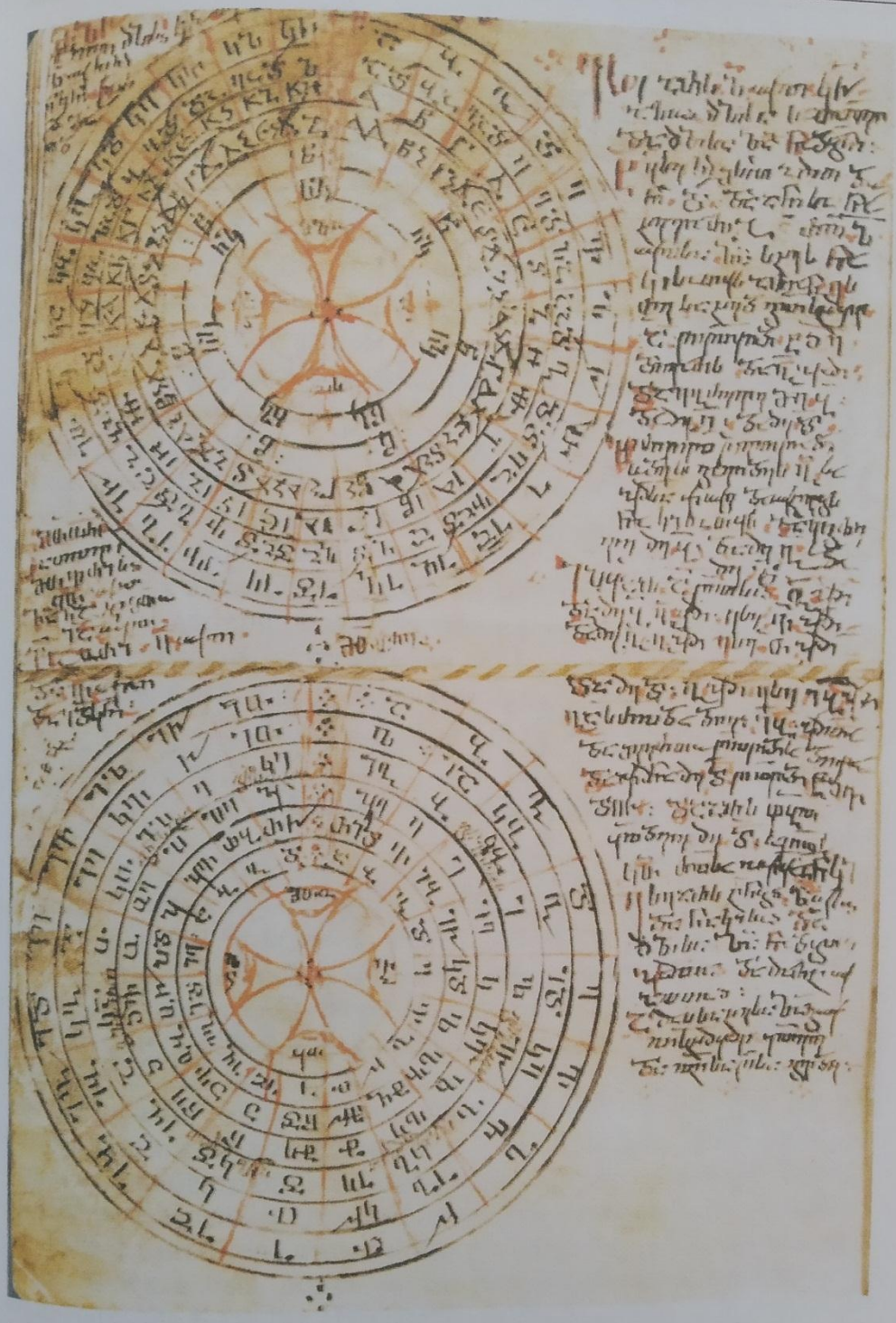

Рис. 1. Фрагмент хронологического труда Иоанна Зосиме. Манускрипт GAM 268, содержит текстовые и графические описания солнечного и лунного циклов, хронологические описания.

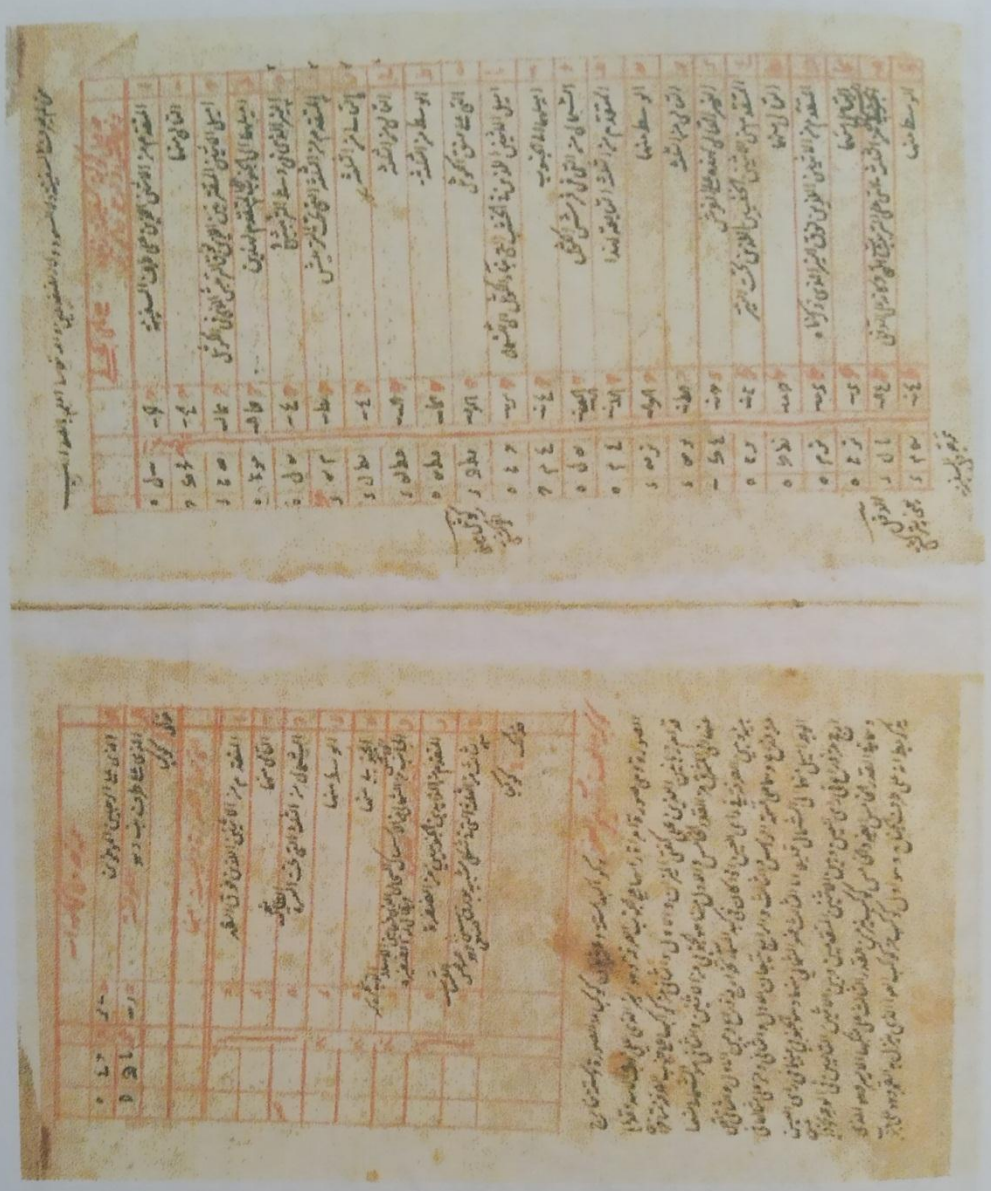

Рис. 2. Описание созвездия Девы из книги «Изображения созвездий» ас-Суфи. В тексте и таблицах манускрипта AM 34 приведены описания 23 созвездий.

ведённому им курсу. Известно, что эти занятия посещал царь Грузии Ираклий II Багратиони (1720–1798). Католикос Антоний I перевёл и труды по физике Баумайстера. Перечислим также несколько бюллетеней: GAM 51 — астрономо-астрологический труд, XIX в. (Рис. 3); GAM 55 — философская книга, относящаяся к XVIII в. (Рис. 4); GAM 292 — пасхальные таблицы, XVI в.; AM 30 — анонимный арабский и персидский астрономический сборник, посвящённый фазам Луны, лунным и солнечным затмениям, XIX в.; AM 50 — анонимный арабский манускрипт, с описанием небесных сфер, XVII в.; AM 60 — анонимный арабский манускрипт под названием «Сочинение о северной астролябии», XVIII в. В бюллетенях представлены труды Ефрема Мцире, Абусеридзе Тбели (Рис. 5) и других грузинских авторов. Бюллетени описывают работы восточных астрономов Насир ад-Дина ат-Туси, ал-Бирджанди, ал-Куртуби (XIII в.), Кади-Заде ар-Руми (1364–1437), ал-Газневи (XI в.) и др. Данное электронное издание обеспечивает доступ к малоизученным материалам, оригинальному рукописному наследию и переводам астрономических трудов Средневековья и Нового времени.

Кратко о перспективах

Рассмотренное электронное издание не лишено недостатков. Во-первых, значителен информационный объём диска — более 1,1 Гбайт. У компьютеров с малой оперативной памятью эта особенность может вызвать замедление загрузки соответствующих файлов. Во-вторых, имеются опечатки в некоторых описательных материалах диска, в-третьих, невелик объём информационных бюллетеней, каждый из которых, как правило, не превышает одну тысячу слов. Однако, несмотря на эти аспекты, можно констатировать, что данный DVD-диск открыл исследователям «окно доступа» к малоизученным и абсолютно неизвестным древним астрономическим материалам.

Ещё одним неофициальным элементом вышерассмотренного проекта был поиск возможного грузинского перевода «Альмагеста» Клавдия Птолемея среди грузинских астрономических манускриптов. По специальным критериям были отобраны и проанализированы сотни астрономических, космографических и смежных манускриптов. Полные, завершенные

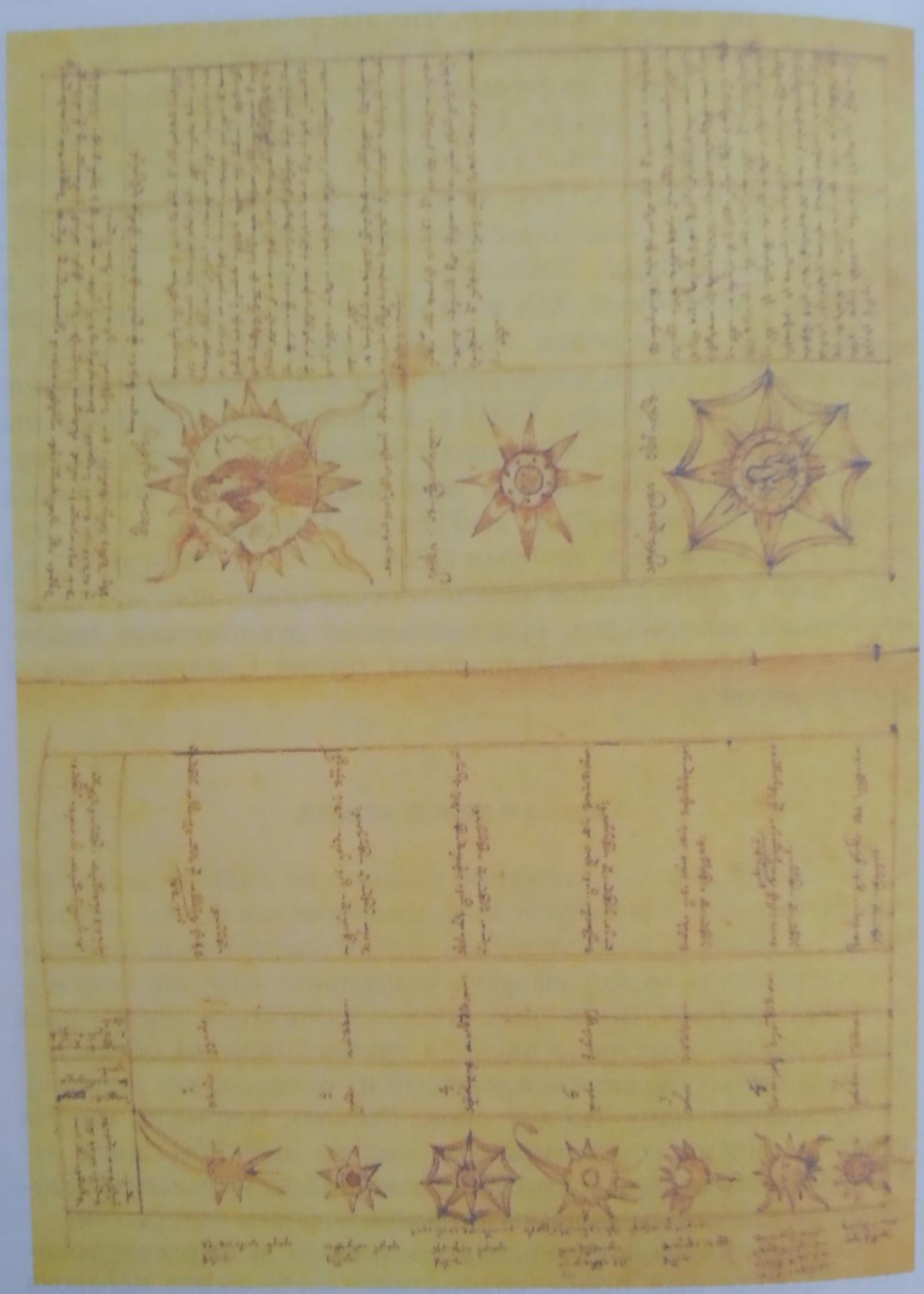

Рис. 3. Манускрипт GAM 51, посвященный астрономии и астрологии. Приведены описания созвездий, семи светил, календарные таблицы, даты новолуний и другие астрономические сведения. Описания дополнены рисунками и графическими символами.

Рис. 4. Графическое и текстовое описания геоцентрической системы мира из «Философской книги» коллекции государственного музея Н. Бердзенишвили города Кутаиси. Манускрипт GAM 55 содержит описания звёзд и планет, а также небесных явлений, включая солнечные и лунные затмения.

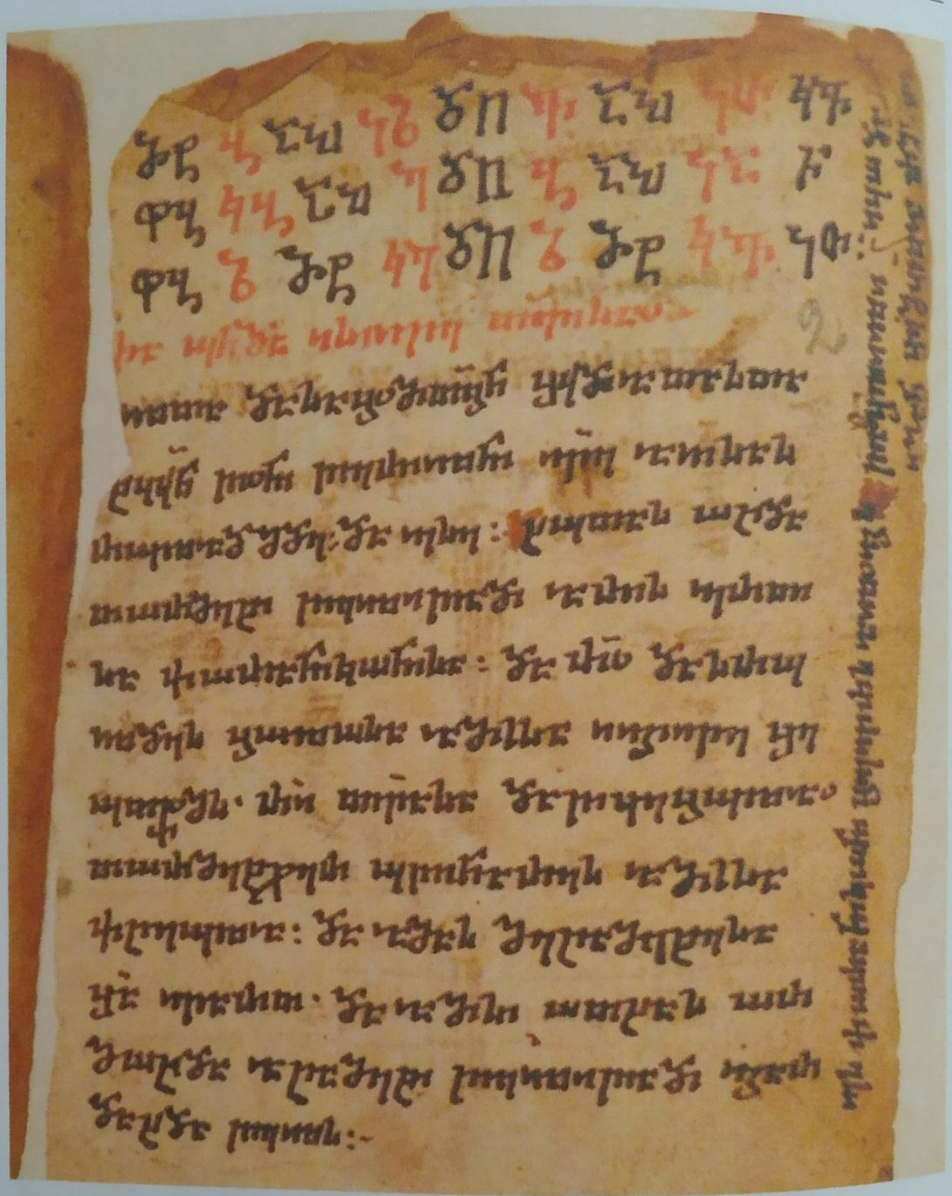

Рис. 5. Фрагмент поздней копии (XVI век) календарного труда Абусеридзе Тбели (XIII век). Рукопись GAM 143.

труды, фрагменты и включения астрономического содержания подвергались соответствующему анализу. Результат поиска показал, что среди проанализированных текстов грузинского перевода «Альмагеста» нет. Однако существует одно важное обстоятельство, которое необходимо отметить. Грузинские астрономические рукописи разных категорий, как оригинальные, так и переводные, очень часто содержат характерные элементы и темы, заимствованные из «Альмагеста», например, в грузинских рукописях рассматриваются геоцентрическая система мира; размеры и формы небесных тел; движения Солнца, Луны и планет; звёздные каталоги и созвездия; астрономические инструменты. Следовательно, можно осторожно предположить, что «Альмагест» переводился на грузинский язык разными переводчиками в разные эпохи, фрагментарно или выборочно. Иными словами, весь переводной грузинский материал насыщен выдержками из «Альмагеста», при этом каждая рукопись содержит что-либо своё, а от первоисточника — главу, таблицу или тему.

Сегодня, в начале XXI века, можно думать о виртуальном воссоединении этих рассеянных элементов и реконструкции возможной грузинской версии птолемеевского «Великого Построения». Для реализации такого проекта потребовались бы значительные научные силы и ресурсы. Вместе с тем грузинский перевод «Альмагеста» может находиться в библиотечных и музейных коллекциях других стран. Это придает такому проекту международный характер. Учитывая разбросанность грузинских астрономических источников, перспективы их изучения можно охарактеризовать следующим образом: 1) анализ грузинских астрономических манускриптов, находящихся не в Грузии, а в библиотеках стран Востока, а также Европы, включая Россию, Грецию, Францию и Великобританию; 2) изучение космологического содержания грузинских рукописей России с целью выявления возможного перевода «Альмагеста». Исследования описаний Вселенной в грузинских астрономических рукописях могло бы стать новым элементом в развитии наших представлений о средневековой науке.

Электронная книга «Астрономические рукописи Грузии» предназначена для специалистов по истории астрономии и истории науки в целом. Она является объёмным источником научной информации, которая, в свою очередь, может стиму-

лировать новые научные изыскания, подготовку новых диссертаций и монографий.

Авторы предоставляют (по запросу) бесплатные экземпляры DVD-диска университетам, научным центрам, библиотекам, отдельным исследователям и аспирантам. Многие грузинские астрономические рукописи остались вне поля рассмотренного проекта. Часть этого материала находится за пределами Грузии, другая же его часть — в частных архивах и временно не функционирующих организациях. Процесс поиска и анализа ранее неизвестных грузинских астрономических материалов долог и труден, но первый шаг уже сделан, теперь необходимо подумать о последующих, более эффективных шагах.

Автор благодарен Т. Л. Абуладзе за ценную дискуссию.

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УДК 52.091

НАСИРЕДДИН ТУСИ В ГРУЗИНСКОЙ АСТРОНОМИЧЕСКОЙ ПРАКТИКЕ

© 2000 г. И. Симония*, Р. Чагунава**

Абастуманская астрофизическая обсерватория АН Грузии,*
*Институт рукописей АН Грузии***

NƏSİRƏDDİN TUSİNİN GÜRCÜ ASTRONOMİYASINDA ROLU, ***İ. Simoniya, R.Çaqunava.*** *Dahi şərq astronomu Nəsirəddin Tusinin gürcü astronomiyasında rolu araşdırılır. Həmçinin Nəsirəddin Tusinin nəzəri araşdırmalarının geniş yayılması işində və təcrübədə tətbiqi məsələlərində, gürcü çarı, mütəfəkkir və alimi Vaxtanq VI Baqrationinin rolu izlənilir. Nəsirəddin Tusinin orijinal əsərlərini, həmçinin onların Vaxtanq VI Baqrationi tərəfindən gürcü dilinə tərcümə edilmiş variantlarını özündə cəmləşdirən xüsusi elmi nəşrin hazırlanması təklif edilir.*

NASIREDDIN TOUSY'S ROLE IN GEORGIAN ASTRONOMICAL PRACTICE, ***I. Simonia, R. Chagunava.*** *The well-known eastern astronomer Nasireddin Tousy's role in Georgian astronomical practice is considered. The Georgian king, scientist and educational worker Vakhtang VI Bagrationy's role in the work of popularization and introduction in the practice of N.Tousy's theoretical works is also expounded. Preparation of a special scientific publication containing N.Tousy's original works and his original translation by Vakhtang VI Bagrationy as well is proposed.*

Выдающийся ученый средневековья Насиреддин Туси (1201-1274), внесший значительный вклад в развитие астрономии и математики, наряду с теоретическими разработками, уделял большое внимание и вопросам прикладного характера. В частности, им был составлен небольшой, но очень содержательный трактат об устройстве и применении астролябии («Трактат в двадцати главах о познании астролябии»). Средневековая астролябия являлась одним из самых распространенных инструментов на Кавказе и в соседней Азии, поскольку это несложное приспособление позволяло успешно решать довольно широкий круг вопросов практической астрономии.

Достоинством трактата Насиреддина Туси являлось то обстоятельство, что он охватывал все основные задачи, которые были поставлены перед астролябией и астрономической практикой того времени. Трактат состоит из 20 глав. Первая глава трактата посвящена устройству астролябии. Этому же вопросу посвящена и последная 20-я глава, в которой описано взаиморасположение наиболее ярких звезд, нанесенных в стереографической проекции на подвижном диске астролябии. Остальные главы посвящены: определению высоты Солнца и звезд , гороскопу по высоте, высоте по гороскопу, обороту ровных и неровных часов и их частей, склонению Солнца и пределу его высоты или расстоянию светила от небесного экватора и его высоте, восхождению знаков зодиака на земном экваторе и в данной местности, градусам прохождения, восходу и заходу и уравнению дня двенадцати владык, часам рассвета и заката, тени по высоте и высоте по тени, гороскопу будущего года по гороскопу истекшего года, широте местности, и исследованиям гороскопа местности не соответствующей диску, высоте полюса эклиптики, азимуту, эфемериде Солнца, высоте объектов находящихся над землей и размерам их

оборотов, действиям с горизонтальным диском, правильности и искривленности астролябии [1].

Благодаря глубине изложения материала и простоте применения на практике, содержащихся в трактате методов, советов и указаний, трактат Насиреддина Туси в течение многих столетий сохранял свою актуальность Наглядным примером большого интереса к этому научному произведению служит тот факт, что в 10-ых годах XVIII столетия трактат был переведен на грузинский язык.

В институте рукописей им. Корнели Кекелидзе Академии наук Грузии хранится рукопись (Р-457), состоящая из 256 листов [2]. В ней дано первичное описание грузинского перевода трактата Насиреддина Туси. Необходимо отметить,что рукопись (Н-457) представляет собой, фактически, сдвоенный историко-научный материал. Страницы 2r-20v, это грузинский перевод трактата Насиреддина Туси. Остальная, бóльшая часть рукописи представляет собой материал астрологического характера. Идентичный астрологический материал хранится в фондах Петербургского отделения Российского института Востоковедения [3,4]. Эта грузинская рукопись имеет название «Тала масала». (Номер по каталогу Е-15). Грузинский перевод трактата снабжен названием выполненным красными чернилами. В названии сказано: «Эта книжка для познания астролябии изложена Ходжей Насиром Туси в 20 главах».

Грузинский перевод трактата Насиреддина Туси принадлежит перу известного грузинского государственного деятеля, царя и ученого Вахтанга VI Багратиони (1675-1737). Царь Вахтанг VI внес огромный вклад в дело возрождения естественнонаучных знаний в Грузии, утерянных в упадочном периоде предыдущих столетий. Воспользовавшись пребыванием в Персии (1712-1719), он основательно изучил богатую восточную естественнонаучную литературу. Кроме вышеуказанного сочинения, в творческом содружестве с неким Мирзой Абдуриза Тавризи, царем были переведены и другие, в основном, астрономические произведения, в том числе «Трактат о науке астрономии» Али Ал-Кушчи и «Зидж» Улугбека. Если с помощью переводов трудов Али Ал-Кушчи и Улугбека, царь Вахтанг VI пытался сформировать базис, фундамент в деле восстанавления общих астрономических знаний в Грузии, то переводу трактата Насиреддина Туси отводилась более конкретная и специфическая роль – ускорителя, стимулятора процесса восстановления астрономических наблюдений в Грузии. В Испахоне, для внедрения в практику своих просветительских планов, царь Вахтанг VI заказал партию астролябии. Соответствующие сведения об этом можно найти в материалах астронома Жозефа Делиля [5, 6]. Сведения Делиля дополняет и подтверждает один из экземпляров астролябии из этой партии. Эта астролябия сохранилась до наших дней и хранится в государственном музее Грузии в городе Тбилиси. Все надписи на астролябии, включая надпись «Вахтанг» выгравированы на грузинском языке. Исключением является лишь одна персидская надпись, содержащая имя изготовителя астролябии, мастера Абдал Аима.

Известно, что Абдал Аим – младший, живший в XVII – XVIII веках, являлся одним из лидеров восточной школы астрономического приборостроения. Астрономические инструменты изготовленные этой школой хранятся теперь в различных музеях мира [7,8]. Тот факт, что на дошедшей до нас астролябии выгравировано имя «Вахтанг» позволяет, с высокой степенью вероятности предположить, что данный инструмент принадлежал лично царю Вахтангу VI Багратиони. Если надписи на личном инструменте царя были выполнены на грузинском языке, по – видимому, и на остальных инструментах партии надписи были выполнены на том же языке. Все выше сказанное говорит о серьезности намерений, планов Вахтанга VI Багратиони по внедрению инструмента астролябии в грузинскую астрономическую практику.

По возвращении в Грузию (1719 г) царь Вахтанг VI Багратиони энергично приступил к воплошению своих замыслов. Хотя его пребывание на родине оказалось

не очень долговременным (в 1724 г. он был вынужден эмигрировать в Россию, где и скончался в 1737 г.), но за короткий срок им было сделано многое. В Грузии царь Вахтанг VI объединил вокруг себя группу молодых людей, которым лично преподавал курс восточной астрономии [3]. Помимо теоретических, он проводил также практические занятия по применению астролябии. Во время этих занятий им широко применялся перевод трактата Насиреддина Туси об астролябии.

Для расширения масштаба популяризации астрономии в Грузии, царь Вахтанг VI перевел и издал труд Али-Кушчи «Аиати». Издание вышло в свет в Тбилиси в 1721 году, в грузинской типографии, основанной ранее самим же царем Вахтангом VI.

Согласно данным из архива Жозефа Делиля по инициативе царя Вахтанг VI и при помощи астролябии, изготовленных в Персии, были проведены измерения географических широт населенных пунктов Кавказа, в частности, Тбилиси, Кутаиси, Ахалцихе, Гянджи. Подробная перечень объектов измерений заключен в двух списках, подготовленных царевичем Вахушти Багратиони, специально для Жозефа Делиля. В этих списках упомянуты названия 66 населенных пунктов Кавказа с соответсвующими числовыми данными [5, 9].

Столь значительное число объектов измерения свидетельствует о масштабности этого научного мероприятия и о наличии группы квалифицированных астрономов – наблюдателей. Естественно, что реализация такого научного мероприятия, была бы невозможна без титанических усилий царя Вахтанг VI и богатых научных знаний, содержащихся в трудах восточных астрономов, ярким представителем которых является Насиреддин Туси.

В 1735 году царевич Вахушти Багратиони составил карты Кавказа и Грузии, где широко использованы данные вышеупомянутых измерений. В 1737 году Жозеф Делил изготовил копии этих карт, и, по возвращении на родину опубликовал общую карту закавказского региона. Этот научный материал вышел в свет в 1766 году и получил положительную оценку европейских астрономов [4].

Выше описанные факты однозначно говорят о том, что Насиреддин Туси и Вахтанг VI Багратиони, яркие личности различных стран и эпох, соединены незримыми нитями общего стремления к познанию и просветительству. Мы выступаем с предложением выпуска специальной книги под названием: «От Насиреддина Туси до Вахтанга VI Багратиони ». Такая книга содержала бы, трактат Насиреддина Туси об астролябии на языке оригинала, перевод трактата, выполненный Вахтангом VI Багратиони на грузинском языке, и, специальный адаптированный английский текст трактата, полученный после сравнения оригинальных рукописей Насиреддина Туси и Вахтанга VI Багратиони. Такая книга могла бы содержать также дополнительную, ранее не изученную историко-астрономическую информацию. Нам представляется, что такого рода издание могло бы быть выполнено в виде мультимедийной книги на CD-ROM-е.

Интересно было бы также, широко осветить роль мастера Абдал Аима в деле популяризации астрономии в Кавказском регионе. Жизнь и научная деятельность Мирзи Абдуриза Тавризи вызывает большой интерес в контексте историко-научных исследований и культурного взаимодействия различных цивилизаций. Мы предлагаем провести совместные исследования научной деятельности упомянутых ученых на благо истории астрономии нашего региона и истории науки в целом.

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ДРЕВНЕГРУЗИНСКИЕ КОСМОГРАММЫ

(статья посвящается американскому астроному Джону Берджизу)

И. Симония

Абастуманская астрофизическая обсерватория АН Грузии

QƏDİM GÜRCÜ KOSMOQRAMLARI, ***İ. Simoniya .*** *Qədim gürcü bürünc lövhələrinə, ilk dəfə olaraq, sırf astronomik izahat verilir. Bu lövhələr, hazırki yüzilliyin ortalarında, Gürcüstan ərazisində tapılmışdır. Onların tarixi, eramızdan öncə, 16 – 14 əsrlərə aid edilir. Lövhələr, çoxlu sayda müntəzəm qurumlu relyef təsvirlərilə zəngindir. İlk dəfə olaraq, kosmoqram və kvaziheliosentrizm anlayışları daxil edilir.*

ANCIENT GEORGIAN COSMOGRAM, ***by I. Simonia.*** *Pure astronomical interpretation of ancient Georgian bronze plates is proposed for the first time. These plates have been discovered in the territory of Georgia on the middle of this century. Bronze plates have been dated in 16 –14 centuries before Christ. The plates abound in plurality, regularity relief image. The concept of cosmogram and quaziheliocentrizm are introduced.*

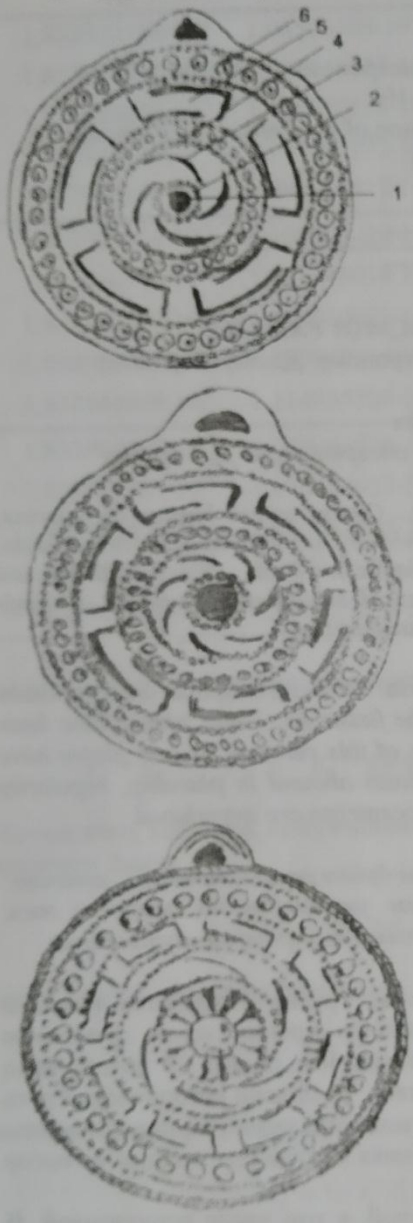
Объекты, которые мы будем рассматривать, конечно, являются предметами украшения, но, вместе с тем, они несут в себе серьезный астрономический смысл.

Грузия – древняя страна на Кавказе. Побережья Грузии омываются теплыми водами Черного моря. На этих землях с древнейших времен жили грузинские племена, занимавшиеся земледелием и ремесленничеством. Более 25 веков назад образовалось первое грузинское государство – Колхети. За долгий исторический путь грузинским народом была создана собственная оригинальная культура, письменность, язык. Сегодня на этих землях располагается республика Грузия со столицей в городе Тбилиси.

С древнейших времен грузины занимались наукой, в том числе астрономией. В специальных институтах и музеях Тбилиси и других городов хранятся древние грузинские астрономические рукописи, книги, инструменты. Грузинскими археологами в древних могильниках Борнигеле и Заден гора, находящихся на территории Грузии, были обнаружены дисковидные бронзовые пластины. Всего было обнаружено более 30 пластин. Обычно пластины обнаруживались в женских погребениях. Археологи датировали пластины 16 – 14 веками д.р.х. Пластины довольно массивны и обладают диаметрами в несколько десятков сантиметров. Поверхности пластин изобилуют интересными рельефными изображениями. В

грузинской научной литературе пластины рассматривались с различных точек зрения, с археологической, исторической, художественной и т.д.

В настоящей работе нами впервые анализируются, интерпретируются поверхностные изображения этих пластин с чисто астрономической точки зрения. Пластин с абсолютно идентичными рельефными изображениями обнаружено не было, однако, все пластины обладают похожими изображениями со следующими основными элементами. В центре пластин находится сквозное отверстие определенного диаметра (1). Затем, по направлению от центра к краю расположена серия повторяющихся шарообразных выпуклых изображений. Эта серия имеет замкнутый вид и очертания окружности (2). Далее, по тому же направлению расположена серия повторяющихся серпообразных сквозных изображений. Эта серия также имеет замкнутый вид и расположена по окружности (3). Далее, как правило, следуют несколько серий, каждая из которой состоит из повторяющихся шарообразных выпуклых изображений. Эти серии также расположены по окружности (4). Ближе к краю располагается серия повторяющихся сквозных треугольных или треугольноподобных изображений. Эта серия также располагается по окружности (5). Наконец, у самого края расположена одна или несколько серий повторяющихся шарообразных выпуклых изображений (6). Общая картина рельефа носит концентрический характер. Общая красота неба и строгая регулярность тех или иных небесных явлений должна была вызвать у древних грузин большой интерес. Грузинские племена занимались земледелием, что требовало наличия календаря. Поэтому, нами делается следующее предположение, что рельефные изображения на древних грузинских бронзовых пластинах носят астрономический характер. Эти изображения отражают астрономическое мировоззрение грузинских племен в период 16 – 14 века д.р.х. На пластинах есть сквозные, выпуклые, одиночные, повторяющиеся изображения. По нашему мнению, таким образом древние авторы пытались изобразить светила, увиденные ими на небе. Сквозное отверстие в центре – это Солнце. Повторяющиеся сквозные серпообразные изображения – это Луна. Повторяющиеся шарообразные выпуклые изображения – это планеты, звезды и т.д. Днем на небе Солнце, а ночью на том же небе Луна, планеты, звезды. Именно это обстоятельство вынуждало древних авторов изображать дневное светило – Солнце и все ночные светила на одной и той же пластине вместе. Для древнего автора поверхность пластины – это небо, а рельефные изображения – светила на нем. Таким образом, пластины с изображениями представляют собой некое подобие плоских моделей Вселенной, хотя вряд ли древние отчетливо понимали это. Может



возникнуть вопрос, почему изображения Луны и планет повторяются, носят характер серий ? По нашему мнению, повторяемостью изображений древние авторы пытались отобразить постоянное видимое движение светил. Попытка отобразить движение говорит в пользу того, что древние авторы сперва наблюдали небесные явления в течение определенного промежутка времени (суток, месяца, года), и, только затем отображали все увиденное ими на одной и той же пластине. Поэтому, мы предлагаем пластины с рельефными изображениями называть космограммами. Одна пластина – одна космограмма с определенным объемом информации. В дохристианские времена грузины проповедовали огнепоклонство. Огонь, свет, тепло играли большую роль в жизни племен. Солнце посылающее столько света и тепла занимало в мировоззрении древних особое почетное место. Поэтому, древние авторы источник света и тепла – Солнце – изображали в центре всех космограмм, а все остальные светила изображали вокруг Солнца. Такое распределение светил, такое мировоззрение является интересным фактом. Это, конечно, не гелиоцентризм, у древних не было соответствующих знаний. Вместе с тем, этот факт требует своего терминологического определения. Мы предлагаем называть его квазигелиоцентризмом. Нам представляется, что квазигелиоцентризм не имел границ и национальных признаков. Не исключено, что различные племена, жившие в тех или иных районах мира и занимавшиеся земледелием также создали материальные памятники, в которых появляется квазигелиоцентрическое мировоззрение. Может возникнуть вопрос, по какому принципу древние авторы распределяли местоположение остальных светил на космограммах. Однозначно ответить на этот вопрос несколько затруднительно. Древние авторы могли руководствоваться различными принципами, как например, а) распределение по яркости светил; б) по их видимому размеру; в) по цвету. Особый интерес вызывают треугольноподобные сквозные изображения у края космограмм. С учетом того факта, что атмосфера на Кавказе обладает высокой прозрачностью, мы выдвигаем предположение, что таким образом древние авторы пытались изобразить планету Сатурн. На космограммах имеются ещё много интересных не интерпретируемых деталей, закономерностей. Поэтому, работа по изучению космограмм должна продолжаться и в дальнейшем. Перспективным может оказаться сравнение грузинских космограмм с их аналогами из других стран или континентов.

Автор выражает благодарность грузинскому археологу О.Гамбашидзе за полезные замечания.

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Old Georgian Astronomical Manuscripts

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Abstract

A general overview of Georgian astronomical manuscripts is given, and the contents of a few, dating from the 12^{th} to the 19^{th} centuries, are given. A partial translation and commentary of manuscript A883, entitled *Cosmos*, and dating from the 18^{th} century, is presented.

1. Introduction

A set of Georgian astronomical manuscripts is one of the most impressive testimonies of the evolution of the astronomical world view in Georgia, an evidence of development of scientific approach, a unique bearer of astronomical information, that has come down to us through Georgia's centuries-old history. Those hard centuries had brought up thousands of causes and reasons that could erase or consign to oblivion the unique scientific material. This might have happened to many old Georgian manuscripts. Nevertheless, museums, research institutes, libraries in Georgia, France, Russia, Greece and other European countries, and libraries and archives in Oriental countries house hundreds of old Georgian astronomical and astrological manuscripts, written in the old Georgian alphabet *Asomtavruli* (used in the 5^{th}–10^{th} centuries), and *Nuskhuri* (11^{th}–17^{th} centuries) as well as *Mkhedruli* (used since the 18^{th} century up to our days). Usually, the term *Khutsuri*, according to the comments frequently occurring for Georgian manuscripts, implies two Georgian alphabets – *Asomtavruli* and *Nuskhuri* (Machavariani 1984).

2. Astronomical Manuscripts

The astronomical manuscripts contain descriptions of celestial phenomena, the Sun, the Moon and planets, calendar systems, observation and calculation methods and other kinds of information. Many manuscripts give also descriptions of the climate and seasons, of certain geographical points, and mention names of astronomers and philosophers. A part of this complex of manuscripts is clearly of astrological nature, devoted to prophesizing human fortunes according to positions of the celestial bodies and celestial phenomena. This layer of historico-scientific information has been little studied and actually remains unknown to the western world. It is worth mentioning here Chagunava's (1990) *Vakhtang Bagrationi's Activities in Natural Sciences*, in which the author analysed several old Georgian manuscripts. Vakhtang VI Bagrationi (1675–1737) was a Georgian king, military leader and scientist.

Keeping close scientific and cultural contacts with countries of the western and oriental worlds, Georgia with her original old culture and scientific tradition absorbed elements of oriental cultures and cultural achievements of Western Europe. In this way a unique alloy of the original Georgian, Eastern and Western cultures was formed, and is reflected in the Georgian manuscripts, these historico-astronomical "mirrors".

Old Georgian astronomical manuscripts bear purely Georgian, as well as Persian, Greek and other names of places, persons and terms all written in Georgian; all non-Georgian names or terms being transliterated into Georgian alphabet characters. On the other hand, old Georgian astronomical manuscripts comprise purely Georgian scientific material. Reading their pages one can easily feel the beauty of the language, and the traditional world view of the Georgian author or translator. For many years, Georgian astronomical manuscripts used to be a subject of study only for philologists and linguists, both Georgian and foreign, their scientific aspect and significance remaining somewhat neglected. Now that nations and cultures are mixing, vigorously exchanging information, time has come to change that practice: by allowing the philologists to continue admiring the beauty of the language, it is our task to reveal the astronomical aspects of old Georgian manuscripts to present-day historians and astronomers. We find it essential to create a Georgian-English dictionary of historico-astronomical terms and names with their transcriptions, a project that would require great efforts. Another useful contribution would be the publication of English or French translations of some of the most important Geor-

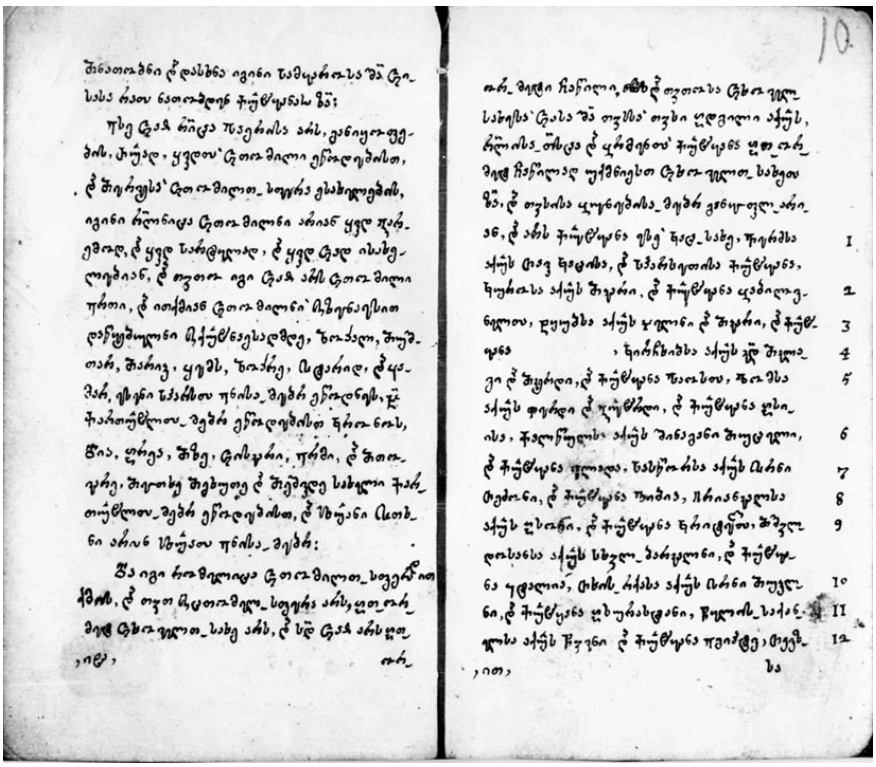

Figure 1. Astronomical manuscript A883, pages 18 and 19.

gian astronomical manuscripts with explanatory notes, comments and glossaries.

It is important to determine the total number of astronomical manuscripts written by Georgian authors, the number of those translated from other languages and the number of mixed manuscripts. This is a multilateral, time-consuming task, since many of the manuscripts were copied and re-copied many times. We hope that this task will be tackled in the future.

We will now consider several old Georgian astronomical manuscripts. The descriptions will contain our approaches and views and will, therefore, vary in volume – some will be brief, others more extensive. Old Georgian astronomical manuscripts are kept in the Research Institute of Manuscripts of the Georgian Academy of Sciences (Simonia 2001). The first catalogue of Georgian astronomical manuscripts was prepared by Kevanishvili (1951); the original is now kept at the Astronomy department of Tbilisi State University.

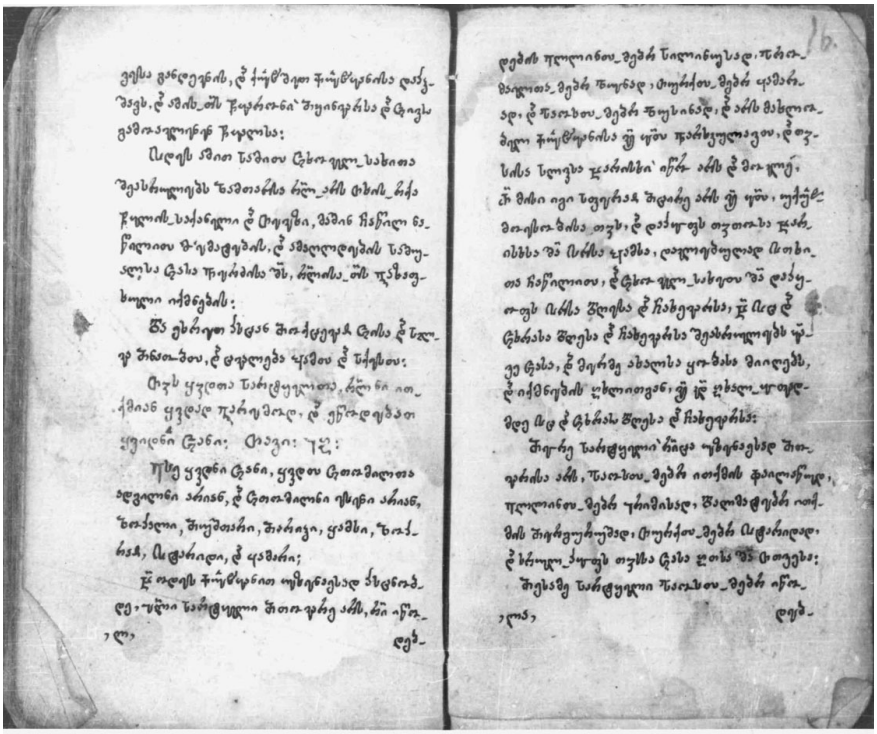

Figure 2. Astronomical Manuscript A883, pages 30 and 31.

Let us now dwell on the description of some manuscripts mentioned in Dr. Kevanishvili's catalogue. Number A24 is a *Khutsuri* manuscript of the 12th century AD, and signed by Efrem Mtsire, a Georgian philologist, philosopher and translator, who lived around the turn of the 11th to the 12th century. Its page 58 features 12 zodiacal constellations. The manuscript contains two books written by Ioanne Damaskeli (Ioannes Damaskenos) under the title *Legends*. Number A442 is a 75-page *Khutsuri* manuscript from the 15th century, containing a calendar from the 1st day of September to the 31st day of August. Number A684 is a *Khutsuri* manuscript of the 11th century. The manuscript comprises several chapters, one bearing the title *About the World*. The *Khutsuri* manuscript A718 of the 14th century gives descriptions of lunar days.

The *Mkhedruli* manuscript A889 written in the late 18th or early 19th century gives descriptions of the passage of the Moon through the constellations, defining the zodiac, identifying constellations by the stars, giving the entry of the Sun into the constellations, and

the appearance and disappearance of the Moon. Another *Mkhedruli* manuscript, H503, dating from 1808, gives descriptions of the Moon and stars, as well as ephemerides. The *Mkhedruli* manuscript S5237 from the 19$^{\text{th}}$ century describes the science of the Sun and the Moon.

This is only a small part of information contained in Dr. Kevanishvili's catalogue. Its descriptions are somewhat irregular, and occasionally rather disordered. We tried to keep the author's style, both in the terms and complete sentences. It is hardly possible to judge the accuracy of the catalogued description of the above listed manuscripts without actually reading them. Therefore, the catalogue can be regarded only as the first approximation of a large unified catalogue of Georgian astronomical manuscripts that has to be created by collective efforts. What makes Dr. Kevanishvili's catalogue particularly valuable is that it is the first regular code of information about Georgian astronomical manuscripts. Among the manuscripts listed above, there are original works of Georgian authors as well as translations. Unfortunately, they have not been studied for their astronomical significance; some of them are in quite poor condition and need to be copied and restored for future generations of researchers.

3. Astronomical Manuscript A883

Let us discuss in detail the *Mkhedruli* manuscript A883 of the 18$^{\text{th}}$ century, catalogued under the title *Cosmos*. It consists of 42 pages and is divided into chapters. The first chapter is named *On the Heavens: in what amount the heavens exist, what they are made of, and by whose order*. On the first page the text begins with

> "The Creator built this World with His wisdow and power. And He made the World visible... To create the World He used four matters – the fire, the wind, the water and the earth. These are the foundation of everything and each other's opposites. From these matters He created meadows and beasts. And no other matter was heavier than the earth, more fluid than the water; no other matter was more mobile than the air (wind), no other matter was brighter than the fire."

We will try here to render a translation, as close as possible to the original text, although it is a rather difficult task. The anonymous writer describes, in the first place, the very first steps of creation of

the Universe. There are some exchangeable terms used in the text, for instance *the wind* is replaced by the word *air* as a synonym. Another point worth noticing is that the author refers to the opposition of different forms of matter. Is that a reference to previous sources or does the unknown author realize the differences in the physical nature of these forms of matter? This way of interpreting things was quite common in the 18th century, though.

On the second page of the manuscript we read

> "And the Great Prophet Moses said: He created for the basis the Heaven and the world. The Heaven presents two matters – the fire and the air; and the world is made of two matters – the earth and the water. And while He created those four matters, the art of His wisdom showed itself in putting, the heaviest earth below, and placing the water on the earth, and setting the air which was lighter than water, above the water, and placing the fire which was lighter than air, above the air, with moisture observable in the air itself."

The second chapter of the manuscript begins on page 5 and has the title *About a second Heaven and about its motion*. The author continued with the description of the process of creation of the world referring to the bible, in a way simplifying and abridging the biblical text.

Chapter 7 *about the airy Heaven in which the Luminaries are* starts on page 17. The anonymous author writes:

> "As the Holy Bible says, God made lights (Luminaries) and set them in the Heaven to give light upon the Earth. The airy Heaven is divided into 8 parts, 7 of which are called planets and the eighth is the sphere of planets. Those which are planets are called seven circumferences, seven belts, seven Heavens. Each Heaven is one planet. And the planets are listed from the highest to the lowest: Zokhal, Mushtar, Marikh, Shems, Zokhre, Otarid and Kamaz. These names are Persian. For the Georgians they are Kronos, Dia, Area, Mze, Tsiskari, Ermi and Mtovare. The 4th, 5th and 7th names are Georgian; the others are in a different language. And that which is called the sphere of planets and which is a planet-sphere itself, has a face of 12 beasts. The Heaven has 12 parts. Each beast has its place in the Heaven."

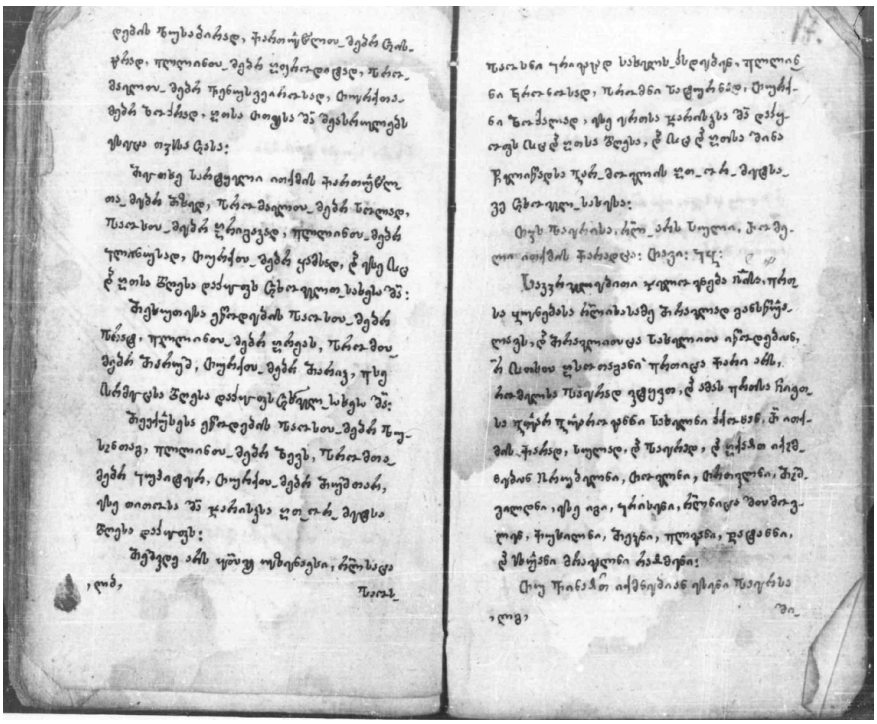

Figure 3. Astronomical manuscript A883, pages 32 and 33.

Then, the author continues to name the zodiacal constellations giving each of them a number and a country. The list of countries includes both Eastern and Western ones. For instance, "Sagittarius has thick thighs and the country is Italy 9, Capricornus has two knees and the country is Asurastan 10, Aquarius has juice and the country is Egypt 11, Pisces has two legs and the country is India 12." The Gemini constellation had no country and the name followed by a free space and a comma. Fig. 1 shows pages 18–19 of the manuscript with the names of planets and constellations with the respective countries. The pages in this manuscript are lettered. The writer continues:

> "and there are 12 beasts in the Heaven and 12 months in a year, and each beast has 30 degrees which are 30 days of a month. The Heaven has 360 degrees which are 360 days of a year, and 5 more additional days appear as small fractions of another chronology."

Further, the writer describes the calendar system, dividing time into centuries. It should be pointed out that the author uses oriental, Greek and Georgian names of the Luminaries. Many of foreign names acquired a Georgian *tinge*, obviously, owing to their fragmentary use during a long period of time. The author uses 3 names that are purely Georgian: Mze – the Sun, Mtovare – the Moon, Tsiskari – Venus. The questions of origin of the Georgian names and adaptation of foreign names in the Georgian language were analysed by Simonia and Simonia (1994).

It is worth noticing that the author put the heavenly bodies in a certain order, from the most distant Saturn to the nearest to us, the Moon. And what did the author expect to follow the Moon? – It was certainly the Earth. Here we have a clear geocentric world attitude of the author. In the 18^{th} century? Was it late Georgian geocentrism?...

Chapter 8 begins on page 20: *How does the Celestial Sphere Move ad Rotate and How Do the Sun, the Moon and the Stars Move?* The author writes:

> "what is that motion of the Heaven; at what time will half of the beast's face rise; this half-face is 15^{th} degree, and 5 degree is equal to one order which is equal to one hour. And when the full face of the beast rises, 2 orders of day will pass."

It should be mentioned here that the author used the term *tsvai*, which can be translated into English as share, order, quarter.

Then the writer gives an example of finding the Sun in the constellation of Aries (spring). He describes the movement of the zodiacal constellations in the sky, for instance, how Aries would, within a certain period of time set behind the horizon in the West, as he put it, into the inner hemisphere, On page 22, we find a description of repetition of rising and setting of constellations, the Sun, the Moon and stars.

Page 22 opens with Chapter 9: *What Examples Evidence that the Sun and Other Luminaries Move from the East.* The text runs:

> "You should also know that the Heaven rotates from the East to the West while the Sun and the Moon and stars move from the West to the East, and their beams will fall southwards."

Furthermore, the author describes in general terms the phenomenon of culmination of celestial bodies. With some faults though, he touches upon the annual motion of the Sun and other bodies, giving further examples, clarifying the diurnal and the annual motion of celestial bodies,

examples that refer to the life of people and animals. The writer continues: *You should also know, that when the Moon is new, it will move into the Sun and will appear in the West. Day after day, facing the East, it will move and when it becomes 12 days old, it will become faint and appear in the East.* Apparently, the author is trying to describe the lunar phases. Later in the text, the writer refers to the rotation of the Earth around its axis. Then again he goes back to the Sun's annual movement through the zodiacal constellations, giving some of their names.

Analyzing the text of the manuscript, one may come to a dual conclusion, namely that the material was set out in a somewhat irregular and inconsistent way, though, on the other hand, the author was clearly aware of the essence of the phenomena he was describing. Here arises the question whether the author of the manuscript obtained this knowledge from his personal experience and observations, or whether he only compiled data, results and theories of other scientists. He seems to have possessed a regular knowledge of astronomy that he had acquired from contemporary sources. At the same time, he might have accumulated his own, rather rich experience of an observer.

Page 25 starts with chapter 10, *About the four parts of a year.* The text of the chapter tells:

> "There is another motion and transition of the luminaries which descend from the North to the South and ascend from the South to the North and give rise to four sections of a year – spring and summer, autumn and winter. There are four sides: East, and West, North and South. And wise men divided the world into 12 parts.
>
> When the Sun goes into Aries and when Libra appears opposite Aries in the West, day and night will become equal and spring will set in. Following this, every day will grow by one part. And the Sun will rise facing the North. And the Sun will pass there faces of beasts – Aries, Taurus, Gemini and there will be spring. When the spring time sets in, seedlings and plants will come to life, people will look beautiful, flowers will bloom, and birds will be born. And after the Sun has moved to the North, though the faces of three beasts, the spring time will be over, and the Sun will go into Cancer and summer time will begin."

We might have re-shaped stylistically the translation of the narration of the anonymous author, but we consider the manuscript as a

historico-scientific document and give a more or less verbatim translation, retaining its roughness and inconsistency. The author's ideas are quite clear. Despite some lack of perfection, they reveal the author's understanding of the reasons for the annual changes in the Sun's altitude above the horizon depending on its ecliptical motion.

Chapter 11 tells *About Seven Belts Which are Spoken of as Seven Worlds, and they Are Called Seven Heavens.* We read:

> "These seven Heavens are places for seven planets. These seven planets are Zokhali, Mushtari, Marikhi, Shamsi, Zokhrai, Otaridi, Kamari... The first belt is Mtovare, which is called Silinus by the Hellenes, Luna by the Romans, Kamar by the Turks, Lusin by the Haoses and it is not far from the world of stars, and the degree of its motion is narrow and short. Its sphere is small and it spends two hours in every degree, diminishing by a fourth part, and spends two-and-a-half days in every beast's face, and completes the whole Heaven within 29 and a half days, then gets a new birth and everything begins all over again."

We see that the author gives different names to the Moon, from Mtovare in Georgian to Lusin in the language of the Haoses (Armenians). He also describes the lunar motion, and defines precisely enough its synodic period. The author continues:

> "The second belt that is above the Moon is called Failatsu by the Haos people, Irmi by the Hellenes, Mergurush by the Dalmati people, Otarid by the Turks. This luminary completes its orbit in 10 months. The third belt is Lusabir for the Haoses, Tsiskari for the Georgians, Aphroditi for the Hellenes, Venusveiro for the Romans and Zokhra for the Turks; and this luminary completes its orbit in 10 months. The fourth belt is called Mze by the Georgians, Sola by the Romans, Origav by the Haoses, Ilinus by the Hellenes, Shams by the Turks. This luminary spends 30 days in the face of each beast. The fifth belt is called Khrat by the Haoes, Area by the Hellenes, Marush by the Romans, Marikh by the Turks. This luminary stays in the face of a beast for 40 days. The sixth is called Lusintag by the Haoses, Zevs by the Hellenes, Jupiter by the Romans, Mushtar by the Turks. This luminary stays in each degree for 12 days. The seventh is the uppermost; the Haoses refer

> to it as Irivak, the Hellenes as Cronos, the Romans as Saturn and the Turks as Zokhal. This luminary stays in each degree for 30 days, and it will pass through the faces of all 12 beasts in 30 years."

Figures 2 and 3 show pages 30, 31 and 32, 33, respectively. This is actually the complete 11th chapter of the manuscript.

An analysis of the abovementioned text section reveals the author's good knowledge of astronomical achievements in different foreign countries. He mentioned Georgians, Hellenes, Romans, Haoses, Dalmats, Turks, which means that he has studied astronomical sources in different languages, such as Greek, Turkish and others. This is evidence of his good general education, in particular, his high level training in astronomy. However, there are some flaws in the definition of periods of rotation of some celestial bodies. Were they errors in the sources or his own mistakes in some measurements? – It is hardly possible to answer this question at present.

The author gives a wrong period of revolution of Mercury. The period of rotation of Venus was given with a smaller error (we mean its sidereal period). However, the author was correct in giving the period of *rotation* of the Sun through the zodiacal constellations. And again, quite a big mistake was made in the period of rotation of Mars.

Assuming, that the term "degree" implied 1.01 angular degrees, the period of rotation of Jupiter will be equal to 4277.2 terrestrial days. This value is close enough to that of the true sideric period of the planet. The author was quite precise, too, in giving the period of rotation of Saturn. Our assumption that each degree is equal to 1.01 is correct, which is confirmed by the author of the manuscript when he states for Saturn "30 days in one degree". Calculation based on the assumption of 1 degree being actually 1.01, results in the number 10693, i.e. 29.3 years. The slight difference between the value 29.3 derived from the author's assumption and the value 30 cited by him elsewhere might have been a result of some errors in the calculations, or using data from two different sources, for instance, an older manuscript and his own calculations.

After the 11th chapter, the contents of the manuscript alters a little, its narration changing from a schematic, step-by-step style to a more generalized one. The author proceeds considering the cyclic character of natural phenomena, though not their agronomical aspects, but climatic ones. The narration itself sounds more like a lecture on nature. It is worth pointing out that in this part of the manuscript the writer, referring to the celestial bodies, no longer used the Georgian

term *mnatobi* meaning *luminary*, that was used in chapters 1 to 11, but another Georgian word, *varskvlavi*, meaning *star*. It appears that the author refers to other literary sources while writing this part of the manuscript. Chapters 12 to 22 are devoted to the descriptions of changes in the weather throughout a year, to the wind, mist and other phenomena. The writer describes the rainbow, with quite a correct general perception of its nature. He tries to describe the appearance of a meteor and some other events. On the whole, this part of the manuscript is of somewhat ambiguous character. On the one hand, some events are treated correctly from a physical point of view; on the other, a number of phenomena are misinterpreted. For instance, in the description of the thunderstorm, he does not even suspect that the light and the sound move at different velocities.

The text of the manuscript contains neither mathematical descriptions of natural phenomena, nor graphs and drawings. It is rather of a descriptive, narrative character. Neither the first nor the last pages of the manuscript reveal the name of the author or the writer. Considering the contents and style of the manuscript, it appears to be a brief manual or text book on elementary cosmography. Anyone possessing an intermediate level or respective knowledge could study the material and apply it in practice. The contents of the manuscript seems to have been designed for scholars of intermediate grades, both of clerical and secular schools. The style of the narrative, the author's level of interpretation of natural events, the list of the countries cited and the fact that the writer used the *Mkhedruli* alphabet, as well as characters of the old *Asomtavruli* alphabet, all strongly indicate a 18^{th} century origin of this manuscript. In that age, without technical devices for making copies, rewriting of historical and historico-scientific materials was the only possible way to preserve them. They were copied again and again, year after year, century after century. This is the way how many old Georgian historical and scientific documents have reached us. And here credit goes to scientists and philosophers as well as to numerous clergymen who had been copying for us old Georgian manuscripts and documents. They seemed to take care of the history of science and history of religion, realizing the importance of handing down the inheritance of knowledge, skills, ideas to future generations. If the above considerations are correct, this copy from the 18^{th} century may be based on an original Georgian manuscript of the $11 - 16^{\text{th}}$ centuries, and this fact may give us the clue to the puzzle of the late Georgian geocentrism.

As concerns the dating of the plausible original manuscript, two points should be mentioned: (a) the *Mkhedruli* alphabet used in the

document doubtlessly indicates an 18th century origin of its composition; and (b) the copyist of this elementary cosmography never used the ancient Georgian names of the luminaries: Jimagi (Mercury), Mtiebi (Venus), Tarkhoni (Mars), Obi (Jupiter), Morige (Saturn). These ancient Georgian names had been used both in western and eastern parts of Georgia up to the third century AD (Simonia 2001). Items (a) and (b) may serve as additional indicators in the process of exact dating of this *elementary cosmography*. The scientific contents and the style of narration suggest that the original belonged to the mid-period of the process of formation of the Georgian astronomical world view. A correct dating of the original text is a complicated task calling for further investigation.

The analysis of the "Elementary Cosmography" is certainly not completed. The document ought to be compared with similar foreign sources. In short, it will take quite a lot of efforts, but the first step has been made, and we will appreciate any ideas, questions and counterarguments.

Acknowledgements

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Little known aspects of the history of Georgian astronomy

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Abstract

The present paper reviews the fundamental achievements of ancient Georgian astronomy and the dynamics of the process by which the Georgian astronomical world view developed in the period from the sixteenth century BC to the eighteenth century AD. It is during this period that the Georgian astronomical world view both formed and became fully developed. The author of the present paper divides this extended period into three shorter periods: an archaeological period, a transitional period, and a period of systematics. The characteristics of these three periods are cited. The paper also presents various facts and other information that illuminate the life and work of Georgian astronomers as well as the functioning of ancient Georgian astronomical and other scientific institutions. Several Georgian astronomical manuscripts are mentioned and described in brief, and a number of other questions are also discussed.

Keywords: *Georgian astronomy, cosmograms, David Gareja complex, Gelati Observatory, Narikala Observatory, The Star Book, Vakhtang IV Bagrationi*

1 INTRODUCTION

The aspect introduced here is quite complicated and an arduous Georgian history makes this task even more difficult. Information and materials, sources and facts have to be gathered piece by piece as precious stones on the beach of an impetuous history. This study is merely a first step in documenting a history of Georgian astronomy, and in this paper we try to reflect the dynamic process by which astronomy developed in Georgia over a protracted period of time. We subdivide this period into shorter periods: an archaeological period, a transitional period, and a period of systematics.

Georgian astronomical and astrological manuscripts, that until now have been unknown to Western researchers, are deserving of study. Approximately 300 such manuscripts are preserved in the various institutes and archives of Georgia. These manuscripts form a huge monolith of astronomical data that bring information of a relict character. These manuscripts did not disappear in the fire of social and natural cataclysms, did not sink into oblivion in the depths of ancient centuries. They were preserved through the self-sacrificing work of Georgian authors, translators, and copyists. It is possible that there are many unknown, unstudied sources of historical-astronomical information in the world – in particular in those countries that are only now re-establishing themselves as independent states. Therefore it seems expedient to propose the creation of an international institute of 'unstudied' historical-astronomical materials or, for that matter, of 'unstudied' historical-scientific materials in general. Such an institute would study the previously-unknown materials and would publish the study results in special bulletins in order to bring the 'new-old' information to the attention of the international scientific community.

The ruins of old observatories, fragments and remains of instruments, numerous manuscripts and books, unclaimed discoveries, and forgotten names – this is the world of ancient Georgian astronomy, which until now has been little known outside of Georgia.

The state of Georgia (see Figure 1) is located in the Caucasus on the very border between Europe and Asia. The Black Sea, Caucasus Mountains, and thick forests together create a unique, beautiful landscape and healthy, temperate climate. This territory was already populated by Georgian tribes in ancient times, and a Georgian state has existed for more than twenty-five centuries. Over these long, difficult centuries the Georgian people created their own language, culture, and world view. Numerous monuments of literature, art, and architecture bear witness to the original culture of these people.

Fire worship and other religions were widespread in Georgia until the fourth century AD. Christianity began to spread across Georgia in the first half of the fourth century, and within 100

years it had acquired the status of the state religion. This process was brought about by the strong political and cultural influence emanating from the eastern provinces of the Roman Empire, with which Georgia had close relations. Poti, on the Black Sea near the ancient city of Phazis, was both one of the first cities and one of the first cultural centres. Later Kutaisi and Mtskheta became major cities and cultural centres. At the present time Georgia's most important city and cultural centre is Tbilisi, which is also the capital of the Republic of Georgia. This city was founded in the fifth century AD by the Georgian king and military leader Vakhtang Gorgasali.

Figure 1. Location map of places mentioned in the text.

Celestial phenomena interested Georgians from ancient times. This is confirmed by real proofs. Oral folk art has brought down to us ancient Georgian sayings and legends that mention individual celestial bodies, various celestial phenomena, and so on. The principal thought or moral of such legends was the 'supremacy of celestial laws' and the 'inevitability of punishment by powerful celestial forces'. The ancient Georgians attached a mystical character to the sky and to celestial phenomena, thereby acknowledging their full grandeur. Ancient material objects of brass, bronze, silver, and gold have also come down to us. When we examine these ornaments, implements of labour, weapons, and household wares, we see images of the Sun, Moon, and stars presented in various shapes and sizes. The fact that ancient Georgians depicted celestial bodies on material objects shows that celestial phenomena interested them.

2 THE ARCHAEOLOGICAL PERIOD

What are the most ancient material objects containing images of an astronomical character? In the 1940s Georgian archaeologists (Gambashidze *et al.*, 1986) discovered bronze plates dating from the sixteenth to the fourteenth centuries BC. In all about thirty plates were discovered – primarily in the graves of women – at various burial sites including the large burial ground known as 'Zadengora'. The plates are massive and measure several tens of centimetres in diameter. Their surfaces are covered by numerous convex, circular apertures, Figure 2. Until now Georgian scientific literature has examined these plates only from the archaeological point of view. In the present article we shall examine them from the astronomical point of view for the first time.

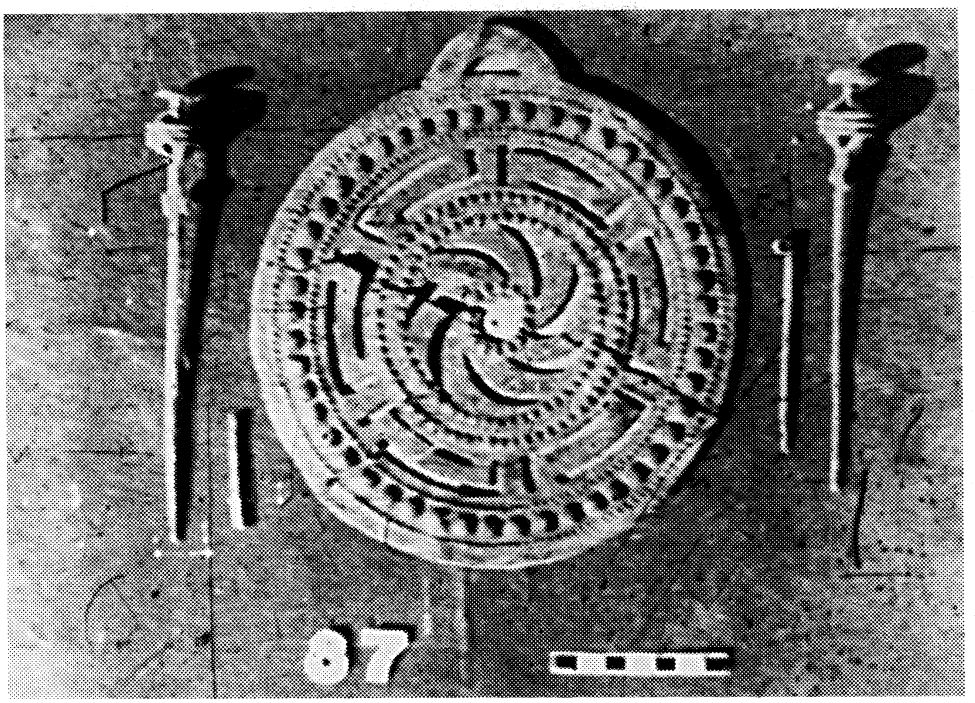

Figure 2. Georgian bronze plate, circa fifteen century BC.

Georgian tribes that populated the eastern regions of Georgia in the sixteenth to fourteenth centuries BC supported themselves mainly through agriculture and by raising cattle. These tribes practised fire worship. Worship of the cults of fire, heat, and light played an important role in the lives of the Georgian tribes. Giving tribute to the Sun as the principal source of light and heat and also seeing its large dimensions, the ancient masters and artists depicted it in the centre of the bronze plates in the form of a circular aperture.

The Moon served as another important source of light for the ancients. It was precisely the Moon that supplied them with bright light at night. Phenomena such as changes in the phases of the Moon provoked their special interest and had overtones of mysticism. As a result, the Moon was depicted on the bronze plates in the form of a sickle-shaped aperture.

The ancients also saw other celestial objects in the sky and noticed that they differed from each other in form, brightness, and colour. Trying to reflect these differences, the ancient Georgian masters gave varying outlines to the spherically-shaped protuberances on the surfaces of the plates. Thus the ancient bronze plates reflect what the Georgian tribes saw in the sky. The religious views of the tribes also played an important role in the distribution of images of celestial bodies on the ancient bronze plates.

The character of the pictures on these bronze plates is clearly systematic. Perhaps the artisans of these plates have put their cosmological understanding in them? Therefore it is suggested to call these ancient Georgian bronze plates 'cosmograms' (Simonia, 2000). It seems to us that these Georgian cosmograms are the earliest known material objects in Georgia to include astronomical images. At the present time the cosmograms are preserved in various Georgian museums and institutes. It would be interesting to conduct a comparison between the Georgian cosmograms and analogous objects that can be found in other parts of the world.

The most ancient Georgian states were formed in the sixth century BC. The western Georgian state was known as Kolkheti, and the eastern Georgian state was called Kartli. (Some literary sources call Kolkheti by the name Egrisi and Kartli by the name Iveria.) New societies and institutions characteristic of that time began to take form in these two Georgian states. Agriculture and cattle-raising continued to develop, but artisanal professions and trade with neighbouring and distant states also arose. In the third century BC the Georgian king Parnavaz united the western and eastern Georgian states into a single state. At that time the religion of Fire-Worship was widespread.

The principal Georgian god was the Moon, which was seen as the symbol for a male warrior. The Moon's sacred animal was the bull, and thus bulls were frequently given as sacrifice. The shape of the bull's horns reminded the ancient Georgians of the Moon. Various depictions of the bull and his horns were widespread on the walls of religious buildings and in the homes of the ancient Georgians. Statues and statuettes of bulls (see Figure 3) and other sacred animals likewise spread widely. Such animals as the lion, boar, donkey, and deer were worshiped by the ancient people and this is the reason for their sacred representation of these animals. Relief images of sacred animals and geometrically complex Georgian ornamental design compositions were cut into the surfaces of such metal objects as containers, women's jewellery, shields, and so on. Among the various compositions and graphical fragments, the diverse symbols and signs of a clearly astral character are of special interest (Figure 4). Symbols showing spatial relationships and symbols of motion are especially widespread.

King Parnavaz played an important role in the development of Georgian language and culture. In the third century BC he invented the first Georgian alphabet. In doing so he became the founder of the written Georgian language, the history of which has been studied by the French orientalist Mary Brosset and the Georgian historian Simon Kauhchishvili (Brosset, 1849-1858). The creation of writing served as a turning point in the development of Georgian culture. The first written inscriptions appeared on material objects, and the process of developing a literature began. We believe that the development of the early Georgian astronomical concepts culminated simultaneously with the creation of a written language. This early period encompasses the sixteenth through the third centuries BC. We propose that this early period be called the archaeological period. In the course of this period the following two processes developed: a) acquisition of the simplest primary knowledge of the sky and celestial objects by the ancient Georgians and b) representation of this acquired knowledge in culture, in oral works, and in the applied arts.

Figure 3. Statuette of bull.

The acquisition of knowledge during the archaeological period, and likewise the invention and spread of a written language transformed and expanded the world view of the ancient Georgians. A new class of citizens appeared in society – a class whose principal activities included the writing of chronicles, the development of grammar and arithmetic, and so on. From this class we must take note of those (generally people close to the king) who were charged with making regular observations of celestial bodies insofar as these were seen to be higher powers upon which earthly life depended. The observers of that time undoubtedly would have noted that many climatic phenomena (e.g., river flooding, cooling and warming trends) were preceded by various celestial phenomena, such as the appearance of certain stars, and the disappearance of others. Having noted this type of regularity, the ancients would have tried to use it for their practical aims such as agriculture. Purely earthly concerns such as fertility and crop yield would have caused the ancients to study deeply and in detail the regularities in the

disposition and motion of celestial bodies. In this way the prerequisites for the appearance of astronomy as a science were created – in particular the prerequisites for those important parts of astronomy concerned with chronology and the calendar.

Figure 4. Relief images of sacred animals on Georgian silver cup, third century BC.

Georgian historical manuscripts and notes that form a historiography called *The life of Kartli* (Kaukhishvili, 1959) tell us that in the second century BC Georgia used a lunar calendar, and we know that this lunar calendar continued to be used until the end of the third century AD. These chronicles have provided us with the ancient Georgian names of the known planets: Mercury–Djimagi, Venus–Mtiebi, Mars–Tarkhoni, Jupiter–Obi, and Saturn–Morige. These names were used in Georgia until the end of the third century AD. In the fundamental work of Ivane Dzhavahishvili, *The History of the Georgian Nation* (1949), it is shown that Mtiebi is an ancient Georgian word meaning 'the star of sunrise', that is, Venus. The word Morige in the ancient Georgian language meant the name of the highest God of the 'seventh sky'. In some parts of Georgia it was believed that Morige was a god of order. Dzhavahishvili compares Morige with Chronos. He also mentions that the word Obi (or Vobi) meant the name of the God of thunderstorm in ancient Georgia. He therefore compares Obi with Dios. In the same work it is also mentioned that the word Djimagi named the God of Wednesday, which corresponds to Hermes or Mercury, while the word Tarkhoni means the God of War, which corresponds to Mars. Dzhavahishvili stresses that all the above names were widely spread in both Eastern and Western Georgia. The history of these names themselves goes back as far as the times of fire-worship and heathenism. When working on this part of the paper it was thought that it would be a good idea to create a dictionary of ancient astronomical terms and names. Such a dictionary could comprise Arabic, Greek, and Georgian terms and names. Analysis and comparison of these names could lighten up many interesting questions of the history of astronomy. We only have to find co-authors from the East and West.

The existence of a calendar and of Georgian names for the planets tells us that in the period between the second century BC and the third century AD, the Georgians had some degree of knowledge of celestial phenomena and that they used this knowledge in practical life. Naturally, at that time this knowledge could only have a limited character.

3 TRANSITIONAL PERIOD

The period from the second century BC to the third century AD was a transitional period in the development of the Georgian astronomical world view. This transitional period was characterized by simple astronomical observations and likewise the creation and use of the first calendars. It was the priests who observed the sky and who played an important role in the organization of regular knowledge, and during this period many generations of priests succeeded each other. Unfortunately, the Georgian chronicles do not give us their names.

The spread of Christianity in Georgia in the fourth century AD gave an impulse to the development of new elements in Georgian culture. New, progressive – in the context of that time – ideas and views as well as knowledge of man and the world penetrated into Georgia. A feudal society began to form. The first schools and educational institutions began to spring up. The process of systematically translating foreign books into the Georgian language began, and new knowledge enriched the Georgian astronomical world view.

4 PERIOD OF SYSTEMATICS

In the second half of the fourth century AD the Julian calendar came into use in Georgia, and from this moment a new period in the development of the Georgian astronomical world view begins. This period can be called the period of systematics. Fragmentary evidence from various sources shows that in the fifth and sixth centuries AD the teachings of the Greek astronomer Claudius Ptolemy began to spread in Georgia. Ptolemy was a popularizer of the geocentric theory. The educated sections of the population (i.e., the priests and the king's courtiers) evidently were well acquainted with the geocentric system. In the Georgian language there exists the word 'Dedamitsa', which literally translates as 'mother Earth'. Here the word 'mother' signifies beginnings, the start of existence. Thus the question arises, did this word not appear at that time when the ideas of geocentricism first penetrated into Georgia? Additional study will be required to answer this question.

In the sixth century AD the priest Father David and his students founded the David Gareja complex in the rocky mountains of Gareji near Tbilisi (Dzhavakhishvili, 1949; Gubinashvili, 1948). The monasteries in this complex were hollowed directly out of the rocks. In various historical periods the number of monasteries grew to as many as twelve. In the seventh through the ninth centuries AD, David Gareja became a major religious and educational centre, and regular observations of the celestial bodies were conducted there. The works of foreign authors were translated into Georgian. At David Gareja a large library of philosophical works was collected. In our view David Gareja could be, in fact, the first Georgian astronomical centre. This complex continued to function through several more centuries, surviving periods both of flourishing activity and of decline. Fragments and ruins of this complex have been preserved until the present time (see Figure 5). Unfortunately, the sources of the above information do not give any details of the scientific research that was carried out in David Gareja.

The earliest manuscript containing astronomical information to survive to the present day dates from the tenth century AD (Kevanishvili, 1951). This manuscript is 263 pages in length, is written using letters from the first Georgian alphabet, and has both religious and astronomical content. The manuscript illuminates questions of chronology, and it describes and gives tables for computing solar days and months (see Figure 6). It discusses the regularities in the day-night cycle and gives other information as well. Evidently the manuscript's religious portion is not itself an original work but is, rather, a translation into Georgian. This manuscript is the first historical document bearing witness to the development of astronomy in Georgia.

In addition to the above we have to say that the name of the author of the manuscript or the name of the copyist who completed his work in year 974, is unknown. The catalogue of Georgian astronomical manuscripts by Galaction Kevanishvili states, though with no proof, that this manuscript is a copy. This at least means that the original manuscript was of an earlier date. We cannot confirm nor disprove the hypothesis that this manuscript has been copied. The manuscript deserves a special study.

Chronicles and other historical materials give evidence that at the end of the first millennium an astronomical observatory was functioning in Tbilisi, in the region called Narikala. The available materials do not allow us to establish the precise date of this observatory's founding, but these same materials do show that it was active in the tenth century. Staff at the observatory carried out various predictive computations and practical observations, and compiled tables and calendars. They also translated the works of Greek and Arab astronomers. There is evidence that Arab astronomers worked at the observatory for an extended period, and thus we cannot exclude the possibility that information about the Narikala observatory could be found in Arab sources. The observatory continued to function until the fourteenth century.

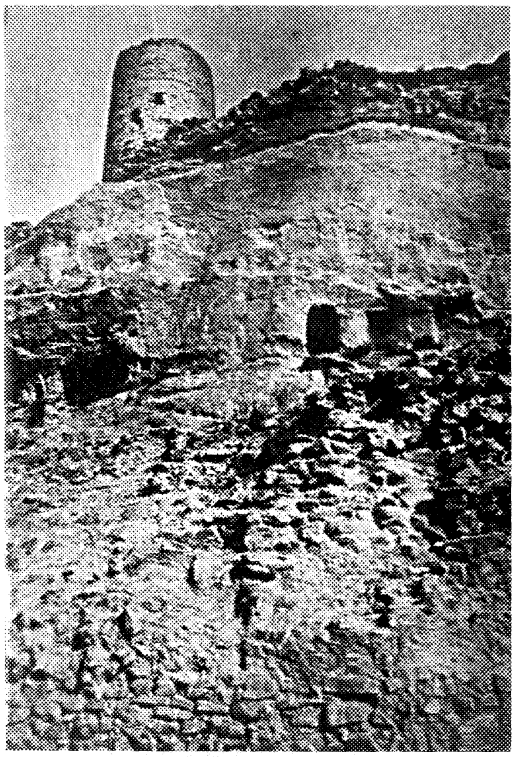

Figure 5. Ruins of part of the David Gareja centre from sixth century AD.

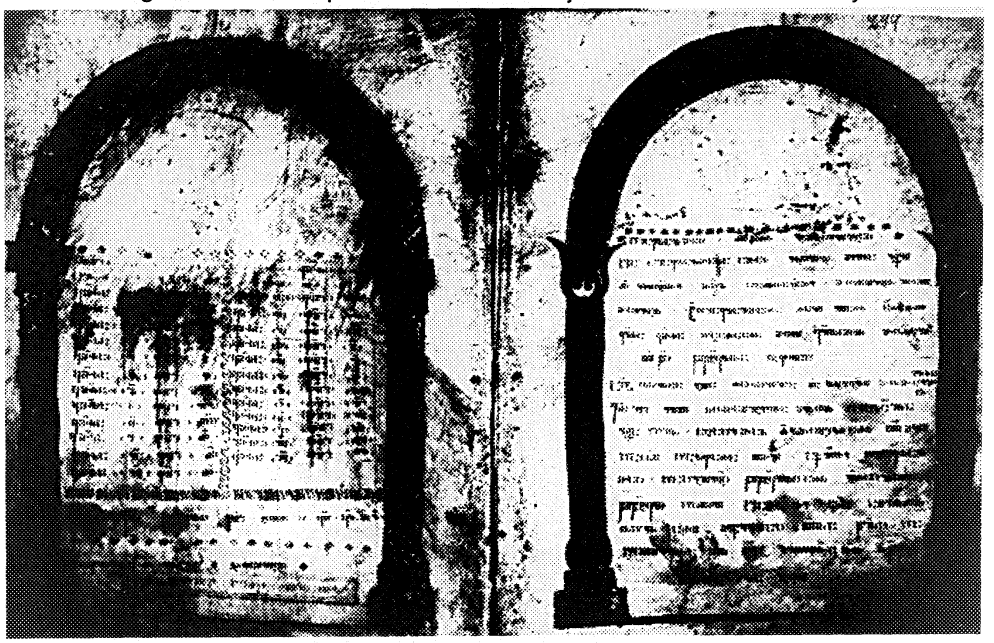

Figure 6. Page from Georgian manuscript, tenth century AD.

In the thirteenth century the Georgian and Eastern astronomer Khlateli (or Ikhlati) worked at the Narikala observatory (Kharadze and Cochlashvili, 1958; Kharadze, 1975). Using simple instruments for making angular measurements, he conducted observations from which he compiled tables, calendars, and so forth. Ikhlati was also a good computer. The well-known Eastern astronomer Nasireddin at-Tusi took note of Ikhlati's scientific abilities and invited him to work at his observatory at Maraga, where Ikhlati adopted the name Fakhredin Ikhlati. As shown in Matvievskaia and Rozenfel'd (1983), Ikhlati was an Eastern astronomer, and one of the closest co-workers of Nesireddin at-Tusi. The authors call the astronomer Fakhr Ad-Din Al-Maragi. We do not know the years when he worked in Georgia. A fair question arises here:

what was the actual name of this astronomer – Ikhlati, Fakhr Ad-Din or Khlateli? In our opinion, he can be called by any of these names, as he contributed to Eastern and Georgian astronomy.

In 1106 the Georgian King David IV Bagrationi founded the scientific and cultural academy Gelati in the western part of Georgia, not far from the city of Kutaisi (Gamsakhurdiia, 1975; Kaukhchishvili, 1948). David IV (1073-1125) played a special role in the history of the Georgian state. Having only a small army, he nevertheless succeeded in liberating Georgian territory from foreign invaders. He also succeeded in uniting the fragmented parts of Georgia into a single state. David IV created state institutes and structures that were progressive for their day. In addition, he devoted a significant amount of time to scientific and cultural activities of various kinds. David IV has gone into Georgian history as David the Builder. He is buried in the grounds of Gelati.

Several of Gelati's buildings and structures have survived to the present day. Some sources (e.g. Kareeva, 1894 and Khakhanov, 1898) note that the Georgian philosophers Arsen Iqaltoeli and Ioanne Petritsi were invited to work at Gelati, where they conducted active scientific, pedagogical, and translating work. These same sources indicate that geometry, arithmetic, music, philosophy, rhetoric, grammar, and astronomy (or, as it was called at that time, astrology) were all taught at Gelati.

Gelati had an astronomical observatory (Figure 7) where a variety of observations were carried out using astrolabes and other instruments. David the Builder in his own works writes that he devoted many nights to the stars, studying their positions in the sky and their effect on the fates of man and the state.

The Georgian astronomer Abuserisdze Thbeli (1190-1240) made an appreciable contribution to the development of the Georgian astronomical world view. Working in the ancient Georgian language, he wrote a fundamental treatise on calendars and chronology, the title of which can be translated approximately as *The Complete Time Keeper* (Dzhavakhishvili, 1945; Lordkinanamidze, 1977). This treatise contains information related to calendars, descriptions of different systems for maintaining chronology, dates of church holidays, tables of moonrise and moonset, information on special cycles, and so on.

Abuserisdze Thbeli did not conduct astronomical observations himself, nor did he work in any astronomical laboratory. His treatise has a theoretical character and is connected to a large degree with his mathematical investigations. *The Complete Time Keeper* is, in fact, the first astronomical work of a theoretical nature produced in Georgia, and this elevates Abuserisdze Thbeli to a special place in Georgian astronomy.

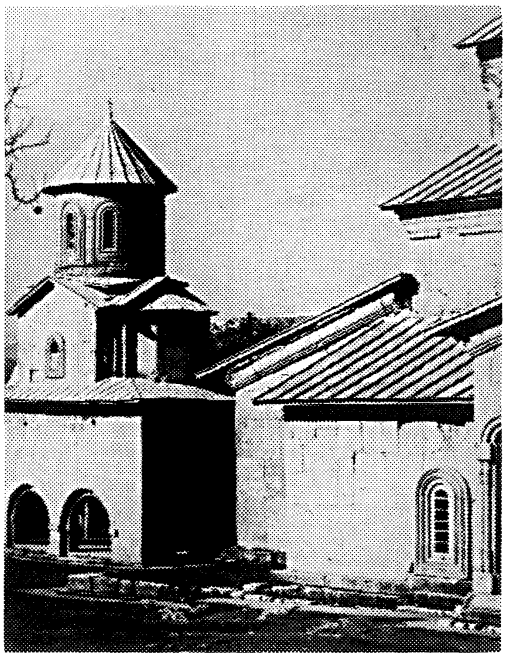

Figure 7. The astronomical observatory at Gelati.

Analysis of manuscripts, books, and material objects shows that the basis for the Georgian astronomical world view in the tenth through the thirteenth centuries remained Ptolemy's geocentric system, a description of which can be found in almost every astronomical manuscript from that period. There are some variations in the description from one manuscript to another, and there are differences in detail. Nevertheless, one can find mention of the Ptolemaic system even in non-scientific manuscripts. These facts show that the geocentric idea had complete control of the minds of Georgian astronomers and philosophers at that time.

The scientific work of Georgian observatories in the tenth through the thirteenth centuries expressed itself primarily in the study of star positions. The following peculiarity is noteworthy: as a rule those manuscripts containing the fundamentals of theory are translations of foreign authors into Georgian, whereas the manuscripts and books of a calendar-chronology character belong to the pens of Georgian authors. This fact implies that fundamental theoretical ideas penetrated into Georgia from outside. The Georgian astronomers and philosophers concerned themselves with developing the more practical, applied areas of astronomy that were necessary to both the people and the state. In particular, they concerned themselves with those practical areas that were needed for the construction of precise calendars, for the determination of time periods, for the prediction of dates for church and civil holidays, and for commercial, military, and other purposes. This was natural, of course. One cannot imagine the normal development of a state without knowledge of precise time, or without the possibility of predicting climatic phenomena connected with the different seasons of the year. We could give the name 'scientific systematics' to these practical works by Georgian astronomers.

Such systematics have both positive and negative aspects. On the negative side, extreme practical aims pushed aside the important necessity of perfecting basic theoretical ideas. On the positive side, the deepening of practical knowledge and habits must have stimulated the development of related disciplines. In particular, constant improvements in the calendar system in Georgia gave a powerful stimulus to the development of Georgian mathematics.

Of course, early scientific systematics were not unique to Georgia. Other countries with analogous social and economic structures and with analogous world views also passed through this phase. An interesting peculiarity of that time is that along with astronomical information and descriptions, the majority of written materials also contained astrological information. As a rule, the astrological information encompasses those questions concerned with predicting, forecasting, or otherwise determining people's fates in accordance with the disposition of the stars and so forth.

Society at that time continued to be under the influence of various types of mystical ideas and concepts. We can conjecture that there was something like a state-supported institute of astrologers in Georgia and that Georgian kings had court astrologers who were responsible for predicting the fate of the king, the state, and even individuals. Astrologers wrote their works, compiled tables and graphs, and distributed all of this among the appropriate layers of society. It is interesting to note that manuscript materials always exhibit a sharp, definite dividing line between their astronomical and astrological parts. It was usual that certain paragraphs in these manuscripts would be devoted to astronomy, while other parts would be concerned with astrology. Astrological predictions in Georgian manuscripts may be characterized by descriptions of life and health of a man in various periods of time (months, weeks, days). These facts demonstrate that in Georgia in the tenth through thirteenth centuries the distinction between astronomy and astrology was already understood. Figure 8 shows the use of symbols for the zodiacal constellations in a Georgian manuscript (Kevanishvili, 1951).

We should like once again to turn to the catalogue of Georgian astronomical manuscripts by Galaction Kevanishvili (1951). It states that the above manuscript contains 209 pages. It was copied (into ancient Georgian language) in 1210, by someone named Isaim. The pictures of zodiacs and Moon phases are done in gold. The manuscript contains descriptions of calendar systems, zodiacs, and Moon phases. Unfortunately, we do not have any reference to the name Isaim.

The most complicated period in Georgian history began with the start of the Tatar-Mongol invasion in the middle of the thirteenth century. This invasion involved numerous battles and resulted in widespread death among the population, and the destruction of cities and cultural centres. The Tatar-Mongols attempted to seize the territory of Georgia. However, loyal

Georgian armies and strong opposition among the populace became an insurmountable barrier in the path of the newcomers. Although at a great cost, the Georgian government was preserved, and relative peace was restored. But Georgia to all intents and purposes lost its freedom through external political action, being forced to pay large tributes and to supply soldiers for the Tatar-Mongol armies on a regular basis.

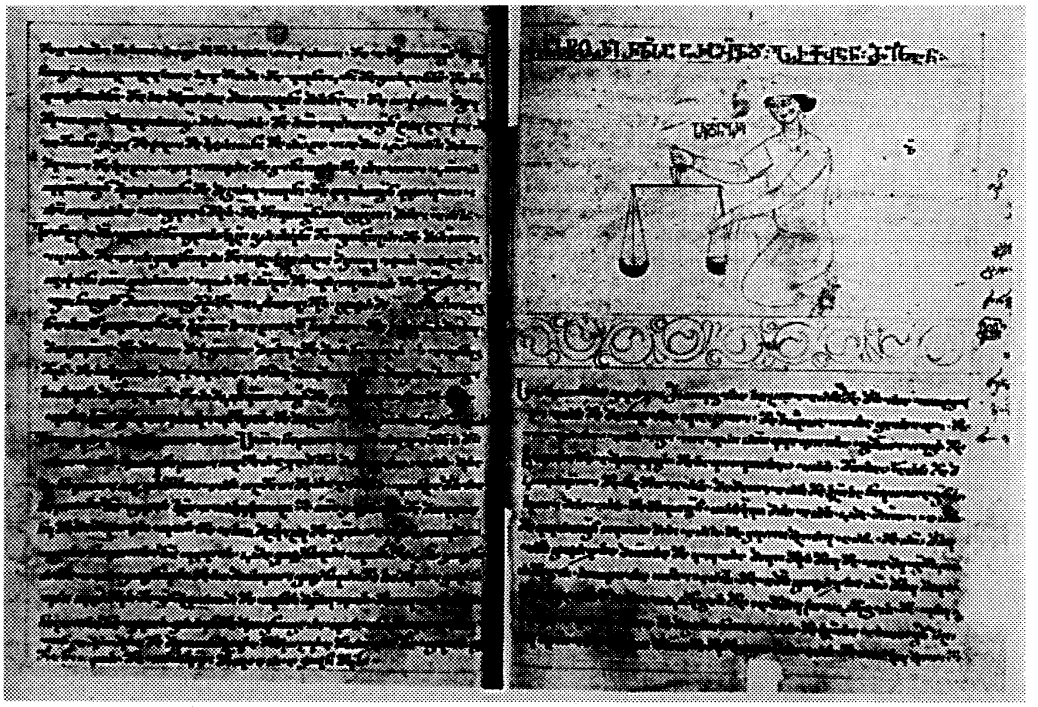

Figure 8. The zodiacal constellation of Libra depicted by symbols in an ancient Georgian manuscript.

Georgian King Georgi V (reigned 1313-1346) used flexible politics to strengthen the Georgian state. As a result Georgia was able finally to free itself from the Tatar-Mongols by the middle of the fourteenth century. This period of calm turned out to be short, however, with Tamerlane's (Timour, 1335-1405) invasion beginning at the end of the fourteenth century. Georgian soldiers and people resisted fiercely, but the forces proved too unequal. Nevertheless, resistance continued. One of the most notable resistance figures was Georgian King Georgi VII (reigned 1393-1407). With the death of Tamerlane, Georgia once again secured its liberation.

The events of the thirteenth through the fifteenth centuries had a negative effect upon the development of Georgian culture and science. The invading hordes destroyed the academies and observatories and burnt the libraries, and the Georgian people had to start over again from the beginning. The process of restoring the Georgian state began at the start of the sixteen century. Cities and cultural centres were resurrected, schools were opened, and the people gradually returned to their accustomed style of life.

The resurrection of scientific thought accompanied the general restoration of the state. Special interest was paid to the science of the sky – in particular to its practical applications. In the sixteenth and seventeenth centuries no fewer than nineteen astronomical works were translated into Georgian – most of them dealing with calendars and chronology. Georgian authors, translators, and book copiers all realized the importance of restoring astronomical knowledge, which to all intents and purposes had been lost in the period from the thirteenth through fifteenth centuries. The writing and translating of astronomical manuscripts continued even into the eighteenth century.

Let us take a closer look at one of these manuscripts entitled *The Star Book*, which dates from the beginning of the eighteenth century (the original is preserved in the Georgian Manuscript Institute in Tbilisi under catalogue No. Q 867). The manuscript, whose author is unknown, consists of 250 pages and is divided into 31 chapters, each of which is devoted to a specific topic of an astronomical or astrological character.

On page 7, chapter 1, of *The Star Book*, we find the following statement: "Zokhar has a single star in the sky." Zokhar is Venus, and the reference to a star "in the sky" is a way of indicating that Venus has a satellite. On page 8 we also find: "Marekhi has a single star in the sky." Marekhi is Mars, and the reference to a star here is also a way of indicating the presence of a satellite. In both cases the manuscript gives a measure of the satellite's orbit. It is difficult to explain these two statements. At that time there were no optical instruments capable of revealing the satellites of Mars, and of course Venus has no satellites at all.

Chapter 8 of *The Star Book* concerns the Moon. Page 42 states: "First we must know that God created the Sun and Moon and ordered that the Moon should receive its light from the Sun. The Moon itself is blank. The Moon illuminates us after receiving its light from the Sun." These quoted sentences, translated from Georgian, show unambiguously that the manuscript's author understood the fact that the Moon shines by reflected light. Page 42 also includes the statement: "Many philosophers, first of all Alexander, say that Galileo built a ten metre tube and, after using it, asserted that the visible dark spots on the Moon's surface are in fact mountains, seas, and rivers." The description of a 10-metre telescope is confusing but we have given the exact meaning of this part of the manuscript. Nevertheless, this citation shows that the author was acquainted with seventeenth and eighteenth century European literature and knew of some of the achievements of European astronomers. The author of the manuscript does not give any information about Alexander, but we have done a wide search of the sources (Metreveli, 1979), and among a long list of names we found Alexander Bagrationi (1674-1711), the son of Georgian King Archil II Bagrationi. Apparently Alexander Bagrationi was doing a lot of things, including translating and copying of the manuscripts Our careful guess is that this is the same Alexander.

Chapter 12 deals with eclipses of the Sun and Moon. Page 59 states: "Belorano was a scientist who for wisdom has no equal in our times. If he had lived at the time of Aristotle, then the latter would have paled before him. This scientist greatly simplified astronomy. He could determine in which year, in which month, in which week, on what day, and at what time eclipses of the Sun and Moon would take place." In translating these lines from the Georgian language we have tried our utmost to preserve the author's style. It is apparent that the manuscript's author was familiar with the scientific works of the European astronomer Belorano. Figure 9 shows page 59 of the manuscript together with an original drawing. On page 60 we find a detailed description of the conditions for both total and partial solar and lunar eclipses. Unfortunately, all our attempts to determine who Belorano was have failed. We hope that our collegues will be interested in this question and we will be able to solve it together.

Chapter 14 concerns planetary motion, and page 72 contains a drawing that reflects the author's cosmological world view. From the centre to the edge we find regions that are labelled as follows: "Earth water," "air," "fire," "sky Mtvare" (the Moon), "sky Otarid" (Mercury), "sky Zokhar" (Venus), "sky Mze" (the Sun), "sky Marekhi" (Mars), "sky Mushtar" (Jupiter), "sky Zokhal" (Saturn), "the fixed sky," "the second movable sky", and "the first movable sky." From this we can see that the author had a geocentric world view.

Chapter 15 is devoted to the motion of the celestial spheres. Page 77 states: "The sky itself moves and rotates, but the stars are fixed to their places. Hence we speak of the 'fixed sky'." Page 78 states furthermore that "its width is 250,230,000 agadji." (The agadji was an ancient Georgian unit of measure that is equal to approximately 4-5 km.) On page 78 we find the following: "The ninth sky – the second movable sky – is like crystal." Chapter 15 contains information on the dimensions, motion, and periods of the different spheres and on the dimensions of the stars, and it also gives information of a religious character. Indeed, chapter 15 is the author's attempt to describe the universe as a whole, and the quoted fragments tell us something about his world view.

The manuscript's subsequent chapters contain information on the 12 zodiacal constellations, on the number of stars in the constellations, on star brightness, on the annual motion of the Sun through the constellations of the zodiac, on the motion of the Moon, on the calendar, on the changes of seasons, on several types of climactic phenomena, and on crop yields to be expected in coming years. The manuscript also contains extensive information of an astrological character.

This general review of *The Star Book* shows that it contains diverse types of information. On the one hand the manuscript contains information that was modern for its time, for example,

information on telescopic observations by Galileo, on the sizes and shapes of the planets, and on the daily and annual motion of celestial bodies. On the other hand the manuscript also includes detailed descriptions of Ptolemy's outmoded geocentric system. It is our view that the manuscript's author attempted to create something of an encyclopaedia – astronomical handbook – containing various types of information that would reflect contradictory world views and ideas. The author evidently relied on various sources and used the achievements and works of various astronomical schools. *The Star Book* is an important historical-astronomical document that reflects the level of the Georgian world view at that moment in its scientific development. (It would be useful to translate and publish *The Star Book* to make it available to researchers.)

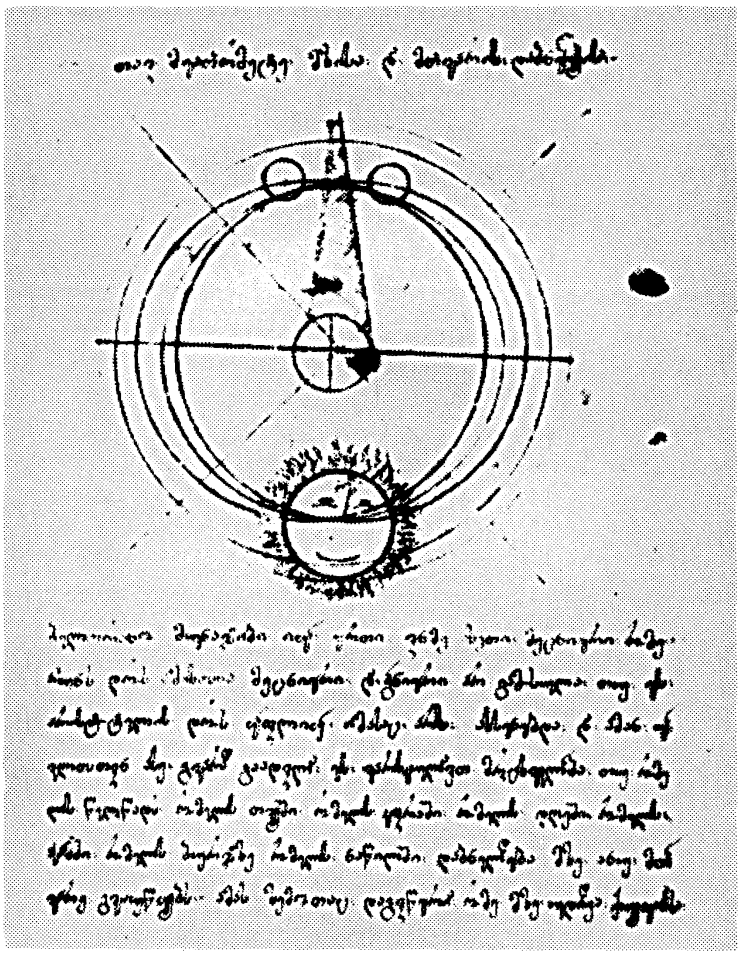

Figure 9. Page 59 of the Georgian manuscript, *The Star Book*.

The first quarter of the eighteenth century was marked by the scientific and educational activity of Georgian King Vakhtang VI Bagrationi (reigned 1703-1723) and his associates. Vakhtang VI was not just a statesman. He was also a scientist. Astronomy, which he studied using ancient Georgian and eastern manuscripts and books, was one of those disciplines that held special interest for him. In his first period of scientific work, Vakhtang VI translated fundamental astronomical works from among the classics of Eastern astronomy into Georgian. Vakhtang VI translated the works of Ulugh Bek, Naseredina Tusi, and Ali Kushchi. In 1721 Vakhtang VI established a printing house in Tbilisi. That same year the printing house issued several hundred copies (according to various sources between 200 and 300) of an astronomical treatise by Ali Kushchi in a translation by Vakhtang VI. Several copies of this book have been preserved to the present day, and one copy is in the rare book division of the Georgian National Library in Tbilisi. Figure 10 shows pages from this book in which we can see a figure representing the geocentric system. King Vakhtang VI also produced his own astronomical works that for the most part were descriptive in nature and as a rule were devoted to descriptions of the geocentric system.

Figure 10. Georgian text and drawing of an astronomical treatise which was translated and printed by king Vakhtang VI Bagrationi.

In his second period Vakhtang VI conducted scientific work that was more practical in character. Persian masters built an astrolabe using plans drawn by the king himself. Vakhtang VI conducted regular observations with the astrolabe and used the results to construct special tables and other materials. Vakhtang VI's astrolabe (Figure 11) is preserved in the Georgian History Museum in Tbilisi.

King Vakhtang VI established scientific contacts with scientists from Georgia and from various countries. One of his main local associates – in both the political and scientific fields – was the Georgian philosopher, writer, and educator Slukhan-Saba Orbeliani (1658-1725}, who compiled an explanatory dictionary of the Georgian language under the title *Bouquet of Words*. This dictionary includes several hundred astronomical terms of both Georgian and foreign origin. Some of the terms first entered the Georgian language from Greek, Arab, or other languages and were then transformed to Georgian lexical forms and began to be used widely in scientific speech. By analysing the astronomical terms in the dictionary of Slukhan-Saba Orbeliani, we can study the process by which Eastern and Western astronomical ideas and views influenced Georgian astronomy (Simonia & Simonia, 1994; Georgobiani, 1986; Gavriushin, 1983).

The period of systematics in the development of Georgian astronomical world view can be characterized by the following processes:

a) formation of fundamental knowledge about celestial objects;
b) creation of a Georgian scientific astronomical literature in the form of a set of manuscripts;
c) practical and theoretical work by Georgian astronomers; and
d) the operation of Georgian astronomical observatories.

Figure 11. The astrolabe of king Vakhtang VI Bagrationi.

The idea of a heliocentric model began to spread through Georgia in the mid-eighteenth century, and by the end of that century the new astronomical world view based upon the heliocentric system of Nicolaus Copernicus had firmly taken possession of the minds of Georgian astronomers and philosophers. During this period the arrival of scientific and educational literature from various countries – including Germany, France, and Russia – acquired an intensive and regular character. Some of the books and scientific publications that arrived from these countries are preserved in the Georgian National Library and in various Georgian museums and archives. These preserved books and publications bear witness to the increased Georgian exposure to Western scientific literature in the eighteenth century.

With the arrival of the nineteenth century we come to the end of our survey.

5 CONCLUDING REMARKS

Of course, it would be unthinkably difficult in the bounds of a single paper to illuminate all details concerning the development of astronomy in Georgia for a period of more than 2500 years. To do so would require a whole series of diverse and complementary studies. We have not touched upon questions connected with the study of ancient Georgian astronomical inscriptions on the walls of such structures as monasteries and churches. We also have not discussed the instrumental aspects of measuring time in ancient days, although in Georgia the tradition of preparing and using solar clocks was well developed. Of course, these as well as many other topics and questions should be analysed in subsequent studies.

What we have tried to do here is describe the principal events, achievements, problems, and ideas of Georgian astronomy, information that was, until now, previously unknown outside of Georgia. We hope that we have been at least partially successful in bringing little known aspects of Georgian astronomical history to an international audience.

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ETHNOGRAPHIC AND LITERARY REFLECTIONS ON ANCIENT GEORGIAN ASTRONOMICAL HERITAGE

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Abstract: Ethnographic records and Georgian literature contain useful information about ancient Georgian astronomical knowledge systems and beliefs, with specific reference to time-keeping, the months of the year, the planets, individual stars and specific asterisms, star clusters, the Milky Way, and various kinds of ancient astronomical instruments. In this paper we examine a selection of such material.

Keywords: Georgian astronomy, ethnoastronomy, Georgian literature.

1 INTRODUCTION

Lately, significant attention has been directed to the study of ancient Georgian astronomy (see Chagunava, 1990; Georgobiani, 1986; Kharadze and Cochlashvili, 1958; Simonia et al., 1994, 2000, 2001, 2003, 2004, 2005). General trends in the development of ancient Georgian astronomy have been outlined; problems connected with the functioning of old scientific centers—and particularly observatories—have been discussed; biographical sketches of a number of important Georgian astronomers and philosophers have been presented; and papers and books discussing calendar systems, old manuscripts and books, and artifacts having archaeoastronomical significance have been published. However, much remains to be done, particularly in relation to

1) ethnographical accounts containing information about the sky and celestial phenomena;
2) stone constructions, ruins, monuments, cult places, temples and churches dating from the Bronze Age to the Middle Ages, and their archaeoastronomical and ethno-cosmological significance; and
3) the complex of ancient Georgian astronomical and astrological manuscripts stored at various institutions, archives and museums both in Georgia and elsewhere.

In this paper we contribute to the first of these priority areas by reviewing the astronomical evidence preserved in a variety of ethnographic sources before briefly examining astronomical references contained in some Georgian literature.

2 ETHNOGRAPHIC RECORDS AS SOURCES OF GEORGIAN ASTRONOMICAL INFORMATION

For the purposes of this study, we subjected the following groups of records to comprehensive analyses: (1) ethnographical notes and investigations carried out by Georgian ethnographers and historians during the twentieth century; and (2) various books and dictionaries published at different times in Georgia. Of course, this material is not uniform, but it contains a variety of interesting facts that reflect the knowledge of ancient Georgians about the sky, celestial bodies and impressive astronomical phenomena. Much of this knowledge had practical applications in everyday life, either during agricultural practices, or in direction-finding while voyaging. While some astronomical knowledge was modified or lost with the passage of time, basic concepts about the Universe survived through to the present day. We believe that the motivating mechanisms that led to accumulation of this celestial knowledge were: (1) the need for orientation and to fix time in order to maintain a continuous agricultural cycle; (2) the need for local and global spatial orientation, in order to bring the land into cultivation (i.e. to be able to build roads, construct settlements, etc.), as well as for military purposes; and (3) the need to 'interact' with bright heavenly bodies for cultic, religious purposes. These were the main factors that served to stimulate the accumulation and adaptation of knowledge about heavenly phenomena, knowledge that was used by ancient people in everyday life. Among ancient Georgians, this eventually led to the formation of a rather harmonious ethno-cosmological system of beliefs. However, our knowledge of this system is far from complete, for we only have snippets of information drawn from scattered ethnographical sources. Let us now examine some of this fragmentary evidence.

2.1 Orbeliani's Dictionary of the Georgian Language

In the seventeenth and eighteenth centuries the Georgian philosopher Sulkhan Saba Orbeliani (1658–1725) composed an explanatory dictionary of the Georgian language (*Sitkvis kona* = Bunch of Words), which included various astronomical words and terms. This dictionary was based of early Georgian and foreign

manuscripts, and the meanings of some of the astronomical terms were discussed by Simonia and Simonia (1994), who took into account the sources used when compiling the dictionary and the philosophical ideas of its author.

The final edition of Orbeliani's dictionary, published under the editorship of Abuladze in 1993, contains some terms relating to the calendar. For example, on pages 650-651 in the second volume the names of the months are given, not just in Georgian but also in Latin, Arabic, Turkish, Greek and Assyrian. Moreover, it is interesting that the author gives two different types of Georgian names for the months: the ancient Georgian literary names and the folk names. First, we shall list the folk names: gantskhadebis tve, phebervali, marti, aprili, maisi, ivanobis tve, kvirikobis tve, mariamobis tve, enkenis tve, gvinobis tve, giorgobis tve and kristeshobis tve (in that order). In English, these respectively mean: the month of Appearance, February, March, April, May, the month of Ivanoba, the month of Kvirikoba, the month of St. Mary, the month of Enkeni, the month of vine-making, the month of St. George and the month of Christmas. From the names it is obvious that the months were connected with important agricultural periods (e.g. the month of vine-making), as well as with the names of Christian Saints and with the birth of Christ. The dictionary demonstrates that these folk names for the months were used from the fourth century AD through to the eighteenth century.

For comparison we now give the ancient Georgian literary names for the months: apani, surtskunisi, mirkani, igrika, vardobis, marialis, tibis, kveltobisa, akhaltslisa, stvlisa, tirisknis and tirisdeni. The meanings of some of these names are clear, but others have still to be interpreted. For example, tibis tve (the seventh month), means the time of haymaking; akhaltslis tve (the ninth month), is the first month of a new year; and stvlis tve (the tenth month), means the month of counting—when they would count the harvest, and in particular the grape harvest.

It is clear that Orbeliani's dictionary contains valuable information about the astronomical and calendrical knowledge of the Georgian people, and that it warrants further study.

2.2 Javakhishvili's *Materials about the History of Georgian Local Manufactures and Small Handicrafts*

In 1983 a five-volume study titled *Materials about the History of Georgian Local Manufactures and Small Handcrafts* was published, based on ethnographic information gathered by I. Javakhishvili in villages throughout Georgia.[1] We found an interesting extract in the second part of the fourth volume, on page 154:

> When the time comes to let oxen off the plough, they (the drovers and ploughmen) eat. The day drover and ploughman go to sleep, while the night drovers send the cattle to pasture. When an ox is tired, it does not eat, but lies down to rest. A good drover does not allow it to lie and makes it eat. Otherwise, the following day a hungry ox cannot work. When the ox is sated, it lies down. A good drover does not lie down until the ox lies down. Then the drover lies down and puts his head on the ox. When the ox gets up, the drover wakes up. At dawn the ox usually runs away. It is tired of work. The drover needs to be very watchful and not allow the ox to run away. The ox goes far away to a pasture and the drover should know the time when to bring it back in order to yoke the ox in time. Night drovers compete with each other, and ploughmen compete in yoking the oxen. Drovers judged the dawn by the stars. When Mravalai was leveled, the drover sent the cattle to pasture. Little by little Mravalai declined and it was assumed that after Mravalai rose Sastsvrebi, and at the very end – Chkita or Tsiskari. Prior to Tsiskari, Khariparia rose. The drover looked up, saw Khariparia and used to say: "I can sleep a little more." He went to sleep and the ox ran away and was lost (an ox usually runs away at dawn). That is why this star is called "Khariparia". (Our translation).

First of all, it should be noted that "Khariparia" in English means "a runaway ox"; "Mravalai" means multiplicity; "Sastsvrebi" is Libra; "Chkita" is to peep out; and "Tsiskari" can mean "the door of the heaven" although it was also the name of the planet Venus. Ethnographers believe that the story of Khariparia has been part of Georgian folklore from time immemorial since farming has a long history in Georgia (see Assatiani et al., 1997; Braund, 1994).

We chose several stars as possible candidates for the 'role' of Khariparia on the basis of the following criteria, and estimated the changes in their coordinates over the last two thousand years as a result of precession.

1) The star had an apparent visual magnitude $\geq$1.5, in that it had to be bright enough to be conspicuous to an inexperienced observer.
2) Since it was visible following the spring period of sowing, we only chose stars with right ascensions between 18h and 05h 30m.
3) Given variations in Georgia's latitude, only stars with declinations north of –20° were considered.

We used the Simbad Astronomical Database for this analysis, and the results are presented in Table 1. This shows that the only viable candidates are α Lyr (Vega), α Aql (Altair) and α Cyg (Deneb). All of these bright stars could attract the attention of ancient drovers and ploughmen.

Table 1: Khariparia candidates.

Name	Magnitude	α 2000 (Simbad)	δ 2000 (Simbad)
α Lyr (Vega)	0.03	18 36 96.3	+38 47 01
α Aql (Altair)	0.76	19 50 46.9	+08 52 05
α Cyg (Deneb)	1.25	20 41 25.9	+45 16 49
α Tau (Aldebaran)	0.86	04 35 55.23	+16 30 33
β Ori (Rigel)	0.3	05 14 32.27	–08 12 05
α Aur (Capella)	0.03	05 16 41.35	+45 59 52

We then decided to extend the search to other objects and examined binary stars, wide pairs of double stars and selected variable stars, and so on, but none of these objects proved to be a suitable candidate on the basis of the aforementioned criteria.

2.3 Bochoridze's *Tusheti Ethnographic-folklore Material*

In his book on Tusheti ethnography and folklore, G. Bochoridze (1993; our translation) writes:

> Below I give brief information collected by me in the village of Omalo on celestial bodies. They are the stars: Khariparia, Tsiskari, Gutneuli, Jaraebi – a row of stars, Mravalai, Tsultokhebi – resembling a sickle. In spring they follow Mravalai at the distance of one sabeli (the unit of measurement in old Georgia), and in winter they are far from each other.
>
> Stars:
>
> 1. Tsultokhebi – rise in summer at supper-time, in the month of "Giorgobistve" they rise at midnight, they are 5 stars.
> 2. Mravalai follows Tsultokhebi as a cluster. Now it is called Jaraebi (Mravalai was its early name).
> 3. Tsiskari follows them, in summer – in the evening, in the month of Giorgobistve - at night, in supper time (in the morning it sets at dawn). It rises before sunrise, it is one star.
> 4. Mejoge, Jogis Tsiskari is one star. It rises after midnight and is a big star.
> 5. Irmebis Nakhtomi (Jump of deer). An ox and a deer competed with each other in serving a peasant, in adroitness and in ability. The ox won and the deer was torn into two parts when it jumped.

The ethnographers who collected this information probably did not have detailed astronomical knowledge or observing experience, and this is why they did not try to identify the different stars. What can we deduce?

It is interesting that in spring Tsiskari, Gutneuli, Jaraebi and Tsultokhebi follow Mravalai at a definite distance and then the distance between them increases. This indicates that some of these stars are 'wandering' stars, i.e. planets. Among them is Tsiskari, which we identify as Venus, and Mejoge—another planet which rises after midnight. However, our identification of Tsiskari and Mejoge as planets creates certain problems in that the positions of the planets change in the sky in the course of the year and from year to year, but this peculiarity is not reflected in the ethnographic record.

Also of interest in the above-mentioned quote is the "Jump of deer." In our opinion, this short legend shows how the ancient Georgian peasants described the faint strip of light that crossed the sky—namely the Milky Way. In modern Georgian, the Milky Way is translated as the 'jump of deer', whereas the *Georgian Encyclopaedia* (Volume 5, page 225) gives the following ancient Georgian synonyms for the Jump of Deer (Irmis nakhtomi): Trace of an Ox, The Way to Jerusalem, The Leg of a Bear and the Trace of a Bear's Knee.

S. Menteshashvili (1943) throws light on some of the other astronomical terms listed above. For instance, Gutneuli (which he terms Khargutani) is the constellation of Ursa Major, while Mravalai relates to Ursa Minor. The *Georgian Encyclopedia* (Volume 8, page 106) shows that the names Mravalai and Khomli (mentioned below in Section 2.4) are ancient Georgian synonyms for the Pleiades star cluster. The fact that the Pleiades lie within the constellation of Taurus is interesting from the viewpoint of the origin of the different names.

2.4 Khomli Stars in Oral Stories and Chronicles

Let us now consider the book by M. Makalatia (1972), in which he describes some ancient traditions associated with pasturing of sheep in different seasons. For example, on page 50 we read:

> The people living in the villages of Khizabavra and Zveli still remember the ancient traditions of determining the time of driving the cattle. After the week of Khomli they could drive the cattle over an upper mountain, as snow was not expected any more. The week Khomli comes in the month of Tibatve, when a group of Khomli stars appear. Khomli rises on the 6th day of Tibatve, but till 12 Tibatve it is not seen by eye. During this week great care is taken with the sheep being in the open air. The peasants … believe that Khomli is dangerous in the morning, when sheep still lie in sheep-pens. If Khomli rises above the lying sheep, it "strikes them and causes the falling-off of their hair and the ulceration of their heads and faces" (Khizabavra) ... In the morning they wake the sheep and drive them (Zveli). In the village of Zveli, during the Khomli week sheep are driven to the nearby fields at the edge of the forest, where there is a protected place Cholaka. (Our translation).

Georgian peasants knew of the heliacal rises of the stars, but they were afraid of this phenomenon. Such beliefs probably originated in pagan times (i.e. prior to the fourth century AD in Georgia). The above ethnographic fragment contains ancient data from a period when Georgians still used ancient terms—including Tibatve—for the names of the months.

The Georgian chronicle *Kartlis Tskhovreba* (*Description of the Kingdom of Georgia*) by Vakhushti Batonishvili (1973) also refers to Khomli. In Volume 4 on page 762 we find (our translation):

> … to the west of the Rioni [a river in western Georgia] at the base of the mountain is Khomli rock, which is very high. It deserves such a name on account of its height. It was identified with the star Khomli. In this rock a cave was cut, which was inaccessible to enemies, and this was used to store the Kings' treasures. (Vakhushti Batonishvili (1696–1784), Georgian historian and geographer, and the son of the Georgian King Vakhtang VI Bagrationi).

This Georgian chronicle accommodates a long period in Georgian history, from antiquity to the eighteenth century AD. Meanwhile, the brief above-mentioned quote indicates that a) knowledge of the Khomli star was widespread in Georgia in the past; and b) the exact spot where Khomli was seen to rise was observed by ancient astronomers from the high rock bearing the same name.

2.5 Bedukadze's *Popular System of Time Determination …*

In a monograph relating to systems of ancient Georgian time-determination, S. Bedukadze (1968; our translation) says:

> In Khevi [a region of Georgia] they have a cult-ceremony, the so called "Astvaglakhoba". On New Year's Eve, three archpriests ascend to the top of

> "Sameba" for the night. They sit in silence leaning against each other's backs and observe the sky until daybreak. In the morning they sacrifice a new-born calf, have a feast, and then predict the weather, the harvest, wars or diseases in the coming year.

In our opinion, this ethnographical account describes the ancient Georgian tradition of carefully-planned methodical observations of the positions of celestial bodies. This tradition was probably perfected over a long period of time. We believe that those living in the mountainous regions of Georgia divided the dome of the sky into three equal triangular sectors for better understanding of the phenomena taking place there. They realized that one observer could not adequately observe the whole sky and understand what he saw. Accordingly, on New Year's Eve three pairs of eyes carefully and simultaneously watched the sky. The division of the sky into two equal parts would have been insufficient and into six parts more than necessary, that this is why three (and not two or six) archpriests ascended to the top of mountain. Information about phenomenon seen by one of them was subsequently added to data obtained by the other two observers, and thus the whole picture was formed. Each of them was responsible for his sector of 120°. The fact that the archpriests predicted the future speaks in favor of the fact that there could be some empirical experience connected with atmospheric climatic phenomena determining the visibility of one or another celestial body. This mosaic triangular Universe impresses one with its thoughtfulness. The ancient priests knew how to observe, calculate time and orient themselves with respect to their environment. Here we speak from our own point of view, but this ethnographical material can be considered from other points of view as well.

2.6 Concluding Comments

The ethnographical examples containing astronomical information presented here in Sections 2.1 through 2.5 form only a small part of ancient Georgian folk heritage. It is to be regretted that the scholars who collected such celestial data lacked the knowledge to adequately investigate ancient Georgian astronomical systems, but this is thoroughly understandable given that the focus of their studies was the everyday life of Georgian peasants.

The landscape of Georgia is diverse and ranges from high mountains to low plains. Large and small villages are scattered throughout the country and the situation would have been the same in the past. Often when there were cold winters or hot summers ancient peasants from one village would have had little opportunity to meet their counterparts from other villages, as such rendezvous often would have involved trips of several hundred kilometers over high mountains and through thick forests. So it is quite possible that the same celestial objects went by totally different names in different regions of the country, or even in neighbouring villages. This interesting possibility clearly requires further investigation.

3 ASTRONOMICAL REFERENCES IN GEORGIAN LITERATURE

Let us now consider another source of ethno-astronomical information about ancient Georgians: classical and modern Georgian literature. Various examples—involving both prose and poetry—are discussed below.

3.1 Rustaveli's *The Knight in the Panther's Skin*

In the poem *The Knight in the Panther's Skin* by the well-known twelfth century Georgian scholar, Shota Rustaveli, one can find plenty of ethno-astronomical material. A full astronomical analysis of this ancient poem needs to be carried out separately, but for the purposes of this study we will only consider a sample of its contents. In 1968, Bedukadze also examined evidence of time-determination as reflected in Rustaveli's poem, and she particularly drew attention to strophae 184, 185, 770 and 1569.

Let us look at strophe 1569 (our translation):

> The star of dawn shines as bright as the moon when together in heaven,
> But if they part and withdraw from each other they fade and grow paler.
> They must alas withdraw from each other if heaven has willed it.
> One must be as high as a hill or a mountain to see them.

Bedukadze assumes that in this poem Rustaveli shows that the old way of determining time was through observations of the motion of specific celestial bodies from the top of a high hill. And the observer had to be able to observe in all four directions.

3.2 Astronomical Instruments Mentioned in Georgian Literature

On the basis of ethnographical documentation, Bedukadze (1968) also proceeded to describe the types of instruments used by the ancient Georgians to determine time:

> In Khevsureti [a region of Georgia] seasons were determined by means of a group of stone columns, the so-called "Sun nests" erected on peaks to the east of villages. According to the motion of the rising Sun from one nest to another, people determined: a month, a season, the end and the beginning of a year, the important dates of agricultural character.
>
> The important element of old houses in Svaneti [Svaneti is a region of Georgia] was a ritual east window (lakhvra), looking towards to the Sun. The head of the family – a man – used to read prayers by the window at each sunrise. Lakhvra was something like a calendar, or fixed tool relating to solar motion. In this calendar, the different places where the first sun-beam fell were marked … [and] the track of its motion during the days and months. In such a way the holy days of each season were determined, and the dates when agricultural work should start. (Our translation).

Bedukadze (ibid.) also describes various moondials and sundials of the simplest construction (circular or with a straight edge), used in different regions of Georgia (Kartli, Trialeti, Meskheti, Javakheti, etc.): a moon or sun beam reflecting a ray of light or a shadow and how these moved in the course of time around the family hearth in the center of the house. The head of the family (the father or the mother) used such dials in everyday life.

3.3 Concluding Comments

It can be seen from the foregoing material that in the twelfth century AD in Georgia a harmonious system

existed to determine and make use of time. If Rustaveli used folklore in his poem then one can assume that this system of time-determination was developed in Georgia earlier than the twelfth century. Thus, Rustaveli's poem contains historical and ethnoastronomical information.

The system of time-determination by means of 'Sun nests' seems to be a very ancient one. In the high mountains of Khevsureti, processed stones and stone constructions served the ancient Georgians as farming implements, arms and simple instruments for time measuring. We think that stone columns on the tops of mountains were prehistoric Georgian sundials.

The Svan lakhvra was a fixed tool for demonstrating the motion of Sun, and was another type of ancient Georgian sundial. It was only used for domestic purposes. Taking into account the tower-like constructions of Svan houses and the mountainous terrain in Georgia, a small east window (lakhvra) seems to have served as a primitive type of sundial. It is obvious that in different regions of ancient Georgia various systems of time-determination were developed, and the simplest of instruments were made and used for measuring time. We think it would make good sense to organize scientific expeditions to mountainous areas of Georgia, such as Khevsureti, Svaneti, as well as some other regions, in order to search for the remains of ancient sundials. We also believe that a full ethnoastronomical analysis of Rustaveli's poem should be carried out.

4 CONCLUSION

Georgian ethnographic accounts contain an abundance of important astronomical information. Though this in-formation is diverse, it is scattered, and specialists working in the fields of history, ethnoastronomy and anthropology should make regular efforts to gather, optimize and analyze it. However, this is not a simple exercise as it requires great effort and time. In the villages in the mountainous and flat regions of Georgia one can still encounter many recorded legends, oral accounts and folk poems containing ancient Georgian information about the sky, the stars and the Universe and the place of a man in this boundless realm.

In this paper we have considered a number of records that contain information about ancient Georgian astronomical traditions and practices. While many such ethnographic records exist in Georgia, most have yet to be analyzed from an astronomical standpoint. Much research remains to be done, and we invite foreign scholars to join us in this endeavour.

5 NOTES

1. Professor Javakhishvili organized ethnographic expeditions to many Georgian villages between 1915 and 1935. He worked up his ethnographic notes and prepared them for publication, but died in 1940 before this could be arranged. The manuscript was kept in the museum, and was only published in 1983.

6 ACKNOWLEDGMENT

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AN ASTRONOMICAL INVESTIGATION OF THE SEVENTEEN HUNDRED YEAR OLD NEKRESI FIRE TEMPLE IN THE EASTERN PART OF GEORGIA

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Abstract: The Nekresi Fire Temple is a second to third century A.D. archaeological site in eastern Georgia that was excavated by archaeologists towards the end of the twentieth century. In 2004 we carried out an archaeo-astronomical investigation of this site, which indicated that it was used for astronomical observations. We now suggest that this structure should be renamed the 'Nekresi Sun Temple'.

Keywords: Georgian astronomy, Nekresi Temple, solar observations

1 INTRODUCTION

The cosmological ideas of ancient populations are reflected in different aspects of their cultural heritage, including architecture, artifacts, folklore and written records. Prehistoric monuments, legends and myths tell us how the ancient people reacted to the regularity and the recurrence of celestial phenomena and the diversity and the brightness of different heavenly bodies. Cosmological ideas and activities often were closely connected with religious notions, and rituals and ceremonies played an important role in the accumulation of knowledge about the Sun, the Moon and the stars. Ancient peoples often used this knowledge and experience to orientate themselves in time and in space. Some knowledge was materialized, manifesting itself in stone instruments, temples and sanctuaries, in architectural complexes serving ritual purposes, where the gods were worshipped and astronomical observations were made. These simple 'astronomical observatories' have been discovered in many different countries (see Aveni, 1997; Heggie, 1981; Iwaniszewski, 1994; Ruggles, 1999).

One such nation is Georgia, an ancient country beside the Black Sea. Over the centuries, the Georgian people created and developed their own language, literature, music and architecture (Bround, 1994). Various sciences also flourished, including astronomy and mathematics. Simonia (2001) and Simonia and Simonia (2005) have outlined the main stages in the development of the ancient Georgian astronomical 'world view' between the sixteenth century BC and the eighteenth century AD, and the ethnocosmological symbolism of certain Bronze Age artifacts. In particular, they have shown that the ancient Georgians had a deep interest in heavenly bodies and astronomical phenomena, as reflected in different artifacts and remnants of stone buildings found during archaeological excavations (see Sanikidze, 2002).

In the final decade of the twentieth century an expedition from the National Museum of Georgia carried out archaeological excavations at Kakheti, in eastern Georgia, where the ruins of the ancient town of Nekresi were discovered (Chilashvili, 2000).[1] Among the ruins at Nekresi was a complex building that was identified as a temple. In this paper we discuss the archaeological features of the Nekresi Fire Temple and then examine its astronomical significance.

2 THE INITIAL ARCHAEOLOGICAL INVESTIGATION OF THE NEKRESI TEMPLE

The first structure at Nekresi investigated by the archaeologists was the stone foundation of a cult building, which was identified as the 'Nekresi Fire Temple'. The aim of the archaeological excavation was to determine the structural peculiarities of this ancient temple and to preserve what remained of it. The temple was located in a field at the foot of Nazvrevi Hill (Figure 1), and Chilashvili (ibid.) noted that on the Hill itself was another temple-like structure which may have been associated with the Nekresi Fire Temple.

The walls and foundations of the Nekresi Fire Temple consisted of mortared cobble-stones and broken stones (Figure 2), but in the upper layer of the construction flat bricks were encountered. The design of the temple was complex. In the center was an almost square building of 76m², around which were four buildings forming the shape of a cross (see Figure 3).

During the archaeological excavations an approximately square area of clay, measuring 4.5m² and containing traces of fire, was discovered in the southwestern corner of the central building (hence the name, 'Nekresi Fire Temple'). Elsewhere, the floor of the central building consisted of brickwork. The eastern building had an entrance in the eastern wall, and on both sides of this extension was a corridor and storerooms. Likewise, the western building had an entrance in the western wall. The length of this western building was 9.5m, and the walls were 1.5m thick. The eastern and western buildings were almost equal in area, and only differed in the details of their construction. The northern and southern buildings leading off the central building were also surrounded by corridors and storerooms. The central building, the four buildings to the north, south, east and west, and their associated corridors and storerooms were all enclosed by a wall, the entire complex measuring ~50m × 50m.

Figure 1: View of the excavated Nekresi Temple from Nazvrevi Hill.

The following facts seem to be important: the walls of the temple complex were constructed of large stones and mortar, the thickness of the walls averaging 1.5m; the width of the doorways was, on average, also 1.5m; and access to any of the rooms in the complex was possible via doors in the external corridors.

During the excavations ceramics in the form of small red and white sherds and fragments of jugs were found, and these and other artifacts dated to the second, third and fourth centuries AD. Radiocarbon dating of charcoal from the entrance doorway to the temple revealed that the complex was destroyed in the fifth century AD.

On the basis of the accumulated evidence, Chilashvili (ibid.) concluded that this archaeological site is the remains of a temple where rituals associated with fire-worship were performed, and he dubbed it the 'Nekresi Fire Temple'. The main 'area of attraction' was the centrally-positioned square building with its altar, which served as a sanctuary for the fire-worshippers during their ceremonies.

Figure 2: View across the archaeological site showing the stone construction of the walls.

Near the Fire Temple Chilashvili discovered other ruins and artifacts of various ages, some of which we also assigned cult functions associated with the worship of the Sun. He noted that these buildings seemed to be aligned with the point of sunrise on the day of the summer solstice, and that they deviated to the north from the direction to the east by about 30º. He also noted that there is a tendency for the older buildings to be more oriented to the north. It is important to stress, however, that all of these conclusions were based upon estimated orientations not surveyed measurements. On this basis, the Nekresi Fire Temple was clearly an excellent candidate for a detailed archaeoastronomical investigation.

3 THE ASTRONOMICAL ROLE OF THE NEKRESI FIRE TEMPLE

In the autumn of 2004 we began studying the archaeoastronomical parameters of the Nekresi Fire Temple. These investigations were carried out in three stages: fieldwork, followed by the processing of the observational data, and finally the theoretical interpretation of the complex.

The fieldwork included:

1. Visual examination of the Nekresi Fire Temple in order to determine the architectural and geometrical peculiarities of the construction.
2. Determination of the exact geographic coordinates and orientation of main structural elements of the Temple.
3. Noting the characteristics of the surrounding landscape, including the height of hills and their azimuths.
4. Observation of sunrise from the main structural elements of the Temple.

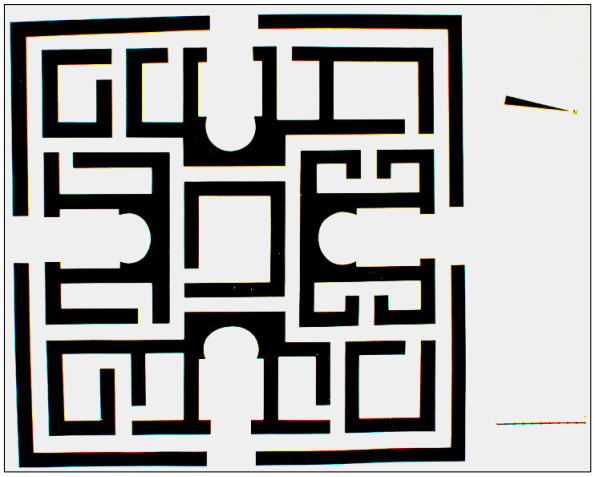

Figure 3: Plan of the Nekresi Fire Temple (after Chilashvili, 2000).

During the field work we used clinometers, an electronic compass, GPS, digital cameras and other instruments, and we took a series of photographs of the Temple and the surrounding landscape in order to create a photo-catalogue.[2]

The visual examination of the temple confirmed the complexity of its construction and its multifunctional purpose, including the ritual associations. The approximate mirror symmetry of the main structural elements—the four rooms off the central room—in our opinion, suggest that regular observations of heavenly bodies and phenomena (such as sunrise and sunset, the heliacal rising of stars and the culmination of the Moon) could have been carried out from these rooms (Figure 4). Our measurements of the orientation of the north-eastern (NE), southeastern (SE), northwestern (NW) and southwestern (SW) points of these structural elements and of the central room are listed in Tables 1 and 2. The orientation of structural elements of con-

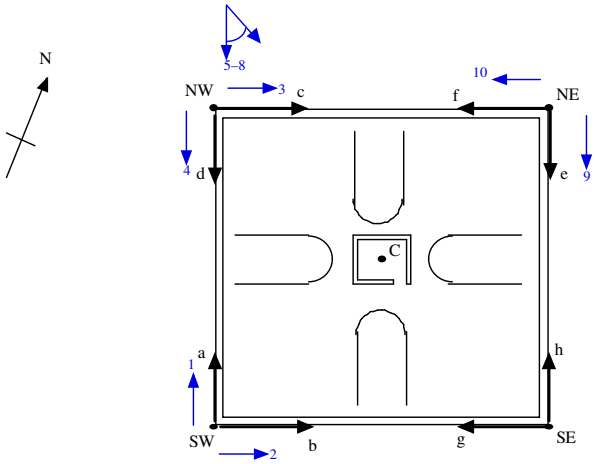

Figure 4: Plan of the Nekresi Fire Temple showing points surveyed during the 2004 expedition.

struction was determined as well, and some features of the surrounding landscape which may have served as orientation points for those observing from the Temple were also recorded. It should also be noted that the hills surrounding the Nekresi Fire Temple have not been thoroughly studied archaeologically, although artifacts and buildings of various ages have been discovered on some of them. Accordingly, the azimuths, heights and distances to various landscape elements were measured.

We also observe the sunrise from the interior of the eastern room and from the central sanctuary. Our observations showed that the first rays of the rising Sun only illuminated some areas of these two rooms, then a little later, the whole Fire Temple was fully sunlit. The peculiarities of illumination of the Fire Temple at the moment of sunrise are connected with the natural landscape in the easterly direction. One cannot exclude the possibility that this landscape may have undergone natural change (e.g. through erosion) over the last thousand years or so. It should also be noted that the landscape (i.e. hills and hillocks) surrounding the Fire Temple does not allow the observer standing in the Temple to fix the moment of sunrise above the horizon.

During the field-work we determined that the Fire Temple is aligned approximately in the direction of the solstice. For an observer standing in the Fire Temple on 22 June the Sun rises over the highest point of eastern part of the visible horizon, while on 22 December the Sun rises over the top of a small hill. It may mean that the summer and winter solstice were important astronomical phenomena for Georgians living in the period of antiquity. Thus, the Fire Temple was aligned such that twice a year, during cult ceremonies, the Sun was seen rising over designated points on the horizon. Only twice a year, would the first rays of the rising Sun fall upon some feature in the sanctuary, indicating the beginning of the season for harvesting or sowing the crops. Thus, observation of the rising Sun on the days of the solstice had very important practical significance for the ancient Georgians, by helping them to orient in time and by allowing them to divide the year into two parts. This is the primary astronomical importance of the Nekresi Fire Temple, although this result warrants further investigation.

The next step in the research project was to analyze the data obtained during the fieldwork, which led to some new conclusions.

Using the measured geographical coordinates of certain structural elements of the Fire Temple, as well as data about the sizes of these elements we determined the orientation of the various rooms in the complex. Our calculations showed that two of the rooms off the central sanctuary were oriented towards the northeast and the southeast, and should be known as the northeastern and southeastern rooms, respectively. In particular, it was determined that the northeastern room was aligned with a point on the horizon with the geodetic azimuth of A' = 32º 40′. Meanwhile, the southeastern room was approximately aligned with the point of sunrise on the day of the mid-winter solstice. We believe that this is further evidence of the astronomical functionality of the Nekresi Fire Temple, which should be renamed the 'Nekresi Sun Temple'.

We believe that the ancient Georgians observed the winter solstice from the southeastern room, and that throughout the year they also observed the rising and setting of certain bright stars from the northeastern, northwestern and southwestern rooms. The orientation of the Nekresi Sun Temple indicates that for the ancient Georgians the key zero point in determining time was the winter solstice, since this was the precursor for the sowing of new crops.

Other heavenly bodies and phenomena, including circumpolar stars, the heliacal rising of certain stars, the culmination of the Moon, eclipses of the Sun, etc., could also have been observed from the rooms in the Sun Temple. On the basis of ethnographic analogies (e.g. see Simonia et al., 2008), we suggest that inside the Temple religion and astronomical observations were combined in order to allow a regular 'interaction' between human beings and celestial bodies. The ancient people prayed and conducted astronomical observations believing that their gods would help them personally and the country in general, that the order of the world would remain the same as usually—that a cold season would be followed by a warm season, that the sowing of crops would be followed by the plentiful harvest, and so on. The regularity of the motion of heavenly bodies and of various astronomical phenomena was caused by peculiarities of the ancient belief system and practical necessity associated with agriculture, the cultivation of grapes, and the like.

4 DISCUSSION

At the beginning of 2008, Professor Clive Ruggles, President of IAU Commission 41, prepared and circulated a document titled "Ancient and Historical Properties Relating to Astronomy". The section on Candidate Properties in Europe includes the following entry:

> Georgia: Nekresi Fire Temple. This pre-Christian temple, dating to the II – III century AD, takes the form of a rectangular building measuring c. 50 × 50m, with various rooms and corridors surrounding a central space where there is evidence of intensive fire. The temple is approximately aligned with the direction of sunrise on the day of the summer solstice, demonstrating a link between pre-Christian cultic beliefs and astronomical observations.

Table 1: The orientation of different parts of the Nekresi Sun Temple, as determined during the 2004 field expedition (for identification of the different parts see Figure 4).

	UTM (WGS84 datum) measured by GPS				Conversion using GRIDLA	
Point	Zone	Grid easting	Grid northing	Error	Latitude N	Longitude E
NW	38	05 630 16	46 464 68	(4m)	41º 58′ 14″	45º 45′ 38″
NE	38	05 630 62	46 464 84	(6m)	41º 58′ 15″	45º 45′ 40″
C	38	05 630 42	46 464 56	(3m)	41º 58′ 14″	45º 45′ 39″
SW	38	05 630 26	46 464 29	(3m)	41º 58′ 13″	45º 45′ 39″
SE	38	05 630 74	46 464 40	(6m)	41º 58′ 14″	45º 45′ 41″

The archaeoastronomical findings presented in Section 3, above, warrant further investigation, but the Nekresi Sun Temple also requires additional study from the archaeological point of view. This applies in particular to the central sanctuary and the northeastern and southeastern rooms. Looking further afield, within a radius of 1.5 km from the center of the Sun Temple and in the directions of horizon points with a geodetic azimuth of 30º 40′ and an astronomical azimuth of −57º 20′ we can expect to find archaeological artifacts that are associated 'genetically' with the Sun Temple, and we cannot exclude the possibility that the Nekresi Sun Temple is, in fact, merely the center of a larger religious-astronomical complex. Such a point of view seems appropriate given the fact that a structure with probable religious and astronomical significance was discovered some kilometers from the Nekresi Sun Temple but was destroyed during building operations.

5 CONCLUDING REMARKS

In this paper, we describe the most important aspects revealed by the archaeological excavation of a seventeen hundred year old temple site in Eastern Georgia. We also describe the results of our initial archaeoastronomical investigation of this site, and show that this temple was oriented towards the summer and winter solstices. On the basis of archaeological and ethnographic evidence we know that the worship of the Sun was an important element in ancient Georgian culture, and we conclude that during the second and third centuries AD the temple at Nekresi was used for solar and other astronomical observations. We suggest that instead of being known as the 'Nekresi Fire Temple' a more appropriate name would be the 'Nekresi Sun Temple'.

We hope that future archaeoastronomical investigations at the Nekresi Sun Temple will reveal interesting new evidence on the ways in which the ancient Georgians developed their astronomical 'world view'.

6 NOTES

1. For information about the ancient city of Nekresi see Kaukhchishvili, 1959: 29.
2. This photo-catalogue has been stored in electronic form, and the various images can be used for future scientific investigations or to illustrate lectures. Copies of individual images can be obtained from the first author of this paper.

Table 2: Azimuths of different parts of the Nekresi Sun Temple.

Direction	Mag az measured (°)	True az deduced (°)
a	340.0	345.5
b	69.5	75.0
c	70.5	75.5
d	160.5	165.0
e*	*158.0*	*163.5*
f	249.5	255.0
g	248.5	254.0

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Megalithic Monument of Abuli, Georgia, and Possible Astronomical Significance

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Abstract

Background/Objectives: In recent years, in purpose of investigation of the artefacts, the ancient culture and religion, based on the astronomy knowledge play significant role. The aim of this work is to identify the orientations of the religious megalithic complexes and their correlation to the celestial luminaries. **Methods/Statistical Analysis:** We harmonized the archeological data, ethnographical, historical information and restoration of ancient celestial sphere (using special astronomy application), which give us possibility to identify the correlations between the acronychal or helical rising/ set of luminaries and directions of megalithic objects. Very often such connections are stored in a current folklore too. **Findings:** This technique of investigations give us more clear understanding of ancient universe. Using this method, we can receive latent information about the ancient Gods – Luminaries, clarify current mythology, date of the megalithic complex. **Application/Improvements:** This method of investigation is an additional instrument for archeological investigations, because it gives us more reliable information concerning the ancient culture, religion and people.

Keywords: Astronomical Significance, Menhir, Megalithic Monuments, Sun Rise

1. Introduction

In the south of Georgia lies the region of Samtskhe-Javakheti. This region is unique, having an abundance of mountains, ridges and cultural monuments. In ancient Georgia there was an expression "go and wheat will be in Murji or Murjakheti" (Murji and Murjakheti are toponyms of Javakheti) (Figure 1). This expression, together with the many Christian and earlier Bronze Age monuments located in Samtskhe-Javakheti, indicate that socioeconomically this region was well developed and advanced. In terms of regional areas Samtske-Javakheti comprises Akhalkalaki, Ninotsminda, and partially Aspindza and Borjomi territories. Historically, Samtske-Javakheti included more territories and was mentioned as "South Gate" of Georgia. Samtske-Javakhety has been populated from time immemorial. Many megalithic monuments, cromlechs, menhirs and dolmens prove development of this region1 (figure 2).

Ancient historical sources mention the "Odzrkhe" province. "Odzrkhe" is the old name of Samtskhe or Meskheti. Zabakha is the old name of Javakheti. According to P. Ingorokva Javakhi is related to the old Georgian Taokh tribe. Taokhs were the native population of Diaokha. They populated the north- east of modern Turkey and the South part of Georgia. In the manuscripts of the king Argisht I of the Urartu kingdom dated 785 B.C., Klarjeti, Samtskhe and Zabakha (or Javakheti) are mentioned as conquered countries. According to Historian Leonty Mroveli, the son of the legendary Mtsketosi, Javakhos possessed Javakheti - "The country from Lake Paravani to the beginning of the river Mtkvari". Historically, Javakheti included two parts: Upper Javakheti and Lower Javakheti. The Upper Javakheti covered the territory from Lake Paravani up to the Mtkvari River Canyon. The Lower Javakheti lied in the Mtkvari River Canyon and on the hills of Buzmareti and Niali[1] (Figure 2).

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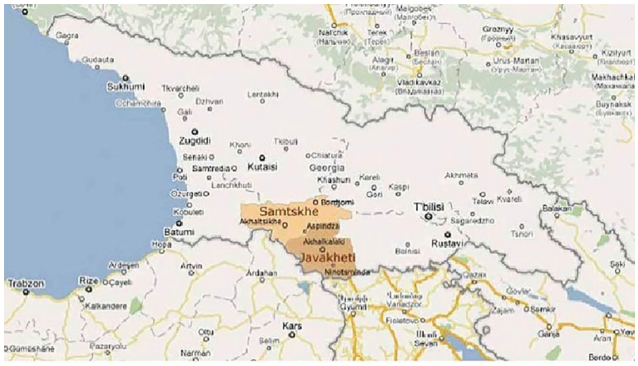

Figure 1. "Samtskhe Javakheti" - Region of Georgia".

Figure 2. Megalithic complex of "Abuli", 2011. Photo is Made by Badri Jijelava.

Figure 3. Menhir near the megalithic complex of "Abuli", 2012. Photo is Made by Badri Jijelava.

In the mountains of Samtskhe-Javakheti called "little Abuli" (*Figure 2*) is located the megalithic complex of Abuli. It is situated at the top of the mountain 2637.129 meters above the sea level. The coordinates of the megalithic monument are:

E 043^0 41' 4,608"

N 41^0 22' 23,166"

Near the Abuli complex is located a menhir with circular symbols. At present, the menhir is located inside a Church.

2. Astronomical Aspects of Cultural and Ethnographical Data

In the researches of **Ivane Javakhishvili the "History of Georgian nation"**[2] is mentioned a legend about the Christ, Elia and Saint Georgy. According this book, when the Christ, Elia and Saint Georgy became hungry they went to a Shepherd and asked him for a sheep. The Shepherd refused the Christ and Elia, and only Saint Georgy was offered not only one sheep, but the whole flock of sheep. Based on the legend the Christ was the Lord of life and death. Elia was the God of Weather and Saint Georgy was the Patron of the poor. As seen from the legend, Saint Georgy being, as one of the most venerated saints, can be traced back to the pre-Christian times. He is also regarded as one of the most prominent saints in many legends of other regions of Georgia - Kartli, Kakheti, Svaneti and others. In Georgia there are 365 churches of Saint Georgy (as number of days in year).

The **Greek historian and geographer Strabo**[3] describes rituals connected with the God of Moon in Albania (Georgia neighbor country, current Azerbaijani Territory). In his researches he mentions the God of the Moon and the Temple of the Moon located near Iberia (the old name of Georgia). Strabo describes the ritual of making offerings to the gods. The sacrificial human victim was anointed with fragrant ointment and sacrificed to the God of the Moon. The priest made a prophecy; then the body was moved to a certain place where the people attending the ceremony trampled on it in order to purify themselves.

According to Leon **Meliksed-Beg** the Georgian legend of Ami(h)rani is related to the region of Samtskhe-Javakheti[4]. The Georgian legend of Ami(h)rani is similar

to the legend of Prometheus in Greece[5]. Ami(h)rani was chained in the Caucasus Mountains, and each morning at sunrise, an eagle flew down from the sky and fed on the liver (or heart) of Ami(h)rani, because he couldn't break the chain. According to the legend the birth of Georgian Ami(h)rani and the birth of Greek Orion are similar[6]**.** The story mentions a little dog which lies at the feet of Ami(h) rani and licks the chain to make it thinner for Ami(h)rani to be able to break it. The ancient name of Ami(h)rani was Amihrani and it comes from the name of the God Mihra - Mithras (**Zoroastrianism**). Mihra was the eye of the God Ahura Mazda and the eye of Ahura Mazda was the Sun[7]. In various cultures the God Mihra was the symbol either of the Moon or the Sun and in the legend about the Christ, Elia and saint Georgy, we suppose the saint Georgy is archetype of the ancient God of Mihra.

We think that in Samtske-Javakheti the God Mihra (or saint Georgy) was the symbol of the Sun. According to the above data, we can suppose that Ami(h)rani was the symbol of the Sun or the son of the Sun[8].

3. Tasks

The task of our investigation was to identify those of the megalithic monuments which were erected for ritualistic procedures where megalithic period people went to and worshipped their gods. The main task was to define what Gods the monuments were built to, what celestial bodies these Gods were associated with, and how the celestial bodies and the configuration of the monument are related.

4. Field Works, Modeling of the Celestial Sphere with the Skymap Pro and Results

The field works were conducted with the application of the following equipment:

1. Theodolite (T15, N25773, 1976 Year)
2. Military Prismatic Sighting Magnetic Compass
3. 50-meter-long tape measure
4. Photo camera (A 200)

The complex includes a central elliptical object with five entrances (two of them are located on the periphery of the central object) and two windows - one of the windows is still in its original state and the other has crumbled with age. In the course of the fieldwork in the Abuli monument we revealed that two entrances are oriented to the west 275^0 True and the mountain tops are seen from them at an angle of 6^0. The orientation of the first window is 108^0 True. The orientation of the crumbled window is 163^0 12' True. Based on our observations conducted in 2012, every summer solstice the first beam of the Sun as before keeps penetrating through the Main North-East entrance whose azimuth is 59^0 43,1 True (*Figure 4*).

In the village of Gandzami near the Abuli megalithic monument is located a menhir. The height of the menhir is 330 cm. Circular symbols are carved on the lateral faces of the menhir (Figure 5) and on the top of the menhir there is a semi-circular cutout. The diameter of this semi-circular opening is 20 cm. The width of the bottom of the menhir is 91cm.The width of the top of the menhir is approximately 134 cm. When one faces the menhir side with the carved symbol of a bird[4], the mountains are in the direction of 63^0 40' True and their tops are visible at an angle of 2^0 50'. the front side the menhir has its own magnetic field and the deviation equals 180^0 (Figure 5).

Figure 4. Sunrise in summer solstice in the NE entrance of the central object of "Abuli" Megalithic complex, 2011. Photo is Made by Badri Jijelava.

Figure 5. Circular symbols (petroglyphs) on the literal sides of menhir, 2012. Photo is Made by Badri Jijelava.

Recently a Christian church was built around this monument. People venerate this monument and believe that this monument helps the childless.

Using the skymap pro soft we defined the Sunrise and Sunset azimuths in the summer, the winter solstice and the vernal and autumnal equinox periods. We determined that within the period from 4000 B.C. up to the present day the Sunrise azimuth on the summer solstice has shifted from 56° 27' 15" to 57° 5' 5" True.

Upon the field works we performed modeling of the celestial sphere from the current days back to 4800 BC, with steps of 500 years, using the skymap pro software. The modeling showed that in 2000 BC on the summer solstice - 10.07.2000 BC, after the heliacal rise of Epsilon (Anlinam) star in Orion's belt (*Figure 6*) which observed through the window 1, the Sun first beam penetrated through the North-East entrance. Consequently, after nine (9) days 19.07.2000 BC took place disappearance of Altair star in Aquila constellation to the horizon (west entrances 1 and 2 - *Figure 6, 7*).

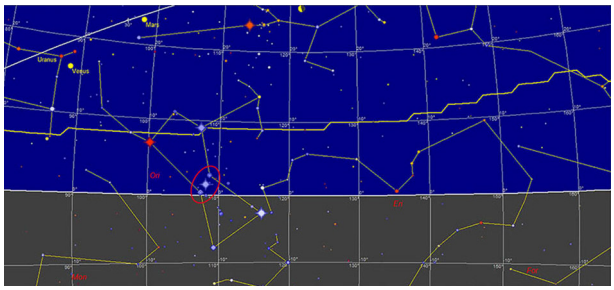

Figure 6. Heliacal rise of the stars (Mintaka, Anlinam, Anlitak) in the belt of the Orion constellation (modeling celestial sphere using skymap pro for the period of 2000 B.C.).

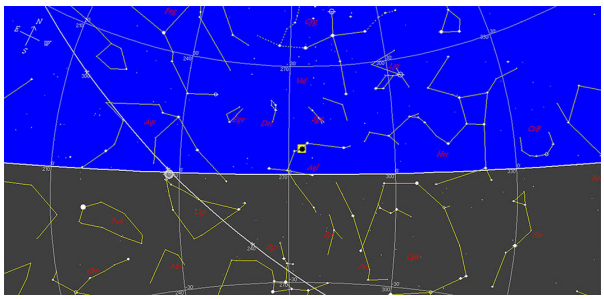

Figure 7. Descending of the Altair star in Aquila constellation (modeling celestial sphere using skymap pro for the period of 2000 B.C.).

Table 1. Results of field works

Name	Azimuth	height of horizon
West entrance 1	275^0	6^0
West entrance 2	276^0	6^0
NE entrance (Figure 3)	59^0 43,1'	1^0
window 1	108^0 40'	1^0 20'
Window 2	163^0 12'	0^0
Menhir in Gandzami	63^0 40'	2^0 50'

Table 2. Results of modeling using Skymap pro, 2000 B.C

Name	Azimuth	altitude
acronychal set of Altair star in Aquila constellation - West entrance 1,2 (after Summer solstice - 19.07.2000 B.C.)	274°	7^0
The sunrise on the Summer solstice (Summer solstice 10.07.2000 BC)	58°	1°
Heliacal rise of the Alnilam star in the belt of Orion constellation (Summer solstice 10.07.2000 BC)	108°	1°
Menhir in the village of Gandzami (Sun rise in Summer solstice)	62^0	2° 50'

According the modeling of celestial sphere, in the summer solstice 10.07.2000 BC (Until 19.07.2000 BC) the Sun rises before the Altair star disappeared to the horizon. 19.07.2000 BC the Altair star first time descended (disappeared) to the horizon before the Sun rises. For our opinion this Astronomical phenomena – the acronychal set of the Altair star was marked by megalithic people in the Abuli megalithic complex, which is described in mythology of Ami(h)rani - "Eagle flies down to the earth".

The direction of the Gandzami menhir is the same as that of the NE entrance the Abuli complex. In view of the fact that the angle of vision of the hill from the menhir is 2^0 50', on the summer solstice the Sunrise will be observed from the semi-circular cutout of the menhir and the NE entrance of Abuli simultaneously.

5. Discussion

In Greek mythology Altair star is associated with Prometheus chained to a rock in the Caucasus Mountains. "After the Sunrise" (parallel - the first beam of the Sun

observed from the NE entrance on the summer solstice) "an Eagle flies down" (parallel –Altair star observed from entrances 1 and 2 goes down to the horizon and then disappears – acronychal set) "to Prometheus and starts tearing at his liver. The eagle only leaves Prometheus at night." Georgian Ami(h)rani is the prototype of Prometheus, he is chained to the Caucasus ridge like Prometheus. Every morning an Eagle flies down to Ami(h)rani. The Orion constellation which is observed from window 1 zodiacally has the shape of a hunter with a bludgeon in the hand and a sword on the waist. In 2000 BC the heliacally rise of the stars in Orion's belt (Delta - Mintaka, Epsilon - Anlinam and Zeta – Anlitak) was observed from window 1 on the Summer solstice (parallel – the birth of Greek Orion and the birth of Ami(h)rani, which are similar according to the myths about the heroes). Approximately After one hour of the Orion constellation rising the Canis Major constellation rises (parallel - the little dog lying at the feet of Ami(h)rani according to the Ethnographic materials. 27.07.2000 BC took place heliacal rising of the Sirius star). The Orion constellation and Sirius star in the Canis Major constellation were mentioned together by the Egyptian civilization.

Based on the above mentioned ethnographic data and the results of the celestial sphere modeling, the Abuli megalithic monument is oriented to the stars in the belt (Delta - Mintaka, Epsilon - Anlinam, Zeta -Anlitak) of the Orion constellation (*Figure 6*) and to the Sun, the Sun beam illuminates the NW entrance of the Abuli megalithic complex. The west entrances 1,2 are oriented to Altair, the brightest star in Aquila (Eagle), which consecutively, after 9 days of the heliacal rising of the stars of the Orion's in summer solstice, the Altair star acronychal sets and disappears to the horizon (*Figure 7*). These astronomical phenomena are similar Georgian mythology of Ami(h)rani.

6. Conclusion

Based on the skymap pro program modeling and the results of the field works it is concluded that this megalithic monument was built in 2000 BC. Taking into consideration the above-mentioned evidences, it is proved that mythology of Ami(h)rani is based to the orientation and astronomical events which had been happening in the megalithic monument of Abuli. The megalithic complex was sacred place for ancient people. Taking into consideration the records of Vakhushti Batonishvili - "one side of the menhir causes the drought and the other - rain" - and the legend about the Christ, Elia and the saint Georgy and the celebration "Eliaoba" which starts in Georgia in July, we think that this monument was built to worship Ami(h)rani, Mihra-Mithras (God of The Sun) and the Elia – the God of weather.

Megalithic people conducted their ritual ceremonies connected with the Sun and the stars, which was of vital importance for them.

7. Acknowledgements

The author thanks Shota Sanishvili for the help me to conduct the field work in Abuli megalithic complex. The author thanks Shota Sanishvili for the help him to conduct the field work in Abuli megalithic complex.

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Astronomical Context of Georgian Folklore

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Abstract

Objectives: The religious Ancient megalithic monuments are accordingly o/riente to the ancient Gods – The Sun, Moon, luminaries. The aim of this work to research the ethnographic data, current folklore and based on the results, harmonize the ancient Gods and the orientations of the religious megalithic complexes. **Methods/Statistical Analysis:** We harmonized the ethnographical, folklore and historical information and restoration of ancient celestial sphere (using special astronomy application) and identified the correlations between the some acronychal or helical rising/set of luminaries and orientations of megalithic objects. Such connections are stored in a folklore. **Findings:** This technique of investigations gives us more clear understanding of ancient universe. Using this method, we can receive additional information about the ancient Gods – Luminaries, clarify current mythology, date the megalithic complex. **Application/Improvements**: This method of investigation - Harmonization cultural astronomy and archae or astronomy with the archeological investigations will be more fruitful, because it gives us reliable information concerning the ancient culture, ancient religion and ancient people.

Keywords: Ancient Astronomy, Ethnographic Data, Folklore, Megalithic Monuments

1. Introduction

In central Georgia, south of the Trialeti ridge and bordering the Algeti river lies the borough of Manglisi. Historically Manglisi also known as Manglisi gorge was bordered on the east with Didgori Field and Bender-Bendeni side-hill; bordered on the west by Arjevani - Kadkaia-kachai mountain ridge and the mountain of Sakrisi; bordered to the south by the Ridge of Bedeni Mountain; and bordered to the north by Didgori ridge. Russian speaker inhabitants of this territory call the mountain of Sakrisi "Yellow Mountain" or "bear beam".

In the mountain of the Sakrisi (bear beam) is located the megalithic complex of Gokhnari. Regarding the Goknhari megalithic complex, Meliksed Beg mentions[1] that the crystal castle mentioned in the famous Georgian myth about Amirani, suggests that it is the megalithic complex of Gokhnari, where Amirani found the entrance of the crystal castle by following the direction of a Sun beam(Figure 1).

Figure 1. The South part of Georgia (Kvemo Kartli), near the Manglisi is located megalithic complex of Gokhnari. From (Melashvili 2016)

Concerning the archeological issues, well known "international style"[2] epoch in 2000 BC was wide spread in the south Caucasia. On the archeological sites of south Caucasus were discovered cylinder seals of both styles, Elaborate and common styles of Mitanian

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glyptic. Today we can find about twenty seal of Mitanian styles in Caucasus. Most seals are common styles. Such seals are found in Trialeti, on Sapar-kharaba graveyard were discovered nine cylinder seals, seven of them have geometrical ornament[3]. In the scientific literature many times was mentioned about the typological and functional similarity between south Caucasian (II BC) and Anatolian standards (III BC) discovered in the barriers of the kings. All this aspect indicates, in ancient epoch habitants of this territory where well developed and had cultural-economical-religious relationship with Egyptian, Mesopotamian and Mitanian civilization.

2. Ethnographical and Cultural Data and their Correlation with Celestial Bodies

There is a question about whether the beliefs of ancient humans were based on respect for mystical, spiritual and unknown astronomical and weather phenomena or whether they worshiped the life-giving powers of these, which they used in their daily life and practical activities. The movement of the Sun, the phases of the Moon, the appearance of twinkling stars, these must have been obscure, mystical, and beyond comprehension for ancient people; therefore, they venerated, deified and worshiped the luminaries.

The mythological aspect of the menhir (located in the "Pativan valley", South of Georgia) is directly related to dry and rainy seasons according to the ethnographic records[4]. The megalith monuments – the menhirs were related to the local religion and this is supported by the mentioning of the menhirs as "Maryam's Cross"[5], as well as the fact of carving the cross on the megalithic monument – the menhir on Tejisi Mountain. Vakhushti Batonishvili wrote the following about the Pativani-Vake boulder: "There is the boulder just below Pativani, if you turn it over during drought and wet it, rain will come, and if you throw ashes and turn it over during rainy weather, there will be drought", it should be mentioned here, that in general that menhirs are often referred to as "stone-women", characterized with such features – in the towns of Manglisi, Gurjaani and so on. menhirs, the religious-ritualistic monuments, are all given the same properties in terms of rain and drought. People of the megalithic era gave certain mystical supernatural power to this god symbol. It is very interesting fact by the view of archeo astronomy, that such megalithic religious-ritualistic elements, such as "Stone-woman" or menhir is associated with natural, climate occurrences, one side of it provokes rain and another – drought. This is reflective of a worldview in which local technology or tools can be used to influence the sky, in this case, to effect the amount of rain. The "Stone-woman" menhirs were perceived to influence the periods of droughts and rains that are directly related to specific locations of the sun in the sky and exactly for that reason, the religious-ritualistic megalithic buildings were built. We hypothesize that people worshiping the menhirs started from this, it was a marker for commencement of agricultural works, watering, harvesting and performance of the agricultural activities, which indicates the cognition of the universe and knowledge of the astronomical occurrences by humans of the megalithic period.

Ancient humans observed and studied celestial bodies (which were perceived to be Gods) and used that knowledge in his daily life for his benefit. In our opinion, this is one of the reasons for the worship and admiration of celestial bodies. A contemporary example illustrative of this fact is the materials from the archive of S. Bedukadze[6], in which a ploughman yokes oxen after the appearance of the specific star - "Sapara's Chuti". Ploughman's songs during the cultivation of the soil (during ploughing), in which the Sun and Moon are mentioned, also deserves attention.

"We used to say that "Sapara's Chuti" appears at dawn, the star is like "Chuti" and "Sapara's Chuti" is Tatar, the Georgians gave it such name, it was an ordinary "Chuti", they had one and they started to joke that it looked like it, that "Chuti" also had oxen yoked, a ploughman ran after it, a dinner-man used to come, a frisky dog (small) followed him, a wolf ran after them - small"[6].

"We used to yoke oxen at night - it was fresh, you need not get angry with the ox, it goes for himself, but as its get hotter, the cattle becomes lazier. We yoked at the beacon star and let them free by noon"[6].

"A good singer did not have to do anything (plough), he used to cheer us up, even a ploughman sang if he knew a song, sometimes I had the drovers, they started singing out loudly such a song as "Orovela", or some other about oxen or other things; some of them sang like this:

"The bright moon said
I am much better than the sun.
Sat and wrote the book.
The wind was carrying away …[6]"

As the records above show, the ploughman's song is

about the Moon, the Sun and the wind; before yoking the oxen he looks at the beacon star and only then he starts yoking them. These materials reveal that the people used to manage their agriculture through observations on celestial bodies. This shows that they possessed certain astronomical knowledge about celestial bodies and their motion, as well as land farming culture and rules passed from generation to generation with their accumulated knowledge. In our opinion, ancient cultic megaliths were created for the purpose of the seasonal breakdown of the year for the ancient people to know when they could plough and sow, when the cold and hot weather started, whether it was rainy or dry season. In essence, the megaliths encode information necessary for survival.

3. Field Work Methodology

In the field we marked the used following tools:

1. Optical theodolite (T15, N25773, 1976), the precision of this Theodolite is 10”
2. Optical-magnetic compass (Military Prismatic Sighting Compass w/ Pouch)
3. 50 m distance measuring device
4. Camera (Sony, a200)
5. GPS (Garmin, model: 010-01199-10)
6. Electronic Watch

During field work we identified possible observation platforms - circular and semicircular objects, they are marked with Latin Characters A, B, C, D, the monoliths with Arabic numbers 1, 2, 3, 4and the rectangular form rooms with Roman Characters I, II, III, IV, V Next, we used line-of-sights from those platforms (Objects A, B, C, D) incorporating the monoliths (1,2,3,4) as possible observations of the sky that ancient people did for agricultural and religious purposes. Then we restored ancient celestial sphere using SkyMap Pro[7] and found which celestial bodies correlated to the line-of-sights of the megalithic complex.

4. Megalitic Complex of Gokhnari

On the way to the Gokhnari megalithic complex lies the Church of Mariam’s Cross or Mariam-Jvari in Georgian. In the yard of the church there is a fallen menhir. It is engraved with a circular petroglyph that looks like the Sun or Moon. If we re-erect the menhir in the upright position, the petroglyph will be facing approximately the summer solstice. (Figure. 2)

Figure 2. The menhir in the yard of the Mariam’s Cross church, near the Gokhnari complex, 2013. Photo by Badri Jijelava.

The Megalithic complex of Gokhnari comprise two parts upper part, which is located to the west direction and downer part, located to the east part of the complex. In the book “Georgian megalithic culture” is mentioned upper part as “fortress” and downer as “Former city” [1].

The orientation of this complex is approximately from North to South. There are four huge natural monoliths within the complex.

Monolith 1 is divided for four stone parts, one of them is located behind the other three and is not visible from the entrance; thus, it looks like a three - column monolith to those who are inside.

Monolith 2 and Monolith 3 are very close to each other and they can be seen from any part of the complex.

Monolith 4 is located south-east of the “fortress”. East of Monolith 4 is built a corridor with entrance of architrave. In the corridor of this entrance, one can find two dolmens connected to each other by dugouts, which go deeper into the ground. One more dolmen is built to the north of this entrance.

The main entrance to the complex faces north-west and its azimuth is 302^0 True. At the north wall of the “fortress” is built a dolmen The roof of the dolmen is ruined and instead of the original roof local shepherds made a tiled one. We determined the azimuth of the direction of the dolmen and it equals 360^0 True. From

Table 1. Modeling with Sky Map Pro software. The comparison of the results of the fieldwork and the modeling

Number	Direction of Objects	Astronomical phenomena, luminaries	Azimuth	Altitude
Summer solstice - 25 July 4000 BC				
1	D object - 2-3 monoliths	Rise of the Planet Venus, Summer solstice - 25 July 4000 BC	Modeling A 82° 28' 35" Field work A 82^0 46'	Modeling H 13° 10' 41" Field work H 13^0 30'
2	C Object -2-3 monoliths	Heliacal rise of Alpha Leo.	Modeling A 65° 35' 33" Field work A 65^0 18,3'	Modeling H 7° 5' 12" Field work H 7^0 16'
3	C Object -2-3 monoliths	Rise of the planet Jupiter - summer solstice - 25 July, 4000 BC (first appearance, based on the configuration of megalithic complex)	Modeling A 63° 58' 5" Field work A 65^0 18,3'	Modeling H 7° 10' 29" Field work H 7^0 16'
4	B object - 1 monolith	Rise of the planet Mercury - summer solstice - 25 July, 4000 BC (first appearance, based on the configuration of megalithic complex)	Modeling A 58° 37' 38" Field work A 57^0 35'	Modeling H 3° 17' 24" Field work H 3^0 08'
5	a) Direction at the entrance located dolmen; b) Direction of "fortress";	Culmination near horizon of Arcturus (Alpha Bootes) (visual magnitude - 0.05)	Modeling A 0° 25' 34" A 4° 36' 49" a) Field work A 0^0 b) Field work A 6^0	Modeling H 8° 8' 10" H 8° 8' 10" a) Field work H 8^0 02' b) Field work H 8^0 02'
6	B Object -1 monolith	The Sunrise - summer solstice - 25 July, 4000 BC	ModelingA 58° 27' 25" Field work A 57^0 35'	Modeling H 3° 3' 19" Field work H 3^0 08'
7	Marim's Cross Church	Direction of the fallen Menhir	A 71^0	H 2^0
Vernal equinox - 22 April, 4000 BC				
8	A Object -2-3 monoliths	Heliacal rise Elnath (Beta Tauri), vernal equinox 22 April 4000 BC	Modeling A 86° 49' 29" Field work A 88^0 06'	Modeling H 3° 14' 56" Field work H 2^0 19'
9	B Object -2-3 monoliths	Rise of Haedus (Zeta Aurigae) (first appearance, based on the configuration of megalithic complex)	Modeling A 72° 35' 12" Field work A 73^0 19'	Modeling H 3° 33' 45" Field work H 3^0 25'
11	Architrave entrance direction, on the continuing of the monolith 4	The Sunrise, Vernal equinox - 22 April, 4000 BC	Modeling A 92° 38' 13" Field work A 94^0	Modeling H 2° 37' 47" Field work H 2^0
Autumnal equinox 22 October, 4000 BC				
12	Architrave entrance direction, on the continuing of the monolith 4	The Sunrise, Autumnal equinox 22 October, 4000 BC	Modeling A 92° 38' 13" Field work A 94^0	Modeling H 2° 37' 47" Field work H 2^0
Winter solstice - 19 January, 4000 BC				
13	B object -1 monolith	Heliacal rise of Shedar (Alpha Cassiopeia).	Modeling A 58° 10' 53" Field work A 57^0 35'	Modeling H 7° 21' 16" Field work H 30 08'
14	D object -4 monolith	Acronychal Set of Rigil Kent (Alpha Centauri). (The first disappearance to the horizon, based on the configuration of megalithic complex.)	Modeling A 219° 24' 4" Field work A 221^0 48'	Modeling H 3° 26' 45" Field workH 3 25'

this, the position the altitude of the landscape horizon is seen at an angle of 8^0(Figure 3).

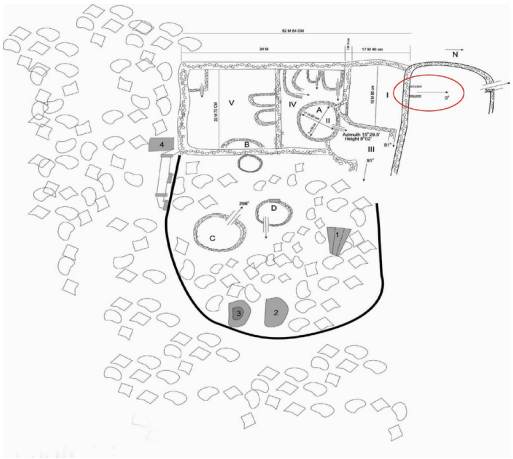

Figure 3. Megalithic complex of "Gokhnari", 2013. The map is made by Badri Jijelava.

At the rock which is located to the north of the megalithic complex a spring emerges to the surface and flows to approach the Gokhnari complex. Then it turns to the west and continues its way south of a "carcnally" ("Carcnally" means "a place with many stones" in Georgian). As it continues the spring-fed stream disappears under the ground to again become visible later on. The general direction of the "fortress" is North-South, more exactly: NE-SW - 6^0-186^0 True geodesic azimuth. During field work, we measured the coordinates of the first (I) room, which is located in the north part of the complex.

Latitude: $44^0$17' 54,054" N

Longitude: 41^0 40' 27,546" E

5. The Results of the Celestial Sphere Modeling and Field Work.

We conducted the modeling of the celestial sphere of the Gokhnari megalithic complex using the software SkyMap Pro[7]. As seen in Table 1, in 4000 BC in the Gokhnari megalithic complex heliacal risings of celestial bodies would occur in the astronomically significant periods (winter and summer solstices, and vernal and autumnal equinoxes) and was correlated with the configuration of the complex.(Table 1)

We have identified 14 possible celestial alignments for the Gokhnari complex. Based on the modeling of the celestial sphere, the dolmen located in the north part is directed towards Arcturus in the summer solstice (Table 1, row 6). This will be discussed in detail in the following sections.

6. Cultural - astronomical destination of Gokhnari megalithic complex

John Rogers in his article "Origins of the ancient constellations" describes the mythology relating to the Bootes constellation. "It follows Ursa Major in the sky, and has always been associated with it, as a hunter of the bear, a guardian of the bears, a herdsman of the oxen, a driver of the wagon, or a ploughman with plough. Bootes probably means Ox-driver"[8-11];

"In Mesopotamia this area, or especially Arcturus, was somehow identified with the god Enlil; but there was an alternative name Shudun, meaning Yoke, which perhaps suggests that association with oxen did reach Mesopotamia"[8,9].

In the Almagest of Ptolemy[12], the Alpha star (Arcturus) in Bootes is mentioned as "Subrufa", it means - slightly red[13]. On the celestial sphere, between the constellations Bootes and Ursa Major is located the Canum Venaticorum (hunting dogs). According to Ptolemy's Almagest, Canum Venaticorum translates to "dogs" constellation. It includes two stars: Cor caroli – Alpha 2 (Visual magnitude 2.84) and Chara (Visual magnitude 4.24).

The Constellation of Bootes is also mentioned in Homer's epic poem the Odyssey. Odysseus navigates away from Calypso by the Stars.

"…nor did sleep ever descend on his eyelids

As he kept his eye on the Pleiades and late-setting Boötes

And the Bear, to whom men also give the name of the Wagon,

Who turns about in a fixed place and looks at Orion…."[14]

According to the Greek mythology, Bootes is associated with a ploughman with 7 yoked oxen (the stars of the Ursa Major).

The above-mentioned historical data indicate that

luminaries had a significant place and role in ancient epochs. They contained not only mythological and religious aspects, but were of vital importance for maritime and agriculture.

The ethnographical data collected by S. Bedukadze in which yoking of the oxen is described are similar to Sumerian, Egyptian and Greek mythologies[8];
Going back to this ethnographic data:

"We used to say that "Sapara's Chuti" appears at dawn, the star is like "Chuti" and "Sapara's Chuti" is Tatar, the Georgians gave it such name, it was an ordinary "Chuti", they had one and they started to joke that it looked like it, that "Chuti" also had oxen yoked, a ploughman ran after it, a dinner-man used to come, a frisky dog (small) followed him, a wolf ran after them – small"[6].

Presumably, the source of the explanation of "Sapara's Chuti" comes from Ptolemy's definition of Arcturus ("Subrufa"), "Chuti" may be from Sumerian "Shup.pa". In ancient folklore, these two definitions transformed into "Sapara's Chuti" and passed down today as "Sapara's Chuti" star.

Hypothetically in the ethnographic data obtained from the ploughman, the star of "Sapara's Chuti" implies the star Arcturus, whose visual magnitude equals 0.05. It is bright enough to be seen with the naked eye and presumably was the marker of the beginning of the agricultural works. Based on the ethnographic data, when "Sapara's Chuti" was observed on the celestial sphere, the ploughman began yoking his oxen. According to the Sumerian and Greek mythology "yoked oxen" were associated with the seven stars of the Ursa Majoris constellation, and the ploughman was the symbol of the constellation of Bootes. "A frisky dog (small) followed him, a wolf ran after them (Bedukadze 1964)" - these are the stars in the Canum Venaticorum (Hunting dogs) constellation, Beta - Chara (visual magnitude 4.24) is the symbol of "a frisky dog - small ", the brighter Alpha star - Cor caroli (visual magnitude 2.84) is the symbol of a wolf, mentioned in the ethnographic data.

"We used to yoke oxen at night, it was fresh, you need not get angry with the ox, it goes for himself, but at its get hotter, the cattle become lazier. We yoked at "beacon star" and let them free by noon"[6].

As seen from the data given by the ploughman, it ("to yoke oxen ") happened at night, when the "beacon-star" was seen at the horizon. The modeling with the use of the Sky Map Pro shows that in antiquity, Arcturus (Alpha Bootes) was a circumpolar star.

Based on the results of the modeling in 4000 BC, Arcturus "culminated below the pole"(USNO 2016), skimming near the horizon before the rising of the sun. Note that culmination is used in the astronomical sense "(astronomy) the highest or lowest altitude attained by a heavenly body as it crosses the meridian"[15]. This astronomical phenomenon could be observed from the northern dolmen. After the lower culmination, the star started moving to the zenith of the celestial sphere increasing in altitude (in a horizontal coordinate system). Hypothetically, ancient people noticed such kind of motion and the bright light from the star (low visual magnitude) during the time of the year for ploughing. They discovered that the appearance of Arcturus at that time of year was very soon followed by the dawn. Owing to these three factors the ancient people began to deify the star along with putting their knowledge to good use. The dolmen, built in the north part of the megalithic complex, has an orientation to Arcturus.

Equating of "Sapara's Chuti" with Arcturus gives us an assumption that in different ethnographical data the worshiped "Beacon star" is Arcturus (Alpha Bootes). The culmination of the star near the horizon meant that the dawn would break soon and the ploughmen began to yoke the oxen.

The ethnographic data collected by S. Bedukadze describes a part of the ancient celestial sphere, the knowledge which had the plowman about the star "saparas chuti" was unknown to him; when he wrote about the plowing process, he had not understoodat that time that he had been describing the celestial sphere and constellations. Based on the results of modeling Skymap Pro only in 4000 BC did Arcturus became circumpolar star and appeared in sky, skimming near the horizon before helical rise of the planet Venus and the Sun rise in the summer solstice period. Such astronomical phenomena is correlated with the ethnographic data collected in the classical period (ethnographic data about beacon star and plowman). In spite of the fact that these ethnographic data was not collected in the classical period, presumably such folklore comes from the prehistory period as do many story and legends of Georgia, legend about Elia, Christ and Saint Giorgi, story about Amirani and so on.The above-mentioned folklore describes a part of the ancient celestial sphere, more precisely, the Bootes (ploughman), Ursa Majoris (Yoked oxen) and Canum Venaticorum (dogs, which in prehistoric Caucasian epistemology were dog and wolf) constellations and their location in the

celestial sphere.
"Dawn was dragging and dragging together with his skin, he (dawn star) rises at the daybreak, was kicked and driven out,
"Beacon star" came, he was made drunk,
dressing gown was changed, and chokha (Georgian national suit) put on"[16].

As seen from the V. Koketishvili ethnographic data the Beacon-star and the Dawn-star are different stars. This fact is a compelling argument in support of our assertion of the identity of Arcturus star as the Beacon-star (as are mentioned in many Georgian ethnographic data).

In the Gokhnari Megalithic complex in 4000 BC on the summer solstice there was a heliacal rising of the planet Venus, which rose after the culmination of Arcturus star near the horizon. The planet Venus is mentioned in the ancient ethnographic data as "Aspirozi – Greek name", "Mtiebi", "Khariparia - oxen stealer", "Tciskris maskvlavi - dawn star", "Mtsukhris maskvlavi-twilight star"[17]. The folklore passed through the generations is the evidence that the planet Venus influenced the religious and cultural aspects of the life of prehistoric people of Georgia.
"ქიმიჩონეგუმათანე - bring "carrier light" (star)
ბჟამიეკმაჩუნჯე- following the Sun"[18]
"ჟინიჰაკასნოთეთრდგრქრ - upon sky (air) standing as beacon,
თუდონჰავაშმასრნთებელო - illuminating the world,
გრმათანემერეხირექრ - illuminator you are the star,
გოთანაშიმახარებელო - daybreak herald"[19]

In the Lexicon of Sulkhan-Saba Orbeliani[20] Aphrodite is explained as "dawn star", in the Greek mythology Aphrodite was the face of the planet Venus.

In 4000 BC in the Gokhari megalithic complex the heliacal rising of the planet Venus was a religious and ritual ceremony for the people of this region. In his book "Georgian Megalithic Culture" L. Meliksed Beg describes the Gokhnari megalithic complex and mentions that in one of the mining digsthe expedition found an ancient stone woman that supposedly represented the religious cult worshipped by the local people[6]. S. Makalatia in his book "Cult of phallus in Georgia" indicates that contemporary Georgian celebrations of "Harikela", "Adrikela", "Saqmisi", "Keenoba", "Berikaoba" are connected to the cult of phallus and kteis, worshiping the goddess of fertility[21]. The stone woman was the materialized symbol of the planet Venus, the Goddess of fertility. She was perceived as the source of life and light, the herald of daybreak and therefore people worshipped Venus which is reflected also in the Gokhari megalithic complex.

7. Conclusion

Though the ethnographic data was not collected during the classical period, our arguments point to the term "saparas chuti," the ploughman stars, and the activities of contemporary ploughmen as being connected to the bright star Arcturus in the ancient ploughman asterism now Bootes. Thus, the ethnographic data is shown to be connected to the ancient sky, though this connection was not known by the ethnographer at the time the interviews were collected. We are the first scientists to present the connection between the ethnographic data and the ancient sky, and our remaining conclusions are based on this connection.

Combining ethnographic data that shows the importance of Venus and Arcturus along with the measurements of possible celestial alignments and computer modeling we conclude that the megalithic complex of Gokhnari was designed for observing the heliacal positions of planets and stars along the horizon. Focusing on the ethnographic data, we established that the "dawn star" refers to Venus which is not uncommon in other cultures and that the "Beacon Star" is Arcturus. The strength of this conclusion is based on the heliacal position of Arcturus to the extreme north and Venus to the east on the summer solstice.

Based on the results, we conclude that the megalithic complex of Gokhnari is oriented to the heliacal rising of the planets and stars. These astronomical phenomena were observed from circular or semicircular megalithic objects that are probable observing platforms. The configuration of the megalithic objects was aligned to the natural monoliths and local topography, thus giving the possibility to observe the risings and settings of the celestial bodies in the astronomical significant periods of winter, summer solstices, and vernal and autumnal equinoxes.

Based on the results of the modeling and corresponding ethnographic data we can conclude that this complex was built in 4000 BC.

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Observational and Cult Sites in Pre-Christian Georgia

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Contents

Abstract

In this chapter, we describe ancient cult and observational sites in Georgia together with cultural traditions that have astronomical significance from various parts of the country. In particular, we present the results of an archaeo-astronomical investigation of the Shaori complex, and consider its possible role as an ancient "solar station" with cult significance.

Introduction

Ethnographic data available within Georgia includes notes from investigations carried out by ethnographers in the 20th century and dictionaries published at various times. Inevitably, the material is not of uniform quality, but it contains

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interesting facts that reflect aspects of ancient Georgians' knowledge about the sky, celestial bodies, and impressive heavenly phenomena.

Such knowledge always has the potential for practical use in everyday life, both in agriculture and in orientation with respect to the terrain during local or long-distance journeys. It was gathered and optimized across the ages, being continually transformed and modernized. In the process, some ancient knowledge would be lost and new knowledge would be accumulated. However, some fundamental elements of ancient people's ideas about the universe may have been preserved up to the present.

The principal motivations for accumulating knowledge about the sky are likely to have been the following:

1. The necessity to keep track of time in order to maintain a continuous agricultural cycle
2. The necessity to keep tabs on local and global orientation in space in order to bring the land into cultivation, to build roads, to construct settlements, etc., as well as for military purposes
3. The necessity to "interact" with bright heavenly bodies for cultic, religious purposes. These are the main factors that stimulated the accumulation and adaptation of knowledge about heavenly phenomena, knowledge used by ancient people in different fields of activity throughout daily life.

We can suppose that the accumulation of such knowledge and its optimization led ultimately to the formation of a rather harmonious ethnocosmological system of ideas among ancient Georgians. However, the ethnographic data on surviving knowledge and practices does not provide direct support for this; we only have separate fragments of data scattered in the ethnographic material.

Folk Traditions Relating to Astronomy

A number of Georgian sources contain information of ethnocosmological importance. For example, Makalatia (1972, p. 50) describes some ancient traditions relating to seasonal practices of driving cattle and pasturing sheep: "The people living in the villages of Khizabavra and Zveli still remember the ancient traditions for determining when to drive the cattle. After the week of Khomli they could drive the cattle over a high mountain, as snow was not expected any more. The week Khomli comes in the month of Tibatve (July), when a group of stars known as Khomli (the Pleiades) appears. Khomli rises on the 6th day of Tibatve, but is not seen by eye until the 12th of Tibatve. During this week great care is taken about the sheep being in the open air. The peasant thinks that Khomli possesses the force to cause the hair of sheep to fall out and their faces to ulcerate. The inhabitants believe that Khomli is dangerous in the morning, when the sheep are still lying down in a sheep-pen. 'If Khomli rises above the lying sheep, it strikes them and causes the their hair to fall out and their heads and faces to ulcerate' (Khizabavra). 'It rises with a noise, causing the hair of sheep to fall out, and ulceration. In the morning they arouse the sheep and drive them' (Zveli). In the village of Zveli, during the

week of Khomli, sheep are driven to the nearby fields at the edge of the forest, where there is a protected place called Cholaka".

The ethnographic sources provide various, even sometimes contradictory, information about the knowledge of the heavenly bodies possessed by ancient peasants in different regions of Georgia. Bochoridze (1993) gives the following names of heavenly bodies: Khariparia, Tsiskari, Gutneuli, Jaraebi, Mravalai, and Tsultokhebi. He mentions the fact that, in spring, some stars follow Mravalai at a fixed distance but then the distance between them increases. This is interesting, and provides evidence that some of the stars mentioned are "wandering" stars, namely planets. Among them is Tsiskari (Venus) and Mejoge, which rises after midnight. Given this and its brightness, it can be assumed that Mejoge is Jupiter.

The following is a list of several traditional names of stars and constellations used in the northern part of Georgia: "Tsiskris varskvlavi" (Tsiskris star); "Shuqur varskvlavi" (Bright star); "Qaravnis varskvlavi" (Caravan star); "Sabedo varskvlavi" (Fate star); "Shvidmoqcevis varskvlavi" (Seven cycles star); "Samshvilde varskvlavi" (Quiver star); "Dzagli varskvlavi" (Dog star); "Morbedi varskvlavi" (Quick star); "Maskvlavkudedi" (Tails star); "Tagdiri varskvlavi" (Red star); "Ikvlivi varskvlavi" (Grass star); "Kondio varskvlavi" (Poisonous star); "Mokhura varskvlavi" (Closing star); "Sakaloe maskvlavi" (Threshing-floor star); "Mosvlis varskvlavi" (Coming star); "Meshvelni" (Helping stars); "Mesakhleni" (Inhabitable stars); "Tserilani" (Letter stars); and "Bevrani" (Numerous stars) (Orbeliani 1991; Chincharauli 2005). The risings and settings of these and other luminaries played an important role in the religious, agricultural, and practical traditions of ancient Georgian peasants. Not all ancient Georgian stars and constellations are confidently identified.

On the basis of ethnographic evidence Bedukadze (1968) describes old instruments used by people for the determination of time. "In Khevsureti [a region of Georgia] the seasons were determined by means of groups of stone columns, called 'sun nests', erected on peaks to the east of villages. According to the movement of the rising sun from one nest to another, people determined the month, the season, the beginning and end of a year, and important dates of an agricultural character".

Stone Constructions as Cult Places and Time-Measuring Instruments

The northern part of Georgia is rich with stone constructions of various sizes and forms. These standing stones, circular walls, and rows of boulders are usually located on the summits or slopes of high mountains (Figs. 128.1, 128.2). The main elements (openings) of several such monuments are aligned to the southeast. During pre-Christian times, monuments of this character probably served cultic purposes and were used also as time-measuring instruments through observations of the rising of the sun, moon, and bright stars. Later, these constructions were transformed into Christian monuments.

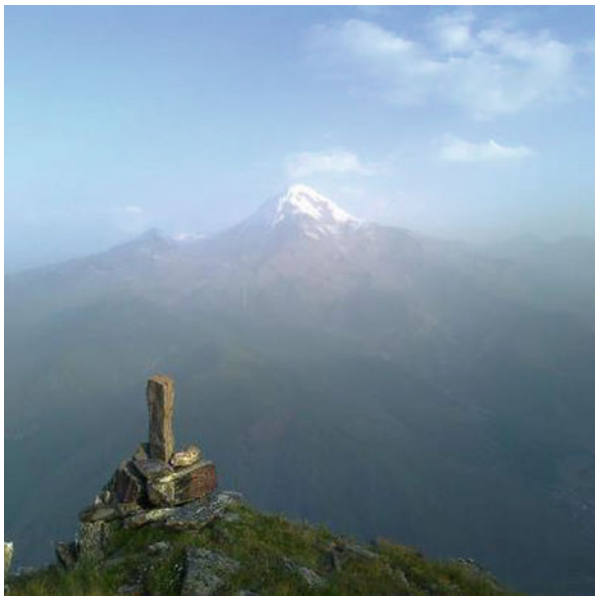

Fig. 128.1 Menhir and remnants of a surrounding construction on a high mountain in the Stephantsminda region, northern Georgia (Photograph: G. Gigauri)

Fig. 128.2 Remnants of a circular stone construction in northern Georgia (Photograph: G. Gigauri)

On the surfaces of large and small stones, boulders, and blocks located in Khevsureti are carved pictograms with various geometrical designs and other peculiarities. Some pictograms have a clear cosmographical character (Fig. 128.3). They include elements such as an eight-petalled flower-like symbol possibly representing stars, palms, and animals and may well reflect the relationship of ancient humans to the celestial order and recurrent astronomical phenomena. Taking into account the northerly location of the Khevsureti Mountains, it is possible that the eight-petalled star could represents Polaris, which played an important role for ancient Georgians. Determining more precisely the astronomical

Fig. 128.3 Pictogram with possible cosmographical significance from the Khevsureti region of Georgia (Photograph: G. Gigauri)

significance of stone monuments and the meaning of the cosmographical pictograms in Khevsureti requires comprehensive investigations taking into account their geographical location and cultural context.

In southern Georgia, near Paravani Lake in the Shaori Mountains, can be found a large megalithic complex constructed from basalt slabs (Kaukhchishvili 1973; Berdzenishvili 2002; Narimanishvili 2009). The Shaori complex consists of two parts – the large Shaori on the highest summit and the small one on the other mountain. The large Shaori building is located at N 41° 29′ 2″, E 43° 44′ 57″, elevation 2739 m, and the small Shaori building is at N 41° 29′ 7″, E 43° 44′ 45″, elevation 2735 m.

The architectural space of the large Shaori comprises an envelope-like shape with the remains of a small column at its center. The inner side of the complex wall contain numerous dolmens. The large Shaori building has a central opening with a door facing southeast (Figs. 128.4, 128.5). The small Shaori building is irregular in shape. The large Shaori building is connected to the bottom of the mountain by a ceremonial road several meters wide and stepped with recumbent menhirs.

These Bronze Age constructions probably had a dual significance both as a cult center and an observational place. Religious ceremonies held in Shaori buildings could have included the observations of heavenly bodies.

The central opening or door of the large Shaori building faces a true azimuth of 121° 40′ as determined by a survey carried out by Ilia State University in 2011. The azimuth of the rising sun at the winter solstice is 121°, so that observers standing near the central column would have seen the rising winter solstice sun through the door. The significance of the surrounding mountains and the existence of the small Shaori building have still to be fully investigated.

In view of what we know of ancient Georgians' religious beliefs it is possible that the Shaori complex was not only a ceremonial center with buildings in

Fig. 128.4 Large Shaori building, 2011 (Photograph: G. Houston)

Fig. 128.5 Large Shaori building – inner view (Photograph: G. Houston)

which diverse rituals were performed, but that it also served as an observational site – a type of ancient "solar station" – in which people worshiped their Gods and watched the rising of diverse heavenly bodies – the sun, moon, and stars – in order to maintain their orientation in time. On the morning of the winter solstice, the ancient Georgians could have observed sunrise from the large Shaori building, marking the onset of the cold season.

Other peculiarities, such as the fact that the door of the large Shaori building was observable from the opening of the small Shaori building, may indicate further links

of cosmological and religious significance. The Shaori complex as an ancient solar station awaits further, more detailed archaeoastronomical investigation.

Astronomical Characteristics of Cultural Heritage

Several examples of ancient Georgian cultural heritage, while known for many years to historians and archaeologists, have only recently been analyzed from the viewpoint of their possible astronomical significance. Georgian legends and folk stories, art, architecture, observational sites, and cult objects contain direct and indirect evidence of astronomical cognition and fragments of cosmological views (Simonia 2001). Astronomical characteristics of cultural heritage in the form of astro-terminology, ornaments, pictures, aligned constructions, and buildings with spatial peculiarities have not yet been studied in detail (Simonia et al. 2009). Much remains to be done to study early astronomical traditions and practices in Georgia, taking into account the ethnocosmological notions and beliefs of ancient Georgians.

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► Astronomy in the Ancient Caucasus

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Metal Artifacts As a Mirror of Ancient Georgian Astronomical World View

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We describe three early metal objects from Georgia: a plate from the 16th–14th century BC, a spoon from the 4th–3rd centuries BC, and a cup from the 3rd century BC, and suggest that the decoration of each is based on astronomical symbolism.

* * *

Background

Ruins of ancient observatories, fragments of instruments, numerous neglected manuscripts and books, so far unclaimed discoveries, forgotten names—all these make up the ancient Georgian astronomy until now unknown to the world. The ancient state of Georgia, where this science developed, is situated in the Caucasus, along the very border between Europe and Asia.

The Black Sea, the Caucasian mountains and thick forests created an exceptionally beautiful landscape and contributed to a healthy, temperate climate. From time immemorial the land had been inhabited by Georgian tribes. The state of Georgia has existed in this territory for over 25 centuries. Through all those years full of hardships, the Georgians were creating and keeping up their own language, culture, and world outlook. Numerous masterpieces of literature, art and architecture are surviving evidence of the originality of the culture of this people. The oldest Georgian states—the West Georgian Kingdom of Colchis and the East Georgian Kingdom of Kartli—were established in the 6th century BC. It was the time when civil societies and special governmental institutions began taking shape in those two states. In the 3rd century BC the eastern and western Georgian states were united

into one country. Before the 4th century AD the Georgian people had been following different religions, such as fire worship, Zoroastrianism, and others. In the early 4th century AD Orthodox Christianity took root in Georgia and within a century became the state religion. This process was enhanced by the strong political and cultural influence of the Roman Empire's eastern provinces which maintained close relationships with Georgia at that time.

Celestial phenomena had always been a subject of particular interest for Georgians. The old Georgian folk tales and legends frequently refer to celestial luminaries and various celestial phenomena. Those legends laid special emphasis upon the "domination of the celestial laws," and "inevitability of punishment by the powerful celestial forces." Perceiving the grandness of the occurring events, the Georgians ascribed some mysterious nature to the sky and celestial phenomena. Examining such artifacts as old Georgian decorations, tools, weapons, household utensils made of brass, bronze, silver, or gold, one can discern celestial luminaries—the Sun, the Moon, the stars—reproduced in different shapes and sizes.

In those times the religious system of Zoroastrianism played an important part in the life of the Georgian people. Their principal deity was the Moon, a symbol of a man-warrior. The sacred animal of the Moon was the Bull. A bull was frequently offered as a sacrifice. The shape of the Bull's horns seemed to remind the Georgians of the Moon. The walls of ritual edifices and dwelling houses frequently bore various images of the Bull and its horns. Different figures and figurines of the Bull and other sacred animals were widely common in the country.

The period from the 16th century BC to the 4th century AD in Georgia was the time of the accumulation of the most elementary, primary knowledge of the sky and celestial bodies; the application of the stored up knowledge in the culture, folklore and art; and the practical use of the knowledge, namely creation of chronology and calendars. This period witnessed the development of the ancient Georgians from mere observers of the sky to skilled astronomers and astrologers at the Royal Court. Old Georgian manuscripts present some evidence that a lunar calendar was used in this country as early as the 2nd century BC and remained in use up to the end of the 3rd century AD.

Because this period is largely unknown outside of Georgia, we describe here three artifacts from this time—a bronze disk (16th–14th centuries BC), a silver spoon (4th–3rd centuries BC), and a silver cup (3rd century BC). We propose astronomical interpretations of the designs on these three objects. Although these interpretations are not unique, and other possibilities exist, we hope that our suggestions will lead to further study of this period.

Bronze Disks ca. 16th–14th Century BC

Disk-shaped bronze plates were found by a Georgian archeologist, O. Gambashidze (1986), in women's burials at Bornigele and Zadengora in Georgia. In all over 30 such plates were recovered and were dated to the 16th–14th centuries BC. The plates are massive, some tens of centimeters in diameter (Figure 1), with curious relief designs on the surface. The plates have previously been studied from the

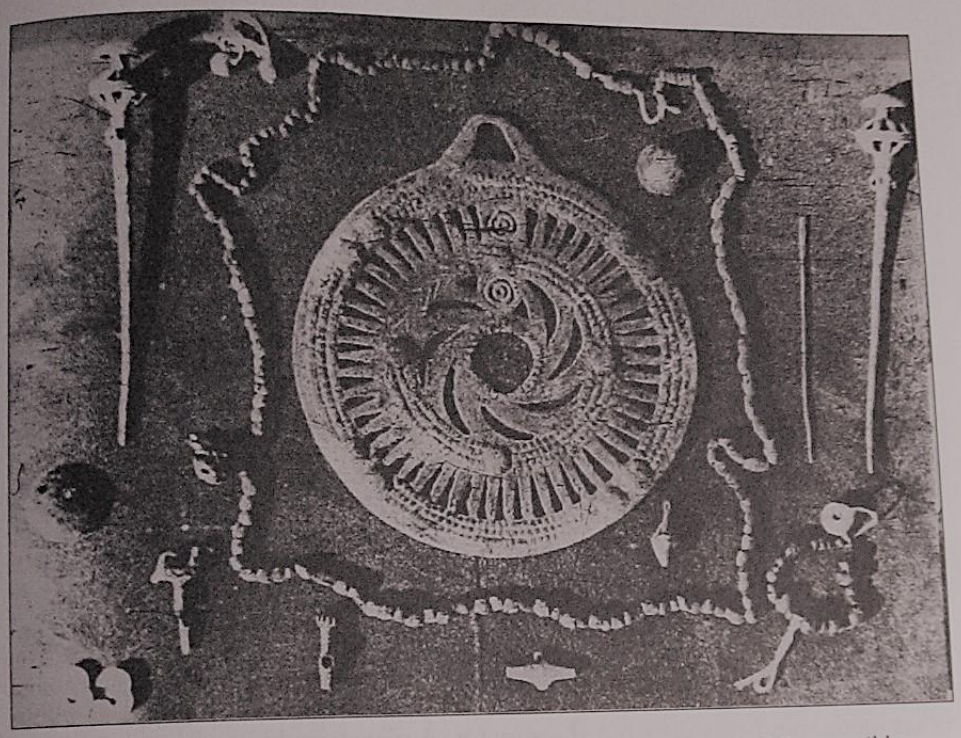

Figure 1. Bronze plate found in Georgia dating from 16th–14th century BC, a possible "cosmogram".

points of view of archeology, history and art. Ours is an attempt to analyze and interpret the surface designs from a purely astronomical viewpoint.

All the recovered plates bear similar designs containing the following basic common elements: a hole of a particular diameter through the center of the plate; surrounding the hole, a pattern involving raised hemispherical images and crescentic holes; further out a set of radial slits; beyond them an embossed rim. The plate illustrated here (Figure 1) has a tab seemingly designed to suspend it. The entire pattern is concentric and symmetric.

The whole sky and the strict regularity of celestial phenomena would have impressed and attracted those who watched them: Georgian tribes practiced land farming and, therefore, needed some kind of a calendar. We thus suggest the following astronomical interpretation of these bronze plates. We argue that they can represent the world view of the Georgian tribes of that time. The designs contain perforated and raised single or repeating components. Supposedly, the people who made these plates tried to represent celestial luminaries that they saw in the sky. The hole through the center could have been meant to represent the Sun. The repeating crescent-shaped holes could represent the Moon. The repeating spherical projections stood for the planets, stars, etc. The Sun is in the sky during the day's light hours; the Moon and the stars and planets are in the selfsame sky at night. The daytime and the nocturnal luminaries are thus represented together on the same plate, with all the celestial bodies being depicted on its surface which was supposed to represent the sky. Thus, the plates with relief designs could have served as a kind of flat model of the Universe.

Figure 2. Silver spoon found in Western Georgia dating from 4th–3rd century BC, with figures of bulls on the handle.

Why are the images of the Moon and the planets arranged in a repeated pattern? We think that by repeating the images the ancient authors tried to show the permanent visible motion of the luminaries. That attempt to show motion suggests that the plates' makers used to watched the celestial phenomena for a certain period of time (a day, a month, a year) before representing what they had seen on the plate. So we suggest the term "cosmogram" for the plates with these patterns, each cosmogram thus holding a certain body of information.

Fire, light and heat were naturally important components of the life of Georgian tribes. A particularly high place of pride was given to the Sun as a source of heat and light. The image of the Sun would thus be put in the center of a cosmogram, all the other luminaries being distributed around it. A planet could be represented in the form of repeating triangular holes. Such an arrangement of the celestial bodies and such a world outlook are quite curious. It is by no means heliocentrism, since it is hardly possible that the ancient people could possess so much knowledge. Nevertheless, there ought to be some kind of definition. And we suggest the term "symbolic heliocentrism." The phenomenon of "symbolic heliocentrism" seems to be free of any limits or national features. It is not unlikely that some other land farming tribes in other parts of the world created artifacts bearing reflections of their possibly heliocentric world outlook.

Other Metal Objects ca. 4th–3rd century BC

The methods of metal design in Georgia underwent some changes during subsequent centuries. The primitive dot-and-line pattern covering different articles—decorations, weapons, tools—were replaced by raised, three-dimensional images of sacred animals possibly symbolizing celestial bodies. Silver, and occasionally gold, figurines of the Bull, the Deer, and the Lion became common. Excavations at Vani, an ancient town in western Georgia, revealed a remarkable number of finds in the form of sacred animals (O. Lordkipanidze, 1984). One of the most interesting finds was a silver spoon with its handle decorated with two figures of the Bull (Figure 2). That spoon dated back to the 4th–3rd century BC. Representation of that sacred animal on such a common household article suggests a possible ritual (or religious)

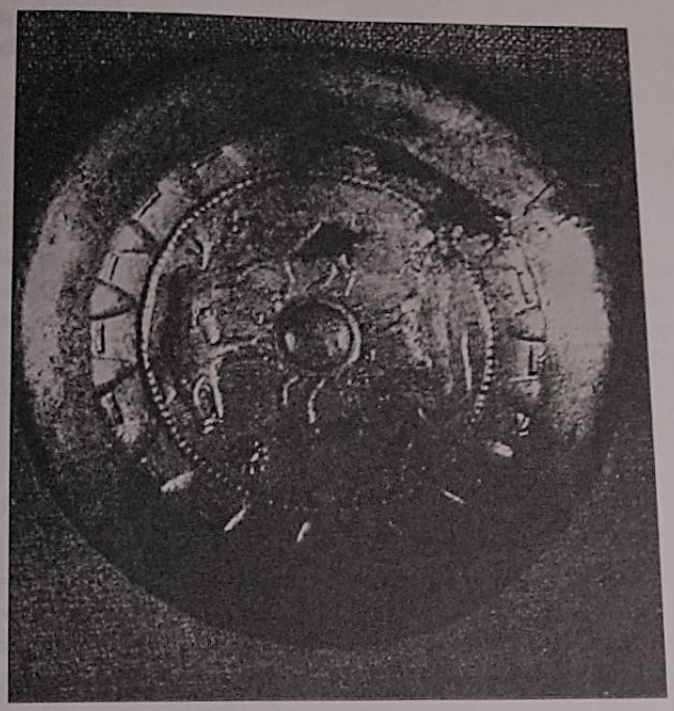

Figure 3. Silver cup found in Western Georgia dating from 3rd century BC, with possible calendric pattern.

meaning: the spoon may have been used during special ceremonies. That the spoon showed the images of the Bull offers one possible interpretation: that the role of the Moon was still important in the world view of the Georgians at this time.

O. Lordkipanidze (1986) reported other metal finds from Vani. They were articles with more elaborate, raised, three-dimensional designs. One of them was a silver cup dating from the 3rd century BC (Figure 3). A curious relief design decorates the outside of the bottom of the cup. A raised, hemispherical central detail of the design is suggestive of an astronomical object. A closed line made in relief and running from the center outward toward the edge resembles an orbit. Close to that orbit are four (possibly sacred) animals, facing four directions. A starlike design is made out near the orbit. Examining the photograph in a clockwise direction, one can notice that the animal figures are placed at the points of 12, 3, 6, and 9 o'clock. The starlike pattern is in the vicinity of the 11 o'clock point. The cup is in poor condition, so it was hard to identify the sacred animals clearly. Opinions are likely to differ in this case. We think that they are the figures of the Boar (in the 12 o'clock site), the Horse (3 o'clock), the Lion (6 o'clock), and the Deer (9 o'clock). The creator of that design seems to have symbolized by these animals celestial luminaries or even constellations. It is noteworthy that the animals are shown in motion, producing an impression of their permanent motion along the orbit. Wasn't that an attempt made by the ancient author to convey the perpetual motion of the celestial sphere or succession of the seasons?

The starlike component could serve as a kind of reference point for keeping time—a day, a month, a year. If our considerations prove to be correct, then the

artifact can be regarded as the simplest form of a metal calendar. The design on this ancient silver cup seems to have been based on a geocentric (or some other similar) point of view.

Conclusion

We have described here for the first time an astronomical analysis of three objects from the early history of Georgia. Thousands of such objects have been discovered there, but they have not been analyzed from this viewpoint before. We feel that much remains to be done to study the evidence of early astronomical traditions and practices in this part of the world. We hope that others will join us in this study.

Acknowledgments

We would like to thank the Organizing Committee of the Conference and, in particular, Dr. Rolf Sinclair, for their concern and interest in our work which made it possible for us to present this report at such an important meeting as this is.

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Editor's Note

The authors present here one possible (but not necessarily unique) interpretation of these objects, arguing that they symbolize the sun, the moon, and other astronomical bodies. They present no further evidence to corroborate this interpretation. However, this is (to our knowledge) the first description of early Georgian artifacts from an astronomical viewpoint, and as such warrants publication to make them better known.

Similar mirrors have been found in China (but assigned later dates) and seen there in several museums by J. Fountain (private communication 1998). There is the possibility of Hellenistic influence in the design of the spoon and the cup, as R. Poss points out (private communication 1997).

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THE EAST AND THE WEST AND ASTRONOMY IN GEORGIA

The State of Georgia exists for more than 25 centuries. This country, part of which lies at the Black Sea coast, in fact borders Europe and Asia. For thousands of years the Georgian people have been developing their ancient culture and language. during that time many literary monuments were created, many of churches and temples were built, and many outputs of appied arts were produced. Along with them, various fields of sciences were developed, including mathematics and astronomy. Georgia was influenced by both the Eastern and Western cultures, due to its geographic position. And in its turn, Georgian original culture had certain influence on these cultures. These processes took place also in the 15th and subsequent centuries. 1600 years ago Georgia adopted Christianity which had a strong effect on the development of its culture.

Unfortunately, at present very little is known in Occident about the history of Georgian astronomy, although this branch of science has long and interesting traditions in Georgia. Celestial phenomena were of special interest for Georgians since ancient times. The representatives of all the layers of Georgian society, from peasants to kings, often observed such rare phenomena as solar and lunar eclipses, comet formation, etc. The Sun and the Moon, planets and constellations had their own georgian names. In the 11th-12th centuries in Georgian academies of Ikalto and Gelati, astronomy was taught along with other topics, and in the Gelati academy an observatory was functioning for a certain period (Kharadze and Cochlashvili 1958). In the 13th century in Tbilisi, the capital of Georgia, existed an astronomical observatory where systematic astronomical observations were carried out by means of azimuth disks. The Georgian astronomers were known as good observers and calculators. Therefore they were often invited by the observatories from the neighbouring countries, namely by the observatory of mukhamed naciredin Tusi in Maraga.

A number of Georgian manuscripts are preserved in the Tbilisi Institute of Manuscripts at the Georgian Academy of Sciences, archives and museums. These manuscripts include various fields of astronomical science, starting with chronology, calendrics, and concluding with the description of the position and motion of heavenly bodies. The greatest part of the manuscripts are original works by Georgian authors, and are written in Old Georgian. The other part represent translations, among which are translations from Arabic and Greek. The French scholar Marie Brossé (1802-1880) was among the investigators of the ancient Georgian manuscripts. The astronomical topics are frequent in Georgian literary works, particularly, in the poem *Vepkhvis Tkaosani* (The Knight in the Panther's Skin) by Shota Rustaveli, The Georgian classic poet of 12th century. The description of heavenly bodies and various elements is frequent in this poem. It means that the author was familiar with basic astronomy, and might have

* Tbilisi

received a certain astronomical education.

On the walls of old temples and cloisters astronomical inscriptions and drawings are placed together with other inscriptions and drawings. Ancient sundials, preserved in Georgian temples may be considered as samples of architectural remains.

In 19th century in Tbilisi fuctioned a physical-astronomical observatory, whose director was an astronomer Paul Morits (1821-1902) from Derpt (Bronshtein and Simonia 1991). At the beginning of 20th century on the hill of Kanobili, in Abastumani, the Georgian astronomer Evgeni Kharadze founded the astrophysical observatory that works till now (Kharadze 1958).

Now let us consider the Eastern and Western influences on astronomical knowledge in Georgia. They were various. A lot of books and manuscripts reached Georgia from Persia, Egypt, Greece and Italy. The astronomers from both East and West arrived in Georgia, importing the newest astronomical ideas and concepts. In turn, Georgian astronomers travelled to Eastern and Western countries to work in foreign observatories.

As a result of all these processes the astronomical reflection in Georgia was enriched by those new ideas and achievements. It can be said that Georgia was a place where astronomical ideas and opinions of the East and West were merged. These processes led to the integration of the geocentric and heliocentric systems in Georgian astronomical tradition and to the improvement and application of new methods in astronomical calculations, construction of instruments and astronomical terminology. The influence of Eastern and Western astronomical ideas can well be traced on some lexical and terminological levels. Some new astronomical terms and names appeared in the language. The Georgian explanatory dictionary, compiled by the wellknown Georgian philosopher, writer and educationist, Sulkhan Saba Orbeliani (1658-1725) (Georgian Encyclopedia, vol. 7), may serve as a good illustration of thie fact. Sulkhan Saba Orbeliani descended from an old Georgian noble family. Many representatives of this family were close to the kings of Georgia. Sulkhan Saba Orbeliani was one of them. He received a good secular and eclesiastical education, wrote popular and scientific books, became educationist and politician. In 1703-1716 visited some countries for dyplomatic missions; Italy and France were among them. One of his most important achievements was the preparation of the explanatory dictionary of the Georgian language, titled *Sitkvis kona* (Banch of words), on which he worked in 1585-1716. In this dictionary astronomical terms are given often with Georgian and foreign variants. Sulkhan Saba Orbeliani even mentioned that while compiling his publication he utilized ancient Latin, Hellenistic, Arabic, Armenian and other books and manuscripts. Consequently, some words and terms compilied in dictionary, adopted from ancient manuscripts may reflect the ideas and concepts used in the corresponding countries. On page 430 of this dictionary the author gives names of "seven stars" in three languages; the first being Georgian, the second - Arabic and the third - Italian. These names are as follows (Orbeliani 1949):

1. Mtvare - Kamar - Luna
2. Ermi - Otarid - Mercurio
3. Afroditi - Aspiroz - Venera
4. Mze - Shams - Sole

5. Aria - Marikhi - Marte
6. Dia - Mushtar - Jove
7. Kronosi - Zual - Saturno

It should be noted that the names *Mtvare* and *Mze* are pure Georgian ones. The above mentioned names show that the Greek, Arabic and Italian astronomies penetrated into Georgia. On the other hand, many of the given names have been naturalized in Georgian, adopting the Georgian endings (Kronos - Kronosi).

The order of the names shows that Orbeliani was inclined to imagining the universe as a geocentric world. The names of heavenly bodies given in the dictionary are accompanied by a detailed description and almost always contain the data on their annual motion and the dimensions with respect to the earth. On page 430 Orbeliani speaks also on the moons revolutions around the earth and on solar and lunar eclipses. He writes: *The Moon itself does not shine, it is mirror like, and has as much light as the Sun faces it.* This proves that Orbeliani guessed that the Moon shined with a reflected light. On page 347 we meet the word *urano* which has two explanations: 1.) "the sky" and 2.) "compelling to look upwards". On page 348 the word "urion" apart of other meanings possess the followin explanation: *these 22 stars are called "urion" and they are situated on the North as one star.* Obviously Orbeliani denoted the stars of the Orion's constellation. on page 564 the author translated the word "urion" as the Italian "Boota".

On page 460 he offered two meanings of the Georgian word "chogri': 1.) a long thin stick or bar, 2.) an instrument for seeing in distance. The second meaning is of considerable interest, as it proves that *chogri* was van optical instrument used to observe remote objects, and it is analogous to telescope. Taking into account the time of the dictionary's compilation, one can conclude that *chogri* as a telescope was known in Georgia since the end of the 18th and/or beginning of the 18th centuries. It is quite possible that *chogri* was used for astronomical observations. Taking into account the two definitions of the word and the fact that Georgia had a long tradition of glass processing, one can assume, that *chogri* as an optical instrument analogous to a telescope could have been invented in Georgia and used for different purposes. The process might have developed as follows: first the word *chongri* denoted a long thin stick or bar, but later, when lenses were invented, old masters would place them on long bars and trying to use them rationally, would perform attempt to find their optimal arrangement according to which lenses placed on sticks could offer a clear image of distant objects. And it was when the word *chogri* acquired its second meaning, i.e. that of an instrument for watching distant objects. As Orbeliani proved, in his time in Georgia other optical instrument also analogous to telescope, was known. It was called *durbini.* The author shows that the word was not of Georgian origin. Specialists today suggest that it comes from Turkish or Persian. On should note that the word *du* in many oriental languages means "two". This fact speaks in favor that *durbini* is a binocular, while *chogri* is, obviously, a monocular. The words *chogri* and *durbini* are widely used at present.

On page 30 Orbeliani gives a description of "Aria" (Mars) and writes *Aria has one star on the orbit.* By this he points to the fact that Mars has a satellite. Besides this, the author speaks on the orbit of this satellite. A careful examinations demonstrates that the orbital data of the mentioned satellite are similar to those of Deimos. This, in turn

needs further explanation. As we know, the dictionary was finished in 1716, i.e. much earlier that the discovery of Asaf Hall. Three different hypotheses may be postulated here. 1.) The Mars satellite could be discovered by Georgian astronomers. 2.) Orbeliani might have used sources containing this information (Georgobiani 1983). 3.) Orbeliani could have found out about the discovery of the satellite during his visits to various countries. All three hypotheses are equally probable and require serious investigations in the future.

The dictionary contains other bits of astronomical information. particularly, it gives Old Georgian names of stars, zodiacal contellations, etc. assuming that Sulkhan Saba Orbeliani's dictionary reflects the level of the astronomical knowledge at least during the period of 15th - 18th centuries the following conclusion can be made: A certain duality was noticed in that epoch: late adherence to geocentricism on the one hand, and on the other, the knowledge of Moon, of a satellite of Mars and of the use of optical instruments are among the particular achievements. At the background it reflects the influence of the East and West astronomies.

If anyone is interested in the dictionary, we can supply him with a copy.

Now let us consider another problem of the practical rather than theoretical nature.

In many Eastern and Western countries as well as in Georgia, a lot of ancient relief inscriptions and drawing were retained, cut on stones and carved in metal and glass. The content of the incsriptions and drawings is of a different kind. It is natural that we are interested in astronomical inscriptions. At the course of time many inscriptions and drawings lost their legibility and on the wiped surfaces of metal, glass and stone objects we can distinguish only weak contours. However, even when the incriptions or drawings are damaged, the hollows, channels of microsizes remained on surfaces. To reveal such wiped images we suggest use the methos close to the luminescent dephectoscopy. The essence of this methos is as follows: the surface, cleaned from external contaminations, is covered with a liquid luminophore layer for a certain period of time. Luminophore penetrates into the microstructure of the surface and into hollows and channels made with cutting tools. Then the surface is rinsed with cold water for some minutes. As a result of this luminosphore is washed away from the surface, remaining in the hollows and channels. After this, the surface is dried in the open air for 30 minutes and then the flow of the ultraviolet radiation is directed to the processed surface. Under the action of ultraviolet the luminophore accumulated in microstructures, hollows, and channels exhibits luminescence in the visual region of spectrum and by this way it reveals the wiped image in detail. The processed surface can be radiated by ultraviolet in luminoscope or luminiscent microscope. The following should be noted: if the surface substance possesses intrinsic luminescence in a certain spectral region, it is necessary to choose such a luminophore which would possess luminiscence in the other spectral region. It will allow to distinguish luminiscence of the surface subtance from the luminescence of luminophore. In Georgia organic luminophore "Noriol" is synthesized. For this luminophore the exciting radiation is ultraviolet in the range of 3400-3800Å. Luminophore glow is in the yellow-green region of the visual spectrum with the maximum at the length of 5500Å. This luminophore allows us to reveal the microstructure of 0.2μ wide. The given method has several applications. We

used it to reveal microstructures of meteorite surfaces (Simonia 1990). We suppose that this method will allow us to reveal the wiped images quite effectively. It would be interesting to apply this methods to reveal the images of the stellar sky incised in stones and glasses.

If anyone is interested in this method we can send it's detailed description and luminophore "Normol".

I would like to note that the study of the problem in question is going on and we hope to obtain new interesting results.

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Figure 1. Photoreproduction of the portrait of Orbeliani.

Figure 2. Graphical designation of heavenly bodies in the explanatory dictionary.

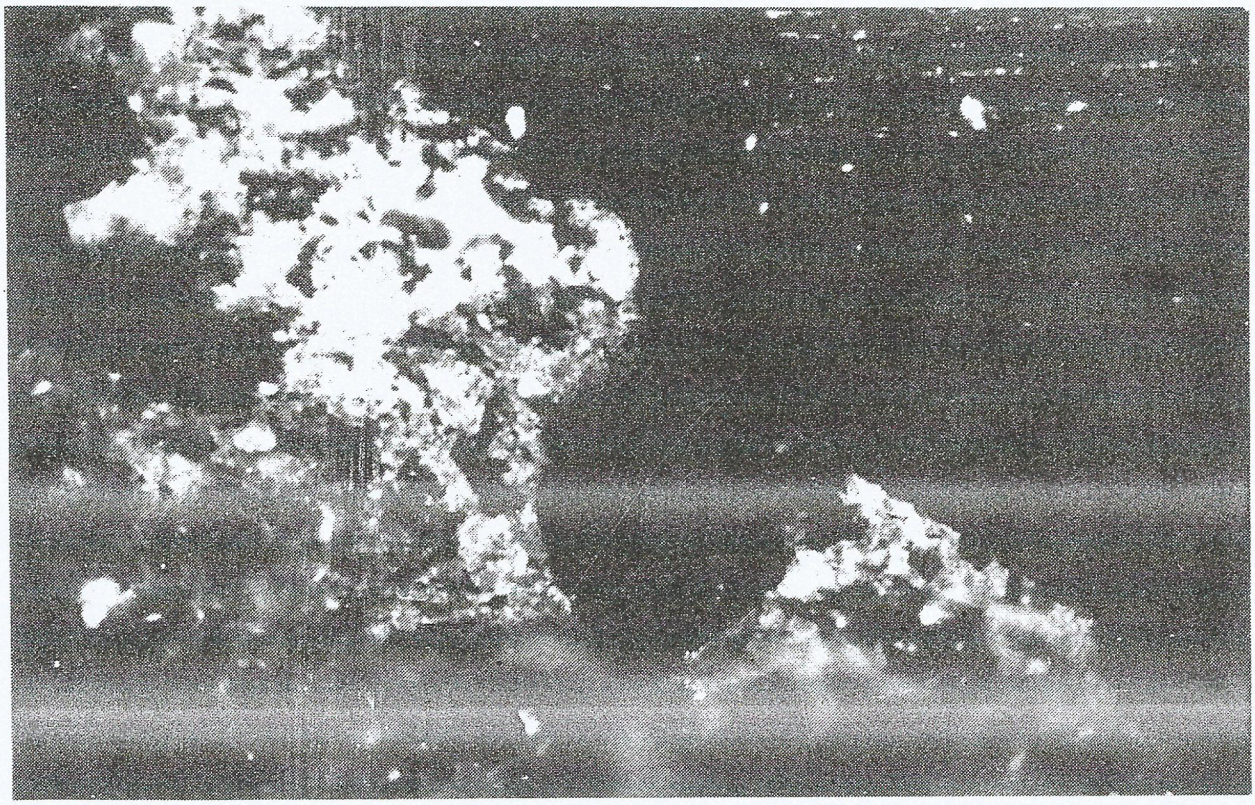

Figure 3. As an example we give an image of the iron meteorite microstructure, which was revealed by the above mentioned method. Light areas of the image are luminous luminophore in the microstructure. Ancient relief wiped images can be revealed by the same way.

ASTRONOMY, COSMOLOGY AND LANDSCAPE

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Jonathan Swift's astronomical prophecies

Irakli Simonia

It was in 1877, the year of the great opposition of Mars, that Asaph Hall of Washington Naval Observatory discovered two satellites of Mars using a 65 cm refractor. Since that time Phobos and Deimos have been a subject of study for many astronomers. This paper, however, concerns a most amazing fact. The great English satirist Jonathan Swift, whose novel *Gulliver's Travels* recounts Gulliver's many different adventures, describes his visit to the Laputan astronomers, and mentions two satellites of Mars. Yet *Gulliver's Travels* was published in 1726, long before Hall's discovery. A few suggestions have been made to explain this fact, the following three of which are worth citing:

(a) It is a result of the writer's imagination, which was boundless.

(b) Swift believed in the harmony of numbers: one satellite for the Earth, two for Mars and so on.

(c) Swift used earlier sources—books, manuscripts, and letters.

Each of these hypotheses can be supported by certain reasoning and all three are equally valid. On the other hand, one should not forget that Swift was a satirist and aimed his criticism at the vices of contemporary society; therefore many, if not all, of his plots and characters reflected reality, even though they had been altered by the writer using artistic licence. The underlying substance remained realistic. The story about the Laputan Observatory might have been a result of certain reminiscences. Describing the cave in which the Observatory was placed, Swift named several sextants, quadrants, telescopes, astrolabes and other astronomical instruments. He described the life of those astronomers devoted to the observation of celestial bodies. Their telescopes were of exceedingly high quality, the largest of them being 3 ft long but much stronger than the 100 ft-long telescopes existing in Swift's time. The Laputan scientists could make discoveries that no European astronomers could even dream of. They compiled a catalogue of 2000 stationary stars, while the existing European catalogues listed only one third of that number. They discovered two small stars or satellites going around Mars. One of them moved at a distance from its centre equal to three of its diameters, while the other one moved at a distance equal to five of its diameters.

The Laputans told Gulliver that they had studied ninety-three comets and precisely established the times of their periodic returns. Swift remarked that those research results ought to become known to the public.

The passage describing the Laputan Observatory and another speaking of their scientific achievements suggest that the writer had visited astronomical observatories, knew some astronomers and had some knowledge of this branch of science. Gulliver's remark concerning the quality of the Laputan telescopes, which he thought to be better than those in his own country, suggests that Swift might have visited at least two observatories. He describes a 3 ft telescope in comparison with a 100 ft one, thus confirming that he had seen both short-focus reflectors (described as 3 ft ones) and long-focus refractors (described as 100 ft ones).

And then comes another curious remark—that the achievements of the Laputan astronomers should become known to the public! Could this be sheer fantasy or a hint that not all discoveries were being made known to the public in Great Britain in Swift's times?

These things, and also the fact that Swift had certain relations with the British Royal Society, suggest another hypothesis: namely, that a contemporary astronomer had discovered the satellites of Mars but did not let anyone know about the discovery. Swift might have witnessed that

discovery and told about it in his book which has thus become a kind of a link between the discoverer and us.

But some further questions then arise: who was that astronomer, and why didn't he officially announce his discovery? These questions are likely to be answerable by examining sources found in archives, libraries or museums, but whichever of these is being pursued, one point must be kept in mind: such a discovery could be made only with the help of a reflecting telescope. Any other telescope of that time (such as those of Hevelius, Huygens and Flamsteed) suffered from different aberrations although their objectives were of quite big diameters and it was altogether possible to observe the satellites of Mars through those telescopes. Moreover, in the late 17th and early 18th centuries the mathematician, physicist and philosopher Tschirnhaus made large concave mirrors and lenses; and in 1722 the astronomer Hadley made one of the first reflectors with a main mirror diameter of 15 cm (Newton and Hook had built smaller reflectors earlier).

One further relevant fact remains. In 1752, the great French writer Voltaire also mentions two satellites of Mars in his *Micromegas*. The same questions arise as with Swift: was this Voltaire's imagination, or did he believe in the harmony of numbers, or did he use earlier written sources? There is currently no definite answer to these questions, but for the present two things are clear. The first is that Hall should rightly be remembered as the discoverer of the satellites, in that it was he who brought information about them into the public domain in 1877. The other is that both Swift and Voltaire have left remarkable traces in the science of astronomy: two craters of Deimos bear their names.

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