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On the Determination of the Geographic North on Archeological Plans in Connection with the Problem of the Quality of Geographic Education

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The publication is dedicated to the memory of N.A. Bogdanov (1954-2020), Doctor of Geography, Leading Researcher of the Laboratory of Geomorphology of the Institute of Geography of the Russian Academy of Sciences, who participated in the preparation of materials and publication of abstracts on March 1, 2020. The article raises the question of the need for the development of universal geographic education, which forms the cultural appearance of a person and the scientific picture of the world of our era. The consequences of typical technical errors in working with the topographic plan are analyzed: the sides of the horizon are not indicated; north is specified with an error; the original high-quality materials were used incorrectly; magnetic north is indicated, but the year of the topographic survey is not indicated; supplemented topographic maps are superimposed on the historically previous topographic base. The changes in the current situation, according to the authors, are facilitated by the following tasks: to increase the number of hours of teaching geography at school; pay more attention to practical orienteering exercises; expand the selection of popular geographic literature to raise public awareness of the possibilities of classical methods and fundamental achievements of modern geography; and some others.

Keywords: *cartography, education, archaeological sites, interpretation, information*

Introduction

Interdisciplinary geo- and astro-archaeological studies of recent decades have shown that cultural heritage objects oriented along the geographic meridian can be investigated as the functions of the simplest astronomical instruments. Comprehensive studies of the orientation of artificial and natural-man-made objects make it possible to obtain a significant amount of additional information about a person in the nature-culture system during the period of anthropogenesis. This information is also needed to clarify the modern natural science picture of the world, to improve the models of the Earth's evolution. It includes processes and characteristics such as planetary parameters (inclination of the earth's axis, illumination mode and solar climate, change in gravity); geological and

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geomorphological conditions (speed of tectonic uplifts, intensity of denudation, etc.), as well as changing climatic conditions.

Prospects for the use of information stored in the structure of prehistoric objects are associated with the creation of a database. It will allow correlating information on objects and taking into account geographical positioning (coordinates, etc.).

The materials accumulated in classical archeology can play a significant role in creating such a database. However, there are a number of problems that complicate the use of archaeological information in complex interdisciplinary research. The most typical of them are: 1) errors in determining the geographical north made in the field descriptions of objects; 2) lack of indication of the year of topographic survey: does not allow making a correction for magnetic declination; 3) the tradition of maintaining the orientation of all subsequent plans corresponding to the first image in the study of the object.

The neglect of such an important characteristic for the geographic positioning of an object (location relative to the geographical north) is explained by the insufficient sensitivity of the methods of classical archeology to this parameter.

As a result, the useful information contained in these objects remains out of sight of most researchers. An artificially created error is the basis for widespread dissemination of the opinion about the chaotic orientation of ancient objects and the low level of astronomical literacy of their creators.

Cultural Heritage and Geographical Culture: Research Methods

In geography, cultural heritage objects are considered as elements of the geo-cultural space, which, according to V.N. Streletsky, is the integrity of nature and culture, created by a continuous flow of matter, energy and information (Streletsky 2005). As a result of a long-term interaction, all elements of this system develop: nature is saturated with natural-human-made and artificial objects necessary for human life, and culture (material and non-material) is saturated with models of nature, which most accurately convey the vital connections of the surrounding world (Paranina 2020). The concept the world around, like the subject of the same name in the system of primary school education, covers geo-space (the geographic shell of the Earth, including elements of the socio-sphere), objects of the Solar System and the Universe. This approach is the basis for the formation of systems thinking in childhood, a resource for increasing the awareness of any practical actions in adulthood, as well as a guarantee of responsibility in the field of managerial decision-making (Mazurov 1999, Solomin 2001, Dronov et al. 2018, Grigoryev et al. 2020). The worldview role of geographic representations is one of the important reasons for the development of geographic education, which could become continuous and universal.

The most important component of the geographical culture of V.P. Maksakovsky called the ability to use the language of geography that represents a system of signs used to express inferences, concepts, laws, theories of geography (Maksakovsky 1998). According to educators, the components of the language of

geography are: concepts and terms; facts, figures and dates; geographical names and language of the map; geographical representations (images) (Tamozhnyaya et al. 2016). In this article, we will try to analyze the influence of geographic education and geographic culture on the quality of scientific products created in the fields of modern humanitarian knowledge. It is difficult to overestimate the severity of the problem, since these concepts shape the mentality and perception of the world.

In modern scientific literature, you can find a wide variety of world models of ancient man, developed by specialists in different scientific fields. Humanitarian studies of cultural heritage are focused on the artistic value and aesthetic qualities of heritage sites and form an idea of the mythopoetic model of the world of ancient man. In the geography of culture, the subject of research is all forms of over-biological adaptation to the environment, and the result of the research is the concept of information modeling of the world, based on the measurement and designation of parts of geographic space and time (Paranina 2020, Paranina and Paranin 2017a, 2017b, 2018, 2019, 2020). Scientific discussion, to a certain extent, is due to the clash of opinions, representing antagonistic schools of thought and ideological trends (mainly the conflict between idealism and materialism). But, in many cases, the problems of understanding are associated with the lack of formation of the authors' geographical competences: poor knowledge of the fundamental laws of nature, incomplete geographical data and elementary errors in field measurements.

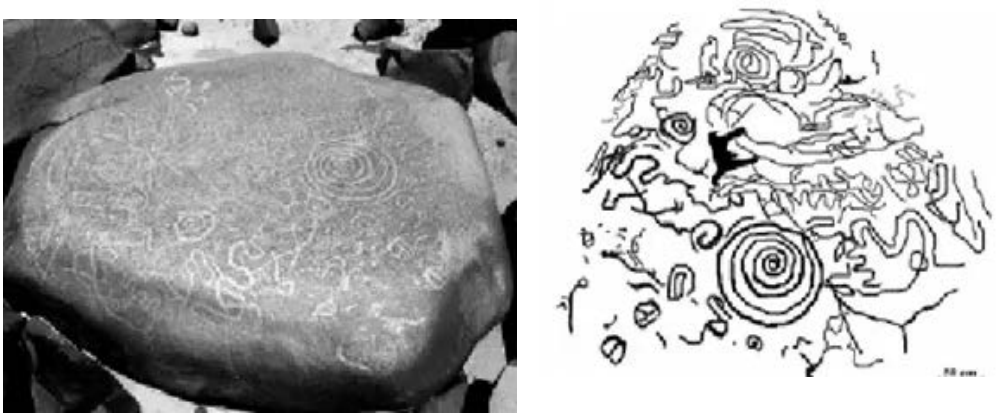
Results and Discussion

Typical Problems of Determining the Geographic North on Topographic Plans

Analysis of publications shows that the determination of the north in the schemes and plans may be difficult or impossible for several reasons: 1) the sides of the horizon are not indicated; 2) north is specified with an error; 3) the original high-quality materials were used incorrectly; 4. marked magnetic north, but not indicated the year of the survey; 5) supplemented topographic maps are superimposed on the historically previous topographic base. Let us analyze a few typical examples.

North is not indicated in the sketches made by archaeologists who study ancient petroglyphs as works of art (Figure 1). In the given example, a sample of the rock art monuments Lahouirra. This place of concentration of a large number of petroglyphs is located in the south of Morocco, 55 km south-south-east of Foum Zguid. The authors note that the images are replete with signs and figures of the symbolic style (spirals, snakes).

Figure 1. *Lahouirra* (Nami et al. 2007): *Photo & Drawing, North is Not Indicated*

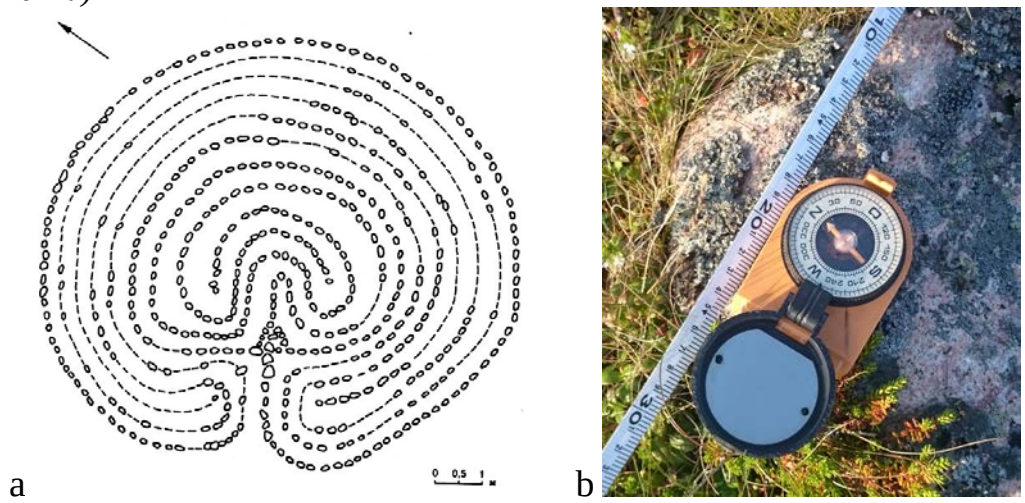


Art analysis focuses on the similarities and differences between objects in terms of the size and shape of signs, the depth and thickness of lines. As a result of this scientific approach, the geographic (spatial) characteristics of these objects are ignored, and the huge amounts of published data on petroglyphs of North Africa remain *dumb* for the study of their rational functions. We are, in particular, interested in the navigational purpose of these objects: as markers of geographic space, tools for determining the time (sundial-calendars), geo-position indicators necessary for orientation in the landscapes of the savannah and desert in the conditions of the transit location of the territory and the nomadic economy.

An example of publications when *a direction* is indicated on the plan *does not correspond to the real azimuth indications of the geographic or magnetic north* (Figure 2a) can be taken from the scientific archaeological journal "Kizhi Vestnik" (Manyukhin 2002). Possible reasons for the error: 1) faulty compass or inability to use it, 2) inability to determine and correct for magnetic declination; 3) negligence in the design of the scientific report and publication. In the text of the article, on the basis of a mistake, the author claims that the object under study is not oriented along the sides of the horizon.

Keretsky Labyrinth was investigated twice by the authors of the article - in 2016 and 2017. The azimuth of the entry is 255º (Figure 2b), the magnetic declination on July 17 is 14ºE, hence the true azimuth is 269º, i.e., the entrance to the labyrinth is from the west (in 2017, measurements were made with a mountain compass, the result was repeated). It follows from this that the Keretsky Labyrinth figure reflects the main geographic directions, and this allows it to be used for orientation in geographic space-time. The location of the axis of the figure on the geographical parallel is convenient for determining the days of the spring and autumn equinox - the main calendar boundaries in the Arctic region, dividing the year into severe winter and summer time, highlighting the boundaries of the period of high productivity of ecosystems and marine navigation.

Figure 2. *Keretsky Labyrinth on Krasnaya Luda (Karelia): a - Plan of the Object with an Error in Indicating the Azimuth (Manyukhin 2002); b - Measurement of the Azimuth along the Line of the Entrance to the Maze (Paranina and Paranin 2017a)*



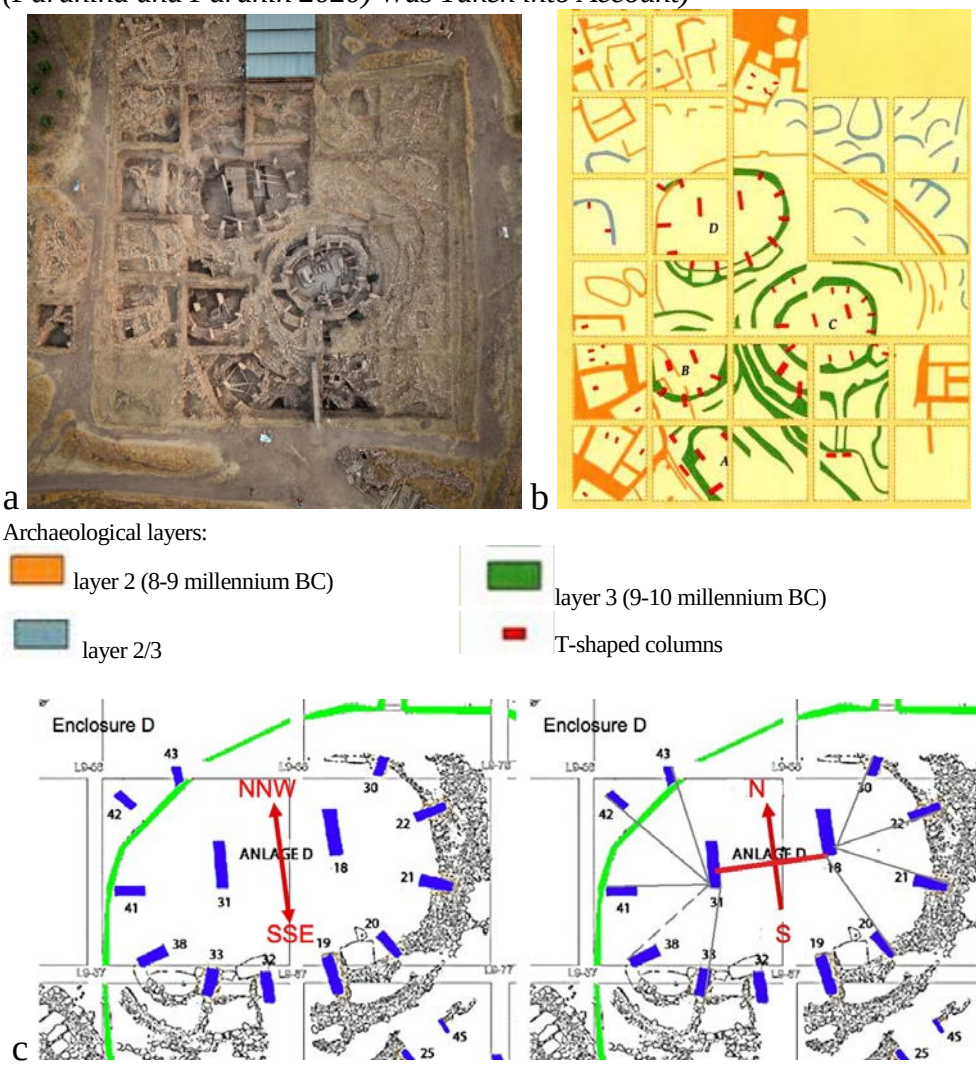
a b

The question arises why the axis of the Keretsky Labyrinth (and a similar labyrinth on the Oleshin Island) was not oriented by the builders along the meridian, which would make it possible to use them as a sundial and a solar calendar along the length of the resulting line, sequentially crossing the arc? This limited function of the instrument can be explained by the fact that the small islands and peninsulas of the White Sea were used not for permanent residence, but for a short stay in the summer - in the season of intense navigation, fishing tuna and sea hunting.

The consequence of insufficient geographic education is not only the replication of errors, but also the incorrect use of quality data. Let us consider this using the example of topographic plans of the Göbekli Tepe megalithic complex, published on the UNESCO website, and two variants of their paleoastronomical interpretation, made with and without magnetic declination (Figure 3 A, B).

At archaeological excavations, topographic work is traditionally carried out with the help of a magnetic compass (azimuth circle), so the topographic plans are oriented to the magnetic north. Differences in directions to the geographic and magnetic north are clearly visible when comparing the scheme of the object and its image on the satellite image (Figure 3a, b). However, some authors, using these materials (and referring to them), forget to correct for magnetic declination before starting complex astronomical calculations, and this leads them to new errors (Collins 2013, Hale and Collins 2013, Lorenzis and Orofino 2015). For example, according to the calculations of Collins, the central steles in sector D of the Göbekli Tepe megalithic complex were aligned in the NW-SE azimuth associated with the position of Orion. However, if we take into account the magnetic declination (here 5.57 ° E + 0.31 ° on July 5, 2019, the displacement rate is 0.08 ° E per year), then it can be seen that the crossbeams of two T-shaped steles standing in the center are oriented along the geographic meridian - i.e., by the sun.

Figure 3. *Göbekli Tepe Temple*[1]*: a - Satellite Image; b - Archaeological Plan; c - Variants of Astroarcheological Interpretation (on the left - Magnetic Declination Was Not Taken into Account (Collins 2013), on the right - Magnetic Declination of 5ºE (Paranina and Paranin 2020) Was Taken into Account)*



For ease of comparison, our scheme (Paranina and Paranin 2020) is based on a topobase copied from the publication (Figure 3c, on the right). The diagram shows: the main geographic directions and positions of the shadows from the steles of the stone fence (at the moments when the shadow has the shape of a straight line). The alignment of the central steles along the geographic meridian allows you to accurately determine the *noon* (at this time the shadow of the T-shaped steles turns into parallel *straight* lines) and the *geographic north*. The use of T-shaped sundials has been noted in different regions of the world and described by archaeologists in materials devoted to the Seti I (Ancient Egypt). The location of the steles on the East-West line makes it possible to determine the days

[1]https://whc.unesco.org/en/list/1572/gallery/(3.12.2022); http://geosfera.org/uploads/fotos/gebeli2.jpg (12.01.2020)

of the equinoxes - only on these days at dawn and dawn are they connected by a shadow. In ancient times, calendars of two steles were used everywhere, because the winter/summer boundary is most important for the seasonal movements of hunters and pastoralists, the economic cycle of farmers, and the astronomical new year (vernal equinox) coincides with the general revival of nature.

It is noticeable that the T-shaped steles in the walls of the circle/ellipse stand at almost the same distance, and the lines of the direct shadow have a close angular distance - this is the basis for determining the hours (parts of the day) by the position of the Sun. The height of the Sun (and the length of the shadow) depends on the season of the year, but the angular velocity of movement across the sky is unchanged, which makes it possible to determine the hours of the day in the direction of the shadow, and the hours of the night - according to the passage of astronomical objects across the celestial sphere. The speed of movement of all astronomical landmarks is equal to the angular speed of the axial movement of our planet: 360 ° in 24 hours or 15 ° / hour (1 ° / min). In the diagram, the connections by the shadows are indicated with the help of thin lines and one dotted line - from 38 to 31 (presumably, the stele could deviate from the original direction during excavations). In the observatory under consideration, it is obvious that the seasons of the year can be determined by the time and azimuth of sunrise, determined by the shadow of several steles that form a local network. This technology naturally preceded the sundial-calendars based on the shadow of a mono-instrument - a gnomon, located in the center of the platform (Paranina 2020).

Since ancient times, sunrises in different months of the year have been associated with the zodiacal belt of the constellations. In this regard, a sighting stone with a hole on the north side of the site (between 43 and 30) could be the main element of the sidereal clock and served as a north marker necessary for building the celestial sphere and night observations. With this approach, the semantics of images on steles (petroglyphs, bas-reliefs and animal sculptures) may be associated with phenological changes in different seasons of the year, determined by sunrise in the corresponding sectors of the horizon.

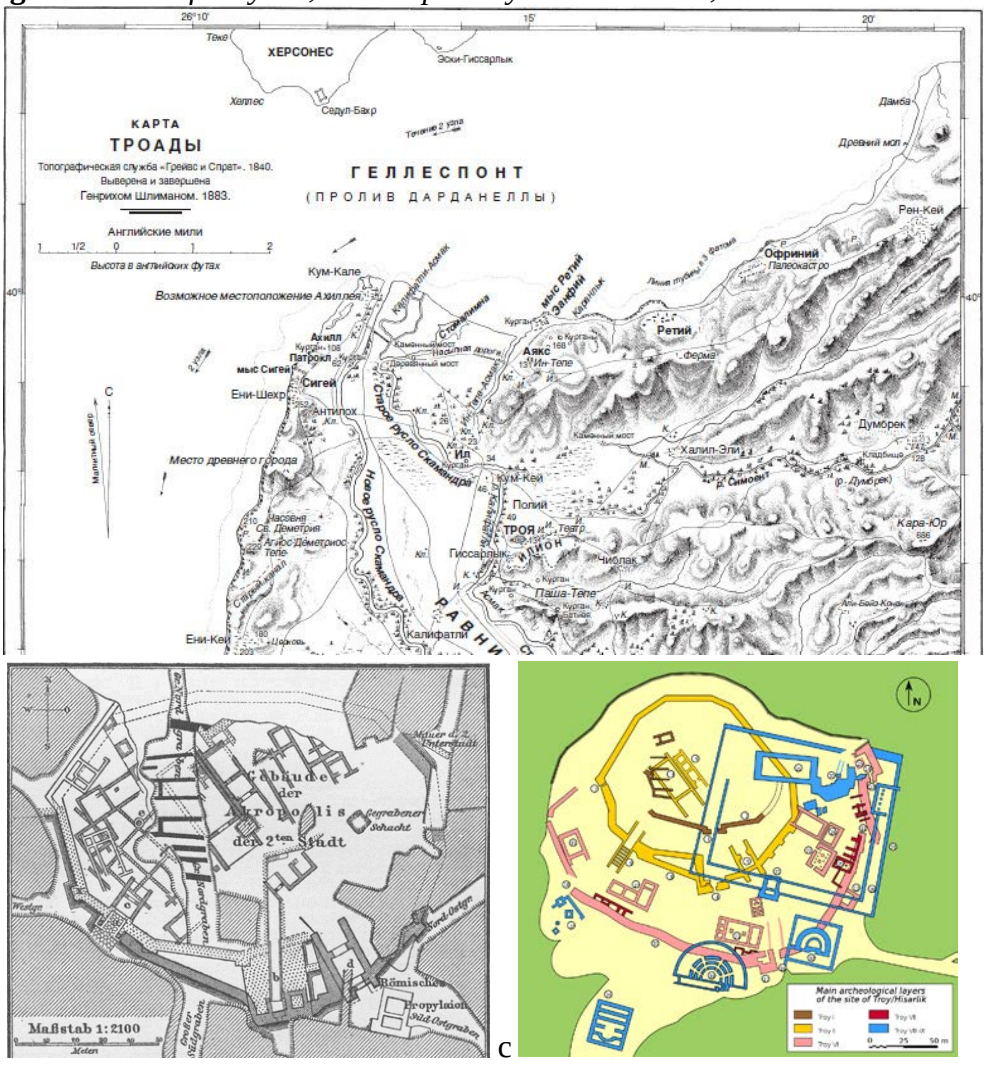
Reconstruction of the calendars for sectors A, B, C, and D, plotted sequentially in the interval from 12 000 to 9 500 years ago, is of interest for understanding the relationship between the evolution of the landscape and the parameters of the planet. Differences in the direction of the central steles of the sectors are up to 15 °, which may be the basis for clarifying the dynamics of the position of the earth’s axis and the rhythm of global climatic changes. However, research of the monument as a masterpiece of art and architecture now prevails, and the main task of such monumental structures is seen in the administration of religious rituals. In general, the interpretation of ancient culture is characterized by the preponderance of idealistic arguments over attempts to analyze the rational functions of objects and the development of technologies for adapting to the dynamic nature of the Earth.

A certain confusion in determining the orientation of objects is introduced by the *tradition of maintaining the orientation of the plan published by the first researcher of a large object.* The fact that it is convenient to compare the details of topographic plans from different years makes it difficult to see the real position of

the object. This situation is well illustrated by a series of plans representing the cultural layers of the archaeological site - the legendary city of Troy (Figure 4). It can be seen that the direction to the north and the general orientation of the objects are the same on the Schliemann plan and on the modern plan. It could be assumed that the magnetic declination for 127 years. But this is not so: on the Troada map, Schliemann indicates the western declination, but according to the calculator, today it is eastern (2019-11-29 5.21 ± 0.32 changing by 0.11E per year).

If we take into account all the above circumstances, it becomes obvious that all objects belonging to the Hellenistic era are clearly oriented to the geographical north - Troy VIII (900-350 BC) and Troy IX (350 BC - 400 AD). And this is in good agreement with the facts of the widespread use of sundials and the associated orientation of urban objects, especially fortresses and public places - streets and theaters (blue in Figure 4C).

Figure 4. *Plan of Troy*[2]*: a, b - Compiled by G. Schliemann, c - Modern*



[2]https://muze.gov.tr/muze-detay?SectionId=TRO01&DistId=TRO (10.01.2020); https://whc.unesco.org/ru/list/849 (3.12.2022).

Loss of Information about the Location of Objects in the Process of their Protection and Museification

Museification measures bring objects closer to the security infrastructure, but at the same time information risks arise associated with distortion of information about the links of objects with the host geocultural space. The separation from the natural and cultural context makes it impossible to correctly interpret and fully disclose the information potential (for the study of rational purpose, semantics of form and ornamentation) (Marsadolov et al. 2019). The transfer of objects to city museums is associated with a change in microclimate and the impact of a whole range of environmentally unfavorable conditions (pollution of all environments, road dust, vibration and exhaust gases from cars). The consequence of isolation in storerooms is the impossibility of performing basic social functions by cultural objects.

It should be emphasized that only the spatial position (geographical coordinates) can give answers to questions about the role of an object in the geocultural space, about the primary rational functions of the object and the symbolism that has come down to us genetically related to them. Practice shows that it is precisely the spatial reference of objects that is lost during museification of objects, because only the administrative region, settlement or large natural object associated with its location is indicated. Moreover, in the presence of a topographic plan, the direction to the magnetic pole is shown without indicating the year and magnetic declination at the time of the topographic survey. Therefore, museums, as far as possible, need to fix the exact coordinates of heritage sites, place photographs of the surrounding landscape, as well as space or aerial photographs of their places of origin in the exposition, and leave a copy of the object or a commemorative plaque in the landscape.

Conclusions

The examples given show that the problem of geographical culture, indicated in the title of the article, has no boundaries: errors and inaccuracies can be found in official scientific journals and on author's websites, in Russian-language literature and in foreign publications. The existing practice of protection and museification makes a significant contribution to the aggravation of the problem of geographically incorrect representation and interpretation of objects.

As a result, in the scientific and popular science literature, addressed both to the specialists and to the general reader, a lot of errors are replicated, including the opinion about the randomness in the location of archaeological sites. From scientific publications, errors are copied into textbooks of schools and universities, and significantly affect our ideas about the history of domestic and world culture.

A change in the current situation, according to the authors, is facilitated by the formulation and solution of a number of tasks, it is necessary:

- to increase the number of hours of teaching geography at school; pay more attention to practical orienteering exercises;
- to deepen the level of teaching the course of General Geography for humanitarian specialties;
- to expand the selection of popular geographical literature to raise the level of public awareness of the possibilities of classical methods and fundamental achievements of modern geography;
- to improve GOSTs (Russian National Standard) and rules for the design of scientific reports and publications;
- to optimize the rules for the protection and museification of objects, taking into account the value of information about their position in spatial systems.

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