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GNOMON AS SOURCE OF INFORMATION ON PLANET RHYTHMS

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ABSTRACT: For millennia, humans have been using the gnomon whose shadow passes the trajectory of the light source (sun or moon) as a measurement tool. With the gnomon authors prove that the ancient stone labyrinths in Northern Europe are solar calendars, sundials and compasses. Studies of cultural heritage around the world show that the majority of them might serve as orientation in space-time. According to the authors, the collection of ancient navigational facilities can be considered as ancient astronomical and geodetic network and as a record of astronomical history of the planet. For systemic analysis of this information it is necessary to create a base of paleo-astronomical data. The acquired information may be useful for studies of the history of the Earth and the history of science: the dynamics of changes of inclination of the Earth's axis, offset of the polar circles and the tropics, the characteristics of long-period rhythms of the planet, the evolution of climatic environments and the development of navigation technologies of the past. In addition, the creation of a network of solar observatories, with the technique of automatic registration shadow or a ray of light, will provide objective information on the solar-terrestrial relations and rhythms of nature

Keywords: Gnomon, Labyrinth, Paleoastronomical research, Navigation, Rhythmic of natural processes

1. INTRODUCTION

Northern labyrinths can be found in England, Iceland, Norway, Denmark, Sweden, Finland, Estonia and Russia. They are located on isles, peninsulas, near harbors and in river mouths. Their picture is complicated but organized. In terms of structure, there are unispiral, bispiral, concentric and radial types. In terms of outer shape: circles, ovals, rarely squares [1].

Hypotheses about the designation of stone labyrinths can be divided into two groups: calendar and non-calendar. It should be noted that despite all the diversity of facts of non-calendar use, most part of them is often associated with time and stage of life.

Hypothesis of calendar designation of labyrinths are mainly based on the assumption of a direct projection of the trajectory of space objects on the Earth's surface (Herman Wirth, Daniel Svyatskiy, Sergei Yershov) or consider pattern of labyrinth as a record of the results of direct sight of the annual variation of the Sun (Yuri Chekmenev). However, direct sight cannot explain the technology for using the labyrinth: 1) it is impossible to explain the quantitative ratios of the trajectory of a celestial object and its reflection in the stone pattern; 2) it is even more difficult to imagine the use of the pattern - with a diameter of 20-30 meters, it is impossible "to read" from the human height; 3) the problem of monitoring the trajectory of the sun is that bright light dazzles eyes, just after sunrise its movement takes off from landmarks.

The proposed concept of the labyrinth-gnomon – a tool of back sight of the sun – from the shadow set in the center of the object, opens the possibility of its use as a sundial compass and calendar [4] - [7]. The shadow of the object is easy to observe, record, measure, and its movement reflects and a form - encodes all the movements of the sun and is consistent with the position of the elements of the structure of the labyrinth; landscape orientation on the horizon (mountains, valleys) are not necessary, on the contrary, water environment is the optimal without creating distortions of azimuths of sunrise/sunset (their normal location is on the island or cape).

Author's concept of a labyrinth-gnomon technology solves the problem of the calendar use, and is consistent with all elements of a wide range of symbolic interpretation of the signs of the labyrinth and Labrys.

Paleo-astronomical studies of natural and cultural heritage indicate the possibility of their use for orientation in space-time. The ubiquity of ancient astronomical instruments deserve systematic study to clarify the concepts of modern science and the history of rhythmic changes in the nature of the Earth.

2. LABYRINTH-GNOMON IN ANCIENT NAVIGATION NETWORK

The objects of study were the monuments of ancient material culture of European Russia (siedis, menhirs, stone labyrinths). From 2009 to 2013 the objects located on coast of the White Sea are

investigated: in the archipelago of Kuzova, in the archipelago Solovki, in the gulf Kandalaksha, in the mouth of the river Vyg (Fig. 1).

Fig. 1 Labyrinth with a stele in the archipelago of Kuzova

Fig. 2 Labyrinth No. 1 Big Zayatsky Island of Solovetsky archipelago

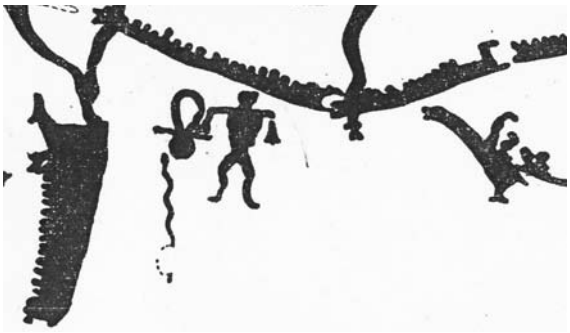


Fig. 3 White Sea petroglyphs (6000 y.o)

The applied field research methods (survey, description, observation, work with maps) and Earth remote sensing, as well as methods of mathematical, conceptual modeling and mapping. Theoretical analysis is based on the theory of reflection and systemic and chorological approach, methodological statements of historical geography by V.I. Paranin [2], [3].

2.1 Labyrinths of Big Zayatsky Island of Solovetsky archipelago as the astronomical instruments

For interpretation of a northern labyrinth the gnomon – the elementary astronomical tool was used. The shadow of a gnomon codes a trajectory of movement of the Sun on a firmament. In 2009 the authors proved that drawing of a labyrinth fixes astronomically significant points: 1) the provision of a midday shadow in days of winter and summer solstice corresponds to extreme arches of spirals, 2) the ends of spirals correspond to azimuths of risings/calling, 3) the entrance to a labyrinth notes the beginning of an annual cycle (in an equinox or a solstice) [4].

The sketch of a shadow of a gnomon in days gives the schedule similar to a pitchfork, horns, wings, a fish tail. The shadow schedule in a year fills the space whose shape form represents labris - a bilateral two-horned axe of god of light [5] – [7].

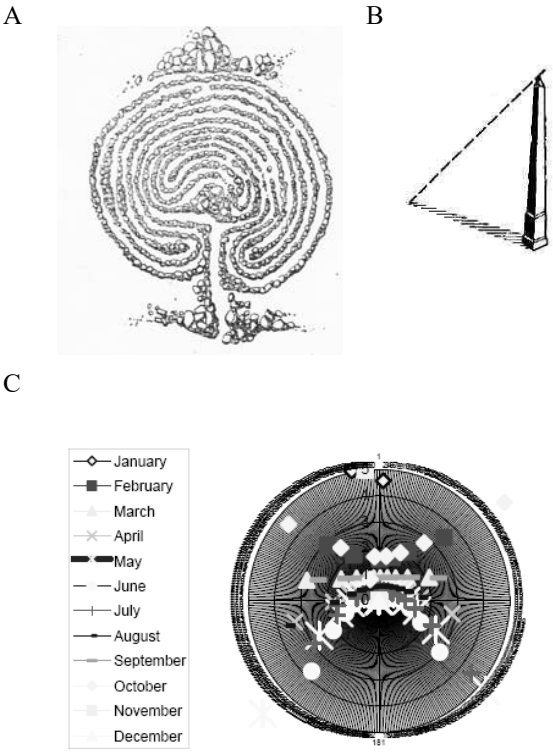


Fig. 4 Labyrinth No. 1: topographical plan (A); gnomon (B) and geometry of its shadows per year (C)

2.2 Labyrinths of Nordic countries as elements of local and regional astronomical and geodetic networks

Stone labyrinths are located, as a rule, on a plot of sea coast estuaries (at the source of fresh water) - it's convenient for rest and orientation, waiting for the desired date of astronomical calendar, in which marks of important phenological events of the area (cycles of fishing animals, climate and hydrological mode, lighting) can be made [5] – [7].

Key elements of the picture calendar are diameters of arcs and azimuths of entrance and end spirals - reflect the effect of two factors: the

latitude and discrepancies of physical horizon (surface relief) with the astronomical horizon.

Polar regions differ from moderate latitudes in terms of azimuths of sunrise/sunset in the solstice that vary considerably in adjacent parallel (Table 1). If latitudes 40 - 50º rise at the summer solstice and shift by only 6.92º, and at latitudes of 50-60º only twice – 13.42º, then advancing further at only 5º (60 - 65º) to the north – rise shifts at 17.37º, and latitudinal range of 1.5º (65 - 66.5º, i.e. B. Zayatsky Island to the Arctic Circle) – to 20.03º. It is obvious that planetary space conditions of astronomical observations in the polar latitudes become the main reason for specific features of drawings.

The distorting influence of the physical horizon line on measurement of astronomical azimuths can be levelled by locating the instrument on the beach, whose calm surface coincides with the astronomical horizon, this explains the location of the labyrinth near water. This fact partly explains the abundance of labyrinths in a small area of the Big Zayatsky Island (more than 30 items on 1.25 km²): firstly, the labyrinths are located on parts of the shore, open to different sectors of the horizon, which provides accurate measurements for different astronomical dates and various astronomical objects (objects in the light of the moon cast a shadow as well); secondly, the construction of new labyrinths is associated with the retreat of the shoreline; thirdly, arranged compactly enough, they form a local network.

An equally important reason for the construction of new labyrinths is variability of subpolar latitudes of astronomical targets not only in space but also in time - here the change in slope of the Earth's axis is most visible; being observed according to displacement of the position of the Arctic Circle at other latitudes, these changes are not as dramatic (Table 1).

Table 1 Dynamics of astronomically significant directions in space and time

N (º)	2010		3000 BC	
	WS 22.12	SS 22.06*	WS 07.01	SS 02.08
65	160.00	20.03	165.31	15.46
60	142.86	37.40	144.82	35.48
50	128.41	51.82	129.55	50.71
40	121.29	58.74	122.25	57.81
30	117.39	62.74	118.20	61.97
20	115.05	64.97	115.83	64.29
10	113.85	66.19	114.50	65.56
0	113.44	66.56	114.09	65.91

*WS - winter solstice, SS - summer solstice

The table shows that 5,000 years ago, the azimuth of the summer solstice (SS) was significantly less than modern, therefore, the line of the Arctic Circle was located closer.

Most labyrinths are located in the most dynamic area approximately from latitude 57° to 66.5°, which primarily determines the differences in their pattern.

At the latitude of the Arctic Circle azimuths of solstices coincide with the meridian, and the boundaries of the astronomical seasons are in the shape of direct cross. In some cases the center corresponding to the polar day, is marked by a closed circle or spiral, as in a labyrinth in Iceland. North of the Arctic Circle, only equinoxes can be reliably determined by azimuth of sunrise/sunset. To divide the year into periods between the polar night and polar day, you can use the azimuths of sunrise/sunset, which, depending on latitude, more or less rapidly move in the range of 0° +/- 180°. When the sun does not set over the horizon, length of midday shade – diameters of arcs – become the only way to divide time into days.

2.3 Labyrinths in global navigation system

Stone labyrinths and their images are known on every continent except Antarctica. In Russia, a high concentration of images is noticed in the North Caucasus (Dagestan). Single units of stone labyrinths are marked by archaeologists on the Russian plain, for example during excavations in Mostishchensky labyrinth 1 – Bronze Age settlement at the Cape of high original bank of the Don River. Mostishchensky labyrinth is located at latitude of famous astronomical observatories like Stonehenge and Archaim. On the same latitude 51-52° – one of the borders of the seven ancient climates there are a number of major European cities and sacred centers of Asia: Big Salbyksky mound in Khakassia, large burial Argens - in Tuva. Kereksur can be considered as analogue of labyrinths - concentric structures in Asia oriented to the horizon. At the same time, in the tropics there are almost no such structures.

3. REGIONAL FEATURES OF ANNUAL DYNAMICS OF SHADOWS

According to the terms of lighting since Aristotle five zones have been identified: tropical – hot, two moderate and two Polar – cold. They are limited by the tropics and the polar circles and different standing height of the midday sun above the horizon, the duration of the day and thermal conditions. The observation conditions of shadows in them differ substantially.

About 40% of the Earth's surface is in the hot area lying between the tropics. Day and night are slightly different in duration, and the sun is at its zenith is twice a year. 52% of the Earth falls on

located between the tropics and the temperate zones of the Arctic Circle, where the sun is never at its zenith, the duration of day and night depending on latitude and time of year. Near the Arctic Circle (60° to 66.5°) for a short time in the summer sun and shallow out to the horizon, evening and morning dawns merge, and there are so-called white nights. The cold (polar) zone occupies only 8% of the earth's surface from the poles to the Arctic Circle. In winter there are polar nights and summer – polar days, which last a day or more.

3.1 Latitudinal differences in the dynamics of the shadows

Reflection of the lighting conditions in the annual dynamics of different regions of the shadows have been studied by means of building and comparison of graphs (Fig. 5) and charts of the annual dynamics of midday shade critical latitudes of the northern hemisphere parallels and all other at intervals of 10º. Models concentric labyrinths for different latitudes are shown in Figs. 6-7.

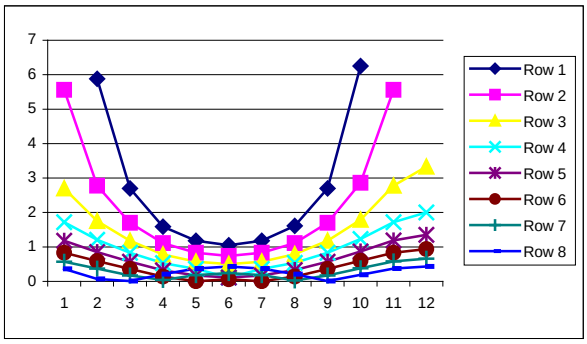
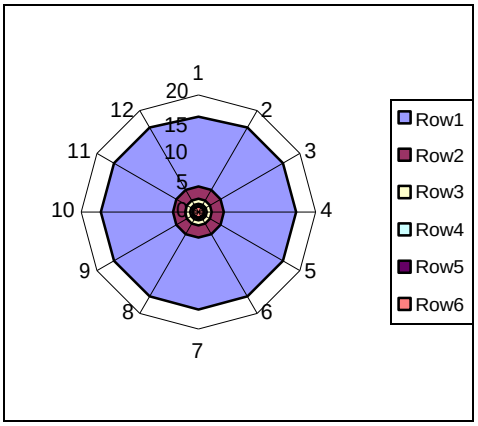


Fig. 5 Modern annual dynamics of length of midday shadow at different latitudes:
Horizontal - months of the year from January (1);
vertical - length of shadow (7 m)

Fig. 5 rows 1-8 – shadows at latitudes from the equator to 70º N at intervals of 10º. In the shadow of the polar latitudes shadows of months 1, 11 and 12 are not indicated for the enlargement zoom, on 50º N the length of the shadows in December is decreased for the same purpose. The graph shows a decrease in the length of the shadow when moving to the equator, the greatest latitudinal differences for the winter, the change in the shortest shadow of the year (6) of a value equal to the height of the gnomon at 70º N (Row 1), up to half of 50º N (Row 3), and close to zero 30º N. No shade is observed on one of the tropics in the solstice at the equator – In the days of the equinoxes, at other times at different latitudes between the tropics. Coding latitude diameter of the inner circle using a standard-sized portable line or anthropometric equivalent (foot length) could be the basis of the latitudinal orientation.

Modeling of concentric labyrinth (Figs. 6, 7) was carried out for the "standard" gnomon height of 1 m, which provided an opportunity to compare them. According to the ratio of the gnomon height to the diameter of the site for monitoring annual dynamics of the shadows, the following three basic types of solar observatories can be found: "labyrinth", "staff" and "rod".

A



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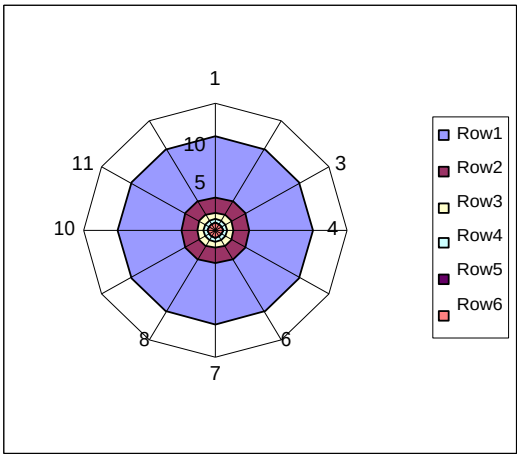


Fig. 6 Models concentric labyrinths:
A - for the Arctic Circle 66.5º N;
B - for Zayatsky island 65º N;
Row 1 - 1 and 11 months; Row 2 - 2 and 10;
Row 3 - 3 and 9; Row 4 - 4 and 8; Row 5 - 5 and 7, Row 6 - June. Winter - Rows 1 and 2; Equinox - Row 3; Summer - Rows 4-6

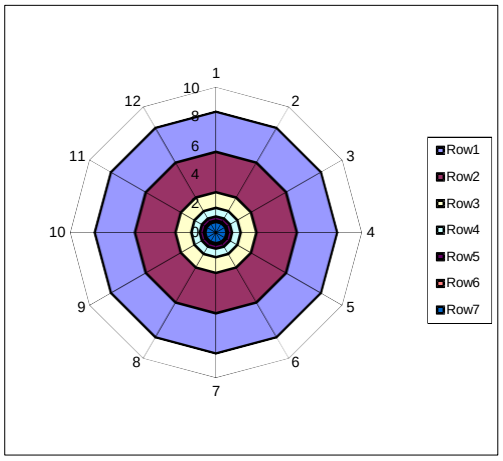
In the subpolar regions of > 60° radius of the model exceeds the height of the gnomon many times, forcing to abandon the arc of large diameter, and summer shadows are grouped in the center – type "labyrinth 11".

At the latitude of 50 - 60° shadows of all months of the year are placed in a circle of relatively small diameter, it is convenient to use 7-arc "classic" labyrinth.

In temperate and subtropical latitudes of 40-30° radius of the outer circle of the gnomon 2-fold – a type of "staff", resorting to associations with high enough staffs Zeus, Egyptian or Babylonian rulers or deities (staves which can be of up to 5 - 7 feet).

In the tropics, the calendar size of the shadow is placed on the gnomon – type "rod". The position of the sun at its zenith twice a year between the Tropic and 0° makes it necessary for the formation of gnomon faces to ensure a consistent record of the provisions of the shadows without imposing seasonal sites for which it passes several times.

A



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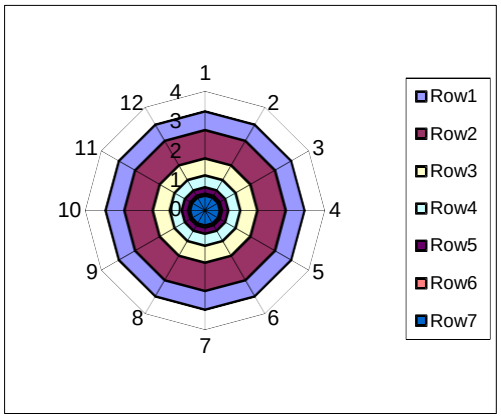

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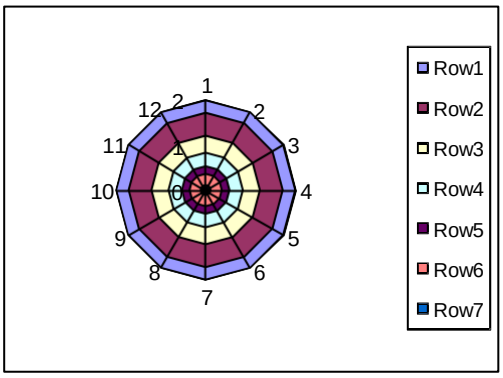

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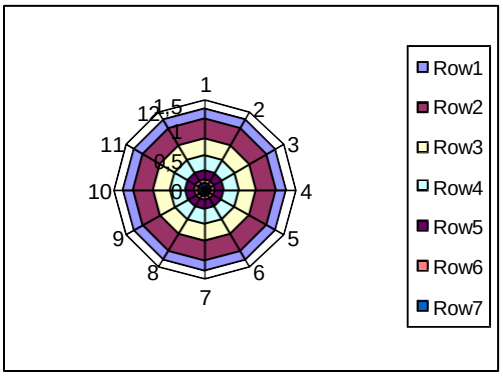

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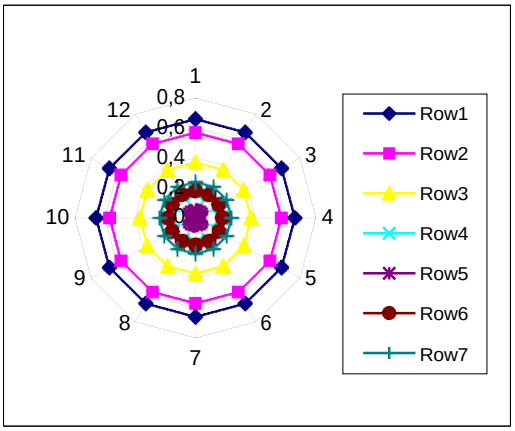

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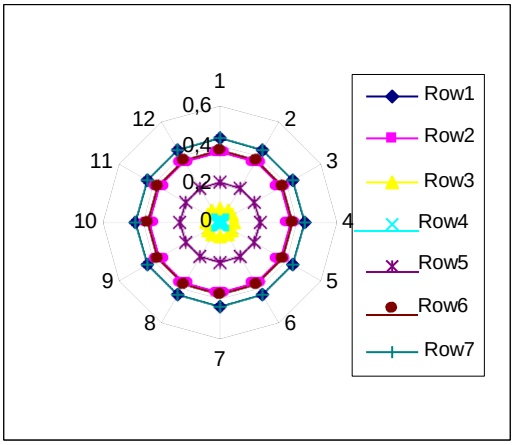

Fig. 7 Models of concentric calendars for different latitudes: A - 60º N; B - 50º N; C - 40º N; D - 30º N; E - 10ºN; F - 0º.
Row 1 - December; Row 2 - January and November; Row 3 - February and October; Row 4 - March and September; Row 5 - April and August; Row 6 - May and July; Row 7 - June;

Thus, analysis of the graphs reveals latitude where the record of calendar positions of the shadow can be in the form of an ornament on the gnomon, or on the floor and walls of the church, in all cases, the gnomon can serve as a ruler. Marking

may also include an indication of the height of the gnomon, which correspond to the length of the marked shadows (especially for staff). The calendar can be ornamental figurative sign, reproducing the stages of the year economic cycle or more abstract forms of specific forms of geometry of shadows; encoding of calendar months is possible in the animal style, which corresponds to the sequence of the zodiac animals. Calendar hexagonal rods in India and cult objects in Ancient Egypt are noteworthy as well.

3.2 Areas of space indication

Obviously, the greatest possibilities of rhythmic changes in the definition of the position of the sun belong to polar circles and the tropics. It is known that changes in the tilt of Earth's axis about 21.9º to 24.3º (according to some sources up 25.3º) causes displacement of the polar circles and the tropics for about 41,000 years. The result is a periodic expansion of the area of the temperate zone and the reduction of the polar and tropical regions.

Nutation of the Earth's axis shifts the line of the Arctic Circle to 3 meters per day and 100 per year. For example, until 2015 the Arctic Circle will move to the north, and then for 9 years, move up to 400 meters south.

The northern regions of the Earth provide other unique features of space observation targets: annual passage of sunrise / sunset 360º circle at the latitude of the Arctic Circle, the full daily observations of the zodiacal circle in 18 hours sidereal time and the position of the North Star. It is no accident ancient science allocated zone of the Arctic at a latitude of about 55° N.

It is worth mentioning that at noticeable annual dynamics of the Sun, in the North simple facilities are accurate, sensitive, accessible to a wide range of observers. In southern latitudes, the increasing the accuracy of the gnomon increase in summer is achieved by increase of its height, and in winter - the erection of screening surfaces, such projects require a significant effort (the legend of the Tower of Babel).

With regard to the influx of solar radiation of low latitudes are more stable, which is proved, in particular, by saturation of endemic and relict forms of life. At high latitudes, the smallest global climate change lead to a fundamental restructuring of the landscape and natural disasters.

Thus, a regional analysis of information resources geographic space shows that the polar regions of the planet are the most dynamic and dependent on solar energy and information. On the one hand, it creates a complexity of development, on the other it explains the appeal of the Arctic region for researchers in the past – rich material is left by ancient authors, there are numerous megalithic sites of navigation, and today – only here you can get accurate information about the current status of the planet and trends development of the global environment.

4. CONCLUSION

Our studies have shown that the gnomon – the simplest astronomical instrument – opens the possibility of using the primary stone labyrinths as solar calendars. The ubiquity of ancient astronomical instruments can be regarded as a source of information to clarify changes (rhythm, dynamics and evolution) of planetary parameters in the past [8] – [10].

The modeling of gnomon shadow during a year, presented in the article, shows the sensitivity of the structure of the labyrinth to the characteristics of lighting modes at different latitudes. It follows that for the purposes of long-term forecast rhythms of the planet it is advisable to create a network of solar observatories.

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