PHYSICAL GEOGRAPHY

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THE CONDITION MONITORING OF ROCK TEMPERATURE AND THE BACKGROUND INDICATORS ON THE TERRITORY OF "SIBIRSKIE UVALY" NATURE PARK

SUMMARY. The article considers condition monitoring of natural territorial complexes in a layer with annual temperature fluctuations. The findings of the research present background indicators of rock temperature in various natural complexes on the territory of "Sibirskie uvaly" Nature Park.

KEY WORDS. Temperature gages, prirodno-territorial complex, natural park "Siberian Uvaly".

Since the early 90's of the XX century loggers (also known as data loggers) have been used in order to measure physical variables (temperature, pressure, humidity, etc.) in a variety of environments, including soil, the loggers being compact digital measuring devices for continuous autonomous data acquisition [1]. The ability to capture and store large amounts of data makes loggers attractive for using as temperature gages. In Russia, the analysis of permafrost complexes with the help of high-precision recording equipment is conducted by V.A. Dubrovin [2], V.P. Chernyadevym, Y. Popov, N. Yelizarov [3], S. Kazantsev, A.D. Duchkovym [4], [5]. In connection with the expected warming in the north of Russia, the evaluation and prediction of the thermal regime of cryogenic rocks is examined by N.B. Kakunov, A.V. Pavlov [6], and at the regional level this topic is covered within the boundaries of sustainable development in climate change. [7] The information and recording system for field measurements of rock temperature is given in more detail by U.A. Popov and K.U. Borisenko [8].

Loggers provide accurate measurements of not less than ± 0,1°C and have a number of measurement channels, equipped with heat sensors with long cables and designed for temperature measurements in boreholes. Since 2010, thee employees of the geoenvironmental research laboratory have been using single-channel thermoregistrarr (DS1921G-F5 with a range of recorded temperatures from -40°C to +85°C and with sensitivity of 0,5°C; DS1921Z-F5 with a range of recorded temperatures from -5°C to +26°C with sensitivity of 0,125°C).

The purpose of the research is to monitor trends in the state of frozen and thawed rocks based on the modern technology data, providing high accuracy, mass and track trends in various environmental systems of "Sibirskie Uvaly" Nature Park. It is especially important to monitor the temperature trend in the zone of the island and high temperature permafrost, which is an indicator of sensitivity. The results are included in the database of background temperature indicators of the upper part of the annual heat exchange, which makes it possible to precisely forecast the changes and to use the data in project work.

The factual material, accumulated through research by A.V. Pavlov [9-11], P.N. Scriabina, Y.B. Skachkova [12], A.A. Vasilieva [13], P.T. Orehova [14], shows that the response of the upper horizons of the perennially frozen rock to the current climate change is highly dependent on the landscape and geological conditions. The place of laying thermorecorders corresponds to the northern taiga subzone of West Siberia ("Sibirskie Uvaly"), where the conditions influence the distribution of insular permafrost among different landscapes. This arrangement of points within this key area provides a background rate for sites, which are not subject to anthropogenic factors and which differ in relief, lithologic composition, climate and moisture conditions, composition of soil and vegetation cover.

In the lichen pine forest the first well was drilled (thermowell 1) at depth of 6 m (62°26'24,5" N, 81°40'52,6" E), and the second well (thermowell 2) 2 m deep was drilled in larch moss-berry forest, located in the valley of the River Gluboky Sabuni (62°26'08,2" N, 81°41'02,1" E) [15]. The thermorecorders in the first and second wells were activated on 20.07.2010, where the depth measurements of 20 cm, 40 cm, 60 cm and 1 m thermochrons of type DS1921G-F5 were used; for depth measurements of 2 m, 3 m, 4 m, 5 m and 6 m thermochrons of type DS1921Z-F5 were used. The third well (thermowell 3) of 2 m depth corresponds to the region of ridge-pool swamp Meggen-Neg-Kui (62°30'47,7" N, 81°39'18,8" E) [16]. The thermorecorders in this well were activated on 22.07.2010; for depth measurements of 2 m the thermochron of type DS1921Z-F5 was used, and at the level above, the loggers like DS1921G-F5 were employed. On 18.07.2010, the logger with a range of recorded temperatures from -40°C to +85°C and with a sensitivity of 0,5°C [17], [18] was set on the meteopost in "Sibirskie Uvaly". On 11.08.2011, to the north-west of the base "Deep Sabuni" the key recorder was laid 1.2 km deep (thermowell 8 — 62°6'51,2" N, 81°40'02,0" E) for fixing temperature of the ridge-pool swamp 1 m depth. For fixing temperature at depth of 20, 40, 60 cm and 1 m the logger of type DS1921G-F5 was inserted; in the frozen peat at depth of 60 cm the sensor of type DS1921Z-F5 was installed. Frozen peat has a capacity of 20 cm and is found from 50 to 70 cm from the surface of the ridge. Thawed peat is found at depth from 0 to 50 cm. The height of the ridge is 70 cm; the width is 4 m; and the length is 10 m. Thermochrones were activated on 12.08.2011. During the field work the temperature of the frozen rock was determined, and the following results were obtained: 11.08.2011 16:50 — 0,500°C; 11.08.2011 17:00 — 0,625°C; 11.08.2011 17:10 — 0,625°C; 11.08.2011 17:20 — 0,625°C; 11.08.2011 17:30 — 0,625°C. The air temperature at the moment of measuring was 19°C, and at the contact of the frozen and unfrozen rock the temperature was 3°C. In 5 meters from the themowell the structure of peat deposits was assessed:

0-0,20 — mat sphagnum, 0.2-0.8 — sphagnum peat, light-brown, of low degree of decomposition, 0,8-2,50 — brown sphagnum peat, diluted, of medium degree of decomposition, 2,50-2,60 — sand, light gray, medium-granular.

According to the logger data, the average air temperature from 18.07.2010 to 16.07.2011 was -2,64°C , the warmer period was in June 2011 (17,38°C) and the colder — in December 2010 (-29,25°C) (Fig. 1). In general, the winter was characterized by normal temperatures; 12 cases of the temperature exceeding 40°C were registered. The analysis of temperature during the day revealed acute drops of temperature indicators. For example, on 12.01.2011 the temperature was -30,91°C, and rose up to -8,75°C on 14.01.2011 C; and on 16.01.2011 the index already dropped to -21,0°C.

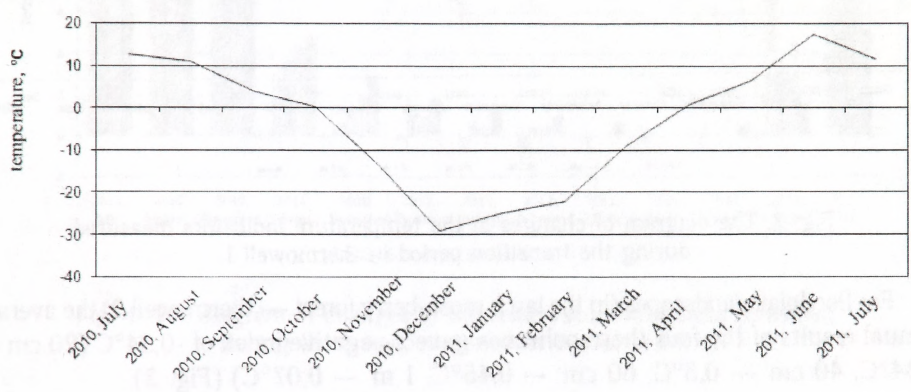

Fig. 1. The diagram of the air temperature measured by the thermochron of type DS1921G-F5

In the lichen pine forest (thermowell 1) at depth of 40 cm the temperature in January reaches -8°C. The transition from positive to negative temperature indicators at depth of 40 cm occurred on 12.11.2010 (25.11.2010 — 60 cm, 28.11.2010 — 1 m, 04.12.2010 — 2 m, 01.02.2011 — 3 m, 18.02.2011 — 4 m, and in the other direction the changes occurred in May 2011 (06.05.2011 — 60 cm, 14.05.2011 — 1 m, 05.21.2011 — 2 m, 06.06.2011 — 3 m, 10.06.2011 — 4 m (Fig. 2). At depths of 40 cm to 4 m in the cold snow period the temperature drops below zero; while at depths of 5 to 6 m the temperature preserve the positive trend in the temperature change throughout the year. The average annual temperature at all depths is above zero and equals 2,3°C (40 cm — 2,35°C, 60 cm — 2,63°C, 1 m — 2,47°C, 2 m — 2,4°C, 3 m — 2,51°C, 4 m — 2,17°C, 5 m — 1,83°C, 6 m — 2,06°C).

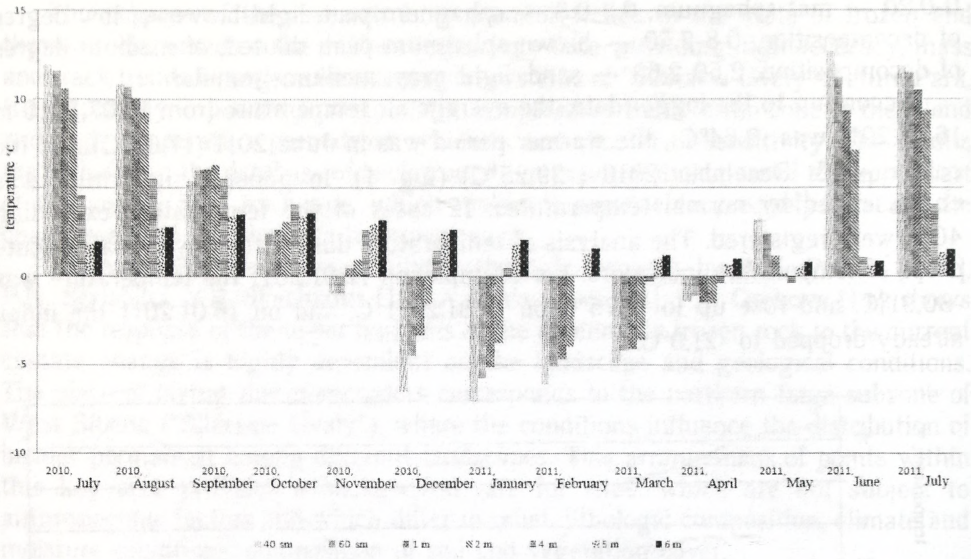

Fig. 2. The diagram of changes in the temperature indicators measured during the transition period in thermowell 1.

For floodplain landscapes (in the larch moss-berry forest — thermowell 2) the average annual results of the four thermochrones gave a negative index of -0,34°C (20 cm — 0,34°C, 40 cm — 0,5°C, 60 cm — 0,45°C, 1 m — 0,07°C) (Fig. 3).

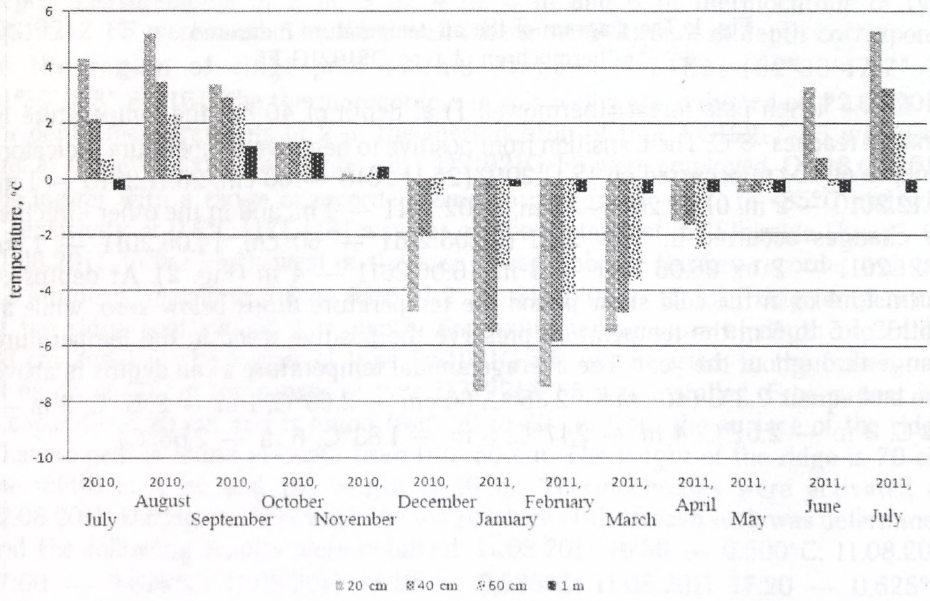

Fig. 3 The diagram of changes in the temperature indicators measured during the transition period in thermowell 2

To the ridge-pool swamp (thermowell 3), namely within the hollows, the average course of the four thermochrones had a high positive rate of 3,55°C (20 cm — 3,91°C, 40 cm — 3,59°C, 60 cm — 3,55°C, 1 m — 3,14°C). The negative indexes were recorded at depth of 20 cm during the period from 17.12.2010 to 25.04.2011. This means these areas are frozen at depth from 20 to 30 cm (Fig. 4, 5).

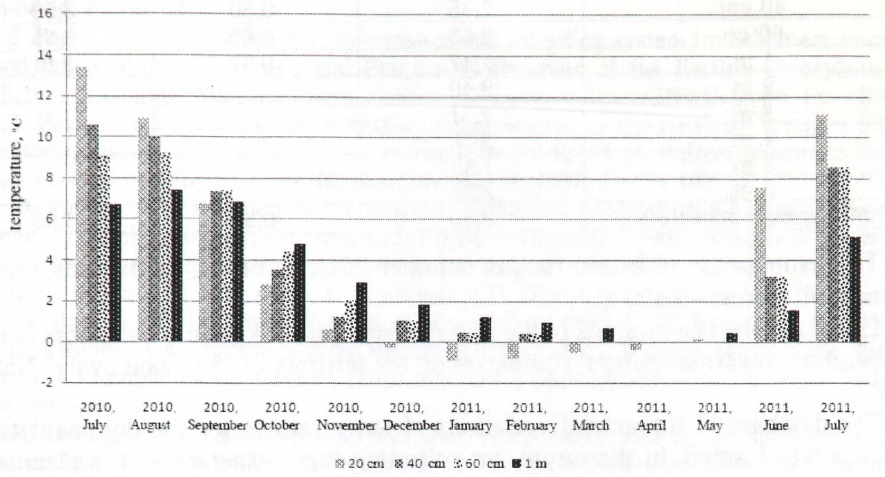

Fig. 4. The diagram of changes in the temperature indicators measured during the transition period in thermowell 3

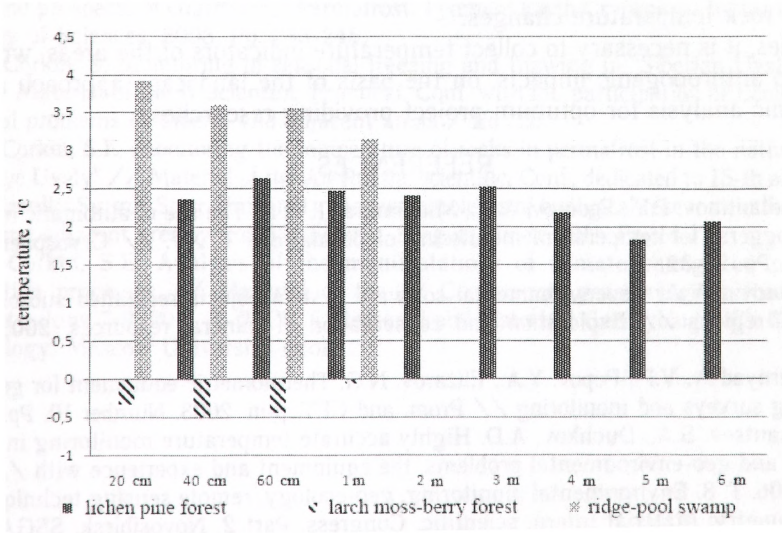

Fig. 5. The diagram of average temperature indicators of the three wells

The results of temperature monitoring of the three thermowells, conducted in "Sibirskie Uvaly" Nature Park are summarized in Table 1.

Table 1

The results of temperature monitoring carried out on the territory of "Sibirskie Uvaly" Nature Park

thermowell No.	1	2	3
20 cm		-0,34	3,91
40 cm	2,35	-0,50	3,59
60 см	2,63	-0,45	3,55
1 m	2,47	-0,07	3,14
2 m	2,40		
3 m	2,51		
4 m	2,17		
5 m	1,83		
6 m	2,06		
Mid-annual indicators	2,30	-0,34	3,55

The temperature of frozen rock in summer 2011, according to the indicators of thermowell 8, was -0,625°C.

Conclusion. The findings of the research present background indicators of rock temperature in various natural complexes on the territory of "Sibirskie uvaly" Nature Park.

The database of the annual variations of temperatures for the dominant types of tracts was formed. In the future, for collecting more exact data, it is planned to use the recommendations presented in works by P.Y. Konstantinov, A.N. Fedorov, T. Machimura and others [6], and to install a complex laboratory fixing changes in frozen rock, which was developed in the Institute of Geophysics, in the Siberian branch of Russian Academy of Science and which will give a reliable overview of trends in rock temperature changes.

Besides, it is necessary to collect temperature indicators of the areas, which are subject to anthropogenic impacts, on the basis of the landscape approach and the geoecotonic analysis for optimum project providing researches.

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