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An attempt to test geothermal anomaly hypothesis on the Bolshoi Solovetsky island using lakes' temperature profiles

Ein Versuch, die Hypothese der geothermischen Anomalie auf der Insel Bolshoi Solovetsky anhand von Temperaturprofilen der Seen zu prüfen

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Cultural and historic ensemble of the Solovetsky Islands is listed by UNESCO as the World Heritage Site. The Solovetsky archipelago comprises six islands in the western part of the White Sea, covering 300 km². Population of the biggest island, Bolshoi Solovetsky, is under 1000, and about 30000 tourists visit the Iceland annually. Regular consumption of electricity is under 1,6 MW during the winter, and about 0,8 MW in the summer period. This energy is being produced by 2 diesel generators. There is no hot water supply on the island, but a part of households is connected to a district heating network consuming up to 2,6 MW (winter peak) of heat produced by 2 boilers [Gasho, 2020].

Some researches speak of geothermal anomaly under the archipelago. The hypothesis is based on studies of biocenose, which occurs to be uncharacteristic for the latitude [Shvartsman, Bolotov., 2004], and, also, on some geological and geophysical signs [Gorny, 2007].

In 2021, Vernadsky State Geological Museum of RAS, with support of Neft-Service, Ltd., has conducted series of temperature measurements in the lakes of Bolshoi Solovetsky island in order to test the hypothesis.

Methods

Depth and temperature measurements have been made from a small boat using Solinst 3001 LTC Levellogger Edge M100 device on a cable. Points of measurements have been chosen at max depths, and the measurements were made during descent of the device with 1 m interval. At each depth, the device stayed until stabilization of the temperature, which took from 1 to 15 minutes. Measurements' error was 50 mm for depth and 0,05 °C – for temperature. All the information including coordinates defined by Garmin GPS navigator was recorded on-line. The results of the temperature measurements have been saved in Excel and Grapher formats, and converted in Tecplot, v.10 formats as well.

Data

The temperature measurements along vertical profiles are presented as 31 thermograms for depths from 2 m to 25 m (408 measurements in total). Beside of vertical profiling, 56 bottom measurements were made in 10 lakes. Points of vertical profiles and of bottom measurements are presented at Fig. 4. Thus, in total, 464 temperature measurements have been made during the field works in July, 2021.

Discussion and conclusion

From a typical thermogram's shape, all the lakes on Bolshoi Solovetsky island are of dimictic type, i.e. during a summer upper layers of water are warm, sometimes – up to 25 °C, and in the winter they get frozen. At the same time, dimictic lakes are supposed, at the depth unaffected by wind mixing and freezing, to have a corresponding with max density of water constant temperature, which is about 4 °C. In our case, all but two lakes respond to the rule. At the Krasnoe lake, the bottom temperature at 15-20 m depth is well over 6 °C, and at the lake Shchuch'e – 5,16-5,26 °C (Fig. 1).

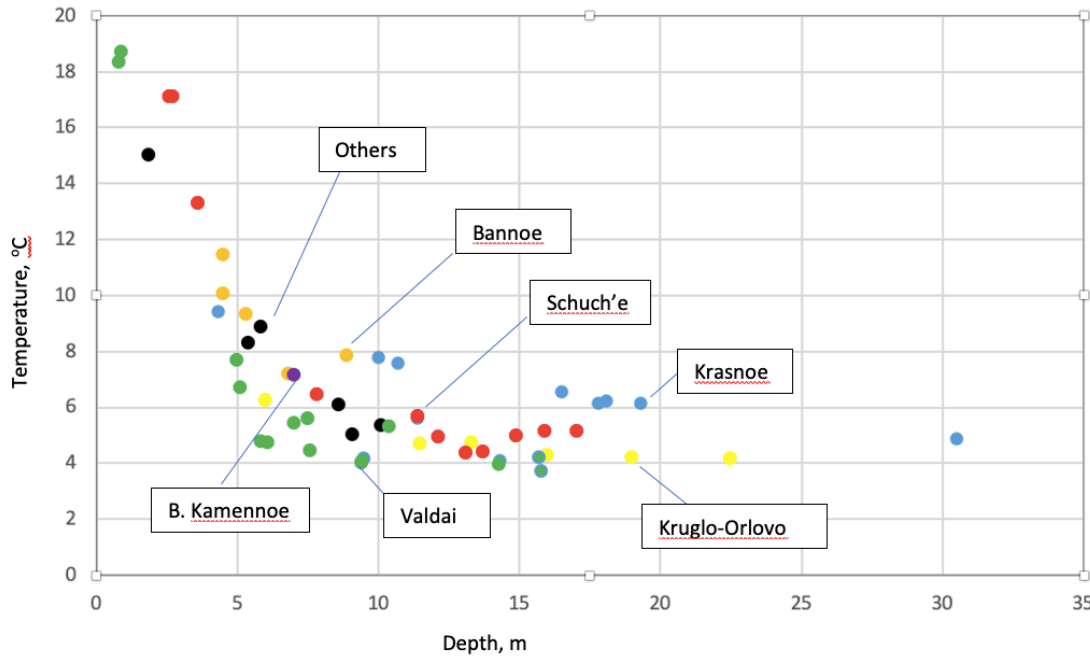


Fig. 1. Bottom temperatures. Dot's colors indicate different lakes

These anomalous values, theoretically, could be caused by one of 3 reasons;

- chemical reactions in the bottom sediments,
- wind mixing of the water,
- local anomaly of endogenic heat flow.

As the goal of the study is to evaluate a possibility of using geothermal resources at the island, we are interested in the 3d reason. But, to exclude the first two, additional researches have to be conducted.

The easiest to deal with (and, also, the most probable to be a reason for the anomaly) is wind mixing, which will be either excluded or confirmed by series of temperature measurements at the beginning of spring. In March-April, dimictic lakes are supposed to be in the most frozen state. And at that state, if the bottom measurements will demonstrate the same anomalous temperature as in the summer, we will definitely exclude the weather conditions from the list of possible reasons. The field work is being planned for March, 2022, and the goal is to conduct temperature measurements at exactly the same points of Bolshoye Krasnoe and Shchuch'e lakes, as in the summer.

If the winter measurements will show regular 4 °C at these points and depths, the issue about the use of geothermal resources can be closed, whereas confirmation of the anomaly will become a basis for more serious and costly studies.

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