Results of the Study Discharging Zone of the Ozernovsky Hot Springs (Kamchatka)

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Abstract. The Ozernovsky hot springs, located in the southern part of the Kamchatka Peninsula, are poorly studied. They are essential in the field of balneology. Previously, the springs were used for balneology. The work is devoted to the study of the discharge zone of springs: geological position, drawing up a detailed layout diagram, temperature of each spring, chemical composition. The research results have been introduced into practice.

1. Introduction

Ozernovsky hot springs (Kamchatka), which are valuable in the field of balneology, are poorly studied. Until now, there was no systematic description of the source unloading area there was no detailed diagram of their location, information about the composition and temperature of each of the sources. To address these issues, the author carried out a number of works on the project "Assessment of the maximum permissible recreational load on the geosystem of the Ozernovsky hot springs in the Ozernovsky keys sanatorium".

The Ozernovsky hot springs are unloaded on the northern slope of the foot of Mount Klyuchevskaya (888 m), 13 km from the coast of the Okhotsk Sea on the left bank of the Ozernaya River.

The first description of the Ozernovsky hot springs belongs to S.P. Krasheninnikov, who visited them in 1738 the sources were visited by members of Ryabushinsky's expedition: S.A. Konradi, N.G. Kell and A.N. Derzhavin. In 1934, the sources were studied in detail by D.K. Aleksandrov [3]. In the 50s of the last century, the sources were studied during a regional hydrogeological survey on a scale of 1: 500000. A general description of the sources is presented in the article by F.A. Lodis, V.I. Semenov [2].

2. Research methods

The geological position and features of the unloading of the sources, as well as the anthropogenic impact on the components of the natural complex of sources, have been studied. Temperature measurements of each of the sources were carried out, water samples were taken for chemical analysis. A detailed layout of the sources has been compiled.

3. Research results and discussion

Thermal springs in the valleys of the Ozernaya and Pauzhetka rivers, the Koshelevsky volcanic massif and the zone of hidden discharge of thermal waters in the area of the Zaporozhye village are controlled...
by two deep mutually orthogonal systems of regional tectonic zones (northeastern, northwestern, sublatitudinal and submeridional strikes). Ozernovsky springs are located at the intersection of two such zones - a sublatitudinal fault, which limits the graben of the river valley. Ozernaya, with a submeridional fault, along which, presumably in the Holocene, the western sector of the edifice of the Eopleistocene paleovolcano of the Klyuchevskaya Mount subsided. However, right at the site of the location of the Ozernovsky sources, faults of the submeridional strike prevail, and the sublatitudinal, related to the graben of the river. Ozernaya (Figure 1, 2).

Figure 1. Map of the location of the Ozernovskiy hot springs (Kamchatka) (number 1).

Figure 2. Red lines show discontinuities, red circle - Ozernovskiy springs, orange square - supposed zone of thermal water discharge on the opposite bank of the Ozernaya river.

The presence of such a discharge zone is assumed at the Ozernovskiy springs on the opposite bank of the river, at the base of the landslide-landslide circus, located within the same submeridional fracture zone that controls the placement of these springs (Figure 3).
Figure 3. Landslide at the foot of Makushka (photo above) in the area of hidden discharge of thermal waters near the village of Zaporozhye, and drawing of the rear zones of the landslide extension (picture below). The arrow shows the location of the well that opened the thermal waters.

On the thermogram for the well at the foot of Makushka, up to 50 m, a temperature of about 30 °C is noted, then it sharply increases to 50 °C, at a depth of 360 m it increases to 70 °C and at a depth of about 500 m the temperature rises to 90 °C. Approximately the same temperatures are noted at the Ozernovsky hot springs.

Mainly rocks of the Neogene-Lower Quaternary age were exposed here, overlain in the west by Middle Quaternary ignimbrites and tufts. The most ancient parts of the section were uncovered on the eastern slopes of the Shumnaya and Klyuchevskaya mountains. They are represented by lavas, lava breccias, tufts and tuff breccias of andesite, basaltic andesite composition. The rocks are intruded by intrusions of quartz diorites and diorite porphyrites [1].

The surface of the ledge at foot of the Klyuchevskaya Mount is covered with a soil-pyroclastic cover up to 2 m thick. Below the ashes are replaced by pumice sands and gravels with numerous inclusions of unconsolidated light gray pumice pebbles up to 10 cm in diameter. Such pumice horizons are well permeable to water.

Sources are discharged from cracks directly in the ledge. Visually, this is clearly seen on the example of the unloading point of source No 7 (Figure 4).

Figure 4. Unloading source No 7.
The places of discharge of thermal waters, located along the ledge, form an arcuate chain of 8 thermal springs (Figure 5, 6).

**Figure 5.** The location of the Ozernovsky hot springs [3] with the additions of the author based on the results of the research.

**Figure 6.** Zone of unloading of thermal waters.
In all springs, low-mineralized thermal weakly alkaline waters of chloride-sulfate composition are unloaded. According to the cationic composition, the waters are calcium-sodium, and only at source No 2 are the waters of the sodium-calcium composition unloaded. It is in the waters of this source that the highest contents of H3BO3, H4SiO4 p and H4SiO4k are noted, which can serve as a sign of the discharge of deep thermal waters here. In terms of the content of metals, lithium sources are most of all (0.14 - 0.17 mg/l). The highest content of manganese is noted in the source No 3 (0.16 mg/l). Spring No 4 has a high iron content (0.08 mg/l), but the lowest - lithium (0.14 mg/l). From source No 1 to source No 8, the zinc content decreases (from 0.07 to almost 0 mg/l), but the lead content increases (from 0.02 to 0.05 mg/l). Nickel is contained only in source No 2 (0.01 mg/l). An insignificant content of cobalt is observed only in sources No 5 and No 6 (0.01 mg/l). All sources have a very low copper content (0.005 mg/l).

The highest temperature was recorded in spring No 3 (80 °C). It can be concluded that the main flow of thermal waters is concentrated at the site of the location of springs No 2, 3, 4, 5. These sources are located in the middle part of the arcuate chain of sources, elongated along the arcuate scarp. Probably, as the sources move away from the axial thermal supply zone, the role of mixing of thermal waters with cold groundwater increases. The same trend is reflected in the temperature distribution of the sources. The lowest temperature is observed in the source No 6 (31 °C) (Figure 7).

![Graph of temperature distribution in Ozernovsky hot springs (Kamchatka).](image)

The presence of dissolved hydrogen sulphide in the water of spring No 7 requires a separate explanation. Probably, in this area, hydrogen sulphide is supplied from the depth in the gas phase. An indirect confirmation of this is also the presence of sulfur mineralization near the outlet of the same source.

4. Conclusions
From the studies obtained, it was established that the Ozernovsky hot springs are unloaded in the rear part on the left bank of the Ozernaya River. In geological and structural terms, the discharge zone is confined to the intersection of the sublatitudinal fault, which limits the graben of the river valley, Ozernaya, with a submeridional fault, included in the structure of the Klyuchevskoy Mount (Eopleistocene). In the discharge zone, the interaction of thermal waters and felsic enclosing volcanic rocks led to the formation of extensively hydrothermally altered rocks. The analysis of temperatures allows us to conclude that sources No 2, 3, 4, 5 are located on the largest and most permeable thermal supply zone. The chemical composition of the springs is formed by mixing thermal waters coming from the depths and cold ground waters. The anionic composition of spring water is determined by the composition of thermal waters, and the cationic composition is determined by their interaction with the host rocks and the degree of dilution of thermal waters by groundwater. On the example of studying the
discharge zone of the Ozernovsky hot springs (Kamchatka), it can be seen that, geologically and structurally, the discharge zones of hydrothermal systems are characterized by: the intersection of sublatitudinal and submeridional faults; the presence of fractured zones; the presence of discontinuities covered by a cover of loose sediments.

The research results were introduced into the practical activities of the municipal health care institution "Ozernovskaya City Hospital" (Ozernovskiy settlement, Ust-Bolsheretskiy District, Kamchatka) in order to develop measures for the use of these sources for balneological purposes and the construction of a new balneological sanatorium.

5. References
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