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PHYSICAL-CHEMICAL FACTORS AFFECTING THE LOW QUALITY OF NATURAL WATER IN THE KHIBINY MASSIF

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One peculiarity of the Khibiny Massif is its spatial location. Rising over 1000 m above the surrounding hilly land and thus obstructing the passage of air masses, it promotes condensation and accumulation of surface and underground water. Annual precipitation here amounts to 600-700 mm in the valleys and up to 1600 mm on mountainous plateaus.

Using this water for drinking and household purposes is problematic due to excess Al and F concentrations and high pH values.

Now it is known that in its profile, the Massif is represented by three hydrogeological subzones: the upper (aerated), medium and lower ones.

The upper subzone spreads throughout the Massif and is affected by the local drainage network and climatic conditions. The medium subzone is permanently saturated with underground water flowing horizontally to sites of discharge at the level of local river valleys and lakes. The fissure-vein water in the lower subzone is confined to tectonic fractures and faults in the so far underexplored, deeper parts of the Massif. Being abundant, this water ascends under high pressure. At places, water has been observed spurting from as deep as 700 m, and even 960 m. In the latter case, the temperature of ascending water was higher than 18 centigrade (Hydrogeology of the USSR, V. 27, 1971).

This work was undertaken to reveal the nature of the low quality of water in the Khibiny by using physical-chemical modeling (software package Selector, Chudnenko, 2010).

Processes of surface and underground water formation in the Khibiny were examined within a physical-chemical model (PCM) of the “water-rock-atmosphere-hydrogen” system. In a multi-vessel model used, each vessel represented a geochemical level of the process interpreted as spatiotemporal data – ξ (Karpov, 1981). The flow reactor consisted of 4 tanks. In the first tank, water of the Kuniok River (1000 L) interacted with atmosphere and an organic substance. The resulting solution proceeded to tanks 2-4 containing with underlying rocks (100g of each) to interact with them following the preset process level, the water-rock ratio being ξ = 1.0; 0.8; 0.6; 0.2 at temperatures (5, 5, 3, 3 centigrade) and pressures (1, 2, 2, 3 bar), respectively. The model had been reliably verified in the aeration zone monitored in the course of the years 2001 and 2010.

Analysis of the chemical composition of deeper water-bearing strata has required to increase the intensity of the water-rock interactions in tank 3 (from 0.2 to 0) and tank 4 (from 0 to -0.2) and simultaneously increase the temperature: (5, 10, 10 centigrade) in the third and (10, 18, 25 centigrade) in the fourth.

At the value of ξ= -0.2 in the temperature range of 18-25 centigrade, the component contents in tank 4 were observed to change (mg/l): Al (8.10-4 -1.10-3), HCO_3- (67-69), Na (25-26,9), Cl (6-6,38), F(0.522-0.882) giving rise to new mineral phases, which agreed with the monitoring data of 1996-1997. The pH values in this case were close to 9. Our findings suggest that factors contributing to changing redox conditions, responsible for the formation of soda and abrupt increment of HCO_3-, fluorine and aluminum concentrations, are time and temperature.