



## **Interaction of surface and subsurface waters in the system “water-rock-atmosphere-carbon” (an example of the Khibiny mountains massif)**

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Khibiny alkaline massif is located in the central part of the Kola Peninsula, it has a ring structure and is composed of nepheline sienites (they make over 90% of the area). The exclusive character of the Khibiny massif consists in the wealth of complex deposits and in that it is, while towering almost 1000 m above the hilly surrounding plain, a natural obstacle on the way of air masses and precipitation which are a supply source of surface and underground water, formed within the Khibiny massif. It is currently believed that the “water - rock aluminosilicates” system possesses a number of fundamental properties, which make it unique.

Purpose of the study – to assess the influence of the Khibiny massif on the formation of the surface and subsurface waters that were generated within its limits, using physical-chemical modeling (Selector software package).

Objects of monitoring – rivers with sources in the upper reaches of the Khibiny massif (surface waters), and holes, located in these rivers' valleys (subsurface waters) were chosen as objects of monitoring.

Processes of formation of surface and subsurface water, generated within the limits of the Khibiny massif, have been considered within the framework of a unified system “water-rock-atmosphere-carbon”. The initial data of the model have been presented through chemical compositions of the Khibiny massif rocks and atmospheric and surface water. The geochemical different mobility of chemical elements has been taken into consideration. Geological-hydrological observations of processes of surface and underground water formation were the basis of physical-chemical models of processes of the formation of surface and underground water.

The list of the base model of the multisystem includes 24 independent components (Al-B-Br-Ar-He-Ne-C-Ca-Cl-F-K-Mg-Mn-N-Na-P-S-Si-Sr-Cu-Zn-H-O-e), 872 dependent components, including, in a water solution – 295, in a gas phase – 76, liquid hydrocarbons - 111, solid phases, organic and mineral substances – 390. The list of solid phases of multisystem is made with consideration of the mineral composition of the Khibiny massif. The processes of the formation of surface and underground water have been investigated:

1. The system “water-rock-atmosphere” has been studied, depending on the degree of interaction ( $\xi$ ) of rock with water. A model like this allowed investigating the interactions of surface water (that of rivers and lakes) with rocks that form the Khibiny massif.

2. The evolution of subsurface water has been considered using reservoir dynamics. It was assumed that the generated surface waters reacted with rock, when getting down at a certain depth, which allowed tracing the process of formation and change of waters in the underground space.

A computer model of surface waters was compared with the results of clean water monitoring (2001), while the computer calculation of subsurface waters was compared to the data of monitoring of Vudjavrjok, Kunijok and Oleny Ruchey rivers deposits, located in the central arc of the Khibiny massif. The monitoring of 2010 allowed to find some changes in the hydrochemistry of surface and underground waters, thus, having confirmed the basic conclusion of thermodynamical modeling, that the evolution of the chemical composition of natural waters leading to an increase of sodium-carbonic-chlorine - fluoride - sulfate component is defined by the degree of the interaction of water with rock, containing Clarke concentrations of fluorine, chlorine, carbon and sulphur.