

Forming chemical composition of surface waters in the Arctic as “water – rock” interaction. Case study of lake Inari and river Paz

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Due to the depletion of fresh water supplies and the deterioration of their quality as a result of anthropogenic impact on the Arctic ecosystems, the research questions of forming surface and ground waters, their interactions with the rocks, development of the foundations for their rational use and protection are of great fundamental and practical importance.

The aim of the work is to evaluate the influence of the chemical composition of rocks of the northern part of the Fennoscandian (Baltic) shield on forming surface waters chemical composition (Lake Inari, river Paz) using physical-chemical modeling (Chudnenko, 2010, Selector software package).

River Paz (Paatsjoki) is the largest river in North Fennoscandia and flows through the territory of three countries - Finland, Russia and Norway. It originates from Lake Inari, which a large number of streams and rivers flow into, coming from the mountain range of the northern Finland (Maanselkä hill).

Within the catchment of inflows feeding the lake Inari and river Paz in its upper flow there are mainly diverse early Precambrian metamorphic and intrusive rocks of the Lapland granulite belt and its framing, and to a lesser extent - various gneisses and migmatites with relicts of amphibolites, granitic gneisses, plagioclase and plagioclase and plagiomicrocline granites, and quartz diorites of Inari terrane (Meriläinen, 1976, fig 1; Hörmann et al, 1980, fig 1; Geologicalmap, 2001).

Basing on the techniques developed earlier (Mazukhina, 2012), and the data of monitoring of the chemical composition of surface waters and investigation of the chemical composition of the rocks, physical-chemical modeling (FCM) (Selector software package) was carried out. FCM includes 34 independent components (Al-B-Br-Ar-He-Ne-C-Ca-Cl-F-Fe-K-Mg-Mn-Na-P-S-Si-Sr-Cu-Zn-Ni-Pb-V-Ba-Co-Cr-Hg-As-Cd-H-O-e), 996 dependent components, of them 369 in aqueous solution, 76 in the gas phase, 111 liquid hydrocarbons, and 440 solid phases, organic and mineral substances. A set of solid phases of the multisystem is formed with the mineral composition of the crystalline rocks of the Fennoscandian (Baltic) shield taken into account.

The processes of forming the surface waters in the “water – rock – atmosphere” system depending on the degree of interaction (ξ) of rocks with aqueous solutions under open conditions (100 kg of atmosphere, 1000 kg of water, T-5, P-1 bar and rock (100 g) – the rock average composition: 1) Inari terrane rocks, 2) granulites of the Lapland granulite belt were investigated. Clarke concentrations of S, C, F, Zn, Ni, Pb, Cu (Vinogradov, 1962) were taken into account in order to determine their influence on forming the chemical composition of water solutions, and water migration coefficients (Perelman, 1989).

Comparison of the modeling results with the monitoring results of the source of river Paz shows that the chemical composition of waters of lake Inari as well as the upper flow of river Paz is formed by interactions of surface waters, ground waters, and fissure waters with granulites of the Lapland granulite belt, as well as gneisses, diorites and granitoids of Inari terrane of the northern Fennoscandia.

Thermodynamic modeling determined that the chemical composition of surface waters is formed as a result of interaction of atmospheric precipitation with intrusive and sedimentary rocks of the northern Fennoscandia, containing clarke concentrations of S, C, F, Zn, Ni, Pb, Cu. The obtained model solutions indicate that surface waters are formed within the considered system as a result of “water-rock-atmosphere” interaction.