ISOTOPE COMPOSITION OF GROUNDWATER IN KARELIA

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The isotopic composition of hydrogen and oxygen (δ2H and δ18O) in groundwater is the basis for assessing the conditions for their formation and the rate of water exchange (Ferronsky, Polyakov, 2009). Isotopic data also help to solve a number of hydrogeology problems, for example, identification of secondary processes (evaporation and freezing), mixing of fresh water with saline water of different genesis, identification of "regenerated" waters formed due to degradation of permafrost and etc.

Fresh groundwater of Karelia in the zone of active water exchange has predominantly bicarbonate calcium-magnesium composition. In the zone of slow water exchange, there is groundwater of various chemical types up to salt chloride sodium ones. The hypotheses both the autochthonous and allochthonous of salinity origin of groundwater in crystalline shields are considered (Nurmi et al., 1988; Lampen, 1992; Krainov, Ryzhenko, 1999], as well as conception of the cryogenic concentration of marine and/or sedimentary waters in glacial times (Herut et al., 1990; Bein and Arad, 1992; Stotler et al., 2009).

In the southern part of region the saline groundwater (TDS > 10 g/l) is located in the platform layered sediments of the Upper Proterozoic and Paleozoic age. There is brackish groundwater (TDS up to 10 g/l) in the Karelian part of the Baltic shield. Note, that boreholes give data only about the upper part (200–300 m) of the shield. Usually the open hole crosses the several fissured or fault zones with groundwater of the specific chemical composition, so blend of waters from different zones is discovered on surface, when water pump out. It could be assumed that the salinity of the deep groundwater is much higher, than the total sample.

Generally, groundwater of Karelia (n = 250, measurements were done in Center of X-ray diffraction studies at the Research park of SPSU) are depleted by heavy isotopes and isotopically "lighter" than weighted average value of atmospheric precipitations (δ^2H = -84 ‰ and δ^{18}O = -11.7 ‰). The brackish water of the crystalline shield has the lightest isotopic composition (δ2H <-100 ‰ and δ18O <-14 ‰), which approaches to the average value of the snow (Fig. 1). It is known the paleoclimate temperature gradient is -5 ‰ / 1 °C for δ^2H and -0,6 ‰ / 1 °C for δ^{18}O (Ferronsky, Polyakov, 2012). The calculated annual air temperature was lower 5–6 °C, than the modern one during formation of the isotopically "light" saline groundwater.

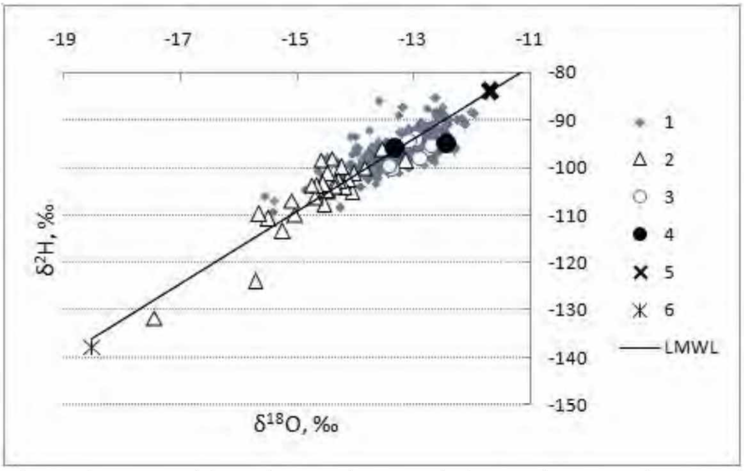

Fig. 1. The isotopic composition of groundwater relative to the meteoric water line (LMWL)
1 - fresh groundwater, 2 - brackish groundwater of the crystalline shield, 3-brackish platform groundwater, 4 – spring "Salt Pit", 5 - precipitation (weighted average), 6 - snow (weighted average).

We associate this type of groundwater in the crystalline rocks with the Valdai glaciation, when the cryogenic concentration of marine water of the Mikulino transgression (the Eemian seawater) took place. Note, that these seawater could slightly diluted by very isotopically light fresh water from continent like it is happened in modern Finnish Gulf or North Dvina estuary. The weak hydraulic permeability of crystalline rocks and small gradients of the regional piezometric surface should be result a very low rate of water exchange in the deep part of the shield. This consideration is supported by high concentrations of helium in salty groundwater.

The brackish groundwater of the Vendian-Phanerozoic deposits are isotopically heavier than the waters of crystalline rocks, and are not distinguished by isotopic composition among the fresh groundwater. Brackish groundwater in platform sediments are much more quickly depleted by sodium and enriched by calcium with increasing salinity in comparison to the brackish groundwater of crystalline rocks, and have more obvious signs of metamorphization of the buried seawater (Fig. 2).

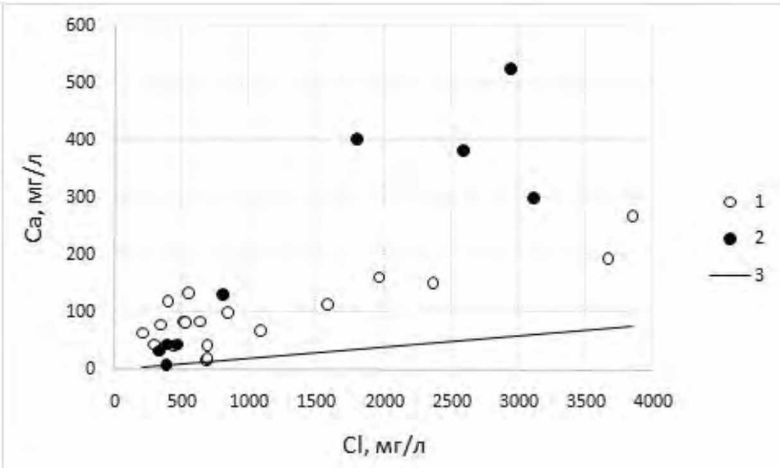

Fig. 2. The Ca^{2+} concentrations plotted against Cl^- concentration in chloride groundwater. 1 – brackish groundwater of crystalline shield, 2 – brackish platform groundwater, 3 – dilution line of sea water

The spring with name "Salt Pit" located on the Zaonezhsky peninsula of Lake Onega is the only known in Karelia natural source of chloride sodium water (TDS ≈ 4 g/l). Among the brackish waters of the crystalline shield, the isotope composition of this spring is the heaviest (in winter δ^2H = -95,8 ‰ and $\delta^{18}O$ = -13,3 ‰; in summer δ^2H = -94,8 ‰ and $\delta^{18}O$ = -12,4 ‰) (Fig. 1). It could be assumed their connection with the halite deposits found in the crystalline shield (Palaeoproterozoic…, 2011).

However, in general, the origin of brackish water in Karelia still requires study.

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BURIED SOILS UNDER STONE MOUNDS IN THE EASTERN PART OF THE LENINGRAD REGION (ON THE EXAMPLE OF THE MONUMENT ZABEL'E 1)

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In 2016 during the archaeological excavations in the forest near the village of Zabel'e (Boksitogorsk district, Leningrad region) some areas with unusual stone mounds were discovered. These objects are restricted to the flat top of the moraine hills (a.s.l. ~ 160 m) of the last Late Pleistocene glaciation (MIS2). This study area belongs to the landscapes of the Valdai Upland.

We have to stress that the complex of archaeological methods did not give an unambiguous answer to the questions about the genesis and time of creation and functionality of these stone mounds (embankments). During the excavation at the sites, neither objects of material culture nor traces of burial were found. This fact allowed specialists to assume that the stone mounds were not cultural, but had an economic purpose. So, stone mounds could have arisen during the cleaning of agricultural lands from stones or as a result of the collection of stones as raw material for construction needs.

Soil studies were carried out on two excavation sites during fieldwork in the summer 2017. The profiles of buried and surface soils (during excavation works the original vegetation was cut) located in close proximity to one another (2-3 m) were described and classified. An additional soil profile was in the forest. Our studies have shown that soils under a bulk material, whose thickness does not exceed three dozen cm, have a good profile safety with an undisturbed sequence of genetic horizons. The buried and surface soils are formed on bipartite sediments: water-glacial sandy deposits, underlain by carbonate moraine loams. The depth of change of parent material in the studied sections varies from 33 to 75 cm. The all soils of both chronosequences are preliminarily classified as Entic Podzol (Arenic) (IUSS Working Group WRB, 2015), which supports the fact that a relatively short time has passed since the construction of the embankments.

The main purpose of the research is to study the soils of the chronosequence "buried soil - surface soil" in order to reconstruct the soil and landscape conditions that existed before the construction of the stone embankments. To study the detected soil profiles, a complex of various