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Isotope signs ($^{234}U/^{238}U$, ^{2}H, ^{18}O) for the paleo-permafrost existence in European Russia

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Global climatic variations have a significant impact on isotopic and chemical composition of the underground hydrosphere. In particular, glacial meltwater formed from the permafrost degradation, as a rule, has a light composition of stable isotopes ($\delta^{13}C$, $\delta^{18}O$, and $\delta^{2}H$) [1]. Apparently, this water should also be marked with excess uranium-234 [2]. We studied groundwater in the central part of the East European Plain on the right bank of the Volga River (middle course) to a depth of 400 m. During the Last Glacial Period, there was an area of continuous permafrost with a thickness of up to 200–250 m and with temperatures of about -5°C [3]. Comparison isotopic and chemical data shows the three-component mixture of groundwater. The first component is modern water, which is unambiguously recorded by the presence of tritium (^{3}H). It is freshwater with salinity S<0.5 g/L, it has the least depletion in the isotopic composition of hydrogen and oxygen with $\delta^{18}O \rightarrow -12{,}9‰$ and $\delta^{2}H \rightarrow -90‰$ that is close to modern precipitation of the region, and practically equilibrium uranium $^{234}U/^{238}U \rightarrow 1$. The second component, more likely, is the water of late and postglacial genesis. It is isotopically lightest water with $\delta^{18}O \rightarrow -17.0‰$ and $\delta^{2}H \rightarrow -119‰$ (maybe it is the water of glacial lake?), it has a slight increase in salinity S≈0.5–1.5 g/L, and a small excess of uranium-234 $^{234}U/^{238}U \approx 4$. The third component, as we explaned, is the meltwater of the former permafrost. It is brackish water S→3 g/L in which a significant growth of salinity is mostly associated with increase in the sulfate content. It could be the result of both presence of evaporites in the water-bearing sediments and the increased solubility of sulfates at near-zero temperature. This water has an intermediate composition of the stable isotopes with $\delta^{18}O \approx -15.0‰$ and $\delta^{2}H \approx -110‰$, and maximum disequilibrium in uranium $^{234}U/^{238}U \rightarrow 15.7$. The abnormal excess of uranium-234 in groundwater is probably the result of its predominantly leaching from a mineral lattice of water-bearing sediments during the thawing of permafrost.

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[1] Vasil'chuk et al.(2018)Geoscience Frontiers,**2**,471-483 [2] Tokarev et al.(2021)Geochemistry Int. in press. [3] Sychova(2012)Cryosphere,**4**,45-56.