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Origin of non-equilibrium uranium ($^{234}U/^{238}U$) in Barents Sea

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Within the Arctic marine expedition “Transarctic-2019” (research vessel «Mikhail Somov», Arctic and Antarctic Research Institute, St.Petersburg, Russia) the isotopic composition of uranium $^{234}U/^{238}U$, stable isotopes (δ^2H, $\delta^{18}O$) and chemical parameters of seawater of the Barents Sea were studied. The data indicate the multicomponent of dissolved substance sources and seawater. Measured uranium isotope ratios $^{234}U/^{238}U$=0.97–1.73 differ significantly from the average for the World Ocean 1.145±0.003 [1]. Ratios $^{234}U/^{238}U$<1.13 in the Barents Sea are due to the contribution of the Arctic Ocean water masses and river runoff. The maximum ratio $^{234}U/^{238}U$>1.3 were found near the western coast of Severny Island of Novaya Zemlya covered with an inner ice cap.

Probable source of ^{234}U excess is groundwater containing meltwater from permafrost. The mechanism of its anomalous enrichment in uranium-234 may be as follows. During the Weichselian glaciation, secular equilibrium in the ^{238}U chain for mineral lattice could be upset only due to ^{234}Th recoil. But this process is negligible if the mineral grain size is > 0.1 mm. As the liquid water was absent in the permafrost zone, the ^{234}U could leave lattice only due to diffusion into the non-freezing water film the host rocks and sediments, which has a small chemical capacity. After the start of permafrost thawing, liquid water appeared and leached ^{234}U from the water-bearing rocks predominantly in comparison to ^{238}U due to the high geochemical mobility of ^{234}U.

In continental conditions confirmation of this mechanism was obtained in the study of groundwater, including the determination of $\delta^{18}O$, δ^2H, $^{234}U/^{238}U$ and helium dating [2, 3]. Detection of increased $^{234}U/^{238}U$>1.3 ratios in modern seawater correlates with an increase of ^{234}U excess in corals and carbonate sediments of the Arctic Seas during warm periods [4].

[1] Henderson & Anderson (2003) Rev. Mineral. Geochem. 52(1), 493-531. [2] Tokarev et al., (2009a) Water Res., 36, 206–213. [3] Tokarev et al., (2009b) Water Res., 36, 345–356. [4] Tokarev et al., (2021) Geochemistry Int. in press.

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