Helium and argon isotopes in corundum rocks from the Nothern Karelia as indicators of mass-dependent isotopic fractionation in the endogenic fluid

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The isotopic composition of noble gases in corundum and the host rocks.

Corundum rocks of the Northern Karelia are known for its anomalously isotopic light oxygen, and their forming fluid implies the involvement of isotopic light meltwaters from surface subpolar glaciers [1,2]. To determine the nature of the anomalies were analyzed isotopic composition of He, Ar, and ratios of He, Ne, Ar from fluid inclusions in minerals of corundum and the host rocks according to the technique of vacuum crushing. Argon in the fluid inclusions do not contain atmospheric component: the ratio of $^{40}Ar/^{36}Ar$ is from 4500 to 8200. Isotopic composition of helium, and the ratios $^{4}He/^{20}Ne$, $^{4}He/^{40}Ar$ also are corresponding to evolution of the fluid in endogenous conditions. The study of isotopes of noble gases has shown that in the endogenous fluid participating in the formation of corundum rocks, there were significant effects of fractionation. Observed a consistent change of parameters in the fluid, from the host rocks to the central part of permeable zone: increase of the isotope ratios $^{3}He/^{4}He$ from 10^{-8} to $5*10^{-7}$ with decreasing $\delta^{18}O$ value in silicates. At the same time elemental relations $^{4}He/^{40}Ar$ and $^{20}Ne/^{40}Ar$ are decreasing to more than order of magnitude, which indicate loss of He and Ne relative to Ar, confirming existence of the thermal gradient across the shear zone.

Discussion

Apparently, during formation of the rocks in endogenous fluid at permeable zones of shear deformation took place mass-dependent fractionation of stable isotopes of oxygen and noble gases. Taking into account existence of thermal gradient across the shear zone, this effect could be caused by thermal diffusion. Amphibolizing host rocks were analogous to the fluid pumps, providing a cascading of thermal diffusion separation cells, which strongly increase separation factors of isotopes [3].

[1] Bindeman *et al* (2014) Geosphere, V.10, 308-339. [2] Herwartz *et al*. (2015) PNAS, V.112, № 17, 5337-5341. [3] Akimova, Lokhov (2015) Journal of Materials Science and Chemical Engineering, № 3, 42-47.