Triple oxygen isotopes in hydrothermal systems: insights into ancient meteoric waters and paleoseawater

ZAKHAROV, D.O. [1], BINDEMAN, I.N. [1], TANAKA, R. [2], FRIÐLEIFSSON, G.Ó.[3], REED, M.[1]

[1]University of Oregon, Eugene, USA; davidz@uoreogon.edu; [2]IPM, Okayama University, Misasa, Japan; [3] HS Orka, Reykjanesbær, Iceland

Recent developments in high precision measurements of $^{17}O/^{16}O$ and $^{18}O/^{16}O$ resolve systematic mass dependent variations in $\Delta^{17}O$ in terrestrial materials. Here we show that $\Delta^{17}O$ of hydrothermally altered rocks provide much needed constraints on temperature, water-rock ratio and $\delta^{18}O$ of altering fluids which have important implications for reconstructing $\delta^{18}O$ of paleoseawater and ancient meteoric water. We test this approach in active hydrothermal systems of Iceland that are charged with modern seawater and meteoric water with known $\delta^{18}O$ values (Reykjanes, Krafla respectively) and in several ancient hydrothermal systems that range in age from Tertiary to Paleoproterozoic: 6 Ma subvolcanic complex Geitafell in Iceland, 6 Ma seafloor rocks from East Pacific Rise (ODP 504B) and 2440-2410 Ma snowball-Earth-age rocks from the Baltic Shield.

The $\Delta^{17}O$ values in hydrothermally altered rock and well fluids from Krafla span from −0.05 ‰ to +0.04 ‰ and indicate involvement of meteoric water with $\delta^{18}O = -15 \pm 3$ ‰, which is in good agreement with modern-day local precipitation ($\delta^{18}O = -13$ ‰). The $\Delta^{17}O$ data at Reykjanes range between −0.05 ‰ and −0.01 ‰ indicating involvement of water with $\delta^{18}O$ and $\Delta^{17}O$ close to 0 ‰ as expected since the system is charged with mostly modern seawater. Hydrothermally altered rocks from ocean floor sampled by ODP 504B record involvement of seawater with $\delta^{18}O$ and $\Delta^{17}O$ of 0 ‰. The $\Delta^{17}O$ values in the 6 Ma Geitafell complex, Iceland are consistent with involvement of meteoric water with $\delta^{18}O$ of about −16 ‰ which is a bit more depleted than the modern-day meteoric water from the Iceland interior. Hydrothermally altered rocks from the Karelian craton contemporaneous with the first Paleoproterozoic snowball Earth glaciation recorded meteoric water with $\delta^{18}O = -37$ ‰ at low latitudes, which in the modern world corresponds to the glacial melt water from Greenland and Antarctica. Contemporaneous deep-water submarine altered basalts from Karelian craton show evidence for seawater having $\delta^{18}O$ and $\Delta^{17}O$ of ~0 ‰. Our results suggest constancy of triple oxygen isotopic composition of seawater through time.