Slab-derived fluid evolution induced from oxygen and hydrogen isotopes compositions of blueschist-facies phengites

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Phengite is the most common metamorphic mineral in HP-UHP metasedimentary rocks, which can convey H₂O, LILEs (especially K, Ba, Cs and Rb), Li, B and N in their structure formed at depths up to 300 km. The breakdown of phengite in a downgoing oceanic slab would cause fluid-induced element transport into the overlying mantle wedge. We have investigated the \( \delta^2H/\delta^1H \) (D/H) and \( \delta^{18}O/\delta^{16}O \) ratios of twenty-four phengite separates from pelitic schists of the Devonian–Carboniferous Renge Belt (SW Japan), Permian Shaiginsky Complex (Far East Russia) and Cretaceous Sambagawa Belt (SW Japan).

We found the presence of the very light hydrogen isotope (\( \delta^D < -95\% \)) in blueschist-facies phengites in the three different metamorphic belts. For example, phengite from the lawsonite- and epidote-grade metasedimentary schists of the Osayama Serpentinite Mélange (OSM) of the Renge Belt are characterized by negative hydrogen isotope compositions (\( \delta^D \) values relative to VSMOW) ranging from -113 to -93.9\% and oxygen isotope compositions (\( \delta^{18}O \) values relative to VSMOW) ranging from +12.9 to +14.6\%.

High-Si features and K-Ar ages of the investigated phengites deny the possibility of meteoric-hydrothermal alteration to have caused the low \( \delta^D \) values. The light values might be attributed to isotopic fractionation during progressive metamorphic dehydration. Assuming a metamorphic temperatures range of 250–350°C for the OSM schists, the inferred metamorphic fluid compositions in blueschist-facies depth for that fossil slab had a range of \( \delta^D = -40 \) to -75\% and \( \delta^{18}O = +13 \) to +15\%. These values are significantly lighter than the slab-fluid induced from the Arima hot spring water in a forearc region of modern SW Japan subduction zone. Our study suggests that slab-derived fluids in ancient Pacific-type subduction zone are characterized by light hydrogen isotope and that the phengite breakdown can affect hydrogen isotope of nominally anhydrous minerals (NAMs) in the deep mantle.