Nature of slab-derived fluids in Pacific-type subduction zone: Oxygen and hydrogen isotope studies of phengites from Renge and Sambagawa metasedimentary rocks

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Phengite is the most common metamorphic mineral in HP–UHP metasedimentary rocks, which can convey H_2O and LILEs (especially K, Ba, Cs and Rb) plus Li, B and N to subarc and/or rear arc depths. The breakdown of phengite in a downgoing slab would cause fluid-induced element transport into overlying hangingwall mantle. What are the oxygen and hydrogen isotope signatures of phengite in metasedimentary rocks in Pacific type subduction zone? What are the stable isotopic compositions of metamorphic fluids equilibrated with phengites? Do they evolve during continuous dehydration reactions? We have investigated the $^{2}H/^{1}H$ (D/H) and $^{18}O/^{16}O$ ratios of twenty-three phengites from pelitic schists of the Devonian–Carboniferous Renge and Cretaceous Sambagawa belts, SW Japan.

We found the presence of the very light hydrogen isotope (δ D < −95‰) in blueschist-facies phengites in two different metamorphic belts. Fourteen phengite separates from the lawsonite- and epidote-grade pelitic schists of the Osayama serpentinite mélange (central Chugoku Mountains) of the Renge belt are characterized by very negative hydrogen isotope compositions (δ D values relative to VSMOW) ranging from −113 to −93.9‰; oxygen isotope compositions (δ^{18}O values relative to VSMOW) range between +12.9 and +14.6‰. Nine samples from the garnet-bearing pelitic schists along the Sarutagawa River (central Shikoku) of the Sambagawa belt show δ D = −95.6 to −60.5‰ and δ 18O = +12.3 to + 14.4‰.

High-Si features and K–Ar ages of the investigated phengites deny the possibility of meteoric-hydrothermal alteration to have caused the low δ D values. The light values might be attributed to isotopic fractionation during progressive metamorphic dehydration. Using the observed values and applying muscovite–H_2O oxygen and hydrogen isotope fractionation factors for nominal temperature, we estimated the isotopic composition of metamorphic fluids equilibrated with phengites. Assuming 250–350˚C and 450˚C for metamorphic temperatures of the Osayama schists and Sarutagawa schists respectively, the inferred metamorphic fluid compositions in ‘blueschist-facies’ depth in fossil slabs have a range of δ D = ˜−40 to −75‰ and δ^{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. Our study suggests that slab-derived fluids in Pacific-type subduction zone are characterized by light hydrogen isotope and also suggests that the phengite breakdown can affect hydrogen isotope of nominally anhydrous minerals (NAMs) in deep mantle.

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