Tracing fluid-rock interaction in white mica

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White mica is an ideal target for petrological and isotope geochemical studies on fluid-rock interaction in subduction zone rocks. It is common in both meta-igneous and metasedimentary rocks, it has a wide stability in pressure-temperature space and it shows a substantial chemical variability, which includes the incorporation of fluid-mobile elements that allow to trace metamorphic dehydration, fluid-rock interaction and fluid sources. For boron (B) and nitrogen (N), white mica represents an important reservoir in subduction-related metamorphic rocks, and knowledge of mineral residency, mobilisation and recrystallisation is fundamental to understand the cycling of these elements through subduction zones with implications for the global water cycle and the evolution of the atmosphere. Here, two case studies from the Italian Western Alps are used to illustrate how geochemical studies of white mica elucidate the effects of fluid-rock interaction during high-pressure metamorphism in subduction zones.

Metamorphic rocks from Lago di Cignana comprise the globally most deeply subducted rocks of oceanic origin. A positive correlation of B concentrations with $\delta^{11}B$ values in eclogite-facies phengite cannot be explained by growth zoning or devolatilization, but instead represents fluid-rock interaction during peak metamorphism, with the fluids likely derived from spatially associated serpentinite (Halama *et al*., 2020). Retrograde metamorphism during exhumation with concomitant fluid-rock interaction caused leaching of B with preferential partitioning of B into the fluid, resulting in lower B contents in white mica. Like B, N is also predominantly hosted in white mica, where ammonium (NH_4^+) replaces K^+. At peak metamorphic conditions, N shows a moderately fluid-mobile character (Harris *et al.*, 2022).

In the Sesia Zone, a section of continental crust that has reached eclogite-facies conditions during Alpine metamorphism, phengite inclusions in omphacite record the highest Si contents (up to 7.3 Si p.f.u.). They are chemically distinct from matrix phengite, which shows higher $\delta^{11}B$ values, lower and more variable Si and increasing B contents (up to 120 µg/g). These changes reflect that initial eclogite-facies equilibration at c. 75 Ma was followed by partial re-equilibration with B addition in the matrix. Complete re-equilibration is evidenced in phengite from nearby blueschist-facies and greenschist-facies rocks. These record consistently lower Si (<6.8 Si p.f.u.), higher $\delta^{11}B$ (> -3‰) and lower B contents (c. 10±3 µg/g), indicating loss of B that was accompanied by complete resetting of age information during intense fluid-rock interaction and deformation at c. 60 Ma. Continuing deformation until at least c. 46 Ma in the greenschist-facies rocks did not significantly mobilise B any further.

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