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Fluid evolution during a regional metasomatic event (Bamble Sector, SE Norway): A halogen concentration and chlorine stable isotope study

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Lower crustal rocks from the Bamble area (SE Norway) show a complex history of metamorphic and metasomatic events. Although the metamorphic history of this high-grade terrain is largely understood, the metasomatic part is still poorly constrained. Here we use halogen concentrations and chlorine isotope composition (δ37Cl) to trace fluid sources and distinguish between different fluid alteration events. We focus particularly on the hydrothermal alteration of gabbroic intrusions of Sveconorvegian age ($\sim$1100 m.y.). The gabbroic bodies, which are cut by amphibolitic and albitic shear zones, show different stages of alteration. Alteration zone 1 (amphibolised zone) close to the pristine gabbro is characterized by progressive alteration of pyroxene to pargasitic amphibole. Zone 2 (scapolitised zone) is defined by the replacement of plagioclase by scapolite and the occurrence of biotite. In zone 3 (albitised zone) near the shear zone, albite becomes more prominent and scapolite and biotite start to disappear.

The bulk rocks show lowest δ37Cl values at the transition from alteration zone 1 to zone 2, whereas mineral separates of amphiboles and scapolites show an overall increase in δ37Cl values from the unaltered gabbro towards the shear zone. This difference in isotopic evolution can either be explained by the interaction of different fluids with the host rock causing scapolitisation with a different δ37Cl value or, more likely, by isotope fractionation and hence the evolution of a distinct infiltrating fluid by reactive flow. The δ37Cl values of coexisting halogen-bearing minerals differ strongly from each other, indicating isotope fractionation during formation or recrystallisation of these phases. For example, the δ37Cl value of amphibole is found to be $\sim$1‰ higher than that of scapolite from the same sample. Differences of modal mineral abundances result in variation of the bulk δ37Cl values along the profile.

Halogen concentrations and ratios also suggest an evolution of one distinct fluid that caused an overall enrichment of Cl, Br and I in samples nearest the shear zone. Due to different mineral specific (fluid-mineral) distribution coefficients, fluid-mineral interaction resulted in either enrichment or depletion of halogens in the fluid as it reacted with the gabbro. For example, the formation of amphibole and biotite caused an increase of the fluid salinity by preferential incorporation of OH- over Cl-. This desiccation process is reflected in the increasing Cl concentrations in amphiboles towards the unaltered gabbro. Br and Cl, though differ concentrations, have similar distribution patterns, suggesting that both halogens behave similarly during fluid-solid interaction. A slight Br/Cl ratio increase from 2x10-3 in the amphibole zone to 3x10-3 in the scapolite zone is attributed to a slightly higher affinity of scapolite for bromine over chlorine. Iodine concentrations (0.3 – 0.6 ppm) remain approximately constant in the reacting rock, which leads to decreasing I/Cl ratios towards the shear zone. The calculated halogen ratios indicate a mantle origin for the least altered samples, whereas samples from close to the shear zone show ratios typical of marine pore fluids.