Determining oxygen isotope fractionation coefficients between metamorphic minerals by in-situ SIMS analysis

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Several approaches have been taken in determining fractionation coeffcients for oxygen isotopes in rock-forming minerals. Theoretical coefficient are derived from mineral bond-strength models, over a virtually infinite P-T range. On the other hand, experiments allow equilibrating different minerals either in hydrothermal conditions or in higher-temperature and pressure dry experiments. The P-T range at which most of the crust sits and most metamorphic processes happen is not easily accessible experimentally, and is better approached by the study of natural samples. The latter relies heavily on the assumption of equilibrium between phases.

A historic approach is to separate minerals and measure their oxygen isotope composition by bulk analysis techniques such as laser-fluorination, with a good precision (down to 0.1 permil). However, in recent years, improved matrix-correction routines allow for ion microprobe reproducibility around 0.3-0.5 permil on a number of minerals, which makes it suitable for fractionation studies. In situ methods provide a great advantage in a petrological context as they allow not only smaller sample sizes (e.g. accessory minerals) but also to measure minerals -and mineral zones- in textural equilibrium. The equilibrium hypothesis can be tested using trace elements or geochronology on the same spots.

Oxygen isotopes were measured in garnet, zircon and monazite of the Dora Maira whiteschists in the Western Alps. Rare-earth elements indicate equilibrium between zircon rims, monazite and garnet in 4 samples. Obtained fractionation for zircon-garnet and zircon-monazite are of 1 permil and 0 permil respectively at around 700°C, 25 to 45 kbar. This study also allowed for the determination of a two-step matrix effect correction scheme for the analysis of monazite with SHRIMP, which may improve accuracy over the yield-dependent laser fluorination method on the same mineral.

A further case study on low-temperature (400-500°C, 20 kbar) eclogites and metasediments from the Tavsanli zone in Turkey will provide results for garnet-apatite as well as garnet-lawsonite and garnet-zircon oxygen isotope fractionation.