

REE systematics in metamorphic garnet: insights from LA-ICP-MS

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Sm-Nd geochronology is an important tool for dating metamorphism and interpreting tectonic history of garnet bearing rocks. Isotopic equilibrium, rare earth element heterogeneity, due to either inclusions or chemical zoning, and closure temperature of the Sm-Nd system are all items that have been questioned for Sm-Nd garnet analyses. In this study, we show that inclusions may play an important role in the REE budget of garnet, how garnets with simple major element chemistry (zoning) may be very complex with respect to the REEs, and how dissimilar garnets from throughout a crystalline terrane may show close trace element similarities.

We used laser ablation ICP-MS to 1) map in detail the trace element zoning of a 1 cm-diameter euhedral garnet with over 1300 quantitative spot analyses, and 2) conducted analytical traverses across a suite of 10 regional metamorphic almandine garnets from a crystalline terrane in the North Cascades Mountains, Washington, USA.

The majority of garnets display trace element and REE zoning that does not reflect the major element zoning. A common pattern is one of cores enriched in HREEs and weakly to unzoned with respect to Y and the MREEs and LREEs. The variation in the magnitude of the REE zoning in the cores of these garnets is striking, and a comparison to ionic radii and zoning profile reveals a linear relationship. We suggest intercrystalline diffusion is the dominant control on trace element zoning in the core of these garnets.

A second feature common to nearly all garnets studied is the presence of an annulus strongly enriched in Y and HREEs. Influx of HREE-rich fluids seems unlikely given the different lithologies. The most probable explanation is the prograde breakdown of a HREE-rich mineral such as xenotime or some other HREE-rich transient phase. These results reveal basic similarities among texturally disparate garnets, and possibly among garnets with somewhat different metamorphic histories. Combining TIMS analyses with LA-ICP-MS allows new insights enabling more detailed and accurate geochronology and tectonic interpretation.

Lithium Isotopes and Crust-Mantle Interaction

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Lithium isotopes can potentially provide valuable insights into crust-mantle interactions because low-temperature fractionation at or near the surface provides stronger isotopic fractionation than igneous processes. Lithium isotopes are supposed to be a more sensitive tracer for altered oceanic crust mixed into the source of ocean island basalts and MORB than oxygen isotopes because it is a trace element that is enriched in crustal rocks. Subarc mantle xenoliths may have isotopic signatures clearly different from MORB materials (Chan et al., 2002). The $\delta^6\text{Li}$ value of the mantle might perhaps have changed over the history of the Earth due to recycling of crustal material (Bouman et al., 2000). To address such problems, it is first necessary to set up a technique for high precision isotopic measurements. This is a difficult task because lithium has only two natural isotopes, ^6Li and ^7Li , with a very high relative mass difference of 16.7%. The mass bias correction has to be done by bracketing unknown samples with standards. Tomascak et al. (1999) reported lithium measurements on VG Plasma 54-30 multiple-collector ICPMS. Here we report the precision of measurements using a NuPlasma multiple-collector ICPMS.

First preliminary results for L-SVEC NIST reference material (Flesch et al., 1973) give a precision of $\pm 1.3\%$ (2 SD). Analyses of pure Li solutions reproduce within better than $\pm 0.6\%$. We also find a small dependence of $\delta^6\text{Li}$ on concentration shifting $\delta^6\text{Li}$ towards lighter values with decreasing lithium concentration. It has also been tested how isotopic measurements of lithium are affected by other elements. The results show that potassium and sodium shift $\delta^6\text{Li}$ toward lighter values by up to 6.5%. Therefore, it is essential for high precision measurements to separate Li completely from other elements. The chemical separation will be performed first on international reference rock standards and optimized. The results will be reported here as well as results for sea-floor basalts and xenoliths from oceanic crust and compared with oxygen isotopic compositions.

References

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