Trace element mapping of garnet by LA-ICP-TOFMS

D. RUBATTO[1], M. BURGER[2], G. SCHWARZ[2], P. KERESZTES SCHMIDT[2], C. NEFF[2], P. LANARI[1], J. HERMANN[1], A. VHO[1], D. GÜNTHER[2]

[1]University of Bern, Institute of Geological Sciences, 3012 Bern, Switzerland; daniela.rubatto@geo.unibe.ch
[2]ETH Zurich, Laboratory of Inorganic Chemistry, 8093 Zurich, Switzerland

Garnet is one of the most robust minerals that records major and trace element zoning during crustal metamorphism. The determination of trace elements with laser ablation inductively coupled plasma mass spectrometry (LA-ICPMS) in garnet is commonly based on spot analyses and line scans, whereas 2D element imaging is in its infancy. We developed an imaging technique for trace elements in garnet using laser ablation inductively coupled plasma time-of-flight mass spectrometry (LA-ICP-TOFMS). This method allows a spatial resolution of 5 microns, which is comparable to what can be obtained for major elements using electron probe microanalysis (EPMA).

The three types of garnet investigated represent different metamorphic conditions: (i) regional metamorphism to 550°C, where the garnet preserves major element zoning; (ii) regional metamorphism to 800°C in the presence of melt that has resulted in major element resetting by diffusion in garnet; and (iii) high-pressure metamorphism associated with fluid infiltration that has produced partial replacement of the original garnet growth zoning.

The high spatial resolution allows the zoning in trace elements to be compared to those of major elements (as obtained by EPMA), to recognize correlations between groups of trace elements and assess relative diffusivities. In the case of low temperature garnet growth, the distribution of trace elements closely matches that of major elements and preserves equally sharp zoning. In the sample where major element zoning is totally erased, trace element zoning is largely preserved, with evidence of limited diffusion over 100-micron scale for the HREE. Like Mn, Y-enrichment marks garnet resorption zones. Elements like P, Sc, Cr and V do not follow the behaviour of Y+REE. An increase in transition metals, such as Ti, Cr and V, marks garnet growth during biotite melting and zones that have reacted with biotite at sub-solidus conditions. The effect of fluid-induced replacement on the trace element distribution in garnet is assessed. These examples highlight that trace element mapping in garnet can open new avenues for investigating high-grade metamorphic processes.