MITT.ÖSTERR.MINER.GES. 161 (2015)

THE ORIGIN OF INCLUSIONS IN A METAPEGMATITE GARNET: PETROLOGICAL INFORMATION AND CHALLENGES

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Peraluminous metapegmatites of Permian origin from the Saualpe-Koralpe complex, Austria (locality Wirtbartl) contain cm-sized almandine-spessartine garnets with extremely abundant submicrometer to micrometer sized inclusions of corundum, ilmenite, rutile, xenotime, zircon, apatite and an Fe-Mn phosphate (wyllieite group). Variations in inclusion abundance, phase assemblage, habit and grainsize define concentric and sector zoning in the garnets. Attempting to determine the origins of these inclusions is the first step towards using them to understand the crystallization of the pegmatites, but also allows critical evaluation of the current state of research into inclusion origin determination.

Observed zoning is related to cm-scale or larger variations in the pegmatite system during magmatic crystallization. Sector zoning reflects differences between crystal facets with different miller indices. In the rarely developed outermost zone, rutile needles are oriented parallel to garnet <111> directions but do not favour all 4 directions equally, suggesting at least these inclusions may have crystallized simultaneously with garnet at its interface. The 3 inclusion phases studied with electron backscatter diffraction (EBSD) each show multiple crystallographic orientation relationships to garnet.

The inclusion phase assemblage and individual compositions are characteristic of pegmatite phases. Microprobe measurements of the integrated composition of garnet and inclusions show small deviations from perfect garnet stoichiometry. Variations in integrated element concentrations correlate with optically visible zoning. Correlations are present between different elements to varying degrees, but are difficult to interpret. The strongest correlation is negative, between Si and Al + P + Ti (r^2=0.99). The weak positive correlation between Al and Ti cannot be explained by known crystal chemical mechanisms of Ti incorporation in garnet.

The only scenario that can be reasonably excluded by the current measurements is inclusion formation by overgrowth of independent, pre-existing crystals. The methods which provided the most useful information were a combination of microstructural observations and EBSD. Formation of the inclusions from exsolution or from oriented nucleation at the garnet surface and subsequent overgrowth cannot be differentiated between. The reason for this difficulty is the lack of studies of host-inclusion systems with known origins against which competing theories can be evaluated. Interpreting inclusions as exsolution products based on their crystallographic orientation relationships and shape-preferred orientations alone is not justifiable.