Geophysical Research Abstracts
Vol. 15, EGU2013-4702, 2013
EGU General Assembly 2013

Intragranular deformation and submicron inclusion re-equilibration

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Pegmatitic almandine-spessartine garnets from the Saualpe-Koralpe crystalline basement complex (Eastern Alps, locality Wirtbartl, Austria) possess extremely high abundances of micro- to nano-inclusions ($<$200 nm – 1 μm sized). Micro- and nano-inclusion density variations define concentric, oscillatory and sector zones in the host garnets. Six different inclusion phases have been identified by electron beam microanalysis: corundum, xenotime, zircon, rutile, ilmenite and a Na-Mg-Al-rich $(AB)_5(PO_4)_3$ phosphate belonging to the wyllieite group.

The Permian magmatic assemblages were affected by eclogite facies metamorphism during the Cretaceous tectonometamorphic event. Microstructural, optical and EBSD analyses have shown that the meta-pegmatite garnet deformed crystal-plastically at this metamorphic stage (Bestmann et al. 2008).

High resolution microstructural, -textural and chemical analyses provide information on material re-distribution and chemical re-equilibration in the garnet interior during metamorphic overprinting and deformation.

A remarkable microstructural feature is the occurrence of inclusion trails which crosscut the magmatic inclusion density zoning in the garnet. Within these trails inclusions have a coarser grain size (1-10μm diameter) than inclusions outside the trails. In 3D the arrays of coarser inclusions define flat to slightly curved geometrical surfaces. In 10-40μm broad zones flanking the inclusion trails the original $\leq$1μm sized inclusions are absent. This lack of submicron inclusions defines characteristic bleaching zones clearly visible in thin section. The inclusion phases found within trails correspond largely to those found in the surrounding garnet. Several additional phases are found to occur exclusively within trails, but they are not homogenously distributed. Trails can be divided into those containing muscovite and Fe-Mn carbonate +/- Zn-Sn spinel and those where these phases are absent. Apatite is the only phase found in all trails that has not been observed in the fine grained inclusion population.

From their microstructural characteristics it is inferred that the trails occur at the site of healed brittle cracks. EBSD data show that trails of coarsened inclusions are sometimes but not always related to adjacent garnet lattice rotation or subgrain formation. Where present, garnet lattice rotation is very small but correlated spatially with the observed bleaching zone.

In order to correlate garnet lattice strain with potential chemical reactions between inclusions or with the host, high resolution (excitation volume $<$500nm in diameter) field emission electron microprobe analysis of inclusion and garnet compositions both inside and outside trails has been carried out. In trails where muscovite and carbonate inclusions are present in addition to apatite, wyllieite inclusions show discrete differences in composition correlating with their perpendicular distance from the trail. Additionally, lateral compositional variation of wyllieite along these trails is observed. In contrast, optically similar muscovite- and carbonate-free trails show isochemical coarsening of wyllieite. In both cases no change in garnet major element composition has been resolved across trails.

Combining knowledge of host crystal deformation mechanisms with highly spatially resolved microstructural and compositional analysis will contribute to an understanding of the influence of deformation on material transport across and within intragranular deformation zones and shed light on possible mechanical – chemical feedbacks during metamorphic overprinting and deformation.