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The behavior of ultra-fine grained mineral inclusions in meta-pegmatite garnet during host deformation

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Crystal-plastic garnet deformation has been described from meta-pegmatites of the Austroalpine Koralpe Complex in the Eastern Alps (Bestmann et al. 2008), which had been affected by Cretaceous eclogite facies metamorphism and deformation overprinting the Permian magmatic assemblages (Habler et al. 2007; Thöni et al. 2008). Coarse grained magmatic almandine-spessartine garnet hosts numerous ultra-fine grained or very fine grained inclusions of various phosphates (xenotime, Mg-Na-bearing Ca-phosphate, fluorapatite, monazite), ilmenorutile-struverite, zircon, muscovite, corundum, aluminosilicate and partly also uranium-oxide. These ultra-fine grained inclusions are either randomly dispersed with spherical grain shape, or form acicular grains with preferred orientation parallel to specific crystallographic directions of the host garnet. The density of dispersed ultra-fine grained inclusions correlates with the coloring intensity of garnet. Furthermore, garnet coloring partly reveals sector zoning reflecting euhedral garnet growth zones. Ultra-fine grained inclusion formation supposedly correlated with magmatic garnet crystallization.

During the eclogite facies metamorphic overprint strongly localized deformation zones developed within garnet, crosscutting the magmatic compositional and microstructural zoning. Different sets of microfractures formed as well as straight or slightly curved inclusion trails of 30 – 50 micrometer sized apatite, rutile, xenotime, muscovite and corundum. Inclusion trails are accompanied by bleached garnet domains, which lack the ultrafine-grained inclusions. Adjacent to microfractures garnet domains may as well appear bleached, or bear recrystallized inclusions. Inclusion trails and microfractures partly terminate within the garnet host grain, thus indicating, that deformation in these domains was accommodated by lattice distortion. Whereas the inclusion trails and bleaching domains of garnet were interpreted to reflect zones of incipient deformation, further evolved deformation zones display subgrain rotation recrystallization of garnet and diffusion accommodated grain boundary sliding (Bestmann et al. 2008).

The chemical compositions of garnet and inclusions indicate that newly formed garnet grains in deformation zones have similar major element composition as the magmatic garnet core. In contrast, domains of significant garnet lattice distortion display decreased Ca-content. The Ca- and inclusion-distribution in garnet indicates strain-related mineral reactions involving the host garnet and recrystallizing inclusions (mainly phosphates and Ti-phases) rather than a simple diffusion gradient between magmatic host and re-equilibrated metamorphic garnet or the rock matrix. Garnet affected by lattice distortion and subgrain formation was depleted in Ca, whereas domains showing new grain formation (fine grained garnet, fluorapatite, rutile) display again slightly increased Ca-content of garnet. Observed compositional characteristics of strained garnet can be explained by a succession of polyphase equilibration stages. Alternatively, chemical potential gradients may have occurred due to limited material transport between strained host garnet and recrystallized domains, or due to an influence of the garnet rheology on the chemical properties of the local assemblages.

New mineral compositional and microstructural data yielded evidence of strain-related mineral reactions between pre-existing inclusions and host garnet during microfracturing and subgrain rotation recrystallization, thus providing information on the interaction of deformation and chemical reactions.

References:

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