

THE IMPORTANCE OF SUB-GRAIN BOUNDARIES IN GARNET FOR ELEMENT RECYCLING DURING METAMORPHISM

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Kinetics of metamorphic reactions and compositional re-equilibration of metamorphic minerals as a response to changing pressure, temperature and/or chemical conditions are mainly controlled by processes that occur along mineral surfaces. Element transport rates, for example, differ significantly between volume diffusion and grain-boundary diffusion, the latter being up to two orders of magnitude faster (e.g. Joesten 1991). Thus, the presence of sub-grain boundaries within mineral grains enhances compositional resetting of internally zoned minerals and allows fast element recycling from mineral interiors into the reacting bulk rock composition.

In this contribution we investigate the influence of sub-grains and sub-grain boundaries in garnets from high- and ultra-high pressure samples on the compositional re-equilibration of garnet as well as on the consequences of element (re-) cycling in subduction zones. The investigated garnet crystals have strong compositional growth zonations, which have been homogenised to different extent. Some grains exhibit domains with well-preserved concentric growth zoning whereas other domains show irregular, mesh-like zonation patterns. Orientation contrast (OC) images revealed complex internal sub-textures with clearly separated mis-oriented segments within the garnet grains. A comparison of OC images with major- and trace-element compositional maps shows that Mn, Mg and Fe zoning patterns correlate with the position of boundaries between crystallographically mis-oriented areas, whereas, Ca, Ti and Y concentrations still preserve concentric patterns that are independent of the sub-structure network.

Our results show that the patchy compositional variations visible in BSE images of many HP and UHP garnets are the result of differential diffusive chemical re-equilibration of pre-existing growth zonations along sub-grain boundaries. Further, there is a decoupling of chemical resetting between apparently fast diffusing elements, such as Mg, and slow diffusing elements such as Ca and Y during the re-equilibration process. Our samples indicate that the extent of diffusional resetting is clearly dependent on the size of sub-grains, which might have severe consequences for the interpretation of diffusional relaxation timescales for garnets with a critical sub-grain size. In addition, differential element resetting could cause major problems in the interpretation of isotopic ages of garnet as trace elements will become decoupled from major element patterns.

References

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