MATERIAL TRANSPORT PHENOMENA RELATED TO GARNET REACTION BANDS FORMED IN METAPELITES AT ECLOGITE FACIES CONDITIONS

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Metapelites from the Monte Rosa nappe (Western Alps) underwent a polymetamorphic history with a high-T / medium-P metamorphism during pre-Alpine stages. During the Alpine metamorphic cycle the rocks experienced a high-pressure overprint, which, among others, led to the formation of garnet reaction rims along former plagioclase-biotite grain contacts. The garnet forming reaction plagioclase (Pl) + biotite (Bt) = garnet (Grt) + phengite (Phe) + quartz (Qtz) took place at about 650 °C and 12.5 kbars.

The Grt rims (10-50 µm) show an asymmetric zoning pattern. Ca concentrations are relatively high towards Pl, but have their maximum within the Grt rim. Towards Bt Ca concentrations are generally low, but near the Grt / Bt interface a small increase in Ca concentrations is observed. Approaching the Gt / Bt interphase boundary Ca again decreases. Fe concentrations behave complementary to the Ca concentrations.

Pl is depleted in Ca towards Grt, indicating that Ca for Grt growth, was derived from incongruent dissolution of Pl, which preferentially extracted the anorthite component. Qtz is formed as a discontinuous rim (< 10 µm) of grains along the Grt / Pl reaction interface. Phe is predominantly formed within the preexisting Pl.

The formation of the reaction rims requires diffusive material transfer across the Grt rim or along interphase boundaries. The high Ca concentrations near the Grt / Bt interface give evidence of rapid transport along grain- or interphase- boundaries. Potential diffusion pathways through the Grt rim are detected by electron backscatter diffraction. Grt rims are composed of (sub)grains separated predominately by low angle boundaries (< 15 °). The grain boundaries within the garnet rim probably allowed for short circuit diffusion between the Gt / Pl and the Gt / Bt reaction interfaces. High-resolution transmission microscopy reveals the internal structure of Grt grain boundaries. These grain boundaries often contain islands of < 5 nm width, where the lattice of the neighboring grains fits badly. The islands contain an amorphous material, the phase nature of which at the presumed P-T conditions of Grt formation is not known, but which may have served as a medium for fast mass transport. Electron energy-loss spectroscopy shows that Ca and Fe segregate to the Grt grain boundaries and Ca is depleted near the grain boundary These observations in combination with the Grt zoning profile demonstrate that material transport indeed occurred via grain boundaries through the Grt rim.

Bright and dark field TEM images of the Ca depleted part of Pl reveal up to 100 nm wide channels filled with amorphous material forming potential diffusion pathways. Newly formed Phe is often spatially associated with such channels.