EGU2020-13093
https://doi.org/10.5194/egusphere-egu2020-13093
EGU General Assembly 2020

Fluid assisted formation and deformation of eclogites - dislocation vs. dissolution-reprecipitation creep

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The classical eclogite assemblage consists of the non-hydrous minerals garnet and omphacite. Nevertheless, it is widely accepted that the transformation of mafic magmatic rocks into eclogite requires fluid infiltration. The most common fluid pathway referred to are cracks acting as brittle precursor for fluid-supplied eclogitization, followed by subsequent strain localization, possibly enhancing further eclogitization. While this seems to be a common observation, it is still not fully understood by which processes fluids enhance the metamorphic processes. Herein a set of eclogites from the type-locality (Hohl, Koralpe, Austria, Eastern Alps) representing three different strain stages has been analyzed by means of their microstructure and petrology. Additionally, thermodynamic forward modelling has been performed to constrain pressure, temperature and water activity during eclogitization. All samples are composed of garnet (grt), sodic-clinopyroxene (cpx), quartz (qtz) and a fine grained polycrystalline aggregate (fgpa) of kyanite (ky), clinozoisite (czo) and retrograde plagioclase (pl). While the mineral assemblage is identical in all investigated samples, we do observe minor variation in the volume fraction of each mineral, the specific mineral chemistry and the microstructure with respect to the different eclogite types.
Almost unstrained eclogites are characterized by grt coronas surrounding cpx in a fgpa matrix. Locally the replacement of coarse crystals of sodium-poor pyroxene by a polycrystalline mixture of qtz and cpx can be observed. In intermediate strained eclogites grt occurs in elongated clusters surrounded by cpx and fgpa matrix. Clinopyroxene grains start to develop a shape preferred orientation (SPO) together with a weak crystallographic preferred orientation (CPO). Highly strained eclogites are characterized by a pronounced foliation defined by a SPO of cpx and elongated layers of fgpa. Garnet again occurs as elongated clusters locally starting to disaggregate perpendicular to the foliation. Though cpx matrix grains develop a more pronounced CPO with increasing strain hardly any intracrystalline deformation can be observed. In all samples we observe symplectites composed of diopside and pl surrounding elongated cpx grains indicating that deformation occurred at eclogite-facies conditions.
Thermodynamic modelling yield formation conditions of approximately 2.4 GPa, 670 °C and a H2O activity slightly lower than 1 suggesting that fluid supply did play an important role during eclogitization and deformation. Nevertheless, different to above mentioned studies, we do not observe any positive correlation between fractures and reaction front. Our microstructural and petrological investigations instead reveal the formation of a micro-porosity along new developed grain boundaries allowing fluids to migrate to the reaction front, slowly consuming the original

gabbroic protolith and replacing it with the stable eclogitic mineral paragenesis. This rather static-type of eclogitization seems to be dominated by dissolution-reprecipitation processes and is resulting in a volume reduction of about 12 %. Subsequent volumetric and tectonic strain is further accommodated by dissolution-reprecipitation resulting in the development of foliated eclogites. Finally, lack of chemical zoning in minerals suggests that formation and deformation of the investigated eclogites occurred under stable P-T-fluid conditions. This study emphasizes that the planar and linear fabric of eclogites might not always be directly related to eclogite facies shear zones.