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Microstructural evolution and element mobility during fluid-mediated gabbro-to-eclogite transformation

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During subduction, dry gabbroic rocks often fail to react to the dynamically changing PT conditions while descending into the hot mantle and only convert directly to eclogites when externally-derived fluids trigger sluggish mineral reactions. The mechanisms of the conversion from a gabbro to an eclogite mineral assemblage and the related mobility of major and trace elements have been studied in a partly eclogitised gabbro, in which the gabbro-to-eclogite conversion is frozen in.
The Kråkenes Gabbro is a partially deformed and transformed igneous body in the UHP/HP transition zone of the Western Gneiss Region (Norway). The body consists mainly of pristine and undeformed gabbro, but is transected by a swarm of cm-wide hydrous eclogite-facies shear zones. We have studied three differently eclogitised samples from the undeformed parts to investigate the textural, chemical and mineralogical evolution through the gradual transition from gabbro to eclogite. Microstructural analyses were carried out by SEM and FIB/TEM, while major element concentrations were determined by EPMA and STEM-EDX. Trace element concentrations were determined using LA-ICP-MS.
(i) Almost pristine gabbro: This gabbro shows only minor alteration with both the igneous assemblage and ophitic texture still preserved. Alteration products are minor and mainly occur along grain-boundaries of reactive mineral pairs and vein-like structures cross cutting the magmatic precursor grains. Igneous Plagioclase (Pl) is replaced by a symplectitic assemblage of Albite (Ab) + Clinozoisite (Czo) along with Amphibole (Am) and Garnet (Grt) directly adjacent to Mg/Fe-phases. Igneous Clinopyroxene (Cpx1) is replaced by Cpx2, which is slightly enriched in Jadeite (Jd) and Aegerine (Aeg) component. Altered areas of Cpx1 appear dark and turbid in colour due to the phase separation of titanium-rich phases in Cpx2. Grt in equilibrium with Omphacite (Omp) is extremely rare and occurs exclusively within replaced Pl at junctions of vein-like structures cutting Cpx1 and magmatic Pl.
(ii) More altered gabbro: With more intense eclogitisation Pl is almost fully replaced by the symplectite. Cpx1 is the least reactive mineral and shows only marginal replacement. Cpx becomes darker, due to an increase in the amount of inclusions formed during the conversion to Cpx2. The Jd-component in Cpx2 increased as well (up to 10 mol%).
(iii) Most altered gabbro: The most intense eclogitised sample shows a full conversion of magmatic Pl to the Ab-Czo symplectite. Very small relics of Cpx1 are preserved but the conversion to Cpx2 and its associated inclusions dominates. Cpx3 (Omp), as the final replacement product of Cpx1, is formed in the regions of highest alteration at the expense of Cpx2 and the phase separation products.
Trace-element signatures are retained in the replacement products, with only minor changes in Eu anomalies. The more intense the eclogitisation the more the trace elements are redistributed as the Pl-Symp and Cpx3 contain very few trace elements. It is evident that element transfer was controlled by discrete transport pathways along grain boundaries and within minerals along vein-like structures. Eclogite-facies mineral assemblages formed only if the element exchange between different subdomains was efficient, otherwise metastable phases (Pl-Symp, Cpx2) formed.