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Unraveling eclogite-facies fluid-rock interaction using thermodynamic modelling and whole-rock experiments: the in-situ eclogitization of metapelites from Val Savenca (Sesia Zone, Western Alps)

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A common feature of HP and UHP terranes is the subduction of crustal rocks to great depths. Previous investigations have shown that this process is triggered by fluids present during an eclogite-facies metamorphic overprint. An examples is exposed in the metapelites at Val Savenca in the Sesia-Lanzo Zone, Italy where Alpine eclogite-facies metamorphism and fluid flow led to partial transformation of Variscan amphibolite-eclogite facies metapelites (garnet + biotite + sillimanite + K-feldspar + plagioclase + quartz) to zoisite ± jadeite + kyanite + phengite + quartz. This transformation took place under P-T conditions of 1.7 – 2.1 GPa at 600°C and low a(H_2O) of 0.3-0.6. The replacement of plagioclase by jadeite + zoisite + kyanite + quartz takes place also along former fractures. Biotite is replaced by the assemblage phengite + omphacite ± kyanite adjacent to former plagioclase, otherwise by phengite + rutile/titanite. Garnet and clinopyroxene show variable compositions depending in which micro-domain (plagioclase or biotite) they grew. The extreme development of microdomains can best be studied by thermodynamic pseudosection modelling of individual microdomains using stoichiometric mixtures of protolith minerals from this domain and the program DOMINO (De Capitani & Petrakakis, 2010). The aim of these calculations was: 1.) to reproduce the observed mineral assemblage and 2.) to provide constraints on the amount of fluid present in the transformation. The results so far indicate that the amount of fluid was very low, otherwise paragonite would have formed instead of jadeite and reproduction of the observed mineral assemblage has only been partly successful so far since biotite is still stable in the calculations.
In addition to understand the role of fluids in the mineralogical and textural transformation piston-cylinder experiments with a fresh, natural orthogneiss granulite from the Moldanubic Unit in upper Austria with the assemblage garnet + biotite + K-feldspar + plagioclase + sillimanite + quarz were carried out. The experiments were conducted using H_2O-NaCl fluids at 600°C and 2 GPa for 2-4 days. The fluids had the compositions X(H_2O) = 1.0, 0.9, 0.8 and 0.7. Oxygen fugacity was either unbuffered or buffered at NNO in the experiments. The results clearly show increasing reaction progress with increasing salinity in the fluid. Biotite breaks down in the experiments along the reaction: 3anorthite + 2K-feldspar + phlogopite + H_2O = 3diopside + 3muscovite. Clinopyroxene composition also changes as a function of NaCl content in the fluid. Omphacite core forms in the experiments at X(H_2O) = 1, in all other experiments, only jadeite occurs. Lack of continuous omphacite growth occurs since the anorthite component of plagioclase goes readily into solution, thus producing zoisite needles only upon quench. These experiments so far show that the biotite breakdown reaction is similar to the one observed in the natural samples and that brines highly effective promote reaction progress in subduction zone processes.

DE CAPITANI & PETRAKAKIS, K. (2010): American Mineralogist, 95, 1006–1016.