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Syn-metamorphic interconnected porosity during blueschist facies reactive fluid fluxes at the slab-mantle interface

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At the slab-mantle interface in subdution zones fluids released from the downgoing plate infiltrate into a mechanical mixture of rocks with different chemical compositions, different hydration states and different rheological behaviour resulting in a highly reactive mélange within a steep temperature gradient. Fluid pathways, reaction mechanisms and reaction rates of such fluxes, however, are poorly known, although these parameters are thought to be crucial for several seismic phenomena, such as those commonly referred to as slow earthquakes (e.g., episodic tremor and slip (ETS)).

We discovered syn-metamorphic fluid-pathways in the form of interconnected metamorphic porosity in eclogite and blueschist facies mélange rocks from the Franciscan Complex near Jenner, CA. The sampled rocks occur as rigid mafic blocks of different sizes (cm to decametre) in a weak chlorite-serpentine matrix interpreted to be an exhumed slab-mantle interface. Some of these mafic blocks record reactive fluid infiltration that transforms dry eclogite into hydrous blueschist with a sharp reaction front clearly preserved and visible from outcrop- down to μm-scale. We can show that a number of interconnected fluid pathways, such as interconnected metamorphic porosity between reacting omphacite and newly formed sodic amphibole enabled fluid infiltration and interface coupled solution-reprecipitation reactions at blueschist facies conditions. We investigated the different types of fluid pathways with TEM and visualized their interconnectivity with 3D focused ion beam (FIB) sections.

The eclogitic parts of the samples preserve porous primary omphacite as a product of amphibole and epidote breakdown during subduction. This primary porosity in omphacite I results from a negative volume change in the solids during amphibole and epidote dehydration. The resulting pores appear as (fluid filled) elongated inclusions the orientations of which are controlled by the omphacite lattice. During decompression of the rocks these inclusions became interconnected by brittle fractures that allowed a first fluid influx and the precipitation of new omphacite (II) within the fracture network and along the rims of the primary omphacite.

The (second) metamorphic/metasomatic porosity occurs along the reaction surfaces between omphacite and sodic amphibole as well as within omphacite grains where new omphacite (III) is formed. This interconnected pore network associated with the re-hydration reaction is up to 1μm but mostly between 50 and 200nm wide.

Reacting omphacite is preferentially consumed in 00-1 direction and has a rugged, often needle-like surface. In contrast, product surfaces (omphacite III and sodic amphibole) are relatively smooth indicating dissolution of older omphacite (I and II) and re-precipitation of omphacite III as well as the formation of sodic amphibole.

Within some of the pores amorphous silica-rich material containing smaller amounts of Al, Ca, Fe and Mg, can be found as worm-like precipitates and as coatings on top of the needle-like omphacite surface.

Phase relations, textures as well as overprinting relations clearly show that the porosity is syn-metamorphic under blueschist-facies conditions. Although difficult to constrain in the samples porosity is likely between 1-5 volume%.