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Fast fluid-flow events within a subduction-related vein system in oceanic eclogite: implications for pore fluid pressure at the plate interface

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A better understanding of the subduction zone fluid cycle and its mechanical feedback requires in-depth knowledge of how fluids flow within and out of the descending slabs. In order to develop reliable quantitative models of fluid flow, the general relationship between dehydration reactions, fluid pathway formation, and the dimensions and timescales of distinct fluid flow events have to be explored. The high-pressure/low-temperature metamorphic rocks of the Pouébo Eclogite Mélange in New Caledonia provide an excellent opportunity to study the fluid flux in a subduction zone setting. Fluid dynamics are recorded by high-pressure veins that cross-cut eclogite facies mélange blocks from this occurrence. Two types of garnet-quartz-phengite veins can be distinguished. These veins record both synmetamorphic internal fluid release by mineral breakdown reactions (type I veins) as well as infiltration of an external fluid (type II veins) and the associated formation of a reaction halo. The overall dehydration, fluid accumulation and fluid migration documented by the type I veins occurred on a timescale of 10^5-10^6 years that is mainly given by the geometry and convergence rate of the subduction system. In order to quantify the timeframe of fluid-rock interaction between the external fluid and the wall-rock, we have applied Li-isotope chronology. A continuous profile was sampled perpendicular to a type II vein including material from the vein, the reaction selvage and the immediate host rock. Additional drill cores were taken from parts of the outcrop that most likely remained completely unaffected by fluid infiltration-induced alteration. Different Li concentrations in the internal and external fluid reservoirs produced a distinct diffusion profile of decreasing Li concentration and increasing δ7Li as the reaction front propagated into the host-rock. Li-chronometric constraints indicate that fluid-rock interaction related to the formation of the type II veins and had been completed within ca. 3 years. The short-lived, pulse-like character of this process is in accordance with the notion that fluid flow related to oceanic crust dehydration at the blueschist-to-eclogite transition contributes to or even dominates episodic pore fluid pressure increases at the plate interface which may trigger slip events reported from many subduction zones.