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Exploring new frontiers in fluids processes in subduction zones
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Fast dehydration-related intraslab fluid-flow events: implications for pore fluid pressure fluctuations at the plate interface

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A better understanding of the subduction zone fluid cycle and its chemical-mechanical feedback requires in-depth knowledge of how fluids flow within and out of the descending slabs. Relicts of fluid-flow systems in exhumed rocks of fossil subduction zones allow for identification of the general relationships between dehydration reactions, fluid pathway formation, the dimensions and timescales of distinct fluid flow events; all of which are required for quantitative models for fluid-induced subduction zone processes. Two types of garnet-quartz-phengite veins can be distinguished in an eclogite-facies mélange block from the Pouébo Eclogite Mélange, New Caledonia. These veins record synmetamorphic internal fluid release by mineral breakdown reactions (type I veins), and infiltration of an external fluid (type II veins) with associated formation of a reaction halo. The dehydration and fluid migration documented by the type I veins likely occurred on a timescale of 10^5-10^6 years, based on average subduction rates and metamorphic conditions required for mineral dehydration and fluid flow. In order to quantify the timeframe of fluid-rock interaction between the external fluid and the wall-rock, we have applied Li-isotope chronometry. This approach is based on bulk-diffusion modeling with the advantage that Li represents a trace-element in the solid and the fluid. Lithium fluid-solid exchange has been controlled by dissolution-precipitation processes, and Li transport occurred exclusively in the fluid. 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 δ^7Li 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 had been completed in the order of 1 to 4 months ($0.150^{+0.14}_{-0.08}$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.