Dehydrating slabs - flow structures, mechanisms, rates and some geochemical consequences

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At subduction zones, seawater-altered oceanic lithosphere recycles back into the mantle, heats up during descent and releases fluids by devolatilization of hydrous minerals. Large-scale fluid flow resulting from this dehydration is implicit in recent models for the formation of arc magmas and appears to be linked to intraslab seismicity. However, the mechanisms as well as spatial and temporal scales of this fluid flow are only poorly known. Exposures of veins in oceanic lithosphere, metamorphosed at high pressures in subduction zones, provide direct evidence for fluid mobility within subducting slabs. Based on field observations and electron microscopy data we develop a thermodynamic and fluid dynamic consistent mechanistic model of porosity formation and initiation of intraslab fluid flow. We also quantify the duration of dehydration-related fluid flow through subducting oceanic plates. Using stable (Li, Ca) isotope data combined with Li-diffusion and reaction kinetic modelling, we demonstrate that large amounts of fluid can be transported along major conduits over km distances, in a pulse-like manner through slabs over surprisingly short time periods of hundreds of years. This indicates that even though the overall slab dehydration is a continuous process, dehydrating slabs release their fluid by short-lived, channelized fluid-flow events, involving aseismic mobile hydraulic fractures that rapidly traverse the subducting slabs.