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Exploring new frontiers in fluids processes in subduction zones

Fluids in subduction-zone rocks

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It is now ascertained that fluids are essential to metamorphism. Early seminal work1 shows that without fluids rocks do not react and preserve metastable on a long-term. This is relevant to subduction zones, where fluids affect properties and physical-chemical behaviour of large rock volumes inside the colliding plates. Importantly, fluids affect rock deformation, seismicity and mass transfer in slabs, in the subduction interface and in the mantle wedge. In the last two decades, efforts have been done to identify fluids in eclogite-facies rocks, their migration pathways and interaction with rocks.
Subduction of variably oxidized, volatile- and incompatible element-rich oceanic lithosphere is accompanied by dehydration and decarbonation reactions of various rock types at different P-T conditions. Emphasis has been placed on serpentinized oceanic and fore-arc mantle as volatile and fluid-mobile element repositories, whose dehydration leads to melting of the sub-arc mantle wedge. Devolatilization is frequently accompanied by fluid drainage in vein networks allowing fluid escape from slabs. Veins provide a wealth of information on fluid mobility and composition. Recent work shows that subduction fluid mobility occurs during short-lived pulses (200 years)2. Moreover, fluid production and drainage in veins is driven by fine-scale chemical heterogeneities. The resultant fluid pressure variations at specific microsites force the fluid flow to organize into vein networks at scales ranging from μm to metres3.
HP-UHP veins and rock-forming minerals trap inclusions of coexisting subduction fluids. Omphacite- and olivine-bearing veins in Alpine eclogite and serpentinite host brine inclusions formed by recycling of seawater trapped during the oceanic alteration of rocks4. The analysis of fluid-related inclusions in de-serpentinized metaperidotite unexpectedly revealed abundant halogens and fluid-mobile elements concentrations in the fluid. This fluid, as probably most subduction fluids, transfers to the mantle a hybrid component (serpentine + sediment) uptaken by the original serpentinite by interacting with sediment-derived fluids in the subduction zone. The aqueous fluids released by dehydrating slab lithologies also promote decarbonation or carbonate dissolution in associated sediments, producing COH fluids that can precipitate microdiamond (or graphite) and carbonate5. Slab fluids are reactive with the supra-subduction mantle: the interaction leads to formation of pyroxenite layers that filter the uprising slab melt/fluid to produce solute-rich mobile aqueous fluids. Possible consequence of such reactions is that the mantle overlying the slabs is heterogeneous in composition and veined. Hence, while hydrous melt and/or silicate-rich fluids are important for scavenging incompatible elements from the slab, they may not be the agents transferring the subduction signature to melting region of the subarc mantle wedge. Much work is still necessary to define the physical and chemical process attending rock dehydration, carbonate dissolution, fluid/rock interactions, and to define the potential of subduction fluids in affecting the composition and redox of mantle wedge rocks.

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