Fluid or melt? Constraining the slab component of arc magmas using high-pressure hydrothermal experiments on subducted sediment

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A series of novel hydrothermal piston-cylinder experiments have been performed to determine the composition of representative fluids and fluid/melt/rock interaction in subduction zones. Experiments were conducted under H_2O saturated conditions at 2.2 GPa over a temperature range from 600-750 ºC. The experiments contained synthetic, trace-element-doped pelitic starting material and fractured quartz chips to trap and preserve synthetic fluid/melt inclusions. Pelite residues from the subsolidus experiments (600-650 ºC) consist of a stable mineral assemblage of quartz, phengite, epidote, rutile, garnet, apatite, and zircon. Analysis and quantification of trapped fluid inclusions from these experiments indicate that subsolidus hydrous fluids released from subducted sediments are relatively dilute. The wet solidus for the pelitic starting material is located at 675 ºC (±10 ºC) at 2.2 GPa. At temperatures above the wet solidus, fluid and melt coexist as immiscible phases at least up to 750 ºC, indicating that the second critical end-point for pelitic rocks is located above 2.5 GPa at around 700 ºC. Residue phases in the supersolidus experiments (700-750 ºC) are garnet, rutile, and zircon, which suggest that HREE and HFSE are retained in slab residues, even under conditions of very-high degrees of melting. Nonetheless, Nb is fractionated from Ta during slab melting and dehydration, leading to a high Nb/Ta flux from the slab into the mantle wedge.

The experimental results are used to show that subducting sedimentary rocks do not undergo significant element loss during metamorphic dehydration. Furthermore, the trace-element contents of subsolidus fluids in subduction zones are too low to significantly contribute to arc magmas, regardless of the volume of fluid considered. Instead, sediment-derived melts can completely account for the slab component of arc magmas, which implies that slab surface temperature must be 700 ºC or higher at sub-arc depths.

^{238}U-^{206}Pb geochronology of eclogite-facies metamorphism, Monte Rosa massif, Western Alps, Italy

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High precision ^{238}U-^{206}Pb geochronology of rutile from Qt+Carb+Rt+white mica veins in eclogite boudins and schist and gneiss within the Monte Rosa massif near the Indren glacier, Val di Gressoney, Western Alps, Italy, indicate that eclogite-facies metamorphism may have lasted from 49 to 38 Ma, which is contemporaneous with eclogite-facies metamorphism in the structurally overlying Zermatt-Saas ophiolite. The veins in eclogite are usually oriented at high angles to the long axis of the boudins and are likely synchronous with boudinage of more coherent tracts of metabasite. The veins in eclogite cross-cut eclogite facies minerals with little or no associated retrogression, suggesting that vein formation occurred under eclogite-facies conditions. Veins near the boudin necks typically contain inclusions of surrounding schist and gneiss, texturally linking them with the eclogite boudins. The age data indicate that the emplacement of the veins, likely associated with fluid pulses, represents a possible age range of eclogite facies conditions of the metabasic boudins as well as the schist and gneiss. Rutile-clinozoisite pairs from assemblages within eclogite-facies metagabbro boudins unfortunately have insufficient spread in $^{206}Pb/^{204}Pb$ to yield meaningful ages, likely reflecting the low U/Pb ratios of the basic protoliths.

Near the terminus of the eastern Lys glacier, upper Val di Gressoney (~6 km west of the Indren glacier), metabasic boudins typically contain greenschist-facies minerals with locally preserved eclogite-facies assemblages. Tension veins in these metabasic boudins are texturally similar to those near the Indren glacier but are typically composed of Qt+ Carb+Ttn+Amp+white mica. U-Pb data from Ttn-Carb and Ttn-Amp pairs from two samples ~10 m apart yield $^{206}Pb/^{204}Pb$ ratios within error of each other, indicating that the fluid that deposited the veins, presumably after eclogite-facies metamorphism, had a very low U/Pb ratio. The initial $^{206}Pb/^{204}Pb$ and $^{207}Pb/^{204}Pb$ ratios of these veins suggest local variability in the Pb isotope composition of vein producing fluids, perhaps indicating that the fluids were derived from sources proximal to the veins.