H_2O Subduction Beyond Arcs

Award: MARGINS-Related

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The amount of H_2O subducted to postarc depths dictates such disparate factors as the generation of arc and back-arc magmas, the rheology of the mantle wedge and slab, and the global circulation of H_2O. Perple_X was used to calculate phase diagrams and rock physical properties for pressures of 0.5–4.0 GPa and temperatures of 300–900°C for a range of bulk compositions appropriate to subduction zones. These data were merged with global subduction zone rock fluxes to generate a model for global H_2O flux to postarc depths. For metasomatized igneous rocks, subducted H_2O scales with bulk rock K_2O in hot slabs. Metasomatized ultramafic rocks behave similarly in cold slabs, but in hot slabs carry no H_2O to magma generation depths because they lack K_2O. Chert and carbonate are responsible for minimal H_2O subduction, whereas clay-rich and terrigenous sediments stabilize several hydrous phases at low temperature, resulting in significant postarc slab H_2O flux in cold and hot slabs. Continental crust also subducts much H_2O in cold slabs because of the stability of lawsonite and phengite; in hot slabs it is phengite that carries the bulk of this H_2O to postarc depth. All told, the postarc flux of H_2O in cold slabs is dominated by terrigenous sediment and the igneous lower crust and mantle and is proportional to bulk rock H_2O. In contrast, in hot slabs the major contributors of postarc slab H_2O are metasomatized volcanic rocks and subducted continental crust, with the amount of postarc slab H_2O scaling with K_2O. The Andes and Java-Sumatra-Andaman slabs are the principal suppliers of pelagic and terrigenous sediment hosted H_2O to postarc depths, respectively. The Chile and Solomon arcs contribute the greatest H_2O flux from subducted continental and oceanic forearc, respectively. The Andean arc has the greatest H_2O flux provided through subduction of hydrated ocean crust and mantle.

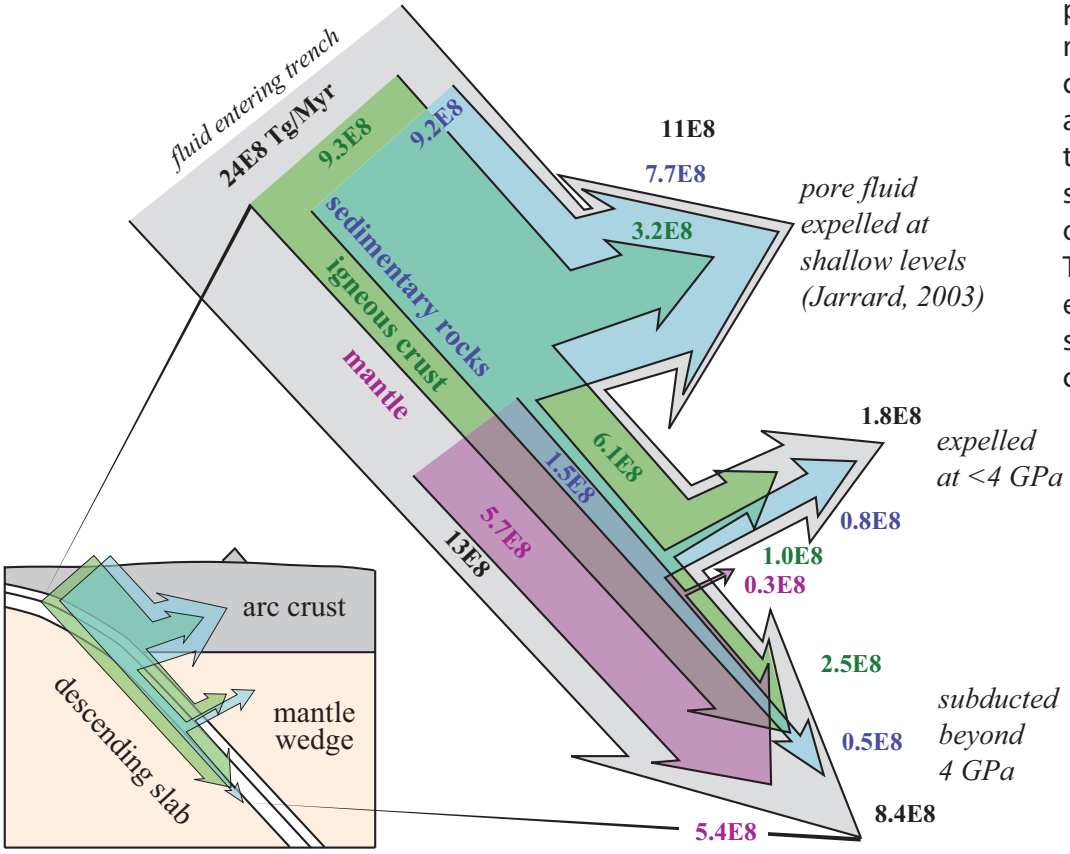

Figure: Global H_2O flux from trench to postarc depths for oceanic lithosphere. Widths of arrows are scaled to flux magnitudes (Tg/Ma). Of the H_2O subducted at trenches in oceanic lithosphere (24E8 Tg/Ma), 46% is driven off by the closure of pores (11E8 Tg/Ma), another 19% (4.6E8 Tg/Ma) is driven off by devolatilization at pressures <4 GPa, and 35% (8.4E8 Tg/Ma) reaches postarc depths.

Hacker, B.R., 2008, H_2O subduction beyond arcs, Geochemistry, Geophysics, Geosystems, v. 9, doi:10.1029/2007GC001707.