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Subduction Gauntlet Revisited

JACKIE E DIXON

University of South Florida

Presenting Author: jdixon@usf.edu

The ‘subduction factory’ describes processes by which raw materials (downgoing slab as input) are processed (metamorphism and dehydration) to produce hydrous fluids/melts and ultimately arc magmas (outputs). The archetypal subduction factory is dominated by fluid/melt metasomatism of the mantle wedge at slab surface depths shallower than 120 km. Evidence now supports extending the subduction factory well beyond 120 km to include at least two additional ‘processing stations’ at: (1) ~200 km, where carbonated sediments may melt, and (2) ~410 km, where carbonated eclogite may melt. Compositions of the resulting supercritical fluids are consistent with those observed in diamonds from the deep upper mantle and transition zone. Metasomatized supra-subduction mantle evolves over time. Station 1 gives EM-type compositions; Station 2 gives enriched HIMU-type compositions.

Slab volatiles and their stable isotopes are decoupled from lithophile elements during subduction by complex dehydration/rehydration processes related to slab thermal parameters. In slower/hotter slabs, dehydrated sediments and igneous crust will preserve the low volatile contents and light stable isotopic signatures created by a combination of dehydration (shallow, beneath forearc) and hydrous melting (beneath arc). In faster/colder slabs, sediments and igneous crust that have undergone near-complete shallow dehydration will have water concentrations increased and hydrogen isotopic compositions restored by addition of fluids derived from deep dehydration of subcrustal serpentine with “arc”-like hydrogen isotopic compositions.

Incipient melts form easily fusible veins of pyroxenite as they migrate through and react with mantle peridotite above the slab. These metasomatized regions get further stretched and mixed into ambient mantle during convection, either in the lower mantle, where they may pick up a high $^{3}He/^{4}He$ signature through interaction with the ULVZ, or in the upper mantle, where they retain their low $^{3}He/^{4}He$ signature. Subsequent redistribution of these components occurs via migration of low degree partial melts in the wings of the upwelling MORB melting regime or at the interface between the low-velocity zone and the cooling oceanic lithosphere. Thus, with the exception of the high-$^{3}He/^{4}He$ mantle rooted within Ultra Low Velocity Zones at the core-mantle boundary, the entire mantle is influenced by varying contributions of fluids/melts derived from the subducting slab.