Extended Subduction Factory Model for Generation of Mantle Heterogeneity

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I present a model for formation of EM- and PREMA-type mantle heterogeneities based on insights from volatiles and light stable isotopes in MORB and OIB involving an expanded subduction factory with melting at key depths of:

- Zone 1: (shallower than 120 km) Mantle wedge sources of arc and back-arc magmas are generated by addition of subcritical fluids and melts of the dehydrating subducting slab to depleted upper mantle peridotite.
- Zone 2: (180 to 280 km) EM-type mantle compositions may be generated above slabs with average to hot thermal profiles by addition of carbonated sediment-derived supercritical fluids/melts to depleted asthenospheric or subcontinental lithospheric mantle. The observed range in EM-type fluid end-member H_2O/Ce is consistent with estimates of slab surface temperature of ~950-1100°C. Lighter δD values in EM-type mantle sources are associated with lower H_2O/Ce and higher temperatures of formation.
- Zone 3: (410 to 660 km) PREMA-type mantle sources are generated, above slabs with average to cool thermal profiles, by addition of carbonated eclogite- and sediment-derived supercritical fluids to depleted mantle. Colder slabs may also produce melts if slab deflection allows additional warming. Heavy δD_{SMOW} in PREMA end-member fluids requires involvement of surface-derived water from deep dehydration of subcrustal hydrous minerals. The limited range and heavy stable isotopic compositions of PREMA end-members and their similarity to antigorite suggests that fluxing by deep fluids in cool to cold slabs is essential to initiate melting of dehydrated igneous crustal materials within the transition zone or that dehydrated hot slabs are unlikely to subduct past 410 km.

The proposed model does not exclude mixing of “raw” recycled crustal materials into depleted mantle, however, creation of mantle sources through addition of incipient recycled crustal melts facilitates broad transport of heterogeneities by stretching and mixing in ambient mantle during convection, either in the lower mantle, where they may pick up a high $^3He/^4He$ signature, or in the upper mantle, where they retain their low $^3He/^4He$ signature.