A Petrologic Model of the Galápagos Plume

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The Paradoxes

Many Galápagos basalts are more depleted than GSC lavas within 400 km

Helium does not get to the ridge. Sr, Nd, Pb, and Hf do.

Galápagos water gets to the ridge. Cannot tell if CO₂ does or not.

Our Hypothesis

Carbonate Solidus

Hydrous Solidus

The Model

We propose a multi-stage melting and mixing model to explain the paradoxical geochemical features of the Galápagos region and the seismic observations:

1. A low degree carbonate melt is produced at 300 to 400 km depth. This melt creates slow seismic velocities and strips the residue of the most highly incompatible trace elements (e.g. He).
2. The residue, depleted in He and CO₂ but not Sr, Nd, Pb, or H₂O, is carried to the GSC by return flow.
3. The carbonate melt segregates from the source and mixes with a shallower silicate melt.
4. Removal of hydrogen from olivine at ~ 100 km depth creates relative fast seismic velocities.
5. The northern Galápagos volcanoes, which have more depleted geochemical signatures than GSC basalts in the region, derive from mantle that underwent melting at the GSC.

Seismic Constraints

Hydrous solidus

Carbonate solidus

55 km depression of solidus for 150 ppm H₂O

We propose that this incipient carbonate melt segregates, ascends vertically, and mixes with a shallower silicate melt.

Although the problem is not well constrained, the trace element composition of Ferroanite basalt is consistent with mixing between a low-degree carbonate melt and 0.1% melt of depleted mantle in the garnet facies. It is possible that in addition to producing the low seismic velocities, this initial phase of melting also strips the residue of He.