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Several plume 'paradoxes' can be resolved by a plume-fed asthenosphere

J. Phipps Morgan (1) and W. J. Morgan (2)

(1) Cornell University, USA, (2) Harvard University, USA

Both Fitton's 'OIB paradox' and Anderson's 'Helium-paradoxes' have simple resolutions if the Mid-Ocean Ridge Basalt (MORB) source is in fact plume-fed asthenosphere. Fitton's Ocean Island Basalt (OIB) paradox can be restated as the observation that typically EMORB (Enriched-MORB) have OIB (e.g. plumelike) chemical fingerprints, often without an obvious nearby plume source. This 'paradox' can be resolved if the OIB fingerprints are due to preferential melting of lower-solidus components that are typically present as lithologic layers in all mantle upwelling in plumes and whose incompatible elements are typically extracted by deep plume melting. If the the asthenosphere is plume-fed, those lower-solidus components that survive plume upwelling without melting to form OIB (for example, by upwelling in the cooler rim of a plume) can then migrate horizontally to ascend beneath a mid-ocean ridge, where they melt to produce E-MORB flavors as discussed in Phipps Morgan and Morgan (1999).

Compilations of the ratios of rare gas abundances in OIB and MORB show complementary ratios of helium relative to the heavier noble gases - ratios in OIB of He/Ne, He/Ar, He/Kr, and He/Xe are consistently lower than ratios in MORB which has a relative surplus of helium. This is evident in observations of 3He/22Ne (both stable, primordial isotopes) and 4He/21Ne (both produced by the decay of U and Th) and also 3He/36Ar (stable) and 4He/40Ar (radiogenic). This evidence conflicts with mantle evolution models that invoke isolated, distinct, long-lived reservoirs as the sources of OIB and MORB but not with our proposed model. A mechanism to preferentially retain helium in residues of OIB melt-extraction (which later melts to produce MORB) is as follows. The mantle has He-rich components that at both extremes of the mantle He-isotope spectrum (Highest 4He/3He in incompatible-element-rich lumps; Lowest 4He/3He in He-poor depleted residues of previous cycles and He-rich streaks of the most ‘primordial’ mantle) and mantle components are typically layered at a fine-enough (< 1 km) scale where He-diffusion between components can be an important transport mechanism over Ga mantle residence times. Helium diffuses orders of magnitude faster than the heavier noble gases. During mantle stirring and plume ascent helium (both 3He and 4He) partially diffuse from the ‘lumps’ of primordial or highly enriched material (high in U and Th among other LIL’s) into the more refractory material surrounding these lumps whereas the heavier noble gases do not. When the easier-to-melt lumps melt to make OIB, their gases have a deficiency of helium because this has diffused out. During more extensive melting at mid-ocean ridges, some refractory material into which helium but not heavier gases of the enriched-low solidus lumps had diffused melt to produce an excess of helium in MORB. Furthermore, correlations between helium and other radiogenic isotopes at Iceland and the Galapagos imply that the mantle upwelling and melting at plumes is more incompatible element-rich and 4He/3He-low than the typical asthenospheric leftovers to plume melt-extraction when they melt a second time beneath a mid-ocean ridge.