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Reservoirs of Undegassed Material in the Deep Mantle and the Origin of Mantle Plumes

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The large scattering in the isotopic Helium ratio (^{4}He/^{3}He) observed in Ocean Island Basalts (OIB) suggests that the plumes at the origin of OIB sample several reservoirs. The low values (< 30000) of the Helium ratio indicates that OIB sample an undegassed reservoir. Its lowest value, around 15000, imposes a constraint on the entrainment of primitive material by plumes, which should not exceed 10%. Numerical experiments of thermo-chemical convection in 3D-Cartesian and spherical geometries showed that reservoirs of primordial material can be maintained at the bottom of the system, the shape and stability of these reservoirs depending on the chemical density contrast and on the thermal viscosity contrast. In addition, plumes are generated at the top of these reservoirs, entraining small fraction of primordial material up to the surface. Numerical experiments showed that this entrainment quantitatively agrees with OIB data, with values around 9%. The location of the undegassed reservoirs is still a matter of debate. Images of slabs penetrating in the deep mantle indicate that the lower mantle itself is not isolated. The undegassed reservoirs may instead consist of pools of chemically distinct material located in the lowermost mantle. Possible candidates for these pools are the low shear-wave velocity provinces (LLSVP) observed by seismic tomography. Additional observations, including the anti-correlation between shear- and bulk-sound velocity anomalies, show that these structures are caused by large scale thermo-chemical anomalies. The exact nature of the chemical component of these anomalies is still unclear, two end-members hypotheses (namely the recycling of MORB by subduction, and the survival of primordial deep reservoirs) being usually advocated. The combination of mineral physics data and global tomographic models shows that LLSVP are better explained by material enriched in iron and silicates than by high pressure MORB, unless these LLVSP are hotter than the average mantle by about 1500 K. Slabs may however reach the bottom of the mantle and numerical models of thermo-chemical convection have shown that they can accumulate there, in which case OIB plumes may also sample high pressure MORB. A full explanation of lowermost mantle tomography and OIB signatures thus requires two chemical sources, recycled MORB and primordial reservoirs.

Deschamps, F., E. Kaminski and P. J. Tackley (2011) The deep origin for the primitive signature of ocean island basalt, Nature Geoscience 4, 879-882, doi:10.1038/ngeo1295.

Deschamps, F., L. Cobden and P. J. Tackley (2012) The primitive nature of large low shear-wave velocity provinces, Earth Planet. Sci. Lett. 349-350, 198-208