5.1.P18

Origin of moderate HIMU source in the Canary Islands: New limits from Nd-Hf-Sr-Pb isotope data

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Ocean island basalt (OIB) with $^{206}Pb/^{204}Pb$ > 20.5 (e.g., Tubai, St. Helena) require evolution of a mantle reservoir with high $^{238}U/^{204}Pb$ (μ>20) over at least 1.5 Gyr. Vidal [1] recognized a second group of HIMU volcanoes, including the Canary Islands, with less radiogenic Pb that requires a source with similarly high U/Pb but shorter mantle residence time (≈0.5 Gyr). We analyzed samples from the Canary Islands (CI) for Nd, Hf, Sr, and high-precision Pb isotopes to determine if a hypothesis of relatively short mantle-source residence time to develop moderate HIMU is compatible with other radiogenic isotope systems.

We studied the westernmost islands of El Hierro, La Gomera and La Palma to minimize complications from interaction with African crust. Measured $^{206}Pb/^{204}Pb$ range from 19.5 to 20.0. Nd, Hf and Sr isotope ratios are strongly correlated and restricted to ε_{Nd} and ε_{Hf} values of 4.5 to 6.5, and 6.0 to 9.0, respectively.

Based on early Hf-Nd analyses of OIB [2,3] it was suggested that compared to other oceanic basalt, HIMU basalts may have relatively low ε_{Hf} for a given ε_{Nd}. With data on >1800 oceanic basalt samples that now define the mantle array and our 45 Hf-Nd analyses from CI, relatively low Hf isotope composition apparently is a robust characteristic of both moderate and extreme HIMU basalts.

The HIMU mantle source may be attributed to ancient recycled oceanic crust. We tested 2-stage models of differentiation, subduction and storage of oceanic crust (N-MORB, E-MORB, altered MORB). For μ-values typical of oceanic crust, the CI moderate HIMU source is restricted to relatively short mantle residence times of 0.7 to 1.0 Gyr. Evolution to isotopic compositions below the Hf-Nd mantle array is qualitatively consistent with Sm/Nd and Lu/Hf typical of oceanic crust; however, only parent-daughter ratios observed in E-MORB reproduce the field observed for the Canary Islands. Modeled mantle resi-dence times range from 0.5 to 1.5 Gyr, partly overlapping ages calculated from U-Pb systematics. The small overlap implies a constrained range of possible parent/daughter ratios in each of the two stages and either enriched MORB or oceanic plateau as the recycled crustal component.

References

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5.1.P19

Solubility controlled noble gas fractionation during magmatic degassing

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Noble gas abundances in basaltic glasses from ocean islands (OIBs) are generally lower than those of mid-ocean ridge basalts (MORBs), contrary to most geodynamic models which usually require that the source of OIBs is less degassed and more trace element enriched than the MORB source. Therefore, noble gas abundances in OIBs are often thought to have been reduced by extensive gas loss from the magma prior to eruption.

The extent of magmatic degassing can be tested as it will cause characteristic changes in the composition of the volatiles; notably the 4He/40Ar* ratio (where 40Ar* is 40Ar corrected for atmospheric contamination) will increase in residual volatiles due to the higher solubility of He relative to Ar. The degree of He-Ar fractionation for a given fraction of gas loss depends on the ratio of the solubilities, SHe/SAr, which is sensitive to (among other things) the CO2 and H2O content of the basalt at the time of degassing.

From a global database of MORB and OIB glasses, we show that 4He/40Ar* ratios of MORB glasses are broadly consistent with degassing of a magma with an initial 40Ar* of ≈7 x 10-5 ccSTP/g, i.e. similar to that of the “popping rock”. However, OIB glasses consistently have lower 40Ar* concentration for a given 4He/40Ar*. While this would appear to require lower 40Ar* abundances in the undegassed OIB magmas, the higher volatile contents of OIBs will reduce SHe/SAr (relative to MORBs) during degassing. By modelling SHe/SAr in OIBs, it is possible to show that extensive degassing of OIBs can occur without dramatically increasing the 4He/40Ar* ratio. We show that undegassed 40Ar concentrations of OIB magmas were probably similar to those of MORBs.