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Ancient Oceanic Plateaus in the Source of EMI Basalts: Evidence from Sardinian Basalt Geochemistry

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Extending the applications of Os, Hf, and particularly O isotopic systems to oceanic basalts is moving mantle geochemistry out of the component taxonomy of the 80's. Consistent geochemical evidence now indicates that the source of Hawaiian basalts contains the entire spectrum of the igneous section of ancient oceanic crust including the associated sediments. Here we address the problem of the nature of the rare EMI-type component, previously known from Pitcairn and the Walvis Ridge basalts, and now in its most extreme form from the Pliocene Logudoro basalts in Sardinia.

The Logudoro volcanics are nearly aphyric, very low Ca/Al basalts with an overall enrichment in incompatible trace elements. The Sr, Nd, and Hf isotopic properties indicate that their mantle source is very mildly enriched. Excess of a plagioclase component in the source is demonstrated by prominent Sr, Ba, and Pb excess and by very low U/Pb and Th/Pb as recorded by nonradiogenic Pb isotopic compositions plotting to the left of the geochron. The plagioclase excess is also supported by contrasting oceanic mantle Nb/U values (48) and low Ce/Pb values (15). Such multiple evidence suggests that the source of the Logudoro basalts, just as that of a few Hawaiian basalts (Sobolev et al., in press), contains ancient metagabbros. The absence of a Nb anomaly as well as the Pb isotopic array and the close isotopic similarity with basalt drilled in the Thyrrhenian sea at Site 654 indicate that contamination by the local continental crust is not important.

The Logudoro volcanics are part of the EMI clan. They are very similar to Pitcairn (Woodhead and McCulloch, 1989) and Walvis Ridge basalts. The protoliths of these different volcanic provinces differ in that Logudoro has a strongly cumulative signature whereas Pitcairn resembles a more normal magmatic liquid as evidenced by Sr, Ba, and Pb. A first interpretation of the EMI component would call for a source in the subcontinental lithospheric mantle (M^c^Kenzie and O'Nions, 1983). Plagioclase, however, is not at the liquidus of basalts at pressures below the continental Moho. A second interpretation calls for the presence of pelagic sediments in the source (Chauvel et al., 1992). However, the Nb/U ratios typical of the oceanic mantle and the lack of a shallow Hf-Nd isotope correlation do not support this view.

A key parameter of the EMI volcanics is their high Th/U ratios (4.0-4.5). Such elevated values are not consistent with a source made of oceanic crust (2.5). Likewise, the mildly enriched character of Sr, Nd, and Hf also rules out such a source composition. High Th/U ratios are characteristic of hotspot basalts. Since the volume of plume heads by far exceeds that of the tail, we conclude that EMI basalts recycle the cumulative and effusive sections of ancient oceanic plateaus. Shallow structures such as plateaus constitute up to 10 percent of the modern seafloor. It can therefore be anticipated that recycled plume material is a ubiquitous component of the mantle recipe. In particular, such a component may help close the inventory of heat-producing elements with respect to heat flow (Kellogg et al., 1999).

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