Osmium isotopic signature of EM1 deduced from Rarotonga Island, Polynesia

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The geology of French Polynesia (i.e., the South Pacific Superswell) is a distinctive region that has generated considerable debate on the causes of ocean island volcanism and, by extension, mantle dynamics and the existence or non-existence of mantle plumes. Rarotonga (Cook/Austral chain) and Pitcairn Island (Gambier chain), separated by approximately 1200 km, are distinct in the South Pacific in that they both have an EM1 mantle component. Here we present new Os data for Rarotonga and, in conjunction with published isotopic data, present a revised value of the EM1 osmium signature.

Osmium concentrations in lavas range from 2 to 126 ppt and are typical of those found in ocean island basalts (OIB). The measured Os isotope ($^{187}Os/^{188}Os$) compositions range from 0.129 to 0.277. When $^{187}Os/^{188}Os_{initial}$ and 1/[Os] are compared, they form a broad positive array and samples with higher Os concentrations (> 25 ppt) show a limited range of $^{187}Os/^{188}Os$ ratios (mean = 0.133 ± 0.006), while those with low Os (< 25 ppt) display variable and relatively radiogenic Os isotopic compositions ($^{187}Os/^{188}Os_{initial}$ = 0.129 - 0.271). This increase of radiogenic Os with decreasing Os concentrations in OIB has been ascribed to assimilation of a radiogenic component by a melt in the crust or lithosphere or by mixing between radiogenic and unradiogenic mantle components. It is clear that Rarotonga (this study) and Pitcairn (Eisele et al., 2002) have virtually identical Os isotope signatures. These values also concur with their argument that previously accepted values for EM1 of $^{187}Os/^{188}Os$ = 0.15 (Reisberg et al., 1993; Schiano et al., 2001) are too high and are probably due to shallow level processes. Therefore a more realistic value of 0.13 should be accepted for EM1. Our data suggests that the Os isotopic signature of Cook-Austral can be explained by mixing between EM1 and HIMU, which is inconsistent with the conclusion by Schiano et al. (2001) that the island chain shows the mixing of Bulk Silicate Earth and HIMU.

Endogenous growth: It’s role in the formation of internal pathways and the emplacement of mafic flow fields

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Endogenous growth is the most important process underpinning the emplacement of mafic pahoehoe lava flow fields. Such flow fields consist of numerous lobes characterized by flow features which are indicative of thermally insulating lava transport and lobe inflation (i.e. lava tubes, tumuli, lava-rise plateaus, etc.). The key constituents of these flow fields are pahoehoe sheet lobes, which exhibit a three-part structural division, viz a vesicular basal crust, a crystalline lava core, and a vesicular upper crust. These structural subdivisions have been shown by studies of the currently active Pu’u O’o-Kupaianaha pahoehoe flow field in Hawaii, to correspond to the bottom crust, the molten core, and the upper surface crust of an actively inflating sheet lobe. Moreover, field evidence demonstrates that upper crusts of considerable thickness (20-50% of final lobe thickness) are formed during lobe emplacement and inflation.

In pahoehoe flows, lava is transported via internal pathways beneath a coherent stationary crust, whose insulating properties reduce cooling rates to <1°C/km. Observations show that lava tubes and tumuli are the products of the localisation of lava flow along preferred internal pathways during lobe inflation. Initially, sheet lobes are emplaced as thin inflating flat-topped sheets onto an undulating substrate. Lava flux in the sheet lobe interiors is variable and highest above substrate depressions. Continued inflation and radial cooling of the lobes result in the locus of flow being progressively concentrated in these regions of high flux. Eventually, the flow of lava is restricted to a few preferred pathways that feed lava to the steadily advancing flow front. As the lava breaks out of the pathways at the flow fronts new lobes are formed and immediately sealed by insulating crust, and then grow in thickness and length by the process of inflation. Ultimately, a new extension of the lava pathway is developed and the process described above is repeated.

This process of lobe-by-lobe advance, inflation, and pathway formation is responsible for the emplacement of the largest pahoehoe flow fields on Earth, and it is accomplished without significant heat loss from the lava, and does not require high lava flux rates and cataclysmic eruptive dynamics. The volcanic architecture of mafic pahoehoe flow fields is remarkably similar to that of ancient komatiites.