Os isotope systematics in the Canary Islands

E. Widom *NIST, Gaithersburg MD 20899 USA.*
K. Hoernle *UC-Santa Cruz, Santa Cruz, CA 95064 USA*
S.B. Shirey *Department of Terrestrial Magnetism, CIW, Washington DC 20015 USA.*

H-U. Schmincke *GEOMAR, Kiel, Germany.*

Introduction

Os isotope ratios have now been measured in basalts from at least 30 oceanic islands from 12 different archipelagos [1-3, and this study]. These data display surprisingly large variations in $^{187}Os/^{188}Os$ from 0.122 to 0.206, with much of this range being observed in single oceanic chains and even individual islands. The represented islands include a large range of compositions in terms of Sr-Nd-Pb-He isotope systematics, but direct correlations of Os isotopes with the other isotope systems have been difficult and inconclusive. This is due largely to the low Os concentrations in many of the oceanic basalts and their propensity for crustal contamination during ascent, and in part to uncertainties in age and blank corrections. However, despite the scatter in the data base, the Os isotope systematics suggest that many of the oceanic basalts are derived from mantle sources with higher than chondritic $^{187}Os/^{188}Os$ ratios [e.g. 4]. It has been further observed that the HIMU basalts have the most radiogenic Os isotope ratios, which has been attributed to the involvement of radiogenic recycled oceanic crust [2].

With these observations in mind, we initiated an Os isotopic study of basalts from the Canary archipelago. The Canary Islands were chosen for several reasons, including the occurrence of historic or Holocene basalts across the chain, which minimizes the need for age correction; the location of the island chain on old, thick oceanic lithosphere (160–180 Ma) with up to 10 Km of sediment underlying the eastern-most islands, which provides the opportunity to evaluate the effect of shallow level processes on Os isotope systematics; and the mixing relationship between a HIMU plume and depleted and EM-rich upper mantle sources inferred from the Sr-Nd-Pb systematics [5] allows further assessment of the effect of recycled oceanic crust in the HIMU source on Os isotope systematics.

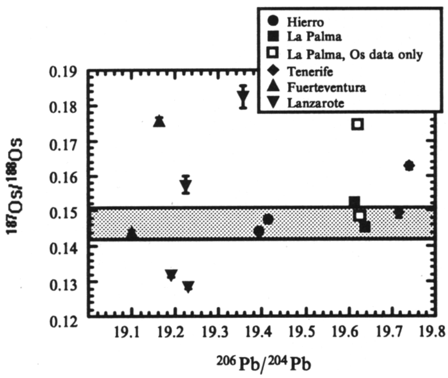

FIG. 1.

Results

We have analyzed 14 samples from 5 islands in the Canaries (Hierro, La Palma, Tenerife, Fuerteventura and Lanzarote), which range in composition from basanite to alkali basalt to tholeiite. The selected samples are all mafic with MgO > 8% and Ni > 110 ppm, in order to minimize the effects of crustal contamination. Samples were processed by the newly employed carius tube method [6], which enabled us to use small samples (2 to 3 gm) and greatly improved spike-sample equilibration over previous bomb digestion techniques. 2-σ uncertainties in the $^{187}Os/^{188}Os$ ratios are 0.5–0.7% for 10 samples, with the other 4 ranging up to 1.7%.

Os concentrations range from 22 to 171 ppt, and display a positive correlation with MgO and Ni. The $^{187}Os/^{188}Os$ ratios show a large range from 0.129 to 0.183. In general the Os isotope ratios increase with decreasing Os concentration, although in detail the relationship is more complicated. Six of the Canaries samples, with Os concentrations between 37 and 120 ppt Os, fall within a narrow range of $^{187}Os/^{188}Os$ ratios from 0.144 to 0.149. Notably, this group represents 4 of the 5 islands analyzed, spanning a range in $^{206}Pb/^{204}Pb$ from 19.10 to 19.74, and including the two western-most islands Hierro and La Palma, the middle island Tenerife and one of 2 eastern-most islands, Fuerteventura (Fig. 1). Six other samples, four of which have Os concentrations ≤30 ppt, have $^{187}Os/^{188}Os$ ratios of greater than 0.157, and may have been affected by crustal contamination. As little as 0.2% contamination with Mn-oxide during ascent through the volcanic pile could explain the range of high Os isotope ratios in these basalts. The two highest Os concentration samples are from Lanzarote, and have the lowest $^{187}Os/^{188}Os$ ratios of 0.129 and 0.132. These include a basanite and alkali basalt (respectively) from the 1730-36 eruption which was zoned from nephelinite-basanite-alkali basalt-tholeiite, and included abundant peridotite xenoliths. We attribute the relatively low Os isotope ratios in these two basalts to interaction with upper mantle peridotite.

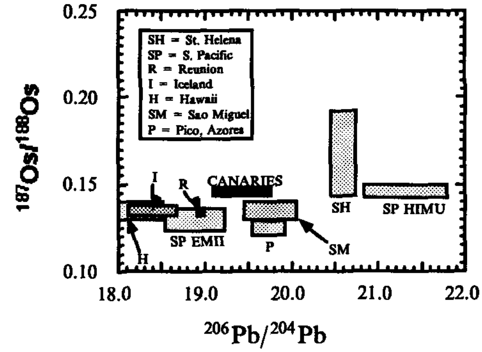

FIG. 2.

Conclusions

The observation that the lowest $^{187}Os/^{188}Os$ ratios for 4 of the 5 islands analyzed fall within the narrow range of 0.144 and 0.149 suggests that this signature is characteristic of the Canaries plume. Although this ratio is higher than that measured in many OIBs such as those from Hawaii, Iceland, Reunion, Samoa and the Azores, it is comparable to the values determined for the South Pacific HIMU islands and St. Helena (Fig. 2). The HIMU signature in some of the Canary Islands is fairly strong with $^{206}Pb/^{204}Pb$ ratios of up to 19.74, but it is relatively diluted in others, with $^{206}Pb/^{204}Pb$ ratios as low as 19.10, suggesting that the $^{187}Os/^{188}Os$ ratio of 0.14 is, at least in the Canaries, independent of any HIMU component. Taken together, the data from the various island groups suggests that the Os isotope signature is decoupled from the other isotope systems, and it is probably not realistic to explain the high Os isotope ratios in some HIMU islands in terms of simple mixing of recycled oceanic crust into the asthenospheric mantle.

The low $^{187}Os/^{188}Os$ ratios of 0.129 and 0.132 found in the peridotite bearing Lanzarote lavas suggests that the lithospheric mantle in this region is characterized by $^{187}Os/^{188}Os$ ratios similar to or depleted relative to chondritic, consistent with results from abyssal peridotites [4] and continental lithospheric mantle xenoliths [7,8]. This implies that the shallow upper mantle is not a likely source of the radiogenic Os isotope ratios measured in most ocean islands, but rather that the source is deeper, perhaps the lower mantle.

References

[1] Reisberg, L. (1993) *Earth Planet. Sci. Lett.* **120**, 149–67.
[2] Hauri, E.H. and Hart, S.R. (1993) *Earth Planet. Sci. Lett.* **114**, 353–71.
[3] Widom, E. *et al.* (1993) *IAVCEI abstr.*, Canberra.
[4] Martin, C.E. (1991) *Geochim. Cosmochim. Acta* **55**, 1421–34.
[5] Hoernle, K.A. *et al.* (1992) *EOS* **73**, 654.
[6] Shirey, S.B. and Walker, R.J. (1994) *AGU abstr.*, Baltimore.
[7] Walker, R.J. *et al.* (1989) *Geochim. Cosmochim. Acta* **53**, 1583–95.
[8] Pearson, D.G. *et al.* (1991) *EOS* **72**, 527.