

Hafnium isotope stratigraphy of Mauna Loa and Mauna Kea lavas from the Hawaii Scientific Drilling Project core

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We report Hf isotope compositions obtained by plasma-source mass spectrometry (the Fisons Instruments Plasma 54 in Lyon) for 8 Mauna Loa and 45 Mauna Kea lavas (plus 12 duplicates) recovered by the Hawaii Scientific Drilling Project (HSDP). The samples span the entire 1-km drill core from 74 to 1052 m and range in age from *c.* 1–100 ka for Mauna Loa and 200–400 ka for Mauna Kea. The Sr, Nd, Pb, He, and Os isotope compositions of the HSDP samples were previously measured by Hauri *et al.* (1996), Kurz *et al.* (1996), and Lassiter *et al.* (1996), leaving $^{176}\text{Hf}/^{177}\text{Hf}$ as the last of the radiogenic isotope variables to be determined.

Mauna Kea Hf isotope systematics

Our data agree well with the much smaller data set of Stille *et al.* (1986). The Mauna Kea lavas show a gradual shift over time (*i.e.* increasing stratigraphic height) toward more radiogenic $^{176}\text{Hf}/^{177}\text{Hf}$ ratios (Fig. 1). This is consistent with observations for $^{143}\text{Nd}/^{144}\text{Nd}$ of the same samples (Lassiter *et al.*, 1996) (Fig. 1). The overall trend of the source characteristics therefore is that of a change toward a more depleted composition. The alkalic lavas occurring at the uppermost 50 m of the Mauna Kea section are, just as for Nd, isotopically indistinguishable from the underlying tholeiitic lavas (Fig. 1), confirming that differences in melting regime rather than source composition dominated at this stage in the evolution of the Mauna Kea volcano. The long-term rate of isotopic evolution of the volcano does not seem to be correlated with the nature of erupted basalts. While Hf isotope compositions for the Mauna Kea section as a whole are variable, ranging from 0.283093 to 0.283143 for $^{176}\text{Hf}/^{177}\text{Hf}$ (corresponding to ϵ_{Hf} of +11.4 to +13.1), the top 100 m are remarkably homogeneous with ϵ_{Hf} varying by less than 0.3 units (Fig. 1). By contrast, the lower part of the section displays considerably more Hf isotopic variability (Fig. 1). While most replicates reproduce well within error, a few differ by almost one ϵ_{Hf} unit, which is a factor two or three more than the external reproducibility of $\pm 0.3 \epsilon_{\text{Hf}}$ units repeatedly observed

for replicate sample dissolutions. We suspect that these samples may have been variably contaminated during coring. The higher resolution at the bottom of the core, which we sampled more densely to check for different time scales of isotopic evolution, does not provide evidence for significant short-term isotopic fluctuations.

Mauna Loa Hf isotope systematics

The transition at about 280 m between Mauna Kea and Mauna Loa lavas is, as for all other petrological and geochemical parameters, conspicuous and defined by an abrupt drop in Hf isotopic composition of 1.4 ϵ_{Hf} units (from +12.9 to +11.5) relative to the homogeneous depleted uppermost lavas of Mauna Kea (Fig. 1). Again, the Hf isotopic signature is mirrored by that of Nd (Hauri *et al.*, 1996) (Fig. 1). As for Mauna Kea, Hf isotopic compositions are variable, spanning $^{176}\text{Hf}/^{177}\text{Hf}$ values from 0.283068 to 0.283099 (corresponding to ϵ_{Hf} of +10.5 to +11.6). While the lowermost 50 m of the Mauna Loa section are isotopically homogeneous, a drop to ϵ_{Hf} of +10.5 occurs at *c.* 60 m above the contact to the Mauna Kea section followed another 60 m up-section by a return to the previous value of ϵ_{Hf} of +11.5, which in turn is followed 75 m further up the pile by yet a drop to ϵ_{Hf} of +10.9 (Fig. 1). These repeated shifts toward a more enriched source composition for Mauna Loa are matched exactly by the corresponding Nd isotopic data (Hauri *et al.*, 1996) (Fig. 1).

Discussion

Although being isotopically distinct, each of the two volcanoes shows a correlation of Hf and Nd isotope compositions consistent with what is known about the mantle array. The overall isotopic shift over the 200 ky of Mauna Kea history present in the HSDP core is smooth, relatively small, but nevertheless identifiable. The lack of correlation between the alkalinity index and the isotopic properties seems to indicate that magma extraction from the mantle did not alter the ϵ_{Hf} and ϵ_{Nd} of the resulting melts.

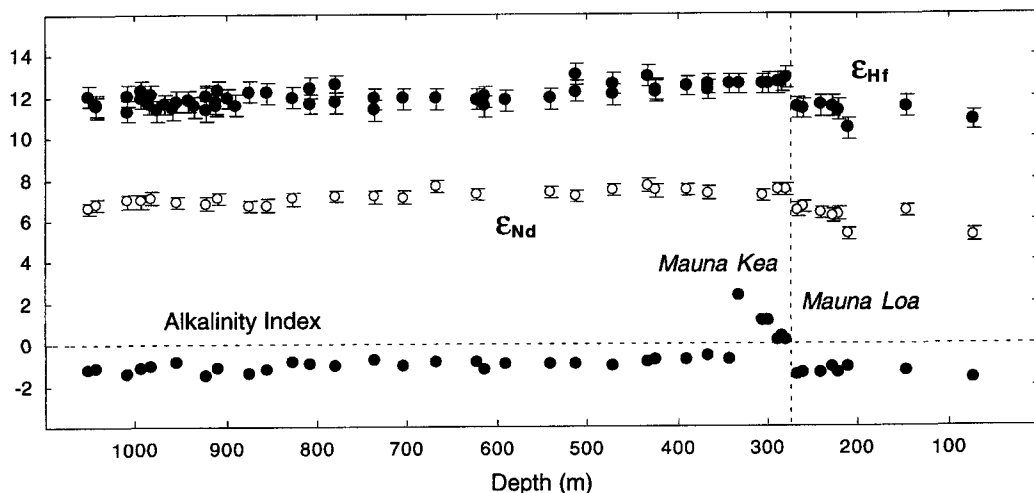


FIG. 1. ϵ_{Hf} stratigraphy of the HSDP samples compared with ϵ_{Nd} (Hauri *et al.*, 1996; Lassiter *et al.*, 1996) and alkalinity (Rhodes, 1996). While collecting the present Hf isotope data set, the $^{176}\text{Hf}/^{177}\text{Hf}$ ratio of the JMC-475 Hf standard was 0.28216 ± 1 . Error bars represent external errors (here given as $\pm 0.5 \epsilon_{\text{Hf}}$ units and $\pm 0.3 \epsilon_{\text{Nd}}$ units).

Different depth or extent of melting or contrasting fractionation histories may explain the alkalic character of the latest Mauna Kea lavas better than interaction with the depleted lithosphere. The long-term isotopic trend of the Mauna Kea section may reflect that the volcano tapped a source that was heterogeneous over length scales of about 10–50 km, and, in particular, that the contribution of the asthenospheric component (Lassiter *et al.*, 1996) increased significantly over this length scale. Alternatively, the plume source may have initially contained homogeneous proportions of a more refractory component (e.g. old lithosphere) that became increasingly visible as melting preferentially

drained the most fertile component.

References

- Hauri, E.H., Lassiter, J.C. and DePaolo, D.J. (1996) *J. Geophys. Res.*, **101**, 11793–806.
 Kurz, M.D., Kenna, T.C., Lassiter, J.C. and DePaolo, D.J. (1996) *J. Geophys. Res.*, **101**, 11781–91.
 Lassiter, J.C., DePaolo, D.J. and Tatsumoto, M. (1996) *J. Geophys. Res.*, **101**, 11769–80.
 Rhodes, J.M. (1996) *J. Geophys. Res.*, **101**, 11729–46.
 Stille, P., Unruh, D.M. and Tatsumoto, M. (1986) *Geochim. Cosmochim. Acta*, **50**, 2303–19.