New hafnium isotopic constraints on the source of MORB

C. Chauvel — Géosciences Rennes, CNRS, Université de Rennes 1, Campus de Beaulieu, F-35042 Rennes Cedex, France

J. Blichert-Toft — Laboratoire des Sciences de la Terre, Ecole Normale Supérieure de Lyon, 46, Allée d'Italie, 69364 Lyon Cedex, France

Since Patchett (1983) measured the first hafnium isotopic compositions of MORB samples, it has been known that basalts produced at ridges have Hf isotopic compositions that vary in a manner which is independant of the variations seen in Sr and Nd isotopic compositions. While ocean island basalts display strong correlation between Hf and Nd isotopic compositions, MORB are characterized by a wide scatter in Hf for almost constant Nd isotopic compositions. Since this pioneering work, few other papers have appeared in literature due to the analytical difficulty of obtaining reliable Hf isotopic compositions for Hf-poor basalts. Salters (1996) contributed greatly to the overall limited data set by setting up a new method that allowed the measurement of Hf isotopic compositions on smaller amounts of Hf. These new data confirmed the spread previously obtained and highlighted the fact that the MORB source is indeed less homogeous in terms of Hf than Nd isotopes.

The development in the early nineties of a new instrument (a mass spectrometer with an ICP source) capable of measuring Hf isotopic compositions on ng quantities of Hf opened up new perspectives and led us to measure MORB samples from the three major ocean basins, the Atlantic, the Pacific, and the Indian Oceans.

We primarily selected samples that had already been measured for Nd, Sr, and Pb isotopes and completed the Nd data set when such data were not available. We analysed over 30 samples and data are presented here in conjonction with Sr, Nd, and Pb isotope data from literature.

Atlantic MORB

Results show large $^{176}Hf/^{177}Hf$ variations (between 0.2830 and 0.28335) associated with minor changes in $^{143}Nd/^{144}Nd$ (from 0.5130 to 0.5132). This confirms Patchett's (1983) original findings. The new data, however, are generally displaced to the left in Hf-Nd isotope space compared to the literature field (see figure). In contrast, the Hf isotopic variation seems to be associated with large Pb isotopic variations (see figure).

Pacific MORB

Results are homogeneous in all respects: $^{176}Hf/^{177}Hf$ vary from 0.2817 to 0.2829 while $^{143}Nd/^{144}Nd$ range from 0.51313 to 0.51327 and $^{206}Pb/^{204}Pb$ range from 17.72 to 18.47.

Indian MORB

We in particular concentrated our efforts on this ocean basin because it had been poorly sampled in previous approaches. Hf isotopic compositions vary widely between 0.28277 and 0.28337 with corresponding $^{143}Nd/^{144}Nd$ ranging from 0.51245 to 0.51308 and $^{206}Pb/^{204}Pb$ falling between 16.95 and 17.76. Most data plot within a limited range but three samples have extremely low $^{176}Hf/^{177}Hf$ with correspondingly low Nd and high Sr isotopic compositions (see figure).

General features of the source of MORB

The most important findings are:

The source of Pacific MORB is the most homogeneous in terms of Hf isotopes, as already noted previously for other isotopic systems (Nd, Sr, and Pb). While it has the most depleted character in Nd-Sr isotope space, this is not the case for Hf isotopes since higher $^{176}Hf/^{177}Hf$ were obtained on one Indian and one Atlantic MORB.

A large range of compositions characterizes the Atlantic MORB. This results in part from new values that are lower than previously reported. The Hf isotopic variation is associated with Nd and Pb isotopic changes suggesting mixing with an OIB-type enriched component.

Three samples from the Indian Ocean have exotic isotopic compositions that resemble EM I type OIB sources.

If these three Indian samples are excepted, there is

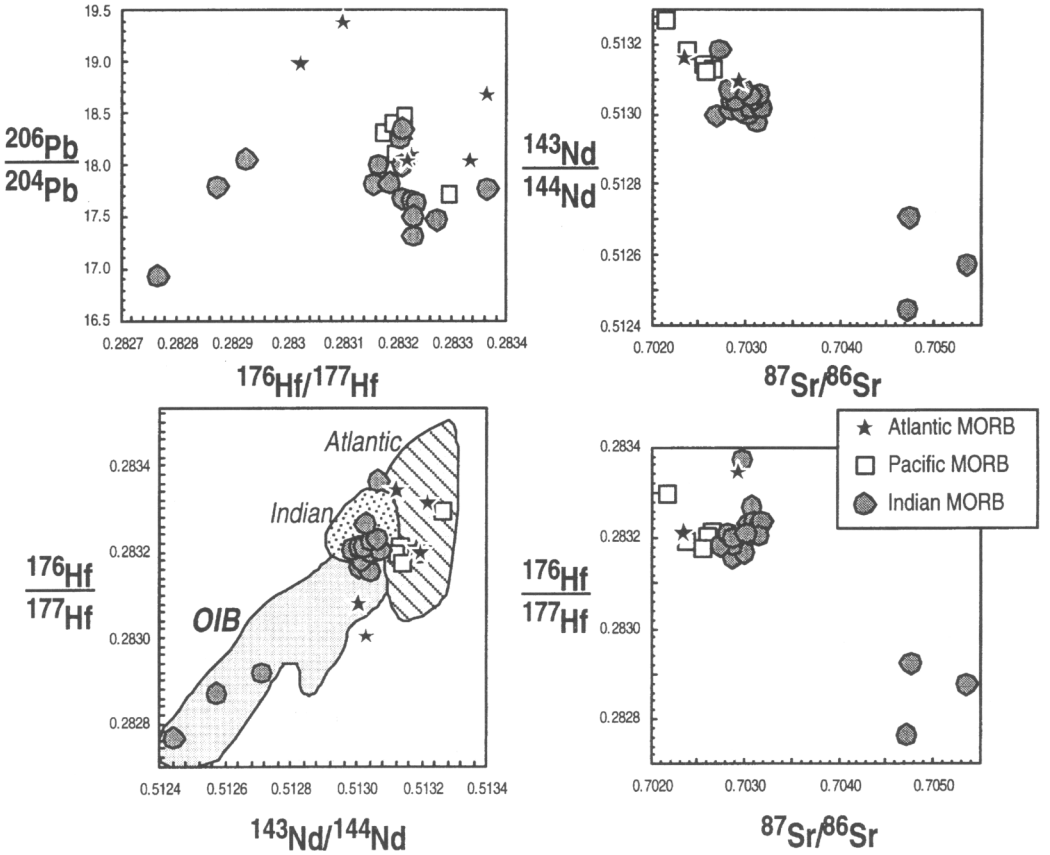

FIG. 1.

a general negative trend between $^{206}Pb/^{204}Pb$ and $^{176}Hf/^{177}Hf$ for all MORB which suggests that the main isotopic variations within the three ocean basins can be explained by a simple two end-member process. The first end-member characterized by high $^{176}Hf/^{177}Hf$ could be an extremely depleted portion of the mantle while the second end-member seems to be similar to common OIB sources.

The systematic isotopic characteristics of Indian MORB (radiogenic Sr and high $^{207}Pb/^{204}Pb$) extend to Hf: Indian MORB have isotopic compositions displaced to lower $^{143}Nd/^{144}Nd$ relative to Hf, higher $^{87}Sr/^{86}Sr$ and lower $^{206}Pb/^{204}Pb$.

These results clearly show that mantle reservoirs underlying the Atlantic, Pacific and Indian ocean basins have distinct compositions.The first two are relatively homogeneous but the reservoir beneath the Indian Ocean has strong heterogeneities, particularly for Hf isotopes. This indicates that the mantle circulates independently beneath the three oceans and that mixing beneath the Indian ocean is particularly inefficient.

References

Patchett, P.J. (1983) *Lithos*, **16**, 47–51.

Salters, V.J.M. (1996) *Earth Planet. Sci. Lett.*, **141**, 109–23.

Sources of Nd, Sr, and Pb compositions too numerous to be cited here.