HFSE mobility at the slab-wedge interface: Hafnium-isotope evidence from the east Sunda-Banda arc

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Models describing trace-element behaviour in the petrogenesis of arc volcanics generally assume that high-field-strength elements (HFSE) are relatively immobile during element transfer between the subducted slab and the overlying mantle wedge. However, recent studies in the East Sunda-Banda Arcs (Vroon *et al.*, 1993; Hoogewerff *et al.*, 1997) modify this view, and suggest that conditions in subduction settings can be favourable for the mobility of a wide range of slab-derived elements, including the HFSE-group. Sr-Nd-Pb isotopic signals in the ESA-BA are strongly dominated by subducted sediments of continental origin (SCM). Correlations between radiogenic isotopes and HFSE ratios provide indications for (1) an SCM-derived contribution to the HFSE budgets, and (2) increased mobility of HFSE down the dip of the subduction zone as a result of changes of the transfer medium from hydrous fluid to siliceous melt. Here, we present Hf isotope data for volcanic centres distributed along and across the ESA-BA, and use the results to trace a slab-derived origin of HFSE in the magmas.

Results

We have analysed 21 whole-rock samples for Hf isotopes by TIMS (Standard JMC 475 = 0.282154 ± 18, 2 s.d.). The northern Banda Arc volcanoes (Banda Archipelago and Manuk) show high $^{176}Hf/^{177}Hf$ ratios with limited variation (0.28315−0.28310), whereas Serua in the central part displays a large variation (0.28299−0.28271). The southern Banda Arc (Nila, Teon, Damar and Romang) has low and variable Hf isotopes (0.28300−0.28269). In the East Sunda Arc, Werung (0.28317−0.28310), situated at the volcanic front, has higher ratios than the centres behind the front (Boleng, Sirung, Lewotolo and Batu Tara; $^{176}Hf/^{177}Hf$ = 0.28306−0.28289). The Hf isotopes of the Southern and Central Banda Arc and the ESA volcanics (except Werung) show a perfect correlation with Nd isotopes, and overlap with the mantle array and the sediment field (Fig. 1). Banda and Werung are offset to higher $^{143}Nd/^{144}Nd$ at a given $^{176}Hf/^{177}Hf$ compared to the other volcanoes.

Discussion and conclusions

Along-arc parallelism of Nd and other isotopic signatures between volcanics and sediments in front of the arc, has provided strong evidence for the role of SCM in the ESA-BA (Vroon *et al.*, 1993). Our Hf isotope data follow this pattern, and thus demonstrate that HFSE can be mobile in subduction zones. In Hf-Nd space (Fig. 1), the Banda Archipelago and Werung (arc tholeiites) plot in the I-MORB field, suggesting that both systems reflect the local mantle signature. The other (calc-alkaline and potassic) rocks of the ESA-BA show a perfect linear trend for the Hf and Nd isotopes between the mantle wedge and SCM, which indicates that the subduction component contributes to the budget of Hf in the magma sources. Across-arc systematics in the ESA show that magma sources behind the front are influenced by SCM-derived siliceous melts (Hoogewerff *et al.*, 1997). This is consistent with the lower Hf isotopic ratios compared to Werung at the arc front, where transfer occurs via hydrous fluids, and HFSE remain largely immobile.

Other HFSE signals are also affected by the sedimentary component. Figure 2 shows Hf isotopes versus Zr/Nb. Although the Zr/Nb ratio is often used

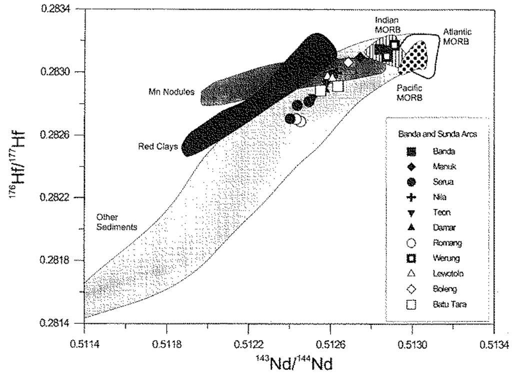

FIG. 1.

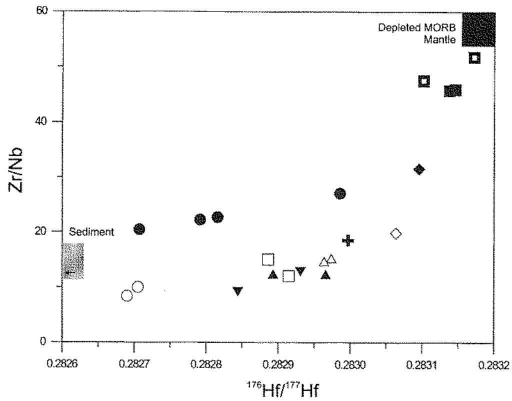

FIG. 2.

as an indicator for variable amounts of partial melting, the observed correlation favours source mixing between depleted MORB (Zr/Nb > 60) and SCM (Zr/Nb = 14.7) as a more likely explanation. Nevertheless, it is impossible to construct realistic bulk mixing lines between MORB mantle and SCM, which calls for an additional control. Partial melting in the presence of a HFSE-retaining mineral residue could generate the fractionation required. Because the stability of a titanate mineral (e.g. rutile) will be enhanced at high f_{O_2} and SiO_2 (e.g. Foley and Wheller, 1990), we infer that partial melting in the SCM environment may have provided the proper conditions.

References

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