

Rhenium-osmium isotopic investigation in subduction zone lavas

S. Alves
P. Schiano
C. J. Allègre

Laboratoire de Géochimie et Cosmochimie, Institut de Physique
du Globe de Paris, 4 place Jussieu, 75252 Paris Cedex 05, France

The Re-Os isotopic system provides a unique perspective on the origin of arc lavas. Due to the behaviour of these elements during melting, MORB (i.e. oceanic crust) have significantly higher Re/Os ratios than their source, and will rapidly develop highly radiogenic Os isotopic ratios. Recycling such radiogenic material will thus increase the Os isotopic ratios of island arc mantle sources.

We measured Os isotopic ratios and Re and Os concentrations on 13 volcanic rocks from West Java island (Sunda island arc). The samples, from 2 to 9.5 Ma old (Marcoux and Milési, 1994), are calc-alkaline rhyolitic to andesitic rocks and dacitic ignimbrites.

The Os concentrations of the samples are extremely variable, ranging from 0.10 to 17.18 ppt; Re concentrations range from 26 to 1617 ppt. Several analyses of some samples revealed that the Os content can also vary significantly within a single rock.

An extremely large variation in the osmium isotopic composition is observed for the whole sample set and also within some single rocks, with $^{187}\text{Os}/^{188}\text{Os}$ ratio ranging from 0.241 to 3.704. The ratios are still very radiogenic when corrected for sample ages (up to 3.146) and significantly higher than in both MORB and OIB (e.g. Schiano, *et al.*, 1997; Roy-Barman and Allègre, 1995; Reisberg *et al.* 1993; Hauri and Hart, 1993).

When reported in a $^{187}\text{Os}/^{188}\text{Os}$ versus $1/^{188}\text{Os}$ diagram (Fig. 1), the samples display two well-defined positive linear correlations. The steeper correlation is typified by the Miocene rocks whereas the Pliocene rocks define the flatter correlation.

The linear correlations do not reflect isochronal relationships, because their calculated ages do not corroborate the K/Ar ages of the samples. These correlations may instead simply reflect binary-mixing trends between two different radiogenic end-members and an unradiogenic one common to both trends. The different values obtained for the heterogeneous samples also plot on the two linear correlations, indicating that the observed bulk heterogeneity expresses the same mixing relationships at the sample scale.

The mixing process could be secondary contamination, the Os-poor samples being the most vulnerable to contamination by radiogenic material. The continental crust, which is enriched in Re relative to the depleted upper mantle, displays highly radiogenic Os isotopic ratios (e.g. Esser and Turekian, 1993, give $^{187}\text{Os}/^{186}\text{Os} \approx 10.5$, i.e. $^{187}\text{Os}/^{188}\text{Os} \approx 1.264$) and can potentially alter the Os isotopic signature of arc volcanic rocks. However, a continental crust contamination mechanism cannot account for the existence of the two distinct radiogenic end-members inferred from the $^{187}\text{Os}/^{188}\text{Os}$ versus $1/^{188}\text{Os}$ diagram, nor for the fact that the two sample groups also have distinct ages.

Alternatively, the relationships observed between Os isotopic compositions and concentrations may represent simple binary mixtures between melts with different Os isotopic ratios and concentrations. Even though Os behaves as a compatible element, a significant differentiation effect can be discarded since fractional crystallisation would be characterised by a horizontal trend in the diagram of Fig.1. Furthermore, no simple relationship is observed between the Os isotopic ratio and concentration of the samples and their degree of differentiation. On the other hand, because Os is compatible during basalt genesis, Os concentrations in melts appear to be only weakly sensitive to variations of the degree of melting. The linear arrays of Fig. 1 may then also record mixing of contaminating materials into the mantle source of Java lavas. The two mixing trends extend to an unradiogenic end-member which conceivably reflects the contribution of the unmodified part of the mantle wedge. The subducting lithosphere may potentially provide high $^{187}\text{Os}/^{188}\text{Os}$ materials for arc magmatism. A simple calculation of the isotopic signature for the subducting oceanic crust under the Java arc (considering its age) yields $^{187}\text{Os}/^{188}\text{Os} = 6$ for the crust, which is greater than the most radiogenic value obtained for Java Miocene rocks. Besides, marine sediments have Os isotopic ratios as high as the sea water value ($^{187}\text{Os}/^{186}\text{Os} = 8.5$, i.e. $^{187}\text{Os}/^{188}\text{Os} = 1.023$) or even higher for terrigenous sediments

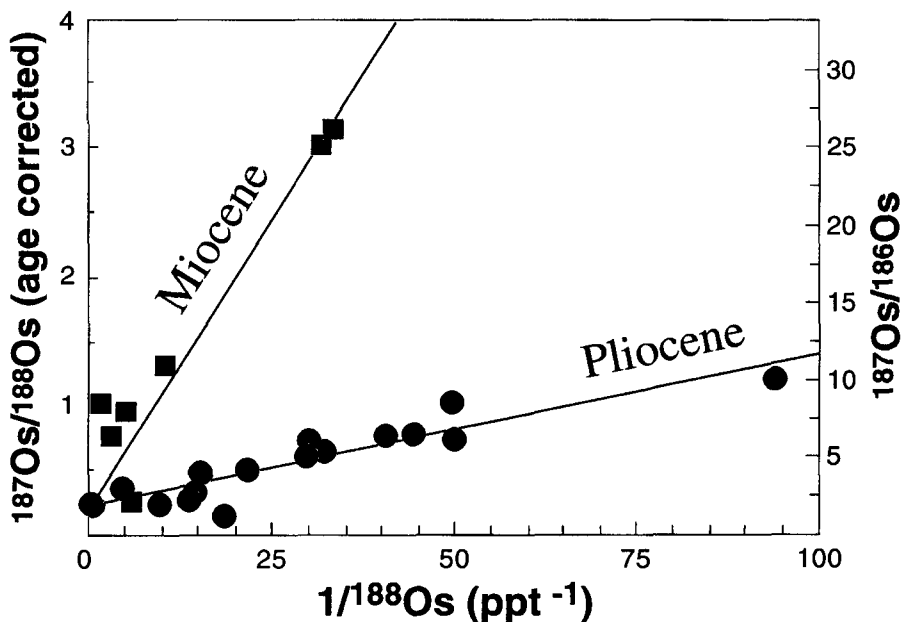


Fig. 1. Os isotopic compositions versus the inverse of ^{188}Os concentrations for Java volcanics, after age correction. Solid squares are for Miocene rocks and solid circles are for Pliocene ones.

(continental values) (e.g. BenOthman *et al.*, 1989, Esser and Turekian, 1993).

Miocene rocks display typical mantle signatures for lead isotopes, whereas Pliocene samples have highly radiogenic $^{207}\text{Pb}/^{204}\text{Pb}$ and $^{208}\text{Pb}/^{204}\text{Pb}$ ratios (Marcoux and Milési, 1994), characteristic of recycled sediments in their magma genesis zone (BenOthman *et al.*, 1989). Moreover, the sediment columns in the Indian Ocean, between Australia and Java, imply a significant increase of the accumulation rate since middle Miocene time and this could explain the Pb and also Os isotopic differences between Miocene and Pliocene rocks in Java (Ludden *et al.*, 1990).

Thus, our results support a slab-derived contamination process recorded in West Java lavas. The existence of two distinct contaminating end-members likely reflects a temporal evolution of the subducted material, resulting in a more significant contribution of sediments in the source of Pliocene rocks, as inferred from lead isotopes and sedimentation rate evolution in the Indian Ocean, north of Australia.

The intrinsic sample heterogeneity shows that

radiogenic and unradiogenic Os-bearing phases can coexist at the sample scale without isotopic equilibration.

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