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Composition of the Mantle Wedge: Insights from Osmium Isotopes

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Mantle peridotites are uncommon in subduction zone systems and so we have very few direct samples of the mantle wedge. However, studies of subduction zone melts indicate that the mantle wedge is both variably enriched and depleted relative to MORB mantle. A particularly striking feature is that the most depleted arcs are considerable more depleted in basaltic components than MORB mantle and this depletion may correspond to a recent melting event in the back-arc (Pearce and Parkinson, 1993). Geochemical and mineralogical studies of subduction zone-related peridotites suggest that 5-25% partial melting occurs in the mantle wedge under oxidising conditions (>FMQ). The highly refractory nature of many arc-related peridotites provides evidence that either high degrees of partial melting are easy attained in the wedge and/or melting of depleted sources is relatively common. In this study we present Os isotope data for suites of both arc-related peridotites and primitive arc lavas in order to constrain the composition of the mantle wedge. Os isotopic studies have the potential to resolve the amount and nature of recycled crustal material in subduction zones because of the large contrast between mantle and subducting plate ^{187}Os/^{188}Os ratios. The compatible nature of Os during partial melting and melt migration means that Os isotopic measurements can also discriminate whether arc melts migrate through the mantle wedge via percolation or channelled flow. Finally, Os isotopes can potentially resolve the age of prior depletion events in the mantle. In order to evaluate the behaviour of Os isotopes in the mantle wedge we analysed residual mantle peridotites from ODP Leg 125 drill sites from the Izu-Bonin-Mariana forearc, highly refractory harzburgites from Merelava Island in Vanuatu and reacted oxidised xenoliths from Grenada in the Lesser Antilles. We also analysed primitive arc lavas from Vanuatu, New Georgia Group in the Solomon Islands and Grenada. The Os isotope data for arc-lavas and peridotites provide some key information about the composition of the mantle wedge. 1) All the primitive arc lavas analysed so far have chondritic to suprachondritic $_1{}^{187}$Os/^{188}Os ratios ranging from 0.1276-0.1446. In the case of Vanuatu (and probably Grenada) the slightly suprachondritic values can be explained by addition of a small amount (<5%) of the locally subducted sediment. 2). Os behaves as a compatible element during mantle melting and fractionation in subduction zones. 3) The lack of sub-chondritic Os isotope values in the lavas indicates that melt transport through the sub-arc lithosphere was by channelled flow rather than by percolation. This is consistent with U-series analyses of arc lavas. 4) ^{187}Os/^{188}Os ratios in arc-peridotites are highly variable ranging from 0.1180-0.1308. Peridotites with^{187}Os/^{188}Os ratios greater than 0.1270 indicate that these peridotites record addition of a radiogenic component. The nonradiogenic values recorded in some ODP Leg 125 peridotites and one Grenada peridotite are lower than those recorded by MORB peridotites. These data can be explained in two ways. Either they represent ancient lithospheric mantle (> 0.8 Ga) which has become stranded within the subduction zone environment. Simple modelling indicates that this mantle would be highly depleted. Alternatively, these peridotites record the most nonradiogenic Os isotope values measured for the convecting asthenospheric mantle so far. Although dependent on the age of Re depletion, these peridotites would probably be still be more depleted than MORB mantle. Either explanation implies that portions of the mantle residing in the mantle wedge are more depleted than the ambient convecting mantle. Although some depletion events are likely to have occurred recently in the back-arc some depletion events may be much older.

Pearce, JA & Parkinson, IJ, *Geol. Soc. Lond. Spec.Publ.*, **76**, 373-403, (1993).