Os isotopes in xenoliths from the Eifel volcanic field: Proterozoic minimum age of separation of the subcontinental European lithospheric mantle from the convecting asthenosphere

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For a clearer understanding of the evolution of the continental crust it is nessasary to know the timing of stabilisation of the underlying mantle lithosphere from which the crust was derived. Lithosphere becomes isolated from the underlying asthenosphere as a result of melt extraction, and thus dating the depletion places an important constraint on lithosphere stabilisation and its relation to the overlying crust. Attempts to characterise and date depletion events in mantle material using conventional isotope systems (Rb-Sr, Sm-Nd and U-Pb) have had limited degrees of success, principally because these elements are all incompatible and their abundances in depleted peridotites are very low and additionally can be effected by metasomatism and alteration (Stosch and Lugmair, 1986).

The geochemical behaviour of Os contrasts markedly with that of Nd, Sr and Pb because Os is highly compatible during mantle melting and is thus retained by the residue. At the same time, Re is lost preferentially to the melt, hence samples of depleted peridotite should possess high Os abundances and low Re/Os ratios and may be used to estimate minimum ages for mantle depletion and melt extraction. Furthermore, the high Os abundances of depleted peridotites should make them relatively insensitive to the effects of subsequent metasomatism and alteration. This approach has been used with considerable success in studies of garnet lherzolite xenoliths from kimberlites, of ultramafic xenoliths from basaltic volcanics, and of massif peridotites.

The metasomatic alteration is known to have profound effects on sulfides as well as lithophile trace elements. Studies have shown that highly metasomatized xenoliths are often nearly devoid of sulfur. In order to characterize the effect of mantle metasomatism on Os, we have undertaken a study of Os isotopes and PGEs in a suite of metasomatized mantle xenoliths from the Pleistocene Eifel volcanic field of western Germany.

Preliminary Os isotopic data for the suite have a minimum $^{187}Os/^{188}Os$ of 0.1206, implying a Proterozoic minimum age of separation of the subcontinental lithospheric mantle (SCLM) from the convecting asthenosphere. This is consistent with results from highly depleted mantle rocks derived from the European SCLM, as observed for example in Ronda (Reisberg and Lorand, 1995). Most of the samples analyzed thus far have Os isotopic compositions between that and the accepted primitive mantle value of 0.129. Two samples however have considerably higher $^{187}Os/^{188}Os$ of 0.1357 and 0.1421 respectively. Mantle samples this radiogenic are rare, and suggest some addition of radiogenic Os. Possibilities include deposition of crustally-derived sulfides to the samples, isotopic re-equilibration with radiogenic metasomatic fluids, and interaction with the host melt.

One characteristic that these samples share with other xenoliths is low Os concentrations (some significantly less than 1 ng/g) and low Os/Ir ratios. This has been found in other areas to be related to the dissolution of sulfide phases from the xenolith during immersion in the host basalt. Either this process or prior breakdown of sulfide during metasomatism may well have rendered these xenoliths more susceptible to isotopic exchange with the host magma than a mantle rock with a full complement of Os (~3 ng/g) normally would be. In this event it is nonetheless difficult to account for the enormous mass of unradiogenic Os that would be released to the magma because almost all terrestrial magmas have very radiogenic Os, at very low concentrations.