Os isotope constraints on the timing of refertilization in the non-cratonic lithospheric mantle

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In recent years, there has been increasing recognition that many, perhaps most, mantle lherzolites are formed by refertilization of depleted harzburgites rather than as partial melting residues [1]. It is often assumed that such refertilization may be completely unrelated to the partial melting event that formed the harzburgites, and could instead reflect tectonic events occuring hundreds of millions of years later. Os isotopes are ideally suited to test the timing of refertilization. In orogenic peridotites and ultramafic xenolith suites from non-cratonic settings, whole rock Os isotope ratios are frequently correlated with peridotite fertility indices such as Al_2O_3 content [2]. Compilation of the more than 50 existing Re-Os studies of non-cratonic peridotite suites confirms the reality of these trends, with more than 50% of the $^{187}Os/^{188}Os$ ratios falling within ±1.5% of a line drawn between the Primitive Upper Mantle composition and the least radiogenic composition of each suite. In contrast, about 35% of the data plot above the trends while less than 15% plot below the trends. Melt percolation modeling was performed to test whether the observed trends could be produced by recent percolation of ancient, unradiogenic harzburgites with melts with more elevated $^{187}Os/^{188}Os$ ratios. This proved to be impossible. None of the suites considered matched the extremely curved trajectories expected for recent melt percolation. On the other hand, melt percolation models using Re sulfide/silicate partition coefficients of 400-800, imposed by the relative fS_2 and fO_2 values of the Earth's mantle [3], produce linear correlations of Re with Al_2O_3 that with time lead to the observed linear relationships between $^{187}Os/^{188}Os$ and Al_2O_3. Together, these observations suggest that large scale production of lherzolites from ancient harzburgites by melt refertilization during much younger events is an extremely rare process. Instead, lherzolite and harzburgite production seem to be linked temporally, placing constraints on the lithosphere formation process. If refertilization is ancient, radiogenic ingrowth of ^{187}Os in sulfides with different Re/Os ratios could explain much of the internal Os isotope heterogeneity observed in peridotite xenoliths. *References*: [1] Le Roux et al., 2007, EPSL *259*, 599-612; [2] Meisel et al., 2001, GCA *65*, 1311-1323; [3] Brenan, 2008, Chemical Geology *248*, 140-165.