

Aluminochrons and Re-Os model ages of peridotites revisited

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Positive correlations of $^{187}\text{Os}/^{188}\text{Os}$ with alumina contents in peridotites from continental lithospheric mantle have been used as isochron proxy (“aluminochron”) to date the age of melt extraction, and thus the approximate age of formation of continental lithospheric mantle (Reisberg & Lorand 1995). Alumina is used as a more robust proxy for Re in altered peridotites. One of the key assumptions in this concept has been that suites of peridotites that show variable Al or Re content are related to each other by variable melt extraction that occurred at roughly the same time. Variable Re contents would lead, with time, to a variable increase of $^{187}\text{Os}/^{188}\text{Os}$. Recent constraints suggest problems with this simple model. (1) Studies of highly siderophile element (HSE) abundances in peridotite bulk rocks and experimental studies have shown that correlations of HSE with fertility indicators such as Al likely reflect refertilization of depleted peridotites by migrating silicate melts (Lorand & Alard 2001; Pearson *et al.* 2004; Becker *et al.* 2006). (2) These results are supported by *in situ* PGE abundance and Re-Os work on sulfides in peridotites. Two compositionally different generations of sulfides occur in peridotites. Texturally younger grain boundary sulfides tend to show higher Re and more radiogenic Os than sulfide inclusions in olivine (Burton *et al.* 2002; Alard *et al.* 2003). (3) Structural and geochemical studies of orogenic peridotite massifs suggest that transformation of previously depleted peridotites to variably fertile lherzolites may occur at the asthenosphere-lithosphere transition (Le Roux *et al.* 2007; van Acken *et al.* 2008). Consequently, some harzburgites and co-existing lherzolites in peridotite massifs and xenolith suites may not be cogenetic. The aluminochron Os model age is largely defined by the depleted peridotites, which yield a minimum age for a melt extraction event. While Os model ages may reflect the time of melt extraction during formation of the lithospheric mantle, there is another scenario that warrants attention. Unradiogenic $^{187}\text{Os}/^{188}\text{Os}$ in harzburgitic abyssal peridotites (Parkinson *et al.* 1998; Harvey *et al.* 2007) suggest that the convecting mantle may contain old, depleted components. Thus, old, depleted lithospheric peridotites and their unradiogenic $^{187}\text{Os}/^{188}\text{Os}$ could be inherited from upwelling asthenosphere mantle and incorporated into lithospheric mantle that may have formed much more recently than the Os model ages would suggest.

Consequences of mixing delaminated crustal restites with mantle: Insights from trace element melting models

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Delamination of restites from anatexis of tholeiitic plateaux or underplated sills may refertilize upwelling mantle and catalyze renewed melting. This could be a common crustal growth mechanism in the Archaean, below LIPS, and under continental arcs. Although high in Ca and Al, the crustal restites have higher mg# than the basaltic protoliths; and their addition into depleted mantle would yield Fe-poor 2nd-stage basalts with low incompatible trace element contents. Different scenarios are investigated using equilibrium melting models applied to basaltic protoliths with near-chondritic Nb/Ta (≈ 23) and Zr/Sm (≈ 33) ratios. Trace element partitioning data was parameterized from published experimental and natural data for amphibole, clinopyroxene, orthopyroxene, olivine, garnet, zircon, titanite, ilmenite, apatite and rutile. Low-pressure melting of amphibolite (no garnet or Ti-minerals) efficiently fractionates Zr/Sm (melt Zr/Sm ≈ 150 at F=5%, ≈ 35 at F=30%), but Nb/Ta varies little (15-25). Addition of 2% ilmenite to the residuae can increase Nb/Ta slightly (≈ 32), but does not affect Zr/Sm. Residues have subchondritic Nb/Ta (10-20) and Zr/Sm (12-30). In contrast, residual titanite is extremely efficient at fractionating Nb/Ta. At F=10%, 2% residual titanite yields melt with Nb/Ta ≈ 40 . Fractionation is especially efficient for high-SiO₂ melts, where D_{Nb} reaches ≈ 11 and D_{Ta} ≈ 300 . Both D values decrease rapidly as SiO₂ drops, and 60-65% SiO₂ melts have titanite D_{Nb}/D_{Ta} ≈ 0.4 . These results suggest that low-pressure, low-degree anatexis where titanite is a residual phase can have major impacts on melt/restite Nb/Ta ratios. High-pressure melting yields different results. Melting of garnet amphibolite protoliths with progressive conversion of hornblende + plagioclase to clinopyroxene + garnet yields steeply increasing Nb/Ta (≈ 12 at F=5%; ≈ 25 at F=18%) caused mainly by increasing residual garnet; with steadily decreasing Zr/Sm caused by residual hornblende (≈ 100 at F=0; ≈ 35 at F=18%). Hornblende-free residues yield melt with limited Zr/Hf fractionation ($\approx 36-40$). Involvement of minor rutile (0.1-0.2%) yields only modest Nb/Ta fractionation (max. ≈ 30). The restite always has subchondritic Zr/Sm, but shows an excursion to superchondritic Nb/Ta in the F0-10% range, followed by a decrease to Nb/Ta ≈ 12 at F=40%.