Manganese and the search for recycled oceanic crust

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The primary mechanism by which the Earth's mantle chemically evolves is through the formation and recycling of oceanic and continental crust. Assuming a constant subduction rate for the past 4 Gyr, the mantle should contain approximately 5% recycled oceanic crust. Thus, recycled crust has the potential to be a significant geochemical reservoir (e.g., [1]). Trace elements and radiogenic isotopes (e.g., [2]) and, recently, Ni and Mn contents of olivine (ol) phenocrysts [3] have been used to infer the presence of recycled oceanic crust—in the form of pyroxenites—in the source regions of ocean-island basalts (OIBs).

I made high-precision measurements of the Mn contents of ol and silicate liquid (liq) from the run products of [4] [5] in which temperature (*T*) and pressure (*P*) were varied together to keep the liq composition approximately constant. For each constant-composition series, the olivine-liquid Mn partition coefficient (D_{Mn}=MnO^{ol}/MnO^{liq}, by wt.) is independent of *T* and *P*, although it does depends on MgO^{liq}: decreasing from ~ 0.90 to 0.65 as MgO^{liq} increases from 12 to 21 wt. %.

Major-element concentrations and phase proportions during melting of a fertile peridotite [6] at 0.5, 1, 2, and 3 GPa were modeled using pMELTS [7]. Mn concentrations in opx, cpx, garnet, and olivine were calculated using partition coefficients from the literature (e.g., [6]) together with the new olivine data presented here. With increasing *P*, partial melts of peridotite become more ol normative (e.g., [8]); thus, MnO concentrations of residual ol are sensitive to the *P* of melting, decreasing from approximately 0.145 to 0.125 as *P* increases from 0.5 to 3 GPa. These concentrations agree well with the median MnO of Mg-rich (Mg# = 90.5) olivines from MORBs and Hawaii, 0.149 and 0.127 wt. %, respectively. Correlations between Mn and Ni contents of ol previously ascribed to pyroxenite melting [3] can be generated by partial melting of peridotite under lithosphere of varying thickness, removing the requirement, based on Ni-Mn, for the presence of significant amounts of pyroxenite in the OIB source.

[1] Stracke et al. (2003) *G^3* **4**, 8003. [2] Hofmann (1997) *Nature* **385**, 219-229.[3] Sobolev et al. (2007) *Nature* **316**, 412-417. [4] Matzen et al. (2013) *J. Pet*. **54**, 2521-2545. [5] Matzen et al. (2014) *Goldschmidt Abstracts* **1627**. [6] Walter (1998) *J. Pet*. **39**, 29-60. [7] Ghiorso et al. (2002) *G^3* **3**, 10.1029/2001GC000217. [8] Presnall et al. (1978) *CMP* **66**, 203-220.