

Seminar 6 (to follow Lecture 10)

“Chemical differentiation of the Earth: The relationship between mantle, continental crust, and oceanic crust”, by Hofmann, EPSL, 90, 297-314, 1988.

Trace element geochemistry contributed significantly to constraining the processes that create the basaltic oceanic crust. Specifically, the glass that forms when MORB magma erupts into seawater is unequivocally a quenched melt. However, this glass, and MORB whole-rocks in general, are characterized by relatively low (i.e., depleted) abundances of highly incompatible elements; this is a paradoxical result since by definition highly incompatible elements are enriched in the melts formed during partial melting. The resolution of this paradox is to conclude that the source of MORB is relatively depleted in highly incompatible elements because it was created as a residue in an earlier melting event; i.e. the low abundances of incompatible elements in MORB reflect the source rock. In this paper Hofmann uses batch melting equations to quantitatively evaluate the following processes: (1) primitive mantle (i.e., bulk silicate earth) = partial melt (the source of continental crust) plus residual mantle (the source of MORB) and (2) the residue formed in process 1 is partially melted to form MORB. Also figure 2 shows that if F_1 (the melt fraction), is 1.6% in stage 1, the melt is highly enriched in incompatible elements, much like average continental crust and that if F_2 is 4.5 to 8.3% in the second process, the incompatible element content of the melt created in process 2 is similar to that in average MORB.

Although it is likely that this model is essentially correct, in detail there are problems that are being debated. For example:

1. Continental crustal averages are ~57% SiO_2 (i.e., andesitic)
 - (a) Can such SiO_2 -rich rocks be generated by partial melting of mantle rocks, such as peridotites?
 - (b) In most oceanic arcs the dominant magma composition forming the crust is basalt with ~50% SiO_2 ; if continental crust is dominantly created in arcs, why is there a discrepancy in SiO_2 content?
2. Some ratios, such as La/Nb are greater than primitive mantle in both MORB (oceanic crust) and continental crust.
 - (a) McDonough, W.F. (1991). Partial melting of subducted oceanic crust and isolation of its residual eclogitic lithology, *Philos. Trans. Royal Soc. London A*, 335:407-418.
 - (b) Rudnick, R.L., Barth, M., Horn, I. And McDonough, W.F. (2000). Rutile-bearing refractory eclogites: missing link between continents and depleted mantle, *Science*, 287:278-281.
 - (c) Kamber, B.S. and Collerson, K.D. (2000). Role of ‘hidden’ deeply subducted slabs in mantle depletion, *Chem. Geol.*, 166:241-254.

Also of interest are two papers that estimate the composition of depleted mantle, the source of MORB:

- (1) Major and trace element composition of the depleted MORB mantle (DMM), by Workman and Hart, *EPSL*, 231, 52-72, 2005.
- (2) Composition of the depleted mantle, by Salters and Stracke, *Geochem. Geophys. & Geosystems*, doi:10.1029/2003GC000597, 2004.