

Seminars 10 and 11 (to follow Lecture 11)

Papers:

- (1) **“Ultra-depleted primary melt included in an olivine from the Mid-Atlantic Ridge”, Sobolev and Shimizu, *Nature*, 363, 151-154, 1993.**
- (2) **“Melt inclusions at the millennium: toward a deeper understanding of magmatic processes” by Hauri, et al., *Chem. Geol.* 183, 1-3, 2002 (this is a special issue on melt inclusions).**
- (3) **“Recycled oceanic crust observed in ‘ghost plagioclase’ within the source of Mauna Loa lava”, by Sobolev et al., *Nature*, 404, 986-990, 2000.**

In the 1970's and 80's there was increasing awareness that the chemical compositions of mantle-derived “primary melts” (i.e., eruption of magmas retaining the compositions of partial melts of mantle rock) are likely to be significantly modified during their ascent through the lithosphere. Moreover, the recognition that the melting process is closer to the fractional melting end-member than the batch melting end-member make the concept of a primary melt moot; i.e., fractional or more likely incremental melting creates a large number of primary melts that are likely to be mixed during magma ascent.

With the advent of micro-analytical techniques, i.e. analysis of very small volumes, such as the ion-microprobe, it became possible to determine the trace element compositions of melt inclusions in phenocrysts. Olivine hosted melt inclusions were emphasized because as an early crystallizing phase olivine phenocrysts potentially trap melts prior to extensive mixing of melts. In the first paper Sobolev and Shimizu report on a melt inclusion in a MORB that has extremely low abundances of highly incompatible elements and large changes in their abundance ratios. Such melt compositions have never been found in erupted magmas, but they are characteristic of fractional melts (see Figure 36, Lecture 11). They infer that this melt inclusion represents a near-fractional melt prior to magma mixing.

Sobolev et al. 2000 (paper 3) found melt inclusions with low abundances of incompatible elements but with a relative enrichment in Sr and strong relative depletion in highly incompatible elements, such as Th and Nb. They infer that such melt inclusions are melts of recycled plagioclase-rich, gabbroic lower oceanic crust that was recrystallized as eclogite.

If valid, the inference that melt inclusions reflect early stages of the partial melting process is an incremental advance in understanding the petrogenesis of mantle-derived magmas. However, there are alternative explanations of melt inclusion compositions. Papers 4, 5, 6 (see following) are indicative of alternative interpretations

and represent the current state of controversy regarding the correct interpretations of melt inclusion composition. These papers are the basis of a second seminar discussion on Melt Inclusions.

Papers:

- (1) **“Survival times of anomalous melt inclusions from element diffusion in olivine and chromite” by Spandler, O’Neill, and Kamenetsky, *Nature*, 447, 303-306, 2007.**
- (2) **“Crustal origin for coupled ‘ultra-depleted’ and ‘plagioclase’ signatures in MORB olivine-hosted melt inclusions: evidence from Siqueiros Transform Earth, East Pacific Rise” by Danyushevsky et al., *Contrib. Mineral. Petrol.*, 144, 619-637, 2003.**
- (3) **“Depleted melt inclusions in MORB plagioclase: messages from the mantle or mirages from the magma chamber?” by Michael et al., *Chem. Geol.*, 183, 43-61, 2002.**