The Kimberlite Olivine Phenocryst/Macrocryst/Xenocryst Problem, Re-Visited

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Detailed petrography, SEM and electron microprobe studies of olivine in the hypabyssal Jos kimberlite dyke, Somerset Island, Canada, were undertaken to re-examine the olivine phenocryst/macrocryst/xenocryst "problem". A parallel integrated trace element and isotopic study was also undertaken (Malarkey et al., submitted). Euhedral to subhedral groundmass olivine phenocrysts (less than ~1 mm in size and typically <.5 mm) have cores with limited, but variable composition (Fo 85-92; 1550-2500 ppm Ni), which exhibit normal and reverse zoning to rims of near constant Mg# (Fo 89-90) with variable Ni (990-2200 ppm) contents. In contrast, larger olivine macrocryst grains (typically 1 – 7 mm), of subhedral to anhedral habit consist of more magnesia- and Ni-rich (Fo 91-93; 2690-3070 ppm Ni) cores that are normally zoned to rim compositions similar to those observed on olivine phenocrysts (~Fo 89; 1080-2450 ppm Ni). The range in olivine macrocryst core compositions is essentially identical to olivine from Somerset Island mantle peridotite xenoliths. The olivine macrocryst grains could thus be all interpreted as xenocrysts, as would smaller (>.4 to <1 mm) anhedral to subhedral olivine grains of similar compositions. However, we suggest that a sub-set of the olivine macrocrysts (Mg# 90-92) likely represent high pressure phenocrysts, but this distinction could not be made with the analytical techniques utilized in this study. This difference is however evident in Sr isotope/trace element systematics.

That two distinct olivine populations in the Jos dyke can be discerned on the basis of petrographic/SEM studies and microprobe data is certainly not new. Previously, similar observations were reported from the De Beers pipe 'peripheral' kimberlite (Boyd and Clement, 1977); and a variety of hypabyssal kimberlites on Somerset Island (Mitchell, 1986) and in the Lac de Gras field (Fedortchouk and Canil, 2005; this study). These studies, along with a variety of other lines of evidence (e.g., experimental petrology and Sr isotopes), are consistent with the idea that the kimberlite liquidus is defined by crystallization of olivine, or that olivine is a very early crystallizing phase (after Cr-rich spinel) and continues to co-crystallize with spinel over a protracted temperature interval.

In contrast, recent studies by Brett et al. (2009) on Diavik kimberlites have concluded that primary magmatic olivine crystallization is limited to 'thin' rims on olivine xenocrysts. This conclusion is then universally applied to all kimberlites worldwide, with the suggestion that virtually all kimberlite olivine is of xenocrystic origin. This interpretation, however, ignores a significant body of work (see above) on a number of kimberlites, and is not supported by our detailed isotopic study (Malarkey et al., submitted). Perhaps the most outstanding problem with the idea that olivine in a kimberlite is a 'late' magmatic crystallizing phase is the implication that the source region of kimberlite cannot be olivine-rich.

References

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