Olivine record of crystal residence times and the internal dynamics of magmatic plumbing systems

LEONID DANYUSHEVSKY[1]*, ALEXEY ARISKIN[2]

[1]CODES, an ARC Centre of Excellence in Ore Deposits, Hobart, Australia, L.dan@ utas.edu.au (* presenting author)
[2]Vernadsky Institute of Geochemistry, Moscow, Russia, ariskin@rambler.ru

Analysis of the kinetics of post-entrapment re-equilibration of melt inclusions in high-Fo olivine phenocrysts in lavas suggests their common short residence times (< 6-12 months). This implies that if eruption does not happen within a few months after a primitive magma begins cooling and crystallisation within the plumbing system, early formed olivines are unlikely to be erupted as phenocrysts, being efficiently separated from the melt, and rapidly incorporated into the cumulate layers within the plumbing system.

These results suggest that in most cases erupted high-Fo olivine phenocrysts retain their original composition, which explains commonly observed large compositional variations between olivine phenocryst cores in a single sample. Short residence times imply that large unzoned cores of high-Fo phenocrysts cannot reflect diffusive re-equilibration of originally zoned phenocrysts. The unzoned cores are a result of fast efficient accumulation of olivines from the crystallising magma, i.e., olivines are separated from the magma faster than melt changes its composition. Thus, the main source of high-Fo crystals in the erupted magmas is the mush zone of the plumbing system. Olivine-phyric rocks represent mixtures of an evolved transporting magma (which forms the groundmass of the rock) with crystals that were formed during crystallisation of more primitive melt(s). Unlike high-Fo olivine phenocrysts, the evolved magma may reside in the magmatic system for a long time. This reconciles long magma residence times estimated from the compositions of rocks with short residence times of high-Fo olivine phenocrysts.

Olivines incorporated in the cumulate layers are sometimes erupted in gabbroic/ultramafic xenolith. Unlike phenocrysts in lavas, olivines in xenoliths commonly have uniform compositions, reflecting diffusive re-equilibration during long residence times.

Slow cooling rates and extensive re-equilibration within the plumbing systems results in complete re-equilibration of the cumulate crystals at near solidus temperatures. In parts of these systems where cumulate compaction and intercumulus melt migration were minimal, correlations between compositions of olivine and the bulk samples can be used to estimate the compositions of the parental magmas and the amount and composition of phenocrysts they carry. Having established the composition of parental magmas, comparing them to the bulk compositions of different parts of the plumbing system can indicate their open or closed behaviour.

Using the Dovyren magmatic system (Northern Baikal region, Siberia, Russia) as an example, we show that the parental magmas were phenocryst rich, the supplying conduits were thermally and compositionally zoned, and the large layered intrusive body of the complex represented an open plumbing system feeding the associated volcanic centres.

Are the "magnetite lava flows" of El Laco (Chile) magmatic? Comparison of trace elements in magnetite with other magmatic Fe-oxide deposits

S.A.S. DARE[1*], S.-J. BARNES[1], G. BEAUDOIN[2] AND J. MERIC[1]

[1] Université du Québec à Chicoutimi, Québec, Canada, sasdare@hotmail.com (*presenting author)
[2] Université Laval, Québec City, Québec, Canada

Magnetite forms under a wide variety of conditions, crystallizing at high temperature from silicate magmas or precipitating at low temperature from hydrothermal fluids or seawater. Trace element content of magnetite may reflect the differences in these conditions. Therefore as part of a larger project examining the trace element content of magnetite, by laser ablation ICP-MS, we have characterized magnetite in magmatic massive Fe-oxide deposits (magnetite-ilmenite, ± apatite) from layered intrusions (Bushveld and Sept Iles Complexes) and a massif anorthosite (Lac St. Jean) in order to study how magmatic processes affect the trace element compositions. We have also collected trace element data from the enigmatic "magnetite lava flows" from El Laco, Chile, in order to consider whether these magnetites are indeed of igneous origin.

Magnetite from the layered intrusions record the evolution of the fractionating silicate liquid (Fig. 1a), with those found lower in the sequence (more primitive) being richer in Cr, Mg, V and Ni whereas those found higher (more evolved) being richer in Ti, Nb and Ta. Magnetite layers from the uppermost parts of the intrusions contain apatite and this magnetite shows the most evolved composition (Fig. 1a). Magnetite from the anorthosite shows similar compositions to those of the layered intrusions. However, magnetite from the El Laco lava flow are much richer in Si (0.4 wt.%), Ca and P and poorer in Ti (<0.1 wt%), Al (<0.2 wt%) and Ga than magnetite from any magmatic Fe-oxide deposit (Fig. 1b) which raises doubts about the El Laco "magnetite lava flow" having formed by igneous processses.

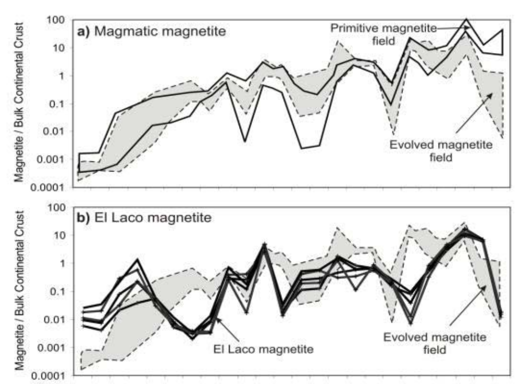

Figure 1: Trace element patterns for (a) magmatic magnetite and (b) El Laco magnetite compared to evolved magmatic magnetite. Order of elements: increasing compatibility into magnetite to the right.