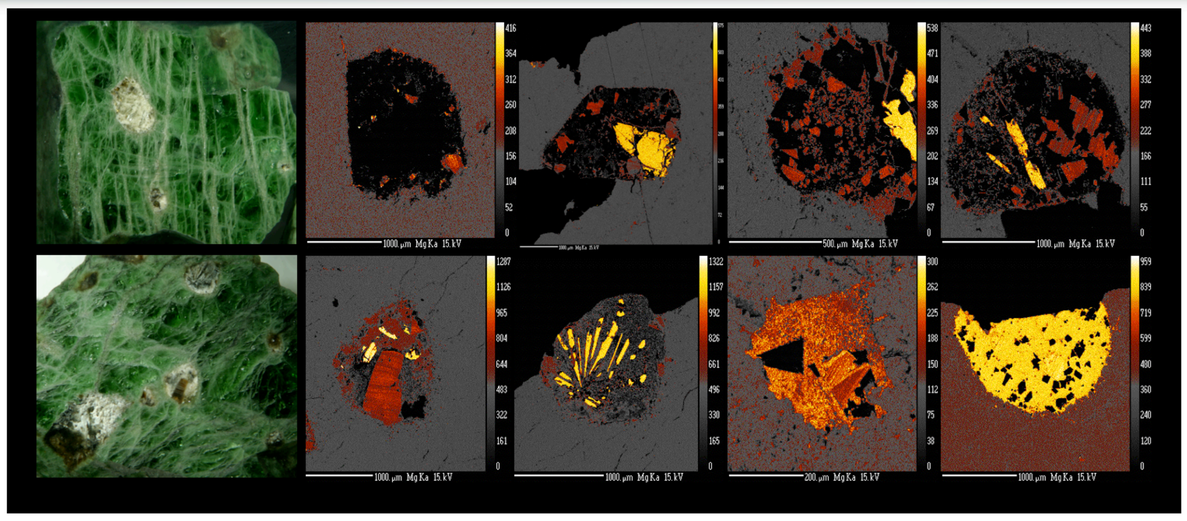
Carbonatitic to silicic melt inclusions in lherzolite xenoliths from Lac de Gras, Slave Craton – Melt differentiation and mantle metasomatism

Débora P. Araújo, William L. Griffin, Suzanne Y. O'Reilly
GEMOC, Dept. Earth & Planetary Sciences, Macquarie Univ., NSW 2109, Australia

MELT INCLUSIONS (MIs)

Globules (1 to 4 mm), patches and veinlets of quenched silicate to carbonate melts occur as inclusions (MI) in the Cr-diopside of megacrystalline lherzolite xenoliths (1000-1200ºC, 5-6GPa; ref.1, 2) from the A154N kimberlite, Slave Craton, Canada. The clinopyroxene xenocrysts are intensively fractured and veined by the material composing the MI. The MI have a large range of textural and chemical variation (see Mg SEM images) from carbonatite (C) to calcitic-silicate (CS) and calcite-bearing silicate (CbS).

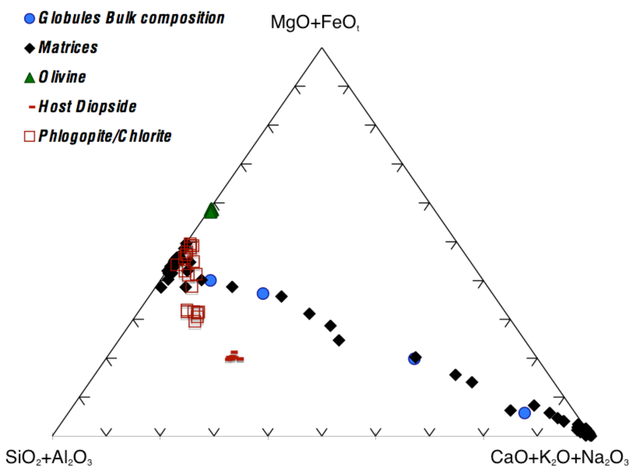
Olivine (yellow; Mg SEM image), calcite (black) and mica (orange to red) are phenocryst phases in matrices ranging from Ca-carbonatitic (black) to Fe-Mg-silicic (orange to yellow) in composition. Matrices with intermediate composition are Ca-Mg-Si rich (gray colour within the melt inclusions). EMP and LA-ICPMS analyses of the phases within the MI and the host diopside were done at GEMOC, Macquarie University, Australia.



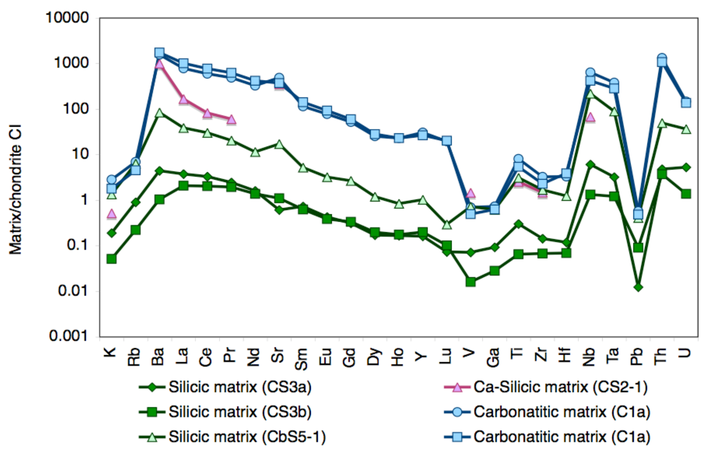
COMPOSITION OF MINERAL PHASES, MATRICES AND HOST DIOPSIDE

Major phenocryst phases are olivine (fo_{88-91}), mica (low to high Al-K, probably interlayered phlogopite-chlorite), and calcite (Ca/Ca+Mg > 0.97) in matrices ranging from Ca-carbonatitic to Fe-Mg-silicic (1wt% Al_2O_3, 0.3wt% K_2O, 0.3wt% Na_2O). Calcite phenocrysts in carbonatitic and silicic globules have high contents of REE (ΣREE = 1250 ppm), Ba (up to 3200 ppm) and Sr (up to 5500 ppm) and flat chondrite-normalised (CN) REE patterns.

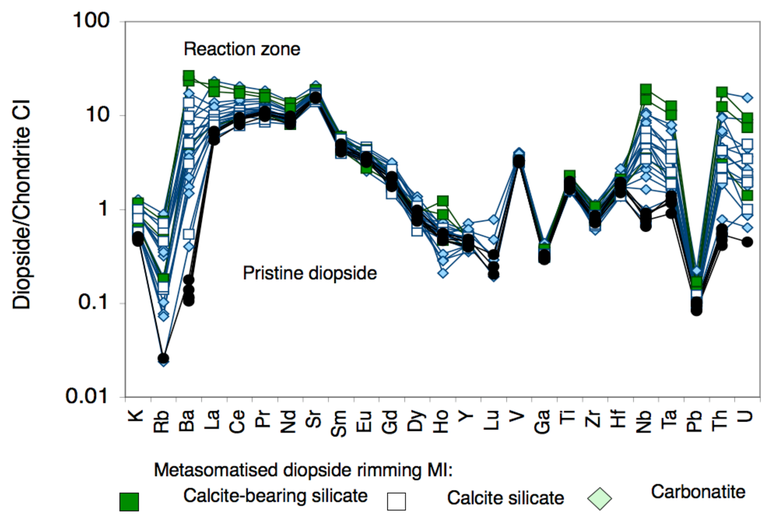
The matrices show a continuum from calcite to Fe-Mg-silicate composition, which coincides with the calculated bulk composition (modal) of selected MIs.



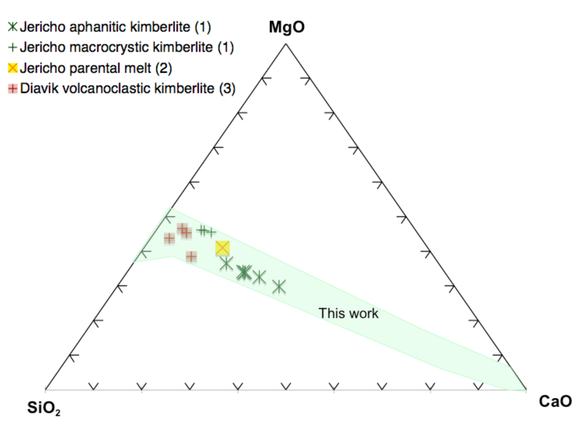
The matrices are enriched in LREE and have overall similar flat CN patterns. Silicic matrix enclosing up to 15% calcite phenocrysts has low REEs contents (Σ up to 6 ppm) and in calcite-bearing silicate MI, the matrix has higher TE contents (Σ_{REEs} = 170 ppm). Carbonatitic matrix has high REE contents (Σ_{REEs} = 1470 ppm).

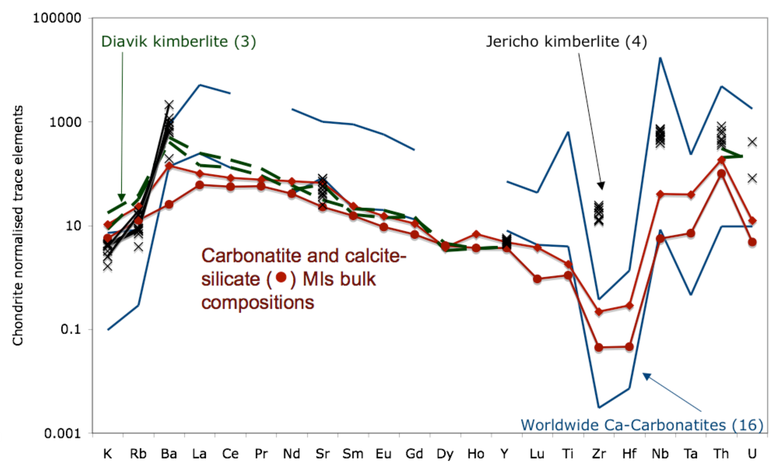


Metasomatised CPX rimming the MI shows marked increase in CaO (20 to 23.4 wt.%) and trace elements, with higher LREE/HREE, Nb/Ta and Th/Pb than the pristine cpx.



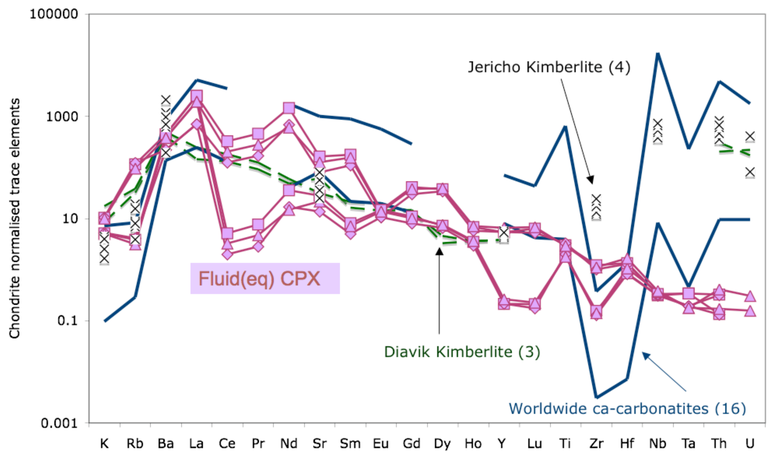
COMPOSITION OF MELT INCLUSIONS





The composition of the MIs are compared with kimberlites and worldwide carbonatites (trace elements). The major elements show a coincident compositional range of kimberlites and Mg-Si-rich MIs. CN trace elements of the MIs (bulk composition) show LREEs pattern comparable to kimberlites and HFSEs comparable to carbonatites.

COMPOSITION OF THE FLUIDS

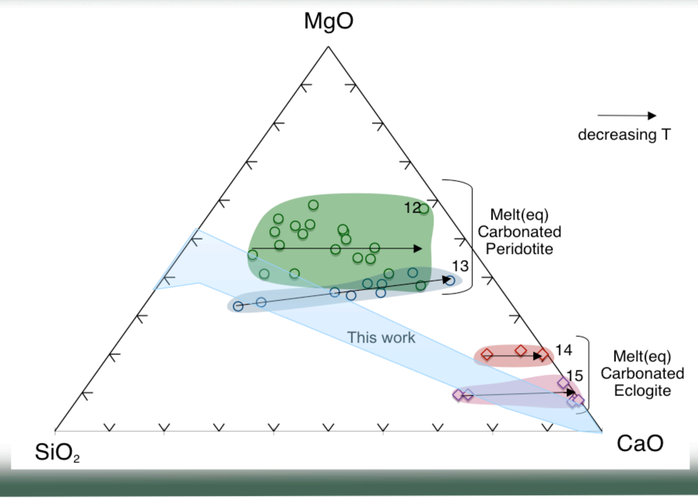


The composition of the fluids in equilibrium with the metasomatised CPX rimming carbonatite (rhombus), calice-silicate (triangle) and calcite-bearing silicate (square) was calculated using $D_{(CPX/Melt)}$ values from the literature (6-11). The results show similarities with the composition of kimberlites (3, 4) and worldwide Ca-carbonatites (16), , except for lower Nb, Ta, Th and U.

ORIGIN OF THE MELT INCLUSIONS

The continuous compositional range defined by the melt inclusions, the chemical similarities of mineral phases and the similar metasomatism in the host diopside are evidences to suggest that the MIs are related and to suggest a link between carbonatite and kimberlite melts. The globules were probably formed by entrapment of percolating melts in the mantle forming melt inclusions (2). Quenched textures suggest crystallization under disequilibrium, probably during ascent of the xenoliths in the kimberlite melt (2).

High-T kimberlitic melts in equilibrium with carbonated peridotite (12, 13) and carbonated eclogite (14, 15) lie close to the range defined by the MI. With decreasing T the kimberlitic composition evolves to carbonatitic ones, which are more magnesian than those found here. We suggest that interaction of the fluids with wall rock and, possibly, fractionation processes could have generated the compositional range seen in the MIs.



1. Griffin et al. 1999, J.Petrology 40, 705-727 **2**. van Achterbergh et al. 2004, Lithos 76, 461-474. **3**. Graham et al. 1999, Proc. 7th IKC, Vol. 1, 262-279. **4**. Price et al. 2000, J.Petrology 41, 789-808. **5**. Kopylova et al. 2007, Geochim. Cosmochim. Acta 71, 3616-3629. **6**. Fujimaki et al. 1984, J. Geoph. Res. 89, 662-672. **7**. Keshav et al. 2005, Geochim. Cosmochim. Acta 69, 2829-2845. **8**. Sweeney et al. 1995, Geochim. Cosmochim. Acta 59, 3671-3683. **9**. Blundy & Dalton 2000, Cont. Min. Petrol.139, 356-371. **10**. Adam & Green 2001, Eur. J. Mineralogy 13, 815-827. **11**. Klemme et al. 1995, EPSL 133, 439-448. **12**. Brey et al. 2008, J. Petrology 49, 3-24.**13**. Gudfinnsson & Presnall 2005, J. Petrology 46, 1645-1659. **14**. Yaxley & Brey 2004, Cont. Min. Petrol. 146, 606-619. **15**. Hammouda 2003, EPSL 214, 357-368, 16. Nelson et al. 1998, Geoch. Cosmo. Acta, 52:1-17.