

# Carbonatites from Recycled Eclogites

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Carbonate melts are frequently invoked as agents of metasomatic mass transfer in the upper mantle. Typically, evidence for the passage of metasomatic carbonate melt (Lc) in mantle rocks is cryptic, for example the presence of secondary clinopyroxene (cpx) rims on primary orthopyroxene (opx) formed by the reaction  $\text{opx} + \text{Lc} = \text{cpx} + \text{olivine} + \text{fluid}$ , and/or unusual bulk trace element signatures. In no case is the pristine metasomatic agent preserved and its composition must always be inferred through calculation. Such calculations hinge critically on assumptions about the partitioning of trace elements between minerals and carbonate melts. Recent experiments in the systems diopside-albite and diopside-albite-dolomite at 3 GPa, doped with a wide variety of trace elements, have been used to characterise the differences between clinopyroxene-silicate melt and clinopyroxene-carbonate melt partitioning (Blundy and Dalton, CMP, 2000). Cpx-melt partition coefficients (D's) are markedly different for Ti, Ga, Zr, and the HREE in the carbonate system compared to the silicate system, but for the LREE, Nb, alkali metals, and alkaline earths D's are broadly similar.

Our cpx-carbonate melt D's have been used to calculate the trace element composition of the metasomatic melt which would be in equilibrium with secondary cpx in mantle xenoliths from both continental and oceanic settings, using published data. The calculated melts are compared to the trace element composition of naturally occurring carbonatites displaying primary characteristics (Figure 1). We find that there is excellent agreement between carbonatites and the calculated melts, for example Ti, Zr, and Nb depletions, variable Sr depletion or enrichment, and overall enrichment in LREE, strongly suggesting that the metasomatic agent was a melt with carbonatitic trace element characteristics.

It is widely thought that the source for metasomatic carbonate melts and carbonatites is carbonated lherzolite. To test this, we have used our partitioning data, combined with the garnet-carbonate melt data of Green et. al. (1992) to calculate the trace element characteristics of a low-degree ( $f=10^{-5}$ ) batch melt of garnet lherzolite with primitive upper mantle (PUM) trace element concentrations. The patterns and concentrations in the calculated melts are overall in good agreement with natural carbonatites, but there are significant differences, in particular the strong Nb and Ti depletions observed in carbonatites are not reproduced by the calculations. Repeating the calculations with an enriched (MORB) source of eclogite mineralogy produces an almost identical trace element profile, because the high modal proportions of garnet and cpx in eclogite offsets the enrichment in trace elements over PUM. Evidently, an additional phase is

required to account for the HFSE depletions in carbonatites. Rutile is a common accessory phase in eclogites and will have high D's for HFSE during partial melting. As a result, even at low modal abundance, rutile will have a strong effect on the partitioning of Nb, Ta, Ti, and to a lesser extent Zr and Hf, between carbonate melt and its source. As no corresponding Ti- and Nb-rich phase is present in lherzolites, we therefore suggest that rutile-bearing carbonated eclogite (subducted oceanic crust) is the likely source for carbonatites and metasomatic carbonate melts.

In accord with experiments and calculations (e.g., Molina and Poli, 2000), we propose that subducted oceanic crust undergoes subsolidus dehydration reactions at depths of <100km, but will not decarbonate at the same time. Provided that the MORB trace element signature is not significantly modified by this dehydration, carbonated rutile-bearing eclogite may persist to considerable depths in the mantle. Intersection of this material with the carbonated eclogite solidus provides a ubiquitous deep source of metasomatising carbonate melt.

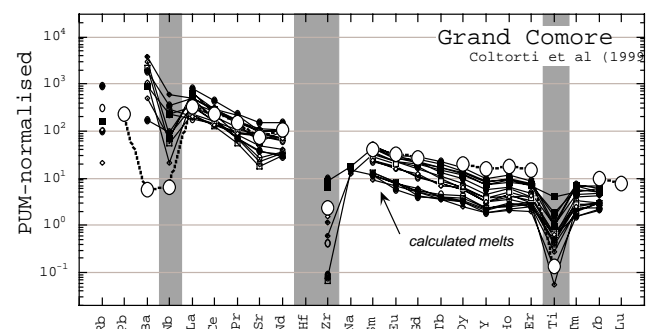


Figure 1. Calculated melts in equilibrium with secondary cpx in mantle xenoliths from Grand Comore (Coltorti et. al., 1999), compared to a cratonic carbonatite from South Africa (Harmer, 1999).

- Coltorti M, Bonadiman C, Hinton RW, Sienna F and Upton BGJ, *J. Petrology*, **40**, 133-165, (1999).  
Green TH, Adam J and Sie SH, *Min. Pet.*, **46**, 179-184, (1992).  
Harmer RE, *J. Petrology*, **40**, 525-548, (1999).  
Molina JF and Poli S, *EPSL*, **176**, 295-310, (2000).