The role of carbonate in alkaline diatremic magmatism

A. E. Brady, K. R. Moore
Department of Earth and Ocean Sciences, National University of Ireland Galway, Galway, Ireland (aoife.brady@nuigalway.ie; kathryn.moore@nuigalway.ie / Fax: +353 (0)91 494533 / Phone: +353 (0)91 492692)

The proposed petrogenetic link between carbonatites and kimberlites has been a controversial issue for many years among earth scientists and is now investigated using the composition of the carbonate phase. Specifically, the relationship and relative affinity of kimberlite and also ultramafic lamprophyre to carbonatite is examined using electron microprobe analyses of carbonate mineral compositions. This is an approach that has not previously been used due to the difficulty in differentiating between mantle carbonate minerals and later low-temperature carbonate minerals produced by interaction with percolating solutions. In addition, carbonate is susceptible to alteration and recrystallisation, making identification of primary magmatic carbonate complicated. Interpretation of rock textures and mineral chemistry is used to compare the carbonate phase in kimberlite and ultramafic lamprophyre from Greenland to comparable carbonatite localities.

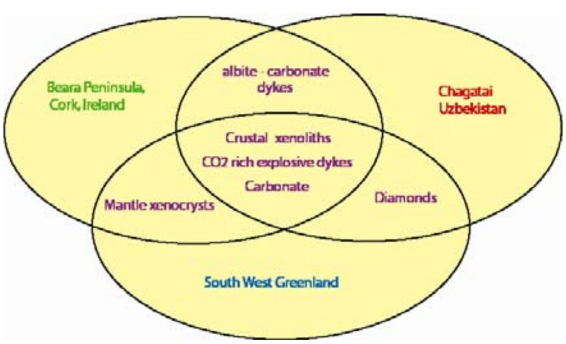

Figure 1: parellels between selected localities.

Three localities have purposely been selected because they have important parallels. Calcite kimberlites and ultramafic lamprophyres from South West Greenland (Fig. 2) are compared to calcite carbonatite, also from Greenland and that is used for comparison as a carbonatite within the same igneous province. Kimberlites and carbonatites may both occur as diatremes and explosive dykes and have both been reported containing diamonds with the diamond-bearing carbonatite locality at Chagatai, Uzbekistan (Djuraev & Divaev, 1999).

Figure 2: South West Greenland

Unlike the Greenland rocks, the Uzbekistan dykes commonly have albite-calcite compositions and are free of mantle material. However, the carbonated diatreme and subvolcanic dykes and sills of County Cork, southern Ireland, which also commonly have an albite-carbonate composition, have entrained mantle material. Cumulatively, the three localities share a number of key collective features including CO_2-rich explosive dykes, an abundance of crustal xenoliths and numerous generations of carbonate minerals. New and published isotopic data indicate that the carbonate component at all three localities has an ultimate mantle source.

Figure 3: Beara Penisula, County Cork, Ireland

At the Irish locality (Fig. 3), electron microprobe analysis has revealed several different carbonate compositions are present: Calcite (up to 54.56 wt% CaO), dolomite (up to 16.99 wt% MgO) and ferroan dolomite-ankerite (up to 24.58 wt% FeO) have all been identified. Calcite is restricted to the carbonated tuffisite diatreme and its associated carbohydrothermal carbonatite and fenite and analysis has revealed that there are two forms of chemically distinct calcite present. The diatreme contains low Mn calcite (0.10 wt %) whereas the carbonate body and shell contain high Mn calcite (0.78 wt % and 0.81 wt % respectively). In addition, there are significant differences in the level of strontium within the calcite, with the diatreme containing high Sr calcite (2.00 wt %) in contrast to the carbonate body and shell containing low Sr calcite (0.80 wt % and 0.84 wt % respectively). These chemical differences in the calcite clearly indicate that there are two different generations of calcite in the Irish diatreme. In contrast to the diatreme, the dolomite and ferroan dolomite-ankerite are confined to the later albite-rich dykes and sills indicating two more generations of carbonate at this locality. In some cases, the carbonate phases have even been found to dominate some of these silica-oversaturated dykes and sills. The distribution of this carbonate occurs as either blebs of carbonate crystals discretely scattered through the groundmass or as carbonate crystals thoroughly dispersed throughout the silicate assemblage. Cumulatively, the diatreme, dykes and sills of County Cork, Ireland record several generations of magmatic activity with a carbonated mantle source, fractionation of primary carbonate magmas to produce a range of carbonate compositions, and sampling of carbonatites and carbonate magmas by compositionally unrelated magmas (Fig. 4).

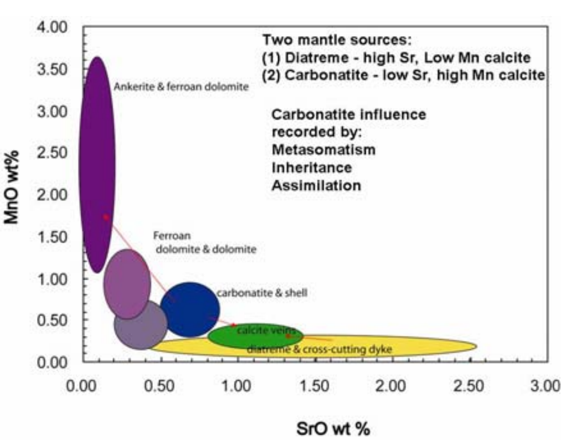

Figure 4: Summary diagram of carbonated volcanism at Beara Penisula, County Cork, Ireland

While the Irish diatreme contains mantle xenocrysts, the Uzbekistan diatreme (Fig. 5) contains abundant lapilli and xenoliths of crustal rock. The carbonate component is more iron-rich than in the Irish case and preliminary analysis has identified calcite and ankerite (Ca/Ca+Mg+Fe = 0.55) in the diatreme host magma and ankerite (Ca/Ca+Mg+Fe = 0.59) in metasomatised xenoliths. The related dykes under investigation are an albite chlorite-rich and an albite calcite-rich dyke and contain predominantly calcite (56.58 wt %), with minor dolomite.

Figure 5: Chagatai, Uzbekistan

The different generations of carbonate in the Irish and Uzbekistan rocks are interpreted in terms of differentiation from primary carbonatite to carbothermal residua. In contrast, calcite kimberlites are viewed as small volume late-forming differentiates unrelated to carbonatites or their parental magmas (Mitchell, R. H., 2005). The role of carbonate in kimberlites will now be systematically evaluated with reference to carbonate from bona fide magmatic carbonatites to carbothermal residua. Numerous kimberlite and ultramafic lamprophyre (UML) dykes sampled from across Southern West Greenland contain a variety of abundant carbonate phases and, in most cases, the carbonate constitutes virtually all the groundmass of these dykes. Analysis has revealed that the carbonate phase, in both the kimberlite and UML dykes, consists of both calcite (kimberlite: up to 56.27 wt % CaO, UML: up to 57.16 wt % CaO) and dolomite (kimberlite up to 19.91 MgO wt %; UML up to 18.59 wt % MgO). Calcite dominates the kimberlite dykes with its distribution occurring primarily as a microcrystalline groundmass phase, which in several dykes forms irregular and embayed segregations. In contrast, the dolomite is found as blebs within calcite and surrounding crystals of various minerals. Calcite is also observed as the major carbonate phase in the UMLs but it is distributed chiefly as segregations encircled by phlogopite and oxide phenocrysts. Dolomite is a minor phase and is dispersed discretely throughout the calcite segregations but in much larger patches than are apparent in the kimberlite dykes. Using these carbonate textures and mineral chemistry the primary subsolidus carbonate phases and secondary late stage influxes of carbonate will be established in the South West Greenland rocks and compared to the Irish and Uzbekistan reference frame to examine the relationships within the suite of Greenland rocks and the relative affinity of Greenland kimberlite and UML to carbonatite.

References

Djuraev A. D., and Divaev F. K. 1999. Melanocratic carbonatites – new type of diamond –bearing rocks, Uzbekistan. In: C. J. Stanley et al. (eds) Mineral Deposits: Processes to Processing. Eds. Balkena, Rotterdam 1, 639-642.

Mitchell, R. H. 2005. Carbonatites and carbonatites and carbonatites. Canadian Mineralogist 43**,** 2049-2068.