Mineralogical Evidence for, and Experimental Evidence against, Carbonate from the Mantle in Xenoliths from Kimberlite Pipes.

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Experimental evidence that carbon is stored in the mantle in the form of carbonate (Wyllie et al, 1983 and refs therein) was at the time not matched by anything but small inclusions of carbonate within mantle-derived minerals (McGetchen and Besancon, 1973; Hervig and Smith 1981; Hunter and Smith, 1981). Berg (1986) described the first millimetre-sized grains interpreted as metacarbonate from the mantle which matched the grain-size of co-existing silicate minerals in their peridotite host nodules. Questions about the validity of these observations stem from both equilibrium and dynamic polybaric experimental petrology. The latter are considered first, below:

Canil (1990) published experimental findings interpreted to show that carbonate that might be present in nodules of peridotite in the mantle would almost inevitably react with co-existing silicates en route to the surface. On this basis he questioned the validity of both Berg's (1986) evidence for carbonate in the mantle, and Boyd and Gurney's (1982) hypothesis that carbonate in heated mantle nodules could lead to their explosive decrepitation as they reached the Earth's surface. This dichotomy of approach requires clarification:

The experiments reported by Canil (1990) were undertaken on mg quantities of 10 micron grain-size powder in standard solid media high-pressure experimental apparatus. The results of **equilibrium** experiments on such 10 micron grain-sized charges can be applied to rocks consisting of millimetre-sized grains, because the phase rule, $P + F = C + 2$, which governs phase equlibria, is independent of both time and grain-size. However, Canil (1990) has interpreted the results of dynamic polybaric experiments, timed to simulate the emplacement rate of kimberlite, but obtained on 10 micron powders, to deduce the **rate** of re-attainment of equilibrium in real rocks that have grain sizes of some 4000 microns. The relevance of these experiments to the problem is debatable, given the orders of magnitude difference in reactive areas and diffusion distances involved in the experimental charges compared to the real rocks.

The critical feature in Fig 1 of Berg (1986) is the texture and volume of the calcite, which is interpreted to reflect down-pressure decarbonation of dolomitic carbonate, following the equation given by Harker (1974): $CaMg(CO_3)_2 \rightarrow CaCO_3 + MgO + CO_2$; the periclase produced in this reaction is thought to either have been hydrated later, or brucite to have been formed directly in an environment of sufficiently high water pressure. There is a possible inconsistency in this interpretation with respect to experimentally determined carbonate equilibria, inasmuch as experimental evidence from a number of independent laboratories points to magnesite rather than dolomite being the stable phase of carbonate at the depth of origin of most peridotite nodules in kimberlite (Wyllie et al 1983 and refs therein). It is not yet clear whether the textures described by Berg (1986) reflect calcic magnesite, or are restricted to rocks from relatively shallow depths. It is also possible that meta-magnesite has simply not been observed because of its poor preservation potential. Pure magnesite decarbonating independently of silicates would produce either periclase, which would readily hydrate to brucite, or brucite directly. Microbe observation suggest that brucite in peridotite nodules is rapidly replaced by serpentine, which has optical properties not dissimilar to brucite. Without some diagnostic metamorphic texture, such serpentine/brucite in a peridotite nodule would be almost impossible to characterise as previously having been a carbonate.

The carbonate in kimberlite is predominantly calcite (Mitchell !986). This is a complicating factor in modeling the origin of kimberlite consistently with the experimental evidence that magnesite is the stable carbonate at its depth of origin.

A combination of carbonate, phlogopite, ilmenite and apatite with peridotite, approximates the major element composition of Type I kimberlites (Berg 1998a, this volume). Experimental petrology near the solidus of this system may help to clarify the origin of these kimberlites, following the pioneering studies of Foley and his co-workers (eg Foley et al 1995). Clearly, experimental work near the liquidus of compositions of macrocrystic hypabyssal kimberlite is far removed from the conditions of kimberlite formation, if it is accepted that the olivine macrocrysts in these kimberlites are "passengers" which were never molten (eg Berg 1998a, this volume).

To contribute to the issues discussed above, the poster accompanying this abstract will concentrate on illustrating the optical and microbeam petrography of metacarbonate, its amount, its alteration, and accompanying minerals in peridotite nodules from kimberlite. Possible ascent paths will be considered.

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