MAGNETITE-SERPENTINE-CALCITE DYKES AT PREMIER MINE AND THEIR RELATIONSHIP TO KIMBERLITE AND TO ALKALIC CARBONATITE COMPLEXES

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Carbonate-rich rocks transgressing the multiple kimberlite plug at Premier Mine are of interest for two reasons. Firstly, there has been controversy as to whether they are igneous bodies (e.g. Daly 1925 and Frick 1970) or the result of metasomatic replacement of pre-existing, kimberlite dykes (e.g. Wagner 1914, Williams 1932 and Gerryts 1951). Secondly, should they be igneous bodies they satisfy current definitions of carbonatite (e.g. Heinrich 1966). Thus, their association with kimberlite would be of critical importance in evaluating the relationship between kimberlite and alkali carbonatite complexes.

Two groups of carbonate-rich rocks can be distinguished at Premier Mine. These occur as:

1. Occasional, apparently unconnected magnetite-serpentine-calcite dykes mostly within the so-called Grey Kimberlite of the mine.
2. A system of connected, dyke-like bodies mostly within so-called Black Kimberlite.

1. A MAGNETITE-SERPENTINE-CALCITE DYKE IN GREY KIMBERLITE

The dyke studied is approximately a metre in width and dips steeply. Contacts with adjacent kimberlite are sharp, even where viewed in thin section. The rock is fine-grained at the margins of the dyke but coarsens to medium-grained in the central portions. Calcite constitutes about 55 per cent of the rock and was the first constituent to crystallise. This was followed by magnetite, which accounts for ten per cent of the rock, and then interstitial material apparently consisting of an intimate mixture of poorly crystalline serpentine and gelatinous magnesium hydroxide. A few per cent of the rock consists of ovoid "inclusions", up to a centimetre in length, of various combinations of serpentinuous material, magnetite and calcite. The outermost four centimetres of the dyke is peculiar in that carbonate crystals have been pseudomorphosed by serpentine. Small amounts of kimberlite-type minerals recovered from the rock can be adequately accounted for by between one and fifteen per cent assimilation of host rock. The chemistry of the magnetite-serpentine-calcite dyke contrasts with that of associated kimberlite mainly in containing greater amounts of CaO, CO_2, Fe_2O_3 and P_2O_5 and lesser SiO_2,MgO, Al_2O_3 and alkalis (Table I).

Consideration of its field relationships and textural characteristics indicates an igneous origin for the magnetite-serpentine-calcite rock.

Megascopic wall rock alteration extends over a width of about twenty centimetres on either side of the dyke. Here, the Grey Kimberlite has been altered from greyish green to dark grey. Instead of exhibiting a turbid matrix as viewed in thin section, this is clear in the altered kimberlite. Talc and tremolite, both of which occur as alteration products of pyroxene in Grey Kimberlite, give way to colourless chlorite whilst biotite, instead of phlogopite, is present in accessory amounts in the altered rock. The proportions of MgO and H_2O^+ appear to have been enhanced in the altered kimberlite whilst SiO_2, CaO and alkalis are apparently reduced in amount (Table I). In addition, alteration seems to have resulted in oxidation of some of the ferrous iron present. It should be noted, however, that the abnormally high SiO_2 values quoted for Grey Kimberlite may be a consequence of Waterberg sandstone contamination in the sample analysed.

2. A MAGNETITE-SERPENTINE-CALCITE DYKE IN BLACK KIMBERLITE

The dyke rock is not unlike that described previously. Calcite is less abundant, however, whilst serpentinuous material and magnetite are more abundant. Magnetite constitutes thirty per cent of the rock examined. Calcite grains are frequently joined in crooked chains: otherwise the texture of the rock is similar to that of the previous dyke described and, by analogy, is also regarded as igneous. Trace amounts of kimberlite-type minerals occur in the dyke.

Wall rock alteration is intense. In this regard the dyke studied, which is less than five metres wide, grades into unaltered Black Kimberlite through a 35 metre-wide zone of carbonatised kimberlite. Where examined, unaltered Black Kimberlite is a completely serpentinised rock without calcite. At twenty metres from the igneous dyke, however, a substantial proportion of the serpentine has been altered to forsterite and phlogopite, and calcite constitutes about fifteen per cent of the rock. Nearer to the igneous dyke calcite becomes progressively more abundant, as do forsterite and magnetite. Kimberlite-type minerals are reduced in amount in carbonatised kimberlite so that the ilmenite content, for example, of samples taken at ten metres and twenty metres, respectively, from the dyke was found to be about twenty per cent of that of Black Kimberlite in each case. A progressive increase in the amounts of CaO and CO_2 and, to a lesser extent, MgO, P_2O_5 and, possibly, MnO and a corresponding decrease in the proportions of SiO_2, Al_2O_3, H_2O^+ and alkalis occurs within carbonatised kimberlite as the dyke rock is approached. Relative proportions of TiO_2, on the other hand, appear to have remained constant (Table I).

It is considered likely that theories of a metasomatic origin for carbonate-rich dykes at Premier Mine may have been influenced by studies made of carbonatised kimberlite rather than actual dyke rock.

The textural characteristics of the magnetite-serpentine-calcite dyke occurring in Grey Kimberlite, in particular, indicate in situ crystallisation of the dykes from an essentially liquid magma. Strontium contents of the dykes (Table I) are considerably higher than is usual for sedimentary carbonate, including Transvaal Dolomite (Verwoerd 1967, p.301) and disproves the contention of Daly (1935) that the carbonate of the dykes was derived from Transvaal Dolomite. Since the carbonate-rich dykes are restricted to the kimberlite plug at Premier Mine they have been regarded (e.g. Frick 1970) as representing a phase of the same igneous activity as was responsible for the kimberlite rocks. Such a supposition is in accordance with age determinations made of Premier Mine materials (Allsop, Burger and van Zyl, 1967). The mineralogical and chemical resemblances between the magnetite-serpentine-calcite dykes and matrix material of many kimberlite rocks suggests, furthermore, that they could represent a residual liquid differentiated from a crystallising kimberlite magma. Such a possibility is supported by experimental results obtained by Franz and Wyllie (1967, p.326).

Whilst the magnetite-serpentine-calcite dykes exhibit many similarities with carbonatite bodies of alkali carbonatite complexes, there are dissimilarities as well. For example, wall rock metasomatism has resulted in basification rather than an introduction of alkalis which tends to negate a direct genetic link between the magnetite-serpentine-calcite dykes and carbonatite of alkali complexes (Le Bas 1973, p.85).

TABLE I

CHEMICAL ANALYSES OF ROCKS STUDIED

	Grey Kimberlite	Altered Kimberlite	Magnetite-serpentine -calcite dyke	Black Kimberlite	Carbonatised Kimberlite 20m	Carbonatised Kimberlite 10m	Magnetite-serpentine -calcite dyke.
SiO_2	50,3	39,1	16,9	41,0	29,5	30,6	20,8
TiO_2	0,9	0,8	0,9	2,2	2,1	2,1	1,7
Al_2O_3	3,3	3,8	0,8	2,9	1,6	1,5	0,1
CrO_3	0,1	0,1	<0,1	0,2	0,2	0,2	<0,1
Fe_2O_3	3,6	4,1	7,0	5,0	6,1	5,1	12,4
FeO	4,4	2,9	3,5	4,3	4,2	6,0	3,2
MnO	0,1	0,3	0,2	0,1	0,2	0,2	0,9
MgO	23,3	36,0	16,6	27,3	32,0	33,0	20,0
CaO	4,2	0,4	26,4	6,0	10,3	11,6	19,3
K_2O	0,5	0,2	<0,1	1,2	0,7	0,3	<0,1
Na_2O	1,0	<0,1	<0,1	0,7	<0,1	<0,1	<0,1
P_2O_5	0,2	0,1	1,4	0,2	0,2	1,5	0,7
CO_2	0,3	0,2	19,2	0,2	5,2	4,3	14,6
H_2O^+	5,0	9,9	5,1	7,5	6,4	1,9	5,4
H_2O^-	2,8	1,9	0,3	1,1	0,3	0,2	<0,1
Sr	-	79	1218	-	634	767	835

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