

# KIMBERLITIC-CARBONATITIC DIKES OF THE SAGUENAY RIVER VALLEY, QUEBEC, CANADA

by

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Dikes of carbonatitic and kimberlitic affinity cut the Precambrian granulite and anorthosite terrane of the Saguenay River Valley in the Arvida Region of Quebec. They are not kimberlites, *sensu stricto*, but have features of carbonatitic kimberlites and appear to indicate the separation of a carbonatitic fluid from a kimberlitic magma, albeit in small amount.

The Saguenay River is a one-hundred mile long tributary of the St. Lawrence river and is now recognized as a rift valley that forms part of the St. Lawrence rift system which includes the Ottawa rift and the Mattawa rift with which many carbonatite and alkalic rock complexes are associated.

The dikes are of Cambrian age (546 my by K/Ar on biotite) and range from a few centimetres to about a metre in width. They have igneous textures such as seriate texture in phlogopite and magnetite, fluidal texture in groundmass phlogopite flakes, quench dendrites of calcite at chilled margins and what appear to be phenocrysts of calcite.

The dikes are composed of former olivine (now pseudomorphed by talc in some cases and by antigorite in others), phlogopite, apatite, titaniferous magnetite, calcite and minor amounts of aluminous diopsidic titan-augite and aluminous titaniferous pargasite.

Three broad groups are recognized: a) those which are primarily kimberlitic and composed of large talc-pseudomorphed olivines, small antigorite-pseudomorphed olivines, strongly zoned phlogopites, apatite and titaniferous magnetite all set in a fine-grained groundmass of phlogopite, calcite, apatite and titaniferous magnetite; b) those which are primarily carbonatitic and composed of calcite, often in phenocrysts, with lesser amounts of phlogopite (largely unzoned), apatite and magnetite all set in a calcite matrix; c) those which are of intermediate character and might be termed carbonatitic-kimberlitic dikes. These have micro-phenocrysts of antigorite-pseudomorphed olivines, phlogopite that is principally unzoned, although some zoned phlogopite is present, apatite, magnetite, calcite and minor pyroxene and amphibole.

Rarely a fourth type of dike is found. These are pure calcite dikes in some of which a prominent comb structure is developed and in which xenoliths of anorthosite are found.

The three principal types of dike display chilled margins and it is in these that the quench dendrites of calcite are found. There seems to be a distinct similarity between these dikes and Benfontein sills

(Dawson and Hawthorne, 1973).

The evolution of the magma is to some extent reflected in the variation of mineral composition with grain size and in mineral zonation.

#### Phlogopite (Fig. 1)

Phlogopite phenocrysts are zoned from deep brown cores through pale brown mantles to pale green rims, and groundmass phlogopite is pale green. Average compositions for these colour variants are Phlog<sub>74</sub> Annite<sub>17</sub> Ti-biotite<sub>9</sub> (cores), Phlog<sub>80</sub> Annite<sub>15</sub> Ti-biotite<sub>5</sub> (mantles), Phlog<sub>90</sub> Annite<sub>9</sub> Ti-biotite<sub>1</sub> (rims and groundmass). In short there is a progressive increase in Mg and decrease in both Ti and Fe as crystallization proceeds which is the reverse of what might normally be expected in a magmatic sequence.

#### Magnetite (Fig. 2)

The range of magnetite composition is from Ulvospinel<sub>16</sub> Magnetite<sub>84</sub> to Ulvospinel<sub>61</sub> Magnetite<sub>39</sub>. Again this is manifested both in zonation of grains and in grain size, the smaller (latest?) grains being the most titaniferous. All the magnetites are single-phase grains and the compositional trend toward iron-poor margins corresponds to crystallization down temperature along the magnetite-ulvospinel join. Magnetites are somewhat aluminous (up to 6% Al<sub>2</sub>O<sub>3</sub>), magnesian (up to 8% MgO), and manganoan (up to 5% MnO) all by weight.

The most likely interpretation of the mineral chemistry is that early crystallization of magnetite progressively raised the Mg/Fe ratio of the magma so that phlogopite which crystallized throughout the cooling history becomes progressively more magnesian. This also appears to have been the case in the Upper Canada Mine kimberlite (Rimsaite, 1971).

In the more carbonatitic dikes phlogopite is both unzoned and varies widely in composition. It seems likely that much of this phlogopite has been scavenged from the more kimberlitic dikes and has not crystallized in equilibrium with the carbonatitic melt.

No fresh olivine is present and it is now represented by pseudomorphs. These are of two distinct sizes and appear to represent two generations. Large phenocrysts are 0.5 to 5 mm across generally ovoid but occasionally six-sided. These consist of fine scaly talc having Fe/Fe+Mg of 0.20. Small (late?) phenocrysts are less than 0.5 mm across and consist of fibrous antigorite aggregates having Fe/Fe+Mg of 0.14. Antigorite also occurs in the groundmass and as a rim on some talc pseudomorphs.

Apparently the kimberlitic magma has undergone extensive differentiation and its crystallization history began prior to its emplacement in dikes. Clearly the carbonatitic fluid had begun to separate before this emplacement since the chilled margins of some of the dikes

contain quenched calcite and apatite. The calcite is in the form of long dendrites and the apatite forms elongate prismatic grains; both are in marked contrast to the rounded phenocrysts.

Analyses of eight rocks are set down in Table I; they lie within the general range of kimberlites *sensu stricto* and the kimberlite-related rocks.

In general they have a much higher Ca/Mg ratio than true kimberlites and this reflects their intermediate character between kimberlites and carbonatites. They appear to lack the pyrope and picro-ilmenite which is generally considered essential to a true kimberlite and in this respect they further resemble the Benfontein rocks.

The development of a carbonatitic liquid during the crystallization of the kimberlitic magma in the Arvida dikes is indisputable and strengthens the view that kimberlitic magmas can generate carbonatitic residual fluids. It should be emphasized, however that the amount is rather small and it would seem to be a great mistake to assume that carbonatite bodies in general are so derived.

#### References

- Dawson, J.B., and J.B. Hawthorne, 1973, Jour. Geol. Soc., v. 129, p.61-85.  
Rimsaite, J., 1969, Contr. Mineral. and Petrol., v. 33, p. 259-272.

Table I

	1	2	3	4	5	6	7	8
SiO <sub>2</sub>	29.1	13.6	14.4	13.8	8.8	9.0	5.8	7.4
Al <sub>2</sub> O <sub>3</sub>	4.1	2.6	2.3	3.4	2.9	1.1	1.2	1.8
Fe <sub>2</sub> O <sub>3</sub>	8.9	7.2	8.0	6.9	4.4	0.6	0.6	3.3
FeO	7.2	5.2	5.4	5.0	4.2	6.5	6.8	3.6
CaO	13.5	31.6	26.6	32.9	34.8	29.6	37.4	43.5
MgO	16.3	8.5	12.9	7.1	8.5	10.5	9.6	6.0
TiO <sub>2</sub>	3.7	2.4	2.5	2.6	1.8	1.0	1.1	1.5
P <sub>2</sub> O <sub>5</sub>	1.3	4.7	4.8	6.1	4.0	5.3	6.1	4.8
MnO	0.4	0.4	0.4	0.5	0.3	0.6	0.6	0.5
Na <sub>2</sub> O	1.6	0.2	0.1	0.3	0.1	0.3	0.3	0.2
K <sub>2</sub> O	1.3	0.9	0.9	1.0	0.6	0.8	0.7	0.1
CO <sub>2</sub>	7.6	19.2	17.2	17.5	25.5	33.6	28.9	25.3
H <sub>2</sub> O+	4.7	2.4	2.9	2.1	2.7	0.3	0.3	1.3
BaO	0.07	0.01	0.55	0.02	0.51	tr	0.09	tr
ΣO	0.01	0.03	0.09	0.01	0.19	0.01	0.03	0.03
	99.8	98.9	99.0	99.2	99.3	99.2	99.5	99.3

- 1        kimberlitic dike  
2-4     kimberlitic-carbonatitic dikes  
5-8     carbonatitic dikes

Analyst: A.G. Loomis

# MANTLED PHLOGOPITES IN ROCK P5-508

CORE → RIM

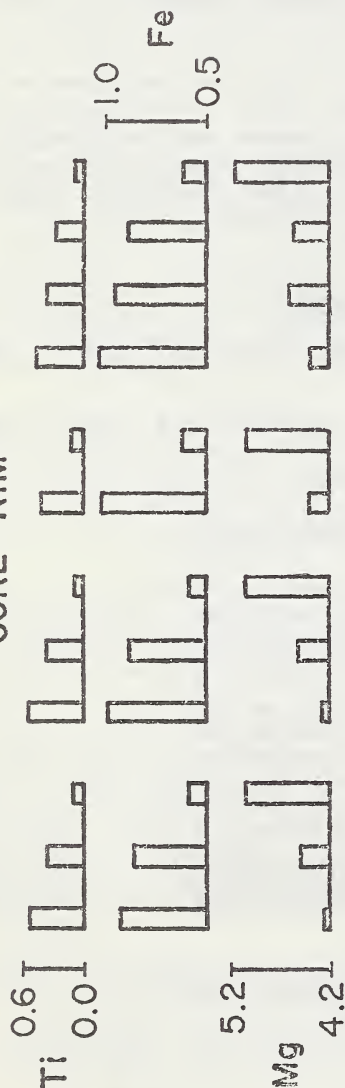


Fig.1.

Variation in composition of four phlogopite grains from a single thin section.

# MAGNETITE IN ROCK P5-508

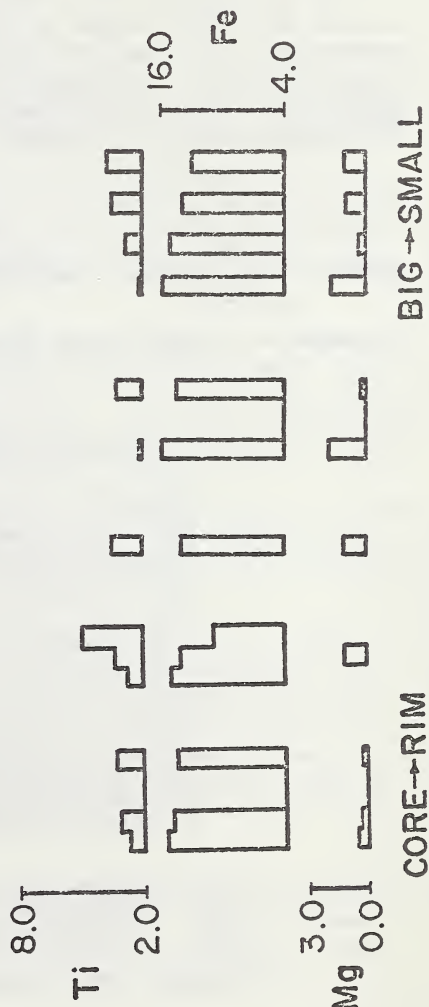


Fig.2.

Variation in composition from core to rim of four magnetite grains and of four grains of different size, in a single thin section.

BIG → SMALL

CORE → RIM