

GEOLOGICAL  
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DEPARTMENT OF ENERGY,  
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PAPER 68-22

A NEW OCCURRENCE OF KIMBERLITE  
IN GAUTHIER TOWNSHIP, ONTARIO

Hulbert A. Lee and D. E. Lawrence



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# CONTENTS

	Page
Abstract .....	v
Introduction .....	1
Occurrence .....	1
Age and magnetic susceptibility .....	1
The definition and properties of kimberlite .....	2
Petrographic features .....	2
Chemical composition .....	3
Trace elements .....	3
The Upper Canada mine kimberlite .....	4
Petrography .....	4
Chemical composition .....	9
Trace elements .....	9
Summary .....	13
Acknowledgments .....	13
References .....	14

Table I Mineralogical composition of kimberlite, Upper Canada mine .....	4
II Chemical analyses, physical properties and end member compositions of chrom- pyropes from kimberlites .....	8
III Chemical analyses of kimberlites .....	10
IV Trace element analyses of kimberlites .....	12

## Illustrations

Figure 1. Index map .....	vi
2. Photomicrograph of kimberlite, Upper Canada mine .....	5
3. Refractive index vs. cell-edge plot of chrom-pyrope from kimberlites .....	7



### ABSTRACT

A dyke rock exposed in the underground workings of the Upper Canada mine, Kirkland Lake region, Ontario, has been identified as kimberlite. It consists of two generations of olivine and phlogopite, pyrope, magnetite, chromite, perovskite, pyrrhotite, apatite, calcite and serpentine. The pyrope and olivine are rich in magnesium as they are in other kimberlites. The  $\text{Al}_2\text{O}_3$  and  $\text{SiO}_2$  values are low,  $\text{TiO}_2$  moderate,  $\text{MgO}$  high and the trace elements Ba, Sr, B, Nb, Zr, Pb and V are high. The K-Ar age of the dyke is  $151 \pm 8$  m.y. Its magnetic susceptibility is  $4,000 \times 10^{-6}$  e.m.u. Fundamentally the kimberlite from Upper Canada mine is similar in bulk chemistry, trace element concentrations and in mineral assemblage to kimberlites from Siberia and South Africa.

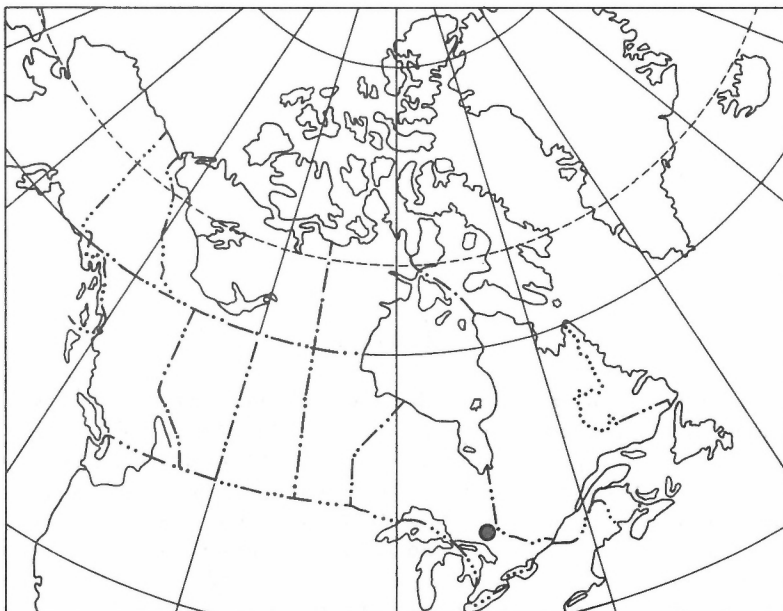


Figure 1. Index map

# A NEW OCCURRENCE OF KIMBERLITE IN GAUTHIER TOWNSHIP, ONTARIO

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## INTRODUCTION

### Occurrence

A micaceous kimberlite dyke was discovered in the underground workings of the Upper Canada mine at Dobie, about 10 miles east of Kirkland Lake, in Gauthier Township, Ontario. The presence of kimberlite in the area was first indicated by the discovery of pyrope garnets in the Munro esker, and a source area in the vicinity of the Upper Canada mine was inferred by using the method of esker glaciofocus (Lee, 1968). The kimberlite dyke was subsequently found by a search of the mine and was sampled by Gordon Bragg and H.A. Lee.

The kimberlite is exposed on the 2,750-foot level in the mine (drift C5 DRE). The strike (340°) and dip (vertical) of the dyke are consistent at several intersections within the mine. The dyke extends vertically towards the surface but as yet no outcrops have been found.

The width of the kimberlite dyke appears constant, averaging about 3 feet (1 metre). A few offshoots, about 2 inches (5 centimetres) wide, occur along the length of the dyke and may encompass the Precambrian country rock before rejoining the main dyke. A comparison of the dyke with other kimberlite dykes of the world, which range from a few centimetres up to several metres, places it amongst the wider dykes. The total length of the dyke has not been established. Dykes in South Africa occur in zones which may extend for several tens of kilometres and are made up of individual intrusions arranged en échelon.

Contacts between the dyke and country rock, which is a porphyritic syenite, are sharp and there is no visible contact alteration. There is, however, a zonation within the dyke, the centre being more coarsely porphyritic than the margins. The geology of Gauthier Township has been described by Thomson and Griffis (1944), and the geology of the mine by Tully (1963).

### Age and Magnetic Susceptibility

A K-Ar age of  $151 \pm 8$  m.y. obtained for phlogopite from the kimberlite (Wanless et al., in press) indicates an Upper Jurassic age.

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There appears to be a related group of kimberlite and kimberlitic rocks of post-Middle Devonian age in eastern North America. A kimberlite at Portland Point, one of a small group of kimberlite dykes near Ithaca, New York, intrudes Upper Devonian sedimentary rocks and has given a K-Ar age of  $155 \pm 4$  m.y. (Watson, 1967, p. 322). A kimberlitic rock and associated lamprophyre at Coral Rapids, Ontario intrude Middle Devonian sedimentary rocks. Alnöite and kimberlite are associated with the Monteregian intrusions of southeastern Quebec (Watson, 1967, p. 322) which have K-Ar ages falling within the range of  $100 \pm 25$  m.y. to  $122 \pm 12$  m.y. (isotope data from Lowdon et al., 1960, 1961; Hurley et al., 1959; Fairbairn et al., 1963; Zartman et al., 1967).

The kimberlite bodies of Ontario are along a linear zone with a regional northwest trend. The dyke at Upper Canada mine is in this zone, as are two kimberlite dykelets 40 miles to the northwest in Michaud Township (Satterly, 1949, p. 13). The post-Middle Devonian kimberlitic rocks at Coral Rapids are a further 140 miles to the northwest. In view of the geographic relationship these occurrences may all be Jurassic in age. Eventually they may be shown to be associated both geographically along a projection of the linear zone to the southeast, and chronologically with the intrusions of the Monteregian Hills, but such correlations still have many uncertainties.

In contrast, the kimberlite at Bachelor Lake, Quebec, 140 miles northeast of the Upper Canada occurrence, dated at 1,100 m.y., is Precambrian in age (Watson, 1967, p. 322).

The magnetic susceptibility of the kimberlite at Upper Canada mine is  $4,000 \times 10^{-6}$  e.m.u. This is not a criterion for correlation, but may be useful in tracing the dyke because of its contrast with the relatively weakly magnetic country rocks.

## THE DEFINITION AND PROPERTIES OF KIMBERLITE

Kimberlite is defined on the basis of its petrographic characteristics but interest in its economic significance has led to the recognition of additional definitive criteria involving chemical composition, trace elements, and the properties of certain key minerals.

### Petrographic Features

Kimberlite has been defined by Dawson (1967a, p. 242) as a serpentinized, carbonated, mica peridotite of porphyritic texture containing ultrabasic nodules characterized by such minerals as pyrope and jadeitic

diopside. It may or may not contain diamond. It occurs in limited-sized diatremes, veins, and sills. This definition will be used in this paper; it differs from the original description of kimberlite by Lewis (1888, pp. 129-131) by omitting the requirement of diamond as an essential constituent.

Smirnov (1959, p. 21) states that the kimberlite minerals associated directly with kimberlite formation may include some or all of the following: pyrope, ilmenite, olivine, magnetite, diopside and chrome-diopside, chrome-spinel, perovskite, micas, and enstatite and hypersthene; the Mg content in pyrope, olivine, diopside, ilmenite etc. is high.

### Chemical Composition

The kimberlite at Upper Canada mine is termed a 'massive micaceous kimberlite' according to the classification quoted by Dawson (1967a, p. 244). The constant chemical features of basaltic kimberlites as given by Dawson (1962, p. 553) are low  $\text{SiO}_2$  and  $\text{Al}_2\text{O}_3$ ; high  $\text{MgO}$  and  $\text{H}_2\text{O}$ ; fairly high  $\text{TiO}_2$ ;  $\text{CO}_2$  usually present;  $\text{Fe}_2\text{O}_3$  greater than  $\text{FeO}$ ;  $\text{K}_2\text{O}$  greater than  $\text{Na}_2\text{O}$ ;  $\text{Al}_2\text{O}_3$  greater than  $\text{K}_2\text{O} + \text{Na}_2\text{O}$ ; and the constant presence of  $\text{P}_2\text{O}_5$ . The micaceous kimberlites have the same general characteristics as the basaltic types, but  $\text{CaO}$ ,  $\text{CO}_2$ , and  $\text{K}_2\text{O}$  are commonly of higher concentration, whereas  $\text{H}_2\text{O}+$  is slightly lower. It should nevertheless be emphasized that within these general terms the chemistry of kimberlites varies considerably.

### Trace Elements

Kimberlites are characterized by two different suites of trace elements (Dawson, 1962, p. 554). One group, consisting of the elements Cu, Sc, Cr, Ni, and Co, occurs in amounts typical of ultramafic rocks. The second group of elements, made up of Li, Rb, Sr, Ba, Y, La, Ga, Zr, V, Pb, and Mo, occurs in much greater amounts than is common for ultramafic rocks, and, in some cases, is more typical of the late stages of magmatic differentiation. In addition, the K-Rb and Ga-Al ratios are typical of late differentiates. Burkov and Podporina (1965) add to the second group of elements, Nb, Ta, Cs and B as determined in kimberlite from diatremes at Yakutia, Siberia.

# THE UPPER CANADA MINE KIMBERLITE

## Petrography

The kimberlite in the Upper Canada mine is a porphyritic, dark greenish grey to greenish black rock. Large rounded olivine grains, glittering mica flakes and the occasional purple-red garnet may be identified in hand specimen. Xenoliths of syenitic country rock are present but are not abundant. A carbonate mineral can be detected by the effervescence of the rock in dilute hydrochloric acid, and the presence of magnetite is indicated by the attraction of the rock to a magnet.

The rock texture varies considerably. Olivine and phlogopite are present both as phenocrysts and as smaller crystals in a turbid green-brown serpentine-carbonate matrix. The mica displays a fluidal (textite) texture, and commonly the phlogopite crystals are broken and bent around the olivines (Fig. 2).

In thin and polished sections the following minerals were identified: olivine, phlogopite, pyrope, magnetite, chromite, perovskite, pyrrhotite, apatite, calcite and serpentine. A few grains of clinopyroxene and amphibole were found in mineral concentrates but were not observed in thin section. An approximate mineral composition is given in Table I.

TABLE I

Mineralogical Composition of Kimberlite from Upper Canada Mine

<u>Mineral</u>	<u>Per Cent</u>
Olivine phenocrysts	31
Phlogopite phenocrysts	25
Groundmass (mostly carbonate and serpentine)	35
Oxides (titaniferous magnetite and chromite)	5
Perovskite	4
Pyrope	tr
Clinopyroxene	tr
Amphibole	tr
Apatite	tr
Pyrrhotite	tr

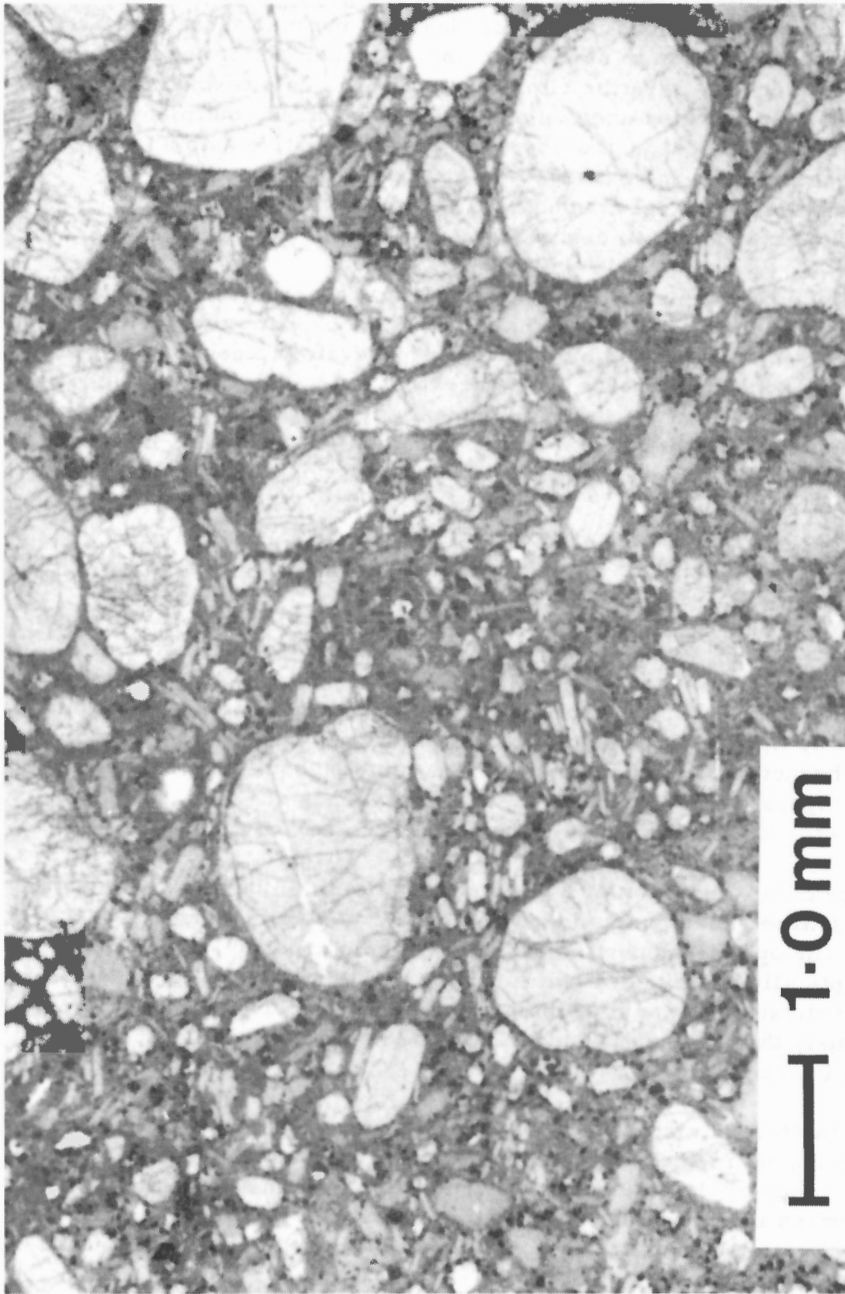


Figure 2. Photomicrograph of kimberlite from Upper Canada mine, Ontario. Note large rounded olivines, smaller laths of phlogopite, in a turbid groundmass. Opaque minerals - magnetite, chromite, perovskite - show as small black grains.

Most olivine occurs as large (0.3-12.0 mm) colourless anhedral grains. The degree of roundness of many of these grains is a striking feature. The olivine displays one imperfect cleavage and many irregular fractures along which alteration to serpentine and emplacement of secondary calcite have taken place. Alteration rims of serpentine, calcite and magnetite are present and some grains are completely serpentinized, but many are remarkably fresh. Optically, the olivine is biaxial positive with a large  $2V$ . Cell-edge measurements indicate that the composition is forsterite ( $Fe_{93-94}$ ). Smaller euhedral to subhedral olivine crystals in the groundmass have a much lower magnesium content ( $Fe_{82-83}$ ).

Phlogopite forms euhedral to anhedral phenocrysts, but these are considerably smaller (0.5-1.0 mm) than the olivine phenocrysts. The mineral is light brown or bronzy in colour and is moderately pleochroic; many of the crystals are zoned and show a darker central core and a lighter, less pleochroic border. The crystals are commonly bent or broken and contain small inclusions of apatite and iron oxide. Phlogopite in the rock matrix has an average size of 0.05 mm. Optically the phlogopite is biaxial negative with a very small  $2V$ .

Purple-red pyrope garnet occurs scattered throughout the rock as large (average 2 mm) rounded grains that are invariably surrounded by greenish grey kelyphitic rims ranging in thickness up to 1 mm. The pyrope has a mean refractive index of 1.745 ( $\pm .002$ ), a cell-edge dimension of 11.541 Å, and a specific gravity of 3.725 (Fig. 3; Table II). The only observed inclusions within the garnets are rounded composite grains of chromite rimmed by titaniferous magnetite. In general, pyrope garnets in kimberlite are characterized by high magnesium values (about 20 per cent, amongst the highest known for garnet) and the presence of  $Cr_2O_3$  (Table II). Garnets from the kimberlite of the Upper Canada mine are typical.

Optical examination of a crushed sample of kimberlite revealed the presence of sparse green grains identified by X-ray as clinopyroxene and amphibole. The optical properties of the amphibole are  $Z\wedge C$ , about  $10^\circ$ ;  $2V$  large, and optically negative. Preliminary analyses by means of an electron microprobe indicate that the amphibole contains 1 to 2 per cent  $Cr_2O_3$ . As noted previously these minerals have not been identified in thin section and their source is uncertain.

Titaniferous magnetite and chromite occur as composite small (0.1 mm average diameter), compact, subhedral grains. The chromite is commonly rimmed by the titaniferous magnetite. Examination of these oxides by electron probe indicates that the chromite is rich in the end member  $FeCr_2O_4$ , whereas the magnetite is highly titaniferous, containing about 20 per cent  $TiO_2$  by weight.

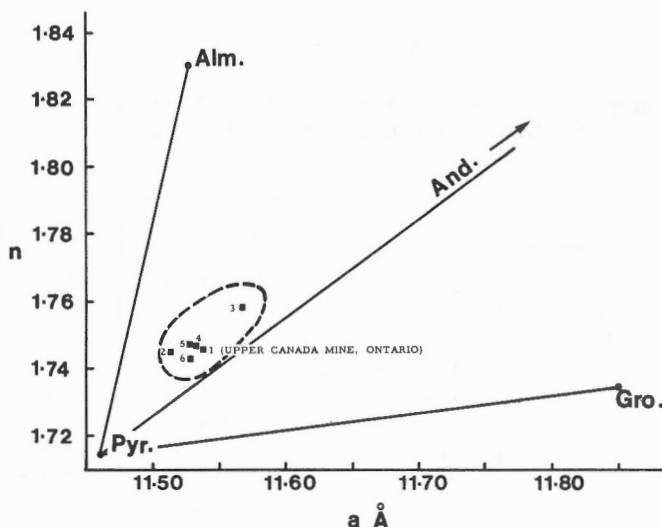


Figure 3. Refractive index vs. cell-edge plot of chrom-pyropes from kimberlite of Upper Canada mine, Ontario, compared to other known kimberlites. Sample localities Table II. Dashed line indicates field of chrome-pyropes from kimberlites of Basutoland and South Africa (Nixon et al., 1963). Diagram modified from Skinner (1956).

Perovskite is scattered through the kimberlite as small (0.05 mm average diameter) subhedral grains. Under crossed nicols it shows a strong brown internal reflection in the centres of the grains and a white internal reflection at the rims; testing with electron probe indicates that this difference is not reflected in any compositional zoning and probably results from the thinning of the grains at their borders. Probe work shows calcium and titanium to be the sole major components, but about 2 per cent FeO is present in all grains examined.

Pyrrhotite occurs as fine to ultra-fine aggregates throughout the rock.

We conclude that the micaceous kimberlite dyke from the Upper Canada mine, Ontario fits the petrographic description of kimberlite given by Dawson.

TABLE II

Chemical Analyses, Physical Properties and End Member Compositions of Chrome-Pyropes from Kimberlites

	1	2	3	4	5	6
SiO <sub>2</sub>	40.2	41.70	41.90	42.11	42.73	42.77
TiO <sub>2</sub>	0.1	0.45	0.11	0.12	0.27	0.30
Al <sub>2</sub> O <sub>3</sub>	21.7	20.42	16.92	22.10	19.83	21.91
Cr <sub>2</sub> O <sub>3</sub>	3.4	1.91	7.52	1.91	2.92	1.90
Fe <sub>2</sub> O <sub>3</sub>	- *	1.42	1.24	0.35	0.81	1.25
FeO	7.7	7.27	6.17	8.24	7.01	6.79
MnO	0.5	0.21	0.59	0.36	0.33	0.26
MgO	19.8	20.86	19.64	19.85	21.54	20.70
CaO	5.6	5.94	6.27	4.80	4.69	4.65
H <sub>2</sub> O	-	-	-	-	-	-
Others	-	1.19	-	-	-	-
Total	99.0	100.38	100.36	100.24	100.13	100.53
n	1.745	1.744	1.758	1.746	1.746	1.743
D	3.725	3.73	3.715	-	3.690	3.712
a(Å)	11.541	11.509	11.565	11.531	11.528	11.528
colour**	10P-RP5/5	orange red	5RP3/2	9RP5/2	-	8R5/2
Pyrope	69.6	73.2	61.7	70.6	74.2	73.7
Almandine	15.2	14.1	12.4	16.4	13.6	13.9
Andradite	-	4.1	3.3	1.0	2.1	3.3
Grossular	4.4	2.0	-	5.9	1.3	3.1
Spessartine	1.0	0.3	1.2	0.7	0.6	0.6
Uvarovite	9.8	5.2	2.8	5.4	8.2	5.4

1 Kimberlite dyke, Upper Canada mine, Ontario. Electron microprobe analysis by A.G. Plant, Mineralogy Section, Geological Survey of Canada.

2 Zarnitsa pipe, Siberia (Smirnov, 1959, p. 27).

3 Sekameng pipe, Basutoland (Nixon et al., 1963, p. 1104).

4 Dutoitspan pipe, South Africa (Nixon et al., 1963, p. 1104).

5 Kao pipe, Basutoland (Nixon et al., 1963, p. 1104).

6 Pipe at Farm Louwrencia, near Gibeon, Southwest Africa (Nixon et al., 1963, p. 1104).

\* Total Fe is determined as FeO.

\*\* Colour from: Munsell Book of Color, Library edition, vol. 1, Munsell Color Company, Baltimore, Maryland, 1929. Measurement is made on crushed mineral fragments under reflected light.

### Chemical Composition

Chemical analyses of two specimens of kimberlite from the Upper Canada mine, one from a coarse porphyritic facies near the centre of the dyke, and the other a less porphyritic facies from the margin are compared with analyses of kimberlites in Africa, U.S.S.R., U.S.A., and Canada which are chiefly micaceous types occurring as dykes (Table III).  $\text{SiO}_2$  and  $\text{Al}_2\text{O}_3$  values in the kimberlite of the Upper Canada mine are low as they are in kimberlites of Siberia, South Africa and Basutoland. Both higher and lower values have been reported for these oxides in other kimberlites (e.g. Dawson, 1962, p. 551).

$\text{MgO}$ ,  $\text{TiO}_2$  and  $\text{CO}_2$  values are high in the Upper Canada mine kimberlite, their concentration being similar to those of other kimberlites.  $\text{H}_2\text{O}$  is lower than in many kimberlites but is within the established range; the analyzed rocks are relatively free from serpentine which may account for the low water content.

$\text{Fe}_2\text{O}_3$  is less than  $\text{FeO}$ ; this is the reverse of  $\text{Fe}_2\text{O}_3:\text{FeO}$  ratios found in most kimberlites. This difference may also be due to freshness of the rock.

$\text{K}_2\text{O}$  is present in greater abundance than  $\text{Na}_2\text{O}$ , and  $\text{Al}_2\text{O}_3$  is more abundant than  $\text{K}_2\text{O} + \text{Na}_2\text{O}$ ; these characteristics conform to kimberlites as defined by Dawson (1962).

$\text{P}_2\text{O}_5$  is present as in almost all other kimberlites. Microcrystalline apatite in the groundmass of the kimberlite can account for the phosphorous.

We conclude that the micaceous kimberlite dyke in the Upper Canada mine is chemically similar to the kimberlites of Siberia, South Africa and Basutoland.

### Trace Elements

Spectrographic analyses in part semiquantitative, were made on the same two specimens of kimberlite from Upper Canada mine. The concentration of trace elements in these specimens, shown in Table IV, are compared with trace element contents of other kimberlites from Yakutia, Basutoland and South Africa.



TABLE III

Comparison of Chemical Analyses of the Kimberlite Dyke  
at Upper Canada Mine with other Kimberlites

	1	2	3	4	5	6	7	8	9
SiO <sub>2</sub>	32.7	33.2	30.13	31.80	27.93	31.60	36.7	23.25	33.20
TiO <sub>2</sub>	2.1	2.1	3.60	1.40	2.73	2.02	1.16	5.10	1.59
Al <sub>2</sub> O <sub>3</sub>	3.2	3.2	4.72	3.41	4.47	3.21	7.95	3.15	4.45
Fe <sub>2</sub> O <sub>3</sub>	3.9	4.1	8.15	5.19	7.04	6.33	5.67	6.97	5.23
Cr <sub>2</sub> O <sub>3</sub>	0.4	0.5	-	-	0.08	-	0.08	0.05	n.d.
FeO	5.8	5.8	6.68	3.48	5.12	3.37	5.04	7.07	3.89
MnO	0.2	0.2	0.12	-	0.23	0.30	0.19	0.18	n.d.
MgO	31.5	31.6	25.87	24.69	25.42	29.45	13.78	20.81	28.19
CaO	8.1	8.3	7.05	10.04	10.01	8.07	13.11	14.78	6.60
Na <sub>2</sub> O	0.5	0.4	0.45	0.29	0.21	0.16	0.30	0.17	3.38
K <sub>2</sub> O	2.0	2.0	0.96	4.32	1.18	0.34	0.67	1.16	0.43
H <sub>2</sub> O	3.4	3.7	8.51	6.26	7.89	12.24	8.80	5.98	7.50
CO <sub>2</sub>	5.1	5.0	5.32	7.65	6.29	1.96	4.08	10.36	8.76
P <sub>2</sub> O <sub>5</sub>	0.4	0.4	0.34	1.49	1.07	0.94	n.d.	0.74	0.35
Total	99.3	100.5	100.38	99.98	99.55	99.99	98.0	-	99.05

- 1 Micaceous kimberlite dyke, Upper Canada mine, Ontario. Coarse porphyritic facies from centre of dyke. New analysis by Analytical Chemistry Section, Geological Survey of Canada, by a combination of rapid chemical and X-ray fluorescence methods.
- 2 Micaceous kimberlite dyke, Upper Canada mine, Ontario. Less porphyritic facies near margin of dyke. New analysis by Analytical Chemistry Section, Geological Survey of Canada, as in 1.
- 3 Kimberlite dyke, Troynoga, Olenek district, Siberia (Krutojarsky, 1958).
- 4 Micaceous kimberlite, Lion Hill dyke, South Africa (Wagner, 1914, p. 110).
- 5 Micaceous kimberlite, Robert dyke, Basutoland (Dawson, 1962, p. 551).
- 6 Kimberlite, Kao pipe, Basutoland (Dawson, 1962, p. 551).
- 7 Kimberlitic dyke, Coral Rapids, Ontario (Brown *et al.*, 1967, p. 18).
- 8 Kimberlite dyke, Bachelor Lake, Quebec, average of 3 analyses (Watson, 1955, p. 573).
- 9 Kimberlitic dyke, Cascadilla Creek, Ithaca, New York (Martens, 1924, p. 312).

It can be seen from Table IV that copper, chromium, nickel and cobalt all fall within their established ranges for kimberlites in general. Nickel is known to vary according to the petrographic character of the kimberlite. For example, Litinski (1961, p. 817) reports that the massive kimberlites with few xenoliths of Yakutia have a much higher content of nickel than is indicated by their average (see locality 3, Table IV). The nickel content approaches 1,000 parts per million, about the same as for the massive kimberlite of Upper Canada mine. The Ni:Co ratio in Upper Canada kimberlite is 14. Other kimberlites of Table IV have Ni:Co ratios of 11, 15 and 24. There is growing evidence that this high Ni:Co ratio is a characteristic of kimberlite (Dawson, 1967b, p. 273). The content of chromium in the Upper Canada kimberlite is approximately 1,500 parts per million. Some of the Cr is in the chromium-bearing minerals of chromite-titaniferous magnetite and pyrope. In the pyrope, the chromium content is about 11,600 parts per million.

The concentrations of the majority of elements (Zr, V, Pb, Nb, B) in the Upper Canada kimberlite are not only within the range of concentrations shown for other kimberlites of Table IV, but approximate closely their averages.

The amounts of strontium and barium in the Upper Canada kimberlite are within the concentration range of other kimberlites (Table IV). Neither strontium-nor barium-bearing minerals have yet been identified in the specimens; it is probable that these two elements are contained in solid solution, barium in proxy for K in phlogopite and strontium as a replacement in calcite in the groundmass. The content of lithium in the Upper Canada kimberlite as determined by a conventional chemical procedure is 3.5 parts per million. This is within the range established for kimberlites but is lower than the averages reported in Table IV. The amount of scandium (< 20 ppm) appears lower in the Upper Canada kimberlite than is known for other kimberlites. Yttrium was not detected in the Upper Canada kimberlite, and molybdenum was detected in only one of the two specimens analyzed.

In summary it can be said that the trace element content of the Upper Canada mine kimberlite as indicated in Table IV is similar to that of other kimberlites. However, it should be noted that data for trace elements in kimberlites are still sparse, and many have been obtained by spectrochemical methods near the limits of sensitivity so that even though there are strong indications of two distinct groups of trace elements for kimberlites, the definite assignment of every element to one or the other group is not clear.

TABLE IV

Comparison of Trace Element Analyses of the Kimberlite Dyke at Upper Canada Mine with other Kimberlites

Upper Canada Mine		Yakutia		Yakutia	Basutoland		Africa
1	2	3		4	5		6
Element		Average	Range	Average	Average	Range	Average
Li	3.5	3.3		34	16	<4-50	20
Cu	56	55	60		100	30-300	
Sr	710	760	200	1140	445	120-1000	600
Ba	1900	2000			740	130-2600	1000
Sc	<20	<20		10	25	20-30	15
Y	nd*	nd			46	<30-75	40
La	150	150			370	100-650	
Ga	1-10	1-10			9	<3-30	10
Pb	5-50	5-50			9	<3-20	30
Zr	250	250	200	97	445	300-700	190
V	130	130	170	120	120	65-180	160
Nb	220	210	70	160	240	130-400	200
Cr	1500	1600	1500		1440	95-2000	1000
Mo	nd	0.5				3-12	
Co	78	78	40		77	65-110	50
Ni	1100	1100	450		1140	500-1700	1200
Zn	10-100	10-100					
Sn	1-10	1-10					
B	20-200	20-200		149			
Ge	0.1-1	0.1-1		0.5			
Ag	0.1-1	0.1-1					

1. Micaceous kimberlite dyke, Upper Canada mine, Ontario. Single specimen, coarse facies from centre of dyke. New analysis by Analytical Chemistry Section, Geological Survey of Canada.
2. Micaceous kimberlite dyke, Upper Canada mine, Ontario. Single specimen, less porphyritic facies from margin of dyke. New analysis by Analytical Chemistry Section, Geological Survey of Canada.
3. Average of 459 specimens, from Litinski (1961).
4. Averages of between 19 and 57 specimens from Mir, Zarnitza and Udashnaya kimberlite pipes, from Burkov and Podporina (1965).
5. Average of four except Y which is average of two, from Janse (1964).

\* nd = not detected.

Lithium analyzed by a chemical method. All other data for Upper Canada kimberlite except La and B, determined by a quantitative spectrochemical method and results are expected to be accurate to within  $\pm 15\%$  of value reported, the results for La and B are semiquantitative.

## SUMMARY

This preliminary study of kimberlite from the Upper Canada mine shows that the mode of occurrence, petrographic features, mineralogy, bulk chemistry, and trace element content of the rock are all characteristic of a massive micaceous kimberlite.

Application of the glaciofocus method of prospecting, using a specific indicator mineral (pyrope) in esker sands led to the kimberlite discovery in the underground workings of the Upper Canada mine.

Evidence for other possible kimberlite occurrences along a zone is indicated by further concentration of pyrope in the esker sands to the southeast (Lee, 1968), and another kimberlite occurrence in Michaud Township to the northwest (Satterly, 1949). The above, combined with the fact that kimberlites are known to occur in groups, indicate this region to be highly favourable for exploration of diamonds.

On a broader scale, kimberlitic and alkaline rocks, including the above occurrences, are known within a broad zone extending from Coral Rapids in northern Ontario to the Monteregian Hills, Quebec, and Ithaca, New York. All are of similar age of about 125 to 155 m.y. These similarities are suggestive of a genetic relationship.

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