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Geology of
Carbonatite - Alkalic Rock Complexes in Ontario:
Cargill Township Carbonatite Complex
District of Cochrane

Ontario Geological Survey
Study 36

by R. P. Sage

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Foreword

The Cargill Township Carbonatite Complex was examined as part of a project to study alkalic rock – carbonatite complexes in Ontario. The study describes the rock types and mineralogy of the complex and outlines the history of the mineral exploration efforts within the complex.

V.G. Milne

Director
Ontario Geological Survey

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CHART (back pocket)

CONVERSION FACTORS FOR MEASUREMENTS IN ONTARIO GEOLOGICAL SURVEY PUBLICATIONS

Conversion from SI to Imperial			Conversion from Imperial to SI		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
		LENGTH			
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709 7	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	**1.609 344**	km
		AREA			
1 cm^2	0.155 0	square inches	1 square inch	**6.451 6**	cm^2
1 m^2	10.763 9	square feet	1 square foot	**0.092 903 04**	m^2
1 km^2	0.386 10	square miles	1 square mile	2.589 988	km^2
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
		VOLUME			
1 cm^3	0.061 02	cubic inches	1 cubic inch	**16.387 064**	cm^3
1 m^3	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m^3
1 m^3	1.308 0	cubic yards	1 cubic yard	0.764 555	m^3
		CAPACITY			
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	**4.546 090**	L
		MASS			
1 g	0.035 273 96	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 75	ounces (troy)	1 ounce (troy)	**31.103 476 8**	g
1 kg	2.204 62	pounds (avdp)	1 pound (avdp)	**0.453 592 37**	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	**907.184 74**	kg
1 t	1.102 311	tons (short)	1 ton (short)	**0.907 184 74**	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	**1016.046 908 8**	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	**1.016 046 908 8**	t
		CONCENTRATION			
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

1 ounce (troy) per ton (short)	20.0	pennyweights per ton (short)
1 pennyweight per ton (short)	0.05	ounces (troy) per ton (short)

Note: Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries, published by the Mining Association of Canada in cooperation with the Coal Association of Canada.

Geology of
Carbonatite - Alkalic Rock Complexes in Ontario:
Cargill Township Carbonatite Complex
District of Cochrane

R.P. Sage[1]

1. Geologist, Precambrian Geology Section, Ontario Geological Survey, Toronto. Manuscript approved for publication by John Wood, Chief Geologist, Ontario Geological Survey, October 19, 1983.

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Abstract

The Cargill Township Carbonatite Complex is situated within the Kapuskasking Subprovince of the Superior Province of the Canadian Shield. The intrusion displays an outer pyroxenite rim which hosts minor copper–nickel mineralization and a carbonatite core consisting of calcitic, dolomitic, and sideritic phases. The intrusion has been isotopically dated by U–Pb techniques at 1907 ± 4 Ma. Weathering of the carbonatite core during Cretaceous time produced an apatite-rich residuum.

Faulting of the complex along a northeast trend has split the complex into two parts giving rise to a dumbbell shaped aeromagnetic pattern.

The body has been explored for copper–nickel and apatite. Testing of the residual accumulation of apatite by the International Minerals and Chemical Corporation (Canada) Limited has indicated an apatite reserve of 56.7 million tonnes (62.5 million tons) grading 19.6% P_2O_5. The residuum also contains niobium, rare earths, vermiculite, clay, and sand although they have not been evaluated as to their economic significance. At the time of writing, the residual apatite accumulation was undergoing additional testing of its economic potential by Sherritt Gordon Mines Limited.

Résumé

Le complexe de carbonatite du canton de Cargill est situé dans la sous–province de Kapuskasing, dans la province Supérieure du bouclier canadien. L'intrusion est formée d'une frange de pyroxénite qui englobe une légère minéralisation de cuivre et de nickel et un noyau de carbonatite composé de phases calcaire, dolomitique et sidéritique. D'après les techniques isotopiques de datation à l'U–Pb, l'âge de l'intrusion est de 1907 ± 4 Ma. L'altération climatique du noyau de carbonatite lors de la période crétacée a produit un résidu riche en apatite.

Les failles nord–est du complexe ont divisé ce dernier en deux, formant ainsi une structure aéromagnétique en forme d'haltère.

Cette formation a fait l'objet d'une prospection en vue de déceler la présence de cuivre–nickel et d'apatite. Les analyses des accumulations résiduelles d'apatite effectuées par International Minerals and Chemical Corporation (Canada) Limited ont révélé la présence d'une réserve d'apatite de 56,7 tonnes métriques (62,5 millions de tonnes) dont la teneur en P_2O_5 est de 19,6 pour 100. Le résidu contient également du niobium, des terres rares, de la vermiculite, de l'argile et du sable dont la valeur commerciale n'a pas été déterminée. Lors de la rédaction du présent résumé, Sherritt Gordon Mines Limited procédait à de nouvelles analyses en vue de déterminer la valeur commerciale de l'accumulation.

Geology of Carbonatite – Alkalic Rock Complexes in Ontario: Cargill Township Carbonatite Complex, District of Cochrane, by R.P. Sage. Ontario Geological Survey, Study 36, 92p. Published 1988. ISBN 0-7729-0571-1.

Introduction

The Cargill Township Carbonatite Complex lies within the Kapuskasing Subprovince of the Superior Province of the Canadian Shield. The complex is one of several that occur within this subprovince. The intrusion has been dated by K–Ar isotopic techniques at 1740 Ma (Gittins *et al.* 1967) and by U–Pb techniques at 1907 ± 4 Ma (S.T. Kwon, Department of Geology, University of California, Santa Barbara, California, personal communication, 1987). The carbonatite complex has been emplaced along regional faults characteristic of the Kapuskasing Subprovince and has been in turn offset by later fault movements. This faulting has split the complex into two parts so that it has a dumbbell shape in plan view with the long axis trending northeast. The body has been the subject of several exploration programs culminating in 1974 with the discovery of residual apatite accumulations by the International Minerals and Chemical Corporation (Canada) Limited. The apatite deposits have potential economic significance as a source of phosphate.

At the time of writing, Sherritt Gordon Mines Limited was undertaking additional work to evaluate the economic potential of the residual apatite deposits lying on the surface of the carbonatite.

Acknowledgments

The present study of the complex would not have been possible without the full cooperation of the International Minerals and Chemical Corporation (Canada) Limited. Mr. Ralph McGinn, in charge of operations at the property, guided the field party while visiting the property. Dr. George Erdosh, senior geologist, and Dr. P.O. Sandvik at the head office in Libertyville, Illinois, provided considerable support and encouragement to the project. All samples described were obtained from diamond drill core of the International Minerals and Chemical Corporation.

In 1976, Mr. Wilbur Wright, senior geological assistant, examined approximately half the core sampled by the field party. Mr. Paul Chamois and Mr. Carl Higgins served as geological assistants, helping both the author and Mr. Wright in sampling. Mr. A. Lisowyk, geological assistant, recalculated statistics on whole-rock chemistry and revised the tables in Appendix A in 1988.

Mr. H.L. Banting, Continental Copper Mines Limited, gave approval to Kennco Exploration (Canada) Limited to release to the Ministry data concerning Kennco's work on the complex. Mr. H.W. Fleming, chief geologist, Kennco Exploration (Canada) Limited released the data to the Ministry.

Mr. Gary Hughes, Exploration Manager, Sherritt Gordon Mines Limited, provided the Ontario Geological Survey with data obtained by that company resulting from its work on the complex. In 1981, Mr. L. Kelley, geologist, Sherritt Gordon Mines Limited, guided the author during operations to uncover the residual apatite deposits for the purpose of bulk sampling.

In 1987, Mr. B. Hystead, Manager, Mineral Resource Development, Sherritt Gordon Mines Limited, Mr. L. Kelley, geologist, Sherritt Gordon Mines Limited, and Mr. P. Potapoff, senior geologist, Camchib Resources Limited, provided reports and data resulting from exploration efforts since 1981.

Location And Access

The Cargill Township Carbonatite Complex is located at approximately 49°19'N Latitude and 82°49'W Longitude (Figure 1) in the northwest corner of Cargill

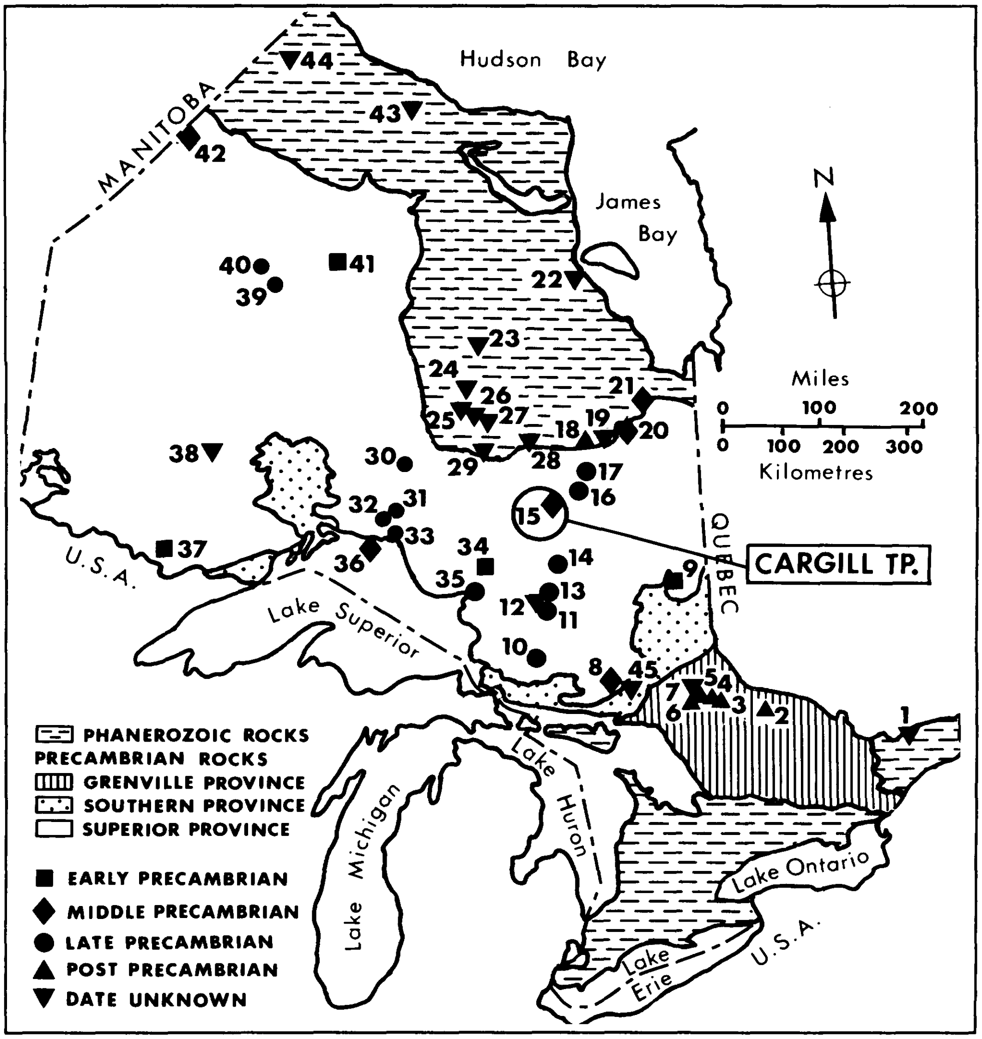

Figure 1. *Key map showing location of carbonatite - alkalic rock complexes in Ontario.*

1. *Eastview*
2. *Brent*
3. *Callander B.*
4. *Manitou Is.*
5. *Burritt Is.*
6. *Iron Is.*
7. *Lavergne*
8. *Spanish R.*
9. *Otto Stock*
10. *Seabrook L.*
11. *Lackner L.*
12. *Borden Tp.*
13. *Nemegosenda L.*
14. *Shenango Tp.*
15. **Cargill Tp.**
16. *Teetzel Tp.*
17. *Clay-Howells*
18. *Hecla-Kilmer*
19. *Valentine Tp.*
20. *Goldray*
21. *Argor*
22. *Lawashi R.*
23. *Poplar R.*
24. *Albany Forks*
25. *L. Drowning R.*
26. *Kingfisher R. West*
27. *Kingfisher R. East*
28. *Martison L.*
29. *Nagagami R.*
30. *Chipman L. (dikes)*
31. *Killala L.*
32. *Prairie L.*
33. *Port Coldwell*
34. *Herman L.*
35. *Firesand R.*
36. *Slate Is.*
37. *Poohbah L.*
38. *Sturgeon Narrows & Squaw L.*
39. *Schryburt L.*
40. *Big Beaver House*
41. *Wapikopa L.*
42. *"Carb" L.*
43. *Gooseberry Br.*
44. *Niskibi L.*
45. *Nemag L. & Lusk L.*

Township and extends into the southwest corner of Cumming Township. The complex can be most easily reached by the private, logging access road of Spruce Falls Pulp and Paper Company Limited which passes within 1.6 km of the body. The International Minerals and Chemical Corporation (Canada) Limited has constructed a subsidiary road to a campsite on "Marilyn" Lake (local name) located on the southern half of the complex.

The complex is dumbell–shaped and has a pronounced northeast elongation. Its general outline is well displayed on aeromagnetic map 2252G (ODM–GSC 1962). The intrusion has a surface area of approximately 9.6 km^2 (Figure 2). Outcrop of the complex is rare, and consists of several small, deeply weathered outcrops of pyroxenite and/or carbonatite.

Physiography

The complex is located in generally flat marshy ground and lacks significant topographic relief. Relief is on the order of 15 m and reflects a topography of rounded hills separated by wet ground.

Previous Geological Work

Bennett *et al.* (1967, Figure 13) first mapped the complex as part of a regional reconnaissance program and Gittins *et al.* (1967) completed a K–Ar isotopic age determination on the complex. Allen (1972) did detailed studies on the mafic rocks on the complex using samples of diamond drill core obtained from Kennco Explorations (Canada) Limited. Sandvik and Erdosh (1977) have published a summary of the results of the work completed by the International Minerals and Chemical Corporation (Canada) Limited on the residual apatite accumulations lying above the bedrock.

Gasparrini *et al.* (1971) published a brief note on the compositions of the amphibole and phlogophite found within the complex. In 1973, Kocman and Rucklidge published data on the composition of clinohumite found at the Cargill carbonatite. Gittins *et al.* (1975) have proposed that the phlogopite found in close association with the pyroxenite at Cargill is the result of fenitization of the pyroxenite by an intruding alkali–rich carbonatite magma.

In 1983, Twyman completed an extensive study of the carbonate–rich phases and contained minerals. His study was an extension of the work completed by Allen (1972) on the mafic silicate phases. Twyman (1983) made numerous comparisons between the Cargill and the similar Argor carbonatite complex.

Kwon (1986) completed isotopic studies on the Cargill complex and Sharpe (1987) completed work in Rb–Sr isotopic systems.

The volume of chemical, microprobe, and isotopic data is too voluminous to present here and readers should refer to the original documents by Twyman (1983) and Sharpe (1987).

Present Survey

Field sampling was completed in 1976. Due to lack of outcrop, sampling was restricted to the diamond drill core of the International Minerals and Chemical Corporation. All drilling consisted of vertical holes and diamond drilling was restricted to approximately 1200 m (4000 feet) in total core–length. The company used reverse circulation techniques for most of its drilling which was primarily done to investigate the residual accumulation of apatite above the bedrock.

As only diamond drill core samples were available it is likely that these samples are not representative of the complex as a whole. Sampling emphasis was placed on obtaining samples from the more homogeneous cores, or sections of core which could be considered to be most representative of the lithologies present. The diamond drill core of Kennco Exploration (Canada) Limited is still at the property; however, the numbers on the core boxes are unreadable due to weathering.

The original version of this study was prepared in 1978. Brief summaries of the conclusions or results of more recent studies (e.g. Twyman 1983, Kwon 1986 and Sharpe 1987) have been added to this study, but no major rewriting has been done. Similarly, the results of exploration work from 1981 to 1987, supplied to the author by Sherritt Gordon Mines Limited, have been consulted to revise the exploration history and geology on the carbonatite complex.

Laboratory Technique

A suite of the texturally and compositionally most homogeneous rocks was selected for thin sectioning and chemical analysis. The thin sections were examined only briefly and the major textural features noted. These observations are summarized in Table A-1 in Appendix A. Allen (1972) presented detailed microprobe analyses of the various mineral phases, some of which is reproduced here in Appendix B.

Nomenclature

The author uses names for the mafic to ultramafic rocks in the conventional manner. The following terms are used to describe the carbonatite rocks.

Sovite: A carbonatite rock containing 50% or more calcite. Various mineralogic modifiers are used to classify the sovite.

Rauhaugite: The dolomitic equivalent of sovite.

Silicocarbonatite: A carbonatite rock composed of 50% or more oxide and silicate minerals. Where the silicate mineralogy exceeds 90% various other rock names are applied, i.e., ijolite, biotitite, pyroxenite, etc.

The definitions of sovite and silicocarbonatite are modified from Heinrich (1966, p.12). The author has found Heinrich's subdivision of the carbonate-rich carbonatitic rocks generally suitable for field use when modified to a two-fold subdivision at about 50% oxide and silicate mineral contents. The two-fold subdivision is more convenient than the four-fold subdivision of Heinrich (1966, p.12) because carbonatites are extremely variable in mineral content over distances of less than a few centimetres. It is difficult to rigorously classify such heterogeneous rocks and they are not mappable at any convenient map scale.

General Geology

The Cargill Township Carbonatite Complex (Table 1, Figure 2 and Figure 3, Chart A, back pocket), as interpreted from ODM–GSC aeromagnetic map 2252G, is a dumbbell–shaped body approximately 7.2 km long consisting of two pronounced aeromagnetic anomalies separated by a narrow band of lower aeromagnetic intensity. The two pronounced aeromagnetic anomalies have been interpreted as being the faulted portions of a once continuous, more circular body (Bennett *et al.* 1967; Sandvik and Erdosh 1977). The International Minerals and Chemical Corporation (Canada) Limited has named these two anomalies the north and south subcomplexes respectively, while a third aeromagnetic anomaly (*see* Figure 2) 4 km west of the main intrusive mass was named the west subcomplex (Sandvik and Erdosh 1977).

The Cargill Township complex is enveloped in Early Precambrian quartz diorite gneiss and amphibolite (Sandvik and Erdosh 1977). Drilling by the International Minerals and Chemical Corporation (Canada) Limited indicates that the complex consists of arcuate to curvilinear bands of siderite, calcite, and dolomite carbonatite enclosed in a wide unit of pyroxenite and hornblendite (Sandvik and Erdosh 1977). The carbonatite is multi–phased and zoned. The outer zone of carbonate rock is calcite carbonatite and the core is dolomite carbonatite (Sandvik and Erdosh 1977). Siderite phases, which are probably the latest, in-

TABLE 1. TABLE OF LITHOLOGIC UNITS FOR THE CARGILL TOWNSHIP CARBONATITE COMPLEX.

MESOZOIC TO CENOZOIC		
	Recent	
		Swamp and stream deposits.
	Pleistocene	
		Glacial lake clays.
		Unconformity
	Late Cretaceous to Early Tertiary	
		Pre–glacial quartz sands, organic clay, and kaolinite.
		Unconformity
		Apatite–rich residuum.
		Unconformity
MIDDLE PRECAMBRIAN (PROTEROZOIC)		
	Cargill Tp. Carbonatite Complex	
		Sovite, rauhaugite, sideritic carbonatite; silicocarbonatite.
		Intrusive Contact
		Pyroxenite, hornblendite, and related rocks.
		Intrusive Contact
EARLY PRECAMBRIAN (ARCHEAN)		
		Quartz diorite gneiss; amphibolite.

trude the earlier carbonatite phases as arcuate or lens–shaped bodies (Sandvik and Erdosh 1977).

Sandvik and Erdosh (1977), reported that fenitization is absent in quartz diorite rocks in contact with the complex to the south but is distinctly present marginal to the west subcomplex. Erdosh (1979) reported that contacts between calcite and dolomite carbonatites are gradational but that the contacts are sharp between siderite carbonatite and the other carbonatites.

The apatite–bearing residuum that was developed during the Cretaceous weathering of the carbonatite forms the phosphate reserves drilled by the International Minerals and Chemical Corporation (Canada) Limited (Sandvik and Erdosh 1977; Erdosh 1979). The residuum is light to dark grey, in places brownish, and consists of predominantly sand–sized unconsolidated material of white to colourless crystals, crystal fragments, and rounded grains of apatite (Sandvik and Erdosh 1977). Sandvik and Erdosh reported that the residuum ranges up to 100% apatite. The residuum in many places is diluted with clay, vermiculite, iron oxide, goethite, quartz and chlorite (Sandvik and Erdosh 1977).

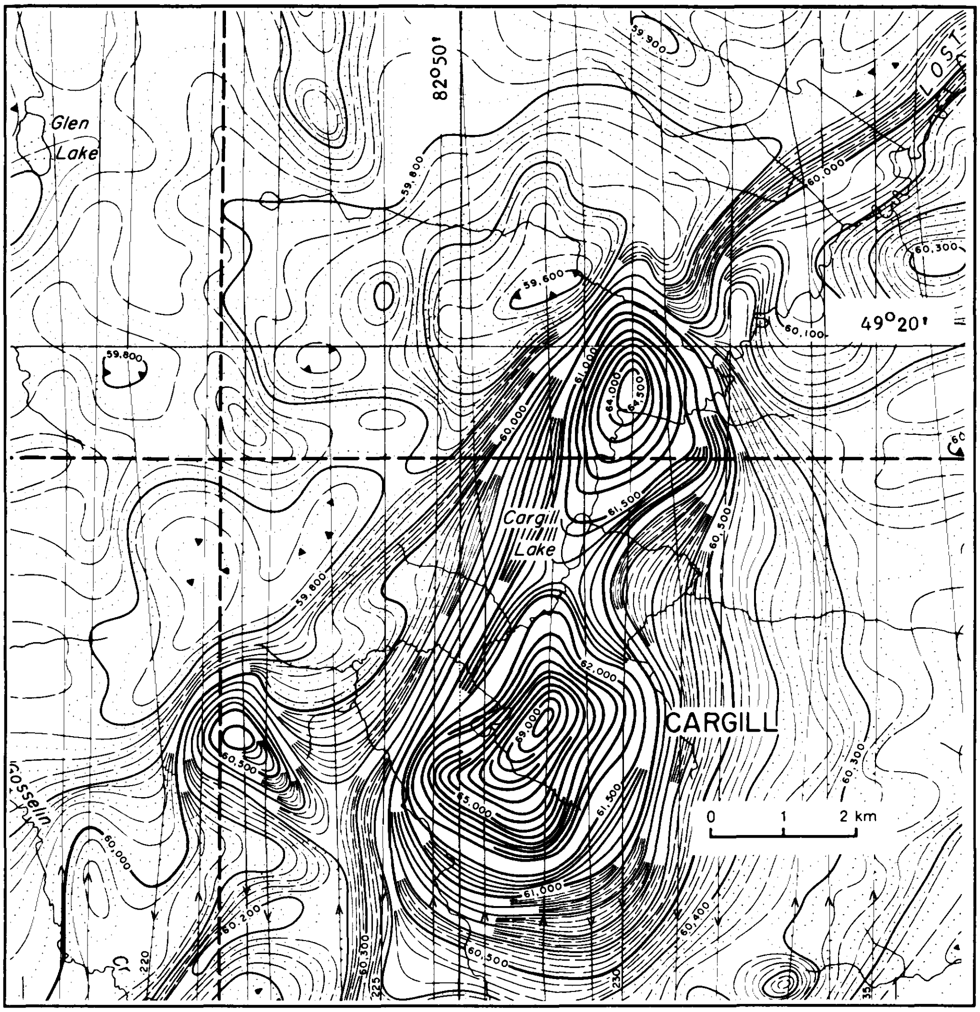

Figure 2. *Aeromagnetic map of the Cargill Township Carbonatite Complex (from Aeromagnetic Map 2252G, ODM–GSC 1962).*

A crandallite–rich blanket near the top of the apatite residuum is high in rare earth values which may ultimately prove of economic interest (Sandvik and Erdosh 1977; Erdosh 1979). Sandvik and Erdosh reported that the apatite residuum may exceed 170 m in thickness in preglacial troughs within the carbonatite complex and may be only a few metres thick on ridges between the troughs.

Even though apatite is present in all phases of the complex, the protore for the apatite residuum is principally sideritic and dolomitic carbonatite (Sandvik and Erdosh 1977).

EARLY PRECAMBRIAN (ARCHEAN)

GRANITIC GNEISSES

Outcrops of the granitic host rocks that enclose the Cargill Township complex are rare. Several very small outcrops of gneissic granitic rock occur along the access road to the property. These rocks are mottled white and black on the weathered surface and have a banded pink and black appearance on fresh surface. Banding up to 2 cm in width is present and is defined by the variation in the relative amounts of the mafic and felsic components. Biotite is the dominant mafic mineral. The banding has a northeast trend and dips steeply northwest.

Sandvik and Erdosh (1977) reported that rock chips, obtained from drill holes west of the south subcomplex, consist of a medium–grained rock that is likely a banded gneiss. Both amphibole–rich and quartz dioritic chips are present implying the presence of a mixed or banded rock beneath the overburden.

Sandvik and Erdosh (1977) reported that fenitization is absent in the gneissic rocks bordering the south complex but outcrops around the west subcomplex are distinctly fenitized.

MIDDLE PRECAMBRIAN (PROTEROZOIC)

CARGILL TOWNSHIP COMPLEX

The Cargill Township complex consists of a suite of Middle Precambrian rocks which have been dated by K–Ar isotopic techniques at 1740 Ma (Gittins *et al.* 1967). Using U–Pb techniques, the age was determined as 1907 ± 4 Ma (S.T. Kwon, Department of Geology, University of California, Santa Barbara, California, personal communication, 1987).

The rock suite studied by Allen (1972) and the rock suite studied by the author are from drill core and thus are incomplete. Neither likely represent all the phases present in the body. The samples examined by each author were the best and most representative that were obtainable at the time of the respective sampling. It would appear that most of the samples examined by Allen (1972) were from Kennco Exploration (Canada) Limited hole No. 2. This hole is inclined (45°) and located such that it represents a cross–section of a small portion of the body. The author examined core obtained from vertical drill holes completed by the International Minerals and Chemical Corporation (Canada) Limited. Presumably these vertical holes in a probably vertically dipping body would not be as likely to provide cross sectional information on the intrusion nor are they likely to provide information on all rock types present.

Twyman (1983, p.73) used samples from Kennco Exploration (Canada) Limited holes 4 and 6 and both Kwon (1986) and Sharpe (1987) used surface and drill core samples provided by Sherritt Gordon Mines Limited.

MAFIC TO ULTRAMAFIC RIM ROCKS

Allen (1972, p.38) (Appendix B) subdivided the ultramafic to mafic rocks of the rim into olivine clinopyroxenite, olivine–rim magnetite clinopyroxenite, magnetite–oligoclase clinopyroxenite, hornblendite, hornblende–oligoclase pyroxenite, soda–pyroxene hornblendite, late stage veins and segregations, phlogopite clinopyroxenite, carbonatite, and ultramafic hybrid rocks. The author observed most of these rock types in the suite examined. Hornblende–oligoclase clinopyroxenite and soda–pyroxene hornblende were not observed by the author. Late stage veins and segregations were noted as a minor constituent of the diamond drill cores but were not examined in thin section. Phlogopite clinopyroxenite was noted in several places on the complex as weathered slump at surface. Its coarse grained and deeply weathered nature made sampling for either thin sectioning or chemical work impractical.

The author found the following rock types in rocks of the pyroxenitic border of the complex: amphibole–olivine clinopyroxenite; olivine–phlogopite–bearing clinopyroxenite, amphibole rock; clinopyroxenite; amphibole clinopyroxenite; and biotite–carbonate amphibole rock. This rock suite is believed to be roughly equivalent to the first four lithologies described by Allen (1972, p.38) as listed above.

Clinopyroxene–Rich Rocks

The pyroxene is a clinopyroxene whose extinction angle is dominantly characteristic of diopside though some extinction angles characteristic of augite were noted. The grains are euhedral to anhedral in form with anhedral to subhedral forms dominating. The grains are equant, colourless, and generally lack noticeable pleochroism. One thin section displays a faint variation in colour from core to rim implying some variation in composition. The pyroxene commonly displays a schiller structure due to oriented inclusions. Allen (1972, p.44) determined that the inclusions are titanomagnetite and that they are oriented along the (100), (010) and (001) crystallographic planes of the pyroxene. Twinning of the crystals is common and Allen (1972, p.44) determined that the twinning is on the (100) crystallographic plane. Allen (1972, p.44) reported that generally the centres of the large crystals are exsolution free, and inclusions become more abundant towards the margins of the crystal which define relict euhedral growth zones destroyed by later intercumulus overgrowth. One thin section examined by the author displays amphibole and pyroxene complexly intergrown with sharp boundaries. The author interprets this texture to result from simultaneous crystallization of the two phases. Allen (1972, p.43) reported the presence of a hiatal texture in the pyroxene and evidence for formation of pyroxene plus magnetite by reaction of olivine and liquid. Zoning of the pyroxene with an increasing iron content from interior to rim becomes more common as the proportion of interstitial magnetite increases (Allen 1972, p.43).

Allen (1972, p.127) has defined two trends in the pyroxene composition. One trend is without soda enrichment and the other is with soda enrichment. The earliest or more primitive pyroxene is rich in calcium and the latest is rich in sodium. The direction of sodium enrichment is from olivine clinopyroxenite to the soda–pyroxene hornblendite. The reader should refer to Allen (1972, p.125–137) for a detailed discussion of pyroxene chemistry.

Olivine occurs interstitial to the clinopyroxene. The olivine occurs in interlocking aggregates of polygonal, equant, densely–packed grains that are irregular, elongate, or lobate in form. The crystal faces of the clinopyroxene are somewhat more euhedral when in contact with the olivine than with each other. The olivine varies from fresh to completely altered. The alteration ocurs along grain boundaries and along fractures within the olivine. Serpentine, iddingsite, and bowlingite appear to be the alteration products. Allen (1972, p.41) also reported the presence of talc.

A very minor amount of olivine occurs as a narrow zone or band separating magnetite and clinopyroxene. These bands are discontinuous and likely represent intercumulus growth. Allen (1972) classified rocks displaying this feature as olivine–rim magnetite clinopyroxenite. On the basis of microprobe data Allen (1972, p.49) determined that the forsterite content of the olivines interstitial to the clinopyroxene varied from 65.4 to 76.0%. The narrow zones or bands of olivine between the magnetite and clinopyroxene vary from 62.5 to 70.8% forsterite (Allen 1972, p.49).

Amphibole occurs as anhedral to rarely subhedral brown or greenish–brown grains. It is common as irregular patches scattered throughout the clinopyroxene. The patchy replacements are crystallographically compatible with, and merge in a diffuse manner into the pyroxene and reflect late stage alteration of the pyroxene. Crystallographic controlled structures within the pyroxene have obviously controlled the replacement by the amphibole. Amphibole is also common as rims of varying widths mantling the pyroxene grains. It is also common as a narrow zone along magnetite–pyroxene contacts and greatly exceeds olivine which also occurs as narrow zones along magnetite–pyroxene contacts.

One thin section contains a clot of carbonate into which euhedral amphibole crystals project. The amphibole crystals lie along the edge of the pyroxene crystals which enclosed the carbonate clot. The crystals have brown to greenish brown bases and pale green rims. The amphibole crystals are strongly zoned and occur with a small subhedral grain of sphene.

Microprobe analyses by Allen (1972, p.52, p.138–146) indicate that the amphibole is paragasite or ferroan paragasite and that the most sodic varieties are hastingsite.

Allen (1972, p.46) considered the amphibole to be primary and the result of crystallization of late–stage interstial residual liquids. The author partly concurs with this interpretation on the basis of textures observed in thin section.

Primary amphibole is likely represented by those grains that lie in sharp contact with other mineral phases and do not display grain morphology or structures that can be traced from pyroxene to the amphibole. Some amphiboles, which display structures traceable from pyroxene into the amphibole across grain boundaries that may be diffuse in appearance, are clearly secondary. This secondary amphibole may result from reaction of late–stage deuteric fluids with previously crystallized pyroxene or may result from reaction of decanted fluids (fenitization) associated with the emplacement of the later carbonatite magma.

All samples contain 5% or more magnetite, although the author did not use magnetite as a modifier in naming the rocks.

Magnetite occurs as anhedral grains throughout the rocks. It is present as an alteration of olivine and commonly displays an affinity for amphibole which may be either primary or secondary in origin. Some of the grains are elongate, lobate, and interstitial to the pyroxene. The textural relations suggest that a major portion of the magnetite is intercumulus and primary in origin. Amphibole, and rarely, olivine occur as thin rims between the pyroxene and magnetite and some of this magnetite is likely secondary resulting from the breakdown of pyroxene or olivine. Magnetite has been observed to completely enclose the pyroxene and one magnetite grain was noted to contain a small grain of olivine. One thin section displays subhedral to euhedral magnetite. This section also contains amphibole and pyroxene displaying optically continuous structures which are complexly intertwined suggesting either simultaneous crystallization or a secondary origin for the amphibole. The euhedral magnetite grains are commonly poikilitically enclosed in the amphibole but euhedral grains straddling the pyroxene–amphibole boundary are also present. Magnetite is rarely poikilitically enclosed in pyroxene. In the amphibole–rich rocks or soda pyroxene–rich rocks it may display a decided skeletal texture consisting of alternating plates of carbonate and magnetite.

Allen (1972, p.47) identified the oxide phases as titanomagnetite, magnetite with ilmenite lamellae, magnetite with exsolved ulvospinel, ilmenite, ilmenite plus magnetite, and magnetite with exsolved ulvospinel and hercynitic spinel. The sulphide phase which consists of pyrrhotite with exsolved chalcopyrite, probably formed as an immiscible sulphide liquid (Allen 1972, p.47). The total sulphide content approaches 10% and rarely 15%. Pyrrhotite is by far the dominant phase. The author purposely avoided samples of high sulphide content for thin section study and complete rock analysis. The sulphides occur interstitially to the oxide and silicate phases and could be the result of either liquid immiscibility or late–stage magmatic crystallization.

Allen (1972, p.47–48) interpreted the oxides in rocks containing low concentrations of oxide minerals as being intercumulus in nature, but those rocks with a high oxide content as being likely cumulates.

Phlogopite is rarely present in the clinopyroxene–rich rocks examined by the author. Where present it occurs as small grains along cracks in the pyroxene and along grain margins. One phlogopite grain was noted to be poikilitically enclosed in pyroxene. Allen (1972, p.86) reported phlogophite as anhedral spongy networks poikilitically containing unaltered relicts of unreplaced amphibole and/or pyroxene. The author did not observe this last textural relation but agrees with Allen (1972, p.96) that the phlogopite is likely non–igneous and is a late replacement phenomenon. This replacement may be the result of late–stage deuteric fluids reacting with the earlier crystallized phases. However the replacement is more likely the result of alkali metasomatism by fluids derived from the younger carbonatite magma which intrudes the pyroxenite. The phlogopite reaches its greatest development in the area of contact between carbonatite and pyroxenite. The phlogopite formation is a form of fenitization and the process has been discussed by Gittins *et al.* (1975). The general lack or very low content of phlogopite observed by the author in the pyroxenite rocks is likely due to the fact that the author avoided sampling rocks that appeared to be altered or of questionable genesis and these generally contain greater quantities of mica.

Trace to minor amounts of sphene and carbonate are present in one or more of the thin sections.

Neglecting the minor components, the clinopyroxene–rich rocks are visually estimated to contain 55 to 80% clinopyroxene, 0 to 20% olivine, 5 to 15% amphibole, and 5 to 35% opaques.

Twyman (1983, p.98) reported banding in the mafic silicate rocks based on mineralogy and grain size and reported that brecciated zones parallel this banding. The mafic silicate rocks were interpreted by Twyman (1983, p.100) to be cumulates. Twyman (1983, p.49) completed a limited number of whole rock chemical analyses of the mafic silicate rocks.

Other Mafic to Ultramafic Rocks

The mafic altered rocks appear to be a transitional phase between the carbonatite and clinopyroxenites and may or may not be hybrid. One thin section of an altered rock contains a visually estimated 10% biotite, 45% green amphibole, 15% magnetite, and 30% carbonate. The amphibole is pleochroic, green to dark green and distinctly different from both the brown to greenish brown amphiboles in the clinopyroxene–rich rocks and the very pale green acicular amphiboles of the carbonatite. The amphibole is likely a soda–iron–rich variety. The magnetite is anhedral, and commonly skeletal, consisting of platey grains that alternate with carbonate. The biotite forms books of anhedral to subhedral outline and rarely displays dark brown cores which imply that the grains are compositionally zoned.

Allen (1972, p.76–77) described a hornblende–oligoclase clinopyroxenite rock. Allen (1972, p.76) found only two specimens and its presence was not observed by the author. This rock is similar to the other clinopyroxene–rich rocks but contains 5 to 8% calcic oligoclase. The oligoclase is described as intercumulus, and occurs as ragged anhedral grains surrounded by kaersutite amphibole (Allen 1972, p.78). The plagioclase is poorly twinned, slightly sericitized, and contains abundant rod–like apatite needles.

The author observed the late stage veins and segregations described by Allen (1972, p.86–94) in the diamond drill core from the pyroxenite but did not analyse them. The simple veins have a maximum thickness of 1 to 1.5 cm and consist solely of hornblende plus minor sphene, calcite and apatite (Allen 1972, p.88). The complex veins and segregations have thicknesses up to and exceeding 14 cm, and have a mineralogy consisting of hornblende, biotite, sphene, soda augite, aegirine augite, apatite, and calcite all of which occur in highly variable amounts (Allen 1972, p.88). The grain size of the complex veins approaches pegmatitic in places (Allen 1972, p.88). Allen (1972, p.86) considered the minerals of the veins to have formed by crystallization of late residual liquids of the magma.

Phlogopite–clinopyroxenite rocks were not examined by the author. Allen (1972, p.94–99) considered the phlogopite to be the product of metasomatic reaction. Allen (1972, p.97) noted that the phlogopite replaces both pyroxene and amphibole with the amphibole being most susceptible to replacement. The preferred habit of phlogopite is interstitial. Allen (1972, p.97) also reported narrow phlogopite–filled fractures where the pyroxene borders appear partially resorbed in contact with phlogopite. In areas of concentrated mica, the clinopyroxene rims at the contact with the phlogopite may be weakly sodic. Replacement of serpentine by phlogopite is also reported by Allen (1972 p.97).

While examining the Cargill complex, blocks of coarse–grained phlogopite pyroxenite were noted to have been dug up along skid trails. The phlogopite sheets are up to 8 cm in diameter and associated with slightly smaller pyroxenes. Some magnetite is present. Due to the deeply weathered and coarse grained nature of the rock they were not sampled for thin sectioning or chemical analysis.

At the Argor carbonatite complex Twyman (1983, p.109) interpreted the hybrid rocks to have resulted from assimilation of the wall rocks by carbonatite magma. Sharpe (1987) estimated the hybrid zone at Cargill to be 20 to 40 m wide.

CARBONATITE OF THE CORE

Sovite

Carbonatite rocks containing more than 50% carbonate were classified as sovite since the dolomite content could not be visually determined in the field. The accessory minerals occur in widely varying proportions and serve as modifiers to the broader term "sovite". The diamond drill core displays mineralogic layering which averages 1–2 cm in width and is sub–parallel to the core axis. Sampling was restricted to the more homogeneous sections of the sovite.

Twyman (1983, p.90) has subdivided the sovites at Cargill into olivine sovite, clinohumite sovite and arfvedsonite sovite and completed a limited number of whole rock chemical analyses. The work by Twyman (1983) concentrated on the carbonate–rich phases.

Allen (1972) concentrated his study on the mafic phases of the Cargill complex, and thus he did not provide a great deal of data for the carbonate–rich phases of the body.

In thin section the sovite is fine to medium grained, inequigranular–seriate, hypidiomorphic to allotriomorphic, with straight to curved grain boundaries. A visual estimate of the mode is trace to 15% phlogopite, 1 to 15% magnetite, 0 to 10% clinohumite, 50 to 100% carbonate, 2 to 15% apatite, 0 to 15% olivine, 0 to 5% pyrrhotite and 0 to 10% amphibole.

The phlogopite forms anhedral to subhedral grains and it commonly displays a pronounced zoning from a light yellow brown core to a much darker reddish brown rim. A number of thin sections contain phlogopite with well developed kinking and/or bending of the (001) cleavage. Thin sections displaying well developed kinking of the phlogopite may contrast sharply with thin sections taken close by in which evidence for deformation is lacking. This observation implies that movement on the Cargill fault likely occurred along numerous parallel zones separated by small blocks or bands of undeformed sovite. Since the core is from vertical drill holes the alternation of deformed and undeformed rock implies that the fault plane is inclined.

The pleochroic rim on the phlogopite may not be of constant width along the perimeter of the grains. It is uncertain as to whether this observation of varying rim width is true or if it is a function of differing angles of intersecting the phlogopite in thin section preparation. Phlogopite rarely poikilitically encloses apatite and rounded blebs of carbonate. In several thin sections the phlogopite has a darker brown pleochroism suggesting that it approaches biotite in composition. Allen (1972, p.146–150) from his work on the pyroxenitic rocks concluded that the phlogopite was a metasomatic–fenitic product. Little work was done by Allen (1972) on the phlogopite of the carbonatite phase. Gasparrini *et al.* (1971) reported that iron increases towards the rim of the phlogopite grains and that magnesium and aluminum decrease. The mica thus has a phlogopite core and biotite rim which is reflected in the pleochroic nature of the mineral. The author interprets the biotite–phlogopite relationship to suggest that early formed phlogopite reacted with more iron–rich late magmatic fluids.

The micas were described by Twyman (1983, p.96, 114) as having cores of phlogopite and rims of tetraferriphlogopite which may display some alteration to hydrobiotite. The trend from core to rim is one of Al depletion and the Cargill micas contain more Mg than the similar micas from the Argor Carbonatite Complex (Twyman 1983, p.115). Hydrobiotite was described by Twyman (1983, p.116) as a mixture of vermiculite and biotite of hydrothermal origin resulting from the loss of K, increase in Fe and constant Al. Twyman (1983, p.115) indicated that the micas in the olivine–clinohumite sovites and arfvedsonite sovites define two different chemical trends which join at high Al and Mg contents.

Magnetite is a ubiquitous mineral and occurs as anhedral to subhedral disseminated grains. The mineral has ragged to smooth curved grain boundaries. In one section magnetite occurs as relatively small grains from the breakdown of olivine. Magnetite rarely is skeletal in form. In one case the skeletal magnetite consists of a series of parallel crystal plates of magnetite alternating with carbonate.

Few bands of magnetite are present at the Argor complex but many are present at Cargill (Twyman 1983, p.150). Microprobe studies by Twyman (1983, p.150) indicate similar magnetite compositions at the two carbonatite complexes: the magnetites are low in TiO_2 (0.38–6.01%) and MnO (0.0–0.40%). Ilmenite, which contains 48.9 to 52.6% TiO_2, has more MnO (1.26–2.95%) than magnetite.

Twyman (1983, p.97) reported the presence of other opaques. These are pyrrhotite, pyrite and a cobalt pentlandite which occurs as blebs within the pyrrhotite. The cobalt pentlandite is present only in his olivine–clinohumite sovite and ilmenite and pyrite are present only in arfvedsonite sovite (Twyman 1983, p.97).

Clinohumite occurs as more or less isolated grains and as patchy replacements of margins of the olivine grains. The grains vary from anhedral to subhedral in form and display a yellow color in thin section. Minor alteration to serpentine may occur along fractures in the clinohumite. Several thin sections display clinohumite enclosing rounded blebs of carbonate. Clinohumite may also enclose acicular, euhedral amphibole crystals. This is an inherited feature retained from the olivine from which the clinohumite was derived*. The author interprets the clinohumite–olivine relationship to be one of reaction of the olivine with late magmatic fluids.

Kocman and Rucklidge (1973) investigated the crystal structure of clinohumite from the Cargill complex. They referred to the clinohumite as titaniferous since microprobe analysis indicated 3.14% TiO_2. Microprobe analysis of the clinohumite gave 36.1% SiO_2, 3.14% TiO_2, 14.6% FeO, 0.62% MnO, 44.7% MgO, 1.15% F, and 1.46% H_2O (calculated) (Kocman and Rucklidge 1973, p.39). The presence of fluorine indicates the carbonatite magma likely contained appreciable fluorine particularly during the later phases of crystallization when peritectic reaction of the olivine with the carbonatite magma occurred.

The clinohumite has been interpreted by Twyman (1983, p.96) as the result of peritectic reaction of olivine with the carbonatite magma, an interpretation the author would concur with (Sage 1983). Twyman (1983, p.97) reported that clinohumite is commonly associated with magnetite, is locally replaced by richterite and dolomite by peritectic reaction, and is locally altered to serpentine and magnetite. On the basis of microprobe data the clinohumite displays increasing Fe and Ti from core to rim (Twyman 1983, p.135).

Carbonate forms an interlocking mosaic of anhedral grains. In those sections displaying deformation textures, grains of carbonate may display bent rhombo-

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**The identification of clinohumite was confirmed by X-ray diffraction techniques by W. Hicks, Geoscience Laboratories, Ontario Geological Survey.*

hedral twin planes. Allen (1972, p.108, p.105) reported that dolomite is ubiquitous and rarely displays exsolution textures.

Twyman (1983, p.95) interpreted the calcite morphology as secondary produced by brecciation. The carbonates contain minor Mg, Fe, Mn, and Sr; carbonates from the nearby Argor carbonatite contain more Fe (Twyman 1983, p.122). The minor elements in calcite are inconsistent with chemical trends established in other mineral phases, however in dolomite Fe enrichment trends are consistent with those found in amphibole and biotite (Twyman 1983, p.122). Twyman (1983, p.125) suggested this inconsistency possibly resulted from exsolution, recrystallization, and exchange of components between liquid and vapor. Twyman (1983, p.95) reported rare exsolved dolomite lamellae in the calcite.

Apatite is present in all thin sections. The mineral occurs as rounded bead–like grains or rounded elongated grains. The mineral varies from anhedral to euhedral in form.

Data obtained by Twyman (1983, p.218) indicate that apatite is a major carrier of rare earth elements (REE). The heavy rare earth element (HREE) concentrations are relatively constant throughout differentiation and the light rare earth elements (LREE) vary only slightly (Twyman 1983, p.219, 233). Twyman concluded that since the REE are not incompatible elements in a carbonatite magma they are not sensitive indicators of magmatic trends. Twyman (1983, p.224) suggested that whole–rock chemical compositions may reflect original magma (REE) compositions.

Sharpe (1987) proposed that low rare earth contents in the rauhaugites may reflect lower apatite contents.

Olivine forms anhedral to crudely euhedral grains*. The olivine in the core occurs as brown, resinous, glomeroporphyritic clots up to 4 cm in diameter within the carbonate. The mineral is generally fresh but commonly displays alteration along grain boundaries and fractures to yellowish clinohumite. The olivine is rarely serpentinized. Allen (1972, p.125) reported a fosterite content of 81 to 82 mole percent for olivine from the carbonatite phase of the complex. Olivine poikilitically encloses apatite and amphibole.

Twyman (1983, p.135) described the olivines as MgO–rich, low in NiO and with moderate to high MnO content. Microprobe analyses showed the forsterite content to be 81 to 82% (Twyman 1983, p.135). Based on olivine chemical compositions, Twyman (1983, p.200) suggested that the carbonatites were generated from mafic source material.

Pyrrhotite occurs as anhedral disseminated grains and is widespread in occurrence.

Amphibole occurs as pleochroic colourless to pale green, acicular grains. The grains are euhedral in outline and commonly display twinning. The amphibole may occur poikilitically within the olivine. In one instance the amphibole crystals appeared to occur as clots within the thin section. Allen (1972, p.105) reported that the amphibole is a richterite or ferri–richterite and is commonly zoned. Gasparrini *et al.* (1971) reported that amphiboles from the carbonatite display an increase of calcium, magnesium, and potassium towards the core of the grain and that iron and sodium increase towards the edge.

Twyman (1983, p.96) indicated that the amphibole in olivine sovite is richterite and within his arfvedsonite sovite the amphiboles are zoned from richterite

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**The identification of olivine was confirmed by X-ray diffraction techniques by C. Peat, Royal Ontario Museum.*

cores to magnesio–arfvedsonite rims. The amphibole composition is richer in Fe and alkalies and poorer in Ca and Mg as differentiation proceeds (Twyman 1983, p.103). Twyman (1983, p.100) reported little or no Mn, Ti, and Al in the amphiboles. At Cargill the K content of the amphiboles was observed to increase with differentiation (Twyman 1983, p.146).

Allen (1972, p.105) reported rare zircon, diopside, and ankerite in this rock unit. Rare zircon and very rare pyrochlore were reported by Twyman (1983, p.97, 140). Probe analysis of this rare pyrochlore indicates Ta, U, and light rare earth elements increase and Nb and Ca decrease from core to rim (Twyman 1983, p.143). Twyman (1983, p.143) correlated the pyrochlore at Cargill with the early formed pyrochlore found at the nearby Argor carbonatite.

Sharpe (1987) completed microprobe analyses on both the carbonate and mafic silicate phases. Microprobe analysis of one sample from International Minerals and Chemical Corporation Limited diamond drill hole 23, drilled in the centre of the southern complex indicated the presence of vesuvianite (Sharpe 1987, p.27). This is the first known occurrence of vesuvianite within a carbonatite of which the author is aware. Sharpe (1987, p.26, 27, 32, 37, 38, 43, 44, 54) presented in tabular form considerable microprobe and chemical data on the Cargill carbonatite to which the reader may wish to refer.

Silicocarbonatite

With increasing accessory mineral content, sovite grades into silicocarbonatite. In thin section the silicocarbonatite is fine to medium grained, equigranular, hypidiomorphic to allotriomorphic, with straight to curved grain boundaries.

An estimate of the mode is 5 to 55% phlogopite, 1 to 30% magnetite, 0 to 10% clinohumite, 15 to 50% carbonate, 0 to 5% apatite, 0 to 30% olivine, and 2 to 70% amphibole.

Phlogopite forms anhedral to subhedral grains, and commonly displays a darker reddish brown rim similar to that observed in the sovite. Some grains display kinking or bending of the (001) cleavage.

Magnetite forms anhedral to subhedral grains. The magnetite occurs as disseminated grains and also as granular aggregates.

Clinohumite occurs as anhedral grains along fractures within, and along grain boundaries of olivine. The clinohumite has a distinctive yellow color in thin section.

Carbonate grains form an anhedral interlocking mosaic. Twin planes on the carbonate grains may be bent in those samples displaying cataclastic textures.

Apatite occurs as rounded bead–like grains and as rounded elongated grains.

Olivine occurs as anhedral to crudely euhedral grains. Trace to minor serpentine may also be present.

Amphibole occurs as acicular crystals with a pale green color. Slight changes in birefringence between core and rims of some grains suggests that the amphibole may, at least locally, be compositionally zoned.

Rauhaugite

Within the central zone of the complex, dolomite becomes the most abundant carbonate phase. The presence of dolomite was confirmed by X–ray diffraction by W. Hicks, Geoscience Laboratories, Ontario Geological Survey. The rauhaugite is yellow–brown in colour and fine grained. The colour and texture contrast sharply with the white, medium grained sovite phase. Limonitic staining occurring along fractures in the core sometimes forms dendritic patterns on fracture surfaces. The core contains cavities up to 1 cm in diameter which may be related to ground water solution of the dolomite. Sampling was restricted to the most homogeneous cavity–free section that could be found. Three samples were taken from hole CCM9.

In thin section the rock is fine to medium grained, massive, inequigranular–seriate, allotriomorphic, with lobate to serrate grain boundaries.

In thin section the rock contains a visually estimated 95% dolomite, 5% apatite, and minor biotite. Magnetite was observed in the core but not in thin section.

In thin section the carbonate displays a cataclastic texture. The carbonate consists of rounded porphyroclasts of carbonate set in a matrix of recrystallized carbonate. Some of the large porphyroclasts are fractured. The matrix is an interlocking mosaic of anhedral grains.

The apatite occurs as rounded grains, and as angular to subangular crystal fragments. The biotite is a deep red–brown in colour and displays a pronounced kinking of the (001) cleavage. Sandvik and Erdosh (1977, p.96) reported that dolomitic carbonatite is the principal rock type from which the apatite–rich residuum was derived.

Sandvik and Erdosh (1977, p.94) and Erdosh (1979) reported the presence of carbonatite of siderite composition, however this phase has not been observed in the core by the author. The siderite is considered by Sandvik and Erdosh (1977, p.94) to be the latest phase but always has been leached where observed. The greatest development of residuum is over dolomitic and sideritic carbonatite (Sandvik and Erdosh 1977, p.94).

MESOZOIC TO CENOZOIC

RESIDUAL DEPOSITS

Overlying the carbonatite complex is a residual accumulation that resulted from weathering of the carbonatite. The following description is abstracted from Sandvik and Erdosh 1977, p.93–95). The residuum consists of a light to dark grey, sometimes brownish, unconsolidated material. The residuum consists predominantly of sand–size material. Sandvik and Erdosh reported that apatite is the dominant residual mineral but that minor goethite, siderite, magnetite, crandallite, and pyrite are present. Apatite locally constitutes up to 100% of the residuum and is diluted in places by clay, vermiculite, quartz, iron oxides, and chlorite. Near the pyroxenite contact the residuum consists entirely of biotite, clay, and chlorite derived from weathering of the pyroxenite.

Sandvik and Erdosh (1977, p.93, Figures 5 and 8) reported that the residuum varies in thickness from a few metres over ridges in the carbonatite to over 170 m in troughs between the ridges. The ridges form considerable relief on the buried preglacial topography. The buried topography has been interpreted as the result of the development of a karst–like surface. These buried ridges trend north in the northern part of the complex and northeast in the southern part of the complex.

Two troughs along the outer edge of the complex converge towards the southwest end of the complex where a thick accumulation of residuum has an undetermined thickness. Sandvik and Erdosh reported that these thick residual accumulations overlie sideritic carbonatite and that the topographic low in the southwest corner has been interpreted by them to be a sinkhole. An unleached calcitic carbonatite of the core of the complex is traversed by a third northeast–trending residuum filled trough which is also underlain by siderite.

Sandvik and Erdosh (1977) reported that the troughs are commonly steep–sided to nearly vertical, and that depth may exceed width. Sinkholes may also occur along a ridge axis. Sandvik and Erdosh suggested that peripheral shearing, later modified by northeast–trending strike–slip faults, and lithologic distribution, have all exerted control on the distribution of residuum accumulations. Erdosh (1979) later suggested that jointing and faulting controlled solution of the carbonate minerals and that joint–fault intersections are particularly favorable sites for solution and development of karst–like features. The present author observed cataclastic textures in the dolomitic protore to the residuum deposits lending support to the above interpretation.

Kelley (1984a) subdivided the phosphate residuum into 3 types: grey, black and red residuum. The grey residuum is apatite mixed with minor clay (32 to 40% P_2O_5); the black residuum is a mixture of organic material, pyrite and apatite (28 to 33% P_2O_5) and the red residuum is a mixture of iron oxides plus apatite (trace to 35% P_2O_5). The red residuum contains from 2 to 30% Fe_2O_3 (Kelley 1984a).

Kelley (1984a) reported that grey and black residuums form interfingering lenses adjacent and beneath the trough of preglacial sediments in the centre of the carbonatite while the red residuum occurs at the northern and western parts and outer margins of the southern part of the carbonatite complex. A zone of uranium, niobium and rare earth element enrichment occurs at the contact of the residuum with overlying preglacial sediments (Kelley 1984a).

Kelley (personal communication) reported that a discrete layer of variable thickness occurs at the base of the residuum which is composed of magnetite, apatite, and chert. This layer has been interpreted by Kelley to be the result of weathering of the carbonatite and deposition by percolating groundwater.

The deep weathering of the Cargill carbonatite, within a granitic terrain that is not readily amendable to solution or groundwater movement, poses an interesting problem. Groundwater movement to promote such deep weathering and solution of the carbonate rock may have been controlled by the Cargill fault which cuts and offsets the carbonate complex. Perhaps faulting is essential in such a terrain to provide groundwater access to the carbonatite so that karst structures can form and a residuum develop.

PREGLACIAL AND GLACIAL DEPOSITS

The residuum is overlain by a blanket of overburden which thickens to the southwest where it exceeds 165 m (Sandvik and Erdosh 1977, p.95). The overburden is generally thickest over the residuum troughs and thinnest over the unleached rock (Sandvik and Erdosh 1977, p.95). This unit is composed of quartz sand that commonly contains wood chips, organic clay, and kaolinite and minor interbedded gravel and silt (Sandvik and Erdosh 1977, p.92). The quartz sand is fine to coarse grained, white to grey in color, and individual grains are irregular in shape and appear unweathered (Sandvik and Erdosh 1977, p.92).

Sandvik and Erdosh (1977, p.92) reported that dark brown to black, soft organic clay interbedded with the quartz sand occurs in thicknesses of up to a few metres. Thin interbeds of sand and gravel are ubiquitous (Sandvik and Erdosh 1977, p.92).

At the southwest end of the south subcomplex, kaolinite at least 22 m in thickness occurs beneath the quartz sand at one location (Sandvik and Erdosh 1977, p.92). The sand–clay unit is variable in thickness but reaches 130 m in thickness in one of the preglacial troughs (Sandvik and Erdosh 1977, p.92).

Overlying the preglacial overburden are stiff, varved, tan to grey lake clays (Sandvik and Erdosh 1977, p.92). Sandvik and Erdosh (1977, p.92) reported that these clays range from 1.5 to 10 m in thickness and average between 6 and 8 m. Erdosh (1979) correlated these clays with glacial Lake Barlow–Ojibway.

A sample of organic material recovered from drill hole B1–1A at a depth of 345 to 350 feet was donated to the Ministry by the International Minerals and Chemical Corporation and examined by G. Norris of the University of Toronto. Norris reported that the sample is tentatively Campanian (Late Cretaceous) to Paleocene (Early Tertiary) in age. The organic material contains pollen not previously reported in North America and which has been previously considered to be indicative of arid warm climates (G. Norris, personal communication). The unit is not correlative to units presently known in the Moose River basin where Upper Cretaceous is absent (G. Norris, personal communication). One of the fluids used for drilling contained Quik–Gel, a Baroid of Canada Limited product, which is a bentonite of Cretaceous age mined in Wyoming (G. Erdosh, written communication). Contamination by drilling mud is unlikely since Cretaceous floras of the western interior are distinctly different from eastern floras (G. Norris, personal communication, 1977).

Len Kelley (geologist, Sherritt Gordon Mines Limited, personal communication, 1981) reported that in the centre of the complex a north–south trough 300–400 m in length and less than 100 m in width is present. This trough consists of stacked layers of sand, clay, peat, organic sand and clean sand. The individual layers are reported by Kelley to vary between 3 and 8 m in thickness. Sides of the trough are steep and locally the trough exceeds 75 m in depth. The trough appears to have formed by progressive collapse concomittant with deposition of the sediments, and leaching of the underlying carbonate (L. Kelley, personal communication, 1981). The trough filling is Cretaceous sediments and visual examination of the sand and clay by the author suggested that it may have too many impurities to be of economic interest.

In 1981, the author visited the site of stripping operations being undertaken by Sherritt Gordon Mines Limited to uncover the apatite–bearing residuum. On the basis of this stripping and a sonic drilling program undertaken by the company to futher evaluate the results obtained by the International Minerals and Chemical Corporation (Canada) Limited, a consistent pattern of stratigraphy of the overburden has been established. Len Kelley (personal communication) has proposed the stratigraphic column shown in Table 2 for the overburden lying above the Cargill residual apatite deposits.

The glacial and preglacial deposits were described by Kelley (1984a) as follows. The stiff, tan–coloured clay of glacial Lake Barlow–Ojibway consists of varves 1 to 10 cm thick. The glaciolacustrine clay averages 2 m thick and overlies an average of 15 m of grey–green glacial till composed of clay, sand, silt, cobbles and boulders. The glacial sediments overlie brown–black organic rich quartz sand with numerous layers of peat, kaolinite and clean, white, well sorted sand 1 to 4 m thick. These late Cretaceous to Paleocene sediments may locally total approximately 80 m in thickness. The white quartz and the kaolinite are nearly pure. Kelley (1984a) proposed that a coal swamp depositional environment existed

TABLE 2. STRATIGRAPHY OF OVERBURDEN COVERING CARGILL RESIDUAL APATITE DEPOSITS.

	Several feet of muck.
	Paraconformity
2–3 m	Varved brown clay. (Glacial Lake Barlow-Ojibway)
	Conformable contact
5–30 m	Till and reworked till, clay, silt, sand, gravel, boulders.
0–50 m	Organic material, quartz sand and kaolin in 2–3 m layers.
	Paraconformity
	Phosphate residuum.

Source: L. Kelley, Geologist, Sherritt Gordon Mines Limited, personal communication, 1981, 1988.

which underwent cyclic changes, and that this environment produced an acidic ground water system that dissolved the carbonate minerals of the carbonatite.

MAGNETIC DATA

The Cargill Township Carbonatite Complex is a dumbbell shaped intrusion as outlined by aeromagnetic map 2252G (ODM–GSC 1962). This map displays a northeast–trending aeromagnetic anomaly which, over the southern subcomplex, exceeds 69,000 gammas absolute total field.

The International Minerals and Chemical Corporation (Canada) Limited completed a detailed aeromagnetic map over the complex. The company flew east–west lines at a quarter mile spacing that provided more detail as to the form of the body. This aeromagnetic survey supports the interpretation that the dumbbell shaped complex has been faulted by a northeast–trending fault. A linear aeromagnetic pattern lying west of the complex is likely a northeast–trending diabase dike.

PETROLOGY

Major and minor element chemical analyses are tabulated in Appendix A (Tables A–2 and A–3). Alkalic rock norms calculated by the method of LeBas (1973) are given in Table A–4. The LeBas calculation treats carbon dioxide as a primary magmatic phase and is thus a more realistic representative of normative mineralogy for these rocks than norms calculated by the method of Irvine and Baragar (1971) which treats carbon dioxide as an alteration.

The carbonatite rocks are likely a product of liquid immiscibility, therefore the rock chemistry cannot be used to speculate on possible liquid trends. Detailed studies of liquid immiscibility in carbonatite magmas have been undertaken by Hamilton (1979) but a discussion of these studies is beyond the scope of this report. Carbonatite magmas are commonly enriched in TiO_2 and P_2O_5 and experimental studies by Visser and Koster Van Groos (1979) indicated that the presence of these elements will encourage liquid immiscibility in artificial alkalic rock systems.

Throughout the voluminous literature on carbonatite complexes the association of carbonatite and ijolite is essentially ubiquitous. This association is also common in Ontario complexes; however it is not present at Cargill Township. Although the pyroxenites are nepheline–normative, their chemistry is generally more typical of pyroxenites from mafic intrusions than of alkalic rocks. One therefore must consider the possibility that the pyroxenite rim and carbonatite core may not be closely related by simple differentiation. Perhaps the carbonatite was emplaced into the pyroxenite and is unrelated to the pyroxenite. The only common denominator could be the local–regional structure controlling the emplacement of the magmas. Both the Goldray and Argor Carbonatite Complexes have a pyroxenite rim and carbonatite core similar to the Cargill Township Carbonatite Complex. These complexes are of similar age (Gittins *et al.* 1967) and spatially related by being located within the same regional structure. The presence of several complexes of carbonatite and pyroxenite is a strong argument for a co–magmatic relationship.

In the case of minor elements the complex appears somewhat lower in niobium and barium than most (*see* Table A–2).

Gittins *et al.* (1975) proposed that the Cargill Township complex resulted from the emplacement of an aqueous alkali–rich carbonate magma into the pyroxenite. The carbonatite magma lost its aqueous phase, halides, and alkalies to the enclosing pyroxenitic rocks. The reaction of the aqueous alkali–rich fluids with the pyroxenite produced phlogopite. This metasomatic process is one of fenitization. The removal of the aqueous alkali–rich fluids caused crystallization of the carbonatite as calcite and dolomite. The carbonate–rich phase of the complex is thus a residue whose composition does not reflect magmatic compositions since the alkalies and aqueous phases were not present when the rock crystallized.

The Argor and Cargill Township Carbonatite Complexes are similar in age (Gittins *et al.* 1967) and nearly identical in geology in that they both have pyroxenite rims and carbonatite cores. Twyman (1983) using experimental data, microprobe analysis, whole–rock chemical analysis and petrographic analysis on samples from both Argor and Cargill complexes has developed a petrogenetic model for these two complexes.

Twyman (1983, p.166) concluded that the mineral and whole–rock chemical compositions show different trends indicating that the rocks do not represent magma compositions. The silicate and carbonate minerals in the sovites and rauhaugites define a single magmatic trend suggesting they formed at the same time (Twyman 1983, p.178). A positive correlation between LREE abundances in carbonatites and associated silicate rocks suggests a genetic relationship between the two rock types (Twyman 1983, p.203). Distinctly different amphibole differentiation trends in carbonatite and silicate rocks indicate early separation of the respective magmas that gave rise to these rocks (Twyman 1983, p.210). Using calcite–dolomite, ilmenite–magnetite, and pyrite–pyrrhotite pairs Twyman (1983, p.184, 186, 187) attempted to calculate crystallization temperatures, however he concluded that due to re–equilibrium of the mineralogy, crystallization temperatures cannot be determined.

Twyman (1983, p.204, 210, 214) proposed that the source magma was a carbonated mafic alkalic silicate magma that underwent immiscibility at approximately 27 kbar in the upper mantle. This gave rise to an olivine sovite magma containing approximately 8% alkalies at 1100–1200°C which differentiated to a natrocarbonatite magma by crystal fractionation.

The conclusions of Twyman (1983) are summarized as follows:

1. The sovites and rauhaugite are cumulates from an alkaline carbonatite magma.
2. Pressure controls silicate minerals present in a carbonatite: amphibole, greater than 4 kbar; pyroxene, 2 to 4 kbar; and monticellite, less than 2 kbar.
3. Mineral chemistry indicates carbonatite magmas undergo extensive fractional crystallization towards Fe and alkali enrichment and Ca and Mg depletion.
4. The carbonate cumulates form by heterogeneous nucleation on magma chamber walls from the walls inward.
5. Olivine carbonatites are the most primitive and arfvedsonite–aegirine carbonatites the most evolved.
6. Minor element enrichment in the silicate minerals indicate that the carbonatites are accumulated products of 90% crystallization of an alkalic carbonatite magma.
7. Late stage crystallization of a carbonatite magma evolves a hydrothermal fluid forming ankerite breccia zones, veins, and replacement of calcite by ankerite.
8. Abundant oxide fractionation at Cargill (relative to Argor) was responsible for more Mg–rich minerals and magma trends exhibiting depletion in Mn and Ti.
9. Parent carbonatite magmas are olivine sovites with 8% alkalies.
10. After 85% crystallization of the parent olivine sovite magma, natrocarbonatite (37% alkalies) magma forms by removal of carbonate, apatite, silicates and opaques.

In 1987, Sharpe calculated a number of major and minor element variation diagrams and proposed that the pyroxenite, sovite, and rauhaugite were genetically related.

METAMORPHISM

Undeformed samples of sovite display fresh primary textures. The complex lacks petrographic evidence of having undergone regional metamorphism. The deformed samples are interpreted to indicate local recrystallization in response to tectonism.

Within the rauhaugite, recrystallization has taken place in response to tectonic activity. This tectonism has created a porphyroblastic texture consisting of rounded porphyroclasts of carbonate in a finer grained matrix of recrystallized carbonate.

Within the complex, alteration of the pyroxenitic rim by the carbonatite was a metasomatic process related to the emplacement of the carbonatite. Allen (1972, p.146–150) and Gittins *et al.* (1975) considered the phlogopite in the pyroxenites to have resulted solely from the metasomatic effects of the carbonatitic fluids. Amphibole replacement of pyroxene, in part at least, was likely the result of interstitial deuteric fluids and thus an autometamorphic effect related to the magmatic event that formed the complex. Some of the amphibole may be related to reaction with metasomatic fluids derived from the carbonatite.

GEOCHRONOLOGY

Gittins *et al.* (1967) obtained the first isotopic age on the Cargill Township Carbonatite Complex. K–Ar isotopic ages obtained from biotite were 1790, 1820, and 1860 Ma.

In 1986, Kwon obtained a U–Pb isotopic age of 1906 ± 30 Ma on zircon. He noted that the U–Th–Pb did not behave as a closed system. Kwon (1986) plotted $^{206}Pb/^{204}Pb$ – $^{207}Pb/^{204}Pb$ isotope ratios and obtained an errorchron age of 1890 ± 100 Ma. He also obtained an Sm–Nd errorchron age of 1903 ± 100 Ma (Kwon 1986). He interpreted his isotopic data as suggesting that a thermal disturbance had occurred at approximately 500 Ma. The lead isotopic data indicates that the carbonatite magma has not been contaminated by Kapuskasing gneissic rocks. Kwon (1986) compared the lead isotopes at Cargill Township with those at the nearby Borden Township carbonatite which may be 30 Ma younger and concluded that the differences can be explained only by a heterogeneous mantle source. Kwon (personal communication, 1987) revised the Cargill zircon U–Pb isotopic age to 1907 ± 4 Ma.

Sharpe (1987) reported an Rb–Sr whole rock–mineral isochron age of 1891 ± 15 Ma with an initial $^{87}Sr/^{86}Sr$ ratio of 0.70185 ± 0.00004. Sharpe (1987) indicated that variation in the $^{87}Sr/^{86}Sr$ ratio exceeds analytical uncertainty which she suggested was a reflection of a heterogeneous mantle source. The ratio is consistent with a mantle source uncontaminated by crustal rocks (Sharpe 1987).

STRUCTURAL GEOLOGY

REGIONAL SETTING

The Cargill Township complex lies within the Kapuskasing Subprovince (Structural Zone) of the Superior Province. This subprovince is characterized geophysically as a northeast–trending zone of gravity highs and pronounced linear aeromagnetic trends (Innes 1960; ODM–GSC 1970). This anomalous gravity zone has been interpreted as reflecting an upwarp in the Conrad discontinuity caused by major regional faulting and the formation of a complex horst structure (Wilson and Brisbin 1965; Bennett *et al.* 1967). This prominent regional structure extends southward from the south end of Hudson Bay, becoming broader and more ill–defined as it approaches the Lake Superior basin. The Cargill Township Carbonatite Complex has been emplaced into this structure, which also contains many other carbonatite–alkalic rock complexes north and south of Cargill Township.

Recent studies of the Kapuskasing Structural Zone indicate it is an oblique section through about 20 km of Archean crust uplifted along a northwest–dipping thrust fault (Percival and Card 1983). To the east, high–grade gneissic rocks are in sharp fault contact with low–grade rocks and to the west high–grade rocks grade westward to low–grade rocks over a distance exceeding 100 km (Percival and Card 1983). The author concurs with Percival and Card (1983) in that the Kapuskasing Structural Zone is likely a tilted upthrust segment of Archean crust.

INTERNAL STRUCTURES

The dumbbell shape of the complex likely resulted from right lateral displacement along a northeast–trending fault that cuts the complex; strike–slip movement is approximately 4.0 km (Sandvik and Erdosh 1977, p.94). The fault may have been a pre–intrusive feature which controlled the emplacement of the carbonate and later became re–activated (Sandvik and Erdosh 1977, p.94). Most of the isotopically dated alkalic rock–carbonatite complexes within the Kapuskasing Subprovince are Late Precambrian (~ 1.0 Ga) in age and the faulting of this Middle Precambrian intrusion may be a function of reactivation of earlier structure concomittant with this younger event. Some evidence of post–emplacement adjustment along the fault is suggested by the presence of unfenitized quartz diorite gneiss in contact with the southern subcomplex along the strike of the interpreted fault zone, and the presence of visible fenitization peripheral to the west subcomplex away from the fault (Sandvik and Erdosh 1977). This distribution of fenitized and unfenitized rock suggests that the quartz diorite gneiss marginal to the south subcomplex was not originally in direct contact with the intrusion at the time of its emplacement. Sandvik and Erdosh (1977, p.45) have also postulated shearing peripheral to the complex.

Sandvik and Erdosh (1977, p.93) reported that the contact zone between carbonatite and pyroxenite consists of interbanded carbonatite and pyroxenite varying from a few centimetres to several metres thick. The banding is steep to vertical in dip. In examination of a limited amount of diamond drill core of International Minerals and Chemical Corporation (Canada) Limited, the author noted that mineralogic banding in the carbonate phases was parallel to, or closely parallel to the axis of the core. This suggests a vertical to subvertical dip to the banding since the core was from vertical holes.

Allen (1972, p.57, 58) reported layering on the order of 2 to 10 cm in the pyroxene–rich section of diamond drill core of Kennco Exploration (Canada) Limited. The banding is at approximately 45° to the core axis. The drill hole from which the core came was not specified by Allen (1972, p.54). Since the drilling of Kennco Exploration (Canada) Limited was at various angles the significance of the orientation of the banding is uncertain.

Banding as displayed in the core of International Minerals and Chemical Corporation (Canada) Limited and reported by Allen (1972) from core of Kennco Exploration (Canada) Limited is defined by variable concentrations of different mineral species. Banding analysis suggests that internal structures within the Cargill Township complex are vertical to subvertical in attitude.

RECOMMENDATIONS FOR FUTURE STUDY

The study of Allen (1972) was concerned mainly with the pyroxenitic border of the complex. Locations of the samples studied are not presented within his thesis. Petrographic examination of samples collected by the author has been very brief and additional study is is warranted. The work of Twyman (1983) and Sharpe (1987) provided a large volume of chemical and microprobe data. Additional chemical and microprobe studies would be best directed to similar but more poorly known complexes so that petrogenetic modeling can be expanded and modified.

An intensive study of the residuum is needed to determine the conditions and time of formation of the residuum. A clearer identification of the age and conditions of formation may have some value in evaluating some aeromagnetic anomalies located in the lowlands of northwestern Ontario for the possibility of residual apatite accumulations along unconformities below younger Paleozoic rocks.

Economic Geology

The Cargill Township Carbonatite Complex was examined for its copper–nickel potential in 1955, 1965, and 1970 by Continental Copper Mines Limited and Kennco Exploration (Canada) Limited. In 1974 International Minerals and Chemical Corporation (Canada) Limited discovered accumulations of apatite residuum overlying the deposit. These residuum deposits are of such a size and grade as to ensure the likelihood that they will ultimately be commercially exploited (Sandvik and Erdosh 1977). Carbonatite complexes such as the Cargill Township complex are known to contain favorable lithologies for exploration for base metals, niobium, uranium, rare earths, vermiculite and apatite. In 1987 Jacobs International Incorporated completed a study of Ontario phosphate resources and indicated that the Cargill Township residuum deposits have considerable economic potential.

PROPERTY DESCRIPTIONS

CONTINENTAL COPPER MINES LIMITED [1955]

The earliest recorded work on this complex was by the Continental Copper Mines Limited who in 1955 completed seven diamond drill holes totalling 931 m (3,102 feet) that tested magnetic anomalies discovered by a ground magnetometer survey in search of base metals (Assessment Files Research Office, Ontario Geological Survey, Toronto). Reports within the files of Kennco Explorations (Canada) Limited indicate that the company also completed a geochemical survey and encountered some copper and nickel mineralization.

KENNCO EXPLORATION (CANADA) LIMITED [1965, 1970]

In 1965 Kennco Explorations (Canada) Limited optioned the property from Continental Copper Mines Limited for the purpose of examining the property for copper–nickel mineralization. After a brief examination of the property Kennco dropped the option (private files, Kennco Exploration). In 1970, Kennco again re–evaluated the available data on the Cargill Township intrusion, and re–optioned the ground held by Continental Copper Mines Limited. They staked additional claims, and proceeded with additional testing of the complex's copper–nickel potential. The company completed assays on soil, rock and Continental Copper Mines Limited diamond drill core; and drilled six diamond drill holes totalling 1089 m (3,486 feet) (private files, Kennco Exploration). Minor copper and nickel mineralization was encountered in the pyroxenitic border of the complex (private files, Kennco Exploration). Scattered assays by the company in reports donated to the Ministry indicate that the copper and nickel contents are generally less than 0.10%.

INTERNATIONAL MINERALS AND CHEMICAL CORPORATION (CANADA) LIMITED

In 1974, International Minerals and Chemical Corporation (Canada) Limited, as part of its exploration program of evaluating carbonatite complexes as a source of phosphorus, re–evaluated all existing data on this complex (Sandvik and Erdosh 1977). The company optioned the claims held by Continental Copper Mines Limited and staked additional ground. The company at this time hoped to locate residual apatite concentrations of economic value within a karst–like topography developed on the surface of a carbonatite intrusion (Sandvik and Erdosh 1977, p.94). The company completed 183 holes using reverse circulation techniques and outlined a residual phosphate–bearing deposit of 56.7 million tonnes (62.5 million tons) with an average grade of 19.6% P_2O_5 (Sandvik and Erdosh 1977, p.96). In evaluating the complex the company completed 18 480 m (60,626 feet) of dominantly reverse circulation drilling (private files, International Minerals and Chemical Corporation). Included in the above is approximately 1200 m (4000 feet) of diamond drilling which was completed to sample bedrock geology. Additional tonnage of phosphate–bearing material may exist below the present calculated pit bottom (152 m or 500 feet) and along the northeast extension (Sandvik and Erdosh 1977, p.96). Dolomitic and sideritic carbonatite form the protore for the residuum deposits (Sandvik and Erdosh 1977, p.96). Fresh calcitic carbonatite generally contains less than 5% P_2O_5 (Sandvik and Erdosh 1977, p.96).

Overlying the residuum deposit is a crandallite–rich layer that contains rare earths. It has not been evaluated as to its economic potential (Sandvik and Erdosh 1977, p.90). Vermiculite, niobium, quartz sand, and clay may be present in commercial quantities (Sandvik and Erdosh 1977, p.90). Sandvik and Erdosh (1977, p.90) reported that uranium is not present in the deposit.

The author collected two specimens of sulphide–rich drill core from the core of International Minerals and Chemical Corporation and submitted them for assay. The results are as follows:

Hole	Depth	Percent Copper	Percent Nickel
55	74.0–74.5	0.37	0.15
30	179.3-179.7	0.18	0.02

The samples were also tested for platinum group metals but these, if present, occur in quantities below the limits of detection. The assays were completed by the Geoscience Laboratories, Ontario Geological Survey.

To simplify their work on the complex, International Minerals and Chemical Corporation subdivided the complex into north and south subcomplexes, and a west subcomplex located 4 km west of the south complex (Sandvik and Erdosh 1977). Up to the present, work has been concentrated on the south subcomplex with more limited drilling on the north subcomplex.

SHERRITT GORDON MINES LIMITED

In 1979 Sherritt Gordon Mines Limited obtained an option from International Minerals and Chemical Corporation (Canada) Limited and commenced further evaluation of the apatite residuum at Cargill. The company completed sonic drill holes for a total length of 4878.0 m (16,000 feet). The SG and P series of holes were completed in 1980 to 1981.

The company cleared and stripped the deposit and obtained a bulk sample for metallurgical testing. Pilot plant tests conducted in 1981 confirmed previous recovery assumptions. Laboratory and pilot plant scale acidulation tests were to be conducted in 1982.

Kilborn Limited (1981) prepared a report presenting a number of grade and tonnage calculations for the Cargill phosphate residuum. These data were calculated to extract varying tonnages from the core of the deposit.

Recovery tests for phosphate were completed in 1982 (Wyslouzil and Williamson 1982).

Thoburn (1984) prepared a geological report on the Cargill carbonatite complex noting a 10–fold increase in P_2O_5 within the residuum over the unweathered bedrock. Using a 30% P_2O_5 cutoff and without constraint on Fe_2O_3 content, Thoburn (1984) estimated that the deposit contains 7,711,000 tons grading 34.6% P_2O_5. With a 10% constraint on Fe_2O_3 he calculated that it contains 5,795,000 tons grading 35.0% P_2O_5.

Kelley (1984a) prepared a geological report on the complex on the basis of work completed up to 1984 by Sherritt Gordon Mines Limited. Approximately 6.1 million tons grading 34.2% P_2O_5 (30% cutoff) with less than 10% Fe_2O_3 as a constraint were indicated. A zone of U/Nb/REE enrichment has been delineated which straddles the boundary between residuum and preglacial sediments. Preliminary mineralogical studies indicate the U/Nb/REE values are contained in zircon, ilmenorutile, and a mineral of the crandallite family. An order of magnitude calculation suggests the presence of 1 million tons of U/Nb/REE enriched material grading 0.015 to 0.1% U_3O_8, 0.07 to 0.4% Nb_2O_5, and 1.0 to 4.0% rare earth oxides (Kelley 1984a).

The vermiculite potential of the Cargill complex was examined in 1984 (Kelley 1984b). Trenching, stripping and drilling were completed disclosing that the existing vermiculite was a surface deposit formed by weathering and thus lacked any vertical dimension (L. Kelley, geologist, Sherritt Gordon Mines Limited, personal communication, 1987). The presence of commercially viable vermiculite appears unlikely. Data relating to this work were not available to the author.

In 1985 the company completed 21 short wink vibra corer holes totalling 76.9 m in preparation for a plant trial. A preliminary plant trial was completed (Mackinnon 1985). Ford (1986) reported that zircon and baddeleyite were present in the heavy mineral separate obtained in the plant trail.

UNION CARBIDE CANADA MINING LIMITED [1969]

In 1969, Union Carbide Canada Mining Limited staked claims west of the ground held by Continental Copper Mines Limited. W.G. Wahl Limited re–evaluated previously existing data on the complex for Union Carbide Canada Mining Limited and recommended two diamond drill holes to test the base metal potential (Assessment Files Research Office, Ontario Geological Survey, Toronto). Union Carbide did not complete the recommended work.

RECOMMENDATIONS FOR THE PROSPECTOR

Rare earths, niobium, clay, quartz sand, and vermiculite may locally exist in sufficient concentrations to be economic by–products of a phosphate mining operation, and need further evaluation. Disseminated pyrrhotite in amounts up to 5% was observed by the writer in the carbonatite phases of the complex, however, sulphides of economic interest were not observed. Disseminated, fine–grained pyrite, pyrrhotite, and chalcopyrite are common in the pyroxenite phase. Even though the assay and drilling results of Kennco Explorations (Canada) Limited and Continental Copper Mines Limited are far from encouraging, the possibility that local accumulations of disseminated sulphide mineralization of potential economic interest may occur in the pyroxenitic phases of the complex can not be totally discounted.

The best site for rare earth mineralization would be the crandallite layer identified by the work of Sandvik and Erdosh (1977).

The best site for vermiculite would be the contact zone between the carbonatite and pyroxenite. This zone would be the location of phlogopitization resulting from the reaction of alkali–rich aqueous fluids from the carbonatite magma with the surrounding pyroxenite. This process is analogous to fenitization and has been described in detail by Gittins *et al.* (1975). Drilling by Sherritt Gordon Mines Limited in 1985 to test for vermiculite indicated that the existing vermiculite is a product of weathering and is a near–surface feature lacking in vertical extent. The work of Sheritt Gordon Mines Limited has diminished considerably the vermiculite potential of the Cargill Township Carbonatite Complex.

Appendix A — Petrographic Descriptions, Chemical Analyses, Normative Compositions, and Statistical Compositions of Lithologic Units of the Cargill Township Carbonatite Complex.

TABLE A-1. PETROGRAPHIC DESCRIPTIONS OF WHOLE-ROCK SAMPLES* FROM THE CARGILL TOWNSHIP COMPLEX.

Reference No. 771
Sample No. CCM6 102.9-103.3
Silicocarbonatite.

Fine to medium grained, equigranular, allotriomorphic, with curved to ragged grain boundaries. Sample has undergone deformation. Apatite forms rounded anhedral grains. Magnetite forms anhedral disseminated grains. Phlogopite forms an anhedral, interlocking mosaic with pervasive and strong kinking of (001) cleavage. Carbonate forms rounded, composite, interstitial grains.

Reference No. 772
Sample No. CCM6 131.8-132.2
Silicocarbonatite.

Fine to medium grained, equigranular, massive, allotriomorphic with curved to straight grain boundaries. Magnetite forms anhedral disseminated grains. Apatite forms rounded to subrounded grains. Amphibole occurs as somewhat acicular, anhedral, irregular grains forming an interlocking mosaic. Carbonate forms an interlocking mosaic of anhedral grains.

Reference No. 773
Sample No. CCM6 140.0-140.4
Silicocarbonatite.

Fine to medium grained, massive, equigranular, hypidiomorphic. Magnetite is anhedral and disseminated throughout. Amphibole forms subhedral to euhedral acicular grains. Phlogopite forms anhedral to subhedral grains in an interlocking mosaic. Carbonate forms anhedral interstitial grains.

Reference No. 774
Sample No. CCM6 141.4-141.65
Apatite, magnetite, amphibole, phlogopite silicocarbonatite.

Medium grained, equigranular, massive, allotriomorphic, with curved to straight grain boundaries. Magnetite forms anhedral disseminated grains. Phlogopite forms anhedral grains with darker brown pleochroic rims. Amphibole is somewhat acicular with very pale pleochroism and weak zoning of larger grains under crossed nicols. Apatite forms rounded anhedral grains. Carbonate forms an interlocking mosaic of anhedral grains.

Reference No. 775
Sample No. CCM6 151.3-151.65
Apatite, magnetite, amphibole, phlogopite sovite.

Medium grained, massive, equigranular, allotriomorphic, with curved to straight grain boundaries. Amphibole is weakly pleochroic, acicular, rarely poikilitically encloses carbonate, and under crossed nicols birefringence suggests zoning. Magnetite is anhedral and disseminated. Phlogopite forms anhedral grains with dark brown pleochroic rims. Minor apatite occurs as rounded anhedral grains.

Reference No. 776
Sample No. CCM6 243.9-244.25
Magnetite, phlogopite, apatite sovite.

Medium grained, massive, equigranular, allotriomorphic, with curved to straight grain boundaries. Phlogopite forms anhedral grains with dark brown pleochroic rims. In some grains there is

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**All samples are from drill core. The locations of the drillholes are shown on Figure 3 (Chart A).*

pronounced bending of (001) cleavage. Actinolite forms a few scattered euhedral acicular grains. Magnetite is anhedral and disseminated. Apatite forms rounded anhedral grains. Carbonate forms an interlocking mosaic of grains. Some grains display bent twin lamellae.

Reference No. 777
Sample No. CCM6 248.65-248.95

Phlogopite, magnetite, apatite sovite.

Medium grained, equigranular, allotriomorphic, with curved to straight grain boundaries. Phlogopite is anhedral to subhedral in form; grains display dark brown pleochroic rims. Magnetite is anhedral and disseminated throughout. Apatite forms rounded anhedral grains. Carbonate forms an anhedral interlocking mosaic of grains.

Reference No. 778
Sample No. CCM6 256.7-257.0

Phlogopite, magnetite, apatite sovite.

Medium grained, equigranular, massive allotriomorphic, with straight to curved grain boundaries. Scattered acicular amphibole grains are anhedral to euhedral in form. Phlogopite forms anhedral grains with dark brown pleochroic rims. Magnetite forms anhedral, disseminated grains. Apatite forms anhedral rounded grains. Carbonate forms an interlocking mosaic of anhedral grains.

Reference No. 779
Sample No. CCM6 274.4-274.8

Olivine, magnetite, phlogopite, apatite sovite.

Medium grained, massive, equigranular, allotriomorphic, with curved to straight grain boundaries. Olivine forms rounded anhedral grains; several grains are altering to clinohumite. Magnetite forms anhedral disseminated grains. Phlogopite forms anhedral grains with brown pleochroic rims; some grains have bent (001) cleavages. Apatite forms rounded grains. Carbonate grains form an interlocking mosaic.

Reference No. 780
Sample No. CCM6 328.05-328.35

Magnetite, biotite, apatite sovite.

Medium grained, massive, equigranular, allotriomorphic, with curved to straight grain boundaries. Phlogopite forms anhedral grains with dark brown pleochroic rims; some display bent (001) cleavage. Magnetite forms anhedral disseminated grains. Olivine forms rounded grains, some with serpentine along fractures. Apatite forms rounded anhedral grains. Carbonate forms an interlocking mosaic of grains with bent twin planes.

Reference No. 781
Sample No. CCM6 381.65-382.05

Phlogopite, olivine, apatite sovite.

Medium grained, massive, equigranular, allotriomorphic, with curved to straight grain boundaries. Phlogopite forms anhedral grains with darker brown pleochroic rims. Some grains have bent (001) cleavages and kink bands. Olivine forms rounded large grains with incipient alteration along rims, possibly serpentine. Magnetite forms anhedral disseminated grains. Apatite forms rounded, anhedral to subhedral grains. Carbonate forms an interlocking mosaic of grains with prominent bent twin planes.

Reference No. 782
Sample No. CCM6 442.5-442.9

Magnetite, apatite, olivine, clinohumite sovite.

Medium grained, massive, equigranular, massive, allotriomorphic, with curved to straight grain boundaries. Apatite is anhedral, rounded or subrounded in form. Olivine is anhedral, rounded in form, and generally fresh-looking with slight alteration along curved fractures. Olivine rarely poikilitically encloses apatite. Carbonate grains form an anhedral, interlocking mosaic. Magnetite forms ragged, anhedral disseminated clots that are randomly distributed.

Reference No. 783
Sample No. CCM6 509.1-509.5

Phlogopite, clinohumite sovite.

Medium grained, equigranular, massive, allotriomorphic, with curved to straight grain boundaries. Phlogopite forms anhedral grains with very weakly developed, pleochroic brown rims.

Clinohumite is anhedral to subhedral in form. Carbonate forms an anhedral, interlocking mosaic of grains.

Reference No. 784
Sample No. CCM6 545.1-545.5
Phlogopite, magnetite, apatite sovite.

Medium grained, massive, equigranular, allotriomorphic, with curved to straight grain boundaries. Phlogopite forms anhedral ragged grains with pleochroic rims that are darker brown than the cores. Apatite forms rounded anhedral grains. Magnetite forms anhedral disseminated grains.

Reference No. 785
Sample No. CCM9 401.8-402.2
Apatite rauhaugite.

Fine to medium grained, massive, inequigranular-seriate, allotriomorphic, with lobate to serrate grain boundaries. Apatite forms angular to subangular fragments set in a matrix of crushed carbonate. Apatite sometimes forms segmented crystals. Rounded porphyroclasts of carbonate are set in a matrix of crushed and recrystallized carbonate.

Reference No. 786
Sample No. CCM9 409.95-410.6
Biotite, apatite rauhaugite.

Fine to medium grained, inequigranular-seriate, allotriomorphic, with lobate to serrate grain boundaries. Apatite forms angular crystals and fragments of crystals. Apatite often forms segmented crystals. Minor anhedral, reddish brown biotite has pronounced kinking of (001) cleavage. Rounded porphyroclasts of carbonate are set in a finer grained matrix of recrystallized carbonate.

Reference No. 787
Sample No. CCM9 515.85-516.2
Apatite rauhaugite.

Fine to medium grained, massive, inequigranular-seriate, allotriomorphic, with lobate to serrate grain boundaries. Apatite forms rounded to angular grains which are often fractured and segmented. Rounded porphyroblasts of carbonate are set in a finer grained matrix of recrystallized carbonate.

Reference No. 788
Sample No. CCM20 162.2-162.65
Sovite.

Fine to medium grained, massive, inequigranular-seriate, allotriomorphic, with lobate to serrate grain boundaries. Carbonate forms an interlocking mosaic of anhedral grains; larger grains are set in a matrix of finer grained carbonate. It is unclear whether larger grains are porphyroclastic or porphyroblastic. Grain boundaries are lobate to serrate. One carbonate phase appears to replace the second. Finer grained carbonate interdigitates with coarser grained carbonate which is at least partially controlled by twinning in the carbonate.

Reference No. 789
Sample No. CCM20 246.1-246.7
Sovite.

Fine to medium grained, inequigranular-seriate, allotriomorphic, with serrate to lobate grain boundaries. Carbonate forms an interlocking mosaic of anhedral grains. Larger grains are set in a matrix of finer grained carbonate and have a weak elongation possibly defining a crude foliation. Rock could be a recrystallized, deformed carbonatite.

Reference No. 790
Sample No. CCM22 168.2-168.6
Apatite, magnetite, phlogopite sovite.

Fine to medium grained, massive, inequigranular-seriate, allotriomorphic, with lobate grain boundaries. Apatite forms anhedral rounded bead-like grains. Magnetite forms anhedral disseminated grains. Phlogopite forms irregular anhedral grains with pale brown cores and deep reddish brown rims. Mica is strongly zoned. Carbonate forms an interlocking mosaic of grains with lobate grain boundaries.

Reference No. 791
Sample No. CCM23 391.25-391.7
Magnetite, phlogopite, apatite sovite.

Fine to medium grained, massive, inequigranular-seriate, allotriomorphic, with curved grain boundaries. Phlogopite forms anhedral irregular grains with pale brown cores and deep reddish brown rims. Magnetite is anhedral and forms disseminated grains. Apatite forms anhedral rounded to subrounded grains, some elongate in outline. Carbonate forms an anhedral interlocking mosaic of grains with curved grain boundaries.

Reference No. 792
Sample No. CCM23 410.0-410.45

Phlogopite, apatite, magnetite sovite.

Fine to medium grained, massive, inequigranular-seriate, allotriomorphic, with curved grain boundaries. Phlogopite forms anhedral grains with pale brown cores and dark reddish brown rims; some grains display strong kinking and bending of (001) cleavage. Apatite forms rounded grains of anhedral form. Some grains are fractured and healed with carbonate. Magnetite forms anhedral disseminated grains. Carbonate with curved grain boundaries forms an anhedral interlocking mosaic. Carbonate occurs in bands of finer grained carbonate separated by coarser grained carbonate. Overall texture is that of a deformed and recrystallized rock.

Reference No. 793
Sample No. CCM24 28.6-29.0

Olivine, magnetite, phlogopite, apatite sovite.

Fine to medium grained, massive, inequigranular-seriate, allotriomorphic, with lobate to serrate grain boundaries. Olivine forms anhedral, rounded to somewhat elongate grains with traces of alteration to clinohumite. Phlogopite forms anhedral grains with pale brown cores and weakly developed reddish brown rims. Kinking of (001) cleavage is common in some grains and larger grains contain irregular blebs of carbonate. Apatite forms rounded anhedral grains somewhat elongated in form. Carbonate forms an interlocking mosaic of grains with lobate to serrate grain boundaries. Possibly minor recrystallization has occurred.

Reference No. 794
Sample No. CCM24 101.0-101.4

Amphibole, phlogopite, apatite sovite.

Fine grained, massive, inequigranular-seriate, allotriomorphic, with curved grain boundaries. Amphibole forms acicular crystals with well-developed twinning; it is colourless to very pale green in colour. Apatite forms rounded anhedral grains somewhat elongate in outline. Phlogopite forms anhedral grains with brown cores and reddish brown rims; weak bending of (001) cleavage. Grains have wavey extinction. Carbonate forms anhedral interlocking grains with curved grain boundaries and weak bending of some twin planes.

Reference No. 795
Sample No. CCM24 174.5-175.2

Amphibole, phlogopite, magnetite, apatite sovite.

Fine to medium grained, massive, inequigranular-seriate, allotriomorphic, with curved grain boundaries. Magnetite forms anhedral, disseminated grains. Phlogopite forms anhedral irregular grains, commonly with pale brown cores and dark reddish brown rims. Amphibole forms acicular crystals with well-developed twinning. Amphibole is colourless to pale green in colour. Apatite forms rounded anhedral grains, commonly elongate in form. Carbonate forms an interlocking mosaic of anhedral grains with curved boundaries.

Reference No. 796
Sample No. CCM24 267.2-267.6

Amphibole, magnetite, apatite, phlogopite sovite.

Fine to medium grained, massive, inequigranular-seriate, allotriomorphic, with curved grain boundaries. Amphibole forms euhedral acicular crystals, which are pale green to colourless. Amphibole is twinned. Magnetite forms anhedral disseminated grains. Some fine grained dusty magnetite is after olivine. Apatite forms rounded often elongate anhedral grains. Phlogopite forms anhedral irregular crystals with brown cores and reddish brown rims. Grains display kinking and bending of (001) cleavage and wavy extinction. Carbonate forms an interlocking mosaic of anhedral grains with curved grain boundaries.

Reference No. 797
Sample No. CCM24 298.2-298.6

Magnetite, amphibole, phlogopite, apatite sovite.

Fine to medium grained, massive, inequigranular-seriate, allotriomorphic, with curved to lobate grain boundaries. Amphibole forms euhedral acicular crystals, which are pale green to colourless. Magnetite forms subhedral disseminated grains. Phlogopite forms anhedral irregular grains with brown cores and reddish brown rims; grains display weak bending of (001) cleavage and wavy extinction. Apatite forms rounded anhedral grains some of which are elongate. Carbonate forms anhedral irregular grains with curved to lobate grain boundaries.

Reference No. 798
Sample No. CCM24 333.4–333.7

Clinohumite, amphibole, phlogopite, apatite, magnetite sovite.

Fine to medium grained, massive, inequigranular-seriate, allotriomorphic, with curved grain boundaries. Clinohumite forms anhedral yellowish grains, possibly after olivine. Clinohumite contains acicular amphibole. Magnetite is anhedral in form and disseminated throughout. Apatite forms anhedral rounded to elongate grains. Phlogopite forms anhedral irregular grains with pale brown cores and reddish brown rims. Amphibole forms euhedral acicular crystals, some of which are twinned. Carbonate forms anhedral interlocking mosaic of grains with curved grain boundaries.

Reference No. 799
Sample No. CCM24 346.5–346.9

Phlogopite, apatite sovite.

Fine grained, inequigranular-seriate, allotriomorphic, with curved to straight grain boundaries. Apatite forms rounded anhedral grains; some are elongate in outline. Phlogopite forms anhedral, brown to reddish brown grains. Carbonate forms an interlocking mosaic of anhedral grains with straight to curved grain boundaries.

Reference No. 800
Sample No. CCM24 357.4–357.75

Olivine, amphibole, apatite, magnetite sovite.

Fine to medium grained, inequigranular-seriate, allotriomorphic, with curved to lobate grain boundaries. Olivine is both fresh and extensively altered to clinohumite. Amphibole forms euhedral pale green to colourless acicular crystals and is closely associated with olivine. Apatite forms rounded anhedral grains some of which are elongated in outline. Magnetite forms anhedral disseminated grains. Carbonate forms an interlocking mosaic of anhedral grains with curved to lobate grain boundaries.

Reference No. 801
Sample No. CCM26 68.6–68.9

Pyrrhotite, magnetite, clinohumite, phlogopite, apatite sovite.

Fine to medium grained, massive, inequigranular-seriate hypiodmorphic. Carbonate forms an interlocking mosaic of anhedral grains. Apatite forms rounded often elongate grains. Clinohumite forms minor anhedral grains, commonly in association with altered olivine or replacing olivine. Phlogopite forms anhedral pleochroic reddish brown grains, rarely with poikilitic apatite. Magnetite forms anhedral irregular disseminated grains. Pyrrhotite forms anhedral, irregular, disseminated grains. Trace to minor amounts of serpentinized olivine, and amphibole are present.

Reference No. 802
Sample No. CCM26 86.25–86.65

Olivine, apatite, phlogopite, magnetite sovite.

Fine to medium grained, massive, inequigranular-seriate, massive, hypidiomorphic. Apatite forms anhedral to subhedral rounded to rounded-elongate grains. Magnetite forms anhedral irregular disseminated grains. Olivine forms rounded to elongate grains with local alteration to clinohumite. Phlogopite forms pleochroic, anhedral to subhedral grains of pale reddish brown colour. Carbonate forms an interlocking mosaic of grains.

Reference No. 803
Sample No. CCM26 89.25–89.6

Olivine, phlogopite, apatite, magnetite sovite.

Fine to coarse grained, massive, inequigranular-seriate, hypidiomorphic. Apatite forms rounded sometimes elongate crystals which are subhedral in form. Olivine forms anhedral somewhat elongated grains with local alteration to clinohumite and serpentine. Magnetite forms anhedral irregular disseminated grains. Phlogopite forms anhedral to subhedral pale brown pleochroic grains. Carbonate forms an interlocking anhedral mosaic of grains.

Reference No. 804
Sample No. CCM26 101.65–102.0

Olivine, phlogopite, magnetite, apatite sovite.

Fine to medium grained, massive, inequigranular-seriate, hypidiomorphic. Apatite forms anhedral to subhedral grains, some of which are elongate in outline. Phlogopite forms pale brown booklets of anhedral to subhedral form. Magnetite forms anhedral disseminated grains. Olivine forms anhedral elongate grains, partially altered to clinohumite and serpentine. Carbonate consists of an interlocking mosaic of anhedral grains.

Reference No. 805
Sample No. CCM26 139.4-139.75

Amphibole, magnetite, phlogopite, apatite sovite.

Fine to medium grained, massive, inequigranular-seriate, hypidiomorphic. Amphibole forms long, acicular, very pale green pleochroic grains. Phlogopite forms anhedral irregular grains commonly with pale brown cores and darker brown rims. Phlogopite is zoned and may contain irregular blebs of carbonate. Magnetite forms anhedral disseminated grains. Apatite forms anhedral to subhedral grains, which are rounded to elongated in form. Carbonate comprises an anhedral interlocking mosaic of grains with lobate grain boundaries. Carbonate is possibly recrystallized.

Reference No. 806
Sample No. CCM26 155.0-155.3

Olivine, apatite, magnetite, phlogopite sovite.

Fine to medium grained, massive, inequigranular-seriate, hypidiomorphic. Olivine forms rounded to elongate anhedral grains which are generally fresh; some grains are altered to clinohumite. Apatite forms rounded anhedral to subhedral grains, some are elongate in outline. Magnetite forms anhedral disseminated grains, segregated into streaks. Phlogopite forms anhedral brown pleochroic grains scattered throughout. Carbonate forms an interlocking mosaic of anhedral grains.

Reference No. 807
Sample No. CCM26 183.4-183.75

Amphibole, olivine, magnetite, phlogopite, apatite sovite.

Fine to medium grained, massive, inequigranular-seriate hypidiomorphic. Amphibole forms pale green to colourless, acicular euhedral crystals with well-developed twinning. Amphibole is closely associated with olivine. Olivine forms rounded grains, which are sometimes fresh; olivine is often replaced by clinohumite, possibly some serpentine. Apatite forms anhedral rounded grains commonly elongate in outline. Magnetite forms anhedral disseminated grains. Phlogopite forms anhedral disseminated brown grains with well developed pleochroism. Phlogopite may contains blebs of carbonate. Carbonate forms an interlocking mosaic of anhedral grains.

Reference No. 808
Sample No. CCM26 195.85-196.25

Olivine, magnetite, phlogopite, apatite sovite.

Fine to medium grained, massive, inequigranular-seriate, hypidimorphic. Olivine forms anhedral rounded to rounded-elongate grains, commonly altered to a yellowish clinohumite. Apatite forms rounded anhedral grains, sometimes elongate in outline. Phlogopite forms anhedral brown pleochroic grains, disseminated throughout. Magnetite forms anhedral disseminated grains. Carbonate forms an interlocking mosaic of anhedral grains.

Reference No. 809
Sample No. CCM26 238.8-239.2

Olivine, phlogopite, magnetite, apatite sovite.

Fine to medium grained, massive, inequigranular-seriate, hypidiomorphic. Olivine forms anhedral irregular grains, partially replaced by clinohumite. Apatite forms rounded bead-like grains, some of which are elongate in form. Phlogopite forms anhedral, brown pleochroic grains scattered throughout. Magnetite forms anhedral disseminated grains. Carbonate forms an interlocking mosaic of anhedral grains.

Reference No. 810
Sample No. CCM26 277.05-277.3

Phlogopite, apatite sovite.

Fine to medium grained, massive, inequigranular-seriate, hypidiomorphic. Apatite forms rounded somewhat elongated bead-like grains. Minor disseminated anhedral magnetite is present. Phlogopite forms anhedral brown pleochroic grains disseminated throughout. Carbonate forms an irregular interlocking anhedral grains with straight to slightly curved grain boundaries.

Reference No. 811
Sample No. CCM29 79.1-79.55

Olivine, amphibole pyroxenite.

Fine to medium grained, massive, inequigranular-seriate, hypidiomorphic. Olivine forms anhedral irregular grains with minor alteration to amphibole and serpentine. Magnetite forms anhedral grains disseminated throughout. Pyrrhotite forms anhedral disseminated grains. Amphibole is brown to reddish brown; it mantles magnetite and occurs along grain boundaries of pyroxene. Clinopyroxene forms large anhedral to subhedral grains which are turbid due to alteration along cleavages and fractures. Some grains display a possible weak zonation.

Reference No. 812
Sample No. CCM29 106.45-106.9

Sovite.

Fine to medium grained, massive, inequigranular, allotriomorphic, with serrate to lobate grain boundaries. Carbonate forms an anhedral interlocking mosaic. Minor apatite occurs as rounded anhedral grains.

Reference No. 813
Sample No. CCM29 117.3-117.8

Apatite, magnetite sovite.

Fine to medium grained, massive, inequigranular-seriate, hypidiomorphic. Apatite forms rounded anhedral to subhedral grains some of which are elongated in outline. Magnetite forms anhedral disseminated grains. Phlogopite forms anhedral brown grains. Phlogopite grains are slightly clustered.

Reference No. 814
Sample No. CCM29 136.85-137.2

Phlogopite, carbonate hornblendite.

Fine to medium grained, massive, equigranular, allotriomorphic, with curved to straight grain boundaries. Magnetite forms anhedral disseminated grains. Carbonate forms anhedral interlocking grains interstitial to interlocking amphibole grains. Phlogopite forms anhedral brown pleochroic grains interlocking with amphibole. Amphibole is an anhedral interlocking mosaic of pale green grains with curved to lobate grain boundaries.

Reference No. 815
Sample No. CCM35 86.2-86.75

Phlogopite-bearing, magnetite, pyroxene amphibole rock.

Fine to medium grained, massive, inequigranular-seriate, hypidiomorphic. Magnetite forms subhedral to euhedral disseminated grains. Amphibole is brown, pleochroic, and anhedral to subhedral in form. The amphibole completely encloses magnetite and pyroxene. Clinopyroxene forms large anhedral to subhedral crystals. Amphibole and pyroxene lie in sharp contact and pyroxene may be enclosed in large amphibole grains. Extinction angle is that of diopside. Large, optically continuous amphibole and pyroxene grains are completely intergrown and suggest simultaneous crystallization of both phases. Minor phlogopite occurs as brown intergranular anhedral grains. There could be a slight zoning of the phlogopite.

Reference No. 816
Sample No. CCM35 134.4-135.0

Silicocarbonatite.

Fine grained, massive, equigranular, allotriomorphic, with curved grain boundaries. Magnetite occurs as anhedral disseminated grains. Amphibole is present as aggregates of pale green to green, anhedral to subhedral, somewhat acicular crystals. Phlogopite forms pale brown to brown anhedral crystals interlocked with amphibole. Some kinking of (001) cleavage is present and extinction is often wavey. Carbonate forms an interlocking mosaic of anhedral grains which display some bending of twin planes. Locally there is microfaulting of mica and carbonate.

Reference No. 817
Sample No. CCM35 128.9-129.3

Silicocarbonatite.

Fine to medium grained, massive, inequigranular-seriate, allotriomorphic, with straight to curved grain boundaries. Magnetite forms anhedral disseminated grains. Apatite forms rounded anhedral grains. Amphibole forms pale green pleochroic, acicular, subhedral to euhedral crystals. Phlogopite forms anhedral interlocking grains commonly with wavey extinction. Carbonate is anhedral forming an interlocking mosaic of grains. Phlogopite occurs in clusters or aggregates of grains.

Reference No. 818
Sample No. CCM35 114.2-114.8

Biotite, magnetite, carbonate, amphibole rock.

Fine grained, massive, equigranular, allotriomorphic, with straight to curved grain boundaries. Biotite forms anhedral grains of a dark brown colour; some display dark brown cores and paler brown rims. Magnetite forms anhedral disseminated grains, some of which are skeletal. Carbonate forms anhedral grains interlocking with each other and amphibole. Amphibole forms elongated grains pleochroic from pale green to dark green. There are some crude amphibole cross sections. Extinction angle is high and amphibole is likely a sodic variety. Some amphiboles are crudely euhedral, others somewhat ragged and nearly anhedral.

Reference No. 819
Sample No. CCM35 100.5-101.0

Magnetite-rich pyroxenite.

Fine grained, massive, equigranular, allotriomorphic, with curved grain boundaries. Minor amphibole forms brown anhedral interstitial grains. Magnetite forms anhedral, irregular interstitial grains. Clinopyroxene forms anhedral colourless grains, commonly twinned. Pyroxene forms an interlocking mosaic with magnetite. Clinopyroxene extinction angles are typical of augite.

Reference No. 820
Sample No. CCM41 248.35-248.7

Phlogopite, magnetite, apatite sovite.

Fine to medium grained, massive, inequigranular-seriate, allotriomorphic, with curved to lobate grain boundaries. Magnetite forms anhedral disseminated grains. Trace of magnetite is skeletal in form. Phlogopite forms anhedral irregular booklets; grains have light brown cores and dark reddish brown rims. Apatite forms rounded anhedral to subhedral grains. Larger grains tend to be elongate in form. Carbonate forms an interlocking mosaic of anhedral grains with curved to lobate grain boundaries.

Reference No. 821
Sample No. CCM41 140.0-140.6

Amphibole, apatite, magnetite, phlogopite sovite.

Fine to medium grained, inequigranular-seriate, hypidiomorphic. Amphibole forms acicular, euhedral, pale green to green grains. Amphibole is somewhat clotty. Magnetite forms disseminated grains. Phlogopite forms anhedral grains, locally with bent (001) cleavage and wavey extinction. Grains have pale brown cores and reddish brown rims and are thus zoned. Apatite forms anhedral rounded grains, larger grains are elongate in outline. Carbonate forms an interlocking mosaic of anhedral grains with curved to lobate grain boundaries. Possibly recrystallized.

Reference No. 822
Sample No. CCM46 225.75-226.3

Olivine, amphibole clinopyroxenite.

Fine to medium grained, massive, inequigranular-seriate, hypidiomorphic. Olivine forms anhedral grains occurring as polycrystalline aggregates interstitial to pyroxene and altered to serpentine and bowlingite. Magnetite forms anhedral grains interstitial to pyroxene. Amphibole forms patchy replacements of pyroxene and is present along pyroxene grain boundaries. Green to greenish brown amphibole commonly rims magnetite. Clinopyroxene forms anhedral to subhedral, colourless grains, commonly with schiller texture.

Reference No. 823
Sample No. CCM46 223.3-223.7

Olivine, amphibole clinopyroxenite.

Fine to medium grained, massive, inequigranular-seriate, hypidiomorphic. Magnetite forms anhedral disseminated grains, interstitial to pyroxene. Olivine forms anhedral grains, which consist of aggregates interstitial to pyroxene. Olivine is extensively altered to serpentine and bowlingite. Amphibole is brown to greenish brown in colour and occurs as a patchy alteration of pyroxene, along grain boundaries of pyroxene, and as narrow rims on magnetite grains. Clinopyroxene forms anhedral to subhedral, colourless grains; some grains display well developed schiller texture.

Reference No. 824
Sample No. CCM46 191.35-191.9

Olivine, amphibole clinopyroxenite.

Fine to medium grained, inequigranular-seriate, hypidiomorphic. Magnetite forms anhedral irregular grains, partially interstitial to pyroxene. Olivine forms anhedral grains and occurs as polycrystalline aggregates interstitial to the pyroxene and may enclose isolated pyroxene grains; there is minor alteration to serpentine and bowlingite. Amphibole forms patchy alterations of pyroxene and occurs along grain boundaries of pyroxene. Amphibole also rims portions of some magnetite crystals. Clinopyroxene is anhedral to subhedral in form, colourless, and has well developed schiller texture. Pyroxene has the extinction angle of augite.

Reference No. 825
Sample No. CCM46 186.0-186.65

Olivine, amphibole clinopyroxenite.

Fine to medium grained, inequigranular-seriate, massive, hypidiomorphic. Olivine forms aggregates of anhedral grains enclosed in pyroxene. One olivine grain encloses a pyroxene grain. Olivine is locally altered to bowlingite along edges; minor serpentine occurs along fractures. Magnetite forms anhedral disseminated grains. Amphibole is pale green to brown, forming spotty replacement of pyroxene, and occurs along pyroxene grain boundaries. Amphibole fills small capillary fractures. Amphibole is common along edges of magnetite grains. Clinopyroxene forms anhedral to subhedral, colourless crystals; schiller structure is essentially absent. Pyroxene has the extinction angle of diopside.

Reference No. 826
Sample No. CCM46 156.45-156.85

Olivine, amphibole clinopyroxenite.

Fine to medium grained, massive, inequigranular-seriate, hypidiomorphic. Olivine forms anhedral grains in part altered to greenish bowlingite and serpentine. Olivine is interstitial to pyroxene and consists of polycrystalline aggregates. Magnetite forms irregular disseminated grains. Amphibole is pale brown to green, forming patchy alteration of the pyroxene and along margins of pyroxene grains. Amphibole appears to occupy a small fracture traversing the section. Clinopyroxene is anhedral to subhedral in form. Pyroxene is colourless and displays well developed schiller texture. Extinction angle is that of diopside.

Reference No. 827
Sample No. CCM46 150.9-151.4

Olivine, amphibole clinopyroxenite.

Fine to medium grained, massive, inequigranular-seriate, hypidiomorphic. Olivine forms anhedral grains interstitial to pyroxene. Olivine is altered to serpentine and magnetite along fractures, and to iddingsite on some edges. Magnetite forms anhedral disseminated grains. Minor disseminated pyrrhotite is present. Amphibole forms as a patchy alteration of pyroxene and along margins of some pyroxene grains. Amphibole is also common along margins of some magnetite grains. Clinopyroxene is anhedral to subhedral, colourless, and displays well developed schiller texture. Pyroxene has the extinction angle of diopside.

Reference No. 828
Sample No. CCM46 145.15-145.65

Amphibole, olivine clinopyroxenite.

Fine to coarse grained, massive, inequigranular-seriate, hypidiomorphic. Olivine forms anhedral grains interstitial to pyroxene. Olivine is altered to iddingsite and serpentine. Magnetite forms anhedral disseminated grains. Amphibole forms as irregular patches in pyroxene grains and along margins of pyroxene grains. Amphibole is common along margins of most magnetite grains. Minor disseminated pyrrhotite is present. Clinopyroxene is colourless, subhedral to anhedral in form and displays well developed schiller texture. Pyroxene has the extinction angle of diopside.

Reference No. 829
Sample No. CCM47 70.25-70.7

Amphibole pyroxenite.

Fine to medium grained, massive, inequigranular-seriate, hypidiomorphic. Magnetite forms anhedral irregular grains. Magnetite completely encloses some pyroxene grains. Amphibole is brown to greenish brown and forms as patchy replacements of pyroxene, along margins of pyroxene grains, and along margins of magnetite grains. Pyroxene forms colourless anhedral to subhedral grains. Some grains have a schiller texture. Trace of olivine is completely altered to reddish brown iddingsite.

Reference No. 830
Sample No. CCM47 47.0-47.5

Amphibole clinopyroxenite.

Fine to medium grained, inequigranular-seriate, massive, hypidiomorphic. Magnetite forms anhedral, irregular, disseminated grains interstitial to pyroxene. Several pyroxene grains contain poikilitic magnetite. Clinopyroxene forms anhedral to subhedral grains, generally fresh; schiller texture generally absent. Amphibole forms brown to pale brown anhedral grains along margins of pyroxene grains. Amphibole occurs as a patchy replacement of pyroxene, and as rims on magnetite. Extinction angle is that of augite.

Reference No. 831
Sample No. CCM49 344.0-344.4

Amphibole, clinohumite, olivine, magnetite silicocarbonatite.

Fine to coarse grained, massive, inequigranular, allotriomorphic, with curved to straight grain boundaries. Amphibole forms acicular twinned crystals and tiny fibres along margins of some olivine grains. Olivine forms large colourless grains with well developed parallel parting. Clinohumite forms anhedral to subhedral grains and patches, is pleochroic in yellow and in part replaces olivine. Under high magnification the clinohumite is seen to contain abundant very small inclusions. Magnetite forms anhedral grains and clots. Carbonate forms an interlocking mosaic of anhedral grains.

Reference No. 832
Sample No. CCM49 332.5-332.9

Biotite, apatite, magnetite sovite.

Fine to coarse grained, massive, inequigranular-seriate, allotriomorphic, with straight to curved grain boundaries. Apatite forms anhedral to subhedral grains, generally elongate in outline. Biotite forms anhedral brown booklets. Magnetite forms anhedral irregular clots; larger clots have ragged edges. Carbonate forms an interlocking mosaic of anhedral grains.

Reference No. 833
Sample No. CCM49 324.75-325.1

Olivine, phlogopite, magnetite, apatite sovite.

Fine to medium grained, massive, inequigranular-seriate, allotriomorphic, with curved grain boundaries. Olivine forms anhedral to subhedral grains moderately altered to yellowish clinohumite. Apatite forms rounded anhedral to subhedral grains some of which are elongate in outline. Phlogopite forms pale brown to brown, pleochroic, anhedral booklets. Magnetite is anhedral and disseminated throughout. Trace of amphibole is enclosed in olivine.

Reference No. 834
Sample No. CCM49 309.65-310.00

Clinohumite, phlogopite, apatite sovite.

Fine to medium grained, massive, inequigranular-seriate, allotriomorphic, with curved to straight grain boundaries. Olivine forms anhedral grains with minor to extensive alteration to clinohumite (?). Apatite forms anhedral rounded grains with the larger grains elongated in outline. Phlogopite forms anhedral irregular grains with bent (001) cleavage and wavey extinction. Weak dark brown rimming of some grains implies a zonation. Carbonate forms an interlocking mosaic of anhedral grains with curved to straight grain boundaries. Clinohumite forms large subhedral grains with poikilitic, euhedral amphibole and blebs of carbonate.

Reference No. 835
Sample No. CCM49 294.1-294.45

Clinohumite, magnetite, phlogopite, apatite sovite.

Fine to medium grained, massive, inequigranular-seriate, allotriomorphic, with curved to lobate grain boundaries. Clinohumite forms anhedral to subhedral grains with poikilitic amphibole. Olivine is commonly altered along edges to yellowish clinohumite. There are blebs of carbonate in clinohumite. Minor amphibole is euhedral, acicular, colourless and associated with olivine. Phlogopite forms anhedral brown grains with bent (001) cleavages and wavey extinction. Some grains display darker reddish brown rims implying a zonation. Magnetite forms anhedral disseminated grains. Apatite forms rounded anhedral grains some of which are elongated in outline. Carbonate forms an interlocking mosaic of grains with curved to lobate grain boundaries.

Reference No. 836
Sample No. CCM49 259.0-259.4

Amphibole, magnetite, olivine, apatite, phlogopite sovite.

Fine to medium grained, massive, inequigranular-seriate, allotriomorphic, with straight to lobate grain boundaries. Amphibole forms euhedral, acicular, pale green to colourless grains. Magnetite forms anhedral disseminated grains. Olivine forms anhedral grains locally extensively altered to clinohumite. Clinohumite encloses some amphibole. Phlogopite occurs as anhedral grains disseminated throughout. Mica has wavey extinction and rims of grains are slightly darker in colour than cores suggesting a zonation. Apatite forms anhedral rounded grains some of which are elongated in outline. Carbonate forms an interlocking mosaic of grains with straight to curved grain boundaries.

Reference No. 837
Sample No. CCM49 246.8-247.25

Clinohumite, apatite sovite.

Fine to medium grained, massive, inequigranular-seriate, allotriomorphic, with curved to lobate grain boundaries. Clinohumite forms anhedral irregular grains partially altered to yellowish clinohumite. Apatite forms anhedral rounded grains; larger grains are somewhat elongated. There is minor anhedral, irregular-shaped, phlogopite. Carbonate forms an anhedral interlocking mosaic of grains. Several grains display bent twin planes. Carbonate has curved to lobate grain boundaries.

Reference No. 838
Sample No. CCM49 193.0-193.4

Olivine, phlogopite, apatite sovite.

Fine grained, equigranular, massive, inequigranular-seriate, allotriomorphic, with curved to lobate grain boundaries. Olivine forms rounded anhedral grains with alteration to clinohumite along edges. Magnetite forms anhedral disseminated grains. Apatite forms rounded anhedral grains. Larger grains are elongated in outline. Phlogopite forms anhedral, irregular, brown grains, commonly with wavey extinction. Carbonate forms an interlocking mosaic of grains with curved to lobate grain boundaries.

Reference No. 839
Sample No. CCM49 190.0-190.7

Phlogopite, magnetite, apatite sovite.

Fine to medium grained, massive, inequigranular-seriate, allotriormorphic, with curved grain boundaries. Olivine forms rounded anhedral grains with local alteration to clinohumite along borders. Phlogopite forms anhedral irregular grains with faintly darker reddish brown rims. Phlogopite encloses small blebs of carbonate, and has wavey extinction. Magnetite forms anhedral irregular grains and may fill fractures. Apatite forms bead-like rounded grains with larger grains elongate in outline. Carbonate forms an interlocking mosaic of anhedral grains with straight to curved grain boundaries.

Reference No. 840
Sample No. CCM51 44.5-45.0

Amphibole, olivine clinopyroxenite.

Fine to medium grained, massive, inequigranular-seriate, hypidiomorphic. Olivine forms anhedral rounded grains, commonly in clusters. Weak alteration to iddingsite and serpentine occurs along edges of olivine grains. Magnetite forms disseminated grains commonly associated with altered olivine or where pyroxene is altered to amphibole. Amphibole is a pleochroic, brown to green anhedral mineral forming irregular replacements of pyroxene and narrow rims on some pyroxene grains. Clinopyroxene is anhedral to subhedral in form and displays local schiller textures.

Reference No. 841
Sample No. CCM51 61.0-61.6

Amphibole, olivine clinopyroxenite.

Fine to medium grained, inequigranular-seriate, massive, hypidiomorphic. Olivine forms anhedral clusters of grains that locally appear interstitial to the pyroxene; there is minor alteration to serpentine. Magnetite forms anhedral disseminated grains in association with altered olivine and amphibole. Amphibole occurs as narrow rims on some pyroxene grains and as patchy alteration of pyroxene. Clinopyroxene forms anhedral to subhedral grains, some with poorly developed schiller texture.

Reference No. 842
Sample No. CCM55 42.6-43.1

Olivine, amphibole-bearing clinopyroxenite.

Fine to coarse grained, inequigranular, allotriomorphic, with curved to straight grain boundaries. Pyroxene forms anhedral to subhedral interlocking grains with well developed schiller texture. Clinopyroxene has the extinction angle of augite. Minor phlogopite occurs as small isolated grains and closely associated with magnetite. Magnetite forms anhedral disseminated grains. Olivine forms anhedral interstitial grains and rounded grains, partially altered to iddingsite and serpentine. Amphibole, sometimes strongly zoned from brown core to deep green rims, occurs in anhedral to euhedral grains. Euhedral grains occur on margins of pyroxene grains and project into carbonate. Other amphibole occurs as anhedral intergranular grains and patchy replacements of pyroxene. There are trace to minor amounts of sphene and calcite. Minor amphibole rims magnetite in contact with pyroxene. Minor olivine lies between pyroxene and magnetite where these two minerals are adjacent.

Reference No. 843
Sample No. CCM55 51.5-52.0

Amphibole, olivine clinopyroxenite.

Fine to coarse grained, massive, inequigranular-seriate, hypidiomorphic. Olivine forms rounded grains partially replaced by iddingsite and serpentine along the edges. Clinopyroxene occurs as anhedral to euhedral grains with well developed schiller texture. Amphibole forms narrow rims on the pyroxene and also occurs as patchy replacements of the pyroxene. Magnetite forms anhedral, rounded, disseminated grains, commonly rimmed with amphibole where in contact with pyroxene. Minor phlogopite occurs along a capillary fracture and along rims of pyroxene grains.

TABLE A-2. MAJOR ELEMENT ANALYSES (WEIGHT PERCENT) OF WHOLE-ROCK SAMPLES FROM THE CARGILL TOWNSHIP CARBONATITE COMPLEX.

	SOVITE						
Ref. No.	**789**	**776**	**778**	**781**	**777**	**784**	**779**
SiO_2	0.44	3.14	2.77	3.76	5.54	2.34	3.35
Al_2O_3	0.36	0.68	0.71	0.79	0.63	0.71	0.46
Fe_2O_3	0.69	1.45	3.05	1.01	1.15	1.50	3.13
FeO	2.96	2.52	3.70	2.37	2.82	2.89	4.15
MgO	18.70	3.70	3.34	4.40	5.76	2.89	7.47
CaO	29.50	47.10	45.40	45.90	44.00	46.80	43.90
Na_2O	0.20	0.66	0.62	0.64	0.66	0.53	0.57
K_2O	0.0	0.31	0.22	0.36	0.21	0.33	0.10
TiO_2	0.00	0.18	0.42	0.14	0.15	0.24	0.35
P_2O_5	0.33	4.08	1.48	5.52	7.04	3.08	1.92
S	0.0	0.26	0.22	0.27	0.16	0.34	0.15
MnO	0.37	0.11	0.11	0.10	0.15	0.10	0.14
CO_2	45.00	33.60	31.10	32.60	29.90	34.40	32.9
H_2O+	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
H_2O-	0.40	0.50	0.51	0.57	0.40	0.45	0.41
Total	99.0	98.3	93.6	98.4	98.6	96.6	99.0

	SOVITE						
Ref. No.	**780**	**783**	**782**	**775**	**788**	**808**	**806**
SiO_2	5.07	3.58	8.27	29.10	0.25	3.57	6.11
Al_2O_3	1.16	0.65	0.61	3.45	0.30	0.57	0.77
Fe_2O_3	4.41	0.49	5.78	6.15	0.0	0.38	1.85
FeO	4.59	2.08	7.49	8.15	4.00	2.74	4.15
MgO	7.11	4.57	9.01	12.80	18.50	4.93	7.30
CaO	41.00	46.80	35.50	17.40	29.80	46.20	41.90
Na_2O	0.49	0.49	0.51	2.93	0.20	0.37	0.41
K_2O	3.06	0.28	0.09	1.96	0.01	0.22	0.34
TiO_2	0.64	0.10	0.82	2.58	0.00	0.06	0.25
P_2O_5	2.08	2.44	3.64	1.17	0.09	5.92	8.88
S	0.21	0.07	0.21	0.41	0.01	0.37	0.16
MnO	0.12	0.10	0.18	0.21	0.38	0.11	0.14
CO_2	27.80	36.10	18.50	11.30	47.10	32.30	25.50
H_2O+	N.D.	N.D.	N.D.	0.36	N.D.	N.D.	N.D.
H_2O-	0.43	0.44	0.29	0.42	0.12	0.29	0.32
Total	98.2	98.2	90.9	98.4	100.7	98.0	98.1

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

All samples are from drill core. The locations of the drillholes are shown on Figure 3 (Chart A).

N.D. = Not Detected

Ref. No.	**Sample No.**	**Ref. No.**	**Sample No.**
789	CCM20 246.1-246.7	780	CCM6 328.05-328.35
776	CCM6 243.9-244.25	783	CCM6 509.1-509.5
778	CCM6 256.7-257.0	782	CCM6 442.5-442.9
781	CCM6 381.65-382.05	775	CCM6 151.3-151.65
777	CCM6 248.65-248.95	788	CCM20 162.2-162.65
784	CCM6 545.1-545.5	808	CCM26 195.85-196.25
779	CCM6 274.4-274.8	806	CCM26 155.0-155.3

TABLE A-2. CONTINUED.

				SOVITE			
Ref. No.	**804**	**802**	**805**	**801**	**810**	**803**	**807**
SiO_2	2.44	2.60	3.90	3.20	4.23	4.09	5.88
Al_2O_3	0.50	0.51	0.52	0.54	0.86	0.50	0.84
Fe_2O_3	2.10	6.56	1.62	4.81	0.00	4.33	0.72
FeO	3.85	6.97	2.30	5.93	1.77	5.19	2.52
MgO	3.71	3.87	4.26	4.35	4.98	4.67	5.44
CaO	46.20	41.70	44.00	43.90	47.10	41.00	43.70
Na_2O	0.23	0.27	0.78	0.30	0.33	0.50	0.36
K_2O	0.18	0.17	0.28	0.18	0.60	0.15	0.55
TiO_2	0.30	0.85	0.16	0.61	0.00	0.51	0.07
P_2O_5	4.16	4.16	3.62	4.88	6.68	3.16	6.56
S	0.48	0.44	0.11	0.62	0.18	0.25	0.28
MnO	0.11	0.15	0.13	0.15	0.10	0.15	0.11
CO_2	33.70	29.00	34.90	29.50	30.80	31.80	29.70
H_2O+	N.D.	N.D.	0.12	N.D.	N.D.	0.27	N.D.
H_2O-	0.36	0.36	0.27	0.38	0.22	0.20	0.29
Total	98.3	97.6	97.0	99.4	97.9	96.8	97.0

				SOVITE			
Ref. No.	**812**	**813**	**809**	**790**	**791**	**792**	**793**
SiO_2	0.63	3.47	8.69	1.04	1.45	3.37	6.25
Al_2O_3	0.29	0.46	0.76	0.56	0.48	0.51	0.92
Fe_2O_3	0.00	0.00	1.70	2.83	1.00	3.49	0.87
FeO	0.96	1.19	4.30	3.33	2.08	3.19	2.67
MgO	1.57	2.52	8.07	16.60	2.84	4.65	6.07
CaO	52.10	48.80	39.70	30.00	47.70	43.80	43.00
Na_2O	0.39	0.59	0.31	0.15	0.48	0.41	0.41
K_2O	0.00	0.16	0.41	0.15	0.28	0.31	0.66
TiO_2	0.00	0.30	0.23	0.06	0.08	0.23	0.05
P_2O_5	0.36	2.04	3.92	3.68	4.12	3.52	6.32
S	0.13	0.12	0.18	0.27	0.22	0.34	0.50
MnO	0.12	0.10	0.15	0.23	0.12	0.15	0.13
CO_2	40.70	35.20	24.10	38.50	35.50	32.10	29.60
H_2O+	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
H_2O-	0.35	0.38	0.31	0.33	0.28	0.24	0.15
Total	97.6	95.3	92.8	97.7	96.6	96.3	97.6

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

All samples are from drill core. The locations of the drillholes are shown on Figure 3 (Chart A).

N.D. = Not Detected

Ref. No.	**Sample No.**	**Ref. No.**	**Sample No.**
804	CCM26 101.65-102.0	812	CCM29 106.45-106.9
802	CCM26 86.25-86.65	813	CCM29 117.3-117.8
805	CCM26 139.4-139.75	809	CCM26 238.8-239.2
801	CCM26 68.6-68.9	790	CCM22 168.2-168.6
810	CCM26 277.05-277.3	791	CCM23 391.25-391.7
803	CCM26 89.25-89.6	792	CCM23 410.0-410.45
807	CCM26 183.4-183.75	793	CCM24 28.6-29.0

TABLE A-2. CONTINUED.

	SOVITE						
Ref. No.	**794**	**795**	**799**	**797**	**798**	**800**	**796**
SiO_2	4.76	7.37	1.16	1.00	3.09	3.54	4.94
Al_2O_3	0.44	0.72	0.45	0.38	0.50	0.38	0.75
Fe_2O_3	0.59	6.61	0.00	0.00	3.43	0.29	2.43
FeO	1.63	4.67	1.26	1.19	3.33	2.08	4.52
MgO	3.58	7.05	2.48	2.62	3.85	4.22	4.62
CaO	44.90	36.80	49.20	48.60	45.00	46.60	42.50
Na_2O	0.90	0.90	0.57	0.40	0.35	0.45	0.56
K_2O	0.19	0.51	0.15	0.05	0.23	0.09	0.53
TiO_2	0.03	0.67	0.00	0.00	0.29	0.00	0.24
P_2O_5	3.58	11.90	3.92	3.10	2.40	3.42	10.40
S	0.49	0.43	0.34	0.28	0.41	0.32	1.10
MnO	0.12	0.13	0.12	0.13	0.15	0.15	0.12
CO_2	34.90	17.40	39.00	39.60	33.10	36.80	25.70
H_2O+	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
H_2O-	0.27	0.31	0.20	0.34	0.37	0.44	0.43
Total	96.4	95.5	98.9	97.7	96.5	98.8	98.8

	SOVITE						
Ref. No.	**820**	**821**	**839**	**838**	**836**	**835**	**834**
SiO_2	1.88	7.98	2.69	7.34	8.30	4.90	5.44
Al_2O_3	0.45	0.58	0.66	0.72	0.92	1.08	0.54
Fe_2O_3	3.97	9.25	0.28	2.15	2.38	5.63	1.05
FeO	4.22	5.63	3.26	3.41	3.63	7.71	2.08
MgO	2.73	8.51	3.11	7.92	7.21	13.60	5.70
CaO	44.20	32.80	46.80	40.00	39.30	29.70	44.00
Na_2O	0.41	1.11	0.42	0.34	0.34	0.38	0.35
K_2O	0.15	0.34	0.19	0.33	0.63	0.71	0.20
TiO_2	0.46	0.73	0.00	0.24	0.29	0.86	0.11
P_2O_5	3.48	6.32	11.90	5.96	6.28	8.24	3.92
S	0.62	0.55	1.24	0.24	0.47	0.52	0.09
MnO	0.14	0.18	0.08	0.15	0.16	0.26	0.14
CO_2	33.90	24.60	28.20	29.00	26.60	13.50	29.3
H_2O+	N.D.	0.02	N.D.	N.D.	0.09	N.D.	N.D.
H_2O-	0.36	0.12	0.25	0.19	0.19	0.22	0.18
Total	97.0	98.7	99.1	98.0	96.8	97.3	93.1

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

All samples are from drill core. The locations of the drillholes are shown on Figure 3 (Chart A).

N.D. = Not Detected

Ref. No.	**Sample No.**	**Ref. No.**	**Sample No.**
794	CCM24 101.0-101.4	820	CCM41 248.25-248.7
795	CCM24 174.75-175.2	821	CCM41 140.0-140.6
799	CCM24 346.5-346.9	839	CCM49 190.0-190.7
797	CCM24 298.2-298.6	838	CCM49 193.0-193.4
798	CCM24 333.4-333.7	836	CCM49 259.0-259.4
800	CCM24 357.4-357.75	835	CCM49 294.1-294.45
796	CCM24 267.2-267.6	834	CCM49 309.65-310.00

TABLE A-2. CONTINUED.

	SOVITE			SILICOCARBONATITE			
Ref. No.	**837**	**833**	**832**	**773**	**772**	**771**	**774**
SiO_2	3.48	3.23	1.47	32.90	25.20	15.20	28.30
Al_2O_3	0.44	0.40	0.69	4.32	3.18	3.48	3.31
Fe_2O_3	1.17	1.78	1.02	7.80	6.00	7.45	10.00
FeO	2.96	2.82	2.44	5.04	8.37	8.15	9.34
MgO	3.48	4.01	1.78	16.50	12.40	10.20	11.80
CaO	46.30	44.40	48.60	14.80	19.60	25.80	16.50
Na_2O	0.34	0.47	0.55	2.54	2.15	0.61	3.00
K_2O	0.08	0.00	0.19	3.20	2.17	2.87	1.21
TiO_2	0.24	0.29	0.18	0.97	3.66	2.20	2.89
P_2O_5	2.84	6.28	3.12	1.70	1.28	1.76	0.58
S	0.31	0.32	0.57	0.30	0.54	1.00	0.35
MnO	0.10	0.12	0.08	0.12	0.22	0.20	0.22
CO_2	35.50	32.60	37.1	7.60	13.7	18.80	10.30
H_2O+	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
H_2O-	0.47	0.27	0.33	0.35	0.38	0.43	0.35
Total	97.7	97.0	98.1	98.1	98.9	98.2	98.2

	SILICOCARBONATITE			RAUHAUGITE	
Ref. No.	**817**	**816**	**831**	**787**	**786**
SiO_2	26.80	26.60	27.70	0.29	0.57
Al_2O_3	5.31	2.78	0.65	0.32	0.38
Fe_2O_3	8.00	11.80	3.50	0.07	0.02
FeO	10.20	9.93	10.00	2.30	2.67
MgO	12.70	9.27	30.70	18.40	19.00
CaO	15.00	17.50	13.90	30.90	31.60
Na_2O	1.39	3.09	0.08	0.0	0.0
K_2O	4.26	1.28	0.12	0.0	0.0
TiO_2	3.98	3.90	0.39	0.0	0.0
P_2O_5	0.99	0.65	0.91	3.20	0.92
S	0.87	0.43	0.32	<0.01	<0.01
MnO	0.24	0.28	0.46	0.24	0.27
CO_2	10.20	12.40	11.10	42.10	44.30
H_2O+	N.D.	N.D.	0.57	0.03	N.D.
H_2O-	0.43	0.35	0.18	0.29	0.41
Total	100.4	100.3	100.6	98.9	100.1

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

All samples are from drill core. The locations of the drillholes are shown on Figure 3 (Chart A).

N.D. = Not Detected

Ref. No.	Sample No.	Ref. No.	Sample No.
837	CCM49 246.8-247.25	774	CCM6 141.4-141.65
833	CCM49 324.75-325.1	817	CCM35 128.9-129.3
832	CCM49 332.5-332.9	816	CCM35 134.4-135.0
773	CCM6 140.0-140.4	831	CCM49 344.0-344.4
772	CCM6 131.8-132.2	787	CCM9 515.85-516.2
771	CCM6 102.9-103.3	786	CCM9 409.95-410.6

TABLE A-2. CONTINUED.

	RAUHAUGITE	PYROXENITE				
Ref. No.	**785**	**811**	**828**	**827**	**826**	**825**
SiO_2	0.24	41.80	40.40	40.70	40.90	49.80
Al_2O_3	0.34	3.18	3.78	3.46	3.77	1.52
Fe_2O_3	0.96	7.10	6.40	5.20	7.20	1.30
FeO	2.52	12.20	12.20	13.00	11.30	6.45
MgO	17.30	13.90	15.30	16.70	15.80	17.90
CaO	32.80	15.60	15.00	14.50	14.90	19.40
Na_2O	0.17	0.65	0.69	0.61	0.61	0.28
K_2O	0.00	0.13	0.11	0.04	0.06	0.00
TiO_2	0.00	2.97	2.72	2.46	2.58	0.77
P_2O_5	4.64	0.10	0.07	0.08	0.08	0.06
S	<0.01	0.63	0.71	0.64	0.62	0.10
MnO	0.24	0.21	0.22	0.21	0.21	0.12
CO_2	42.00	0.58	0.72	0.72	0.56	0.62
H_2O+	N.D.	N.D.	N.D.	0.15	N.D.	N.D.
H_2O-	0.30	0.35	0.51	0.53	0.48	0.37
Total	101.5	99.4	98.8	99.0	99.1	98.7

	PYROXENITE					
Ref. No.	**824**	**823**	**822**	**819**	**830**	**829**
SiO_2	43.10	39.30	39.20	39.40	39.20	40.60
Al_2O_3	4.09	3.62	3.41	3.75	4.19	4.30
Fe_2O_3	4.60	10.00	9.10	15.30	11.50	10.40
FeO	12.00	10.00	11.40	5.41	9.49	9.19
MgO	12.90	16.90	16.80	12.50	11.40	12.00
CaO	17.60	12.80	13.40	18.30	17.30	17.60
Na_2O	0.73	0.60	0.45	0.52	0.89	0.63
K_2O	0.03	0.13	0.02	0.16	0.04	0.00
TiO_2	2.69	2.68	2.80	4.02	3.13	2.73
P_2O_5	0.06	0.06	0.06	0.03	0.09	0.04
S	0.96	0.36	0.44	0.05	0.48	0.41
MnO	0.18	0.22	0.22	0.20	0.23	0.19
CO_2	0.40	0.55	0.42	0.10	0.72	0.55
H_2O+	N.D.	1.61	0.84	N.D.	N.D.	0.24
H_2O-	0.28	0.43	0.40	0.48	0.18	0.30
Total	99.6	99.3	99.0	100.2	98.8	99.2

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

All samples are from drill core. The locations of the drillholes are shown on Figure 3 (Chart A).

N.D. = Not Detected

Ref. No.	Sample No.	Ref. No.	Sample No.
785	CCM9 401.8-402.2	824	CCM46 191.35-191.9
811	CCM29 79.1-79.55	823	CCM46 223.3-223.7
828	CCM46 145.15-145.65	822	CCM44 225.75-226.3
827	CCM46 150.9-151.4	819	CCM35 100.5-101.0
826	CCM46 156.45-156.85	830	CCM47 47.0-47.5
825	CCM46 186.0-186.65	829	CCM47 70.25-70.7

TABLE A-2. CONTINUED.

	PYROXENITE				MISCELLANEOUS		
Ref. No.	**840**	**841**	**842**	**843**	**815**	**818**	**814**
SiO_2	44.90	46.00	50.10	34.30	28.30	31.80	33.50
Al_2O_3	3.16	3.18	2.63	4.40	7.22	3.17	1.89
Fe_2O_3	4.20	4.82	3.51	12.60	19.50	9.20	8.30
FeO	9.78	8.08	4.89	13.00	14.50	9.34	8.82
MgO	18.00	18.00	15.70	15.90	9.67	9.46	12.30
CaO	15.50	16.00	19.90	11.60	10.16	14.80	16.00
Na_2O	0.61	0.84	0.64	0.33	1.44	4.72	3.54
K_2O	0.08	0.09	0.00	0.10	1.07	1.11	1.12
TiO_2	1.24	1.23	1.00	3.92	4.34	3.80	2.54
P_2O_5	0.08	0.08	0.05	0.04	0.11	0.12	0.43
S	0.57	0.18	0.09	0.62	0.03	0.10	0.51
MnO	0.20	0.19	0.14	0.27	0.31	0.26	0.20
CO_2	0.95	0.77	0.45	0.39	0.40	10.40	9.90
H_2O+	0.27	0.84	N.D.	0.42	N.D.	N.D.	N.D.
H_2O-	0.29	0.25	0.40	0.30	0.38	0.46	0.50
Total	99.8	101.6	99.5	98.2	97.4	98.7	99.6

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

All samples are from drill core. The locations of the drillholes are shown on Figure 3 (Chart A).

N.D. = Not Detected

Ref. No.	**Sample No.**	**Ref. No.**	**Sample No.**
840	CCM51 44.5-45.0	815	CCM35 86.2-86.75
841	CCM51 61.0-61.6	818	CCM35 114.2-114.8
842	CCM55 42.6-43.1	814	CCM29 136.85-137.2
843	CCM55 51.5-52.0		

TABLE A-3. TRACE ELEMENT ANALYSES (PPM) OF WHOLE-ROCK SAMPLES FROM THE CARGILL TOWNSHIP CARBONATITE COMPLEX.

				SOVITE			
Ref. No.	**789**	**776**	**778**	**781**	**777**	**784**	**779**
Ag	<1	<1	<1	<1	<1	<1	<1
Au							
As							
Ba	60	310	310	280	290	280	270
Be	<1	<1	<1	<1	<1	<1	<1
Bi							
Co	7	20	25	20	20	20	20
Cr	5	6	<5	<5	<5	<5	<5
Cu	6	35	35	20	30	20	20
Ga	<1	3	2	4	2	3	2
Hg							
Li	<3	<3	<3	<3	<3	<3	<3
Mn							
Mo	<1	<1	<1	<1	<1	<1	<1
Nb	<30	<30	<30	<30	<30	<30	<30
Ni	<5	<5	<5	<5	<5	<5	<5
Pb	25	15	15	15	25	10	10
Rb	<10	10	<10	10	<10	10	<10
Sb							
Sc	15	15	8	8	10	7	10
Sn	<3	<3	<3	<3	<3	<3	<3
Sr	4000	3000	2500	2500	2000	3500	3500
Ti							
V	<10	100	150	60	70	100	150
Y	<15	150	150	150	150	150	150
Zn	25	40	65	35	50	40	70
Zr	<10	200	25	700	250	150	700
La	<100	300	300	300	300	300	250
Nd	<100	500	600	450	450	300	400
Ce	50	470	530	460	500	500	500
Yb	<1	5	5	5	5	6	6
Eu	<100	<100	<100	<100	<100	<100	<100

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

All samples are from drill core. The locations of the drillholes are shown on Figure 3 (Chart A).

Ref. No.	Sample No.	Ref. No.	Sample No.
789	CCM20 246.1-246.7	777	CCM6 248.65-248.95
776	CCM6 243.9-244.25	784	CCM6 545.1-545.5
778	CCM6 256.7-257.0	779	CCM6 274.4-274.8
781	CCM6 381.65-382.05		

TABLE A-3. CONTINUED.

				SOVITE			
Ref. No.	**780**	**783**	**782**	**775**	**788**	**808**	**806**
Ag	<1	<1	<1	<1	<1	<1	<1
Au							
As							
Ba	320	300	140	350	50	270	250
Be	<1	<1	<1	9	<1	<1	<1
Bi							
Co	25	10	35	40	9	20	20
Cr	5	<5	<5	35	<5	<5	6
Cu	30	15	15	150	8	15	15
Ga	7	2	5	3	<1	3	6
Hg							
Li	<3	<3	<3	3	<3	<3	<3
Mn							
Mo	<1	<1	<1	<1	<1	<1	<1
Nb	45	<30	<30	100	<30	<30	<30
Ni	<5	<5	<5	55	<5	<5	<5
Pb	10	20	20	20	15	15	15
Rb	20	<10	<10	40	<10	10	10
Sb							
Sc	6	10	8	35	20	15	15
Sn	<3	<3	<3	7	<3	<3	<3
Sr	2500	3500	3000	1000	2500	3500	4000
Ti							
V	250	45	300	350	<10	60	150
Y	150	150	100	40	10	100	150
Zn	85	35	115	130	15	35	65
Zr	200	90	700	500	<10	1500	250
La	300	250	200	<100	<100	300	300
Nd	450	350	450	<100	<100	400	500
Ce	560	300	500	480	90	480	620
Yb	6	6	5	1	<1	5	5
Eu	<100	<100	<100	<100	<100	<100	<100

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

All samples are from drill core. The locations of the drillholes are shown on Figure 3 (Chart A).

Ref. No.	**Sample No.**	**Ref. No.**	**Sample No.**
780	CCM6 328.05-328.35	788	CCM20 162.2-162.65
783	CCM6 509.1-509.5	808	CCM26 195.85-196.25
782	CCM6 442.5-442.9	806	CCM26 155.0-155.3
775	CCM6 151.3-151.65		

TABLE A-3. CONTINUED.

	SOVITE						
Ref. No.	**804**	**802**	**805**	**801**	**810**	**803**	**807**
Ag	<1	<1	<1	<1	<1	<1	<1
Au							
As							
Ba	280	250	290	240	270	220	270
Be	<1	<1	<1	<1	<1	<1	<1
Bi							
Co	30	35	10	35	15	25	20
Cr	<5	<5	<5	<5	<5	<5	<5
Cu	15	10	9	10	15	9	10
Ga	3	5	3	4	7	3	7
Hg							
Li	3	<3	<3	3	<3	<3	<3
Mn							
Mo	<1	<1	<1	<1	<1	<1	<1
Nb	<30	<30	<30	<30	<30	<30	<30
Ni	<5	<5	<5	<5	<5	<5	<5
Pb	15	10	20	20	15	10	20
Rb	<10	<10	10	10	20	<10	20
Sb							
Sc	15	15	25	15	15	10	15
Sn	<3	4	<3	3	<3	7	<3
Sr	4000	5000	3500	5000	4000	5000	4000
Ti							
V	250	700	150	350	10	450	60
Y	100	90	100	100	150	100	150
Zn	55	110	40	85	25	80	35
Zr	35	350	15	1000	1000	200	200
La	300	200	300	300	350	200	300
Nd	500	800	400	600	<100	500	350
Ce	520	550	520	510	510	480	490
Yb	5	5	5	5	5	5	4
Eu	<100	<100	<100	<100	<100	<100	<100

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

All samples are from drill core. The locations of the drillholes are shown on Figure 3 (Chart A).

Ref. No.	Sample No.	Ref. No.	Sample No.
804	CCM26 101.65-102.0	810	CCM26 277.05-277.3
802	CCM26 86.25-86.65	803	CCM26 89.25-89.6
805	CCM26 139.4-139.75	807	CCM26 183.4-183.75
801	CCM26 68.6-68.9		

TABLE A-3. CONTINUED.

				SOVITE			
Ref. No.	**812**	**813**	**809**	**790**	**791**	**792**	**793**
Ag	<1	<1	<1	<1	<1	<1	<1
Au							
As							
Ba	410	270	250	40	290	310	250
Be	<1	<1	<1	<1	<1	<1	<1
Bi							
Co	7	6	20	30	9	25	25
Cr	<5	<5	<5	<5	<5	<5	<5
Cu	30	25	10	10	9	15	15
Ga	<1	1	6	2	7	2	6
Hg							
Li	<3	<3	3	<3	<3	<3	<3
Mn							
Mo	<1	<1	<1	<1	<1	<1	<1
Nb	<30	<30	<30	<30	<30	<30	<30
Ni	<5	<5	<5	<5	<5	<5	<5
Pb	15	15	25	20	10	<10	15
Rb	<10	<10	10	10	10	10	20
Sb							
Sc	<5	10	15	15	8	20	15
Sn	<3	<3	<3	<3	<3	<3	<3
Sr	4000	5000	3500	3000	4500	4500	4500
Ti							
V	<10	15	100	60	100	150	45
Y	90	100	100	45	150	100	150
Zn	10	15	10	30	30	65	35
Zr	<10	300	500	10	250	1000	600
La	200	300	300	150	250	250	350
Nd	<100	400	450	150	300	400	400
Ce	450	510	540	210	410	400	450
Yb	2	5	4	25	6	4	6
Eu	<100	300	300	<100	<100	<100	<100

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

All samples are from drill core. The locations of the drillholes are shown on Figure 3 (Chart A).

Ref. No.	**Sample No.**	**Ref. No.**	**Sample No.**
812	CCM29 106.45-106.9	791	CCM23 391.25-391.7
813	CCM29 117.3-117.8	792	CCM23 410.0-410.45
809	CCM26 238.8-239.2	793	CCM24 28.6-29.0
790	CCM22 168.2-168.6		

TABLE A-3. CONTINUED.

	SOVITE						
Ref. No.	**794**	**795**	**799**	**797**	**798**	**800**	**796**
Ag	1	<1	<1	<1	<1	<1	<1
Au							
As							
Ba	240	110	240	350	270	280	230
Be	<1	3	<1	<1	<1	<1	<1
Bi							
Co	20	30	15	15	25	20	50
Cr	<5	5	<5	<5	<5	<5	<5
Cu	20	30	15	15	10	10	35
Ga	1	5	3	<1	3	2	7
Hg							
Li	<3	<3	<3	<3	<3	<3	<3
Mn							
Mo	<1	<1	<1	<1	<1	<1	<1
Nb	<30	40	<30	<30	<30	<30	<30
Ni	<5	<5	<5	<5	<5	<5	<5
Pb	10	<10	25	15	15	15	15
Rb	<10	10	<10	<10	<10	<10	20
Sb							
Sc	25	15	7	8	10	20	10
Sn	<3	<3	<3	<3	<3	<3	<3
Sr	5000	3500	4500	3500	4500	3500	3000
Ti							
V	30	400	<10	<10	150	25	150
Y	100	100	100	150	100	150	150
Zn	20	90	10	15	60	25	55
Zr	150	60	<10	10	40	3500	300
La	300	300	250	300	250	250	400
Nd	300	600	200	200	350	<100	500
Ce	450	510	370	370	420	250	560
Yb	5	4	5	4	5	6	6
Eu	<100	<100	<100	<100	<100	<100	<100

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

All samples are from drill core. The locations of the drillholes are shown on Figure 3 (Chart A).

Ref. No.	**Sample No.**	**Ref. No.**	**Sample No.**
794	CCM24 101.0-101.4	798	CCM24 333.4-333.7
795	CCM24 174.75-175.2	800	CCM24 357.4-357.75
799	CCM24 346.5-346.9	796	CCM24 267.2-267.6
797	CCM24 298.2-298.6		

TABLE A-3. CONTINUED.

				SOVITE			
Ref. No.	**820**	**821**	**839**	**838**	**836**	**835**	**834**
Ag	<1	<1	<1	<1	<1	<1	<1
Au							
As							
Ba	310	170	210	190	230	160	260
Be	<1	4	<1	<1	<1	<1	<1
Bi							
Co	30	50	55	25	30	50	15
Cr	<5	5	5	<5	<5	<5	<5
Cu	20	30	35	15	20	25	10
Ga	3	5	3	4	8	10	2
Hg							
Li	<3	<3	<3	<3	<3	<3	<3
Mn							
Mo	<1	<1	<1	<1	<1	<1	<1
Nb	<30	<30	<30	<30	<30	<30	<30
Ni	<5	<5	<5	<5	<5	<5	<5
Pb	10	15	20	10	10	10	15
Rb	<10	10	10	10	20	20	<10
Sb							
Sc	7	15	6	10	10	15	10
Sn	<3	<3	<3	<3	<3	<3	<3
Sr	3500	3000	3000	3500	3500	3000	4000
Ti							
V	150	250	10	100	70	250	50
Y	100	80	150	100	100	80	150
Zn	75	115	20	60	60	125	40
Zr	250	700	200	1500	1500	1500	300
La	250	200	500	250	250	200	300
Nd	400	400	<100	400	350	500	300
Ce	460	450	590	460	430	540	500
Yb	5	4	5	4	4	3	5
Eu	<100	<100	<100	<100	<100	<100	<100

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

All samples are from drill core. The locations of the drillholes are shown on Figure 3 (Chart A).

Ref. No.	**Sample No.**	**Ref. No.**	**Sample No.**
820	CCM41 248.25-248.7	836	CCM49 259.0-259.4
821	CCM41 140.0-140.6	835	CCM49 294.1-294.45
839	CCM49 190.0-190.7	834	CCM49 309.65-310.00
838	CCM49 193.0-193.4		

TABLE A-3. CONTINUED.

	SOVITE			SILICOCARBONATITE			
Ref. No.	**837**	**833**	**832**	**773**	**772**	**771**	**774**
Ag	<1	<1	<1	<1	<1	<1	<1
Au							
As							
Ba	240	270	300	350	250	320	200
Be	<1	<1	<1	9	6	3	10
Bi							
Co	20	20	35	30	40	70	35
Cr	<5	<5	<5	10	85	35	195
Cu	20	20	35	65	105	190	75
Ga	2	1	3	25	20	20	15
Hg							
Li	<3	<3	<3	3	3	4	4
Mn							
Mo	<1	<1	<1	<1	<1	<1	<1
Nb	<30	<30	<30	<30	100	100	150
Ni	<5	<5	<5	15	30	45	30
Pb	<10	15	20	15	25	20	50
Rb	<10	<10	<10	80	50	60	20
Sb							
Sc	8	7	8	30	60	10	35
Sn	<3	<3	<3	<3	5	<3	10
Sr	4500	4000	4500	1500	1500	3000	900
Ti							
V	150	150	90	250	300	350	600
Y	100	100	100	40	40	60	25
Zn	60	45	30	100	115	115	135
Zr	15	40	900	2500	300	300	450
La	300	300	300	<100	<100	150	<100
Nd	500	500	400	250	<100	<100	<100
Ce	390	530	510	200	570	440	510
Yb	4	5	4	2	2	2	2

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

All samples are from drill core. The locations of the drillholes are shown on Figure 3 (Chart A).

Ref. No.	Sample No.	Ref. No.	Sample No.
837	CCM49 246.8-247.25	772	CCM6 131.8-132.2
833	CCM49 324.75-325.1	771	CCM6 102.9-103.3
832	CCM49 332.5-332.9	774	CCM6 141.4-141.65
773	CCM6 140.0-140.4		

TABLE A-3. CONTINUED.

	SILICOCARBONATITE			RAUHAUGITE	
Ref. No.	**817**	**816**	**831**	**787**	**786**
Ag	<1	<1	<1	6	<1
Au					
As					
Ba	690	390	110	40	50
Be	7	10	<1	<1	<1
Bi					
Co	45	40	75	6	7
Cr	15	5	5	<5	<5
Cu	185	110	20	7	6
Ga	20	20	2	<1	3
Hg					
Li	4	3	4	<3	<3
Mn					
Mo	<1	<1	<1	<1	<1
Nb	200	150	50	<30	<30
Ni	<5	<5	<5	<5	<5
Pb	<10	10	10	<10	<10
Rb	90	30	<10	<10	<10
Sb					
Sc	15	15	20	10	15
Sn	<3	8	<3	<3	<3
Sr	1000	1000	1000	1500	1500
Ti					
V	350	500	15	<10	<10
Y	30	35	25	30	30
Zn	145	150	145	15	20
Zr	250	300	700	<10	150
La	<100	<100	<100	<100	<100
Nd	<100	<100	<100	<100	<100
Ce	850	890	180	100	80
Yb	2	2	<1	<1	<1
Eu	<100	<100	<100	<100	<100

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

All samples are from drill core. The locations of the drillholes are shown on Figure 3 (Chart A).

Ref. No.	Sample No.	Ref. No.	Sample No.
817	CCM35 128.9-129.3	787	CCM9 515.85-516.2
816	CCM35 134.4-135.0	786	CCM9 409.95-410.6
831	CCM49 344.0-344.4		

TABLE A-3. CONTINUED.

	RAUHAUGITE	PYROXENITE				
Ref. No.	**785**	**811**	**828**	**827**	**826**	**825**
Ag	<1	<1	<1	<1		1
Au						
As						
Ba	90	80	60	60	50	40
Be	<1	<1	<1	<1		<1
Bi						
Co	10	110	120	125	120	65
Cr	<5	820	740	680	680	2320
Cu	6	1060	1350	1090	1420	260
Ga	2	8	9	10		3
Hg						
Li	<3	4	4	4	<3	<3
Mn						
Mo	<1	1	1	<1		<1
Nb	<30	<30	<30	<30		<30
Ni	<5	500	760	700	820	480
Pb	10	10	20	15	29	15
Rb	<10	<10	<10	<10	<10	<10
Sb						
Sc	10	45	40	35		50
Sn	4	<3	<3	<3		<3
Sr	1500	1000	150	150		150
Ti						
V	15	700	600	500		150
Y	45	15	10	10		<10
Zn	25	115	120	115	110	50
Zr	150	100	150	100		35
La	150	<100	<100	<100		<100
Nd	<100	<100	<100	<100		<100
Ce	160	490	390	330	370	110
Yb	<1	2	2	1		<1
Eu	<100	<100	<100	<100		<100

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

All samples are from drill core. The locations of the drillholes are shown on Figure 3 (Chart A).

Ref. No.	Sample No.	Ref. No.	Sample No.
785	CCM9 401.8-402.2	827	CCM46 150.9-151.4
811	CCM29 79.1-79.55	826	CCM46 156.45-156.85
828	CCM46 145.15-145.65	825	CCM46 186.0-186.65

TABLE A-3. CONTINUED.

	PYROXENITE					
Ref. No.	**824**	**823**	**822**	**819**	**830**	**829**
Ag	1	<1	<1	<1	<1	<1
Au						
As						
Ba	30	70	20	140	50	50
Be	<1	<1	<1	<1	<1	<1
Bi						
Co	110	120	125	80	90	90
Cr	1060	780	660	680	500	560
Cu	1500	690	630	500	310	320
Ga	10	9	10	15	15	10
Hg						
Li	<3	<3	3	<3	4	4
Mn						
Mo	<1	2	1	<1	1	<1
Nb	<30	<30	<30	<30	<30	<30
Ni	680	500	480	135	170	160
Pb	25	20	<10	20	<10	10
Rb	<10	<10	<10	<10	<10	<10
Sb						
Sc	45	35	40	40	40	45
Sn	4	3	3	4	3	<3
Sr	150	60	60	200	150	100
Ti						
V	600	600	700	400	700	700
Y	10	10	10	10	15	15
Zn	85	120	120	100	120	90
Zr	85	120	120	200	150	100
La	<100	<100	<100	<100	<100	<100
Nd	<100	<100	<100	<100	<100	<100
Ce	430	350	380	660	330	430
Yb	2	2	2	1	2	2
Eu	<100	<100	<100	<100	<100	<100

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

All samples are from drill core. The locations of the drillholes are shown on Figure 3 (Chart A).

Ref. No.	Sample No.	Ref. No.	Sample No.
824	CCM46 191.35-191.9	819	CCM35 100.5-101.0
823	CCM46 223.3-223.7	830	CCM47 47.0-47.5
822	CCM44 225.75-226.3	829	CCM47 70.25-70.7

TABLE A-3. CONTINUED.

	PYROXENITE				MISCELLANEOUS		
Ref. No.	**840**	**841**	**842**	**843**	**815**	**818**	**814**
Ag	<1	<1	<1	<1	<1	<1	<1
Au							
As							
Ba	60	60	50	80	410	470	200
Be	<1	<1	<1	<4	<1	15	15
Bi							
Co	100	90	55	135	105	30	55
Cr	1060	1180	1900	620	75	85	700
Cu	920	500	250	640	125	80	1440
Ga	7	7	4	20	25	15	8
Hg							
Li	6	4	<3	4	<3	3	<3
Mn							
Mo	<1	<1	<1	7	<1	<1	<1
Nb	<30	<30	<30	<30	30	150	150
Ni	580	400	310	440	140	25	500
Pb	20	15	10	<10	15	15	10
Rb	<10	<10	<10	<10	20	30	20
Sb							
Sc	45	50	60	30	30	20	40
Sn	<3	<3	<3	4	10	7	8
Sr	250	200	150	150	300	700	1000
Ti							
V	300	350	200	700	500	400	80
Y	15	10	10	10	10	25	25
Zn	95	90	50	160	180	85	135
Zr	100	100	60	100	300	300	200
La	<100	<100	<100	<100	<100	<100	<100
Nd	<100	<100	<100	<100	<100	<100	<100
Ce	200	200	180	510	940	620	420
Yb	1	1	<1	2	3	2	2
Eu	<100	<100	<100	<100	<100	<100	<100

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

All samples are from drill core. The locations of the drillholes are shown on Figure 3 (Chart A).

Ref. No.	Sample No.	Ref. No.	Sample No.
840	CCM51 44.5-45.0	815	CCM35 86.2-86.75
841	CCM51 61.0-61.6	818	CCM35 114.2-114.8
842	CCM55 42.6-43.1	814	CCM29 136.85-137.2
843	CCM55 51.5-52.0		

TABLE A-4. NORMATIVE MINERALS (ALKALIC ROCKS) FOR WHOLE-ROCK SAMPLES FROM THE CARGILL TOWNSHIP CARBONATITE COMPLEX.

	SOVITE						
Ref. No.	**789**	**776**	**778**	**781**	**777**	**784**	**779**
QZ	0.0	1.12	0.0	0.0	1.22	0.0	0.0
CO	0.03	0.34	0.0	0.40	0.40	0.35	0.35
OR	0.0	1.83	0.0	1.28	1.24	0.0	0.0
AB	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LC	0.0	0.0	0.0	0.66	0.0	0.0	0.0
KAL	0.0	0.0	0.74	0.0	0.0	1.11	0.34
NEPH	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CAR	0.92	0.0	0.0	0.0	0.0	0.0	0.0
NS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AC	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TH	0.0	1.51	1.42	1.47	1.51	1.21	1.31
GEH	0.0	0.0	1.27	0.0	0.0	0.0	0.0
AKM	0.0	0.0	12.76	0.0	0.0	1.16	8.03
FE-AK	4.09	0.0	9.10	0.0	0.0	0.80	2.04
D.WO	-3.12	0.0	-11.30	0.0	0.0	-1.59	-8.38
D.EN	0.0	0.0	-5.94	0.0	0.0	-0.85	-5.88
D.FS	-3.55	0.0	-5.02	0.0	0.0	-0.69	-1.77
FO	0.0	0.0	6.69	4.01	5.79	3.96	14.34
FA	5.67	2.81	6.24	2.86	3.48	3.56	4.78
ANDR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HM	0.0	0.0	3.06	0.0	0.0	0.0	0.0
MT	1.00	2.11	0.0	1.47	1.67	2.18	4.55
SPH	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PERV	0.0	0.0	0.71	0.0	0.0	0.0	0.0
RU	0.0	0.18	0.0	0.14	0.15	0.24	0.35
AP	0.78	9.66	3.50	13.07	16.66	7.29	4.54
CC	51.83	74.41	70.44	68.89	61.93	76.22	73.77
MGS	38.97	7.71	0.0	4.36	5.05	1.63	0.83
FL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ZR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BAD	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H_2O	0.40	0.50	0.51	0.57	0.40	0.45	0.41
SUM	97.01	102.18	94.17	99.17	99.52	97.02	99.60

QZ - Quartz; CO - Corundum; OR - Orthoclase; AB - Albite; LC - Leucite; KAL - Kalsilite; NEPH - Nepheline; CAR - Carnegieite; NS - Na_2SiO_3; AC - Acmite; TH - Thenardite; GEH - Gehlenite; AKM - Akermanite; FE-AK - Fe-Akermanite; D.WO - Wollastonite; D.EN - Enstatite; D.FS - Ferrosilite; FO - Forsterite; FA - Fayalite; ANDR - Andradite; HM - Hematite; MT - Magnetite; SPH - Sphene; PERV - Perovskite; RU - Rutile; AP - Apatite; CC - Calcite; MGS - Magnesite; FL - Fluorite; ZR - Zircon; BAD - Baddeleyite

Note: For sample descriptions, see Table A-1. Alkalic norms were calculated using the method of LeBas (1973).

All samples are from drill core. The locations of the drillholes are shown on Figure 3 (Chart A).

Ref. No.	Sample No.	Ref. No.	Sample No.
789	CCM20 246.1-246.7	777	CCM6 248.65-248.95
776	CCM6 243.9-244.25	784	CCM6 545.1-545.5
778	CCM6 256.7-257.0	779	CCM6 274.4-274.8
781	CCM6 381.65-382.05		

TABLE A-4. CONTINUED.

	SOVITE						
Ref. No.	**780**	**783**	**782**	**775**	**788**	**808**	**806**
QZ	0.0	0.0	0.0	2.79	0.0	0.0	0.0
CO	0.0	0.8	0.0	0.0	0.02	0.33	0.40
OR	0.0	0.0	0.0	11.57	0.0	0.0	0.0
AB	0.0	0.0	0.0	6.83	0.0	0.0	0.0
LC	0.0	0.0	0.0	0.0	0.0	0.0	0.05
KAL	3.60	0.67	0.30	0.0	0.0	0.74	1.10
NEPH	0.0	1.01	0.0	0.0	0.12	0.0	0.0
CAR	0.0	0.0	0.0	0.0	0.65	0.0	0.0
NS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AC	0.0	0.0	0.0	1.12	0.0	0.0	0.0
TH	1.12	0.75	1.17	4.52	0.09	0.85	0.94
GEH	0.0	0.0	1.38	0.0	0.0	0.0	0.0
AKM	16.38	0.05	23.99	0.0	0.0	0.06	0.0
FE-AK	4.40	0.02	12.76	0.0	6.44	0.03	0.0
D.WO	-12.34	-0.06	-17.73	0.0	-4.91	-0.08	0.0
D.EN	-8.57	-0.04	-10.34	0.0	0.0	-0.04	0.0
D.FS	-2.73	-0.02	-6.52	0.0	-5.59	-0.03	0.0
FO	14.15	4.94	16.73	22.23	0.0	5.14	9.82
FA	4.97	2.79	11.65	8.19	8.39	3.82	4.91
ANDR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HM	0.74	0.0	5.79	0.0	0.0	0.0	0.0
MT	5.34	0.71	0.0	8.37	0.0	0.55	2.69
SPH	0.0	0.0	0.0	5.10	0.0	0.0	0.0
PERV	1.09	0.0	1.40	0.0	0.0	0.0	0.0
RU	0.0	0.10	0.0	0.50	0.0	0.06	0.25
AP	4.92	5.78	8.62	2.77	0.21	14.01	21.02
CC	63.17	77.72	42.04	25.68	52.93	68.48	53.86
MGS	0.0	3.62	0.0	0.0	38.55	4.13	3.43
FL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ZR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BAD	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H_2O	0.44	0.44	0.29	0.78	0.12	0.29	0.32
SUM	96.67	98.56	91.52	100.45	97.01	98.34	98.79

Note: For sample descriptions, see Table A-1. Alkalic norms were calculated using the method of LeBas (1973).

All samples are from drill core. The locations of the drillholes are shown on Figure 3 (Chart A).

Ref. No.	Sample No.	Ref. No.	Sample No.
780	CCM6 328.05-328.35	788	CCM20 162.2-162.65
783	CCM6 509.1-509.5	808	CCM26 195.85-196.25
782	CCM6 442.5-442.9	806	CCM26 155.0-155.3
775	CCM6 151.3-151.65		

TABLE A-4. CONTINUED.

	SOVITE						
Ref. No.	**804**	**802**	**805**	**801**	**810**	**803**	**807**
QZ	0.0	0.0	0.43	0.0	0.0	0.59	0.25
CO	0.31	0.33	0.0	0.35	0.21	0.34	0.24
OR	0.0	0.0	1.65	0.0	0.0	0.89	3.25
AB	0.0	0.0	1.11	0.0	0.0	0.0	0.0
LC	0.0	0.0	0.0	0.0	0.0	0.0	0.0
KAL	0.60	0.57	0.0	0.60	2.01	0.0	0.0
NEPH	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AC	0.0	0.0	0.94	0.0	0.0	0.0	0.0
TH	0.53	0.62	1.20	0.69	0.76	1.15	0.82
GEH	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AKM	1.05	3.30	0.0	3.69	1.28	0.0	0.0
FE-AK	0.94	2.57	0.0	2.12	0.35	0.0	0.0
D.WO	-1.61	-4.77	0.0	-4.76	-1.35	0.0	0.0
D.EN	-0.77	-2.42	0.0	-2.71	-0.93	0.0	0.0
D.FS	-0.82	-2.23	0.0	-1.84	-0.30	0.0	0.0
FO	3.94	6.65	0.86	8.35	7.80	3.51	5.97
FA	4.60	6.78	2.62	6.27	2.77	4.82	3.28
ANDR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HM	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MT	3.05	9.53	1.88	6.99	0.0	6.29	1.05
SPH	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PERV	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RU	0.30	0.85	0.16	0.61	0.0	0.51	0.07
AP	9.85	9.85	8.57	11.55	15.81	7.48	15.53
CC	72.61	64.59	69.96	66.82	68.30	65.69	62.52
MGS	3.33	1.10	7.85	0.18	1.41	5.52	4.17
FL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ZR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BAD	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H_2O	0.36	0.36	0.39	0.38	0.22	0.47	0.29
SUM	98.27	97.68	97.62	99.30	98.33	97.24	97.43

Note: For sample descriptions, see Table A-1. Alkalic norms were calculated using the method of LeBas (1973).

All samples are from drill core. The locations of the drillholes are shown on Figure 3 (Chart A).

Ref. No.	**Sample No.**	**Ref. No.**	**Sample No.**
804	CCM26 101.65-102.0	810	CCM26 277.05-277.3
802	CCM26 86.25-86.65	803	CCM26 89.25-89.6
805	CCM26 139.4-139.75	807	CCM26 183.4-183.75
801	CCM26 68.6-68.9		

TABLE A-4. CONTINUED.

	SOVITE						
Ref. No.	**812**	**813**	**809**	**790**	**791**	**792**	**793**
QZ	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO	0.29	0.0	0.0	0.40	0.18	0.17	0.21
OR	0.0	0.0	0.0	0.0	0.0	0.0	3.07
AB	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LC	0.0	0.0	0.0	0.0	0.0	0.0	0.65
KAL	0.0	0.52	1.38	0.50	0.94	1.04	0.0
NEPH	0.0	0.06	0.0	0.0	0.0	0.0	0.0
CAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AC	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TH	0.89	1.33	0.71	0.34	1.10	0.94	0.94
GEH	0.0	0.73	0.85	0.0	0.0	0.0	0.0
AKM	1.83	1.27	12.03	0.0	0.22	0.70	0.0
FE-AK	0.88	0.41	3.96	0.37	0.33	0.23	0.0
D.WO	-2.23	0.17	-6.38	-0.28	-0.44	-0.77	0.0
D.EN	-1.34	0.11	-4.25	0.0	-0.16	-0.52	0.0
D.FS	-0.77	0.04	-1.66	-0.32	-0.29	-0.20	0.0
FO	2.90	3.97	13.90	0.0	1.29	6.08	6.75
FA	1.83	1.66	5.99	3.37	2.60	2.59	3.42
ANDR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HM	0.0	0.0	1.26	0.0	0.0	0.0	0.0
MT	0.0	0.0	0.64	4.11	1.45	5.07	1.26
SPH	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PERV	0.0	0.51	0.39	0.0	0.0	0.0	0.0
RU	0.0	0.0	0.0	0.06	0.08	0.23	0.05
AP	0.85	4.83	9.28	8.71	9.75	8.33	14.96
CC	92.06	79.98	54.76	44.85	75.38	69.84	61.84
MGS	0.35	0.0	0.0	34.59	4.44	2.60	4.55
FL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ZR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BAD	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H_2O	0.35	0.38	0.31	0.33	0.28	0.31	0.15
SUM	97.91	95.97	93.18	97.04	97.15	96.66	97.84

Note: For sample descriptions, see Table A-1. Alkalic norms were calculated using the method of LeBas (1973).

All samples are from drill core. The locations of the drillholes are shown on Figure 3 (Chart A).

Ref. No.	Sample No.	Ref. No.	Sample No.
812	CCM29 106.45-106.9	791	CCM23 391.25-391.7
813	CCM29 117.3-117.8	792	CCM23 410.0-410.45
809	CCM26 238.8-239.2	793	CCM24 28.6-29.0
790	CCM22 168.2-168.6		

TABLE A-4. CONTINUED.

	SOVITE						
Ref. No.	**794**	**795**	**799**	**797**	**798**	**800**	**796**
QZ	3.03	0.0	0.01	0.26	1.40	1.74	0.10
CO	0.23	0.17	0.29	0.33	0.25	0.28	0.18
OR	1.12	2.82	0.89	0.30	1.36	0.53	3.13
AB	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LC	0.0	0.15	0.0	0.0	0.0	0.0	0.0
KAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NEPH	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AC	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TH	2.06	2.06	1.31	0.92	0.80	1.03	1.28
GEH	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AKM	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FE-AK	0.0	0.0	0.0	0.0	0.0	0.0	0.0
D.WO	0.0	0.0	0.0	0.0	0.0	0.0	0.0
D.EN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
D.FS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FO	0.87	10.94	0.0	0.0	0.0	1.34	3.10
FA	2.11	2.59	1.96	1.88	2.75	2.98	5.04
ANDR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HM	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MT	0.86	9.60	0.0	0.0	4.98	0.42	3.53
SPH	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PERV	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RU	0.03	0.67	0.0	0.0	0.29	0.0	0.24
AP	8.47	28.17	9.28	7.34	5.68	8.10	24.62
CC	71.66	37.68	78.53	79.38	74.61	75.06	51.36
MGS	6.42	1.56	5.17	5.46	8.02	7.18	5.91
FL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ZR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BAD	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H_2O	0.27	0.31	0.20	0.34	0.37	0.44	0.43
SUM	97.14	96.72	97.62	96.19	100.51	99.11	98.91

Note: For sample descriptions, see Table A-1. Alkalic norms were calculated using the method of LeBas (1973).

All samples are from drill core. The locations of the drillholes are shown on Figure 3 (Chart A).

Ref. No.	**Sample No.**	**Ref. No.**	**Sample No.**
794	CCM24 101.0-101.4	798	CCM24 333.4-333.7
795	CCM24 174.75-175.2	800	CCM24 357.4-357.75
799	CCM24 346.5-346.9	796	CCM24 267.2-267.6
797	CCM24 298.2-298.6		

TABLE A-4. CONTINUED.

	SOVITE						
Ref. No.	**820**	**821**	**839**	**838**	**836**	**835**	**834**
QZ	0.11	3.32	0.62	1.66	0.91	0.0	0.0
CO	0.29	0.21	0.45	0.36	0.24	0.0	0.0
OR	0.89	2.01	1.12	1.95	3.72	0.0	0.0
AB	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LC	0.0	0.0	0.0	0.0	0.0	0.0	0.0
KAL	0.0	0.0	0.0	0.0	0.0	2.38	0.67
NEPH	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AC	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TH	0.94	2.54	0.96	0.78	0.78	0.87	0.80
GEH	0.0	0.0	0.0	0.0	0.0	0.84	0.87
AKM	0.0	0.0	0.0	0.0	0.0	0.0	4.40
FE-AK	0.0	0.0	0.0	0.0	0.0	0.0	0.84
D.WO	0.0	0.0	0.0	0.0	0.0	1.45	-2.17
D.EN	0.0	0.0	0.0	0.0	0.0	1.02	-1.60
D.FS	0.0	0.0	0.0	0.0	0.0	0.30	-0.36
FO	0.27	6.20	0.0	7.76	8.94	22.90	9.89
FA	3.66	2.34	4.56	3.68	3.86	7.49	2.48
ANDR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HM	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MT	5.77	13.44	0.41	3.12	3.46	8.18	1.53
SPH	0.0	0.0	0.0	0.0	0.0	0.89	0.0
PERV	0.0	0.0	0.0	0.0	0.0	0.84	0.19
RU	0.46	0.73	0.0	0.24	0.29	0.0	0.0
AP	8.24	14.96	28.17	14.11	14.86	19.50	9.28
CC	70.64	43.65	55.51	57.33	55.33	30.67	66.58
MGS	5.36	10.29	6.48	7.19	4.29	0.0	0.0
FL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ZR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BAD	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H_2O	0.36	0.14	0.25	0.19	0.28	0.22	0.18
SUM	96.98	99.83	98.53	98.38	96.97	97.57	93.57

Note: For sample descriptions, see Table A-1. Alkalic norms were calculated using the method of LeBas (1973).

All samples are from drill core. The locations of the drillholes are shown on Figure 3 (Chart A).

Ref. No.	Sample No.	Ref. No.	Sample No.
820	CCM41 248.25-248.7	836	CCM49 259.0-259.4
821	CCM41 140.0-140.6	835	CCM49 294.1-294.45
839	CCM49 190.0-190.7	834	CCM49 309.65-310.00
838	CCM49 193.0-193.4		

TABLE A-4. CONTINUED.

	SOVITE			SILICOCARBONATITE			
Ref. No.	**837**	**833**	**832**	**773**	**772**	**771**	**774**
QZ	0.95	2.24	0.0	0.0	4.94	0.0	2.12
CO	0.35	0.40	0.48	0.0	0.42	0.37	0.0
OR	0.47	0.0	0.57	2.47	12.81	0.0	7.14
AB	0.0	0.0	0.0	0.0	0.0	0.0	10.28
LC	0.0	0.0	0.43	11.65	0.0	7.61	0.0
KAL	0.0	0.0	0.0	0.0	0.0	4.11	0.0
NEPH	0.0	0.0	0.0	3.27	0.0	0.0	0.0
CAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AC	0.0	0.0	0.0	10.73	0.0	0.0	0.76
TH	0.78	1.08	1.26	1.33	4.93	1.40	3.85
GEH	0.0	0.0	0.0	0.0	1.12	0.0	0.0
AKM	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FE-AK	0.0	0.0	0.0	0.0	0.0	0.0	0.0
D.WO	0.0	0.0	0.0	4.54	0.0	0.0	1.21
D.EN	0.0	0.0	0.0	3.52	0.0	0.0	0.83
D.FS	0.0	0.0	0.0	0.52	0.0	0.0	0.27
FO	2.70	0.21	0.0	26.19	21.53	17.12	19.91
FA	3.60	3.04	2.93	4.31	8.37	7.10	7.15
ANDR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HM	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MT	1.70	2.59	1.48	5.94	8.72	10.82	14.15
SPH	0.0	0.0	0.0	2.38	0.0	0.0	7.09
PERV	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RU	0.24	0.29	0.18	0.0	3.66	2.20	0.0
AP	6.72	14.86	7.39	4.02	3.03	4.17	1.37
CC	75.89	64.43	79.34	17.27	31.13	41.87	23.40
MGS	4.01	8.10	3.71	0.0	0.0	0.71	0.0
FL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ZR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BAD	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H_2O	0.47	0.27	0.33	0.35	0.38	0.43	0.35
SUM	97.89	97.51	98.10	98.50	101.02	97.92	99.89

Note: For sample descriptions, see Table A-1. Alkalic norms were calculated using the method of LeBas (1973).

All samples are from drill core. The locations of the drillholes are shown on Figure 3 (Chart A).

Ref. No.	**Sample No.**	**Ref. No.**	**Sample No.**
837	CCM49 246.8-247.25	772	CCM6 131.8-132.2
833	CCM49 324.75-325.1	771	CCM6 102.9-103.3
832	CCM49 332.5-332.9	774	CCM6 141.4-141.65
773	CCM6 140.0-140.4		

TABLE A-4. CONTINUED.

	SILICOCARBONATITE			RAUHAUGITE	
Ref. No.	**817**	**816**	**831**	**787**	**786**
QZ	0.0	6.14	1.41	0.0	0.0
CO	0.06	0.0	0.52	0.32	0.38
OR	14.93	7.55	0.71	0.0	0.0
AB	0.0	7.17	0.0	0.0	0.0
LC	8.01	0.0	0.0	0.0	0.0
KAL	0.0	0.0	0.0	0.0	0.0
NEPH	0.0	0.0	0.0	0.0	0.0
CAR	0.0	0.0	0.0	0.0	0.0
NS	0.0	0.0	0.0	0.0	0.0
AC	0.0	1.29	0.0	0.0	0.0
TH	3.18	4.74	0.18	0.0	0.0
GEH	1.71	0.0	0.0	0.0	0.0
AKM	0.0	0.0	0.0	0.0	0.36
FE-AK	0.0	0.0	0.0	2.56	2.48
D.WO	0.0	0.0	0.0	-1.96	-2.20
D.EN	0.0	0.0	0.0	0.0	-0.27
D.FS	0.0	0.0	0.0	-2.23	-2.16
FO	22.05	16.10	51.51	0.0	0.56
FA	9.72	7.25	12.62	4.43	5.00
ANDR	0.0	0.0	0.0	0.0	0.0
HM	0.0	0.0	0.0	0.0	0.0
MT	11.62	16.49	5.08	0.10	0.03
SPH	0.0	2.95	0.0	0.0	0.0
PERV	0.0	0.0	0.0	0.0	0.0
RU	3.98	2.70	0.39	0.0	0.0
AP	2.34	1.54	2.15	7.57	2.18
CC	23.18	28.18	22.65	47.59	54.19
MGS	0.0	0.0	2.16	38.34	39.04
FL	0.0	0.0	0.0	0.0	0.0
ZR	0.0	0.0	0.0	0.0	0.0
BAD	0.0	0.0	0.0	0.0	0.0
H_2O	0.43	0.35	0.75	0.32	0.41
SUM	101.22	102.45	100.15	97.05	100.00

Note: For sample descriptions, see Table A-1. Alkalic norms were calculated using the method of LeBas (1973).

All samples are from drill core. The locations of the drillholes are shown on Figure 3 (Chart A).

Ref. No.	Sample No.	Ref. No.	Sample No.
817	CCM35 128.9-129.3	787	CCM9 515.85-516.2
816	CCM35 134.4-135.0	786	CCM9 409.95-410.6
831	CCM49 344.0-344.4		

TABLE A-4. CONTINUED.

	RAUHAUGITE	PYROXENITE				
Ref. No.	**785**	**811**	**828**	**827**	**826**	**825**
QZ	0.0	6.97	7.10	6.83	7.20	6.00
CO	0.12	0.0	0.0	0.0	0.0	0.0
OR	0.0	0.77	0.65	0.24	0.35	0.0
AB	0.0	0.0	0.0	0.0	0.0	0.0
LC	0.0	0.0	0.0	0.0	0.0	0.0
KAL	0.0	0.0	0.0	0.0	0.0	0.0
NEPH	0.0	0.0	0.0	0.0	0.0	0.0
CAR	0.60	0.0	0.0	0.0	0.0	0.0
NS	0.0	0.0	0.0	0.0	0.0	0.0
AC	0.0	0.0	0.0	0.0	0.0	0.0
TH	0.09	1.49	1.58	1.40	1.40	0.64
GEH	0.0	8.17	9.84	9.18	9.96	4.08
AKM	0.0	0.0	0.0	0.0	0.0	0.0
FE-AK	3.34	0.0	0.0	0.0	0.0	0.0
D.WO	-2.55	19.24	16.66	16.53	16.95	33.75
D.EN	0.0	11.20	10.42	10.44	10.64	24.13
D.FS	-2.90	7.11	5.20	5.03	5.24	6.56
FO	0.0	16.30	19.28	21.69	19.99	14.19
FA	4.43	11.42	10.63	11.55	10.86	4.26
ANDR	0.0	0.0	0.0	0.0	0.0	0.0
HM	0.0	6.01	1.73	0.0	4.96	1.30
MT	1.39	1.60	6.79	7.55	3.27	0.0
SPH	0.0	7.29	6.67	6.03	6.33	1.89
PERV	0.0	0.0	0.0	0.0	0.0	0.0
RU	0.0	0.0	0.0	0.0	0.0	0.0
AP	10.98	0.24	0.17	0.19	0.19	0.14
CC	47.59	1.32	1.64	1.64	1.27	1.41
MGS	36.05	0.0	0.0	0.0	0.0	0.0
FL	0.0	0.0	0.0	0.0	0.0	0.0
ZR	0.0	0.0	0.0	0.0	0.0	0.0
BAD	0.0	0.0	0.0	0.0	0.0	0.0
H_2O	0.30	0.35	0.51	0.68	0.48	0.37
SUM	99.46	99.47	98.86	98.99	99.08	98.73

Note: For sample descriptions, see Table A-1. Alkalic norms were calculated using the method of LeBas (1973).

All samples are from drill core. The locations of the drillholes are shown on Figure 3 (Chart A).

Ref. No.	**Sample No.**	**Ref. No.**	**Sample No.**
785	CCM9 401.8-402.2	827	CCM46 150.9-151.4
811	CCM29 79.1-79.55	826	CCM46 156.45-156.85
828	CCM46 145.15-145.65	825	CCM46 186.0-186.65

TABLE A-4. CONTINUED.

	PYROXENITE					
Ref. No.	**824**	**823**	**822**	**819**	**830**	**829**
QZ	6.72	8.60	7.29	1.29	6.40	6.74
CO	0.0	0.0	0.0	0.0	0.0	0.0
OR	0.18	0.77	0.12	0.94	0.24	0.0
AB	0.0	0.0	0.0	2.43	0.0	0.0
LC	0.0	0.0	0.0	0.0	0.0	0.0
KAL	0.0	0.0	0.0	0.0	0.0	0.0
NEPH	0.0	0.0	0.0	0.0	0.0	0.0
CAR	0.0	0.0	0.0	0.0	0.0	0.0
NS	0.0	0.0	0.0	0.0	0.0	0.0
AC	0.0	0.0	0.0	0.0	0.0	0.0
TH	1.67	1.37	1.03	0.53	2.04	1.44
GEH	10.90	9.35	9.11	8.34	11.14	11.56
AKM	0.0	0.0	0.0	0.0	0.0	0.0
FE-AK	0.0	0.0	0.0	0.0	0.0	0.0
D.WO	22.05	13.06	14.67	24.85	19.66	21.10
D.EN	12.43	8.87	9.70	17.11	11.46	12.64
D.FS	8.69	3.14	3.89	5.69	7.24	7.32
FO	13.70	23.14	22.38	9.73	11.77	11.99
FA	10.58	9.05	9.90	3.57	8.21	7.66
ANDR	0.0	0.0	0.0	0.0	0.0	0.0
HM	4.61	5.26	3.47	15.33	11.52	10.42
MT	0.0	6.90	8.19	0.0	0.0	0.0
SPH	6.60	6.57	6.87	9.86	7.68	6.70
PERV	0.0	0.0	0.0	0.0	0.0	0.0
RU	0.0	0.0	0.0	0.0	0.0	0.0
AP	0.14	0.14	0.14	0.07	0.21	0.09
CC	0.91	1.25	0.95	0.02	1.64	1.25
MGS	0.0	0.0	0.0	0.0	0.0	0.0
FL	0.0	0.0	0.0	0.0	0.0	0.0
ZR	0.0	0.0	0.0	0.0	0.0	0.0
BAD	0.0	0.0	0.0	0.0	0.0	0.0
H_2O	0.28	2.04	1.24	0.48	0.18	0.54
SUM	99.46	99.52	98.95	100.25	99.39	99.45

Note: For sample descriptions, see Table A-1. Alkalic norms were calculated using the method of LeBas (1973).

All samples are from drill core. The locations of the drillholes are shown on Figure 3 (Chart A).

Ref. No.	Sample No.	Ref. No.	Sample No.
824	CCM46 191.35-191.9	819	CCM35 100.5-101.0
823	CCM46 223.3-223.7	830	CCM47 47.0-47.5
822	CCM44 225.75-226.3	829	CCM47 70.25-70.7

TABLE A-4. CONTINUED.

	PYROXENITE				MISCELLANEOUS		
Ref. No.	**840**	**841**	**842**	**843**	**815**	**818**	**814**
QZ	8.28	5.08	5.20	7.65	0.0	0.0	2.51
CO	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OR	0.47	0.53	0.0	0.59	4.65	4.53	6.61
AB	0.0	4.16	3.94	0.0	6.31	4.40	3.48
LC	0.0	0.0	0.0	0.0	0.0	0.0	0.0
KAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NEPH	0.0	0.0	0.0	0.0	3.51	4.25	0.0
CAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AC	0.0	0.0	0.0	0.0	0.0	22.66	15.97
TH	1.40	0.80	0.40	0.76	0.31	1.11	2.26
GEH	8.26	6.11	5.01	11.53	10.52	0.0	0.0
AKM	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FE-AK	0.0	0.0	0.0	0.0	0.0	0.0	0.0
D.WO	20.55	23.89	34.15	7.40	5.40	0.0	2.14
D.EN	13.51	16.37	24.95	5.03	3.45	0.0	1.36
D.FS	5.55	5.57	5.92	1.78	1.59	0.0	0.64
FO	21.80	19.80	9.79	24.09	14.38	16.43	20.40
FA	9.88	7.44	2.57	9.42	7.34	12.76	10.54
ANDR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HM	4.21	4.83	3.52	0.0	0.0	0.0	0.0
MT	0.0	0.0	0.0	18.30	28.33	1.99	4.04
SPH	3.04	3.02	2.45	9.62	10.65	4.86	6.23
PERV	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RU	0.0	0.0	0.0	0.0	0.0	1.82	0.0
AP	0.19	0.19	0.12	0.09	0.26	0.28	1.02
CC	2.16	1.75	1.02	0.89	0.09	23.63	22.49
MGS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ZR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BAD	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H_2O	0.56	1.09	0.40	0.72	0.38	0.46	0.50
SUM	99.86	100.62	99.44	97.87	97.17	99.17	100.20

Note: For sample descriptions, see Table A-1. Alkalic norms were calculated using the method of LeBas (1973).

All samples are from drill core. The locations of the drillholes are shown on Figure 3 (Chart A).

Ref. No.	Sample No.	Ref. No.	Sample No.
840	CCM51 44.5-45.0	815	CCM35 86.2-86.75
841	CCM51 61.0-61.6	818	CCM35 114.2-114.8
842	CCM55 42.6-43.1	814	CCM29 136.85-137.2
843	CCM55 51.5-52.0		

TABLE A-5. AVERAGE CHEMICAL COMPOSITIONS* (WEIGHT PERCENT AND PPM) OF LITHOLOGIC UNITS FOR THE CARGILL TOWNSHIP CARBONATITE COMPLEX.

	Sovite (N = 48)		**Silicocarbonatite (N = 8)**	
	Mean	**Std. Deviation**	**Mean**	**Std. Deviation**
SiO_2	4.58	4.25	25.95	5.00
Al_2O_3	0.68	0.45	3.24	1.34
Fe_2O_3	2.59	2.47	7.57	2.55
FeO	3.68	1.83	8.68	1.68
MgO	6.26	4.15	14.48	6.89
CaO	41.76	6.86	17.84	3.86
Na_2O	0.54	0.41	1.86	1.09
K_2O	0.37	0.50	2.16	1.30
TiO_2	0.34	0.43	2.70	1.39
P_2O_5	3.89	2.21	1.14	0.44
MnO	0.15	0.06	0.25	0.10
CO_2	30.55	7.59	12.31	3.39
S	0.35	0.24	0.54	0.26
H_2O+	0.02	0.07	0.07	0.20
H_2O-	0.32	0.11	0.35	0.08
LOI	0.00	0.00	0.00	0.00
TOTAL	97.35	1.86	99.17	1.08
Ag	<0.96	0.29	<1.00	0.00
Ba	242.29	77.80	318.75	174.23
Co	25.37	12.62	46.87	16.46
Cr	<2.23	6.83	54.37	65.92
Cu	22.00	20.83	106.87	57.75
Li	<2.50	1.68	3.62	0.52
Ni	<3.75	8.66	16.87	19.81
Pb	13.54	8.38	17.50	16.90
Zn	55.52	34.54	127.50	18.52
Be	<0.42	1.88	6.25	3.77
Mo	<1.00	0.00	<1.00	0.00
Sc	12.73	6.30	30.62	19.90
Sr	3614.58	864.42	1425.00	688.17
V	148.96	145.59	339.37	172.72
Y	111.04	36.41	36.87	11.32
Ga	3.77	2.95	17.75	6.90
Nb	<22.60	25.76	115.00	78.01
Rb	3.12	13.23	46.25	32.49
Zr	508.12	666.58	614.37	780.89
Sn	<2.31	2.36	1.87	5.51
Eu	<23.75	242.66	<100.00	0.00
Yb	4.87	3.33	1.62	1.06
Ce	455.00	114.24	528.75	261.07
La	253.12	108.87	<68.75	88.39
Nd	354.17	223.33	<56.25	123.74

*The average compositions may include duplicate samples or analyses which are not listed in Tables A-2 to A-4.

TABLE A-5 . CONTINUED.

	Pyroxenite (N = 16)		Rauhaugite (N = 4)	
	Mean	**Std. Deviation**	**Mean**	**Std. Deviation**
SiO_2	42.48	4.54	0.37	0.15
Al_2O_3	3.45	0.74	0.35	0.03
Fe_2O_3	7.25	3.91	0.31	0.44
FeO	9.63	2.78	2.50	0.15
MgO	15.34	2.17	18.37	0.76
CaO	16.21	2.52	31.58	0.87
Na_2O	0.58	0.18	0.04	0.09
K_2O	0.06	0.05	0.00	0.00
TiO_2	2.37	1.02	0.00	0.00
P_2O_5	0.06	0.02	2.48	1.77
MnO	0.20	0.04	0.25	0.02
CO_2	0.56	0.20	43.17	1.30
S	0.44	0.27	0.01	0.00
H_2O+	0.30	0.45	0.01	0.01
H_2O-	0.35	0.12	0.32	0.06
LOI	0.00	0.00	0.00	0.00
TOTAL	99.35	0.76	99.75	1.43
Ag	<0.87	0.52	0.75	3.50
Ba	59.37	26.70	60.00	21.60
Co	99.37	25.62	7.75	1.71
Cr	1010.00	553.53	<5.00	0.00
Cu	730.62	438.15	6.25	0.50
Li	1.00	3.69	<3.00	0.00
Ni	464.06	211.73	<5.00	0.00
Pb	11.81	12.13	<5.00	10.00
Zn	99.69	29.69	20.00	4.08
Be	<0.67	1.29	<1.00	0.00
Mo	0.27	2.15	<1.00	0.00
Sc	44.00	8.49	12.50	2.89
Sr	204.67	225.42	1500.00	0.00
V	496.67	203.07	<3.75	12.50
Y	10.00	5.98	31.25	10.31
Ga	9.40	4.55	2.00	2.16
Nb	<30.00	0.00	<30.00	0.00
Rb	<10.00	0.00	<10.00	0.00
Zr	105.33	40.55	77.50	84.61
Sn	0.00	3.34	0.50	4.04
Eu	<35.40	250.19	<100.00	0.00
Yb	1.13	1.19	<1.00	0.00
Ce	365.62	142.59	125.25	41.52
La	<100.00	0.00	<37.50	125.00
Nd	<100.00	0.00	<100.00	0.00

Appendix B — Electron Microprobe Mineral Analyses and Chemical Analyses of Rocks from the Cargill Township Carbonatite (from Allen 1972).

Rock units as defined by Allen 1972.

Unit 1 - Olivine clinopyroxenite	Unit 6 - Soda-pyroxene hornblendite
Unit 2 - Olivine-rim magnetite clinopyroxenite	Unit 7 - Late stage veins and segregations
Unit 3 - Magnetite hornblende clinopyroxenite	Unit 8 - Phlogopite clinopyroxenite
Unit 4 - Hornblendite	Unit 9 - Carbonatite-ultramafic hybrid rocks
Unit 5 - Hornblende oligoclase clinopyroxenite	Unit 10 - Carbonatite

TABLE B-1. MICROPROBE MINERAL ANALYSES FOR OLIVINE CLINOPYROXENITE.

			Pyroxene			
	1	2	3	4	5	6
SiO_2	55.03	53.87	54.09	54.15	53.48	51.57
Al_2O_3	0.59	1.26	0.70	0.85	1.84	2.38
TiO_2	0.25	0.37	0.07	0.32	0.54	0.49
FeO*	3.82	5.20	3.80	4.17	5.70	5.02
MnO	0.12	0.12	0.02	0.09	0.11	0.08
MgO	17.63	16.10	16.07	17.15	15.77	15.19
CaO	23.44	23.40	23.53	23.21	23.32	22.97
Na_2O	0.45	0.55	0.78	0.45	0.65	0.47
K_2O	0.02	0.01	-	-	0.01	0.02
Sum	101.35	100.88	99.06	100.39	101.42	98.19

			Pyroxene			
	7	8	9	10	11	12
SiO_2	50.98	52.61	52.67	51.33	51.39	52.22
Al_2O_3	2.23	1.78	2.42	3.46	3.04	3.98
TiO_2	0.66	0.19	0.64	0.92	0.83	0.16
FeO*	6.76	4.98	5.81	7.29	6.17	6.17
MnO	0.13	0.16	0.09	0.13	0.15	0.03
MgO	14.72	15.35	15.57	14.50	15.00	13.81
CaO	21.48	22.95	22.60	22.01	22.16	22.41
Na_2O	0.70	0.58	0.84	0.84	0.99	1.09
K_2O	0.02	0.02	-	-	0.02	-
Sum	97.68	98.62	100.64	100.48	99.75	99.87

			Pyroxene			
	13	14	15	16	17	18
SiO_2	52.17	51.60	50.43	53.03	51.92	50.49
Al_2O_3	1.83	2.01	2.88	1.94	2.74	4.36
TiO_2	0.55	0.83	1.23	1.06	0.63	1.20
FeO*	6.36	6.50	9.73	7.02	6.49	7.89
MnO	0.18	0.18	0.27	0.12	0.09	0.13
MgO	14.97	14.63	11.25	15.67	15.06	13.54
CaO	22.58	22.07	21.11	22.45	21.72	22.00
Na_2O	0.50	1.12	1.79	0.40	0.85	0.89
K_2O	-	-	-	-	0.01	0.02
Sum	99.14	98.94	98.69	101.69	99.51	100.50

1. P5-699 core
2. P5-699 rim
3. P7-130
4. P5-653 core
5. P5-653 rim
6. 4552 core
7. 4552 rim
8. P7-198
9. 4553 core
10. 4553 rim
11. P6-287
12. P7-237
13. P5-701
14. P7-138 core
15. P7-138 sodic edge against apatite
16. P7-207
17. P6-294 core
18. P6-294 rim

*Total Fe as FeO

TABLE B-1. MICROPROBE MINERAL ANALYSES FOR OLIVINE CLINOPYROXENITE.

	Amphibole and Phlogopite					
	1	2	3	4	5	6
SiO_2	43.83	42.74	42.25	41.73	39.86	39.15
Al_2O_3	9.67	11.35	10.94	12.17	13.14	14.21
TiO_2	2.51	3.26	2.41	1.23	0.47	1.65
FeO*	8.42	11.98	14.29	11.88	6.21	9.31
MnO	0.03	0.09	0.15	0.11	0.05	0.00
MgO	16.18	15.00	13.12	13.54	23.61	21.15
CaO	11.77	11.86	11.40	11.67	0.04	0.04
Na_2O	3.23	2.71	3.15	3.19	1.47	1.42
K_2O	0.58	1.07	1.26	0.87	8.06	8.54
H_2O**	2.03	2.07	2.03	2.00	4.10	4.14
Sum	98.24	102.12	101.19	98.39	97.03	99.61

1. Amphibole P7-198
2. Amphibole 4552
3. Amphibole P7-138
4. Amphibole P7-237
5. Phlogopite P7-130
6. Phlogopite P7-138

* Total Fe as FeO

** H_2O required to satisfy structural formula

		Olivine				
			Weight%			
Sample	Average Fo%	Range	MnO	NiO	CaO	Cr_2O_3
P7-130	76.0	76.4-75.7	0.53	0.04	-	-
P6-294	74.2	74.7-73.7	0.47	0.10	0.04	0.00
P5-653	74.1	74.8-72.4	0.38	0.21	0.05	0.00
4555	73.7	75.1-73.2	0.39	-	0.08	-
P6-287	73.5	74.8-72.5	0.56	0.20	0.07	0.00
4553	73.5	73.7-73.2	0.44	-	0.08	-
4552	73.1	73.4-73.0	0.36	-	0.08	-
P5-699	73.0	74.1-72.1	0.38	0.18	0.05	0.00
P7-198	70.8	71.3-69.9	0.33	0.33	-	-
P7-137	70.0	72.7-68.9	0.54	0.03	-	-
P7-138	69.8	70.6-68.5	0.62	0.23	-	-
P7-207	68.2	68.9-67.4	0.38	0.22	-	-
P5-701	65.4	66.5-64.1	0.36	0.09	-	-

TABLE B-2. MICROPROBE MINERAL ANALYSES FOR OLIVINE-RIM MAGNETITE CLINOPYROXENITE.

	Pyroxene					
	1	2	3	4	5	6
SiO_2	52.36	55.10	53.15	51.19	52.18	49.81
Al_2O_3	2.25	0.91	2.05	4.04	2.08	4.42
TiO_2	0.89	0.40	0.66	0.80	0.88	1.93
FeO*	6.45	4.39	6.96	7.54	7.75	8.41
MnO	0.13	0.11	0.21	0.14	0.16	0.16
MgO	15.06	16.99	15.38	14.58	15.27	14.37
CaO	22.84	22.69	22.11	22.10	21.89	21.28
Na_2O	0.57	0.50	0.71	0.94	0.49	0.49
K_2O	0.02	-	-	0.01	-	-
Sum	100.57	101.09	101.23	101.34	100.70	100.87

1. P5-652
2. P5-654 core
3. P5-654 rim
4. 4554
5. P7-157
6. 4551

*Total Fe as FeO

		Olivine				
			Weight%			
Sample	Average Fo%	Range	MnO	NiO	CaO	Cr_2O_3
4551	70.8	73.4-67.8	0.43	-	0.08	-
4554	68.2	69.6-67.5	-	-	-	-
P5-654	65.2	66.8-63.8	0.51	0.06	-	-
P7-157	62.5	64.2-61.2	0.47	0.10	-	-

TABLE B-3. MICROPROBE MINERAL ANALYSES FOR MAGNETITE HORNBLENDE CLINOPYROXENITE.

	Pyroxene					
	1	2	3	4	5	6
SiO_2	52.87	52.71	53.46	53.10	51.56	52.15
Al_2O_3	0.83	1.49	0.91	0.83	3.10	2.43
TiO_2	0.15	0.29	0.18	0.30	0.86	0.82
FeO*	4.22	5.49	4.79	5.26	6.15	6.80
MnO	0.08	0.11	0.11	0.08	0.11	0.15
MgO	16.69	15.32	15.87	16.64	15.00	14.34
CaO	22.64	23.03	23.46	22.12	22.66	22.00
Na_2O	0.54	1.05	1.05	0.61	0.68	1.33
K_2O	0.01	0.01	0.02	-	-	0.02
Sum	98.03	99.50	99.85	98.94	100.12	100.04

	Pyroxene					
	7	8	9	10	11	12
SiO_2	52.04	52.58	52.20	50.26	51.80	51.16
Al_2O_3	2.16	1.83	2.17	3.35	1.92	2.30
TiO_2	0.83	0.19	0.22	0.95	0.26	1.09
FeO*	5.17	5.17	5.46	5.77	5.73	6.24
MnO	0.12	0.17	0.18	0.12	0.17	0.13
MgO	15.35	14.57	14.83	14.53	14.48	14.42
CaO	23.34	23.13	22.94	23.41	23.27	22.80
Na_2O	0.86	0.97	0.62	0.49	0.64	0.78
K_2O	0.02	0.02	0.02	0.01	0.02	0.02
Sum	99.89	98.63	98.64	98.89	98.29	98.94

	Pyroxene						
	13	14	15	16	17	18	19
SiO_2	52.21	50.90	52.02	51.34	50.55	49.82	49.54
Al_2O_3	1.75	2.48	3.76	2.79	4.04	4.64	3.81
TiO_2	0.75	0.50	0.21	0.51	1.09	1.35	1.36
FeO*	6.71	6.63	6.45	6.78	7.22	7.75	8.47
MnO	0.12	0.12	0.03	0.14	0.18	0.20	0.20
MgO	14.94	14.49	13.65	14.61	13.98	13.90	12.50
CaO	23.16	23.12	22.50	23.09	22.81	21.65	22.59
Na_2O	1.12	0.87	1.42	0.96	0.58	0.74	1.22
K_2O	0.03	0.02	-	0.02	0.01	0.02	0.01
Sum	100.79	99.13	100.04	100.24	100.46	100.07	99.70

1. P7-163 core
2. P7-163 rim
3. P7-153
4. 4555 core
5. 4555 rim
6. P6-301 core
7. P6-301 rim
8. P7-206
9. P7-159
10. 4550
11. P7-193 core
12. P5-657
13. P7-132
14. P7-194
15. P7-247
16. P7-204
17. P7-248
18. P6-274
19. P5-671

*Total Fe as FeO

TABLE B-3. MICROPROBE MINERAL ANALYSES FOR MAGNETITE HORNBLENDE CLINOPYROXENITE.

	Amphibole			
	1	2	3	4
SiO_2	45.52	43.09	41.70	43.91
Al_2O_3	12.11	11.01	10.26	8.24
TiO_2	3.19	2.91	2.22	3.84
FeO*	9.47	9.31	9.83	11.11
MnO	0.09	0.10	0.10	0.10
MgO	15.88	15.55	16.10	14.91
CaO	12.09	11.85	11.66	9.77
Na_2O	2.85	3.34	3.40	4.91
K_2O	1.25	1.13	1.05	0.99
H_2O**	2.08	2.05	2.00	2.03
Sum	101.53	100.35	98.32	99.80

	Amphibole			
	5	6	7	8
SiO_2	41.95	42.47	40.89	45.56
Al_2O_3	10.15	11.40	12.20	8.35
TiO_2	3.69	2.44	3.61	1.73
FeO*	11.27	11.85	11.87	10.08
MnO	0.28	0.13	0.19	0.07
MgO	13.92	14.45	13.66	17.58
CaO	11.84	11.57	11.71	10.71
Na_2O	2.96	3.52	3.10	4.51
K_2O	0.95	1.07	1.58	0.70
H_2O**	2.01	2.04	2.03	2.08
Sum	99.03	100.95	100.87	101.37

1. 4555
2. P5-657
3. P7-163
4. P7-206
5. P7-248
6. P7-247
7. P5-671
8. P6-301

	Phlogopite						
	1	2	3	4	5	6	7
SiO_2	39.48	39.53	38.68	37.84	38.33	38.98	40.20
Al_2O_3	15.17	14.31	14.06	13.82	13.33	13.70	12.32
TiO_2	1.96	1.83	2.61	3.48	2.81	0.64	1.15
FeO*	5.84	7.71	7.68	10.31	8.67	10.00	8.38
MnO	0.04	0.00	0.02	0.06	0.05	0.09	0.03
MgO	22.67	22.02	20.38	18.67	21.39	21.15	22.98
CaO	0.06	0.03	0.04	0.02	0.02	0.04	0.05
Na_2O	1.24	1.42	0.88	0.93	1.26	0.80	1.21
K_2O	8.44	8.75	8.87	8.80	8.89	9.00	8.94
H_2O**	4.20	4.18	4.07	4.04	4.10	4.08	4.14
Sum	99.12	99.78	97.29	97.97	98.87	98.49	99.42

1. P5-657
2. P7-163
3. P7-193 in pyroxenite
4. P7-193 against hornblendite vein
5. P7-206
6. P7-153
7. P6-301

*Total Fe as FeO

**H_2O required by structural formula

TABLE B-4. MICROPROBE MINERAL ANALYSES FOR HORNBLENDITE.

	Pyroxene						
	1	2	3	4	5	6	7
SiO_2	49.91	51.52	48.60	50.02	52.01	51.88	50.69
Al_2O_3	3.63	2.23	5.98	3.83	2.16	2.88	4.18
TiO_2	1.67	0.97	1.53	1.84	0.75	1.40	2.03
FeO*	7.12	9.32	8.64	9.45	9.21	6.71	7.98
MnO	0.19	0.27	0.25	0.18	0.25	0.11	0.14
MgO	13.21	12.08	12.48	12.62	12.44	13.73	12.44
CaO	22.91	21.08	22.68	22.48	21.61	23.50	22.65
Na_2O	1.09	2.02	0.77	1.51	1.74	1.09	1.47
K_2O	-	-	-	0.01	0.01	-	-
Sum	99.73	99.49	100.93	101.94	100.18	101.30	101.58

1. P5-669B core
2. P5-669B rim
3. P5-658
4. 4549
5. P5-670
6. P7-100 core
7. P7-100 rim

	Amphibole						
	1	2	3	4	5	6	7
SiO_2	40.54	40.17	40.38	39.80	40.15	39.78	39.51
Al_2O_3	11.87	13.33	11.65	10.97	11.68	12.00	11.87
TiO_2	4.04	4.22	3.75	3.06	3.52	5.60	5.69
FeO*	12.47	12.76	14.32	13.88	12.71	9.93	13.01
MnO	0.20	0.16	0.22	0.23	0.19	0.10	0.15
MgO	13.15	12.59	12.01	11.84	12.88	14.23	12.30
CaO	11.45	11.58	10.67	10.00	10.65	11.57	10.97
Na_2O	3.14	3.14	3.42	3.93	3.59	3.16	3.57
K_2O	1.82	0.99	1.65	1.53	1.37	1.75	1.63
H_2O**	2.02	2.03	1.99	1.93	1.98	2.02	2.00
Sum	100.69	100.98	100.08	97.18	98.72	100.14	100.70

1. 4549
2. P5-658
3. P5-670
4. P5-669B
5. P5-669A
6. P7-100 core
7. P7-100 rim

	Phlogopite				
	1	2	3	4	5
SiO_2	38.26	36.65	35.75	36.02	37.38
Al_2O_3	14.38	15.21	14.94	14.61	14.26
TiO_2	1.80	1.67	6.46	2.94	3.82
FeO*	12.05	12.35	12.26	13.34	13.68
MnO	0.13	0.14	0.10	0.15	0.17
MgO	19.40	18.53	17.01	16.81	17.21
CaO	0.03	0.02	0.01	0.03	0.02
Na_2O	1.24	1.06	0.78	1.10	0.74
K_2O	8.72	8.77	9.23	8.59	9.37
H_2O**	4.10	4.02	4.09	3.96	4.08
Sum	100.11	98.44	100.66	97.56	100.75

1. P5-669B
2. P5-669A
3. P7-100
4. P5-670
5. 4549

*Total Fe as FeO

**H_2O required to satisfy structural formula

TABLE B-5. MICROPROBE MINERAL ANALYSES FOR HORNBLENDE OLIGOCLASE CLINOPYROXENITE.

	P7-146			P7-201		
	CPx core	CPx rim	Amph	CPx core	CPx rim	Amph
SiO_2	49.41	49.95	41.06	50.86	51.14	41.06
Al_2O_3	4.37	4.18	11.85	2.85	3.51	11.56
TiO_2	2.68	2.67	4.27	1.62	1.98	4.40
FeO*	6.87	7.87	13.15	6.18	7.48	14.04
MnO	0.17	0.20	0.14	0.19	0.27	0.14
MgO	13.98	13.50	11.83	14.39	13.54	11.58
CaO	21.93	21.75	10.87	21.88	21.67	11.23
Na_2O	0.81	0.98	3.54	0.81	1.04	3.31
K_2O	-	-	1.04	-	-	1.07
H_2O**	-	-	2.01	-	-	2.01
Sum	100.22	101.10	99.76	98.78	100.63	100.40
Plag. Comp.	An34.6,Ab64.8,Or0.6 to An19.4,Ab79.8,Or0.8			An29.6,Ab69.6,Or0.8 to An17.1,Ab81.5,Or1.4		

*Total Fe as FeO

**H_2O required by structural formula

			Olivine			
			Weight%			
Sample	Average Fo%	Range	MnO	NiO	CaO	Cr_2O_3
P7-201	54.4	54.9-54.0	0.72	0.22	-	-

TABLE B-6. MICROPROBE MINERAL ANALYSES FOR SODA-PYROXENE HORNBLENDITE.

	Pyroxene					
	1	2	3	4	5	6
SiO_2	54.46	51.47	52.00	48.59	49.39	50.34
Al_2O_3	0.82	1.17	1.81	3.88	2.91	3.26
TiO_2	0.60	1.07	1.08	1.62	1.28	1.23
FeO*	5.10	9.53	7.33	6.36	9.85	8.54
MnO	0.10	0.18	0.13	0.17	0.29	0.21
MgO	16.03	14.46	13.90	12.93	11.81	11.85
CaO	23.13	22.27	22.62	23.99	22.03	21.96
Na_2O	0.82	0.93	0.99	0.89	1.64	1.80
K_2O	-	-	-	-	-	-
Sum	101.16	101.08	99.86	98.43	99.20	99.19

	Pyroxene				
	7	8	9	10	11
SiO_2	50.03	52.16	53.09	50.62	50.43
Al_2O_3	2.49	1.64	0.91	3.22	2.57
TiO_2	1.05	0.62	0.33	0.91	0.81
FeO*	10.26	10.50	12.37	9.29	14.36
MnO	0.25	0.29	0.32	0.17	0.29
MgO	11.23	11.80	11.26	12.29	9.96
CaO	21.75	20.81	19.10	20.97	19.56
Na_2O	1.99	2.33	3.40	1.91	3.16
K_2O	-	-	-	0.03	0.02
Sum	99.05	100.15	100.78	99.41	101.16

1. P7-228 core
2. P7-228 exsol. zone
3. P7-228 rim
4. P5-646 core
5. P5-646 rim
6. P5-645 core
7. P5-645 rim
8. P5-647 core
9. P5-647 rim
10. P7-225 core
11. P7-225 rim

	Amphibole				
	1	2	3	4	5
SiO_2	40.97	43.46	40.99	42.93	40.77
Al_2O_3	11.45	9.83	10.91	9.68	11.29
TiO_2	3.26	2.80	0.84	2.42	2.90
FeO*	15.51	15.76	18.51	15.41	16.04
MnO	0.26	0.31	0.26	0.24	0.26
MgO	11.63	11.32	10.27	13.78	11.58
CaO	10.85	9.74	10.20	10.00	10.74
Na_2O	3.69	4.43	3.68	4.27	3.56
K_2O	1.53	1.20	1.49	1.20	1.64
H_2O**	2.00	2.01	1.94	2.03	1.99
Sum	101.14	100.88	99.09	101.97	100.76

1. P5-645
2. P5-647
3. P7-225
4. P7-228
5. P5-646

*Total Fe as FeO

**H_2O required by structural formula

TABLE B-6. MICROPROBE MINERAL ANALYSES FOR SODA-PYROXENE HORNBLENDITE.

	Biotite				
	1	2	3	4	5
SiO_2	37.07	36.97	37.46	36.80	38.71
Al_2O_3	14.89	14.39	13.46	14.24	13.07
TiO_2	2.15	2.26	2.74	0.90	1.99
FeO*	14.94	16.32	15.58	18.15	13.57
MnO	0.20	0.22	0.24	0.22	0.16
MgO	16.96	16.34	14.47	14.88	19.60
CaO	0.07	0.05	0.05	0.02	0.04
Na_2O	0.74	0.71	1.13	0.22	0.97
K_2O	9.22	9.37	8.50	9.26	9.01
H_2O**	4.04	4.02	3.93	3.92	4.11
Sum	100.32	100.06	97.58	98.63	101.23

1. P5-645 2. P5-646 3. P5-647 4. P7-225
5. P7-228

*Total Fe as FeO

**H_2O required to satisfy structural formula

TABLE B-7. MICROPROBE MINERAL ANALYSES FOR LATE-STAGE VEINS AND SEGREGATIONS.

			Pyroxene		
	1	2	3	4	5
SiO_2	50.98	50.47	51.08	51.29	52.23
Al_2O_3	2.63	2.94	2.53	2.50	3.34
TiO_2	0.24	1.90	1.24	1.25	0.91
FeO^*	9.03	11.13	11.78	12.51	6.58
MnO	0.30	0.38	0.29	0.33	0.16
MgO	11.34	10.23	9.86	9.40	13.82
CaO	21.38	20.25	20.10	19.02	22.80
Na_2O	1.41	2.50	2.81	3.34	1.34
K_2O	0.01	-	-	-	0.01
Sum	97.32	99.80	99.68	99.64	101.19

		Pyroxene		
	6	7	8	9
SiO_2	52.81	52.25	50.21	51.23
Al_2O_3	2.65	2.37	2.80	2.51
TiO_2	0.67	0.72	0.83	0.75
FeO^*	13.07	13.21	14.69	14.89
MnO	0.31	0.25	0.32	0.29
MgO	9.76	9.58	9.73	9.66
CaO	19.43	18.56	20.23	18.89
Na_2O	3.14	3.89	2.57	3.69
K_2O	0.01	-	0.01	0.02
Sum	101.85	100.83	101.39	101.93

1. P7-193 rim. Sodic edge of pyroxene from Unit 3 against simple vein
2. P7-158 complex vein
3. P7-231 complex vein pyroxene core
4. P7-231 complex vein pyroxene rim
5. P7-224 salite core in aegirine-augite
6. P7-224 aegirine-augite in above
7. P7-216 aegirine-augite
8. P7-156 complex vein
9. P7-230 aegirine-augite - sphene rock

				Amphibole			
	1	2	3	4	5	6	7
SiO_2	41.84	42.28	42.19	40.92	40.94	40.94	40.66
Al_2O_3	10.45	9.30	9.23	10.73	10.50	10.69	8.44
TiO_2	3.24	2.72	2.26	2.20	1.64	2.52	2.50
FeO^*	12.80	17.45	17.03	17.00	18.25	18.46	19.37
MnO	0.13	0.32	0.29	0.25	0.24	0.35	0.36
MgO	12.74	10.04	10.48	10.12	9.63	9.93	9.90
CaO	11.09	9.27	8.79	10.35	9.40	9.38	10.31
Na_2O	3.09	4.26	4.63	3.64	4.49	4.08	3.50
K_2O	1.50	1.36	1.16	1.64	1.46	1.51	1.84
H_2O^{**}	1.99	1.95	1.94	1.94	1.93	1.95	1.90
Sum	98.86	98.96	98.00	98.00	98.48	99.81	97.93

1. P7-193 simple vein
2. P7-216 complex vein
3. P7-230 complex vein
4. P7-158 complex vein
5. P7-231 complex vein
6. P7-224 complex vein
7. P7-156 complex vein

*Total Fe as FeO

**H_2O required to satisfy structural formula

TABLE B-7. MICROPROBE MINERAL ANALYSES FOR LATE-STAGE VEINS AND SEGREGATIONS.

	Biotite				
	1	2	3	4	5
SiO_2	37.21	35.89	35.42	35.65	36.90
Al_2O_3	13.07	14.35	14.25	13.97	12.26
TiO_2	3.07	2.40	3.01	2.16	3.22
FeO*	17.54	18.89	19.13	18.94	20.56
MnO	0.26	0.32	0.17	0.18	0.28
MgO	14.10	13.57	12.66	13.04	12.65
CaO	0.03	0.06	0.02	0.03	0.02
Na_2O	0.47	0.47	0.93	0.65	0.57
K_2O	9.33	9.25	8.79	9.28	9.31
H_2O**	3.94	3.91	3.87	3.85	3.90
Sum	99.05	99.12	98.26	97.76	99.67

1. P7-216 aegirine-augite
2. P7-224 aegirine-augite
3. P7-158 complex vein
4. P7-231 complex vein
5. P7-156 complex vein

*Total Fe as FeO

**H_2O required to satisfy structural formula

TABLE B-8. MICROPROBE MINERAL ANALYSES FOR PHLOGOPITE CLINOPYROXENITE.

	1	2	3	4	5	6	7
SiO_2	50.85	54.03	54.09	44.41	43.79	37.43	39.39
Al_2O_3	2.20	0.72	0.93	10.23	10.85	14.82	13.61
TiO_2	1.01	0.32	0.47	2.91	2.20	2.56	1.96
FeO*	7.67	2.92	4.27	11.91	8.27	11.14	8.94
MnO	0.22	0.07	0.13	0.16	0.14	0.09	0.10
MgO	13.81	16.97	15.26	15.04	16.71	19.08	22.16
CaO	22.45	22.13	22.69	11.12	11.29	0.04	0.03
Na_2O	1.42	0.79	0.94	3.55	3.88	1.05	1.28
K_2O	-	0.04	0.03	1.19	0.92	8.98	8.54
H_2O**	-	-	-	2.08	2.06	4.07	4.17
Sum	99.63	97.99	98.81	102.63	100.11	99.26	100.19

1. P5-640 pyroxene
2. P5-660 pyroxene core
3. P5-660 pyroxene rim
4. P5-640 amphibole
5. P5-660 amphibole
6. P5-640 phlogopite
7. P5-660 phlogopite

*Total Fe as FeO

**H_2O required by structural formula

TABLE B-9. MICROPROBE MINERAL ANALYSES OF CARBONATITE AND CARBONATITE-ULTRAMAFIC HYBRID ROCKS.

	Hybrid Rocks						
	1	2	3	4	5	6	7
SiO_2	45.10	46.52	54.17	56.70	53.44	41.74	38.88
Al_2O_3	8.47	7.24	1.45	0.57	1.62	9.53	12.97
TiO_2	0.76	1.47	0.76	0.46	1.15	0.86	1.97
FeO*	14.65	14.09	8.82	7.98	12.48	10.82	13.43
MnO	0.20	0.16	0.14	0.12	0.18	0.07	0.09
MgO	13.91	13.91	19.01	19.49	16.40	21.97	18.55
CaO	7.78	7.95	6.21	4.32	4.31	0.10	0.03
Na_2O	6.28	5.68	5.25	6.02	6.38	0.35	1.05
K_2O	0.39	0.75	0.71	0.98	0.46	9.41	8.88
H_2O	2.01	2.02	2.08	2.11	2.05	4.08	4.07
Sum	99.64	99.79	98.61	98.75	98.47	98.95	99.91

1. P5-669B sodic amphibole edge on pargasitic amphibole
2. P5-669A amphibole in felted amphibole-biotite mass
3. P7-132 amphibole replacing pyroxene (totally) in Unit 3
4. P7-132 amphibole in carbonatite vein adjacent to above
5. P7-206 amphibole replacing pyroxene of Unit 3
6. P7-132 reversed pleochroism phlogopite near carbonatite vein
7. P5-669A phlogopite in felted amphibole-phlogopite mass

*Total Fe as FeO

Olivine from Carbonatite						
			Weight%			
Sample	Average Fo%	Range	MnO	NiO	CaO	Cr_2O_3
P7-118	81.5	82.0-81.2	0.64	0.04	-	-

TABLE B-10. CHEMICAL ANALYSES OF ROCKS FROM THE CARGILL COMPLEX.

	1	2	3	4	5
SiO_2	49.4	46.5	42.4	37.1	38.4
TiO_2	0.78	1.4	2.6	4.8	3.3
Al_2O_3	2.7	2.9	3.3	5.0	4.0
Fe_2O_3	1.8	3.5	8.5	13.4	12.6
FeO	7.4	9.0	10.9	12.1	11.6
MnO	0.17	0.18	0.18	0.23	0.18
MgO	18.6	16.1	13.2	11.5	11.3
CaO	17.4	18.5	17.8	14.5	16.5
Na_2O	0.69	0.54	0.52	0.60	1.0
K_2O	0.04	0.050	0.01	0.03	0.16
P_2O_6	n.d.	0.00	0.015	0.03	0.025
CO_2	0.38	0.68	0.38	0.37	0.79
H_2O+	0.58	0.43	0.31	0.49	0.46
Sum	99.94	99.78	100.12	100.15	100.32

	6	7	8	9	10
SiO_2	37.8	37.7	35.6	45.2	37.2
TiO_2	4.6	4.1	6.2	2.0	5.4
Al_2O_3	5.3	11.1	5.6	3.3	4.8
Fe_2O_3	9.1	4.5	13.8	6.2	10.2
FeO	14.1	13.4	12.6	6.9	13.9
MnO	0.21	0.22	0.33	0.16	0.30
MgO	11.6	11.3	8.8	15.9	9.6
CaO	15.7	10.0	14.0	15.2	14.1
Na_2O	0.61	2.6	1.5	1.1	1.4
K_2O	0.68	1.8	0.69	1.8	0.90
P_2O_6	0.017	0.007	0.05	0.01	0.09
CO_2	0.60	1.5	0.37	0.42	0.58
H_2O+	0.42	1.3	0.70	1.1	0.69
Sum	100.74	99.53	100.24	99.29	99.16

1. 4552 Olivine clinopyroxenite, Unit 1
2. 4553 Olivine clinopyroxenite, Unit 1
3. 4555 Magnetite hornblende clinopyroxenite, Unit 3
4. 4554 Olivine-rim magnetite clinopyroxenite, Unit 3
5. 4550 Magnetite hornblende clinopyroxenite, Unit 3
6. 4551 Olivine-rim magnetite pyroxenite, Unit 2
7. 4549 Hornblendite, Unit 4
8. P5-646 Soda-pyroxene hornblendite, Unit 6
9. P5-660 Phlogopite pyroxenite, Unit 8
10. P5-640 Phlogopite magnetite pyroxenite, Unit 8

All analyses by A.G. Loomis

Samples dried at 105°C for one hour

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Chart A — Cargill Carbonatite Complex

Figure 3. Geology of the Cargill Carbonatite Complex at the 50 metre level (drill holes and outcrops projected from surface). Geology by P.O. Sandvik and G. Erdosh for International Mineral and Chemical Corporation (Canada) Ltd., 1976, adapted by R.P. Sage. Map coordinates, in metres, are from the grid used by International Mineral and Chemical Corporation (Canada) Ltd.

Diamond Drilling Summary

Series	Drill Holes	Notes	Depth (m)	Depth (ft)	No. of holes
A	IMC holes CG1 to 67	1	6255	20,518	55
B	IMC holes BL1 to 6	1	1240	4069	6
C	IMC holes CCM1 to 126	1	10 985	36,039	123
	IMC TOTAL		18 480	60,626	184
D	Continental Copper holes 1 to 7	2	945	3102	7
E	Kennco holes 1 to 6	3	1062	3485	6
	SUBTOTAL		2007	6587	13
F	Sherritt Gordon holes SG1 to 82	4	4347	14, 258	82
G	Sherritt Gordon holes P1 to 11	4	531	1742	11
	SUBTOTAL		4878	16,000	93
TOTAL			25 365	83,213	290

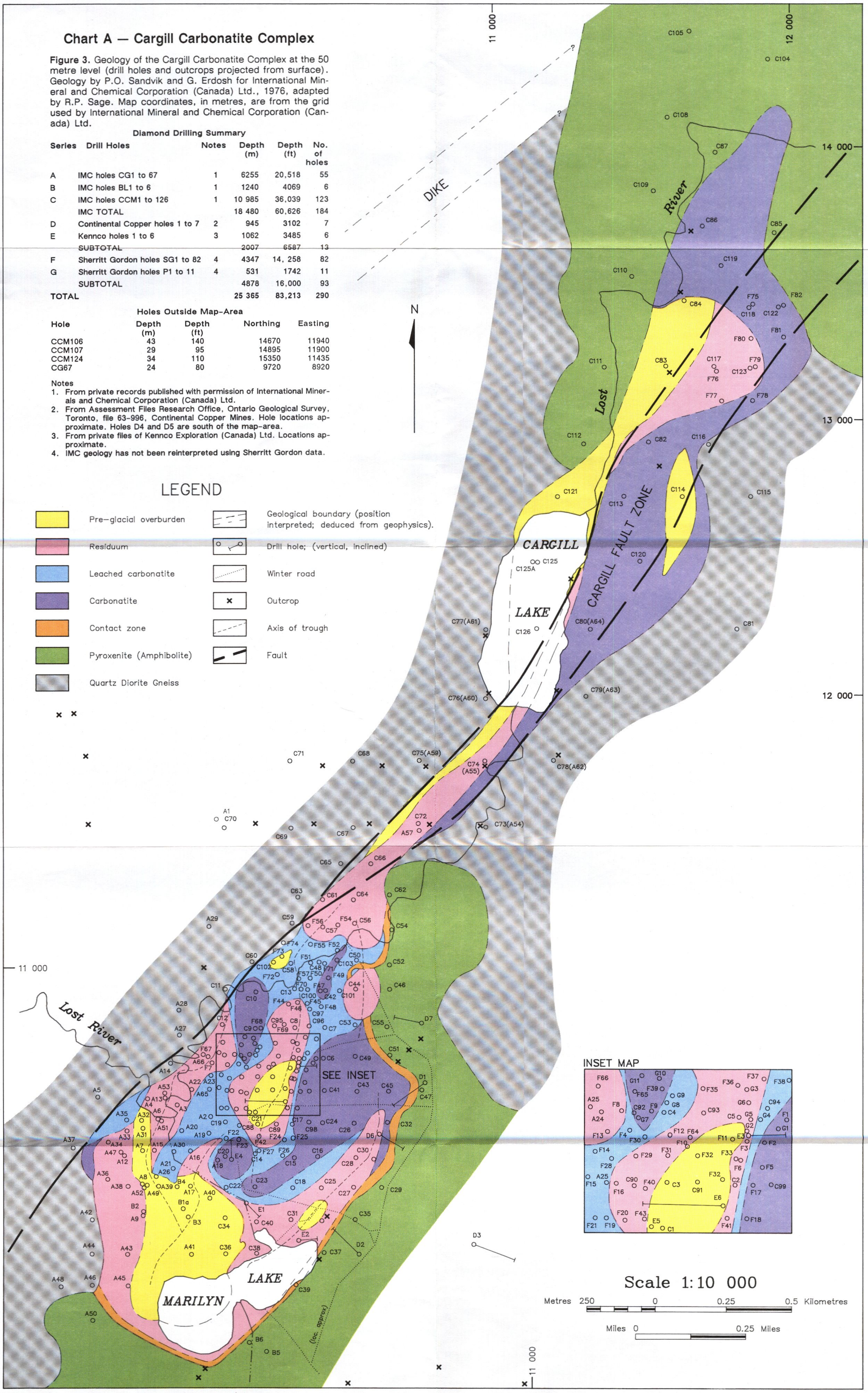
Holes Outside Map-Area

Hole	Depth (m)	Depth (ft)	Northing	Easting
CCM106	43	140	14670	11940
CCM107	29	95	14895	11900
CCM124	34	110	15350	11435
CG67	24	80	9720	8920

Notes
1. From private records published with permission of International Minerals and Chemical Corporation (Canada) Ltd.
2. From Assessment Files Research Office, Ontario Geological Survey, Toronto, file 63-996, Continental Copper Mines. Hole locations approximate. Holes D4 and D5 are south of the map-area.
3. From private files of Kennco Exploration (Canada) Ltd. Locations approximate.
4. IMC geology has not been reinterpreted using Sherritt Gordon data.

LEGEND

🟨	Pre-glacial overburden	┄	Geological boundary (position interpreted; deduced from geophysics).
🟥	Residuum	○	Drill hole; (vertical, inclined)
🟦	Leached carbonatite	┈	Winter road
🟪	Carbonatite	×	Outcrop
🟧	Contact zone	┄	Axis of trough
🟩	Pyroxenite (Amphibolite)	▬	Fault
▨	Quartz Diorite Gneiss		



Scale 1:10 000

Metres 250 0 0.25 0.5 Kilometres

Miles 0 0.25 Miles