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Geology of the Martison Carbonatite Complex

By

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V.G. Milne

V.G. Milne, Director
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Foreword

The Martison 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 mineral exploration history within the complex.

V.G.Milne
Director
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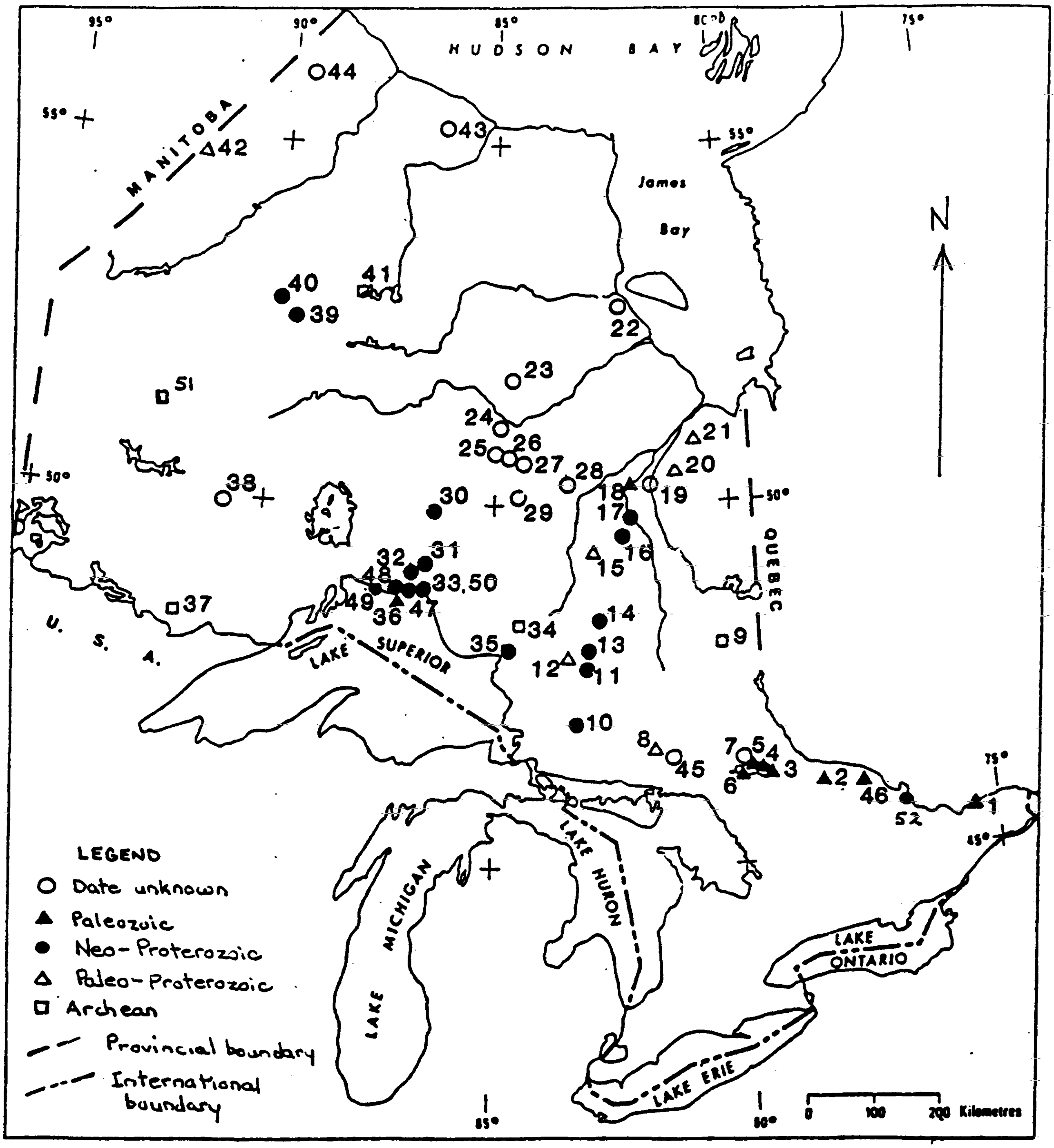

Location map and Fig. 1

Geology of the Martison Carbonatite Complex, District of Cochrane

by

R.P. Sage[1]

Introduction

The existence of the Martison Carbonatite Complex was first interpreted by Satterly (1970) on the basis of a diamond drill hole completed in 1965 by a consortium, Falconbridge Nickel Mines, Uranium Ridge Mines Limited and Matachewan Consolidated Mines Limited. This drill hole drilled to test a circular aeromagnetic anomaly outlined in privately financed aeromagnetic surveys (Fisher 1982a) and encountered magnetite-rich sands and possible apatite but failed to reach bedrock. Ferguson (1971) prepared a very brief description of this drill hole. The circular aeromagnetic anomaly representing the Martison carbonatite complex was outlined in 1967 by aeromagnetic surveys completed by the Ontario Geological Survey and Geological Survey of Canada (ODM-GSC, 1967).

In 1979 as part of the program by the Ontario Geological Survey to examine the economic potential of alkalic rock-carbonatite complexes of Ontario, a brief examination of existing data on known and interpreted alkalic complexes of the James Bay region was completed (Sage 1987). Examination of the drill log by the author for

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the 1965 drill hole suggested an analogy with the phosphate residuum deposits found at the Cargill Township Carbonatite Complex and described by Sandvik and Erdosh (1977). Sage (1979) recommended exploration for a phosphate-rich residuum comparable to that found at Cargill. This recommendation was taken under advisement by Mr. Dave Fisher, Shell Canada Resources Limited, who planned and executed a program to test for a phosphate-rich residuum at Martison. The company completed five reverse circulation holes, four of which encountered phosphate-rich residuum with niobium values, (Fisher 1982a; AFRO, Toronto). Since discovery of the phosphate-rich residuum the Martison Carbonatite Complex has been subjected to 3 exploration programs.

Acknowledgements

The discovery of large reserves of phosphate-rich residuum is due to the enthusiasm and persistence of Mr. Dave Fisher, Shell Canada Resources Limited, who followed through on the recommendation of Sage (1979). Mr. Fisher kept the Ontario Geological Survey advised of results as exploration progressed and made relevant geological data available.

In 1982 Shell Canada Resources Limited sold the Martison property to Eastern Petroleum Corporation and Camchib Mines Incorporated. Camchib Mines Incorporated were the joint venture operator and additional work was completed by the company under the direction of Mr.Peter Potapoff chief staff geologist Campbell Resources Incorporated. Mr. Potapoff has made available to the author residuum samples, core samples and geologic data resulting from the work completed by Camchib Mines Incorporated.

The Martison Carbonatite Complex was originally referred to as the Martison Lake Carbonatite Complex (Satterly, 1970). Martison Lake however lies 15 km northeast of the Carbonatite Complex and therefore the carbonatite is referred to only as the Martison in this report (Fisher 1982a). The carbonatite is named after N.W. Martison a Shell geologist who explored the area for petroleum in 1946 (Fisher 1982a).

Location and Access

The Martison Carbonatite Complex is located at approximately 50°18' North Latitude and 83°25' West Longitude (Figure 1). Due to wet marshy conditions access to and work on the complex is best completed under winter conditions after freeze-up.

The complex is accessible from Highway 11, 28 km west of Hearst, then 36 km of good gravel road (Fushimi Lake Road) and then 46 km of winter road over flat wooded muskeg. The present distance from Hearst by road during winter months is 110 km. During the summer months access to the site is by helicopter.

Field Methods

There is no outcrop and thus all geologic data is the result of drilling. Samples and data provided by Shell Canada Resources Limited and Campbell Resources Incorporated form the basis for this report.

Previous Geological Work

Other than reports on file in the Assessment Files Research Office (AFRO), Toronto, the only work completed on the complex is a study of the mineralogy of the residuum by Hart (1983). This study is based on samples obtained by Shell Canada Resources Limited.

Physiography

The land surface over the Martison Carbonatite Complex is typical of the vast region south of Hudson Bay. It is flat and alternates between wet and dryer areas that stand just above water.

Potapoff (1983 p.7) reports that lakes in the area have a maximum depth of 4 metres and that maximum relief in the region is approximately 3 m. Over the deposit itself maximum relief is 1.4 m and averages 0.5 m (Potapoff 1983 p.7).

Laboratory Techniques

Very few samples of fresh bedrock are available. Samples of available fresh bedrock and some of the consolidated residuum were prepared for thin section examination.

Hart (1983) completed a detailed mineralogical study of the residuum. Five specimens of consolidated residuum were studied by Wyslouzil and Gochnaeur (1983) and Mainwaring (1983) completed mineralogical studies on residuum samples being studied for metallurgical purposes. For this report studies were restricted to the examination of relatively fresh samples and to a lesser extent weathered consolidated carbonatite at the base of the residuum.

Nomenclature

In describing the lithology of the Martison Carbonate Complex the author has used only two rock names to describe the carbonatite rocks: sovite and silicocarbonatite. Some of the silicocarbonatite may be carbonate-rich lamprophyre dikes.

Sovite is a carbonatite rock containing 50 percent or more calcite. Various mineralogical modifiers are used to classify the sovite.

Silicocarbonatite is a carbonatite rock containing 50 percent or more oxide and silicate minerals. Where the silicate mineralogy exceeds 90 percent, the rock is no longer considered to be silicocarbonatite and 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 percent oxide and silicate mineral contents, because carbonatites are extremely variable in mineral content over distances of less than a few centimetres.

General Geology

The Martison Carbonatite Complex is situated in the large expanse of low ground southwest of Hudson Bay. There are no exposures of the carbonatite or its enclosing wall rocks and all geological data result from drilling.

Archean bedrock was encountered 10 km northwest of the Martison carbonatite complex in Shell Canada Resources diamond drill hole SL-82-1 near Serinack Lake (Fisher 1982b, AFRO, Toronto). This hole, percussion drilled to test a northwest-striking linear aeromagnetic anomaly, returned coarse-grained clear quartz and milky feldspar with medium grained biotite and magnetite (AFRO, Toronto). The bedrock was interpreted to be gneissic and was encountered at a depth of approximately 82 m. Chips of green gneiss were reported and the drill log indicates an absence of Paleozoic cover rocks; gravel, sand and clay lie directly on the weathered bedrock (AFRO, Toronto).

In the search for kimberlite, Selco Mining Corporation Limited has completed 5 diamond drill holes in 1980 and 1982 close to the Martison Carbonatite Complex (AFRO, Toronto). Northeast of the carbonatite, Selco Mining Corporation Limited logged carbonatite (?) breccia in hole 42J/6-12-2 and in hole 42J/6-17-1 to the southwest an ultramafic breccia (?) was logged (AFRO, Toronto).

To the east-northeast diamond drill hole 42J/6-12-1 intersected ultrabasic breccia and to the east hole 42J/6-11-1 encountered serpentinized breccia. Hole 42J/6-9-2 northwest of the Martison Carbonatite Complex (not shown on figure 1) is indicated to have intersected kimberlitic breccia (AFRO, Toronto).

None of the nearby diamond drilling completed by Selco Mining Corporation Limited intersected Paleozoic rocks even though existing maps (Ayres et al. 1970a) indicate that the Martison Carbonatite Complex is covered by Cretaceous sediments consisting of clay, sand, lignite, fireclay, kaolinite and quartz sand. Potapoff (1985 p.6) states that Paleozoic sediments are absent for a 10 km radius around the Martison Carbonatite Complex.

The Martison Carbonatite Complex may form a topographic high in the Precambrian basement from which pre-glacial sediments have been removed by erosion or perhaps not deposited.

The diamond drilling by Selco Mining Corporation Limited indicates the presence of a number of diatreme structures of carbonatitic and kimberlitic affinity near the Martison Carbonatite Complex. This spatial distribution does not establish a magmatic relationship between the two. The kimberlitic and carbonatitic diatremes drill tested by Selco Mining Corporation Limited in other areas of the region cut the Paleozoic rocks and have been classified as Mesozoic by Lumbers (1978). On the other hand carbonatite complexes of Mesozoic age are unknown in Ontario. Most carbonatites in Ontario are of Precambrian age (Sage 1986). The identified age groupings are 1800 to 1900 Ma, 1000 to 1100 Ma, 450 to 600 Ma (Sage 1986). The Martison Carbonatite Complex may be Precambrian in age as are most carbonatite complexes in Ontario but it is not known to which age grouping it belongs. It is surrounded by numerous diatreme structures of possible Mesozoic age (Lumbers 1978). This implies that there were at least a minimum of two periods of alkalic rock-carbonatite magmatism in the area.

The Martison Carbonatite Complex lies 150 km west of the Kapuskasing Structural Zone which hosts numerous alkalic rock-carbonatite complexes, and lies 60 km east of a cluster of circular aeromagnetic anomalies underlying Paleozoic cover rocks previously interpreted to be carbonatite intrusions (Satterly, 1970). The Martison carbonatite Complex is too far west of the Kapuskasing Structural Zone to be connected to that regional structure and its many manifestations of alkalic magmatism. Most of the circular aeromagnetic anomalies to the east(Satterly, 1970) appear to be gabbros with the exception of the Albany Forks Carbonatite and Nagagami River Alkalic Rock Complex. Examination of existing geological compilation maps (Ayres et al. 1970a,b) suggests that the Martison Carbonatite Complex lies along the extrapolated northeast extension of the Garden River Fault Zone (Sage 1986, p.45). The western end of the Garden River fault zone is one of the bounding faults for the northwestern corner of the Lake Superior basin of Late Proterozoic age (Figure 2). The Garden River Fault Zone extension passes through the site of the Nagagami River Alkalic Rock Complex as it is extrapolated to the site of the Martison Carbonatite Complex. Alkalic rock-carbonatite magmatism lying along the Trans-Superior Tectonic Zone, which bisects the Lake Superior basin, is dominated by Proterozoic age events (Sage 1986). It may ultimately be established that the Martison Carbonatite Complex may belong to this Late Proterozoic age grouping.

All diamond drilling at the Martison Carbonatite Complex to date encountered carbonatite and possibly lamprophyre dikes but has not penetrated to any great depth into the carbonatite. Alkalic silicate rocks have not been encountered. The Martison Carbonatite Complex consists of three closely spaced circular aeromagnetic anomalies known to be underlain by carbonatite rocks, herein named subcomplexes A, B, and C. There may be three separate carbonatite intrusions or a large single carbonatite complex. If the Martison Carbonatite Complex is in reality one complex, it is one of the world's largest. The largest circular aeromagnetic anomaly exceeds 4 km in diameter (a surface area of 19.0 square kilometers) and by itself represents a large carbonatite intrusion.

Table 1 presents the lithologic units.

Table 1 Tentative Table of lithologic units for the Martison Carbonatite Complex.

Cenozoic

Quaternary

Recent

Swamp and stream deposits

Pleistocene

Glacial drift, varved clay, boulders, gravel, sand and silt

Glaciolacustrine deposits

Unconformity

Mesozoic(?)

Diatremes of lamprophyric, carbonatitic, and kimberlitic affinity

Intrusive contact(?)

Pre-glacial quartz sands, organic clay, and kaolinite

Unconformity

Phosphate and niobium enriched residuum

Unconformity

Precambrian (Proterozoic)(?)

Martison Carbonatite Complex

Sovite, silicocarbonatite, lamprophyre(?)

Intrusive Contact

Precambrian (Archean)

Granitic gneisses

The Martison Carbonatite Complex has been deeply weathered with the development of residuum-filled karst-like features. The presence of karst-like features on the surface of the Martison carbonatite is suggested by rapid changes in the thickness of the residuum over relatively short distances. By analogy with the Cargill Township Carbonatite Complex this weathering probably took place during Cretaceous time. The residuum consists of unconsolidated and consolidated residuum and weathered bedrock gradational into each other. A very thin zone of pre-glacial sediments may overlie the residuum and this is in turn overlain by a thick sequence of glacial gravels, sand, and gravel and clay deposits.

Archean

The lack of outcrop prevents any evaluation of the granitic rocks which likely enclose the Martison carbonatite complex. The Shell Canada Resources Limited drill hole SL-82-1 10 km northwest of the carbonatite encountered granitic rocks that may be trondhjemite or quartz diorite in composition (AFRO, Toronto). The drill log indicates the rocks to be gneissic and reports the presence of chips of green gneiss. The significance of the green gneiss is unknown.

Proterozoic

The Martison Carbonatite Complex is tentatively classed as Proterozoic in age since nearly all carbonatite complexes in Ontario would be so classified. The closest suite of alkalic-rock complexes located along the Trans-Superior Tectonic Zone are dominantly Proterozoic in age.

Martison Carbonatite Complex

Sovites and Silicocarbonatites

All drill holes that intersected bedrock cut material that can be interpreted as being the product of weathering of sovite or silicocarbonatite rocks of a carbonatite complex. Obtaining fresh material has been technically impossible with the exception of perhaps sample 1601 (See Table A-2, A-3). A restricted group of samples was prepared for complete rock analysis and even though these were the freshest obtainable material, all but sample 1601 displayed some evidence of weathering by the presence of iron oxide along grain boundaries. All material submitted for analysis was examined in thin section. All sample material examined by the author came from the more recent work completed by Campbell Resources Limited.

In thin section the sovites and silicocarbonatites display a fine-grained inequigranular-seriate to equigranular allotriomorphic to hypidiomorphic granoblastic to granoblastic-elongate texture (Photographs 1 and 2). Grain boundaries are generally straight to curved. The presence of granoblastic elongate textures in some samples indicates deformation and recrystallization implying faulting has affected the complex.

Thin section mode is estimated as phlogopite 1 to 50 percent, magnetite 0 to 5 percent, apatite trace to 10 percent and 50 to 99 percent carbonate. Traces of pyrochlore are present and secondary iron oxide occurs along grain boundaries and in association with magnetite and phlogopite. Phlogopite occurs as anhedral to euhedral tabular grains that may have iron oxide along grain boundaries and along cleavage planes. The least weathered samples have the least amount of iron oxide. Inclusions of carbonate within phlogopite have been observed and some grains of phlogopite display a weak alteration to chlorite. Bent (001) cleavages are present in some samples but it is uncertain as to whether this is due to tectonic deformation or collapse during solution and karst development.

Accessory magnetite is common and occurs in anhedral to euhedral grains. Some alteration to secondary iron oxides occurs. Uncommonly magnetite contains inclusions of phlogopite or carbonate.

The apatite occurs as elongated rounded grains varying from anhedral to euhedral in shape. The apatite occurs as aggregates or clusters of grains, some of which are crudely radiating or crudely subparallel in orientation. The specimens displaying the most iron oxides tend to have apatite occurring in clusters and grain aggregates. The apatite crystals tend to be subhedral in those specimens that display more intense weathering but the individual crystals generally retain their primary shape. In those specimens displaying minimal weathering the apatite is more euhedral and more evenly distributed. The apatite crystals also tend to be larger in least altered specimens. The presence of the clusters and aggregates of apatite may indicate a secondary accumulation of apatite crystals in weathered consolidated surface carbonatite rocks. Such apatite aggregation has not been observed by the writer in specimens of fresh unweathered carbonatite from other carbonatite complexes within Ontario.

Carbonatite always forms an interlocking anhedral mozaic of grains. Some specimens are granoblastic and some granoblastic-elongate. Granoblastic and granoblastic-elongate textures can be observed in a single thin section. The granoblastic-elongate textures may indicate deformation and recrystallization in response to fault movement in some instances but in the more weathered specimens perhaps some is due to solution, collapse and recrystallization during karst development on the surface of the carbonatite.

One grain of possible aegirine was noted and it contained poikilitic inclusions of apatite and phlogopite. Traces of pyrochlore, when present, occur as euhedral to subhedral crystals which may partially enclose carbonate.

Mesozoic

Apatite- and Pyrochlore-Rich Residuum

The apatite- and pyrochlore-rich residuum is the main item of economic interest at the Martison Carbonatite Complex. The time at which this residuum formed is unknown but by analogy with the Cargill Township carbonatite complex it is assumed to be Cretaceous in age (Sage 1988).

The Cargill phosphate residuum was identified as Campanian (Late Cretaceous) to Paleocene (Early Tertiary) in age on basis of pollen found in organic remains associated with the residuum (personal communication by G. Norris, University of Toronto, cited in Sage 1988).

The first detailed work on the Martison Carbonatite complex was completed by Shell Resources Canada Limited. The residuum appears to be a karst-like feature to which Shell Resources Canada Limited geologists applied the customary "A", "B" and "C" terminology for horizons of soil morphology (Hart 1983, p.73). At Martison the soil "A" horizon consisting dominantly of minerals resistant to weathering is absent (Hart 1983, p.73). The residuum characterized by primary and secondary minerals is equivalent to the soil "B" horizon and the deepest level of weathering consisting of altered debris and rock fragments grading downward into bedrock is the "C" horizon, (Hart 1983, p.73). There are no contacts between "B", "C" and bedrock since all zones are gradational into one another. Potapoff (1985, p.8), after much work, subdivided the residuum into cemented residuum, unconsolidated residuum, leached carbonatite, and unleached carbonatite. He

(Potapoff 1985, p.8) also recognized the possibility of a thin zone of pre-glacial sediments lying directly on the residuum. The term residuum will be used to describe the weathered and leached carbonatite and resulting products.

The deeply weathered residuum at the upper part of the weathering profile is coloured light tan to brown, deep red-brown, to almost black depending on the limonite-goethite content (Hart 1983, p.35). The residuum consists of sand and silt-size particles with fragments of consolidated residuum (Hart 1983, p.35). Zones containing 60 percent titanomagnetite were encountered and zones rich in mica were penetrated (Hart 1983, p.35,44).

In a summary report completed by Canchib Mines Incorporated after the last work was finished on the Martison Carbonatite Complex, the unconsolidated residuum thickness of potential economic interest was described as averaging 20 m in thickness but locally is 50 to 100 metres in thickness (Potapoff 1985, p.9) The unconsolidated residuum contains zones of consolidated residuum which compose up to 10 percent of the residuum (Potapoff 1985, p.10). The consolidated zones vary from several centimetres to several metres in thickness (Potapoff 1985, p.10).

The residuum caps leached carbonatite that grades downward into fresh carbonatite. Potapoff (1985, p.11) indicates this zone to be 1 to 55 metres thick, averaging 11 metres. In specimens examined by the author all except one showed evidence of iron oxide staining indicating weathering. Some drill holes never completely penetrated the unconsolidated residuum and those that penetrated the leached carbonatite rarely encountered truly pristine carbonatite.

Mineralogical studies have been completed by a large number of investigators but they have been restricted to a limited number of samples or sample sites. The number of minerals present in the weathered carbonatite probably greatly exceeds the number reported. All the studies completed to date should be considered as preliminary and some of the minerals reported need confirmation. The minerals reported as being present in the residuum are summarized in Table 2. The mineralogy reported by Fisher (1982b) was based largely on field identification and brief examinations of samples submitted to J. Gittins, University of Toronto (1981, 1982). The mineralogy described by Potapoff (1983, 1984a,b, 1985) has been largely summarized from the work of Hart (1983) Wyslouzil and Gochnaeur (1983) and Mainwaring (1983).

The minerals of the residuum fall into three categories, primary, secondary and detrital. The primary minerals such as apatite, magnetite and pyrochlore are the minerals resistant to solution of the carbonatite and remain after the carbonate minerals have been dissolved. The secondary minerals such as limonite-goethite, columbite and francolite are the breakdown products of the primary minerals (limonite-goethite), replacements of the primary minerals (columbite) or redeposition of elements after solution (francolite). The feldspar and some of the quartz is likely detrital in origin derived from the surrounding granitic gneiss terrain.

Nearly all mineral studies report the presence of clay in the residuum but the variety of clay has not been identified. The clay mineralogy has not been studied.

Discussion of mineralogy will be restricted to the major mineral species.

<u>Apatite</u>

Apatite is a residual mineral which accumulated in the residuum as the surrounding carbonate minerals were dissolved away. In nearly all cases the apatite is described as a fluorapatite (Table 2). The apatite occurs as oval elongated grains which are commonly broken or fractured and have carbonate plus goethite along fractures (Hart 1983, p.20, Photographs 3 and 4). Hart (1983, p.20) reports that carbonate may pseudomorph apatite and that large apatite grains may have fluid inclusions. In the upper portion of the residuum apatite may be partly or completely replaced by francolite which proceeds from the end of the grain inwards (Hart 1983, p.37). In the upper part of the residuum francolite cements grains of apatite. Mainwaring (1983, p.4) reports that the apatite contains many very fine inclusions, perhaps of iron oxide.

Barite

Hart (1983, p.15) describes the presence of considerable barite in the lower ("C" horizon) of the residuum where he estimates 20 percent of the horizon is barite. No other investigator reports barite in significant quantities. The discrepancy may be due to the small number of samples and size of the samples examined by each investigator.

Hart (1983, p.15) describes the barite as prismatic to bladed grains 0.05 to 0.5 mm in size commonly occurring as clusters of interlocking grains. The barite is reported to be in fractures or veins where it is associated with carbonates, pyrite, pyrochlore and iron oxides (Hart 1983, p.15,16). The barite grain boundaries may display dissolution and may occur as irregular randomly oriented diffuse grains resembling a fibrous texture (Hart 1983, p.16). Barite may compose 50 percent of veins or fracture fillings and on the basis of x-ray diffraction patterns Hart (1983, p.16,25) suggests a composition of $(Ba_{0.8}\ Sr_{0.2})\ SO_4$.

Columbite - Magnocolumbite

Columbite is the second most common niobium-bearing mineral and was identified by Mainwaring (1983) using microprobe techniques. The columbite is associated with pyrochlore (Mainwaring 1983, p.3) and may be pseudomorphic after pyrochlore. Mainwaring (1983, p.3) reports that the columbite contains approximately 57 percent niobium oxide and the tantalum content is low. Mainwaring (1983, p.3) indicates that columbite may form 10 to 50 percent of the reported pyrochlore in some samples Table 3 presents microprobe data on columbite. The microprobe data indicates that the columbite is magnocolumbite and lacks the iron and manganese content of typical columbite. This mineral requires additional study.

Table 2: Mineralogy of the Martison Carbonatite Complex residuum. Compiled from Fisher (1982b) (1); Potapoff (1983, 1984a,b, 1985) (2, 3, 4, 5); Wyslouzil and Gochnaeur (1983) (6); Mainwaring (1983) (7); Hart (1983) (8); Gittins (1981, 1982) (9, 10).

Mineral	Reference	Comments
Amphibole	1, 2, 3, 4	Variety of amphibole not determined
Anatase	2, 3, 4	TiO_2, Triomorph with rutile and brookite
Ankerite	3, 4, 6	Possible a secondary carbonate
Apatite	1, 2, 3, 4, 5 6, 7, 8, 9	Nearly all reports describe this as a fluorapatite, Ca5 $(PO_4)F$
Apophyllite	2, 3, 4	
Barite	2, 3, 4, 5, 8	Reported by Hart (1983) to be common
Bastnasite	2, 3, 4, 5	Rare earth carbonate, (Ce, La) (CO_3) F
Biotite	1, 2, 3, 4, 5, 6,	
Calcite	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	Both primary and secondary in origin. Dolomite and calcite intergrown in least altered carbonatite.
Cerianite oxide	5, 7	Dominantly a cerium (Ce, Th) O_2
Chlorite	1, 2, 3, 4, 5, 6, 7	Occurs as an alteration of micas
Columbite-Magnocolumbite Fe) Fe,	2, 3, 4, 5, 7	Present as a replacement of pyrochlore (Mn, (Nb, Ta)$_2$ O_6 Magnocolumbite (Mg, Mn) (Nb, Ta)$_2$ O_6
Crandallite	2, 3, 4, 5	$CaAl_3$ $(PO_4)2(OH)_5$ H_2O

Dolomite	2, 4, 6, 8, 10	Probably both secondary and primary
Feldspar	1, 2, 3, 4, 5, 7	Type of feldspar not reported
Florencite	2, 3, 4, 5, 7	Cerium bearing end member of Crandallite group (Nd, Ce) $Al_3 (PO_4)_2 (OH)_6$
Fluorite	2, 3, 4, 8	
Francolite	2, 3, 4, 5, 8	Wyslouzil and Gochnaeur (1983) describe some as staffelite Carbonate-fluorapatite $Ca_5 (PO_4, CO_3)_3 F$
Hematite	1, 2, 3, 4, 5, 6, 7, 8, 9,	Alteration of magnetite, phlogopite and biotite
Ilmenite	1, 2, 3, 4, 5, 6, 7	
Limonite-Geothite	1, 2, 3, 4, 5, 6, 7, 8, 9	Alteration of magnetite, phlogopite, ilmenite
Maghemite	2, 3, 4	Diamorph of hematite

Magnetite	1, 2, 3, 4, 5, 6, 7, 8, 9	Routinely described as titaniferous. Wyslouzil and Gochnaeur (1983) describe some as martite (hematite pseudomorphic after magnetite)
Monazite	2, 3, 4, 5, 7	Mainwaring (1983) reports monazite as being niobium bearing and in all samples examined by him (La, Ce, Nd) PO_4
Pennine	2	Variety of chlorite, $Mn_5 Al(Si_3Al)O_{10}(OH)_8$
Perovskite	5, 7	
Phlogopite	1, 2, 3, 4, 5, 6 8, 9	
Pyrite	2, 5, 8	
Pyrochlore	1, 2, 3, 4, 5, 6, 7, 8	Dominant niobium-bearing mineral $(Ca, Na)_2 Nb_2O_6 (OH, F)$
Quartz	1, 5, 9	
Rutile	5, 6, 7	Described as niobium -bearing
Siderite	2, 5, 8	Probably secondary
Sphene	5	
Thorianite	7	Thorium oxide $ThO2$
Vermiculite	2, 3, 4, 6	
Waylandite	2, 3, 4, 5	Member of Crandallite group $(Bi, Ca) Al_3 (PO_4, SiO_4)_2 (OH)_6$
Witherite(?)		Barium carbonate, $BaCO_3$
Woodhousite	2, 3, 4, 5	$CaAl3(PO_4)(SO_4)(OH)_6$
Zircon	2, 3, 4, 5, 7	
Zirkelite	5, 7	Member of pyrochlore group, $(Ca, Th, Ce) Zr (Ti, Nb)_2 O_7$

Table 3: Microprobe Analyses (Weight %) Columbite-Magnocolumbite (from Mainwaring 1983)

Oxide	Grain No. 11	12	13
FeO	3.53	3.94	3.80
Na_2O	0.00	0.00	0.00
MgO	34.66	34.21	35.06
MnO	2.23	2.05	2.03
Nb_2O_5	58.72	57.18	59.81
CaO	0.00	0.00	0.00
Ta_2O_5	1.07	0.81	0.65
SrO	0.00	0.00	0.00
ZrO_2	0.55	3.10	0.57
BaO	0.00	0.00	0.00
La_2O_3	0.00	0.00	0.00
Ce_2O_3	0.00	0.00	0.00
Pr_2O_3	0.00	0.00	0.00
Nd_2O_3	0.00	0.00	0.00
Total	100.78	101.31	101.96

Sample from hole 51 depth 37.2 - 38.7 m

Carbonates

Both primary and secondary calcite and dolomite occur while the ankerite and siderite are secondary (Table 2).

The least weathered carbonates have a grain size of 0.2 to 1.0 mm which may be enclosed in turbid microcrystalline carbonate (Hart 1983, p.15). Clean unaltered grain boundaries are uncommon (Hart 1983, p.15). Microcrystalline carbonate is stained brown due to the presence of limonite-goethite and may contain witherite ($BaCo_3$) (Hart 1983, p.15). Hart (1983, p.15) describes the texture of the carbonatite as consisting generally of large carbonate grains sitting in microcrystalline carbonate matrix.

X-ray diffraction patterns of carbonatite drill cuttings from least altered carbonatite suggests that dolomite and calcite are intermixed and that relative proportions among samples examined are not constant (Gittins 1982).

Wyslouzil and Gochnaeur (1983) indicate that dolomite is the dominant carbonate present and that minor ankerite is present. Their petrographic study was on least weathered specimens.

The petrographic studies completed to date on least weathered carbonatite samples, suggest that the primary carbonatite may contain approximately equal amounts of dolomite and calcite even though the ratio of dolomite to calcite may vary dramatically between specimens.

Hart (1983, p.55-58) identified siderite by X-ray diffraction techniques where it occurred in vugs lined with francolite. The siderite occurs as brown, rounded botryoidal masses and single globes on the walls of francolite-lined cavities (Hart 1983, p.55-58). The siderite grains grow in radial manner and may also occur interstitially to the francolite matrix (Hart 1983, p.55-83).

Francolite

Francolite is a hydrous secondary phosphate similar in X-ray diffraction patterns to primary apatite. The quantity of francolite increases vertically and at the top of the residuum the ratio of apatite to francolite is 1:5 (Hart 1983, p.60). In the unconsolidated deeply weathered residuum, francolite is the dominant phosphate mineral. With increasing depth the francolite content decreases, apatite increases and phosphate assays decrease (Hart 1983, p.60).

Hart (1983, p.45-51) completed the most extensive study on the secondary phosphates and subdivided the francolite into 3 generations. Francolite cements the residuum to form consolidated blocks. It forms green to pale green botryoidal masses lining cavities and fractures. In the cavities it commonly displays a radiating prismatic structure normal to the cavity walls (Photograph 5) readily visible in thin section. The identification of this botryoidal mineral as apatite was confirmed by X-ray diffraction techniques (Ontario Geoscience Laboratories, Ontario Geological Survey, Toronto).

The first generation francolite is described by Hart (1983, p.48) as a breakdown product of apatite where minute brush-like crystals grow in concentric rims perpendicular to the ragged margins of primary apatite grains. These secondary phosphate crystals are colorless to orange-brown in colour with colour dependent on the relative amount of enclosed goethite (Hart 1983, p.48). Hart (1983, p.48) reports that the dark concentric rims represent zones of massive amorphous phosphate (collophane). Borders and rims of francolite grains are commonly clouded with minute needles of goethite (Hart 1983, p.48).

The second generation francolite consists of very fine, randomly oriented grains cementing primary minerals into consolidated fragments (Hart 1983, p.48). The second generation francolite is associated with needles of goethite implying simultaneous crystallization of goethite crystals and francolite. Dark areas within the francolite which lack crystallinity are interpreted by Hart (1983, p.48-51) to be amorphous collophane. This francolite stage is associated with sheet silicates altered to goethite where francolite occurs between altered and separated sheets (Hart 1983, p.51). Hart (1983, p.48) suggests this second stage francolite is the dominant stage of francolite development.

Third stage francolite is present as colloform fan shaped crystal aggregate lining vug walls and fractures (Hart 1983, p.51). This stage of francolite development is coarser than the first two generations, contains less goethite, and near the very edge of the grains may be intergrown with siderite (Hart 1983, p.51). Hart (1983, p.51) indicates several periods of fracturing and fracture filling have taken place. The last formed francolite in these fractures is generally clear and contains unidentified dust-like inclusions.

Hematite

Hart (1983, p.55) reports that the deeply weathered portion of the residuum may contain up to 1 percent hematite where it is an alteration of and rims titanomagnetite. The hematite is interstitial to goethite, may completely enclose titanomagnetite, and may contain inclusions of francolite (Hart 1983, p.55). Hematite is replaced by goethite (Hart 1983, p.55).

Wyslouzil and Gochnaeur (1983, p.3) report hematite pseudomorphic after magnetite (martite).

Ilmenite

Ilmenite was reported by Wyslouzil and Gochnaeur (1983, p.4) as a major oxide phase in samples examined by them. No additional mineralogical descriptions are provided by Wyslouzil and Gochnaeur (1983).

Limonite-Goethite

Limonite-goethite is a major secondary phase within the residuum and is the pigment colouring the residuum. Its ubiquitous presence can make mineral identification difficult since it coats, stains and replaces other minerals.

Hart (1983, p.26) describes goethite in the lower part of the weathered zone as occurring as very fine-grained brown orange clusters and very fine-grained palm leaf-like mats of radiating needles. The goethite needles nucleate on the large altered carbonate grains and grow into the enveloping microcarbonate (Hart 1983, p.26). The goethite crystals are described by Hart (1983, p.28) as translucent with dark orange centres and progressively less coloured margins. In the lower part of the weathered horizon the goethite occurs as concentric shells and as radiating needles with the needle goethite associated with carbonate (Hart 1983, p.28). The needles are prominent within fragments while the concentric shells mantle the fragments.

Goethite forms from the breakdown of the iron-rich minerals such as hematite, pyrite, titano-magnetite and mica. It may form concentric shells around mica grains and ultimately replace the mica grain starting at cleavage planes (Hart 1983, p.28-55). Goethite also pseudomorphs pyrite and mica (Hart 1983, p.28-30).

In the upper part of the residuum, goethite may compose 25 percent of consolidated portions of the residuum (Hart

1983, p.51). Where it occurs as interstitial needles associated with francolite and as large masses of fine-grained needles and masses associated with titanomagnetite, hematite, and apatite which occupies fractures in consolidated residuum (Hart 1983, p.53). Hart (1983, p.53) reports hematite, francolite and titanomagnetite may be enveloped in goethite with goethite occurring as an alteration of hematite and titanomagnetite.

Hart (1983, p.53) observed relict grain boundaries of apatite outlined by goethite needles perpendicular to the former grain boundaries.

Titanomagnetite

Titanomagnetite occurs throughout the weathered profile Hart (1983, p.33). It has a grain size of 0.02 to 0.5 mm, was identified by X-ray diffraction, alters to hematite and goethite and may contain inclusions of francolite, goethite and hematite (Hart 1983, p.39,43).

Monazite

Mainwaring (1983, p.3) reported the rare earth phosphate monazite in all samples examined by him. The monazite was reported to be intergrown with pyrochlore or zircon and to contain 15 to 20 percent uranium plus thorium (Mainwaring 1983, p.3). Monazite was not reported as being present by other investigators. The presence of uranium and thorium in the suspected monazite requires additional analytical work. Table 4 gives microprobe analyses of possible monazite reported by Mainwaring (1983). These data were originally described as representing apatite by Mainwaring (1983). The author of the present report reexamined the analyses and noticed the low content of calcium, which is much too low for apatite. Grains 1, 2, and 3 could be monazite but this should be confirmed by X-ray diffraction techniques. Incomplete analyses of grains 4, 5 and 6 prevent mineral identification.

Table 4: Microprobe analyses of possible Monazite - (compiled from Mainwaring 1983)

Weight % of Oxides in Grains Analysed

Oxide Grain No.	1	2	3	4	5	6
P_2O_5	29.59	28.51	30.11	24.52	27.34	24.76
CaO	0.10	1.86	2.81	3.22	3.19	8.31
Al_2O_3	0.00	0.00	0.00	0.27	0.08	0.12
La_2O_3	26.10	16.05	27.33	13.43	16.47	2.90
Ce_2O_3	30.52	29.63	19.95	21.03	21.60	7.27
Pr_2O_3	10.64	7.54	11.37	7.00	7.96	1.57
Nd_2O_3	6.07	8.28	6.76	8.82	9.77	4.11
TiO_2	0.00	0.00	0.00	0.00	0.00	0.13
ZrO_2	0.41	0.61	0.48	0.91	0.89	0.42
Total	103.46	92.50	98.84	79.24	87.32	49.63
U + Th	?	?	?	?	?	approx. 50%

Sample from hole 61, depth 104.18 to 105.52 m

Phlogopite (biotite)

Micas are abundant in the weathered carbonatite. In the least weathered samples they have been optically identified as phlogopite. The phlogopite is commonly altered and replaced by iron oxides.

Hart (1983, p.22,23) reports that phlogopite is up to 2 mm in maximum size, light brown to colourless and not extensively altered to goethite (Hart 1983, p.23). It is randomly oriented, commonly associated with barite, carbonate, and goethite and was identified by X-ray diffraction techniques (Hart 1983, p.23). Large green brown mica grains, possibly a different variety of mica or altered phlogopite, display kinked (001) cleavages, expansion along cleavage planes, and are extensively altered to goethite (Hart 1983, p. 26,44). The presence of phlogopite was confirmed by Gittins (1981).

Pyrite

Hart (1983, p.45) reports the uncommon presence of pyrite in the consolidated residuum as euhedral grains less then 0.01 mm in size. The pyrite occurs with francolite and is uncommon in fractures associated with magnetite, goethite and hematite (Hart 1983, p.45). The pyrite appears to be a secondary mineral.

In the lower part of the weathered horizon pyrite occurs in quantities of less than 1% and is common in grains up to 1mm (Hart 1986, p.33). Small grains, up to 2mm occur throughout the weathered carbonate zone, and larger grains occur in fractures associated with barite, carbonate and iron oxide, (Hart 1983, p.33).

Large pyrite grains may contain inclusions of rounded titanomagnetite and carbonate (Hart 1983, p.33).

<u>Pyrochlore</u>

Pyrochlore is the dominant niobium-bearing mineral within the residuum and is a primary mineral concentrated by the weathering process.

Hart (1983, p.30) reports that the pyrochlore occurs as irregular anhedral grains ranging in size from 0.01 to 1.5 mm. In plane light the pyrochlore grains range from light green to deep orange in colour with darker cores and lighter rims (Hart 1983, p.30). Hart (1983, p.30) reports that the pyrochlore is associated with pyrite. Pyrite occurs as inclusions in pyrochlore, and replaces pyrochlore along growth planes. The pyrochlore rarely encloses titanomagnetite and the identity as pyrochlore was confirmed by X-ray diffraction techniques (Hart 1983, p.30).

In the more deeply weathered residuum Hart (1983, p.43) reported the pyrochlore grain size to be 0.5 to 4.0 mm and that the grains were fractured. The pyrochlore contain inclusions of francolite, hematite and goethite (Hart 1983, p.43). The rounding and fracturing of the pyrochlore was interpreted to be the result of mechanical breakdown of the pyrochlore due to weathering (Hart, p.43). In contrast with the deeper part of the weathering profile, pyrite does not occur with pyrochlore in the deeply weathered upper portion of the residuum (Hart 1983, p.43). Hart (1983, p.43) reports that pyrochlore may exist as a remobilized phase in association with goethite and francolite.

Wyslouzil and Gochnaeur (1983) report that pyrochlore occurs in crystals from less than 10 to more than 900 microns and Mainwaring (1983, p.2) reports a maximum grain size of 300 microns in size. Mainwaring (1983, p.2) observed the pyrochlore to be associated with hematite and apatite. The pyrochlore is zoned with the main elemental variation being the replacement of Ca + Na by Sr, Ba and rare earth elements. Mainwaring (1983, p.2) did not describe the nature of this zoning. Microprobe data obtained by Mainwaring (1983) on pyrochlore is given in Table 5.

The microprobe data for most grains is incomplete. For those grains whose totals are 97.0 percent or greater the pyrochlore identity can be established, however the remaining grains require additional data. Assuming that the identification of the mineral as pyrochlore is correct the report data suggest up to 10 to 15 percent U + Th in some grains. However the grains were not analysed for uranium and thorium and reports on file in AFRO (Toronto) indicate that the Martison pyrochlore contains little uranium and thorium. The presence of titanium is indicated in samples 19, 20, 21, and 22 but the basis for determining its presence was not indicated. Analysis for F and OH were not done and are required for proper classification of pyrochlore.

Tantalum is not abundant in the pyrochlore but zirkelite a zirconium-bearing pyrochlore was identified (Mainwaring 1983, p.3).

The residuum is overlain in several areas by unconsolidated sediments thought to be Cretaceous in age. Fisher (1982b) first reported the possible presence of Cretaceous sediments after completion of the first drill testing of the residuum. In 1985, Potapoff described the pre-glacial material as a narrow layer of non-calcareous clay up to 2.0 m thick. The clay varies in colour from buff, brownish grey, greyish green, brown, red, dark blue and black (Potapoff 1985). Where underlain by residuum the clay may contain inclusions of phosphate and in one small area below the clay there is a soft coal-like black carbonaceous silt possibly a paleosoil that contains black silicified and pyrite-replaced wood fragments (Potapoff 1985). In two areas Potapoff (1985) reports that clean relatively pure silica sand is interbedded with the clays. The carbonaceous paleosoil and silica sands suggest that Cretaceous sedimentation and vegetation matter covered the area prior to glaciation and after formation of the upper part of the residuum (Potapoff 1985).

Ford (1986) suggests that the sediments overlying the residuum are correlative with the Mattagami Formation of Late Early Cretaceous age.

Cenozoic

Pleistocene

The residuum or Cretaceous sediments are now overlain by a thick section of glacial sediments. These glacial sediments consist of dense clay-rich tills with layers of gravel and sand (Fisher 1982b). At the conclusion of the latest exploration efforts on the Martison Carbonatite Complex Potapoff (1985) described the glacial deposits as grey calcareous clay till of silt size particles with up to 20 percent limestone and dolomite fragments. The fragments vary in size from grains a fraction of a millimeter in size to boulders over 1 m in diameter (Potapoff 1985). Potapoff (1985) reported that the till is very hard and dry and as long as it remains dry it behaves like consolidated material. There are discontinuous lenses of sand and gravel up to several meters thick covering areas of several hundreds of square metres within the till (Potapoff 1985). Potapoff (1985) reports that directly below the organic debris at the surface there is a grey calcareous silty to pure clay layer several metres thick. The glacial till deposits vary from 30 to 90 m in thicknesses (Potapoff 1985).

Recent

The area covering the Martison Carbonatite Complex is swampy and covered by vegetation. From the surface down the upper part of the recent deposits consist of decayed trees and peat moss and a bottom half of black peat (Potapoff 1985). These recent deposits vary from 0.5 to 4.0 m and average approximately 2.0 m thick (Potapoff 1985).

Structural Geology

Structure within the primary carbonatite is poorly known due to the lack of outcrops and the lack of drilling into fresh carbonatite. On the basis of examination of least altered carbonatite material a vertical to sub-vertical banding or mineralogical layering is expected. Fisher (1982b) suggested subvertical banding on the basis of drilling by Shell Canada Resources Limited.

The unweathered surface of the carbonatite likely is irregular and varies dramatically in topographic expression over short distances. Troughs, depressions and holes are likely at the surface in response to the development of karst-like structures on the carbonatite surfaces. These troughs, depressions and holes now contain the residuum of potential economic interest.

Zones of equigranular granoblastic coarse carbonate grains separated by zones of fine-grained granoblastic elongate carbonate grains are observed in some thin sections. This implies some deformation within discreet bands in the carbonatite. Since drilling has not penetrated deeply into the carbonatite and evidence exists for some weathering even in the freshest samples, perhaps development of some of this texture is the result of solution, collapse and recrystallization in the near surface environment. The granoblastic elongate texture within the carbonate is interpreted to be the result of movement and recrystallization but it is unknown whether this represents a near surface feature related to the development of Karst-like features or a deeper feature related to tectonic activity.

The aeromagnetic interpretation by Allan Spector and Associates Limited for Camchib Resources Incorporated suggests the complex is cut by a number of equally spaced northwest-trending faults. An interpreted northeast-trending fault passes just south of subcomplex "B" (AFRO, Toronto) and is on trend with the proposed extension of the Garden River Fault Zone. Faulting is important at the Cargill Township carbonatite and may have played an important role in development of the Cargill phosphate residuum. Indeed faulting may be essential for developing a residuum and development of karst-like surface features (Sage 1986).

Geophysics

Aeromagnetic maps published by the ODM-GSC (1967) were the first public record of geophysical data showing circular magnetic anomalies in the area (Figure 4). Three closely spaced aeromagnetitic anomalies were identified which on the basis of one uncompleted drill hole in 1965 were referred to as the Martison Lake carbonatite (Satterly 1970) (Figure 2). These three aeromagnetic anomalies are shown as subcomplexes "A", "B" and "C" on Figure 3.

In 1981 just prior to drilling the discovery holes locating the Martison carbonatite residuum, Kenting Earth Sciences Limited completed a detailed aeromagnetic and electromagnetic survey of the property for Shell Resources Canada Limited (Wilson 1981). The surveys were flown at a line spacing of 200 metres with a terrain clearance of 30 to 60 metres (Wilson 1981). The aeromagnetic survey clearly outlined the three subcomplexes (AFRO, Toronto). Subcomplex "A", the largest, is approximately 4.5 km in diameter, subcomplex "B" approximately 2 km in diameter and anomaly "C" approximately 1.5 km in diameter (AFRO Toronto). The anomalies may indicate carbonatite complexes with surface areas approximating 19.0 km^2, 3.1 km^2 and 1.7 km^2, respectively. Subcomplex A is outlined with isomagnetic contour relief of approximately 1,200 gammas over regional values of approximately 60,800 gammas (AFRO, Toronto). Subcomplex "B" has magnetic relief of approximately 2,000 gammas and subcomplex "C" approximately 1200 gammas (AFRO, Toronto). The geophysical survey cannot be used to distinguish whether there is one carbonatite complex wherein concentrations of magnetic minerals break the isomagnetic contour pattern into three smaller circular patterns or whether there are three distinctly separate carbonatite intrusions. The geophysical data suggest that the complex is one of the larger carbonatite complexes in the world.

The aeromagnetic survey interpretation by Allan Spector and Associates Limited for Camchib Resources Limited suggests the presence of numerous, roughly equally spaced northwest striking faults (AFRO, Toronto). A northeast-striking fault was interpreted to be present south of subcomplex "B" (AFRO, Toronto). These proposed faults have not been confirmed.

Estimates of depth to bedrock based on the interpretation of aeromagnetic data by Allan Spector and Associates Limited have proven reasonable (Potapoff 1983).

Shell Canada Resources Limited completed seismic refraction and DC resistivity surveys along a picket line between holes 81-03 and 81-04. The Surveys were undertaken to locate and determine residuum thickness (Fisher 1982b). The seismic refraction survey, however, disclosed only two layers, the base of the muskeg at 4 m and top of the bedrock (Fisher 1982b). There is insufficient velocity contrast to detect the overburden/residuum contact (Fisher 1982b). The seismic refraction survey did disclose considerable relief on the bedrock surface (Fisher 1982b).

The aeromagnetic survey has proven to be the only useful geophysical technique for locating possible residuum but magnetic relief reflects different features not all of which are residuum related (Fisher 1982b). Fisher (1982b) reports that in hole 82-08 the magnetic anomaly is due to magnetite in the bedrock (residuum absent), in hole 82-27 it is related to a layer of magnetite sand within the residuum, and in hole 82-26 the magnetite is present in clay layers within the residuum. While helpful, the presence or absence of a residuum cannot be confidently predicted on the basis of aeromagnetic data.

Recommendations for Future Study

In spite of the completion of a great deal of exploration work on the Martison Carbonatite Complex a great deal remains to be investigated.

A pollen age is needed so that the assumed equivalent Cretaceous age for the Martison residuum to the Cargill Township carbonatite residuum can be firmly established.

Detailed mineralogical study of the secondary and primary mineralogy is desirable so that the petrology of the carbonatite can be modeled and conditions of residuum development be established. Existing mineralogical studies are largely incomplete or were completed on a very small sample population.

Isotopic study and age dating of the primary carbonatite should be undertaken as soon as suitable sample material becomes available.

The regional structural setting is largely unknown and is unlikely to be resolved unless detailed regional geophysics can be completed. The lack of outcrop means that geophysical methods are the only viable means of determining regional structure.

It is unknown whether the three subcomplexes "A", "B" and "C" described above represent 3 independent alkalic rock-carbonatite intrusions or two, or just one.

Economic Geology

The apatite-pyrochlore residuum found at the Martison Carbonatite Complex may be one of the world's largest such accumulations(Sage 1986, p.149-152). The extent of these residuum deposits remains to be completely defined.

The search in Ontario for phosphate deposits resulting from the weathering of carbonatite was instigated by the International Minerals and Chemical Corporation in approximately 1974. The model employed by the company was one in which weathering of a carbonatite will develop karst-like features as would develop in a sedimentary limestone terrain (Sandvik and Erdosh 1976). The development of karst-like features on the surface of a carbonatite results in deep troughs and holes filled with resistant minerals as the carbonate minerals are dissolved. These troughs may be narrower than they are wide, steep-sided and contain unweathered blocks of carbonatite. Faulting or extensive development of a joint system may be essential to the development of a karst-like surface on a carbonatite complex (Erdosh 1979, Sage 1986). In the case of the Cargill

Township and Martison Carbonatite Complexes, which have been emplaced into a granitic terrain, groundwater movement would be inhibited without a through-going fault/fracture system.

The development of the karst model was based on observations on the Sokli carbonatite in northern Finland where a phosphatic residuum was developed on a carbonatite complex in a temperate climate (Paaema 1970). In 1979 Vartiainen and Paaema completed a more detailed study of the Sokli carbonatite which indicated a number of characteristics which are similar to those observed at the deposits. The Sokli residuum that is is referred to as an apatite-francolite residuum generally brown in colour due to the presence of secondary iron oxides (Vartiainen and Paaema 1974). Vartiainen and Paaema (1974) report the presence of a black manganese-rich residuum at Sokli which has so far not been found at either Cargill or Martison.

In east Africa, the Sukula carbonatite complex has a thick residuum containing apatite, pyrochlore, magnetite, zircon and baddeleyite (Reedman 1984). The Sukula residuum appears similar to those found in Ontario but it also offers a potential for by-product magnetite, zircon and baddeleyite which do not appear to be concentrated within the Ontario residuum (Reedman 1984).

The residuum presents resistant mineral concentrations that vary from 10 to 15 times that found within primary carbonatite and may under the right market conditions be economic.

Drilling and exploration at the Martison Carbonatite Complex has not penetrated fresh carbonatite to any degree so the economic viability of the fresh carbonatite is unknown.

At the Cargill Township carbonatite, a narrow crandallite-rich layer occurs at the contact of the residuum with the overlying pre-glacial sediments (Kelley 1984). This zone is enriched in uranium, niobium, and rare earth element values. Preliminary testing at the Martison Carbonatite Complex in Camchib Resources Incorporated holes 38, 39, 49, 56, 59, 60, and 61 suggest that a crandallite layer may exist in some areas of the Martison residuum but it is not nearly as well developed as at the Cargill Township carbonatite (Camchib Resources Incorporated, private records, 1988, Kelley 1984).

At the conclusion of the Shell Canada Resources Limited program, reserves were estimated at 140,000,000 tons grading 20 percent P_2O_5 (Vos 1982). The most recent estimate of grade and tonnage for all classes of material available total 145,400,000 tons grading 20.1 percent P_2O_5 and 0.35 percent Nb_2O_5 (Potapoff 1985). The most recent estimate includes the results of the last work completed on the complex.

Property Descriptions

Uranium Ridge Mines Limited, Falconbridge Nickel Mines Limited, Matachewan Consolidated Mines Limited (1965)

In 1965, a consortium of Uranium Ridge Mines Limited, Falconbridge Nickel Mines Limited, and Matachewan Consolidated Mines Limited completed one diamond drill hole to 166 m (544 feet) (AFRO, Toronto). This hole failed to encounter bedrock but passed through abundant magnetite sand and from 109 to 166 m (358 to 544 feet) (AFRO, Toronto). At 109 m (358 feet) the hole passed through a boulder identified as a carbonatite by the consortium and the drill results were interpreted to indicate the presence of a weathered zone above a carbonatite complex (Satterly, 1970). The weathered residuum was recognized to contain oxidized titaniferous magnetite and a hydrous basic phosphate, which possibly resulted from the breakdown of primary apatite (AFRO, Toronto). No further work was reported.

Soweska Claim Group

In 1968, 98 claims were staked over subcomplex "A" and a helicopter aeromagnetic survey completed (Gledhill 1968). Subcomplex "A" was interpreted to be a carbonatite and drilling recommended (Gledhill 1968). There is no record of work being completed (AFRO, Toronto).

Selco Mining Corporation Limited

Selco Mining Corporation Limited completed 5 diamond drill holes 1980, 1982 in widely separated areas outside the known limits of the Martison Carbonatite Complex. This drilling was completed in search of kimberlite and disclosed a number of diatreme structures representing manifestations of alkalic magmatism (AFRO, Toronto). The relationship of these diatremes to the Martison Carbonatite Complex is unknown but the diatremes are believed to represent a much younger event since similar intrusions are known to intrude Paleozoic rocks in other portions of the region (AFRO, Toronto).

To the east, hole 42J/6-12-1 85.3 m (280.0 feet) intersected ultrabasic breccia, hole 42J/6-12-2 58.8 m (193.0 feet) intersected brecciated carbonatite and hole 42J/6-11-1 102.7 (337.0) intersected diatreme breccia (AFRO, Toronto). Southwest of the Martison carbonatite, Selco Mining Corporation Limited drill hole 42J/6-17-1 110.0 m (361.0 feet) encountered ultramafic breccia and north of the carbonatite drill hole 42J/6-9-2 100.0 m (328.0 feet) (not shown) encountered kimberlitic breccia (AFRO, Toronto).

The work by Selco Mining Corporation Limited indicates widespread manifestations of alkalic rock magmatism and established the possibility of two alkalic magmatic events widely separated in time. The company selected its targets on the basis of regional aeromagnetic surveys (AFRO, Toronto). The airborne magnetic anomalies are generally strong and from 300 to 500 m in diameter (AFRO, Toronto).

Shell Canada Resources Limited (1980-1982)

In 1979, Sage recommended drilling the Martison Carbonatite Complex in search for residual apatite and pyrochlore deposits. This recommendation was based on the results of the drill hole completed by Uranium Ridge Mines Limited, Falconbridge Nickel Mines Limited and Matachewan Consolidated Mines Limited on subcomplex "B" in 1965 indicating the presence of a carbonatite residuum and on the success of exploration efforts by the International Minerals and Chemical Corporation at the Cargill Township carbonatite in outlining a phosphate residuum of potential economic interest (Sandvik and Erdosh 1977). All indications were that the Cargill model could be applied to the Martison Carbonatite complex.

In 1980, Mr. Dave Fisher, Geologist, Shell Canada Resources Limited, proposed a program of drill testing the Martison Carbonatite Complex for residuum deposits.

The company completed an airborne magnetic and electromagnetic survey of the Martison Carbonatite Complex and completed 5 reverse circulation drill holes (Wilson 1981, Fisher 1982a). The drilling totaled 554.0 m and all holes except 8008-81-02 encountered phosphate-rich residuum.

As a result of positive drill results in 1981, the company launched a major exploration effort in 1982. The company completed 37 drill holes all but 3 of which were by reverse circulation, (Fisher 1986). The company completed 2953.34 m of drilling (AFRO, Toronto).

The company completed a seismic refraction survey and DC resistivity survey between drill holes 81-03 and 81-04 (Fisher 1982b) The surveys were run to determine if these techniques could be used to determine residuum thickness (Fisher 1982b). Fisher (1982b) reports that there is insufficient velocity contrast and insufficient resistivity contrast for either method to be used to determine the overburden-residuum contact.

Using samples from 3 sonic holes 82-32, 82-34 and 82-36, the company completed preliminary beneficiation tests and determined that it was likely possible to produce phosphate and niobium concentrates of commercial interest (Fisher 1982b).

All of the 1982 work was in subcomplex "A" with the exception of hole 13 in subcomplex "C". Hole 13 encountered carbonatite bedrock but no residuum (AFRO, Toronto)

Camchib Resources Incorporated (1982-present)

In late 1982 the Martison carbonatite property was acquired jointly by Camchib Resources Incorporated and Eastern Petroleum Corporation as Shell Canada Resources Limited closed its minerals operations (Potapoff 1983).

In 1983 Camchib Resources Incorporated completed 2,781.8 m of drilling in 29 holes, mostly by sonic drilling techniques (Potapoff 1983). This 1983 drilling included holes 83-38 to 83-66 (Potapoff 1983).

The company re-interpreted the airborne geophysical survey completed by Shell Canada Resources Limited, and contracted a geotechnical study of the unconsolidated overburden and residuum, a hydrological study of the ground water, and a geochemical study of the surface waters (Potapoff 1983). The surface waters survey did not detect elements of economic interest (Potapoff 1983).

The company completed some preliminary beneficiation tests (Potapoff 1983).

Camchib Resources Incorporated examined the residuum-pre-glacial contact for a uranium enriched crandallite layer in 1983 (AFRO, Toronto). The company tested holes 38, 39, 49, 56, 59, 60, and 61 and obtained U_3O_8 values ranging from less than 0.001 percent to 0.043 percent U_3O_8 (AFRO, Toronto). The data suggests the presence of a crandallite layer but one that is much poorer in development than the one reported by Kelley (1984) at the Cargill Township carbonatite.

In 1984, the company completed 33 drill holes from 84-67 through 84-99 using sonic and NQ diamond drilling techniques. (Potapoff 1984b). Drilling totalled 2,815.8 m and was completed as fill-in drilling in Subcomplex "A" (Potapoff 1984b). The company attempted to complete two 48-inch diameter holes for a bulk sample but one hole was abandoned (Potapoff 1984b). A 45 ton bulk sample was obtained and metallurgical bench and pilot plant tests conducted on P_2O_5 and Nb_2O_5 recovery (Potapoff 1984b). The metallurgical tests were considered successful in producing commercially viable phosphate and niobium concentrates (Potapoff 1984b).

Recommendations to the Prospector

In spite of extensive drilling, the limits of the residuum are poorly defined. Additional drilling of Subcomplex "B" is needed to outline the residuum located here and additional drilling on Subcomplex "C" is needed before the absence of a residuum can be positively established there. Selected drilling of Subcomplex "A" remains to be completed so that the residuum limits can be better defined. Due to the rapid change in bedrock relief the residuum thickness is likely to vary considerably between relatively closely spaced holes and some holes may even fail to encounter residuum.

The bedrock remains largely untested. Testing of the bedrock will be difficult since drilling vertical holes into an intrusion that is likely to display a subvertical internal structure is not likely to give meaningful results other than to identify the presence or absence of mineral phases. The primary minerals are likely to be concentrated in narrow vertical bands in the fresh carbonatite and unless drilling is completed across the anticipated banding, the location and delineation of mineralized zones will be difficult. The Martison Carbonatite Complex is large, thus any mineralized zone identified could have tonnage potential.

The residuum- pre-glacial sediment contact should be routinely checked for the presence of an uranium-niobium and rare earth element-rich crandallite layer. Perhaps the best area to look would be directly below the organic layers described by Potapoff (1985).

In addition to phosphorous and niobium, the residuum may have the potential to produce by-product zircon, magnetite, monazite and baddeleyite.

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Appendix A-1 - Petrographic Descriptions, Chemical Analyses, Normative Compositions, and Statistical Compositions of Lithologic Units of the Martison Carbonatite Complex.

TABLE A-1, PETROGRAPHIC DESCRIPTIONS OF WHOLE-ROCK SAMPLES FROM THE MARTISON CARBONATITE COMPLEX.

Reference No. 1595

Sample No. 83-42-65.00M

Sovite

Fine grained equigranular allotriomorphic granoblastic with curved to straight grain boundaries. Carbonate forms an interlocking mozaic of anhedral grains. Traces of apatite. Traces of magnetite. Iron oxide after magnetite and some grain boundaries are stained with iron oxide.

Reference No. 1596

Sample No. 83-42-64.15M

Phlogopite-Bearing Sovite

Fine grained equigranular allotriomorphic granoblastic with curved to straight grain boundaries. Minor phlogopite occurs as subhedral to euhedral grains which may enclose carbonate. Carbonate forms a mozaic of interlocking anhedral grains.

Reference No. 1597

Sample No. 83-40-78.22M

Apatite-Bearing Phlogopite, Sovite

Fine grained equigranular allotriomorphic granoblastic elongate with straight to curved grain boundaries. Apatite is present as elongated rounded crystals and as bladed masses. Apatite occurs in bands or as elongated aggregates. Phlogopite is present as subhedral to euhedral tabular crystals, commonly in clusters of crystals. Pyrochlore is present in trace amounts as euhedral to subhedral brownish grains. Pyrochlore may partially enclose carbonate grains. Carbonate forms a mozaic of interlocking anhedral grains. Traces of iron oxide.

Reference No. 1598

Sample No. 83-60-90.8M

Apatite, Sovite

Fine grained equigranular hypidiomorphic granoblastic with curved to straight grain boundaries. Apatite is present as euhedral prismatic crystals. Traces of phlogopite with iron oxide along grain boundaries and cleavages. Traces of magnetite. Traces of iron oxide along some carbonate grain boundaries. Carbonate grains form an anhedral interlocking mozaic. Some iron oxide staining along rhombohedral twin planes of carbonate.

Reference No. 1599

Sample No. 83-40-73.48M

Apatite-Bearing Sovite

Fine grained equigranular allotriomorphic granoblastic with curved to straight grain boundaries. Minor apatite as elongated rounded grains and bladed aggregates. Carbonate forms an anhedral mozaic of elongated grains. Traces of iron oxide.

Reference No. 1600

Sample No. 83-40-77.34M

Magnetite, Phlogopite Silicocarbonatite

Fine grained inequigranular seriate hypidiomorphic granoblastic with straight to curved grain boundaries. Phlogopite occurs as tabular subhedral to euhedral grains with some chloritic alteration and secondary iron oxides along (001) cleavages. Magnetite occurs as euhedral to subhedral crystals which may enclose phlogopite. Carbonate is anhedral forming an interlocking mozaic of grains. Secondary iron oxides along some grain boundaries. Traces to minor quantities of euhedral pyrochlore possibly weakly weathered.

Reference No. 1601

Sample No. 83-52-99.50M

Apatite Sovite

Fine to medium grained equigranular hypidiomorphic with curved to straight grain boundaries. Apatite forms euhedral prismatic crystals. The carbonate occurs as a mozaic of interlocking anhedral grains. Traces of magnetite and phlogopites. Very fresh rock with good igneous texture.

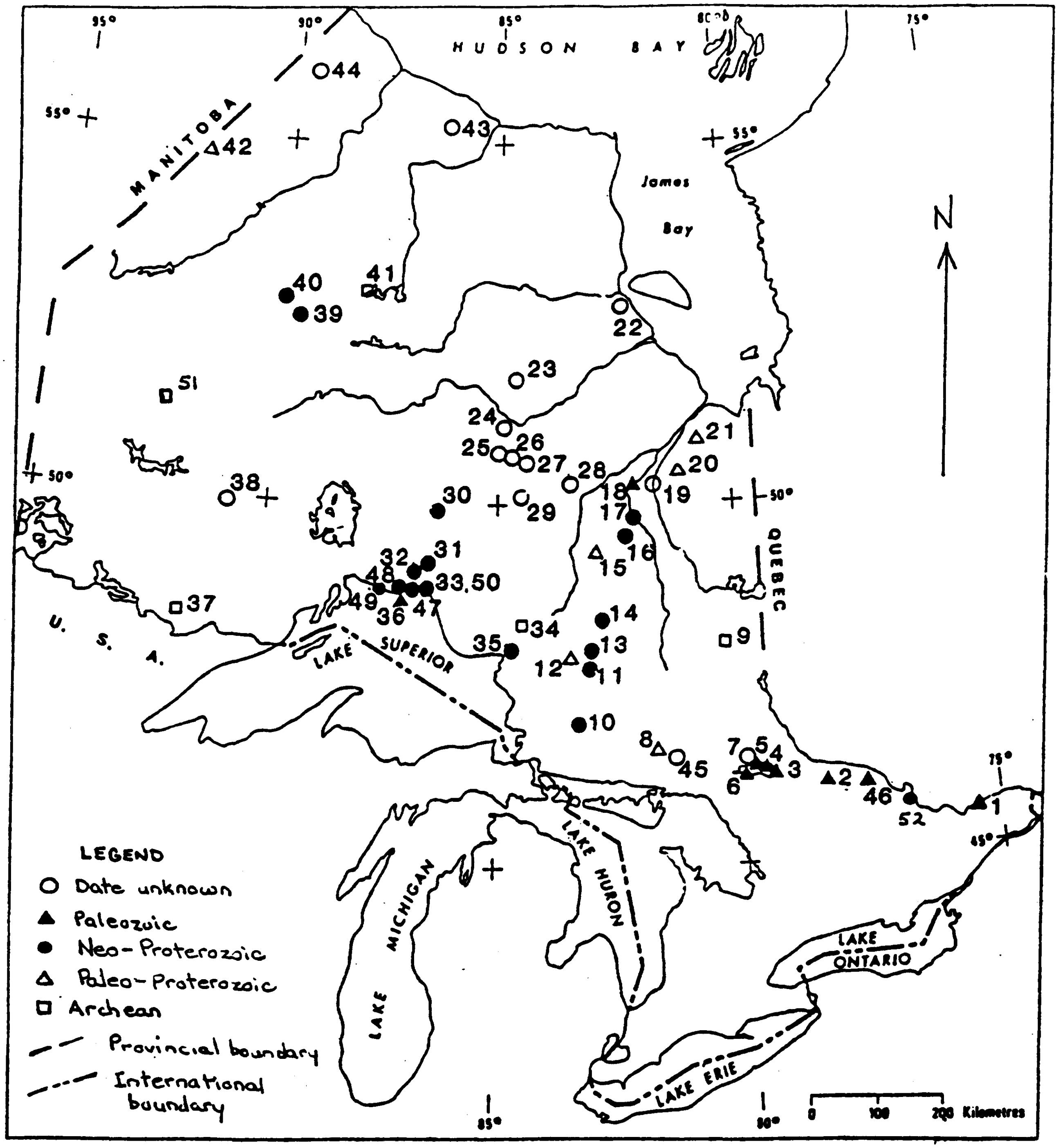

HUDSON BAY
MANITOBA
James Bay
QUEBEC
U. S. A.
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
LAKE ERIE
N
LEGEND
Date unknown
Paleozoic
Neo-Proterozoic
Paleo-Proterozoic
Archean
Provincial boundary
International boundary
0 100 200 Kilometres

Fig.1.

LIST OF FIGURES AND CAPTIONS

Figure 1: Location of magmatic events, Superior Province and nearby areas in Ontario - alkalic-carbonatite complexes, aeromagnetically inferred alkalic complexes and fenites.

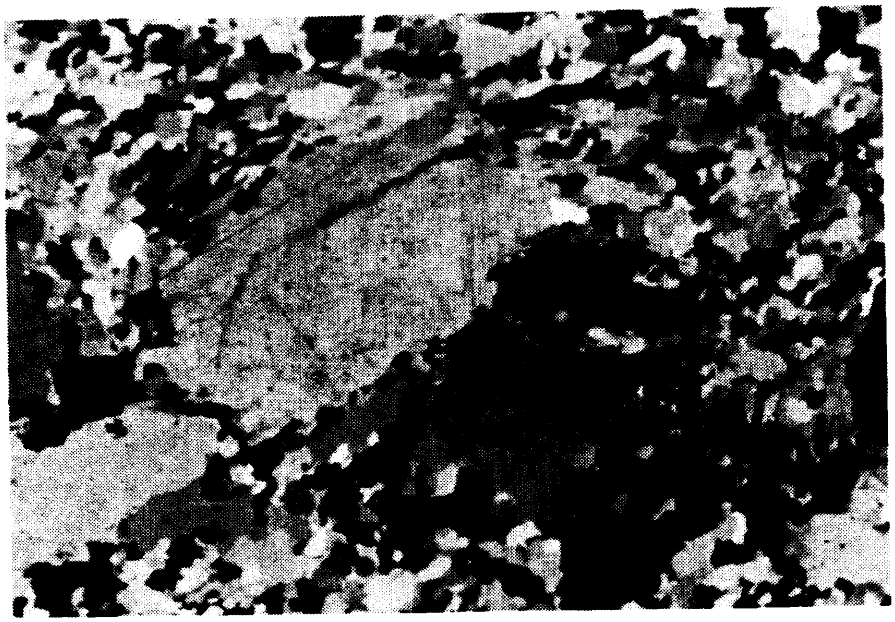
1. Eastview carbonatite(s)
2. Brent Crater
3. Callander Bay carbonatite
4. Manitou carbonatite
5. Burritt Island carbonatite
6. Iron Island carbonatite
7. Lavergne carbonatite
8. Spanish River carbonatite
9. Otto alkalic complex
10. Seabrook Lake carbonatite
11. Lackner Lake alkalic carbonatites
12. Borden Township carbonatite
13. Nemogosenda Lake alkalic complex
14. Shenango Township alkalic rock
15. Cargill Township carbonatite
16. Teetzel Township carbonatite
17. Clay-Howells alkalic complex
18. Hecla-Kilmer alkalic complex
19. Valentine Township carbonatite
20. Goldray carbonatite
21. Argor carbonatite
22. Lawashi River aeromagnetic anomaly
23. Poplar River aeromagnetic anomaly
24. Albany Forks carbonatite
26. Little Drowning River aeromagnetic anomaly
26. Kingfisher River West aeromagnetic anomaly
27. Kingfisher River East aeromagnetic anomaly
28. Martison carbonatite
29. Nagagami River alkalic complex
30. Chipman Lake fenites and carbonatite dikes
31. Killalla Lake alkalic complex
32. Prairie Lake carbonatite
33. Port Coldwell alkalic complex
34. Herman Lake alkalic complex
35. Firesand River carbonatite
36. Slate Islands diatremes
37. Poohbah Lake alkalic complex
38. Sturgeon Narrows alkalic complex
39. Schryburt Lake carbonatite
40. Big Beaver House carbonatite
41. Wapikopa River alkalic complex
42. Carb Lake carbonatite
43. Gooseberry Brook aeromagnetic anomaly
44. Niskibi Lake aeromagnetic anomaly
45. Nemag and Lusk Lake fenites

46. Allen Lake carbonatite
47. Dead Horse Creek diatreme
48. McKellar Creek diatreme
49. Gold Range diatreme
50. Neys diatreme
51. Springpole Lake
52. Sullivan Island


4300
4200
4300
5000
4800
4500
4500
NETIC
4200
4300
4200
223 A
4300
4800
4500
215
216 A
220
221 A
225
25'

Figure A:

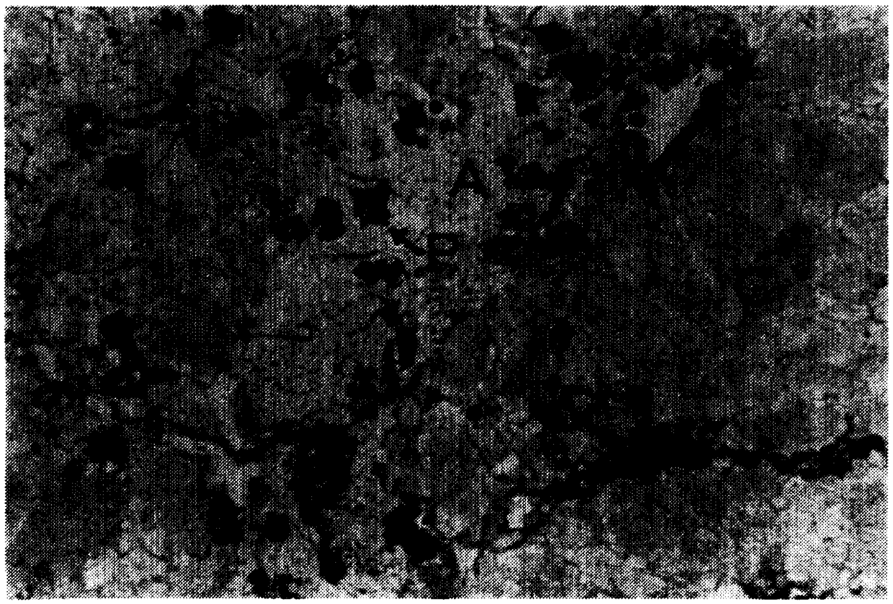
Photograph 1 Porphyroclastic carbonate grains in fine grained granoblastic carbonate. Magnification 16X, crossed polars. Photograph by A. Lisowyk, sample 1597.



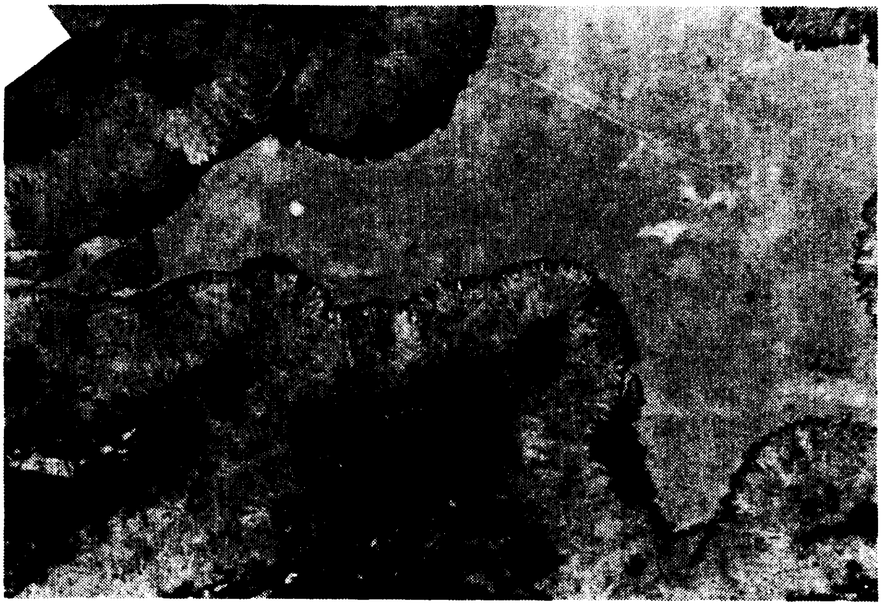
Photograph 2 Foliated (elongated carbonate grains) carbonatite. Elongated porphyroblasts set in a granoblastic elongate matrix of carbonate. Magnification 10X, crossed polars. Photograph by A. Lisowyk, sample 1599.

Photograph 3 Prismatic apatite (A) grains with pyrochlore (P) filling fracture in granoblastic carbonate (C). Magnification 20X, crossed polars. Photographed by A. Lisowyk. Sample collected by M.J. Ford.

Photograph 4 Euhedral pyrochlore (P) in association with apatite (A) occupying fracture in granoblastic carbonate (C). Magnification 20X, uncrossed polars. Photograph by A. Lisowyk.



Photograph 5 Radiating francolite projecting into open space in consolidated residuum. Magnification 16X, crossed polars. Photograph by A. Lisowyk. Sample collected by M.J. Ford.



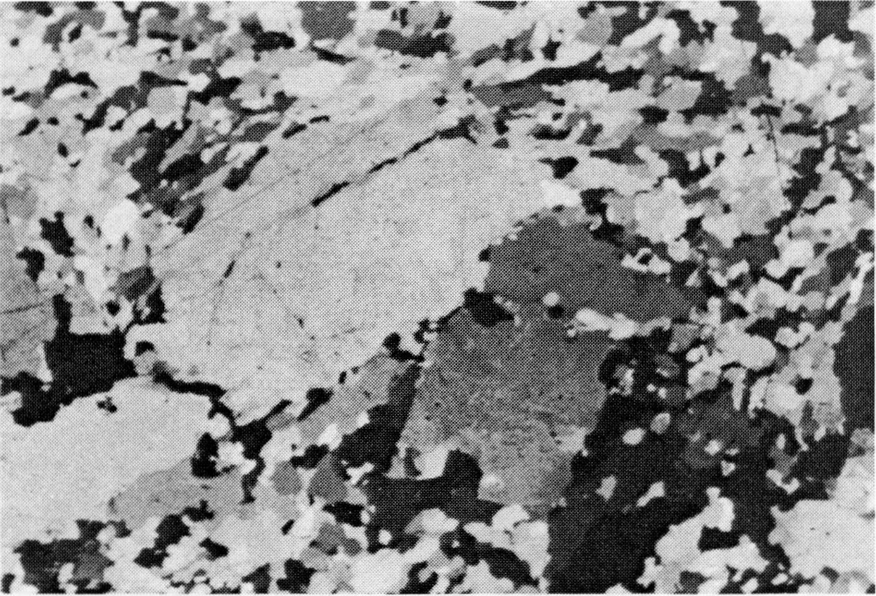
CONVERSION FACTORS FOR MEASUREMENTS IN ONTARIO GEOLOGICAL SURVEY PUBLICATIONS

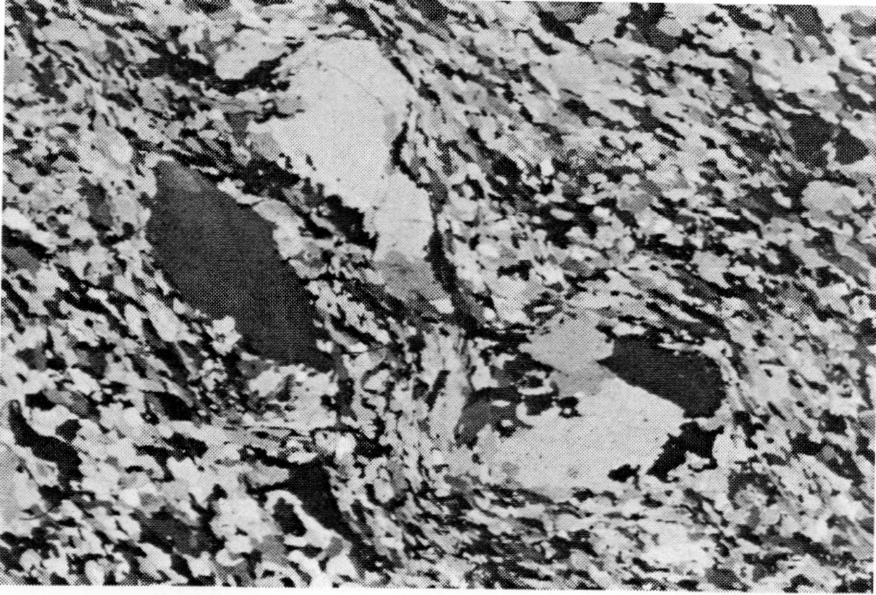
Conversion from SI to Imperial			Conversion from Imperial to SI		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
			LENGTH		
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709 7	chains	1 chain	20.116 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

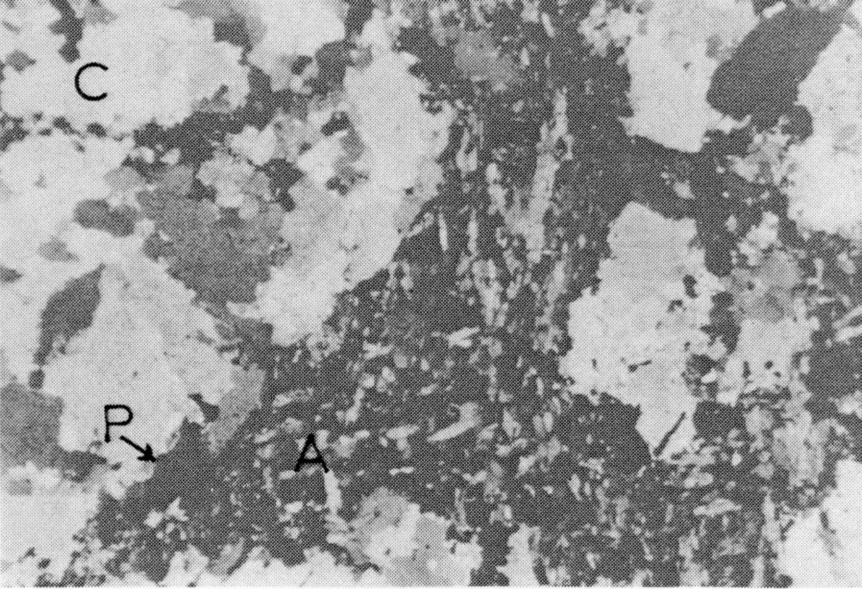
OTHER USEFUL CONVERSION FACTORS

	Multiplied by	
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 co-operation with the Coal Association of Canada.



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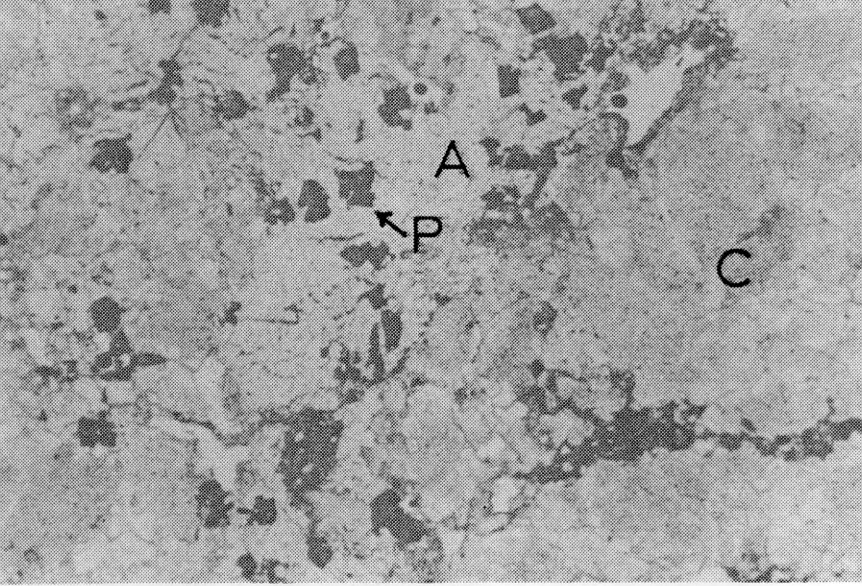
A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