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Field guide to the Oka area, description and itinerary

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GOUVERNEMENT DU QUÉBEC
DEPARTMENT OF NATURAL RESOURCES
MINES BRANCH
GEOLOGICAL EXPLORATION SERVICE

FIELD GUIDE

to the

OKA AREA

Description and Itinerary

by

D.P. Gold and M. Vallée

QUÉBEC

1969

QUEBEC DEPARTMENT OF NATURAL RESOURCES

Honorable PAUL-E. ALLARD, Minister

MINES BRANCH

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THE OKA AREA

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GENERAL GEOLOGY

Until recently, the Oka area probably has been better known for the cheese produced at the La Trappe Monastery than for its unusual and rare minerals and rocks. Despite early reports (Gauthier, 1917; Stansfield, 1923; Grimes-Graeme, 1935) of rare melilite-bearing rocks and crystalline limestone in this area, its potential as a mineralogical and petrological curiosity was not realized until the discovery in 1952 of radioactive and rare earth minerals. Some 72 different minerals have been found here, and the carbonate and alkaline rocks form an association constituting a "Carbonate Complex".

The Complex is about 20 miles west of Montreal on the north shore of Lake of Two Mountains, and forms a shallow depression $4\frac{1}{2}$ miles long by $1\frac{1}{2}$ miles wide among the Oka Hills. These hills rise to a height of 700 feet above the St. Lawrence Lowlands as an inlier of Precambrian rocks, about 10 miles in diameter, along the axis of the Beauharnois arch (a broad northwest trending arch which extends from the Adirondacks to the Laurentians). The regional structural trend of the hills is northeast, and a topographic divide separates anorthosites of the Morin Series, which underlie the northwestern sector, from folded paragneisses of the Grenville Series in the southeastern sector. Crystalline carbonate and feldspathoidal-bearing silicate rocks of the Oka Complex intrude the Precambrian rocks as a double ring structure. The long axis of the Complex is almost perpendicular to the regional structure and coincides with the axis of the Beauharnois arch. Parts of the Complex are overlain by as much as 400 feet of Pleistocene till and sediments deposited in the Champlain Sea.

Petrology

The rocks comprising the Oka "carbonatite and alkaline complex" may be divided into 5 main groups. Most of these rocks are undersaturated meta-aluminum rocks contemporaneous (100 m.y.) with the alkaline rocks of the Monteregeian Hills to the east.

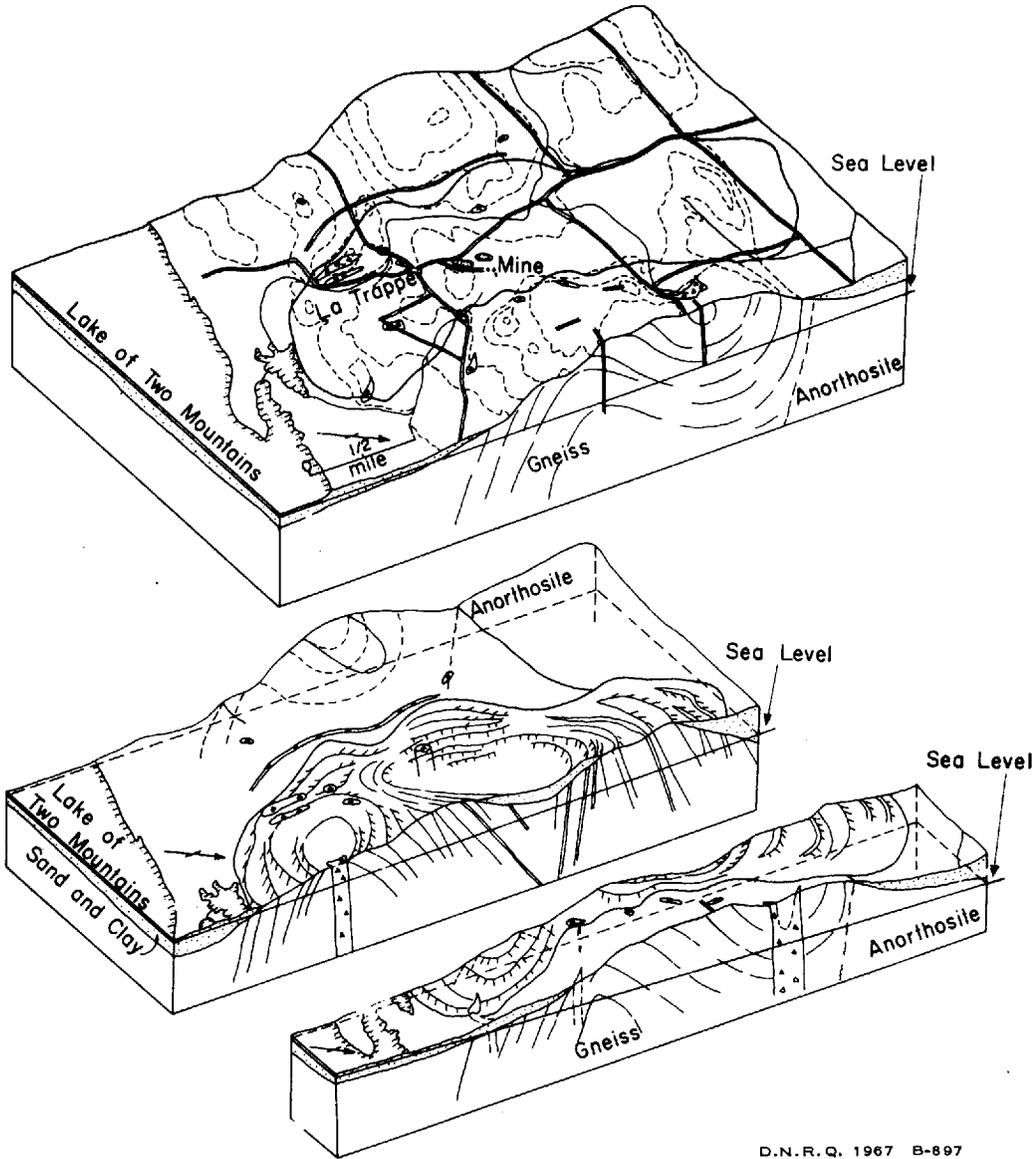
- 1) Carbonate rocks of at least 9 main types underlie more than half of the surface area of the Complex. These are classified on a mineralogical and/or textural basis. Most types are coarse grained and banded, and except for dolomitic varieties, calcite is the dominant mineral. Commonly one or more of the following minerals; sodian augite, biotite, magnetite, apatite, monticellite, melilite, pyrochlore, perovskite, niocalite, pyrite, pyrrhotite are present in minor or accessory amounts and impart a banded appearance to the rock.
- 2) Okaite-jacupirangite series. These consist of a gradational sequence from melilite-rich, through monticellite, nepheline, and hauynite-bearing varieties to titanaugite-rich rocks. In places, magnetite is abundant.
- 3) The Ijolite series includes all rocks consisting essentially of nepheline and sodian augite. These grade from melteigite (pyroxene-rich) through ijolite to urtite (nepheline-rich). In the southern part of the Complex, wollastonite- and melanite-bearing varieties are exposed.
- 4) Replacement and alteration rocks occur in zones or discontinuous bands throughout the Complex. Hydrothermal solutions apparently were the agent; the effect was to thoroughly biotitize any silicate rocks encountered. Locally, in sheared zones, the silicate minerals have been partly or completely altered to chlorite, and vugs of pyrite, galena, and calcite are present.
- 5) Alnoite and basic lamprophyre dikes and plugs are intruded into the Complex and its border in a remarkably regular pattern. Some of these are texturally and chemically similar to kimberlite.

Petrogenesis

In the southern ring, the outward-dipping litho-structural units are interpreted as ring-dikes. Outward dips in the peripheral zones of the northern ring are similarly interpreted, whereas the transgressive, inward-dipping bands, and core, could represent, respectively, cone-sheet intrusives and a central plug. These structural features and the regional structural settings are illustrated in Figure 1.

Figure 1

BLOCK DIAGRAM SHOWING THE STRUCTURAL RELATIONSHIPS OF THE OKA COMPLEX



D.N.R.Q. 1967 B-697

ISOMETRIC DIAGRAMS OF THE OKA COMPLEX (looking west)

In places, relict cores of quartzofeldspathic gneiss within the massive ijolite attest to ijolitization (pyroxenization) of the country rock. In these masses, carbonate rocks are clearly transgressive and intrusive. Elsewhere, ijolite dikes, some completely disrupted into boudins in a discontinuous planar array, demonstrate a late ijolite intrusive phase followed by movement in a somewhat mobile carbonatite (which has complicated considerably the interpretation of cross-cutting relationships).

The sequence of events envisaged is:

- 1) Fenitization of gneissic cover-rock, followed by emplacement of early carbonatite phase as dikes, and ring-dikes, and ijolitization of enclosed country rock. Peripheral juvite and urtite (particularly in the southern ring) may represent mobilized ultrafenites.
- 2) Intrusion of the okaite-jacupirangite rock series as crescentic-shaped masses and arcuate dikes.
- 3) Intrusion of the main pyrochlore carbonatite, followed by emplacement of the monticellite carbonatite.
- 4) Intrusion of ijolite and microijolite dikes, followed by solid state flow in the carbonatite to form boudins.
- 5) Soaking by hydrothermal solutions along cone-sheet type fractures, causing biotitization and enrichment by thorian pyrochlore.
- 6) Late white carbonatite dikes with pyrite, rare-earth carbonates (synchisite and parisite), and galena.
- 7) Late diabase and lamprophyre dikes.
- 8) Emplacement of alnoite and alnoite breccia pipes and dikes. Stages 5 to 8 may all be part of the same event.

The ring-dikes exhibit well defined patterns on the aeromagnetic maps: a vertical conduit of great vertical extent is consistent with the gravity data. A magmatic origin is proposed for most rock types, except some metasomatic ijolites and the fenites, associated with the Complex. Carbon, oxygen, strontium, and sulfur isotope ratios are typically similar to those from other carbonatites and kimberlites. The Oka Complex is similar to the Rangwe Carbonatite of a Pleistocene volcano in Kenya.

NOMENCLATURE

- ALNOITE - a lamprophyre containing biotite, olivine, augite, hornblende, and melilite with accessory apatite, perovskite and magnetite.
- ALNOITE BRECCIA - foreign inclusions in an alnoitic matrix.
- BRECCIA PIPE - polymict fragments in a comminuted country rock, calcite and chlorite matrix.
- CARBONATITE - rocks consisting mainly of carbonate minerals in an intrusive association.
- FENITE - metasomatically altered country rocks, usually accomplished by the addition of Ca, Mg, Na and the removal of Si and K.
- MELILITITES - silicate rocks containing melilite as an essential constituent. These include OKAITE (melilite with minor or accessory amounts of nepheline, hauynite, perovskite, apatite, biotite, magnetite and calcite); NEPHELINE OKAITE - (nepheline-rich okaite); MONTICELLITE MELILITITE (monticellite phenocrysts in a trachytic textured melilite matrix); HAUYNITE OKAITE (Hauynite-rich okaite).
- NEPHELINITES - silicate rocks consisting essentially of nepheline and soda-pyroxene. These are divided on a color basis, i.e. proportion of femic to salic minerals into URTITE, a leucocratic rock consisting predominantly of nepheline; IJOLITE, a mesocratic rock containing about equal proportion of nepheline and pyroxene; MELTEIGITE - a melanocratic rock composed of about 70% pyroxene and 30% nepheline.
- PYROXENITES - silicate rocks consisting essentially of pyroxene. These include JACUPIRANGITE and NEPHELINE-JACUPIRANGITE - melanocratic rocks consisting essentially of titanite with varying amounts of nepheline, and accessory magnetite, hercynite, apatite, calcite, and perovskite.
- REPLACEMENT ROCKS - the most common of these is the BIOTITE REPLACEMENT ROCK, a silicate rock now altered mainly to biotite crystals set in a calcite matrix and accompanied by very fine-grained pyrochlore.

MINERALS (General Chemical formulae mainly after Deer, Howie and Zussman, 1966. An Introduction to Rock Forming Minerals).

Carbonates

Calcite CaCO_3	Ancylite $4\text{Ce}(\text{OH})\text{CO}_3 \cdot 3\text{SrCO}_3 \cdot 3\text{H}_2\text{O}$
Dolomite $\text{CaMg}(\text{CO}_3)_2$	Parisite $(\text{CeLaDi})\text{F}_2\text{Ca}(\text{CO}_3)_3$
Siderite FeCO_3	Synchisite "
Magnesite MgCO_3	Strontianite SrCO_3

Silicates

Orthoclase KAlSi_3O_8	Forsterite MgSiO_3
Microcline "	Chrysolite $(\text{MgFe})\text{SiO}_3$
Albite $\text{NaAlSi}_3\text{O}_8$	Monticellite $(\text{CaMg})\text{SiO}_3$
Labradorite $4\text{NaAlSi}_3\text{O}_8 + 1\text{CaAl}_2\text{Si}_2\text{O}_8$	Serpentine $\text{Mg}_3(\text{Si}_2\text{O}_6)(\text{OH})_4$
Nepheline $(\text{NaK})\text{AlSiO}_4$	Melilite $(\text{CaNaK})_2(\text{MgFe}^2\text{Al})(\text{AlSi})_2\text{O}_7$
Hauynite $(\text{Na,Ca})_{4-8}(\text{Al}_6\text{Si}_6\text{O}_{24})(\text{SO}_4, \text{S})_{1-2}$	Biotite $\text{K}_2(\text{MgFe}^2)_{6-4}(\text{Fe}^3\text{AlTi})_{0-2}(\text{Si}_{6-5}\text{Al}_{2-3}\text{O}_{20})(\text{OH}, \text{F})_4$
Augite	Phlogopite $\text{K}_2(\text{MgFe}^2)_6\text{Si}_6\text{Al}_2\text{O}_{20}(\text{OH}, \text{F})_4$
Titanaugite } $(\text{CaNaMgFe}^2\text{MnFe}^3\text{AlTi})_2(\text{SiAl})_2\text{O}_6$	Vermiculite $(\text{MgCa})_{0-7}(\text{MgFe}^3\text{AlSi})_8\text{O}_{20}(\text{OH})_4\text{H}_2\text{O}$
Sodian augite }	Sericite $\text{K}_2\text{Al}_4(\text{Si}_6\text{Al}_2\text{O}_{20})(\text{OH}, \text{F})_4$
Diopside $2\text{CaMgSi}_2\text{O}_6$	Chlorite $(\text{MgAlFe})_{12}[(\text{SiAl})_8\text{O}_{20}](\text{OH})_{16}$
Aegerine $\text{NaFe}^3(\text{Si}_2\text{O}_6)$	Melanite $\text{Ca}_3(\text{Fe}^3\text{Ti})_2\text{Si}_3\text{O}_{12}$
Hornblende $(\text{N K})_{0-1}\text{Ca}_2(\text{MgFe}^2\text{Fe}^3\text{Al})_5(\text{Si}_{6-7}\text{Al}_{2-1}\text{O}_{22})(\text{OH}, \text{F})_2$	Andradite $\text{Ca}_3\text{Fe}_2\text{Si}_3\text{O}_{12}$
Arfvedsonite $\text{Na}_3(\text{MgFe}^2)_4\text{Al}(\text{Si}_8\text{O}_{22})(\text{OH}, \text{F})_2$	Grossularite $\text{Ca}_3\text{Al}_2\text{Si}_3\text{O}_{12}$
Soda amphibole (probably richterite)	Zirconium garnet $\text{Ca}_3(\text{Fe}^3\text{TiAl})_2(\text{SiZr})_3\text{O}_{12}$
Tremolite $\text{Ca}_2\text{Mg}_5\text{Si}_8\text{O}_{22}(\text{OH})_2$	
Niocalite $(\text{CaNb})_{16}\text{Si}_8(\text{O}, \text{OH}, \text{F})_{36}$	
Cancrinite $(\text{NaCaK})_{6-8}(\text{Al}_6\text{Si}_6\text{O}_{24})(\text{CO}_3, \text{SO}_4, \text{Cl})_{1-2} \cdot 1-5\text{H}_2\text{O}$	
Quartz SiO_2	Wollastonite $\text{Ca}(\text{SiO}_3)$
Kaolinite $\text{Al}_4(\text{Si}_4\text{O}_{10})(\text{OH})_8$	Sphene $\text{CaTi}(\text{SiO}_4)(\text{O}, \text{OH}, \text{F})$
Natrolite $\text{Na}_2(\text{Al}_2\text{Si}_3\text{O}_{10}) \cdot 2\text{H}_2\text{O}$	Vesuvianite $\text{Ca}_{10}(\text{MgFe})_2\text{Al}_4(\text{Si}_2\text{O}_7)_2(\text{SiO}_4)_5(\text{OH}, \text{F})_4$
Thompsonite $\text{NaCa}_2[(\text{AlSi})_5\text{O}_{10}]_2 \cdot 6\text{H}_2\text{O}$	Cebollite $\text{Ca}_5\text{Al}_2\text{Si}_3\text{O}_{14}(\text{OH})_2$
Wairakite $\text{CaAl}_2\text{Si}_4\text{O}_{12} \cdot 2\text{H}_2\text{O}$	Analcite $\text{Na}(\text{AlSi}_2\text{O}_6) \cdot 2\text{H}_2\text{O}$

Phosphates

Flourapatite } $\text{Ca}_5(\text{PO}_4)_3(\text{OH}, \text{F}, \text{Cl})$	Britholite $(\text{CaReThFeMgTi})_5[(\text{PSiAl})\text{O}_4]_3(\text{OH}, \text{F})$
Apatite }	Monazite $(\text{CeLaTh})\text{PO}_4$
Wilkeite }	

Oxides

Magnetite Fe_3O_4	Pyrochlore } $(\text{NaCaUThRe})_{16-x}(\text{Nb}, \text{Tc}, \text{TaTi})_{16}(\text{O}, \text{OH})_{48}(\text{F}, \text{OH})_{18}$
Maghamite Fe_2O_3	Th pyro. }
Hercynite FeAl_2O_4	Perovskite CaTiO_3 }
Hematite Fe_2O_3	Niobium perovskite } $(\text{CaNaFeCe})(\text{TiNb})\text{O}_3$
Ilmenite FeTiO_3	Latrappite
Rutile TiO_2	Periclase MgO

Sulphides, Sulphates, fluorides

Pyrite FeS_2	Sphalerite ZnS
Pyrrhotite Fe_7S_8	Barite BaSO_4
Chalcopyrite CuFeS_2	Fluorite CaF_2
Galena PbS	Jarosite $\text{K}_2\text{Fe}_6(\text{OH})_{12}(\text{SO}_4)_4$

Note: Re = Rare Earth elements.

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ITINERARY

The suggested route to Oka is as follows:

Miles

- 0 From the "Centre Social de l'Université de Montréal" turn right onto Maplewood Avenue and travel east to main intersection.
- 0.2 Turn left onto Bellingham Road and travel north to
- 0.3 Cote Ste-Catherine Road: turn right and travel east to
- 0.9 Stuart Avenue: turn left and proceed north towards the Rockland overpass.
- 2.0 At Beaumont Avenue, turn right and drive east to
- 2.1 L'Acadie Blvd. Turn left and proceed north to traffic
- 3.7 circle and onto Laurentide Autoroute (entrance on west side). Proceed north on Auto route for approximately 14 miles. People driving independently from Kingston may exit from the Trans Canada Highway onto the Laurentide Autoroute and join the field trip.
- 7.0 Bridge - Rivière des Prairies.
- 13.0 Bridge - Rivière des Mille Iles.
- 17.6 Exit 14: proceed west for approximately 9 miles on service road to Route 29. General Motors Assembly Plant to the west (right) of exit 14.
- 26.6 At intersection turn right onto Route 29 and drive west towards Oka.
- 29.3 Note beach terraces to the right, Oka Hills ahead.

STOP No. 1

- 31.8 Breccia pipe intruding country rock approximately 1500 feet to the east of the Complex.

BRECCIA PIPE INTRUDING COUNTRY ROCK APPROXIMATELY 1500 FEET TO THE EAST OF THE COMPLEX

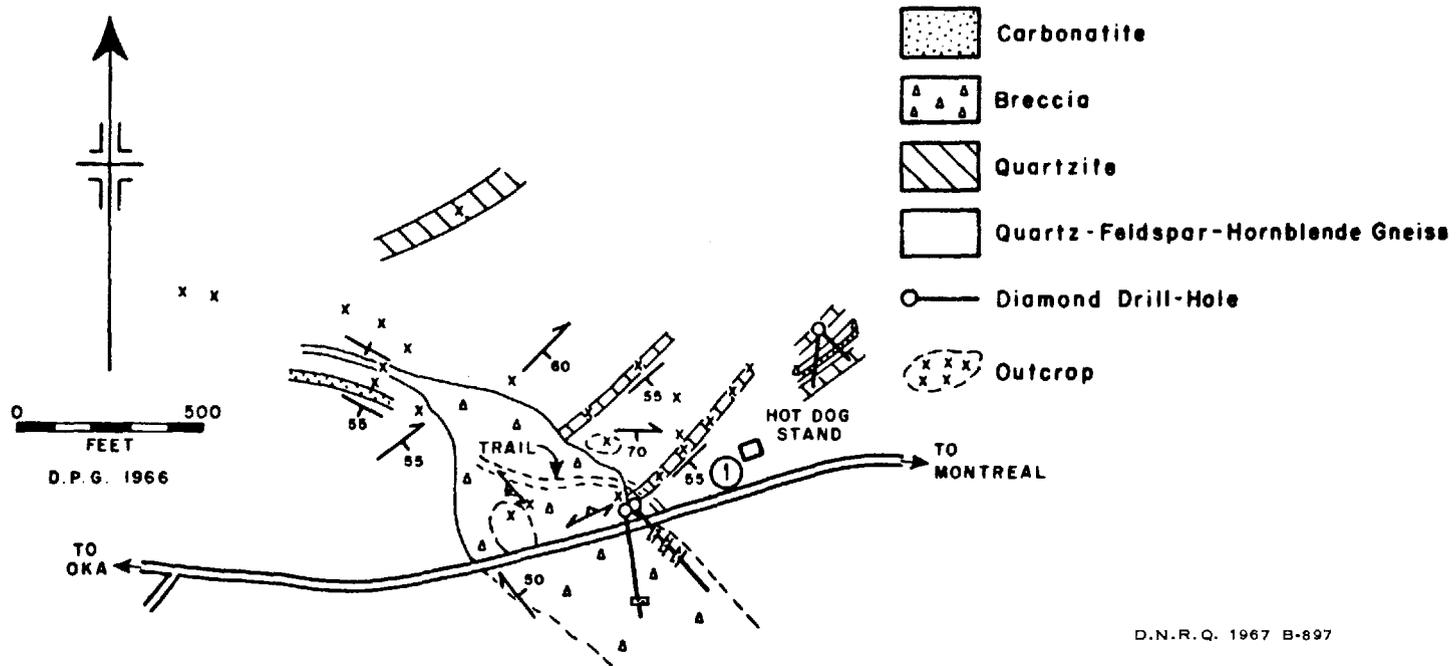


Figure 3

GEOLOGICAL MAP OF THE EASTERN BRECCIA PIPE (stop 1)

D.N.R.Q. 1967 B-897

At this locality, the outcrop pattern is tear-drop shaped, and probably represents a local blow-out along a dike. Generally, the pipe is filled with a polymict breccia, which is highly charged with fragments from 5 mm. to 15 cm. in diameter set in a fine-grained matrix of comminuted country rock, calcite, and chlorite. Country rock fragments (Precambrian gneiss and quartzite) are most common near the margin of the pipe, whereas Paleozoic rock fragments, gabbro, titanite gabbro, pyroxenite, alnoite and carbonatite fragments, set in a carbonate matrix containing microphenocrysts of augite and phlogopite, occur towards the center of the pipe. In places, especially near the center, the fragments are concentrated into steeply dipping planes.

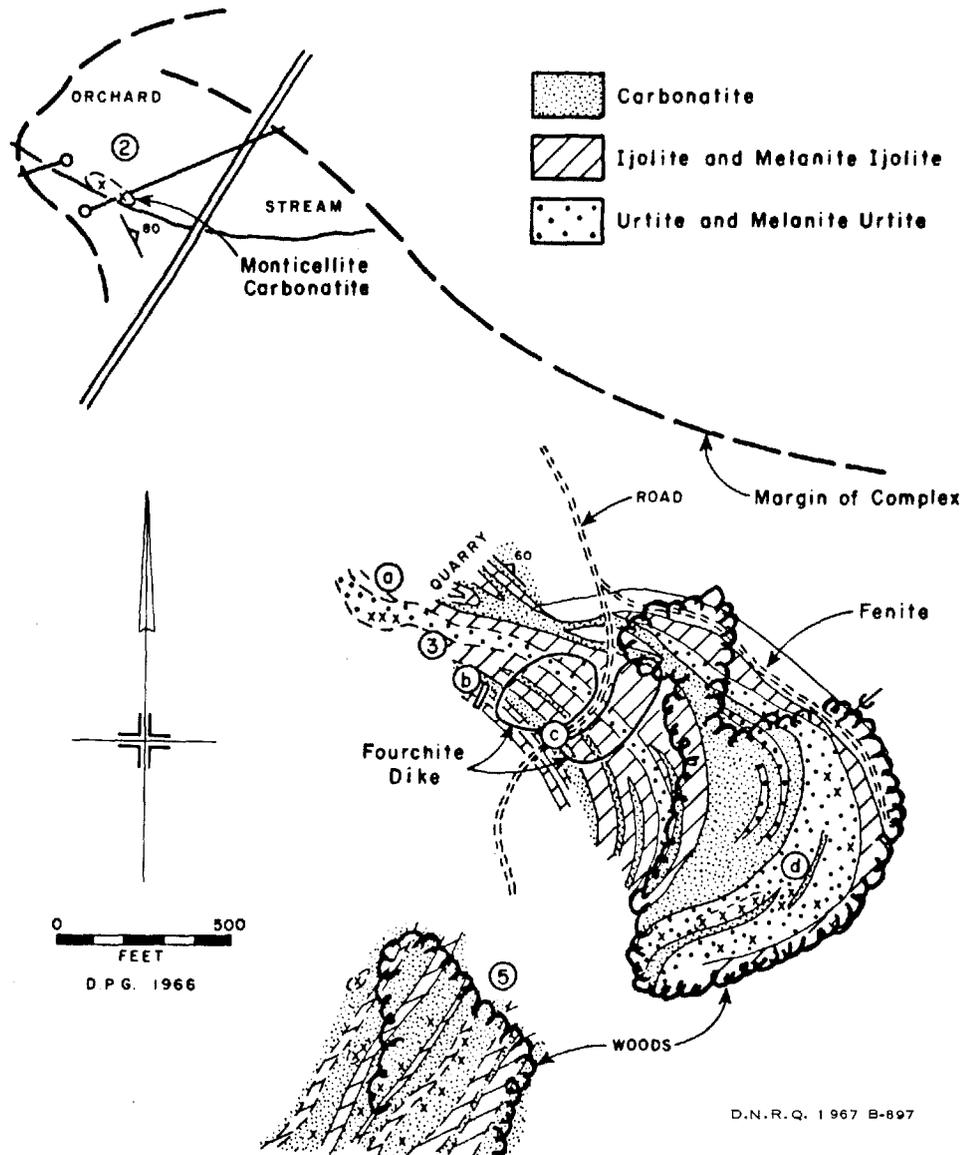
The margins of the pipe tend to be gradational, from polymict breccia, to shattered country rock, to veins of chloritized breccia filling fractures in the country rock. The presence of rounded and smooth inclusions, lapilli of alnoite, and the persistence of quartzite fragments in a discontinuous planar array suggest drilling of the pipe by a gas-streaming process. No coesite has been found in any of the shattered rocks nor have any shatter cones been observed.

The presence of Trenton limestone and Utica shale fragments in this, as well as in the large breccia pipe 10,000 feet north-northwest, indicates a Paleozoic rock cover over the Oka Hills at the time of intrusion. A coarse-grained carbonatite dike parallels the northwestern extremity of the pipe.

32.0 Turn left on unpaved road near sign for Poodles-Haven Farm.

STOP No. 2

32.2 Disembark near white pump shack. Two glaciated outcrops of monticellite carbonatites are located approximately 220 feet to the northwest on the north side of the stream, in the apple orchard. Cross stream above 20 feet from gate leading into orchard (see Figure 4). The rock is a coarse-grained, banded, monticellite carbonatite. It contains calcite, monticellite (brown mineral), biotite, apatite, magnetite, and niobium perovskite (black crystals with a cubic habit). The magnetite is unusual in that it commonly shows trapezohedral faces, and contains hercynite and spinel either as exsolved lamellae within, or as blebs within and/or around, the crystals. This is a good locality for collecting magnetite and perovskite, especially from weathered surfaces.



D.N.R.Q. 1 967 B-897

Figure 4

SURFICIAL GEOLOGY OF STOPS 2, 3 and 5

- (a) On a low spur to the north of the hill is exposed massive microurtite (light gray rock with a greasy luster). This rock consists essentially of nepheline, with in places, minor amounts of potash feldspar. An analysis of this rock is given on the following page (sample A-454).
- (b) On the north face of the hill, bands of coarse-grained melanite ijolite, biotite replacement rock, and sodaproxene carbonatite are exposed in a shallow cut. Much of the nepheline in the melanite ijolite has altered to hydro-nepheline (pink) and zeolite minerals (chalky white), which accounts for the high water content in the chemical analysis (sample number A-380).
- (c) In the road-cut near the top of the hill, a gently undulating subhorizontal dike of fourchite (?) is exposed cutting fresh melanite ijolite and urtite. The dike is approximately 25 cms thick, exhibits a well developed chilled margin, and locally is amygdaloidal.
- (d) Through the woods 750 feet to the east-southeast, on the southern slope of the hill, are some large blocks of melanite, carbonatite, representing a band of carbonatite within essentially coarse-grained ijolitic rocks. An analysis of melanite ijolite is given below (sample A-384).

Analyses of rocks from localities 3 and 5:

	Urtite	Melanite ijolite		V. c-g carbonatite
	A-454	A-380	A-384	A-436
SiO ₂	47.19	34.55	32.31	0.67
TiO ₂	0.00	1.11	1.16	0.15
Al ₂ O ₃	27.17	11.37	10.10	0.02
Fe ₂ O ₃	0.43	7.43	8.22	0.65
FeO	0.21	2.26	1.95	0.29
MnO	0.27	0.72	0.65	0.40
MgO	0.30	3.05	3.23	1.09
CaO	8.64	25.62	27.32	51.22
SrO	-----	-----	-----	1.95
BaO	-----	-----	-----	0.12
Na ₂ O	10.01	3.83	3.24	0.14
K ₂ O	3.19	1.04	1.19	0.49
P ₂ O ₅	0.05	2.27	3.29	1.81
CO ₂	1.14	3.64	4.18	40.44
H ₂ O+	0.79	3.38	2.89	0.03
H ₂ O-	0.12	-----	-----	0.05
Nb ₂ O ₅	-----	-----	-----	0.14
	<u>99.51</u>	<u>100.27</u>	<u>99.73</u>	<u>99.66</u>

STOP No. 4

32.3 Walk 1500 feet south-southeast of Stop 3 into the maple woods on the hill slope near La Grande Bay.

Scattered through the woods are boulders of coarse-grained, wollastonite-melanite ijolite. The type rock consists essentially of wollastonite (15%), melanite (10%), sodian augite (11%), nepheline (57%), apatite (3%), and calcite (4%), but the proportion of the major minerals varies locally to produce wollastonite-melanite melteigite (dark minerals predominating) and wollastonite-melanite urtite (light minerals dominating). Analyses of two varieties are given below: (Samples A-297 and G15-330).

Wollastonite occurs as silky green blades, in places up to 10 cms. long. Melanite (black) is commonly zoned, and is intergrown with sodian augite (dark green). Fresh nepheline is white; pink where altered to hydronepheline. Analyses of these minerals, taken from the type specimen G15-330, are given on the following page.

	Ijolite A-207	Ijolite G15-330	Wollastonite G15-330	Nepheline G15-330	Melanite G15-330	Sodian augite G15-330
SiO ₂	39.39	38.87	50.15	40.86	33.86	47.16
TiO ₂	0.45	0.59	0.00	0.00	2.07	0.24
Al ₂ O ₃	15.95	13.59	0.14	33.64	0.00	1.49
Fe ₂ O ₃	4.05	5.57	0.04	1.21	20.93	5.33
FeO	0.98	1.98	0.60	0.14	1.72	6.61
MnO	0.71	0.68	0.96	0.02	1.05	1.36
MgO	1.30	3.10	0.00	0.07	1.08	10.92
CaO	19.77	21.26	46.97	0.89	32.34	23.70
SrO	0.12	-----	-----	-----	-----	-----
BaO	0.89	-----	-----	-----	-----	-----
Na ₂ O	7.79	6.50	0.35	14.74	0.27	1.07
K ₂ O	2.57	2.41	0.05	6.78	0.04	0.04
P ₂ O ₅	0.74	2.98	0.00	0.53	5.93	0.59
CO ₂	3.38	1.56	0.45	0.56	0.00	0.00
H ₂ O+	1.69	0.51	0.38	0.39	0.41	1.14
H ₂ O-	-----	0.20	-----	-----	0.02	-----
	<u>99.98</u>	<u>99.80</u>	<u>100.09</u>	<u>99.83</u>	<u>100.02</u>	<u>99.65</u>

	Modes		Number of ions per:			
Nepheline	43.7	46.4	18(O)	32(O)	24(O)	6(O)
Altered nepheline	11.4	11.1	Si 5.940	8.135	6.446	Si 1.863
Pyroxene	16.6	11.5	Al 0.019	7.892	-----	Al 0.069
Melanite	5.0	10.2	Zr -----	-----	0.027	Al -----
Wollastonite	19.1	14.8	Ti -----	-----	0.296	Ti 0.007
Apatite	0.6	2.6	Fe ³⁺ 0.004	0.121	2.996	Fe ³⁺ 0.158
Calcite	1.8	3.3	Mg ₂₊ -----	-----	0.306	Mg ₂₊ 0.643
Magnetite	0.3	0.1	Fe 0.059	-----	0.273	Fe ₂₊ 0.218
Biotite	0.6	-----	Mn 0.096	-----	0.169	Mn 0.045
	<u>100.0</u>	<u>100.0</u>	Na 0.081	5.686	0.101	Na 0.082
			Ca 5.886	-----	5.161	Ca 0.969
			K 0.008	1.743	0.009	K 0.002

STOP No. 5

- 32.3 Walk 2000 feet northwest from Stop 4, or 1000 feet west-southwest of Stop 3. For location see Figure 4.

Large weathered blocks of very coarse-grained carbonatite are scattered in the woods. This is a distinctive type of carbonatite, rarely ore grade, but which contains as much as 2% Sr. It is composed almost entirely of calcite (as crystals up to 5 cms. long), with accessory amounts of magnetite, apatite, pyrochlore, and soda-amphibole. It is in this rock-type that biaxial calcite has been found. A chemical analysis of sample A-436 from this locality is given with the Stop 3 rock analyses.

Proceed along road 0.2 miles and stop near Poodle Farm.

STOP No. 6

- 32.5 Walk northwest 400 feet across field to outcrops in the woods.

Scattered outcrops of "altered" monticellite carbonatite are scattered along the base of the slope near the edge of the woods. The monticellite is altered to a blue cryptocrystalline material, which at first was thought to be a new mineral. An X-ray diffractometer pattern of this material can be resolved into quartz, calcite, dolomite, and crocidolite. A chemical analysis of the blue aggregate is as follows:

SiO ₂	21.61
Al ₂ O ₃	0.71
Fe ₂ O ₃	3.85
FeO	1.45
CaO	23.41
MgO	14.74
SrO	0.11
Na ₂ O	3.21
MnO	1.19
P ₂ O ₅	0.69
CO ₂	27.71
H ₂ O ⁺	0.93
H ₂ O ⁻	0.11
Total	<u>99.62</u>

- 32.5 Follow gravel road to main highway.

- 33.2 Turn left on Route 29.

- 33.3 Turn left at La Trappe Monastery and stop near the cheese factory.

The village of Oka, 4 miles farther west, was originally founded as a mission for the Iroquois Indians early in the 18th century. The Trappist Order took over the mission towards the end of the 19th century, and built a monastery at La Trappe. In 1893 they founded here one of the leading schools of agriculture in Quebec and this has recently been incorporated by the Faculty of Agriculture of Laval University. There will be a short stop over at the dairy where interested persons may purchase the famed Oka cheese. Drive from the dairy across main highway onto the Ste-Sophie road. Note the shaft of the St. Lawrence Columbian and Metals Company mine to the north.

- 33.6 St. Lawrence Columbian and Metals Company open pit and underground workings to the right (Stop No. 11). The mine offices and mill can be seen farther up the hill.

- 36.0 Turn right on farm road at Husereau Farm and drive one-quarter mile to near gravel quarry on the south flank of Husereau Hill.

- 36.3 Walk up west flank of hill to diamond drill-hole S-5. Lunch stop. Fresh water issues from the casing of this drill-hole. From the top of the hill (the highest point of the Complex) there is a good view of the oval nature of the northern ring, with the Bond Zone on the right, Dufresne Hill, a low copse of trees in the foreground and the St. Lawrence Property on the left.

STOP No. 7

Husereau Hill is a crescentic-shaped hill near the northern margin of the Complex and is underlain by rocks of the okaite-jacupirangite series. These are intruded as a swarm of arcuate dikes which vary from melilite-magnetite rocks, through melilite, melilite-nepheline, melilite-nepheline-hauynite, melilite-monticellite, melilite-nepheline-titanaugite, titanaugite-nepheline, to titanaugite-magnetite rocks (jacupirangite). These rocks all contain accessory apatite, perovskite, calcite and biotite. Between Husereau Hill and Dufresne Hill there are 7 dikes of melilite-bearing rocks. Much of the early geological work done in the Oka area (Gauthier 1917, Howard 1922, and Stansfield 1923) was on rocks from Husereau Hill. Despite the occurrence of unusual rock types (this is the type locality of Okaite described by Stansfield), there was no systematic geological mapping of this hill until the synthesis by the senior writer in 1960.

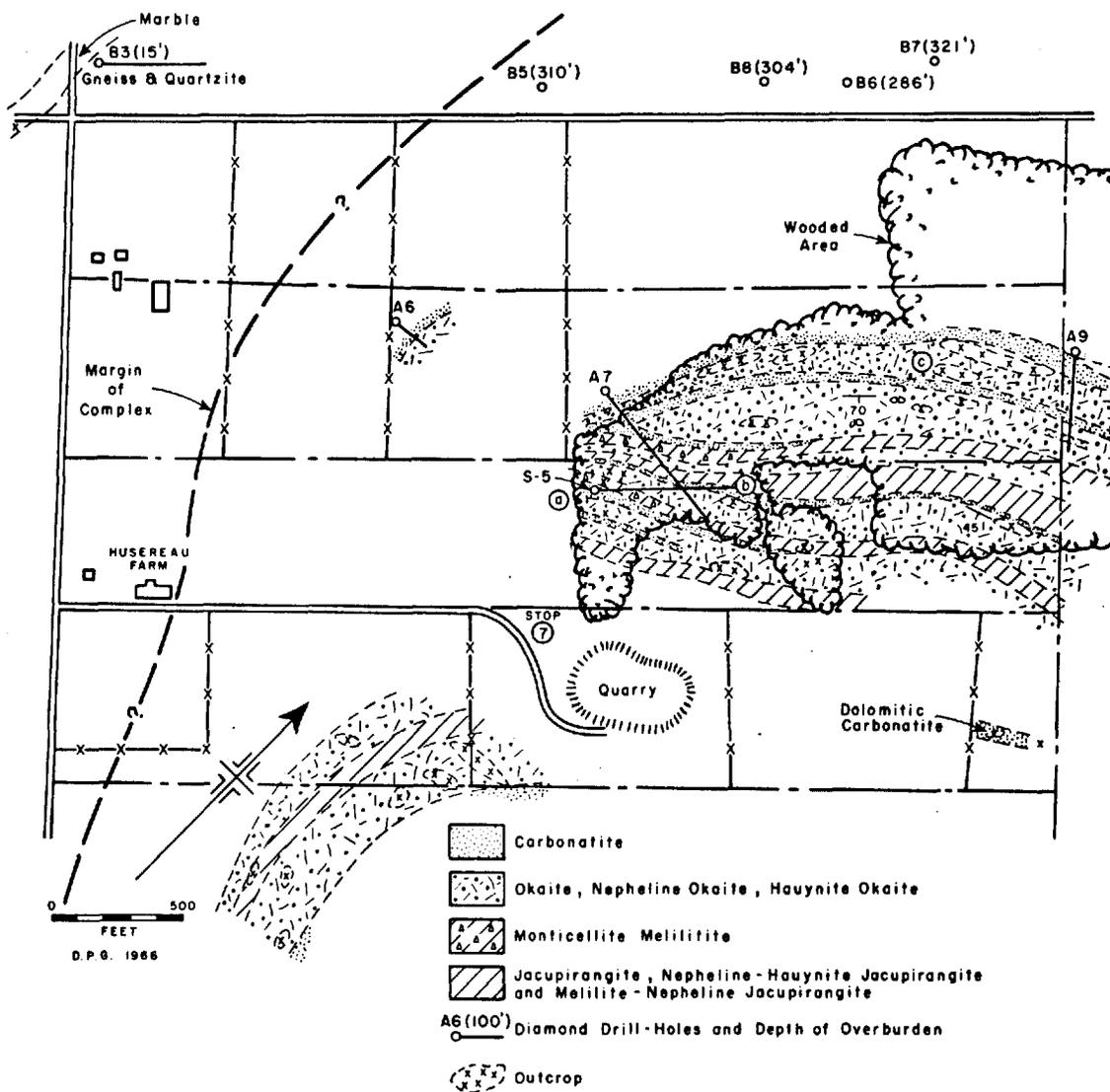


Figure 5

SURFICIAL GEOLOGY OF PART OF HUSEREAU HILL. (Stops 7a, b and c)

	Okaite (after Stansfield)	Neph. Okaite A-72	Jacup. S-5	Neph. jacup. S-9	Hauy-mel- jacup. A-172	Melilite A-72	Nepheline A-72
SiO ₂	27.43	34.90	33.52	33.53	31.91	38.68	37.88
TiO ₂	3.39	1.16	3.05	3.44	2.11	0.00	0.00
Al ₂ O ₃	12.70	15.99	11.30	13.20	14.69	10.60	31.57
Fe ₂ O ₃	4.85	7.28	9.18	7.27	6.12	0.45	0.13
FeO	6.33	3.82	3.52	3.41	3.38	1.81	0.29
MnO	0.21	0.72	0.25	0.40	0.63	0.35	0.01
MgO	6.00	5.02	8.38	8.66	5.98	7.66	0.39
CaO	25.24	19.35	22.61	19.14	19.62	34.28	5.60
SrO	-----	-----	0.24	0.25	-----	0.44	0.21
BaO	0.14	-----	0.67	0.35	-----	-----	-----
Na ₂ O	2.39	7.27	1.90	2.45	7.55	3.92	15.85
K ₂ O	1.28	2.08	0.54	2.16	0.98	0.00	7.47
P ₂ O ₅	1.64	0.68	2.33	2.37	2.15	0.11	0.22
CO	1.98	1.29	0.90	2.34	1.87	1.14	0.00
H ₂ O+	0.73	0.60	1.08	1.64	1.19	0.36	0.10
H ₂ O-	0.28	0.02	0.06	0.09	0.05	0.01	0.01
Other	3.86	-----	-----	-----	S= 1.39	-----	-----
	<u>99.57</u>	<u>100.18</u>	<u>100.43</u>	<u>100.70</u>	<u>99.62</u>	<u>99.81</u>	<u>99.73</u>
		<u>Modes</u>			<u>Number of ions per:</u>		
Titanaugite	-----	-----	61.3	69.5	8.8	14(0)	32(0)
Hauynite	-----	6.7	-----	-----	42.0	Si 3.636	7.650
Nepheline	-----	40.9	18.4	14.4	-----	Al 1.174	7.513
Melilite	-----	41.3	-----	-----	26.9	Zr -----	-----
Biotite	-----	2.3	3.4	4.8	8.5	Ti ₃₊ -----	-----
Apatite	-----	1.8	5.9	5.4	4.1	Fe 0.031	0.019
Perovskite	-----	0.9	0.2	1.2	2.0	Mg ₂₊ 1.072	0.117
Magnetite	-----	3.0	10.7	2.0	2.7	Fe 0.142	0.048
Calcite	-----	3.1	0.1	2.7	4.8	Mn 0.027	0.001
Melanite	-----	-----	-----	-----	-----	Na 0.714	6.202
						Ca 3.294	1.145
						K -----	1.924
						Sr 0.023	0.024
		<u>100.0</u>	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>		

6.08
4.03

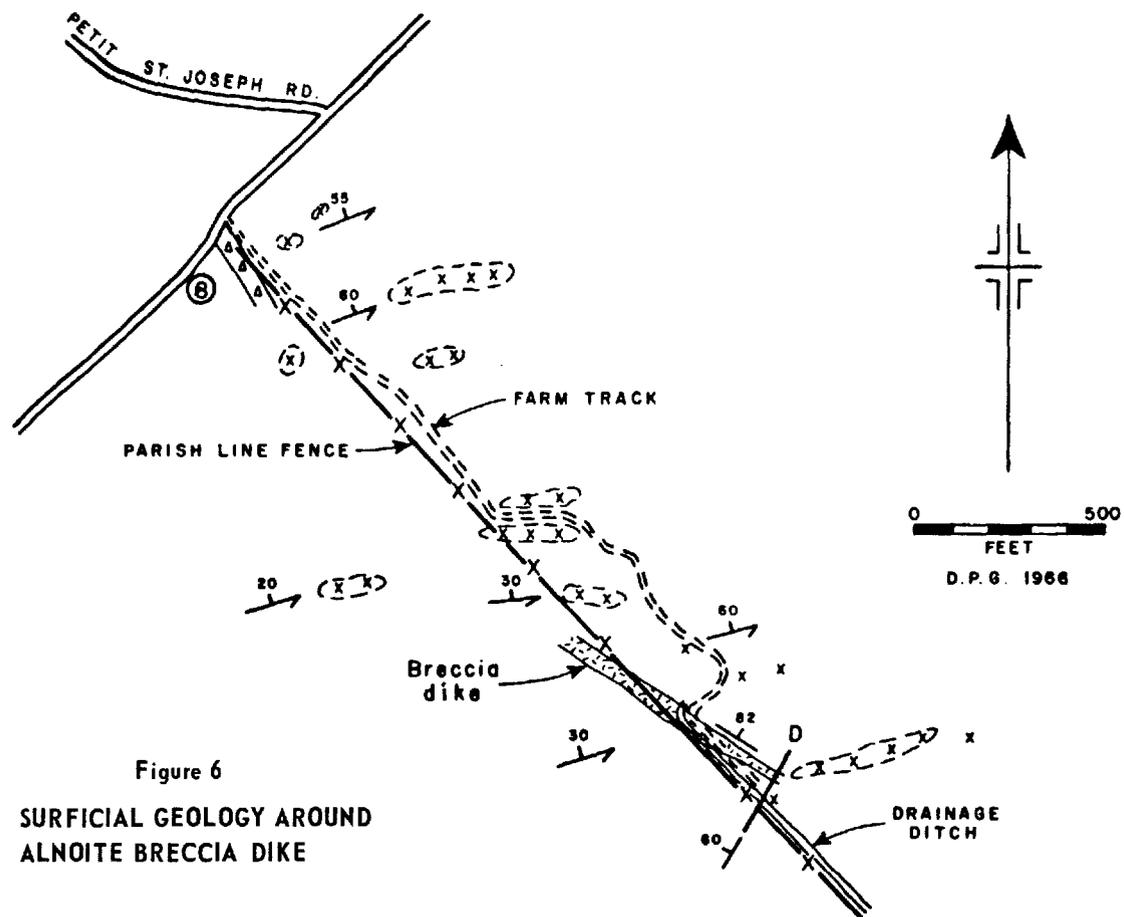


Figure 6
SURFICIAL GEOLOGY AROUND
ALNOITE BRECCIA DIKE

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- 36.3 Retrace route to paved road and turn right on the Ste-Sophie Road.
- 36.5 Drive northwest to intersection.
- 36.8 Turn right on Ste-Germaine Road and cross the northern flank of Husereau Hill. Drill-holes drilled from north of the road penetrated up to 400 feet of Champlain sediments before coring bedrock. If one considers the Pre-Pleistocene topography then Husereau Hill attains a relief comparable to that of Mt. Johnson.
- 38.1 Turn right at intersection onto the Petit St. Joseph Road. Note the terraces (Champlain Sea) as we travel over them. On the left are paragneisses of the Grenville Series; to the right, rocks of the Complex.
- 39.6 Turn right at intersection onto gravel road.
- 39.7 Leave automobile about 200 yards from intersection, just over the crest of the hill. Follow farm track (located north of and parallel to the Parish line) southeast through the orchard and on for 1700 feet. The track winds around easterly trending ridges of Grenville gneiss (mainly quartz-feldspar-biotite, and quartz-feldspar-hornblende gneiss, locally garnetiferous). In the drainage ditch a breccia dike about 40 feet thick is exposed.

STOP No. 8

A polymict breccia dike in an alnoite matrix strikes obliquely to the drainage ditch and fragments of fresh dike material which were blasted out are available nearby. The brownish red weathered surface is typical of the alnoite breccias. Inclusions are numerous; some are as large as 45 cm. in diameter. They include fine-grained gray limestone, sandstone, coarse-grained carbonatite, gneiss, anorthosite, and lamprophyre in a carbonate-rich globular-textured (lapilli) alnoitic matrix. The lamprophyre inclusions are composed of phenocrysts of titanite and biotite in an aphanitic matrix of melilite, augite, and magnetite.

This is a good locality for collecting fresh alnoite breccia.

- 39.7 Drive southwestward to intersection.

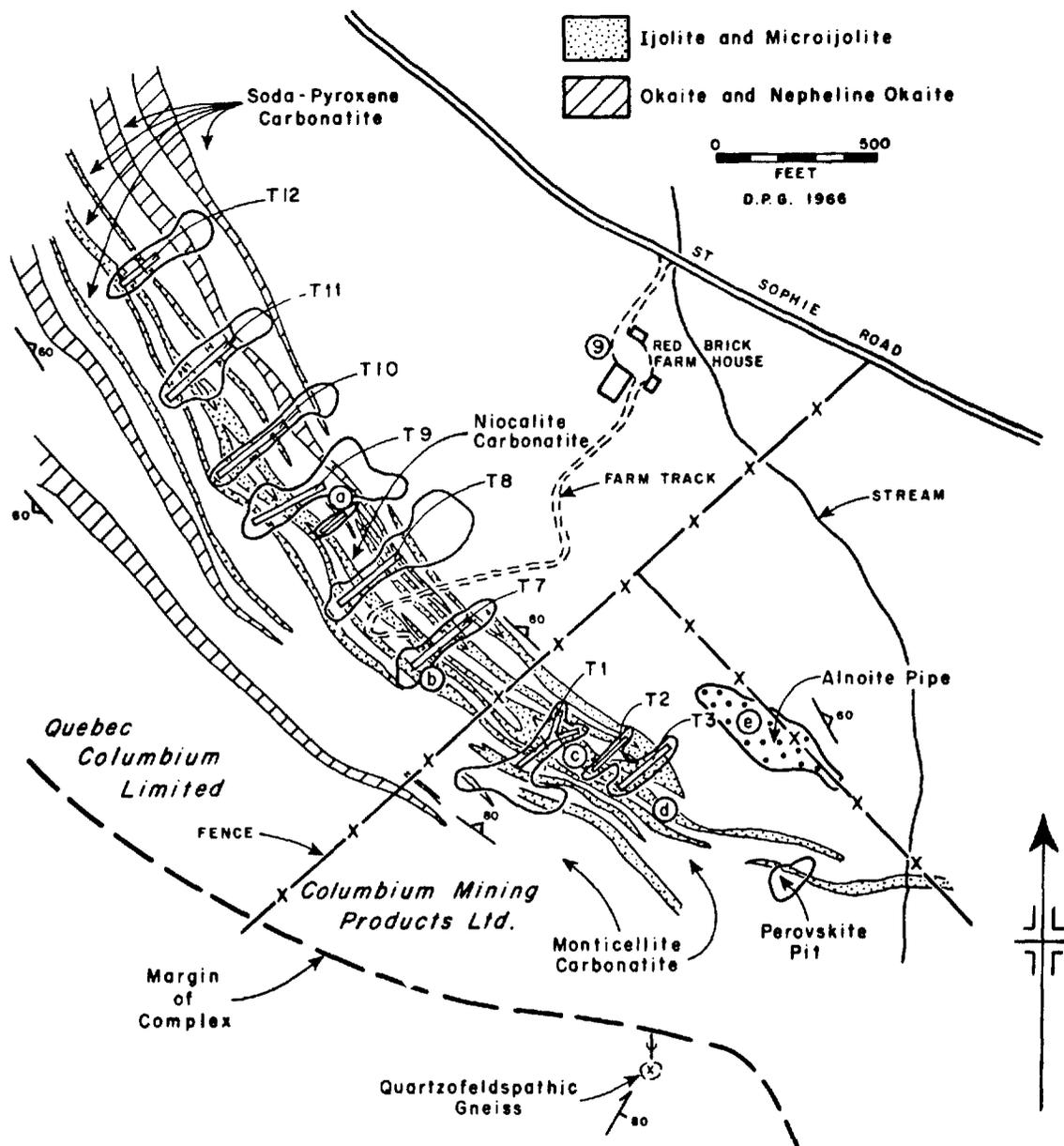


Figure 7

SURFICIAL GEOLOGY OF THE TRENCHES OF THE BOND ZONE (Stops 9a, b, c, d, e)

(a) Trench 4 (sample A-436): lower part is in the niocalite carbonatite band. The niocalite occurs as yellow tetragonal crystals 1 mm. to 3 cm. long. Melilite is the light brown mineral. Note the vermicular intergrowths between magnetite and calcite. (b) Boudinaged ijolite block. Note the replacement breccia in ijolite lower down in trench 7. (c) Banded monticellite carbonatite is exposed in the trench. Perovskite occurs preferentially in this type, and in pit (d) the niobium variety "latrappite" (Nickel and McAdam, 1963) can be picked out of the decomposed carbonatite. Lower down the hill is some olivine carbonatite (sample C-H). (e) An elongate plug of massive alnoite is exposed on the terrace below the trenches. It is a dense, blue-gray, porphyritic rock, with phenocrysts of olivine, titanaugite, biotite, and hornblende set in a fine-grained matrix of augite, melilite, calcite, magnetite, melanite and apatite (sample A-368).

- 40.9 Turn left onto Ste-Sophie Road and travel southeast. You are now almost directly over the core of the northern ring.
- 42.3 Turn right, just before crossing the stream, into the yard of the red brick house. Park near the shed at the back of the house. Leave the automobile and walk southwest, up the hill to the Bond Zone.

STOP No. 9 (Bond Zone)

This section is called the Bond Zone after Stephen Bond, manager of Quebec Columbiun Limited (Molybdenum Corporation of America and Kennecott Copper Corporation), and one of the finders of the economic potential of the Complex. The hill is underlain by the largest potential niobium ore zone in the Complex. Plans to develop the northern part (Quebec Columbiun Limited) have been under consideration for some time. The southern part is owned by Columbiun Mining Products Limited (McDonouth Bros., Toronto) and they have planned to mine their section.

Banded coarse-grained carbonatite with ijolite dikes (locally rafted and boudinaged) are well exposed in the trenches. A band, about 60 feet thick, of niocalite carbonatite is exposed in trenches 4,7,8 and 9 (niocalite is a niobium silicate mineral peculiar to Oka - see E. Nickel, Canadian Mineralogist, 1958, p. 264). Other minor and accessory minerals in the carbonatite are forsterite melilite, apatite, pyrochlore, perovskite, latrappite, magnetite, biotite and sodian augite.

Chemical analyses of the niocalite carbonatite (Sample A-436) and some of the minerals (melilite and niocalite) from trench 4; of latrappite; olivine from (Sample C-H); and of alnoite (Sample A-368) and biotite are:

BOND ZONE

	Niocalite Carbonatite A-436	Alnoite A-368	Biotite A-368	Melilite A-434	Olivine C-H	Latrappite	Niocalite
SiO ₂	6.04	35.41	37.65	39.98	39.36	TiO ₂ 10.05	CaO 47.50 46.96
TiO ₂	0.14	2.57	3.73	0.00	0.28	CaO 25.95	SiO ₂ 29.70 29.90
Al ₂ O ₃	4.41	11.25	18.25	4.47	0.00	Nb ₂ O ₅ 43.90	Nb ₂ O ₅ 16.56 18.86
Fe ₂ O	2.67	6.27	1.43	1.89	0.81	Ta ₂ O ₅ -----	Al ₂ O ₃ 1.31 ² 0.16 ²
FeO	1.57	5.07	5.28	2.59	2.84	Na ₂ O 4.05	Re ₂ O ₃ -----
MnO	0.43	0.24	0.10	1.21	4.78	K ₂ O 0.03	Fe ₂ O ₃ } 0.54 0.54
MgO	0.62	13.29	20.96	7.29	49.15	Ce ₂ O ₃ 2.03 [*]	FeO -----
CaO	49.64	18.42	0.57	34.86	1.49	MgO 2.20	TiO ₂ 0.22 0.26
SrO	2.28	0.12	-----	1.59	0.03	FeO } 8.74	MnO 1.28 0.99
BaO	-----	0.22	-----	0.01	-----	FeO } -----	MgO 0.28 0.70
Na ₂ O	0.34	2.53	0.61	3.08	0.07	MnO 0.77	Na ₂ O 0.78 0.55
K ₂ O	0.48	2.20	9.30	0.12	0.01	SiO ₂ 0.45	K ₂ O 0.02 0.00
P ₂ O ₅	1.98	1.05	0.08	2.14	0.87	ThO ₂ -----	P ₂ O ₅ 0.60 0.07
CO ₂	27.83	0.24	0.00	0.00	0.00	S 0.90	H ₂ O+ 0.16 0.18
H ₂ O+	0.10	1.21	1.10	0.86	0.47	H ₂ O+ 0.36	F 1.70 1.73
H ₂ O-	0.00	0.00	-----	-----	-----	ThO ₂ -----	-----
Nb ₂ O ₅	2.14	-----	F 0.18	ZrO 0.30	-----	L.o.I. 0.29	100.65 100.90
	100.67	100.09	99.24	100.39	100.16	Al ₂ O ₃ -----	0.71 0.73
						99.70	99.94 100.17

Number of ions per:

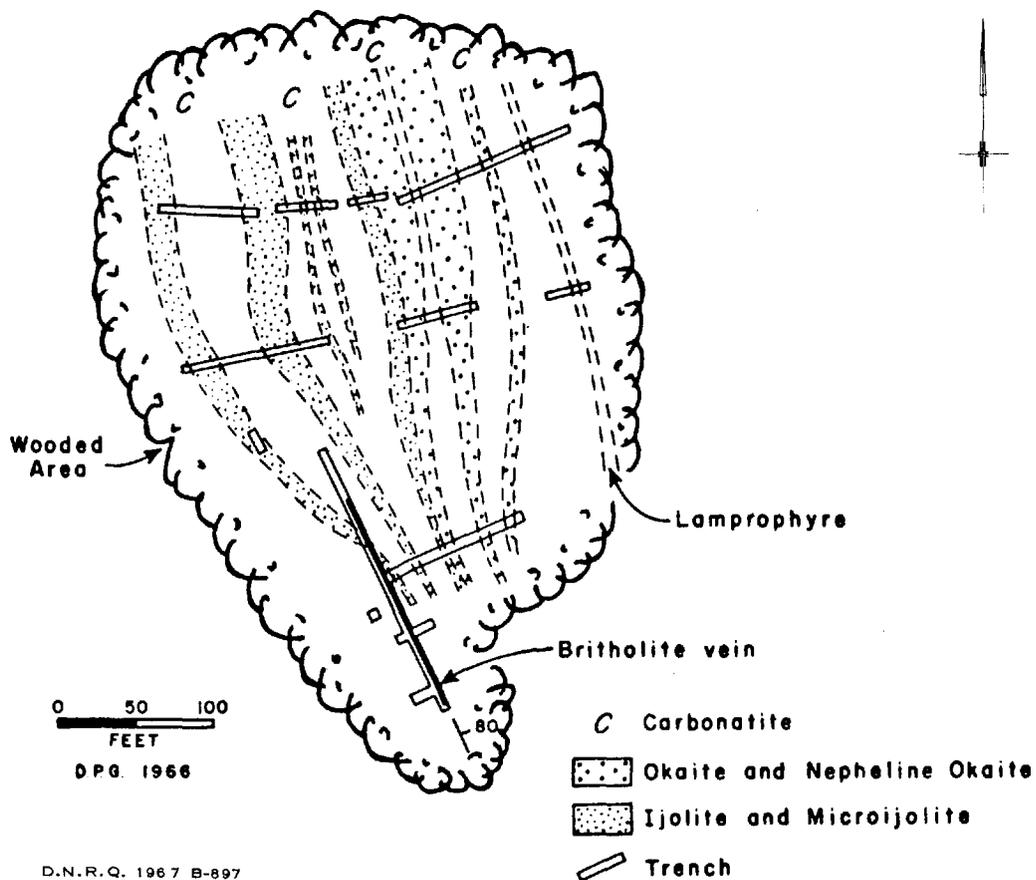
	Biotite 24(O, OH, F)	Melilite 14(O)	Olivine 4(O)		Niocalite 36(O, OH, F)
Si	5.463	3.925	0.983	Si	0.097
Al	3.120	0.517	-----	Al ₃₊	-----
Al	-----	0.014	-----	Ca	12.852
Ti ₃₊	0.407	-----	0.005	Na	0.389
Fe	0.157	0.139	0.015	K	0.006
Mg ₂₊	4.529	1.066	1.828	Nb	1.923
Fe	0.640	0.213	0.059	Th	-----
Mn	0.012	0.101	0.101	Fe	0.105
Na	0.171	0.586	0.003	Mg	0.106
Ca+Ba+Sr	0.071	3.368	0.009	Mn	0.279
K	1.720	0.015	tr	Ti	0.043
OH	1.065	0.090	Sr tr	RE	-----
F	0.083	Ba	Ba	Al	0.397
				Si	7.632
				P	-----
				OH	0.273
				F	1.381
				Nd	0.161

*Total rare earth oxides

42.3 Proceed to Dufresne Hill (Stop 10), otherwise bypass this Stop and drive directly to the St. Lawrence Mine. For Dufresne Hill, turn left, on Ste-Sophie road and drive northwest to intersection with the L'Annonciation road.

43.0 Turn right into farm yard at this T intersection. Leave automobile, and walk 1000 feet due north to the low wooded hill.

STOP No. 10



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Figure 8

SURFICIAL GEOLOGY OF THE TRENCHES ON DUFRESNE HILL
(Trenches logged in 1960 by D. P. Gold)

Dufresne Hill (Sample A-463)

	Okaite	Melilite	Magnetite	Perovskite	Britholite
SiO ₂	30.58	39.78	2.21	0.48	12.28
TiO ₂	1.64	0.00	3.85	51.79	0.09
Al ₂ O ₃	9.52	10.33	7.25	0.44	0.47
Fe ₂ O ₃	9.17	2.02	56.98	5.85	0.14
FeO	4.50	1.44	21.60	0.86	}
MnO	0.83	0.38	1.49	0.00	
MgO	6.40	7.06	3.91	0.00	0.20
CaO	27.28	33.02	1.54	33.88	28.84
SrO	-----	0.88	-----	-----	-----
BaO	-----	0.09	-----	-----	-----
Na ₂ O	4.29	3.69	-----	0.67	0.21
K ₂ O	0.71	0.24	-----	0.00	0.00
P ₂ O ₅	1.84	0.69	0.39	Nb ₂ O ₅ 4.86	P ₂ O ₅ 16.96
CO ₂	2.13	0.00	-----	Ta ₂ O ₅ 0.39	RE ₂ O ₃ 33.43
H ₂ O ⁺	0.78	0.38	-----	0.40	0.54
H ₂ O ⁻	0.02	0.06	-----	-----	F 2.10
ZrO	-----	0.18	-----	0.00	ThO ₂ 5.62
	<u>99.69</u>	<u>100.24</u>	<u>99.22</u>	Ce ₂ O ₃ 0.19	100.88
				99.81	O ~ F <u>0.90</u>
					<u>99.98</u>

Mode

Mode	87.3	Number of ions per:		24(O)	26(O,OH,F)
		14(O)	32(O)		
Melilite	87.3				
Biotite	2.5				
Magnetite	3.9	Si 3.687	0.623	Si 0.089	Ca 6.474
Apatite	1.6	Al 1.128	2.407	Al ₃₊ 0.096	Na 0.086
Calcite	2.3	Zr 0.008	-----	Fe 0.813	K -----
Perovskite	2.1	Ti ₃₊ 0.141	0.816	Mg -----	Nb -----
Hauynite	0.3	Fe 0.975	12.079	Ti 7.203	Th 0.268
		Mg ₂₊ 0.112	1.642	Nb 0.402	Fe 0.023
	<u>100.0</u>	Fe 0.030	5.089	Ta ₂₊ 0.020	Mg 0.063
		Mn 0.663	0.355	Fe ⁺ 0.133	Mn -----
		Na 0.3187	-----	Mn -----	Ti 0.014
		Ca 0.029	0.308	Na 0.240	RE 2.564
		Sr 0.047	-----	Ca 6.713	Al 0.106
		Ba 0.003	-----	Si -----	Si 2.575
				K -----	P 3.008
				Th -----	OH 0.754
				Zr -----	F 1.391
				Ce 0.013	

This is where radioactive minerals were first found in the Oka area. A vein of massive britholite (a rare earth phosphate, containing thorium) about 9 inches thick was found on the southern slopes of the hill. Unfortunately, very little remains (especially once the 1962 guide book was published) but the scars of the mineral miners still remain. Unfortunately, most of the trenches are now partly caved in, but in the first big trench to the right, a dike of fresh , massive okaite is exposed. Analyses of this rock (Sample A-463), and some of its constituent minerals (melilite, perovskite, magnetite), are given on the preceding page.

43.0 Turn left onto Ste-Sophie Road, and drive southeastward to St. Lawrence ColumbiuM and Metals Corporation Mine.

44.5 Turn left onto Mine Property.

44.8 Stop at Mine Offices and Mill.

STOP No. 11

THE ST. LAWRENCE COLUMBIUM AND
METALS CORPORATION MINE

by

Marcel Vallée

History

Exploration of the Oka Complex started in 1953 with a staking rush, followed by magnetometer and scintillometer surveys. Between 1954 and 1959, approximately 230,000 feet of diamond drilling was done. The economic commodity sought was, and still is, niobium (columbium); the main economic mineral being pyrochlore. Zones of niobium-rich carbonatite were found on the following properties; St. Lawrence ColumbiuM and Metals Corporation, Main Oka Mining Corporation, Oka ColumbiuM and Metals Corporation, Montrose Securities, Quebec ColumbiuM Limited, ColumbiuM Mining Products, Bouscadillac Mines, and Advance Red Lake Mines. Ore dressing experiments, conducted in the Quebec Department of Natural Resources Laboratory, at Ecole Polytechnique in Montreal, and at the Mines Branch in Ottawa, established a practical method of concentrating pyrochlore disseminated in the carbonatite.

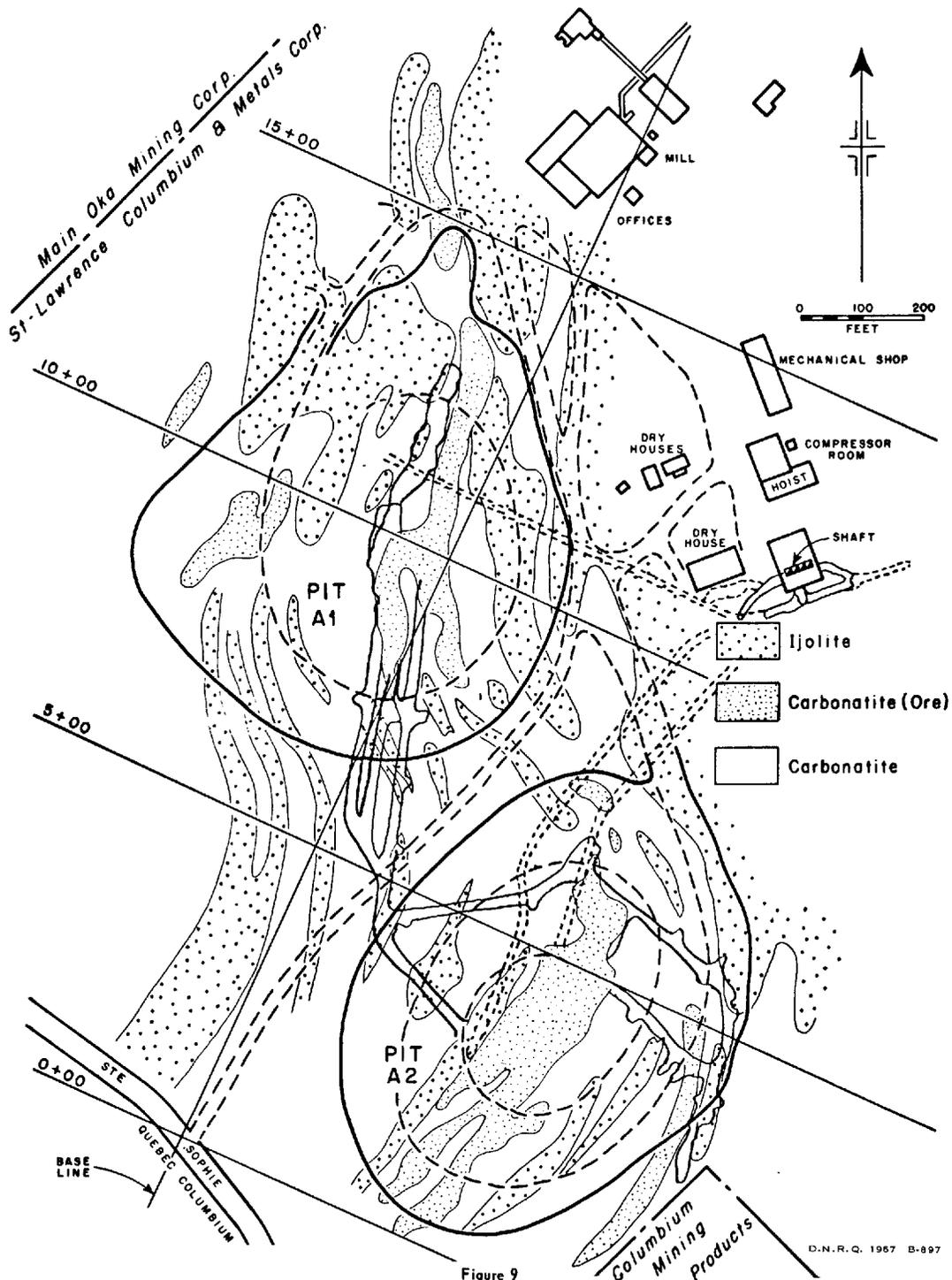


Figure 9
MINE LAY-OUT AND GEOLOGICAL MAP OF THE "A" ORE ZONE

To date the St. Lawrence Columbian and Metals Corporation has developed the only mine in the area. A concentrating plant was built in 1960, after feasibility studies had indicated the economic potential of the enterprise, and a market had been established for the niobium concentrates.

Ore production for the first 3 1/2 years came from two open pits, which now (1966) have reached depths of respectively 180 feet in the A-1 zone and 300 feet in the A-2 zone (see figure 9). During 1965, an underground adit system was developed from the A-2 pit to gain access to blocks and lenses of ore near the pit walls. Later, this was developed into an inclined adit ramp system serving the lower levels of the A-1 zone (under pit A-1), and also the lower levels of the A-2 zone.

The original 500-ton-per-day mill was expanded to 1,000 tons per day in November, 1962. Production of concentrate (containing approximately 52% Nb_2O_5) increased from about 250,000 pounds to the current annual total of 2 1/2 million pounds.

As of September 1966, excavation tonnages were as follows:

	<u>Ore</u>	<u>Waste</u>
Open pit	1,502,200 tons	923,000 tons
Underground	174,100 tons	71,400 tons
Shaft and stations	-----	40,200 tons

In January-September 1966, a four-compartment vertical shaft, with six stations (four for operating levels and two for loading pockets), was sunk to a depth of 1,335 feet. Hoisting of ore from the shaft is scheduled to start in the Spring of 1967. It is anticipated that by 1968 all the ore will be hoisted via the shaft.

Geology

The A ore zone is in the east-central part of the Complex and, structurally, is part of the northern ring. The carbonatite and accompanying ijolites and nepheline okaites have a general strike of N.20°E. and dip at about 80° westward (toward the center of the Complex).

The main rock types in the A ore zone are:

1. Carbonate rocks of several types that belong to several intrusive phases (established from cross-cutting relationships). These types,

distinguished by their mineralogy and texture, may be summarized as follows:

a) Niobium-poor carbonatite (Early Stage)	% CaCO ₃	% Nb ₂ O ₅
Pyroxene-biotite	70-73	0.05-0.10
Monticellite-magnetite	70-80	0.05-0.08
Coarse-grained calcite	90-100	0.03-0.08
b) Niobium-rich carbonatites (Middle Stage)		
Pyroxene-biotite-magnetite-pyrochlore	74-80	0.30-0.80
Monticellite-magnetite-pyrochlore and /or perovskite	78-80	0.20-0.60
Tremolite(?) -biotite-pyrochlore	82-88	0.40-0.60
c) Rare earth carbonatite (Late Stage)		
Rare earth carbonates, pyrite, galena	85-98	0.02-0.05

Dark accessory minerals impart a banded appearance to the rock.

1. Rocks abnormally rich in one or more of the minor minerals occur locally. The most common of these are pyroxene-magnetite-calcite pyrochlore, monticellite-magnetite calcite, and apatite-biotite-pyroxene-magnetite calcite types.
2. Ijolitic rocks of different ages occur in the mine area. The main mass exhibits a general concordant attitude with the carbonatite, but in detail there are many discontinuities and much evidence of rupturing. The smaller dikes transgress the carbonatite, and, in places, are boudinaged within it.
3. The okaite suite is represented in the mine by some bands, and by a thick mass of nepheline okaite on the east side of pit No. 1.
4. Replacement rocks due to alteration by hydrothermal solutions occur in a discontinuous zone. Biotite and chlorite are the common alteration minerals.
5. Alnoite and lamprophyre bands were intersected in some drill holes.

Mineralization

The salient facts concerning niobium mineralization are summarized below.

PYROCHLORE

	1	2	3	4	5	6	7	8	9	10	11
Nb ₂ O ₅	40.53	46.97	48.04	48.80	54.80	55.80	56.30	57.97	60.00	47.40	65.80
Ta ₂ O ₅	3.08	2.18	2.77	2.10	0.75	0.50	0.25	0.26	0.50	3.54	0.04
TiO ₂	10.42	7.49	8.64	7.20	5.80	6.52	5.20	5.36	4.50	6.38	2.59
Fe ₂ O ₃	-	1.98	-	1.90	1.66	2.70	1.14	1.08	2.70	1.89	0.56
FeO	1.80	-	2.06	-	-	-	-	-	-	-	-
ZrO ₂	1.45	0.99	1.99	0.95	0.66	1.00	2.03	2.09	1.00	4.10	0.60
Na ₂ O	2.88	2.39	1.46	2.30	5.10	4.50	5.10	5.25	3.50	2.05	6.20
K ₂ O	0.00	-	0.00	-	-	-	-	-	0.60	-	0.00
CaO	17.11	18.68	20.32	19.80	17.20	15.08	17.90	15.11	15.08	19.80	15.80
SrO	0.65	0.49	0.67	0.47	0.32	1.09	0.76	0.78	0.60	0.26	0.93
BaO	tr	-	tr	-	-	-	-	-	-	-	-
MgO	0.00	0.15	tr	0.42	-	-	0.68	0.56	1.00	-	0.00
MnO	1.17	0.08	0.09	0.08	0.06	0.07	0.05	0.06	0.37	0.28	0.00
Ce ₂ O ₃	2.20	7.70	8.87	7.06	7.34	3.00	3.78	4.09	3.00	8.66	1.63
La ₂ O ₃	-	1.45	-	1.39	1.09	0.70	0.68	0.70	0.70	1.22	0.37
Nd ₂ O ₃	-	1.89	-	1.82	1.06	-	1.83	1.89	-	1.22	0.39
Y ₂ O ₃	0.20	0.07	0.10	0.07	0.12	0.12	0.08	0.08	0.12	0.21	0.17
U ₃ O ₈	1.83	0.72	0.59	0.69	0.02	0.45	0.08	0.08	0.10	0.56	0.03
ThO ₂	7.23	1.15	1.08	1.10	0.02	0.63	1.47	1.51	0.23	0.03	0.20
Gd ₂ O ₃	-	-	-	-	-	0.20	-	-	0.20	-	-
SnO ₂	0.00	-	0.00	-	0.20	-	-	-	-	-	0.00
TiO ₂	-	-	-	0.12	0.03	-	0.03	-	-	-	0.00
F	2.17	3.93	2.30	3.80	3.92	3.69	2.13	2.19	3.69	2.15	4.61
H ₂ O+	7.50	-	0.87	0.12	0.18	1.24	0.35	-	1.24	0.36	0.59
F ₂ O ₅	-	-	-	0.02	0.08	-	0.24	-	-	0.04	0.07
S	-	-	-	0.01	0.11	-	0.04	-	-	0.05	0.04
SiO ₂	-	-	-	0.83	0.10	0.08	0.42	-	-	0.15	0.17
Al ₂ O ₃	-	-	-	0.00	0.00	-	0.00	-	-	0.00	0.00
PbO	0.10	-	0.06	-	-	-	-	-	0.08	-	-
L on Ig.	-	1.54	-	-	-	-	-	0.91	-	-	-
	<u>100.30</u>	<u>98.82</u>	<u>99.90</u>	<u>101.05</u>	<u>100.62</u>	<u>97.37</u>	<u>100.54</u>	<u>99.97</u>	<u>99.21</u>	<u>100.35</u>	<u>100.79</u>
O ~ F	<u>0.90</u>	<u>1.65</u>	<u>1.00</u>	<u>1.60</u>	<u>1.65</u>	<u>1.55</u>	<u>1.00</u>	<u>0.92</u>	<u>1.55</u>	<u>0.91</u>	<u>1.94</u>
	<u>99.40</u>	<u>99.17</u>	<u>98.90</u>	<u>99.45</u>	<u>98.97</u>	<u>95.82</u>	<u>99.54</u>	<u>99.05</u>	<u>97.66</u>	<u>99.44</u>	<u>98.85</u>
SG.			4.33		4.38						
a ^o A	10.36		10.38	10.43	10.393		10.428			10.395	10.4195

1. Thorian pyrochlore. Manny Zone. (Hogarth, 1961: sample No. H7. $Ce_2O_3 = \xi$ cerium earths, $Y_2O_3 = \xi$ yttrium earths).
2. Deep red pyrochlore (type 1), from St. Lawrence Columbium and Metals Corporation property. (G. Joncas, University of Sherbrooke, Quebec. Personal communication, 1962).
3. Reddish-brown pyrochlore (type 1), from Bond Zone. (Hogarth, 1961: sample No. H8a. $Ce_2O_3 = \xi$ cerium earths, $Y_2O_3 = \xi$ yttrium earths).
4. Deep-red pyrochlore (type 1) in ijolite, from pit A2, St. Lawrence Columbium and Metals Corporation property. (G. Perrault, École Polytechnique, Montreal. Personal communication, 1964).
5. Chocolate-brown, cerian pyrochlore (type 2) from soda pyroxene-calcite rock, pit A1, St. Lawrence Columbium and Metals Corporation property. (Perrault, 1964, and personal communication).
6. Red pyrochlore (type 3), from St. Lawrence Columbium and Metals Corporation property. (Perrault, 1961).
7. Very fine grained, brownish red pyrochlore (type 3) from biotitized ijolite, between pits A1 and A2, St. Lawrence Columbium and Metals Corporation property. (Perrault, 1964, and personal communication).
8. Red pyrochlore (type 3), from St. Lawrence Columbium and Metals Corporation property. (G. Joncas, University of Sherbrooke, Quebec. Personal communication, 1962).
9. Red pyrochlore (type 3). Average chemical composition of mill concentrate. St. Lawrence Columbium and Metals Corporation. (Engineering and Mining Jour. Oct. 1961).
10. Black zirconium pyrochlore (type 4), from biotite-monticellite calcite rock, footwall of pit A2, St. Lawrence Columbium and Metals Corporation property. (Perrault, 1964, and personal communication).
11. Buff pyrochlore (type 5) from coarse-grained calcite rock, from pit A2, St. Lawrence Columbium and Metals Corporation property. (Perrault, 1964, and personal communication).

1. The economic niobium mineralization in the A ore zone occurs in pyrochlore disseminated in specific types of carbonatite. Of these, the biotite-pyroxene and the monticellite carbonatite are the most important, though in places the soda amphibole and perovskite-rich monticellite carbonatite are ore grade.
2. The pyrochlore content varies from band to band and within individual bands.
3. The niobium content of the pyrochlore varies according to mineral association (see analyses, pages 32 and 33).
4. Pyrochlore mineralization associated with the zones of hydrothermal alteration is erratic in grade and extent.
5. Though perovskite (latrappite) containing as much as 39% Nb_2O_5 has been found in the A-2 zone, it has not been profitable to concentrate it.

Concentration Plant

The ore from the pits and the underground workings is brought by truck to the crushing plant, where it is reduced, in two stages, to minus 1 inch. From a storage bin the ore is fed by conveyor belt into grinders, where it is ground to minus 40 mesh. Basically, the concentration process involves a bulk flotation circuit followed by several stages of cleaning. The main steps after closed circuit grinding and classification are: sulfide flotation + magnetic separation + bulk flotation + cleaning circuits + tables + filtration + drying.

Mining and Milling Control

The concentration process is less efficient for rocks that produce excessive amounts of slimes (leached and chloritized rocks). Also, the bulk flotation and the cleaning circuits require adjustment with change in mineral composition of the ore. For example, pyrochlore recovery varies proportionately with the Nb_2O_5 grade and also the percentage of $CaCO_3$ in the ore, and inversely to the amount of silicate and other minerals. Grading of drill intersections is made on a graph based on mill recovery as a function of percentage Nb_2O_5 and $CaCO_3$ in the rock.

The variability of mineral content of the ore, as well as of the grade of the pyrochlore minerals, requires constant geologic control based on assays from drill holes and mapping of rock exposure. Typical compositions of mill feed and the final concentrate are:

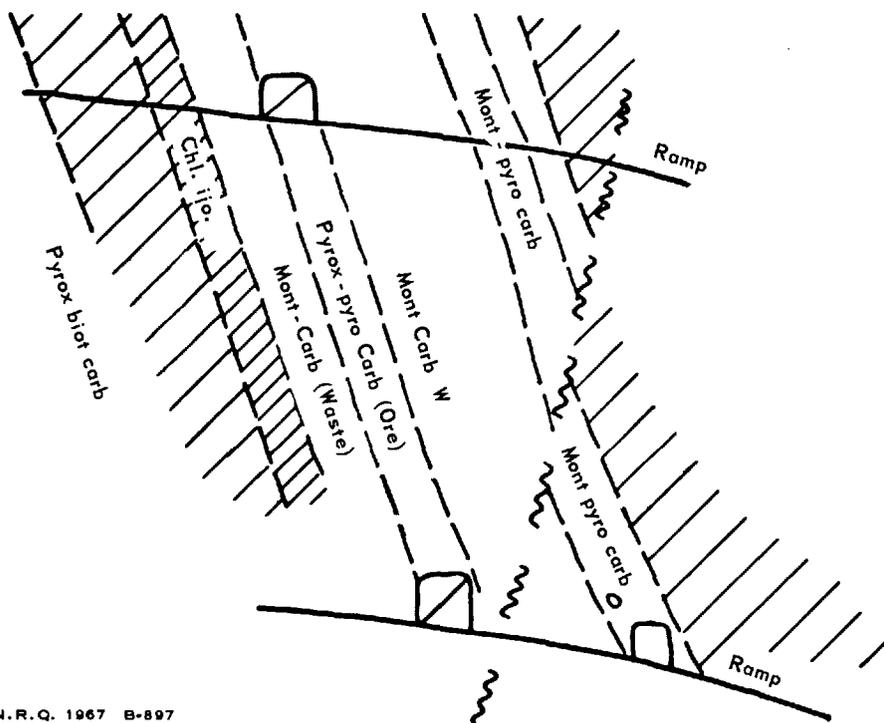
Range of mineral composition of mill feed		Range of mineral composition of concentrate	
Calcite	75 - 80%	Pyrochlore	92 - 98%
Apatite	5 - 8	Perovskite	Tr - 5
Mica	3 - 95	Mica	Tr - 5
Pyroxene	0 - 10	Pyroxene	Tr - 5
Monticellite	0 - 10	Monticellite	Tr - 3
Magnetite	0.5 - 5	Tremolite	Tr - 1
Sulfides	1 - 3	Sulfides	Tr - 0.3
Pyrochlore	1	Magnetite	Tr - 1
Others	0 - 2	Calcite	Tr - 1

Tour of the Mine Property

1. Mill. The various stages of the beneficiation process are summarized in the accompanying flow sheet (figure 10).

2. Pit No. 2. Walk down the ramp to the south of the mine dry room (change house) into the larger of the open pits.

(i) First bench level. Note the ijolite in the east and west walls.



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Figure 11

SCHEMATIC VIEW OF THE SOUTH WALL OF PIT No. 2

- (ii) Second bench level. Ijolite and biotite-pyroxene carbonatite (early stage, low niobium content) are exposed. Looking south into pit, notice structure of south wall between benches 3 and 8 (see figure 11). Two 15- by 15-foot adits were used to mine a lens of pyroxene-pyrochlore carbonatite in monticellite-biotite-magnetite carbonatite of sub-ore grade (0.15 - 0.20% Nb_2O_5). A band of chloritized ijolite is exposed to the east of the ore zone. Samples of dark, fairly coarse pyrochlore (type 4 - approximately 47% Nb_2O_5) can be picked up near the western contact of the ore zone. The trace of the fault exposed in the wall strikes into the pit and swings sharply east to cross the haulage road near the center of the pit. The pattern of the ijolite dikes in the west wall of the pit can be observed from the east side.

- (iii) Fifth bench level. The northern end of the ore zone can be seen from this point. Samples of fine-grained pyrochlore (type 5 - high niobium content) can be collected here.

Return to mill.

3. Pit No. 1. Walk down ramp from mill into smaller open pit.

- (i) Second bench level. A band of carbonatite (niobium-poor) can be seen in the south wall of the pit. In the southeast corner there are two lenses of ore. Note the boudinaged dikes of ijolite.

- (ii) Second to third bench level. In the east wall is exposed altered ijolite and nepheline okaite, which vary in grain size and in degree of alteration. The northern extension of the main ore zone mined in this pit is exposed in the northeast corner. It is the typical soda pyroxene-pyrochlore carbonatite, grading 0.5-0.7% Nb_2O_5 , and is the type locality of COQ-1 (a standard carbonatite sample).

- (iii) Walk down to the sixth bench level. Note the exposures of ijolite, chloritized ijolite and "lean" carbonatite in the wall.

Return to mill

End of field trip.

If you are returning to Montreal by car, turn left at the Mine gate, and left again, onto Route 29. at the La Trappe Monastery. If you are returning to points south of Montreal, turn right at La trappe and drive on to Oka village, cross the Ottawa by ferry and turn left to join the Trans Canada Highway.

