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CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

PAPER 54-22

NOTES ON COLUMBIUM MINERALIZATION, OKA DISTRICT, TWO MOUNTAINS COUNTY, QUEBEC

(Report and Map)

By

Robert B. Rowe

OTTAWA
1955

Price, 50 cents

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NOTES ON COLUMBIUM MINERALIZATION, OKA DISTRICT, TWO MOUNTAINS COUNTY, QUEBEC

INTRODUCTION

Columbium-bearing rocks of economic interest were discovered in 1953 near Oka, Quebec, by Mr. Stephen Bond, Molybdenum Corporation of America, and a mining property of about 7,000 acres was acquired by the company to cover the occurrence. Considerable trenching has been done and diamond drilling is in progress. The occurrence is of interest because it is a potential large tonnage source of columbium, and because the mineralization is associated with Monteregian ultra-alkaline rocks.

The writer examined the property during part of June and July 1954, and this report is a preliminary description of the rocks and minerals occurring in the trenches and drill-core.

The writer thanks Molybdenum Corporation of America, 500 - 5th Avenue, New York, for generously making available information concerning the property. In particular, the writer is greatly indebted to Mr. Stephen Bond of that company for information and help. Capable field assistance was given by Mr. C. M. Wright.

GENERAL GEOLOGY

REGIONAL GEOLOGY

The Oka district is part of the Monteregian petrographical province that probably extends east from Como, Vaudreuil county, to Big Megantic Mountain, Compton and Frontenac counties, Quebec, a distance of about 150 miles (See Figure 1).

Adams (1)[1] originated the name "Monteregian Hills" to include eight hills (Royal, St-Bruno, St-Hilaire, Johnson, Rougemont, Yamaska, Shefford, and Brome) whose cores are closely related alkaline intrusive rocks, and suggested that these rocks comprise a petrographical province. The Monteregian province was extended to the west by Harvie (7), Gauthier (5), Bowen (2), Howard (8), Stansfield (14), and Grimes-Graeme (6), and to the east by Osborne (9, p. 81).

Two principal types of alkaline rocks occur in the eight hills, alkaline gabbro and alkaline syenite (4). In places the gabbro and syenite grade into one another, whereas elsewhere the syenite

[1]Numbers in parentheses are those of references in Bibliography at end of this report.

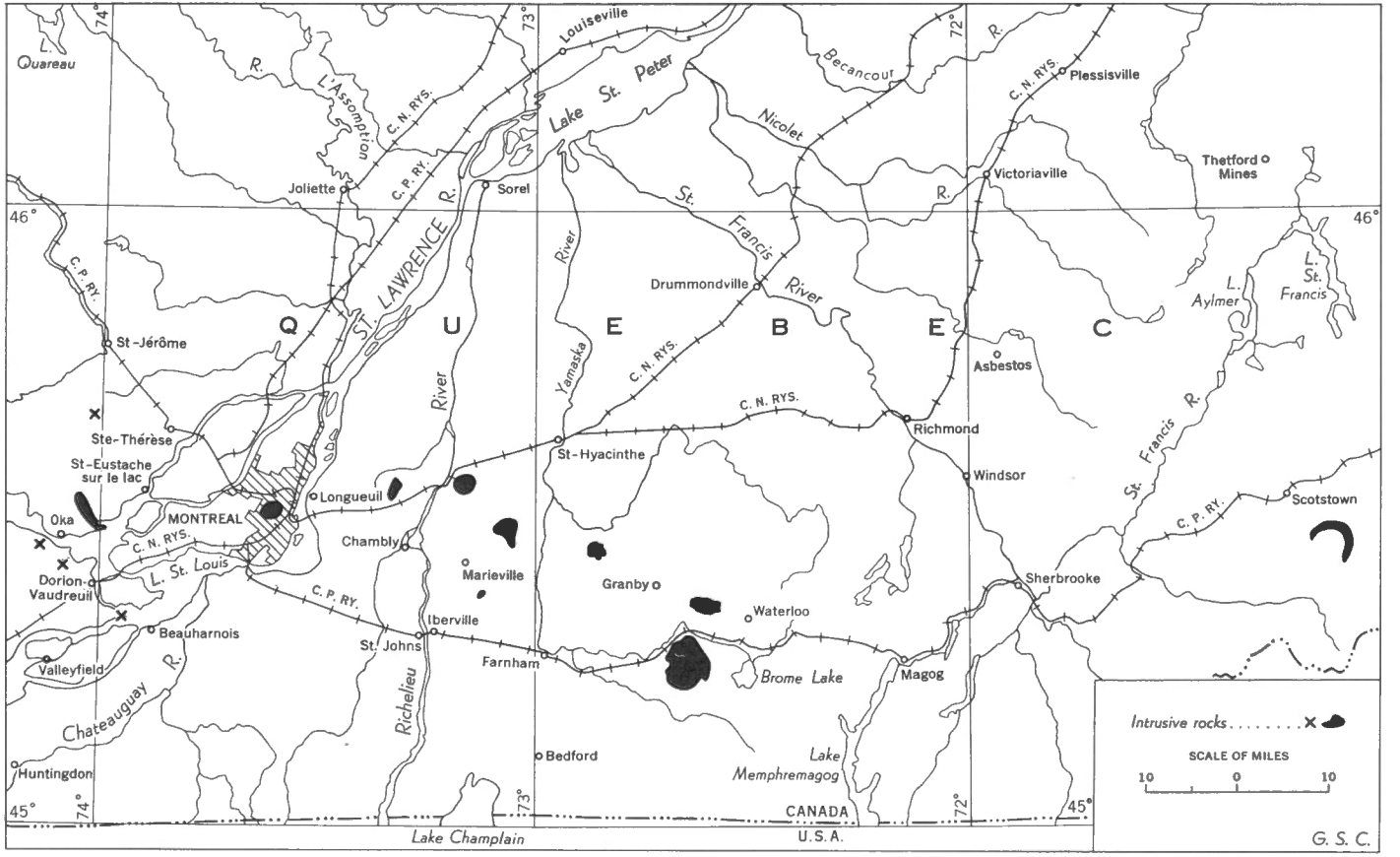

Figure 1. Map showing distribution of Monteregian intrusive rocks.

intrudes the gabbro. These rocks and the sedimentary rocks that they intrude are themselves intruded in places by swarms of co-magmatic dykes and sills, many of which are composed of lamprophyre rocks. Various types of breccia are associated with the igneous activity.

Intrusive rocks occurring in that part of the Monteregian province west of Mount Royal include okaite, ultra-alkaline rocks, and lamprophyre rocks. A partial ring dyke of nordmarkite (a variety of syenite) occurs at Big Megantic Mountain, which is 70 miles east of Brome and Shefford Mountains.

The Monteregian rocks are probably post-Middle Devonian in age, and possibly as young as Tertiary (4). Large blocks of fossiliferous Lower Devonian limestone occur in the Ste-Helen Island breccia, and the rocks of Yamaska and Shefford Mountains intruded Ordovician rocks that had been folded in Middle Devonian time. Osborne (9, p. 80) noted that pleochroic haloes in the Monteregian rocks are poorly developed and resemble those in Tertiary intrusive rocks, whereas the haloes in nearby Devonian granites are well developed. Helium method age determinations made by Urry (15, p. 1221) also suggest that the Monteregian rocks are Tertiary.

LOCAL GEOLOGY

The Oka Precambrian inlier, which is composed chiefly of anorthosite and gabbro, gneisses, quartzites, and marbles, was affected in places by Monteregian structural, metasomatic, and intrusive activity (3, 6, 7, 8, 11, and 14). An area of marble about 3½ miles long and 1½ miles wide was affected greatly by the activity so that it is now a complex that is composed chiefly of marble and related rocks, okaite, ultra-alkaline rocks, lamprophyre rocks, igneous breccias, and biotite replacement rocks (See Figure 2). The complex is characterized by above normal radioactivity and high magnetite content.

Columbium minerals occur in various rocks of the complex exposed in trenches on the Molybdenum Corporation of America property and in diamond drill-core. It is probable that columbium-bearing rocks will be found elsewhere in the complex, and possibly elsewhere in the Oka district, as exploration progresses.

Weathered rock, glacial drift, and Champlain clays, sands, and gravels overlie the rocks of the complex.

THE COLUMBIUM OCCURRENCE

The descriptions of general features, mineralogy, and lithology are based on a study of the trenches and the drill-cores from seven of the fourteen diamond drill-holes put down previous to November 1, 1954, and are subject to addition and revision as more information becomes available.

GENERAL FEATURES

The geology of the occurrence is extremely complex. Marble has been intruded by okaite and ijolite with accompanying contact metamorphism. This was followed by several stages of hydrothermal activity that resulted in the formation of secondary hydrous minerals, biotite replacement rocks, and columbium minerals. Lamprophyre dykes were intruded after the hydrothermal activity began but before it ended. Late carbonate veinlets and veins occur in places.

Four columbium minerals, columbian perovskite, pyrochlore, betafite, and columbium-bearing titanian magnetite, have been identified to date. These minerals occur as disseminated grains that are closely associated with biotite and apatite.

Very little is known about the structure because of the lack of sufficient outcrops, and wide spacing of the existing diamond drillholes.

MINERALOGY

The columbium minerals have been identified by X-ray powder pictures. Two qualitative spectrographic analyses of columbian perovskite, one of pyrochlore, one of betafite, and three of magnetite are given in Table I. Perovskite and magnetite are similar in megascopic appearance, but perovskite has a light grey streak and is non-magnetic, whereas magnetite has a black streak and is strongly magnetic. Pyrochlore and betafite are very similar megascopically and microscopically except that the betafite grains are commonly rimmed by, or altered to, a greenish yellow material.

Columbian Perovskite

Generalized formula: $(Ca, Na, Ce)_8 (Ti, Cb)_8 O_{24}$

Columbian perovskite occurs as disseminated grains in apatite-biotite-magnetite rock, monticellite rock, akermanite rock, and altered ultra-alkaline rocks. The grains are commonly anhedral to subhedral and range up to 7 mm. in size, although most of them are under 1 mm. Cubo-octahedral crystals occur in a few places. Other properties are: very dark purplish brown to purple colour; metallic lustre; light grey streak; and uneven fracture. In thin section the perovskite grains are dark brown to reddish brown, generally anisotropic, and very complexly twinned. They have a very high relief and commonly contain rounded inclusions of biotite, calcite, and apatite (See Figures 3 and 4).

Table I

QUALITATIVE SPECTROGRAPHIC ANALYSES OF COLUMBIUM MINERALS FROM OKA, QUEBEC

Mineral	Columbian perovskite	Columbian perovskite	Pyrochlore	Betafite	Magnetite	Magnetite	Magnetite
Rock type	Apatite-biotite--magnetite rock	Altered ultra-alkaline rock	Marble	Biotite-calcite rock	Monticellite rock	Apatite-biotite-magnetite rock	Apatite-biotite-magnetite rock
Major constituent 10-100%	Ca, Cb, Ti	Cb, Ti	Cb, Th	Cb, Ti	Fe	Fe	Fe
Minor constituent 1-10%	Fe, Al	Ca	Ti, Al	Th	Al, Ti	Al, Ti, Mn	Al, Ti, Mn
Strong trace 0.1-1%	Mn, Ca, La	Fe, Si, Al, Mn	Zr, Fe, Mn	Zr, Mn	Mg, Mn, V	Mg, V	Mg, V, Cb
Trace 0.01-0.1%	Y, Si, Mg, V, Sr	Mg	Mg, Si, Ca Y, La, Ce	Ca, Ba, Al	Cb, Ba, Si Zn	Cb, Si, Zn	Si, Zn
Faint trace 0.001-0.01%	Pb, Zr, Cu Ba	Cu, Ba	Pb, Sc, Cu, V, Ba, Sr	Mg, Pb, Fe Cu, Si, Sr	Zr, Cu, Co Sr, Ca, Sc	Cu, Co, Zr, Ba, Sr, Ca	Cu, Ca, Ba, Zr

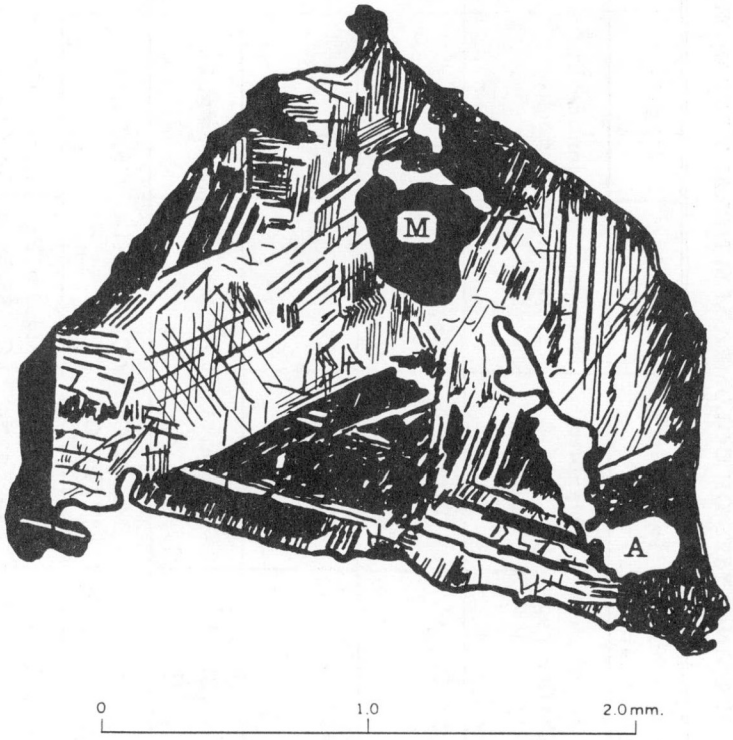

Figure 3. Camera-lucida drawing of columbian perovskite from altered ijolite showing complex twinning. Crossed nicols. Note inclusions of magnetite (M) and apatite (A).

Figure 4. Camera-lucida drawing of altered ijolite showing columbian perovskite (Per), magnetite (M), soda pyroxene (Pyr), apatite (A), biotite (B), calcite (C), natrolite (N), and vesuvianite-pyroxene-carbonate aggregate (Agg).

Pyrochlore

Generalized formula, pyrochlore-microlite series: $A_2B_2O_6$ (O, OH, F)

A = Na, Ca, K, Mg, Fe^2, Mn^2, Sb^3, Pb?, Ce, La, Di, Er, Y, Th, Zr, U

B = Cb, Ta, Ti, Sn?, Fe^3, W?

Pyrochlore occurs in apatite-biotite-magnetite rock, in soda pyroxene-calcite rock, and in marble as disseminated, anhedral to euhedral grains ranging up to 5 mm. in size. On the smooth surfaces of diamond drill-core it is brownish red in colour, but on rough surfaces it is usually chocolate-brown. In thin sections, it has high relief, is isotropic, and bright brownish red to reddish brown in colour. Inclusions of calcite, apatite, and biotite are common. Biotite grains near pyrochlore grains are commonly bright orange in colour in thin section, but there is no noticeable megascopic difference. Pleochroic haloes are poorly developed. Figure 5 shows pyrochlore grains in marble.

Betafite

Generalized formula, betafite series: $AB_3O_9 \cdot nH_2O$?

A = U, Ca, Th, Pb, Ce, Y

B = Ti, Cb, Ta, Fe, Al

Disseminated, anhedral to euhedral betafite grains occur in biotite replacement rocks. On the smooth surface of drill-core the grains are reddish brown, but on rough surfaces they are dark purplish grey. Many of the grains are rimmed or entirely replaced by greenish yellow material. In thin section, the unaltered betafite is reddish brown, isotropic, and has very high relief. Some euhedral grains are zoned. The altered crystals are mottled yellowish and greenish brown. Biotite grains near betafite grains are commonly bright orange in colour, and pleochroic haloes are poorly developed. If the thin section is viewed in reflected light, the crystals are yellow to orange to metallic purplish red in colour. Most of the grains are less than 0.5 mm. in size. Figure 6 is a camera-lucida drawing showing betafite in biotite replacement rock.

Magnetite

Magnetite is a constituent of almost every rock type found on the Molybdenum Corporation of America property. It occurs as disseminated, dark steel-grey, submetallic dull to splendent grains

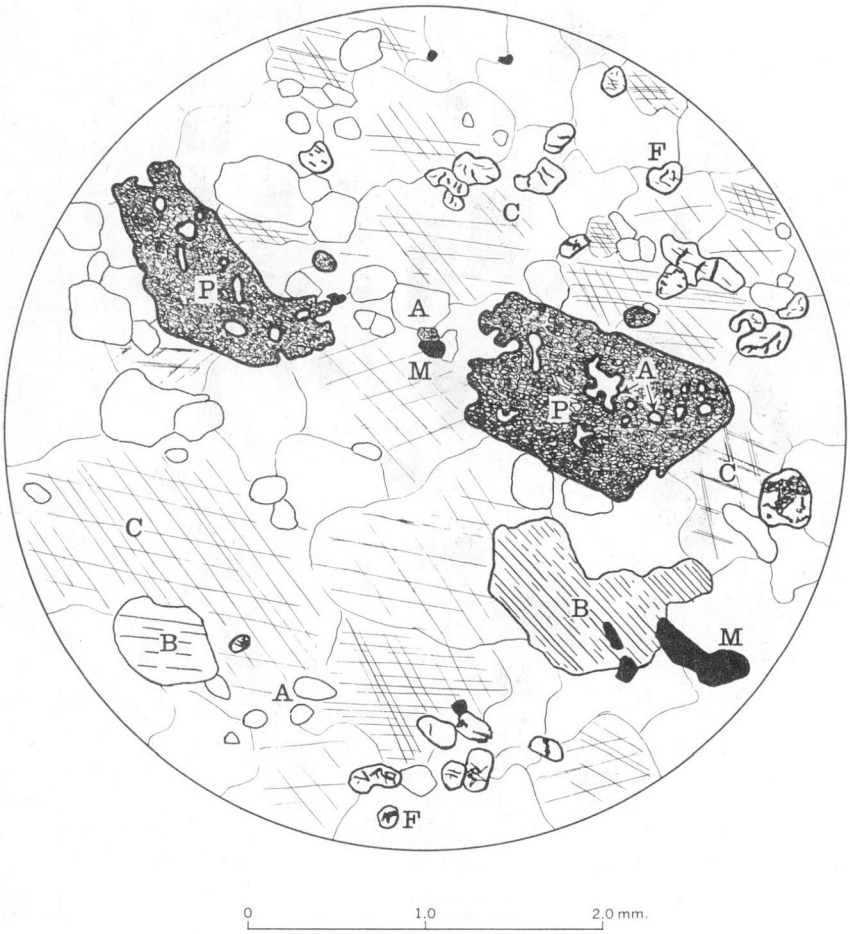

Figure 5. Camera-lucida drawing of marble, showing pyrochlore (P), magnetite (M), apatite (A), biotite (B), forsterite (F), and calcite (C). Note inclusions of apatite in pyrochlore.

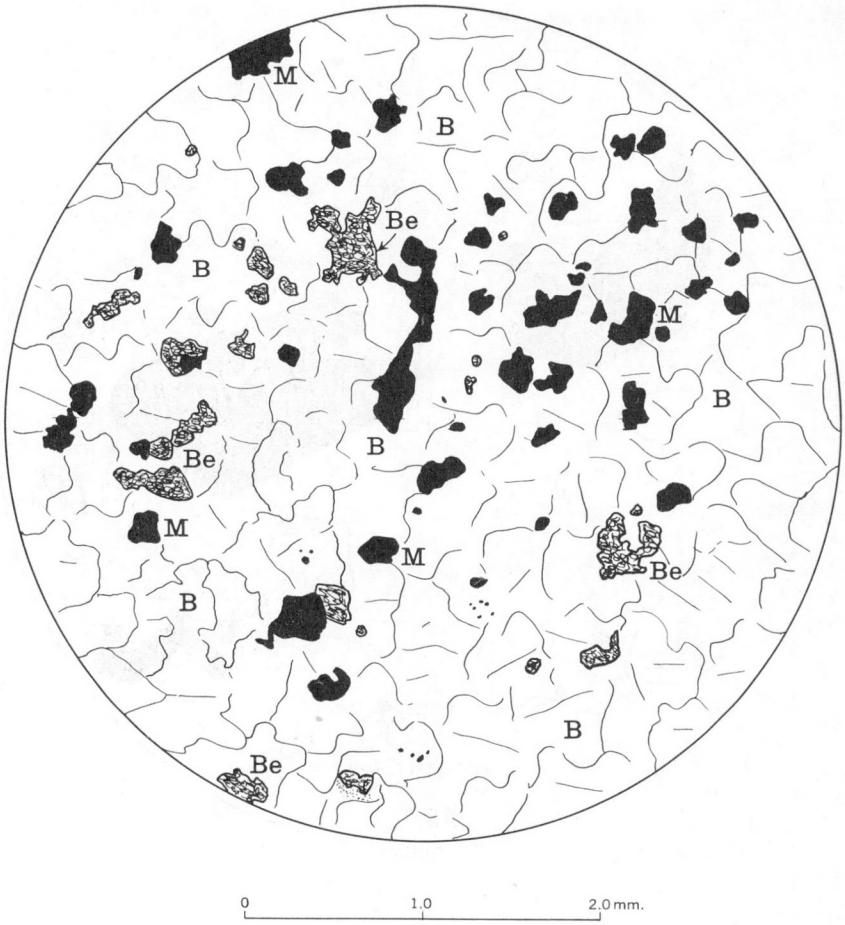

Figure 6. Camera-lucida drawing showing betafite (Be) and magnetite (M) in biotite (B) replacement rock.

that are strongly magnetic and have a black streak and subconchoidal fracture. Thin sections show that magnetite grains are commonly moulded onto perovskite grains and contain rounded inclusions of perovskite, green spinel, and other minerals (See Figure 4).

LITHOLOGY

A great variety of rocks occur in the trenches and diamond drill-core, and only the principal types are described here.

Marble and Related Rocks

Marble

Marble is probably the most abundant rock. It was probably originally a siliceous, dolomitic limestone that has undergone deformation, recrystallization, and contact metasomatism. The marble is generally medium to coarse grained, and composed of colourless to grey to white calcite with narrow bands, streaks, and patches containing sugary apatite, pale grey to green forsterite, pale olive-green soda pyroxene, biotite, magnetite, pyrrhotite, and, in places, brownish red pyrochlore. A few grains of perovskite were seen but it is generally absent. Figure 5 is a camera-lucida drawing of marble containing pyrochlore.

Apatite-Biotite-Magnetite Rock

In places, bands and patches of marble have been transformed into a massive, fine- to coarse-grained rock composed chiefly of magnetite, biotite, and sugary apatite, with lesser amounts of calcite and perovskite. Forsterite and soda pyroxene occur as unreplaced remnants.

Soda Pyroxene-Calcite Rock

This rock occurs in places at the contacts of marble and ijolite, as patches in the marble near the contacts, and intermixed with the ultra-alkaline rocks. It is generally massive, medium to coarse grained, and is composed principally of white calcite and crystals of prismatic, olive-green to dark green soda pyroxene, with lesser amounts of biotite, magnetite, and apatite. Brownish red pyrochlore grains were seen in one section of this rock in the drill-core.

Monticellite Rock

Three types of monticellite rock are distinguished. The first type is composed of irregular, fine- to coarse-grained, grey, monticellite metacrysts in a groundmass of fine- to medium-grained calcite. The second is composed of fine- to medium-grained, grey monticellite, magnetite, and perovskite. The third consists of angular fragments of monticellite grains in a groundmass of calcite, apatite, silvery brown mica, magnetite, perovskite, forsterite, and soda pyroxene. These rocks occur as bands within the marble, and intermixed with the ultra-alkaline rocks.

Okaite

The okaite is a very distinctive rock that was described first by Stansfield (14), who recognized two types, okaite and nepheline-okaite. It is generally massive, but trachytic texture due to subparallel arrangement of akermanite laths occurs in a few places. The rock is fine to very coarse grained, and composed chiefly of glassy, grey to bluish grey akermanite[1] with lesser amounts of dull, blue-grey, altered

[1] Akermanite ($Ca_2 Mg Si_2 O_7$) is an end member of the melilite series. It occurs in silica-deficient igneous rocks.

nepheline, magnetite, biotite, calcite, perovskite, and pale greenish yellow, very fine-grained aggregates. Patches and streaks consisting of altered nepheline and pale greenish yellow aggregates are common. Weathered surfaces are chalk-like.

Okaite occurs as dykes and small bodies cutting marble, and intermixed with altered ijolite. The relationship of okaite and ijolite is obscured by later biotitization, but an angular fragment of okaite in altered ijolite was seen in one of the trenches.

Under the microscope, it can be seen that the altered nepheline consists of very fine-grained aggregates of natrolite, and, less commonly, thomsonite or cancrinite. The pale greenish yellow aggregates are composed of colourless vesuvianite, colourless pyroxene, and carbonate. In places, the akermanite is partly altered to very fine-grained, fibrous, brown vesuvianite. Figure 7 is a camera-lucida drawing of okaite.

Chemical analyses of okaite and nepheline-okaite are given in Table II.

Figure 7. Camera-lucida drawing of okaite, showing akermanite (Ak), natrolite (N), thomsonite (T), biotite (B), magnetite (M), columbian perovskite (Per), and apatite (A).

Ultra-alkaline Rocks

Ijolite

This very fine- to medium-grained rock is composed chiefly of nepheline and soda pyroxene, and occurs as dykes and small bodies. On fresh surfaces the rock is medium grey or olive-green, whereas on smooth drill-core surfaces it is light grey or mottled green and white. Some of the nepheline grains are partly or completely altered to pink aggregates of analcime and muscovite. The rock is generally massive, but very fine banding was noted in some specimens. Calcite may be present in amounts up to 50 per cent. Black garnet, biotite, apatite, and magnetite are present in places as accessory minerals. Patches of fine-grained biotite, and white carbonate veinlets with irregular biotite borders are common. Pyrite is present in some of the veinlets, and pyrrhotite occurs in places in the biotite borders and patches.

Altered Ijolite

The altered ijolite is mottled in colour, inequigranular, fine to medium grained, and composed principally of: bluish grey aggregates of very fine-grained thomsonite or natrolite; pale greenish yellow aggregates of very fine- to fine-grained vesuvianite, colourless augite, and carbonate; magnetite; perovskite; biotite; apatite; calcite; olive-green soda pyroxene; and grey to light brown nepheline. Pyroxene-rich varieties are olive-green in colour. Under the microscope, it can be seen that the soda pyroxene and nepheline grains are unreplaced remnants. Figure 4 is a camera-lucida drawing of altered ijolite.

Altered Nepheline Rock

This very distinctive rock occurs intermixed with the altered ijolite, and is composed of light brown to grey, ragged, nepheline remnants, magnetite, and perovskite, in a very fine-grained, greenish yellow groundmass of vesuvianite, colourless augite, and carbonate. The nepheline grains range up to ½ inch in length. Bluish grey, very fine-grained aggregates of thomsonite and natrolite, needle-like apatite crystals, and biotite occur in places.

Lamprophyre Rocks

The lamprophyre rocks occur as dykes, and are composed of medium- to very coarse-grained phenocrysts of black titanaugite and black olivine in a very fine- to fine-grained groundmass consisting chiefly of nepheline, magnetite, pyroxene, green amphibole, biotite, black garnet, and carbonate. Many of the olivine

phenocrysts have well-developed coronas. Some of the lamprophyre dykes contain angular inclusions of ultra-alkaline rocks. In places, at marble-lamprophyre contacts, the marble is heavily biotitized or is sheared up to a few inches from the contacts.

Biotite Replacement Rocks

All of the rock types described above have been more or less replaced in places by biotite rocks. Two stages of replacement are apparent; the first resulted in the formation of dense, fine-grained biotite rock, and the second in medium- to coarse-grained apatite-calcite-biotite rock. All gradations exist from rocks with small replacement patches to rocks with rounded, unreplaced remnants and ultimately to massive biotite rock or apatite-calcite-biotite rock. The apatite is commonly reddish brown. These biotite replacement rocks contain betafite in places (See Figure 6), and, in general, are more radioactive than the other rocks of the occurrence. Some of the unreplaced fragments also contain betafite.

ORIGIN

The formation of the columbium minerals and associated secondary minerals was probably due to complex hydrothermal metasomatism with the addition of water, iron, titanium, potassium, phosphorus, fluorine, columbium, rare earths, thorium, sulphur, and many other elements. This activity closely followed the intrusion of marble by okaite and ijolite, and there is little doubt that the two events are related genetically.

The okaite and ijolite are somewhat different from the normal Monteregian alkali gabbro and alkali syenite. Stansfield (14, pp. 447-448) suggested that solution of a shaly limestone in a magma is capable of giving rise to okaite. It is possible that reaction between coarse-grained Grenville limestone and an alkali gabbro-syenite magma could produce both okaite and ijolite. Table II gives the chemical analyses of alkali gabbro and alkali syenite from Mount Royal, okaite and nepheline-okaite, and average ijolite.

RECOMMENDATIONS FOR PROSPECTING

The following facts should be useful in prospecting for columbium in the Oka district and possibly elsewhere in the Monteregian province:

(1) The mineralization on the Molybdenum Corporation property is associated with Monteregian okaite and ijolite.

Table II

CHEMICAL ANALYSES OF VARIOUS MONTEREGIAN ROCKS AND AVERAGE IJOLITE

	Mount Royal				
	Alkali gabbro	Alkali syenite	Okaite	Nepheline-okaite	Average ijolite
SiO_2	43.10	55.90	29.43	31.37	42.58
TiO_2	2.80	0.70	3.39	2.00	1.41
Al_2O_3	13.94	19.75	12.70	15.16	18.46
Fe_2O_3	4.92	1.00	4.85	4.94	4.01
FeO	6.93	2.05	6.33	3.46	4.19
MnO	0.14	0.10	0.21	0.51	0.20
MgO	8.86	0.59	6.00	4.77	3.22
CaO	14.65	3.10	25.24	27.10	11.38
Na_2O	2.50	7.25	2.39	4.55	9.55
K_2O	0.89	5.61	1.28	1.06	2.55
H_2O+	0.55		0.73	0.83	0.55
P_2O_5	0.27	0.01	1.64	1.66	1.52
CO_2	0.64	1.85	1.98	1.74	0.38
Cl				0.04	
H_2O-	0.15		0.28	0.04	
Rest	0.28	0.77	3.12		
H_2O+, H_2O		2.00			
BaO				0.16	
Li_2O				tr.	
FeS_2				0.21	
Fe_7S_8				0.13	
SO_3				0.35	
Reference	(4)	(4)	(4)	(14)	(10)

(2) Rocks that contain columbium have one or more of three general characteristics: abnormal radioactivity, high magnetite content, and high secondary biotite content.

(3) Much of the soil overlying the marble-ultra-alkaline rock complex has formed in part from the underlying rocks. In many fields, the soil contains biotite from the matrix of biotite replacement rock, and the stone fences are made of resistant fragments of unreplaced, altered ultra-alkaline rocks.

(4) Most of the radioactivity is due to thorium, and the use of a beta-gamma Geiger counter or a scintillation counter is recommended.

Study of the columbium mineralization near Oka, and on the Beaucage Mines property, Lake Nipissing (13) suggests that areas of alkaline rocks should be prospected for columbium.

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