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GEOLOGICAL REPORT 110

BRISTOL-MASHAM AREA

PONTIAC AND GATINEAU

COUNTIES

by

R.-J.-E. SABOURIN

QUEBEC

1965

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BRISTOL-MASHAM AREA*
Pontiac and Gatineau Counties

by
R.J.E. Sabourin**

INTRODUCTION

General Statement

The Bristol-Masham area, mapped by the writer during the summers of 1953 and 1954, lies chiefly in the Laurentian Uplands of the Precambrian shield. The Precambrian terrane is underlain by a complex of paragneisses of the Grenville series cut by intrusive rocks of various ages. Some exposures of Ordovician sedimentary rocks occur near Ottawa river. Large parts of the Uplands are mantled by glacial deposits, whereas marine clay and sand terraces cover most of the lowlands.

Hilton Mines, formerly known as the Bristol mine, has been an active producer of iron ore since early 1958. Molybdenite deposits in the area have been exploited intermittently, and occurrences of barite, brucite, mica, zinc, radioactive minerals, dolomite, marl, and sand and gravel are present.

Location and Access

The area is bounded by latitude 45°45' on the north, by Ottawa river on the south and by longitudes 76°00' and 76°30'. It comprises about 420 square miles of which one-quarter is in Gatineau county and the remainder, in Pontiac county. It includes parts of Masham and Eardley townships in Gatineau county, as well as all of Onslow and Bristol and parts of Aldfield, Clarendon, and Thorne townships, in Pontiac county.

The southeastern corner of the area is approximately 17 miles northwest of Hull via provincial Highway 8. This highway and a

*Includes parts of the national topographic sheets Fort Coulonge 31 F/NE (Department of Mines and Technical Surveys) and of Arnprior 31 F/8 (Department of National Defence).

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roughly parallel Canadian Pacific Railway line crosses the area from east to west relatively close to Ottawa river. A Canadian National Railway line crosses from the Ontario side of the river in the southwestern corner of Onslow township and passes through the southern parts of Bristol and Clarendon townships.

Most of the area is easily accessible by a network of roads in fair to poor condition. A few old roads, now little better than trails, were useful west of Lapêche lake and northwest of Notre-Dame lake.

Gatineau Park, under the supervision of the Federal District Commission, is a game sanctuary that extends, roughly, from Lapêche lake east to the Gatineau Highway (No. 11).

Field Work

The base map on which the geology was plotted is an enlargement to a scale of one mile to two inches, of the Fort Coulonge and Arnprior sheets (see footnote, p. 1).

The wooded areas were examined by means of pace and compass traverses at 1/2-mile intervals. Exposures and unconsolidated materials on the open areas were mapped directly on aerial photographs having a scale of about 3,300 feet to one inch. The shores of the larger lakes and of Ottawa river were traversed by boat.

Acknowledgements

The writer is deeply indebted to Professor F.F. Osborne who supervised the field work and who also directed the doctoral thesis on which this report is based. This thesis was submitted to the Graduate School of Université Laval in 1955. Laboratory work done by the author was subsidized by the National Research Council of Canada.

Able assistance was given in the field by Peter L. Money in 1953 and by Bohdan Pavlu in 1954. Both were students at McGill University.

Previous Work

Vennor (1876-1877) and Ellis (1907) included parts of the area in their broad regional studies. In 1917, Wilson (1924) studied the Arnprior-Quyon area, which overlaps the south-central part of the present area. Béland (1954) mapped the area immediately to the east and Baker (1954) mapped that immediately to the north. Many of the mineral occurrences of the present area are described in reports by Spence (1929), Eardley-Wilmot (1925), and Cirkel (1909).

GENERAL DESCRIPTION OF THE AREA

Topography

At least half of the area lies in the Laurentian Uplands and is characterized by rounded hills rising to 300 feet or more above narrow valleys. The highest hills (west of Lola and Notre-Dame lakes and northeast of Thorne and Loups lakes) are usually made up of more resistant formations such as granite gneisses. The highest point is about 1,350 feet above sea-level and is 1/2 mile south of Lusk lake. The mean level of the Ottawa, just south of Eardley, is 192 feet above sea-level. Thus, the local relief is about 1,150 feet.

The Laurentian Upland of the area is characterized by features typical of the Upland as a whole, namely, a markedly uneven surface, irregular lakes and youthful drainage. In the eastern half of the area, the Upland is sharply bounded to the south by the Eardley escarpment which rises steeply above the lowlands 3 to 4 miles north of Ottawa river. In the western half of the area, the Uplands pass gradually into lowlands along an arcuate zone, convex to the northeast.

The Eardley escarpment is an outstanding topographic feature of the area (Fig. 1). It enters the area east of Luskville and trends northwest with a maximum height of 700 to 800 feet, for about 3 miles to where it bifurcates, one branch swinging northwest and the other westward. The northwestern branch continues for 3 miles or so before disappearing among the irregularities of the Upland. The other branch continues to the west another 5 miles, becoming progressively less prominent, and dies out northwest of Quyon. Much has been written about this feature and some aspects of it are discussed below in the section on structural geology.

The lower ground south of the Uplands is not typical of the St. Lawrence Lowlands because Precambrian rocks outcrop there. However, as flat-lying Paleozoic formations rest on some of the Precambrian and as sediments of the Champlain sea fill in most depressions, the low ground has the physiographic appearance of the St. Lawrence Lowlands. The writer agrees with Wilson (1924, p. 7) in considering this lower ground as an overlapping border zone between the St. Lawrence Lowlands proper and the Laurentian Upland.

Slumping of the clay banks of Quyon river is quite common. Hummocky topography immediately north of the village of Quyon resembles the scars of an old earthflow (see also Wilson, 1924). A younger earthflow may have occurred at the west end of the sand terrace on lot IV, Onslow township. Here, a depression on the east side of the road north of the

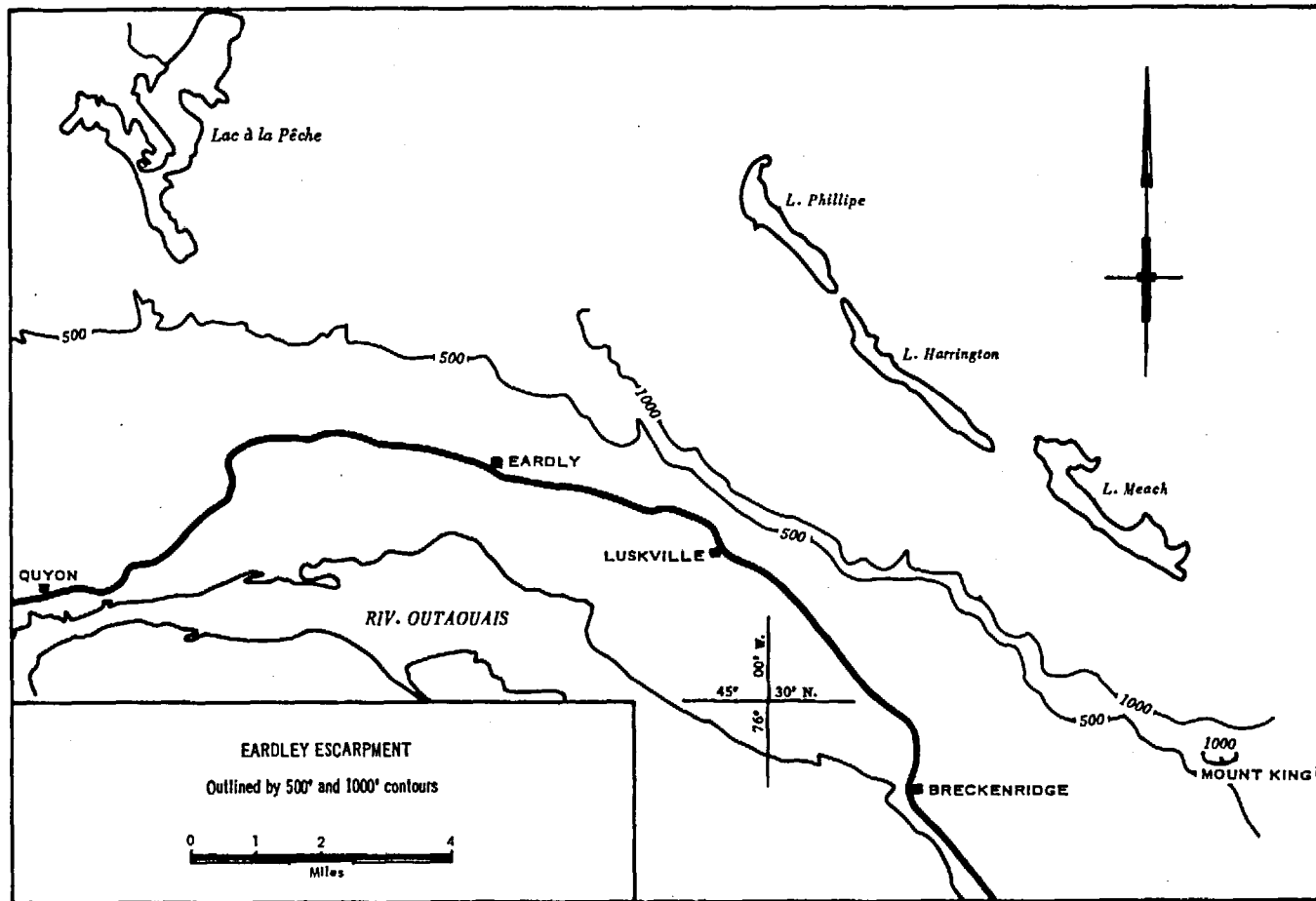


FIGURE 1

D.N.R.Q. 1982 NO. 1498

railroad track shows the typical bottleneck through which material could have passed. Concentric patterns in the material that flowed are not noticeable in the field, but are apparent on aerial photographs of the locality.

Drainage

The largest body of water in the area, except for Chats and Deschênes lakes which are but wider parts of Ottawa river, is Lapêche lake. This lake covers 5 square miles in the northern half of Onslow township. The other important lakes are, in decreasing order of size, Notre-Dame, Mahon, Loups, Phillippe and Thorne. The area is dotted by at least 175 lakes. These are generally irregular in shape and seem to be under little structural control. Northwest of Charteris, a group of small lakes, lying in unconsolidated material, trend northwest. They may be "kettles", the result of filling of basins left where stagnant ice melted. The small lakes northwest of Quyon probably had a similar origin. At the western boundary of the area, Ottawa river is slightly more than 243 feet above sea-level; to the southeast, where it leaves the area, it is slightly less than 192 feet. Most of the 51-foot drop takes place at the Chats Falls hydroelectric power project. Quyon river, which is the next most important stream and drains most of the western half of the area, enters the Ottawa at Quyon. The northern two-thirds of the eastern half of the area is drained by Lapêche river into the Gatineau at Wakefield. This stream is a good example of the meandering type, with small oxbow lakes and well developed loops, all within a relatively narrow meander belt.

The rest of the area drains directly into Ottawa river by several small streams.

Population and Resources

The farms of the Uplands are generally marginal and the livelihood of most of the population comes chiefly from lumbering. The lumber cut is mainly poplar and spruce, which is trucked to paper mills at Gatineau Mills. Small enterprises, such as saw-mills, are of local importance.

The soil of the lowlands, in part a rich clay loam, supports many prosperous farms. Farming is of the mixed type, although the raising of beef cattle is gaining in importance in the western half of the area.

The many lakes of the area attract tourists and summer residents. The lakes contain some game fish, mainly bass and trout, and a small amount of commercial fishing is done in the Ottawa. Gatineau Park furnishes safe breeding grounds from which game overflows. Black bear and deer are abundant in the wooded uplands. Among the smaller animals, beaver, raccoon, mink and muskrat are numerous.

GENERAL GEOLOGY

General Statement

Most of the area is underlain by Precambrian rocks. However, Ordovician formations are exposed close to Ottawa river, mainly near Quyon and southwest of Bristol Mines.

The oldest Precambrian rocks are gneisses, quartzite, and limestones of the Grenville series. They outcrop as bands and lenses throughout most of the area and also form part of the group which, mapped as injection gneiss, is exposed mainly in the northern half of the area. Masses of granite, granite gneiss and some syenite are present. A northeasterly-striking band of diorite, anorthosite and gabbro outcrops south of the injection gneiss. These rocks also occur as lenses in the injection gneiss and as large inclusions in the porphyritic syenite which underlies most of the southeast quarter of the area. The Onslow syenite complex is exposed in a relatively restricted area north of Quyon. A silicified dyke of this complex is traced from west of Lapêche lake to the Ottawa. At one place it cuts an altered diabase dyke. The latter is apparently older than most of the other diabase dykes of the area.

Table of Formations

CENOZOIC	Recent and Pleistocene	Till, gravel, sand, clay
PALEOZOIC	Ordovician	Chazy: shale and sandstone Beekmantown: dolomite
PRECAMBRIAN	Post-Grenville Intrusives	Diabase
		Onslow syenite complex
		Porphyritic Wakefield syenite, minor porphyritic granite, quartz-syenite, and diorite
		Diorite, gabbro, anorthosite, peridotite
		Biotite granite and granite gneiss (fine-grained and porphyritic facies), minor syenite
		Injection gneiss: largely Grenville formations intruded by granite; some paragneiss and crystalline limestone
	Grenville Series	Crystalline limestone, quartzite, garnetiferous paragneisses, rusty-weathering gneisses, hornblende-biotite gneisses, amphibolite, metamorphic pyroxenite

PRECAMBRIAN

Grenville Series

The limestones, gneisses, and quartzites of the Grenville series are the most extensively exposed rocks of the area. In addition, the injection gneiss complex is composed of varying amounts of Grenville formations and granitic injections.

The Grenville rocks are more or less evenly distributed throughout the area, but are most extensively exposed in the north. In the southeast quarter of the area, the Wakefield porphyritic syenite cuts the Grenville formations. That part of the western half of the area that is largely drift-covered apparently is underlain by one, if not two, layers of crystalline limestone as well as by paragneisses.

Crystalline Limestones

Bands and lenses of crystalline limestones are particularly well exposed in the western half of the area, and also occur in the paragneisses and in the injection gneiss complex. The limestones generally weather white or pale grey, but, in the more dolomitic exposures, they weather buff. On the fresh surface they vary from white to blue-grey, and there is some pink limestone in localities where hydrothermal solutions were active. Their grain size is medium to coarse.

Silicate layers, which may be broken or contorted (Plate I), are generally associated with the limestone, and placed in relief by differential erosion.

The most common accessory mineral, phlogopite, occurs as randomly oriented idiomorphic flakes. Other common accessories are graphite and small rounded grains of quartz. Colourless to very pale green tremolite is abundant in a few exposures in the southern part of the area. Pyrite (some partly oxidized), apatite, microcline and plagioclase, chlorite, forsterite, antigorite, magnetite and hematite were also identified. The last two minerals occur in the small masses of crystalline limestone at the Hilton iron mine. The hematite, with accessory magnetite and some sulphides, has been introduced parallel to the layering of the limestone.

Considerable activity followed the discovery of radioactive minerals associated with pink crystalline limestone at Sandy Creek, in Huddersfield township, north of the area. Within the area, many

specimens of pink limestone were tested with a Geiger counter, but nothing of interest was found.

As elsewhere in the general region, mica has developed along some of the contacts between crystalline limestone and intrusions. The best example is on lot 17, range VII, Onslow township (12), near the contact between crystalline limestone and porphyritic Wakefield syenite. With the phlogopite, well developed diopside crystals occur embedded in coarse-grained, pink calcite. Inclusions of limestone in the porphyritic Wakefield syenite are commonly brucitic.

The limestone commonly shows layering that is parallel to the contact of more resistant nearby formations.

Wilson (1924) mapped some crystalline limestone on the shore of Chats lake as part of the Bristol series. This limestone consists of alternating light and dark grey layers (Plate II A,B). The darker layers, rich in finely disseminated graphite, are less than an inch thick and the light ones rarely exceed 2 inches.

Wilson mapped the limestone on the west side of the bay on the north shore of Chats lake as Bristol limestone and that on the east side of the bay as Grenville. The limestones on the two sides of the bay are quite similar and the structure indicates them to be parts of the same band. Similar layered limestone was observed in other parts of the area, for example in contact with Wakefield porphyritic syenite on the northeast shore of Philippe lake.

Quartzites

Quartzites are not abundant in the area. They occur interbedded with the paragneisses or as thin layers or fragments of layers in the crystalline limestone. The only extensive quartzite occurrence is a band, exposed across a width of 500 feet, that extends from the islands in the northeast bay of Chats lake to the Pontiac Station road.

The quartzites of the area are of two varieties: normal Grenville quartzites of variable purity, including graphitic quartzites, and the thin-bedded quartzites of the Bristol Mines locality.

The normal quartzites are light grey to greenish on fresh surfaces and rusty brown to white where weathered. A few small exposures south of the Mashan road on the east boundary are pinkish owing to potassic feldspars. Granularity varies from fine to medium. Thin-

sections show the quartz grains to be recrystallized, and in some cases sutured together. Many show undulatory extinction indicative of stress. Quartz generally comprises 80% or more of the rock, except in the very impure facies. The most common accessory is sphene; microcline, apatite, chlorite and pyrite are also common. Plagioclase, varying in composition from sodic oligoclase (An_{11-14}) to andesine (An_{38}), was identified in a few thin-sections. Other minerals identified include epidote, calcite, tremolite, phlogopite, muscovite, wollastonite and magnetite. Sillimanite, of the fibrolite variety, occurs as sheaf-like aggregates in the quartzite exposures immediately west of Ste-Cécile-de-Masham.

Well foliated, impure, graphitic quartzites were seen at two localities: one at the northeast tip of Notre-Dame lake, and the other southeast of Barnes lake where quartzite is interbedded with the paragneiss. They are fine to medium grained, rusty weathering, and dark grey on the fresh surface. The quartz is recrystallized, and in places the grains form leaf-like aggregates oriented parallel to the schistosity. The quartz of the Notre-Dame Lake exposure contains many fine needles of what may be rutile and which apparently cause its blue colour. They contain a few grains of altered sodic andesine, partly chloritized phlogopite, pyrite, and 3%-5% graphite. Foliation, outlined by the graphite and mica, is well developed, and the quartzite breaks into slabs.

Garnetiferous Paragneisses

A few occurrences of garnet gneiss were observed on the shores of Lapêche and Loups lakes and in the paragneisses east of Thorne lake.

The garnet gneiss from the north shore of Loups lake is dark pinkish grey, medium-grained and well foliated. It contains a few small grains of much altered oligoclase. Quartz makes 40% of the rock and reddish-brown biotite, about 30%. The remainder is garnet, chlorite, apatite, and sillimanite; the last is commonly interlayered with the biotite but may be in contorted sheaves.

A garnetiferous-hornblende-andesine gneiss was seen on the east side of the paragneiss lens, at the eastern end of range II, Thorne township, and also some 5,000 feet farther east in a small ridge in the limestone band. It is associated with rusty-weathering gneisses at both localities. The rock is medium-grained, dark grey on fresh and weathered surfaces, massive in the eastern exposure and gneissic in the western. It consists of about 10% garnet, 10% quartz, 5%-10% calcic andesine (An_{48}) that is partly scapolitized, 50% light to dark green

hornblende, and the remainder is scapolite, sphene, apatite, and scattered grains of magnetite and pyrite. The garnets (Plate IVA) have rims that are free of ferromagnesian minerals and are composed essentially of quartz and plagioclase. These rims are quite evident even in the hand specimen. The garnets apparently developed, at least in part, at the expense of the adjacent ferromagnesian minerals.

Rusty-weathering Gneisses

The name "rusty-weathering gneisses" has been applied to diverse kinds of rocks in the Grenville region. In general the rocks are fissile and contain pyrite or pyrrhotite or both. Many exposures show differential erosion. They are rusty and friable as a result of the oxidation of the iron sulphides. A thin-section was prepared from one of the more resistant specimens collected from the paragneiss band north of the road west of Loups lake. This specimen shows biotite-rich layers up to 1/2 inch thick alternating with layers composed essentially of feldspar and quartz. It consists of 50% quartz (the grains of which show evidence of recrystallization and of trituration with alignment of the fragments parallel to the layering), 5%-10% microcline, 30% plagioclase (almost completely altered but originally oligoclase), along with biotite (pleochroic from straw-yellow to brown) and iron oxide (apparently limonite, pseudomorphous after pyrite and as stains in the fractures).

Although some primary sulphides may be present, most of the sulphides are believed to have been introduced metasomatically. This belief is supported by the common association of rusty-weathering gneiss with mineralized shear zones in gneissic rocks.

Hornblende-biotite Gneisses

In this area, the hornblende-biotite gneisses are the second most important member of the Grenville series, the limestone being the most important. This group includes minor amounts of hornblende-plagioclase gneisses in which there is little or no biotite and also biotite gneisses in which there is little or no hornblende. Their fissility would allow injection by igneous solutions, and much of the rock mapped as injection gneiss was originally hornblende-biotite gneiss. Typical specimens are light to dark grey on the fresh surface, dark grey weathering, and fine to medium grained. Foliation is well developed.

Rosival analyses were made of specimens collected in various parts of the area and Table 1 shows the comparative amounts of the mineral constituents of the main types of this group. Microcline is rare. Plagioclase (An₁₁ to An₃₆) is an important constituent, but is generally

altered and poorly twinned. Green hornblende and brown biotite are the main ferromagnesian minerals. Quartz constitutes about 3% of the rock. Accessory minerals include apatite, calcite, sphene, chlorite and epidote. Hypersthene was seen altering to green hornblende in one section. Pyrite and magnetite occur as disseminated grains.

Table 1

	<u>A</u>	<u>B</u>	<u>C</u>
	Vol.%	Vol.%	Vol.%
Plagioclase	(An ₁₂ av) 55.9	(An ₂₅ av) 43.1	(An ₉₀ av) 25.4
Quartz	14.8	3.1	4.4
Hornblende	-	39.2	55.1
Biotite	26.6	8.8	-
Accessory minerals	2.6	5.8	4.0
TOTAL	99.9	100.0	99.9

A- Biotite gneiss. Average of two Rosiwal analyses.

B- Hornblende-biotite gneiss. Average of five Rosiwal analyses.

C- Hornblende gneiss. Average of two Rosiwal analyses.

The quartz content is appreciably higher in the biotite gneiss than in the hornblende and hornblende-biotite gneisses. The composition of the more mafic gneisses suggests intermediate igneous rocks of andesite or diorite composition. Metamorphism has removed all traces of original textures and structures except possibly bedding.

Amphibolites

Amphibolites occur interlayered with hornblende-biotite gneisses and as small bodies in the paragneiss and in the injection gneiss. In the field they are distinguished from the hornblende-biotite gneisses by two characteristics: a commonly granular texture, and the dominance of ferromagnesian minerals over quartz and feldspar. Some of the amphibolites show orientation of the constituents, but the prevalence of the ferromagnesian minerals is everywhere evident. In a few localities, they appear to grade into hornblende-biotite gneisses, but generally their contacts with other gneisses are sharp.

Commonly they are fine to medium grained and dark grey on both fresh and weathered surfaces.

Rosiwal analyses were made of several thin-sections and the average composition is given in Table 2. Plagioclase feldspars,

highly altered in part, vary in composition from An₂₆ to An₄₅. Dark green hornblende is the predominant mineral and constitutes 50%-75% of the rock. Biotite is a minor constituent where present, never exceeding 3.3%; it is pleochroic to dark brown and commonly is an alteration product of the hornblende. Quartz ranges from absent to as much as 12% of the rock. Accessory minerals are chlorite, apatite, sericite, sphene, augite, magnetite, and pyrite.

Table 2

Amphibolite

(Average of nine Rosiwal analyses)

	<u>Vol. %</u>
Plagioclase (An ₃₂ av.).....	23.4
Hornblende	62.0
Biotite	2.4
Quartz	5.4
Accessory minerals	6.7
Total	<u>99.9</u>

Garnetiferous amphibolite is rare. One occurrence is a pinched layer or lens in injected biotite-garnet gneiss along the north boundary of the area about 2,500 feet west of the road through Thorne-Centre. In this facies the plagioclase is partly scapolitized.

Metamorphic Pyroxenite

Green pyroxenite is found in many places in small masses. The main exposures are: (1) in crystalline limestone on the east side of the road along the shore of Lola lake, (2) west of the limestone band at the north-central limit of the area, (3) at the mica deposit south of Lapêche lake, (4) in the fields south of Ste-Cécile-de-Masham, and (5) at various places in the paragneiss band that bisects Lapêche lake.

Most of the occurrences are in or near limestone and apparently were produced by hydrothermal alteration of limestone. Grain size may vary from fine to coarse in an individual exposure. A thin-section of a coarse-grained pyroxenite showed it to consist essentially of diopside altered to pale green amphibole of the tremolite-actinolite group, with calcite as a secondary constituent.

Bristol Quartzite and Volcanics

Thin-bedded, fine-grained, dark grey quartzite with a few tremolitic layers occurs in ranges A and I, Bristol township. It is commonly intercalated with crystalline limestone. The quartzite contains some calcite (in places replacing the quartz) and tremolite, with minor amounts of chlorite, phlogopite, muscovite, sphene, apatite and partly oxidized pyrite. The quartz grains are commonly sutured together, but do not show the advanced recrystallization of the coarser quartzites of the series.

The thin-bedded quartzite was mapped separately from other Grenville formations by Wilson (1924, p. 23), who considered the Bristol series, in which he places it, to be a less metamorphosed facies of the Grenville series or, possibly, younger than the Grenville. The rocks are superficially less metamorphosed than the usual Grenville of the area, but the writer does not believe the Bristol to be a distinct unit or series. The eastward strike of the Bristol beds, quite different from the regional trend, indicates that they were in a place that was protected from the more intense metamorphism that affected the rest of the area. They may have been in the pressure shadow of an intrusive mass, or have been protected by whatever pre-existent structure controlled the intrusion of the porphyritic syenite to the east.

Wilson (1924, p. 25) describes rhyolite, andesite, diorite, and hornblende schist on ranges A to III, Bristol township. He suggests that these rocks, except for the rhyolite, are mineralogically similar to some of the altered facies of the Buckingham intrusive series and that they may be volcanic flows. The writer studied these rocks both in the field and in thin-section, and found no evidence to indicate an igneous origin for these rocks except for the diorite exposed due east of Bristol Mines.

"Rhyolite" - Two specimens were examined from exposures of well-layered rock mapped as rhyolite by Wilson.

The first is from one of the scattered exposures on lots 16 and 17, range II, Bristol. Weathering alteration has penetrated about 1/4 inch below the surface in places and the rock weathers to a cream colour. The grain is very fine and the rock breaks with almost conchoidal fracture. Under the microscope, the rock consists essentially of quartz and oligoclase (An_{16}). Most of the feldspar is untwinned, a feature which, combined with the fine grain, makes estimations of relative feldspar and quartz content difficult. Careful examination of the section, confirmed by a stain test, revealed no potassic feldspars. Calcite constitutes up to 10% of the rock and minor amounts of apatite and pyrite are present. The writer considers this rock an altered calcareous siltstone.

The second specimen studied under the microscope was collected from the island south of lots 15 and 16, range 1, Bristol township. The rock is fine grained, dark greenish grey and, owing to introduced hematite, reddish brown weathering. The layers are very regular and 1/4 to 1/2 inch thick (Plate III B). A thin-section, cut across the layers, reveals a variation in granularity from top to bottom of each band (Plate III A) similar to the grain gradation of arenaceous sediments. The layers show a well developed foliation outlined by the ferromagnesian minerals and enhanced by the elongation of the recrystallized quartz grains. The quartz is a major element in the rock along with abundant and fresh microcline. Untwinned plagioclase with indices approaching those of oligoclase is present in minor amount. Bleached biotite and pale green chlorite, parallel to the layering, are important accessories. Apatite, sphene and small blebs of hematite occur, as well as a few scattered crystals of a colourless to dark bluish-green tourmaline of the schorlite variety.

Both of the specimens described above are classed as altered siltstones by the writer, and they are somewhat similar to the paragneisses of Lake and Methuen townships, Ontario, described by Adams and Barlow (1910, p. 176).

"Andesite" - A thin-section taken from andesite close to the contact with diorite in the south part of lots 17 and 18, range II, Bristol township, was studied. The rock is fine grained, well layered, greenish grey and light grey weathering.

Microcline, only a few grains of which show the typical grid twinning, and poorly twinned sodic andesine (An_{33}) are about as abundant as quartz. A few grains of hornblende (light green to bluish green) have altered to biotite (pleochroic from straw-yellow to brownish green). This biotite, partly chloritized, and green chlorite combine to give a greenish tint to the rock. Accessory minerals include epidote, calcite, apatite, sphene, and schorlite. The mineral assemblage is that of a quartzose paragneiss rather than of andesite.

The diorite of this "series" is discussed below with the basic and ultrabasic rocks. It is considered to be related to the gabbro and anorthosite. A small dyke of diorite cuts the metasedimentary rocks just described.

Injection Gneiss (migmatite)

The injection gneisses of the area comprise well-layered metamorphic rocks in which granitic material is intercalated with mafic

gneisses. Most of these gneisses resulted from injection of granitic material, although some probably resulted from metamorphic differentiation, and there has been some granitization. The gneisses may be in thin or thick layers (Plate IV B).

Thin-sections of various specimens of thin-layered gneiss, as well as of the paragneiss layers of lit-par-lit gneiss, reveal a composition similar to that of the hornblende-biotite gneisses, but with addition of minerals from the granitic injections. Microcline, plagioclase (An₁₁₋₂₈), quartz, green hornblende and brown biotite are the essential minerals and epidote, chlorite, muscovite, apatite, sphene and magnetite are accessory.

Table 3

Injected hornblende-biotite and biotite gneiss
(Average of 5 Rosiwal analyses)

	<u>Vol. %</u>
K Feldspar	31.7
Plagioclase	30.9
Quartz	21.3
Biotite, hornblende	15.0
Accessory minerals	2.0
TOTAL	100.9%

Most of the injecting material is considered comagmatic with the granite and granite gneisses that occur in the area.

POST-GRENVILLE INTRUSIONS

Granites

Granitic rocks are widespread in the area both as mappable units and as layers or lenticles in other formations. The larger masses lie on either side of the northeast-striking band of gabbro and anorthosite, and underlie some of the higher hills of the area. Two general groups are recognized, namely, (1) fine-grained biotite granite and granite gneiss with syenitic facies; and (2) medium- to coarse-grained porphyritic granite and granite gneiss. Facies of these two types of granites are similar, and in places there seems to be gradation from one to the other.

Fine-grained Biotite Granite and Granite Gneiss

Fine-grained biotite granite occurs as mappable bodies in the northeast corner of the area, at the south end of Lapêche lake, and east and west of Lola lake. Medium-grained facies occur east of Caldwell and north of Pontiac Station.

The typical biotite granite is fine grained and grey to pink. Gneissic structure is common although not everywhere evident because of the small amount of ferromagnesian minerals and the close examination required to reveal their orientation. Flaser structure seen in a few thin-sections indicates that some deformation occurred after consolidation.

Rosival analyses of some thin-sections reveal differences in the proportions of the essential minerals of the grey and pink facies. These relationships are based on averages, and individual specimens may show variations from the modes of Table 4.

Table 4

	A Pink biotite granite Vol. %	B Grey biotite granite Vol. %
Microcline	35.2	16.0
Plagioclase (An ₁₂)	27.8	(An ₂₀) 37.5
Quartz	31.4	37.5
Biotite and chlorite	3.0	7.8
Accessory minerals	2.6	1.2
TOTAL	100.0	100.0

A - Average based on 8 Rosival analyses. Average An content based on feldspars in 17 thin-sections.

B - Average based on 2 Rosival analyses. Average An content based on feldspars in 6 thin-sections.

Thin-sections show the essential minerals to be microcline, sodic plagioclase (An₃₋₂₅) and quartz. As shown in Table 4, the grey variety has a higher average content of plagioclase of slightly higher calcicity than the pink facies. The latter is lower in biotite and contains more microcline.

The main ferromagnesian mineral is biotite, pleochroic from yellow to brown, and occasionally partly chloritized. Fragments of green hornblende were observed in a few thin-sections. Secondary and accessory minerals include sericite, chlorite, calcite, apatite, and pyrite. Allanite was identified in the granite from west of Lola lake.

Syenite

Syenite facies of the biotite granite were identified, although not in mappable units, in the granite gneiss west and south of Notre-Dame lake and east of Bristol Mines.

The syenite from the Notre-Dame Lake occurrence is massive and has an allotriomorphic granular texture. It consists essentially of microcline and oligoclase (An_{12}), with dark green hornblende and brown biotite as the main ferromagnesian minerals. Accessory minerals are chlorite, sericite, apatite, sphene and magnetite. One specimen has 5% quartz, and zircon rimmed with sphene was identified in another. The appearance and composition of this syenite suggest kinship with the adjoining granite.

The syenite from east of Bristol Mines is medium grained, pinkish grey, and consists of 60% oligoclase (An_{18}), 10%-15% microcline, and less than 5% quartz. The principal ferromagnesian mineral is a light green to bluish green hornblende similar to that observed in the porphyritic syenite to the north of this locality. Minor amounts of calcite and tourmaline were identified. This rock may be a reaction facies between the granite and the porphyritic syenite immediately north of it.

Porphyritic Granite and Granite Gneiss

Medium- to coarse-grained, greyish pink, porphyritic granite and granite gneiss, although not mapped separately, constitute the bulk of the granitic masses east of Ireland lake and south and east of St-Louis-de-Masham. Massive, almost pegmatitic facies also are present. Occurrences of fine-grained gneiss with phenocrysts of microcline (for example, south of Caldwell) suggest that most of the porphyritic granite may be a facies of the same magma that gave rise to the fine-grained biotite granite. Some exposures, however, show some similarity to the porphyritic syenite.

The rock consists of microcline phenocrysts, generally pink but lilac-coloured in some exposures, in a groundmass of smaller microcline grains, plagioclase (An_{8-22}) quartz, biotite, and accessories. An average specimen has 32% microcline, 32% plagioclase, 24% quartz and

8% biotite. Accessory minerals include chlorite, apatite, sphene, magnetite and pyrite. Fragments of dark bluish green hornblende were identified in a few thin-sections. Magnetite occurs in some sections in idioblastic crystals up to 1/8 inch in diameter.

The northwest corner of the area contains part of a large granitic mass that extends north and west beyond the limits of the area. It is probably an extension of the granite mapped by Osborne (1944) near Calumet island to the west. This granite is generally medium grained and is porphyritic in some exposures. It is greenish pink and generally massive, although gneissic facies do occur. It consists essentially of microcline, plagioclase (An_{0-20}) and quartz. Some of the feldspars of the gneissic facies show bent twin-lamellae, an indication of deformation after consolidation. This granite is characterized by a green pyroxene whose optical properties suggest a composition between that of hedenbergite and aegirine-augite. The colour of the pyroxene is too dark for normal hedenbergite and its birefringence is not quite high enough for aegirine-augite. The pyroxene alters to hornblende, pleochroic from yellowish green to dark bluish green. The hornblende, in turn, alters to brown biotite. Accessories include sericite, apatite, sphene, allanite and magnetite. Some of the magnetite is in well-developed octahedra that exceed 1/4 inch in diameter.

Relationships

The presence of granite and anorthosite in the same area automatically brings up the question of the pre-anorthosite granite. Wilson (1924) considers that the biotite granite is younger than the anorthosite and the porphyritic syenite. He bases this conclusion on the presence of granitic dykes in the anorthosite and porphyritic syenite. The writer believes that these dykes are related to the Onslow syenite complex and not to the granite, although he has no direct evidence of this. Some of the porphyritic granite seems to be related to the porphyritic Wakefield syenite and, if so, would be younger than the gabbro and anorthosite.

The fine-grained granite and granite gneiss are closely similar in composition and appearance to the Trembling Mountain gneiss mapped by Osborne (1935) in areas to the east. Faessler (1943) has summarized the conclusions, both written and inferred, of geologists who mapped granites and anorthosites in areas containing Grenville rocks. He concludes that a fine-grained (Trembling Mountain type) granite is older than the anorthosite, which in turn is older than a coarse-grained, porphyritic (Pine Hill type) granite. Osborne divides the Morin series into a basic facies (Buckingham) containing anorthosite and gabbro and an acidic facies (Pine Hill) containing porphyritic granites and syenites.

Diorite, Gabbro, Anorthosite, Peridotite

Diorite, gabbro, anorthosite, and related rocks outcrop in a wide band that extends northeast from near the centre of the area. Exposures of these rocks are also scattered along the general projection of this band southwest to Ottawa river. What is probably another band extends westward from the northeast bay of Chats lake to west of Bristol Mines.

Diorite and gabbro lenses outcrop in the northern part of the area. Three lenses or inclusions of scapolite gabbro occur in the porphyritic syenite at about the latitude of Philippe lake, and there is a body of scapolitized diorite and gabbro east of Caldwell. One small mass of peridotite was seen in the crystalline limestone on lot 10, range III, Thorne township.

The contacts between diorite, gabbro and anorthosite are commonly gradational across considerable distances, and it is generally impossible to distinguish the diorite from the gabbro in the field. The anorthosite in its purer forms is easily recognized, but it occurs in such small amounts and passes so gradually into gabbro that it cannot be mapped separately.

In the wide band it was impossible to separate the units, but in the smaller masses the rocks are generally of one type. The main standard used in separating the diorite from the gabbro was the calcicity of the feldspars. Borderline cases were determined by the predominance of pyroxene or of hornblende.

Diorite

The diorite is medium to coarse grained and dark grey on both fresh and weathered surfaces. Hand specimens seem to be composed of equal amounts of feldspar and hornblende. However, in thin-section the proportions are seen to be more variable. The diorite is usually allotriomorphic granular, but some facies show hypidiomorphic tendencies. It consists essentially of plagioclase (An_{30-40}) and hornblende. The latter is generally pleochroic from pale to dark green. The hornblende of the diorite band close to Chats lake has a pleochroism somewhat similar to that of the amphibole of the porphyritic (Wakefield) syenite. Augite, partly altered to hornblende, was identified in some sections. Quartz occurs in very minor quantities associated with hornblende. Biotite, pleochroic from yellow to brown, is common but not abundant. Accessory minerals include chlorite, calcite, apatite, sphene, epidote, tourmaline (schorlite), magnetite and pyrite. The average composition of the diorite is given in Table 5.

PLATE I



Differential erosion in crystalline limestone; the drag-folds are in quartzose layers.
Northeast shore of Notre-Dame lake.

PLATE II



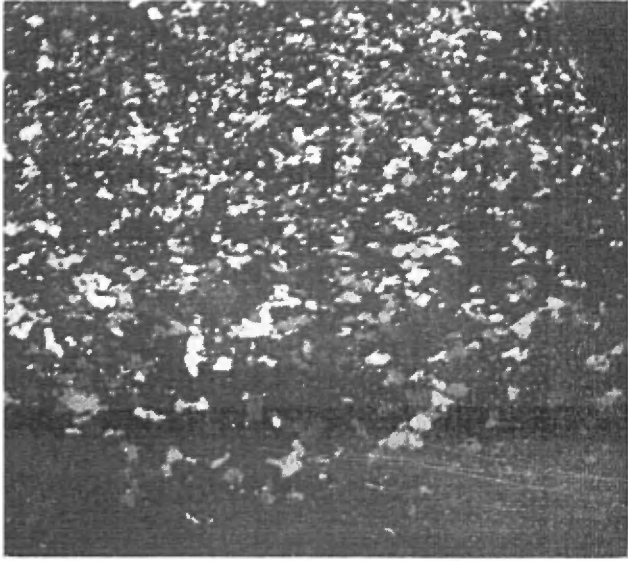
A



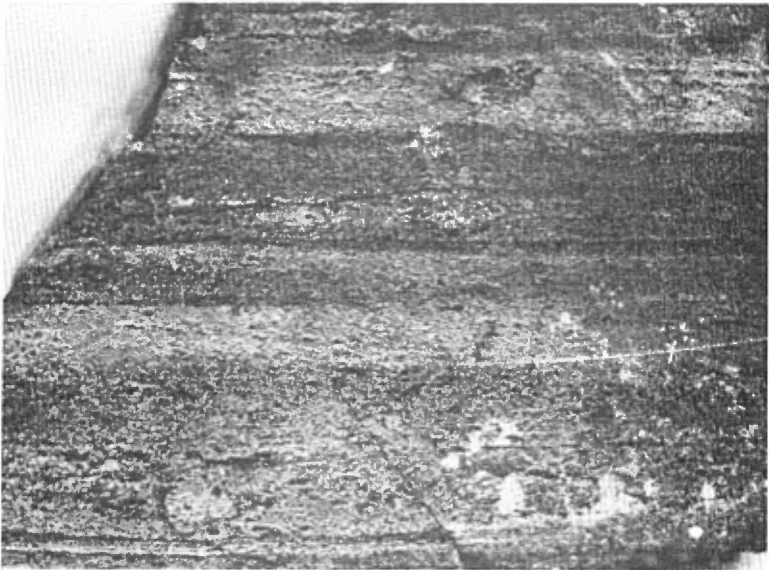
B

Well-layered crystalline limestone. Note relative size of light and dark layers in block in bottom right corner of B.
North shore of Chats lake.

PLATE III

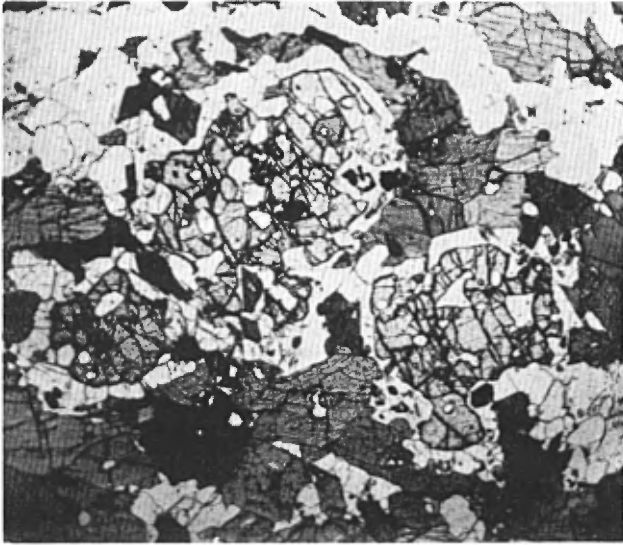


A — Photomicrograph of section cut perpendicular to layering of specimen shown below. Variation of granularity from top to bottom is suggestive of graded bedding.



B — Thin-layered, fine-grained meta-sedimentary rock. Island in Chats lake, lot 16, range 1, Bristol township.

PLATE IV

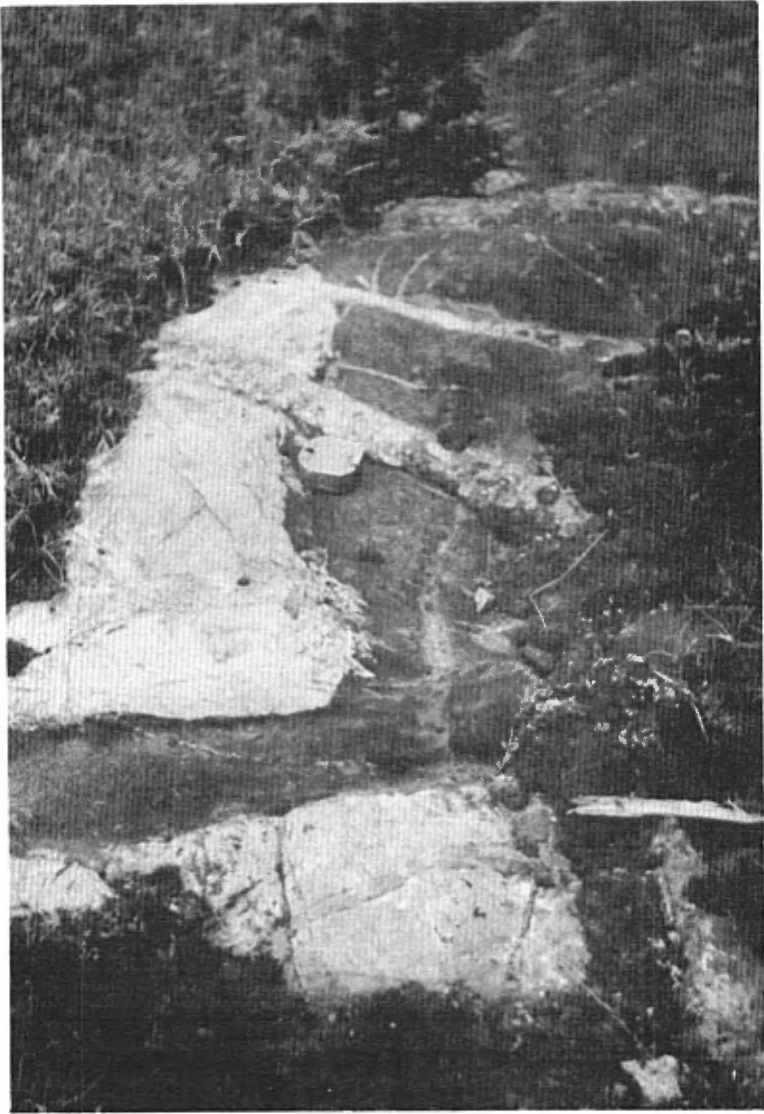


A — Garnet porphyroblasts with rims free of ferromagnesian minerals. Photomicrograph.



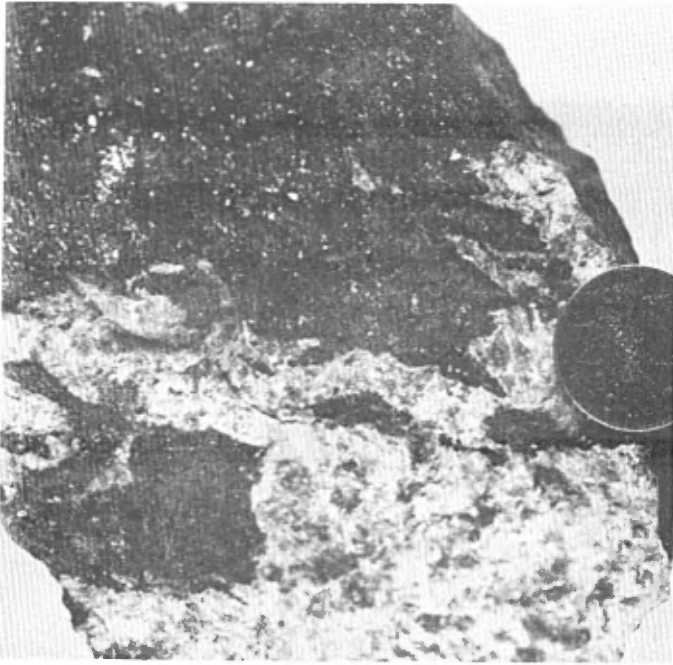
B — Lit-par-lit injection gneiss. Note transgressive pegmatitic layer. North shore of Janese lake, Aldfield township.

PLATE V



Anorthosite intruded by hornblende-plagioclase rock. Both are cut by pegmatite.
North side of road from Duclos to Mahon lake.

PLATE VI



A — Apparent replacement of anorthosite by ferromagnesian minerals. Gabbroization (?).



B — Silicified aplite dyke showing network of quartz veinlets. West end of range VIII, Onslow township.

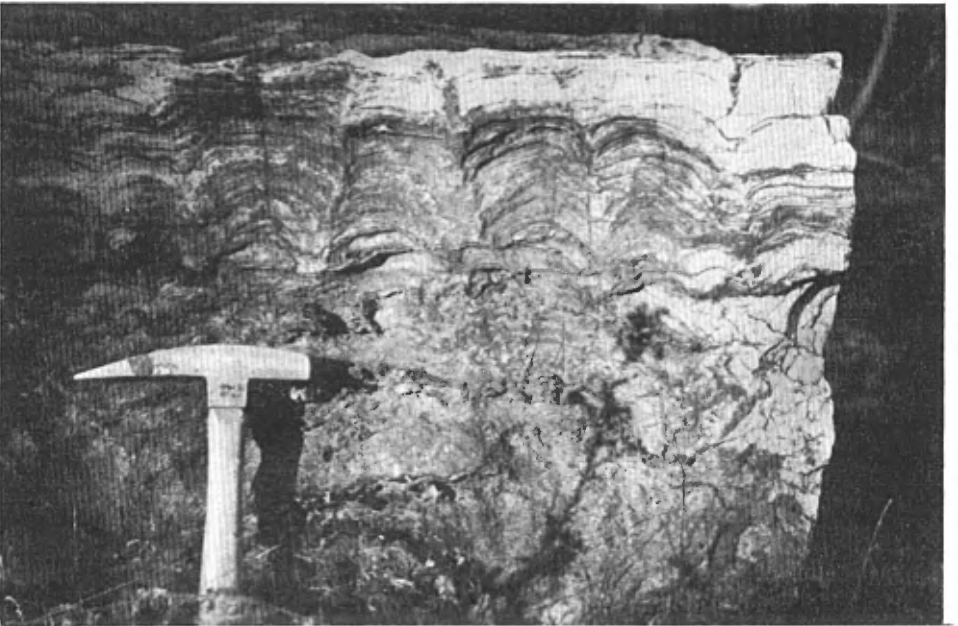


Diabase cut by quartz veinlets from adjoining silicified aplite dyke. Range III, Bristol township.

PLATE VIII



A — Cryptozoon in Beekmantown dolomite. East of Quyon.



B — Section in same exposure showing concentric dome structure of Cryptozoon.

Table 5

Diorite

	<u>Vol. %</u>
Plagioclase (An ₃₄)	41.5
Hornblende	43.0
Pyroxene	10.6
Accessory minerals	5.1
TOTAL	100.2

Average based on 7 Rosiwal analyses. Average An-content based on feldspars of 16 thin-sections.

Gabbro

The calcicity of the feldspars is, in many cases, the only basis for distinguishing the diorites from the gabbros. The change from anorthosite to gabbro is more evident, but transitions are so gradual that transitional facies could not be shown on the scale of mapping. "Gabbro-anorthosite complex" is a descriptive name for the whole group.

The gabbro may be separated into two facies whose main distinguishing features are the proportions of scapolite and pyroxene; thus, these two facies are only a reflection of a kind of alteration.

Scapolite gabbro occurs as large lenses or inclusions in the porphyritic syenite. A body northeast of Caldwell is also classed with this group because, although the feldspars indicate a composition close to that of diorite, they are scapolitized and pyroxene is abundant.

The scapolite gabbro is medium to coarse grained and very dark grey on both weathered and fresh surfaces. Although commonly massive, it is gneissic locally. Thin-sections reveal the rock to be allotriomorphic granular. It consists of 25% plagioclase, generally altered and scapolitized, 18% scapolite, 30% augite, 12% green hornblende, and the accessory minerals biotite, sphene, calcite, apatite, epidote, wilsonite, pyrite and magnetite.

Hornblende gabbro outcrops chiefly in the wide band striking northeast through the centre of the area. All variations exist from gabbro through anorthositic gabbro and gabbroic anorthosite to anorthosite. For purposes of this report, all rocks of the gabbro-anorthosite group with more than 10% dark minerals are classed as gabbro.

Many exposures of this generally massive rock are characterized by clots of ferromagnesian minerals around which the feldspars are generally etched out by weathering. Some clots are elongated into thin lenses, perhaps indicating a certain amount of primary flow.

The rock is medium to coarse grained and in varying shades of greenish grey. The texture is generally allotriomorphic granular but is hypidiomorphic in some exposures. Phenocrysts of purplish plagioclase are present locally. Under the microscope the gabbro consists largely of plagioclase (An_{47} to An_{55}). Hornblende, pleochroic in shades of green, is the predominant dark mineral and makes up 10%-47% of the sections examined. Augite accounts for 12% in some facies. Pale brown biotite was identified in one thin-section. Accessory minerals include epidote, apatite, sphene, sericite, scapolite and a little magnetite.

Anorthosite

Pure anorthosite is relatively rare and in small masses. Good exposures occur near Duclos and at the west end of range VIII, Onslow township.

Typically the rock is medium grained, very pale green, and white weathering. It consists essentially of allotriomorphic granular, sodic labradorite having an average composition of about An_{55} . The plagioclase commonly is partly saussuritized, with minor amounts of epidote, sericite and calcite present. Accessory minerals include hornblende, sphene and a few flecks of iron sulphides.

Peridotite

A small body of peridotite in range III, Thorne township, is the only occurrence of this rock noted. It is medium to coarse grained, greenish black, brown weathering, dense and massive. Serpentinization has removed all traces of original texture in the coarse facies; the medium-grained facies has not been altered so much and is allotriomorphic granular. The rock originally consisted of nearly equal amounts of orthorhombic pyroxene and olivine, and as such is a harzburgite type of peridotite.

In thin-section, the coarser facies consists of 30% enstatite and 30% olivine, both altering to antigorite. The latter releases some magnetite during alteration. A small amount of tremolite, possibly an alteration product, is present. Analysis of a small specimen in the laboratories of the Department gave 0.30% chromium and 0.01% vanadium among other elements.

Hornblende-plagioclase Dykes in Diorite, Gabbro and Anorthosite

The diorite, gabbro and anorthosite are cut by fine-grained dykes of intermediate composition, and all are cut by aplitic and pegmatitic dykes. The younger, acidic, dykes are believed related to the Onslow complex and are discussed below in the section dealing with that complex. Some exposures show the age relationships of the three rock types (Plate V).

The dykes of intermediate composition are gneissic and fine grained. A thin-section consists of 31% calcic oligoclase or sodic andesine (An_{28-33}) with poorly developed twinning. Hornblende, constituting 57%, is pleochroic from yellowish green to dark green and alters to brown biotite. Accessory minerals include apatite, magnetite and pyrite. The mineralogical composition would place this dyke rock in the diorite clan. Reaction structures which may be related to the dykes (Plate VI A) were noted in some of the gabbro and anorthosite exposures. The rock may be metasomatic, or may represent injections from the gabbroic magma into the already solidified outer portions of the intrusive.

Age Relationships and Discussion

The diorite, anorthosite and gabbro are older than the Wakefield porphyritic syenite. They would correspond to Wilson's (1924) Buckingham series. Osborne (1936) considers Buckingham-type rocks such as anorthosite, quartz monzonite, and diorite as the basic facies of the Morin series. The acidic facies of the Morin, Osborne's Pine Hill porphyritic rocks, would be the equivalent of the Wakefield porphyritic syenite of the present area. Where the diorite, anorthosite and gabbro bands are in contact with the porphyritic syenite, gradational changes from syenite to gabbro through diorite seem to indicate a certain absorption of the basic rocks by the syenitic magma.

The clot-like aggregates of ferromagnesian minerals in the gabbro and anorthosite are particularly common in the band striking northeast through the centre of the area. These may have formed immediately before intrusion since some show deformation indicative of flow structure.

The clots possibly represent growths of ferromagnesian minerals around centres of crystallization. After emplacement of the intrusive they would start to settle, thereby leaving certain zones relatively free of ferromagnesian minerals. However, final crystallization would take place before distinct layers could form. Such a history

would account for the relatively small areas of pure anorthosite and its gradual change to gabbro through increasing numbers of ferromagnesian clots. An alternative explanation is that a relatively pure plagioclase rock was basified with the introduction of mafic minerals. Some of the ferromagnesian clots show a form suggesting replacement (Plate VI A). The gabbroization probably went on concurrently with the injection of the younger acidic intrusives.

Porphyritic Wakefield Syenite, Minor
Porphyritic Granite, Quartz-syenite and Diorite

Porphyritic Wakefield syenite forms the largest intrusive mass in the area. It outcrops in a nearly continuous band from Lapéche lake to the eastern boundary and beyond. It is exposed south to the Eardley escarpment and apparently underlies much of the lowlands between the escarpment and Ottawa river. Porphyritic granite, possibly related to the syenite, occurs in minor amounts in the granite masses near St-Louis-de-Masham and was described with these older granites. Some of the contacts of the porphyritic syenite with older rocks show evidence of assimilation with resulting changes in composition to quartz syenite or to diorite. About 2 miles northwest of Bristol Mines, the Bristol Mines road crosses rocks mapped as syenite but which may belong to the diorite of the group described above; its composition, however, is closer to that of the syenite.

The bulk of the syenite is greyish pink, medium to coarse grained and porphyritic. The phenocrysts are of lilac-coloured microcline and are up to an inch long. They are more resistant to weathering than the other constituents and generally stand in relief on the weathered surfaces. The syenite is generally massive, although locally gneissic, and irregularly jointed. An alignment of the ferromagnesian minerals, which is undoubtedly a primary flow feature, was seen in many places in the massive facies.

Under the microscope, the phenocrysts lie in an allotriomorphic granular matrix of microcline, plagioclase and other minerals. The microcline is generally perthitic. None of the phenocrysts are truly idiomorphic. Embayments in them commonly are filled by the matrix-forming minerals, and their edges are irregular. The plagioclase averages An_{18} but varies from An_{10} to An_{30} . Hornblende is the most common ferromagnesian mineral. Its optical properties are somewhat variable, as shown by specimens taken from different parts of the intrusive. The principal optical properties are as follows: negative $2V = 60-70^\circ$; $Z\wedge c = 15-25^\circ$ (variable); X = yellowish green; Y = green, bluish green; Z = deep green, deep bluish green. The blue tints in the pleochroic colours would suggest an amphibole

rich in alkalies. The hornblende commonly contains small grains of quartz, feldspar and apatite. The quartz may be a released mineral and is generally the only quartz observed in thin-sections of the porphyritic syenite. Augite is fairly common and is usually partly altered to hornblende. Common accessories are apatite, sphene and magnetite; biotite, epidote and chlorite are present in a few sections. The sphene occurs both as individual grains and as rims around the magnetite. These rims probably indicate some ilmenite in the magnetite. The composition of the average porphyritic syenite is indicated in Table 6.

Table 6

Porphyritic Wakefield syenite

Average of 5 Rosiwal analyses

	<u>Vol. %</u>
Microcline	38.9
Sodic plagioclase	45.2
Hornblende	6.8
Pyroxene6
Biotite	4.1
Accessory minerals	4.5
TOTAL	100.1

Porphyritic Granite

Some of the porphyritic granite associated with the older granite near St-Louis-de-Masham has lilac microcline phenocrysts and a hornblende similar to minerals commonly found in the porphyritic syenite, and it may represent a granitic facies of the syenite.

About 2 1/2 miles southeast of St-Louis-de-Masham granitic rock forms a ridge that overlooks open country and is adjacent to exposures of the Grenville series. The granitic rock is pinkish grey, brown weathering and allotriomorphic granular. It consists of 68% feldspar (poorly twinned perthitic microcline and oligoclase, An₁₇) and 20% quartz, along with chlorite and minor amounts of epidote, apatite and magnetite, and one small fragment of bluish hornblende. This granitic rock is believed to have resulted from the incorporation of quartzose paragneisses by the porphyritic syenite magma.

Quartz Syenite

In places, the syenite contains sufficient quartz to be called quartz syenite. This rock was seen mainly on the shores and islands of Lapêche lake and in the narrow, southeast-striking syenite band that extends to a point north of Quyon.

The texture and mineral constituents are essentially the same as those of the porphyritic syenite except that the phenocrysts are smaller and that quartz, calcite and epidote are increased.

Diorite

On the big, southeast-trending peninsula in Lapêche lake there is a gradational contact zone between porphyritic syenite and gabbro. The resulting rock has the composition of a diorite and is believed to be the result of absorption of some of the gabbro by the syenite. It contains a few small grains of microcline, calcic oligoclase (An_{26-28}), and less than 3% quartz. The ferromagnesian minerals are dark bluish green hornblende and dark brown biotite. Minor constituents include chlorite, apatite, sphene and magnetite.

The diorite lens in the porphyritic syenite northwest of Bristol Mines has a similar composition, except for a slightly higher microcline and quartz content.

Relationships and Discussion

The porphyritic syenite constitutes the youngest of the large intrusive masses of the area. It contains many inclusions of older formations, particularly gabbro and Grenville. The porphyritic syenite corresponds to Osborne's Pine Hill group, and thus could be the acidic facies of the original magma which gave rise to the Buckingham-type rocks of the area. The abundance of magnetite in the porphyritic syenite and its scarcity in the gabbro and anorthosite suggest that the magma kept most of its iron oxides in solution until its more acidic differentiates were precipitated. Béland (1954) came to a similar conclusion when mapping the area to the west and the presence of hydrothermal hematite in a locality north of Old Chelsea is considered by him to be further evidence of this.

The porphyritic syenite of the Bristol-Masham area is the westward extension of the equigranular Wakefield syenite mapped by Béland (1954). Béland (personal communication) noted a gradual increase in the size of the microcline southwest from the type locality. His

impression is that the northeastern part of the syenite in the area mapped by him is the uppermost part of the intrusive and is characterized by finer and more equigranular texture.

The Onslow Syenite Complex

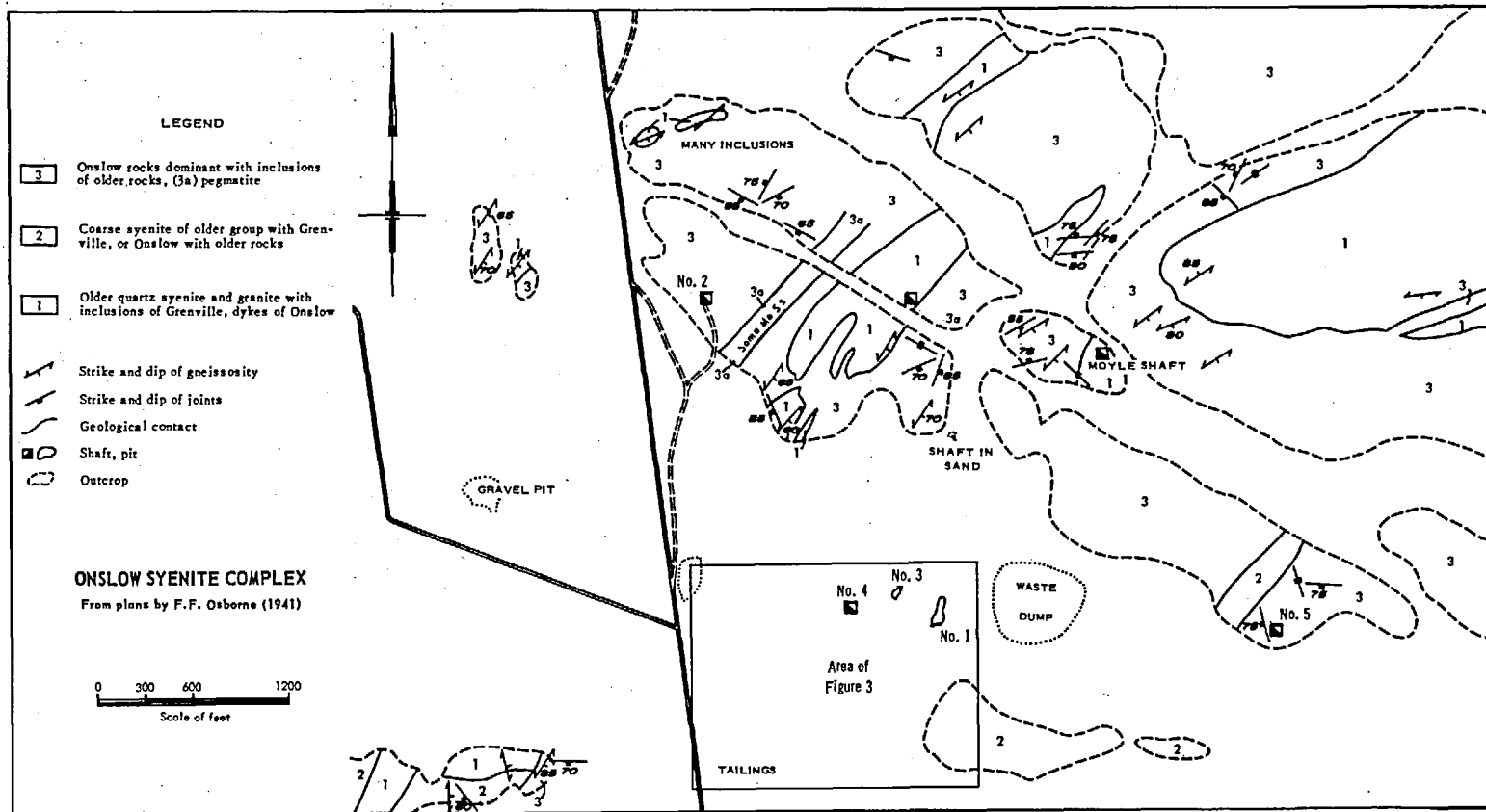
The Onslow syenite complex occupies an area of about 2 square miles, some 4 miles north of Quyon. Rocks of this complex also occur as dykes in the gabbro, anorthosite and porphyritic syenite, and an intensely silicified dyke trends southwest to Ottawa river from west of Lapêche lake.

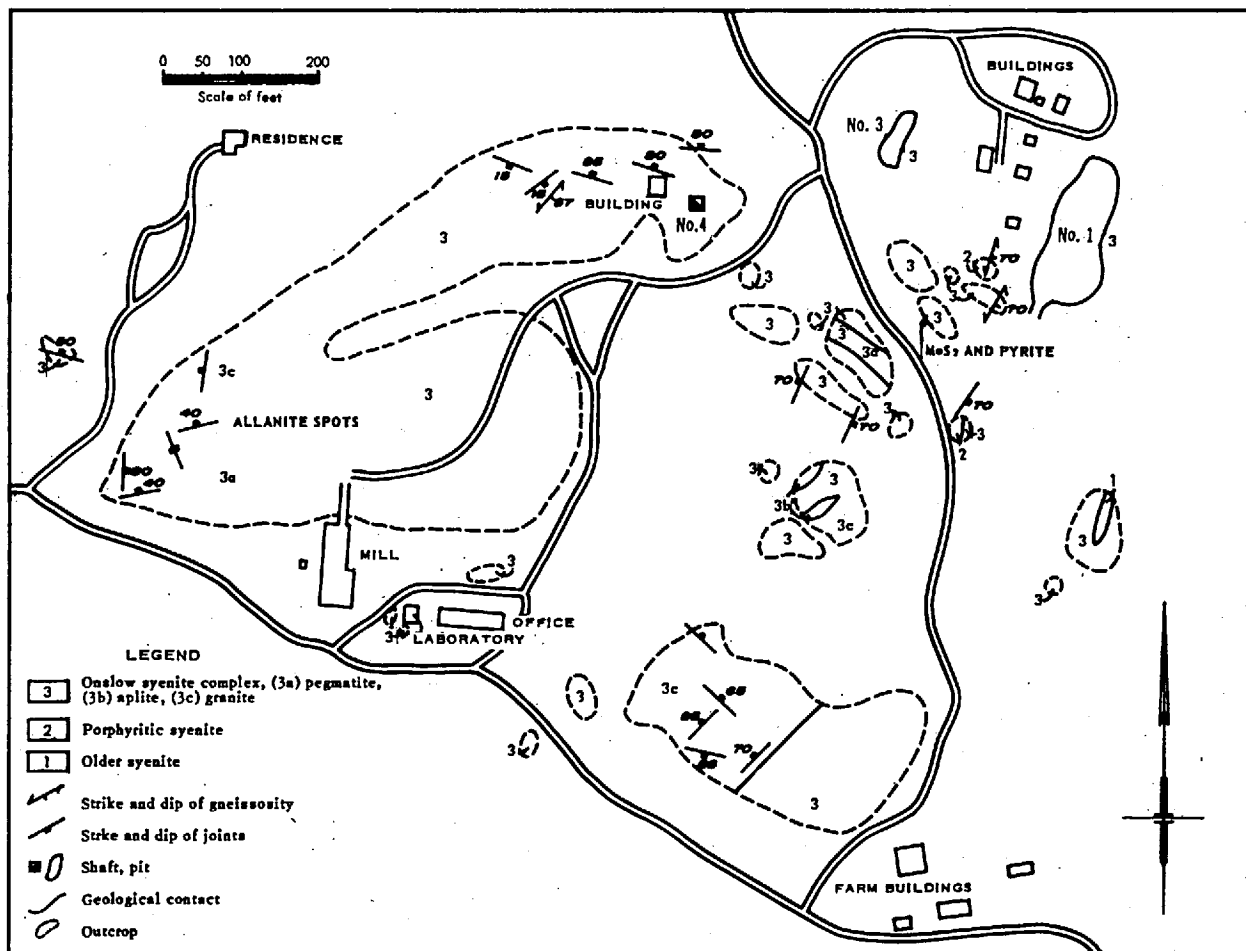
The Onslow syenite complex is a mixture, impossible to separate at the present scale of mapping, of pegmatite and pink aplitic syenite, quartz syenite and granite, and porphyritic syenite. Most of the writer's information on this complex is taken from Osborne (1941) who had the opportunity to study it in detail. He mapped part of the area on a larger scale, and his report contains many details of both petrology and mineralogy. Scaled-down copies of two of his maps of the complex are included in this report (Figures 2A, 2B).

Osborne considers the complex to be a multiplicity of injections of rocks of syenite, quartz-syenite and granite compositions, with aplitic and pegmatitic textures. He found the rocks to be composed of varying proportions of microcline, sodic oligoclase, quartz, green hornblende, biotite, minor pyroxene and muscovite. Among accessory minerals he noted apatite, sphene, zircon and tourmaline. Allanite, pyrite and magnetite are also present. Most of the pyrite, as well as the molybdenite and fluorite, is considered to be metasomatic.

The writer examined sections of the aplitic granite that cuts the anorthosite and the porphyritic syenite. The granite is typically fine to medium grained, and pink on both fresh and weathered surfaces. Aplitic texture is common. The rock consists of approximately equal amounts of microcline (much of which is perthitic), sodic plagioclase (An_{5-17}) and quartz. Secondary minerals are brown biotite and muscovite. Accessory minerals include chlorite, sphene, apatite, magnetite and pyrite. Allanite was identified in a sulphide-rich aplite cutting porphyritic syenite.

An unusual aplite dyke, intensely silicified, was traced along a relatively straight line for about 14 miles from the Ottawa (Chats lake) west of Bristol Mines, to west of the north end of Lapêche lake. Wilson (1924, p. 39) considered this dyke to be older than the Onslow syenite and called it a brecciated aplite.





MOSS MOLYBDENITE MINE

From plans by F.F. Osborne (1941)

FIGURE 3

D.N.R.Q. 1962 NO.1498

Exposures of the dyke show a network of quartz veins and veinlets cutting and enclosing fragments of aplite (Plate VI B). In places the aplite has a greenish cast that suggests hydrothermal alteration, whereas in others, it is apparently unaltered although well veined. Such variations may be seen in adjacent exposures.

Thin-sections reveal varying proportions of fairly fresh microcline, altered sodic plagioclase (AN_{10}) and quartz. Some of the plagioclase twins are displaced along fractures and bent, suggesting fairly strong mechanical stresses after consolidation. Some of the thin-sections contain finely granulated bands that could represent microbrecciation. It is impossible to distinguish the primary quartz from that introduced into the dyke. Secondary epidote and chlorite are important constituents and are responsible for the greenish cast of the more altered aplite. Sphene and apatite are accessory minerals.

The present condition of the dyke probably is the result of fracturing, followed by penetration of siliceous solutions from which quartz was deposited to cement the whole. No evidence of movement along the contacts of the dyke with older formations was found.

Relationships

Rocks of this complex contain inclusions of Grenville formations and of porphyritic syenite. They cut gabbro, anorthosite and porphyritic syenite. Wilson (1924, p. 41) reports poorly defined dykes of Onslow syenite cutting biotite granite. Many of the dykes that cut both the granite and the injection complex were probably of the same origin. The silicified aplite dyke cuts a dyke of "older" diabase in the southern part of Bristol township (the dykes of fresher diabase to the north are believed to be younger). Except for the ubiquitous regular, or fresher, diabase, the Onslow syenite complex is considered to be the youngest of the post-Grenville intrusives in the area.

Diabase

Dykes of diabase striking east cut most of the Precambrian rocks of the area. However, as indicated above, all the diabase dykes may not be of the same age. Some exposures of diabase on ranges III and IV, Bristol township, are believed to be remnants of an older diabase dyke.

The dykes of the northern part of the area are fresh and tough, generally medium grained, ophitic, dark greenish-grey and brown weathering. Joints, both horizontal and vertical, are common. A thin-section from a specimen of the second dyke north of Mahon lake, collected

east of the eastern limit of the area, showed lath-shaped labradorite (An₅₀), in a matrix of light green augite. Minor amounts of amphibole of the tremolite-actinolite group may indicate incipient uralitisation. Accessory minerals include magnetite and biotite(?).

The diabase in the southern part of Bristol township is somewhat different from that just described both in the exposure and under the microscope. It is generally coarse grained, brown weathering and dark green. It is quite altered and crumbly. That part of the dyke cut by the silicified aplite dyke is fine grained but ophitic. Both fine- and coarse-grained facies were examined under the microscope, and, except for grain size, are essentially the same. Ophitic texture is well developed. The plagioclase is extensively altered, but the optical properties still apparent are those of labradorite (An₅₁₋₅₂). Pyroxene is absent, having been completely converted to a pale green amphibole of the tremolite-actinolite group. Some green chlorite and a few fragments of brown biotite are present. One fractured grain of what might be quartz was observed. Accessory minerals include calcite, apatite, sphene and magnetite.

The extensive alteration of this diabase as compared with that to the north and the apparent cross-cutting relation of the aplite dyke suggest that it is older than the other diabase dykes of the area. Veinlets of quartz from the silicified aplite penetrate the diabase (Plate VII) and small pegmatitic stringers are found in the extension of this dyke on the road along the Bristol-Onslow township line.

PALEOZOIC

Ordovician

The Paleozoic is represented in the lowlands near or bordering Chats lake by the Beekmantown and Chazy formations of Ordovician age. Both are essentially flat although in some exposures there is a gentle dip to the southwest.

Beekmantown

The Beekmantown, or older, formation is much more extensively exposed than the Chazy. It occurs mainly near the village of Quyon and over a mile-wide strip along the shore of Chats lake, southwest of Bristol Mines. It rests unconformably on Precambrian formations, and may be seen in contact with porphyritic syenite on the shore of Deschênes lake, southwest of Luskville, and in a railway cut in lot 17, range 1, Bristol township. The latter occurrence is well described by Wilson (1924). According to Wilson, the maximum thickness of the Beekmantown is 30 feet.

The typical rock of the formation in this area is a fine-grained, grey, buff weathering dolomite. Cryptozoon sp. (Plate VIII, A,B) is abundant in the exposures north of the highway east of Quyon and occurs along the trail bordering the dolomite of range I, Bristol township, and on one of the islands of Chats lake.

Chazy

The only occurrence assigned to the Chazy formation (Wilson, 1924) is on lot 11, range III, Onslow township, where it is in fault contact with porphyritic syenite to the east. It consists of approximately 15 feet of non-fossiliferous and thinly bedded shales, sandstones and argillaceous limestone, all with a characteristic green colour.

PLEISTOCENE AND RECENT

The main valleys in the uplands are largely floored by glacial material, mostly outwash sand and gravel, but with some isolated areas of till. Terraced marine clay and sand mantle most of the lowlands part of the area.

Till

Till was observed in the northwest quarter of the area and as a thin veneer over other parts of the uplands.

Sand and Gravel

Bedded sand and gravel overlie most of the lowlands. Mixed, or poorly sorted, sand and gravel occur along the main valleys of the northern part of the area. Bedded sand and gravel, with some clay, were deposited in the arm of the Champlain sea that covered areas about Ste-Cécile-de-Masham. At the height of the marine invasion, this was probably connected with the main body to the south through Lapêche lake and, perhaps, through the valley that bisects the porphyritic syenite, southeast of St-Louis-de-Masham.

Clay

The only type of clay recognized in the area is of marine (Champlain sea) origin. It varies from massive to well bedded. It occurs as patches about Ste-Cécile-de-Masham but is most extensively exposed in the lowlands where the main streams have carried away some of the overlying sands and gravels. The highest elevation at which it was observed was slightly less than 600 feet, to the north of Ste-Cécile-de-Masham.

Pleistocene Fossils

The only known occurrence of Pleistocene fossils is that reported by Wilson (1924, p. 62) on lot 7, ranges VI and VII, Onslow township. A section exposed in an eastward-striking gully shows 15 feet of stratified clay containing Saxicava rugosa and Macoma baltica. The top of the clay is about 390 feet above sea-level.

Direction of Ice Movement

North of the Eardley escarpment, in the uplands, glacial striae trend a few degrees west of south. South and west of the uplands the striae trend southeast, a direction that suggests that the advance of the waning ice was controlled by the Ottawa River valley and the Eardley escarpment.

STRUCTURAL GEOLOGY

Gneissic Structure

Gneissic structure is well developed in most of the Precambrian rocks. Strikes are predominantly northeast, and this is reflected in the elongation of some of the intrusive masses. Strikes in the northwest corner of the area are northwest but swing north to the north of Charteris. The limestone and paragneiss band south of Bristol Mines strikes east, although the adjacent igneous rocks trend northwest. From this anomalous structure it would appear that this part of the area was somehow protected from the regional deformation.

Dips are steep and generally southeast throughout most of the area, indicating that the formations are tightly folded. However, north of Charteris, the dips are more gentle and are predominantly to the southeast and east. The east-striking Grenville below Bristol Mines dips north.

Bedding

The Paleozoic formations of the area are flat or dip gently southwest. Original bedding in the regular Grenville formations of the area is rarely recognizable, although silicate layers in the limestone (Plate I) probably represent quartz-rich interbeds. The banding of the crystalline limestone, such as that on the shores of Chats lake (Plate II A,B); may be relic bedding in part. The banding of the more deformed limestones in the rest of the area is generally considered to be a result

of flow caused by dynamic metamorphism, and is parallel to the contacts with the more resistant formations. Some of the less recrystallized, fine-grained paragneisses of the Bristol Mines area show a layering that is probably relic bedding (Plate III B).

Folds

The Grenville rocks of the area seem to be tightly folded along northeast trending axes. The folds are regional in extent and have been intensely deformed and partly obliterated by continued metamorphism and igneous intrusions. A local fold is recognizable near East Aldfield. The axial plane strikes northeast. The east limb, southeast of Janese lake, is marked by a small anticline plunging east. Another fold with similar attitude occurs in the paragneiss lens east of Loups lake.

Drag folds, many of which are contorted, are common in some of the silicate layers of the crystalline limestone (Plate I).

Joints

Joints developed in most of the Precambrian rocks of the area, particularly in the intrusives, but no definite sets were observed except those in the diabase dykes. The dykes themselves are generally considered to occupy regional tension joints. Many of the diabase exposures show two sets: one vertical and parallel to the walls and the other horizontal. Two small trap dykes cutting the porphyritic syenite on the east shore of Lapêche lake show incipient columnar joints.

Aerial photographs of the area show three different sets of linear topographic features. Two of them are in the porphyritic syenite, one trending N.50°E. and the other northwest. The third set trends N.30°W. across the various gneisses northwest of Loups lake. Although such linear features have been interpreted as the result of weathering along fault planes, no faults were observed in these formations. More probably they resulted from weathering along regional joints that perhaps were more closely spaced than elsewhere.

Shears and Faults

Two small shear zones south of Loups lake strike eastward and dip north. A third shear zone, cutting the porphyritic syenite of the southeast corner of the area, strikes N.60°W. and dips northeast.

The only fault observed in the area cuts Paleozoic formations about 1/2 mile east of the bridge at Quyon, and is of particular

interest because of associated barite. It strikes about N.65°W., dips southwest, can be traced for about a mile, and has a vertical displacement of 30 feet or so.

The Eardley Escarpment

The Eardley escarpment (Fig. 1) extends for about 25 miles northwest from King's mountain, which is northwest of Hull, to a point 3 miles north of Quyon. Because of its striking aspect, it has long been commented on by geologists. It is generally considered to be the result of erosion along a fault plane. Kindle and Burling (1915) believed it to be part of a normal, through-going fault of post-Ordovician age that extends along the border between Precambrian and Paleozoic formations north of the Ottawa and St. Lawrence valleys. Wilson (1924, p. 59) thought it to be the result of more local faulting.

Traverses across the main escarpment and also its northwest-trending branch revealed no evidence of faulting. The general structure of the area is transverse to the trend of the escarpment, but the structure in the porphyritic syenite, in which the greater part of the escarpment is found, is parallel to the escarpment and northeast trends are limited to the northern part of the syenite. The dyke of silicified aplite extending from Lapêche lake southwest to Ottawa river should, logically, be offset if cut by a fault, yet no appreciable offset is observed. Furthermore a geophysical map of the area shows no evidence of faulting, but does show the porphyritic syenite sharply outlined by isomagnetic lines of higher intensity.

The Eardley escarpment may be the remnant of a pre-Paleozoic fault-line scarp, which had originally developed farther south and which retreated to the present emplacement. Or, it may represent the erosional remnant of the porphyritic syenite, which was intrusive into formations that have long since been eroded away. In the latter case, the massive character of the porphyritic syenite and the large size of the intrusion would have an appreciable effect on the development and maintenance of steep slopes.

ECONOMIC GEOLOGY

The Bristol-Masham area has been the scene of considerable prospecting since the early days of settlement in the Ottawa and Gatineau valleys, and some iron and some molybdenite have been mined at various times within the past 80 years. Exploration work was carried on at the Bain and Kirkham molybdenite properties and at the Bristol Iron mine (now Hilton Mines) during the period of the writer's mapping of the area.

In the following outlines, numbers within brackets correspond to those beside mineral occurrences indicated on the accompanying map.

Barite (1,2,3)

Barite occurs in veins up to a foot thick along the fault zone cutting Beekmantown dolomite, near Quyon. The best showings are on lots 12, 13 and 16, range III, and on lot 13, range IV, Onslow township. It is usually massive, although in places lamellar with a radial structure, and of various shades of pink. It carries a few thin layers of fluorite.

Brucite (4,5,6)

Brucite occurs as small nodules in white, medium-grained, crystalline limestone in lots 13 and 16, range XIII, Eardley township. The limestone itself occurs as inclusions in porphyritic Wakefield syenite. The nodules, which may be irregular in shape, are 2 to 3 mm. in diameter, usually yellowish to white, and weather to a white hydromagnesite. The weathered surface of the limestone is commonly pitted with small cavities formed by leaching of the altered brucite. Although these occurrences are of little economic importance in themselves brucitic limestone is being actively mined at Wakefield immediately to the east of the area.

Graphite

Some graphitic paragneisses east of Charteris (lots 8a and 8b, range XII, and lots 7, 8a and 8b, range XIII, Clarendon township; and on lots 8 to 17, range I, and lots 9 and 10, range II, Thorne township) were staked during the winter of 1954-55, but were not developed. Some specimens are reported to contain up to 7% graphite.

Iron (magnetite and hematite) (7)

An extensive diamond-drilling program, guided by geophysical surveying, revealed magnetite-hematite concentrations on the site of the old Bristol iron mine, lots 21 and 22, range II, Bristol township. These operations were carried out during the winter of 1953-54. (See Appendix, page 42, for later developments.)

Operations at the Bristol iron mine were first started in the winter of 1872-73, and the mine closed down in 1894. Wilson (1924, pp. 107-112) reviewed the history of this mine up to 1894. As his field work was done in 1917, the workings were inaccessible to him, and he had to rely on the dumps and older reports for his information.

The mine is in an area of mixed paragneiss, crystalline limestone, granite and granite gneiss. The ore consists of magnetite, mixed with hematite, pyrite, calcite, potassic feldspar, quartz and various silicate minerals, particularly amphiboles of the tremolite-actinolite group and epidote. The mineral assemblage and geologic setting suggest a pyrometamorphic origin for the deposit. The ore is somewhat granulated. The miniature faults that occur in it confirm the possibility of fracturing.

Analyses of hand-picked samples, given by Wilson (1924, pp. 110-111), yielded from 43% to 62% metallic iron.

Minor hematite occurrences are reported by Cirkel (1909) on lots 2 and 22, range I, Bristol township.

Marl (8,9,10,11)

Good quality marl is to be found in at least four localities in the area: a) at the west end of Ruthledge lake on lots 47, 48, range I, Aldfield township (8); b) on the south shore of Ireland lake, lot 11, range X, Bristol township (9); c) along a small lake on lots 7 and 8, range I, Thorne township (10); and d) in Barnes lake, range V, Thorne township (11).

As farmers can obtain lime cheaply from the brucite processing mill at Farm Point, on Gatineau river to the east, marl is not in demand locally.

Mica (12)

The only mica occurrence that has been in production in the area is on lot 17-N 1/2, range VII, Onslow township (12). A pit 20 feet long by 15 feet wide and now filled with water has been dug, and is reported to have been worked in the year 1900 and to have produced \$450 worth of mica. The deposit is along the contact between porphyritic, Wakefield syenite and crystalline limestone. Dark phlogopite mica is associated with pink calcite and well-crystallized diopside.

Minor amounts of mica are reported on lot 22, range VII, Onslow township, and on lots 2, 3, and 51, range III, Thorne township. These localities were not examined by the writer.

Molybdenite (13,14,15,16,17)

The Bristol-Masham area is remarkably rich in molybdenite occurrences, but only three of more than passing interest are known. These are described below.

a) Moss mine (15) lots 9,10, range VII, Onslow township

The Moss mine, north of Quyon, is the only molybdenite property from which appreciable ore has been produced. Wilson (1924, p. 65), Eardley-Wilmot (1924, p. 150), and Osborne (1941) describe the geology and structure of this mine. As the workings have long been abandoned and flooded, and the buildings removed, the writer has taken most of his information from Osborne because his work is the most recent and detailed. The simplified small-scale map of the geology and workings of the Moss mine (Figures 2A and 2B) are based on Osborne's maps. The only change made is in the shape of No. 1 pit which the writer resurveyed because it had been worked after Osborne's examination.

This mine was operated by several companies intermittently from 1916 to 1940. During this period, it produced about 550 tons of molybdenite (calculated from figures given by Osborne, 1941, p. 5). Flotation cells were used to concentrate the molybdenite extracted from open pits and shallow inclined shafts.

The molybdenite is disseminated and the grade is low. Wilson (1924) identified the following additional minerals in the ore: pyrite, pyrrhotite, magnetite, hematite, sphene, fluorite, microcline, albite, biotite, pyroxene and siderite. Osborne, in addition, identified important amounts of allanite. This allanite is no doubt responsible for the 0.006% U_3O_8 equivalent radioactive value measured in samples of ore submitted to the Quebec Department of Mines laboratories.

The molybdenite occurs partly in disseminated flakes and partly in aggregates. Wilson considered the deposits to be due to magmatic segregation. Osborne and the writer favour a pegmatitic origin because the Onslow syenite complex is composed of aplitic and pegmatitic rocks that are closely related in origin to the molybdenite-bearing pegmatites. Also, as Osborne pointed out, the geochemistry of molybdenite is more in accord with a pegmatitic origin.

b) Bain property (16) lots 53-56, range X, Masham township

The Bain property, situated at the north end of Janese (Indian) lake, was first developed in 1917 and was the site of sporadic

activity until World War II. Descriptions of this property may be found in Wilson (1924, p. 82), Eardley-Wilmot (1925, p. 138) and, most recent and most complete, in Ingham (1943).

The country rock in which the mineralization occurs is a mixture of injection gneiss, paragneiss and orthogneiss. The origin of the mineralization is pegmatitic. The ore occurs in high-grade pockets and lenses separated by leaner rock. The average tenor in any of the exploratory workings does not exceed 1% and the amount of ore is small. Small amounts of pyrite, pyrrhotite and chalcopyrite are associated with the molybdenite. Some radioactive minerals, discussed in a later section, are also present.

Although a small mill was erected, the property never was in production.

c) Kirkham property (Onslow Molybdenum Co.) (17)

Lot 5, range XII, Clarendon township

The Kirkham property is in an area of mixed rusty-weathering paragneiss, crystalline limestone, pegmatite and some metamorphic pyroxenite. The molybdenite is associated with massive sulphides, chiefly pyrite and pyrrhotite with minor amounts of chalcopyrite, galena and pink calcite. The mineralization is somewhat similar to that of the Bain property, although the proportions are different.

An 800-foot adit was driven into the hillside and an 87-foot raise was cut to surface from the second crosscut. The orebody has been followed for 200 feet by means of the adit and diamond-drilling. The amount of ore blocked out was estimated at 85,000 tons. Car samples are reported to have given an average of 0.37% molybdenum. All underground work had ceased at the time of the writer's visit and only diamond-drilling exploration was being carried out.

d) Other occurrences

Two prospects in the area, now inactive, yielded some molybdenite by hand-picking. These are the Tippin prospect (13) on lots 4, 5-S1/2, range XII, and the Welsh prospect (14) on lot I, range XIII, Clarendon township. The molybdenite in these two properties is associated with pyrite and minor chalcopyrite.

Some molybdenite is found on lots 1, 2, range III, and on lots 1, 2, 3, range IV and V, Aldfield township (Eardley-Wilmot, 1925, p. 141). Other occurrences of molybdenite have been reported on lot 2,

range XII, Bristol township; on lots G,J, and 3, range I, and lot 2, range IV, Thorne township. These were not examined by the writer.

Radioactive Minerals (18)

The discovery of radioactive minerals in association with the molybdenite of the Bain property during the summer of 1953 led to the re-staking of that property, as well as of many adjoining claims. X-ray determination has shown the primary ore to be uraninite and the secondary mineral to be uranophane. Grab samples taken by the writer from two zones averaged an U_3O_8 equivalent of 0.021%, the most radioactive piece giving 0.1%. A scintillometer survey was carried out during the summer of 1954, along with trenching, extensive stripping and diamond drilling, by Stratmat Limited.

Traces of radioactivity were also found in various pegmatites and pegmatite-injected occurrences in other parts of the area, and drilling was done in Aldfield, Eardley and Clarendon townships without encouraging results.

Sphalerite (19)

Some blasting and stripping was carried out on a zinc sulphide occurrence on lot 51, range II, Aldfield township (19). The mineralized zone, which is a foot thick, is in altered limestone and consists of dark brown sphalerite with minor chalcopyrite associated with some vuggy quartz.

Dolomite

A lens of crystalline limestone 15 feet wide was mined out in 1951 by A. and W. Wallingford of Hull. The deposit yielded 270 tons of dolomitic material that ran 53.58% $CaCO_3$ and 42.52% $MgCO_3$. The locality is lot 10-N. 1/2, range IV, Aldfield township, on the east side of Lola lake.

Sand and Gravel

Good quality sand and gravel from numerous small pits are used for building purposes and in road work.

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APPENDIX

The Hilton Mines: (formerly Bristol Mines) are jointly operated by Stelco Mines Quebec Limited and Bristol Mining Quebec Company, giving employment to some 400 people.

A 3,000-ton-per-day concentrator was completed in 1957 and open-pit mining began in February 1958. In 1959, 560,000 tons of 67% pelleted iron concentrate was produced. In 1960, production was 699,021 tons of 67.26% iron from 4,885,408 tons of mined material.

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