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DONCASTER AREA, ELECTORAL DISTRICTS OF TERREBONNE AND MONTCALM

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GEOLOGICAL SURVEYS BRANCH

GEOLOGICAL REPORT 94

DONCASTER AREA

ELECTORAL DISTRICTS OF TERREBONNE AND MONTCALM

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DONCASTER AREA

TERREBONNE AND MONTCALM ELECTORAL DISTRICTS

by

M.A. KLUGMAN

INTRODUCTION

General Statement

The Doncaster area, mapped during the summer of 1956, lies within the Grenville subprovince of the Canadian shield. The underlying formations are all Precambrian in age and consist of anorthositic, gabbroic, and quartzose rocks of the Morin series, paragneisses of the Grenville series, and various minor intrusions.

The deposits of massive sulphides of possible economic interest occur near Route 18 in the area. In 1956, assessment work was being done by the Laurentian Titanium Corporation on the larger of the two deposits.

Location

The area, which is in the Laurentian Uplands, is bounded by longitudes 74°00' and 74°15' and by latitudes 46°00' and 46°15', thus covering an area of 210 square miles. Three-quarters of the area is in Terrebonne electoral district and the remainder is in Montcalm. It includes nearly all of Doncaster and Wexford townships, and parts of Beresford and Morin townships in Terrebonne electoral district, and parts of Chilton, Archambault, Chertsey, and Wexford townships in Montcalm electoral district. Sainte-Marguerite, the largest town, is in the southeast corner, and is 60 miles northwest of Montreal. Doncaster Indian Reserve No. 17 occupies about 30 square miles in the centre of the area.

Access

Travel facilities within the map-area are excellent. A Canadian Pacific Railway line and Route 11, both connecting Montreal and Mont-Laurier, cross the southwestern corner of the area. Route 30 (Montreal to Saint-Donat) follows the western-boundary from Lantier to the southern tip of Archambault lake in the northwestern corner. Route 18 (Montreal - Rawdon - Saint-Donat) enters the map-area near Saint-Emile-de-Montcalm, in the east-centre, and runs northwest across the northeastern part to the southern tip of Ouareau lake in the north-centre.

Several secondary roads are easily travelled by car and, in conjunction with farm roads and trails, give access to most of the area. An old road that traverses the Indian Reserve from Sainte-Lucie-de-Doncaster to Notre-Dame-de-la-Merci can still be used by jeep over most of its length.

Field Work and Acknowledgments

The base-map employed is an enlargement to one inch to one-half mile of the eastern half of the unpublished preliminary map No. $31^{J}/_{I}$ (Sainte-Agathe - Saint-Jovite Sheet). Traverses were spaced at half-mile intervals and were run by pace and compass with the aid of aerial photographs taken by the Royal Canadian Air Force.

The writer was ably assisted in the field by Y. Sylvestre, who performed the duties of a senior assistant for half the summer, and by N.E. Goodman and M. DeRouin. The writer is indebted to Dr. F.F. Osborne for many useful suggestions during the field season.

Previous Work

The first geological work in this area was by Logan (1857; 1863). In the later report, Logan referred the anorthosite of the region to the top of the "Laurentian system", and believed it to be sedimentary in origin.

Adams (1893) discussed the Morin anorthosite and other anorthosites of the world and established that they are of igneous origin. Later (1896), he published a report on the area around the Morin anorthosite. Adams first gave the name "Morin" to the anorthosite mass of the area, inclusive of the associated gabbroic rocks.

Osborne mapped areas to the west (1935; 1936) and to the south (1938). He extended (1936) the term "Morin" to embrace "the quartzose rocks" of the region, these rocks being of igneous origin and apparently related to the anorthosite.

Côté (1960) mapped the area immediately to the east of the present area. A broad zone of fine-grained anorthosite, referred to as the Chertsey facies by Adams and Côté, borders the eastern margin of the Morin massif. The coarser-grained anorthosite was referred to as the Ashton facies by Côté.

DESCRIPTION OF THE AREA

Settlement and Resources

Inhabitants

The largest town, Sainte-Marguerite, is in the southeast corner of the area. Other towns are Val Morin, Val David, and Préfontaine in the southwestern part, Sainte-Lucie-de-Doncaster in the centre, Lantier in the west centre, Saint-Emile-de-Montcalm in the east centre, and Notre-Dame-de-la-Merci in the northeast. Farms are numerous in the western and southern parts of the area, but many of them are now abandoned because of the poor quality of the soil. The hilly sections of the area are either too steep or have too thin a covering of soil for successful farming. Summer cottages border most of the lakes, particularly in the southern half.

Timber

The area has been extensively lumbered and most of the coniferous trees have now been replaced by hardwoods. Maple is by far the most abundant growth. Black spruce, balsam fir, jackpine, tamarack, white birch, and poplar are present.

Fish and Game

Most of the larger lakes and many of the smaller ones contain an abundance of fish. Several fishing clubs have rights to lakes in the area and there are also many privately owned, well-stocked lakes. Lake trout, brook trout, pike, perch, and catfish are plentiful. Moose, deer, and bear are present in the area and partridge are abundant.

Climate

A weather observation station has been maintained by the Quebec Department of Lands and Forests at Sainte-Agathe for the past 31 years. The mean annual temperature for the Sainte-Agathe area is approximately 40°F., and the mean annual precipitation is 43.38 inches. The hottest months during the summer of 1956 were June and July, with mean monthly temperatures of 59°F. in each case.

Precipitation during the summer months of 1956 was greater than the normal, as shown in the following table:

	1956	Normal
May	3.95"	3.20"
June	3.11"	3.65"
July	5.66"	3.92"
August	6.44"	3.60"
September	3.01"	3.80"

Physiography

The area lies within the Laurentian uplands, and its highest point is about 2,800 feet above sea-level. The local relief varies up to 1,500 feet.

There are two principal drainage systems in the area. One, the Dufresne river and its tributaries, drains the northern and eastern parts of the area. Dufresne river rises at Dufresne lake, in the northwestern corner, and flows east-northeast to Ouareau river just northeast of the area. Ouareau river flows south-southeasterly to enter Assomption river, which discharges into St. Lawrence river at Charlemagne. Most of the rest of the area drains southward and westward by way of the Doncaster River system into the North river, which the Doncaster enters just southeast of Sainte-Marguerite Station, and which in turn drains into Ottawa river at Carillon bay.

The area can be divided into three physiographic districts, as outlined below.

From the top of the highest mountain in the area, Mount Kaaikop, which is east of Legault lake in the northern section and has an elevation of 2,800 feet, an accordance of summit levels can be noticed to the north, west, and east. South of Mount Kaaikop the hills also rise to a common elevation, but here the summit levels are lower. Osborne (1936) has pointed out that the more northern and higher mountains, which include Mount Tremblant on the northwest, define a monadnock with an area of more than 200 square miles. The portion of the monadnock in the present area owes its existence to the highly resistant quartz syenite and quartz monzonite which underlie it. The anorthosite, which crops out south of Mount Kaaikop, although resistant to erosion itself, is apparently not so resistant as the quartz syenite and quartz monzonite, and this may be the main reason for the lower elevations in this part of the area. The third physiographic district is made up of those areas that have a thick mantle of moraine overlying the bedrock.

The highest of the three districts is rugged. There are many steep slopes to cliffs several hundred feet high. Most of these face southwest or southeast and do not have any obvious relationship to the direction of ice movement. Most of the summits of hills are between 1,400 and 2,800 feet above sea-level. The drainage pattern is controlled by joints in the rock and, to a minor extent, by the gneissic structure. The major valleys trend northwest, and the minor valleys trend northeast. The drainage pattern produced is sub-parallel to sub-rectangular.

The second physiographic district includes most of the area, and is underlain principally by anorthosite. Here, elevations range from 600 feet to 2,000 feet or more above sea-level. Thus, the topography in this district also is rugged. The intersecting valleys are deeply disected and follow joints that strike northeast, northwest, and east. The major valleys trend northeast, the secondary valleys east, and the minor valleys northwest. The drainage pattern is sub-rectangular, but the pattern of some of the minor valleys is dendritic.

The third topographic division includes the lower parts of the area, most of which are overlain by a thick mantle of glacial drift. Much of the drift has been reworked along the valleys and in the low-lying areas and is now well stratified with alternating layers of coarse- and fine-grained sediments. The local drainage pattern within these areas is dendritic. Away from valleys the glacial drift has produced a gently rolling topography with a local relief of not more than 300 feet. In places, bedrock protrudes through the drift to form hills most of which have steep south-facing slopes and gentle north-facing slopes.

GENERAL GEOLOGY

General Statement

The area includes the north-central portion of the Morin anorthosite massif. The northern and northwestern parts of the area are underlain by quartz syenite and quartz monzonite, rock-types that were included by Osborne (1936) in the "quartzose rocks" of the Morin series.

The Morin anorthosite massif, with an area of approximately 860 square miles, is surrounded on all sides by quartzose rocks of the Morin series. Small masses of Trembling Mountain gneiss and rocks of the Grenville series abut against, and penetrate, the anorthosite mass at a number of places around its margin. Bodies of Grenville series rocks are also found enclosed within the anorthosite itself. The dominant strike of the rocks, which make up the Grenville series in the vicinity of, and in, the mass, is north.

The formations of the present area, listed in order of abundance, include: anorthositic and gabbroic rocks, which underlie more than half of the area; quartzose rocks of the Morin series; paragneisses of the Grenville series; and various minor intrusive rocks.

Table of Formations

Cenozoic	Pleistocene and Recent	Sand, gravel, clay, till, boulder moraine
PRECAMBRIAN		Diabase - - - - Pegmatite (not shown on map)
	Morin series	Quartz syenite; quartz monzonite - - - - Anorthosite, gabbroic anorthosite, anorthositic gabbro, gabbro, layered anorthositic rocks
		Reaction gneiss (quartzofeldspathic gneiss)
	Grenville series	Quartzite, impure quartzite, graphite gneiss, crystalline limestone, meta-pyroxenite, quartz-garnet-sillimanite gneiss, hornblende-andesine gneiss, biotite-andesine gneiss

Precambrian

Grenville Series

Quartzite, varying from relatively pure to quite impure varieties, occupies more than two-thirds of the area underlain by the Grenville, and thus is by far the most abundant formation. Limestone is exposed at only one locality, but the number of angular boulders in the northern section of the area indicates a second nearby source.

Correlation of these sedimentary rocks and of the various associated gneisses with the Grenville is justified on the basis of continuity as well as of petrography. Rocks of the Grenville series have been traced from the type locality, near Grenville village in Argenteuil electoral district, through the adjacent areas to the south and west (Osborne 1936; 1938) into the present area. Although limestone is the dominant rock at the type locality, it has been shown (Osborne 1936) that quartzite is as abundant in the Grenville series as is limestone.

Quartzite

Quartzite is found in nearly all exposures of the Grenville paragneisses either as thin layers showing excellent bedding or as apparently massive layers, some of which are tens of feet thick. It is white to grey, and, in places, is opalescent. Near the contacts with intrusive rocks it is commonly recrystallized. In some places, small rust-lined cavities, caused by the weathering out of grains of iron-rich minerals, may be seen.

The quartzite varies from fine to coarse in grain, both extremes being present in most thin sections. The large grains nearly all show undulose extinction, whereas the small grains do not. In those quartzites that show bedding, the grains of quartz and the flakes of mica are commonly elongated parallel to the bedding. Accessory minerals include clino-pyroxene, hornblende, biotite, phlogopite, plagioclase feldspar, sphene, ilmenite, zircon, and limonite.

Impure Quartzite

Impure quartzite is more abundant than the pure variety. It is white to pink, and commonly weathers to a very friable, sugary aggregate. The most common impurities are plagioclase feldspar, graphite, limonite, clino-pyroxene, biotite, and garnet.

A plagioclase-rich variety is the most abundant. This occurs near the contact of the Grenville series with the anorthositic and gabbroic rocks and also as separate layers within the other paragneisses. Under the microscope, it is seen to be highly granulated with larger grains of quartz surrounded by fine grains of quartz. Plagioclase (An_{38}) feldspar makes up as much as 22 per cent of some specimens. Other minerals present are: augite, hornblende, biotite, chlorite (clinochlore), sphene, magnetite, apatite, zircon, garnet, and limonite. In some thin sections sillimanite makes up as much as 12 per cent of the rock.

The graphitic quartzite is white to yellow and rusty-weathering. Graphite makes up 15 per cent of some specimens. Accessory minerals are garnet, magnetite, sphene, apatite, biotite, chlorite, and limonite (iron stain). Iron stain is extensive, giving the whole thin section a deep yellow colour.

Limonitic quartzite is very similar in composition to the graphitic quartzite, and is also rusty-weathering. However, it contains a lesser amount of graphite and a larger amount of limonite, the latter commonly appearing in the hand specimen as rounded 'blebs'. The limonite appears to have resulted from the weathering of garnet, magnetite, and mafic minerals.

Micaceous (predominately biotite) quartzite is common as well-defined layers within the plagioclase-rich quartzite. In places, it grades into quartzofeldspathic gneiss (reaction gneiss). Biotite makes up as much as 17 per cent of the rock. The other minerals present, besides quartz, are phlogopite, orthoclase, plagioclase, apatite, zircon, sphene, magnetite and pyrite.

Graphite Gneiss

Graphite gneiss was observed in only two localities, both in the northwestern part of the area. It is medium-grained, grey and weathers to a rusty, sugary mass. It is composed of plagioclase (An_{29}), quartz, and graphite with accessory epidote, sericite, limonite, and magnetite.

Crystalline Limestone

Crystalline limestone was observed in place in the area, only on the east shore of Wexford lake. It is coarsely crystalline, pale blue to white, and weathers to an angular rubble. The essential mineral is calcite, and the accessory minerals are phlogopite, garnet and pyrite.

Metamorphic Pyroxenite

Much of the metamorphic pyroxenite in the area was classed in the field as hornblende andesine gneiss which it resembles.

It occurs as layers within the quartzites and gneisses of the Grenville series. The rock is green to dark green, medium-grained, slightly gneissic, and weathers to a brown-black and white speckled surface.

Under the microscope, it is composed of diopside, plagioclase, and quartz, with biotite, potash feldspar, sphene, apatite, allanite, calcite, and magnetite as accessories. Quartz makes up from 3 to 20 per cent of the rock. Untwinned potash feldspar and biotite in equal amount make up from 4 to 12 per cent of the rock. Biotite occurs both as an alteration product after diopside and as a primary mineral. Sphene and magnetite are the most abundant accessory minerals. In one thin section, sphene makes up 16 per cent of the rock. Magnetite usually accounts for about 5 per cent of the rock.

Quartz-Garnet-Sillimanite Gneiss

Quartz-garnet-sillimanite gneiss was seen at two places in the area, interbedded with other rocks of the Grenville series. Under the microscope, it is seen to be highly granulated, with grains of dark minerals and sillimanite oriented with their long axes in the plane of the gneissic layering. The quartz shows undulose extinction and most of the grains have sutured margins. Generally, the rock could be classed with the impure quartzites for it contains only a little less quartz.

The essential minerals are quartz, 70 per cent; sillimanite, 18 per cent; garnet, 7 per cent; and chlorite, 5 per cent. The accessory minerals are allanite and magnetite.

Hornblende-Andesine Gneiss and Biotite-Andesine Gneiss

Hornblende-andesine gneiss occurs as well-defined layers in many exposures of the Grenville. It is green to dark green depending on the proportion of the hornblende, granoblastic and commonly equigranular in texture, and medium-grained. The rock is strongly gneissic, the dark minerals being oriented with their long axes parallel to the gneissic layering.

Amphibolites are considered, for the purpose of this report, a variety of hornblende-andesine gneiss which contains more hornblende than the rest of the gneiss. The essential minerals are hornblende, plagioclase, and biotite. Accessory and alteration minerals include quartz, apatite, hypersthene, augite, potash feldspar, sphene, garnet, and magnetite.

The biotite-andesine gneiss resembles the hornblende-andesine gneiss and its mineralogical composition is the same. The only difference is in the ratio of hornblende to biotite.

Reaction Gneiss

Reaction gneisses occur along or near the contacts between the Grenville rocks and either of the younger intrusives (anorthosite; quartz syenite). They are the result of contamination of Grenville rocks by the intrusion of either anorthositic or syenitic material. Inasmuch as quartzite and impure quartzite are the most common Grenville rocks in the area, they are naturally the most affected. The reaction gneisses have retained many of the features of Grenville rocks and, therefore, in many cases, are difficult to distinguish from the true Grenville in the field. Also, because they are the result of reaction between older and younger rocks, they cannot rightfully be assigned to either, and they must therefore be given an arbitrary position between the Grenville series and the later intrusives.

In petrographic terms, the reaction gneiss may be called quartzofeldspathic gneiss. The rock is light grey to grey, fine- to medium-grained, and well layered. In some places, the layering is highly contorted and deformed, whereas in others it is quite regular. The layering is parallel to that in the Grenville proper.

The composition of the reaction gneisses is diverse, as the Grenville formations have been affected to a greater or lesser extent in different places.

In general, the rock is composed of quartz and plagioclase feldspar. Potassic feldspar is present here and there. The dark minerals are augite, hypersthene, biotite, and, occasionally hornblende. Alteration and accessory minerals include chlorite, muscovite, epidote, sericite, apatite, zircon, garnet, sillimanite, spinel, pyrite, magnetite, and ilmenite. Under the microscope, the rock is highly granulated and is in alternating medium- and fine-grained layers. Nearly all grains of quartz and feldspar have sutured margins, and a myrmekitic intergrowth between grains of quartz and feldspar is common. Many grains of quartz and feldspar have undulose extinction, and recrystallization of these minerals in the interstices was observed in a number of thin sections.

Plagioclase (An_{40} to An_{57}) is present in amounts up to 26 per cent. Some grains show carlsbad as well as albite twinning and a few also show pericline twinning. Many of the plagioclase crystals are bent. Most grains are clear, but there has been some alteration to sericite. In two thin sections, the plagioclase showed excellent antiperthitic intergrowth. In some places, particularly in the northern part of the area, orthoclase perthite makes up as much as 30 per cent of the rock.

Hypersthene and augite, which make up to 12 and 10 per cent of the rock respectively, are the most common dark minerals. Both are commonly oriented with their long axes in the plane of the gneissic layering. The hypersthene is faintly, but clearly, pleochroic from pale pink to pale green. It has a schiller structure in some places, and alters to biotite, chlorite, and magnetite. Augite is pale green to dusty-blue and alters to biotite, chlorite, magnetite, and ilmenite. Biotite, which makes up as much as 20 per cent of the rock in some places, is strongly pleochroic from red-brown to pale brown. Chlorite is present in all of the thin sections examined. It is most common as an alteration product after pyroxene, hornblende, or biotite. In most thin sections it is too iron-stained for the variety to be identified, but in two sections it was identified as pennine. The chlorite content ranges between 1 and 15 per cent of the rock. Hornblende, strongly pleochroic from dark green to green, was observed in only one thin section. This rock was probably originally a hornblende-andesine gneiss.

One of the reaction gneisses in the northwestern corner of the area, contains quartz, orthoclase perthite, hypersthene, sillimanite, garnet, and spinel. This rock shows all the features of, and can definitely be said to belong to, the granulite metamorphic facies. Most of the other reaction gneisses are not of as high a grade of metamorphism.

Morin Series

Anorthositic and Gabbroic Rocks

Anorthosite and gabbroic anorthosite, in 3:1 proportion, underlie almost two-thirds of the area. Areas underlain by more gabbroic or layered anorthosite have not been shown, because of their limited extent, but are included with the gabbroic anorthosite.

Anorthosite

The anorthosite is commonly medium- to coarse-grained, but a fine-grained variety dominates in some places. Crystals of plagioclase up to 7 inches long were observed in some localities but these are not common. Grain-size may vary from fine to coarse within short distances. The 'block structure' described by Balk (1931) in the Adirondack anorthosite and by Côté (1960) in the adjacent area to the east was observed in several places in the eastern half of the area. Blocks up to tens of feet in diameter of coarser grained, grey to dark grey anorthosite are surrounded by a finer grained, light grey anorthosite. Stringers of the finer facies cut the coarser facies. The blocks are slightly more gabbroic in composition than the matrix and probably represent a slightly earlier facies of crystallization.

Pale green, blue, mauve, grey, and dark grey colours are the most common. A maroon and blue anorthosite occupies large areas in the southern and southwestern parts of the area. The colours do not seem to indicate differences in composition. In some places in the maroon and blue anorthosite, the colour of the maroon grains of plagioclase appears to be caused by dust-like inclusions of iron oxide, probably hematite.

Plagioclase makes up from 90 to 98 per cent of the rock. It is well twinned according to the albite law, and pericline twins are common. Carlsbad twins are rare, but a few were observed in some thin sections. The plagioclase is andesine (about An_{45}). In most of the thin sections examined the plagioclase shows little alteration, but in places it is altered to a felted aggregate in which no individual minerals can be identified. Granulation is a pronounced feature in several thin sections. In some, the grains have been slightly rounded and are surrounded by crushed and recemented fragments, whereas in others the rock appears to have been ground down to a fine-grained aggregate. In this latter case, the size and shape of the original grains can sometimes be estimated from the shattered fragments.

Augite is the most common dark mineral in the anorthosite. It makes up from 1 to 7 per cent of the rock and is commonly altered to biotite, chlorite, magnetite, and, in places, hornblende. In thin section it is pale green to mauve. Hypersthene makes up from 1 to 4 per cent of the anorthosite and is commonly found in the same specimen as augite. It is distinctly pleochroic from very pale green to very pale pink. Schiller structure is present in many of the grains, and faint lamellae were observed in one of the thin sections. The hypersthene is commonly altered to biotite, chlorite, and magnetite.. Hornblende and biotite are present both as alteration minerals and as primary constituents. The hornblende is strongly pleochroic from dark green to green. It alters to biotite, chlorite, and magnetite. Biotite, which is pleochroic from yellow-brown to brown, has been partly altered to chlorite and magnetite.

Quartz is present in amounts of up to 2 per cent in many thin sections. It occurs both as a primary mineral and as a secondary mineral after plagioclase. As a secondary mineral, it occurs as small grains within the plagioclase and also forms myrmekitic textures along the margins of many of the grains of plagioclase. More than half of the thin sections examined contain at least a trace of quartz. The above does not include the quartz that has been injected.

Accessory and alteration minerals include chlorite, magnetite, ilmenite, sericite, epidote, sphene, and zircon.

Gabbroic Anorthosite

Although a number of isolated patches of gabbroic anorthosite are found within the anorthosite, the anorthosite becomes more gabbroic in composition near the contact with quartz syenite and quartz monzonite in the northern part of the area and also near many of the roof pendants of Grenville rock in the anorthosite. Along Routes 11 and 30, the change in composition can be traced from coarse-grained anorthosite through gabbroic anorthosite to anorthosite gabbro. The last may be seen on Dufresne lake, just south of the anorthosite-quartz syenite-monzonite contact. There is also a marked, although not always progressive, decrease in grain size from the centre towards the contact of the mass.

The gabbroic anorthosite is massive to gneissic, fine- to medium-grained, and grey to dark green. Near the contact in the northwestern part of the area, the gneissic structure becomes more and more pronounced as the rock becomes more gabbroic or mafic in composition. The mafic minerals have their long axes in the plane of the gneissic layering. The strike of the gneissic layers is parallel to the contact, the dip is outwards, and the angle of dip increases towards the contact. Such structures also prevail near contacts with the Grenville rocks, although here the gneissic layering is not so prominent.

Numerous stringers of quartz and apophyses of quartz syenite or monzonite cut the anorthosite near the contacts between the anorthosite and these two rocks. In the northwestern part of the area, the gabbroic anorthosite contains quartz and porphyroblasts of potash feldspar. The contact is not actually exposed here, but it appears to be gradational. At other localities there is little or no contamination of the gabbroic anorthosite, and the contact appears to be sharp.

Under the microscope, the gabbroic anorthosite is seen to be fine- to medium-grained, slightly granulated to highly granulated with some of the larger grains of plagioclase surrounded by a groundmass of fine-grained fragments of plagioclase. The plagioclase forms up to 85 per cent of the rock and is from An_{45} to An_{50}. It is commonly well twinned according to the albite law, but some of the larger grains show undulose extinction and have their twinning partly obscured. Pericline twinning is also present in some places, and many of the grains show mortar structure. In some of the thin sections the plagioclase contains dust-like inclusions, but even in the 'cloudiest' grains the twinning is retained. Most grains are clear but alteration to sericite and to an indeterminable alteration aggregate occurs in some places.

In the gabbroic anorthosite, hypersthene is the most abundant dark mineral. It makes up from 7 to 16 per cent of the rock, is clearly pleochroic from pale green to pale pink, and alters to biotite, chlorite, and magnetite. Augite, present in amounts up to 11 per cent, alters to biotite, chlorite, magnetite, and ilmenite. Hornblende, as an alteration product of pyroxene, makes up less than 2 per cent of the rock. It is strongly pleochroic from green to dark green. The biotite is pleochroic from honey brown to brown and alters to chlorite and magnetite. Garnet is present in some places, especially near the quartz syenite-monzonite contact. In many places, particularly between Notre-Dame-de-la-Merci and Saint-Emile-de-Montcalm and southeast of Wexford lake, the gabbroic anorthosite contains as much as 30 per cent of either magnetite or ilmenite or both. Other minerals include chlorite (clinochlore), sericite, epidote, phlogopite, apatite, sphene, calcite, quartz, and pyrite.

Gabbroic anorthosite makes up three-quarters of the total area of rock so labelled on the accompanying map. Also included in this mapping are anorthositic gabbro, gabbro, and layered anorthosite. Anorthositic gabbro and gabbro have the same mineralogical composition as the gabbroic anorthosite but contain more mafic minerals. Some of these rocks contain far more magnetite or ilmenite (as much as 70 per cent) than does the gabbroic anorthosite. Disseminated sulphides are commonly associated with these iron-rich rocks.

The layered anorthosites have an essentially uniform mineralogical composition. They differ only in that they contain more or less of one of the essential constituents. The essential minerals are plagioclase, hypersthene, augite, hornblende, and biotite. Accessory and alteration minerals are the same as those found in the other anorthositic and gabbroic rocks. The layers range in composition from anorthosite to gabbro and have no definite sequence. They may be well or poorly defined, regular or irregular, and they strike and dip in the same direction as the gneissic layering in the gabbroic anorthosite. The arrangement of the mafic minerals within the various layers differs. The most common structure is one with the mafic minerals uniformly distributed throughout the rock and with their long axes parallel to the gneissic layering. In some places pyroxenes form pods. The containing rock has very little pyroxene in it, but the over-all composition, including the pods, is that of gabbroic anorthosite or anorthositic gabbro. A third structure, in which the dark minerals are concentrated in patches, gives the rock a mottled appearance.

The colour of the various rocks is dependant on the tenor of the dark minerals, and it varies from grey-white to green-black. The structure is most commonly gneissic, and the grain-size is from fine to coarse.

Quartz Syenite and Quartz Monzonite

A large mass of quartz syenite and quartz monzonite underlies the northwestern and northern parts of the area. The rock is pink to grey-green on the fresh surface and pink to white on the weathered surface, medium-grained, and varies from very gneissic to massive. No contacts between the quartz syenite or quartz monzonite and older rocks were observed in the field. However, in places, the anorthositic and gabbroic rocks are cut by dykes and apophyses of quartz syenite and quartz monzonite; in other places the contact between these two groups appears to be gradational. The strike of the gneissic layering in this body is always parallel to the contacts between it and the surrounding rocks, and the dip is commonly steep towards the contact.

The mineralogical composition of the rock is diverse, with quartz syenite and quartz monzonite forming the end members. No field evidence of the change in composition was noted. Quartz syenite is the dominant rock type in a proportion of seven to one.

Under the microscope, the rock is seen to have an allotriomorphic granular fabric with alternating medium- and fine-grained layers. In the finer layers many of the grains of feldspar and quartz occur as lenticles, with their long axes in the plane of the gneissic layering. Nearly all grains of feldspar and quartz have undulose extinction, and many of the grains of plagioclase are untwinned. No accurate determination of the composition of the plagioclase was made. In some places large grains of quartz or feldspar are surrounded by a very fine-grained rim of the same mineral. The grain-size of the rest of the 'groundmass' is coarser than the rims, and the whole gives the rock a porphyritic appearance. The light coloured minerals are granulated, and recrystallization textures are a notable feature of the rock. Nearly all the grains of quartz and feldspar have sutured margins, and many show myrmekitic textures.

The essential minerals of the quartz syenite are orthoclase, quartz, pyroxene, biotite, and plagioclase. Accessory and alteration minerals include chlorite, epidote, apatite, magnetite, limonite, and garnet. Orthoclase may make up as much as 71 per cent of the rock. It shows very little alteration and most grains are microperthitic. Quartz makes up from 19 to 27 per cent of the rock. It often contains liquid inclusions and commonly forms myrmekites with the feldspar. Plagioclase is not always present. The pyroxenes are more or less altered to chlorite, biotite, and magnetite and cannot always be determined. Both hypersthene and augite were identified; they do not appear to occur together in the same rock. Chlorite is the most abundant alteration product of pyroxene. It makes up from 5 to 8 per cent of the rock, and it is commonly very iron-stained. In some places, porphyroblasts of garnet (probably almandine) make up as much as 10 per cent of the rock. Biotite (from 2 to 4 per cent) is pleochroic from light brown to red-brown. It occurs both as an alteration product after pyroxene and as a primary mineral. Magnetite makes up as much as 5 per cent of the rock.

The quartz monzonite has a mineral assemblage similar to that of the quartz syenite, but orthoclase does not exceed 55 per cent. Plagioclase, on the other hand, commonly makes up about 30 per cent.

Near and along parts of the eastern margin of the area are two other masses of quartz syenite and quartz monzonite. The gneissic structure is not as well developed in these masses as in the northern body. In this region two contacts between the quartz syenite-quartz monzonite and the older rocks were observed in the field. Numerous apophyses and dykes of the syenitic rocks cut the anorthositic rocks and the rocks of the Grenville series. The quartz syenite-quartz monzonite of the southern bodies is the same colour as that of the northern body, but it is not as coarse-grained and it has a finer texture. Quartz syenite is the dominant rock type at this locality also. Under the microscope, it is fine-grained, allotriomorphic granular, with some larger grains of quartz. All of the light coloured minerals have sutured margins, and recrystallization around the margins of the grains is common. The rock is highly granulated and most of the quartz and feldspar have undulose extinction. The rocks are composed of the same minerals as those of the northern body, with the addition of zircon as an accessory. The pyroxenes are less altered with the result that chlorite is less abundant.

Pegmatites and Mylonites

Pegmatites and mylonites composed of quartz and alkali feldspar cut all the rocks described above. Crystals of feldspar as much as 6 inches in diameter are common in most of the pegmatites. So far as observed, pegmatite dykes cut the anorthosite mass only near its margin. Mylonite dykes are common in the southeastern and eastern parts of the area. Most of these strike south or south-southwest and dip steeply east or west.

Diabase

Several dykes of diabase were observed. One dyke, in the northwestern part of the area, is exposed for 100 feet. At its southern end it is 20 feet thick, but halfway along the exposure it splits and continues as two parallel dykes, both of which are about 5 feet thick. A thin dyke in the Indian Reserve crops out in two exposures about half a mile apart.

The diabase is dark green to green-black, fine- to medium-grained, and sub-ophitic to ophitic. It is composed of plagioclase (An_{39}), augite, hornblende, and biotite. Accessory minerals are apatite, sphene, magnetite, and ilmenite.

Cenozoic

Pleistocene and Recent

Sand, gravel, clay, and moraine mantle large sections of the area, particularly in the north central, western, and south central parts. Well-bedded sand and clay overlie bedrock in large areas adjacent to Doncaster and Dufresne rivers and several of their tributaries. Crossbedding was noted in a number of places. The beds vary in thickness from less than an inch to several feet. Interbeds with well-rounded and sorted pebbles or cobbles up to 7 inches in diameter are common. Well-defined terraces can be traced for short distances along these rivers.

South of Doncaster river, the ground is heavily mantled by moraine through which bedrock protrudes in places. The moraine has produced in this area a rolling topography. Scattered, angular boulders, many of which are tens of feet in diameter, are common. A few indistinct drumlins and eskers were noted.

Thick mantles of moraine are present north of Notre-Dame-de-la-Merci and also south of Dufresne river in the western section of the area. In both of these areas a number of distinct drumlins and eskers were seen.

Glacial striae and the shape of the drumlins indicate that the ice moved almost due south over the area.

STRUCTURAL GEOLOGY

A large mass of anorthosite occupies most of the southern two-thirds of the area. Intruded into the anorthosite, near and along parts of the eastern margin, are two masses of quartz syenite-quartz monzonite. A large intrusive mass of quartz syenite-quartz monzonite occupies most of the northern third of the area. Included within these masses are several bodies of Grenville paragneisses, which strike roughly northwest.

The anorthosite of this area represents the north central part of the Morin anorthosite massif. Both the core and the border facies are present. The latter is more gabbroic in composition and tends to be finer grained than the core. The border facies occupies the northern section of the mass, and also forms a southeasterly trending 'tongue' in the eastern half of the area. Most of the more gabbroic anorthosite is gneissic, with the strike of the gneissic layering parallel to the contacts of the mass in the marginal areas and in the 'tongue'. The dip in the marginal zone is outward and most of the dips in the 'tongue' are westward.

Associated with the 'tongue' of gabbroic anorthosite are a number of locally contorted bodies of Grenville rocks. Prior to the intrusion of the anorthosite and quartz syenite-quartz monzonite, these various bodies probably formed one continuous northwesterly striking body of Grenville rocks. The northwesterly strike is retained in the separate bodies, and the general dip is westward.

One of the more significant discoveries made during the mapping of the area is that the anorthosite massif is not continuous but is divided into an eastern and a western part by Grenville rocks and by masses of quartz syenite and quartz monzonite. The eastern part of the anorthosite is richer in mafic minerals than the western part. The younger intrusive rocks can be explained as a result of injection along the contact of Grenville rocks and anorthosite. The status of the Grenville rocks is not clear. They may be part of the roof of the anorthosite massif or a screen separating anorthosite bodies of slightly different age.

Faults

Two possible faults cut the anorthosite and Grenville series in the east-central and central parts of the area. The strike of both faults would be about N.80^{o}W. The northern fault crosses Route 18, 1 1/2 miles north of Saint-Emile-de-Montcalm and extends into the Indian Reserve. Evidences for this fault are the truncation of part of the gabbroic anorthosite 'tongue', and the high degree of granulation of the adjacent anorthosite. The second fault runs through

Wexford lake about half a mile south of Saint-Emile-de-Montcalm. Evidences for this fault are the off-set beds of Grenville rocks and quartz syenite on one of the islands in Wexford lake, and the alignment of bays in Wexford lake with a lake to the west.

Joints

Joints are common, particularly in the anorthositic rocks. The most prominent joints strike N.85°E. and dip vertically or steeply north or south. Other joints strike northeast, south-southeast, and north. The dips are vertical in the first two, and steeply west in the last. Minor joints, commonly with moderate dips, are also present. In the quartz syenite and quartz monzonite body in the northern part, the dominant joints strike northwest and the minor ones strike northeast. The dip in both sets is nearly vertical.

Magnetometer Surveys as an Aid to Interpreting the Structure

As an aid and check to the interpretation of the structure of the area, four critical sections were surveyed by Askania magnetometer. In three cases, the magnetometer survey confirmed the geological interpretation; in the fourth, an indefinite result was obtained. The surveys were run as an experiment to ascertain whether this type of survey could be used in determining the structure in areas where the bedrock is heavily mantled by overburden. In this case, where the rocks have such contrasting magnetic properties (anorthosite, quartz syenite-quartz monzonite, Grenville series), the method generally gave adequate information.

The base station for the surveys was in a small field on the south shore of Wexford lake, 285 feet on bearing S.50°E. from the front of Restaurant Trudel, Entrelac. All four surveys were along roads.

The first survey (Figure 1) was from Saint-Emile-de-Montcalm around Wexford lake to Entrelac. This survey indicated the ilmenite and magnetite in the gabbroic anorthosite, the contact between the gabbroic anorthosite and anorthosite, and the contact of anorthosite with Grenville rocks.

The second survey (Figure 1), from Gai lake to the southern tip of Archambault lake in the northwest corner of the area, was run in two sections. The results of this survey were not as useful as the first. The contact between the anorthosite and the quartz syenite-monzonite was clearly defined, but that between the quartz syenite-monzonite and the Grenville series was not indicated probably owing to the similarity between the magnetic properties of these latter groups of rocks.

The third and most successful survey (Figure 1) was from the road fork at Dufresne River bridge, east of Dufresne lake northeast along Dufresne river to Route 18 in the northeastern corner of the area. This survey clearly indicated both observed and projected contacts between the formations in this part of the area.

The fourth survey (Figure 1), from Dufresne River bridge to Dufresne lake, also indicated both the observed and the projected contacts, but the norm for the non-anorthositic rocks was not as low as in the other three cases and therefore showed little contrast to the normal high for anorthosite.

ECONOMIC GEOLOGY

Ilmenite and Magnetite

Small occurrences of ilmenite and magnetite were observed at many places throughout the anorthosite, particularly in the more gabbroic facies.

Sulphides

Small amounts of finely disseminated sulphides were noted in many exposures of quartzose rocks of the Morin series and also of the Grenville series. Two deposits of massive sulphides of possible economic interest were examined. Both of these are near Route 18.

The larger of the two occurrences is about three-quarters of a mile northwest of the northwestern tip of Marcheur lake, on ground held by the Laurentian Titanium Corporation. The Corporation holds (1956) lots 5, 6, 7, and 8, of range III, lots 6, 7, 8, and 9, of range IV, and lots 6 and 7, of range V, in Chilton township, Montcalm electoral district. The deposit is massive, highly magnetic pyrrhotite, which weathers to a dark red-brown gossan. It is exposed on and near the top of a steep, east-facing hill overlooking Route 18. The host rock is fine-grained, white, crystalline quartzite, which has been intruded by a medium-grained, magnetite-rich gabbroic anorthosite. Disseminated throughout the pyrrhotite are crystals and pods of pyroxene. The higher grade ore occurs in a zone with a total length of about 2,000 feet along the strike, and a width across strike of 150 feet. Assays show 0.3 per cent copper and 0.2 per cent nickel. Magnetometer and self-potentiometer surveys were made on the property by the Corporation and, in 1956, drilling was going forward.

The smaller of the two showings is one mile northwest of the point where Route 18 crosses the eastern boundary of the area. Its geological relationships are very similar to those of the larger showing, but it is much smaller.

Sand and Gravel

Several gravel pits are worked for road material in the area.

Building Stone

Some of the massive anorthosite would make a very attractive decorative stone, particularly the maroon and blue variety from the southwestern part of the area.

APPENDIX

Mining Developments from 1956 to 1959

by J.-E. Gilbert

Geophysical surveys, geological mapping and diamond drilling were carried out in Wexford, Chertsey and Chilton townships for ilmenite and titaniferous magnetite between 1953 and 1956, and large deposits of material averaging close to 20.0 per cent titanium dioxide and about 27.5 per cent iron were reported to have been outlined by Laurentian Titanium Mines Limited, just to the south of the present area.

Some exploration work, including diamond drilling, was also carried out recently by the same company on a nickel-copper occurrence in Ranges III and IV of Chilton township.

November 16, 1959.

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