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Geology of Chandos Township
Peterborough County

By
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and

Geology of Wollaston Township
Hastings County

By
D. F. HEWITT

Geological Report No. 11

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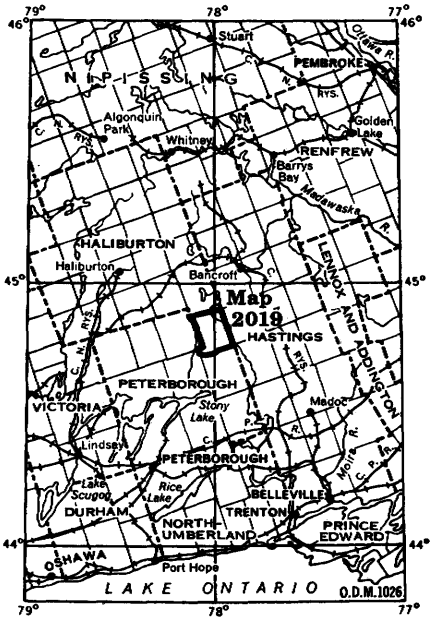
Geology of Chandos Township

By

D. M. Shaw[1]



Key map showing location of Chandos township. Scale, 1 inch to 50 miles.

Abstract

This report describes the geology, structure, and mineral deposits of Chandos township, Peterborough county, comprising an area of 90 square miles located about 10 miles south of Bancroft. The township lies mainly within the Hastings Basin structural subdivision of the Haliburton-Bancroft area, which forms part of the Grenville province of the Canadian Precambrian Shield.

The area is underlain by marble, paragneiss, para-amphibolite, schist, arkose, and basic volcanics of the Mayo Group. These metasediments and metavolcanics are intruded by gabbro, diorite, syenite, and granite. The principal intrusive body is the Loon Lake granite pluton in southern Chandos.

The area was highly folded during the Grenville orogeny with the main axes of folding being northeast-southwest, parallel to the regional folding. Strongly developed crossfolding occurred along axes trending northwest-southeast.

Deposits of iron, copper, and uranium have been found in the township, but there has been no mineral production.

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Introduction

General

The township of Chandos covers an area of about 90 square miles in the northeast corner of Peterborough county. The area is covered by the Coe Hill, Bannockburn, and Bobcaygeon sheets of the National Topographic Series (published on the scale of 1:50,000, 1:50,000, and 1:126,720, respectively, by the Department of National Defence; available from the Canadian Department of Mines and Technical Surveys.) Schools and postal services are available in the village of Apsley, which adjoins the southwestern part of the township.

Chandos Lake (formerly Loon Lake) occupies the central part of the township; on its shores are several hundred private cottages and several tourist lodges.

Prospecting and Mining Activity

In spite of active prospecting for many years, no economically important deposits have been found in Chandos township.

The earliest prospecting was for iron; a small magnetite showing near the south boundary has been known for over 50 years.

More recently there has been extensive prospecting for radioactive deposits. Of the several showings that have been trenched, blasted, and drilled during the past 10 years, none has warranted development work. The geology of the township differs in several ways from that of the radioactive mineral belt to the north; proximity to the Bancroft region gives no assurance that radioactive deposits should also be found in Chandos township.

Sporadic sulphide showings that occur in the township are chiefly pyrite. An old copper prospect exists in lot 32, concession II, close to the southeast corner of the township. No other base-metal prospects have been reported.

Present Geological Survey

The present geological survey of Chandos township was carried out mostly in the summer of 1958, by a party consisting of three geologists and two junior assistants. About 70 square miles were mapped during the season, leaving about 20 square miles in the northeast corner uncompleted. This section was completed in 1959 by D. F. Hewitt and assistants.

The geology was plotted on acetate sheets attached to air photographs of the scale of 1 inch to 1,320 feet. Fields and open areas were mapped directly; in bush areas, pace-and-compass traverses, usually ¼ mile apart, were made between selected points. With the exception of lakes and swamps, no area larger than 10 chains square remained unvisited. Stereoscopic examination of the air photographs revealed likely outcrop areas and other topographic and structural features.

The data obtained in the field was transferred to a basemap on the same scale, using a sketchmaster. The information was then generalized and compiled on a final map at the reduced scale of 1 inch to ½ mile (map No. 2019, in map case). It should be realized that, on this scale, much of the detail is lost: of the two or more rock types, which are found at almost every outcrop, only the most abundant is shown. The outcrop boundaries shown on the map usually indicate the limits of exposure of solid rock, or rocks, within a few inches of the surface; in some cases numerous small exposures have been generalized. Moreover, outcrop areas change continuously; land is cleared, fields grow over into bush again, and lake levels rise and fall.

Field examination of the rocks provided most of the information on which was based the classification of the rocks that are shown by symbols on map No. 2019 (map case). However, additional information was obtained from more than 300 hand specimens that were collected and subjected to binocular microscopic and, in some cases, petrographic examination.

Acknowledgments

The author was ably assisted in 1958 by P. S. Simony, D. E. Thompson, W. E. Wiley, and D. Morris. The geological mapping was carried out by Messrs. Shaw, Simony, and Thompson. Numerous residents of the area assisted the party in many ways. D. F. Hewitt was assisted in 1959 by P. S. Simony, K. A. MacLean, and R. D. Todd.

Means of Access

The first settlers arrived in the region in the mid-nineteenth century, when the Burleigh colonization road was opened north from Peterborough past Stony Lake. As agriculture was developed, a network of lot and concession roads was built. At the present time, most of the township is still accessible by these roads, which have been provided with gravel surfaces adequate for automobiles. In addition, access roads to the shores of Chandos Lake are continually being built for the convenience of summer residents.

Highway No. 28, from Peterborough to Bancroft, passes through Apsley, close to the southwest corner of the township, and crosses the northwest corner. Highway No. 504 starts at Apsley and makes a 29-mile circuit of Chandos Lake, mostly following lot and concession lines, returning to Apsley. At Glen Alda, a connecting road leads east to Coe Hill.

The nearest rail connections are at Nephton in Methuen township, which is the terminus of a C.P.R. spur-line, and at Coe Hill, which is served by a C.N.R. spur.

Drainage is poor in Chandos township, and there is no access by water.

Natural Resources and Industry

Chandos township was first surveyed by J. Fitzgerald in 1862; additional survey work was done by F. Wilkins in 1867. In 1951, some re-surveying was carried out by L. Pierce. The township contains 17 concessions, each containing 32 lots, together with a gore of 12 additional lots near Apsley; owing to an error, concession I is non-existent, and the numbers run from II to XVIII. Most lots measure 20 by 50 chains.

Much of the northern, eastern, and southern parts of the township have been settled by farmers. Hay and grain crops are grown; some livestock is raised, including beef- and dairy-cattle, pigs, and sheep. However, much of the cleared land has been poor for farming, and many farms are now abandoned; the land is slowly reverting to bush.

Although lumbering is an important industry in the township, good stands of timber have been depleted. There is still some pine; in addition, spruce, balsam, cedar, hemlock, poplar, maple, and birch are cut; there are several sawmills in the township. Most of the poplar is trucked to Coe Hill, and from there it is sent to Trenton as pulpwood. In recent years many acres have been reforested, mainly with pine. Although some of these trees are being allowed to mature, many are cut, after a few years growth, for the Christmas tree industry.

Summer residents provide a major source of income in the region. Many residents are occupied in the building of cottages and boats, and some residents work in the Bancroft uranium mines.

Several sand and gravel pits are operated in the township. Pickerel, bass, lake trout, whitefish, and perch are fairly abundant in Chandos Lake and attract many anglers. Deer, bear, fox, and other land animals are common. Beaver and muskrat are plentiful, especially in the swamps on the west and south shores of Chandos Lake.

Topography

Chandos township forms part of the Laurentian peneplain of the Precambrian Shield. The relief is about 200 feet, the highest hills in the region attaining an elevation of about 1,200 feet. The terrain consists chiefly of low rounded hills with swampy areas between. Owing to the low relief, the drainage is very sluggish; most of the smaller lakes and ponds, which number about twenty, drain into Chandos Lake, which is drained from its north end by the Crowe River (formerly the Deer River). The Crowe River flows east, then south through the township, and continues into Hastings county. The northwest corner of the township drains into Eels Creek, which flows south to Stony Lake. This corner is, geographically, in the Haliburton Highlands, but geologically the township lies in the Hastings Basin.

Throughout its course through Chandos township, the Crowe River meanders through an extensive swamp, most of which is bordered by thick deposits of sand and gravel. It is likely that the swamps occupy a buried valley, nearly filled with sand. The region was glaciated in Pleistocene times but, except in the vicinity of the Crowe River and a few other parts of the township, the glaciofluvial deposits are not thick. Nevertheless, only about 10 percent of the area is solid rock. No Pleistocene clay or till was seen.

The main body of water in the township, Chandos Lake, occupies nearly 10 square miles and is said to possess 230 miles of shoreline. The depth of the lake is not known but is unlikely to exceed 100–200 feet; the deepest parts are in the vicinity of South Bay near the contact of the Loon Lake pluton. The main section of the lake trends at about N.30°W., which is a prominent joint-direction, while the long parallel sections of West Bay and South Bay roughly parallel the strike of N.45°E. The lake occupies a depression probably created by glacial scour parallel to these directions and dammed at the north end by the sands of the Crowe River swamp.

Previous Geological Work

The first report and geological maps of the area were by Adams and Barlow (1910). Their account of the geology of the region was very comprehensive, and is still a standard reference for geologists working in the region. The map of Chandos township by Adams and Barlow (1910, Map No. 770), although made on a much smaller scale, is shown, by the results of the present report, to be essentially correct.

Some of the data on Map No. 770 were checked and amended by D. F. Hewitt and J. Satterly in preparing the Ontario Department of Mines map, No. 1957b, that covers the Haliburton-Bancroft area.

Much of the southern part of Chandos township was mapped by A. K. Saha while studying the Loon Lake pluton near Chandos Lake, and two other southeastern Ontario plutons for Ph.D. thesis (Saha 1957). The present report confirms most of Saha's findings.

Other information relevant to the discussion of the area is available in reports by E. Cloos (1934) and D. F. Hewitt (1956); Chandos township is shown on Map No. 52a by J. Satterly (1943).

General Geology

General

DEFINITION OF GEOLOGICAL TERMS

Some of the common geological terms have several meanings and do not have the same significance to different readers. In following the practice recommended by a subcommittee of the National Advisory Committee on Research in the Geological Sciences (Ottawa, Canada) (Shaw 1957), a few of the more important definitions are presented here.

Amphibolite. A metamorphic rock of medium to coarse grain, consisting predominantly of amphibole but also containing essential plagioclase. Amphibolites are commonly massive, and the amphibole often has an elongated or acicular habit, but some varieties can be classed as schist or gneiss.

Foliation. An interleaved fabric caused by planar disposition of fabric elements in any rock. The elements may be tabular (e.g., mica flakes, layers of varying composition) or linear (e.g., hornblende prisms in random or parallel but planar distribution, as in some amphibolites and schists). Foliation can be applied to igneous, sedimentary, or metamorphic rocks. It is a family name for such diverse features as bedding, schistosity, gneissosity, flow layering in igneous rocks, etc.

Granulite. A medium- or coarse-grained metamorphic rock of even granular (granoblastic) texture. Owing to the minor importance or lack of orientation, of mica, hornblende, etc., foliation is weak or absent.

Gneissic Structure. A planar structure in a metamorphic or plutonic rock, caused by the alternation of layers, streaks, or lenticles of contrasting mineralogical composition or texture.

Gneiss. A rock possessing gneissosity. The directions of easiest fracturing may be parallel or transverse to the banding, but parallel cleavage is less regular than in schists. Granular (equi-dimensional) minerals such as quartz, feldspar, and garnet predominate, but smaller amounts of mica, amphibole, pyroxene, and other silicates, contribute to the foliation or lineation. Invariably, this is a rock of medium or high metamorphic grade, and is usually rather inhomogeneous.

Schistosity. A foliation of metamorphic origin, caused by parallel orientation of abundant platy, lathlike or acicular grains. Schistosity is a texture that commonly imparts a fissility to the rock, although in some cases this is poorly developed.

Schist. A rock possessing schistosity. The most typical schists are of pelitic composition and are rich in lamellar or platy minerals in subparallel orientation. Granular (equi-dimensional) minerals such as garnet, quartz, or feldspar, are common, and some degree of layering may be present. Used in this way, the term schist would include slate and phyllite as fine-grained varieties. As the abundance of micaceous minerals decreases, the schistosity becomes weaker, and other names become more appropriate: e.g., biotite quartzite, phlogopite marble, garnet gneiss, amphibolite.

Metasedimentary Rocks

Metasedimentary rocks, mainly paragneiss, para-amphibolite and marble underlie about three-quarters of Chandos township.

PARAGNEISS AND PARA-AMPHIBOLITE

Rocks grouped in the paragneiss and para-amphibolite lithologic subdivision occupy much of the central and southwestern parts of Chandos township, and belong to the Chandos Subgroup of the Mayo Group. Northwest of the Pratts Creek fault, paragneiss, para-amphibolite, arkose, and metavolcanic amphibolite make up the Hermon Formation of the Mayo Group.

Along strike, north in Cardiff township, D. F. Hewitt (1959, pp. 20–21) has divided the Mayo Group into the Hermon Formation and the Dungannon Formation. In Chandos township, the Dungannon Formation makes up part of the Chandos Subgroup.

Chandos Subgroup

The paragneisses of the Chandos Subgroup are a series of medium-grained schists, gneisses, and amphibolites, which can be conveniently divided into those containing abundant hornblende but little biotite, and those with abundant biotite but little hornblende. Where hornblende is abundant, the rocks are called amphibolites and are frequently more massive than the biotite paragneisses. Plagioclase feldspar is usually abundant in both groups, but in a few areas there is little feldspar present, and the rocks pass into quartzites.

In addition to hornblende, other lime-bearing minerals, such as augite and epidote, are commonly encountered. Where these constituents are abundant, the rocks become indistinguishable from those mapped as lime-silicate rocks (3S).

TABLE OF FORMATIONS
Chandos Township

CENOZOIC	PLEISTOCENE	Sand, gravel, and clay.
		Great Unconformity
PRECAMBRIAN	PLUTONIC ROCKS	Pegmatite, aplite, leucogranite.
		Intrusive Contact
		Loon Lake Pluton: Granite, granodiorite. Syenite, monzonite. Metadiorite, metagabbro inclusions.
		Intrusive Contact
		Glen Alda syenite—metagabbro. Duck Lake–Tallan Lake metagabbro.
		Intrusive Contact
		Methuen granite.
		Metamorphism, Folding, Granitization
	GRENVILLE-TYPE METASEDIMENTS AND SOME IGNEOUS ROCKS	*LITHOLOGIC SUBDIVISION* Marble Group:(1) Marble; interbedded marble and paragneiss or amphibolite; silicated marble; lime-silicate rock; skarn. Paragneiss-Amphibolite Group:(2) Amphibolite; biotite and garnet amphibolite; scapolite amphibolite; biotite paragneiss; sillimanite and cordierite paragneiss and hornfels; quartzite; quartzo-feldspathic paragneiss.

STRATIGRAPHIC SUBDIVISION(3)

	Formations		Members
Chandos Sub-group(4)	East Road paragneiss and amphibolite.	Hermon Formation	Tremolite marble.
	Lasswade marble.		Upper arkose.
	Apsley paragneiss and amphibolite.		Upper amphibolite.
	Dungannon marble and feather amphibolite.		Lower arkose.
			Lower amphibolite.

(1) Includes all carbonate-bearing rocks.
(2) Includes all psammitic and pelitic rocks together with some impure calcareous rocks.
(3) All sedimentary rocks are of Hastings Basin type.
(4) Correlates with Mayo Group in Faraday, Dungannon, and Mayo townships.

Amphibolite

The hornblendic rocks are usually rather massive but, nevertheless, possess some foliation or lineation. They are black and grey speckled rocks and usually contain sufficient hornblende to be called amphibolites. The other principal constituent is plagioclase feldspar ranging from oligoclase to labradorite; quartz is usually present also. Where hornblende is less abundant, the rocks are classed as hornblende gneisses or granulites. Other minerals that are abundant in some localities include biotite, augite, epidote, garnet, scapolite, and microcline. Sphene is an invariable accessory mineral and is commonly accompanied by magnetite, pyrite, apatite, tourmaline, and calcite. Porphyroblasts of plagioclase feldspar, scapolite, or garnet are common.

Amphibolites and related rocks are not, quantitatively, very important in Chandos township. It may be seen from the map that they commonly occur as narrow bands, a few hundred feet thick, interrelated with the other paragneisses. They are most commonly encountered between marble and biotite paragneisses and represent sedimentary passage-beds originally having consisted of calcareous shales and silts. It is unlikely that they represent igneous rocks, whether sills, flows, or tuffs, in Chandos township, although they do so in townships to the east.

Many of the amphibolites and hornblende gneisses have a characteristic texture consisting of irregular prismatic hornblende crystals lying in a criss-crossed aggregate suggesting feathers, along with a light-coloured granular aggregate of feldspar and quartz. Furthermore, there are considerable textural variations within this group of feather-amphibolites (2Af): some are medium- or fine-grained and some are coarse; some have two-dimensional sheets of hornblende feathers, interleaved with quartzo-feldspathic layers; others have a more random, three-dimensional, distribution of hornblende grains. In one case (on highway No. 504 at W. Park's farm, 1.4 miles east of Apsley) a striking example shows dendritic amphibole grains in a pure white aggregate of plagioclase, microcline, and quartz; in this section, the hornblende grains are seen to be full of inclusions of quartz and feldspar.

In Chandos township the feather amphibolites always occur in gneissic bands adjacent to, or interbedded with, marbles and almost certainly have formed from sedimentary rocks. In some cases the feather amphibolites are so intimately interbedded with the marbles that they cannot be shown separately on the map and have therefore been included with the marble series (3Af); this applies particularly to the wide band of marbles adjacent to the Duck Lake metagabbro. That band appears to be an extension of the Dungannon Formation, northeast in Faraday and Dungannon townships, with which it may be correlated.

Excellent descriptions of these feather amphibolites have been given by Adams and Barlow (1910) and Hewitt and James (1956). It is clear that this interesting texture developed under the conditions of metamorphism of the Hastings Basin, but its cause remains unknown.

Biotite Paragneiss

The biotite schists and gneisses occur in well-bedded sequences, and usually possess a marked schistosity that is parallel to the bedding. They have a fine or medium grain-size, are brown to black or speckled in a fresh specimen, and weather grey. The principal mineral constituents invariably include quartz, oligoclase, and biotite; in some varieties, microcline, garnet, scapolite, and hornblende are present. Common accessory minerals include tourmaline, muscovite, magnetite, pyrite, sphene, apatite, zircon, and calcite. Porphyroblasts of feldspar are common. The average modal composition is given in the accompanying table.

AVERAGE COMPOSITION OF THE APSLEY BIOTITE PARAGNEISS

Mode(1)			Chemical Composition(2)		
	Sodic Type (average of 6 samples)	Potassic Type (average of 6 samples)		Sodic Type (average of 8 samples)	Potassic Type (average of 2 samples)
Oligoclase	50.4	34.9	SiO_2	69.53	69.96
Quartz	28.7	28.1	TiO_2	0.52	0.48
Microcline	0.5	14.7	Al_2O_3	13.91	13.90
Biotite	17.7	17.8	Fe_2O_3	1.11	0.35
Muscovite	1.3	1.9	FeO	4.10	3.79
Garnet	0.7	trace	MnO	0.13	0.06
Sulphides	0.5	1.8	MgO	1.28	1.58
Calcite	0.1	0.6	CaO	1.88	1.39
			Na_2O	3.96	2.80
			K_2O	1.93	4.57
			H_2O+	0.51	0.44
			Total	98.86	99.32

(1) Determined by P. S. Simony by point-counting.
(2) Analysis by Ontario Dept. Mines, Provincial Assay Office, 1959.

Biotite gneisses constitute the most abundant member of the paragneiss sequence and underlie much of Chandos township. They are well exposed in the vicinity of Apsley and along highway No. 504 between Apsley and Lasswade. The latter rocks are highly folded and show numerous zones of rusty weathering. As the belt is followed south towards Methuen township they become intimately injected with sills and dikes of pegmatite; few of these pegmatites are large enough to show on the map, but in places they amount to nearly half the area of outcrop.

In all the paragneisses minor amounts of sulphides are common constituents. Where the sulphide content exceeds 1 percent, the gneisses usually weather very readily to a rusty surface, and it becomes difficult to identify the rock. Rusty-weathering gneisses may be of any composition within the paragneiss group, but are usually rich in biotite and feldspar; this increase in sulphide content is especially common where strong folding has taken place.

The well-bedded character, and the frequent slight textural and compositional changes from layer to layer, indicate that the biotite paragneisses were originally sediments. The usual absence of the aluminous minerals characteristic of high-grade pelitic schists and the abundance of feldspar show that they were originally sandy mud or possibly greywacke.

Minerals that are characteristic of true argillaceous or pelitic metamorphic rocks (sillimanite, cordierite, staurolite) are seldom encountered outside the metamorphic aureole of the Loon Lake pluton or the Hermon Formation. In the main biotite paragneiss belt, it thus appears that true shales were rare in the original greywacke sequence; if this is true, the rareness is very unusual because in younger rocks, it is common to find greywacke interbedded with shale.

The rocks of the Loon Lake aureole are discussed later (see p. 25).

Hermon Formation

The rocks northwest of the Pratts Creek fault belong mainly to the Hermon Formation and consist of interbanded paragneiss, para-amphibolite, metavolcanic amphibolite, and pink arkose.

The diagnostic feature of the Hermon Formation is the presence of several well-defined bands of arkosic quartzo-feldspathic rock of pink or buff colour, commonly containing porphyroblasts of muscovite, and (or) magnetite. The matrix is of medium grain-size and few dark minerals are present, although a little biotite is common. They are lithologically quite distinct from feldspar-rich members of the Chandos Subgroup and are usually more massive, although they possess a definite foliation. Evidence of overgrowths on original sedimentary quartz grains has been observed with the microscope, and it seems likely that these rocks were originally arkose or feldspathic sandstone.

Interbedded with the arkosic rocks are bands of amphibolite and metamorphosed shale.

The amphibolites differ from those of the Chandos Subgroup only in that they tend to be rather more massive and of coarser grain. In the extreme northwest corner of the township they pass into lime-silicate rocks and impure marbles. Feather amphibolites again are present but tend to possess a coarser and less regular texture.

A band of amphibolite, interpreted by P. Simony as metavolcanic, occurs in the Hermon Formation. At its widest point it has a width of about 25 chains. The rock is generally massive, and contains some scapolite spots and epidotized bombs up to 2 feet in length and 8 inches in diameter. The metavolcanic band is overlain and underlain by well-bedded pink arkose.

Several bands of sillimanite-garnet gneiss represent original shale beds, and in one locality cordierite was also found. This mineral usually is restricted to hornfelses and similar thermally-metamorphosed shales but, in this case, there is no nearby body of igneous rock.

The strike of the Hermon Formation is very constant (see p. 19), and the sedimentary belts appear to change composition along the strike, giving a lenticular disposition on the map. This is probably an original sedimentary facies change, although the situation is undoubtedly complicated by the extensive faulting that has occurred in this local area.

Igneous rocks appear to be uncommon in this series. A few pegmatites occur, and there are amphibolites that show a massive texture and have been mapped as basic intrusives.

MARBLE AND RELATED ROCKS

The rocks in this lithologic subdivision are commonly referred to as crystalline limestone and dolomite and are widespread in the township.

Most of the marbles in Chandos township contain calcite in excess of 30 percent. They are medium- to coarse-grained rocks that commonly possess a well-defined foliation owing to the alignment of other minerals. They are typically well-banded rocks whose composition and mineral proportions vary widely from layer to layer; weathering, consequently, produces a ribbed surface. On a fresh surface they are usually grey to white when calcite is the major constituent. Dolomite was not detected in most samples, but a wide variety of silicate minerals was encountered; among those present are quartz, plagioclase, microcline, scapolite, phlogopite, green hornblende, tremolite-actinolite, diopside-augite, epidote, and serpentine. The common accessory minerals include graphite, magnetite, tourmaline, pyrite, sphene, and possible brucite. Two silicates that are common elsewhere in the Grenville province, forsterite and chondrodite, were nowhere detected.

The marbles represent the products of metamorphism of impure limestone and dolomites. Where the original sediments were particularly impure, the resulting rocks are now seen as assemblages of calcium-magnesium minerals with lesser amounts of calcite. Such rocks are commonly more massive granulites and pass into pyroxenites and amphibolites. They are shown on the map as lime-silicate rocks.

In many parts of the Grenville province, the marbles have been extensively deformed and flowage has given rise to erratic, discontinuous lenses and masses whose relations with adjacent rocks are commonly very complex. In Chandos township this is seldom the case. Although extensive crumpling and dragfolding has indeed taken place in some localities (e.g., the marble band along the Lasswade road), the marbles have, in general, remained as continuous bands interbedded within the paragneiss sequence; in most parts of the township the structures in the marble conform to those in the surrounding rocks. This situation is more typical of the Hastings Basin than of the Haliburton Highlands. It is consequently possible to make limited stratigraphic interpretations.

The extensive interbedding of marble and feather amphibolite in the Dungannon Formation has already been discussed.

Plutonic Rocks

BASIC PLUTONIC ROCKS

Three major units of basic igneous rocks occur in Chandos township. These are the Clydesdale Lake (formerly Duck Lake) mass, the Tallan Lake mass, and the Glen Alda mass. In addition, there are numerous satellitic dikes and sills associated with these bodies and other small intrusions throughout the township. The rock types in all of these bodies, except the Glen Alda mass and the Loon Lake pluton inclusions, are similar and can be considered together.

The commonest rock type is a black, brown-weathering, hard, heavy, and massive amphibolite. In some cases foliation or lineation is present, but more commonly there is a weakly oriented fabric. The major constituents are green hornblende and plagioclase. The latter ranges in composition from oligoclase to labradorite, but andesine is the most common. Quartz is usually present; accessory magnetite, sphene, apatite, pyrite, calcite, and tourmaline are usual. The grain is medium or coarse, and occasional glomeroporphyroblastic aggregates of plagioclase are seen.

Varieties of this rock-type are characterized by the presence of additional minerals, which include biotite, garnet, augite, epidote, and scapolite. The garnet and scapolite are commonly porphyroblastic, and the latter is readily identified in the field by white weathering. By variation in the mineral composition and texture the rock passes into metadiorite, metagabbro, metadiabase, and hornblendite (more than 90 percent hornblende).

In most cases the rocks have been metamorphosed, but the features mentioned above identify the rocks as having been originally igneous. Contact skarns serve to strengthen this interpretation.

Duck Lake and Tallan Lake Metagabbro

The Duck Lake metagabbro forms a nearly perfect annular ring centred on Clydesdale Lake (formerly Duck Lake). Its diameter is about 2 miles, and the annular outcrop width averages 2,500 feet. Faint gneissossity is generally present and dips outwards at 5°–30°, showing that the body is a sheet, conformable with the surrounding marbles, about 850 feet thick. This nearly symmetrical dome structure was attributed by Adams and Barlow (1910) to the upthrusting of a batholith below, but there is no evidence for this. There is a slight topographical expression of the dome in a concentric elevation of a few score feet around the central depression occupied by Clydesdale Lake, which is underlain by marble.

At several points, the intruding gabbro reacted with adjacent marble to form a skarn, usually only a few feet thick. These skarns are very coarse-grained rocks consisting of irregular masses of garnet, pyroxene, epidote, scapolite, and other lime silicates.

On the inner western margin of the ring, the amphibolite is in contact with a narrow body of biotite granite gneiss which, from its foliation and outcrop-shape, appears to be part of a conformable sheet below the basic rock. The age relations are uncertain; nevertheless if the granite represents the "red rock" that is commonly found associated with, and derived from, gabbroic rocks elsewhere, its confinement to the base of the sheet is unusual.

The Tallan Lake metagabbro forms a linear body, from 500 to 1,300 feet wide, that extends from Eels Creek on the west for at least 4 miles in a northeasterly direction. The gneissossity dips southeast at angles from 45° to vertical, averaging 70°. The mass appears conformable with the adjacent marbles and obtains topographic expression as a low ridge. The true thickness of the sill is about 950 feet, which is similar to that of the Clydesdale Lake sheet.

Moreover, there is a conformable body of biotite granite gneiss exposed at the lower contact of the Tallan Lake metagabbro for a distance of about 2 miles. It is evident that the two sills resemble each other in several details, and it is concluded that they are parts of the same mass. This is in excellent agreement with the overturned syncline trending northeastwards through Tallan Lake, and the very abundant dikes and sills of basic rock to be found in the marbles lying between the two sheets. The gabbro must have been intruded as a continuous sill, which was subsequently folded and metamorphosed.

Glen Alda Metagabbro

This body is exposed intermittently over an elliptical area measuring about 1½ by 1 miles, centred on Glen Alda. The rocks exposed show more variation than in the Clydesdale Lake—Tallan Lake sill and commonly show coarse-grained aggregates of biotite flakes that impart a marked gneissossity. Microscopic examination shows that, in addition to the usual amphibolites, metagabbros, and metadiorites, alkali feldspar is an abundant constituent in many of the biotite-rich rocks, that are therefore, classified as syenite or monzonite. Augite and sphene are often characteristic constituents.

The rocks of the Glen Alda body closely resemble the basic-intermediate rocks of the Loon Lake pluton and are probably related to them. Gneissossity in the Glen Alda mass is quite striking and shows a conformity with the surrounding rocks of the Glen Alda syncline. The metagabbro-syenite body is, therefore, a synclinal sheet or sill, plunging to the southeast at an angle ranging from zero to 45°. (Actually, there appear to be two sills, separated by a septum of marble.) The conformable structure, and the presence of amphibolites, indicate that intrusion preceded folding and metamorphism. It seems probable, however, that parts of the sill were later altered or augmented by solutions or a satellite intrusion from the Loon Lake pluton.

At several localities, contact skarns have developed between gabbro (or syenite) and marble. The most noteworthy is at the common corner of lots 29 and 30 of concessions X and XI, on the east side of the road. Here is found a series of pegmatitic rocks consisting mainly of scapolite, augite, hornblende, sphene, and apatite.

Other Basic Intrusions

Dikes and sills of amphibolite are common throughout the township. The rock types correspond closely to those already described for the Clydesdale Lake—Tallan Lake sill.

One prominent sill extends from Apsley for 2 miles southeastward and is a few tens of feet thick.

Small metagabbro bodies occur in a group southwest of West Bay on Chandos Lake, near the township boundary. They appear to form irregular dikes, but are intimately associated with amphibolites of the paragneiss series and are frequently difficult to delineate. In addition, the rocks at this locality are commonly cut by irregular basic gneissic bodies containing abundant thin pegmatitic veins, which are interpreted as metamorphosed shear zones.

SILICIC PLUTONIC ROCKS

This group includes monzonite, syenite, tonalite, granodiorite, granite, aplite, and pegmatite, together with associated hornfelses and migmatites. They are divided into the Methuen granite extension, the Loon Lake pluton, and minor intrusions.

Methuen Granite

In the southeast corner of Chandos township, there occurs an oval mass of quartzo-feldspathic rock occupying an area of about 1 square mile. This represents the northerly extension of the Methuen granite, which continues south into Methuen township for a distance of about 12 miles.

The rock is strongly gneissose, and commonly is an augen-gneiss containing ovoids of feldspar, which deform the adjacent micaceous laminae to simulate streamlining. Biotite is the principal dark mineral, contained in an aggregate of pink or grey feldspar and quartz. The plagioclase is albite or sodic oligoclase, and microcline is always present, showing some replacement of plagioclase. Fluorite is a common accessory mineral; zircon, calcite, and magnetite were also found.

The gneissosity of the granites conforms to the surrounding rocks and indicates an anticlinal structure that is horizontal near the township border, but plunges about 45°N. at the north end. The mass may be part of an elongated dome. The rocks are well-exposed and have two sets of prominent vertical joints trending north-south and east-west.

The adjacent gneisses possess a strong foliation and, for the most part, are pink quartzo-feldspathic rocks containing biotite. Muscovite and magnetite are prominent locally, as is hornblende. A thin discontinuous band of serpentine dolomite is present and may be continuous around the nose of the fold. On the west side of the fold some of the pink muscovite-biotite paragneisses show a strong resemblance to a metamorphosed arkose.

Granitic layers and streaks are abundant in the paragneisses and increase in quantity to give migmatites as the granite body is approached. It is believed that the granite may represent the end-product of this migmatization and may be the result of granitization of the paragneisses. It was emplaced during folding and metamorphism (synkinematic) and is lithologically quite different from the later (postkinematic) Loon Lake pluton.

Loon Lake Pluton

This mass is centred on the southern part of Chandos Lake (formerly Loon Lake) and has a surface area of about 16 square miles. The shape is very roughly ovoid, with a rather regular abrupt southern contact that contrasts with the irregular northwestern marginal zone of hybrid gneisses. Eastward, the pluton passes beneath the Crowe River swamp, and its contact is concealed; about a third of the total surface area is concealed by this swamp and by the lake.

The principal rocks exposed are gabbro-diorite, monzonite-syenite, and granodiorite-granite. In the contact-zones there are extensive hornfelses and hybrid rocks. Aplite and pegmatite bodies are widespread. The pluton has been studied in detail by Saha (1957), and some of the data following are taken from his work. The geological map of the pluton given by Saha agrees in most details with the map accompanying this report (No. 2019, map case). However, the present map does not distinguish granite from granodiorite.

Basic Rocks

Rocks of gabbroic or dioritic appearance occur in bodies up to ½ mile long, associated with the syenites. They are dark-coloured coarse-grained rocks that commonly are hard and massive. The feldspar is grey to brown, and is usually interspersed with dark minerals in a gabbroic texture. Biotite is a prominent constituent in some varieties, where it forms large scaly aggregates up to ½ inch wide.

There is considerable textural and compositional variation among these rocks. The commonest variety is diorite, containing biotite, hornblende, and plagioclase feldspar (usually andesine). More basic varieties contain augite and hypersthene, along with a labradorite or bytownite feldspar, and occur as finer-grained hornfelses. Accessory apatite, magnetite, sphene, and quartz are common. In several cases the hornblende and biotite were observed to have grown at the expense of an earlier pyroxene, which has by now largely disappeared.

In some varieties microcline appears; it may be locally so abundant that the diorites pass into monzonites. These in turn pass into syenites, as the proportion of alkali feldspar increases and the dark minerals decrease. There is continuous variation from basic to syenitic rocks; nevertheless the latter are younger in age, as shown by crosscutting relationships at a roadside outcrop on highway No. 504, 1.4 miles from the store at the head of Gilmour Bay, on the east side of the Bay.

Saha (1957), considering all available evidence, concludes that these rocks are not early differentiates of the monzonite, but represent inclusions or roof pendants of gabbros previously injected into the paragneisses.

Intermediate Rocks

A large part of the pluton is made up of rocks that were mapped as syenite or monzonite. These are coarse-grained rocks having a colour index of 10–30. Some foliation is commonly present, but the rocks are rather homogeneous, suggesting the fabric has formed during flow.

Basic varieties are rich in a grey-green plagioclase feldspar of sodic andesine composition. The principal dark mineral is biotite, but augite and hornblende occur. Potash feldspar is present only in subordinate quantities, and the rock is classified as monzonite. As the potash feldspar content increases, the rock takes on a pink colour, the colour index decreases, and the rock becomes a syenite. At the same time the quartz content increases, and the syenites merge into the granites; the contacts shown on the map between syenite and granite are accordingly not very precise, but were delimited on the basis of an apparent (megascopic) absence of quartz. Saha (1957) has observed that the body becomes more potassic (syenitic) towards the outer edge.

In many cases the dark minerals consist of an aggregate of grains of hornblende, biotite, magnetite, sphene, and apatite, suggesting alteration products of some pre-existing mineral. Evidence of shearing, in the form of bent and fractured plagioclase twins, mortar texture, and undulant extinction in quartz, is commonly encountered.

Silicic Rocks

Included in this group are all the rocks that contain quartz visible to the naked eye or with a lens. As previously mentioned they merge imperceptibly into syenites.

These are grey or pink, faintly gneissic coarse-grained biotitic rocks, having a colour index of 5–20. Apart from a few examples that contain phenocrysts of oligoclase, they are rather homogenous but invariably contain inclusions, which are discussed later. Biotite is the principal dark mineral but, in some cases, epidote or muscovite also occur. Muscovite, however, is confined to the zone of hybrid rocks north of South Bay. Microcline and quartz are invariable constituents; plagioclase ranges in composition from albite to andesine but is commonly oligoclase. Accessory magnetite, pyrite, sphene, apatite, zircon, allanite, tourmaline, and calcite are common.

The relative proportions of plagioclase and microcline vary widely, and there are few examples of true granite. The majority of the specimens examined are granodiorite or tonalite (quartz diorite). In the work quoted previously, Saha (1957) distinguished a belt of granodiorite trending east-west and lying immediately north of the main body of syenite, and another belt of granite farther north. In the present report, it has not been found possible to draw boundaries between granite and granodiorite.

In many outcrops, the granodiorite is cut by, or grades into, bodies of leucogranite, aplite, and pegmatite. These are seldom large enough to be shown separately on the map, but they are particularly abundant in the northwestern contact zone extending as far as West Bay and beyond. In this region the pegmatites are certainly part of the pluton; because such dikes and sills are abundant throughout the township, they are discussed separately.

Contact Zones and Inclusions

The igneous rocks of the Loon Lake pluton have affected their adjacent country rocks in a wide variety of ways. Apart from the contact zones themselves, inclusions of paragneiss and marble are common throughout the pluton. In some cases these bodies are large enough to suggest that they might be roof pendants or large stoped blocks.

In the southern and central parts of the mass, there occur numerous bodies of hornfels. These rocks are laminated but massive, fine-grained, and usually dark-coloured. They possess a rather flinty fracture and commonly weather to a ribbed appearance.

The composition varies widely but includes most mineral assemblages encountered in the paragneiss sequence. Marble is rare, but one example occurs at a road-corner 500 feet west of the store at Gilmour Bay. Magnesian hornfelses that occur ½ mile northwest of the Lasswade corner contain cordierite, hypersthene, biotite, hornblende, and andesine; cordierite was also found about 1 mile northwest near a small swamp. Calcareous hornfelses, rich in scapolite, augite, hornblende, garnet, and epidote, are abundant throughout the east-west belt of amphibolites that forms the southern contact. Basic igneous hornfelses consist of augite, hypersthene, labradorite-bytownite, and hornblende.

The southern contact is remarkably abrupt, and there is relatively little evidence of forcible intrusion and veining. An intrusion-breccia is found at one or two localities, notably 1¾ miles along the road east of the Lasswade corner, in front of a farmhouse in lot 27, concession IV. The calcareous gneisses and hornfelses along this contact show injection by granite stringers over a width of only a few hundred feet.

The northern and western contact zones are much more prominent, and true hornfelses are less common. Approaching the pluton from the northwest, there is first a zone rich in quartz-veins, then one containing abundant pegmatite and aplite; southeast of the road along the peninsula, the biotite paragneisses become more coarse-grained and show abundant injections of aplite and pegmatite. These veins consist mainly of quartz and feldspar, but mica and tourmaline are not uncommon.

Along a zone ½ mile wide, extending northwest from South Bay, the proportions of paragneiss and intrusive rock are about equal. The paragneisses here are commonly rich in red garnet and in some belts sillimanite and cordierite are also prominent; these sillimanite-cordierite rocks are approximate, in composition, to true shales, and it has already been noted that such rocks are not found elsewhere in the Chandos Subgroup. It is possible that shales were originally present in this region only but, in view of the association with intrusive rocks, it is alternatively possible that extensive metasomatism has taken place and that the rocks were originally normal biotite paragneisses. No direct evidence supporting this view was found, however. The presence of sillimanite and cordierite is compatible with a contact metamorphism that has been superimposed on an earlier regional metamorphism. The sillimanite rocks were encountered throughout this contact zone, intermingled with biotite paragneiss and granite; in a few belts, the composition was sufficiently constant to be shown on the map as sillimanite gneiss.

In this zone the country rocks are so intimately associated with intrusive material that they become hybrid gneisses and migmatites. As the proportion of igneous material becomes dominant, individual masses of gneiss become surrounded by granite and pass imperceptibly to a zone of granite choked with inclusions. In this region the granitic rocks are most variable. They are locally rich in biotite and feldspar phenocrysts, and commonly pass into pegmatite. It is not possible to find a clearcut contact, and the northwestern boundary of the pluton is therefore subjective.

Farther into the pluton, the distinction between granodiorite and inclusions becomes clear again. The homogeneous granodiorite contains innumerable small inclusions in the exposures along the eastern end of South Bay. These inclusions are grey biotite-plagioclase aggregates and are commonly aligned in parallel swarms, conformable with the foliation in the granodiorite. Dilation effects, where matching fragments of inclusions have been separated by granodiorite, testify to intrusion of the igneous rocks in a liquid or porridge-like state.

The outcrops near the west end of the pluton are well exposed and are particularly interesting. On the hill that lies north of the east end of Lasswade Lake (formerly Mink Lake), a few hundred feet west of a farmhouse, there are large outcrops of a coarse garnet-rich sillimanite-cordierite gneiss that shows interesting contact relationships with the crosscutting granitic sheets and dikes. In several instances, the main body of the rock is rich in garnets (with white coronas of plagioclase), but in the few inches adjacent to the granite there is a garnet-free zone. The same effect can be seen on the south shore of this lake, where the road turns a corner within 50 feet of the water. Here the garnet-free zone is adjacent to a 2-foot dike of pegmatite. The cause of this effect is uncertain, but it is probably connected with the possible instability of garnet in a hot-contact zone.

The hills southwest of the last locality show large and remarkable exposures of agmatite or intrusion-breccia. The outcrops are best reached by walking ¼ mile due west from the corner in the road leading to Lasswade Lake, ½ mile north of highway No. 504. These outcrops cover a few acres on the top of a low hill. The biotite paragneisses have been injected and brecciated into a jumble of disoriented fragments by the intruding granite that permeated and injected the breccia and partly assimilated the fragments so that it is consequently rich in biotite and very inhomogeneous.

Form and Structure

The Loon Lake pluton is, in general, conformable with the surrounding rocks, although local crosscutting relations may be observed. The igneous rocks are rather massive in the core of the pluton, indicating that intrusion is younger than the regional metamorphism of the surrounding gneisses. The presence of hornfelses also support this view. Especially near the contacts, however, foliation and lineation can be measured; they represent flow effects during the intrusion of a partially solid mass. The flow foliation conforms with surrounding trends, and dips always towards the centre of the mass, which, therefore, must have the shape of a bulbous, asymmetric funnel. The attitude of the gneisses lying north and south thus conforms to a syncline, but this may be due to thrusting apart of the walls of the pluton during intrusion.

The relations at the west end are much more contorted and chaotic. Extensive crumpling of the gneisses in the region to the west will be discussed in more detail later, but is probably a consequence of the forcible intrusion. The east end is inaccessible, owing to overburden.

On the southeast side it seems likely that the force of intrusion may have impinged on the pre-existing Methuen granite, which provided a massive buttress, confining the Loon Lake pluton. The attitude of the gneisses in the anticline around the Methuen granite shows that the present level of erosion must be located near the top of that body, and the Loon Lake massif may formerly have extended above it.

Unusual outcrops that extend westward from highway No. 504 towards the lake, about 3,200 feet north of Gilmour Bay, are interpreted as being a series of contact-altered basic igneous rocks. Farther north, offshoots of the main pluton interfinger with the gneisses all along the east side of the lake.

Study of the joints in the Loon Lake rocks reveals no clear pattern related to the mechanics of intrusion. This conclusion was previously reached also by Cloos (1934).

Cataclastic effects in the monzonite and granodiorite in numerous localities indicate movement subsequent to consolidation. These appear to be related to regional faulting.

Geological History

Modal compositions and chemical analyses of Loon Lake rocks are given in the two tables below; the data are taken from Saha (1957).

The observations summarized in the previous sections allow the following interpretation of the Loon Lake complex. At some time following regional metamorphism of the Chandos Subgroup and emplacement of the Methuen granite a body of magma was injected into the region now occupied by the Loon Lake mass. The source of this magma is not known; however, it must have already crystallized to a notable extent because the solid crystals were oriented during flow to give the foliation and lineation now visible. The composition was approximately that of a monzonite, and the intrusion formed a bulbous funnel-shaped mass that forced apart the walls and produced contact metamorphism of inclusion and country rock. The magma proceeded to consolidate from the centre outwards, producing a concentric syenitic facies encircled by a granodioritic rim.

It must be concluded that the granodiorite was strongly influenced by assimilation, especially of silica and perhaps soda. If this were not so, the matrix of the intrusion-breccias would be monzonitic; otherwise, a second intrusion of granodiorite would be necessary. It is not possible to conceive of a process whereby the monzonite was intruded, then differentiated to form granodiorite that, at this stage, injected the walls again to form the breccias. Similarly, there is no evidence for a separate granodiorite intrusion. Accordingly, it is believed that granodiorite, which nearly encircles the syenite-monzonite, represents a product of differentiation and contamination; that is to say, it is a syenite that has gained silica from the wall-rocks.

The analyses on page 17 are in accord with this hypothesis: that is, a removal of about 20 percent of silica and 1 percent of soda from the granodiorite analysis would leave a residue having a composition similar to the syenite.

MODAL COMPOSITION OF ROCKS OF THE LOON LAKE PLUTON
(After Saha)

	Syenite (average of 15 samples)	Granodiorite (average of 9 samples)	Biotite Granite (average of 18 samples)
Quartz	2.1	24.0	25.1
Plagioclase	40.6(1)	50.3	32.2
Potash feldspar	45.9	12.8	36.5
Biotite and hornblende	8.1	11.4	3.7
Magnetite	1.6	0.2	0.8
Accessories	1.7	1.3	1.7
	100.0	100.0	100.0

(1) Composition $An_{17.5}$

CHEMICAL ANALYSES OF ROCKS OF THE LOON LAKE PLUTON
(After Saha)

	Weight	
	Syenite	Granodiorite
	percent	percent
SiO_2	59.88	68.48
TiO_2	1.07	0.45
Al_2O_3	18.27	15.80
Fe_2O_3	2.46	1.35
FeO	1.99	2.42
MnO	0.08	0.06
MgO	1.26	0.91
CaO	2.35	2.53
Na_2O	4.54	4.38
K_2O	6.78	3.83
P_2O_5	0.25	0.19
H_2O+	0.76	0.40
H_2O-	0.02	0.00
	99.71	100.80

The residual magma from such a process would have a granitic or granodioritic composition and would be available for injection as dikes and sills along any joints that opened up in the country rock and the pluton.

According to this interpretation, much silica and some soda must have migrated out of the surrounding rocks, especially in the northwest where granites are abundant. There is no shortage of quartz in this region, but it must be recalled that there are extensive outcrops of sillimanite-cordierite-garnet rocks, which are rare elsewhere in the township. Such rocks have a composition similar to a biotite paragneiss that has lost silica and soda, and they may have originated in this manner.

Minor Intrusions

Small bodies of pegmatite and aplite are abundant throughout the township. In some cases, where aplite occurs as conformable sheets within the paragneisses, the possibility exists that the aplite is really a metamorphosed sandstone. In most instances, however, the structure and texture indicate an intrusive origin.

The pegmatite is usually of simple composition, being composed mainly of alkali feldspars and quartz. Lesser amounts of tourmaline, biotite, and garnet are common, however, especially in the large area of biotite paragneiss south of the Lasswade road. A vuggy texture is sometimes found, with well terminated crystals of black tourmaline. At one locality on the border with Methuen township, a few prismatic green beryl crystals were found.

Aplite is usually a pink to buff, fine-grained rock, containing a small amount of biotite and possessing a sugary texture together with a faint foliation. Aplite veins and sills are common in the Glen Alda syncline west of Glen Alda and north of highway No. 504, and they usually have a rather coarser microgranitic texture. In many cases aplite and pegmatite occur together in the same bodies, without any clear relationship between them.

In many cases, these rocks form dikes, up to about 100 feet in width. In the vicinity of the Loon Lake pluton, their directions are somewhat irregular; elsewhere in the township, especially in the western part, there is a strong correlation with joint-directions, the joints having clearly served to control these dikes. There are two prominent joint-systems, both nearly vertical and striking at N.30°–50°W. and about N.30°E., respectively. Many dikes and dike-networks conform to these directions. One of the most prominent pegmatite dikes can be traced for about a mile, trending at N.30°W., from near the Methuen boundary, about 1 mile east of the southwest corner of Chandos township, towards highway No. 504.

The most prominent complex of pegmatite-aplite dikes occurs in the country northwest of West Bay. Branching dikes following both trends are common, particularly along the southwestern contact of the Duck Lake metagabbro, where one dike extends in a northwesterly direction for 1 mile with numerous subordinate offshoots. A related mass of leucogranite is located on the peninsula northwest of the constriction in West Bay. Many of the dikes are too narrow to be shown on the map.

Since the same joint-systems are found in the Loon Lake pluton and in the rest of the township, some of the pegmatite-aplite bodies must be younger than the emplacement of that pluton. It is possible that some represent residual magma from the massif.

Structural Geology

General

The rocks of Chandos township lie in the Precambrian Grenville province, a region of intense folding and complex geology that covers southeastern Ontario and Quebec. In recent years, detailed mapping in Haliburton, north Hastings, Renfrew, and Peterborough counties, by D. F. Hewitt and associates (*see* Bibliography), has demonstrated the existence of several structural-stratigraphical units, two of which are the Haliburton Highlands and the Hastings Basin. Rocks of the Highlands show abundant granite and syenite migmatites, a very high metamorphic grade, and generally confused structural and stratigraphic relationships. The Haliburton Highland region is bounded on the southeast by a series of faults or fault zones that probably extend from Stony Lake in Peterborough county, northeast towards Bancroft, then east-northeast into Renfrew county, for a distance of more than 50 miles.

Southeast of this major tectonic break is found the Hastings Basin. In this region, migmatites are much more restricted in their development, the grade of metamorphism is somewhat less, and stratigraphic relationships are easier to interpret. Certain distinctive rock types, notably the feather amphibolites, are characteristic of this region, and in general the topographic relief is less. Chandos township is located within, but near the northwest edge of, the Hastings Basin.

In general, the segment of the Grenville province in which Chandos township lies shows a regional strike of about N.30°E., with southeast dips. This trend, however, is interrupted by numerous folds and by divergencies resulting from batholithic and lesser intrusions, including the Loon Lake pluton. Within Chandos township, there are several clearly recognized folds and a variety of intrusions. The detailed field mapping, however, reveals that the stratigraphic relationships are amenable to correlation with those of adjoining areas, although it is impossible to determine thicknesses because of extensive marble flowage, probable faulting, and complex crumpling. In addition, the tops of formations could not be determined, owing to the lack of necessary evidence, but they, too, may be inferred from the relationships in nearby townships.

The relative success in stratigraphic correlation stems from the continuity of marble beds in particular. By contrast, in the Haliburton Highlands, flowage has often been so intense that marble units have been completely detached from their roots and, therefore, show no continuity.

The major structural features are shown on the figure on page 20.

Structure, Stratigraphy, and Metamorphism

FOLDING

The principal fold pattern was developed at the time of regional metamorphism when a secondary foliation or schistosity developed, usually parallel to the bedding that is interpreted as being parallel to the lithological discontinuities. Angular discordance between bedding and schistosity was observed at only two localities.

In addition to the main folding, later crossfolding took place, but it is not known whether any substantial length of time separated these two activities. The main folding took place about axes that generally trend in a northeast direction; crossfolding was roughly perpendicular.

The Glen Alda syncline is about 3 miles wide and lies northeast of Chandos Lake. It is a relatively symmetrical fold of semicircular plan, which plunges southeast at angles that average 40°. The west limb sweeps around to form the parallel Owenbrook anticline that enters the aureole of the Loon Lake pluton. The lowest member of these folds is the Dungannon marble and feather amphibolite, and is succeeded by the paragneiss and amphibolite sequence, correlated with the Apsley Formation. Above this lies the Owenbrook marble, correlated with the Lasswade marble, which is succeeded by an amphibolite and a paragneiss, correlated with the East Road Formation.

The west limb of the Owenbrook anticline crosses Chandos Lake, and the Owenbrook marble apparently pinches out. This is probably due to flowage under the pressure of the intruded Loon Lake pluton, the marble unit being represented by occasional outcrops of thin marble bands on the west side of the lake.

The underlying paragneiss and amphibolite units, however, continue across the lake to form the peninsula separating West Bay and South Bay. These units swing north again around the West Bay anticline, whose axis trends somewhat east of north. This anticline is succeeded by the parallel Chandos syncline on the west border of the township. These last two folds plunge south at varying angles. The Chandos syncline is symmetrical near the location of the former village of Chandos (about 1½ miles north of the community of Chandos Lake), but its axis swings around to the northeast in the vicinity of Tallan Lake where the fold is overturned to the southeast. The fold dies out northeast of Tallan Lake.

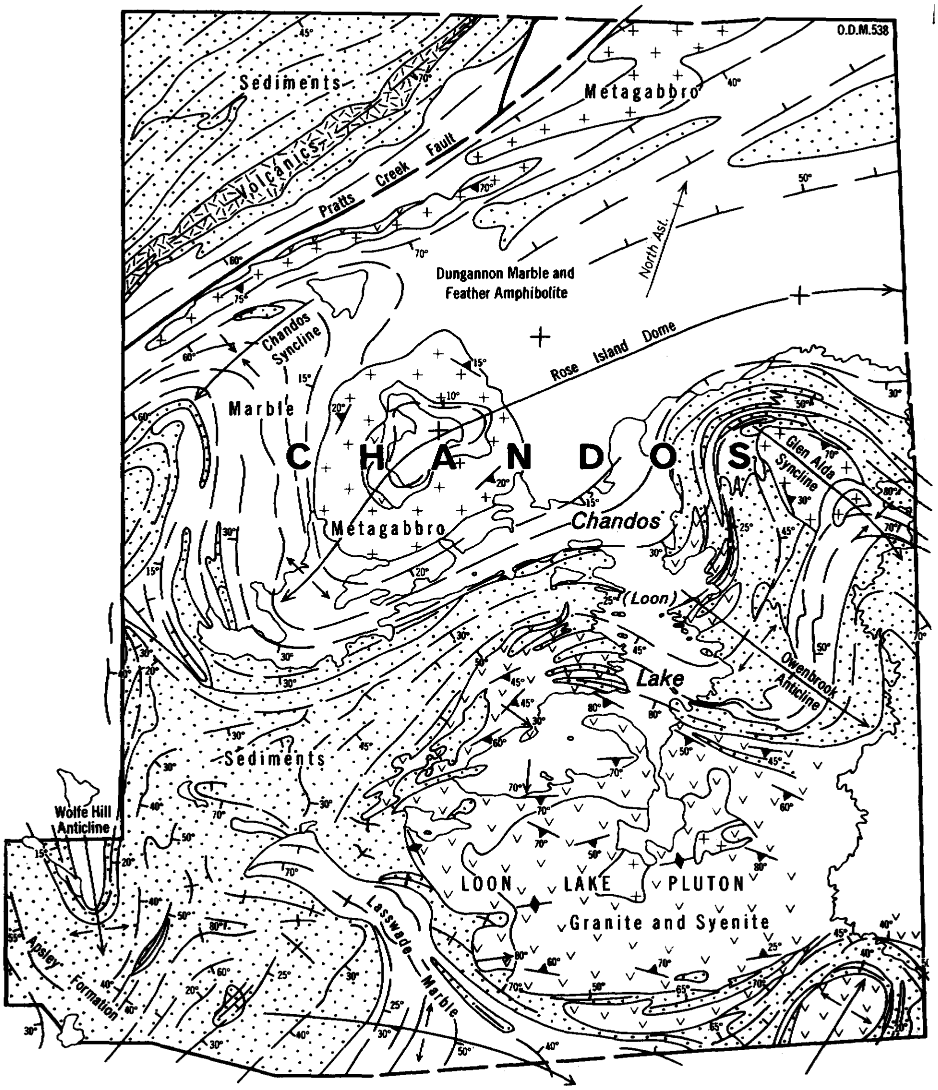
The northeast extension of the West Bay anticline is crossfolded to form the Clydesdale Lake dome. Between Clydesdale Lake and the head of Chandos Lake the Dungannon Formation is nearly horizontal. Northwest of Tallan Lake the Hermon Formation strikes uniformly N.45°E. with southeast dips of 50°–70°. The faulting in this region is discussed on page 22.

Numerous minor dragfolds occur in the region described above, and all are concordant with the directions of closure and plunge of the folds.

In the southern parts of the township, the structure has been complicated by the intrusion of the Loon Lake pluton.

The Apsley Formation has its type locality near the village of Apsley. It comprises a lower amphibolite and feather amphibolite member and an upper biotite paragneiss member. East of Apsley, the Wolfe Hill anticline is encountered. This fold has a core of marble that is well-exposed on Wolfe Hill and may be correlated with the Dungannon Formation. The fold axis trends north-northwest and the plunge is variable. On highway No. 504 the axis is horizontal, but farther south it plunges gently to the south-southeast.

The Apsley Formation follows around the southerly nose of this anticline; it extends south as far as Jack Lake in Methuen township, thence swinging back up into Chandos township in a large salient that is crumpled along nearly horizontal axes into an extensive series of minor folds or crenulations. As the belt continues northwest of highway No. 504, crossfolding becomes more



Structural trends.

Scale of Miles

1 0 1 2 3 4

Structural Features of Chandos Township

pronounced, and a region of intense deformation is encountered in which almost every outcrop shows extensive dragfolding, the dragfold axes plunging in all directions. A small sickle-shaped lake 2 miles northeast of Apsley occupies the nose of a synclinal crossfold. This crossfolding and crumpling is again attributed to the Loon Lake pluton.

As a consequence of this intense deformation, the relationships between the Wolfe Hill anticline to the south and the West Bay anticline to the north are obscure and cannot be interpreted until the adjoining parts of Anstruther township have been mapped.

Succeeding the Apsley Formation to the east, there is a band of marble, which trends northwest from Methuen township. This is the Lasswade Formation, and its type-exposures adjoin highway No. 504, 1 mile south of Lasswade Lake (locally called Mink Lake). This band ends 1 mile west where it enters the zone of intense folding, but a few discontinuous outcrops west of South Bay suggest that it may correlate with the Owenbrook marble.

The Lasswade marble is overlain by an amphibolite that is mostly seen as hornfels in the aureole of the Loon Lake pluton. In part, this band continues as a screen or septum within the pluton; however, it is, also in part, overlain by, or passes into, the feldspathic gneisses (arkose?) that form the major unit in the Methuen granite anticline, in the southeast corner of the township. These feldspathic gneisses, together with the thin underlying amphibolite, comprise the East Road Formation. Prior to intrusion of the pluton, they probably were continuous with the upper units of the Glen Alda syncline, above the Owenbrook marble.

The evidence cited above suggests that the Loon Lake pluton was intruded from the east as well as from below.

CORRELATION

The preceding discussion of folding shows a certain amount of continuity with the main stratigraphic units in the Chandos Subgroup. The stratigraphy is summarized in the table below, together with the formation names proposed.

STRATIGRAPHY AND CORRELATION OF THE CHANDOS SUBGROUP

<table>
<tr><th></th><th>Chandos Syncline</th><th>Wolfe Hill Anticline</th><th>Lasswade</th><th>Glen Alda Syncline</th><th>Formational Name</th></tr>
<tr><td rowspan="5">Chandos Subgroup</td><td rowspan="5">Paragneiss and amphibolite</td><td rowspan="4">Paragneiss</td><td>Paragneiss</td><td>Paragneiss</td><td rowspan="2">East Road paragneiss and amphibolite</td></tr>
<tr><td>Amphibolite</td><td>Amphibolite</td></tr>
<tr><td>Marble</td><td>Marble</td><td>Lasswade marble</td></tr>
<tr><td>Amphibolite?</td><td rowspan="2">Paragneiss and amphibolite</td><td rowspan="2">Apsley paragneiss and amphibolite</td></tr>
<tr><td>Amphibolite</td><td>Paragneiss</td></tr>
<tr><td></td><td>Marble and feather amphibolite</td><td>Marble and feather amphibolite</td><td></td><td>Marble and feather amphibolite</td><td>Dungannon marble and feather amphibolite</td></tr>
</table>

Using information supplied in the report on Dungannon and Mayo townships, by D. F. Hewitt and W. James (1956), it is possible to correlate the rocks of these townships with the Chandos Subgroup, at least in part. The Chandos Subgroup correlates with part of the Mayo Group.

FAULTING AND JOINTING

Numerous linear features are visible on the air photographs of Chandos township. In some cases, these are merely consequences of erosion along linear beds or represent resistant dikes. In other cases, there is no clear evidence of their significance, but many are likely to be faults.

As mentioned previously, many rocks show evidence of shearing, and in some places mylonites have formed. It is clear that the region has undergone considerable folding, but in few cases is there direct evidence.

A well-defined fault extends from the border with Anstruther township for about 6 miles northeast along Pratts Creek. Mylonitized marbles are to be found at several localities, and dragfolds suggest that the dislocation is a reverse-fault with movement mainly from southeast to northwest, roughly parallel to the southeasterly dip, but with a horizontal component towards the north. Near the border with Faraday township, this fault splits into two. There is a parallel fault, 1½ miles northwest of this in a sillimanite gneiss, with the same sense of movement. Several well-defined linear features, all at N.30°–40°W., are located in the Hermon Formation; the dip of these faults is unknown.

It is possible that the Pratts Creek fault continues south into Anstruther and Burleigh townships and may join the Burleigh fault. In any case, it is probably part of the major fault system that separates the Haliburton Highlands from the Hastings Basin.

A pronounced linear feature controls the major axis of Chandos Lake, trending N.30°W. As previously mentioned, this extends north from the south end of the lake for some 12 miles to Paudash Lake in Faraday township. This direction is parallel to one of the principal joint systems in the region, but there is no direct evidence of faulting in Chandos township in the form of offsetting of units on either side of Chandos Lake. Some slight movement, however, may have occurred.

As mentioned on several occasions, there are two principal joint systems. One trends N.30°–50°W. and the other N.30°E., and both are usually vertical.

METAMORPHISM

The metamorphic history of Chandos township has two aspects: at an early period the region was subjected to extensive regional metamorphism, during which time the main structural pattern was developed; at a later date the Loon Lake pluton intruded, and it superimposed a contact metamorphic aureole on the nearby rocks. The figure on page 24 shows some details relevant to the metamorphic history.

Regional Metamorphism—The characteristic feature of all grades of metamorphism is the tendency of stable mineral assemblages to form in each rock type, according to the temperature, pressure, water-vapour pressure, and carbon dioxide pressure of the environment.

The degree of metamorphism is then classified according to the various assemblages developed. At the present time, it is difficult to correlate these assemblages precisely with the temperature and pressure acting at the time but, as experimental evidence accrues, a correlation may be hoped for in the future.

The regional metamorphism in Chandos township produced the various assemblages listed in the table opposite. The petrography of the rocks has already been discussed in this report. The facies classification of metamorphic rocks has been discussed extensively by Turner and Verhoogen (1951), and has been revised by Fyfe, Turner, and Verhoogen (1958). According to the revised classification, the assemblages listed in the table are, in part, characteristic of the sillimanite-almandine subfacies of the almandine amphibolite facies, and are, in part, characteristic of the hornblende hornfels facies (previously the cordierite-anthophyllite subfacies of the amphibolite facies).

CHARACTERISTIC REGIONAL METAMORPHIC MINERAL ASSEMBLAGES

Rock Type	Characteristic Mineral Assemblages	Additional Minerals in Any Assemblage
Basic Igneous	hornblende-plagioclase. hornblende-plagioclase-biotite. hornblende-plagioclase-biotite-garnet. hornblende-plagioclase-augite.	quartz, scapolite, microcline, magnetite, sphene, pyrite, calcite, apatite.
Feather Amphibolite	hornblende-plagioclase-epidote. hornblende-plagioclase-epidote-augite. hornblende-plagioclase-epidote-biotite. hornblende-plagioclase-biotite. hornblende-plagioclase-biotite-garnet.	quartz, microcline, scapolite, magnetite, sphene, pyrite, calcite, apatite, zircon.
Sedimentary Amphibolite	*Same as for Basic Igneous rocks, plus:* hornblende-plagioclase-augite-epidote. hornblende-plagioclase-augite-biotite.	
Arenaceous	muscovite-biotite-garnet. muscovite-biotite-plagioclase. muscovite-biotite-plagioclase-epidote. biotite-plagioclase. biotite-plagioclase-garnet. biotite-plagioclase-augite.	quartz, microcline, tourmaline, calcite, apatite, magnetite, zircon, scapolite, pyrite.
Argillaceous	sillimanite-muscovite-biotite-plagioclase. sillimanite-muscovite-biotite-plagioclase-epidote. sillimanite-biotite-staurolite[1]-garnet-plagioclase. staurolite([1])-garnet-biotite-cordierite-plagioclase.	quartz, magnetite, pyrite, tourmaline, zircon, rutile.
Marble, Impure Marble	amphibole([2]). amphibole-pyroxene([3]). amphibole-pyroxene-biotite([4]). amphibole-biotite. biotite. pyroxene. scapolite-pyroxene. scapolite-pyroxene-amphibole. scapolite-pyroxene-amphibole-biotite. scapolite-amphibole-epidote. scapolite-amphibole-epidote-biotite.	calcite, dolomite, plagioclase, microcline, quartz, magnetite, tourmaline, sphene, graphite, apatite, pyrite.

([1])Staurolite occurs as an unstable relict.
([2])Tremolite, actinolite, hornblende, etc.
([3])Diopside, augite, etc.
([4])Phlogopite, biotite.

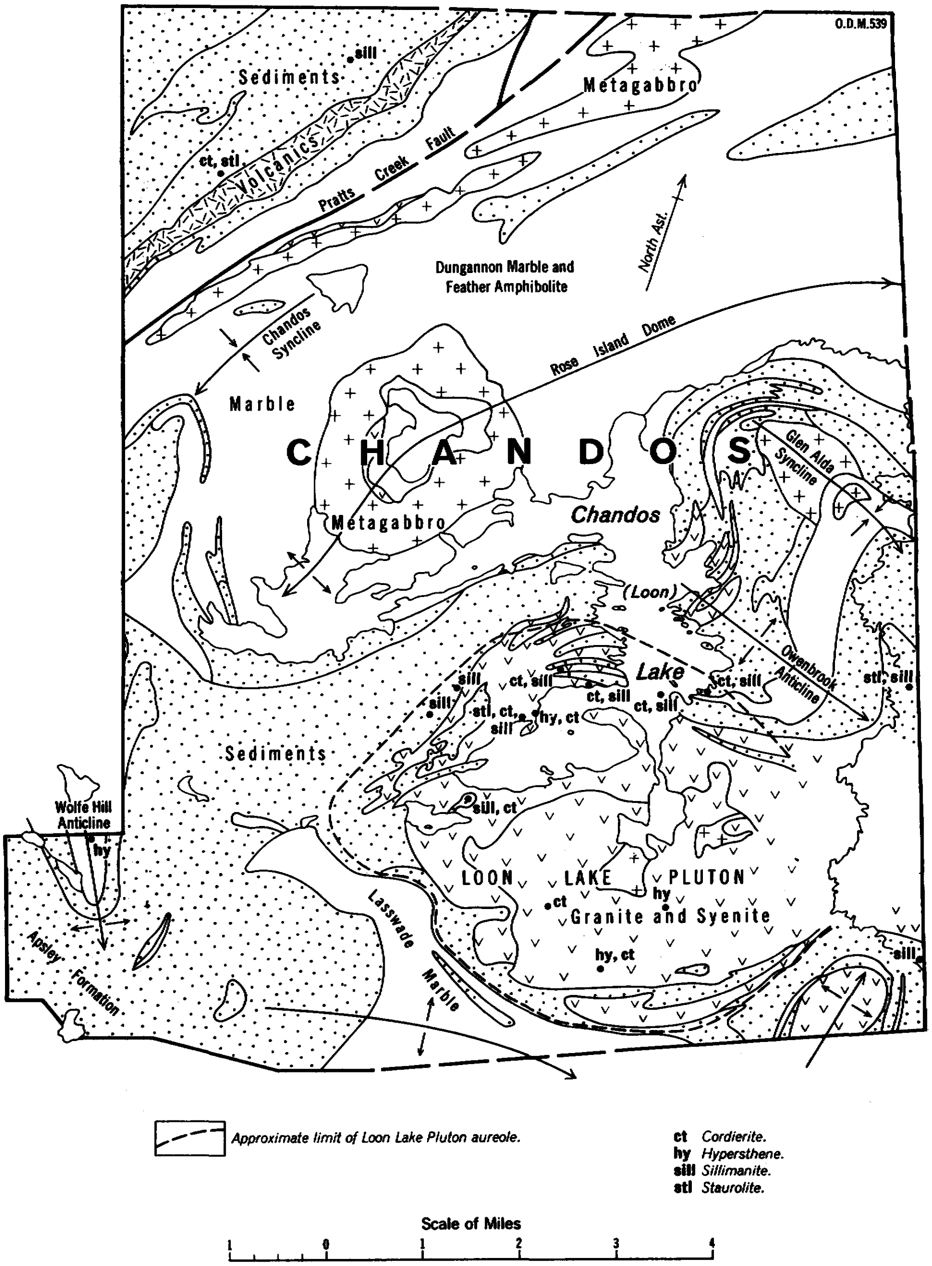
The following assemblages are found in Chandos township and are diagnostic of the sillimanite-almandine subfacies:

sillimanite-almandine (in pelitic rocks).
hornblende-plagioclase.
hornblende-plagioclase-almandine (in basic igneous rocks).
hornblende-plagioclase-pyroxene (in basic igneous rocks).

By contrast, some of the assemblages are not to be expected in the sillimanite-almandine subfacies:

muscovite-biotite.
sillimanite-muscovite (-biotite).
sillimanite-staurolite.
staurolite-cordierite.

The occurrence of muscovite and cordierite is to be expected in the hornblende hornfels facies and, in spite of the inclusion of hornfels in the name for



Distribution of Metamorphic Minerals

this facies, such rocks do, indeed, occur on a regional scale in Banffshire, Scotland, and in other parts of the world.

The evidence suggests that, in general, there is little variation in metamorphic grade throughout the township. The presence of staurolite is usually indicative of a lower grade but, in the rocks in question, this mineral occurs only sparsely, as small irregular grains, which may well be unstable relicts of an earlier, lower grade.

It should be noted that epidote occurs in several assemblages in company with plagioclase (lime-bearing). This is a fairly common situation, and the presence of epidote is indicative of lower-grade metamorphism only when it is accompanied by albite.

The significance of scapolite is uncertain. The author's work (unpublished) on this mineral shows that it is not confined either to highly-metamorphosed rocks or to contact aureoles, but rather occurs in a wide variety of environments. It commonly forms in place of plagioclase feldspar; however, this is not essential and the two can co-exist in equilibrium. Although its formation undoubtedly was facilitated by the abundant carbon dioxide available from the marbles in this region, chlorine and sulphur were also necessary.

It is noteworthy that forsterite, chondrodite, and spinel were nowhere observed in the marbles, although they are quite common in the Haliburton Highlands. This absence may be attributed to the presence of quartz that is both commonly present in the Chandos marbles and incompatible with these minerals. A mineral that was tentatively identified as brucite was observed in the tremolite dolomite marble band in the Methuen granite anticline.

Contact Metamorphism—The aureole of metamorphism surrounding the Loon Lake pluton has already been discussed in part. There is no clear sequence of zones of contact metamorphism, because the country rock had already been raised to a high regional metamorphic grade before intrusion of the pluton. The approximate limit of the aureole is indicated on the figure opposite, which shows the metamorphic features of Chandos township.

Inclusions within the pluton, and the rocks of the southern contact, are hornfelses. In the northwestern contact zones it is more common to find gneissic rocks whose mineral assemblages are, however, characteristic of contact metamorphism. Some of the characteristic assemblages are listed in the table below; the common occurrences of cordierite and of hypersthene are noteworthy, and the assemblages are typical for the pyroxene hornfels facies, some of whose critical assemblages are as follows:

cordierite-microcline.
hypersthene-augite-plagioclase.

Marbles are not abundant in the aureole and have not been examined in detail. Wollastonite should, however, be present in this grade of metamorphism if the magnesia or alumina contents are not too high.

A very rough estimate of the physical conditions of metamorphism of this grade may be taken from Fyfe, Turner, and Verhoogen (1958, Figure 107). This would suggest a temperature in the range of 600°–800°C. and a pressure equivalent to a depth of 5–10 km. The earlier regional metamorphism took place at a lower temperature (500°–700°C.) and a greater depth (15–20 km.).

Some Characteristic Metamorphic Mineral Assemblages in the Loon Lake Pluton Aureole

Rock Type	Characteristic Mineral Assemblage	Additional Minerals in Any Assemblage
Argillaceous	sillimanite-biotite-muscovite. sillimanite-biotite-muscovite-epidote. sillimanite-biotite-garnet, sillimanite-biotite-garnet-cordierite. cordierite-biotite-microcline.	quartz, plagioclase, magnetite, tourmaline, pyrite, apatite, graphite.
Basic Igneous	hypersthene-augite. hypersthene-augite-hornblende. hypersthene-biotite. hypersthene-biotite-hornblende. hypersthene-biotite-hornblende-cordierite.	plagioclase, quartz, microcline(1), magnetite, apatite, calcite.

(1)Not present in the more basic rocks.

Economic Geology

There were no economically valuable deposits known in the township in 1958. The area is unusually devoid of mineral deposits for southeastern Ontario. There are one or two old prospects for iron and copper and some radioactive showings.

Copper

There are several old pits on a ridge of biotite-feldspar gneiss in lots 31 and 32, concession II, about 10 chains west of the road near the township corner. No signs of mineralization other than rust stains were seen. This is said to be the Cameron Prospect, which was opened for copper about the turn of the century.

Iron

Several concentrations of magnetite occur in the southeast corner of the township, and several bands of gneiss contain abundant accessory magnetite.

LOT 27, CONCESSION II (BLACK ROCK MINING CO.)

Magnetite showings in lots 27 and 28, concession II, have been known for many years, and were described by Lindeman (1913)[1] and by Miller (1899, p. 214). The land belongs to A. J. Knox and E. Reynolds, according to information furnished by Mr. J. G. Reynolds. The property has been drilled by Ventures Limited and, in 1958, by Canadian Longyear Limited on behalf of Black Rock Mining Company. Lindeman (1913, p. 14) describes the occurrence as follows:

> An open cut, 53 by 21 feet, has been made into a hill, exposing a dark-coloured amphibolite, associated with some magnetite. Magnetic indications of several other deposits in the immediate vicinity were also noticed, but they all appeared to be of very small extent.

The deposit was examined on 28 August 1958, and Lindeman's description was confirmed. The magnetite-rich rock, up to 80 percent magnetite, forms a lens-like mass about 15 feet thick, striking about N.45°E., and dipping 55°NW. It is overlain by a magnetite-biotite paragneiss, which is widespread in this part of the township. A band of biotite-marble lies on-strike with the footwall that is, however, covered near the open cut; beneath this are more magnetite paragneisses, with some conformable granite pegmatite. Existing outcrop was insufficient to trace any extension of the body.

The deposit is readily accessible by a trail leading south-southwest from the East Road for 50 chains.

Radioactive Minerals

Several radioactive showings occur in the township. None appears to have economic significance.

LOT 31, CONCESSION II (CANFIELD-SHORTT PROSPECT)

An area of 600 by 300 feet on the road east from Lasswade, in lot 31, concession II, was stripped and blasted in 1955. This exposed a complex of brecciated amphibolite generally striking N.65°W. and dipping at 70°N. Cutting the amphibolite is a stockwork of granite pegmatite consisting mainly of pink

[1]Listed, in error, as being in concession I.

microcline, grey-green peristerite, and grey quartz. Accessory biotite, magnetite, black tourmaline, and purple fluorite occur, but no radioactive minerals were seen. Several other pits occur in the immediate vicinity.

According to information supplied to the author, the property was investigated by Messrs. Canfield and Shortt.

LOTS 1 AND 2, CONCESSION XV (BUNKER HILL EXTENSION MINES LTD.)

This property has been examined by J. Satterly and the following description is taken from his report (Satterly 1957, p. 170):

Bunker Hill Extension Mines Limited holds a group of 15 claims adjoining Eels Creek in the northwestern part of Chandos township, Peterborough county. The company acquired a 90-percent interest in the property from Pioneer Consultants Limited in 1954.

Four drill-holes, totalling 2,009 feet,(1) were put down on four claims, lots 1 and 2, concession XV.

The property is underlain by biotite paragneiss striking northeast and dipping about 50°SE. The logs of the drill-holes (above) record intersections of pegmatite stringers all under 1 foot in thickness except for one 14-inch dikelet. No radioactivity was recorded in the logs.

(1)Ont. Dept. Mines, File No. 56723.

LOT 9, CONCESSION XVI (CONSOLIDATED URANIUM CORPORATION LTD.)

This property was examined by J. Satterly in 1954. By 1958, the prospect was assumed to be grown over, because it could not be found by the author. The following description is taken from J. Satterly's report (1957, p. 170):

In 1954, Consolidated Uranium Corporation, Limited, held nine claims under option in lots 9–11, concessions XVI and XVII, Chandos township, Peterborough county.

Radioactive showings in pegmatite dikes in the south half of lot 9, concession XVI, were explored in 1954 by trenches and seven shallow diamond-drill holes.

No. 1 showing has been explored by two trenches and four diamond-drill holes. According to the company, these holes cut core lengths of pegmatite of 12.3, 6.5, and 2.0 feet. The trenches and stripping expose red leucogranite and granite pegmatite with accessory magnetite, purple fluorite, allanite, and uranothorite. The latter is in orange grains in magnetite, or in biotite flakes. A brown mineral, occurring as grains in magnetite, may be anatase.

No. 2 showing, 150 feet west of No. 1, has been explored by a stripping 70 feet long, three cross-trenches, and three drill-holes under the three trenches. A brick-red granite pegmatite dike is exposed cutting a biotite-hornblende gneiss. The dike, which strikes about N.60°W., has been traced for 200 feet and is 5–12 feet in width. The granite pegmatite consists of red microline, a yellow-green sodic plagioclase, grey quartz, and accessory purple fluorite, magnetite, and uranothorite. Yellow uranium stain is present as coatings on fractures.

No. 4 showing, 200 feet north of No. 2, has been exposed by a stripping. It is a pink, fine-grained leucogranite dike containing irregular patches of granite pegmatite, and inclusions of fine-grained hornblende amphibolite. A little magnetite was noted as an accessory at one contact. The dike is 25–50 feet wide and is exposed for a length of 160 feet. The country rock is amphibolite. Low geiger readings were recorded on the granite, mainly 2x with a high of 3x.

Four specimens with radioactive minerals were submitted to Dr. S. C. Robinson of the Geological Survey of Canada for identification. He confirms the presence of uranothorite and allanite and also identified bastnaesite (a cerium lanthanum fluo-carbonate) and uranophane.

Sand and Gravel

The township contains abundant sand and gravel suitable for roadfill and general purposes. In 1958, three pits were operating intermittently. F. McColl has a pit in lot 21, concession II; A. Oitment and E. Trotter own pits in lot 2, concession VII; and the township operates pits in lots 11 and 12, concession XV.

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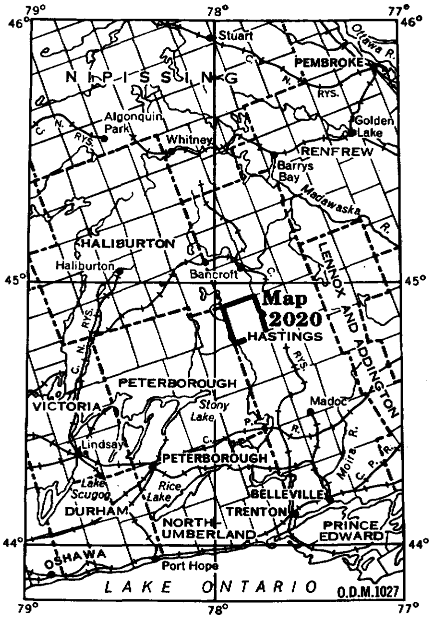
Geology of Wollaston Township

By

D. F. Hewitt[1]



Key map showing location of Wollaston township. Scale, 1 inch to 50 miles.

Abstract

This report describes the geology, structure, and mineral occurrences in Wollaston township, Hastings county, an area of 88 square miles located about 10 miles south of Bancroft. The township lies wholly within the Hastings Basin structural subdivision of the Haliburton-Bancroft area of the Grenville province of the Canadian Shield.

The area is underlain by Precambrian rocks of the Mayo Group, consisting of marble, paragneiss, para-amphibolite, schist, and basic and acid volcanic rocks. These metasediments and metavolcanics are intruded by gabbro, diorite, syenite, and granite. The largest gabbro bodies are the Umfraville and Thanet gabbros in the eastern part of the township. The principle granite plutons are the Wollaston and Coe Hill granites.

The Mayo Group was folded, metamorphosed, and intruded during the Grenville orogeny. The main axes of folding are northeast-southwest, parallel to the regional folding. Strongly developed crossfolding occurred along axes trending northwest-southeast.

Deposits of iron, copper, arsenic, talc, mica, granite, and uranium have been found in the township; there has been production of iron and granite.

[1]Geologist, Ontario Department of Mines.

Introduction

This report describes the geology and structure of Wollaston township, Hastings county, covering an area of 88 square miles, located in the Hastings Basin about 10 miles south of the town of Bancroft. The area is underlain by Precambrian rocks of the Mayo Group (Hewitt and James 1956) consisting of marble, paragneiss, para-amphibolite, schist, and basic and acid volcanic rocks. These Precambrian metasediments and metavolcanics which form part of a thick series of Proterozoic(?) rocks, are intruded by gabbro, syenite, and granite. The Mayo Group is thought to correlate in part with the Hastings series named and described by earlier workers.

Wollaston township forms part of the Haliburton-Bancroft area (O.D.M. 1957). The Coe Hill map sheet of the National Topographic Series includes the area. The village of Coe Hill is situated in the geographic centre of Wollaston township and is served by a spur-line of the Canadian National Railways from Ormsby Junction on the Bancroft-Belleville line. The post offices and settlements of Rose Island, Faraday, Gilroy, The Ridge, and Murphy Corners, lie within the area.

All parts of the township are easily accessible by roads. Highway No. 620 extends westward across the centre of the township.

Prospecting and Mining Activity

Prospecting and mining activity have been mainly confined to iron, copper, arsenic, talc, mica, granite, and uranium deposits. There has been production of iron ore and granite in the past, but no properties are currently in production.

The Coe Hill iron mine opened in the early 1880's, and shipments were made from 1884 to 1887. This mine was responsible for the settlement of the village of Coe Hill and for the railway spur-line to Coe Hill. Small shipments of ore were made between 1900 and 1909, but the property has been inactive since 1910. Other small iron deposits, such as the Jenkins, Ridge, Bald Lake, and Umfraville showings, have been examined and drilled.

In 1957, diamond-drilling was carried out on a magnetite showing west of Ragged Lake on the west margin of the Umfraville gabbro, by A. T. Griffis and Rio Tinto Canadian Exploration Limited.

There is current interest in a copper-iron showing, being explored by V. A. McMurray of Gilmour, in southeastern Wollaston township, east of The Ridge.

Present Geological Survey

The author and his geological field party, consisting of P. S. Simony, senior assistant, K. A. MacLean and R. D. Todd, junior assistants, mapped Wollaston township and 14 square miles of northeastern Chandos township during the summer of 1959. Geological mapping was done by the author and Mr. Simony; Messrs. MacLean and Todd ran the pace-and-compass traverses. Traverses were run between easily recognizable points, on 4-inch to the mile air photographs. Owing to the abundance of topographic control, such as fields, roads, rivers, creeks and lakes, no picketed baselines were run. Traverses were usually spaced at ¼ mile intervals and were mainly run across structure. Plotting of geological data was done on acetate sheets fitted over the air photographs.

Geological data were transferred by sketchmaster from the air photographs to a basemap, on a scale of 1,320 feet to the inch, prepared by the Cartography Section of the Ontario Department of Mines from maps of the Forest Resources Inventory of the Ontario Department of Lands and Forests. The final map (No. 2020, map case) is reproduced on a scale of 1 inch to ½ mile.

On the generalized geological map many small outcrops appear as single outcrop areas. Outcrop areas visited by the geologists are indicated on the map, and the geological interpretation is based on these outcrops. When using the map, the prospector should realize that geological generalization is based on traverses spaced at ¼-mile intervals, and that the percentage of outcrop actually seen by the geologists on the traverse may be small, especially in areas of heavy drift or heavy bush.

Acknowledgments

The author was ably assisted by P. S. Simony, K. A. MacLean, and R. D. Todd; Mr. Simony, as senior assistant, did independent geological mapping. The author gratefully acknowledges the keen interest and co-operation of the members of the field party.

Previous Geological Work

Wollaston township was first described and mapped geologically, in a reconnaissance fashion, by F. D. Adams and A. E. Barlow in the 1890's, and is included in their geological report on the Haliburton and Bancroft areas, published in 1910 (Adams and Barlow 1910).

The non-metallic mineral resources of the area were described in 1930 by F. F. Osborne (1931, pp. 22–59).

During World War II, strategic mineral occurrences in the area were examined and described by J. E. Thomson (1943).

The Coe Hill aeromagnetic sheet (G.S.C. 1949) includes the area, and a report describing magnetic anomalies in the area was compiled in 1951 by E. M. Abraham (1951).

The Wollaston granite in Wollaston township was recently restudied by A. K. Saha (1958, pp. 609–19).

Physiography

Physiographically, the area forms part of the Precambrian peneplane of the Hastings Basin (Hewitt and James 1956, p. 42) and lies on the watershed between the Ottawa River and Trent River drainage systems. The height-of-land passes south of Ragged and McMurray lakes in northeastern Wollaston township. These lakes drain northeast, via Bear Shanty and Egan creeks, into the York and Madawaska rivers.

The Crowe River and its tributary, the Deer River, drain most of the township, flowing southward into the Trent River system. The largest lake in the township, Wollaston (Eagle) Lake, located in the centre of the township just south of the village of Coe Hill, is 2 miles long and ½ to ¾ mile wide.

The area is a peneplane with a maximum relief of about 300 feet. The highest part of the area is the Umfraville gabbro hills south of Ragged Lake in northeastern Wollaston township, which have a maximum elevation of 1,300 feet. The valley of the Deer River, on the south boundary of the township, has an elevation of 1,000 feet and is the lowest point in the township. The average elevation of the whole area is 1,050–1,150 feet. There are numerous spruce swamps in the central part of the township, and outcrop is scarce or lacking in these areas of low ground.

Although the township lies on the watershed between the Ottawa River and Trent River systems, the relief and general elevation above sea-level is much less than that in the Hastings-Haliburton Highlands to the north, where elevations reach 1,700 feet, and relief reaches 1,000 feet (Hewitt 1954, p. 6).

Natural Resources and Development

The area was opened for colonization in the 1850's by the Hastings colonization road built north from Belleville, through Madoc, to Bancroft and Maynooth. The township was settled in the 1850's and 1860's, and numerous farms were cleared. At present over half of the farms are abandoned, and the farm population must now be much smaller than in the latter part of the nineteenth century when lumbering of white pine took place throughout the area. Log drives took place on Egan Creek and on the Deer and Crowe rivers. Lumbering is still an important industry in the area, and there are over a dozen small lumber mills operating seasonally in the township.

There still are numerous farms operated in the township, but the rough topography and rocky nature of much of the area makes most of it poorly suited to agriculture. The best farms lie on a clay moraine on The Ridge in the south-central part of the township. Hay and oats are the chief crops, and sheep, cattle, and pigs are raised.

General Geology

The area lies wholly within the Hastings Basin structural subdivision of the Haliburton-Bancroft area of the Grenville province of the Canadian Shield (Hewitt 1956, pp. 22–41). It adjoins Faraday, Chandos, and Lake townships, which have been recently mapped by the Ontario Department of Mines. The bedrock formations are all of Precambrian age and consist of metamorphosed sediments and volcanic rocks of the Mayo Group (Hewitt and James 1956, pp. 6–24), intruded by gabbro, diorite, granite, and syenite. The rocks were folded and metamorphosed during the Grenville orogeny, and the intrusions were emplaced during the late stages of the orogeny. The main axes of folding are northeast-southwest, parallel to the regional pattern of folding. Strongly developed crossfolding occurred along axes trending northwest-southeast.

TABLE OF FORMATIONS

CENOZOIC

PLEISTOCENE: Boulder clay, sand, and gravel.

Great Unconformity

PRECAMBRIAN

PLUTONIC ROCKS:

Granite.

Intrusive Contact

Syenite.

Intrusive Contact

Gabbro, diorite.

Intrusive Contact

METASEDIMENTS AND METAVOLCANICS (Mayo Group)

Marble, paragneiss, schist, conglomerate, arkose, para-amphibolite, volcanic amphibolites, volcanic schists.

Metasediments and Metavolcanics (Mayo Group)

No unconformities were found within the sedimentary and volcanic section in Wollaston township, and the rocks are therefore assigned to the Mayo Group described in Cardiff, Faraday, Dungannon, and Mayo townships to the north (Hewitt 1959: Hewitt and James 1956).

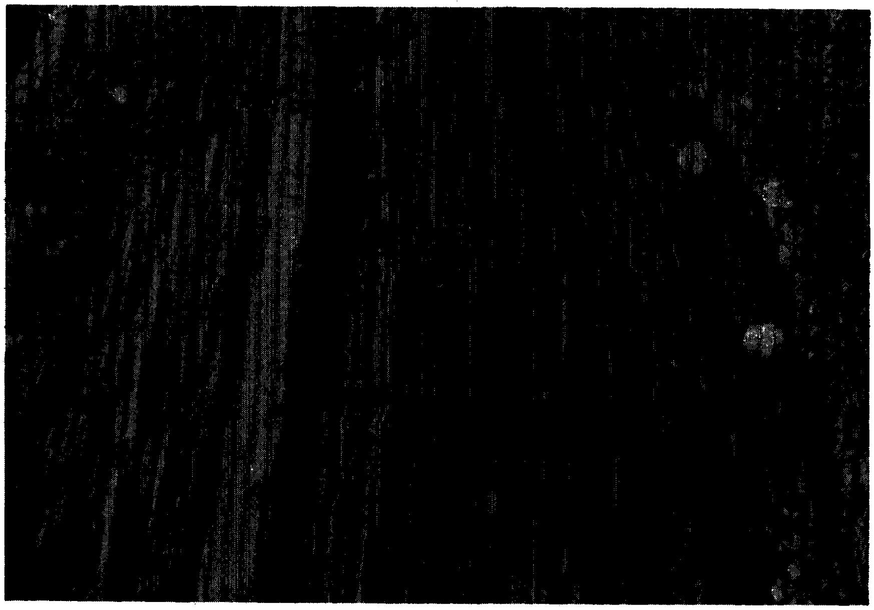
On the geological map (No. 2020, map case) the rocks of the Mayo Group are divided into five lithologic subdivisions (each indicated on the map by a separate colour) as follows:

Marble (and associated calcareous sediments).
Para-amphibolite (and associated sediments).
Arkose, quartzite, felsite (and associated acid volcanic rocks).
Paragneiss and psammopelitic schists.
Basic volcanic rocks, now largely amphibolite gneisses and schists.

MARBLE AND ASSOCIATED CALCAREOUS SEDIMENTS

As indicated on the geological map, marble occurs in all parts of the township, and at several stratigraphic horizons in the Mayo Group. In the northwestern part of the township, grey-to-buff, laminated calcite marble of the Dungannon Formation extends into Wollaston township from Chandos and Faraday townships. Some feather amphibolite and granular para-amphibolite occurs interbedded with these laminated marbles, and part of the marble sequence correlates with the Detlor feather amphibolite member of the Dungannon Formation described in Mayo township (Hewitt and James 1956, pp. 20–22).

About 50 percent of the metasedimentary rocks of Wollaston township is marble. These calcareous sediments are almost entirely limestone and mag-



Thin laminated marble and feather amphibolite of the Dungannon Formation; lot 20, concession XV Wollaston township.

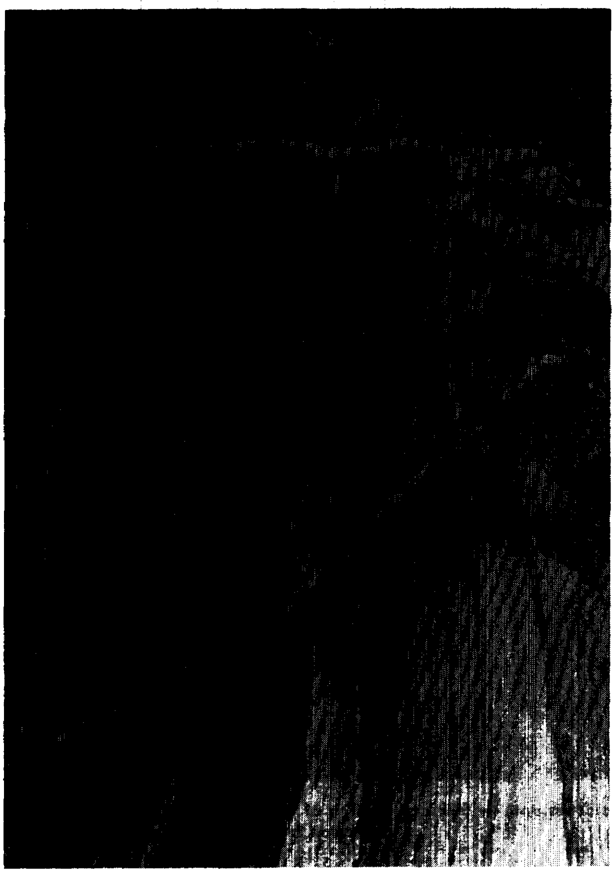
nesian limestone. Dolomite is rare; only two narrow dolomite bands were recognized: one 300-foot wide band crosses the road north of Coe Hill, in lot 15, concession XI; another narrow band trends north along the east side of the Deer River in the vicinity of a talc showing in lots 9 and 10, concession XI.

Structure and Texture

The limestones are generally well bedded, thin bedded, and they frequently show fine lamination. They are often grey to blue-grey in colour and are of the "Hastings type" described by Adams and Barlow (1910, pp. 221–26).

In grain size they range from fine-grained (often with silty and argillaceous or micaceous impurities) to medium-grained. Recrystallized, white crystalline limestone of coarse-grain size, often characteristic of the Haliburton-Hastings Highland gneiss complex, is uncommon in Wollaston township. The metamorphic grade, as indicated by the fineness of grain and preservation of fine lamination, is less than in the gneiss complex to the north. In places (as on the fire tower hill at Ormsby), grain gradation is preserved in the grey, well-bedded limestones.

Flowage does not appear to have been important in the marble sequence in Wollaston township, although occasionally marble tectonic breccias of small extent do occur, as in lot 32, concession VII, near the Chandos boundary. Fracture cleavage is developed in the impure diopsidic marble band, which passes through Deception Lake in northwestern Wollaston.

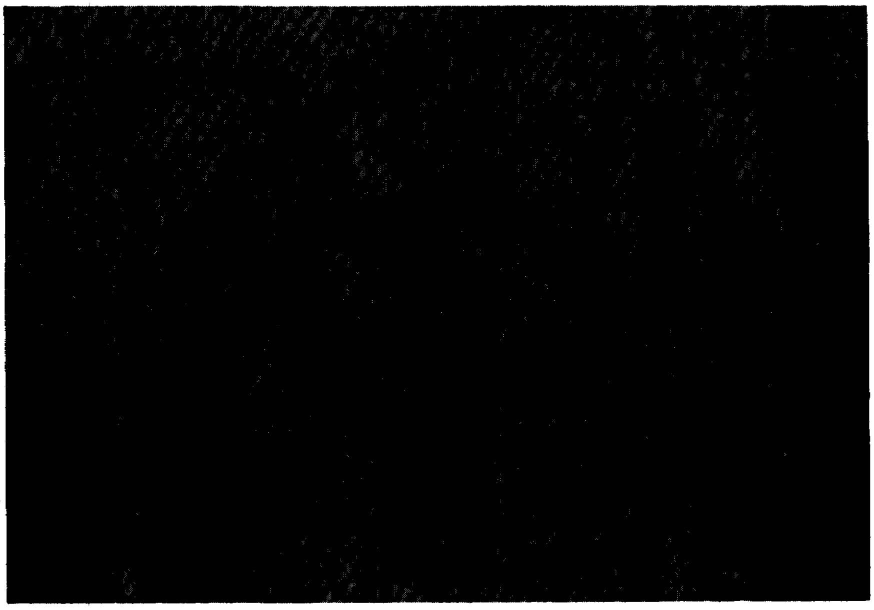


Granite dikelets cutting thin laminated marble; lot 20, concession XV, Wollaston township.

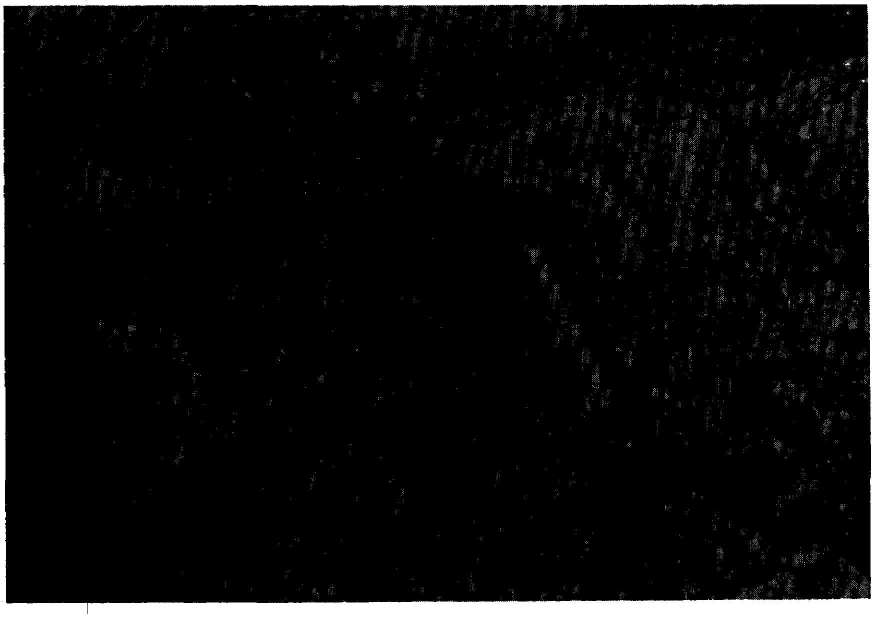
A marble conglomerate, consisting of white medium-crystalline marble, with rounded, 1- to 4-inch pebbles of buff-coloured marble or diopsidic marble, was observed in lot 21, concession VIII. The photo (p. 35, top) illustrates this marble conglomerate, which does not appear to be a tectonic breccia. It is exposed over a length of about 100 feet and is at least 30 feet wide.

Lithology

Several types of limestone are recognized in the township. In the northwest corner of the township the sequence is typical of the Detlor member of the Dungannon Formation (Hewitt and James 1956, pp. 20-22), and well-bedded, marble and feather amphibolite occur interbedded. Feather amphibolite interbeds are also common in the marble sequence elsewhere throughout the township, except in the marble of the Urbach Lake anticline in east-central Wollaston township. Greenish diopside and phlogopite marble, characteristic of the



Marble conglomerate; lot 21, concession VIII, Wollaston township.



Contorted marble and schist; lot 26, concession VIII, Wollaston township.

Dungannon Formation south of L'Amable Lake (Hewitt and James 1956, p. 24) in Faraday and Dungannon townships, occurs in the Deception Lake area. Narrow white quartzite bands, from ½ inch to several feet thick, occur in the marble south of Deception Lake.

In colour, the marbles may be slate-grey, blue-grey, white, buff, pink, greenish (due to diopside), or brownish (due to phlogopite). Grey laminated marble predominates. Frequently the fine-grained, grey, laminated marble contains patches of recrystallized, medium-grained, buff-to-creamy marble. Sometimes these coarser recrystallized patches have stringers of white granular quartz in them, suggesting that silica-bearing aqueous solutions promoted the irregular patchy recrystallization during metamorphism. Sometimes the coarser recrystallized patches and streaks of marble fill fracture cleavage planes, indicating a late secondary origin.

Although silt and clay are common impurities in the fine-grained grey marbles, the metamorphic grade is often high enough for the development of phlogopite, diopside, and amphibole minerals. Tremolite and actinolite in blades and rosettes are not uncommon.

PARA-AMPHIBOLITE AND ASSOCIATED SEDIMENTS

As indicated in the previous description, para-amphibolite frequently occurs interbedded with marble in the sedimentary sequence. The average amphibolite is composed essentially of hornblende and plagioclase, usually oligoclase or andesine. Biotite, quartz, pyroxene, scapolite, and garnet are characterizing accessories. Minor accessories include carbonate, titanite, epidote, pyrite, magnetite, and apatite. Amphibolites grade in composition to pyroxene granulites, in which the essential minerals are plagioclase and pyroxene. Texturally, the amphibolites are even grained, fine to medium grained, and generally granoblastic, consisting of a mosaic of hornblende and (or) pyroxene and plagioclase. A noteworthy textural facies is the "feather amphibolite", which is composed of hornblende and plagioclase; the hornblende occurs in large blade-like poikiloblastic aggregates, which look like feathers on the bedding surfaces of the rock. These interesting amphibolites are discussed in more detail in the report on the Dungannon-Mayo area (Hewitt and James 1956, pp. 20–22). The author believes that the feather amphibolites may represent andesitic or basaltic tuffaceous material laid down in the Hastings Basin with the limestones during a period of basic volcanism. James (1957) points out that chemical analyses of the feather amphibolites closely approximate those of some basalt and basalt tuff.

ARKOSE, QUARTZITE, FELSITE, AND ASSOCIATED ACID VOLCANIC ROCKS

In the southern part of Wollaston township, pink, fine-grained arkosic sediments occur interbedded with the paragneisses and quartz-pebble conglomerates of the Ridge dome. These pink arkosic rocks much resemble fine-grained, pink biotite granite gneiss, and where the bedding is not well defined it is very difficult in the field to distinguish them from granitic gneiss. However, they occur interbedded with undoubted sediments (conglomerate and paragneiss).

These pink arkosic rocks are very similar in lithology and appearance to those of the Oak Lake formation described by the author in Methuen township (Hewitt 1961, pp. 117–18). In Methuen township, however, quartzite, feldspathic schist, and some basic volcanic rocks occur in the section.

The Oak Lake arkose was first recognized and described by Adams and Barlow (1910 p. 180) at Oak Lake in Methuen township. However, it seems to have been a "problem rock type" because the pink arkosic rocks of The Ridge dome are described by Adams and Barlow (1910, pp. 337, 338) as felsite. They describe these rocks as follows:

> The third area of these felsites lies in the northern part of the township of Lake, and passes over into the township of Wollaston, forming a wide band, which may be said to stretch from Lake Tangamong to the Ridge settlement. The rock in this band is rather more coarsely

crystalline than that of the bands just described, having the character of an extremely fine-grained granite, through which are often seen little splashes of quartz and tourmaline. This granite is massive and uniform in character over large areas, but in many places possesses a very faint foliation, which on the shore of Lake Tangamong in places becomes more pronounced, the rock passing into a very finely foliated quartzose-muscovite gneiss. . . . .

. . . . A comparative study of these three belts [of felsite in Lake and Wollaston townships] leads to the conclusion that all are formed of one and the same rock, which has the composition of an orthophyre, but that processes of crystallization, probably of the nature of devitrification, have taken place in the rock, and have become progressively more pronounced on going north in the area, so that while the rocks are everywhere holocrystalline, the finer grained aggregates, many of them still showing the flow structure distinctly, are confined to the southern area, the central belt being represented on the average by rather coarser grained varieties, and the most northerly bands by rocks which partake of the nature of a very fine-grained reddish gneiss, although practically free from iron-magnesia constituents.

It appears likely that some of this rock may represent a recrystallized rhyolitic tuff. This pink "arkosic" rock is very similar to the arkose of the Hermon Formation in Chandos, Cardiff, and Faraday townships.

Lithologically, the pink arkose is a fine-grained, banded rock, composed essentially of quartz and microcline, with varied amounts of plagioclase, muscovite, magnetite, biotite, titanite, and hornblende. Although usually fine grained, these rocks frequently show irregularity of grain size. The feldspars often show dusty alteration. The rocks differ in thin section from the granites in that they are generally much finer in grain, have a great range in grain size, and frequently exhibit banding. They appear to be recrystallized; some secondary microcline appears to be replacing the other minerals and may have been introduced.

A second band of pink arkose, feldspathic schists, felsite, acid tuffs, and associated sediments extends from highway No. 620 west of Coe Hill, in a north-northeasterly direction for a distance of about 4 miles, where it terminates at a fault south of Bald Lake. This band of rock has a maximum width of ½ mile and pinches out to the south. It consists of felsitic acid volcanic rocks, acidic arkose-like sediments, quartz-pebble conglomerate, feldspathic schist, and tuff. Fragmental tuff bands carry fragments of acid and basic rocks. The rocks are grey to pink in colour, and are mainly composed of quartz and microcline, with some biotite, plagioclase, muscovite, and opaque minerals. Some varieties are rather massive; very rarely there is a faint spheroidal banding; bedding is present in some facies, and narrow beds of quartz-pebble conglomerate are also present. These beds are rarely more than a few feet thick, the pebbles averaging ¼ to 1 inch in size in a matrix of quartzo-feldspathic mica schist.

These acid volcanic rocks and feldspathic schists interfinger with, and pass into, rusty biotite paragneiss along strike to the south.

PARAGNEISS AND PSAMMOPELITIC SCHISTS

The rocks grouped in this subdivision include biotite-quartz-plagioclase gneiss and schist, garnet-biotite-sillimanite gneiss and schist, pelitic mica schist, and psammopelitic schist, as well as minor quartz-pebble conglomerates. These rocks occur in five areas, mainly in the south half of the township, namely: on the east flank of the Glen Alda syncline between the Wollaston and Coe Hill granites; on the northwest side of Wollaston Lake; in the Urbach Lake anticline above the Urbach Lake basic volcanics; in The Ridge dome; and at Murphy Corners.

The rocks of the paragneiss-pelitic schist subdivision are mainly derived by metamorphism of argillaceous and sandy (or silty) argillaceous sediments. Mineralogically, they consist essentially of quartz, plagioclase, and biotite; but hornblende, muscovite, scapolite, garnet, sillimanite, and potash feldspar may be locally important. In one rather common lithological type, the rusty schist, pyrite is invariably present and accounts for the rusty weathering. Minor accessories include apatite, zircon, magnetite, carbonates, chlorite, diopside, tourmaline, titanite, and zoisite.

An unusual spotted hornblende paragneiss band extends from the Chandos boundary, in lots 31 and 32, concessions VI and VII, eastward for over 2 miles. The rock is composed essentially of plagioclase, quartz, biotite, hornblende, and scapolite, with minor microcline, titanite, tourmaline, and apatite often present. The scapolite occurs as white spots from ⅛ to ⅜ inch in diameter. This "spotted paragneiss" is a very distinctive facies and may be traced for some distance into Chandos township.

To the south of this spotted paragneiss band a second marker facies developed in the paragneiss is characterized by muscovite porphyroblasts up to ½ inch in diameter. These muscovite porphyroblasts show a poikiloblastic texture.

On the northwest side of Wollaston Lake there is a band of rusty paragneiss and schist, interbedded with diopsidic quartzite. These formations are exposed along the lakeshore near the outlet of Wollaston Lake.

Another band of rusty and feldspathic schists lies above the Urbach Lake Volcanics. These sediments are fine-grained, well-bedded, and sometimes show grain gradation in beds 1-5 inches thick. These may be in part tuffaceous.

The paragneisses of The Ridge dome consist mainly of rusty schist and garnet-sillimanite paragneiss, with occasional thin interbeds of quartz-pebble conglomerate. These rocks are brownish weathering. Along the west side of the Deer River at the south township boundary, a narrow band of pelitic sericite schist contains grey porphyroblasts of plagioclase up to ¾ inch in size. Farther to the west along the township boundary, there is a band of sandy-weathering, friable, diopsidic, limy, quartzo-feldspathic sandstone.

Interbedded with the paragneiss and schist of The Ridge dome is pink, well-bedded arkose, which was described in the previous section.

The paragneiss of the Murphy Corners area is a light-grey, biotite, quartzo-feldspathic metasediment with interbedded feldspathic and rusty paragneiss, and para-amphibolite.

BASIC VOLCANIC ROCKS

The basic volcanic rocks consist mainly of amphibolite schists and gneisses. The volcanic amphibolites are similar in lithology to the para-amphibolites, but were recognized by the preservation of volcanic structures such as pillows, ropy flow, epidotized bombs, and volcanic agglomerate. Four belts of volcanic rocks were recognized in Wollaston township.

The main band of basic volcanic rocks is the Urbach Lake volcanic band in southeastern Wollaston township. This band begins at highway No. 620, north of Peter Lake (where it is scarcely 100 feet wide), and extends southwest around the nose of the Urbach Lake anticline where it attains a width of ½ mile, thence it widens eastward to over 1 mile in width. One branch extends northward along the west flank of the Thanet gabbro and is cut off by that body; a second branch swings around the synclinal axis shown on the map (No. 2020, map case) and pinches out near the crest of the Murphy Corners anticline. The volcanic amphibolite interfingers with para-amphibolite and marble, which predominates to the south. A good outcrop of volcanic amphibolite schist may be seen on the Murphy Corners road on the east bank of Dickey Creek.

Microscopic examination of thin sections of the volcanic amphibolite indicates that it is composed essentially of fine-grained hornblende, with accessory plagioclase, carbonate, zoisite, and opaque minerals. The plagioclase is mainly untwinned. East and southeast of Urbach Lake, the volcanic amphibolite contains as much as 30 percent scapolite in places. The scapolite, which may be in grains up to ¼ inch in size, weathers out, giving the rock a pitted surface. On fresh surfaces the scapolite is grey to white. Under the microscope it shows poikiloblastic texture.

A second band of vertically dipping, basic volcanic rocks, from ½ to ¾ mile wide, was traced from the Wollaston township–Lake township boundary (in lots 13 and 14, east of Steen Creek) in a northwesterly direction around the nose of The Ridge dome to the Deer River, where it is cut off by the Wollaston

Lake gabbro. This volcanic band lies in a synclinal structure (the Henderson Lake syncline), between the Murphy Corners anticline and The Ridge dome. Its correlation and stratigraphic position is not clear, but it is possible that it may be the other limb of the Urbach Lake Volcanics (on the southwest limb of the Henderson Lake syncline).

This band of basic volcanic rocks is mainly composed of dark green to black amphibolite schist, with abundant epidote, epidote nodules, and frequent epidotized bombs and amygdules. Acid tuff and acid agglomerate bands are also present. In lots 13, 14, and 15, concession II, there is a lens of agglomerate with acid felsite fragments in a basic matrix. The fragments are generally rounded and elongate, and range from 1 inch to 1 foot in length. Other outcrops of agglomerate were observed in lots 17 and 18, concession II, and lot 17,

Epidotized bombs in volcanic amphibolite; lot 13, concession I, Wollaston township.

concession III. At the latter locality, agglomerate outcrops are exposed on the east side of The Ridge road. The fragments are felsite and amphibolite in a matrix of feldspathic schist.

Another feature of this volcanic band is the presence of an epidote-garnet skarn zone containing magnetite, pyrite, and chalcopyrite. This skarn zone extends north from the Murphy Corners road in lot 15 for over a mile; it appears to have a maximum width of about 500 feet at its widest point. The zone shows up as a series of anomalies on the Coe Hill aeromagnetic sheet (G.S.C. 1949) and extends southward into Lake township.

A third narrow band of basic volcanic amphibolite containing epidotized bombs extends in a northerly direction from the Lake township–Wollaston township boundary, about ½ mile west of the Deer River.

The fourth band of basic volcanic rocks is in east-central Wollaston township and is exposed in a band extending around the Urbach Lake anticline just west of Ormsby. This band is stratigraphically below the Urbach Lake volcanic band. It is well exposed on the fire tower hill at Ormsby, where it consists of massive to schistose, black to dark green amphibolite.

Plutonic Rocks

DIORITE AND GABBRO

There are three major basic intrusive bodies: the Umfraville, Thanet, and Wollaston Lake gabbro and diorite, as well as several smaller basic intrusive bodies. Diorite and gabbro appear to be the oldest intrusive rocks in the township; they are intruded by granite and granite pegmatite.

Although some of the basic intrusions are fresh and unaltered, many of them, especially the smaller bodies, are metamorphosed to metagabbro and amphibolite. The term metagabbro is used to describe a medium- to coarse-grained, hornblende-plagioclase amphibolite or gneiss, in which the ferromagnesian minerals are recrystallized to clotted aggregates of hornblende, and the plagioclase crystals are recrystallized to an equigranular granoblastic mosaic of andesine. The metagabbro and amphibolite bodies in Wollaston township do not appear to have been highly scapolitized, as in some of the adjacent townships to the north.

Umfraville Gabbro

The Umfraville gabbro has an area of about 10 square miles and lies mainly in Wollaston, Faraday, and Limerick townships, although a small portion extends into Dungannon township. The body has a length of 5 miles and a maximum width of a little over 2 miles. It shows up as a prominent anomaly on the Coe Hill aeromagnetic sheet. The gabbro may be readily examined in highway cuts along highway No. 62 in Limerick township, along the Hastings road in Wollaston and Dungannon townships, and on the Ragged Lake road. It is well exposed on the shores of Ragged Lake. Detailed mapping now indicates that the Umfraville gabbro is much smaller than shown on the Haliburton-Bancroft sheet of Adams and Barlow (1910, map) and on map 1957b of the Ontario Department of Mines (O.D.M. 1957).

The Umfraville gabbro body is composed of fresh gabbro, pyroxenite, norite, diorite, and metagabbro. Quartz diorite and diabase are uncommon. The distribution of these facies is irregular. The gabbro is composed of augite and labradorite, with accessory hornblende, biotite, calcite, magnetite, apatite, pyrrhotite, and pyrite sometimes present. Occasionally a little chalcopyrite is seen in drill core. The gabbro grades to a hypersthene gabbro. In some facies, hypersthene is the only pyroxene, and the rock is termed norite. The pyroxenite facies is composed mainly of augite, with minor plagioclase and opaque minerals.

A prominent magnetic anomaly, in lots 10 and 11, concession XVI, was drilled in 1957 by Rio Tinto Canadian Exploration Limited. The magnetite-bearing zone was in pyroxene granulite composed mainly of pyroxene, hornblende, magnetite, ilmenite, apatite, and plagioclase.

The gabbro is intruded by the Umfraville syenite, and by granite pegmatite and aplite dikes. Several of the granite pegmatite bodies are of large size, one southwest of McMurray Lake being ¾ mile long and over 100 feet wide.

Thanet Gabbro

The Thanet gabbro occupies an area of about 9 square miles in southern Wollaston and Limerick townships. It may be seen along the Hastings road between Ormsby and Murphy Corners. This body was first described by Adams and Barlow (1910, pp. 150-51).

On the north and south, in Wollaston township, it is bounded by marble and para-amphibolite of the Mayo Group. On the west side it is bounded by amphibolite of the Urbach Lake volcanic band. The contact between the amphibolite and the metagabbro is easily discerned owing to the difference in texture, structure, and grain size between them.

The Thanet body, although termed gabbro by Adams and Barlow, consists mainly of diorite, quartz diorite, and metagabbro. Some fresh gabbro does occur, but it is not the predominant facies. The chief mafic mineral is hornblende, especially in the metagabbro where it is probably secondary after pyroxene. The diorite facies is composed essentially of hornblende, biotite, and andesine, with minor magnetite, apatite, titanite, and sometimes quartz. One thin section examined by the author, from lot 5, concession V, consisted of hypersthene and plagioclase, with accessory biotite, apatite, and magnetite. However, hypersthene was only seen in one of eleven sections examined from this body.

Near Lighthouse Lake the gabbro contains large fragments of green pyroxenite. Along the north shore of the lake, light-coloured diorite is cut by medium-grained gabbro.

The Thanet body appears to be a multiple intrusion, with the subsequent intrusions differing slightly in composition from one another. The three main facies now represented are gabbro, metagabbro, and diorite, the last two predominating. The Thanet body does not give a prominent aeromagnetic anomaly as does the Umfraville gabbro; this is due to the predominance of metagabbro and diorite facies in the Thanet body. When the gabbro recrystallized to metagabbro much of the magnetite was taken up by hornblende.

Wollaston Lake Gabbro

The Wollaston Lake gabbro is an elongate body 4 miles long and up to 1 mile wide, extending from Wollaston Lake to Castoroil Lake in south-central Wollaston township. Inclusions of gabbro and diorite in the Coe Hill granite indicate that this gabbro body probably extended at least 2 miles farther to the southwest, before the intrusion of the Coe Hill granite.

The body consists of biotitic gabbro, diorite, and metagabbro. The gabbro is medium to coarse grained and consists predominantly of augite and plagioclase, with hornblende, biotite, apatite, and magnetite as accessories. Biotite may occur in porphyroblasts up to 1 inch in diameter.

Porphyroblastic diorite or porphyroblastic amphibolite inclusions of the Wollaston Lake gabbro occur in the Coe Hill granite. These porphyritic rocks consist of large (½-inch) porphyroblasts of pink perthitic feldspar in a matrix of fine-grained hornblende, pyroxene, and plagioclase. Sometimes the porphyroblasts make up as much as 70 percent of the rock; they are frequently rectangular in outline.

Medium-grained norite is exposed on a point on Wollaston Lake, in lot 19, concession VI.

Other Basic Intrusive Bodies

Numerous other small basic intrusive stocks, sills, and dikes may be found in the township. A small plug of olivine gabbro, gabbro, diorite, and metagabbro is exposed in lots 21 and 22, concession IX. This body is ¾ mile long and about 1,000 feet wide and shows up as a prominent magnetic anomaly on the Coe Hill aeromagnetic sheet (G.S.C. 1949).

A sill-like metadiorite body, about 2 miles in length, extends from the road north of Coe Hill in lot 15, concession XI, in a north-northeasterly direction, to lot 10, concession XIII. The rock is a massive, medium- to coarse-grained, dioritic amphibolite or metadiorite, composed essentially of hornblende and plagioclase, with characterizing accessory biotite, garnet, and quartz.

A small gabbro body, and a surrounding ring of syenite, together form a composite intrusion about 1 mile in diameter, south of Tommy Lake in lots 2 to 5, concessions XI, XII, and XIII, in northeastern Wollaston township. The syenite is younger than the gabbro.

An amphibolite and metagabbro sill, about 2 miles long and up to 600 feet wide, extends from lot 5, concession IX, just north of Drumm Lake, to lot 1, concession XI. This sill lies on the northwest limit of the Urbach Lake anticline, on the contact between marble and rusty paragneiss.

Other amphibolite sills and dikes are common in the marble and para-amphibolite sequence of north-central Wollaston township. Several of the narrow sills may be traced for over a mile along strike. These amphibolites are occasionally garnetiferous.

SYENITE

There are three main syenite occurrences in Wollaston township: (1) the pink to buff, coarse-grained Umfraville syenite, which occurs within, and associated with, the Umfraville gabbro; (2) a syenite forming the outer ring of the syenite-gabbro ring complex in lots 2 to 5, concessions XI to XIII; (3) the Coe Hill syenite exposed between Coe Hill village and Wollaston Lake. These syenitic rocks are frequently coarse grained and contain large phenocrysts of buff to grey microperthite. They are of the Umfraville syenite type.

The Umfraville syenite, which occurs closely associated spatially and genetically with the Umfraville gabbro body, has been described in the report on Cardiff and Faraday townships. (Hewitt 1959, pp. 27, 28). The syenite is a coarse-grained, pink to buff porphyritic rock, made up mainly of microperthite or cryptoperthite crystals up to ½ inch in diameter, with interstitial plagioclase, hornblende, and biotite; magnetite, apatite, and titanite are minor accessories. The Umfraville syenite can be seen on the Ragged Lake road in lot 9, concession XVI, and at the east end of Ragged Lake. A syenite dike about 1 mile long cuts the gabbro south of Ragged Lake. This syenite is similar in lithology to the Fraser Lake syenite associated with the Boulter gabbro in Carlow township (Hewitt 1955, p. 14).

The syenite body in lots 2 to 5, concessions XI to XIII, forms part of a ring complex, one square mile in area, consisting of diorite and gabbro in the centre, surrounded by a ring of syenite. The outer ring of syenite is about ¼ mile wide and encloses the gabbro except at the west end. The syenite is a coarse-grained, pink to buff rock, composed essentially of blocky crystals of microperthite and plagioclase, with accessory biotite, hornblende, titanite, and magnetite. The syenite intrudes the gabbro and diorite of the core of the ring structure; porphyroblasts of pink feldspar may occur in the diorite or gabbro adjacent to the syenite. Accessory magnetite in the gabbro and syenite gives rise to a pronounced magnetic anomaly.

Numerous small outcrops of pink, medium-grained biotite syenite may be seen along the streets of Coe Hill village, and in the area between the village and Wollaston Lake. Due to the lack of outcrop, it is impossible to state whether or not the syenite forms a single intrusive body.

GRANITE

There are two large granite bodies in western Wollaston township: the Wollaston granite, and the Coe Hill granite. Smaller dikes and sills of granite and granite pegmatite occur throughout the township.

Wollaston Granite

The Wollaston granite pluton occupies an area of 5 square miles in northwestern Wollaston township, extending north from highway No. 620 for 5 miles, to concession XV. The pluton has an average width of about 1¼ miles. It is composed of grey and pink, biotite hornblende granite, which in some places shows a gneissic structure. The granite pluton forms a sheet dipping steeply eastward, intruded into the marble–para-amphibolite metasedimentary sequence. At the south end, tongues of the granite interfinger with the sediments. Some sedimentary inclusions and roof pendants occur within the granite pluton. An excellent detailed study of the Wollaston pluton has been made by A. K. Saha, and the results are published in two papers (Saha 1958, pp. 609-19; 1959, pp. 1293-1326). The reader is referred to these papers for a detailed description of the pluton.

The granite pluton consists of two main facies: a central core of grey biotite granite generally having a gneissic structure, and an outer pink biotite hornblende granite. The former extends from the Rose Island road to the north end of the pluton and is rarely over ½ mile wide.

The pink biotite hornblende granite facies forms the bulk of the pluton. Some parts of this facies are coarse grained and show a distinct mineral lineation of biotite, and an east-dipping foliation. This variety of granite grades into pink granite containing augen of pink feldspar. The coarse granite is well exposed in roadcuts on highway No. 620. The borders of the pluton are frequently composed of a pink, finer-grained leucogranite.

The grey granite of the central zone is more gneissic and contains phenocrysts of pink potash feldspar. This facies is well exposed on the Rose Island road. It grades into an even-grained, grey biotite granite of medium-grain size. Saha has suggested that the grey granite represents granitized paragneiss, but the author believes it is a separate and distinct intrusive facies of the Wollaston pluton. Where paragneiss inclusions occur in the Wollaston granite they are not notably granitized, and the contacts of the granite body with the paragneiss do not show extensive granitization or any notable contact effects. These features, together with the uniformity of the grey granite gneiss and its lack of gradation to a recognizable paragneiss, suggest to the author that it is an intrusive facies of the pluton itself. In most cases, contacts with the pink granite facies are distinct and not gradational; there was little difficulty in mapping the contacts of the two major facies.

Chemical and modal analyses of the two facies of the Wollaston granite are given by Saha (1959, p. 1310) as follows:

CHEMICAL ANALYSES

	W608 (Pink Wollaston Granite Gneiss)	W487 (Grey Wollaston Granite Gneiss)
	percent	percent
SiO_2	71.88	70.68
TiO_2	0.37	0.48
Al_2O_3	11.66	14.07
Fe_2O_3	1.34	0.69
FeO	2.63	2.65
MnO	0.06	0.05
MgO	0.72	0.57
CaO	1.13	1.90
Na_2O	3.92	4.13
K_2O	4.18	3.88
P_2O_5	0.10	0.12
H_2O+	0.71	0.57
H_2O-	0.02	0.00
CO_2	0.57	0.45
	99.29	100.24

MOLECULAR NORMS

	W608	W487
	percent	percent
q	28.6	25.2
or	25.5	23.0
ab	36.0	37.5
an	1.0	5.5
hy	4.8	4.8
wo	—	—
c	0.4	1.2
mt	1.5	0.8
il	0.6	0.6
cc	1.4	1.2
ap	0.3	0.3
	100.1	100.1

The work of A. K. Saha has indicated that samples of the Wollaston granite within 100 yards of the contact are distinctly more sodic and silicic, and poorer in potash and mafic minerals, than the rest of the body. The average modal compositions of the 100-yard "Border" zone and the remainder of the pluton are given by Saha (1958, p. 611) as follows:

MODES

	W608	W487
	volume percent	volume percent
Quartz	30.4	29.3
Microcline (usually perthitic)	26.4	19.2
Plagioclase	29.4	39.8
Biotite + chlorite	7.4	10.4
Hornblende	4.2	—
Magnetite	0.4	—
Calcite	1.0	0.8
Non-opaque accessories	0.8	0.5
	100.0	100.0

MODAL ANALYSES

Minerals	Border Zone	Main Body
	volume percent	volume percent
Quartz	31.8	27.9
Plagioclase	41.7	30.8
Microcline	22.1	32.8
Biotite + chlorite	3.6	5.6
Hornblende	0.3	2.2
Magnetite	0.1	0.1
Rest	0.4	0.6
Average An	$An_{9.5}$	$An_{12.5}$
Average $\frac{Kf \times 100}{\text{total feldspar}}$	34.6	51.6

Saha postulates that the variation in the border zone, as compared with the main body of the granite, may be explained by diffusion of silica and soda in aqueous solution from the heated paragneiss into the adjacent granite magma, at an early stage of the crystallization of the magma.

The foliation and lineation present in the Wollaston granite is indicated on the geological map (No. 2020, map case). In general, the foliation strikes in a northerly direction and dips steeply east. The foliation, however, is generally parallel to the contacts of the pluton, as for example at the north end where it swings around to the west, parallel to the north contact. A regional south-pitching lineation of biotite and hornblende is generally present throughout the pluton. The west contact of the pluton dips east; along the Rose Island road the dips of the granite foliation near the west contact are 40–50°E. Along this west contact, the marble and para-amphibolite country rocks dip about 20°E., so the granite appears to truncate them. Along the east contact of the pluton the foliation of the granite is steeper, from 60°E. to vertical.

The contact between the granite pluton and the country rocks is everywhere sharp. Contact effects in the metasedimentary rocks are meagre. On the west side, a few feet of coarse- to medium-grained diopside marble may be found. The east contact is poorly exposed, but coarse- to medium-grained, recrystallized white marble may be present in a 500-foot zone from the contact eastward. There is no metamorphic aureole.

Large inclusions of marble, paragneiss, and para-amphibolite, up to 200 feet wide, may be seen in the Wollaston pluton along the Rose Island road. Inclusions of ortho-amphibolite occur north of the Rose Island road near the west contact of the pluton. In other areas inclusions are uncommon. In places, some small inclusions of paragneiss up to about 3 feet in diameter may be seen. The contacts between these inclusions and the granite are sharp, and the inclusions are not noticeably granitized.

Coe Hill Granite

The Coe Hill granite pluton in southwestern Wollaston township is irregular in shape. It has a north-south length of 4 miles and a maximum width of 2 miles. The contacts are well defined but irregular in shape. The south half of the granite is full of large inclusions of metagabbro, diorite, amphibolite, and paragneiss, and it is likely that this section represents the roof of the granite body. Two granite quarries have been worked in the Coe Hill granite: Ebonridge Quarries, in lot 24, concession V; and Upper Canada Granite Quarries, in lot 27, concession III. These quarries were inactive in 1959.

The Coe Hill granite pluton is composed mainly of pink, medium- to coarse-grained, massive, biotite granite. A second facies, which appears more commonly around the margins of the body, is a pink gneissic biotite granite, frequently carrying augen of feldspar. This type of granite is cut by the coarse-grained, massive, pink granite; inclusions of the gneissic augen facies occur in the massive facies. Sometimes the border facies of the pluton is medium-grained, pink leucogranite.

The Coe Hill granite consists essentially of quartz, plagioclase, microcline, and microcline perthite, with varietal biotite and minor hornblende, muscovite, zircon, titanite, apatite, and magnetite. Modal analyses of four samples of the Coe Hill granite are given in the accompanying table:

MODAL ANALYSES OF COE HILL GRANITE(1)

Minerals	H59-16	H59-17	S59-36	S59-44
	volume percent	volume percent	volume percent	volume percent
Quartz	23.0	22.5	23.2	27.0
Microcline	26.1	21.7	13.9	18.9
Perthite	11.5	13.3	20.5	6.0
Plagioclase	28.2	33.1	27.6	30.3
Biotite	8.6	5.2	10.2	11.5
Muscovite	—	—	0.5	3.2
Hornblende	0.1	1.8	0.2	—
Zircon	trace	trace	trace	0.2
Titanite	1.1	1.2	1.6	0.8
Apatite	trace	0.2	0.3	0.1
Carbonate	—	—	0.7	1.6
Opaque minerals	0.8	1.0	1.3	1.4

(1)Analyses by P. S. Simony.

The contact between the granite pluton and the surrounding country rocks is irregular, with many tongues of granite intruding the sediments, and re-entrants, roof pendants, and inclusions of the sediments in the granite. At the north end of the body, the sediments appear to be little affected near the granite contact; there is no border migmatite zone nor any apparent metamorphic aureole. In the south half of the granite body, inclusions are much more numerous; some inclusions are not granitized, but others, both of gabbro and para-amphibolite, are extensively granitized. The Wollaston Lake gabbro must have originally extended at least 2 miles farther to the southwest, since gabbro inclusions are common in the granite as far west as the road.

Other Granite Intrusions

A small sill-like body of pink, coarse-grained leucogranite, with accessory biotite and hornblende, occurs on the northeast flank of The Ridge dome; it may be seen on the Murphy Corners road ½ mile east of The Ridge.

Numerous other small bodies of pink and grey granite occur in the western and northern parts of the township.

Granite Pegmatites

In northeastern Wollaston township, several large granite pegmatite dikes are found intruding the Umfraville gabbro. A large pink granite pegmatite dike forms a ridge trending N.50°E. across lots 8 and 9, concessions XIV and XV, southwest of the south end of McMurray Lake. The granite pegmatite is exposed on the south side of a ridge, over a width of 100–200 feet, and can be traced for a distance of ⅜ mile. The pegmatite consists mainly of pink and white graphic granite and is remarkably free of mafic minerals. It might be a potential source of quartz and feldspar for the ceramic industry, where a graphic granite can be utilized.

Another large granite pegmatite dike, striking N.60°E. and dipping steeply south, is exposed in lots 2 and 3, concession XVI, Wollaston township, 14 chains southeast of the southeast end of Ragged Lake. The dike intrudes the Umfraville gabbro and is exposed on a south-facing hillside, over a width of 250 feet and a length of 750 feet. The attitude of the pegmatite contacts cannot be determined, so that the true width is not known. The pegmatite is largely composed of pink and white graphic granite. A feature of this dike is the presence of clusters of black tourmaline crystals in segregations of quartz and albite. The tourmaline crystals are up to 1 inch in diameter and 6–7 inches in length. This dike may be a possible source of tourmaline crystals.

A second large, tourmaline-bearing, granite pegmatite dike strikes north in lot 3, concession XVI, at the northeast end of Ragged Lake. It can be traced for over ¼ mile to the north of the lakeshore. Other sizable granite pegmatite dikes are shown on the geological map (No. 2020, map case).

Granite pegmatite dikes are not commonly associated with the Wollaston granite. The associated dikes are mainly biotite granite or pink leucogranite. Pink, tourmaline-bearing, granite pegmatites are present in the Coe Hill granite and in adjoining parts of the Wollaston Lake gabbro.

Structure, Stratigraphy, and Metamorphism

Structurally, the area falls within the Hastings Basin subdivision of the Grenville province of Eastern Ontario. The rocks of the area are highly folded, and the metamorphic grade is medium to high; however, the tectonic style and metamorphic grade are distinctly different from that in the Haliburton-Hastings Highland gneiss complex to the north. Migmatitic and hybrid mixed gneisses are rare or absent, in contrast to the conditions pertaining in the Highland gneiss complex. The granite and gabbro plutons are typical of the mesozone (Buddington 1959, pp. 671-748). These are post-tectonic or emplaced late in the Grenville orogeny. Contact metamorphic effects are limited or absent.

Folding

The main direction of folding is north-northeast and conforms with the pattern of regional folding in the Hastings Basin. However, secondary cross-folding along northwest-southeast axes is well developed, and the series of domes and basins present due to this crossfolding in Methuen township (Hewitt 1961, pp. 105-61), extends northeastward into Wollaston and Chandos townships. About ten major fold structures were recognized. The Clydesdale–Rose Island dome is a northeastward-trending, flat domical structure extending from Clydesdale Lake in Chandos township to northwestern Wollaston township. On the east flank of the dome, dips steepen rapidly into the north-trending Gilroy syncline, whose axis extends northward from the north end of the Coe Hill Granite and then swings to the west to join the Lavalee Lake crossfold in Faraday township. The Wollaston granite is emplaced on the east flank of the Rose Island dome (which is the west limb of the Gilroy syncline). The south end of the Wollaston granite terminates in the core of the Wollaston anticline, a southward-pitching anticline to the east of the Glen Alda syncline in Chandos township described by D. M. Shaw (*see* p. 19). Tongues of the granite interfinger with the sediments near the Wollaston-Chandos townships boundary on the east limb of the Glen Alda syncline, and the emplacement of the granite pluton was apparently influenced by these structures.

East of the Gilroy syncline there is the north-pitching Coe Hill anticline, which is overturned towards the east. Good fracture cleavage to bedding relationships on both arms of this anticline confirm the structure, which is apparently cut off to the east against a fault. East of this there is the Tommy Lake syncline, which pitches to the south. The composite gabbro-syenite ring structure of northeastern Wollaston township is within the Tommy Lake syncline.

Southeast of the Tommy Lake syncline there lies one of the major folds of the area, the Urbach Lake anticline. The axis of this anticline enters the township north of Ormsby, trends and pitches to the south and southwest between Brooks and Peter lakes, through Urbach Lake, and terminates to the west, where it plunges into the Henderson Lake syncline.

In the southeast corner of the township the axis of the Murphy Corners anticline trends and pitches southwest by west. Between this anticline and the Urbach Lake anticline a synclinal axis is indicated; the Thanet gabbro body occupies this syncline.

The main structural feature of southwestern Wollaston township is The Ridge dome. This domical structure is mainly within Lake township, but the north end of the dome (which is elongated along a northeast axis) enters Wollaston township. Between The Ridge dome and the Urbach Lake and Murphy Corners anticlines to the northeast, lies the Henderson Lake syncline, which is a crossfold trending northwest. This may possibly be the eastward extension of the Glen Alda synclinal crossfold. The Coe Hill granite occupies the position where this axis of crossfolding intersects the extension of the Gilroy Lake syncline. Within Chandos township to the west, the crossfolding is very marked, as noted by Shaw (*see* pp. 19-21) and Saha (1959).

Foliation and Bedding

Stratiform foliation in the metasedimentary rocks is parallel to the bedding, as indicated by compositional differences between beds (e.g. interbedded marble and feather amphibolite), by grain gradation, colour banding, etc. Although grain gradation may be observed in some of the pelitic rocks, and occasionally in the blue-grey marbles, it is very rarely good enough to give indications of tops of beds.

In the metavolcanic rocks there is often a strongly developed stratiform foliation, due to alignment of the hornblende of the amphibolite. This stratiform foliation is parallel to the contacts of the underlying and overlying marble and schists.

Lineation

A subparallel lineation (or B-lineation) is developed in places in the sediments and intrusive rocks. This lineation is generally parallel or subparallel to the north- or northeast-trending fold axes, and pitches to the south or southwest. The B-lineation conforms to that observed and described by the author in Methuen township (Hewitt 1961, pp. 105-61) and contrasts with the conditions pertaining in the Highland gneiss complex to the north, where there is a regional A-lineation, generally plunging to the southeast.

Fracture Cleavage

The relationship between fracture cleavage and bedding was used to determine tops of beds in several places, mainly in northern Wollaston township. Fracture cleavage appears to develop parallel to the fold axes in northern Wollaston and is prevalent in the interbedded marble and amphibolite sequence north and east of the Wollaston granite pluton. Fracture cleavage and bedding relationships in the para-amphibolites of the area north of Coe Hill village indicate an overturned anticlinal structure pitching to the north (the Coe Hill anticline).

Faulting

There are several prominent lineaments apparent on air photos, which have topographic expression as valleys and scarps, and which may represent normal faults. A series of these strike northwest in north-central Wollaston township, north and east of the Wollaston granite pluton. In the vicinity of Deception Lake these lineaments are subparallel to the bedding foliation; but as the strike of bedding swings around to the south, on the east side of the granite pluton, the lineaments, which are marked by prominent scarps up to 100 feet high, continue southeast to the Kelly flats. These lineaments are parallel to the axis of the Lavallee Lake crossfold in Faraday township, which extends southeast into Wollaston township in the vicinity of Neil Lake. It is noteworthy that the Lavallee Lake crossfold is strongly expressed by folding and faulting in northern Wollaston township; it is expressed by folding of the marble and feather amphibolite of the Dungannon Formation in Faraday township, but farther to the northwest, the more competent Hermon Formation is unaffected by the crossfolding. The crossfolding is expressed only in the less competent marble and amphibolite sequence.

A north-striking fault extends from the east end of Wollaston Lake to Bald Lake and cuts off the east limb of the Coe Hill anticline. Talc and serpentine are developed in the marble in parallel shears just east of the fault, in lots 8 and 9, concession XI.

Other northwesterly-trending lineaments are developed just north of Henderson Lake, along the direction of the Henderson Lake synclinal crossfold.

Stratigraphy and Correlation

Several factors make it difficult to determine the stratigraphic section in Wollaston township and correlate it with the adjoining townships. The structure is complicated by crossfolding and faulting; and lithological units, such as the volcanic bands, thicken and thin rapidly, often pinching out along strike. Good stratigraphic marker horizons are rare. Although grain gradation, crossbedding, fracture cleavage, and pillowed structures are occasionally found, it is difficult to get good top determinations in the township.

The arkose and paragneisses of The Ridge dome extend across Lake township and correlate with the Oak Lake formation of Methuen township. These rocks are overlain by the band of basic volcanics that includes the agglomerate and skarn southwest of Henderson Lake. These volcanics are overlain in turn by the marbles of the Henderson Lake syncline.

On the northeast limb of the Henderson Lake syncline, the Urbach Lake basic volcanic rocks and rusty schists probably correlate with the basic volcanic rocks on the southwest arm of the structure above the aforementioned arkoses. The marble, para-amphibolite, and paragneiss of the Murphy Corners anticline would then possibly be the equivalent of the Oak Lake formation of The Ridge dome, in stratigraphic position, although quite different in lithology. These rocks would also be equivalent to the marble and volcanic rocks below the Urbach Lake Volcanics in the Urbach Lake anticline.

Correlation in the northwest half of the township is even more doubtful, since marker horizons are lacking, and continuity is poor owing to faulting. The marble and feather amphibolite sequence of northwestern Wollaston township belongs to the Dungannon Formation of the Mayo Group, described in previous reports on Dungannon, Mayo, and Faraday townships (Hewitt and James 1956: Hewitt 1959). Whether all the marble and para-amphibolite rocks of the township may be correlated with the Mayo Group is problematical.

In Dungannon and Mayo townships there are two basins of sedimentation represented, in the Deltor anticline to the north and the Mayo anticline to the south, with somewhat different lithofacies in each. There is a southwest-trending line of division between these two anticlines, which may be a fault. Along the southwestern extension of this trend, through Wollaston township, the author found difficulty in correlating across the township owing to the presence of the Umfraville gabbro, the Coe Hill granite, and the Bald Lake–Wollaston Lake fault, which lie along this trend. Similarly, Methuen township is separated into two parts along this same trend by the Methuen granite batholith.

Metamorphism

As pointed out in the description of the granitic rocks, the granite plutons have been emplaced in the mesozone, rather than in the catazone, and the regional grade of metamorphism in this zone, although high, is much less than in the catazone as exemplified in the Haliburton-Hastings Highland gneiss complex to the west and north. The development of feather amphibolite throughout Wollaston township indicates that the rocks are of the amphibolite facies. Garnet is common in the amphibolite and paragneiss of the area, and some sillimanite is present in the paragneiss of The Ridge dome.

Hydrothermal scapolitization has taken place in the Urbach Lake Volcanics and in the paragneiss of the Glen Alda syncline. Epidotization is common in the southern volcanic bands. Very little contact metamorphism is associated with the granitic and gabbroic plutons.

A noteworthy feature of the area is the lack of coarse white crystalline limestone, which is very common in the Hastings Highland gneiss complex. Most of the marble is well-bedded, grey or blue-grey limestone of the "Hastings type." Small patches of white to buff, recrystallized marble occur in the grey marble, but this type of recrystallization is limited. This would indicate that these limestones were not metamorphosed in the catazone.

Economic Geology

Deposits of iron, granite, arsenic, copper, talc, and mica have been opened up in Wollaston township. There has been commercial production of iron and granite in past years, but no properties have been in production recently. Currently there is prospecting activity for copper and iron in the township.

Arsenic

LOT 16, CONCESSION XIV

In lot 16, concession XIV, a small pit measuring 15 by 10 feet and 15 feet deep exposes a 15-inch quartz-carbonate vein cutting marble. The vein is mineralized with arsenopyrite. M. E. Hurst (1927, p. 100) reports that two carloads of ore were shipped to the Deloro smelter by D. E. K. Stewart of Madoc. The shipments are reported to have averaged 27.2 percent arsenic, but gold content was too low to pay for extraction.

Copper–Iron

A series of strong magnetic anomalies indicated on the Coe Hill aeromagnetic sheet (G.S.C. 1949) follows the basic volcanic band, which flanks the northeast side of The Ridge dome. These anomalies were examined and described by E. M. Abraham in 1951 (Abraham 1951), who termed them The Ridge and The Ridge extension anomalies. Within the basic volcanic belt there are several strong zones of garnet-epidote-magnetite-pyrite-pyrrhotite skarn. The sulphides are quite common in the skarn, and chalcopyrite is present in some places. The skarn may be observed in a roadcut on the north side of the Murphy Corners road, in lot 14, concession I, and extends northwest for over 1 mile.

The Ridge anomaly, in lots 16, 17, and 18, concessions II and III, is centred over a band of volcanic amphibolite and interbedded para-amphibolite, on the east side of The Ridge road near the foot of The Ridge hill. Outcrops are sparse. The garnet-epidote skarn is exposed in an old prospect pit, and the skarn is well mineralized with magnetite and sulphides. A sample taken by E. M. Abraham (1951, p. 17) assayed 37.77 percent Fe, 8.85 percent S, 0.25 percent TiO_2, 0.64 percent P_2O_5, 12.79 percent SiO_2, and 0.1–0.3 percent Co. A reconnaissance dip-needle survey by Abraham indicated "three well defined linear zones of high magnetic intensity each about 500 feet long and parallel to the geologic structure. The zones are separated from one another by about 500 feet of weak magnetic intensities."

In 1951, W. S. Moore Company of Duluth drilled four holes totalling 1,885 feet to test The Ridge anomaly. Two holes were put down on an anomaly just east of the road on the Reid farm, in lot 18, concession III, and two holes on an anomaly 2,200 feet to the east, in lot 16, concession II. Drilling indicated that the magnetite occurred disseminated in bands in the volcanic amphibolite, in association with sulphides. The following chemical analyses of composite samples of the magnetite-bearing bands from the Reid farm anomaly were kindly supplied to the author by W. S. Moore Company:

Hole	Footage (vertical)	Fe	SiO_2	CaO	MgO	Al_2O_3	S	Insolubles
		percent	percent	percent	percent	percent	percent	percent
No. 1	69.5-106.5	39.50	14.93	10.90	0.83	3.72	2.49	27.30
	122 -139.5	26.74	21.64	15.70	1.26	4.42	2.83	37.92
	165 -178	27.34	21.20	16.71	1.34	2.91	2.36	38.08
No. 2 (50°)	133 -284	30.94	20.59	11.15	1.88	3.74	1.75	42.57

Magnetic concentration tests on these samples gave the following results:

Hole	Footage (vertical)	Weight	Fe	Insolubles	Grind Required
		percent	percent	percent	
No. 1	69.5-106.5	50.7	67.0	4.0	100-mesh
	122 -139.5	32.1	67.0	5.4	100-mesh
	165 -178	30.7	65.9	5.4	100-mesh
No. 2	131 -284	38.5	64.1	7.0	100-mesh

The Ridge extension anomaly (30A), just north of the Murphy Corners road, in lots 14 and 15, concessions I and II, is centred over magnetite-bearing skarn zones in the basic volcanics. Abraham (1951, p. 18) reports that "a reconnaissance dip-needle survey outlined 4 linear zones of medium to high magnetic intensity parallel to the geologic structure. Three of the zones are 300 feet long each and the fourth zone of medium magnetic intensity is about 2,000 feet long." A sample of the magnetite skarn taken by E. M. Abraham assayed 23.3 percent Fe, 0.55 percent S, 0.56 percent TiO_2, 0.11 percent P_2O_5, and 20.33 percent SiO_2.

In 1959, V. A. McMurray of Gilmour staked the south half of lots 13, 14, and 15, concession III, and lots 14, 15, and 16, concession II. Some prospecting and trenching was carried out on rusty skarn zones in the volcanic amphibolite band. Several small prospect pits have been opened up on the magnetite-chalcopyrite skarn zone. The main showing is on a low ridge trending northwest about ⅝ mile northwest of the Murphy Corners road. Five trenches and several pits have been put down on the ridge. The trenches trend north-south. Two trenches measure about 15 feet long and two others are 25 feet long; they are all about 5 feet wide and 2–4 feet deep. Rusty gossan is exposed in all the trenches. Magnetite, pyrite, pyrrhotite, and chalcopyrite mineralization was observed in the skarn, which is composed of hornblende, diopside, epidote, garnet, and calcite, composite chip samples taken down the entire length of two of the trenches by the author assayed 0.39 and 0.43 percent copper.

Granite

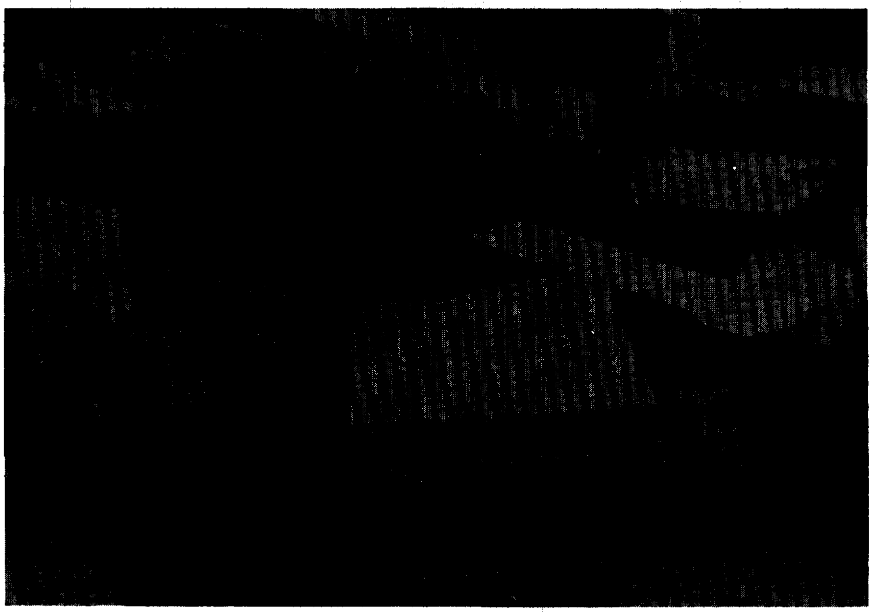
Granite has been quarried at several places in the Coe Hill area, but the main production came from the Ebonridge quarries, in lot 24, concession V, and the Upper Canada granite quarries, in lot 27, concession III; these quarries are in the Coe Hill granite pluton. A pink granite body located in lot 17, concession VII, was tested by C. E. Muffit of Bancroft. A few test blocks were taken in lot 17, just south of the road to Wollaston Lake, but there was no commercial production. The Bachelor granite quarry, located on the north slope of the hill near the Ebonridge quarries, was worked to a limited extent.

UPPER CANADA GRANITE QUARRIES
(Lot 27, Concession III)

In 1940 and 1941, Upper Canada Granite Quarries operated a small red granite quarry in lot 27, near the lot 26 line, in concession III, Wollaston township. The quarry is located on the northeast side of a small granite knoll, about ½ mile south of the Coe Hill–Lasswade road, and may be reached by wagon road.

The quarry face is about 12 feet high, and the quarry has been advanced to the southwest into the side of the hill. The face trends northwest and has a length of about 80 feet. The width of the present quarry floor is about 30 feet.

The stone is a medium-grained, pink biotite granite. Irregular horizontal sheeting makes quarrying difficult. One vertical set of joints strikes N.30°–50°W. A second set of joints strikes N.60°E. and dips 80°SE. Quartz stringers



Granite blocks, Upper Canada granite quarry.

up to ½ inch in width are occasionally found cutting the granite. Narrow dikelets of granite pegmatite, up to 6 inches in width, and dikelets of pink, fine-grained leucogranite cut the pink biotite granite.

The granite forms part of the Coe Hill granite, an irregular composite granite stock much contaminated by inclusions of diorite and amphibolite. A few chains south of the quarry the granite contains many diorite inclusions. To the west of the quarry, the granite contains large inclusions of diorite containing pink feldspar porphyroblasts. The ground north of the quarry is low and swampy.

The stone has a pleasing red colour and makes a satisfactory building and monumental stone.

Ebonridge granite quarry.

EBONRIDGE QUARRIES LIMITED
(Lot 24, Concession V)

Ebonridge Quarries Limited was opened in 1921 by the Morrison brothers and operated until 1930. There are two small quarries, in lot 24, concession V, about 500 feet west of the Gilroy Lake road. One quarry is in greyish pink biotite granite, the other is in black, medium- to fine-grained diorite.

The greyish pink granite, called heather granite, is medium grained and consists of grey and pink microcline and albite, grey quartz, and biotite. Mafic minerals make up to 10–15 percent of the rock, giving it a rather dark colour. Apatite, titanite, magnetite, and carbonate are minor accessories.

The granite is massive to slightly gneissic. The heather granite quarry is located on the east face of a low granite knoll not far from the farmhouse in lot 23, concession V. The quarry opening measures about 80 by 30 feet, with a face of about 8 feet in depth. Flat, irregular horizontal sheeting in the granite parallels the rock surface. These joints are spaced 2–3 feet apart. One prominent set of vertical joints strikes N.30°W.; a second set of joints strikes

N.85°E. and dips 80°N. Inclusions of porphyritic biotite granite gneiss occur in the massive granite. Patches of pink leucocratic granite, and minor granite pegmatite stringers, were also noted.

To the northwest a small body of black dioritic rock is intruded by and caught up within the granite. A small quarry has been opened in this "black granite" about 500 feet north of the heather granite quarry. The quarry opening is 30 by 30 feet and about 6 feet deep. The rock is a medium-grained, black, silver-grey-weathering, massive biotite diorite consisting of plagioclase, hornblende, and biotite. It is cut by pink biotite granite. Irregular jointing has made it difficult to quarry regular mill blocks of this stone, and the stone frequently breaks into wedge-shaped blocks. Some pyrite occurs in the stone causing rusty discolouration on weathered surfaces.

Iron[1]

COE HILL IRON MINE
(Lots 15 and 16, Concession VIII)

The Coe Hill iron mine is located on the top of a small knoll 500 feet south of the main street in Coe Hill village, in lots 15 and 16, concession VIII, Wollaston township. The mine, which operated from 1884 to 1887, is served by a spur-line of the Canadian National Railways. It is reported that 80,000–100,000 tons of iron ore was mined during the period of operation, but the high sulphur content of the ore proved objectionable, and much of the ore was stockpiled. The stockpiled ore on the property has now cemented together. The property was drilled in 1910. At present the mine is owned by Canada Iron Mines Limited, a subsidiary of Ventures Limited.

The workings consist of an open cut about 600 feet in length, striking N.50°E., having a width of 15–30 feet. The depth of the cut averages 20–40 feet, but two shafts, reported to be 130 and 100 feet deep, were sunk from the bottom of the open cut. A third shaft of 95 feet depth was sunk about 300 feet to the northeast on strike of the open cut, on a small magnetite pod. Two entry cuts, 100–130 feet long, run to the southeast from the main open cut and expose a good cross-section of the country rocks. The country rocks on the knoll where the mine is located are otherwise poorly exposed.

The rock exposed in the open cut is rusty magnetite and pyrite-bearing pyroxene amphibolite. Magnetite, pyrite, and pyrrhotite occur with bright green diopside and black hornblende in a granular, medium-grained rock, which occurs as pods and lenses in the marble and para-amphibolite country rock. Interbanded marble and paragneiss are exposed in the entries to the south of the main cut. Pink, medium-grained biotite syenite dikes and stringers cut the ore zone, the marble, and the paragneiss. The biotite syenite is well exposed at the south end of the southwest entry cut. Here also there are rounded outcrops of massive-weathering biotite paragneiss. The country rocks strike N.50°E. and dip 50°–70°SE.

The following excerpts are taken from the description of the Coe Hill iron mine in the 1923 Report of the Ontario Iron Ore Committee:

> An average sample taken across the ore body by Lindeman gave the following analysis: 47.30 percent iron; 30.90 percent insoluble; 2.21 percent sulphur and 0.018 percent phosphorus.
>
> The owners estimate the main body to have a length of 600 feet, a width of 30 feet, and a depth of 360 feet, and they estimate the probable tonnage of ore contained in it at 600,000 tons (W. J. McLaughlin) and the average composition of this ore to be as follows: 51.40 percent iron; 13.00 percent silica; 1.71 percent sulphur; 0.045 percent phosphorus.

[1] *See also* E. R. Rose "Iron Deposits of Eastern Ontario and adjoining Quebec" Geol. Surv. Canada, Bull. 45, 1958.

JENKINS MINE
(Lots 17 and 18, Concession VIII)

The Jenkins iron mine lies ½ mile west of the Coe Hill iron mine, about 400 feet south of highway No. 602. A shallow open cut, 180 feet long and 10–20 feet wide, exposes rusty pyroxenic amphibolite containing magnetite and pyrite. The country rocks are not exposed in the vicinity of the pit, which itself is heavily overgrown with trees. The deposit is similar to that of Coe Hill iron mine.

UMFRAVILLE IRON PROPERTY
(Lots 10 and 11, Concession XVI)

A prominent magnetic anomaly, of 5,000 gammas magnetic relief on the Coe Hill aeromagnetic sheet, lies within the western margins of the Umfraville gabbro, in lots 10 and 11, concession XVI, Wollaston township. This anomaly is named the McMurray Lake anomaly in Abraham's report (Abraham 1951, p. 13), and a sample of the magnetite-bearing gabbro taken by Abraham from the anomaly area assayed 18.29 percent Fe; 0.15 percent S; 7.40 percent TiO_2; 3.70 percent P_2O_5, and 17.91 percent SiO_2. The anomaly crosses the Ragged Lake road in lot 10.

This anomaly was examined, and a dip-needle survey was carried out by A. T. Griffis in 1957. The property was optioned to Rio Tinto Canadian Exploration Limited in 1957, and magnetometer surveys, geological mapping, and diamond-drilling were carried out. This work indicated a magnetite-bearing pyroxenic amphibolite zone about 3,000 feet long and 400–750 feet wide within the Umfraville gabbro. The magnetite occurs disseminated in a medium-grained pyroxenic amphibolite composed essentially of pyroxene, hornblende, magnetite, and ilmenite, with accessory biotite and apatite. The amphibolite is within the Umfraville gabbro, and in places the amphibolite grades into gneissic meta-gabbro. The magnetite-bearing amphibolite is cut by granite pegmatite, aplite, and diorite. The amphibolite appears to strike in a northerly direction and to dip 50°–80°W.

Seven diamond-drill holes, totalling 2,218 feet, were drilled on three sections about 700 feet apart. The holes were drilled at 40°W. on sections running S.70° W. across the ore-bearing zone. The diamond-drilling indicated a large magnetite-bearing zone grading from 10–20 percent iron.

Mica

Thomson (1943, p. 61) describes a showing as follows:

> A few shots have been blasted out of a pegmatite dike in lot 25, concession I, Wollaston township. The dike, which contains a little sheet muscovite at one point, attains a width of 50 feet and is traceable for 350 feet but shows little sign of sheet mica except where the work was done. Books of mica up to 15 inches in long dimension may be seen, but the amount is very small. The lot is owned by Herbert Moore, of The Ridge.

Talc

LOTS 8 AND 9, CONCESSION XI

A small pit, measuring 8 by 10 feet by 10 feet deep, was sunk on a talc showing in lot 8, concession XI, Wollaston township. The pit is located about ½ mile north of the Deer River. The talc occurs in a white tremolite-diopside rock, which forms a narrow band striking N.20°E., dipping 60°–70°W. The talc-bearing material consists largely of tremolite and is quite hard. It occurs in a linear valley between two ridges of white crystalline dolomite. Syenite intrudes the dolomite.

Other trenches were put down on the zone to the south along strike, but no good quality talc was observed by the author. The talc-bearing zone is reported to have been drilled in the 1930's by Roy Taylor of Canada Talc Company, Madoc.

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INDEX

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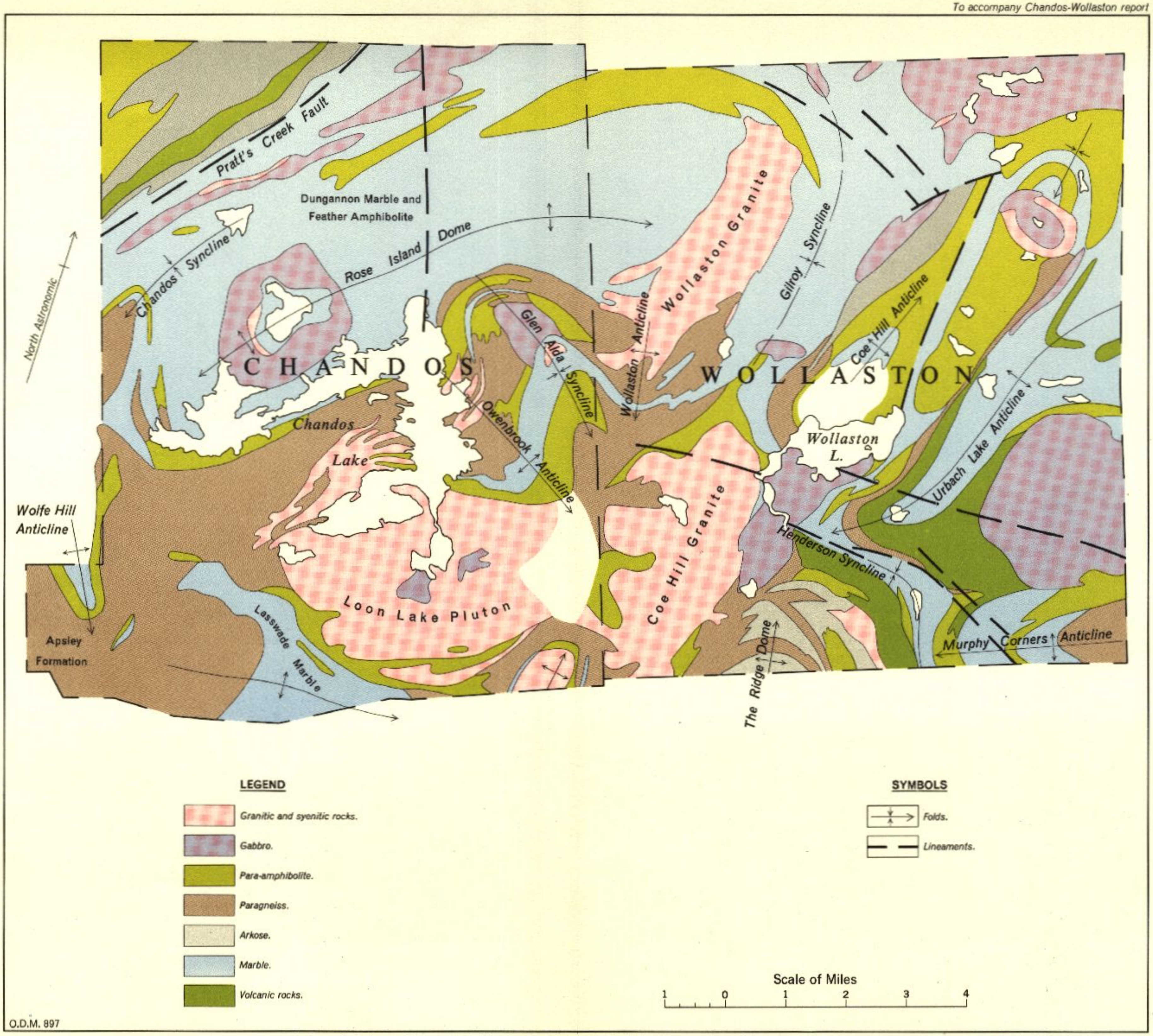
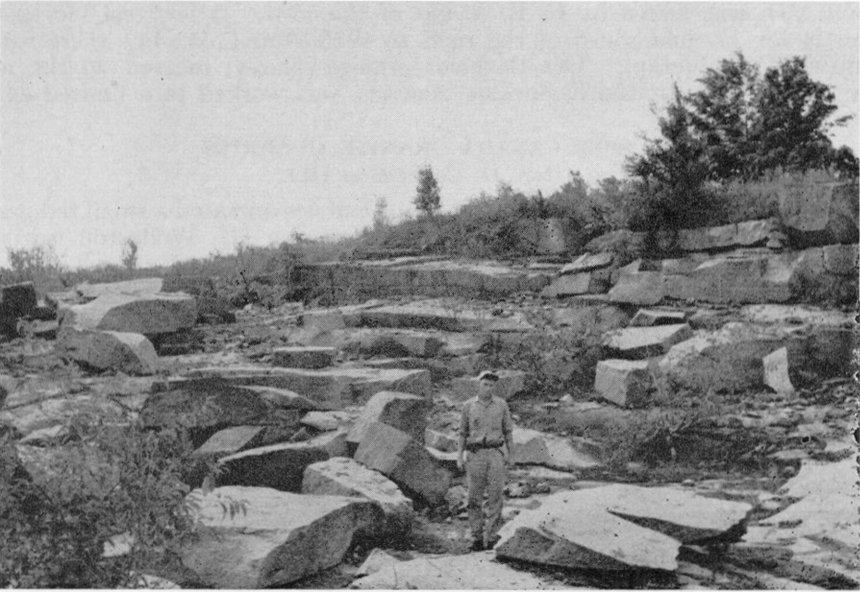


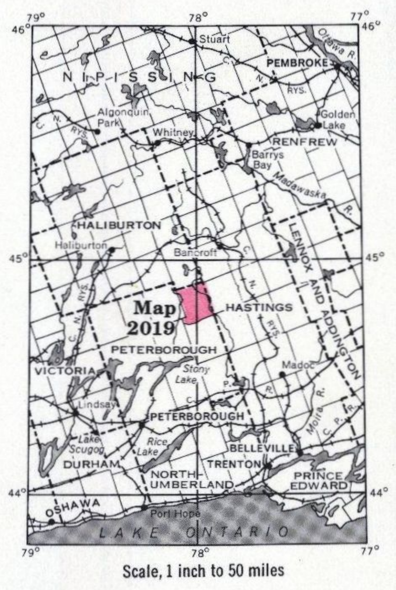
Generalized geological and structural map of Chandos and Wollaston Townships

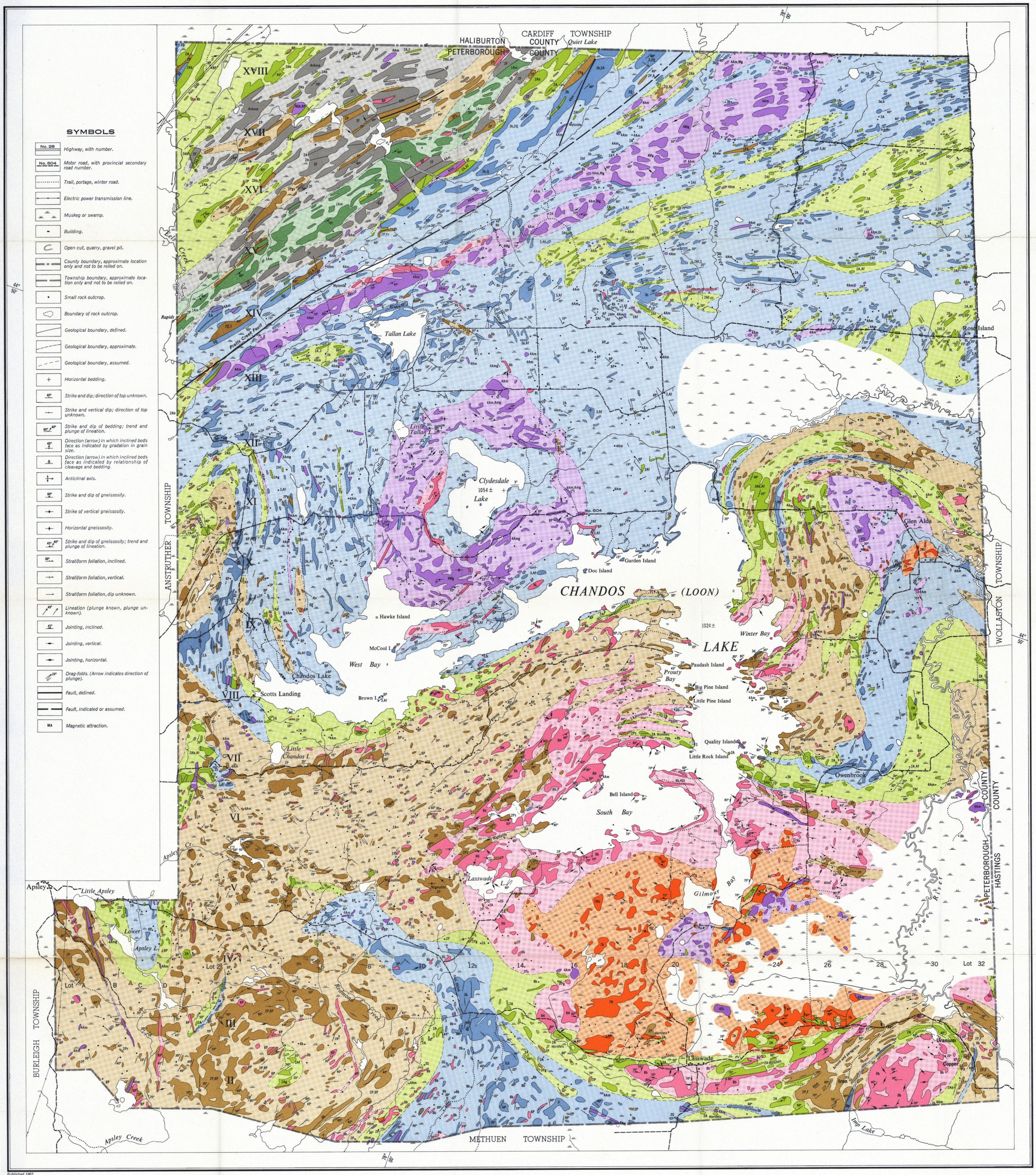


ONTARIO
DEPARTMENT OF MINES

HON. G. C. WARDROPE, *Minister of Mines*
D. P. Douglass, *Deputy Minister*   M. E. Hurst, *Director, Geological Branch*

Map No. 2019
Chandos Township





Map 2019

CHANDOS TOWNSHIP

COUNTY OF PETERBOROUGH, ONTARIO

Scale 1:31,680 or 1 Inch to ½ Mile

Chains 80 60 40 20 0 1 2 Miles
Metres 1000 0 1 2 3 Kilometres
Feet 1000 0 5,000 10,000 Feet

LEGEND

CENOZOIC*

RECENT AND PLEISTOCENE
Sand, gravel and clay.

GREAT UNCONFORMITY

PRECAMBRIAN**

PLUTONIC ROCKS

GRANITIC ROCKS

- 8L *Pink and white leucogranite; granite gneiss.*
- 8b *Biotite granite; biotite granite gneiss.*
- 8H *Hybrid granite gneiss, (interbanded granite gneiss and amphibolite); granitized gneiss.*
- 8P *Granite pegmatite; pegmatitic granite.*

INTRUSIVE CONTACT

SYENITIC ROCKS

- 7b *Biotite syenite; biotite syenite gneiss.*
- 7H *Hybrid syenite gneiss, (interbanded syenite gneiss and amphibolite); syenitized gneiss.*
- 7Mz *Monzonite.*
- 7P *Syenite pegmatite.*

INTRUSIVE CONTACT

OLDER BASIC INTRUSIVE AND META-INTRUSIVE ROCKS

- 4Di *Diorite.*
- 4Gb *Gabbro.*
- 4Hb *Hornblendite.*
- 4Mg *Metagabbro; hornblende-plagioclase gneiss.*
- 4Am *Amphibolite; hornblende schist; 4Amg, garnet amphibolite; 4Amb, biotite amphibolite.*
- 4Db *Diabase.*

INTRUSIVE CONTACT

METASEDIMENTS

MARBLE

- 3 *Crystalline limestone; dolomite; marble; 3Af, interbedded marble and feather amphibolite.*
- 3a *Interbedded marble and paragneiss or amphibolite.*
- 3b *Silicated marble; marble with accessory silicates.*
- 3d *Diopside marble.*
- 3Q *Sandy limestone or marble.*
- 3S *Lime silicate rock; metamorphic pyroxenite; skarn; diopside or tremolite rock.*

PARA-AMPHIBOLITE

- 2A *Para-amphibolite; hornblende-plagioclase gneiss and schist; 2Ab, biotite amphibolite; 2Af, feather amphibolite, 2Ag, garnet amphibolite.*

FELDSPATHIC SCHIST AND GNEISS, ARKOSE, FELSITE

- 2F *Feldspathic paragneiss and schist; arkose; felsite; quartzo-feldspathic paragneiss and schist; 2Fb, biotite feldspathic and quartzo-feldspathic gneiss and schist; 2Fr, rusty feldspathic schist.*

PARAGNEISS, QUARTZITE AND PSAMMOPELITIC SCHIST

- 2P *Paragneiss; biotite-quartz-plagioclase gneiss and schist; 2Pg, garnet paragneiss; 2Pgs, garnet-sillimanite paragneiss; 2Ps, sillimanite paragneiss; 2Pr, rusty paragneiss and schist.*
- 2Q *Quartzite, sandstone.*

METAVOLCANICS

- 1Am *Amphibolite, amphibolite schist.*

**Unconsolidated deposits. Cenozoic deposits are represented by the lighter coloured and uncoloured parts on the map.*

***Bedrock geology. Outcrops and inferred extensions of each rock unit are shown, respectively, in deep and light tones of the same colour.*

****Some acid volcanics occur in the 2F subdivision of metasedimentary group.*

SOURCES OF INFORMATION

Geology by D. M. Shaw and assistants, 1958; D. F. Hewitt and assistants, 1959.

Cartography by D. F. Jupe, Ontario Department of Mines, 1961.

Base map derived from maps of the Forest Resources Inventory, Ontario Department of Lands and Forests, with additional information by D. F. Hewitt.

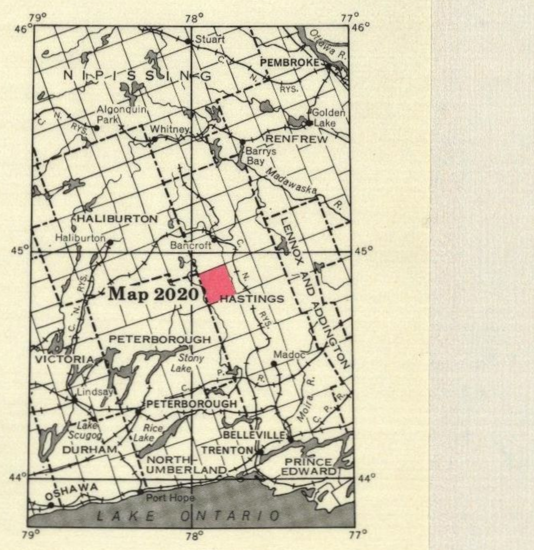
Magnetic declination approximately 11° W.

ONTARIO
DEPARTMENT OF MINES

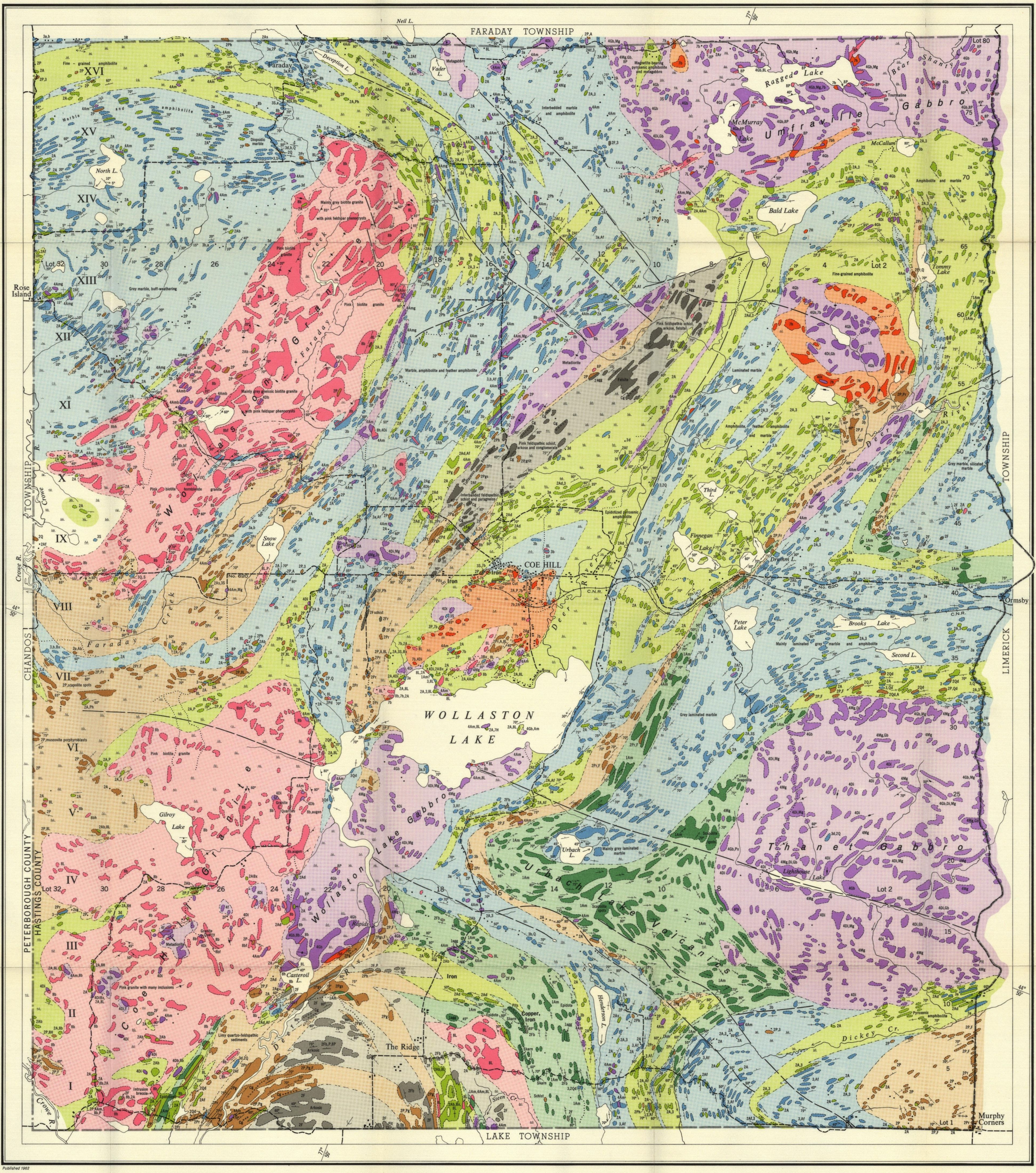
HON. G. C. WARDROPE, *Minister of Mines*

D. P. Douglass, *Deputy Minister* M. E. Hurst, *Director, Geological Branch*

Map 2020
Wollaston Township



Scale 1 inch to 50 miles



Published 1962

SYMBOLS

- Motor road, with provincial secondary road number. (No. 620)
- Trail, portage, winter road.
- Railway.
- Muskeg or swamp.
- Building.
- County boundary, approximate location only and not to be relied on.
- Township boundary, approximate location only and not to be relied on.
- Small rock outcrop.
- Boundary of rock outcrop.
- Geological boundary, defined.
- Geological boundary, approximate.
- Geological boundary, assumed.
- Horizontal bedding.
- Strike and dip; direction of top unknown.
- Strike and vertical dip; direction of top unknown.
- Strike and dip; top in direction of arrow.
- Strike and dip of bedding; trend and plunge of lineation.
- Direction (arrow) in which vertical beds face as indicated by gradation in grain size.
- Direction (arrow) in which overturned beds face as indicated by gradation in grain size.
- Direction (arrow) in which inclined beds face as indicated by relationship of cleavage and bedding.
- Direction (arrow) in which overturned beds face as indicated by relationship of cleavage and bedding.
- Direction in which lava flows face as indicated by shape of pillows.
- Synclinal axis.
- Strike and dip of schistosity.
- Strike of vertical schistosity.
- Strike of schistosity, dip unknown.
- Strike and dip of gneissosity.
- Strike and dip of gneissosity; trend and plunge of lineation.
- Strike of vertical gneissosity.
- Stratiform foliation, inclined.
- Stratiform foliation, vertical.
- Lineation (plunge known, plunge unknown).
- Jointing, inclined.
- Jointing, vertical.
- Drag-folds. (Arrow indicates direction of plunge).
- Fault, indicated or assumed; lineament.
- Test pit.

LEGEND

CENOZOIC*

RECENT AND PLEISTOCENE
Sand, gravel and clay.

GREAT UNCONFORMITY

PRECAMBRIAN**

PLUTONIC ROCKS

GRANITIC ROCKS

- 8L *Pink and white leucogranite; granite gneiss.*
- 8b *Biotite granite; biotite granite gneiss; 8bh, biotite-hornblende granite; 8bf, biotite granite with feldspar phenocrysts.*
- 8h *Hornblende granite; hornblende granite gneiss.*
- 8H *Hybrid granite gneiss, (interbanded granite gneiss and amphibolite); granitized gneiss.*
- 8P *Granite pegmatite; pegmatitic granite.*

INTRUSIVE CONTACT

SYENITIC ROCKS

- 7L *Pink and white leucosyenite; syenite gneiss; albitite.*
- 7b *Biotite syenite; biotite syenite gneiss; 7bh, biotite-hornblende syenite; 7bf, biotite syenite with feldspar phenocrysts.*
- 7h *Hornblende syenite; hornblende syenite gneiss.*
- 7H *Hybrid syenite gneiss, (interbanded syenite gneiss and amphibolite); syenitized gneiss.*

INTRUSIVE CONTACT

OLDER BASIC INTRUSIVE AND META-INTRUSIVE ROCKS

- 4Di *Diorite; 4DiBx, diorite breccia.*
- 4Gb *Gabbro.*
- 4Hb *Hornblendite.*
- 4Mg *Metagabbro; hornblende-plagioclase gneiss.*
- 4Am *Amphibolite; hornblende schist; 4Amg, garnet amphibolite; 4Amb, biotite amphibolite.*
- 4Px *Pyroxenite.*
- 4f *Amphibolite porphyry with feldspar porphyroblasts.*

INTRUSIVE CONTACT

METASEDIMENTS

MARBLE

- 3 *Crystalline limestone; dolomite; marble; 3,Af interbedded marble and feather amphibolite; 3 lam, laminated marble.*
- 3a *Interbedded marble and paragneiss or amphibolite.*
- 3b *Silicated marble; marble with accessory silicates.*
- 3d *Diopside marble.*
- 3Q *Sandy limestone or marble; 3Qd, sandy diopside marble.*
- 3R *Argillaceous limestone or marble; impure shaly or silty limestone.*
- 3S *Lime silicate rock; metamorphic pyroxenite; skarn; diopside or tremolite rock.*
- 3Bx *Marble tectonic breccia.*

PARA-AMPHIBOLITE

- 2A *Para-amphibolite; hornblende-plagioclase gneiss and schist; 2Ab, biotite amphibolite; 2Ad, diopside amphibolite; 2Af, feather amphibolite; 2Ag, garnet amphibolite; 2Ar, rusty amphibolite; 2As, scapolite amphibolite; 2ABx amphibolite breccia.*

FELDSPATHIC SCHIST AND GNEISS, ARKOSE, FELSITE

- 2F *Feldspathic paragneiss and schist; arkose; felsite; quartzo-feldspathic paragneiss and schist; 2Fb, biotite feldspathic and quartzo-feldspathic gneiss and schist; 2Fr, rusty feldspathic schist;*
- 2agg *Agglomerate.*
- 2cg *Conglomerate.*

PARAGNEISS, QUARTZITE AND PSAMMOPELITIC SCHIST

- 2P *Paragneiss; biotite-quartz-plagioclase gneiss and schist; 2Pd, diopside paragneiss; 2Pg, garnet paragneiss; 2Pgs, garnet, sillimanite paragneiss; 2Ph, hornblende paragneiss; 2Pr, rusty paragneiss and schist.*
- 2cg *Conglomerate.*
- 2Q *Quartzite, sandstone; 2Qb, biotite quartzite; 2Qd, diopside quartzite.*

METAVOLCANICS***

- 1Am *Amphibolite, amphibole schist.*
- 1agg *Agglomerate.*

**Unconsolidated deposits. Cenozoic deposits are represented by the lighter coloured and uncoloured parts on the map.*

***Bedrock geology. Outcrops and inferred extensions of each rock unit are shown, respectively, in deep and light tones of the same colour.*

****Some acid volcanics occur in the 2F subdivision of metasedimentary group.*

SOURCES OF INFORMATION

Geology by D. F. Hewitt and assistants, 1959.

Cartography by J. E. Stankiewicz, Ontario Department of Mines, 1961.

Base map derived from maps of the Forest Resources Inventory, Ontario Department of Lands and Forests, with additional information by D. F. Hewitt.

Magnetic declination approximately 11° W.

Map 2020

WOLLASTON TOWNSHIP

COUNTY OF HASTINGS, ONTARIO

Scale 1:31,680 or 1 Inch to ½ Mile

Chains — Miles — Metres — Kilometres — Feet