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Geology of Ashby and Denbigh Townships

By

A. M. EVANS

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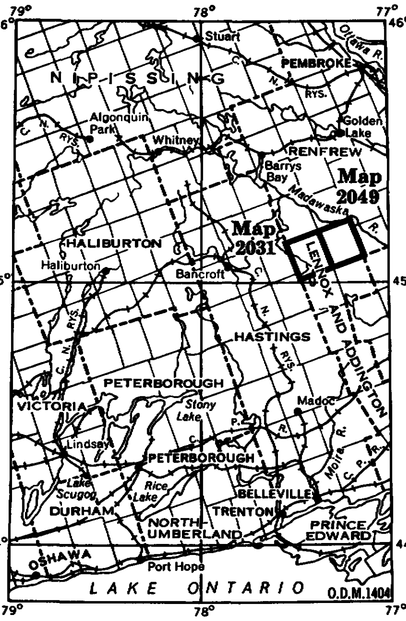
ABSTRACT

All of the bedrock in Ashby and Denbigh townships is Precambrian. The oldest rocks are marbles, paragneisses, and para-amphibolites. These are assigned to the Dungannon and Hermon formations (already defined) and to the newly defined Denbigh Formation. These formations, which were intruded by a number of basic igneous bodies before their regional metamorphism, occupy most of Denbigh township and the northern part of Ashby township.



Key map showing the location of the Ashby-Denbigh map-area. Scale, 1 inch to 50 miles.

Most of Ashby township is underlain by the north half of a large batholith of granitic gneiss. This deflects the folds present in the metasediments and is clearly intrusive into them. Beyond the influence of this batholith, the folds trend approximately northeast; but this trend is much modified in Denbigh township by west-northwest-trending crossfolds that have produced marked plunge depressions and culminations in the major folds.

The dominant structure in Denbigh township is the Slate Falls synform occupying most of the centre of the township. The foliation of the Weslemkoon granite has been thrown into a series of major and minor folds trending northeast and southwest. The grade of metamorphism in the metasediments is that of the sillimanite-almandine-muscovite subfacies of the almandine-amphibolite facies.

Graphite and garnet have been mined in Denbigh township. Gravel is available for road building and marble is quarried for lime production. Dolomitic areas in the marble are indicated on Maps Nos. 2031 and 2049. The small metagabbro bodies are potential host rocks for base metals. Veinlets of iron sulphides are present in the Ashby metagabbro.

Geology of Ashby and Denbigh Townships

By

A. M. Evans[1]

INTRODUCTION

Ashby and Denbigh townships form the most northern part of Lennox and Addington county in eastern Ontario. They extend over 160 square miles and are covered by the Bancroft and Denbigh sheets of the National Topographic Series.[2]

The villages and post offices of Denbigh and Slate Falls are in Denbigh township.

Prospecting and Mining Activity

Little prospecting appears to have been carried out in these townships. An early note of such activity mentions two reported occurrences of gold in Denbigh township (Ells 1904; 1905). Later prospecting in the area has been concerned with graphite, garnet, asbestos, base metals, and uranium. Mining activity in the township has been restricted to graphite and garnet.

During 1902 and 1903, J. G. Allan of Hamilton worked a small graphite mine in lot 34, concession VIII, of Denbigh township.

Bancroft Mines Syndicate Ltd. operated a garnet quarry and mine in the northeastern part of Ashby township from 1922 to 1924; this is known locally as the Ruby mine.

Present Geological Survey

The present geological survey of Ashby and Denbigh townships was made during the summers of 1956 and 1957. The field work was carried out by two senior assistants, who were responsible for the field mapping, and two junior assistants who ran pace-and-compass traverses.

Air photographs on the scale of 1 inch to ¼ mile were employed in field mapping, and most of the area was surveyed by running traverses between points readily locatable on these photographs. Probable outcrop areas were outlined on the photographs by using a pocket stereoscope, and the traverses were planned to cross as many areas of potential outcrop as possible. The general traverse interval was ¼ mile Information obtained on the traverses was supplemented by examining the rock exposures around nearly all the lakes in the area and along all the roads and many of the trails.

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[2]Published on the scale of 1:50,000 by the Canada Department of National Defence, and available from the Canada Department of Mines and Technical Surveys, Ottawa.

The geology was recorded on acetate (Perfatrace) sheets placed over the air photographs. From these it was transferred by the use of a Sketchmaster to a basemap on the scale of 1 inch to ¼ mile, prepared by the Cartography Unit of the Ontario Department of Mines from maps of the Forest Resources Inventory, Ontario Department of Lands and Forests. The final maps, Nos. 2031 and 2049 (*back pocket*), are reproduced on the scale of 1 inch to ½ mile.

The outcrops shown on the published map record as much detail as can be presented on this scale. Areas with many small outcrops are shown as large outcrops. Within these areas, bedrock could be reached in many places by trenching. Because the traverse interval was large, many outcrops in the area were not visited during this survey. The final map must, therefore, be regarded as a generalization based only on the data collected during the survey and open to revision as soon as further detailed surveys are performed in these townships.

The colour and first symbol of each outcrop area indicate the dominant rock present. Rock types present in subsidiary amounts in the same outcrop area are indicated by the succeeding symbols. It must be emphasized that in these townships, as in other parts of the Grenville Province, the rocks may show considerable lithological variations over short distances. Some of the rock types weather away much more rapidly than others. Therefore, the rocks present in some outcrops may give a somewhat erroneous impression of the general geology of the area immediately around them. This is particularly true of granite pegmatites. These often stand out in contrast against the paragneisses and may therefore be thought to form more of the bedrock than they actually do.

Acknowledgments

The author was ably assisted in the field in 1956 by E. C. Appleyard, E. Thompson, and J. Verity, and in 1957 by E. C. Appleyard, G. L. Rock, and T. Pugsley. Mr. Appleyard, as senior assistant, was responsible for half the geological mapping. The author would like to thank all the members of the party for their able assistance during the course of the survey.

The writer wishes to express his appreciation to the residents of the area, who generously rendered assistance in various ways during the field season.

Means of Access

Much of Denbigh township is readily accessible by road. Highway No. 41 from Napanee to Eganville runs across the township. The gravel roads leading off the highway are unequal in merit but, in general, they provide easy access to the township.

Ashby township is less accessible. The northern parts are best approached from gravel roads in Raglan township, the most useful being the road joining McArthurs Mills (Mayo township) to the village of Hardwood Lake and the road from Hardwood Lake to Denbigh. The gravel road running south in Raglan township to lot 15, concession XVI, of Ashby township has been extended southward by the Ontario Department of Lands and Forests to the otherwise inaccessible centre of the township. The positions of this road and also of a short branch road were plotted by means of a pace-and-compass survey and are shown on map No. 2031. Two other branch roads diverge from this gravel road to give access to Spring and Len lakes.

The western section of Ashby township can be approached by using a gravel road from McArthurs Mills to Weslemkoon Lake. A trail runs from this road to

Barnard Lake; there is another trail (not shown on the map) to Crystal Lake. Boats are usually available on both these lakes and can be hired for use in penetrating to other parts of the township. Crystal Lake is particularly useful from this point of view.

Weslemkoon and Cotter lakes give access to a large part of Ashby township. Gravel roads lead from highway No. 41 in Denbigh to Ashby Lake and Ashden Lake, both in Ashby township. An easy portage links Ashby Lake to King Lake, and another easy portage allows Barker Lake to be reached. The southeastern corner of Ashby township can be approached by a gravel road from highway No. 41.

Previous Geological Work

The only geological mapping of Ashby and Denbigh townships done prior to the present survey was conducted in 1895 and 1896 (Ells 1904; 1905). The resulting map, identified as the Perth sheet (Geol. Surv. Canada, map No. 119), was published in 1904 on a scale of 1 inch to 4 miles.

In his review of Canadian graphite resources, Ells describes the mining of graphite in Denbigh township (Ells 1904a). His description of the deposit was subsequently repeated by Spence (1920, p. 39). Details of the garnet mine[1] in Ashby township were recorded later (Eardley-Wilmot 1927, pp. 13, 14). This mine was revisited still later and carefully studied by Satterly (1945, p. 126).

The results of a stratigraphical and structural survey of the Ottawa-Bonnechère graben and adjacent areas were also published (Kay 1942, pp. 585–646). The conclusions of Kay's report are discussed in this report in the section on topography.

Aeromagnetic maps, published by the Geological Survey of Canada, are available for the whole area. The two relevant sheets are: Map No. 15G—Bancroft, Ontario, 1950; and Map No. 96G—Denbigh, Renfrew, Frontenac, Hastings, and Lennox and Addington counties, Ontario, 1952.

A geological reconnaissance of Matawachan township, east of Denbigh township, has been made (Satterly 1945, map); the two townships (Raglan and Lyndoch) north of the area have been described (Hewitt 1954); and Mayo township, to the west, has been surveyed (Hewitt and James 1956).

Topography

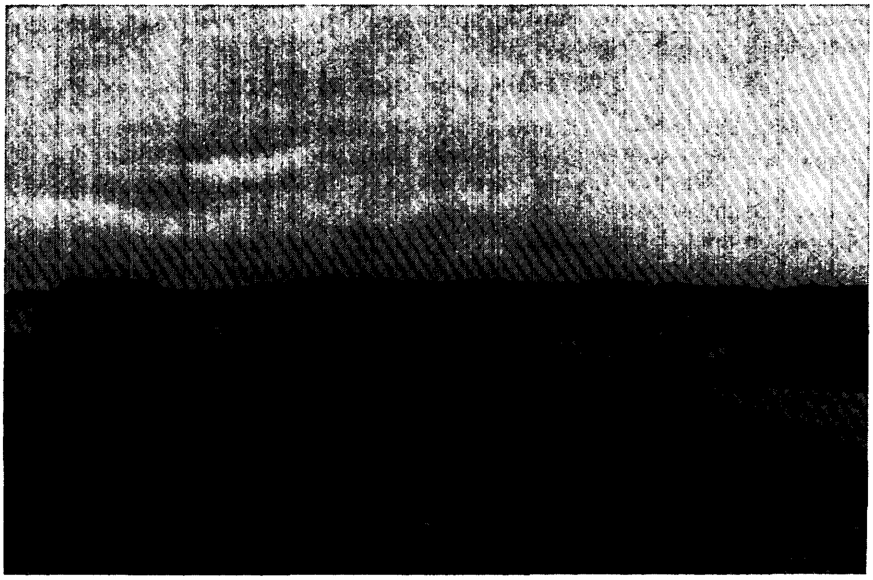
The general elevation of the area is between 1,100 and 1,300 feet. The highest points in the area reach nearly 1,600 feet and are in the hills 2 miles northwest of the village of Denbigh. The lowest point in the area, about 840 feet, is in the northeast corner of Denbigh township where Hydes Creek crosses the boundary into Lyndoch township.

The physiography of the area has been described by Kay (1942). According to Kay, most of Denbigh township and the northeastern corner of Ashby township belong (physiographically) to the Madawaska Highlands, and the rest of Ashby township and the southwest corner of Denbigh township belong to the Cashel peneplane. One paper (Hewitt 1956) on the regional geology of this part of Ontario has assigned the area (geologically) to the Madawaska Highlands.

The nature of the region's underlying bedrock has had a considerable influence on the topography of both townships. The highest ground is usually

[1]Location given by Eardley-Wilmot was lot 9; this lot No. has since been found to be incorrect.

formed of syenite gneiss, metagabbro, or granitic rocks. Granitic pegmatites often give rise to prominent ridges. In general, marked ridges in the area are parallel to the foliation of the bedrock. The granodioritic Weslemkoon batholith is an exception to the rule that granitic rocks usually give rise to high ground. Much of the area underlain by this unit is below 1,300 feet in height. The low ground outside the Weslemkoon batholith is usually underlain by marble.



View looking northwestward from lot 22, concession VI, Denbigh township, showing the highest ground in the area.

Drainage

The two townships contain more than 100 small lakes and ponds. The largest body of water, Weslemkoon Lake, lies in the southwest corner of Ashby township and stretches southward well into Effingham township. Weslemkoon Lake and the other large lakes of the area lie on, or close to, the Weslemkoon batholith. Most of the lakes and ponds outside the bounds of this geological unit owe their existence to the differential erosion of marble bands in the gneissic complex. Some creeks also follow marble bands or the strike of the foliation in the gneisses, but many creeks cut across the geological boundaries at great angles, as does the Little Mississippi River. The directions followed by many creeks are apparently related to the joint directions of the area. These joint directions also control the linear portions of the shorelines of Weslemkoon Lake.

The majority of the lakes in Ashby township drain through creeks and through Weslemkoon Lake to the Little Mississippi River. West of the map-area, this river joins the York River (a tributary of the Madawaska River) in Raglan township.

The lakes and creeks in the northeastern part of Ashby township and most of Denbigh township drain northward or eastward to the Madawaska River.

Natural Resources

A few farms have been established near the eastern and northern boundaries of Ashby township, but the main area of settlement is in Denbigh township. Denbigh township also contains a number of abandoned farmsteads on which the cleared ground is slowly being reclaimed by the bush.

Lumbering is an important industry in the area. Most of the timber cut is spruce, maple, yellow birch, hemlock, poplar, and pine.

The tourist industry is becoming increasingly important, and many cottages and summer resorts have been established on Weslemkoon, Denbigh, and Ashby[1] lakes.

GENERAL GEOLOGY

Ashby and Denbigh townships belong to the Grenville Province of the Precambrian Shield. All the bedrock is of Precambrian age. Unconsolidated deposits of Pleistocene age occur throughout the townships. In places, these deposits are sufficiently thick to mask the nature of the underlying bedrock; such an area appears on map No. 2049 (Denbigh) and has been left uncoloured.

From the regional point of view the area is similar in its rock types and structure to the Hastings Basin (Hewitt 1956, pp. 30, 31) (Hewitt and James 1956, pp. 6–11, 16–24). Some formations recognized in the Hastings Basin have been traced into the two townships.

The oldest rocks of the area are marbles, paragneisses, and amphibolites. These were formed by the regional metamorphism of a varied succession of sediments including limestones, greywackes, and normal and calcareous shales. After their deposition, these sediments were intruded by a number of basic igneous rocks, strongly folded, and then metamorphosed. Throughout the two townships, the metamorphism has produced sillimanite in rocks that have a suitable composition.

During the metamorphism, some of the metasediments were feldspathized and granitized, resulting in the production of syenite gneisses, granite gneisses, and some of the pegmatites. The latest events in this part of the geological history were the emplacement of the McArthurs Mills and Weslemkoon granites and the development of more pegmatites.

The metasediments are best seen in Denbigh where they underlie most of the township (*see* facing map). They also extend across the northern part of Ashby township where they have been mapped by Hewitt and James (1956). This continuity of outcrop across northern Ashby has enabled certain stratigraphical correlations to be made with the successions established by these workers in Dungannon and Mayo townships. It must be emphasized that this correlation depends upon the tentative structural interpretation advanced in this report.

The major structural feature of the metasedimentary terrane is a "synform"[2] occupying the central part of the north half of Denbigh township. This is referred to here as the Slate Falls synform. It is believed to be flanked by two antiforms:

[1] This lake is referred to locally as Thirty Islands Lake.

[2] The area has revealed only one exposure containing a primary rock structure indicating the direction in which the formations face. The noncommittal terms "antiform" and "synform" are therefore employed in place of anticline and syncline, because the use of the latter terms would imply that the strata forming the structures are known to be the right way up.

one of these appears to cross the northern part of Ashby township to join the Mayo anticline mapped by Hewitt and James; the other, the Rose Hill antiform, lies east of the Slate Falls synform and runs parallel to it.

TABLE OF FORMATIONS

CENOZOIC

PLEISTOCENE — Boulder clay, silt, sand, gravel.

Great Unconformity

PRECAMBRIAN

PLUTONIC ROCKS — Granite pegmatites.
McArthurs Mills granite.
Weslemkoon granite.

Intrusive Contact

Granite and syenite gneisses and pegmatites.
Eagle Hills metagabbro and other metamorphosed basic igneous intrusions.

Intrusive Contact

GRENVILLE-TYPE METASEDIMENTS

Mayo Group:
- Denbigh Formation:
  - Paragneiss member; marble member.
- Hermon Formation:
  - Paragneiss and amphibolite.
- Dungannon Formation:
  - Marble member; amphibolite member.

The structure of the whole area has been complicated by the emplacement of the Weslemkoon granite. This forms a large batholith underlying a number of townships south of the area, the greater part of Ashby, and the southwest corner of Denbigh township. The distribution of the other plutonic rocks of the area is indicated on the generalized geological map (facing p. 5). The probable age relationships of the Precambrian rocks are indicated in the Table of Formations.

Long after the last metamorphic and plutonic events, the whole area was peneplaned. This was probably late in the Precambrian.

In adjoining areas, Hewitt has mapped northwest-trending faults of Tertiary age (Hewitt 1954, pp. 5, 6, 31–34). Faults of the same system are not prominent in Ashby or Denbigh townships; but a number of weakly developed lineaments have the same trend and probably indicate that the area was affected by minor faulting at this time.

During the Pleistocene, the whole region was glaciated by a continental ice-sheet. As the ice retreated, deposits of boulder clay and glaciofluvial sand and gravel were formed. These lie as a mantle on the bedrock.

Precambrian

Metasediments of the Mayo Group

Because the three formations of the Mayo group mapped in Ashby and Denbigh townships have a number of rock types in common, the principal characteristics of these formations are discussed here, and the petrography of the rocks they are composed of is described.

The Dungannon Formation and the Hermon Formation were defined by

MAP LEGEND
(As shown on maps Nos. 2031 and 2049 in back pocket.)

CENOZOIC

RECENT AND PLEISTOCENE Sand, gravel, and clay.

Great Unconformity

PRECAMBRIAN

PLUTONIC ROCKS

Granitic Rocks:

8a Pink and grey leucogranite gneiss.
8b Hornblende granite or hornblende granodiorite; hornblende granite gneiss or hornblende granodiorite gneiss.
8c Biotite granite or biotite granodiorite; biotite granite gneiss or biotite granodiorite gneiss.
8p Pegmatite.

Syenitic Rocks:

7a Pink and grey leucosyenite; leucosyenite gneiss.
7b Hornblende syenite; hornblende syenite gneiss.
7c Biotite syenite; biotite syenite gneiss.
7p Pegmatite.[1]

Nepheline Syenitic Rocks:

6m Nepheline-aegirine-augite syenite gneiss.[1]

Intrusive Contact

Metamorphosed Basic Intrusive Rocks:

4d Metagabbro, hornblende-plagioclase schist.
4s Hornblende-scapolite gneiss.
4e Amphibolite, hornblende schist.

METASEDIMENTS

Marble:

3 Marble, largely or wholly calcite.
3z Dolomitic marble.
3b Silicated marble, silicates include chondrodite, diopside, phlogopite, plagioclase, tremolite.
3c Marble with graphite.[1]
3s Calc-silicate rock.

Paragneiss-Amphibolite Group (Includes all metasedimentary rocks except marbles. Some areas mapped as para-amphibolite may represent metamorphosed basic igneous rocks.):

2a Amphibolite (hornblende-plagioclase gneiss and schist), includes biotite amphibolite, biotite-scapolite amphibolite, garnet amphibolite, rusty-weathering amphibolite containing small amounts of iron sulphides.
2f Quartzo-feldspathic gneiss, includes muscovite-quartz-feldspar gneiss or schist, sometimes with sillimanite.
2p Paragneiss (biotite-quartz-plagioclase gneiss), includes garnet paragneiss, muscovite-garnet paragneiss, sillimanite-garnet paragneiss, hornblende paragneiss, *lit par lit* gneiss (centimetres-thick bands of paragneiss and granitic gneiss), rusty-weathering paragneiss containing small amounts of iron sulphides.
2q Quartzite, includes garnet quartzite.

METAVOLCANICS[1]

1a Amphibolite.

[1]Not on map No. 2031.

Hewitt and James (1956, pp. 8, 16–24). The Denbigh Formation is believed to overlie them; it is defined in this report on pages 10, 11.

DUNGANNON FORMATION

Only the uppermost member of this formation has been positively identified in the area. This is the marble member forming the core of the Mayo anticline where it crosses the township boundary between Mayo and Ashby. Because this fold plunges northeast, the outcrop of the marble narrows rapidly and, soon after passing into Ashby, the marble disappears below the overlying Hermon Formation. The plunge depression ends near Len Lake, and the marble reappears and follows the fold around the Weslemkoon granite into Denbigh township where, owing to another plunge depression, it again disappears below the Hermon Formation.

The marble immediately northeast and southeast of the Eagle Hills metagabbro is believed to represent the continuation of the Mayo core. North of Simpson and Ashden lakes, an amphibolite member occurs in the marble. This horizon may be of the same age as the Turriff rusty schist and Detlor feather amphibolite and marble members of Dungannon and Mayo townships. It does not, however, have any development of feather amphibolite.

Near the south end of Ashden Lake, a few outcrops of a metamorphosed basic volcanic rock have been found. One outcrop contains what are obviously pillow structures. This rock could represent volcanicity of the same age as the volcanicity responsible for producing the basic volcanic member in Dungannon township.

The maximum thickness attained by the members of the Dungannon Formation in this area is about 2,000 feet.

HERMON FORMATION

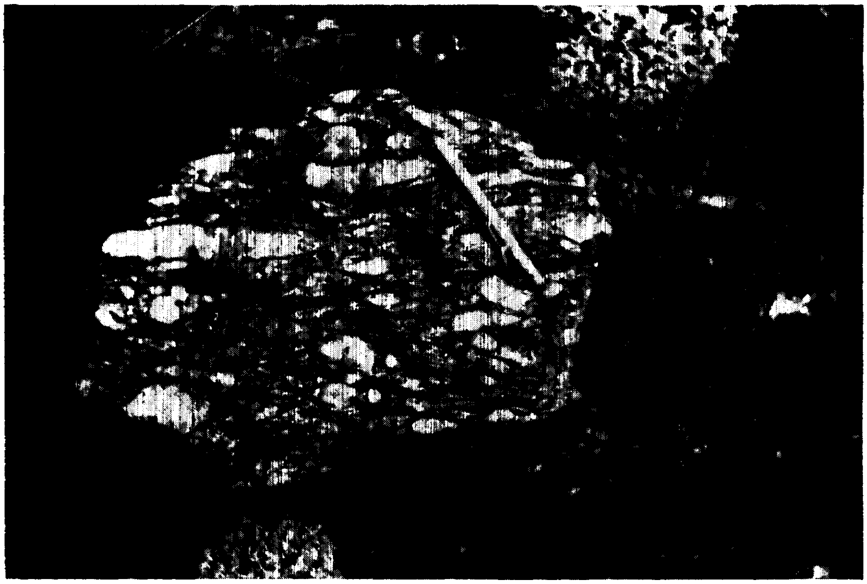
All the paragneiss and para-amphibolite in the northwestern part of Ashby township belong to this formation. The same rocks can be traced with few interruptions along both limbs of the Mayo anticline, from Mayo through Ashby and Denbigh, to Abinger township. If the structural interpretation of the area is correct, then the Hermon Formation is also present in eastern Denbigh township in the core of the Rose Hill antiform.

The Hermon Formation has been mapped previously in Dungannon and Mayo townships (Hewitt and James 1956, pp. 8, 16–24) and in Cardiff and Faraday townships (Hewitt 1959, pp. 20, 21). It attains its greatest thickness, namely 10,000 feet, around Silent Lake in Cardiff township. Despite its extensive development in these townships, the upper limit of the formation cannot be clearly defined, as it is cut off by the McArthurs Mills fault to the north and by the Weslemkoon granite to the south. In Denbigh township, however, it is overlain by the fairly persistent marble layer used in this report to define the base of the overlying Denbigh Formation. The Hermon Formation reaches a thickness of about 6,000 feet in the southern part of Denbigh township.

The principal rock types present in the Hermon Formation in Ashby and Denbigh townships are biotite-quartz-plagioclase gneiss, para-amphibolite, and pelitic schist. Also present are quartz-feldspar gneiss, marble, metaconglomerate, quartzite, and pyritic varieties of the major rock types. The formation is well exposed in roadside outcrops along highway No. 41 south of the village of Denbigh. This part of the Hermon Formation is predominantly biotite-quartz-plagioclase gneiss and para-amphibolite. Pelitic schist becomes more common in the northeast corner of Ashby township.

Some bands of amphibolite in the Hermon Formation may be of volcanic origin, and ellipsoidal structures, probably representing deformed pillow lavas, were found in a band north of Barnard Lake and in a roadside outcrop on highway No. 41 near the village of Vennacher Junction. In the bands north of Barnard Lake, rounded patches rich in epidote are present in parts of the amphibolite; these may represent altered volcanic bombs. However, most of the amphibolite in the Hermon Formation is intimately interbanded with undoubted paragneisses and usually contains appreciable quantities of biotite, so that its sedimentary origin can hardly be doubted.

Quartzo-feldspathic gneiss bands are well developed in this formation in the townships to the west of Ashby, but they are few and thin in the area now being



Specimen of pseudoconglomerate from the Hermon Formation near Barnard Lake. The "pebbles" are deformed fragments of vein quartz.

described. Bands of quartzite are even rarer. A few bands of metaconglomerate can be seen near the boundary of Mayo township. They are developed near a horizon about ⅜ mile from the contact with the Weslemkoon granite. The original rocks appear to have been pebble conglomerates with an impure sandy matrix. They are all now intensely deformed and many of the pebbles are stretched beyond recognition; still-recognizable pebbles are frequently about 3–5 inches long, 1 inch across, and ¼ inch thick.

The rock types of the Hermon Formation noticeably richer in quartz than the average often contain veins and stringers of quartz; these usually parallel the foliation. Their most prolific development is in Ashby township. Some of these quartz bodies were clearly emplaced before the final deformations of the area were completed; as a result, some of the quartz veins have been drawn out into elongate rod-like shapes having, in cross-section, the appearance of quartz pebbles. Rocks containing these pseudo-pebbles in well-developed form could easily be mistaken for quartz-pebble conglomerates; but some adjoining outcrops show various stages of the process whereby these pseudoconglomerates were produced.

Sulphide-rich varieties of the principal paragneisses of the Hermon Formation occur as beds up to 70 feet thick in various parts of the formation. The principal sulphide is pyrite, but pyrrhotite is as common in some places. The occasional presence of small amounts of copper minerals is indicated by rare malachite incrustations. These beds are usually only 5–20 feet thick and are readily identifiable by their characteristic manner of weathering. Outcrops of these beds have a rusty-yellow appearance due to the development of hydrous iron oxides. White seams of gypsum are also developed during the weathering of these beds. A good example of a sulphide-bearing amphibolite can be seen on the Ashby-Mayo boundary near the contact with the Weslemkoon granite. The sulphides show a definite restriction to certain sedimentary beds and are accompanied by accessory amounts of graphite. These observations suggest that the sulphides are of sedimentary origin.

A few discontinuous bands of marble are developed at various levels in the Hermon Formation. In Ashby township these are too small to be shown on the map, but in southern Denbigh township a number of marble bands up to a mile long were found during the survey.

An important feature of the Hermon Formation in the northern part of Ashby and in the northwestern part of Denbigh townships is the widespread development of garnet. The richest area for garnet occurs in the northeastern part of Ashby township where it was once mined. Another good locality for garnet lies about 1 mile northeast of Barnard Lake. The garnet is best developed in pelitic schist and gneiss, but some hornblendic gneisses also contain appreciable amounts of garnet. The associated rock types around these localities are also rich in garnet. They include garnetiferous amphibolite, and also granite gneisses and syenite gneisses.

The scapolitization of portions of the Hermon Formation, which is a distinctive characteristic of the formation in north-central Mayo township (Hewitt and James 1956, p. 18), continues into Ashby township. Here, however, it is not nearly so marked a feature and the actual distribution of scapolite in the two townships could only be outlined by the use of innumerable thin sections. A few of the thin sections prepared from rocks of the Hermon Formation show partial scapolitization of plagioclase. Some scapolite-rich bands were also found in the marble of the Dungannon Formation around Ashden Lake.

DENBIGH FORMATION

In the western half of Denbigh township a fairly persistent marble horizon lies structurally above the Hermon Formation. This marble is believed to be the same as the marble occurring in the eastern limb of the Slate Falls synform. The bottom of this marble is here defined as marking the base of the Denbigh Formation. Above the marble, and forming the core of the Slate Falls synform, is a thick sequence of paragneisses constituting in this area the upper part of the Denbigh Formation.

No convenient marker horizon suitable for defining its upper limit is present at or near the top of this member. It is possible that a suitable upper limit may be given to this formation when it has been mapped in adjoining townships. The Denbigh Formation achieves its maximum thickness in the western limb of the Slate Falls synform. Here it is 10,000–15,000 feet thick.

As defined here, the Denbigh Formation is present in Denbigh township in the core of the Slate Falls synform. This synform carries it northward into Lyndoch township and southward into Abinger township. The formation is also present in the eastern side of the Rose Hill antiform and extends eastward into Matawatchan township. In the northwestern part of Ashby township, a northeast-trending synform in the neighborhood of Spring Lake contains marble in its core. This marble overlies the Hermon Formation with apparent conformity and may therefore be correlated with the marble member forming the lower part of the Denbigh Formation.

The marble member consists predominantly of coarsely crystalline calcite, but in places the marble may be entirely dolomite. It is rarely completely free of calc-silicate minerals. These are sometimes freely disseminated throughout the rock but they are also concentrated in siliceous layers parallel to the foliation. Thin amphibolite layers are present here and there throughout the member. These, too, parallel the foliation and probably represent former partings of calcareous shale in the original limestone.

The paragneiss member is principally composed of para-amphibolite and biotite-quartz-plagioclase gneiss with amphibolite predominating in most parts of the formation. Subordinate amounts of pelitic gneiss and marble are present. As in the Hermon Formation, pyritic varieties of the gneisses are present at the various levels. A number of these are well exposed in fields around Slate Falls and other easily accessible occurrences can be seen in fields south of Plotz Lake.

Feldspathization and granitization have affected various portions of the paragneiss member, thus giving rise to the development of permeation gneiss, *lit par lit* gneiss, and syenitic granitic gneisses. In the last two rock types, partially transformed relicts of the metasediments are commonly encountered, and garnets inherited from the transformed paragneisses are sometimes widespread. (This latter is especially true of the areas of syenite and granite gneiss present in the western limb of the Slate Falls synform.) Permeation gneisses are particularly well exposed in outcrops along Hydes Creek in lot 5, concession XIV, Denbigh township.

PETROGRAPHY OF THE METAVOLCANIC ROCKS OF THE MAYO GROUP

Amphibolite

The only rocks of undoubted volcanic origin form an amphibolite band about ½ mile long in lots 33, concessions IX and X, Denbigh township. This band occurs in marble of the Dungannon Formation. The lower contact with the marble was seen in two exposures. It is sharp, and parallel to the foliation in both rocks. The outlines of former pillows can be seen in several outcrops.

In others, white spots of feldspar occur, representing, perhaps, recrystallized amygdules. Under the microscope, this rock is seen to consist essentially of hornblende and plagioclase, though subordinate amounts of scapolite and carbonate are also present. Accessory minerals include apatite and magnetite. The rock is not as well foliated as the typical para-amphibolites. The parent rock type was probably basalt.

A few occurrences of what may be metavolcanics were found in the Hermon Formation. The locations of these are mentioned above. Some of them contained possible pillow lavas, and others possessed small rounded patches of feldspar and scapolite, possibly representing former amygdules.

PETROGRAPHY OF THE METASEDIMENTARY ROCKS OF THE MAYO GROUP

Amphibolite

The great majority of the amphibolites in the two townships are believed to have been formed by the metamorphism of calcareous sediments. The reasons for this interpretation are as follows: (1) the considerable development of biotite in many of the rocks; (2) the intimate interlayering on various scales with rocks of undoubted sedimentary origin; (3) the abundance of accessory graphite to be seen in many examples; (4) the considerable quantity of quartz (up to 30 percent) found in some specimens; and (5) the absence of any structures indicative of volcanic or intrusive origin.

Para-amphibolite with a segregation vein of feldspar developed in a fracture. Note the hornblende-rich margin in the host rock and the foliated nature of the amphibolite. Outcrop alongside highway No. 41, Denbigh township.

Three rocks may be considered as possible ancestors of the para-amphibolites: calcareous tuffs, calcareous greywackes, and calcareous shales. The first possibility appears to be unlikely in the absence of any evidence of associated volcanic activity. The second is a more distinct possibility, but, in view of the absence of any supporting evidence, is less favored by the author than the third alternative—that the original rocks were calcareous shales. Supporting evidence for this last possibility exists in the high biotite content of some para-amphibolites and in the way they are interlayered with, and otherwise spatially related to, the marbles.

In hand specimens the para-amphibolites are medium-grained dark gneisses. Unweathered samples are tough and compact. All varieties possess some degree of foliation. This is best developed in the hornblende-rich and biotite-rich varieties. These two minerals usually show a good parallel alignment, thus imparting a lineation to the rock.

The principal minerals of the para-amphibolites are hornblende and plagioclase (usually oligoclase); considerable amounts of biotite, quartz, and scapolite may also be present. Accessory amounts of garnet, carbonate, graphite, magnetite, epidote, apatite, pyrite, and pyrrhotite are often present. No pyroxene is developed in the normal amphibolites, but it does appear in varieties that contain considerable quantities of carbonate and very little hornblende and plagioclase, and these varieties are clearly intermediate in chemical composition between the amphibolites and marbles. Potash feldspar is developed in the amphibolite in areas where all the rocks show evidence of feldspathization.

Under the microscope, the hornblende-rich and biotite-rich varieties of para-amphibolite are seen to possess a lepidoblastic texture. This is less pronounced in specimens containing more quartz and feldspar, which display an even-grained or granulitic appearance.

Rusty-weathering amphibolites with appreciable amounts of accessory iron sulphides can be found as bands in the paragneisses throughout the area.

Quartzo-Feldspathic Gneiss

Quartzo-feldspathic gneiss is uncommon in Ashby and Denbigh townships. It is more frequently encountered in the Hermon Formation than elsewhere. Small areas in the Weslemkoon granite are often rich in enclaves of this gneiss.

The principal minerals are quartz and feldspar; both potash and plagioclase feldspar are usually present. The next most abundant mineral, though present in smaller amounts, is muscovite; accessory biotite, sillimanite, and magnetite have also been seen in these rocks. Texturally, the rocks are even-grained, but the principal minerals show some degree of elongation in the plane of foliation.

Although the parent sediment was presumably an arkose or feldspathic quartzite, it must be recorded that many outcrops of this rock type occur in areas of intense feldspathization and some of the feldspathic material may be metasomatic in origin.

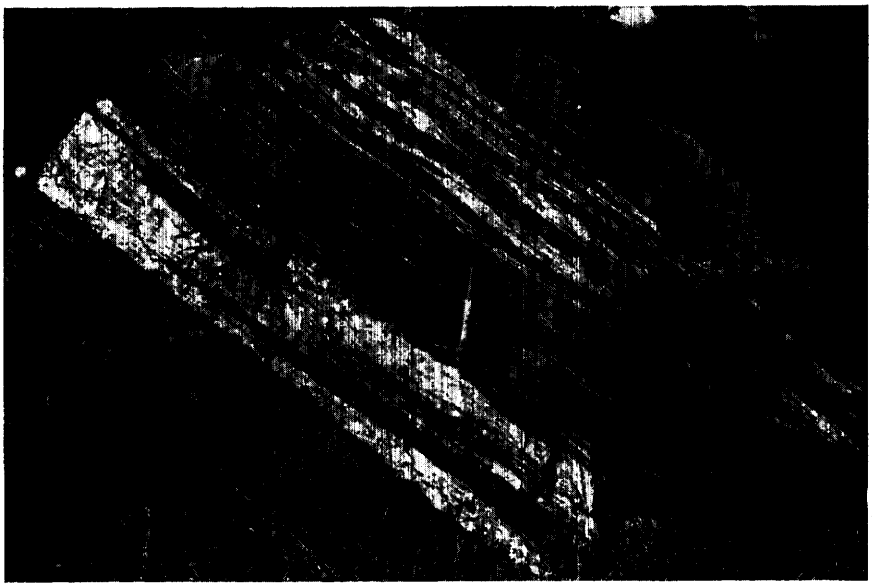
Biotite-Quartz-Plagioclase Gneiss

This is a very common rock type of the Grenville Series. It has been carefully investigated in the Adirondack Mountains and an attempt was made to determine its parentage (Engel and Engel 1953, pp. 1049–1098). A later discussion favours the conclusion that the parent rock is greywacke (Engel 1956). The principal minerals are quartz, plagioclase, and brown biotite. Garnet and muscovite are present in the more pelitic varieties of the rock. Another variation of this rock type contains small amounts (5–15 percent) of green hornblende, thereby indicating that the original sediment was sometimes slightly calcareous. All these varieties of the rock occasionally contain about 3–8 percent of iron sulphides. The sulphide-bearing paragneisses weather to a rotten yellow-brown-stained rock possessing abundant hydrous iron oxides and millimetre-thick veins and seams of gypsum.

Other accessory minerals include microcline, apatite, scapolite, tourmaline, carbonate, and magnetite. The magnetite is often concentrated in bands a few millimetres thick that are parallel to the foliation; it is in these bands that scattered crystals of green tourmaline occur. These magnetite-tourmaline layers probably represent sedimentary concentrations of heavy minerals.

In outcrops and in hand specimens the rock is a medium-grained foliated grey gneiss peppered with flakes of biotite. Under the microscope, the texture is seen to vary from granoblastic to lepidoblastic, depending upon the content of micaceous minerals.

Some of the occurrences of this gneiss in the northwestern part of Ashby township are notable for their possession of green lenses of calc-silicate minerals (diopside, scapolite, hornblende). These have the general shape of boudins. Representative dimensions seen in sections perpendicular to the foliation and lineation are 8 by 1.5 centimetres. The longest dimension is parallel to the lineation and may be as much as 25 centimetres. These calc-silicate lenses presumably represent boudinaged or sheared beds or concentrations of impure dolomitic limestone.



Grey biotite-quartz-plagioclase gneiss of the Hermon Formation with layers of pegmatite and granite. Roadside outcrop on highway No. 41 just north of Vennachar Junction.

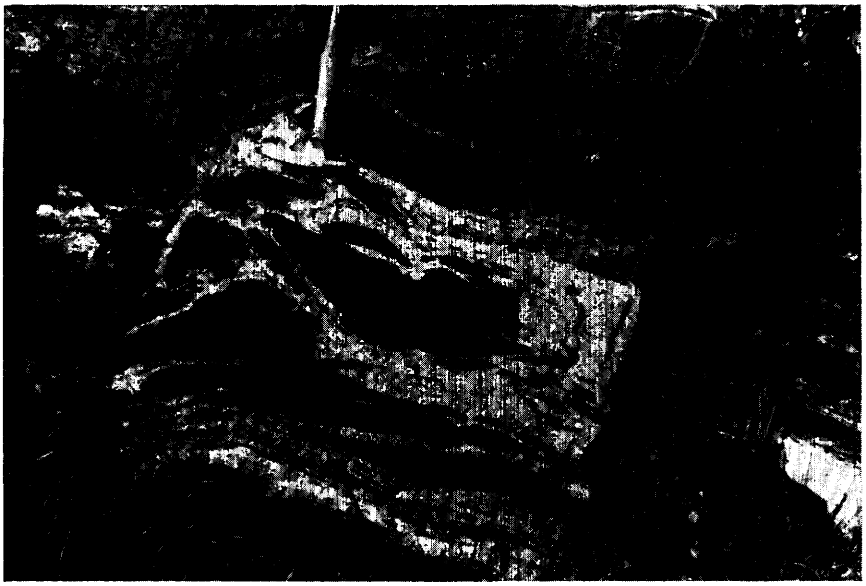
Pelitic Gneiss

The occurrence of aluminium silicates (sillimanite, kyanite, staurolite), together with considerable amounts of biotite and muscovite, in some of the gneisses indicates the presence of metamorphosed shales. Such bands of pelitic gneiss are usually found in thin beds, 1–10 feet thick, in the biotite-quartz-plagioclase gneiss; but other beds may be as much as 100 feet thick. Some samples of this rock are sufficiently rich in micas to be classified as schists; otherwise the rock, in hand specimens, is very similar to the biotite-quartz-plagioclase gneiss.

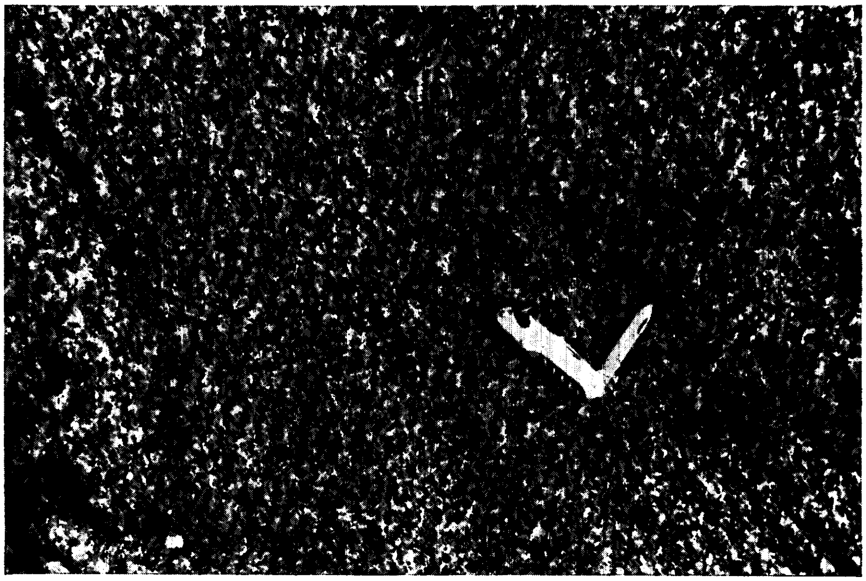
The main constituents of the gneiss are biotite, muscovite, and quartz; garnet is sporadically distributed. Some occurrences of this gneiss are extremely rich in pink garnets, especially in the northeastern part of Ashby township, but other occurrences contain pink garnet only as a minor accessory mineral. Varying amounts of plagioclase (oligoclase) are present. The most common aluminium silicate is sillimanite; kyanite and staurolite are present in some specimens (the last named usually as inclusions in garnet). The minor accessory minerals are tourmaline, apatite, magnetite, iron sulphides, graphite, and zircon. The dominant texture is lepidoblastic.

Lit Par Lit Gneiss

Lit par lit gneiss is essentially a mixed gneiss or migmatite. It consists of layers of paragneiss (usually rich in biotite) that alternate with layers of granitic



Marble tectonic breccia. Roadcut, highway No. 41, north of Denbigh.



Typical metagabbro fabric. Eagle Hills metagabbro, Denbigh township.

composition. The granitic layers are medium- to coarse-grained, some being pegmatitic. Some alternate regularly with the paragneiss layers so that the rock is composed of nearly equal proportions of the two, but others show a more sporadic distribution. Most of the *lit par lit* gneisses appear to be altered biotite-plagioclase-quartz gneisses or pelitic gneisses.

Quartzite

Quartzite is rare in this area. Occasional beds a few inches thick occur in the marbles; a few thicker beds have been found in the paragneisses. The latter beds usually contain some muscovite and occasionally garnet. Sillimanite was discovered in one of these beds.

Metaconglomerate

Little metaconglomerate was seen during the survey. Its distribution within the Hermon Formation is described on page 9. The original rocks appear to have been polymictic pebble conglomerates with an impure sandy matrix.

Marble

Marble is the third most extensive metasediment of the area. It includes pure-white crystalline limestone and dolomite (together with blue and grey varieties), silicated marble, calc-silicate rocks, and marble tectonic breccia.

By the use of dilute acid in the field, an attempt was made to determine whether the dominant carbonate in each outcrop was calcite or dolomite. A marble composed largely or wholly of calcite is designated 3 on the map. Dolomitic marble is shown as 3z. Within the marble areas, dolomite appears to be irregularly distributed, and the dolomitization probably occurred after the deposition of the original limestone.

Silicates are common in the marbles. When they constitute more than half the rock the legend 3b is used; chondrodite, diopside, phlogopite, plagioclase, tremolite, and actinolite are not separately distinguished in the legend. When silicates make up less than half the rock the letter b is omitted. Where the rock is composed entirely of silicates it is designated 3s–calc-silicate rock. Some of the marble contains small flecks of graphite (3c). Other outcrops that have thin quartzite bands are not separately designated. Other minerals present in the silicated marbles include scapolite, microcline, quartz, and sphene.

Marble tectonic breccia is occasionally developed. It consists of fragmented and contorted pieces of amphibolite in a matrix of coarsely crystalline marble and amphibolite. During the deformation of the area, this marble was mobilized; its flow broke up and contorted the more competent interbeds of amphibolite. The best exposures of this breccia occur in roadcuts along highway No. 41 north of the village of Denbigh.

Plutonic Rocks

METAMORPHOSED AND BASIC INTRUSIVE ROCKS

A number of basic masses occur in the area. They usually consist of medium-grained amphibolite with hornblendes up to 6 millimetres long. Large-zoned plagioclases (andesine) up to 3 millimetres across are present in some of these rocks. Well inside the masses, the grain size is distinctly greater than that of the para-amphibolites; but, close to their margins, the rocks may be much more gneissic, with a finer grain size, and so appear to pass gradationally into rocks mapped as para-amphibolites. The contacts shown on the map between these two rock types are therefore somewhat arbitrarily drawn.

The usual mineralogy of these rocks suggests that most of them resulted from the metamorphism of rocks of the same gabbro clan—either gabbros or dolerites. They are therefore referred to for the sake of convenience as metagabbros.

There are two main metagabbro masses. These are: the Ashby metagabbro, which occurs in the very north of Ashby township and extends across the boundary into Raglan township; and the Eagle Hills metagabbro, which lies about 2½ miles south of the village of Denbigh near the contact with the Weslemkoon granite.

Ashby Metagabbro

The main part of this mass is roughly oval-shaped in plan, but from the southern end apophyses reach southward to Len Lake, and a few isolated outcrops of coarse amphibolite to the west and southwest may represent further offshoots from the main mass. The Ashby metagabbro appears to disturb the structures in the metasediments surrounding it, thus indicating that it was emplaced intrusively.

Most of the mass is composed of medium-grained hornblende-plagioclase gneiss. Thin sections of this rock are notable for the size of the hornblendes, which are often as much as 6 millimetres long. Parts of these hornblendes are rich in tiny grains of iron oxide that are concentrated in irregular trains whose general shape is very similar to the trains of magnetite present in cracks in the olivine of basic igneous rocks. Other parts of the hornblendes contain patches rich in regularly oriented short rods of iron oxide, similar to those commonly seen in the pyroxenes of gabbroic rocks.

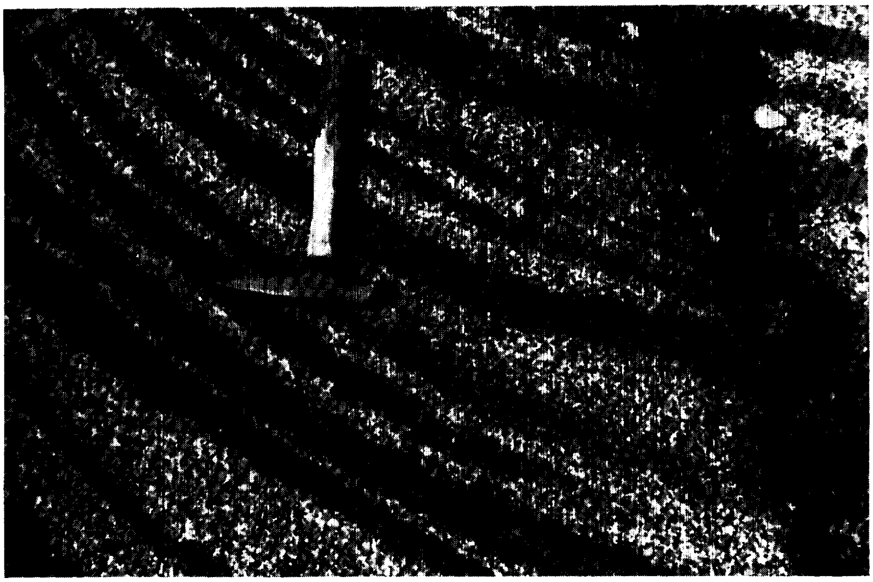
Some of the plagioclase is present as lath-shaped inclusions in the hornblende, thereby giving the appearance of relict ophitic texture. The larger hornblendes are set in a finer-grained granoblastic mosaic of plagioclase (andesine) and hornblende, but a few, somewhat larger, zoned plagioclases (andesine) can be found here and there. Accessory minerals include magnetite, biotite, apatite, and scapolite.

A number of metasedimentary inclusions were found in the metagabbro; these consisted of marble, hornblende-biotite-plagioclase-quartz gneiss, and possibly para-amphibolite. Some outcrops of hornblende schist may represent former autoliths.

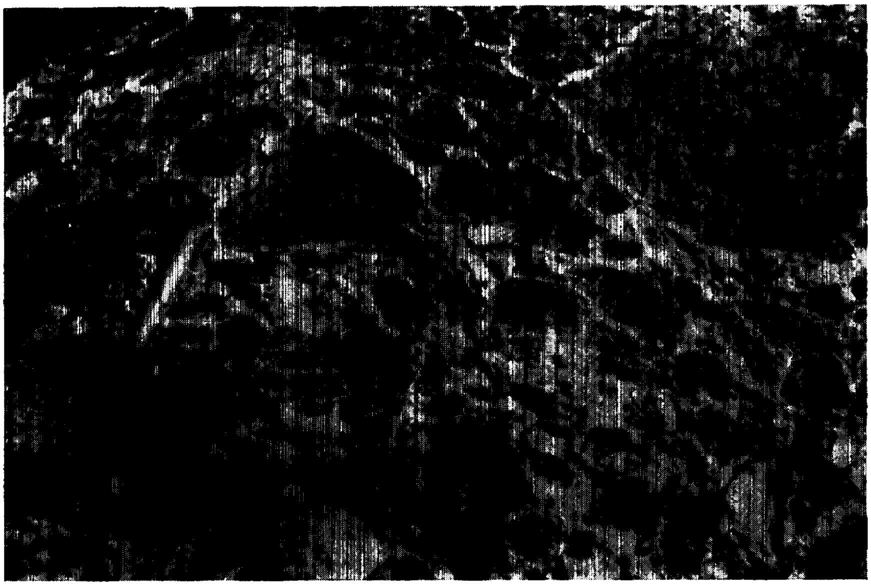
A few small shear zones up to 1 foot wide were found in various parts of the metagabbro. These are mineralized with pyrite and pyrrhotite.

Eagle Hills Metagabbro

This intrusive mass is like the Ashby metagabbro and gives rise to an area of high ground. At three points, at or near its contact, small bodies of syenite occur. Again the dominant rock type is a medium-grained amphibolite; but in this case the large crystals of hornblende with relict igneous textures, so well developed in the Ashby metagabbro, have not been found. Large normally zoned



Banded metagabbro, Eagle Hills metagabbro, Denbigh township.



Reticulating veins of white granitic material in metagabbro.
Eagle Hills metagabbro, Denbigh township.

crystals of plagioclase (andesine) are, however, well developed in parts of this mass. Accessory minerals are apatite (often as crystals up to 3 mm. long), magnetite, biotite, and carbonate. Garnet is developed in a few outcrops.

Parts of this metagabbro are characterized by a well-developed banding. The banding consists of dark layers rich in hornblende alternating with lighter-coloured layers containing much more plagioclase (*see* accompanying photographs). Similar banding has been recorded from the Faraday metagabbro in Faraday township (Hewitt 1959, p. 23).

Hewitt has interpreted this banding as being the result of metamorphic differentiation. In the Faraday metagabbro, the banded areas are associated with zones of intense shearing belonging to the McArthurs Mills fault zone. No shear zones have been seen in the Eagle Hills metagabbro; it is possible that the present banding and foliation are mimicking pre-existing magmatic banding and igneous lamination.

Another feature of this metagabbro is the development of areas of reticulating veins of white granitic material. These consist of a granoblastic mosaic of quartz and feldspar. They are assumed to represent the metamorphosed equivalents of the veins of granophyre, which are such a common feature of many gabbros.

Other Metamorphosed Basic Intrusive Rocks

A small body composed of medium-grained amphibolite is situated in the small re-entrant of metasediments projecting into the Weslemkoon granite about 1¼ miles south of Ashden Lake. This is a less homogeneous mass than the Ashby and the Eagle Hills metagabbros. It contains numerous inclusions of fine-grained amphibolite (perhaps representing para-amphibolite) and hornblende-biotite-quartz-plagioclase gneiss. Moreover, the degree of perfection of the foliation varies rapidly from outcrop to outcrop, being very high in some places. It is usually developed at a great angle to the foliation in the enclosing metasediments; and strong contortions of the foliation can be seen in some outcrops. Occasionally a hornblende-rich facies of the metagabbro occurs. Elsewhere the effects of feldspathization give rise to leucocratic varieties of the metagabbro.

The only other important occurrence of metagabbro is in the ground north of Big Yirkie Lake where three sill-like bodies of amphibolite have been mapped. These are from ¾ mile to nearly 2 miles long, and are about 600 feet thick. They contain inclusions of para-amphibolite and act as the host rocks for a few granite pegmatites.

A number of much smaller bodies of metagabbro and hornblende were encountered during the mapping of the area. Some of these are too small to be represented on the map. Those emplaced in areas of feldspathization or granitization frequently show varying degrees of migmatization, either by the growth of feldspar and quartz throughout the body of the rock, or by the development of a great number of syenite or granite veins. In such circumstances, quartz may also be present. Sometimes considerable deformation occurred during the migmatization; this resulted in the shearing of the metagabbro into fish-shaped fragments now surrounded by granitic material.

A small intrusion of biotite-hornblende schist was found near Slate Falls (lot 14, concession XIII, Denbigh township). This may represent a former biotite pyroxenite.

NEPHELINE SYENITE GNEISS

Nepheline syenite gneiss occurs in an area of syenite gneiss in lot 34, concession IX, Denbigh township. It can be recognized in the field by its characteristic weathering resulting in feldspar and dark minerals standing out in relief from a more-rapidly-weathering white powdery material derived from the alteration of nepheline.

The essential minerals are nepheline, microcline, and albite; microcline forms the bulk of the feldspar. All the nepheline is altered to felted areas of gieseckite. The principal accessory mineral is green aegerine-augite. This occurs as parallel plates, thus imparting to the rock a gneissosity that is seen in hand specimens. Minor accessories include yellow garnet, magnetite, pyrite, apatite, sphene, carbonate, hastingsite, and scapolite. The yellow garnet generally forms complete or partial rims around some of the aegerine, magnetite, and pyrite crystals.

SYENITIC ROCKS

Syenite gneisses occur in a number of places where the metasediments have undergone intense feldspathization. Much evidence indicates that many of the occurrences represent transformed metasediments rather than metamorphosed igneous rocks.

The largest body of syenite gneiss forms a belt up to ¾ mile across stretching southwestward from Cronkshaw Lake almost to the village of Denbigh. It forms the highest ground in the two townships. In parts it is plainly exposed, forming rugged outcrops and bluffs. It is generally a hornblende syenite gneiss in which garnet occurs as a common accessory mineral. Many inclusions of feldspathized amphibolite are also present.

Other areas of syenite gneiss occur: in the northeast corner of Ashby township; at the southeast end of Ashden Lake around the Eagle Hills metagabbro; about 2½ miles east-northeast of Denbigh village; and as inclusions in the Weslemkoon granite.

These syenitic rocks contain variable amounts of microcline and plagioclase (albite or oligoclase). The characteristic accessory minerals are hornblende or biotite; but muscovite is well developed in the bodies around the Eagle Hills metagabbro. Quartz is often present in small amounts. With an increase in the amount of quartz, the syenite gneisses grade into granite gneiss. In areas where this gradation occurs, remnants of syenite gneiss abound in the granite gneiss, thus indicating their greater age.

GRANITIC ROCKS

The geological data obtained during the survey may be interpreted as indicating that the granitic rocks can be divided into the following three groups: granite gneiss (the oldest granitic rocks) and associated gneissic granite pegmatites; the Weslemkoon granite and associated massive pegmatites; and the McArthurs Mills granite (the youngest granite). It must be emphasized, however, that the age relations between the various granitic bodies have not yet been fully elucidated and the age classification indicated above must be regarded as tentative.

Granite Gneiss

Larger bodies of granite gneiss include the following five: northwest of Spring Lake a body that extends into Raglan township; one in the northeast corner of Ashby township; a sill-like area of granite just northwest of Denbigh village;

various bodies of granitic gneiss (often pegmatitic) in the middle of the Slate Falls synform; and the most extensive development of granite gneiss, which occurs in northeast Denbigh, and is referred to here as the Leatherroot Lake gneiss.

Evidence indicates that these granitic rocks were all developed at the same time; and, since no observations suggest otherwise, they are considered here to be coeval. A number of them are genetically related to adjacent syenite gneisses; and almost doubtlessly both rock types were, in most cases, formed by the transformation of pre-existing sediments. In such cases, the mineralogy of the syenitic and granitic gneisses is often identical, apart from the presence of quartz in the granitic gneisses.

Migmatitic granite gneiss, near Slater Lake, Denbigh township.

Like the syenite gneisses, the granite gneisses are frequently migmatitic, and contain patches of para-amphibolite, biotite-quartz-plagioclase gneiss, and marble. The foliation in the granite always parallels the foliation in the included metasediments and the country rocks. These granitic bodies do not appear to have disturbed the structure of the surrounding rocks during emplacement.

Even within the extent of one outcrop, the granite gneisses are somewhat variable in their mineralogy. The essential minerals are quartz and feldspar; the feldspar consists of microcline and plagioclase (albite or oligoclase) in variable proportions. The characteristic accessory minerals are hornblende, biotite, and muscovite, and garnet is important in some of the gneisses. Other accessory minerals include magnetite, sphene, apatite, and zircon.

Some of the granite gneisses grade into gneissic pegmatites, but similar rocks may also form discrete bodies lacking any granite gneiss. Petrographically, these pegmatites differ from the gneisses only in possessing a larger grain size. Some are decidedly gneissose, others almost massive. Most show no evidence of forcible intrusion and often contain inclusions of metasediments that do not appear to have been moved during their emplacement. A few, however, do occupy fractures whose walls can be matched. These fractures are usually near and parallel to the axial surfaces of the minor folds in the metasediments. This is quite a common feature of part of the Grenville Series, and Satterly (1956, p. 19) has described an example of it in Lount township.

Weslemkoon Granite

The Weslemkoon granite forms the bedrock of most of Ashby township. It extends westward into Mayo township, eastward into Denbigh township, and then continues onward through the townships to the south. The rocks of this

Typical granodiorite gneiss in the Weslemkoon granite. This photograph was taken well inside the batholith, at Cotter Lake. Note the strong gneissic structure of the rock.

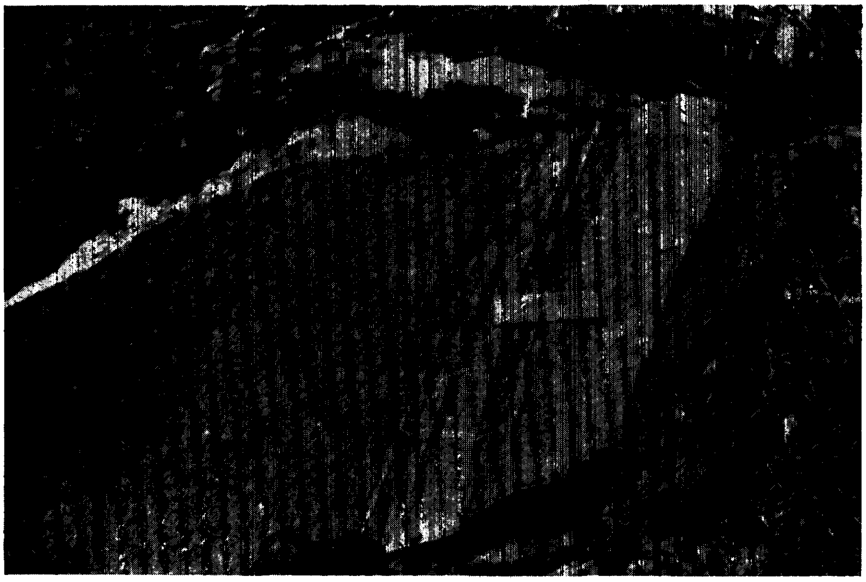
batholith are well exposed in many parts of the area but are especially well displayed along the shores of Weslemkoon Lake. Contacts between the batholith and its envelope are plainly shown in outcrops along the shores of the lakes extending across the contact. This contact is also well exposed near the farm buildings on lot 34, concession VIII, Denbigh township.

In the townships of Ashby, Denbigh, and Mayo, the major rock type of this large batholith is grey granitic gneiss. It shows a well-developed foliation everywhere. This is accentuated close to the contacts where some shearing appears to have occurred along the foliation surfaces.

The foliation is seen under the microscope to be caused not only by the parallel alignment of biotite flakes but also, when hornblende crystals or muscovite flakes are present, by the parallel arrangement of these latter. The crystals of feldspar and quartz have been strongly elongated parallel to the foliation.

In addition to the foliation imparted by the parallel arrangement of the crystals of feldspar, quartz, and hornblende, and the flakes of biotite and muscovite, a distinct colour banding parallel to the foliation was seen in a few outcrops. This banding is only evident on absolutely fresh surfaces revealed by blasting. It is not visible on the weathered surfaces of the same outcrops. It may therefore be much more common than the available evidence suggests. The banding is due to the varying content of biotite in the different layers, with the dark bands containing as much as 17 percent biotite.

The principal minerals of the rock are feldspar and quartz. The former consists of microcline and plagioclase (usually oligoclase). The proportion of the two feldspars varies from place to place, consequently all gradations between granite and granodiorite are present. The characteristic accessory mineral is



Banded granite gneiss, Weslemkoon granite roadside outcrop near Gin Creek, Ashby township.

biotite; hornblende or muscovite accompany it in various parts of the batholith. The other accessory minerals are epidote, apatite, chlorite, tourmaline, sphene, magnetite, and zircon. Symplectic textures, resulting from the intergrowths of quartz and muscovite, and of quartz and plagioclase (myrmekite), are seen in some thin sections. The pronounced foliation of this rock is also seen in thin sections, with the biotite-rich varieties showing a distinctly lepidoblastic texture.

No zonal arrangement of the various granitic rock types was discovered during the survey. But it is apparent that muscovite is more plentiful near the contact than in the central portion of the batholith. Quartz-tourmaline pods up to 2 feet long and 1 foot thick are occasionally encountered in various parts of the granite. (A chemical analysis of a sample of Weslemkoon granite is given on p. 27 at the end of the description of the McArthurs Mills granite.)

Inclusions of older rocks were found throughout the part of the batholith mapped during the present survey. They are usually rare, but small areas of the granite gneiss can aptly be described as migmatitic because metasediments and granite gneiss are present in these places in about equal proportions. The metasedimentary inclusions, and the foliation contained in them, parallel the foliation in the enclosing gneiss. Petrographically the inclusions are: para-amphibolite (usually showing varying degrees of feldspathization); quartz-feldspar gneiss; quartzite; biotite-quartz-plagioclase gneiss; metagabbro; and syenite gneiss. Some of these inclusions are sufficiently large to be shown on the accompanying maps (Nos. 2031 and 2049).

Migmatite, Weslemkoon granite, Weslemkoon Lake. Dark bands are granite gneiss; light bands are feldspathic quartzite.

In Ashby and Denbigh townships, a number of major and minor folds are indicated by changes in the direction of foliation. The larger structures could not be mapped satisfactorily during the first survey on the scale employed. During the course of the subsequent mapping work, however, a number of such structures became apparent. They may be divided into northwest-trending and northeast-trending folds. The axes of the minor folds also follow these two directions.

Near the margins of the batholith, the foliation swings around parallel to the contact, and here it is always parallel to the foliation in the rocks of the envelope. Only one possible offshoot of granite gneiss into the surrounding metasediments was found (near the southern boundary of Denbigh township); the general impression might be gained from a study of the contact that the Weslemkoon granite was not intrusively emplaced. But, a close study of the minor structures on either side of the contact suggests that at one period the granite both moved upward and expanded laterally and, as the result of these movements, the granite deformed and stretched its enclosed metasediments and its marginal facies.

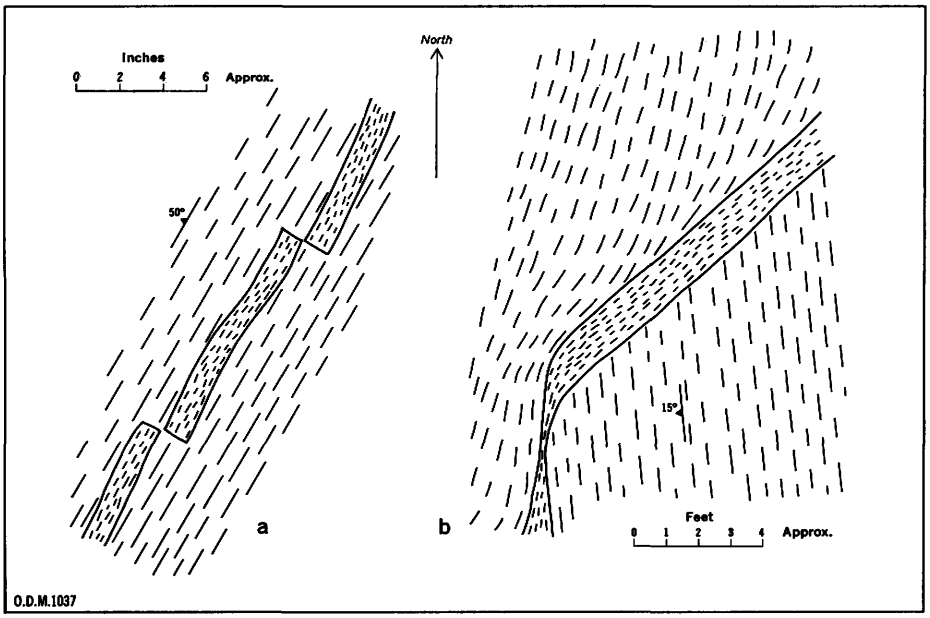
Evidence in support of this conclusion is as follows: the development of boudinage in the margins of the batholith and in the envelope rocks near the contact (the boudins have subvertical and subhorizontal axes); the presence of bedding slip-type structures in both the granite and the metasediments near the contact; the vertical extension of pebbles in the metaconglomerates of the envelope; and the development of shear zones due to stretching in metasediments near the contact. Finally, a study of the maps accompanying this report clearly shows that the major structures of the area have been considerably deflected from their former northeasterly trend by the Weslemkoon granite.

Shear zone in banded amphibolite near the contact with the Weslemkoon granite. Outcrop in farmyard near the Mayo-Ashby boundary.

Thus the origin, age, and history of the Weslemkoon granite present an interesting problem. This granite possesses the same structural features as the surrounding rocks (northeast folds with northwest crossfolds), but it plainly shoulders aside these folds in the neighbouring metasediments. Possibly, therefore, both the Weslemkoon granite and the metasediments underwent the same phase (or phases) of folding when the granite was at a lower structural level; and then, at the end of the folding or at a later time, the granite rose into its present position. This being so, the granite may have been essentially a solid during this final period of emplacement.

Because of this late period of emplacement, the possession of patches of massive pegmatite (which contrast with the often gneissic pegmatites associated with the other granite gneisses of the area), and the lack of associated masses of syenite gneisses, the Weslemkoon granite is tentatively placed farther up in the table of formations than the other granite gneisses of the area. These, it will be remembered, do not displace the structures in the rocks surrounding them.

In addition to the inclusions mentioned above, the Weslemkoon granite possesses a number of small bodies of fine-grained biotite granodiorite gneiss or hornblende-biotite granodiorite gneiss. The shapes of these are variable; some look like inclusions of older rocks but a great number have a dike-like form. They are always foliated. The foliation may be parallel to the foliation of the surrounding granite gneiss or it may be highly inclined instead. Some of the smaller dikes have been offset; these cases show no sign of faulting in the contiguous granite gneiss. The ends of other dikes give the impression of having been sheared into parallelism with the foliation of the host rock. The foliation in these microgranodiorites may have been developed as the result of shearing generated by a mechanism similar to the one described by F. G. H. Blyth to account for the occurrence of foliated dikes in nonsheared country rocks in the southern part of Galloway in Scotland (Blyth 1949, pp. 393–421).



Dike-like occurrences of microgranodiorite gneiss in the Weslemkoon granite.
a. Outcrop on lot 32, concession VIII, Ashby township.
b. Lakeshore, lot 27, concession VI, Ashby township.

Irregular patches of massive granitic pegmatite are distributed throughout the Weslemkoon granite in the area mapped. They are usually composed of quartz and feldspar. Other minerals that in some places form more than 5 percent of the rock are biotite in books up to 2 inches long, muscovite in books up to ½ inch long, and tourmaline in crystals up to 6 inches long. In a few places, graphitic textures are present in the pegmatites.

McArthurs Mills Granite

Most of the McArthurs Mills granite lies in Mayo township but the eastern end projects for nearly a mile into Ashby township. It is emplaced in the rocks of the Hermon Formation, but it does not appear to have displaced those rocks during its emplacement. Large and small inclusions of paragneiss are present. The rock is almost structureless, but a faint planar structure can be discerned in most of the outcrops in Ashby township. This structure is essentially parallel to that of the inclusions and the country rock.

The principal minerals are microcline, plagioclase, and quartz. These three minerals combine to make up a medium-grained pink rock containing occasional plates of plagioclase and microcline up to 1 centimetre in length; consequently the rock has a poorly developed porphyritic texture in places. Accessory minerals include green biotite, sphene, apatite, and magnetite. At a number of places along the contact, and for a centimetre or two in from it, scapolite replaces the plagioclase. At these points, scapolite is also developed in the adjacent country rocks. In some places, where this alteration has occurred, small amounts of metamict radioactive minerals are developed in the granite. These are probably uranothorite.

At one place along the contact, thin sections of an amphibolite showed that it had been coarsened, with the resulting destruction of most of its foliation; scapolite has replaced the plagioclase, and the hornblende has been partially changed to diopside. This might be interpreted as a contact metamorphic effect.

CHEMICAL ANALYSES OF GRANITES
(from Hewitt and James 1956, pp. 28, 41)

	Sample No. 3 Weslemkoon Granite	Sample No. 4 McArthurs Mills Granite
	percent	percent
SiO_2	66.78	63.92
Al_2O_3	16.79	17.18
Fe_2O_3	0.26	1.33
FeO	2.60	2.51
MgO	1.48	0.73
CaO	4.34	2.55
Na_2O	4.50	4.40
K_2O	1.65	5.30
H_2O+	0.48	0.48
H_2O-	0.11	0.14
CO_2 (calculated from loss on ignition)	0.27	0.37
TiO_2	0.35	0.70
P_2O_5	0.00	0.19
Cr_2O_3	0.01	0.01
MnO	0.04	0.01
V_2O_3	0.01	0.01
Total	99.67	99.92
Loss on ignition	0.86	0.65

Grade of Metamorphism

Apart from the region underlain by the Weslemkoon granite, the grade of metamorphism may be defined with considerable exactitude by reference to the mineralogy of the metasediments. The most useful rocks for this purpose are the pelitic schists. These are present throughout the metasedimentary terrane and always contain sillimanite. In some specimens, minor amounts of staurolite and (more rarely) kyanite accompany this sillimanite. Muscovite invariably appears to be stable in these rocks, and thin sections provide good evidence that the sillimanite arises from the reaction:

$$\text{staurolite} + \text{quartz} \rightarrow \text{sillimanite} + \text{almandine} + H_2O$$

This indicates that the rocks of the area belong to the sillimanite-almandine-muscovite subfacies of the almandine-amphibolite facies as defined by Turner and Verhoogen (1960, pp. 548, 549). This subfacies is not equivalent to the sillimanite zone as defined in the Scottish Highlands but is a lower-pressure equivalent of the kyanite zone. The staurolite in these rocks is usually preserved as unstable relicts included in garnet. The surrounding garnet has presumably prevented the reaction with quartz which would have destroyed this staurolite.

The mineralogy of the para-amphibolites also points to this grade of metamorphism. The plagioclase is commonly about An_{25} to An_{35}. Epidote minerals are present but not abundant, and the metamorphic grade required to produce clinopyroxene in amphibolites has not been attained.

Pleistocene

During the Pleistocene epoch, the area was covered by a continental ice-sheet. This removed all previously existing superficial deposits and smoothed-off the surface of the bedrock with the resulting production of many *roches moutonées.* These are particularly conspicuous around the shores of Weslemkoon Lake. No glacial striae were seen, but the orientation of the *roches moutonées* shows that the main movement of ice was toward the southeast.

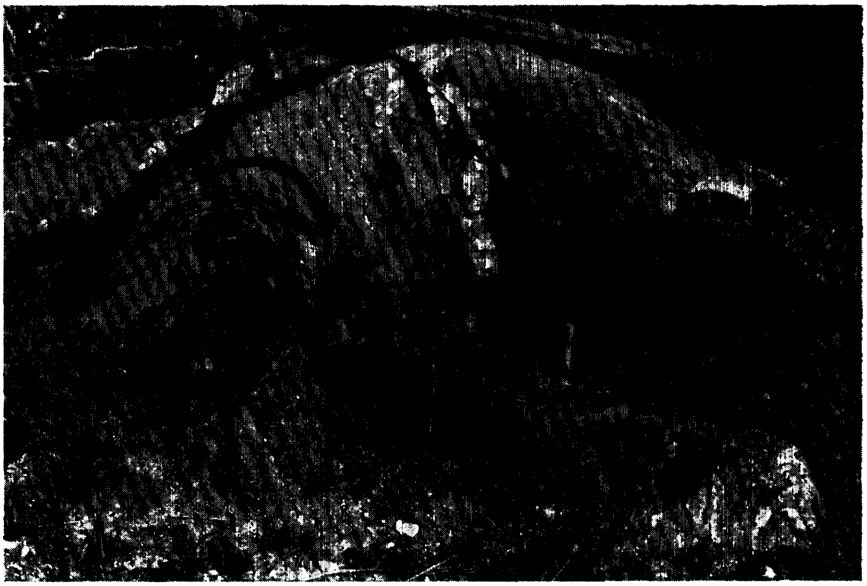
Much of the area is plastered-over with glacial drift forming, in some areas, a thick mantle. The sandy nature of the drift suggests that much of it is of glaciofluvial origin. Small sand flats are common in Denbigh township; these may represent deposits formed in glacial lakes.

STRUCTURAL GEOLOGY

In his excellent discussion of the regional geology of the Grenville Series in Ontario, D. F. Hewitt (1956) tentatively assigned the Ashby-Denbigh area to his Haliburton, Hastings, and Madawaska division. This is an area characterized by high-grade metamorphic rocks (with abundant migmatites and granites) whose metasedimentary formations can be traced only for short distances and whose structures are largely or wholly controlled by numerous batholithic masses. The Highland gneiss complex contrasts with the Hastings Basin to the south. In the Hastings Basin the grade of metamorphism is lower and migmatites are rare, the original sedimentary sequences can be established and traced for considerable distances, and the geological structures have a dominant northeasterly trend. Hewitt suggested that the western contact of the Weslemkoon granite marks the eastern boundary of the Hastings Basin.

The McArthurs Mills fault zone, representing the northern boundary of the Hastings Basin, extends across the northern part of Mayo township and the southern part of Raglan township. It lies north of Ashby township. The metasediments of the northern parts of Ashby township are thus a continuation of rocks of the Hastings Basin type. Consequently, the geology of Denbigh township has features, such as good continuity of metasedimentary horizons, that are typical of basement-type rocks.

But Denbigh township also has geological features more commonly observed in the Highland area to the north. Thus migmatites, together with large bodies of granitic and syenitic gneiss, are fairly common; the metamorphic grade everywhere reaches that of the amphibolite facies; and, marbles have tended to yield plastically instead of brittlely. The Ashby-Denbigh area may, therefore, be regarded as representing a transition between the Highland and Basin areas.



Crossfolding in the Denbigh Formation, roadside outcrop, highway No. 41 north of Denbigh village. The hammer handles are parallel to the fold axes.

Folding

A tentative structural interpretation of the Ashby-Denbigh area is shown on the generalized geological map (facing p. 5). The folds mapped by Hewitt and James (1956, pp. 41, 42) in the south half of Mayo township continue into Ashby township. The more northerly folds cross the boundary into Raglan township but the Mayo anticline continues around the Weslemkoon granite into Denbigh township. It forms a much tighter fold in Ashby and Denbigh townships than it does in Mayo township. This compression of the fold limbs was probably caused by the emplacement of the Weslemkoon granite. The axial surface of the limbs usually dips away from the batholith.

The dominant structure in Denbigh township is the Slate Falls synform. This occurs in the central part of the township. The northern portion of the synform plunges northward and the southern part plunges southeast. The plunge culmination is near the village of Denbigh and marks the position of a distinct bend in the axial trace of the fold. A similar change in trend occurs in the Rose Hill antiform[1] that lies to the east and is parallel to the Slate Falls synform. A second plunge culmination and another change in trend affect these folds near the boundary with Lyndoch township, where they are warped around from a northerly to a north-easterly trend. These plunge culminations accompanied by marked changes in the trend of the folds are believed to be due to crossfolding. The re-entrant of the meta-sediments projects into the Weslemkoon granite immediately to the south of Ashden Lake. It lies on the crossfold passing through the village of Denbigh. The axial surfaces of the Slate Falls synform and the Rose Hill antiform generally dip towards the east.

Interbanded amphibolite and biotite-quartz-plagioclase gneiss showing incipient development of shear foldings in flowage-folded rocks. Outcrop on the eastern limb of the Slate Falls synform, lot 6, concession XIV, Denbigh township.

The eastern limb of the Slate Falls synform is clearly much thinner than the western limb. This appears to be partially or wholly a tectonic development, for the rocks along this limb are intensely deformed and it is here that the main development of marble tectonic breccias occurs. Along this belt, minor folds that appear to have been formed initially by flow folding have been further deformed by shear folding along shears parallel to their axial surfaces.

Foliation, Lineation, and Minor Folds

Practically all the rocks of the area possess a metamorphic foliation. The principal foliation in the metasediments is usually parallel to the original bedding but, in one thin section, the bedding as outlined by biotite concentrations is seen

[1] In the absence of primary-way-up structures, the noncommittal terms antiform and synform are used instead of anticline and syncline, since the latter terms imply knowledge of how, directionally speaking, the strata face.

to be thrown into tight isoclinal folds whose axial surfaces are parallel to the principal foliation. Another foliation, not as well developed, is present in rocks near the northern contact of the Weslemkoon granite; it may have been formed by late upward movement of this batholith. Where this second foliation is present in the metaconglomerates, the pebbles are sheared so that their longest axes are nearly vertical.

All the metasediments and a number of the other gneisses possess a marked mineral lineation. This is usually subparallel to the axes of the major folds. Where the major crossfolds are developed, a second lineation is apparent, and it follows the trend of the crossfolds. Minor folds also follow these two trends.

Shearing

A few small shear zones were found during the survey. Nonmineralized shear zones are developed in the metasediments around the Weslemkoon granite. Minor shears up to a foot wide are present in the Ashby metagabbro. They are mineralized with pyrite and pyrrhotite.

Faulting

This is discussed under General Geology (pp. 5–7). No major faults were proved during the course of the survey.

ECONOMIC GEOLOGY

Graphite and garnet are the only minerals that have been mined in Ashby and Denbigh townships. Gravel deposits have been worked for road- and building-construction materials, and marble has been quarried and calcined for building and agricultural purposes.

Tremolite

Ashby Township

FORMER CONCESSION XIV, LOT 17 (SUBDIVISION ANNULLED)

There is an asbestos showing on a small promontory at the west end of Len Lake on former lot 17, concession XIV. Here, a small pit about 8 feet across and 4–6 feet deep has been blasted into a banded and silicated marble. The silicate minerals include colourless to pale-green asbestiform tremolite, talc, and quartz. The banding is due to the alternation of layers rich in tremolite, talc, and quartz or carbonate, with layers containing a mixture of these minerals. This banding strikes N.67°E. and dips at about 83°N. Crossing the banding at right angles are veins of asbestiform tremolite. These are generally ¼ to 1 inch thick; the widest vein is 6 inches across. They do not offset the banding, and there is no evidence that they have formed along shears. These cross-cutting veins usually end where they meet the tremolite-rich bands of the host rock, and the result is a poorly developed rectangular network of tremolite seams. The longest tremolite fibres found are 1¼ inches in length.

The talc-rich bands in the host rock are up to 7 inches thick; some are almost pure white talc.

An older and shallower pit, about 20 feet long and 2–4 feet deep, is also present on this headland.The rock here is now largely covered by moss, but some asbestiform tremolite can be seen together with much nonfibrous tremolite.

This occurrence does not appear to be of any economic significance.

Copper

A number of small metagabbro bodies in the Ashby-Denbigh area may be potential host rocks for base metals. A number of iron sulphide veinlets are present in the Ashby metagabbro. Iron sulphides are also present in some of the paragneisses of the area and a few of these occurrences have been investigated in the past by pitting. However, careful examination of the rock discarded from these pits has not revealed any copper minerals apart from a small malachite stain on one hand specimen.

Dolomite

Areas of dolomite marble are indicated on the maps (Nos. 2031 and 2049) accompanying this report. They are rarely completely free of accessory minerals.

Feldspar

None of the pegmatites found during the survey contains commercial feldspar. The potash feldspar crystals in these rocks are usually less than 6 inches across.

Garnet

Many of the paragneisses of the northern part of Ashby township are rich in garnet, and at one place a mine was established to recover this mineral. This area, and the ground west of Len Lake, is worthy of attention in any search for garnet deposits.

Ashby Township

CONCESSION XVI, LOT 3

This deposit has been described by V. L. Eardley-Wilmot (1927, pp. 13, 14), D. W. Atchison (1937), and J. Satterly (1945, p. 126). Eardley-Wilmot's report contains a small sketch map of the workings. The location given by Eardley-Wilmot was lot 9; this lot number has since been found to be incorrect. The workings are now covered by dense bush and undergrowth, and the quarry and strippings are no longer readily accessible. J. Satterly visited the deposit in September 1943, and described it as follows in Appendix II of his report (1945, p. 126):

A Garnet Deposit in Ashby Township, Lennox and Addington County[1]

A garnet occurrence on lot 3, concession XV [XVI], Ashby township, Lennox and Addington county, is known locally as the Ruby mine. Lot 3, concession XV, and adjacent lots were staked by James Coyne and Thomas Ryan in 1910, and the claims transferred to J. H. Jewell and Company in the same year. A shaft was sunk in the valley several hundred feet from the present quarry site and was known locally as the Jewell Ruby mine.

[1] Personal communication from Dr. J. Satterly confirms the correction made to the Concession No., as shown in square brackets.

Bancroft Mines Syndicate, Limited, worked the occurrence from 1922 to 1924. The quarry is about 1 mile by wagon road south of the Hardwood Lake–Denbigh road. Experimental shipments of crude garnet were made in 1922. A small concentrator was erected in 1922, and in 1923, 1,250 tons of garnet ore and concentrates for use in sandpaper manufacture were produced and shipped to the Carborundum Company, of Niagara Falls, N.Y. Shipments in 1924 amounted to 360 tons, worth $7,200. The company's mill burnt down on November 1, 1923, and operations ceased in March, 1924. The deposit was restaked in 1943 by L. Garbutt, but no work had been performed up to September, 1943, when the deposit was visited by the writer. At that date about 60 tons of garnet gneiss was stock-piled in the quarry.

The workings consist of a quarry, 40 by 50 feet and 15 feet deep, facing northeast. The rock exposed is a medium-grained, hornblende-biotite-garnet paragneiss, which strikes N.5°E. and dips 50°W. The exposed width of the garnet rock is 250 feet. Its limits are not known. The garnets are of a deep-red colour, range from a twentieth of an inch to half an inch in diameter, and may average a tenth of an inch across. They form 30 per cent of the rock. The hornblende tends to occur in bands with a maximum thickness of 1 inch, and the garnets in these bands are larger than the average but contain minute inclusions of quartz and other minerals. Quartz forms 5 per cent of the rock as narrow lenses and stringers.

The deposit has been described by Eardley-Wilmot, who states that "the garnet has been proved to be well suited for the abrasive purposes required, and commands a price equal to the best on the market."

No work appears to have been done on the property since Satterly's visit. Large reserves of garnet rock remain to be exploited.

FORMER CONCESSION XV, LOT 30 (SUBDIVISION ANNULLED)

A small pit (not shown on accompanying Map No. 2031) has been blasted out of sillimanite-garnet gneiss on this lot, presumably during prospecting for garnet. It reveals a richly garnetiferous gneiss. The surrounding gneiss is also rich in garnets that are pink and about the size of peas.

Gold

Two localities in Denbigh township were reported to R. W. Ells (1904; 1905) as having auriferous quartz veins. Ells was unable to confirm the presence of gold. The localities are said to be near Eagle Hills and Ferguson Corners.

Graphite

Graphite is sporadically developed in many of the marbles in Ashby and Denbigh townships. Only one occurrence of economic importance was seen during the survey. This is described below.

Denbigh Township

CONCESSION VIII, LOT 34

In 1920 H. S. Spence (1920, p. 39) reported on this deposit as follows:

On lot 34, concession VIII, township of Denbigh, in Addington, a small amount of mining was carried out during 1902–3, by J. G. Allan, of Hamilton, Ont. In the bulletin on Graphite, issued by the Geological Survey in 1904, p. 25, the ore on this property is stated to run as high as 76 per cent carbon, with an average of 50 per cent, and to be of the amorphous variety. The latter term probably signifies flakes so small as to give the ore a powdery character. About 200 tons of ore were mined from a shaft 50 feet deep and shipped in the crude state. No further work has been performed at this locality. On lot 1, concession VIII, of Ashby township, (the adjoining lot to the west) similar ore is stated to occur.

The mine workings can still be reached by an old trail from Ferguson Corners. They are not far from the north end of Little Birch Lake. The workings consist of two pits and an inclined shaft. The shaft is inclined at 65° in a direction N.52°W.;

it is nearly full of water. The larger pit, about 55 by 15 feet, is alongside the shaft and is partially filled with water. The smaller pit is about 20 feet to the west; it is 18 by 8 feet and 6–9 feet deep.

The rock seen in the pits is a micaceous calcitic marble containing rusty-weathering bands of grey and white biotite-syenite gneiss and pegmatite. It strikes N.42°E. and dips 66°NW. The marble contains disseminated graphite, and graphite seams up to 4 inches thick. Graphite is also present in the syenite bands. The surrounding rocks are poorly exposed, and it is impossible to assess the potentialities of this deposit without further exploration work.

Gravel

A number of gravel pits have been opened in the two townships for local use. The gravel is unsorted material with much sand and silt of glacial outwash origin.

Mica

No mica deposits of economic significance were found during the survey. The largest books of mica that were found were up to 2 inches long and occurred in pegmatites in the Weslemkoon granite.

Sillimanite

Sillimanite-bearing paragneisses are common in the Ashby-Denbigh area, but the mineral is never sufficiently concentrated to be of economic importance.

Uranium

Some claims were staked for uranium in the area south of Cotter Lake. The rocks of this part were carefully examined by the use of a geiger counter, but no signs of uranium mineralization were discovered.

No radioactive occurrences of economic significance were discovered during the survey.

APPENDIX

Harvey Simon Property[1]

Lyndoch Township, County of Renfrew
Denbigh Township, County of Lennox and Addington

In 1961, Noranda Exploration Co. Ltd. optioned the Harvey Simon copper property in Lyndoch and Denbigh townships, in the counties of Renfrew, and Lennox and Addington, respectively. The claim group is about 4 miles northeast of the village of Denbigh, and at the time of the option comprised 46 claims, and 3 lots.

At the same time, a number of other companies carried out staking, prospecting, or geophysical work on groups adjacent to the Simon property. These companies included Faraday Uranium Mines Ltd., Mining Corporation of Canada Ltd., Prospectors Airways Co. Ltd., and George MacMillan.

The following description of the property is compiled from information contained in two company reports (Wilton 1961) (Cross 1961) for Noranda Exploration Co. Ltd.

Noranda Exploration Co. Ltd. carried out an electromagnetic survey, and subsequent geological mapping at 1 inch to 50 feet, on parts of claims E.O. 19161, E.O. 19162, and E.O. 19163, Lyndoch township, and patented lot 40, East Range, Denbigh township. In September–October 1961, 13 holes (AX core) were drilled totalling 2,502 feet. Eleven of these holes were in E.O. 19161, one in E.O. 19162, and one hole in patented lot 40. Twelve holes were drilled at N.86°W., dip 45°, and the other hole, No. 11, was drilled vertically. The longest hole was No. 13; it reached a depth of 266 feet. The drilling was suspended in early October 1961, and the option was dropped.

The main rock type in the area mapped is a fine- to medium-grained amphibolite gneiss composed of hornblende and plagioclase with minor biotite and quartz. In places, accessory garnet is abundant, and quartz is common either in quartz-rich bands or as quartz eyes. Many bands in the amphibolite gneiss are hornblende amphibolite. The foliation strikes N. to N.15°E., and dips 30°–50°E., with local dips of 65°–70°E. Coarse-grained leucogranite pegmatite is present in varying amounts as *lit par lit* injections and as dikes.

The south showing is near the south boundary of claim E.O. 19161, the east half, lot 1, Range B, Lyndoch township. It is exposed in two trenches totalling 150 feet, and was explored by the 13 drillholes.

The mineralized zone strikes north and dips 30°–50°E. In the surface workings the gossan is exceedingly thick. The drilling program showed the zone to range from 2 to 30 feet in thickness. It is in highly altered interbanded amphibolite gneiss and hornblende amphibolite cut by leucogranite dikes and sills. Most core has coarse-grained feldspar and "blobs" of quartz intimately mixed with the sulphides. The sulphides in order of abundance are: pyrrhotite, chalcopyrite, pyrite, and sphalerite. Other minerals present in the mineralized zone are quartz,

[1]Prepared by J. Satterly, and published with the permission of Harvey S. Simon.

feldspar, chlorite, garnet, and biotite occurring as narrow bands of biotite schist. Pyrrhotite is the most abundant sulphide, and it frequently contains garnets.

The assay results from the drilling are given in the following table.

ASSAY PLAN FOR SOUTH COPPER SHOWING, HARVEY SIMON PROPERTY

Hole No.	From	To	True Width	Copper
	feet	feet	feet	percent
1	49.4	74.0	23.2	0.21
	80.0	84.0	4.0	0.05
2	141.4	144.0	2.6	1.85
3	32.8	54.8	22.0	0.85
4	50.0	60.4	10.4	1.33
	65.2	67.2	2.0	1.10
5	65.8	95.0	30.2	1.10
	107.5	109.5	2.0	0.50
6	89.2	91.7	2.5	0.81
	103.0	107.4	4.4	0.55
7	148.0	176.0	25.8	0.63
8	73.9	76.0	2.1	0.45
9	133.4	149.8	16.4	0.88
10	143.7	150.1	6.4	0.30
	160.4	163.6	3.2	0.65
11 (cut zone at 45°)	175.4	178.9	2.47	0.28
	181.5	185.0	2.47	0.55
	194.2	207.7	9.54	2.48
	211.0	216.9	4.17	1.45
12	104.0	110.6	6.6	0.35
13	115.6	123.8	8.2	0.90

The north showing, 900 feet north of the south showing, has been exposed in two trenches totalling 80 feet. In 1956 this showing was explored by Eugene Simon by means of a few pits and by six diamond-drillholes totalling 1,077 feet. Copper values were indicated, but further work will be required to determine tonnage and grade. The country rocks are a mixture of amphibolite gneiss, hornblende amphibolite, leucogranite, and minor amounts of garnet-sillimanite schist. The ore minerals are massive pyrite, chalcopyrite, and very abundant magnetite. The mineralized zone is essentially parallel to the gneissosity although one high-magnetite zone striking northeast cuts across the foliation. At the bottom of the hill, 500 feet east of the north showing, is a small showing of massive pyrite and chalcopyrite in a zone about 1 foot wide, conformable with the foliation. On the road between the two main showings is a very small showing of coarse but disseminated pyrite and chalcopyrite in a dark amphibolite.

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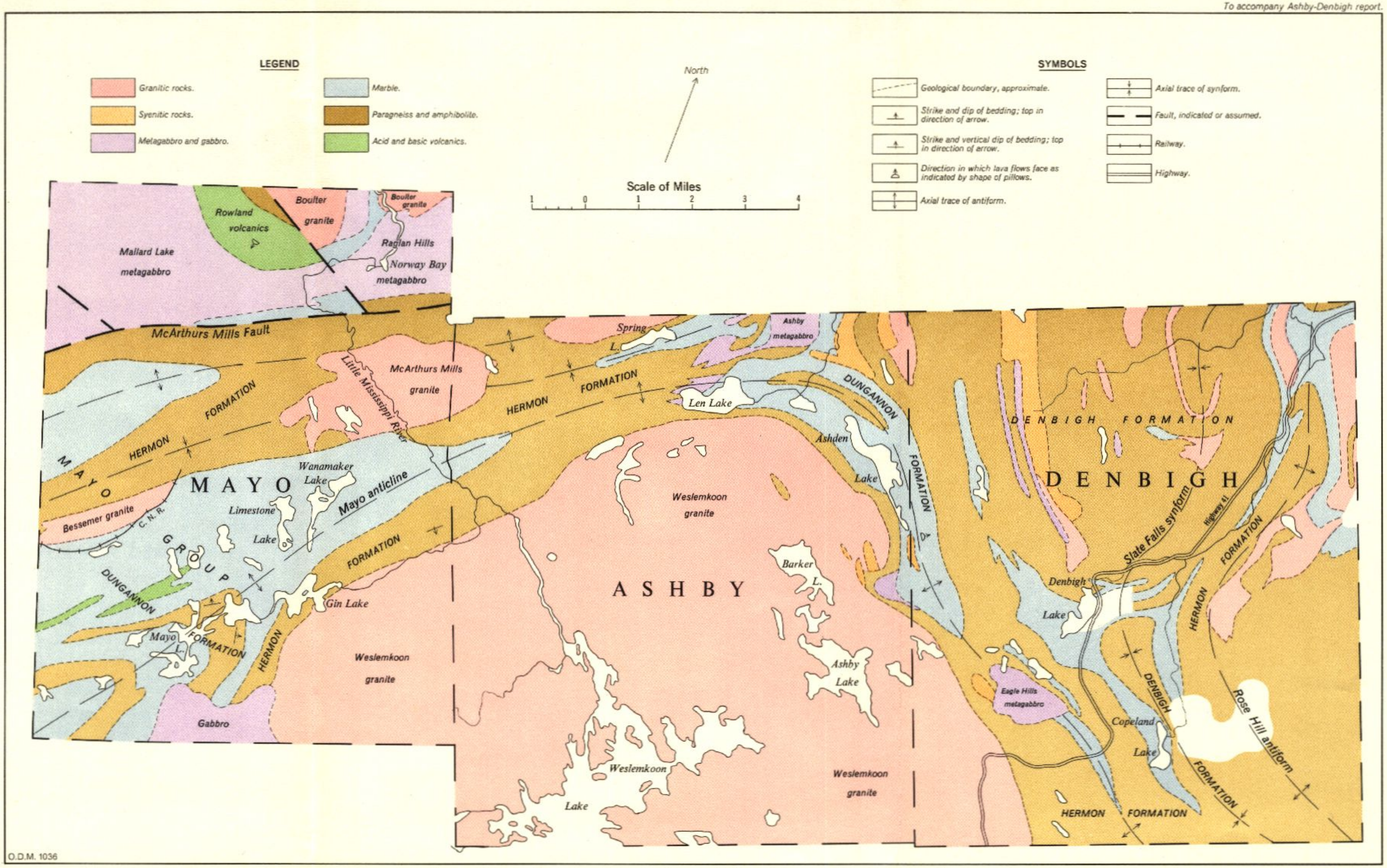
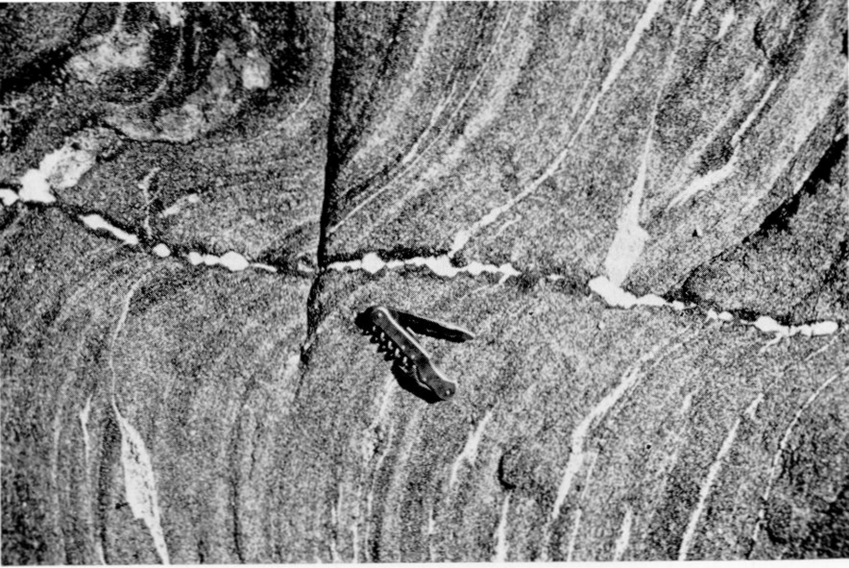
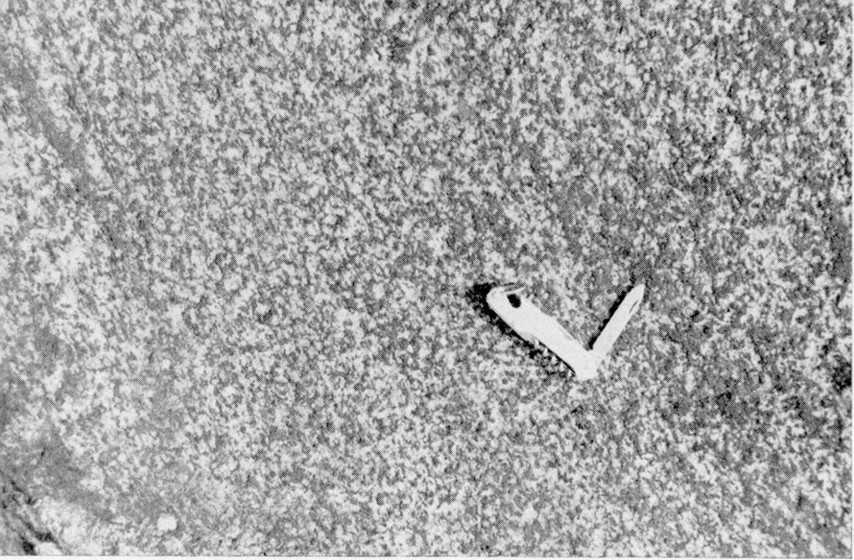
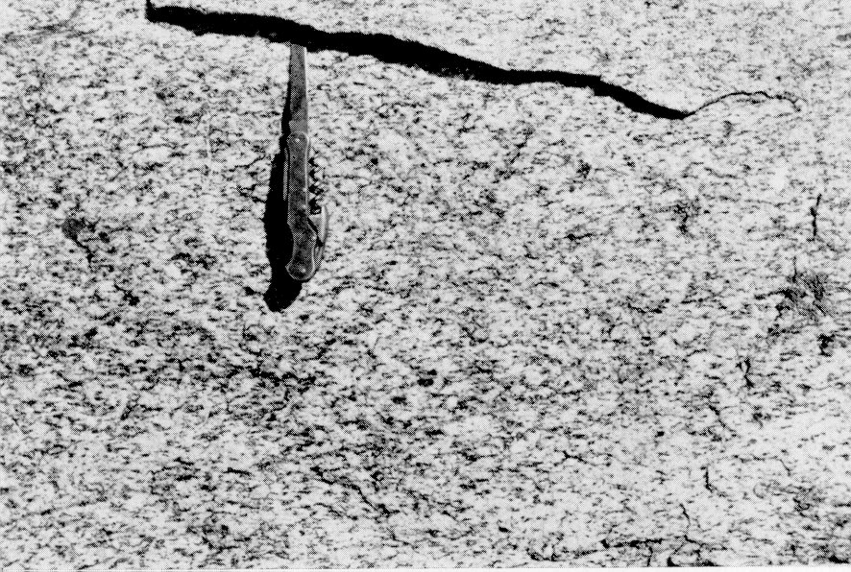
To accompany Ashby-Denbigh report.

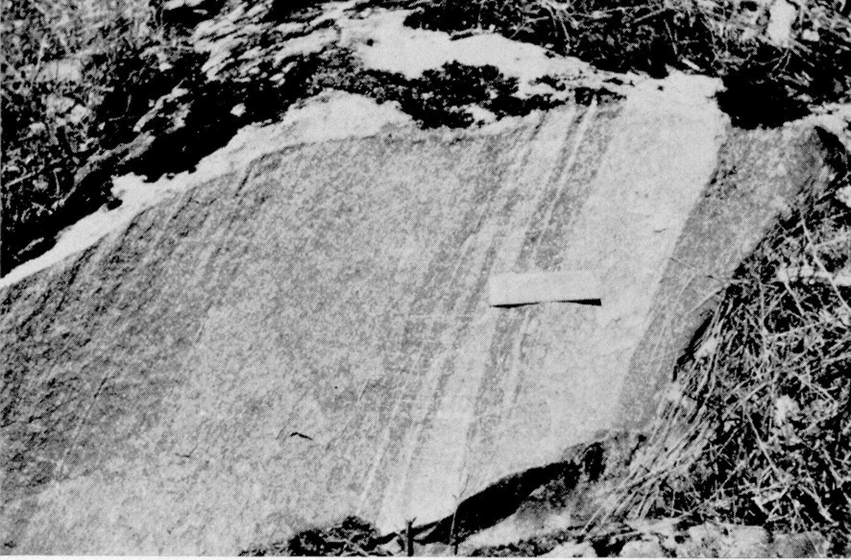


Generalized geological and structural map of Mayo, Ashby, and Denbigh Townships









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Geology of Ashby and Denbigh Townships

By
A. M. EVANS

Geological Report No. 26

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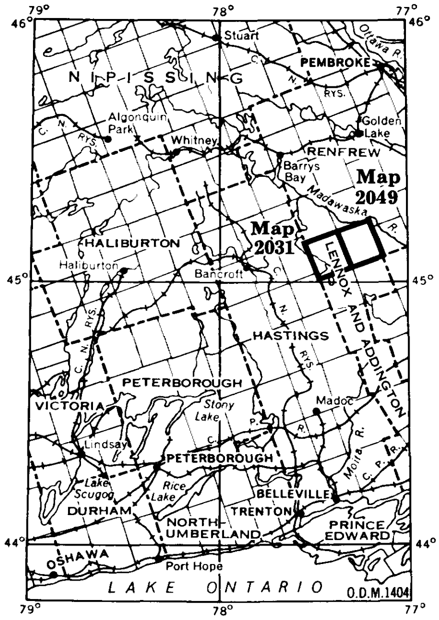
ABSTRACT

All of the bedrock in Ashby and Denbigh townships is Precambrian. The oldest rocks are marbles, paragneisses, and para-amphibolites. These are assigned to the Dungannon and Hermon formations (already defined) and to the newly defined Denbigh Formation. These formations, which were intruded by a number of basic igneous bodies before their regional metamorphism, occupy most of Denbigh township and the northern part of Ashby township.



Key map showing the location of the Ashby-Denbigh map-area. Scale, 1 inch to 50 miles.

Most of Ashby township is underlain by the north half of a large batholith of granitic gneiss. This deflects the folds present in the metasediments and is clearly intrusive into them. Beyond the influence of this batholith, the folds trend approximately northeast; but this trend is much modified in Denbigh township by west-northwest-trending crossfolds that have produced marked plunge depressions and culminations in the major folds.

The dominant structure in Denbigh township is the Slate Falls synform occupying most of the centre of the township. The foliation of the Weslemkoon granite has been thrown into a series of major and minor folds trending northeast and southwest. The grade of metamorphism in the metasediments is that of the sillimanite-almandine-muscovite subfacies of the almandine-amphibolite facies.

Graphite and garnet have been mined in Denbigh township. Gravel is available for road building and marble is quarried for lime production. Dolomitic areas in the marble are indicated on Maps Nos. 2031 and 2049. The small metagabbro bodies are potential host rocks for base metals. Veinlets of iron sulphides are present in the Ashby metagabbro.

Geology of Ashby and Denbigh Townships

By

A. M. Evans[1]

INTRODUCTION

Ashby and Denbigh townships form the most northern part of Lennox and Addington county in eastern Ontario. They extend over 160 square miles and are covered by the Bancroft and Denbigh sheets of the National Topographic Series.[2]

The villages and post offices of Denbigh and Slate Falls are in Denbigh township.

Prospecting and Mining Activity

Little prospecting appears to have been carried out in these townships. An early note of such activity mentions two reported occurrences of gold in Denbigh township (Ells 1904; 1905). Later prospecting in the area has been concerned with graphite, garnet, asbestos, base metals, and uranium. Mining activity in the township has been restricted to graphite and garnet.

During 1902 and 1903, J. G. Allan of Hamilton worked a small graphite mine in lot 34, concession VIII, of Denbigh township.

Bancroft Mines Syndicate Ltd. operated a garnet quarry and mine in the northeastern part of Ashby township from 1922 to 1924; this is known locally as the Ruby mine.

Present Geological Survey

The present geological survey of Ashby and Denbigh townships was made during the summers of 1956 and 1957. The field work was carried out by two senior assistants, who were responsible for the field mapping, and two junior assistants who ran pace-and-compass traverses.

Air photographs on the scale of 1 inch to ¼ mile were employed in field mapping, and most of the area was surveyed by running traverses between points readily locatable on these photographs. Probable outcrop areas were outlined on the photographs by using a pocket stereoscope, and the traverses were planned to cross as many areas of potential outcrop as possible. The general traverse interval was ¼ mile Information obtained on the traverses was supplemented by examining the rock exposures around nearly all the lakes in the area and along all the roads and many of the trails.

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[1]Assistant Lecturer, Dept. Geology, The University, Leicester, England.

[2]Published on the scale of 1:50,000 by the Canada Department of National Defence, and available from the Canada Department of Mines and Technical Surveys, Ottawa.

The geology was recorded on acetate (Perfatrace) sheets placed over the air photographs. From these it was transferred by the use of a Sketchmaster to a basemap on the scale of 1 inch to ¼ mile, prepared by the Cartography Unit of the Ontario Department of Mines from maps of the Forest Resources Inventory, Ontario Department of Lands and Forests. The final maps, Nos. 2031 and 2049 (*back pocket*), are reproduced on the scale of 1 inch to ½ mile.

The outcrops shown on the published map record as much detail as can be presented on this scale. Areas with many small outcrops are shown as large outcrops. Within these areas, bedrock could be reached in many places by trenching. Because the traverse interval was large, many outcrops in the area were not visited during this survey. The final map must, therefore, be regarded as a generalization based only on the data collected during the survey and open to revision as soon as further detailed surveys are performed in these townships.

The colour and first symbol of each outcrop area indicate the dominant rock present. Rock types present in subsidiary amounts in the same outcrop area are indicated by the succeeding symbols. It must be emphasized that in these townships, as in other parts of the Grenville Province, the rocks may show considerable lithological variations over short distances. Some of the rock types weather away much more rapidly than others. Therefore, the rocks present in some outcrops may give a somewhat erroneous impression of the general geology of the area immediately around them. This is particularly true of granite pegmatites. These often stand out in contrast against the paragneisses and may therefore be thought to form more of the bedrock than they actually do.

Acknowledgments

The author was ably assisted in the field in 1956 by E. C. Appleyard, E. Thompson, and J. Verity, and in 1957 by E. C. Appleyard, G. L. Rock, and T. Pugsley. Mr. Appleyard, as senior assistant, was responsible for half the geological mapping. The author would like to thank all the members of the party for their able assistance during the course of the survey.

The writer wishes to express his appreciation to the residents of the area, who generously rendered assistance in various ways during the field season.

Means of Access

Much of Denbigh township is readily accessible by road. Highway No. 41 from Napanee to Eganville runs across the township. The gravel roads leading off the highway are unequal in merit but, in general, they provide easy access to the township.

Ashby township is less accessible. The northern parts are best approached from gravel roads in Raglan township, the most useful being the road joining McArthurs Mills (Mayo township) to the village of Hardwood Lake and the road from Hardwood Lake to Denbigh. The gravel road running south in Raglan township to lot 15, concession XVI, of Ashby township has been extended southward by the Ontario Department of Lands and Forests to the otherwise inaccessible centre of the township. The positions of this road and also of a short branch road were plotted by means of a pace-and-compass survey and are shown on map No. 2031. Two other branch roads diverge from this gravel road to give access to Spring and Len lakes.

The western section of Ashby township can be approached by using a gravel road from McArthurs Mills to Weslemkoon Lake. A trail runs from this road to

Barnard Lake; there is another trail (not shown on the map) to Crystal Lake. Boats are usually available on both these lakes and can be hired for use in penetrating to other parts of the township. Crystal Lake is particularly useful from this point of view.

Weslemkoon and Cotter lakes give access to a large part of Ashby township. Gravel roads lead from highway No. 41 in Denbigh to Ashby Lake and Ashden Lake, both in Ashby township. An easy portage links Ashby Lake to King Lake, and another easy portage allows Barker Lake to be reached. The southeastern corner of Ashby township can be approached by a gravel road from highway No. 41.

Previous Geological Work

The only geological mapping of Ashby and Denbigh townships done prior to the present survey was conducted in 1895 and 1896 (Ells 1904; 1905). The resulting map, identified as the Perth sheet (Geol. Surv. Canada, map No. 119), was published in 1904 on a scale of 1 inch to 4 miles.

In his review of Canadian graphite resources, Ells describes the mining of graphite in Denbigh township (Ells 1904a). His description of the deposit was subsequently repeated by Spence (1920, p. 39). Details of the garnet mine[1] in Ashby township were recorded later (Eardley-Wilmot 1927, pp. 13, 14). This mine was revisited still later and carefully studied by Satterly (1945, p. 126).

The results of a stratigraphical and structural survey of the Ottawa-Bonnechère graben and adjacent areas were also published (Kay 1942, pp. 585–646). The conclusions of Kay's report are discussed in this report in the section on topography.

Aeromagnetic maps, published by the Geological Survey of Canada, are available for the whole area. The two relevant sheets are: Map No. 15G—Bancroft, Ontario, 1950; and Map No. 96G—Denbigh, Renfrew, Frontenac, Hastings, and Lennox and Addington counties, Ontario, 1952.

A geological reconnaissance of Matawachan township, east of Denbigh township, has been made (Satterly 1945, map); the two townships (Raglan and Lyndoch) north of the area have been described (Hewitt 1954); and Mayo township, to the west, has been surveyed (Hewitt and James 1956).

Topography

The general elevation of the area is between 1,100 and 1,300 feet. The highest points in the area reach nearly 1,600 feet and are in the hills 2 miles northwest of the village of Denbigh. The lowest point in the area, about 840 feet, is in the northeast corner of Denbigh township where Hydes Creek crosses the boundary into Lyndoch township.

The physiography of the area has been described by Kay (1942). According to Kay, most of Denbigh township and the northeastern corner of Ashby township belong (physiographically) to the Madawaska Highlands, and the rest of Ashby township and the southwest corner of Denbigh township belong to the Cashel peneplane. One paper (Hewitt 1956) on the regional geology of this part of Ontario has assigned the area (geologically) to the Madawaska Highlands.

The nature of the region's underlying bedrock has had a considerable influence on the topography of both townships. The highest ground is usually

[1]Location given by Eardley-Wilmot was lot 9; this lot No. has since been found to be incorrect.

formed of syenite gneiss, metagabbro, or granitic rocks. Granitic pegmatites often give rise to prominent ridges. In general, marked ridges in the area are parallel to the foliation of the bedrock. The granodioritic Weslemkoon batholith is an exception to the rule that granitic rocks usually give rise to high ground. Much of the area underlain by this unit is below 1,300 feet in height. The low ground outside the Weslemkoon batholith is usually underlain by marble.

View looking northwestward from lot 22, concession VI, Denbigh township, showing the highest ground in the area.

Drainage

The two townships contain more than 100 small lakes and ponds. The largest body of water, Weslemkoon Lake, lies in the southwest corner of Ashby township and stretches southward well into Effiingham township. Weslemkoon Lake and the other large lakes of the area lie on, or close to, the Weslemkoon batholith. Most of the lakes and ponds outside the bounds of this geological unit owe their existence to the differential erosion of marble bands in the gneissic complex. Some creeks also follow marble bands or the strike of the foliation in the gneisses, but many creeks cut across the geological boundaries at great angles, as does the Little Mississippi River. The directions followed by many creeks are apparently related to the joint directions of the area. These joint directions also control the linear portions of the shorelines of Weslemkoon Lake.

The majority of the lakes in Ashby township drain through creeks and through Weslemkoon Lake to the Little Mississippi River. West of the map-area, this river joins the York River (a tributary of the Madawaska River) in Raglan township.

The lakes and creeks in the northeastern part of Ashby township and most of Denbigh township drain northward or eastward to the Madawaska River.

Natural Resources

A few farms have been established near the eastern and northern boundaries of Ashby township, but the main area of settlement is in Denbigh township. Denbigh township also contains a number of abandoned farmsteads on which the cleared ground is slowly being reclaimed by the bush.

Lumbering is an important industry in the area. Most of the timber cut is spruce, maple, yellow birch, hemlock, poplar, and pine.

The tourist industry is becoming increasingly important, and many cottages and summer resorts have been established on Weslemkoon, Denbigh, and Ashby[1] lakes.

GENERAL GEOLOGY

Ashby and Denbigh townships belong to the Grenville Province of the Precambrian Shield. All the bedrock is of Precambrian age. Unconsolidated deposits of Pleistocene age occur throughout the townships. In places, these deposits are sufficiently thick to mask the nature of the underlying bedrock; such an area appears on map No. 2049 (Denbigh) and has been left uncoloured.

From the regional point of view the area is similar in its rock types and structure to the Hastings Basin (Hewitt 1956, pp. 30, 31) (Hewitt and James 1956, pp. 6–11, 16–24). Some formations recognized in the Hastings Basin have been traced into the two townships.

The oldest rocks of the area are marbles, paragneisses, and amphibolites. These were formed by the regional metamorphism of a varied succession of sediments including limestones, greywackes, and normal and calcareous shales. After their deposition, these sediments were intruded by a number of basic igneous rocks, strongly folded, and then metamorphosed. Throughout the two townships, the metamorphism has produced sillimanite in rocks that have a suitable composition.

During the metamorphism, some of the metasediments were feldspathized and granitized, resulting in the production of syenite gneisses, granite gneisses, and some of the pegmatites. The latest events in this part of the geological history were the emplacement of the McArthurs Mills and Weslemkoon granites and the development of more pegmatites.

The metasediments are best seen in Denbigh where they underlie most of the township (*see* facing map). They also extend across the northern part of Ashby township where they have been mapped by Hewitt and James (1956). This continuity of outcrop across northern Ashby has enabled certain stratigraphical correlations to be made with the successions established by these workers in Dungannon and Mayo townships. It must be emphasized that this correlation depends upon the tentative structural interpretation advanced in this report.

The major structural feature of the metasedimentary terrane is a "synform"[2] occupying the central part of the north half of Denbigh township. This is referred to here as the Slate Falls synform. It is believed to be flanked by two antiforms:

[1] This lake is referred to locally as Thirty Islands Lake.

[2] The area has revealed only one exposure containing a primary rock structure indicating the direction in which the formations face. The noncommittal terms "antiform" and "synform" are therefore employed in place of anticline and syncline, because the use of the latter terms would imply that the strata forming the structures are known to be the right way up.

one of these appears to cross the northern part of Ashby township to join the Mayo anticline mapped by Hewitt and James; the other, the Rose Hill antiform, lies east of the Slate Falls synform and runs parallel to it.

TABLE OF FORMATIONS

CENOZOIC	
Pleistocene	Boulder clay, silt, sand, gravel.
	Great Unconformity
PRECAMBRIAN	
Plutonic Rocks	Granite pegmatites. McArthurs Mills granite. Weslemkoon granite.
	Intrusive Contact
	Granite and syenite gneisses and pegmatites. Eagle Hills metagabbro and other metamorphosed basic igneous intrusions.
	Intrusive Contact
Grenville-Type Metasediments	
	Mayo Group: Denbigh Formation: Paragneiss member; marble member. Hermon Formation: Paragneiss and amphibolite. Dungannon Formation: Marble member; amphibolite member.

The structure of the whole area has been complicated by the emplacement of the Weslemkoon granite. This forms a large batholith underlying a number of townships south of the area, the greater part of Ashby, and the southwest corner of Denbigh township. The distribution of the other plutonic rocks of the area is indicated on the generalized geological map (facing p. 5). The probable age relationships of the Precambrian rocks are indicated in the Table of Formations.

Long after the last metamorphic and plutonic events, the whole area was peneplaned. This was probably late in the Precambrian.

In adjoining areas, Hewitt has mapped northwest-trending faults of Tertiary age (Hewitt 1954, pp. 5, 6, 31–34). Faults of the same system are not prominent in Ashby or Denbigh townships; but a number of weakly developed lineaments have the same trend and probably indicate that the area was affected by minor faulting at this time.

During the Pleistocene, the whole region was glaciated by a continental ice-sheet. As the ice retreated, deposits of boulder clay and glaciofluvial sand and gravel were formed. These lie as a mantle on the bedrock.

Precambrian

Metasediments of the Mayo Group

Because the three formations of the Mayo group mapped in Ashby and Denbigh townships have a number of rock types in common, the principal characteristics of these formations are discussed here, and the petrography of the rocks they are composed of is described.

The Dungannon Formation and the Hermon Formation were defined by

MAP LEGEND
(As shown on maps Nos. 2031 and 2049 in back pocket.)

CENOZOIC

RECENT AND PLEISTOCENE Sand, gravel, and clay.

Great Unconformity

PRECAMBRIAN

PLUTONIC ROCKS

Granitic Rocks:

8a Pink and grey leucogranite gneiss.
8b Hornblende granite or hornblende granodiorite; hornblende granite gneiss or hornblende granodiorite gneiss.
8c Biotite granite or biotite granodiorite; biotite granite gneiss or biotite granodiorite gneiss.
8p Pegmatite.

Syenitic Rocks:

7a Pink and grey leucosyenite; leucosyenite gneiss.
7b Hornblende syenite; hornblende syenite gneiss.
7c Biotite syenite; biotite syenite gneiss.
7p Pegmatite.[1]

Nepheline Syenitic Rocks:

6m Nepheline-aegirine-augite syenite gneiss.[1]

Intrusive Contact

Metamorphosed Basic Intrusive Rocks:

4d Metagabbro, hornblende-plagioclase schist.
4s Hornblende-scapolite gneiss.
4e Amphibolite, hornblende schist.

METASEDIMENTS

Marble:

3 Marble, largely or wholly calcite.
3z Dolomitic marble.
3b Silicated marble, silicates include chondrodite, diopside, phlogopite, plagioclase, tremolite.
3c Marble with graphite.[1]
3s Calc-silicate rock.

Paragneiss-Amphibolite Group (Includes all metasedimentary rocks except marbles. Some areas mapped as para-amphibolite may represent metamorphosed basic igneous rocks.):

2a Amphibolite (hornblende-plagioclase gneiss and schist), includes biotite amphibolite, biotite-scapolite amphibolite, garnet amphibolite, rusty-weathering amphibolite containing small amounts of iron sulphides.
2f Quartzo-feldspathic gneiss, includes muscovite-quartz-feldspar gneiss or schist, sometimes with sillimanite.
2p Paragneiss (biotite-quartz-plagioclase gneiss), includes garnet paragneiss, muscovite-garnet paragneiss, sillimanite-garnet paragneiss, hornblende paragneiss, *lit par lit* gneiss (centimetres-thick bands of paragneiss and granitic gneiss), rusty-weathering paragneiss containing small amounts of iron sulphides.
2q Quartzite, includes garnet quartzite.

METAVOLCANICS[1]

1a Amphibolite.

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[1]Not on map No. 2031.

Hewitt and James (1956, pp. 8, 16–24). The Denbigh Formation is believed to overlie them; it is defined in this report on pages 10, 11.

DUNGANNON FORMATION

Only the uppermost member of this formation has been positively identified in the area. This is the marble member forming the core of the Mayo anticline where it crosses the township boundary between Mayo and Ashby. Because this fold plunges northeast, the outcrop of the marble narrows rapidly and, soon after passing into Ashby, the marble disappears below the overlying Hermon Formation. The plunge depression ends near Len Lake, and the marble reappears and follows the fold around the Weslemkoon granite into Denbigh township where, owing to another plunge depression, it again disappears below the Hermon Formation.

The marble immediately northeast and southeast of the Eagle Hills metagabbro is believed to represent the continuation of the Mayo core. North of Simpson and Ashden lakes, an amphibolite member occurs in the marble. This horizon may be of the same age as the Turriff rusty schist and Detlor feather amphibolite and marble members of Dungannon and Mayo townships. It does not, however, have any development of feather amphibolite.

Near the south end of Ashden Lake, a few outcrops of a metamorphosed basic volcanic rock have been found. One outcrop contains what are obviously pillow structures. This rock could represent volcanicity of the same age as the volcanicity responsible for producing the basic volcanic member in Dungannon township.

The maximum thickness attained by the members of the Dungannon Formation in this area is about 2,000 feet.

HERMON FORMATION

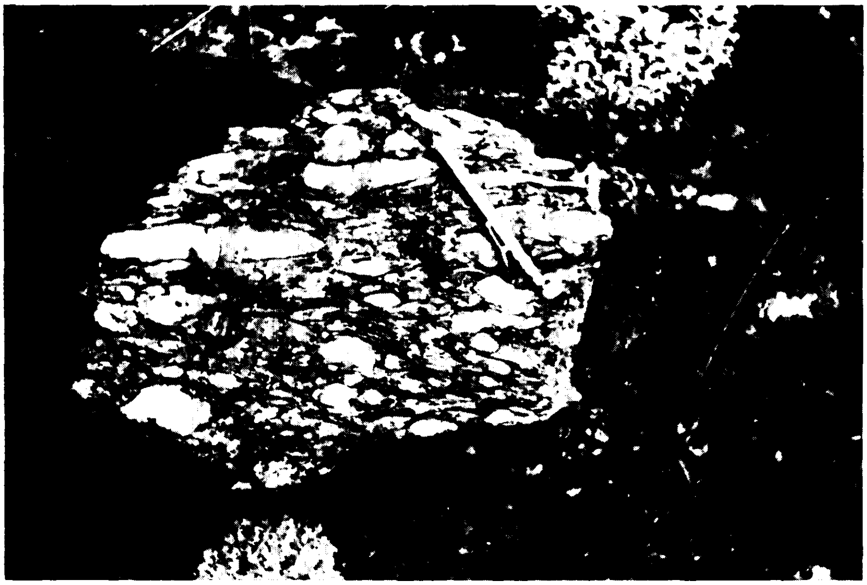
All the paragneiss and para-amphibolite in the northwestern part of Ashby township belong to this formation. The same rocks can be traced with few interruptions along both limbs of the Mayo anticline, from Mayo through Ashby and Denbigh, to Abinger township. If the structural interpretation of the area is correct, then the Hermon Formation is also present in eastern Denbigh township in the core of the Rose Hill antiform.

The Hermon Formation has been mapped previously in Dungannon and Mayo townships (Hewitt and James 1956, pp. 8, 16–24) and in Cardiff and Faraday townships (Hewitt 1959, pp. 20, 21). It attains its greatest thickness, namely 10,000 feet, around Silent Lake in Cardiff township. Despite its extensive development in these townships, the upper limit of the formation cannot be clearly defined, as it is cut off by the McArthurs Mills fault to the north and by the Weslemkoon granite to the south. In Denbigh township, however, it is overlain by the fairly persistent marble layer used in this report to define the base of the overlying Denbigh Formation. The Hermon Formation reaches a thickness of about 6,000 feet in the southern part of Denbigh township.

The principal rock types present in the Hermon Formation in Ashby and Denbigh townships are biotite-quartz-plagioclase gneiss, para-amphibolite, and pelitic schist. Also present are quartz-feldspar gneiss, marble, metaconglomerate, quartzite, and pyritic varieties of the major rock types. The formation is well exposed in roadside outcrops along highway No. 41 south of the village of Denbigh. This part of the Hermon Formation is predominantly biotite-quartz-plagioclase gneiss and para-amphibolite. Pelitic schist becomes more common in the northeast corner of Ashby township.

Some bands of amphibolite in the Hermon Formation may be of volcanic origin, and ellipsoidal structures, probably representing deformed pillow lavas, were found in a band north of Barnard Lake and in a roadside outcrop on highway No. 41 near the village of Vennacher Junction. In the bands north of Barnard Lake, rounded patches rich in epidote are present in parts of the amphibolite; these may represent altered volcanic bombs. However, most of the amphibolite in the Hermon Formation is intimately interbanded with undoubted paragneisses and usually contains appreciable quantities of biotite, so that its sedimentary origin can hardly be doubted.

Quartzo-feldspathic gneiss bands are well developed in this formation in the townships to the west of Ashby, but they are few and thin in the area now being



Specimen of pseudoconglomerate from the Hermon Formation near Barnard Lake. The "pebbles" are deformed fragments of vein quartz.

described. Bands of quartzite are even rarer. A few bands of metaconglomerate can be seen near the boundary of Mayo township. They are developed near a horizon about ⅜ mile from the contact with the Weslemkoon granite. The original rocks appear to have been pebble conglomerates with an impure sandy matrix. They are all now intensely deformed and many of the pebbles are stretched beyond recognition; still-recognizable pebbles are frequently about 3–5 inches long, 1 inch across, and ¼ inch thick.

The rock types of the Hermon Formation noticeably richer in quartz than the average often contain veins and stringers of quartz; these usually parallel the foliation. Their most prolific development is in Ashby township. Some of these quartz bodies were clearly emplaced before the final deformations of the area were completed; as a result, some of the quartz veins have been drawn out into elongate rod-like shapes having, in cross-section, the appearance of quartz pebbles. Rocks containing these pseudo-pebbles in well-developed form could easily be mistaken for quartz-pebble conglomerates; but some adjoining outcrops show various stages of the process whereby these pseudoconglomerates were produced.

Sulphide-rich varieties of the principal paragneisses of the Hermon Formation occur as beds up to 70 feet thick in various parts of the formation. The principal sulphide is pyrite, but pyrrhotite is as common in some places. The occasional presence of small amounts of copper minerals is indicated by rare malachite incrustations. These beds are usually only 5–20 feet thick and are readily identifiable by their characteristic manner of weathering. Outcrops of these beds have a rusty-yellow appearance due to the development of hydrous iron oxides. White seams of gypsum are also developed during the weathering of these beds. A good example of a sulphide-bearing amphibolite can be seen on the Ashby-Mayo boundary near the contact with the Weslemkoon granite. The sulphides show a definite restriction to certain sedimentary beds and are accompanied by accessory amounts of graphite. These observations suggest that the sulphides are of sedimentary origin.

A few discontinuous bands of marble are developed at various levels in the Hermon Formation. In Ashby township these are too small to be shown on the map, but in southern Denbigh township a number of marble bands up to a mile long were found during the survey.

An important feature of the Hermon Formation in the northern part of Ashby and in the northwestern part of Denbigh townships is the widespread development of garnet. The richest area for garnet occurs in the northeastern part of Ashby township where it was once mined. Another good locality for garnet lies about 1 mile northeast of Barnard Lake. The garnet is best developed in pelitic schist and gneiss, but some hornblendic gneisses also contain appreciable amounts of garnet. The associated rock types around these localities are also rich in garnet. They include garnetiferous amphibolite, and also granite gneisses and syenite gneisses.

The scapolitization of portions of the Hermon Formation, which is a distinctive characteristic of the formation in north-central Mayo township (Hewitt and James 1956, p. 18), continues into Ashby township. Here, however, it is not nearly so marked a feature and the actual distribution of scapolite in the two townships could only be outlined by the use of innumerable thin sections. A few of the thin sections prepared from rocks of the Hermon Formation show partial scapolitization of plagioclase. Some scapolite-rich bands were also found in the marble of the Dungannon Formation around Ashden Lake.

DENBIGH FORMATION

In the western half of Denbigh township a fairly persistent marble horizon lies structurally above the Hermon Formation. This marble is believed to be the same as the marble occurring in the eastern limb of the Slate Falls synform. The bottom of this marble is here defined as marking the base of the Denbigh Formation. Above the marble, and forming the core of the Slate Falls synform, is a thick sequence of paragneisses constituting in this area the upper part of the Denbigh Formation.

No convenient marker horizon suitable for defining its upper limit is present at or near the top of this member. It is possible that a suitable upper limit may be given to this formation when it has been mapped in adjoining townships. The Denbigh Formation achieves its maximum thickness in the western limb of the Slate Falls synform. Here it is 10,000–15,000 feet thick.

As defined here, the Denbigh Formation is present in Denbigh township in the core of the Slate Falls synform. This synform carries it northward into Lyndoch township and southward into Abinger township. The formation is also present in the eastern side of the Rose Hill antiform and extends eastward into Matawatchan township. In the northwestern part of Ashby township, a northeast-trending synform in the neighborhood of Spring Lake contains marble in its core. This marble overlies the Hermon Formation with apparent conformity and may therefore be correlated with the marble member forming the lower part of the Denbigh Formation.

The marble member consists predominantly of coarsely crystalline calcite, but in places the marble may be entirely dolomite. It is rarely completely free of calc-silicate minerals. These are sometimes freely disseminated throughout the rock but they are also concentrated in siliceous layers parallel to the foliation. Thin amphibolite layers are present here and there throughout the member. These, too, parallel the foliation and probably represent former partings of calcareous shale in the original limestone.

The paragneiss member is principally composed of para-amphibolite and biotite-quartz-plagioclase gneiss with amphibolite predominating in most parts of the formation. Subordinate amounts of pelitic gneiss and marble are present. As in the Hermon Formation, pyritic varieties of the gneisses are present at the various levels. A number of these are well exposed in fields around Slate Falls and other easily accessible occurrences can be seen in fields south of Plotz Lake.

Feldspathization and granitization have affected various portions of the paragneiss member, thus giving rise to the development of permeation gneiss, *lit par lit* gneiss, and syenitic granitic gneisses. In the last two rock types, partially transformed relicts of the metasediments are commonly encountered, and garnets inherited from the transformed paragneisses are sometimes widespread. (This latter is especially true of the areas of syenite and granite gneiss present in the western limb of the Slate Falls synform.) Permeation gneisses are particularly well exposed in outcrops along Hydes Creek in lot 5, concession XIV, Denbigh township.

PETROGRAPHY OF THE METAVOLCANIC ROCKS OF THE MAYO GROUP

Amphibolite

The only rocks of undoubted volcanic origin form an amphibolite band about ½ mile long in lots 33, concessions IX and X, Denbigh township. This band occurs in marble of the Dungannon Formation. The lower contact with the marble was seen in two exposures. It is sharp, and parallel to the foliation in both rocks. The outlines of former pillows can be seen in several outcrops.

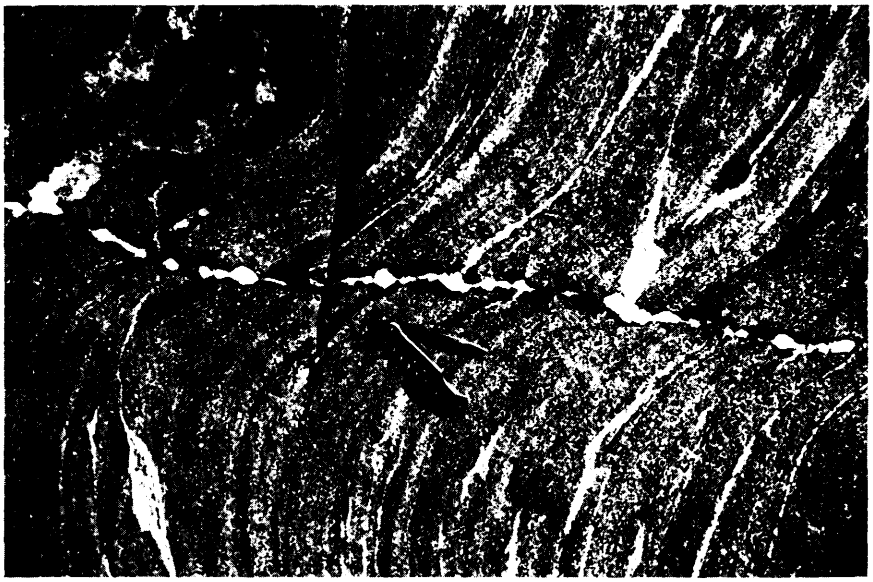
In others, white spots of feldspar occur, representing, perhaps, recrystallized amygdules. Under the microscope, this rock is seen to consist essentially of hornblende and plagioclase, though subordinate amounts of scapolite and carbonate are also present. Accessory minerals include apatite and magnetite. The rock is not as well foliated as the typical para-amphibolites. The parent rock type was probably basalt.

A few occurrences of what may be metavolcanics were found in the Hermon Formation. The locations of these are mentioned above. Some of them contained possible pillow lavas, and others possessed small rounded patches of feldspar and scapolite, possibly representing former amygdules.

PETROGRAPHY OF THE METASEDIMENTARY ROCKS OF THE MAYO GROUP

Amphibolite

The great majority of the amphibolites in the two townships are believed to have been formed by the metamorphism of calcareous sediments. The reasons for this interpretation are as follows: (1) the considerable development of biotite in many of the rocks; (2) the intimate interlayering on various scales with rocks of undoubted sedimentary origin; (3) the abundance of accessory graphite to be seen in many examples; (4) the considerable quantity of quartz (up to 30 percent) found in some specimens; and (5) the absence of any structures indicative of volcanic or intrusive origin.



Para-amphibolite with a segregation vein of feldspar developed in a fracture. Note the hornblende-rich margin in the host rock and the foliated nature of the amphibolite. Outcrop alongside highway No. 41, Denbigh township.

Three rocks may be considered as possible ancestors of the para-amphibolites: calcareous tuffs, calcareous greywackes, and calcareous shales. The first possibility appears to be unlikely in the absence of any evidence of associated volcanic activity. The second is a more distinct possibility, but, in view of the absence of any supporting evidence, is less favored by the author than the third alternative—that the original rocks were calcareous shales. Supporting evidence for this last possibility exists in the high biotite content of some para-amphibolites and in the way they are interlayered with, and otherwise spatially related to, the marbles.

In hand specimens the para-amphibolites are medium-grained dark gneisses. Unweathered samples are tough and compact. All varieties possess some degree of foliation. This is best developed in the hornblende-rich and biotite-rich varieties. These two minerals usually show a good parallel alignment, thus imparting a lineation to the rock.

The principal minerals of the para-amphibolites are hornblende and plagioclase (usually oligoclase); considerable amounts of biotite, quartz, and scapolite may also be present. Accessory amounts of garnet, carbonate, graphite, magnetite, epidote, apatite, pyrite, and pyrrhotite are often present. No pyroxene is developed in the normal amphibolites, but it does appear in varieties that contain considerable quantities of carbonate and very little hornblende and plagioclase, and these varieties are clearly intermediate in chemical composition between the amphibolites and marbles. Potash feldspar is developed in the amphibolite in areas where all the rocks show evidence of feldspathization.

Under the microscope, the hornblende-rich and biotite-rich varieties of para-amphibolite are seen to possess a lepidoblastic texture. This is less pronounced in specimens containing more quartz and feldspar, which display an even-grained or granulitic appearance.

Rusty-weathering amphibolites with appreciable amounts of accessory iron sulphides can be found as bands in the paragneisses throughout the area.

Quartzo-Feldspathic Gneiss

Quartzo-feldspathic gneiss is uncommon in Ashby and Denbigh townships. It is more frequently encountered in the Hermon Formation than elsewhere. Small areas in the Weslemkoon granite are often rich in enclaves of this gneiss.

The principal minerals are quartz and feldspar; both potash and plagioclase feldspar are usually present. The next most abundant mineral, though present in smaller amounts, is muscovite; accessory biotite, sillimanite, and magnetite have also been seen in these rocks. Texturally, the rocks are even-grained, but the principal minerals show some degree of elongation in the plane of foliation.

Although the parent sediment was presumably an arkose or feldspathic quartzite, it must be recorded that many outcrops of this rock type occur in areas of intense feldspathization and some of the feldspathic material may be metasomatic in origin.

Biotite-Quartz-Plagioclase Gneiss

This is a very common rock type of the Grenville Series. It has been carefully investigated in the Adirondack Mountains and an attempt was made to determine its parentage (Engel and Engel 1953, pp. 1049–1098). A later discussion favours the conclusion that the parent rock is greywacke (Engel 1956). The principal minerals are quartz, plagioclase, and brown biotite. Garnet and muscovite are present in the more pelitic varieties of the rock. Another variation of this rock type contains small amounts (5–15 percent) of green hornblende, thereby indicating that the original sediment was sometimes slightly calcareous. All these varieties of the rock occasionally contain about 3–8 percent of iron sulphides. The sulphide-bearing paragneisses weather to a rotten yellow-brown-stained rock possessing abundant hydrous iron oxides and millimetre-thick veins and seams of gypsum.

Other accessory minerals include microcline, apatite, scapolite, tourmaline, carbonate, and magnetite. The magnetite is often concentrated in bands a few millimetres thick that are parallel to the foliation; it is in these bands that scattered crystals of green tourmaline occur. These magnetite-tourmaline layers probably represent sedimentary concentrations of heavy minerals.

In outcrops and in hand specimens the rock is a medium-grained foliated grey gneiss peppered with flakes of biotite. Under the microscope, the texture is seen to vary from granoblastic to lepidoblastic, depending upon the content of micaceous minerals.

Some of the occurrences of this gneiss in the northwestern part of Ashby township are notable for their possession of green lenses of calc-silicate minerals (diopside, scapolite, hornblende). These have the general shape of boudins. Representative dimensions seen in sections perpendicular to the foliation and lineation are 8 by 1.5 centimetres. The longest dimension is parallel to the lineation and may be as much as 25 centimetres. These calc-silicate lenses presumably represent boudinaged or sheared beds or concentrations of impure dolomitic limestone.

Grey biotite-quartz-plagioclase gneiss of the Hermon Formation with layers of pegmatite and granite. Roadside outcrop on highway No. 41 just north of Vennachar Junction.

Pelitic Gneiss

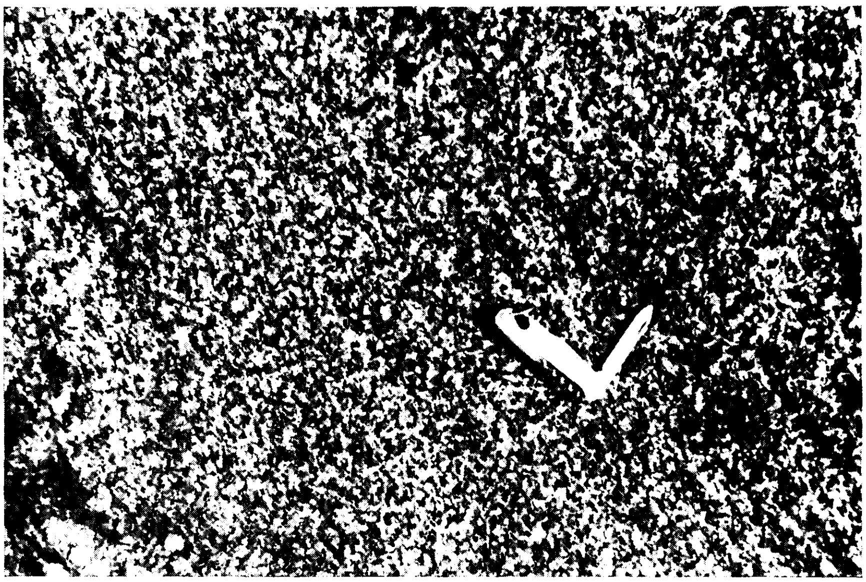
The occurrence of aluminium silicates (sillimanite, kyanite, staurolite), together with considerable amounts of biotite and muscovite, in some of the gneisses indicates the presence of metamorphosed shales. Such bands of pelitic gneiss are usually found in thin beds, 1–10 feet thick, in the biotite-quartz-plagioclase gneiss; but other beds may be as much as 100 feet thick. Some samples of this rock are sufficiently rich in micas to be classified as schists; otherwise the rock, in hand specimens, is very similar to the biotite-quartz-plagioclase gneiss.

The main constituents of the gneiss are biotite, muscovite, and quartz; garnet is sporadically distributed. Some occurrences of this gneiss are extremely rich in pink garnets, especially in the northeastern part of Ashby township, but other occurrences contain pink garnet only as a minor accessory mineral. Varying amounts of plagioclase (oligoclase) are present. The most common aluminium silicate is sillimanite; kyanite and staurolite are present in some specimens (the last named usually as inclusions in garnet). The minor accessory minerals are tourmaline, apatite, magnetite, iron sulphides, graphite, and zircon. The dominant texture is lepidoblastic.

Lit Par Lit Gneiss

Lit par lit gneiss is essentially a mixed gneiss or migmatite. It consists of layers of paragneiss (usually rich in biotite) that alternate with layers of granitic

Marble tectonic breccia. Roadcut, highway No. 41, north of Denbigh.



Typical metagabbro fabric. Eagle Hills metagabbro, Denbigh township.

composition. The granitic layers are medium- to coarse-grained, some being pegmatitic. Some alternate regularly with the paragneiss layers so that the rock is composed of nearly equal proportions of the two, but others show a more sporadic distribution. Most of the *lit par lit* gneisses appear to be altered biotite-plagioclase-quartz gneisses or pelitic gneisses.

Quartzite

Quartzite is rare in this area. Occasional beds a few inches thick occur in the marbles; a few thicker beds have been found in the paragneisses. The latter beds usually contain some muscovite and occasionally garnet. Sillimanite was discovered in one of these beds.

Metaconglomerate

Little metaconglomerate was seen during the survey. Its distribution within the Hermon Formation is described on page 9. The original rocks appear to have been polymictic pebble conglomerates with an impure sandy matrix.

Marble

Marble is the third most extensive metasediment of the area. It includes pure-white crystalline limestone and dolomite (together with blue and grey varieties), silicated marble, calc-silicate rocks, and marble tectonic breccia.

By the use of dilute acid in the field, an attempt was made to determine whether the dominant carbonate in each outcrop was calcite or dolomite. A marble composed largely or wholly of calcite is designated 3 on the map. Dolomitic marble is shown as 3z. Within the marble areas, dolomite appears to be irregularly distributed, and the dolomitization probably occurred after the deposition of the original limestone.

Silicates are common in the marbles. When they constitute more than half the rock the legend 3b is used; chondrodite, diopside, phlogopite, plagioclase, tremolite, and actinolite are not separately distinguished in the legend. When silicates make up less than half the rock the letter b is omitted. Where the rock is composed entirely of silicates it is designated 3s–calc-silicate rock. Some of the marble contains small flecks of graphite (3c). Other outcrops that have thin quartzite bands are not separately designated. Other minerals present in the silicated marbles include scapolite, microcline, quartz, and sphene.

Marble tectonic breccia is occasionally developed. It consists of fragmented and contorted pieces of amphibolite in a matrix of coarsely crystalline marble and amphibolite. During the deformation of the area, this marble was mobilized; its flow broke up and contorted the more competent interbeds of amphibolite. The best exposures of this breccia occur in roadcuts along highway No. 41 north of the village of Denbigh.

Plutonic Rocks

METAMORPHOSED AND BASIC INTRUSIVE ROCKS

A number of basic masses occur in the area. They usually consist of medium-grained amphibolite with hornblendes up to 6 millimetres long. Large-zoned plagioclases (andesine) up to 3 millimetres across are present in some of these rocks. Well inside the masses, the grain size is distinctly greater than that of the para-amphibolites; but, close to their margins, the rocks may be much more gneissic, with a finer grain size, and so appear to pass gradationally into rocks mapped as para-amphibolites. The contacts shown on the map between these two rock types are therefore somewhat arbitrarily drawn.

The usual mineralogy of these rocks suggests that most of them resulted from the metamorphism of rocks of the same gabbro clan—either gabbros or dolerites. They are therefore referred to for the sake of convenience as metagabbros.

There are two main metagabbro masses. These are: the Ashby metagabbro, which occurs in the very north of Ashby township and extends across the boundary into Raglan township; and the Eagle Hills metagabbro, which lies about 2½ miles south of the village of Denbigh near the contact with the Weslemkoon granite.

Ashby Metagabbro

The main part of this mass is roughly oval-shaped in plan, but from the southern end apophyses reach southward to Len Lake, and a few isolated outcrops of coarse amphibolite to the west and southwest may represent further offshoots from the main mass. The Ashby metagabbro appears to disturb the structures in the metasediments surrounding it, thus indicating that it was emplaced intrusively.

Most of the mass is composed of medium-grained hornblende-plagioclase gneiss. Thin sections of this rock are notable for the size of the hornblendes, which are often as much as 6 millimetres long. Parts of these hornblendes are rich in tiny grains of iron oxide that are concentrated in irregular trains whose general shape is very similar to the trains of magnetite present in cracks in the olivine of basic igneous rocks. Other parts of the hornblendes contain patches rich in regularly oriented short rods of iron oxide, similar to those commonly seen in the pyroxenes of gabbroic rocks.

Some of the plagioclase is present as lath-shaped inclusions in the hornblende, thereby giving the appearance of relict ophitic texture. The larger hornblendes are set in a finer-grained granoblastic mosaic of plagioclase (andesine) and hornblende, but a few, somewhat larger, zoned plagioclases (andesine) can be found here and there. Accessory minerals include magnetite, biotite, apatite, and scapolite.

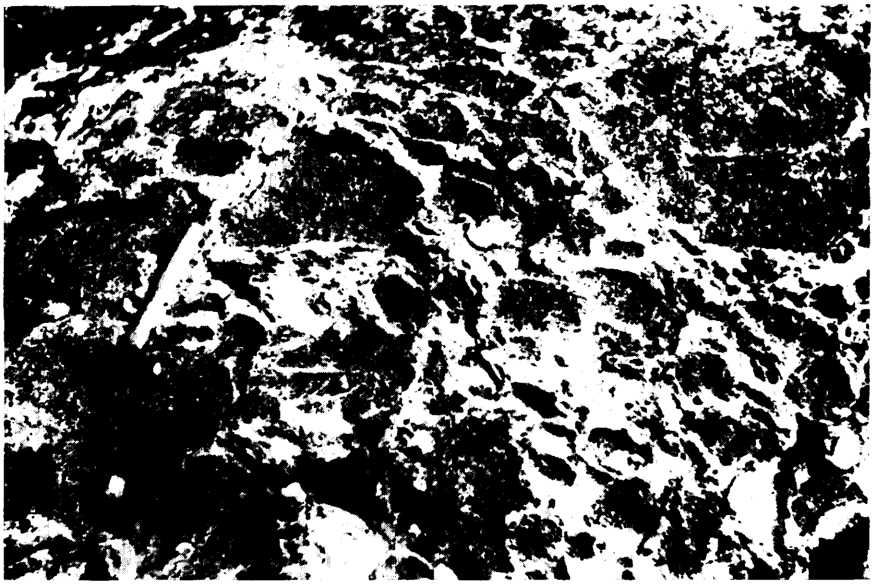
A number of metasedimentary inclusions were found in the metagabbro; these consisted of marble, hornblende-biotite-plagioclase-quartz gneiss, and possibly para-amphibolite. Some outcrops of hornblende schist may represent former autoliths.

A few small shear zones up to 1 foot wide were found in various parts of the metagabbro. These are mineralized with pyrite and pyrrhotite.

Eagle Hills Metagabbro

This intrusive mass is like the Ashby metagabbro and gives rise to an area of high ground. At three points, at or near its contact, small bodies of syenite occur. Again the dominant rock type is a medium-grained amphibolite; but in this case the large crystals of hornblende with relict igneous textures, so well developed in the Ashby metagabbro, have not been found. Large normally zoned

Banded metagabbro, Eagle Hills metagabbro, Denbigh township.



Reticulating veins of white granitic material in metagabbro.
Eagle Hills metagabbro, Denbigh township.

crystals of plagioclase (andesine) are, however, well developed in parts of this mass. Accessory minerals are apatite (often as crystals up to 3 mm. long), magnetite, biotite, and carbonate. Garnet is developed in a few outcrops.

Parts of this metagabbro are characterized by a well-developed banding. The banding consists of dark layers rich in hornblende alternating with lighter-coloured layers containing much more plagioclase (*see* accompanying photographs). Similar banding has been recorded from the Faraday metagabbro in Faraday township (Hewitt 1959, p. 23).

Hewitt has interpreted this banding as being the result of metamorphic differentiation. In the Faraday metagabbro, the banded areas are associated with zones of intense shearing belonging to the McArthurs Mills fault zone. No shear zones have been seen in the Eagle Hills metagabbro; it is possible that the present banding and foliation are mimicking pre-existing magmatic banding and igneous lamination.

Another feature of this metagabbro is the development of areas of reticulating veins of white granitic material. These consist of a granoblastic mosaic of quartz and feldspar. They are assumed to represent the metamorphosed equivalents of the veins of granophyre, which are such a common feature of many gabbros.

Other Metamorphosed Basic Intrusive Rocks

A small body composed of medium-grained amphibolite is situated in the small re-entrant of metasediments projecting into the Weslemkoon granite about 1¼ miles south of Ashden Lake. This is a less homogeneous mass than the Ashby and the Eagle Hills metagabbros. It contains numerous inclusions of fine-grained amphibolite (perhaps representing para-amphibolite) and hornblende-biotite-quartz-plagioclase gneiss. Moreover, the degree of perfection of the foliation varies rapidly from outcrop to outcrop, being very high in some places. It is usually developed at a great angle to the foliation in the enclosing metasediments; and strong contortions of the foliation can be seen in some outcrops. Occasionally a hornblende-rich facies of the metagabbro occurs. Elsewhere the effects of feldspathization give rise to leucocratic varieties of the metagabbro.

The only other important occurrence of metagabbro is in the ground north of Big Yirkie Lake where three sill-like bodies of amphibolite have been mapped. These are from ¾ mile to nearly 2 miles long, and are about 600 feet thick. They contain inclusions of para-amphibolite and act as the host rocks for a few granite pegmatites.

A number of much smaller bodies of metagabbro and hornblende were encountered during the mapping of the area. Some of these are too small to be represented on the map. Those emplaced in areas of feldspathization or granitization frequently show varying degrees of migmatization, either by the growth of feldspar and quartz throughout the body of the rock, or by the development of a great number of syenite or granite veins. In such circumstances, quartz may also be present. Sometimes considerable deformation occurred during the migmatization; this resulted in the shearing of the metagabbro into fish-shaped fragments now surrounded by granitic material.

A small intrusion of biotite-hornblende schist was found near Slate Falls (lot 14, concession XIII, Denbigh township). This may represent a former biotite pyroxenite.

NEPHELINE SYENITE GNEISS

Nepheline syenite gneiss occurs in an area of syenite gneiss in lot 34, concession IX, Denbigh township. It can be recognized in the field by its characteristic weathering resulting in feldspar and dark minerals standing out in relief from a more-rapidly-weathering white powdery material derived from the alteration of nepheline.

The essential minerals are nepheline, microcline, and albite; microcline forms the bulk of the feldspar. All the nepheline is altered to felted areas of gieseckite. The principal accessory mineral is green aegerine-augite. This occurs as parallel plates, thus imparting to the rock a gneissosity that is seen in hand specimens. Minor accessories include yellow garnet, magnetite, pyrite, apatite, sphene, carbonate, hastingsite, and scapolite. The yellow garnet generally forms complete or partial rims around some of the aegerine, magnetite, and pyrite crystals.

SYENITIC ROCKS

Syenite gneisses occur in a number of places where the metasediments have undergone intense feldspathization. Much evidence indicates that many of the occurrences represent transformed metasediments rather than metamorphosed igneous rocks.

The largest body of syenite gneiss forms a belt up to ¾ mile across stretching southwestward from Cronkshaw Lake almost to the village of Denbigh. It forms the highest ground in the two townships. In parts it is plainly exposed, forming rugged outcrops and bluffs. It is generally a hornblende syenite gneiss in which garnet occurs as a common accessory mineral. Many inclusions of feldspathized amphibolite are also present.

Other areas of syenite gneiss occur: in the northeast corner of Ashby township; at the southeast end of Ashden Lake around the Eagle Hills metagabbro; about 2½ miles east-northeast of Denbigh village; and as inclusions in the Weslemkoon granite.

These syenitic rocks contain variable amounts of microcline and plagioclase (albite or oligoclase). The characteristic accessory minerals are hornblende or biotite; but muscovite is well developed in the bodies around the Eagle Hills metagabbro. Quartz is often present in small amounts. With an increase in the amount of quartz, the syenite gneisses grade into granite gneiss. In areas where this gradation occurs, remnants of syenite gneiss abound in the granite gneiss, thus indicating their greater age.

GRANITIC ROCKS

The geological data obtained during the survey may be interpreted as indicating that the granitic rocks can be divided into the following three groups: granite gneiss (the oldest granitic rocks) and associated gneissic granite pegmatites; the Weslemkoon granite and associated massive pegmatites; and the McArthurs Mills granite (the youngest granite). It must be emphasized, however, that the age relations between the various granitic bodies have not yet been fully elucidated and the age classification indicated above must be regarded as tentative.

Granite Gneiss

Larger bodies of granite gneiss include the following five: northwest of Spring Lake a body that extends into Raglan township; one in the northeast corner of Ashby township; a sill-like area of granite just northwest of Denbigh village;

various bodies of granitic gneiss (often pegmatitic) in the middle of the Slate Falls synform; and the most extensive development of granite gneiss, which occurs in northeast Denbigh, and is referred to here as the Leatherroot Lake gneiss.

Evidence indicates that these granitic rocks were all developed at the same time; and, since no observations suggest otherwise, they are considered here to be coeval. A number of them are genetically related to adjacent syenite gneisses; and almost doubtlessly both rock types were, in most cases, formed by the transformation of pre-existing sediments. In such cases, the mineralogy of the syenitic and granitic gneisses is often identical, apart from the presence of quartz in the granitic gneisses.

Migmatitic granite gneiss, near Slater Lake, Denbigh township.

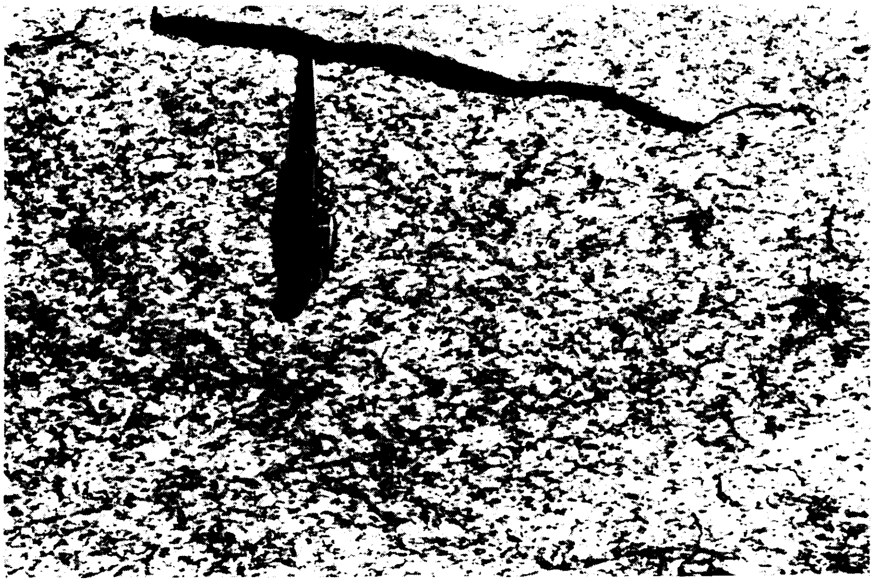
Like the syenite gneisses, the granite gneisses are frequently migmatitic, and contain patches of para-amphibolite, biotite-quartz-plagioclase gneiss, and marble. The foliation in the granite always parallels the foliation in the included metasediments and the country rocks. These granitic bodies do not appear to have disturbed the structure of the surrounding rocks during emplacement.

Even within the extent of one outcrop, the granite gneisses are somewhat variable in their mineralogy. The essential minerals are quartz and feldspar; the feldspar consists of microcline and plagioclase (albite or oligoclase) in variable proportions. The characteristic accessory minerals are hornblende, biotite, and muscovite, and garnet is important in some of the gneisses. Other accessory minerals include magnetite, sphene, apatite, and zircon.

Some of the granite gneisses grade into gneissic pegmatites, but similar rocks may also form discrete bodies lacking any granite gneiss. Petrographically, these pegmatites differ from the gneisses only in possessing a larger grain size. Some are decidedly gneissose, others almost massive. Most show no evidence of forcible intrusion and often contain inclusions of metasediments that do not appear to have been moved during their emplacement. A few, however, do occupy fractures whose walls can be matched. These fractures are usually near and parallel to the axial surfaces of the minor folds in the metasediments. This is quite a common feature of part of the Grenville Series, and Satterly (1956, p. 19) has described an example of it in Lount township.

Weslemkoon Granite

The Weslemkoon granite forms the bedrock of most of Ashby township. It extends westward into Mayo township, eastward into Denbigh township, and then continues onward through the townships to the south. The rocks of this



Typical granodiorite gneiss in the Weslemkoon granite. This photograph was taken well inside the batholith, at Cotter Lake. Note the strong gneissic structure of the rock.

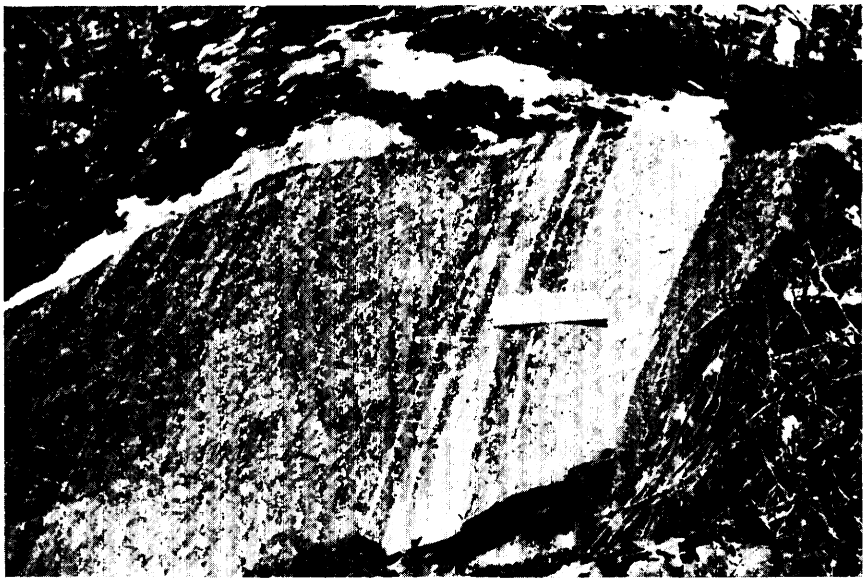
batholith are well exposed in many parts of the area but are especially well displayed along the shores of Weslemkoon Lake. Contacts between the batholith and its envelope are plainly shown in outcrops along the shores of the lakes extending across the contact. This contact is also well exposed near the farm buildings on lot 34, concession VIII, Denbigh township.

In the townships of Ashby, Denbigh, and Mayo, the major rock type of this large batholith is grey granitic gneiss. It shows a well-developed foliation everywhere. This is accentuated close to the contacts where some shearing appears to have occurred along the foliation surfaces.

The foliation is seen under the microscope to be caused not only by the parallel alignment of biotite flakes but also, when hornblende crystals or muscovite flakes are present, by the parallel arrangement of these latter. The crystals of feldspar and quartz have been strongly elongated parallel to the foliation.

In addition to the foliation imparted by the parallel arrangement of the crystals of feldspar, quartz, and hornblende, and the flakes of biotite and muscovite, a distinct colour banding parallel to the foliation was seen in a few outcrops. This banding is only evident on absolutely fresh surfaces revealed by blasting. It is not visible on the weathered surfaces of the same outcrops. It may therefore be much more common than the available evidence suggests. The banding is due to the varying content of biotite in the different layers, with the dark bands containing as much as 17 percent biotite.

The principal minerals of the rock are feldspar and quartz. The former consists of microcline and plagioclase (usually oligoclase). The proportion of the two feldspars varies from place to place, consequently all gradations between granite and granodiorite are present. The characteristic accessory mineral is



Banded granite gneiss, Weslemkoon granite roadside outcrop near Gin Creek, Ashby township.

biotite; hornblende or muscovite accompany it in various parts of the batholith. The other accessory minerals are epidote, apatite, chlorite, tourmaline, sphene, magnetite, and zircon. Symplectic textures, resulting from the intergrowths of quartz and muscovite, and of quartz and plagioclase (myrmekite), are seen in some thin sections. The pronounced foliation of this rock is also seen in thin sections, with the biotite-rich varieties showing a distinctly lepidoblastic texture.

No zonal arrangement of the various granitic rock types was discovered during the survey. But it is apparent that muscovite is more plentiful near the contact than in the central portion of the batholith. Quartz-tourmaline pods up to 2 feet long and 1 foot thick are occasionally encountered in various parts of the granite. (A chemical analysis of a sample of Weslemkoon granite is given on p. 27 at the end of the description of the McArthurs Mills granite.)

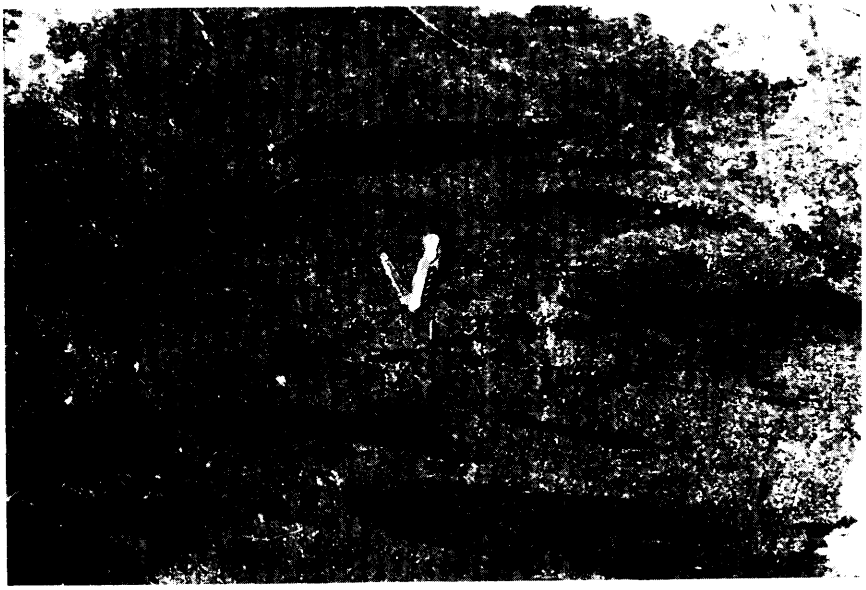
Inclusions of older rocks were found throughout the part of the batholith mapped during the present survey. They are usually rare, but small areas of the granite gneiss can aptly be described as migmatitic because metasediments and granite gneiss are present in these places in about equal proportions. The metasedimentary inclusions, and the foliation contained in them, parallel the foliation in the enclosing gneiss. Petrographically the inclusions are: para-amphibolite (usually showing varying degrees of feldspathization); quartz-feldspar gneiss; quartzite; biotite-quartz-plagioclase gneiss; metagabbro; and syenite gneiss. Some of these inclusions are sufficiently large to be shown on the accompanying maps (Nos. 2031 and 2049).

Migmatite, Weslemkoon granite, Weslemkoon Lake. Dark bands are granite gneiss; light bands are feldspathic quartzite.

In Ashby and Denbigh townships, a number of major and minor folds are indicated by changes in the direction of foliation. The larger structures could not be mapped satisfactorily during the first survey on the scale employed. During the course of the subsequent mapping work, however, a number of such structures became apparent. They may be divided into northwest-trending and northeast-trending folds. The axes of the minor folds also follow these two directions.

Near the margins of the batholith, the foliation swings around parallel to the contact, and here it is always parallel to the foliation in the rocks of the envelope. Only one possible offshoot of granite gneiss into the surrounding metasediments was found (near the southern boundary of Denbigh township); the general impression might be gained from a study of the contact that the Weslemkoon granite was not intrusively emplaced. But, a close study of the minor structures on either side of the contact suggests that at one period the granite both moved upward and expanded laterally and, as the result of these movements, the granite deformed and stretched its enclosed metasediments and its marginal facies.

Evidence in support of this conclusion is as follows: the development of boudinage in the margins of the batholith and in the envelope rocks near the contact (the boudins have subvertical and subhorizontal axes); the presence of bedding slip-type structures in both the granite and the metasediments near the contact; the vertical extension of pebbles in the metaconglomerates of the envelope; and the development of shear zones due to stretching in metasediments near the contact. Finally, a study of the maps accompanying this report clearly shows that the major structures of the area have been considerably deflected from their former northeasterly trend by the Weslemkoon granite.

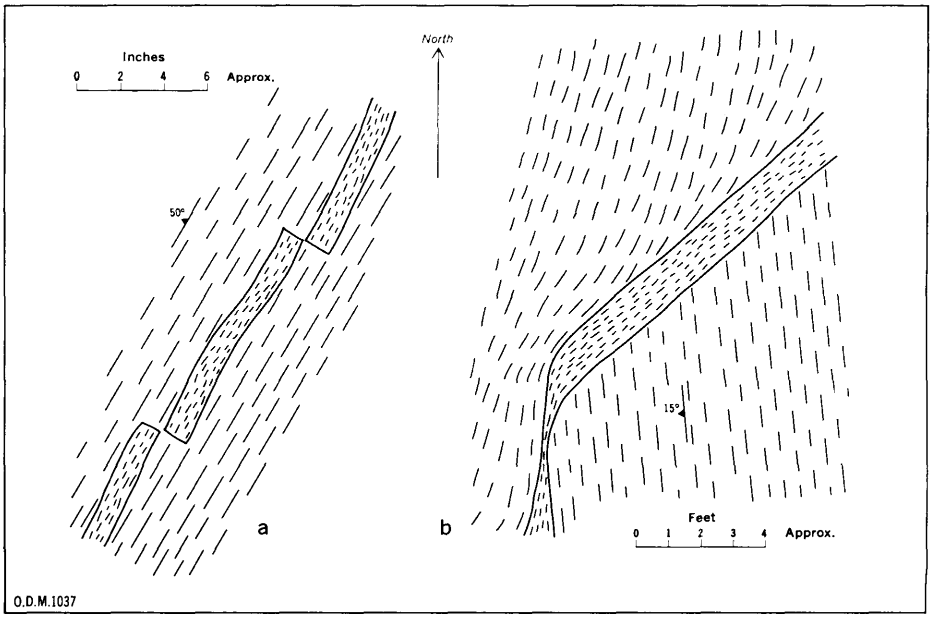


Shear zone in banded amphibolite near the contact with the Weslemkoon granite. Outcrop in farmyard near the Mayo-Ashby boundary.

Thus the origin, age, and history of the Weslemkoon granite present an interesting problem. This granite possesses the same structural features as the surrounding rocks (northeast folds with northwest crossfolds), but it plainly shoulders aside these folds in the neighbouring metasediments. Possibly, therefore, both the Weslemkoon granite and the metasediments underwent the same phase (or phases) of folding when the granite was at a lower structural level; and then, at the end of the folding or at a later time, the granite rose into its present position. This being so, the granite may have been essentially a solid during this final period of emplacement.

Because of this late period of emplacement, the possession of patches of massive pegmatite (which contrast with the often gneissic pegmatites associated with the other granite gneisses of the area), and the lack of associated masses of syenite gneisses, the Weslemkoon granite is tentatively placed farther up in the table of formations than the other granite gneisses of the area. These, it will be remembered, do not displace the structures in the rocks surrounding them.

In addition to the inclusions mentioned above, the Weslemkoon granite possesses a number of small bodies of fine-grained biotite granodiorite gneiss or hornblende-biotite granodiorite gneiss. The shapes of these are variable; some look like inclusions of older rocks but a great number have a dike-like form. They are always foliated. The foliation may be parallel to the foliation of the surrounding granite gneiss or it may be highly inclined instead. Some of the smaller dikes have been offset; these cases show no sign of faulting in the contiguous granite gneiss. The ends of other dikes give the impression of having been sheared into parallelism with the foliation of the host rock. The foliation in these microgranodiorites may have been developed as the result of shearing generated by a mechanism similar to the one described by F. G. H. Blyth to account for the occurrence of foliated dikes in nonsheared country rocks in the southern part of Galloway in Scotland (Blyth 1949, pp. 393–421).



Dike-like occurrences of microgranodiorite gneiss in the Weslemkoon granite.
a. Outcrop on lot 32, concession VIII, Ashby township.
b. Lakeshore, lot 27, concession VI, Ashby township.

Irregular patches of massive granitic pegmatite are distributed throughout the Weslemkoon granite in the area mapped. They are usually composed of quartz and feldspar. Other minerals that in some places form more than 5 percent of the rock are biotite in books up to 2 inches long, muscovite in books up to ½ inch long, and tourmaline in crystals up to 6 inches long. In a few places, graphitic textures are present in the pegmatites.

McArthurs Mills Granite

Most of the McArthurs Mills granite lies in Mayo township but the eastern end projects for nearly a mile into Ashby township. It is emplaced in the rocks of the Hermon Formation, but it does not appear to have displaced those rocks during its emplacement. Large and small inclusions of paragneiss are present. The rock is almost structureless, but a faint planar structure can be discerned in most of the outcrops in Ashby township. This structure is essentially parallel to that of the inclusions and the country rock.

The principal minerals are microcline, plagioclase, and quartz. These three minerals combine to make up a medium-grained pink rock containing occasional plates of plagioclase and microcline up to 1 centimetre in length; consequently the rock has a poorly developed porphyritic texture in places. Accessory minerals include green biotite, sphene, apatite, and magnetite. At a number of places along the contact, and for a centimetre or two in from it, scapolite replaces the plagioclase. At these points, scapolite is also developed in the adjacent country rocks. In some places, where this alteration has occurred, small amounts of metamict radioactive minerals are developed in the granite. These are probably uranothorite.

At one place along the contact, thin sections of an amphibolite showed that it had been coarsened, with the resulting destruction of most of its foliation; scapolite has replaced the plagioclase, and the hornblende has been partially changed to diopside. This might be interpreted as a contact metamorphic effect.

CHEMICAL ANALYSES OF GRANITES
(from Hewitt and James 1956, pp. 28, 41)

	Sample No. 3 Weslemkoon Granite	Sample No. 4 McArthurs Mills Granite
	percent	percent
SiO_2	66.78	63.92
Al_2O_3	16.79	17.18
Fe_2O_3	0.26	1.33
FeO	2.60	2.51
MgO	1.48	0.73
CaO	4.34	2.55
Na_2O	4.50	4.40
K_2O	1.65	5.30
H_2O+	0.48	0.48
H_2O-	0.11	0.14
CO_2 (calculated from loss on ignition)	0.27	0.37
TiO_2	0.35	0.70
P_2O_5	0.00	0.19
Cr_2O_3	0.01	0.01
MnO	0.04	0.01
V_2O_3	0.01	0.01
Total	99.67	99.92
Loss on ignition	0.86	0.65

Grade of Metamorphism

Apart from the region underlain by the Weslemkoon granite, the grade of metamorphism may be defined with considerable exactitude by reference to the mineralogy of the metasediments. The most useful rocks for this purpose are the pelitic schists. These are present throughout the metasedimentary terrane and always contain sillimanite. In some specimens, minor amounts of staurolite and (more rarely) kyanite accompany this sillimanite. Muscovite invariably appears to be stable in these rocks, and thin sections provide good evidence that the sillimanite arises from the reaction:

$$\text{staurolite} + \text{quartz} \rightarrow \text{sillimanite} + \text{almandine} + H_2O$$

This indicates that the rocks of the area belong to the sillimanite-almandine-muscovite subfacies of the almandine-amphibolite facies as defined by Turner and Verhoogen (1960, pp. 548, 549). This subfacies is not equivalent to the sillimanite zone as defined in the Scottish Highlands but is a lower-pressure equivalent of the kyanite zone. The staurolite in these rocks is usually preserved as unstable relicts included in garnet. The surrounding garnet has presumably prevented the reaction with quartz which would have destroyed this staurolite.

The mineralogy of the para-amphibolites also points to this grade of metamorphism. The plagioclase is commonly about An_{25} to An_{35}. Epidote minerals are present but not abundant, and the metamorphic grade required to produce clinopyroxene in amphibolites has not been attained.

Pleistocene

During the Pleistocene epoch, the area was covered by a continental ice-sheet. This removed all previously existing superficial deposits and smoothed-off the surface of the bedrock with the resulting production of many *roches moutonées.* These are particularly conspicuous around the shores of Weslemkoon Lake. No glacial striae were seen, but the orientation of the *roches moutonées* shows that the main movement of ice was toward the southeast.

Much of the area is plastered-over with glacial drift forming, in some areas, a thick mantle. The sandy nature of the drift suggests that much of it is of glaciofluvial origin. Small sand flats are common in Denbigh township; these may represent deposits formed in glacial lakes.

STRUCTURAL GEOLOGY

In his excellent discussion of the regional geology of the Grenville Series in Ontario, D. F. Hewitt (1956) tentatively assigned the Ashby-Denbigh area to his Haliburton, Hastings, and Madawaska division. This is an area characterized by high-grade metamorphic rocks (with abundant migmatites and granites) whose metasedimentary formations can be traced only for short distances and whose structures are largely or wholly controlled by numerous batholithic masses. The Highland gneiss complex contrasts with the Hastings Basin to the south. In the Hastings Basin the grade of metamorphism is lower and migmatites are rare, the original sedimentary sequences can be established and traced for considerable distances, and the geological structures have a dominant northeasterly trend. Hewitt suggested that the western contact of the Weslemkoon granite marks the eastern boundary of the Hastings Basin.

The McArthurs Mills fault zone, representing the northern boundary of the Hastings Basin, extends across the northern part of Mayo township and the southern part of Raglan township. It lies north of Ashby township. The metasediments of the northern parts of Ashby township are thus a continuation of rocks of the Hastings Basin type. Consequently, the geology of Denbigh township has features, such as good continuity of metasedimentary horizons, that are typical of basement-type rocks.

But Denbigh township also has geological features more commonly observed in the Highland area to the north. Thus migmatites, together with large bodies of granitic and syenitic gneiss, are fairly common; the metamorphic grade everywhere reaches that of the amphibolite facies; and, marbles have tended to yield plastically instead of brittlely. The Ashby-Denbigh area may, therefore, be regarded as representing a transition between the Highland and Basin areas.

Crossfolding in the Denbigh Formation, roadside outcrop, highway No. 41 north of Denbigh village. The hammer handles are parallel to the fold axes.

Folding

A tentative structural interpretation of the Ashby-Denbigh area is shown on the generalized geological map (facing p. 5). The folds mapped by Hewitt and James (1956, pp. 41, 42) in the south half of Mayo township continue into Ashby township. The more northerly folds cross the boundary into Raglan township but the Mayo anticline continues around the Weslemkoon granite into Denbigh township. It forms a much tighter fold in Ashby and Denbigh townships than it does in Mayo township. This compression of the fold limbs was probably caused by the emplacement of the Weslemkoon granite. The axial surface of the limbs usually dips away from the batholith.

The dominant structure in Denbigh township is the Slate Falls synform. This occurs in the central part of the township. The northern portion of the synform plunges northward and the southern part plunges southeast. The plunge culmination is near the village of Denbigh and marks the position of a distinct bend in the axial trace of the fold. A similar change in trend occurs in the Rose Hill antiform[1] that lies to the east and is parallel to the Slate Falls synform. A second plunge culmination and another change in trend affect these folds near the boundary with Lyndoch township, where they are warped around from a northerly to a north-easterly trend. These plunge culminations accompanied by marked changes in the trend of the folds are believed to be due to crossfolding. The re-entrant of the meta-sediments projects into the Weslemkoon granite immediately to the south of Ashden Lake. It lies on the crossfold passing through the village of Denbigh. The axial surfaces of the Slate Falls synform and the Rose Hill antiform generally dip towards the east.

Interbanded amphibolite and biotite-quartz-plagioclase gneiss showing incipient development of shear foldings in flowage-folded rocks. Outcrop on the eastern limb of the Slate Falls synform, lot 6, concession XIV, Denbigh township.

The eastern limb of the Slate Falls synform is clearly much thinner than the western limb. This appears to be partially or wholly a tectonic development, for the rocks along this limb are intensely deformed and it is here that the main development of marble tectonic breccias occurs. Along this belt, minor folds that appear to have been formed initially by flow folding have been further deformed by shear folding along shears parallel to their axial surfaces.

Foliation, Lineation, and Minor Folds

Practically all the rocks of the area possess a metamorphic foliation. The principal foliation in the metasediments is usually parallel to the original bedding but, in one thin section, the bedding as outlined by biotite concentrations is seen

[1] In the absence of primary-way-up structures, the noncommittal terms antiform and synform are used instead of anticline and syncline, since the latter terms imply knowledge of how, directionally speaking, the strata face.

to be thrown into tight isoclinal folds whose axial surfaces are parallel to the principal foliation. Another foliation, not as well developed, is present in rocks near the northern contact of the Weslemkoon granite; it may have been formed by late upward movement of this batholith. Where this second foliation is present in the metaconglomerates, the pebbles are sheared so that their longest axes are nearly vertical.

All the metasediments and a number of the other gneisses possess a marked mineral lineation. This is usually subparallel to the axes of the major folds. Where the major crossfolds are developed, a second lineation is apparent, and it follows the trend of the crossfolds. Minor folds also follow these two trends.

Shearing

A few small shear zones were found during the survey. Nonmineralized shear zones are developed in the metasediments around the Weslemkoon granite. Minor shears up to a foot wide are present in the Ashby metagabbro. They are mineralized with pyrite and pyrrhotite.

Faulting

This is discussed under General Geology (pp. 5–7). No major faults were proved during the course of the survey.

ECONOMIC GEOLOGY

Graphite and garnet are the only minerals that have been mined in Ashby and Denbigh townships. Gravel deposits have been worked for road- and building-construction materials, and marble has been quarried and calcined for building and agricultural purposes.

Tremolite

Ashby Township

FORMER CONCESSION XIV, LOT 17 (SUBDIVISION ANNULLED)

There is an asbestos showing on a small promontory at the west end of Len Lake on former lot 17, concession XIV. Here, a small pit about 8 feet across and 4–6 feet deep has been blasted into a banded and silicated marble. The silicate minerals include colourless to pale-green asbestiform tremolite, talc, and quartz. The banding is due to the alternation of layers rich in tremolite, talc, and quartz or carbonate, with layers containing a mixture of these minerals. This banding strikes N.67°E. and dips at about 83°N. Crossing the banding at right angles are veins of asbestiform tremolite. These are generally $\frac{1}{4}$ to 1 inch thick; the widest vein is 6 inches across. They do not offset the banding, and there is no evidence that they have formed along shears. These cross-cutting veins usually end where they meet the tremolite-rich bands of the host rock, and the result is a poorly developed rectangular network of tremolite seams. The longest tremolite fibres found are $1\frac{1}{4}$ inches in length.

The talc-rich bands in the host rock are up to 7 inches thick; some are almost pure white talc.

An older and shallower pit, about 20 feet long and 2–4 feet deep, is also present on this headland.The rock here is now largely covered by moss, but some asbestiform tremolite can be seen together with much nonfibrous tremolite.

This occurrence does not appear to be of any economic significance.

Copper

A number of small metagabbro bodies in the Ashby-Denbigh area may be potential host rocks for base metals. A number of iron sulphide veinlets are present in the Ashby metagabbro. Iron sulphides are also present in some of the paragneisses of the area and a few of these occurrences have been investigated in the past by pitting. However, careful examination of the rock discarded from these pits has not revealed any copper minerals apart from a small malachite stain on one hand specimen.

Dolomite

Areas of dolomite marble are indicated on the maps (Nos. 2031 and 2049) accompanying this report. They are rarely completely free of accessory minerals.

Feldspar

None of the pegmatites found during the survey contains commercial feldspar. The potash feldspar crystals in these rocks are usually less than 6 inches across.

Garnet

Many of the paragneisses of the northern part of Ashby township are rich in garnet, and at one place a mine was established to recover this mineral. This area, and the ground west of Len Lake, is worthy of attention in any search for garnet deposits.

Ashby Township

CONCESSION XVI, LOT 3

This deposit has been described by V. L. Eardley-Wilmot (1927, pp. 13, 14), D. W. Atchison (1937), and J. Satterly (1945, p. 126). Eardley-Wilmot's report contains a small sketch map of the workings. The location given by Eardley-Wilmot was lot 9; this lot number has since been found to be incorrect. The workings are now covered by dense bush and undergrowth, and the quarry and strippings are no longer readily accessible. J. Satterly visited the deposit in September 1943, and described it as follows in Appendix II of his report (1945, p. 126):

A Garnet Deposit in Ashby Township, Lennox and Addington County[1]

A garnet occurrence on lot 3, concession XV [XVI], Ashby township, Lennox and Addington county, is known locally as the Ruby mine. Lot 3, concession XV, and adjacent lots were staked by James Coyne and Thomas Ryan in 1910, and the claims transferred to J. H. Jewell and Company in the same year. A shaft was sunk in the valley several hundred feet from the present quarry site and was known locally as the Jewell Ruby mine.

[1] Personal communication from Dr. J. Satterly confirms the correction made to the Concession No., as shown in square brackets.

Bancroft Mines Syndicate, Limited, worked the occurrence from 1922 to 1924. The quarry is about 1 mile by wagon road south of the Hardwood Lake–Denbigh road. Experimental shipments of crude garnet were made in 1922. A small concentrator was erected in 1922, and in 1923, 1,250 tons of garnet ore and concentrates for use in sandpaper manufacture were produced and shipped to the Carborundum Company, of Niagara Falls, N.Y. Shipments in 1924 amounted to 360 tons, worth $7,200. The company's mill burnt down on November 1, 1923, and operations ceased in March, 1924. The deposit was restaked in 1943 by L. Garbutt, but no work had been performed up to September, 1943, when the deposit was visited by the writer. At that date about 60 tons of garnet gneiss was stock-piled in the quarry.

The workings consist of a quarry, 40 by 50 feet and 15 feet deep, facing northeast. The rock exposed is a medium-grained, hornblende-biotite-garnet paragneiss, which strikes N.5°E. and dips 50°W. The exposed width of the garnet rock is 250 feet. Its limits are not known. The garnets are of a deep-red colour, range from a twentieth of an inch to half an inch in diameter, and may average a tenth of an inch across. They form 30 per cent of the rock. The hornblende tends to occur in bands with a maximum thickness of 1 inch, and the garnets in these bands are larger than the average but contain minute inclusions of quartz and other minerals. Quartz forms 5 per cent of the rock as narrow lenses and stringers.

The deposit has been described by Eardley-Wilmot, who states that "the garnet has been proved to be well suited for the abrasive purposes required, and commands a price equal to the best on the market."

No work appears to have been done on the property since Satterly's visit. Large reserves of garnet rock remain to be exploited.

FORMER CONCESSION XV, LOT 30 (SUBDIVISION ANNULLED)

A small pit (not shown on accompanying Map No. 2031) has been blasted out of sillimanite-garnet gneiss on this lot, presumably during prospecting for garnet. It reveals a richly garnetiferous gneiss. The surrounding gneiss is also rich in garnets that are pink and about the size of peas.

Gold

Two localities in Denbigh township were reported to R. W. Ells (1904; 1905) as having auriferous quartz veins. Ells was unable to confirm the presence of gold. The localities are said to be near Eagle Hills and Ferguson Corners.

Graphite

Graphite is sporadically developed in many of the marbles in Ashby and Denbigh townships. Only one occurrence of economic importance was seen during the survey. This is described below.

Denbigh Township

CONCESSION VIII, LOT 34

In 1920 H. S. Spence (1920, p. 39) reported on this deposit as follows:

On lot 34, concession VIII, township of Denbigh, in Addington, a small amount of mining was carried out during 1902–3, by J. G. Allan, of Hamilton, Ont. In the bulletin on Graphite, issued by the Geological Survey in 1904, p. 25, the ore on this property is stated to run as high as 76 per cent carbon, with an average of 50 per cent, and to be of the amorphous variety. The latter term probably signifies flakes so small as to give the ore a powdery character. About 200 tons of ore were mined from a shaft 50 feet deep and shipped in the crude state. No further work has been performed at this locality. On lot 1, concession VIII, of Ashby township, (the adjoining lot to the west) similar ore is stated to occur.

The mine workings can still be reached by an old trail from Ferguson Corners. They are not far from the north end of Little Birch Lake. The workings consist of two pits and an inclined shaft. The shaft is inclined at 65° in a direction N.52°W.;

it is nearly full of water. The larger pit, about 55 by 15 feet, is alongside the shaft and is partially filled with water. The smaller pit is about 20 feet to the west; it is 18 by 8 feet and 6–9 feet deep.

The rock seen in the pits is a micaceous calcitic marble containing rusty-weathering bands of grey and white biotite-syenite gneiss and pegmatite. It strikes N.42°E. and dips 66°NW. The marble contains disseminated graphite, and graphite seams up to 4 inches thick. Graphite is also present in the syenite bands. The surrounding rocks are poorly exposed, and it is impossible to assess the potentialities of this deposit without further exploration work.

Gravel

A number of gravel pits have been opened in the two townships for local use. The gravel is unsorted material with much sand and silt of glacial outwash origin.

Mica

No mica deposits of economic significance were found during the survey. The largest books of mica that were found were up to 2 inches long and occurred in pegmatites in the Weslemkoon granite.

Sillimanite

Sillimanite-bearing paragneisses are common in the Ashby-Denbigh area, but the mineral is never sufficiently concentrated to be of economic importance.

Uranium

Some claims were staked for uranium in the area south of Cotter Lake. The rocks of this part were carefully examined by the use of a geiger counter, but no signs of uranium mineralization were discovered.

No radioactive occurrences of economic significance were discovered during the survey.

APPENDIX

Harvey Simon Property[1]

Lyndoch Township, County of Renfrew
Denbigh Township, County of Lennox and Addington

In 1961, Noranda Exploration Co. Ltd. optioned the Harvey Simon copper property in Lyndoch and Denbigh townships, in the counties of Renfrew, and Lennox and Addington, respectively. The claim group is about 4 miles northeast of the village of Denbigh, and at the time of the option comprised 46 claims, and 3 lots.

At the same time, a number of other companies carried out staking, prospecting, or geophysical work on groups adjacent to the Simon property. These companies included Faraday Uranium Mines Ltd., Mining Corporation of Canada Ltd., Prospectors Airways Co. Ltd., and George MacMillan.

The following description of the property is compiled from information contained in two company reports (Wilton 1961) (Cross 1961) for Noranda Exploration Co. Ltd.

Noranda Exploration Co. Ltd. carried out an electromagnetic survey, and subsequent geological mapping at 1 inch to 50 feet, on parts of claims E.O. 19161, E.O. 19162, and E.O. 19163, Lyndoch township, and patented lot 40, East Range, Denbigh township. In September–October 1961, 13 holes (AX core) were drilled totalling 2,502 feet. Eleven of these holes were in E.O. 19161, one in E.O. 19162, and one hole in patented lot 40. Twelve holes were drilled at N.86°W., dip 45°, and the other hole, No. 11, was drilled vertically. The longest hole was No. 13; it reached a depth of 266 feet. The drilling was suspended in early October 1961, and the option was dropped.

The main rock type in the area mapped is a fine- to medium-grained amphibolite gneiss composed of hornblende and plagioclase with minor biotite and quartz. In places, accessory garnet is abundant, and quartz is common either in quartz-rich bands or as quartz eyes. Many bands in the amphibolite gneiss are hornblende amphibolite. The foliation strikes N. to N.15°E., and dips 30°–50°E., with local dips of 65°–70°E. Coarse-grained leucogranite pegmatite is present in varying amounts as *lit par lit* injections and as dikes.

The south showing is near the south boundary of claim E.O. 19161, the east half, lot 1, Range B, Lyndoch township. It is exposed in two trenches totalling 150 feet, and was explored by the 13 drillholes.

The mineralized zone strikes north and dips 30°–50°E. In the surface workings the gossan is exceedingly thick. The drilling program showed the zone to range from 2 to 30 feet in thickness. It is in highly altered interbanded amphibolite gneiss and hornblende amphibolite cut by leucogranite dikes and sills. Most core has coarse-grained feldspar and "blobs" of quartz intimately mixed with the sulphides. The sulphides in order of abundance are: pyrrhotite, chalcopyrite, pyrite, and sphalerite. Other minerals present in the mineralized zone are quartz,

[1] Prepared by J. Satterly, and published with the permission of Harvey S. Simon.

feldspar, chlorite, garnet, and biotite occurring as narrow bands of biotite schist. Pyrrhotite is the most abundant sulphide, and it frequently contains garnets.

The assay results from the drilling are given in the following table.

ASSAY PLAN FOR SOUTH COPPER SHOWING, HARVEY SIMON PROPERTY

Hole No.	From	To	True Width	Copper
	feet	feet	feet	percent
1	49.4 80.0	74.0 84.0	23.2 4.0	0.21 0.05
2	141.4	144.0	2.6	1.85
3	32.8	54.8	22.0	0.85
4	50.0 65.2	60.4 67.2	10.4 2.0	1.33 1.10
5	65.8 107.5	95.0 109.5	30.2 2.0	1.10 0.50
6	89.2 103.0	91.7 107.4	2.5 4.4	0.81 0.55
7	148.0	176.0	25.8	0.63
8	73.9	76.0	2.1	0.45
9	133.4	149.8	16.4	0.88
10	143.7 160.4	150.1 163.6	6.4 3.2	0.30 0.65
11 (cut zone at 45°)	175.4 181.5 194.2 211.0	178.9 185.0 207.7 216.9	2.47 2.47 9.54 4.17	0.28 0.55 2.48 1.45
12	104.0	110.6	6.6	0.35
13	115.6	123.8	8.2	0.90

The north showing, 900 feet north of the south showing, has been exposed in two trenches totalling 80 feet. In 1956 this showing was explored by Eugene Simon by means of a few pits and by six diamond-drillholes totalling 1,077 feet. Copper values were indicated, but further work will be required to determine tonnage and grade. The country rocks are a mixture of amphibolite gneiss, hornblende amphibolite, leucogranite, and minor amounts of garnet-sillimanite schist. The ore minerals are massive pyrite, chalcopyrite, and very abundant magnetite. The mineralized zone is essentially parallel to the gneissosity although one high-magnetite zone striking northeast cuts across the foliation. At the bottom of the hill, 500 feet east of the north showing, is a small showing of massive pyrite and chalcopyrite in a zone about 1 foot wide, conformable with the foliation. On the road between the two main showings is a very small showing of coarse but disseminated pyrite and chalcopyrite in a dark amphibolite.

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INDEX

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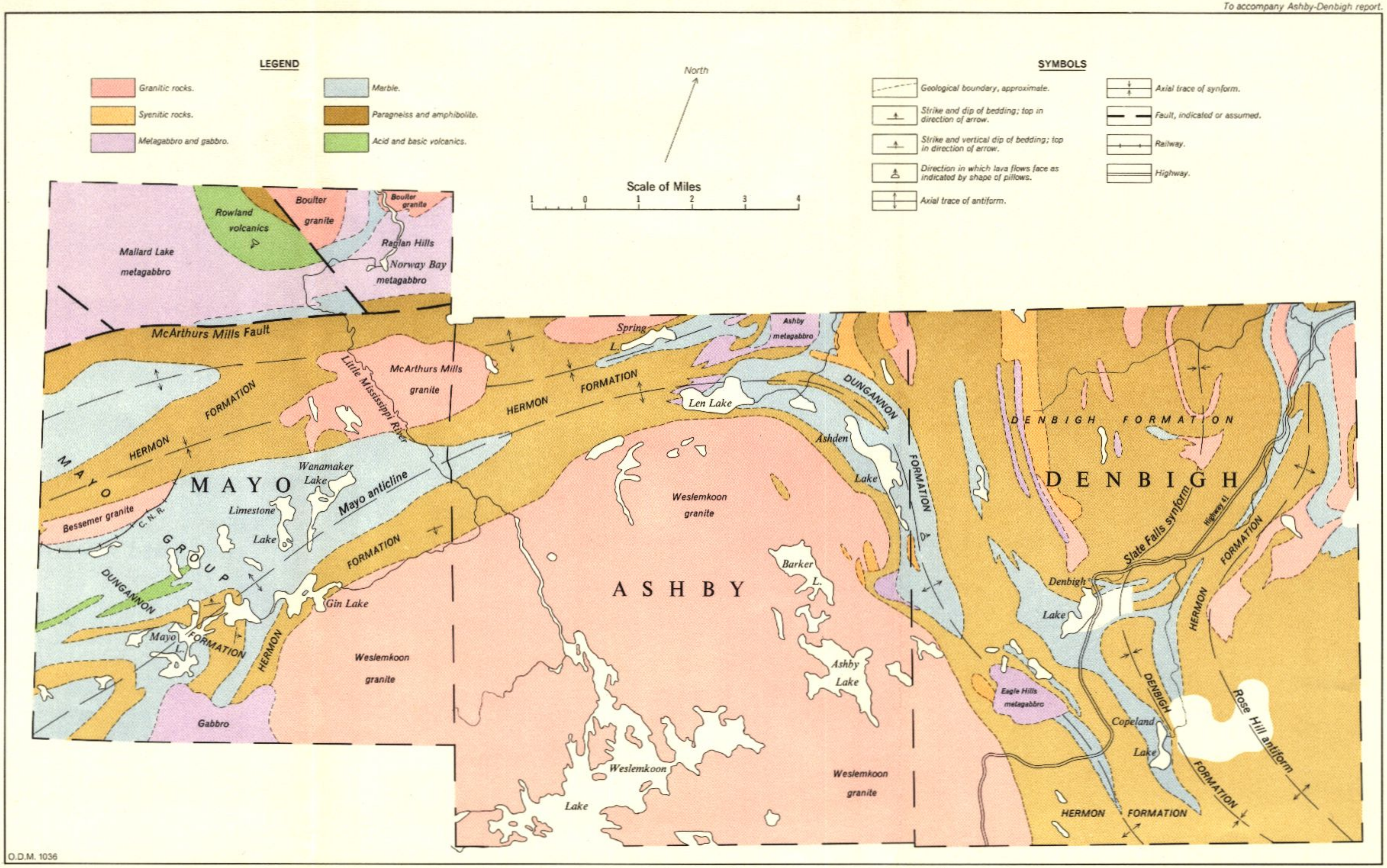
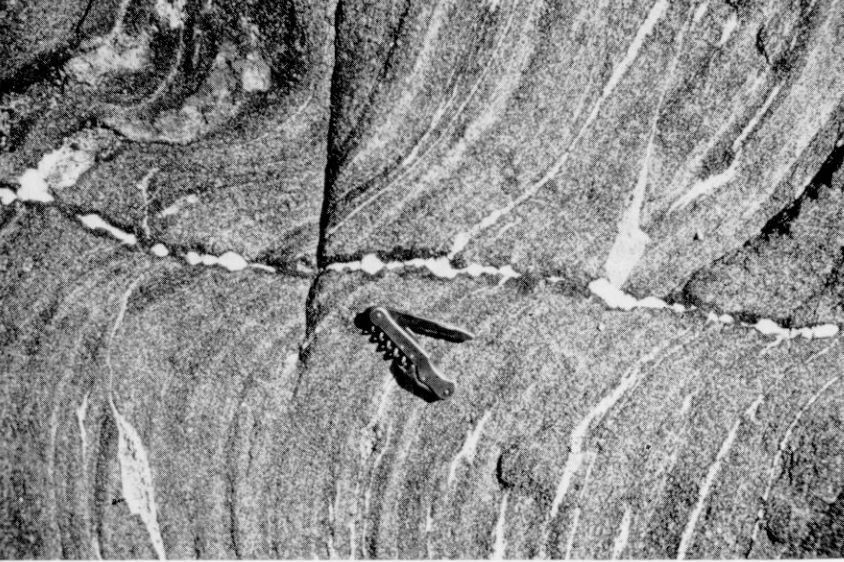
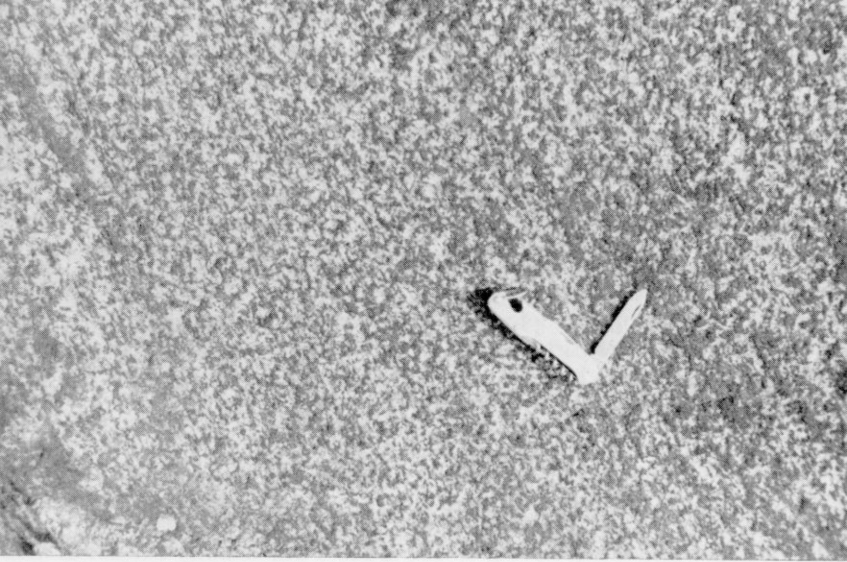
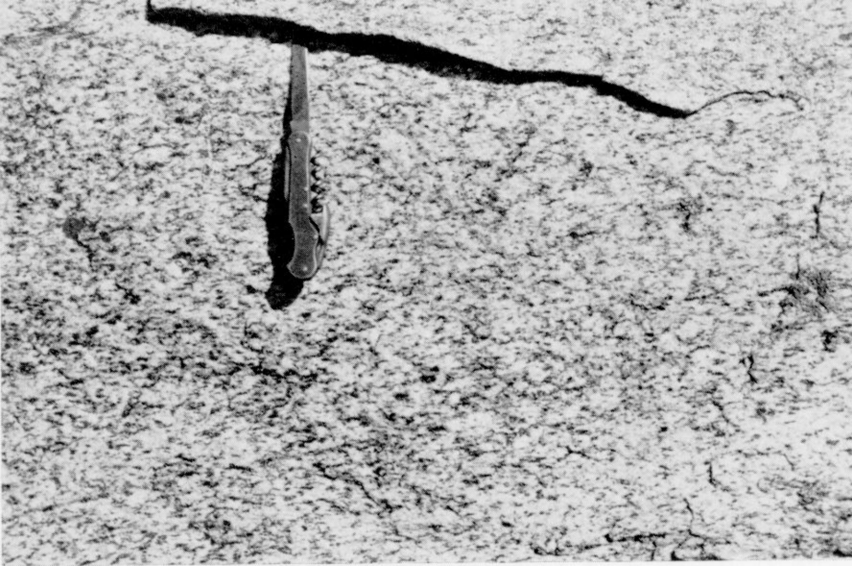
To accompany Ashby-Denbigh report.

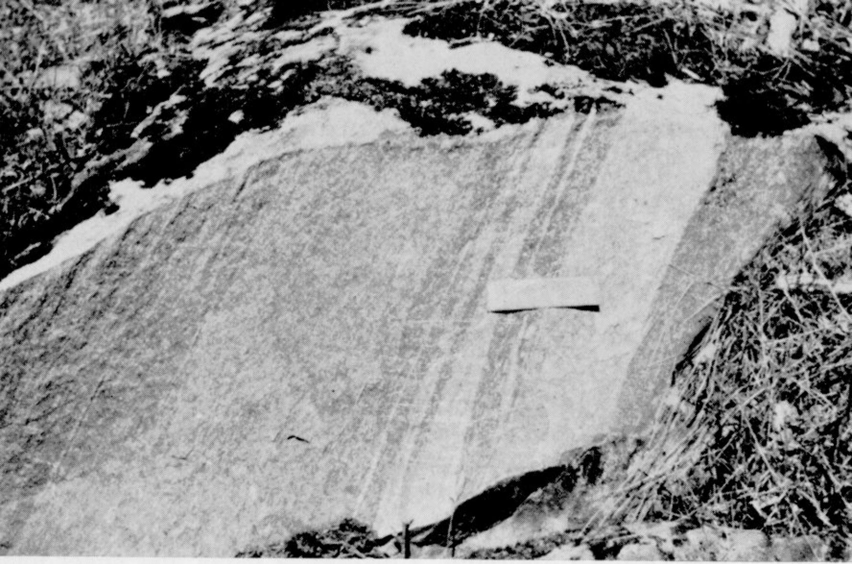


Generalized geological and structural map of Mayo, Ashby, and Denbigh Townships



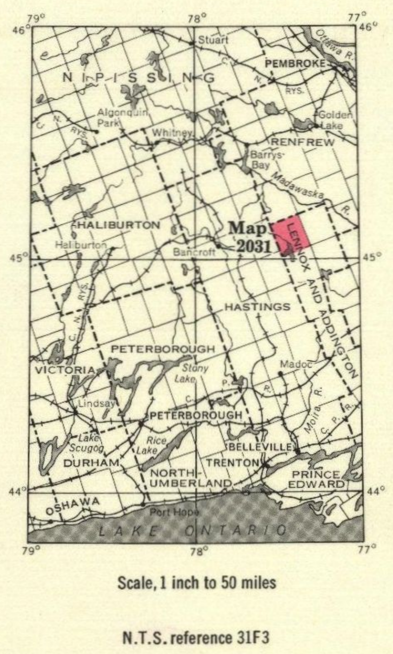


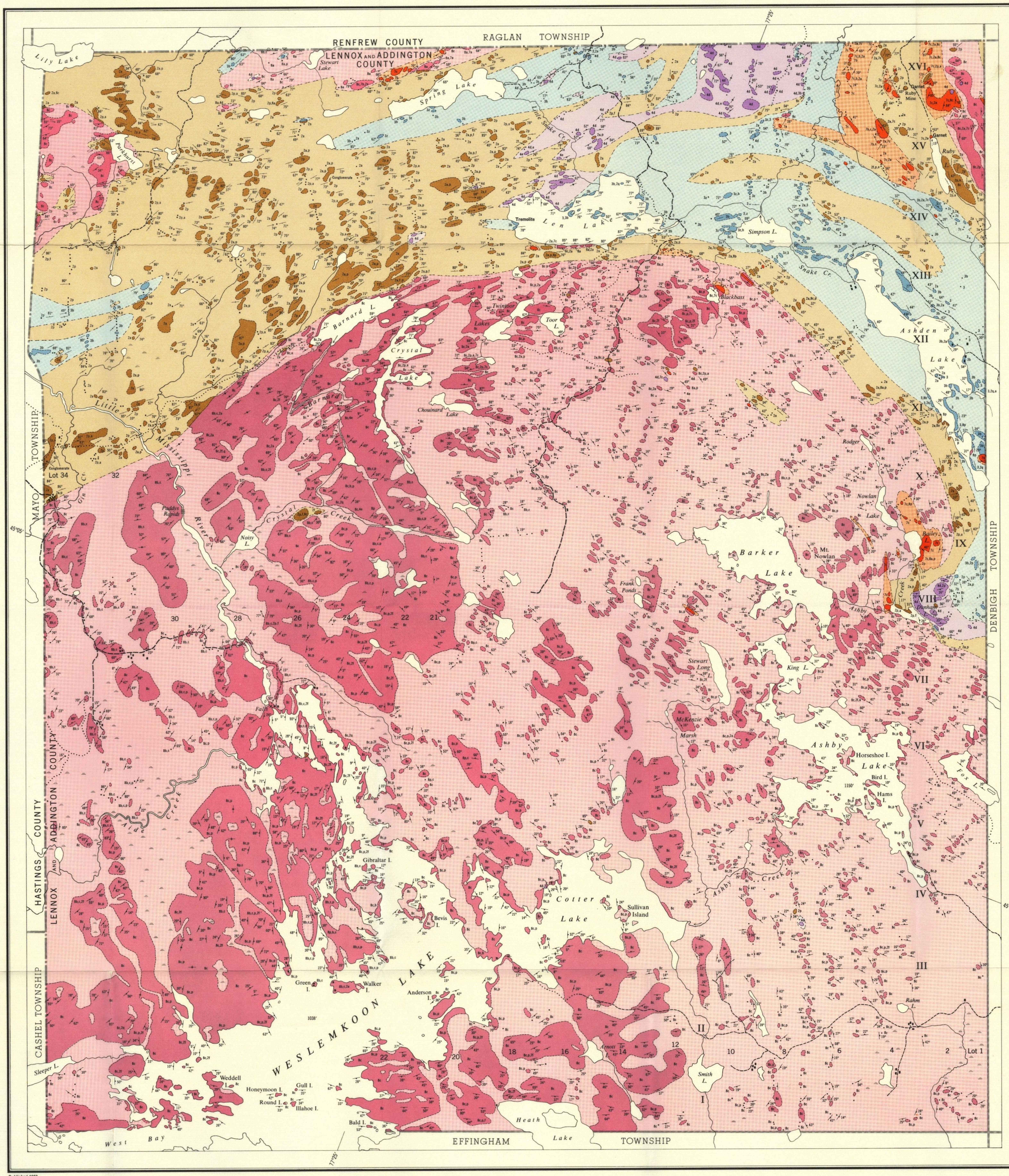




Map 2031
Ashby Township

ONTARIO
DEPARTMENT OF MINES
HON. G. C. WARDROPE, Minister of Mines
D. P. Douglass, Deputy Minister M. E. Hurst, Director, Geological Branch





Map 2031
ASHBY TOWNSHIP
COUNTY OF LENNOX AND ADDINGTON, 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

SYMBOLS

- Small rock outcrop.
- Boundary of rock outcrop.
- Geological boundary, defined.
- Geological boundary, approximate.
- Geological boundary, assumed.
- 40° Strike and dip; direction of top unknown.
- Strike and vertical dip; direction of top unknown.
- 45° Direction of plunge of fold axis, crest line or trough line.
- 55° Strike and dip of schistosity.
- 75° Strike and dip of gneissosity.
- Strike of vertical gneissosity.
- Horizontal gneissosity.
- 40° Lineation (plunge known, plunge unknown.)
- 25° Drag-folds. (Arrow indicates direction of plunge).
- S Sulphide mineralization.
- Higher ground.
- 1150′ Altitude in feet above sea level.
- Muskeg or swamp.
- Motor road.
- Wagon road.
- Trail, portage, winter road.
- Building.
- County boundary, approximate location only and not to be relied on.
- Township boundary, approximate location only and not to be relied on.

LEGEND

CENOZOIC*

RECENT AND PLEISTOCENE
Sand, gravel and clay.

GREAT UNCONFORMITY

PRECAMBRIAN**

PLUTONIC ROCKS

GRANITIC ROCKS

8
- 8a *Pink and grey leucogranite; leucogranite gneiss.*
- 8b *Hornblende granite or hornblende granodiorite; hornblende granite gneiss or hornblende granodiorite gneiss.*
- 8c *Biotite granite or biotite granodiorite; biotite granite gneiss or biotite granodiorite gneiss.*
- 8p *Pegmatite.*

SYENITIC ROCKS

7
- 7a *Pink and grey leucosyenite; leucosyenite gneiss.*
- 7b *Hornblende syenite; hornblende syenite gneiss.*
- 7c *Biotite syenite; biotite syenite gneiss.*
- 7p *Pegmatite.* †

NEPHELINE SYENITIC ROCKS†

6
- 6m *Nepheline-aegirine-augite syenite gneiss.*

INTRUSIVE CONTACT

METAMORPHOSED BASIC INTRUSIVE ROCKS

4
- 4d *Metagabbro, hornblende-plagioclase gneiss.*
- 4s *Hornblende-scapolite gneiss.*
- 4e *Amphibolite, hornblende schist.*

METASEDIMENTS

MARBLE

3
- 3 *Marble, largely or wholly calcite.*
- 3z *Dolomitic marble.*
- 3b *Silicated marble, silicates include chondrodite, diopside, phlogopite, plagioclase, tremolite.*
- 3c *Marble with graphite.* †
- 3s *Calc-silicate rock.*

PARAGNEISS-AMPHIBOLITE GROUP***

2
- 2a *Amphibolite (hornblende-plagioclase gneiss and schist), includes biotite amphibolite, biotite-scapolite amphibolite, garnet amphibolite, rusty-weathering amphibolite containing small amounts of iron sulphides.*
- 2f *Quartzo-feldspathic gneiss, includes muscovite-quartz-feldspar gneiss or schist, sometimes with sillimanite.*
- 2p *Paragneiss (biotite-quartz-plagioclase gneiss), includes garnet paragneiss, muscovite-garnet paragneiss, sillimanite-garnet paragneiss, hornblende paragneiss, lit-par-lit gneiss (centimetres-thick bands of paragneiss and granitic gneiss), rusty-weathering paragneiss containing small amounts of iron sulphides.*
- 2q *Quartzite, includes garnet quartzite.*

METAVOLCANICS†

1
- 1a *Amphibolite.*

**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.*

****Includes all metasedimentary rocks except marbles. Some areas mapped as para-amphibolite may represent metamorphosed basic igneous rocks.*

† These rocks do not occur on this map.

SOURCES OF INFORMATION

Geology by A. M. Evans and E. C. Appleyard, 1956-57.

Cartography by J. E. Stankiewicz, Ontario Department of Mines, 1962.

Base map compiled from maps of the Forest Resources Inventory, Ontario Department of Lands and Forests, with additional information by A. M. Evans and E. C. Appleyard.

Magnetic declination approximately 12° W., 1961, but varies locally.

Effective 1957 the subdivision of the following areas were annulled: lots 6 to 30, concessions IX to XVI; lots 6 to 20, concessions V to VIII; lots 6 to 15, concessions III and IV.

ONTARIO
DEPARTMENT OF MINES

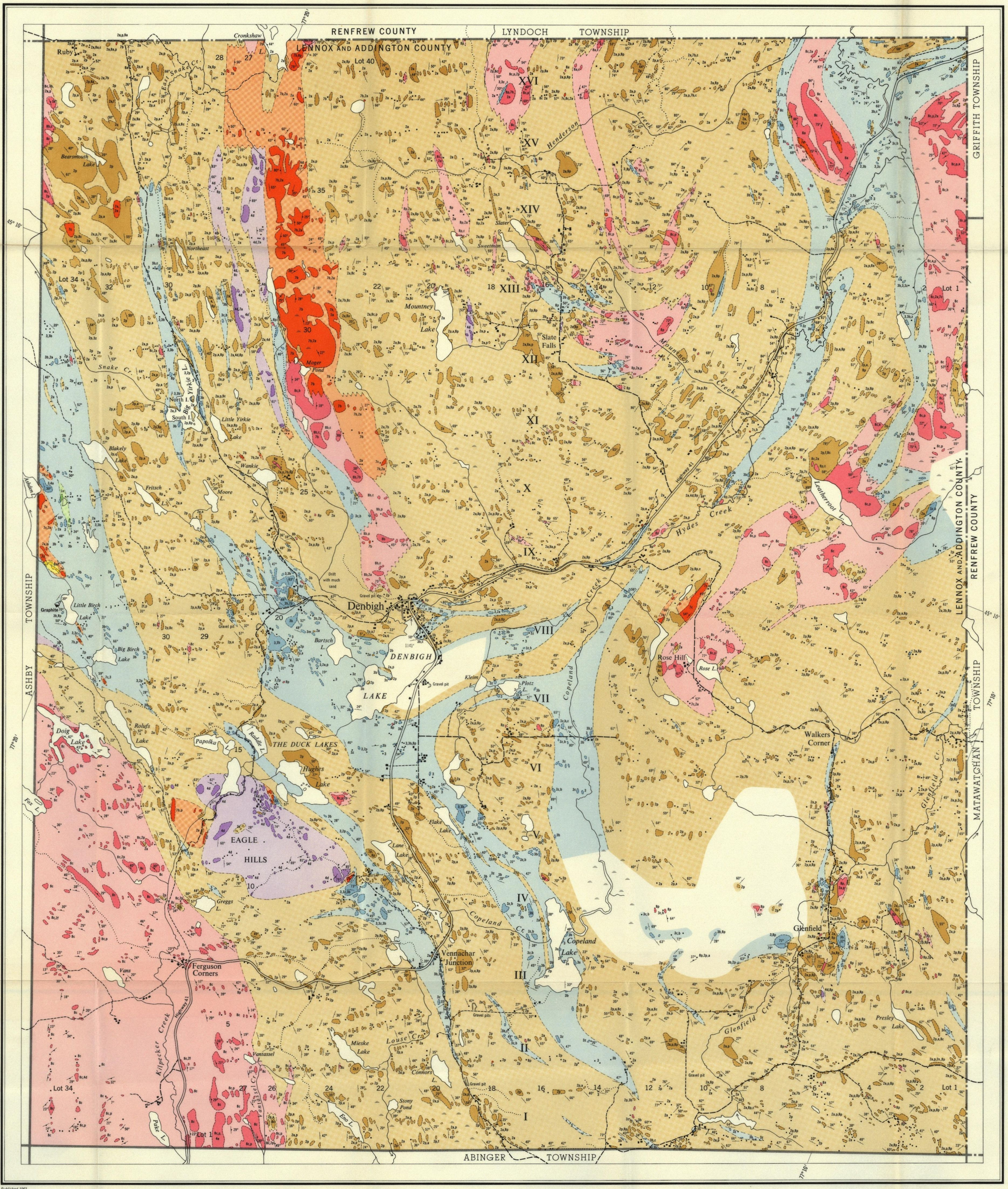
HON. G. C. WARDROPE, *Minister of Mines*
D. P. Douglass, *Deputy Minister*   M. E. Hurst, *Director, Geological Branch*

Map 2049
Denbigh Township

Scale, 1 inch to 50 miles

N.T.S. reference 31F3

Magnetic North 12° North Astronomic



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- Direction in which lava flows face as indicated by shape of pillows.
- Strike and dip of schistosity.
- Strike and dip of gneissosity.
- Strike of vertical gneissosity.
- Lineation (plunge known, plunge unknown).
- Drag-folds. (Arrow indicates direction of plunge).
- Shaft, inclined.
- Open cut, quarry, gravel pit.
- 1141′ Altitude in feet above mean sea level.
- Muskeg or swamp.
- Bridge.
- 41 Highway.
- Motor road.
- Wagon road.
- Trail, portage, winter road.
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