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Geological Branch

Open File Report 5021

Geology of Glamorgan and Monmouth Townships, Haliburton County

1968

ONTARIO DEPARTMENT OF MINES

GEOLOGICAL BRANCH

OPEN FILE REPORT

No. 5021

GEOLOGY OF GLAMORGAN AND MONMOUTH TOWNSHIPS HALIBURTON COUNTY

By

H.S. Armstrong and J. Gittins

SEPT. 5, 1968

1968

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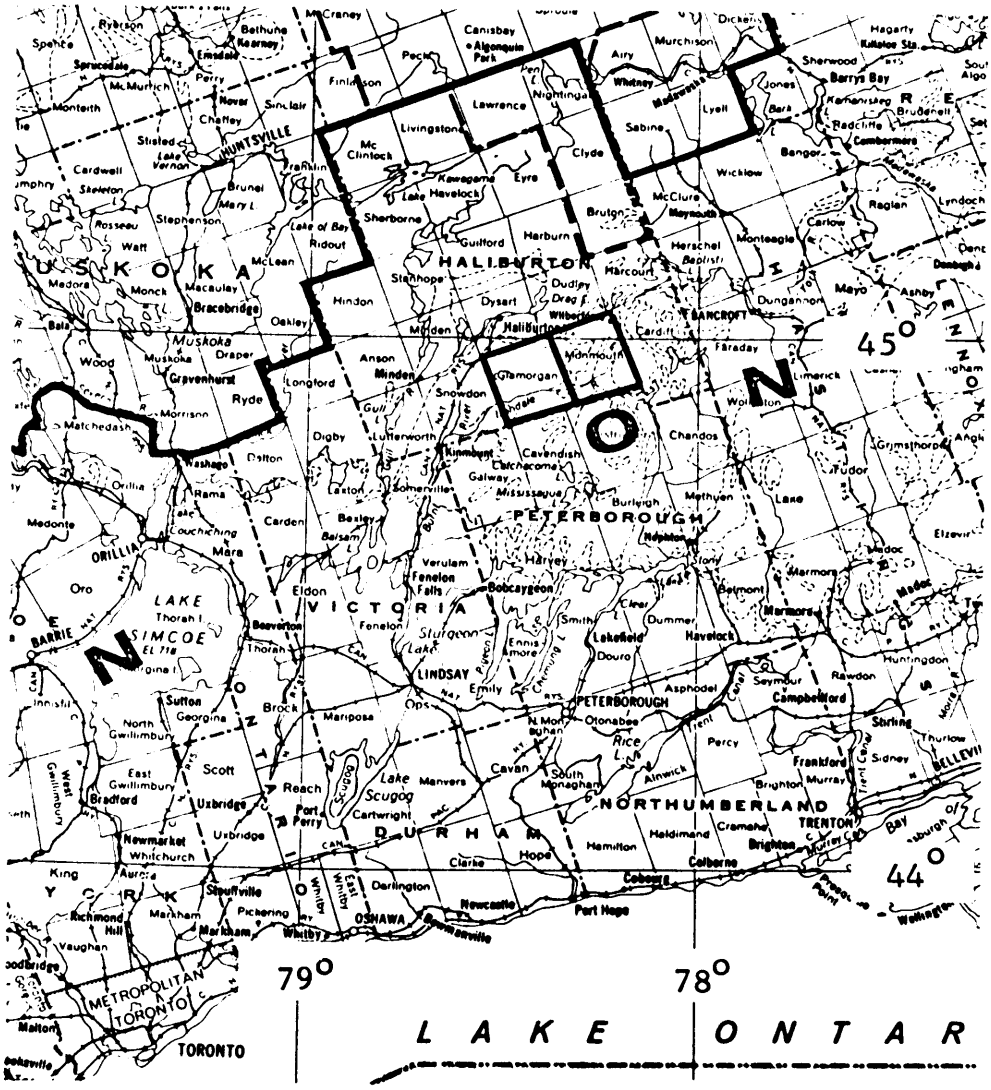

Key map showing location of Glamorgan and Monmouth townships, Haliburton County. Scale 1 inch to 25 miles.

Preliminary Geological Maps
(back pocket)

P.59 Glamorgan Township, Haliburton County.
Scale 1 inch to 1/2 mile.

P.60 Monmouth Township, Haliburton County.
Scale 1 inch to 1/2 mile.

Preliminary maps may be purchased at the Publications Office, Ontario Department of Mines, Whitney Block, Parliament Buildings, Toronto.

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Geology of

GLAMORGAN AND MONMOUTH TOWNSHIPS

HALIBURTON COUNTY

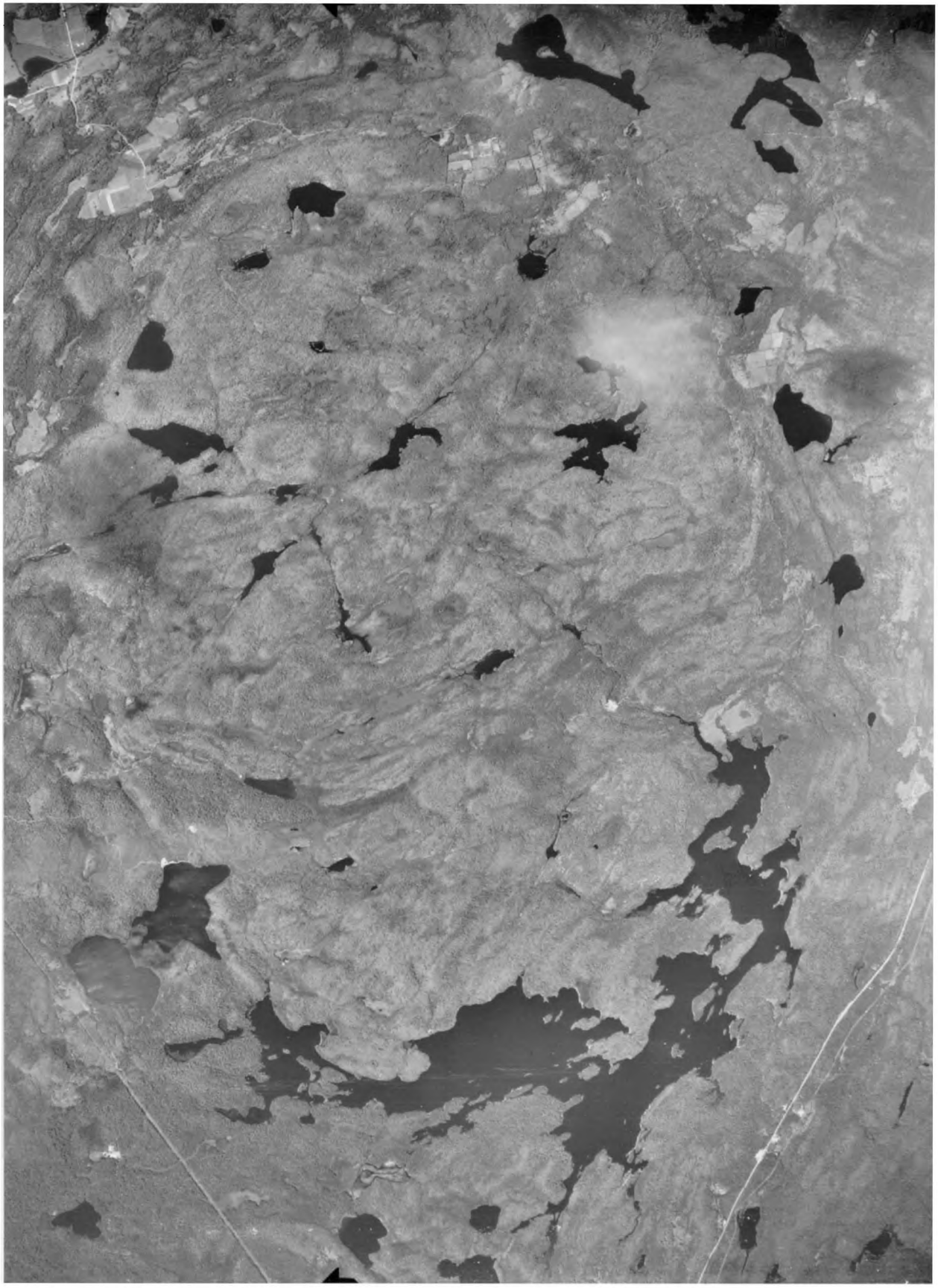
by

H.S. ARMSTRONG and J. GITTINS

GEOLOGICAL REPORT

TORONTO

1968



Vertical Air photo (A13126-58) of the Cheddar granite gneiss body showing parts of Monmouth, Cardiff and Anstruther Townships (courtesy of National Air Photo Library, Ottawa). Scale: 1 inch to 1 mile.

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17. Map of Lot 3, Con. III, Monmouth Township.

ABSTRACT

Glamorgan and Monmouth Townships are an area of about 165 square miles in the Grenville Province of the Canadian Precambrian shield. It is a highly metamorphosed terrane comprising granitic, basic, ultramafic and feldspathoidal intrusives and a sedimentary sequence of marbles, calc-silicate gneisses, quartzites and intermediate paragneisses. Granitic rocks are of two distinct ages; the older granites are mappable as large, gneissic and essentially conformable bodies and the younger granites as small, massive, jointed discordant bodies with sharp intrusive contacts. Basic rocks are essentially gabbroic and dioritic but at least one body has troctolitic and ultramafic phases. For the most part they are distinctly metamorphic in both their mineralogy and fabric but some retain obvious igneous characteristics such as igneous flow features, dikes and xenoliths. Many of these rocks are nepheline normative. Nepheline-bearing rocks are generally gneissic but there are small bodies of nepheline syenite and nepheline gabbro (theralitic canadite) that are clearly igneous rocks. Gneisses are both metamorphosed igneous rocks and metamorphosed metasomatic (nephelinized) rocks. The report contains a discussion of the processes of nephelinization and of the regional metamorphism of nepheline rocks. The metasedimentary rocks are for the most part calcareous and have developed calc-silicate assemblages very widely during the regional metamorphism of the Grenville orogeny. It is generally agreed that the maximum grade of metamorphism reached in this part of the Grenville Province was

the almandine amphibolite facies but there are clear indications that the hornblende granulite facies was reached. Only the olivine gabbros have developed the indicative orthopyroxene. In the other rocks of the region the lime content inhibits the formation of orthopyroxene.

There has been no major mineral production in the area but there has been a long history of prospecting and minor production. The most noteworthy activity was exploration for uranium during the 1950's. Two properties reached the stage of underground exploration, one by means of two shafts, but neither was able to enter production. In this area all radioactive mineral occurrences are in granitic pegmatites or in calc-silicate complexes intimately associated with the intrusion of pegmatites.

GEOLOGY OF GLAMORGAN AND MONMOUTH TOWNSHIPS

by

H.S. Armstrong[1] and J. Gittins[2]

Introduction

Glamorgan and Monmouth townships in southern Haliburton County are about 100 miles north east of Toronto. Together they cover roughly 165 square miles.

The population is principally in the villages of Gooderham, Tory Hill and Wilberforce with a number of houses and farms scattered outside the villages and numbers approximately.

The area is well served by paved roads from all parts of the province (see Official Road Map of Ontario) and local improvement of the road system is a regular activity. Several dirt roads built by mining companies in the 1950's together with old logging roads provide access to some parts of the townships but their condition tends to vary from year to year and most of these are omitted from the map where they have already become undriveable or where there seems little likelihood of their remaining driveable for any length of time.

---

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[2] Associate Professor of Geology, University of Toronto.

The Canadian National Railway line from Kinmount to Bancroft, originally built as the Irondale Bancroft and Ottawa Railway in 18 in the hope of exploiting mineral wealth, was closed in 1959 and the track removed. Some sections of the right of way between bridges, all of which have been removed, are now driveable but these are not distinguished on the map.

The countryside is typical of the region, gently rolling and with the relief rarely exceeding 300 feet. The most prominent single feature is Greens Mountain in Glamorgan Township. There is a reasonable scattering of lakes which, with the exception of those on the Cheddar granite mass in the south east corner of the area, drain by shallow streams to the Irondale River which flows westerly across the two townships. The larger lakes are dammed. Farming dates from the original settlement in the 1860's but has always been marginal; the soil is generally thin and rocky and on sloping land much of it has washed away leaving bedrock exposed. Much of the originally cleared land has been abandoned for decades, some is overgrown to the point of being barely recognizable as former farmland and much more is slowly becoming overgrown. This should be remembered in the future when trying to locate outcrops that were in fields when the mapping was done. The area is far from wealthy, and with the closing of the railway employment is limited to road maintenance, saw mills and a light wood working industry, the Ontario Department of Lands and Forests and the

Ontario Department of Highways. A slightly wider range of employment is available outside the two townships in Haliburton and Bancroft. The shores of many of the lakes have summer cottages and there are commercial tourist developments on several of them. Overnight accommodation and restaurants, however, are not abundant.

The area is one of treat geological complexity that has attracted the attention of geologists and prospectors since late in the previous century. The two townships figure prominently in the classic memoir by Adams and Barlow (1910) "Geology of the Haliburton and Bancroft areas". A particular attraction has been the abundantly displayed nepheline rocks which have earned permanent recognition of the area in the literature of alkaline rocks and contributed to the plethora of names with which this group of rocks is plagued, -- such names as Gooderite, Toryhillite, Monmouthite (Johannsen, 1938, p. 58, 298, 317). The area combines most of the rock types and geological features that characterize the Grenville region and its problems. More recently the presence of radioactive minerals attracted a short-lived flurry of activity in the 1950's which involved some twenty odd properties.

Prospecting has gone on intermittently since the coming of the first settler. The area abounds in old pits, shafts and trenches, many of which are now hardly recognizable but mineral production has been limited to a few properties that

have rarely operated for more than 4 or 5 years or produced more than a few hundred tons of any mineral product. Most production was feldspar, nepheline and graphite in the first half of the present century.

Present Geological Survey

Field mapping covered the summers of 1952, 1955, and 1956 with some brief review work between 1965 and 1968.

In using the map the reader should bear in mind that outcrops in many parts of the Grenville Province contain a variety of rock types and inevitably the geologist must omit some of them in the map notations. This caution applies particularly to the interpretation of contacts which in a great many cases indicate not a sharp break in rock type but rather a complicated merging of two types or an almost imperceptible gradation from one to another. The latter is particularly true of some areas of nepheline gneiss that pass through a zone of hybrid syenite into clearly intrusive red syenite or granite, and of feldspathized paragneiss areas where obvious metasediment grades into feldspathized rocks and eventually into granite with ghost-like remnants.

Aerial photographic coverage is available from the National Air Photograph Library in Ottawa and from the Ontario Department of Lands and Forests. Topographic coverage at a scale of 1:50,000 is provided by sheets 31 E/1 west, 31 E/2 east,

31 D/16 west and 31 D/15 east. Aeromagnetic coverage is given by sheets

Acknowledgments

H.S. Armstrong was in charge of field operations with D. Hogarth as senior assistant in 1952 and J. Gittins in 1955 and 1956. Other assistants were W. Harrison, P. Simony, W. Cowan, F. Kozela, and J.C. Van Loon. Many residents of Gooderham and Tory Hill together with Mr. and Mrs. Max Archer of Haliburton extended many kindnesses and courtesies to the party and have continued to do so during the many return visits to the area made by J. Gittins up to 1968.

The Ontario Department of Lands and Forests at Gooderham lent valuable assistance on a number of occasions.

The basic preparation of the geological map and the supervision of the majority of the field work were by H.S. Armstrong. The report was written by J. Gittins and while it is very much a co-operative effort with H.S. Armstrong responsibility for much of the petrological interpretation and analytical studies must be carried by J. Gittins by whom or under whose direction most of this work was done.

The party benefited in the field from visits by Prof. C.E. Tilley, D.F. Hewitt and J. Satterly and from many discussions with them.

Previous Geological Work

The first geological report of the area is that of Adams and Barlow (1910) which, with its accompanying map at 2 inches per mile, has become one of the classics of Canadian geology and earned for the area a permanent place in the petrological literature. The standard of mapping is excellent and, partly because of the extensive system of lumber roads available in 1890's and long since overgrown one is sometimes hard pressed to find all the outcrops that they saw. Their map was revised by Satterly (1943) during his review of the mineral resources of Haliburton County. Many refinements were incorporated into this map and the report contains a very complete list of mineral occurrences and mining properties up to that date. Because the report has been out of date for many years Satterly's descriptions are reproduced in the present report. A similar account of radioactive mineral occurrences with maps of several of them was compiled by Satterly (1957) and summaries of this work are included here. These two reports are essential companion volumes to the present report. A summary of the nepheline rock occurrences appears in the report by Hewitt (1960) and is a valuable source of information on the nepheline rocks of the surrounding regions.

A number of papers have dealt with specific mineralogical and petrological problems and are listed as follows: Barlow (1915), Foye (1915, 1916), Gittins (1961), Goldich (1939),

Hewitt (1946), Kinser (1937), Tilley and Gittins (1961), Chesworth (1966), Harrison (1953), Wenban-Smith (1967), Grieve (1967), Satterly (1943, 1957), Satterly and Hewitt (1955).

The Geological relations to the surrounding district can be seen most clearly on the general compilation of Map 1957B.

GENERAL GEOLOGY

Glamorgan and Monmouth Townships are within the high-grade metamorphic zone known as the Haliburton Highlands structural division of the Grenville province (Hewitt, 1956, pp. 22-41). With the exception of a surficial blanket of Pleistocene to recent sediments the rocks are all of Precambrian age consisting of metasedimentary rocks among which crystalline limestones are very common, granitic and gabbroic intrusive rocks and an abundance of nepheline-bearing rocks which have drawn the attention of petrologists for many years and made the area a household word in the literature of alkaline rocks.

TABLE OF FORMATIONS

Glamorgan and Monmouth Townships

CENOZOIC (PLEISTOCENE)	Glacial deposits of various types including clay, sand and gravel.
	Great unconformity
	Post-kinematic - YOUNGER GRANITE GROUP
	Granites and syenites (Hadley type); granitic and syenitic pegmatites, some radioactive.

PRECAMBRIAN

——— intrusive contact ———

Late-Kinematic

Nepheline syenite, nepheline gabbro (theralite, theralitic canadite), essexite, ijolite, urtite, nepheline gneisses and nepheline-scapolite gneisses of many types (igneous and metasomatic), nepheline-feldspar pegmatites.

Gabbro, diorite, troctolite, pyroxenite, peridolite, metagabbro (including amphibolite, hornblende-plagioclase gneiss and scapolitic hornblende-plagioclase gneiss).

——— intrusive contact ———

Pre-kinematic

OLDER GRANITE GROUP

White feldspar-quartz pegmatites
Granitic gneisses generally hybrid, (Cheddar and Anstruther type), migmatites and areas of granitic pegmatite.

——— intrusive contact ———

METASEDIMENTARY ROCKS

Marble, calc-silicate rocks and micaceous marbles, metamorphic pyroxenite. Paragneisses of psammitic to psammopelitic type, calcitic paragneisses, quartzite.

Metasedimentary Rocks

A great range in compositions can be found from pure quartzite through quartz-plagioclase rocks containing biotite, pyroxene or hornblende to calcareous amphibolite, marbles and calc-silicate rocks.

The mineralogy varies according to whether these rocks were originally calcareous sediments. Most appear to have been calcareous and so hornblende and pyroxene are extremely common. Purely pelitic rocks are rare and so mica schists are uncommon. Garnet is not a common constituent, and no staurolite, anadalusite sillimanite or kyanite have been seen. The few places where garnet is abundant appear to be skarns attributable to thermal metamorphism associated with intrusive episodes prior to regional metamorphism. Examples are the garnetiferous nepheline rocks of Lot 3, Con. III, Monmouth Township, interpreted as nepheliniation of a skarn formed at the border of the Glamorgan gabbro, the Garnet mica schist near the border of the Hadlington Lake gabbro, and skarns in limestone around the Greens Mountain gabbro.

Paragneiss-amphibolite group

Many rocks are described in the field as siliceous paragneiss. They are generally fine-grained, very hard, dense greenish grey to greenish rocks. Typically they contain quartz, plagioclase and green diopsidic pyroxene with minor microcline and biotite. With decreasing quartz they pass into plagioclase-rich rocks with biotite, pyroxene or hornblende, or combinations of these minerals. The more calcareous gneisses contain calcite and generally hornblende as well as plagioclase. Other minerals

commonly present are epidote, vesuvianite and potash feldspar.

These various types grade into one another and are often interbedded. Despite the intense deformation of all these rocks there can be no reasonable doubt that they represent an original sequence of sandstones, siltstones, shales and limestones.

Particularly fine examples of the siliceous paragneisses can be seen along Highway 500 between Esson Creek and the junction with Highway 121. Here they appear to be exceptionally well-bedded (a few inches to a few feet thick) but sections perpendicular to the "beds" display marked crenulation with fold axes plunging parallel to the "bedding planes". Thus what appears to be a broad belt of well-bedded sediments is seen to have been so intensively deformed and sheared as to have acquired a pseudo-bedding. At the junction of Highways 121 and 500 the intrusion, assimilation and permeation of these rocks by granite can be clearly observed.

The more amphibolitic type is best observed in the cuts along Highway 500 immediately east of the Irondale River where the road crosses a prominent ridge of calcareous amphibolites. Veins, stringers and dikes of granite and pegmatite are common in these rocks and adjacent to them the amphibolites often contain potash feldspar and tourmaline. Pods of coarse calcite are common.

Quartzite

Quartzite, rather uncommon in the surrounding townships, is a fairly common rock type in Monmouth and Glamorgan Townships.

In Glamorgan Township it forms a belt $\frac{1}{4}$ to $\frac{1}{2}$ mile wide surrounding a granite mass immediately east of Salerno Lake in a

manner suggestive of a sheet underlying the granite. In Monmouth it is part of the broad wedge of metasedimentary gneisses that crosses diagonally toward the north east corner. Here it appears to be interbedded with marbles. In addition there are scattered outcrops within the large Glamorgan-Monmouth granite-gneiss complex.

Typically the rocks form "beds" 2" to 12" thick. Grain size varies from medium to very coarse and variations can sometimes be recognized within a single outcrop. The rocks often are well-foliated because of lenticular elongation of the quartz grains. No conglomerate is seen among the quartzites.

Many variants between siliceous paragneiss and true quartzite are recognizable but a number of types can be distinquished among the true quartzites.

The commonest type is pyroxene or actinolite quartzite, both minerals occurring as dark green prismatic grains. The rock varies from rather dark to white according to the nature of the quartz. Other common varieties are coarse-grained quartzite with no mafic mineral, fine-grained sugary white quartzite, rusty-weathering biotite quartzite and milky (opalescent) quartzite. In most of these plagioclase is a frequent accessory and calcite is occasionally present. Feldspathic quartzite is not uncommon but in many of these the pink potash feldspar appears to have been introduced from granite or pegmatite intrusions. However, some probably represent arkose or feldspathic sandstone. The distinction between feldspathic quartzite of arkosic origin and feldspathized quartzite is sometimes quite difficult to make.

Particularly good exposures of quartzites are to be seen

in Monmouth Township on the high ridge forming the east shore of Esson Lake, at the dam at the south end of Esson Lake, in the fields immediately south of Mountain Lake, and in the woods north of McCue Lake at Tory Hill.

In thin section the quartz is generally a ragged mosaic with no indication of original grain boundaries, although the accessory plagioclase is often in rounded grains. Pyroxene and actinolite are the common deep green varieties. Most specimens show a number of well-rounded deep brown zircon grains.

One very unusual type is glaucophane-bearing and outcrops in the woods north of McCue Lake. The rock is mostly a finely granular type suggestive of shearing but some specimens are the commoner mosaic of course, ragged-edged grains with prominent strain shadows and well-rounded zircons. Both kinds contain minor microcline and plagioclase and some contain accessory muscovite, calcite and garnet. Several specimens contain grains of partly oxidized pyrite. Glaucophane occurs as short stubby crystals; basal sections show perfect cleavage and crystal form; pleochroism is through shades of delicate lilac or mauve to pale greenish blue. It occurs either alone or with a common green diopsidic pyroxene. In one specimen a cluster of plagioclase grains is surrounded by a vermicular intergrowth of quartz and cryptoperthetic alkali feldspar suggesting that melting must have begun during metamorphism where the appropriate eutectic composition of quartz and alkali feldspar made this possible at localized points within the rock.

The association with apparently sheared quartzites and

its apparent absence in the other quartzites of the area probably explains the glaucophane as due to metasomatic introduction of sodic and ferric solutions. However, no extensive petrographic search has been made for glaucophane in the quartzites generally and its presence is never suspected in hand specimen.

Marble and calc-silicate rocks

All gradations can be found between pure white massive crystalline limestone and calc-silicate rocks. These range from massive to well-foliated. A common type is a medium-, to coarse-grained white marble with accessory graphite or phlogopite or both. Diopside-phlogopite marble and diopside marble are also extremely common. The more intensely silicated varieties contain a wide variety of ferromagnesian silicates together with apatite, quartz feldspar and sphene.

The typical crystalline limestones display a very characteristic weathered surface in which the cleavage planes and grain boundaries of the individual calcite grains are prominent. Silicates stand out in marked relief on such a surface. Some types are essentially massive while others display a distinct foliation that may be due to the elongation of calcite crystals or to the distribution of silicates (phlogopite, diopside, etc.) in bands.

The silicate-rich marbles and the calc-silicate rocks are often closely associated with granite and pegmatite bodies and seem to be the product of very extensive metasomatism and recrystallization. These have usually undergone considerable

deformation and flowage that is displayed in two ways. The commonest results in lenticular or pod-like masses of minerals such as diopside, hornblende, feldspar, quartz, or biotite. In some cases these are apparently deformed zones that have been carried from a calc-silicate layer; in other cases, particularly quartzo-feldspathic pods, they appear to be remnants of pegmatite dikelets and quartzitic bands. Flowage can be seen very clearly in certain graphite-rich sheared marbles. In thin section these rocks are almost opaque because of the minute graphite flakes. They appear to be in rather restricted zones and in some places may be the result of fault movements of much more recent age than the precambrian metamorphism.

Serpentine marble is not present in large amount but many examples can be found. It is well displayed on Lot 6, Con IX, Monmouth Township (Camex property) beside the former CNR right of way where the serpentine has developed from forsterite. The serpentine is a brownish green and in thin section is seen to enclose grains of forsterite.

Adams and Barlow (1910, p. 214) rejected such an origin for serpentine marbles of the entire region arguing that olivine is unknown in the marbles. In their eyes it was formed from pyroxene. This is not a tenable explanation because nowhere does pyroxene appear in these rocks in a partly serpentinized state. Wherever pyroxene has altered it has gone to hornblende.

Forsterite-muscovite marble with chondrodite in some zones is well-exposed on highway 500 one quarter mile west of the

Irondale River. The rock is easily mistaken for serpentine marble but in thin section the generally fresh forsterite is easily recognized. It is distributed in distinct bands giving the rock a strongly foliated appearance. In hand specimen the forsterite is deep green to almost black the colour being due to very slight serpentinization.

Chondrodite marble occurs in several places. The chondrodite (rarely clinohumite) is always pale to deep orange and usually forms zones a few inches wide. These rocks are always very restricted in extent. One readily accessible locality is an outcrop on the south side of highway 121 immediately west of Wilbermere Lake, Monmouth Township.

Very coarse-grained tremolite marble is found in several parts of Glamorgan Township particularly along the Conteau Lake Road (Hell Street) south, south west from Gooderham and in overgrown fields north of the dam on Salerno Lake in Lot 1 Con. I . The tremolite is in bladed crystals up to 6 inches long and is colourless to pale grey. It commonly occurs as rosettes and in some places these radiate from masses of sugary white tremolite or diopside rock. Very coarse crystals of white diopside several inches long are found in the same rocks.

In a few places graphite is sufficiently abundant as to have attracted commercial attention prior to World War I. Satterly (1943) lists five old prospects in Monmouth Township and several others were found in the course of the present mapping. Satterly's descriptions are reproduced on pp. These range from marbles with 10 to 20 per cent graphite to pods of solid graphite

ten feet or so across. Drill cores obtained during the radioactive prospecting period of the mid 1950's occasionally show intersections of graphite 2-3 inches long.

In pegmatitic granites ultra-coarse calcite, often salmon to orange in colour, is often found in pods a few inches to several feet across; these commonly consist of calcite intergrown with diopside, apatite, fluorite or sphene or occasionally small grains of allanite, uraninite or uranothorite.

A peculiar rock also associated with granitic pegmatite is a coarse-grained calcite-alkali feldspar-biotite rock sometimes with magnetite. They are best displayed on lots 17 con XII Monmouth Township in fields between highway and the power line. The rock appears as irregular patches within the pegmatites and adjacent to the pegmatites. The feldspar is perthitic. A similar rock containing more feldspar occurs as small pods a few inches across in the red alkali syenites that intrude nepheline gneisses on highway 500 at the Esson Creek road cut. In the same road cut is a large patch of biotite-calcite rock several feet across in which the grain size is ¼ to ½ inch. This seems to be a metasomatic product of the feldspathoidal magma whereby large amounts of iron-rich biotite have been introduced into the calcite and the calcite has itself either been melted by the magma or at least softened and plastically deformed by it.

In a number of places quartzite appears to have been interbedded with limestone in thin beds resulting in the formation of banded diopside-quartz rocks. Several examples of this can be seen in the pits of the former Homer Yellowknife Mines property

west of Wilberforce (Lot 31, Cons. XVII).

The marbles display the effects of metasomatism more spectacularly than any other rocks in the area. A particularly fine example of this can be seen on Lot 33, Con XIV Monmouth, (Acmac property). An adit has been driven a short distance into a complex of mica pyroxenite, marble and amphibolite. On the hill above the adit a number of trenches and pits expose similar rocks cut by graphic granite pegmatite. Many of the diopside crystals are very coarse and some are euhedral. Amber phlogopite is common.

No dolomite was recognized in the field (although no extensive testing was done) but much of the limestone must have been dolomitic originally to account for the diopside and phlogopite. Satterly (1943) mentions a belt of white crystalline dolomite 20 feet wide on Lot 2, Concession VI, Glamorgan Township.

A peculiar rock of unknown affinity is listed here for convenience. It appears as a body about ¼ mile across south of the railroad right of way on Lot 32, Concession XVI, west of Wilberforce. One small outcrop of the same rock was noted about ¼ mile to the north. It is very coarse-grained pyroxene-feldspar rock with coarse flakes of molybdenite up to 1 inch in diameter. Feldspar is white and pyroxene deep green. Sphenes up to ¼ inch in length plus pyrrhotite and pyrite are not uncommon. The rock is cut by veins of deep bluish amphibole and contains very coarse crystals of the same amphibole up to a foot in length. In thin section the pyroxene is colourless diopside with incomplete extinction even in perfectly basal sections while feldspar consists of microcline cores surrounded by broad rims of albite or occasionally

of coarse patchy intergrowths of twinned albite and microcline. Minor amounts of epidote are found in the pyroxene. The rock is very well exposed in trenches opened in 1917 and 1965. It appears to have a metasomatic origin but it is the only rock of its type in the area.

Limestone throughout the area has undergone intense flowage, frequently marked by more graphitic zones, and blocks of other rock types, often considerably deformed, are found within the marbles. It is clear that these are xenoliths immersed in a plastically deformed medium and the marble is not a tectonic breccia of the type encountered in the Hastings Basin.

In the very coarsely recrystallized marbles there is often a variation all the way from pyroxene marbles to pyroxenite. These may be intense green pyroxenites, very dark green pyroxenites, or creamy white sugary pyroxenite as in the vicinity of Salerno Lake, Glamorgan Township.

In many places free quartz is found in the marbles, and it is significant that wollastonite is not found except perhaps in the skarns associated with the intrusion of the Glamorgan Gabbro where it is a product of thermal metamorphism. Nowhere has the metamorphism developed any higher temperature calc-silicates than diopside, phlogopite and forsterite.

Apatite, sometimes in crystals over one foot long, is common in the more coarsely recrystallized marbles, and is also found in calcite-apatite veins and calcite-apatite-sphene veins. Sphene in these occurrences may be in crystals several inches across.

In summary the metasediments represent the regional metamorphism of a series of calcareous sediments in which truly pelitic types were rare.

The presence of quartzite units implies the erosion of a granitic terrain during Grenville sedimentation. Their generally well-sorted nature and close association with limestone (in the vicinity of Tory Hill they are clearly interbedded) together with diopside and actinolite requiring a ferruginous dolomitic cement in the original quartz sandstone are the most noteworthy features. Although they are relatively abundant rocks in Glamorgan and Monmouth Townships they are not nearly as abundant in the surrounding area. This raises the possibility that they represent a localized re-working of more normal Grenville sediments to give fairly clean quartzites in this relatively narrow belt, possibly in a sea encroaching on coastal waters in which originally unsorted sandstones had been deposited.

Granitic Rocks

Very little attention has been directed to these rocks by the authors since the field mapping was completed and not enough is known of either the petrography or the chemistry to merit classification as other than "granitic rocks". Clearly many of them are not granites *sensu stricto*.

Broadly speaking the granitic rocks are of two distinct ages and it is practicable in the field to distinguish a Younger Granite Series from an Older Granite Series. The Older Granites

TABLE IA

Analyses of the standard granite sample H1 from the Hadley Granite Quarry

MAJOR ELEMENTS

	1	2	3	4	5	6	7
SiO_2	73.44	73.44	73.49	73.41	73.29	73.48	73.33
TiO_2	0.13	nil	0.11	0.15	0.11	0.12	0.12
Al_2O_3	13.90	14.82	14.67	14.59	14.60	14.76	14.69
Fe_2O_3	$<$.01	1.12	0.45	0.51	0.44	0.48	0.47
FeO	0.87	0.07	0.45	0.42	0.47	0.46	0.49
MnO	0.007	0.02	0.01	0.10	0.02	0.01	0.02
MgO	0.22	0.19	0.21	0.70	0.30	0.16	0.14
CaO	0.77	0.89	0.87	0.30	1.02	0.93	0.89
Na_2O	5.15	4.33	4.05	3.86	4.23	4.09	4.44
K_2O	5.25	4.69	5.33	5.10	5.07	4.87	5.17
P_2O_5	0.08	0.06	0.04	0.03	0.05	0.05	0.05
CO_2	-	-	0.06	-	0.07	0.10	0.08
SrO	-	-	0.02	-	-	0.01	-
H_2O+	0.20	0.32	0.18	0.25	0.18	0.14	0.16
H_2O-		-	nil	0.06	nil	0.01	nil
	100.03	99.95	99.94	99.48	99.85	99.67	100.05

Analysts

1. Andrew S. McCreath & Son Inc., 236-242 Liberty Street, Harrisburg, Penna., U.S.A.
2. W.H. Herdsman, 229 West Regent Street, Glasgow C2, U.K.
3. J.R. Muysson, Dept. of Geology, McMaster University, Hamilton, Ontario, Canada.
   (now at Mineral Constitution Laboratories, Pennsylvania State University, University Park, Penna., U.S.A.)
4. Loomis Laboratories, 2490 Channing Way, Berkeley, California 94704, U.S.A.
5. Dept. of Geology, University of Manchester, Manchester, U.K. (Mr. J. Esson).
6. Analytical Laboratories of the Geological Survey of Canada, Ottawa.
7. J.H. Scoon, Dept. of Mineralogy and Petrology, University of Cambridge, U.K.

are large gneissic bodies occupying many square miles such as the Glamorgan Granite, the Anstruther Granite and the Cheddar Granite, frequently containing an assortment of metasedimentary rocks along with the "granite". The Younger Granites are small discrete intrusions usually without much metasedimentary material and are clearly discordant bodies with sharp contacts against the surrounding rocks. A typical example is the Hadley Granite on Highway 500 between Gooderham and Tory Hill. Jointing is a feature of these smaller bodies. A 300 lb sample of this granite has been developed as the geochemical standard H-1 and a series of analyses of this sample are given in Table IA.

Both the older and the younger series have given rise to pegmatites. Pegmatites from the older series are uncommon; they are white in colour generally not more than a few feet in width and are always folded along with the metasediments that they intrude. The pegmatites from the younger granites are very much larger, up to several hundred feet in width and are strictly post metamorphic. They are always red and vary in texture from coarse pegmatite to normal granite. Graphic texture is not uncommon. The radioactive pegmatites are always of the younger type.

Chesworth (1966) has studied the Glamorgan granite and in his re-mapping he has established divisions which serve to indicate that many of the granitic terranes in the Grenville province are capable of finer division if mapped in sufficient detail. Owing to colour limitations on the main map Chesworth's divisions are brought out in a separate map (Fig. 2). The following descriptions of the Glamorgan granite are summarized from his work by kind permission.

What has been loosely referred to as the Glamorgan granite is seen to consist of migmatite with an area of pink leucogranite gneiss and another area of gray granodioritic gneiss. It must be appreciated that these are not discretely mappable units so much as areas that contain relatively few biotitic or hornblendic bands as opposed to others that contain considerable amounts of such bands. However, none of the rocks is completely free from included material.

Glamorgan Granite

Grey granite gneiss

This zone lies in the western part of Glamorgan township and overlaps Snowdon township. Within it is the Bark Lake dioritic intrusion.

The rock is described as a well-foliated gneiss with biotite and lesser amounts of hornblende forming the mafic layers. The granitic component consists of oligoclase, microcline and quartz. Quartz and oligoclase often form myrmekitic intergrowths. Chemical analyses[1] are given in Table I.

The gneiss is a sodic granite or trondjhemite.

Pink Granite Gneiss

The rock has less hornblende and biotite and more micro-

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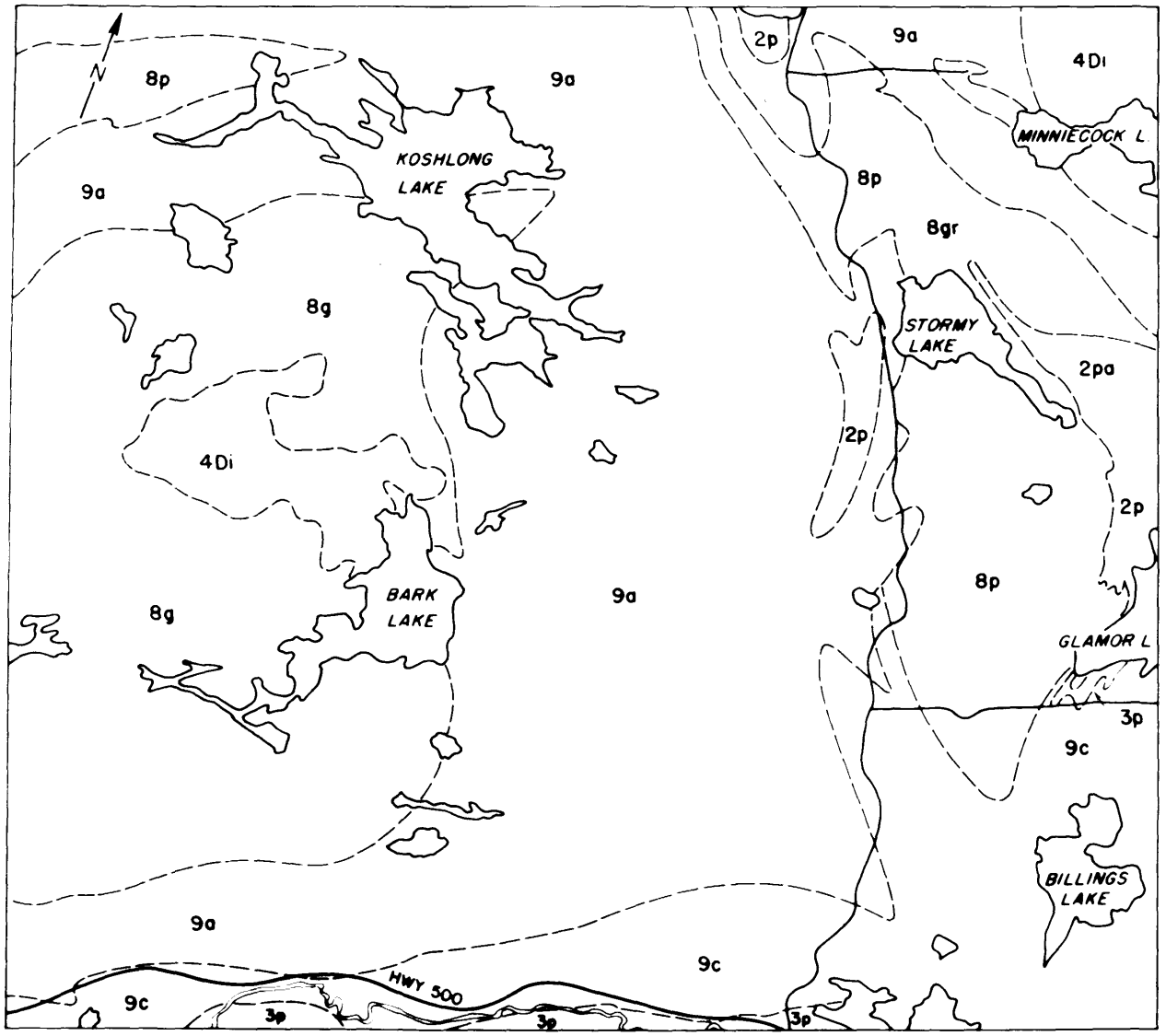
[1] Chemical analyses are not of individual hand specimens but of 2LB samples collected as chips over an outcrop area of 100 square feet. Details are given by Chesworth (1966, p. 64-68).



GEOLOGICAL MAP OF PART OF THE GLAMORGAN GRANITE COMPLEX

9a	MIGMATITE: Alternating granitic and nongranitic layers, latter do not contain calcite
9c	MIGMATITE: Alternating granitic and nongranitic layers, latter contain calcite but not quartz
8g	Grey granodioritic gneiss, 8gr graphic granite
8p	Pink leucogranite gneiss
4Di	Diorite, gneissic at borders and massive internally
3p	Marble, phlogopite - bearing
2pa	Amphibolitic paragneiss

0 1/2 1
MILE

Adapted from Chesworth (1966)
Geology by H.S. Armstrong (1958)
and W. Chesworth (1961 - 1964)

TABLE I

CHEMICAL ANALYSES OF GRAY GRANITE

GNEISS

	C7	D1	F2	H4	K2
SiO_2	69.9	69.71	70.6	72.0	69.8
TiO_2	.56	.67	.46	.44	.51
Al_2O_3	14.5	14.08	14.0	14.2	13.8
Fe_2O_3	1.81	2.33	1.86	1.59	1.32
FeO	1.84	1.92	1.78	1.57	2.33
MnO	.05	.11	.05	.03	.07
MgO	1.01	.87	.72	.81	1.8
CaO	2.61	2.37	1.8	1.86	3.3
Na_2O	4.76	4.45	4.47	4.25	4.00
K_2O	1.59	2.28	2.45	3.06	2.11
P_2O_5	.14	.21	.14	.12	.13
H_2O+	.35	.36	.39	.36	.45
H_2O-	.07	.11	.03	.05	.03
CO_2	.05	.04	.02	.00	.03
	99.2	99.51	98.8	100.3	99.7

Analyst: J. Muysson

TABLE I (contd.)

NORMS

	C7	D1	F2	H4	K2
Quartz	28.7	28.8	29.8	30.0	28.2
Orthoclase	9.4	13.3	14.5	18.1	12.5
Albite	40.2	37.7	37.8	35.9	33.8
Anorthite	12.6	10.8	8.9	9.2	13.4
Diopside	----	----	----	----	2.4
Hypersthene	3.6	3.0	2.9	2.9	5.8
Magnetite	2.6	3.5	2.7	2.3	1.9
Ilmenite	1.1	1.2	.9	.8	1.0
Calcite	.1	----	----	----	----
Corundum	.3	.3	.7	.5	----
Apatite	----	.5	----	----	----

MODES

Microcline	9.8	10.6	11.9	14.8	7.7
Plagioclase	45.9	51.1	48.2	44.4	48.3
Quartz	35.1	30.2	32.1	32.3	23.6
Biotite	6.2	6.7	6.8	7.4	12.6
Hornblende	1.5	trace	trace	----	6.7
Accessories	1.5	1.4	1.0	1.1	1.1
Plag. Comp.	An_{25}	An_{19}	An_{15}	An_{21}	An_{28}

cline than the grey gneiss. The mass south of Stormy Lake is described by Chesworth as a phacolith and free of foreign inclusions. Again it is to be emphasized that the rock is gradational into the migmatites. It is composed of quartz, albite-oligoclase, microcline and biotite. Plagioclase is partly altered and myrmekite is common in the quartz - rich portions.

North of Stormy Lake and partly continuous with the mass to the south is a north-dipping sheet of pink granite pegmatite that is in part graphic.

Another mass described as a phacolith by Chesworth is in the south west corner of Glamorgan Township. Analyses of the pink granite gneiss are shown in Table II. It can be seen that the rocks are more potassic than the grey granite gneisses.

Pink granitic veins and dikes

These are found within the grey granite gneiss and the migmatite area but not in the pink granite gneiss area. One type is fine-grained and close to a cotectic granite in composition (Table III); the other is coarse to very coarse-grained and richer in microcline. Their width varies from an inch to several feet. Granitic pegmatite occurs as irregular veins, lenses and patches both cross-cutting and conformable and has an average mode: quartz 20, microcline 60, albite 20. Analyses appear in Table III.

Migmatite

Although shown on the maps as distinct units the migmatite

TABLE II

CHEMICAL ANALYSES OF PINK GRANITE GNEISS

	A1	A11	D13	E13	G13	H13	J13	N7
SiO_2	74.9	77.9	76.9	79.4	78.5	75.0	73.6	71.54
TiO_2	.16	.15	.14	.22	.13	.11	.06	.33
Al_2O_3	14.2	12.7	12.8	11.1	12.4	14.5	16.2	14.78
Fe_2O_3	.57	1.1	1.0	.86	.52	.77	.04	.67
FeO	.42	.52	.65	.68	.46	.37	.42	1.44
MnO	.00	.00	.00	.02	.01	.00	.00	.04
MgO	.26	.22	.18	.36	.20	.26	.20	1.21
CaO	1.02	.43	.36	.33	.32	.72	.82	1.52
Na_2O	3.93	3.09	3.56	2.79	3.20	3.48	4.43	3.66
K_2O	4.43	4.31	4.38	4.36	4.57	5.08	4.57	4.41
P_2O_5	.02	.00	.00	.03	.00	.01	.00	.05
H_2O+	.18	.22	.19	.14	.13	.21	.17	.37
H_2O-	.06	-----						.08
CO_2	.02	.00	.03	.01	.02	.00	.00	.01
	100.2	100.6	100.2	100.3	100.5	100.5	100.5	100.1

Analyst: J. Muysson

TABLE II (cont'd.)

NORMS

	A1	A11	D13	E13	G13	H13	J13	H7
Qtz	32.2	42.2	38.3	45.2	41.2	33.4	28.0	27.6
Or	26.5	25.5	25.9	25.8	1.6	30.0	27.0	26.1
Ab	33.2	26.1	30.1	23.6	27.0	29.4	37.4	30.9
An	5.1	2.1	1.6	1.6	27.0	3.6	4.1	7.5
Hyp	1.0	.6	.8	1.1	.9	.7	1.3	4.6
Mte	.8	1.6	1.5	1.2	.8	1.1	----	1.0
Ilm	----	----	----	.4	----	----	-----	.6
Cte	----	----	.1	----	----	----	----	----
Cor	1.0	2.2	1.6	1.2	1.6	2.0	2.5	----

MODES

Micro	23.3	16.0	16.2	15.0	15.7	25.7	24.2	23.7
Perth	----	15.1	15.8	17.3	16.1	2.1	2.0	----
Plag	36.9	32.5	24.1	19.1	20.6	26.2	36.0	43.8
Qtz	35.8	34.5	38.9	45.8	40.2	37.9	28.1	29.2
Bio	2.8	1.0	tr.	0.4	0.4	4.7	5.9	1.1
Musc	0.2	----	----	----	1.7	1.9	2.0	1.3
Acc	1.0	0.9	1.3	2.4	1.3	1.5	1.8	0.9
Plag Comp	An_{12}	An_{10}	An_{9}	An_{6}	An_{10}	An_{10}	An_{14}	An_{19}

TABLE III

CHEMICAL ANALYSES OF VEIN ROCKS

	Pegmatite[1]				Granite
	A12	B14	N4	014	J3
SiO_2	68.7	63.49	73.5	73.8	71.29
TiO_2	.12	.61	.09	.03	.33
Al_2O_3	16.0	17.05	15.6	15.6	14.90
Fe_2O_3	1.0	1.43	.13	.07	1.22
FeO	.78	1.17	.23	.14	.84
MnO	.04	.07	.00	.00	.03
MgO	.68	.80	.25	.21	.07
CaO	.18	2.96	1.2	.07	2.25
Na_2O	3.73	4.85	2.89	4.08	4.19
K_2O	7.84	6.76	6.40	6.42	4.34
P_2O_5	.00	.13	.00	.00	.09
H_2O+	.32	.25	.11	.19	.22
H_2O-	----	.21	----	----	.09
CO_2	.01	.07	.01	.01	.02
Sum	11.4	99.85	100.4	100.6	99.88

Analyst: J. Muysson

[1]Too coarse to determine mode from thin section.

TABLE III (cont'd.)

NORMS

	A12	B14	N4	016	J3
Quartz	15.3	4.1	29.1	25.9	26.0
Orthoclase	46.4	40.0	37.9	38.0	25.7
Albite	31.5	41.0	24.4	34.5	35.4
Anorthite	.9	4.7	6.0	.3	9.0
Diopside	---	4.5	---	---	.1
Wollastonite	---	1.6	---	---	.9
Hypersthene	2.4	---	1.0	.8	---
Magnetite	1.5	2.1	---	---	1.8
Ilmenite	---	1.2	---	---	.6
Calcite	---	.2	---	---	---
Corundum	1.0	---	1.7	1.8	---

MODES

	1	2	3	4	5	6	J3
Microcline	32.0	12.5	31.1	32.5	22.3	37.1	23.1
Perthite	----	----	6.1	3.4	9.4	20.5	4.7
Plagioclase	46.6	53.9	28.9	19.3	20.4	19.3	37.3
Quartz	15.2	25.5	33.7	44.0	47.2	19.5	32.3
Biotite	5.0	7.9	----	0.7	0.2	3.4	0.8
Accessories	1.2	.2	.2*	.1	.5*	.2	1.8*
Plag. Compn.	An_{17}	An_{19}	An_{8}	An_{5}	An_{5}	An_{12}	An_{15}

*Includes muscovite

grades in one direction into paragneiss and in the other into calcitic migmatites which in turn pass into marble that is cut by the occasional granite dike or sill.

The migmatites form a prominent zone along the southern margin of the Glamorgan granite mass and are extremely well exposed in the many road cuts on highway 500 west of Gooderham. Their typical appearance is seen in Fig. 3.

The calcitic migmatites consist of calcite, phlogopite and hornblende with a quartz-plagioclase-microcline-biotite granitic component that is mostly grey or greyish pink but which is distinctly pink toward the southern margin.

The non-calcitic migmatite has dark bands that are essentially paragneiss, i.e. quartz-plagioclase-hornblende-biotite. There is frequently a hornblende - rich selvage against the granitic component.

Chemical analyses of both the light and dark fractions are shown in Table IV.

It can be seen that this is no simple granitic intrusion but rather a complex of granitic gneiss and migmatite which Chesworth has called the Glamorgan gneiss series. He chooses to consider the origin of the gneisses under two headings, - the more sodic gray granite gneiss and the potassic pink gneiss. He suggests that the grey, sodic gneiss is the product of partial melting of sedimentary rocks possibly under the influence of heat released by the Bark Lake diorite intrusion. He proposes that the pink granite gneiss was derived from the same anatectic melt by differentiation. The derivation of the potassic pegmatites and

Migmatite; highway 500 west of Gooderham. Rocks of this type are very typical of the migmatite zone along the southern margin of the Glamorgan granite body.

TABLE IV

CHEMICAL ANALYSES OF MIGMATITE LIGHT BANDS.

Grey Granite Type

	B4	B8	D10	E8	F9	H8	I10	J11	L5	L13	M1	M6
SiO_2	75.84	75.8	71.1	75.6	72.8	74.16	69.65	74.0	73.5	70.4	69.5	63.38
TiO_2	.20	.17	.39	.18	.34	.30	.54	.24	.33	.41	.39	.68
Al_2O_3	12.46	12.6	15.2	13.5	14.3	13.82	14.37	14.8	13.4	15.3	14.8	16.33
Fe_2O_3	1.30	1.37	.94	.71	1.4	.74	1.56	1.0	1.65	1.2	1.57	1.91
FeO	.80	.71	1.55	.84	1.44	1.08	2.28	.99	1.09	1.77	2.19	3.27
MnO	.03	.04	.05	.02	.08	.02	.06	.02	.05	.04	.09	.10
MgO	.21	.28	.98	.39	.64	.41	1.27	.39	.48	1.5	1.17	2.25
CaO	.93	.57	2.54	1.14	1.2	1.50	2.00	.99	1.6	1.8	2.99	4.39
Na_2O	4.38	5.21	4.27	4.72	4.77	3.96	4.31	4.83	4.90	5.13	4.87	4.53
K_2O	3.08	2.86	2.44	2.65	2.60	3.18	2.82	2.21	1.83	1.67	1.96	1.57
P_2O_5	.04	.02	.10	.02	.07	.05	.13	.00	.10	.05	.13	.16
H_2O+	.21	.15	.46	.22	.38	.36	.60	.21	.22	.40	.32	.72
H_2O-	.15	.05	.09	.03	----	.11	.25	----	.02	----	.05	.19
CO_2	.01	.02	.02	.03	.00	.01	.03	.00	.02	.00	.01	.02
Sum	99.64	99.9	100.1	100.1	100.0	99.70	99.87	99.7	99.2	99.7	100.0	99.50

Analyst: J. Muysson

TABLE IV (cont'd.)

				Pink Gte. Type	
	M8	M10	M11	A6	E6
SiO_2	69.57	70.78	73.24	75.42	74.7
TiO_2	.61	.66	.44	.27	.13
Al_2O_3	15.13	14.56	13.53	13.01	14.8
Fe_2O_3	2.04	2.08	1.71	.77	.98
FeO	1.76	1.48	1.18	.46	.62
MnO	.10	.08	.03	.00	.00
MgO	.78	.58	.66	.22	.52
CaO	1.99	2.00	1.52	.60	.11
Na_2O	5.47	5.64	4.96	3.39	4.38
K_2O	1.92	1.89	2.31	5.19	3.87
P_2O_5	.13	.12	.11	.04	.03
H_2O+	.36	.35	.38	.63	.21
H_2O-	.15	.11	.07	.09	----
CO_2	.04	.00	.01	.00	.03
Sum	100.05	100.33	100.15	100.09	100.4

Analyst: J. Muysson

TABLE IV (cont'd.)

NORMS

	B4	B9	D10	E3	F9	H8	J10	J11	L5	L13	M1	M6
Quartz	36.3	33.1	29.4	34.7	31.1	34.7	27.1	34.5	33.8	29.4	25.1	30.7
Orthoclase	18.2	16.9	14.4	15.7	15.4	18.8	16.7	13.1	10.8	9.9	11.5	10.6
Albite	37.0	44.0	36.1	39.9	40.3	33.5	36.4	40.8	41.4	43.4	41.2	47.7
Anorthite	4.6	2.5	12.6	5.7	6.0	7.4	9.7	4.9	7.9	8.9	12.8	6.2
Diopside	----	----	----	----	----	----	----	----	----	----	1.7	----
Hypersthene	.6	.7	4.0	1.7	2.7	1.9	5.3	1.6	1.4	2.0	4.3	1.3
Magnetite	1.9	1.9	1.4	1.0	2.0	1.1	2.3	1.5	2.4	1.7	2.3	2.8
Ilmenite	.4	.3	.7	.3	.6	.6	1.0	.5	.6	.8	.7	.5
Corundum	.2	---	.9	.8	1.4	1.1	.6	2.7	.4	1.8	----	----
Calcite	----	----	----	----	----	----	----	----	----	----	----	----

TABLE IV (cont'd.)

MODES

	B4	B8	D10	E8	F9	H8	I10	J11	L5	L13	M1	M6
Microcline	11.8	21.7	12.4	15.7	13.1	14.6	12.7	11.0	19.8	13.4	7.0	11.2
Plagioclase	42.1	42.3	44.9	41.4	45.4	42.0	46.9	48.6	40.6	47.2	51.7	48.5
Quartz	38.6	34.0	26.8	38.2	30.0	37.5	28.2	31.3	36.8	30.2	29.1	32.1
Biotite	6.0	1.2	10.2	3.5	10.0	4.1	11.0	6.3	1.9	8.4	6.1	7.1
Muscovite	----	trace	----	----	0.3	----	----	1.1	----	----	----	----
Hornblende	----	----	0.6	----	trace	----	----	----	----	----	4.8	----
Accessories	1.5	0.8	1.1	1.2	1.2	1.4	1.2	1.2	0.9	0.8	1.3	1.1
Plag. Comp.	An_9	An_6	An_{20}	An_{15}	An_{13}	An_{18}	An_{21}	An_{14}	An_{13}	An_{15}	An_{21}	An_{10}

TABLE IV (cont'd.)

NORMS

	M8	M10	M11	A6	E6
Quartz	24.7	25.9	31.3	34.2	33.3
Orthoclase	11.4	11.2	13.7	30.7	22.9
Albite	46.2	47.7	41.9	28.7	37.0
Anorthite	9.9	8.8	7.5	3.0	.5
Diopside	----	.9	----	----	----
Hypersthene	2.7	1.1	1.7	.6	1.6
Magnetite	3.0	3.0	2.5	.7	1.4
Ilmenite	1.2	1.3	.8	.3	----
Corundum	.4	----	.1	.7	3.2
				Hem. .3	

MODES

Microcline	9.9	12.2	13.3	30.8	25.2
Plagioclase	49.8	43.8	44.0	29.3	36.3
Quartz	28.7	29.1	32.1	36.9	35.1
Biotite	10.2	13.8	10.1	1.8	1.0
Muscovite	----	trace	----	----	1.5
Hornblende	trace	trace	----	----	----
Accessories	1.4	1.1	0.5	1.2	0.9
Plag. comp.	An_{20}	An_{18}	An_{20}	An_{9}	An_{9}

TABLE IVA

CHEMICAL ANALYSES OF MIGMATITE DARK BANDS.

	D4[1]	D6[2]	H2[1]	H9	J1[1]	K3[1]	K8	K11	L6	L10
SiO_2	61.9	61.5	63.2	62.89	63.5	63.38	61.42	63.6	62.5	63.30
TiO_2	.9	.90	.75	.71	.69	.68	.79	.70	1.24	.83
Al_2O_3	16.3	15.9	16.6	15.89	15.9	16.33	15.89	15.5	15.5	15.02
Fe_2O_3	2.81	2.47	2.25	1.98	1.71	1.91	2.08	2.21	2.99	1.84
FeO	3.73	3.62	3.08	3.76	3.56	3.27	4.30	3.48	3.44	3.66
MnO	.12	.13	.13	.12	.10	.10	.11	.11	.17	.06
MgO	2.32	2.48	1.80	2.54	2.35	2.25	3.07	2.47	1.92	2.94
CaO	4.78	4.90	4.10	4.96	4.53	4.39	5.71	4.64	4.16	4.90
Na_2O	4.65	4.29	5.43	4.31	4.47	4.53	4.05	4.11	5.83	3.75
K_2O	1.51	2.27	1.54	1.57	1.83	1.57	1.54	1.82	1.32	2.53
P_2O_5	.28	.26	.22	.17	.15	.16	.18	.17	.43	.17
H_2O+	.34	.73	.65	.62	.70	.72	1.08	.88	.59	.72
H_2O-	.11	.06	.05	.16	.06	.19	.16	.10	.11	.14
CO_2	.01	.06	.02	.16	.03	.02	.02	.03	.01	.00
Sum	99.8	99.6	99.8	99.84	99.6	00.50	100.40	99.8	100.2	99.91

[1]Dark, non-granitic inclusions in grey granite gneiss.

[2]D6 contains a thin vein of micropegmatite.

TABLE IVA (cont'd.)

NORMS

Quartz	15.5	13.6	13.9	16.8	16.4	17.2	14.5	18.5	13.2	16.7
Orthoclase	8.9	13.4	9.1	9.3	10.8	9.3	9.1	10.8	7.8	15.0
Albite	39.3	36.3	45.9	36.4	37.8	38.3	34.2	34.7	49.3	31.7
Anorthosite	19.2	17.4	16.3	19.3	17.9	19.6	20.6	18.4	12.2	16.6
Diopside	2.0	5.6	3.3	3.5	3.6	1.8	6.3	3.7	4.8	6.2
Hypersthene	7.7	6.8	5.7	9.0	8.3	8.2	9.7	8.0	4.6	8.4
Magnetite	4.2	3.6	3.3	2.9	2.5	2.8	3.0	3.2	4.3	2.7
Ilmenite	1.8	1.7	1.4	1.3	1.3	1.3	1.5	1.3	2.4	1.6
Calcite	----	----	----	.4	.1	----	----	----	----	----
Apatite	0.7	----	----	----	----	----	----	----	0.9	----

MODES

Microcline8	8.2	7.3	10.7	8.4	7.6	7.2	trace	13.1	6.6	7.9
Plagioclase	49.9	47.5	47.7	44.0	49.8	48.5	48.4	37.6	49.3	45.4
Quartz	16.9	20.5	17.1	15.3	21.6	25.0	11.2	22.1	24.9	10.3
Biotite	7.7	5.2	6.5	10.6	7.1	6.1	9.0	8.7	6.1	8.0
Hornblende	15.7	18.1	16.9	20.3	12.6	11.9	29.7	17.4	11.3	27.2
Accessories	1.6	1.4	1.1	1.4	1.2	1.3	1.7	1.1	1.8	1.2
Plag. Comp.	An_{28}	An_{28}	An_{25}	An_{29}	An_{25}	An_{28}	An_{30}	An_{27}	An_{28}	An_{30}

graphic granites is an unsolved problem.

Chesworth has contributed a useful chemical petrological study and further detailed work on Grenville complexes is required.

As with most granitic areas the Grenville region has drawn comment on the origin of the granitic rocks and the term "granitization" is encountered rather frequently for the migmatitic terranes. It seems that the term is surrounded by a vagueness appropriate to the confused appearance of the rocks it purports to describe. There can be little doubt that granitic magmas were the primary factor in the petrogenesis of these granitic rocks. Widespread melting must clearly have occurred during the Grenville orogeny and the formation of granitic melts presents no problem. The migmatites may well represent a combination of partial melting of sediments and the forcible injection of melt previously formed. It is certainly to be expected that the melts once formed will be fairly mobile. In the same way the frequently observed ghost-like inclusions of biotitic and hornblendic rocks within the granites are what one would expect to see if assimilation of xenoliths has generated a granitic melt leaving a refractory residuum. It is equally conceivable that a certain amount of feldspar is deposited in the metasedimentary rocks by the vapour that must exist in equilibrium with the silicate liquid for, in places at least, one might expect the silicate melt to be water saturated and hence to give rise to a granitic vapour. This may well be the source of some of the coarse pegmatites.

It is worth noting that no granite in the area is of the one-feldspar or hypersolvus type that is found around Madoc.

The petrogenesis of these rocks is seen as a normal consequence of melting during high grade regional metamorphism.

Mafic and Ultramafic Rocks

There are a number of large gabbroic and dioritic bodies within the two townships and one of them contains ultramafic phases. Most are intensely metamorphosed and the term metagabbro is used in the field in a general sense to include all rocks of gabbroic parentage even though many of these are now amphibolites simply because it is not always possible to make meaningful distinctions in the field.

The largest body is undoubtedly the Glamorgan gabbro which appears on earlier maps as a continuous body extending from Greens Mountain to Hadlington Lake in Monmouth Township. It has now been mapped as three separate bodies designated the Glamorgan, Monmouth and Hadlington gabbros. Several other bodies of variable size appear on the map.

It seems likely that these are for the most part sheet-like bodies; the metasediments exposed between the Glamorgan and Monmouth bodies are probably the floor underlying what was once a continuous sheet of gabbro. A hole drilled on Lot 2, Con. IV of Monmouth Township passed into limestone at a depth of about 430 feet and continued in limestone until terminated at 630 feet.

Some parts of the body are amphibolite while vague patches

Anorthositic bands in the Glamorgan gabbro.

Possible igneous layering in the Greens Mountain gabbro.

and bands are anorthositic and much of it is scapolitic. Pyroxene is generally a diopsidic augite and is usually at least partly altered to green hornblende. Scapolite forms both discrete grains and minute veinlets penetrating plagioclase. In places it is a hornblende - scapolite gneiss.

In several parts of the large metagabbro masses there are remnants of the pre-metamorphic texture and mineralogy and it appears likely that the intrusions have, during metamorphism, sheared into large blocks perhaps thousands of feet across in the cores of which the gabbro has been only mildly metamorphosed, whereas toward the margins of the blocks metamorphism has generated an amphibolite. An analysis of one of these relatively unaffected gabbros is given in Table V together with an analysis of a typical hornblende-plagioclase gneiss.

Very little could be said about the petrogenesis of these basic rocks if it were not for the extensive survival of an igneous texture in two widely separated intrusions. The mineralogy of these rocks tells much about their origin and the grade of metamorphism that must have been reached in the area.

The Gooderham Lobe, Glamorgan Gabbro

One area of particular interest is a lobe of the Glamorgan Gabbro about 1½ miles south of Gooderham on highway 507 and about half a mile across. In outcrop the rock is a typical igneous rock showing no indication of metamorphism; dikes are relatively common. It appears to be bordered by marbles, except on the south where it

TABLE V

	1	2
SiO_2	44.42	43.77
TiO_2	0.54	0.74
Al_2O_3	16.19	21.10
Fe_2O_3	1.31	1.18
FeO	10.53	7.37
MnO	0.29	0.15
MgO	8.51	9.70
CaO	15.32	12.74
Na_2O	1.96	2.38
K_2O	0.30	0.42
P_2O_5	Trace	Trace
CO_2	Trace	0.04
H_2O+	0.55	0.84
H_2O-	0.18	0.05
	100.10	100.48

1. Mildly metamorphosed gabbro (C 82560) Lot. 3, Con. III, Monmouth Township.
2. Hornblende - plagioclase gneiss (C 82545) Lot. 3, Con. III, Monmouth Township.

Analyst: J. Gittins

Numbers in brackets in this and subsequent analyses are the catalogue numbers of the specimens in either the Department of Mineralogy and Petrology, University of Cambridge (C numbers) or the Department of Geology, University of Toronto (T numbers).

merges into the gneissic main mass of the Glamorgan gabbro, and it might be that flowage of that marble during regional metamorphism has protected the gabbro from most of the deforming stresses. The body has been studied by Wenban-Smith (1967) from whose work most of the following is summarized.

In hand specimen the rock is characterized by laths of plagioclase feldspar from ½ to 1½ inches in length distributed in such a way as to suggest turbulent flow in a semi-crystallized magma. Many of the laths are bent. There is evidence in the form of ragged and convoluted contacts of intrusion of pulses of partly crystallized magma into rocks which were themselves not completely solid. Superimposed on this turbulent flow texture is a curious planar structure in which the feldspars become strongly aligned in narrow bands varying from 3 or 4 inches to several feet apart. There is a broad tendency for the many dikes which cut the body to parallel this structure (see map fig. 6). The most likely interpretation is that we see here a unique example of an arrested stage in the development of a gneissic structure in an igneous rock whereby shearing stress began to deform the intrusion before crystallization was complete. Thus the layers of parallel-aligned feldspars represent the development of shear planes in a semi solid medium and pulses of the final magmatic differentiate have found their way into these shears. The structure is shown diagramatically in fig. 7.

The dikes frequently contain xenoliths of the surrounding gabbro (see fig. 8).

The effects of metamorphism are to be seen in the mine-

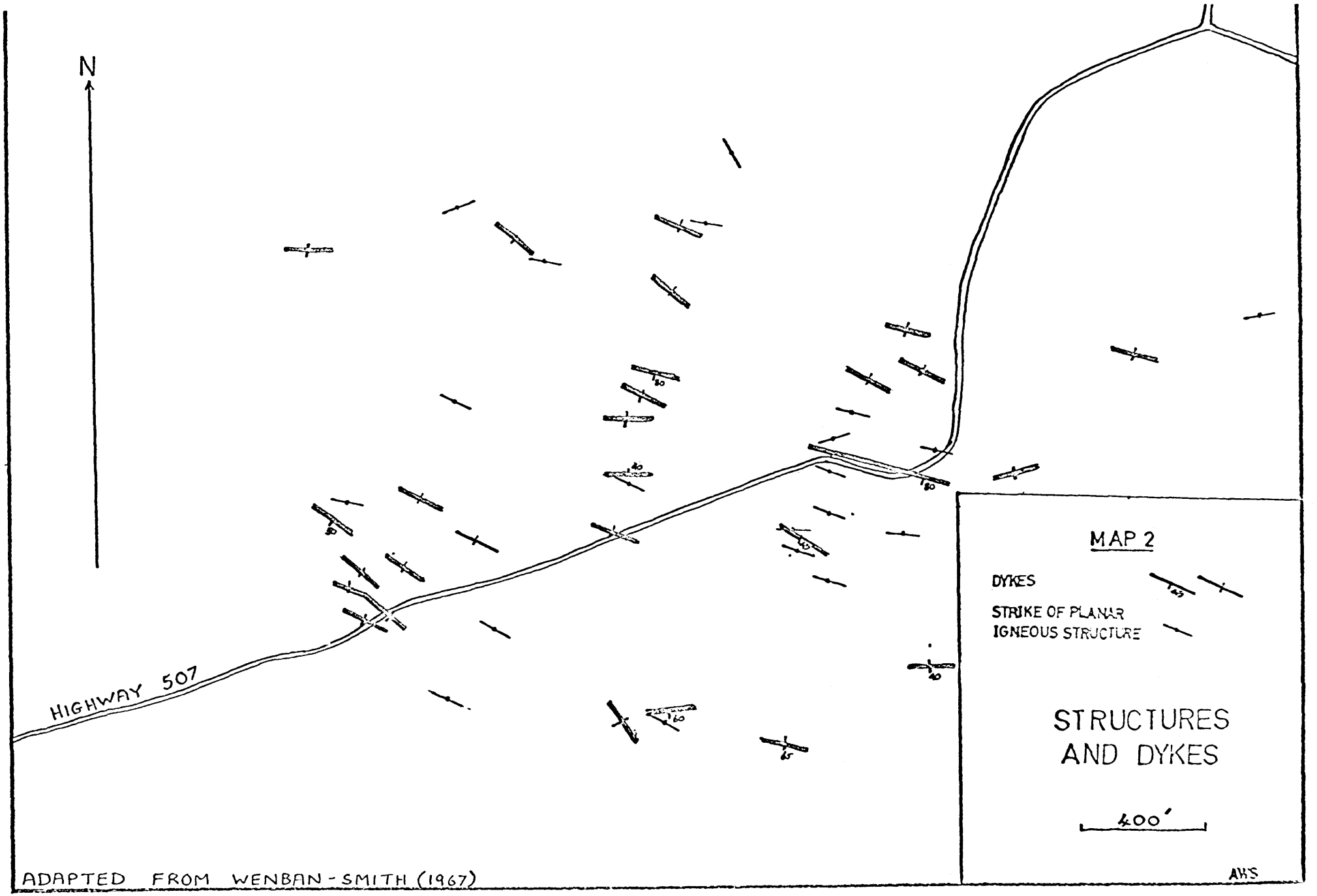
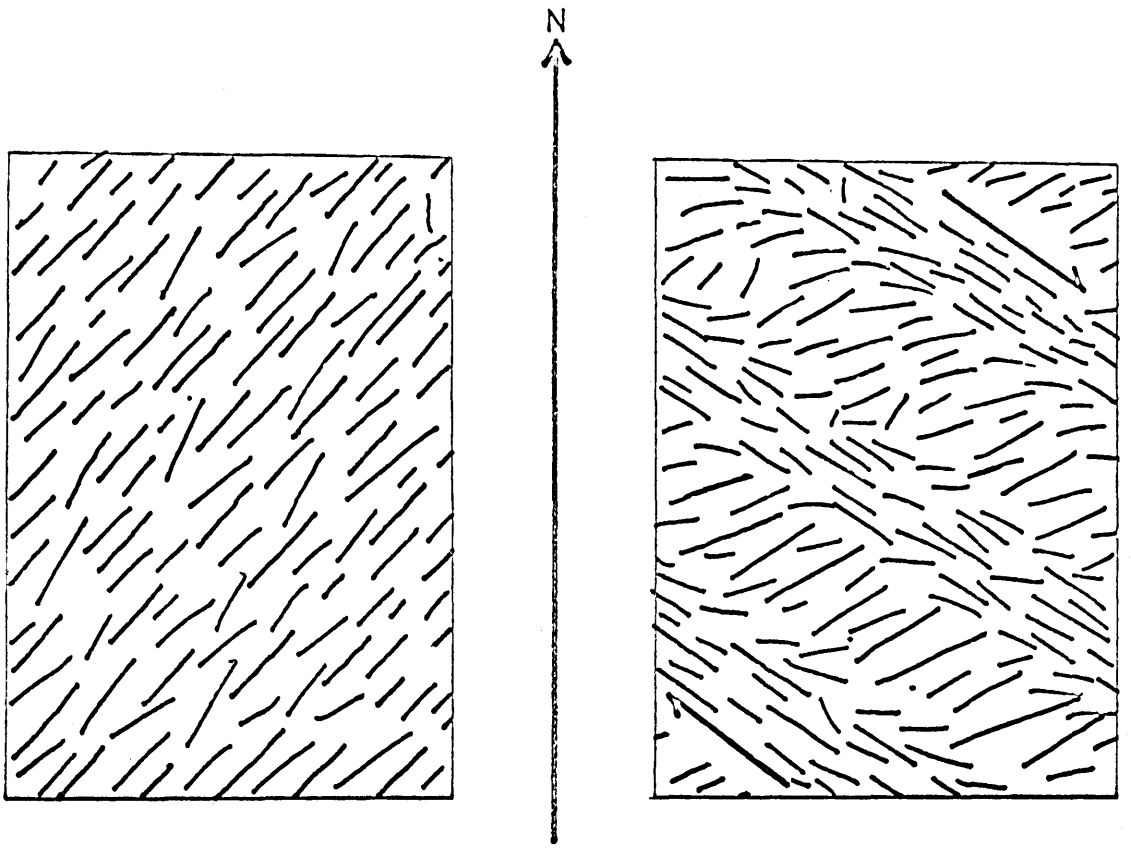

N
HIGHWAY 507
MAP 2
DYKES
STRIKE OF PLANAR IGNEOUS STRUCTURE
STRUCTURES AND DYKES
400'
AWS
ADAPTED FROM WENBAN-SMITH (1967)

Fig. 6



SUGGESTED MECHANISM FOR PRODUCING
THE PLANAR IGNEOUS STRUCTURE

Fig. 7

Xenoliths of gabbro within a dike cutting the gabbro of the Gooderham Lobe.

ralogy of the rocks. The plagioclase laths vary between An_{40} and An_{60} (andesine) and are invariably clouded with minute inclusions. The ferromagnesian constituents occupy the spaces between these laths. The principal mineral is green hornblende occurring as granular clots with relict cores of clinopyroxene and occasionally of orthopyroxene. The clinopyroxene forms discrete grains suggestive of original igneous texture, with oriented dark brown exsolution lamellae. Most grains are partly uralitized. The hornblende which surrounds these clinopyroxenes contains many minute grains of quartz presumably derived from the pyroxene during its metamorphic conversion. Orthopyroxene never forms large grains. Always it occurs as aggregates of small grains containing minute magnetite inclusions and is very fresh in contrast with the clinopyroxene. Both types of pyroxene have a relatively narrow range of composition which is shown in as determined by electron microprobe analysis: En_{31-36} Fs_{22-24} Wo_{44-48} and En_{50-59}.

Ilmenite is the chief opaque mineral, and is always rimmed by hornblende-biotite coronas, and occasionally by biotite-hornblende-garnet coronas. Apatite is always present as an accessory mineral.

Near the margins of the body there appears to be a pyroxenite probably developed as a consequence of local assimilation of the surrounding limestone. Some specimens of gabbro close to the contact contain calcite and the plagioclase is partly replaced by scapolite. Sphene is a comparatively rare accessory mineral in these same rocks. Skarns of diopside, garnet and calcite with

lesser amounts of plagioclase apatite and hornblende generally surround the gabbro.

A series of analyses of various phases of the gabbro are presented in Table VI with their norms. Some are nepheline normative and some are orthopyroxene normative but all lie close to the critical plane of silica saturation in the expanded basalt tetrahedron (Schairer and Yoder 1964). However, both the FeO/FeO+MgO and FeO/Fe_2O_3 ratios are more variable than would be expected in an igneous body of such size and it seems probable that this variability reflects the effects of metamorphism. In Table VII the norms are also given for the analyses recalculated to an FeO/Fe_2O_3 = 7.3:1 which is the value for the chilled margin of the Skaergaard intrusion. There is no way of knowing what the original value was but this is not an unlikely value. It is immediately apparent that all the rocks now become nepheline normative and hence fall into the alkalic field of the basalt tetrahedron.

The contrast between the nepheline normative but orthopyroxene modal character of these gabbros is thus emphasized even farther and reinforces the view that the orthopyroxene is of metamorphic origin. All the rocks are strongly olivine normative but no olivine appears in the mode. The explanation is probably that olivine has been converted to hornblende and to orthopyroxene during metamorphism. It is worth noting that the orthopyroxene is usually pleochroic, a feature common to charnockitic rocks that are generally considered to have suffered deep-seated metamorphism, but not known in igneous rocks that have not been metamorphosed.

TABLE VI

	1	2	3	4
SiO_2	47.15	51.22	44.86	47.69
TiO_2	0.65	0.42	1.95	1.52
Al_2O_3	15.39	18.55	17.31	18.26
Fe_2O_3	3.02	2.70	5.42	2.82
FeO	11.99	6.48	7.07	8.18
MnO	0.21	0.12	0.17	0.15
MgO	8.07	4.72	5.34	4.78
CaO	6.94	8.73	11.34	10.52
Na_2O	3.05	4.42	3.05	3.72
K_2O	1.70	0.91	0.61	0.61
P_2O_5	0.25	0.12	0.79	0.40
CO_2	0.43	0.91	1.09	0.57
H_2O	1.19	0.65	1.21	0.78
TOTALS	100.04	99.95	100.21	99.92

NORMS

Or	10.05	5.38	3.60	3.60
Ab	25.80	37.39	25.80	30.39
An	23.27	28.08	31.73	31.31
Ne	0.00	0.00	0.00	0.59
Cpx	5.62	7.14	10.06	12.08
Opx	1.31	5.52	6.42	0.00
Ol	25.62	8.73	5.50	12.04
Mt	4.38	3.91	7.86	4.09
Il	1.24	0.80	3.71	2.89
Ap	0.60	0.29	1.89	0.96
Ct	0.98	2.07	2.48	1.30

1-4 Gabbros from the Gooderham Lobe of the Glamorgan gabbro
Analyst: W.H. Herdsman with FeO values corrected by C. Paresis

TABLE VI (cont'd.)

	5	6	7	8
SiO_2	47.66	50.26	44.92	77.02
TiO_2	2.34	1.56	0.76	0.00
Al_2O_3	17.42	19.61	16.83	14.06
Fe_2O_3	2.97	1.78	3.60	0.01
FeO	8.58	6.80	8.56	0.39
MnO	0.16	0.12	0.21	0.02
MgO	4.73	3.38	2.17	0.17
CaO	9.60	9.08	14.54	2.70
Na_2O	3.69	4.19	3.08	4.62
K_2O	0.85	1.97	1.61	0.88
P_2O_5	0.65	0.26	0.75	0.06
CO_2	0.13	0.28	2.11	0.17
H_2O	1.14	0.74	0.49	0.20
TOTALS	99.92	100.03	99.63	100.30

NORMS

Qtz	0.00	0.00	0.00	41.06
Or	5.02	11.64	9.51	5.20
Ab	31.22	29.50	17.57	39.08
An	28.45	28.87	27.33	11.93
Ne	0.00	3.22	4.59	0.00
Cor	0.00	0.00	0.00	1.13
Cpx	11.61	10.52	22.70	0.00
Opx	1.30	0.00	0.00	1.13
Ol	10.63	8.74	4.35	0.00
Mt	4.31	2.58	5.22	0.01
Il	4.45	2.97	1.45	0.00
Ap	1.56	0.62	1.80	0.14
Ct	0.30	0.64	4.80	0.39

5-6 Gabbros from the Gooderham Lobe of the Glamorgan gabbro

7 Dike of hornblende-plagioclase-calcite-scapolite rock intrusive into gabbro

8 Vein of quartz-plagioclase (An_{30}) rock within gabbro

Analyst: W.H. Herdsman with FeO values corrected by C. Parisis.

TABLE VII

NORMS RECALCULATED WITH FeO: Fe_2O_3 = 7.33: 1

		1	2	3	4
Or		10.05	5.38	3.60	3.60
Ab		25.07	37.39	24.82	28.52
An		23.27	28.08	31.73	31.31
Ne		0.40	0.00	0.53	1.60
Cpx		5.65	7.23	10.38	12.21
Opx		0.00	2.17	0.00	0.00
Ol		28.87	14.17	17.40	14.82
Mt		2.60	1.57	2.12	1.88
Il		1.24	0.80	3.71	2.89
Ap		0.60	0.29	1.89	0.96
Ct		0.98	2.07	2.48	1.30
Cpx Mol %	En	27.4	27.0	26.6	26.2
	Fs	22.6	23.0	23.4	23.8
	Wo	50.0	50.0	50.0	50.0
Opx Mol %	En		53.9		
Ol Mol %	Fo	54.7	53.9	53.2	52.4

MODES (Wt. %)

Plag.	35.5	36.0	32.8	36.5
Compn.	An 41	An 40½	An 50	An 51½
Recryst Plag.	10.1	19.5	9.2	6.0
Bi	11.2	9.9	5.7	2.2
Il	1.9	0.9	4.7	4.8
Opx	11.2	0.0	2.6	0.0
Cpx	tr.	0.0	2.3	0.0
Qtz	tr.	1.1	0.9	0.0
Hb	29.5	29.4	36.0	46.3
Cum	0.3	1.6	2.0	2.7
Ap	0.1	0.6	1.8	1.5
Ct	0.3	1.0	2.0	0.0

Calculations by A.K. Wenban-Smith (1967)

TABLE VII (cont'd.)

NORMS RECALCULATED WITH FeO: Fe_2O_3 2 7.33: 1

	5	6	7
Or	5.02	11.64	9.51
Ab	30.00	28.59	14.93
An	28.45	28.87	27.33
Ne	0.66	3.71	6.02
Cpx	11.74	10.60	22.82
Opx	0.00	0.00	0.00
Ol	14.51	10.09	8.21
Mt	1.99	1.48	2.09
Il	4.45	2.97	1.45
Ap	1.56	0.62	1.80
Ct	0.30	0.64	4.80

MODES (Wt. %)

Plag.	39.3	60.9	0.0
Recryst Plag.	6.6	4.0	27.0
Bi	3.3	6.6	0.0
Il	3.8	6.2	1.5
Opx	4.4	6.1	0.0
Cpx	4.3	6.9	9.3
Qt	0.9	0.0	0.0
Hb	35.6	6.9	39.0
Scap	0.0	0.0	9.9
Zeolite	0.0	0.0	5.7
Ap	1.8	1.7	2.3
Ct	0.0	0.0	5.0

Calculations by A.K. Wenban-Smith (1967)

There is clear evidence in this gabbroic body then that the metamorphic grade in the area reached the hornblende granulite facies but from the sporadic development of orthopyroxene it seems likely that this grade was only just reached and did not obtain for long enough to bring about equilibrium in the facies.

One final feature of interest in this portion of the Glamorgan gabbro is the sporadic occurrence of acidic veins from a few inches to two feet in width and only a few feet in length at most. Many are cut by the fairly abundant dikes. They are composed of almost equal parts of quartz and sodic plagioclase (An_{30}) together with small amounts of hornblende and biotite; accessory minerals are tourmaline and zircon. An analysis and norm are shown in Table VI. A striking feature is the presence of normative corundum in such an acidic rock. It is difficult to conceive of an igneous rock with such a composition and particularly of such a rock originating by differentiation from a basaltic magma. In addition since the veins are cut by basic dikes it could hardly be considered a late differentiate even if its chemistry made such a possibility reasonable. The most likely explanation is that these veins are melted xenoliths of argillaceous sandstone. This is consistent with their very limited dimensions.

Dikes are fairly common and range in width from less than one foot to more than thirty feet and as was pointed out earlier they generally parallel the strike of the planar structure in the gabbro. They are dark, fine-grained and sometimes contain xenoliths and xenocrysts derived from the adjacent gabbro. Most contain

plagioclase (An_{30}) and dark green hornblende which together form about 80% of the rock - the remainder is apatite, magnetite, biotite. Occasional constituents are sphene, calcite, scapolite, quartz, microcline and zeolites. An analysis of a dike is given in Table VI and the high CaO content is immediately apparent. Together with the presence of scapolite this suggests that some of the late residual magma might have concentrated lime derived by assimilation from the neighbouring limestone.

The Hadlington Gabbro

This is a relatively small body extending westward from Hadlington Lake and covering a little more than one square mile. It has been studied by Grieve (1967) from whose work most of the following is summarized. By contrast to the Gooderham lobe of the Glamorgan Gabbro this one is composed of gabbro and olivine gabbro (coronite), cut by four dike-like bodies of troctolite, peridotite and pyroxenite. Orthopyroxene is here limited to reaction rims and does not occur as grains within the main body of the rock. The complex is cut by narrow dikes of basaltic and micro-dioritic composition which are themselves cut by syenitic, aplitic and granite pegmatite dikes. As in the previously described body there is a pronounced igneous texture and the metamorphic effects are apparent only in thin section. The one exception to this is on the shores of Hadlington Lake along the south east contact where a complete transition from the igneous textured gabbro to a strongly gneissic metagabbro is visible over a distance of one hundred feet. Elsewhere the southern contact is marked a zone of metapyroxenite about

one hundred feet wide which seems to be essentially a skarn.

The metagabbro is medium-grained and made up of andesine, (An_{48}) sometimes zoned with clouded cores and clear rims, augite generally heavily clouded with minute opaque inclusions, and iron oxide minerals. Metamorphic recrystallization of the plagioclase in some places has resulted in fine-grained, more sodic plagioclase (An_{40}) along grain boundaries. Augite is usually somewhat uralitized and occasionally is completely replaced by an aggregate of green hornblende. Calcic scapolite in some rocks has replaced plagioclase but the lath-shape of the original plagioclase remains. Biotite is sometimes present with uralite amphibole and as coronas around ilmenite. Almandine garnets up to half an inch across and surrounded by hornblende are rare. Apatite and sphene are accessory minerals.

The olivine gabbro (coronite) forms two zones within the complex. It is a medium-grained rock with well-developed coronas around olivine grains that are readily visible in hand specimen. Some of these coronas contain garnet. The basic fabric of the rock is controlled largely by laths of plagioclase which make up from 50 to 80 percent of the rock. Plagioclase crystals are oscillatory zoned with cores of An_{70} and rims of An_{50}. Very much less feldspar has been recrystallized than in the metagabbro, but calcic scapolite is present in that which has been recrystallized. Clinopyroxine, a salite-augite, has a sub-ophitic relation to the plagioclase and is heavily clouded and slightly uralitized. They are somewhat aluminous pyroxenes (Table VIII) (Al_2O_3=3-6%) but are not titaniferous. Olivine

TABLE VIII

Partial analyses of clinopyroxenes from olivine gabbros.

SiO_2		51.1	48.7	51.3	51.3
TiO_2		1.1	1.3	1.3	1.0
Al_2O_3		6.1	6.1	3.3	4.0
Total Fe as FeO		7.4	8.6	8.5	7.5
MgO		12.6	14.1	13.1	14.6
CaO		20.7	20.1	21.1	20.8
		99.0	98.9	98.6	99.2
Compn.	Wo	48	44	46	44
	En	39	42	40	43
	Fs	13	14	14	13

Partial analyses of orthopyroxenes from olivine gabbros

SiO_2		53.3	54.5	51.8	51.6
TiO_2		-	-	-	-
Al_2O_3		1.2	0.9	1.7	1.7
Total Fe as FeO		19.6	20.3	19.7	22.6
MgO		22.8	22.7	23.4	21.7
CaO		2.0	0.4	0.1	0.2
		98.9	98.8	96.7	97.8
Compn.	Wo	3.9	0.8	0.2	0.4
	En	64.8	66.1	68.1	62.8
	Fs	31.3	33.1	31.7	36.8

Electron microprobe analyses by R.A.F. Grieve

originally made up 10 to 40 per cent of the rocks but has now been extensively converted to other minerals during corona development. Where fresh the olivine varies between Fo_{52} and Fo_{63} (Table IX). Coronas are of two types: two-zone, and three-zone coronas. Two-zone coronas consist of an inner zone of hypersthene with crystals elongated perpendicular to the margin of the olivine. This is surrounded by a zone of pale green amphibole full of minute inclusions of green pleonaste spinel. Sometimes there are vermicular intergrowths of pleonaste and amphibole. Three-zone coronas are similar with an inner hypersthene zone against the olivine, a middle zone of brown-green amphibole with little or no spinel and an outer rim of almandine garnet. Three zone coronas are relatively rare and often transitional into two zone coronas. Always it is plagioclase that has reacted with olivine to generate the coronas. Coronas are never found between clinopyroxene and olivine. Analyses of orthopyroxenes from coronas are presented in Table X. Between ilmenite and plagioclase are coronas with an inner biotite zone and an outer rim of brown hornblende and rare spinel. Alteration of the olivine is only slight and generally to yellow serpentine.

Troctolite and peridotite are genetically associated, forming four ridges with a north easterly trend and uncertain width. The troctolites contain 10 to 30 per cent plagioclase and the peridotites less than 5%. The majority of the rocks have more than 50 per cent of olivine as subhedral to rounded grains often extensively altered to yellow serpentine and magnetite. Olivine composition ranges from Fo_{63} to Fo_{72}. Poikilitic plates of clouded augite,

TABLE IX

Partial analyses of olivines from olivine gabbro

SiO_2	36.0	36.0	36.7	37.4	35.7
TiO_2	-	-	-	-	-
Al_2O_3	-	-	-	-	-
Total Fe as FeO	35.8	34.7	34.2	31.3	39.0
MgO	25.9	27.8	28.5	29.8	23.3
CaO	0.1	-	-	-	-
	97.8	98.5	99.4	98.5	98.0
Comptn.	Fo_{53}	Fo_{59}	Fo_{60}	Fo_{63}	Fo_{52}

Electron microprobe analyses by R.A.F. Grieve

TABLE X

	1	2	3	4
SiO_2	53.3	54.5	51.8	51.6
TiO_2	0.0	0.0	0.0	0.0
Al_2O_3	1.2	0.9	1.7	1.7
Total Fe as FeO	19.6	20.3	19.7	22.6
MgO	22.8	22.7	23.4	21.7
CaO	2.0	0.4	0.1	0.2
	98.9	98.8	96.7	97.8
Comptn. (wt.%) En	64.8	66.1	68.1	62.8
Fs	31.3	33.1	31.7	36.8
Wo	3.9	0.8	0.2	0.4

Electron microprobe analyses by R.A.F. Grieve

highly altered to brown hornblende, surround the olivines. This is a more magnesian and less aluminous pyroxene than the olivine gabbro. Plagioclase is bytownite averaging about An_{75} and is extensively replaced by scapolite. Wherever plagioclase adjoins olivine there is a two zone corona of hypersthene surrounded by plagioclase. Accessory minerals are chromite, ilmenite, spinel, apatite and biotite. Spinel is olive green picotite and in the troctolite coronas is strongly zoned with a deep brown core. Generally these rocks are extensively altered resulting in serpentine - hornblende rocks with minor plagioclase or scapolite. Analyses of olivines and a clinopyroxene from these rocks are given in Table XI.

Chemical analyses of five rocks from the complex are presented in Table XII and it can be seen that here also the gabbro is nepheline normative.

The metamorphic grade, as in the Gooderham Lobe, is clearly indicated by the mineralogy of the rocks and by the corona mineralogy in particular. Olivine and plagioclase have reacted to produce orthopyroxene and hornblende, and in some instances garnet. Thus the metamorphism reached the hornblende granulite facies, but the rocks have not equilibrated in this facies. As in the Gooderham Lobe of the Glamorgan gabbro the mineralogy is representative of both hornblende granulite and almandine amphibolite facies. This is commented upon further in a general discussion of metamorphism within the region.

The Bark Lake diorite

This reasonably large body has been mapped as diorite

TABLE XI

Partial analyses of olivines from peridotites and troctolites

SiO_2	35.7	36.2	36.5	36.9	37.0	36.9	37.7
TiO_2	0.1	0.1	0.0	0.1	0.1	0.2	0.1
Al_2O_3	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total Fe as FeO	31.8	30.9	26.0	26.5	27.5	26.9	25.3
MgO	30.1	31.3	34.9	33.7	35.4	34.0	36.0
CaO	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	97.8	98.6	97.5	97.3	100.1	98.4	99.1
Compn.	Fo_{63}	Fo_{64}	Fo_{71}	Fo_{69}	Fo_{70}	Fo_{70}	Fo_{72}

Partial analyses of clinopyroxene from peridotite

SiO_2	52.1
TiO_2	0.3
Al_2O_3	1.3
Total Fe as FeO	5.1
MgO	16.2
CaO	23.1
Compn.	Wo 46
	En 46
	Fs 8

Electron microprobe analyses by R.A.F. Grieve

TABLE XII

	1	2	3	4	5
SiO_2	48.34	46.78	45.97	39.76	38.69
TiO_2	0.83	1.21	0.70	0.52	0.61
Al_2O_3	17.65	20.91	18.71	5.92	2.69
Fe_2O_3	1.11	0.76	1.34	4.44	7.14
FeO	7.17	8.10	10.24	14.21	15.95
MnO	0.15	0.14	0.19	0.27	0.36
MgO	6.51	6.01	8.76	26.55	24.48
CaO	11.58	10.64	9.19	3.71	4.65
Na_2O	3.78	2.42	1.85	0.66	0.51
K_2O	1.06	0.68	0.44	0.17	0.28
P_2O_5	0.12	0.32	0.20	0.11	0.24
CO_2	0.05	0.19	0.40	0.63	0.50
H_2O+	1.13	1.10	1.22	3.37	4.44
	99.48	99.26	99.21	100.32	100.54

1. Metagabbro, Hadlington Gabbro, Monmouth Township (TGMSc-J8)
2. Olivine gabbro, Hadlington Gabbro, Monmouth Township (TGMSc-J33)
3. Olivine gabbro, Hadlington Gabbro, Monmouth Township (TGMSc-D2)
4. Troctolite, Hadlington Gabbro, Monmouth Township (TGMSc-J38)
5. Peridotite, partly serpentinized, Hadlington Gabbro, Monmouth Township (TGMSc-J14)

Analyst: A.G. Loomis

NORMS

Or	-	4.02	2.60	1.0	1.65
Ab	6.26	20.47	15.65	5.58	4.31
An	18.07	44.17	41.43	12.68	4.22
Ne	7.53	-	-	-	-
Cpx	23.14	4.39	0.27	0.82	11.36
Hyp	-	7.40	19.20	16.54	17.05
Fo	6.66	6.84	7.66	37.43	31.28

Table XII (Cont'd)

Fa	5.05	6.30	6.55	13.77	13.03
Mt	1.61	1.10	1.94	6.44	10.35
Ilm	1.58	2.30	-	0.99	1.16
Ap	0.29	0.77	0.48	0.26	0.58
Ct	0.11	0.43	0.91	1.43	1.14

Compositions of normative minerals

Cpx	$Wo_{50}En_{33}Fs_{17}$	$Wo_{50}En_{31}Fs_{19}$	$Wo_{50}En_{31}Fs_{19}$	$Wo_{50}En_{40}Fs_{10}$	$Wo_{50}En_{39}Fs_{11}$
Opx	-	En_{61}	En_{63}	En_{80}	En_{78}
Ol	Fo_{66}	Fo_{61}	Fo_{63}	Fo_{80}	Fo_{78}

TABLE XIII

Analyses of Bark Lake diorite, Glamorgan Township (Quoted from Chesworth, 1966).

	F4	G6
SiO_2	50.8	53.1
TiO_2	2.42	2.15
Al_2O_3	16.0	16.0
Fe_2O_3	5.50	4.84
FeO	4.60	6.31
MnO	0.14	0.19
MgO	3.50	3.14
CaO	7.39	5.09
Na_2O	4.44	4.41
K_2O	2.34	2.92
P_2O_5	1.19	0.67
H_2O+	0.54	0.73
H_2O-	0.21	0.11
CO_2	0.46	0.39
	99.5	100.1

MODE

	F4	G6
Plagioclase	69.7	68.2
Hornblende	19.3	17.8
Biotite	5.7	9.3
Augite	1.8	1.1
Microcline	1.4	1.7
Accessories	2.1	1.9
Plag. Comp.	An_{35}	An_{33}

Analyst: J. Muysson (McMaster University; Penn. State University).

but there has been no detailed study of its petrography. Chesworth (1966) has given two analyses which are quoted in Table XIII.

Diabase

A small dike of diabase cuts paragneiss between the Monmouth and Hadlington gabbros. The country rocks are garnetiferous but it is uncertain whether the garnet is of thermal metamorphic origin.

The effect of limestone assimilation on the gabbros

In several places gabbro appears to have assimilated limestone usually to form a pyroxenite. On Lot 4, Con III, Monmouth Township this assimilation has been studied chemically. The general geology is described on pp.85-92 where it will be seen that nepheline gneisses occurring between gabbro and marble are interpreted as nephelinized skarn, the skarn having formed at the time the gabbro was intruded.

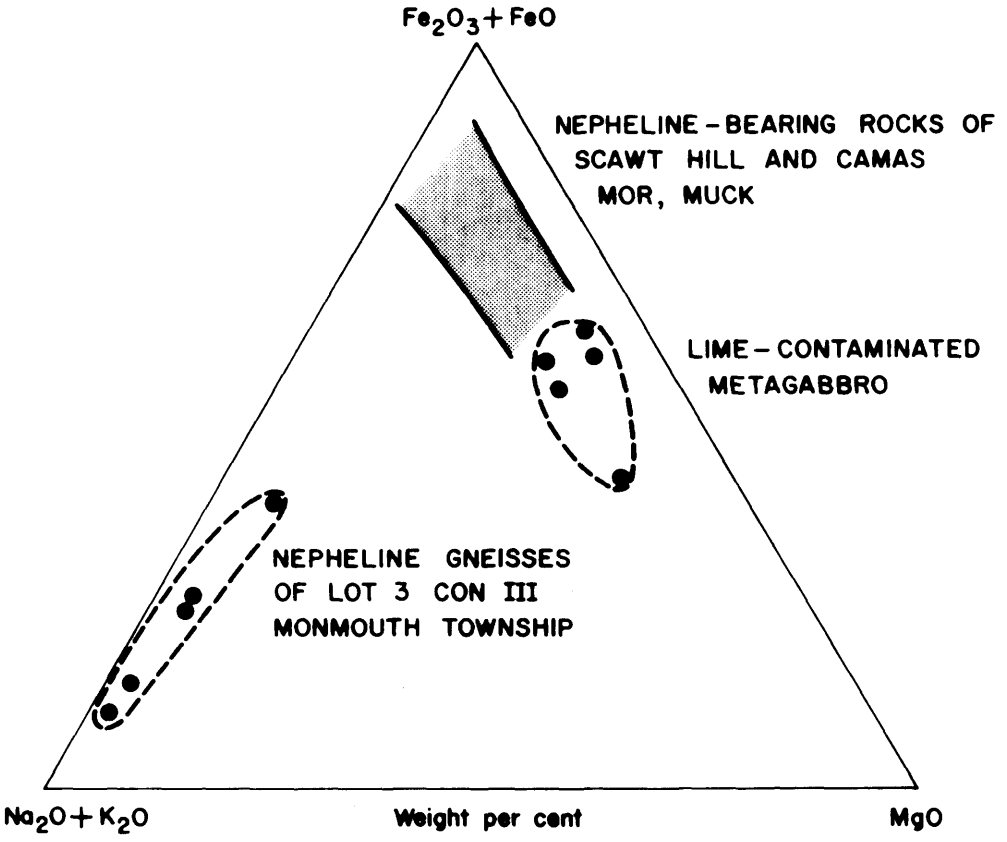
The hybrid border of the gabbro is composed of garnet - epidote amphibolized metapyroxenite about 300 feet in outcrop width. The commonest metapyroxenite has less than 20 per cent of plagioclase and scapolite. Clinopyroxene is pale green diopsidic augite general extensively uralitized and traversed by veinlets of garnet and blebs of scapolite. Occasionally only relict cores of pyroxene remian within areas of dark green hornblende. Plagioclase is zoned from An_{60-67} at the core to An_{35} at the rim but calcic scapolite is much commoner than plagioclase. Garnet is usually 5-15 per cent of the rock but sometimes reaches 25 per cent. It forms rounded grains between pyroxene and also occurs as minute

veinlets along the pyroxene cleavages but these never extend into the mantling hornblende. Epidote forms long prismatic crystals which may be separate, interlocking or even branching and occasionally it is seen as irregularly shaped porphyroblasts. Grain size is 1-10 mm. Accessory minerals are calcite, sphene, zircon, pyrrhotite and iron oxide minerals.

Three analyses in Table XIV shows the increasing lime content toward the nepheline rocks, and hence toward the original contact with limestone. They may be contrasted with the lime values of the gabbros given in Tables I, III, VIII and X.

A similar lime-rich pyroxenite is found at the eastern edge of the Hadlington gabbro. The rock is composed essentially of strongly pleochroic titaniferous augites with a high Al_2O_3 content. Also present is a bright green spinel which amounts to sixteen percent of some rocks. Accessory minerals are spatite, calcite, ilmenite and pyrrhotite. Analyses of these pyroxenes are given in Table XV. There is no evidence in these lime-rich rocks of metamorphism exceeding the almandine- amphibolite facies.

There is also no evidence in the two townships that assimilation of limestone by gabbro magma has led to the generation of nepheline rocks. While the geology of Lot 3, Con. III might at first appear to indicate this, the possibility is ruled out by the chemical trends of the hybrid rocks. In fig. 9 the Monmouth contaminated gabbros are compared to those other localities where limestone assimilation has led to limited nepheline formation. In all cases the iron enrichment is far more extreme than in the Monmouth example.



Iron enrichment of metapyroxenites compared to Hebridean examples.

TABLE XIV

	1	2	3
SiO_2	43.50	42.77	43.31
TiO_2	0.91	1.56	1.57
Al_2O_3	16.17	9.10	9.42
Fe_2O_3	2.93	2.87	3.81
FeO	8.00	10.24	10.30
MnO	0.07	0.18	0.10
MgO	5.67	8.05	7.40
CaO	18.81	21.07	20.95
Na_2O	2.04	1.24	1.24
K_2O	0.77	0.62	0.48
P_2O_5	0.01	0.06	0.05
CO_2	0.27	1.32	0.94
H_2O+	0.63	0.78	0.70
H_2O-	0.04	0.04	0.05
S	0.34	-	-
	100.16	99.90	100.32
O=S	0.15		
	100.01		

1. specimen C82492
2. specimen C82494
3. specimen C82584

} Amphibolized metapyroxenites with garnet, epidote and scapolite; Lot 3, Con. III, Monmouth Township.

Analysts: J. Gittins (1, 2, 3); A.G. Loomis (4).

TABLE XV

Partial analyses of clinopyroxenes from metapyroxenites

SiO_2	47.6	45.7	45.0	47.4	41.8
TiO_2	3.4	3.1	3.1	2.1	2.0
Al_2O_3	6.3	10.4	9.8	7.2	12.0
Total Fe as FeO	5.2	3.0	7.9	6.1	3.4
MgO	11.6	12.7	10.0	12.1	16.6
CaO	24.1	23.7	22.9	24.2	23.1
	98.2	98.6	98.7	99.1	98.9

Compn.	Wo	53	54	54	53	47
	En	38	41	32	37	47
	Fs	9	5	14	10	6

Electron microprobe analyses by R.A.F. Grieve

Contact metamorphism

In many places there is a prominent contact metamorphic skarn bordering the gabbro. It has been mapped on both the north and south sides of Greens Mountain and varies considerably in width. Generally the skarn is a simple garnet-pyroxene-calcite rock but may contain hornblende, plagioclase, scapolite and pyrrhotite. Pyroxene is always on the diopside-hedenbergite join. In 1952 some loose blocks of wollastonite-bearing skarn were found beside highway 507 east of Greens Mountain but nothing similar has been found in outcrop.

The skarns are always between gabbro and limestone and they appear not to have undergone any mineralogical readjustment during subsequent regional metamorphism. Where the Hadlington gabbro is seen in contact with amphibolite gneiss on Hadlington Lake there is no evidence of any reaction.

The presence of skarns in some places is indicative of the extent to which marble has become plastic and flowed during regional metamorphism for along highway 507 the Glamorgan gabbro, thoroughly recrystallized to a granular rock is in knife-sharp contact with graphitic limestone and there is not a trace of skarn. A few blocks of the recrystallized gabbro within the marble suggest that flowage of the marble has torn away any skarn that might have been present at this locality and created a mechanical contact in place of the original intrusive contact. At the same time this gives some idea of the diverse possible origins for the calc-silicate bands and nodules in the deformed marbles.

Nepheline - bearing rocks

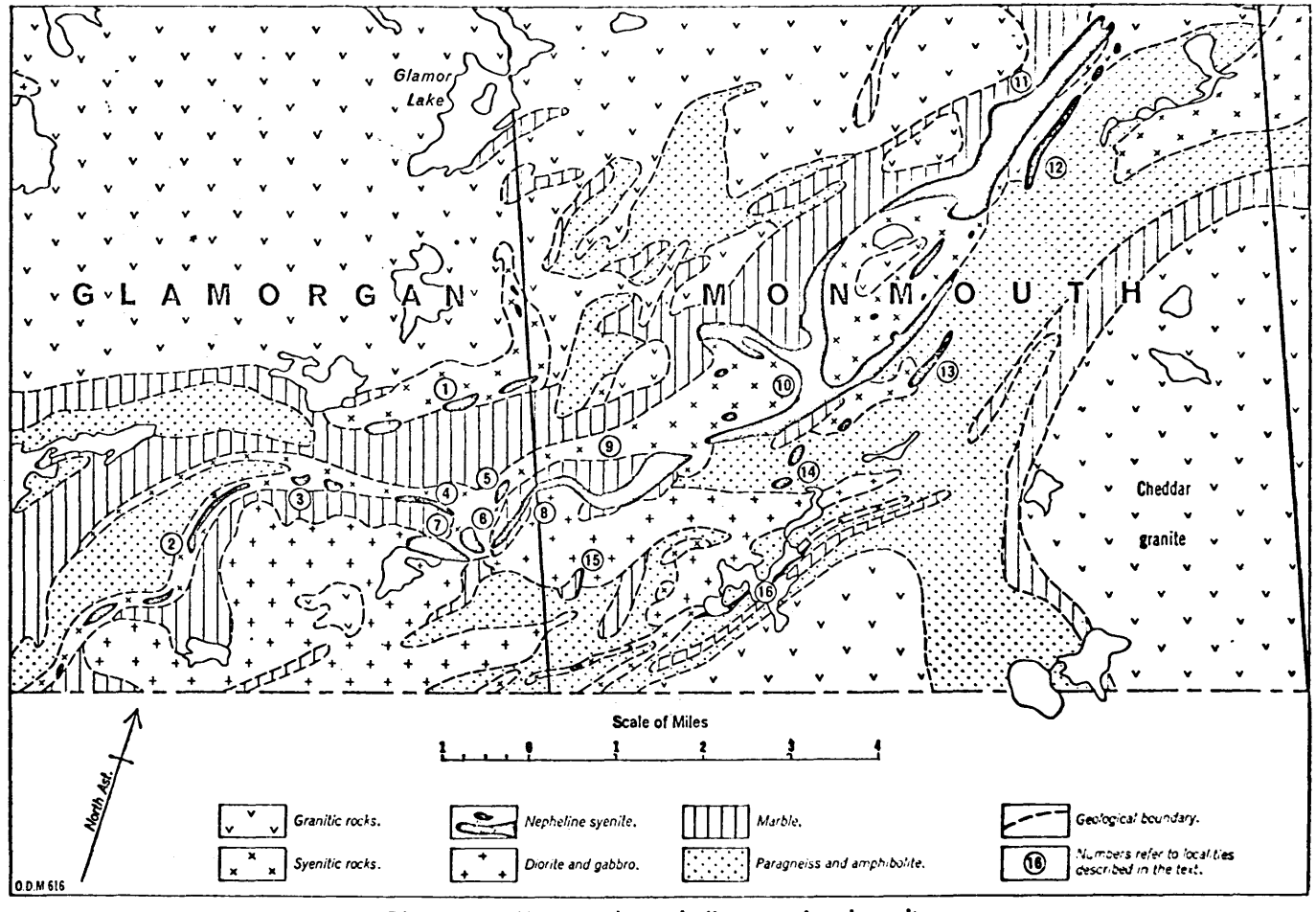
Glamorgan and Monmouth Townships contain some of the finest examples of nepheline-bearing rocks in the world and have figured prominently in the literature of these rocks throughout the controversies that have involved the origin of feldspathoidal rocks.

The nepheline rocks are chiefly gneisses and pegmatites and a series of hybrid syenites and gneisses formed by the intrusion of granite and syenite and consequent assimilation of nepheline rocks. These constitute a highly variable group of rocks that represent every gradation from types containing glassy fresh nepheline to varieties in which only the characteristic alteration products known for convenience in the field as "gieseckite" and "hydronephelite" indicate their origin as feldspathoidal rocks.

Of particular interest, and petrological importance, however, are the series of theralites, theralitic canadites and hypersolvus nepheline syenites that appear to have survived regional metamorphism owing to fortuitous cushioning by marble in a few places. These rocks are unique to Glamorgan and Monmouth Township being unknown anywhere else in the Haliburton-Bancroft district, and unsuspected before the present survey.

Descriptions of individual occurrences follow, their locations being shown on the map fig. 10.

(1) Nepheline Syenite Gneiss; Lot 27, Concession V, to Lot 35, Concessions VI to VIII, Glamorgan Township; Lot 2, Concessions VII and VIII, Monmouth Township:



Glamorgan-Monmouth nepheline syenite deposits.

Nepheline-biotite-plagioclase gneisses, light-grey to pinkish in colour, occur sporadically near the hanging wall side of a curved body of pink to buff biotite (locally hornblende) syenite gneiss.

The syenite gneiss is bordered on the north by the Glamorgan granite gneiss complex, and on the south by a marble-paragneiss complex intruded by leucogranite and granite pegmatite. To the east of the syenite, in Monmouth Township, is an area chiefly composed of hybrid granitic gneisses with remnants of marble and paragneiss. The syenite gneiss dips southward at 35 to 50 degrees and, after curving northward, shows a steep easterly dip.

The syenite mass has a maximum width of about 30 chains on the boundary between Lots 31 and 32. It tapers to about 6 chains at Gooderham village to the west, and to about 12 chains where it passes under the swamp in Concession VIII. The grey nepheline rock occurs as four discontinuous areas within the syenite gneiss as shown in Figure 1. The westernmost of these is about 12 chains by 30 chains, the central group about 8 chains by 40 chains, the east group about 6 chains by 35 chains and the north group about 1 chain by 17 chains.

Nepheline is not abundant even in the nepheline rock itself and although clots up to 1 inch by 3 inches have been noted, it is usually sparsely disseminated. No nepheline pegmatites have been observed in this belt. The nepheline rock in Lot 35, Concession VI has grains of magnetite up to one-eighth inch across.

White corundum in scattered crystals up to one quarter inch across is found in a patch of white nepheline syenite in Lot 35, Concession VIII.

In addition to the patches of nepheline rock, the biotite syenite gneiss also contains relict patches of paragneiss and of marble with a deep brown phlogopite or biotite. The biotite syenite gneiss and patches of nepheline gneiss and metasediments are cut by irregular masses of pink to red granite, locally containing hornblende. All are cut, in turn, by pink to red granite pegmatite. This is a characteristic sequence of events in the nepheline belt.

(2) Nepheline Syenite Gneiss; Lot 13, Concession I to Lot 23, Concession IV, Glamorgan Townships:

Nepheline-biotite-plagioclase gneiss, white to pinkish in colour, occurs in four well-defined localities within this western portion of the main belt of syenite gneisses. The syenite gneiss band is about 6 chains in width at the south boundary of Glamorgan Township. Toward the north the band increases to a width of about 15 chains, which is maintained to the northernmost occurrence of nepheline rock, about one-half mile north of the Buckhorn road, in Lot 23, Concession IV. Throughout the greater part of this extent the nepheline rocks lie on a footwall of hornblende syenite gneiss, and are overlain, in turn, by biotite syenite gneiss. Both the hornblende syenite and the biotite syenite are buff to pink or reddish, the biotite syenite in some places, however, being white. The syenite gneiss

band lies between an area of biotite paragneisses to the northwest and a band of marble fringing the Glamorgan gabbro of Greens mountain on the southeast. Bodies of paragneiss and phlogopite marble with the syenite gneiss appear to be remnants. The sequence dips southeastward at 30 degrees, locally steepening to 45 degrees.

The southernmost occurrence of nepheline rock is represented by a few small outcrops of a white nepheline-poor biotite syenite gneiss lying between pink biotite syenite gneiss to the northwest and phlogopite marble to the south-east. The next occurrence, to the north, extends continuously for 45 chains, tapering from a width of about 4 chains at its central part to about 1 chain at each end. The nepheline rock here includes both hornblende- and biotite-bearing varieties, the nepheline content ranging from sparse to about 10 per cent. An interesting feature of this occurrence is the presence of a pyroxene-garnet skarn in the marble at the southern portion. These skarn rocks outcrop within a band of hornblende syenite gneiss to the southeast of the biotite syenite gneiss. Marble containing phlogopite and graphite outcrops between this hornblende syenite gneiss and the gabbro of Greens mountain.

The third occurrence of nepheline rock lies about 7 chains to the northwest of the trail to the fire tower on Greens mountain. The body is almost pear-shaped, being 6 chains wide at its southwest, and 1 chain wide at the northeast end; the length is about 25 chains. It is a nepheline-poor gneiss, chiefly biotitic, but with hornblende patches. In the latter the nepheline is fresh and

displays the characteristic blue-grey weathering, while in the biotite variety it is altered to pink hydronephelite or a chalky-white alteration product.

The northernmost occurrence comprises a narrow belt of numerous outcrops extending for 100 chains. Throughout most of its length nepheline rocks are found across a width of 1 to 2 chains, although near the southern end they were found across 8 chains. The hornblende syenite gneiss of the footwall is generally rich in mafics and is marketly darker coloured than the biotite syenite gneiss of the hanging wall. Reddish brown garnets up to one-eighth inch are abundant near the south end, while near the north end the hornblende syenite gneiss contains numerous grains of yellow vesuvianite. The nepheline rocks are, for the most part, biotite-plagioclase gneisses containing sparse nepheline but near the south end nepheline reaches about 50 per cent. Fresh nepheline with the characteristic blue-grey weathered surface is rare; more common is pink hydronephelite or chalky-white alteration. Near the north end the nepheline rock adjacent to the hornblende syenite footwall is itself hornblende-bearing, being overlain by the commoner biotitic nepheline rocks. A special feature of this occurrence is the presence of pegmatitic nepheline in stringers up to 3 or 4 inches across and several feet in length. The blocky nepheline in these stringers, and in isolated clots, occurs as masses up to 1-½ inches across, subhedral in shape; some contain prismatic crystals of brown zircon up to one-quarter inch long.

(3) Buckhorn Road Nepheline Rocks; Lots 25 and 26, Concession IV; Glamorgan Township:

Nepheline-bearing hornblende-plagioclase and biotite-plagioclase gneisses and nepheline-plagioclase pegmatites occur within the main band of syenite gneisses in these two lots. The hornblende syenite gneiss of the footwall is characterized by abundant magnetite in octahedra up to one-quarter inch across. The syenite gneisses here have a maximum exposed width of 18 chains, but swampy ground to the north and south makes width measurements uncertain. The gneisses strike east-west with dips generally southerly but there are local reversals of dip, and variations in strike. Zones of mylonite in the magnetite-hornblende syenite gneiss just west of the Buckhorn road indicate later movements.

Near the western boundary of lot 25 three pits have been sunk on nepheline-plagioclase pegmatites in nepheline-biotite-plagioclase gneisses. Other outcrops expose nepheline-hornblende-plagioclase gneiss to the north. The total width is about 2-½ chains, and the length about 6 chains. The pegmatite bodies are generally lenticular or pod-like, with a maximum width of 2 feet, the average being about 1 foot; the lengths generally are less than 10 feet. Sodalite and cancrinite are common, as also are zircon crystals up to three-quarters inch in length, magnetite up to 2 inches, and calcite. A 10-inch sill-like band of hornblende-biotite syenite gneiss containing numerous small grains of purple fluorite cuts the nepheline-hornblende-plagioclase gneiss in a small outcrop about 50 feet north of the easternmost pit.

Immediately west of the Buckhorn road are exposures of red to pink hornblende syenite gneiss containing abundant magnetite

grains. Some mylonite was noted here. Bordering these on the south are outcrops of coarse-grained white biotite-plagioclase gneiss containing disseminated nepheline, mostly chalky-white, but with some patches of streaks of blue-weathering nepheline.

To the east of the Buckhorn road a high ridge consists chiefly of magnetite-hornblende syenite gneiss, with some biotite syenite gneiss and syenite pegmatite. On the south slope of the ridge, from 12 to 20 chains east of the road nepheline-poor biotite-plagioclase and hornblende-plagioclase gneisses are exposed. One outcrop of magnetite-bearing nepheline-biotite-plagioclase gneiss is bordered by magnetite-hornblende syenite on the north and magnetite-biotite syenite on the south. In this section the dips are generally southward at about 30 degrees.

These occurrences are evidence of the general continuity of nepheline rocks throughout this main band of syenite gneiss.

(4) Fraser Nepheline Pegmatite; Lots 29 to 31, Concession IV, Glamorgan Township:

Nepheline rocks are exposed in three occurrences over a length of about one-half mile, centering at the Fraser quarry in Lot 30. The nepheline rocks are found along the contact between biotite syenite gneiss and the overlying marble, containing feldspar and biotite. The biotite syenite gneiss passes northward into a magnetite-rich hornblende syenite gneiss, which is bounded on the north by marble with numerous interbeds of paragneiss. The magnetite-bearing rock represents the eastward continuation of the similar rocks noted at locality 3. The syenite gneiss sequence has

a maximum width of about 20 chains, trends generally north to east, and dips southward at 40 to 45 degrees. The syenite gneiss contains patches of marble similar to that of the hanging wall. White-weathering granite pegmatite bodies cut all these rocks.

The western most occurrence, in Lot 29, is a single small outcrop of nepheline-albite pegmatite, in a sandy knoll 15 chains north of the concession road. The pegmatite contains a few inclusions of the hanging wall marble. Nepheline crystals are up to 2 inches across.

The easternmost occurrence, in Lot 31, consists of three outcrops of coarse-grained white nepheline-biotite-plagioclase gneiss, in the central part of the lot, 13 chains north of the concession road. Chalky-white altered nepheline is abundant and the rock is cut by veins and irregular patches of blue-weathering nepheline. A 2-foot syenite pegmatite dike cuts one of these outcrops. An outcrop of the hanging wall marble separates two outcrops of nepheline gneiss, with which it is directly on strike.

The main occurrence, the Fraser nepheline pegmatite, lies 18 chains north of the concession road. The footwall biotite syenite gneisses are not exposed in the workings but lie 3 chains to the north. The hanging wall marble is exposed immediately adjacent to the quarry on the south and east, and the quarry walls expose these marbles as part of the complex. The quarry rocks include not only the nepheline pegmatite bodies and marble, but also nepheline-biotite gneisses and biotite and hornblende para-

gneisses. The nepheline rocks forming the east wall of the upper quarry consists of two parts comprising an opening about 5 chains in length and 30 feet in width. The minerals present in the nepheline pegmatite are grey albite, nepheline, muscovite, biotite, hornblende, zircon, calcite, sodalite, cancrinite, hydronephelite and corundum. Most of the muscovite occurs with corundum. Corundum rimmed by muscovite can be seen at one locality on the rim of the open pit.

Production from the quarry amounted to 3,178 tons in 1937 and 1938 and there has been no production since.

(5) Gill Nepheline Pegmatite; Lot 34, Con. IV, Glamorgan Township:

Two small quarries now partly overgrown were opened in the 1930's on the eastern slopes of a ridge near Laronde Creek. The pegmatite appears to be a dike-like body 200 to 300 feet wide and about 2,500 feet long. The strike of the enclosing rocks is northerly with an easterly dip ranging from 25 degrees to vertical but at the north end, the trend curves easterly and the dip is more uniform at about 45 degrees south. The rocks adjacent to the pegmatite are nepheline-biotite gneiss, nephelinized limestones, coarse-grained pink hornblende-biotite syenite gneiss and dark coloured massive scapolite-hornblende syenite, all of which are probably a metasomatic envelope surrounding intrusive pegmatite. Farther from the pegmatite the rocks are biotite paragneisses and marbles.

Leuco-syenite pegmatite cuts the nepheline- and syenitic gneisses. The southerly quarry is a very coarse nepheline-albite-biotite pegmatite with accessory apatite, zircon, sodalite, cancrinite and the usually characteristic alteration products of nepheline. The pegmatite is in contact with nepheline-albite biotite gneiss and with crystalline limestone that contains both albite and nepheline in crystals up to 1 by 3 inches.

The upper quarry is also a nepheline-albite pegmatite with biotite but the nepheline is riddled with brownish ankerite or siderite. In some specimens the carbonate and nepheline co-exist without trace of reaction while in other specimens the carbonate has a clear reaction rim of yellow cancrinite. Another interesting feature is the amount of perthitic alkali feldspar in large crystals with the perthitic character clearly visible in hand specimen. This is the only nepheline pegmatite where perthite has been observed in such amount. It does not appear to be the result of intrusion by leuco-syenite pegmatite but rather seems to have crystallized with the nepheline and carbonate.

Six car loads of nepheline are reported to have been shipped from the quarries.

(6) Nepheline Pegmatite; Lots 32 and 33, Concession III; Glamorgan Township:

Nepheline-plagioclase rocks comprise the north part and east slope of an arcuate ridge in the north half of Lot 32, continuing a few chains into the northwest corner of Lot 33. The

trend changes from northwest in the southern part of the ridge to north of east in the northern part, dips being vertical to steep. The body of nepheline rock, roughly triangular in shape, has a length of 20 chains in a northwest-southeast direction. The width tapers from 15 chains, at the northern end, to 2 or 3 chains at the southern end. The nepheline rocks are bordered on the south and west by biotite syenite gneisses. On the north the border rocks include, in addition, hornblende syenite gneiss and marble containing feldspar and biotite. The rocks are cut by syenite pegmatite bodies some of which contain hornblende. At the extreme northeast a pink granite pegmatite dike cuts the nepheline-plagioclase pegmatite and a hornblende syenite pegmatite body. The nepheline rocks disappear under swampy ground to the east. A single exposure of leucosyenite (albitite?) in the swamp probably represents the border rocks to the east and southeast.

The nepheline-bearing rocks are of two types. The greater part of the exposure is a massive white albitite containing variable amounts of blue-grey-weathering nepheline in subhedral crystals up to two or three inches across. These may comprise as much as 10 to 15 per cent of the rock over areas of several square feet. In some places very coarse pegmatitic nepheline occurs in blocky aggregates up to 12 inches or more across. The second type is the nepheline-albite pegmatite, which forms discontinuous irregular masses in the former type. Throughout most of the mass biotite is rare or lacking, but the southerly exposures contain sufficient amounts of this mineral that the rock may be designated a nepheline-

biotite-albite rock. Carbonate, widely disseminated through the nepheline bearing albitite, is readily weathered, leaving small cavities which characterize the weather surface.

Two noteworthy features are the inclusions of marble, and the local occurrence of zircon. Coarse-grained, white marble containing feldspar and biotite occurs as inclusions, up to several feet across, in the nepheline rock, particularly near the northern and northwestern margin of the mass. Pyramidal zircon crystals, up to one-helf inch in length, were found to be localized with the nepheline-bearing albitite on the slope to the east. Satterly (1943, p. 71) reports two patches of zircon-rich rock, "several square feet in area containing 5 per cent of that mineral".

An area about 80 feet across has been stripped of overburden but not further development work was carried out.

(7) Trooper Lake Nepheline Rocks; Lots. 30 to 33, Concession III; Glamorgan Township:

Nepheline-bearing rocks comprise a band extending nearly one mile from their contact with the metagabbro north of Trooper Lake eastward almost to Laronde Creek. For the greater part of its course the band maintains a remarkably uniform width of 20 chains, the width at the eastern end being difficult to establish because of topography and scarcity of outcrop. The band of nepheline rocks is bounded on the west and south by metagabbro. On the north, coarse-grained, blue-grey graphitic marbles form

the border rocks in Lots 30 and 31, while in Lots 32 and 33 the syenite gneiss complex noted in locality 6 delimits the nepheline band. On the east outcrops of graphitic marble can be seen which appear to underly the nepheline rocks.

The predominant rock type, unlike those described for the preceding localities, is a dark coloured nepheline-hornblende-plagioclase gneiss in which the abundant amphibole is hastingsite. The blue-weathering subhedral nepheline crystals averaging one-quarter inch across are commonly grouped in clusters of three or four grains. The nepheline content varies from about 10 to 50 per cent, but averages about 25 per cent. The variation is due chiefly to the fact that the amphibole is concentrated in bands or streaks several inches in width in which the nepheline content is low. Deep brown biotite is locally abundant, for example, along the farm road in central Lot 32 where the nepheline has been altered to greenish grey gieseckite and pink hydronephelite. In several places the nepheline-hornblende-plagioclase gneiss has weathered to produce a granular detritus.

Nepheline-bearing skarn rocks occur in the woods and fields in the northern part of Lots 30 and 31. The skarn rocks are typically coarse-grained, with brown garnet (grossularite), clinopyroxene (partly altered to hornblende), scapolite, plagioclase, and nepheline (generally altered). These rocks appear to be the result of nephelinization of a skarn formed at the contact of gabbro and the limestone.

Theralite and theralitic canadite occur on the north

shore of Trooper Lake. They are very dark coloured rocks many displaying distinct laths of plagioclase and composed of nepheline, plagioclase, titanaugite and hornblende, with accessory apatite, magnetite and fayalitic olivine. Occasional rounded xenoliths of fine-grained, light-coloured ~~nepheline syenite~~ pyroxene - plagioclase rock can be seen. ~~in these rocks~~.

(8) Laronde Creek Nepheline Rocks; Lots 33 and 34, Concession III, Lots 34 and 35, Concession IV, Glamorgan Township, and Lots 2 and 3, Concession V, Monmouth Township:

Nepheline-bearing rocks occur sporadically in a narrow belt up to 3 chains in width extending eastward from a point 8 chains west of Laronde Creek toward the metagabbro ridge east of the creek, and continuing as a fringing belt along the north-western base of the ridge. Exposures are poor but this belt has been traded farther northeast and then easterly for more than 60 chains before swinging southward into the area described as locality 9. The band of nepheline rocks is bounded on the north by graphitic marble. To the west of Laronde Creek the rocks are overlain by biotite-syenite gneiss and east of Laronde Creek by graphitic marble. Farther east, on the Glamorgan Township boundary and in western Monmouth Township metagabbro lies directly on the nepheline rocks. Throughout most of their length the nepheline rocks dip south-easterly under the metagabbro at about 40 degrees, locally the dip is as high as 60 degrees and, at the northern end, 30 to 35 degrees.

The principal rock is a dark coloured nepheline-hornblende-plagioclase gneiss, sometimes containing biotite. Locally biotite predominates over hornblende. The nepheline commonly shows the characteristic blue-grey weathered surface, although both pink and white hydronephelite may be found. It is very irregularly distributed through the rocks, some bands containing only a few per cent, others as much as 60 to 70 per cent. These latter bands, however, are generally only a few inches thick. In the most spectacular, subhedral nepheline grains up to one-quarter inch in diameter are commonly grouped into aggregates up to several inches in length, with little mafic biotite or hornblende. Most of the nepheline, however, is finer grained and not so conspicuously aggregated.

At the old Pusey property several very interesting rocks are to be seen. On a low knoll beside a long abandoned logging road theralite and theralitic canadite are separated from the underlying limestones by a 2-3 foot thick layer of nepheline-oligoclase-biotite-(graphite)-(calcite) gneiss believed to represent nephelinized marble adjacent to an igneous intrusion.

Farther up the hillside to the east are several small pits in a magnetite-rich rock originally described by Adams and Barlow (1910 and by Foye (1916) as part of the Glamorgan gabbro. The rock is largely titanaugite and magnetite with minor hornblende, apatite, plagioclase and the green alteration product of nepheline commonly known as gieseckite. Field relations are obscured by very dense bush and the lack of continuous outcrop but the rock is believed to be related to the essexite known from dril-

ling to underlie the gabbro on Lot 2, Concession IV and Lot 3 Concession III, Monmouth, rather than the gabbro. It is discussed more fully on P.

(9) Nepheline Syenite; Lots 3 and 9, Concession IV and V, Monmouth Township:

Nepheline-bearing rocks of two major types comprise an elongate pear-shaped mass lying between the gabbro hills to the south and Laronde Creek and the Irondale River to the north. The western portion, about one-half mile in length, is an arcuate band 10 chains wide extending southeast from the nepheline-gneisses of locality 8 toward a small pond near the line between Lots 3 and 4. The larger, eastern, portion expands to a maximum width of about 30 chains before tapering out in Lot 9, Concession V. The total length is nearly two miles. The body dips southward under the gabbro at angles ranging from 20 to 60 degrees.

The underlying rocks in the western portion are graphitic and phlogopitic marbles. Toward the east, however, as the body approaches the Irondale River the relationships are less clear. About one-half mile upstream from the confluence of Laronde Creek outcrops on the river are of calcareous paragneiss cut by a red syenite. Farther east other outcrops on the river are of red syenite, and it seems probable that the body of nepheline rocks is here cut out by the syenite. For a mile eastward from the pond near the Lot 3 - Lot 4 line scattered outcrops of graphitic marble separate the nepheline rocks from the overlying gabbro mass.

The west and northwest of the pond no marble was seen, and the nepheline rocks are shown in contact with the gabbro. It is possible, however, that closer mapping would reveal marble continuously between the two bodies.

The arcuate band comprising the western portion of the nepheline rock mass is an igneous-textured, olivine-bearing nepheline syenite. The rock is poorly exposed and is not readily recognized in the field. Some specimens are very dark in colour, the nepheline does not always show the characteristic blue-grey weathering even though the pitted surface is often present. It is very easy in the poor light of the thick brush to mistake the rock for the very similar textured gabbro of Lots , Concession Glamorgan, especially since the outcrops are approached from the gabbro that lies to the south. The grain size is one-half to two mm. Tabular feldspars up to 2 cms. long are rudely foliated in the coarser grained varieties. The petrography is described more fully on p.

The major part of the nepheline-rock mass at this locality consists of nepheline-plagioclase gneisses containing both hornblende and biotite. In some the biotite predominates and in others hornblende. Some at least are believed to be the regionally metamorphosed equivalents of the igneous-textured rocks and one of these is discussed more fully on p. . The nepheline content of these, as of the other gneisses previously described, is highly variable. Some bands are nepheline-poor; in other bands nepheline is the predominant mineral, and some outcrops are cut by nepheline-plagioclase pegmatites with nepheline

individuals up to two inches across. These nepheline gneisses are on low wooded between the Irondale River and the gabbro hills to the south, and outcrops are scarce.

(10) Central Monmouth Nepheline Complex; Lots 10 to 16, Concession VI, Lots 10 to 19, Concession VII, Lots 10, 11, 12, 14, 15, 20 and 21, Concession VIII, and Lots 15 and 16, Concession IX, Monmouth Township:

This locality includes a variety of nepheline-bearing gneisses and nepheline pegmatites and cover an area having roughly the shape of the Greek Letter , inverted. The two "legs" diverge northward, and are underlain by the Tory Hill marble band, a coarse-grained phlogopitic, graphitic marble. To the south, and overlying the nepheline rocks, is a paragneiss complex, including some marble as the border rock in the mid-portion of the mass. Between these two bands of metasedimentary rocks the nepheline rocks are intimately associated with the central Monmouth syenite complex, along the southern border, is 3.5 miles; the greatest width, in Lot 15, is 1.75 miles. The two northward diverging "legs", and the two southern "arms", are each approximately one-quarter mile across. Within the syenite complex are isolated small bodies of nepheline-rock, considered to be remnants of a formerly continuous sheet of nepheline-rock.

(i) The Northwest "leg": Two main types of nepheline rocks are found in this area. The first of these is a rather massive rock consisting of nepheline, hornblende, garnet and calcite. The

hornblende has formed from pyroxene, and gieseckitic alteration of nepheline is common. Associated with these nepheline rocks are nepheline-hornblende-scapolite rocks. Both contain blocks of coarse silicated marble, consisting of hornblende, feldspar and calcite, with smaller amounts of biotite, garnet and, occasionally, gieseckite. These appear to represent a nephelinized skarn, but the origin of the skarn itself is not clear.

The second rock type in this area is the nepheline-bearing gneisses, ranging from dark to light in colour as the proportion of mafic minerals changes. Adams and Barlow (1910, pp. 269-278) describe three varieties in some detail, a dark rock containing abundant hornblende, together with nepheline, albite, and calcite; and two light rocks containing less hornblende and differing from each other in the relative proportions of nepheline and albite. The albite-poor variety was named "monmouthite". In reviewing these rocks in the field, however, biotite was found to be abundant in some outcrops, even exceeding hornblende in places and the three varieties of gneiss appear to be gradational into one another. Blue-grey-weathering nepheline is the commonest, but pink hydronephelite and the waxy white alteration are also found. The nepheline content of the different bands, ranges from less than 25 per cent in some of the darker gneisses, to more than 75 per cent in the lighter "monmouthite".

(ii) The Northeast "Leg": Here nepheline-bearing gneisses lie between the large area of phlogopite-graphite marbles to the west and northwest, and a syenite - quartz syenite - granite complex

to the east. The nepheline rocks range from a nepheline-poor biotite-albite gneiss containing sparsely disseminated nepheline, to a nepheline-biotite-albite gneiss with a nepheline content of about 10 per cent. The bordering syenite complex is a red biotite or hornblende syenite gneiss, grading into lighter quartz syenite which, in turn, locally grades into granite.

Exposures are excellent in the fields adjoining the old Hotspur road near the junction with the old Monck road. The syenite complex contains numerous patches of nepheline gneiss up to 50 or more feet in length. The cores of these gneiss masses show the typical blue-weathering nepheline, but toward the border pink hydronephelite appears and the nepheline gneiss passes into the red syenite. Similar changes to the peristerite syenite may be seen along fractures in the nepheline gneiss patches. Dikes of red syenite cut both the nepheline gneiss and the peristerite syenite. The whole aspect of the terrain strongly suggests invasion of nepheline gneisses by the syenite-granite complex. The nepheline gneiss patches are xenoliths at the borders of which the nepheline has been converted to peristerite. Farther into the syenite-granite complex xenoliths up to several feet in length of biotite and hornblende paragneiss and black amphibolite are found.

This interpretation differs markedly from that of Adams and Barlow who regarded the occurrence as a stage in the development of nepheline syenite from granite, and is discussed more fully on p.

Satterly (1943, p. 16) also has briefly described this replacement relationship, both at this locality and at locality 11 (Otter (now Esson) Creek).

(iii) The Southern "Arms": Nepheline gneisses are the chief rock type found in this portion of the locality. For the most part they are nepheline-hornblende-albite gneisses, characterized by extreme variability in nepheline content. Their general aspect is very similar to the occurrences described in the northwest "leg" - some of the rocks being strongly reminiscent of the type "monmouthite". The gneissic structure is less obvious in some outcrops where the rock appears to be much more massive. The rocks not only range from nepheline-poor varieties, but they also show considerable variability in grain size, from less than 1 mm to more than 5 mm., within a few inches across the strike. Under the microscope relicts of pyroxene may be seen, most of the mineral having been altered to hornblende.

Nepheline pegmatite occurs in the westernmost part of the southern "arm" and is exposed by test pits and trenches. Nepheline masses up to 3 feet across are characterized by a well-defined columnar or prismatic structure, the closely packed nepheline prisms being separated by thin films of biotite. The colour of the fresh nepheline varies from white to dark grey, even within a single crystal. The rock is a nepheline-albite pegmatite in which the nepheline content ranges from 10 to 50 per cent. In addition to the major minerals Satterly (1943, p. 75, 76) records "minor amounts of carbonate, yellow cancrinite, and sodalite" from 1 to 2 inches in diameter, a little green apatite, and, rarely, zircon". The apatite prisms up to 2-1/2 inches long are intergrown with the nepheline. The yellow cancrinite occurs as masses up to 2-1/2 inches across, sometimes surrounding carbonate grains. Additional minerals noted include pyrrhotite, graphite,

and a brown-weathering carbonate.

The dimensions of the pegmatite are unknown but 20 chains southeast on the Irondale River a nepheline-albite pegmatite is exposed. Although very coarse grained (6 inches to 2 feet) the nepheline is altered to greenish-brown gieseckite.

(11) Eastern Monmouth Nepheline Rocks; Lots 18 to 23, Concession X, Lots 21 to 24, Concession XI, Lots 24 to 26, Concession XIII, and Lots 26 to 29, Concession XIII, Monmouth Township:

The nepheline rocks at this locality appear to represent what is essentially the continuation to the northeast of the association that characterizes the northeast "leg" at locality 10. Nepheline gneisses and more massive nepheline-biotite-albite rocks form an almost continuous belt about 3-1/2 miles in length, and ranging from one-quarter to one-half mile in width, generally averaging about 30 chains throughout most of the length. The belt bifurcates to the southwest at a point about one mile east of Tory Hill, the northern branch being traced in the hills south of the village and the southern branch (with an outlier) trending to the south of Lorraine Lake. Throughout most of its length the gneissic structure in this belt, as in that of locality 10, dips southward to eastward although local reversals have been noted. The nepheline rocks are bounded on the north by the band of graphitic and phlogopite marbles noted to the north at locality 10. On the south they are separated from the elongate belt described as locality 12 by the syenite-granite complex continuous with that of locality 10. The outlier mentioned above is completely enclosed by the syenite body.

The nepheline rocks at this locality are nearly all markedly gneissic, although more massive varieties have been found. The road cuts on Highway 500 at Esson (formerly Otter) Creek one and one-quarter miles east of Tory Hill offer excellent exposures. At this point a prominent north-south trending ridge has been cut through, exposing a complex of nepheline-biotite-feldspar-magnetite rock and red biotite syenite. Both rocks are very coarse grained and range from gneissic to massive. Features of the rock in this occurrence are the abundant magnetite and the presence of alkali feldspar as albite microcline and perthite. Near the contacts with the syenite and along veins leading to the syenite, nepheline has been extensively altered to pink hydronephelite or to green gieseckite, imparting to the otherwise light grey rock a strong reddish or greensih cast. It appears to be a sill of nepheline syenite now regionally metamorphosed. Patches of silicated marble seen in the road cut represent xenoliths of the original country rock. The nepheline content of the rock here, as elsewhere, is highly variable, but seldom exceeds 40 to 50 per cent even over a few inches.

Other than in the Esson Creek occurrence most of the nepheline rock in this locality is a light- to dark-grey nepheline-biotite-albite gneiss strongly resembling that of locality 10 near the Hotspur road. It is intimately associated with later biotite syenites and biotite granite, the relationship being readily seen along the old Essonville road about one-half mile east of the old railroad right-of-way southwest of Wilberforce. Again the nepheline content of the gneisses is extremely variable, narrow patches up to

a few inches in length are nearly all nepheline, but in general the nepheline is sparsely disseminated.

The general aspect of the nepheline rocks at this locality is one of extensive assimilation of nepheline rocks by a syenite-granite complex.

(12) Nepheline Gneiss; Lot 25, Concession X, Lots 25 to 27, Concession XI, Lots 27 to 29, Concession XII, and Lots 29 to 30, Concession XIII, Monmouth Township:

A band of nepheline-biotite-feldspar gneiss averaging 5 chains in width extends northeastward for two miles from its southernmost appearance in a road cut on Highway 500 about one-quarter mile east of Esson Creek. Throughout most of its length the belt of nepheline gneiss is bordered on the northwest by granites of the syenite-granite complex. To the southeast the bordering rocks are paragneisses of the main band of these rocks extending through Monmouth Township. At the north end isolated patches of nepheline rock are completely enclosed with the granite. At the south end the road cuts on Highway 500 disclose a complex of dark silicated marble, nepheline rock, and syenite, much of the nepheline having been converted to green gieseckite. While biotite is elsewhere the common mafic mineral, at this latter occurrence hornblende is dominant. Albite appears in a microcline microperthite as well as in separate grains.

The southeasterly dip of the nepheline gneisses, together with their mineralogical similarity to those of locality 11

suggest that this belt may represent the hanging wall portion of a formerly continuous broader band of nepheline rocks intruded by the syenite-granite complex.

(13) Rare Earth Nepheline Gneiss; Lots 19 and 20, Concession VI, Lots 20 to 22, Concession VII, Monmouth Township:

A northeast-trending belt of nepheline gneisses, from 2 to 5 chains wide, extends for a length of 3 miles about one-half mile southeast of the southern "arm" of locality 10. The belt lies on the property of Rare Earth Mining Corporation of Canada, Limited, and is readily accessible, near its north end, on the mine road about 15 chains southeast of the northernmost shaft.

Throughout most of their length, the nepheline rocks dip 35 to 40 degrees southeast. They lie within the broad band of paragneisses cut by hornblende syenite and granite pegmatite masses. At the southern end, however, they are cut off by a body of hronblende syenite.

The nepheline rocks are predominantly nepheline-hornblende-feldspar gneisses, in some of which there is considerable biotite. The nepheline content of these, as of other nepheline gneisses, is variable.

(14) MacKay Nepheline Pegmatite; Lot 14, Concession VI, Monmouth Township:

Nepheline pegmatite masses within a broad area of paragneisses have been exposed in two surface strippings. The northern exposure measures about 400 to 250 feet, and the southern exposure about 230 feet in diameter. The two are 10 chains apart.

The northern body is a biotite-poor nepheline-albite pegmatite, the nepheline content ranging from 10 to 50 per cent. Satterly (1943, p. 76) estimates that "the best material would average 40 per cent nepheline". The biotite occurs in masses up to 10 inches across, and comprises up to 5 per cent of the rock. In addition to the zircon noted by Satterly, deep blue sodalite, green apatite in slender prisms up to inches long, and black tourmaline have been found.

The southern exposures are of a similar rock in which nepheline individuals range from 2 inches to 3 feet across, some of it having the columnar structure noted in the pegmatite described under locality 10. The plagioclase is a potassic oligoclase (Or_{15} Ab_{77} An_8). In addition to the sodalite, tourmaline, and green apatite noted by Satterly, zircon and brown-weathering carbonate have been observed.

About one-half mile to the northeast of the north showing, outcrops of biotite-nepheline-plagioclase gneiss are exposed at the western end of a sharp, narrow ridge. The nepheline gneiss forms a folded structure plunging to the southwest. Outcrops of silicated marble indicate that the nepheline gneiss lies within a marble unit of the predominantly paragneiss sequence.

Both members are cut by hornblende syenite and by minor granite pegmatite. The total length of nepheline rock exposed in the fold is about 10 chains; its width is about 50 feet.

About one-quarter mile south of the south showing there is an occurrence of nepheline rock at the Irondale River. The occurrence includes hornblende-nepheline gneiss, biotite-nepheline gneiss and nepheline pegmatite, together with some scapolitic varieties. Diamond drill core from drilling done during the winter of 1955-56 indicates the presence of a body of grey nepheline-biotite (and/or hornblende)-plagioclase gneisses of unknown dimensions (the core having been scattered). Marble in outcrops along the river and in pieces of core, suggests that this is the major country rock. The cover of sands and gravels in the river valley, however, obscures the relationships. The nepheline pegmatite is a very coarse-grained nepheline-albite rock containing abundant hornblende. It is, therefore, quite unlike the MacKay bodies.

(15) Nepheline gneiss and nephelinized skarns; Lot 3, Concession III, Monmouth Township:

A small exposure of nepheline gneiss flanked by marble and metagabbro occurs on the southern side of the large Glamorgan-Monmouth metagabbro mass. It was described by Adams and Barlow (1910, p. 282) and at the time it was on an important lumber road. This same road still provides access on foot or perhaps by jeep at most times of the year and leads to a driveable road from Gooderham.

The outcrops occur along a ridge about thirty feet high which is bounded on three sides by low swampy ground. Marble outcrops on the west side of the ridge and is overlain by a belt of nepheline gneiss approximately 800 feet long and 80 feet in outcrop width. Both nepheline gneiss and marble strike northerly and the prominently exposed contact between the two dips easterly at 40°-60°. The nepheline gneiss is well foliated near its contact with the marble but becomes progressively more massive toward the east until it is succeeded by metamorphosed essexite. This is followed eastward by a 300-foot-wide zone of garnet-epidote metapyroxenite, which is in turn followed by metagabbro. The undulant, fluted contact between marble and nepheline gneiss is well exposed on the west-facing slope of the ridge, but all other contacts are gradational.

The entire sequence is interpreted as the east limb of an anticline that exposes the base of the Glamorgan-Monmouth metagabbro mass.

The different varieties of nepheline rocks are described more completely on pp. 85-92 in a discussion of nephelinization. They are essentially biotite-garnet nepheline gneiss and hornblende-garnet nepheline gneiss. The latter is a patchy rock containing clots of hornblende and garnet. At the junction with marble the characteristic rock is a completely altered leucocratic variety in which nepheline has been completely replaced by the waxy-white alteration product. Farther north along the ridge the hornblende-garnet nepheline gneiss gives way to skarn which occurs

as recognizable xenoliths in a more nepheline rich rock and occasionally as xenoliths in marble. The entire sequence is considered to be a nephelinized skarn. On the west slope of the ridge a cliff about 15 feet high exposes nepheline-titanaugite pegmatite. The nepheline gneisses are succeeded to the east by a more massive essexite. In outcrop it is a coarse-grained rock with knobs of titanaugite standing out on the weathered surface. This is followed to the east by metapyroxenite and metagabbro which are described on pp.

(16) Hadlington Lake Nepheline Gneiss; Lot 10, Concession II, Lots 10 to 14, Concession III, Monmouth Township:

The southern belt of syenitic gneisses at Hadlington Lake has been referred to in the introduction to this section. The occurrence is described by Adams and Barlow (1910, p. 280) to whom the lake was known as Pine Lake. On the east shore of the outlet bay (on the north side of the lake) very fine-grained paragneisses, strike N. 20 degrees E, and dip steeply east. Directly overlying these paragneisses is an 80-foot band of coarse grey hornblende syenite, which comes out to the shore near the tip of the point. Disseminated throughout most of the rock is nepheline, some of it blue-grey-weathering variety is concentrated in the lower (western) half of the band. In addition to the disseminated nepheline there are also threads and stringers of pale transparent pink nepheline, most of which are not more than

a few inches wide, and a foot or so in length. The disseminated nepheline is more highly concentrated near these stringers, but in general the nepheline content of the rock is less than 10 per cent. The nepheline-bearing rock is strongly gneissic, striking at about N. 10 degrees E., and dipping eastward at 60 degrees or more. While most of it is hornblendic, there are also some biotite-rich bands. Magnetite is scattered through the band, but appears to be relatively concentrated in the footwall portion. In thin section the hornblende is a very dark green hastingsite. It is accompanied by grains of a similar coloured pyroxene. Albite, microcline, and microperthite are all present, with albite predominant. The nepheline gneiss band is overlain by biotite-rich and hornblende-rich paragneisses. It has been traced northward a little more than one-half mile from the shore.

On the south shore of the lake, on strike with the north shore exposures, are further outcrops of similar rocks, although no nepheline was found as stringers. In addition to the grey type found on the north shore, there is also a dark, distinctly gneissic rock, containing lenticular clots of altered (pink and green) nepheline up to one inch in length. The rocks to the east are paragneisses, as on the north shore, but to the west the rocks are fine-grained massive gabbro containing titanaugite.

Along strike the band of syenitic gneisses curves gradually westward. Nepheline-poor masses were observed almost continuously for three-quarters of a mile southwest from the south shore. About one mile from the shore the syenite gneiss band

bifurcates. The more easterly band, trending N. 30 degrees E., is composed of yellow and dark red hornblende syenite gneiss, and contains no nepheline. The more westerly band, trending N. 50 degrees E., is grey, buff, or pink biotite syenite gneiss. At a point near the west boundary of Monmouth Township, about 170 chains southwest of the nepheline occurrence at the south shore of Hadlington Lake, it contains a small area of nepheline-biotite-feldspar gneiss. The nepheline is altered to pink hydronephelite or a chalky white mineral, no blue-grey-weathering nepheline being seen. It comprises less than 20 per cent of the rock. Albite and microperthite are the chief feldspars present, the former predominating. Magnetite is a noteworthy accessory, being found not only in the nepheline gneiss at this point, but also throughout most of the biotite syenite gneiss band.

Both the hornblende syenite gneiss and the biotite syenite gneiss lie within the paragneiss sequence, all members of which are cut by numerous granite pegmatite bodies.

PETROLOGY

The origin of the alkaline rocks seems always to have been involved in controversy. In the early part of the present century an igneous origin was not disputed but the manner in which the alkaline magma was generated was highly contentious. Essentially the argument was between straightforward magmatic differentiation and differentiation consequent upon the assimilation of limestone. In both of these views the Haliburton-Bancroft

district and Glamorgan-Monmouth in particular figured prominently. Commencing in the 1940's the controversy became even more complex with the proposal that the nepheline-bearing rocks in this region at least are not igneous rocks at all but the result of metasomatic alteration of metasedimentary rocks by a process known as nephelinization.

The present survey, and the studies which have followed from it, have enabled the igneous versus metasomatic controversy to be clarified, have established the presence of nepheline-bearing rock types not previously known in the area, and enabled an outline to be given of the chemical changes involved in nephelinization.

An adequate solution to the controversy has been complicated in the past by inadequate knowledge of the detailed field relations, by a failure to recognize that the nepheline gneisses are metamorphic rocks, and by a failure to appreciate that they have been extensively intruded and assimilated by granitic magma and of course the failure to find the truly igneous rocks described in this report.

It was not until the careful re-mapping by Hewitt between 1950 and 1957 along the extent of the nepheline belt that these problems began to be alleviated. The Brudenell-Raglan report (Hewitt, 1954) clearly stated the metamorphic character and the subsequent granitic intrusion.

Because of the role that Glamorgan and Monmouth Townships have played in resolving the problems of the nepheline rocks

a brief outline is given of the controversy as it pertains to this area.

The discussion really begins with Adams and Barlow in 1910; it is sometimes said that they believed in limestone syntexis as the major factor but in fairness this misinterpretation ought to be corrected. Possibly the following passages contributed to the misunderstanding:

> "The nepheline and associated alkali syenites are found either along the actual contact of the granite and the limestone or in the limestone itself near the granite contact." (Adams and Barlow, 1910, p. 277).
>
> "The nepheline syenite occurs almost invariably along the border of the granite intrusions where these are intruded into the limestone." (Adams and Barlow, 1910, p. 332).

It is, of course, possible that they had begun to incline in the direction of limestone assimilation since the last page of their memoir states:

> "The origin of the nepheline syenite-----is ----- in some way connected with the granite intrusions. It is a differentiation phase, or a product of the magma in question, and is almost invariably associated with limestones, which are in some way genetically connected with it." (Adams and Barlow, 1910, p. 408).

There can be no doubt, however, that they looked upon the nepheline rocks primarily as a differentiation product of granitic magma:

> "A careful study of the area shows that the nepheline syenite and its associated alkali syenites represent a peripheral differentiation phase of the granite (fundamental gneiss)----- -----". (Adams and Barlow, 1910, p. 228).

The idea that the nepheline rocks generally occur between limestone and granitic intrusives has been widely quoted and was used extensively by Daly and Shand in championing their case for an origin by limestone assimilation. It is, however, not strictly true that the nepheline rocks lie adjacent to limestone as can be seen from Hewitt's maps of the remainder of the Haliburton-Bancroft area, the frequent association with granite has a different explanation entirely as will be seen later.

Adams and Barlow failed to recognize the regionally metamorphosed character of most of the nepheline rocks and the fact that the granite which they considered parental to the feldspathoidal magma is really intrusive into them. They recognized four divisions of their differentiated magma: nepheline syenite, urtites and ijolites, white alkali syenite, and red alkali syenite, failing to recognize that the white alkali syenite is a metasomatic rock produced during the intrusion of the red syenite and granite. Although they realized that in places the red syenite had cut other types they clearly considered them derived from the same magma and there is nothing to suggest that they believed them separated by any appreciable interval of time.

> "Although there is usually a more or less definite line of separation between the red and gray types of syenite the general relations of the two rocks offer much presumptive evidence for considering them as differentiated forms of the same magma, the red being the later in crystallization". (Adams and Barlow, 1910, p. 317).

Their views on the field relations of granite and nepheline syenite are summarized in a discussion of Lot 15, Con. VIII, Monmouth Township.

> "This granite-syenite fades away into the nepheline syenite on either side. This takes place by the disappearance of the quartz, if any be present, with the concomittant increase of the soda feldspars, and the increase of the proportion of the iron-magnesia constituents present. A little nepheline also appears in most cases. An albitic phase of the nepheline syenite thus results. (Adams and Barlow, 1910, p. 260).
>
> "The transition between a syenitic phase of the granite mass and the nepheline syenite is well seen at the southern end of Lot 15, Con. VIII, Monmouth. The nepheline syenite here has a schlieren structure caused by the variation in the relative amounts of the constituent minerals in different streaks. Some of these schlieren consist of the red syenite, and others are intermediate in character between the red syenite and the nepheline syenite. There is thus represented in these schlieren a complete transition from the red syenite to the normal white or gray nepheline syenite". (Adams and Barlow, 1910, p. 261).

Such a theory is untenable because it is a misinterpretation of the field evidence. The character of Lot 15, Con. VIII, Monmouth, has changed very little in the past seventy years and the same outcrops can be examined. A re-examination lends no support to the Adams and Barlow interpretation. The nepheline-bearing rocks have been intruded, feldspathized and assimilated by a granite-syenite magma. Xenoliths of nepheline gneiss varying in size from a few feet to more than fifty feet are surrounded by gray-weathering, white to pink, peristerite syenite. The cores may be strongly gneissic with fresh nepheline while toward the margin

the surface remains pitted but fresh nepheline gives way to pink hydronephelite and finally the rock passes into a homogeneous, massive syenite. This alteration can be traced as a zone a few inches to a few feet wide on each side of a joint or other fracture. The foliation in these xenoliths is essentially parallel to the regional strike of the nepheline gneisses, suggesting that the syenitization began as a quiet metasomatic process without undue disruption. Still closer to the main granite mass dikes of red granite and quartz syenite cut both the hybrid syenite and the nepheline gneiss xenoliths. Ptygmatically folded veins pass from the dikes into the surrounding rock. The "sclieren" of Adams and Barlow are really well-defined dikes.

The roughly elliptical belt of nepheline gneiss surrounding a body of pegmatitic granite is not as complete as it is shown on the 1910 map. It appears that a broad belt of nepheline rocks existed across the central part of Monmouth Township and this has been intruded by a body of granite magma. Fractures extending outward from the rising magma have allowed fluids to penetrate the nepheline gneiss and partly alter it to a hybrid, peristerite syenite. Some of this hybrid syenite was then assimilated by the advancing granite magma.

Lot 15, Con. VIII, Monmouth represents not an arrested stage in the development of nepheline rocks from granite but rather an arrested state in the destruction of nepheline rocks by granite.

In summary, then, Adams and Barlow interpreted the nephe-

line-bearing rocks as igneous rocks that had crystallized from a magma derived from granite magma by differentiation at the margins of the body. No clear process is implied by the term "differentiation" since the idea of fractional crystallization or crystallization differentiation after the manner enunciated by Bowen had not yet evolved. They failed to recognize that granite has intruded and assimilated nepheline rocks on a wide scale, and tended to exaggerate the spatial association with limestone.

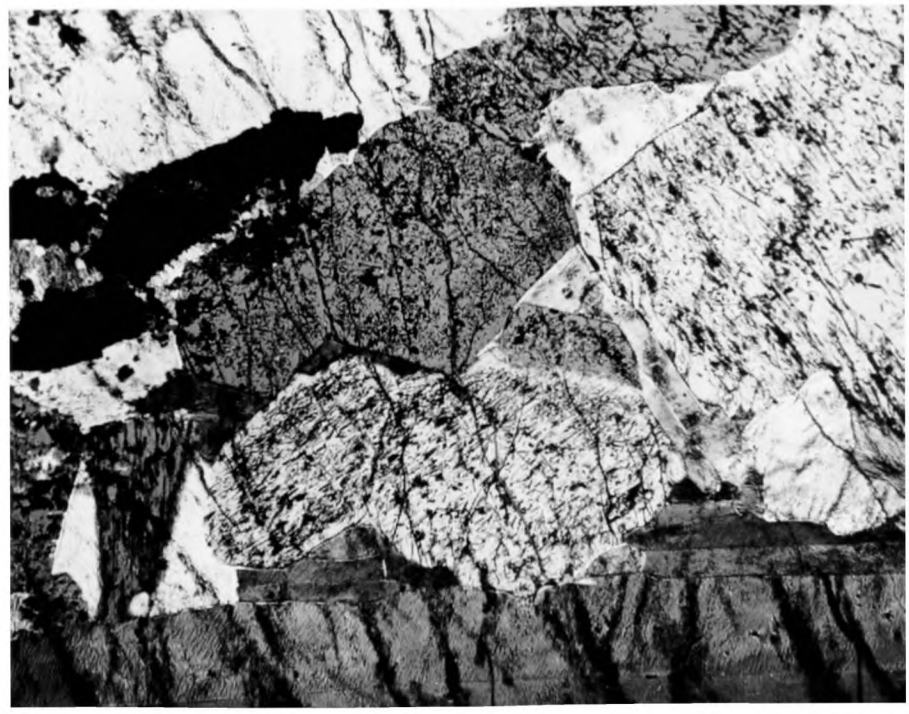
The term nephelinization was introduced independently by Gummer and Burr (1943) and von Eckermann (1942) but in rather different senses. von Eckermann was concerned with the generation of nepheline rocks from granitic rocks in a metasomatic aureole surrounding a carbonatite plug, whereas Gummer and Burr were concerned with the transformation of a series of sedimentary rocks into nepheline gneisses on an essentially regional scale. Gummer and Burr expanded their views were extended into a full statement in 1946 which can be summarized in this extract:

> ."--------the nephelinization hypothesis calls for the addition of material in liquid form (or volatile or both) to solid strata in situ, without the actual formation of a separate feldspathoidal magma or magmas".

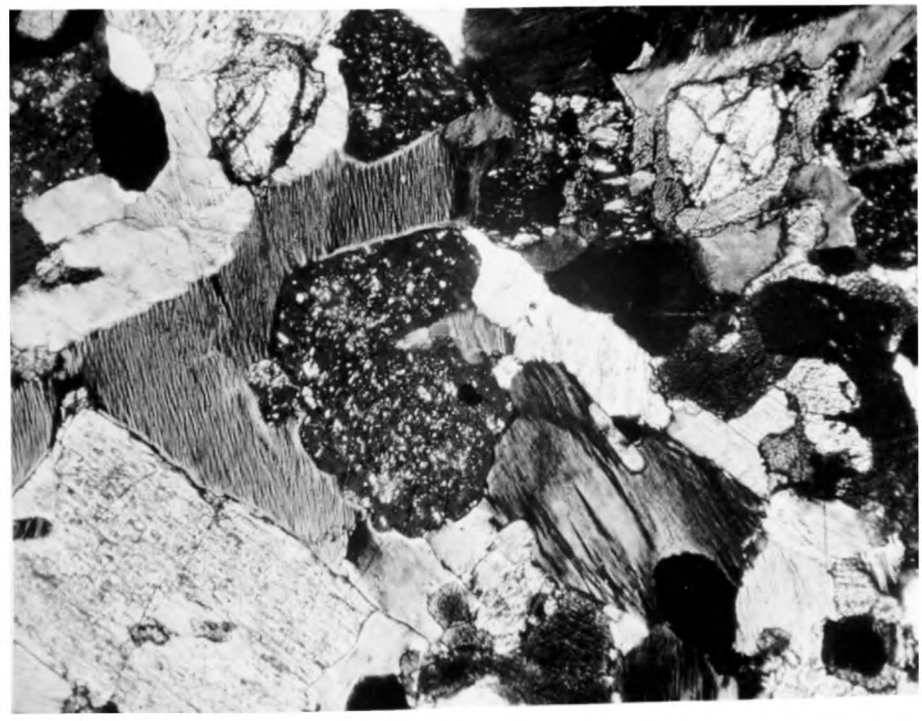
Gummer and Burr's work was based on extensive mapping of the nepheline rocks, particularly in the York River district. Between 1943 and 1946 three reports of the Ontario Department of Mines were published (Satterly 1943, 1944; Thomson 1943) in which the

authors, largely on field evidence, reached essentially similar conclusions. Whereas Gummer and Burr had left the source of the nephelinizing solutions unknown (although expressing a preference for a granitic source) Moyd (1949) derived them from granitic magma and postulated the reactions involved. In 1951 Derry extended the idea of nephelinization and argued that the large body of fairly massive nepheline syenite at Blue Mountains had also arisen by replacement of essentially arkosic sediments. Friedlander in 1952 concluded replacement of limestone and paragneiss, Phipps in 1955 agreed in principle with Derry, and Derry and Phipps restated their views in shortened form in 1957. Baragar (1953) and Tilley (1958) both gave detailed mineralogical descriptions of the sequence of nepheline gneisses at York River, and Tilley gave the first discussion of the nephelinization process from a quantitative point of view with the aid of several analyses, at the same time mentioning the presence of igneous rocks in Glamorgan and Monmouth Townships and deriving the nephelinizing solutions from the attendant nepheline magma. The chemistry of the nephelinization process was the subject of a detailed study by Gittins (1961).

During the course of the present survey a group of igneous-textured nepheline rocks was discovered that includes types not previously recognized in the Haliburton-Bancroft area. They are theralites, theralitic canadites and nepheline syenites (sensu stricto) and are interpreted as relicts of igneous rocks that elsewhere have been converted into metamorphic gneisses.



Hypersolvus (one-feldspar) nepheline syenite (C82460). Note the long lath of alkali feldspar and two euhedral grains of nepheline which are full of acicular needles of pyroxene 24X crossed nicols.



Hypersolvus nepheline syenite (C82464) 60X crossed nicols.

They establish beyond doubt that at least some of the nepheline rocks in this area are genuine igneous rocks and provide, in the form a feldspathoidal magma, a likely source for the metasomatic fluids which in other parts of the area appear to have developed nepheline rocks by nephelinization.

Petrography of the igneous suite

Nepheline syenite

Field relations can not be determined because of the poor exposure but there is a rapid alternation in outcrop between fine-grained and coarse-grained varieties which give the appearance of having intruded each other while one was still only partly consolidated. In this respect they resemble the igneous-textured gabbros of the Gooderham Lobe (p.26). The rocks are mesocratic to melanocratic (colour index 20-40) with a grain size of ½ - 2 mm and tabular feldsp rs 1 - 3 cms across. There is a rude foliation due to alignment of feldspar tablets in the coarse-grained variety (Fig. 11) but not in the fine-grained. An average mode (in wt. %) is approximately alkali feldspar 55, nepheline 24, clinopyroxene 16, magnetite 4, olivine 1. Analyses of two of these nepheline syenites are given in Table XVI. The alkali feldspar is a fine microperthite with Carlsbad twinning (Fig. 12) often showing a very narrow rim of albite that is continuous with the albite component of perthite. Analyses of two feldspars are given in Table XVII and can be expressed as $Or_{48.4}$ $Ab_{49.1}$ $An_{2.5}$ and $Or_{44.9}$ $Ab_{54.0}$ $An_{1.1}$. X-ray study confirms that

TABLE XVI

	1	2
SiO_2	52.23	51.72
TiO_2	0.42	0.32
Al_2O_3	19.50	19.38
Fe_2O_3	4.44	4.22
FeO	5.78	6.70
MnO	0.21	0.17
MgO	0.20	0.45
CaO	3.52	3.45
Na_2O	7.59	7.06
K_2O	5.41	5.17
H_2O+	0.57	0.75
H_2O-	0.03	0.06
P_2O_5	0.14	0.16
CO_2	0.12	0.03
C	0.19	
	100.35	99.64

1. Nepheline syenite with clinopyroxene (C65270), coarse-grained type; lot 4, Con IV, Monmouth Township. Analyst: J.H. Scoon.

2. Nepheline syenite with clinopyroxene (C82464), fine-grained type; lot 4, Con. IV, Monmouth Township, Analyst: J. Gittins.

TABLE XVII

	1	2
SiO_2	65.38	65.72
TiO_2	nil	nil
Al_2O_3	19.73	19.65
Fe_2O_3 / FeO	0.08	0.14
MnO	nil	nil
MgO	0.08	nil
CaO	0.49	0.36
Na_2O	5.77	5.60
K_2O	8.16	8.33
H_2O+	0.28*	0.29*
H_2O-	0.03	nil
	100.00	100.09

* loss on ignition

1. Microperthite from nepheline syenite C65270: Analyst: J.H. Scoon.

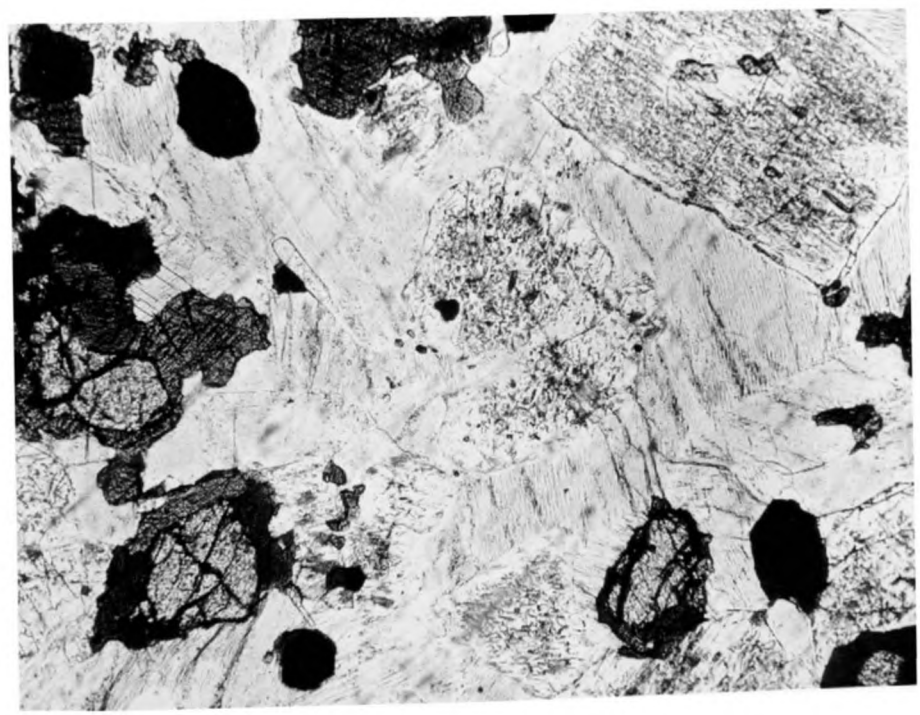
2. Microperthite from nepheline syenite C82464: Analyst: J. Gittins.

they are orthoclase low albite microperthites. The feldspars have undoubtedly unmixed from an originally homogeneous alkali feldspar and the presence of orthoclase contrasts with the potash feldspar of the metamorphosed nepheline rocks which is always microcline.

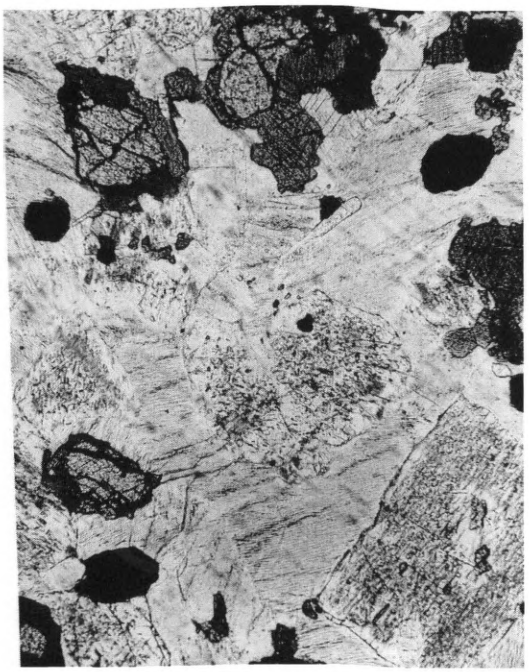
The subidiomorphic nepheline has a considerable range in grain size; it is usually fresh but it is characterized by an abundance of acicular inclusions of pale green clinopyroxene, sometimes amounting to 15% by weight (Figs. 13, 14). A dominant set is perpendicular to the c-axis in optic axis sections. Analyses of two nephelines are given in Table XVIII. Clinopyroxene is sodic hedenbergite to sodic ferroaugite, pleochroic from yellow green to deep grass green and unzoned. An analysis is given in Table XIX. Most of the grains contain hair-like inclusions of magnetite (identified by x-ray study) and in some grains they are sufficiently abundant as to make the pyroxene almost opaque. Olivine is a pale straw brown fayalite-rich (approx. Fa_{65}) type and always has a reaction rim of clinopyroxene (Fig. 13). Many pyroxene grains have a rim of oligoclase followed by a rim of hastingsite amphibole. Generally this corona is developed against nepheline but not against feldspar (Figs. 15, 16). It is interpreted as a metamorphic feature and is discussed later.

The rocks are typical hypersolvus assemblages or one-feldspar nepheline syenites as defined by Tuttle and Bowen (1958) indicating a magmatic origin. Furthermore the compositions of the nepheline lying on the sodic side of the Morozewiz-Buerger convergence field give further confirmation that these are magmatic

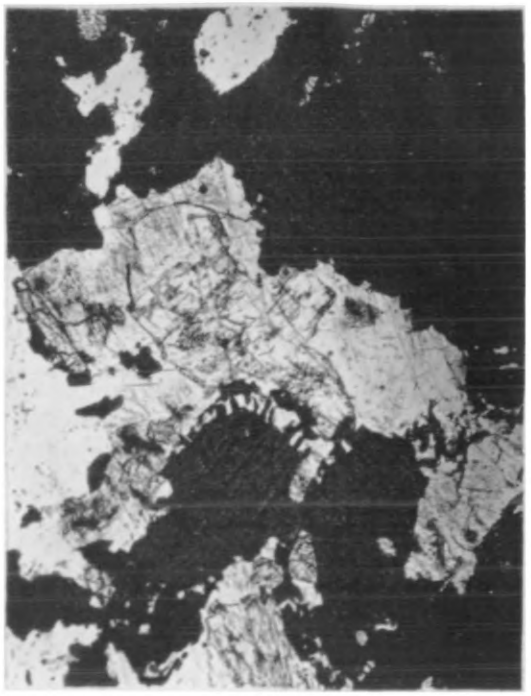
Hypersolvus nepheline syenite. Olivine is rimmed by clinopyroxene 60X plane polarized.



Oriented needles of clinopyroxene in nepheline from hypersolvus nepheline syenite 30X plane polarized.



Theralite showing extensive metamorphic development of hornblende-plagioclase coronas between nepheline and pyroxene. 10X plane polarized.



Theralite showing composite corona between pyroxene and nepheline consisting of an inner zone of amphibole and an outer rim of sodic amphibole separated by plagioclase. Note that the reaction occurs only between pyroxene and nepheline and never not between pyroxene and feldspar. Several euhedral grains of apatite can be seen 25X plane polarized.

TABLE XVIII

SiO_2	43.61	43.35
TiO_2	nil	nil
Al_2O_3	33.05	33.03
Fe_2O_3 FeO	0.85	1.12
MnO	0.01	nil
MgO	0.05	0.11
CaO	0.53	0.71
Na_2O	16.09	16.15
K_2O	4.92	5.38
H_2O+	0.70	0.60
H_2O-	0.01	0.03
	99.82	100.48

1. Nepheline from nepheline syenite C65270. Analyst: J.H. Scoon.

2. Nepheline from nepheline syenite C82464. Analyst: J. Gittins.

TABLE XIX

SiO_2	46.83
TiO_2	0.52
Al_2O_3	2.65
Fe_2O_3	5.88
FeO	21.02
MnO	0.84
MgO	1.57
CaO	18.87
Na_2O	1.86
K_2O	0.05
H_2O+	nil
H_2O-	nil
	100.09

Clinopyroxene (sodic hedenbergite) from nepheline syenite C65270. Analyst: J.H. Scoon.

assemblages.

These rocks and several related types from other parts of the world were the object of a special study by Tilley and Gittins (1961) and in that paper the typically magmatic feldspar-nepheline tie lines of these rocks may be compared.

The compositions of the hypersolvus nepheline syenites plot very close to the ternary minimum in the system $NaAlSi_3O_8$ - $KAlSi_3O_8$ - SiO_2 and supply additional evidence of their magmatic origin.

Theralite and theralitic canadite

These rocks are exposed on the north shore of Trooper Lake, and in the fields and woods to the north of the lake as well as on the eastern border of the township where not all the outcrops are very accurately located in the dense bush.

The rocks are darker in colour than the nepheline syenites and contain more pyroxene and magnetite. Analyses of five theralitic rocks are given in Table XX. Feldspar is dominantly plagioclase (oligoclase-andesine) with rare microperthitic alkali feldspar which occasionally forms patches within the plagioclase. Plagioclase is not always twinned and is not in such distinct plates as the alkali feldspar of the nepheline syenite; it is always darkened by fine dusty inclusions. A number of plagioclase grains contain minute globules of nepheline which are too small to identify without staining. Several plagioclase grains contain the same minute inclusions of pyroxene that are found in the

TABLE XX

	1	2	3	4	5
SiO_2	41.79	42.40	42.66	41.66	37.40
TiO_2	1.48	0.95	1.25	1.02	1.56
Al_2O_3	18.07	18.48	22.00	18.63	21.19
Fe_2O_3	3.94	5.31	4.45	7.51	7.22
FeO	13.54	12.94	9.16	9.86	10.95
MnO	0.24	0.41	0.18	0.23	0.17
MgO	1.19	0.98	1.60	1.74	2.50
CaO	9.84	6.43	8.05	9.79	11.31
Na_2O	6.61	7.79	6.87	5.84	4.68
K_2O	1.93	1.62	1.60	1.51	1.16
P_2O_5	0.34	0.51	0.39	0.35	0.18
CO_2	0.15	0.44	0.18	0.12	0.04
H_2O+	1.16	1.35	1.42	1.38	1.51
H_2O-	0.14	0.10	0.09	0.58	0.02
	100.42	99.71	99.90	100.22	99.89

1. Theralitic Canadite (C64870) } From the fields west of the road to Mintz.
2. Theralitic Canadite (C64872) } Farm, Lots. 31 and 32, Con. III, Glamorgan Township.
3. Theralitic Canadite (C82505) Lot 35, Con. III, Glamorgan Township.
4. Theralitic Canadite (C82471) Lot 30, Con. IV, Glamorgan Township.
5. Theralitic Canadite (C82508) Lot 35, Con. III, Glamorgan Township.

Analyst 1, 2: J.H. Scoon; 3,4,5: J. Gittins

nepheline of both nepheline syenites and the theralites and theralitic canadites.

In addition to the acicular pyroxene needles the coarse nepheline grains contain rounded blebs of pyroxene and some hold acicular amphibole inclusions. Analyses of two nephelines are given in Table XXI.

Clinopyroxene is a paler green than in the nepheline syenites and frequently has a pink pleochroic titaniferous core. It is distinguished from the pyroxene of the nepheline syenite by lower lime and distinctly higher alumina. Two analyses are given in Table XXII. Minute rod-like magnetite inclusions are common. Fayalitic olivine is also present.

Apatite and titaniferous magnetite (with exsolved ilmenite) are accessories; the two latter are occasionally concentrated into magnetite-apatite patches.

Hornblende occurs as coronas around pyroxene and as separate distinct grains. Some varieties have distinctly more hornblende than pyroxene and a few types are essentially hornblende-nepheline rocks with subordinate albite; these are probably metamorphic derivatives.

Essexite

The rock is known only from a diamond drill core obtained from a hole drilled on Lot 2, Con. IV, Monmouth Township and from outcrops on Lot 3, Con. III, Monmouth Township. The core indicates that the gabbro here is about 430 feet thick and is underlain by crystalline limestone. About 70 feet below the base of the gabbro

TABLE XXI

	1	2
SiO_2	44.40	42.39
TiO_2	nil	
Al_2O_3	33.14	34.00
Fe_2O_3 FeO	0.18	1.28
MnO	0.01	nil
MgO	0.05	0.08
CaO	0.36	1.15
Na_2O	17.17	15.63
K_2O	3.72	4.36
H_2O+	0.94*	0.85
H_2O-	0.02	0.02
	99.98	99.76

* loss on ignition

1. Nepheline from theralitic canadite C64872

2. Nepheline from theralitic canadite C82471

Analyst: 1, J.H. Scoon; 2, J. Gittins.

TABLE XXII

	1	2
SiO_2	42.02	40.21
TiO_2	1.03	1.68
Al_2O_3	6.56	10.43
Fe_2O_3	8.77	5.55
FeO	18.73	20.66
MnO	0.67	0.62
MgO	3.91	4.56
CaO	15.24	13.30
Na_2O	1.52	2.17
K_2O	0.46	0.53
H_2O+	0.76	-
H_2O-	0.28	nil
	99.95	99.71

1. Clinopyroxene from theralitic canadite C82471. Analyst: J. Gittins.

2. Clinopyroxene from theralitic canadite C82508. Analyst: J. Gittins.

the drill cut 44 feet of essexite forming what is probably a sill. The upper and lower contacts are marked by a prominent skarn.

It is a coarse-grained rock with clots of pyroxene grains unevenly distributed, together with milky white altered nepheline in grains ½ to 2 cms across equally widely scattered. The result is a rock of varied composition and dark mineral content ranging from a nepheline-poor essexite to an essexitic gabbro with smaller areas of plagioclasite. The base of the sill is a pyroxenite and this grades upward into the more leucocratic varieties. Plagioclase is andesine-labradorite (An_{56}) often strongly zoned, and some grains have minuted crystallites similar to those recorded in nepheline from the nepheline syenite and theralite but distinctly less abundant. Very rarely microperthite is found as cores within plagioclase grains.

Nepheline is rarely fresh but some grains have the characteristic pyroxene inclusions previously described.

Pyroxene is a titanaugite pleochroic from green to purplish pink and is generally quite fresh, many grains having sharp, angular boundaries and some being truly euhedral. Almost every grain has a narrow selvage of green hornblende and where pyroxene adjoins nepheline a corona has formed with hornblende separated from pyroxene by tine granules of plagioclase and often a rim of garnet between the hornblende and nepheline. In addition hornblende surrounds magnetite grains; it is brown against magnetite but becomes deep blue-green against nepheline. Accessory minerals are apatite, calcite and pyrite. Garnet is widely scattered in

the rock generally as tiny grains but occasionally as rims on other minerals such as nepheline and calcite. Ilmenite or titaniferous magnetite is often rimmed by sphene. The basal pyroxenite contains only minor amounts of feldspar, nepheline, hornblende and magnetite with accessory apatite, calcite, zircon and graphite. Pyroxene is pleochroic titanaugite occasionally replaced to a slight extent by hornblende. A few apatite-rich patches contain many euhedral grains.

A few inches above the skarn at the upper boundary of the sill, two veins each 2-3 inches thick of garnet-nepheline pyroxenite cut the crystalline limestone. They are composed of titanaugite and garnet with interstitial altered nepheline and streaks of graphite. The titanaugite has the usual purplish pink pleochroism and is traversed by countless veinlets of red-brown garnet in minute granules. Garnet is abundant between the grains as well. These veins appear to represent highly contaminated magma that was injected into the marble adjacent to the sill. An analysis is given in Table XXIII.

The "Pusey Iron Mine"

Adams and Barlow (1910) described a peculiar rock on Lot 35, Con. IV, Glamorgan Township as a differentiation phase of the Glamorgan gabbro. It is known as the Pusey iron ore body. Upon re-examination, however, it is clear that the rock is related not to the gabbro but to the suite of basic nepheline rocks for the characteristic nepheline alteration "gieseckite" is found in some

abundance there. The pits might have been blasted during the 1939-1945 war when the area was prospected for the Steel Company of Canada Ltd. and this might explain why Adams and Barlow did not see the gieseckite. Foye (1916) also described the rocks but makes no mention of gieseckite and specimens in the collections at Cambridge University collected by Harker in 1913 also do not contain gieseckite.

It is principally a magnetite-pyroxene rock with minor amounts of hornblende, apatite, feldspar and gieseckite. Clinopyroxene is a strongly pleochroic titanaugite with a few small patches of very fine, iron-titanium oxide hairs. It is quite fresh but is often surrounded by a corona of blue-green hornblende against magnetite. Plagioclase is An_{50-55} but is frequently altered. Magnetite is highly titaniferous with exsolved ilmenite. Dark green spinel is a very rare accessory mineral.

Specimens vary from magnetite with a few grains of pyroxene to a magnetite pyroxenite. An analysis of a rock with its constituent pyroxene appears in Table XXIV.

The origin of the rock is obscure. Adams and Barlow (1910) considered it to be simply a magnetite-rich accumulate at the base of the gabbro. Foye (1916) opposed this view and argued that it was a metasomatic rock resulting from the introduction of magnetite by gaseous transfer from the underlying nepheline syenite magma.

TABLE XXIII

SiO_2	39.96
TiO_2	0.90
Al_2O_3	10.58
Fe_2O_3	5.25
FeO	9.01
MnO	0.21
MgO	4.93
CaO	23.67
Na_2O	1.44
K_2O	0.43
P_2O_5	0.62
CO_2	0.29
C	1.47
S	0.43
H_2O+	1.29
H_2O-	0.06
	100.38

Lime contaminated essexite (garnet-nepheline pyroxenite) vein 3 inches thick in limestone a few inches above the upper contact of essexite sill. Drill core intersection at depth 491 feet below surface (vertical).

Analyst: J.H. Scoon.

TABLE XXIV

	1	2		3	
SiO_2	37.00	45.16	Si	1.73	2.00
TiO_2	4.67	2.12	Al	0.27	
Al_2O_3	13.30	9.49	Al	0.16	1.09
Fe_2O_3	8.70	2.40	Fe^{3+}	0.07	
FeO	12.88	10.52	Fe^{2+}	0.34	
MnO	0.26	0.02	Mn	-	
MgO	5.88	8.08	Mg	0.46	
CaO	12.82	20.32	Ti	0.06	
Na_2O	1.77	1.40	Ca	0.83	0.94
K_2O	1.11	0.29	Na	0.10	
P_2O_5	0.11	-	K	0.01	
CO_2	0.14	-			
H_2O+	1.61	0.46			
H_2O-	0.14	nil			
	100.39	100.24			

1. Magnetite-pyroxene rock with gieseckite (C82608), Pusey Iron Mine, Lot 35, Con. IV, Glamorgan Township.
2. Clinopyroxene from same rock.
3. Number of ions on the basis of six oxygens.

Analyst: J. Gittins

Igneous petrology

In summary, there is abundant evidence of truly igneous rocks that represent various phases in the differentiation of feldspathoidal magma. Many of these rocks have been preserved with barely a trace of metamorphism and in others the metamorphism has not proceeded far enough to mask the original texture or mineralogy.

It is clear from the foregoing descriptions that there exists in Glamorgan and Monmouth Townships a differentiated series of nepheline rocks extending from theralite and theralitic canadite to nepheline syenite, all of which possess a characteristic igneous texture. Compared to some alkaline rocks these are geochemically very simple; they do not possess notable concentrations of zirconium, fluorine, niobium or rare earths. The Haliburton-Bancroft nepheline rocks may, therefore, be ignored as potential sources of the rarer elements. The magma from which the rocks crystallized was sufficiently oxidized to precipitate magnetite in abundance but not to crystallize aegirine. Olivine is fayalite rich suggesting that the rocks are fairly highly differentiated.

The ultimate origin of the feldspathoidal magma remains unknown and is one of the most important of the unsolved petrological problems of the Haliburton-Bancroft region. A very likely possibility, however, is that they are derived from the gabbroic magmas. The nepheline normative character of at least two gabbro bodies has already been discussed (pp.). No chemical studies of the

gabbros of the Haliburton-Bancroft region exist; they are badly needed.

The magmatic origin of at least some of the Haliburton-Bancroft nepheline rocks is established beyond question. The ultimate origin of the feldspathoidal magma, however, is unclear.

Metasomatic nepheline rocks and nephelinization

The majority of the nepheline rocks are gneissic or occasionally massive without a trace of an igneous texture and characterized by an extremely varied mineralogy which is quite different from that of the known igneous suite. Clinopyroxene is rare and never carries hair-like magnetite inclusions; biotite and hornblende are abundant; garnet and calcite are common; olivine is unknown; feldspar is generally albite and microcline, never orthoclase; nepheline never carries oriented inclusions of pyroxene and tends to be concentrated in nepheline-rich bands that alternate with mafic,nepheline-poor bands. Lenticular pods and stringers of pure nepheline are common.

It is fairly clear that some of those rocks are the regionally metamorphosed equivalents of the igneous series but it seems equally clear that others are far too variable for this and are more likely to be metasomatic rocks generated by nephelinization.

Two localities serve to illustrate the metasomatic process:

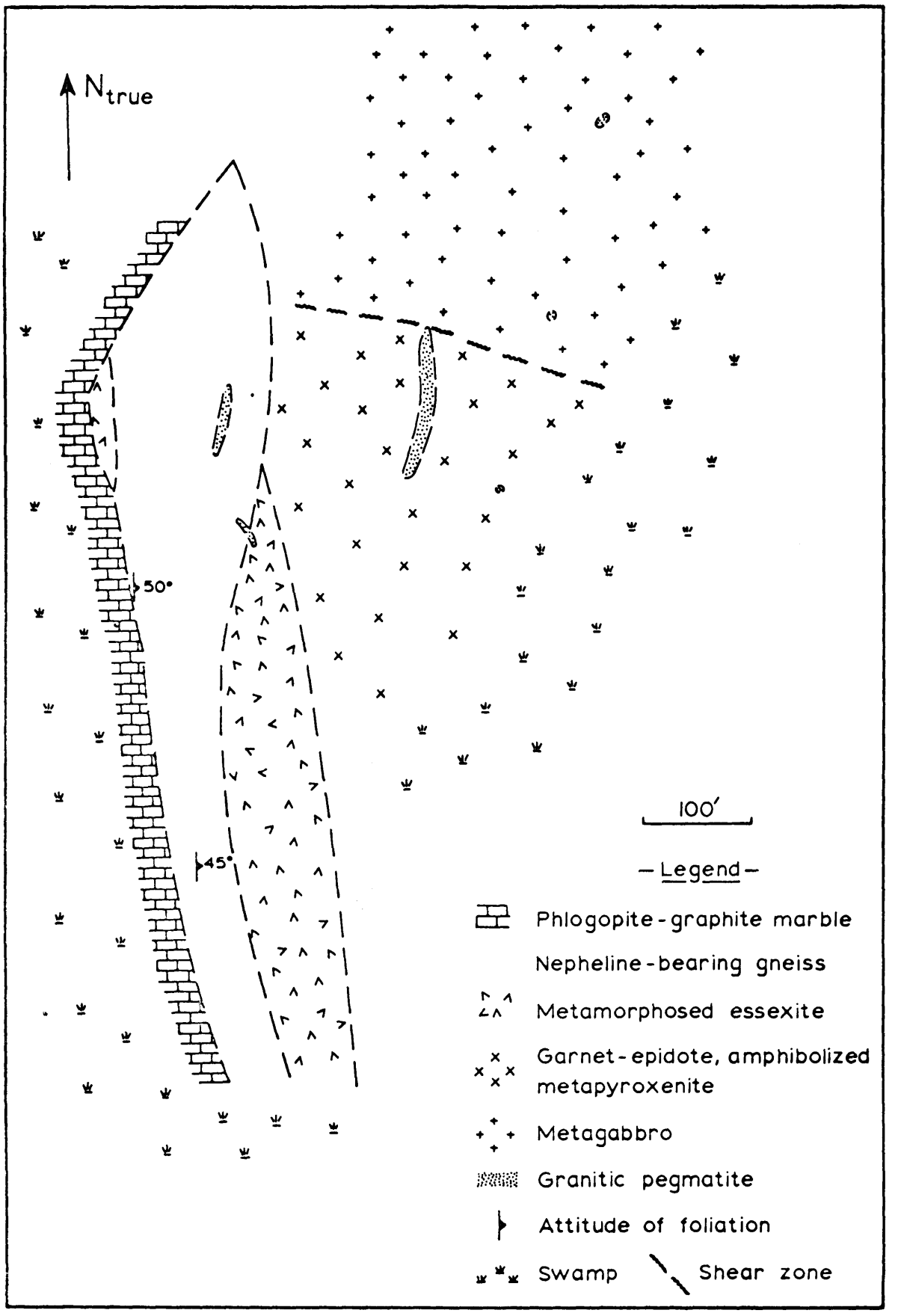


Fig. 17 Sketch map showing relationship between marble, nepheline gneiss, essexite, and Glamorgan metagabbro.

Pusey Knoll, Lot 35, Concession III, Glamorgan Township

This was described previously (p.) as part of locality 8 and is a low knoll of theralite and theralitic canadite underlain by gray graphitic marble. Between the igneous rock and the marble is a 2-3 foot thick layer of nepheline-oligoclase-biotite-(graphite) gneiss. It is a coarse-grained, granular but well-foliated rock. Nepheline is completely altered and imparts a dull, waxy lustre to the rock. It is interpreted as a nephelinized limestone, a clear sample of contact metasomatism adjacent to an igneous intrusion. An analysis of the rock and the biotite from it are given in Table XXV.

← Lot 3, Concession III, Monmouth Township

This was previously described on p. 64 as locality 15. A breached anticline exposes on a narrow ridge the base of the great metagabbro mass underlain by essexite, nepheline gneisses, ijolite pegmatite and marble. The essential features are shown in the map (Fig. 17).

The various rock types are described in order below: Biotite-garnet nepheline gneiss. -- This is a fairly leucocratic nepheline-andesine-microcline-scapolite-biotite-garnet gneiss with striking, euhedral garnets. It is limited to the extreme southern end of the ridge and to the immediate base of the sequence, where it is occasionally present without garnet. Its foliation is prominently marked by biotite-rich layers about one-helf inch thick, every inch or so through the rock. Nepheline is generally fresh, but in occasional layers it is completely altered. Microcline and

TABLE XXV

	1	2		3	
SiO_2	45.11	32.11	Si	5.11	8.00
TiO_2	0.43	2.34	Al	2.89	
Al_2O_3	26.42	18.23	Fe^{3+}	0.26	
Fe_2O_3	1.31	2.20	Fe	3.68	
FeO	4.78	27.65	Mn	0.06	5.77
MnO	0.04	0.43	Mg	0.96	
MgO	1.09	4.06	Ca	-	
CaO	5.51	0.04	Ti	0.28	
TiO_2	0.43	2.34	Na	0.18	1.93
Na_2O	4.08	0.59	K	1.75	
K_2O	4.49	8.61	OH	4.00	
P_2O_5	0.10	-			
CO_2	2.08	-	= 1.657		
H_2O+	4.58	3.76			
H_2O-	0.11	nil			
C	0.04	-			
	100.17	100.02			

S.G. 2.723

1. Nepheline-oligoclase-biotite-(graphite)-(calcite) gneiss (C.82502). A metasomatic gneiss between limestone and theralite; Lot 35, Con. III, Glamorgan Township.

2. Biotite from same rock.

3. Number of ions on the basis of 24(O, OH).

Analyst: J. Gittins

TABLE XXVI

	1	2	3	4		5
SiO_2	-	-	-	48.52	Or	17.24
TiO_2	-	0.58	-	0.15	Ab	9.43
Al_2O_3	-	-	-	28.62	Ne	29.82
Fe_2O_3	3.56	0.81	6.07	0.51	An	35.31
FeO	4.75	2.41	3.50	1.30	Wo	0.87
MnO	0.14	0.15	0.27	0.02	Di	2.30
MgO	0.18	0.24	Tr	0.35	Hed	2.90
CaO	33.84	30.61	32.90	8.93	Mt	0.70
Na_2O	-	-	-	7.59	Ilm	0.30
K_2O	-	-	-	2.92	Ct	0.14
P_2O_5	-	-	-	0.04	Ap	-
CO_2	-	-	-	0.06	Rest	0.78
H_2O+	-	-	-	0.67		99.79
H_2O-	-	-	-	0.11		
				99.79		
n	1.755	1.752				

1. Garnet from nepheline-andesine-microcline-scapolite-biotite garnet gneiss (C.85416) Lot 3, Con. III, Monmouth Township.

2. Garnet from nepheline-andesine-microcline-scapolite-biotite-garnet gneiss (C.85417) Lot 3, Con. III, Monmouth Township.

3. Garnet from nepheline-andesine-microcline-scapolite-biotite-garnet gneiss (C.82530) Lot 3, Con. III, Monmouth Township.

4. Nepheline-andesine-microcline-scapolite-biotite-garnet gneiss (C.82522) Lot 3, Con. III, Monmouth Township.

5. Norm of C.82522.

Analyst: J. Gittins

andesine are the principal feldspars, but occasional rounded, corroded relicts of a plagioclase of undetermined composition are found within the andesine. Scapolite is calcic and shows no sign of having replaced other minerals. The biotite is a low-iron type. Garnet is a very pale yellow-brown; some grains approximate to dodecahedral outline, while others are quite anhedral. All have a spongy appearance, enclosing any of the other minerals of the rock. Partial analyses of these garnets are given in Table XXVI. They are essentially grossular, containing small amounts of almandine and andradite. A chemical analysis of one of the rock is also given in the same table.

Hornblende-garnet-nepheline gneiss. -- This variety has a heterogeneous appearance owing to the mafic minerals being distributed unevenly through the rock in clots and streaks composed of green hornblende and garnet which, in many cases, surround a core of pale green clinopyroxene from which the hornblende has clearly developed. Garnet is usually intergranular between the hornblende and around the mafic clots, but it occasionally veins the relict core of pyroxene. The remainder of the rock is nepheline and plagioclase. Nepheline is generally fresh and lacks any inclusions. Plagioclase is albite-oligoclase and occasionally encloses relict zoned plagioclase similar to that described under biotite-nepheline gneiss. Some grains are embayed by nepheline. Calcite is a minor constituent and zircon and sphene are universal accessories.

The key to the heterogeneous appearance of this rock is provided by an outcrop at the contact between marble and nepheline gneiss, where blocks of fine-grained garnet-pyroxene-calcite skarn are found in both the marble and the nepheline gneiss. They are xenoliths 2-8 inches across, and, once they have been recognized, all gradations can be traced between these larger xenoliths and the smaller, streaked-out mafic clots through the scattered grains of garnet and hornblende.

The skarn is composed principally of light green diopsidic pyroxene and pale brown garnet with minor calcite. Toward the margins of the xenoliths a few grains of microperthitic alkali feldspar and alteration after nepheline begin to appear, increasing in amount at the edge where green hornblende forms a narrow selvage around the xenoliths. Analyses of one of the least altered of these xenoliths and of garnets from other skarn xenoliths are given in Table XVII.

Analyses of two rocks and a hornblende from the hornblende-garnet nepheline gneiss group are given in Table XXVIII.

Scapolite-plagioclase-biotite gneiss. -- In the marble a few feet below the nepheline gneiss two lenses of scapolite-andesine-biotite-(calcite) gneiss are found, each 2-3 feet long and about 12 inches thick with a core of white micaceous alteration after nepheline. The scapolite is calcic. Analyses of scapolite rock and core and the scapolite are given in Table XXIX. The alteration is a very fine-grained unidentified mica with tiny granules of corundum.

TABLE XXVII

	1	2	3	4
SiO_2	40.60	37.87		
TiO_2	0.12	0.70		
Al_2O_3	14.70	18.30		
Fe_2O_3	3.65	5.20	5.62	5.52
FeO	3.95	7.71	3.41	3.72
MnO	0.05	0.36	0.12	0.05
MgO	3.88	0.62	Tr	Tr
CaO	29.49	29.63	33.25	33.09
Na_2O	0.70	-		
K_2O	0.27	-		
P_2O_5	nil	-		
CO_2	2.30	-		
H_2O+	0.63	0.09		
H_2O-	0.06	-		
	100.40	100.49		
S.G.	3.454			

1. Clinopyroxene-garnet-(calcite) skarn with accessory nepheline (C.82483). Xenolith in nepheline gneiss, Lot 3, Con. III, Monmouth Township.

2. Garnet from garnet-pyroxene-epidote nephelinized skarn (C.82485). Lot 3, Con. III, Monmouth Township.

3. Garnet from slightly nephelinized skarn (C.82476). Lot 3, Con. III, Monmouth Township.

4. Garnet from extensively nephelinized skarn (C.82478). Lot 3, Con. III, Monmouth Township.

Analyst: J. Gittins

TABLE XXVIII

	1	2	3		4	5
SiO_2	41.30	41.25	38.40	Or	12.94	19.02
TiO_2	0.50	0.48	0.80	Kp	4.42	2.84
Al_2O_3	28.29	28.42	15.78	Ne	49.16	48.02
Fe_2O_3	1.08	2.37	4.94	An	18.66	14.48
FeO	3.59	2.84	16.26	Cor	-	1.47
MnO	0.04	0.01	0.22	Hed	0.83	-
MgO	0.94	0.94	7.82	Fo	1.66	1.57
CaO	6.93	5.84	11.52	Fa	3.23	1.98
Na_2O	10.73	10.48	1.98	Mt	1.58	3.43
K_2O	3.51	4.07	0.07	Ilm	0.96	0.91
P_2O_5	0.04	0.01	-	Ct	4.93	5.21
CO_2	2.17	2.29	-	Ap	-	-
H_2O+	0.62	1.32	1.64	Rest	0.64	1.37
H_2O-	0.02	0.05	nil		99.66	100.30
	99.76	100.37	99.43			
S.G.	2.75	2.70				

1. Hornblende-(pyroxene)-nepheline-plagioclase gneiss (C.82585) Lot 3, Con. III, Monmouth Township.

2. Nepheline-plagioclase-hornblende-(biotite) gneiss (C.82599) Lot 3, Con. III, Monmouth Township.

3. Hornblende from hornblende-garnet-nepheline-plagioclase gneiss (C.82527), Lot 3, Con. III, Monmouth Township.

4. Norm of C.82585

5. Norm of C.82599

Analyst: J. Gittins

Metamorphosed essexite. -- This differs markedly from the adjoining nepheline gneiss. It lacks of prominent foliation and is coarse-grained with knobs of titanaugite standing out in relief above the weathered surface. A few specimens of the rock have a suggestion of diabasic texture, with plagioclase feldspar forming laths several millimeters long.

In the least metamorphosed rock, fresh titanaugite has a strong purplish-pink pleochroism and is usually surrounded by a narrow selvage of green hornblende. The plagioclase is labradorite (An_{56}), often complexly twinned and unzoned. Scapolite is present as separate grains and, less commonly, as veinlets traversing plagioclase. Nepheline varies in amount and degree of alteration but generally contains rods and blebs of hornblende or green pyroxene. Most grains have a narrow rim of garnet which, in the earliest stages of development, is continuous and unbroken.

The extent of metamorphism is highly variable from outcrop to outcrop and with it the degree of replacement of pyroxene by hornblende. As the degree of metamorphism increases, the selvage of hornblende increases in width and develops into a corona separated from pyroxene by tiny grains of plagioclase (albite-oligoclase), while the titanaugite becomes extensively uralitized and traversed by veinlets of garnet. The ultimate stage is a spongy mass of green hornblende and plagioclase grains, sometimes with a relict grain of uralitized pyroxene at the core. In this more strongly metamorphosed type, plagioclase becomes strongly zoned, particularly against hornblende, and the garnet rims on nepheline

TABLE XXIX

	1	2	3	4		5	6
SiO_2	43.02	43.98	46.9	47.6	Or	14.62	40.20
TiO_2	0.70	0.10	0.1	nil	Ab	9.80	18.24
Al_2O_3	22.58	35.16	37.5	26.7	Ne	12.70	5.56
Fe_2O_3	0.88	0.13	0.1	nil	An	36.64	12.48
FeO	5.93	0.31	0.3	0.5	Cor	-	19.97
MnO	0.08	nil	nil	nil	Di	1.76	-
MgO	2.72	0.59	0.6	0.4	Hed	2.04	-
CaO	11.99	3.27	3.5	14.3	Fo	6.20	0.93
Na_2O	3.93	3.16	3.4	4.7	Fa	4.19	0.63
K_2O	2.48	6.39	6.8	1.1	Ct	6.57	1.73
P_2O_5	0.19	nil	nil	-	Ilm	1.34	0.22
CO_2	2.89	0.71	0.8	3.3	Mt	1.28	0.23
H_2O+	1.71	6.48	-	0.7	Ap	0.67	-
H_2O-	0.03	0.23	-	nil	Rest	2.26	-
S	nil	-	-	nil		100.07	100.19
CL	0.31	-	-	0.6			
	99.44	100.51	100.0	99.9			
O=CL,S	0.07						
	99.37						

Ne=1.551
No=1.583

1. Scapolite-biotite-andesine-(calcite) gneiss (C.82592) Lot 3, Con. III, Monmouth Township.

2. Hydrated nepheline or scapolite. Core of (C.82592). Specimen (C.82593).

3. C.82593 recalculated water free

4. Scapolite analysis recalculated from analyses of scapolite-andesine mixture. From C.82592. (Shaw, 1960a, p. 240).

5. Norm of C.82592

6. Norm of C.82593

Analyst: J. Gittins

TABLE XXX

	1
SiO_2	42.76
TiO_2	1.75
Al_2O_3	21.84
Fe_2O_3	5.56
FeO	4.49
MnO	0.12
MgO	2.91
CaO	14.88
Na_2O	3.28
K_2O	0.97
P_2O_5	0.54
CO_2	0.59
H_2O+	0.90
H_2O-	0.04
	100.63

1. Metamorphosed essexite: titanaugite-plagioclase-nepheline rock (C.82591) Lot 3, Con. III, Monmouth Township.

increase in size until they are composed of a string of garnet grains. Garnet rims are also found on calcite grains.

An analysis of one of the least metamorphosed specimens of the essexite is given in Table XXX.

Ijolite pegmatite. -- This is an unusual rock that has not been noted elsewhere. Exposures are not sufficient to be able to tell whether the pegmatite is intrusive into the rest of the nepheline rocks or grades into them. The grain size is very coarse, up to several inches. There is no feldspar at all and garnet is fairly common. The nepheline is fresh. The titanaugite is highly pleochroic, partly uralitized, and has continuous trains of garnet in minute granules following each cleavage trace.

Metapyroxenite and metagabbro. -- The metamorphosed essexite is succeeded by garnet-epidote amphibolized metapyroxenite which passes eastward into metagabbro. It is about 300 feet in outcrop width, has a varied mineralogy, and no trace of igneous texture has survived.

The commonest variety is metapyroxenite with less than 20 per cent plagioclase and scapolite. Clinopyroxene is light green diopsidic augite, extensively uralitized and often traversed by veinlets of garnet and blebs of scapolite. Replacement by hornblende may be so advanced that only occasional tiny pale green areas of pyroxene remain within a larger grain of dark green hornblende. Plagioclase, when present, is zoned from An_{60-70} at the core to An_{35} at the rim. Scapolite is much commoner than

feldspar and fills the interstices between pyroxene grains; it is calcic and fresh except where micro-shear zones have fractured the rock along zones 1-2 millimeters wide. Garnet occurs as rounded grains, and as veinlets within pyroxene grains, but these veinlets never extend into the secondary hornblende. It may amount to 25 per cent of the rock but is usually in the range of 5-15 per cent. Calcite, sphene, zircon, pyrrhotite, and iron oxide minerals are the usual accessories. Zircon is frequently found as clusters of small grains 0.5-2 millimeters across. Epidote, which is colourless but possesses a high birefringence, forms long prismatic grains that may be separate, interlocking, or even branching, but some grains are irregularly shaped porphyroblasts. Grain size is fairly uniform within any one specimen but varies from 1 to 10 millimeters from outcrop to outcrop.

A plagioclase amphibolite composed of plagioclase and long prismatic grains of green hornblende, and completely lacking in clinopyroxene, is less common.

In several places the original gabbro has escaped complete recrystallization and is found in all stages of metamorphism. Where least altered, it is a black, medium-grained rock with interlocking feldspar laths enclosing clinopyroxene and olivine. Plagioclase is labradorite, and clinopyroxene is light brown, faintly pleochroic, with exsolved plates of ilmenite. Green spinel is an occasional accessory. In the more metamorphosed types, first olivine, and then pyroxene, is altered to secondary amphibole.

The calcic nature of these metapyroxenites and metagabbros

is revealed by four analyses in Tables V and XIV (pp.
The CaO-content increases toward the contact with the nepheline rocks, hence also toward the base of the metagabbro intrusion. Elsewhere in the complex, dunite is occasionally found, and one might expect an olivine-rich accumulate at the base of an olivine gabbro. The absence of any such olivine accumulation is probably due to the assimilation of limestone which generates, locally, a lime-rich magma which crystallizes a calcic titanaugite rather than olivine.

It might be argued that the whole sequence is an example of the generation of nepheline syenite by syntexis at the contact between gabbro and limestone. This is an untenable view for if the iron enrichment trend for known cases of such desilication of gabbro (Scawt Hill, N. Ireland; Camas Mor, Muck) are compared with the Monmouth Township occurrence (Fig. 9, p it can be seen that there is no similarity.

The petrogenetic history of these rocks is complex. There is no prominent order of emplacement such as cross-cutting relations. However, in Carlow and Faraday Townships Hewitt (1954, 1957) has recognized nephelinization of gabbro and it seems likely that the same age relation between gabbro and nepheline rocks will apply in Glamorgan and Monmouth Townships. In addition the calcic nature of the base of the gabbro body makes it highly likely that the gabbro magma was emplaced directly against the limestone rather than against nepheline rocks. It appears then that the skarn is a product of the thermal metamorphism

of limestone by gabbro and that subsequently a dike of essexite was intruded approximately along the contact between the gabbro and its skarn breaking up and nephelinizing the skarn, fragments of which are strung out in the resultant nepheline gneiss.

Further examples of the nephelinization of skarns can be seen in a series of outcrops in the fields and woods between Trooper Lake and the concession line road to the north. Again there is a close association of amphibolized metapyroxenite, nepheline gneiss and limestone which is thought to represent the lime-contaminated margin of the Glamorgan-Monmouth gabbro and the metamorphosed limestone underlying it, the whole sequence having been nephelinized and subsequently metamorphosed. Igneous-textured theralite outcrops on the shore of Trooper Lake and in the woods to the north of it. The metapyroxenite shows a more complete passage to skarn than in the previously described occurrence and vesuvianite appears in addition to garnet. Altered nepheline forms the ground-mass of the nephelinized hybrid rocks which can be seen in small outcrops in the fields. The amphibolized metapyroxenite without nepheline occurs in the woods beside the fields and is highly garnetiferous and scapolitic. An analysis of this scapolite is given in Table XXXI Adjacent to these rocks are nepheline gneisses that are interpreted as nephelinized limestones, the limestone having suffered thermal metamorphism by the gabbro prior to nephelinization. They are scapolite-plagioclase-nepheline-hornblende-garnet gneisses.

TABLE XXXI

SiO_2	45.14
CO_2	3.78
S	0.08
Al_2O_3	27.83
Fe_2O_3	0.31
MgO	0.29
MnO	nil
CaO	17.34
Na_2O	3.72
K_2O	0.20
H_2O+	0.64
H_2O-	--
Cl	0.66
	99.99
less O=S,CL	0.20
	99.79

Scapolite from garnetiferous amphibolized metapyroxenite in woods north of Trooper Lake, Glamorgan Township (Shaw 1960a, p. 240).

Analyst: J. Gittins

The chemistry of nephelinization was studied by Gittins (1961) and it was concluded that Si, Al, Fe, Na and K were added to the host rocks during the metasomatism. The rocks which Gummer and Burr (1946) thought were the original paragneisses are now thought to be an arrested stage of nephelinization. Nephelinization is defined as a series of related processes rather than a single process, which result in the formation of nepheline-bearing rocks, but rocks representing many stages in this formation may be preserved. For example, there is considerable evidence that limestone was first converted to a plagioclase rock and then to a nepheline-plagioclase assemblage. Details of the processes involved are discussed by Gittins (1961). An example of the development of almost pure albitite can be seen in the Frazer Quarry. Here a white, medium-grained rock composed almost entirely of albite occurs adjacent to the nepheline-albite pegmatite. An analysis of the rock is given in Table XXXII.

The source of the fluids responsible for nephelinization have been attributed by Gummer and Burr (1946) and Moyd (1949) to granitic magma. Such a source is ruled out, however, by more recent work. Experimental studies of nepheline syenites indicate that the vapour in equilibrium with a water-saturated nepheline syenite melt is very much enriched in Na_2O and Al_2O_3 relative to the liquid and consequently is even more undersaturated than the liquid. The vapour in equilibrium with a water-saturated granite

melt, however, is very close to the composition of granite and could not precipitate nepheline. Clearly the fluids escaping from a nepheline syenite magma are quite capable of nephelinizing the surrounding rocks whereas those escaping from a granitic intrusion are not. Since we already know that a nepheline syenite magma was present this magma becomes the logical source of the nephelinizing fluids.

Limestone was believed by Shand and Daly to play a prominent role in the genesis of feldspathoidal magmas by desilicating more saturated magmas. This tends to obscure the possibility that alkaline magmas might themselves assimilate limestone and it seems very possible that some of the calcite in the nepheline gneisses of the region may have originated in this way. It is also conceivable that some of the garnet-bearing nepheline gneisses represent nephelinization of skarns that were themselves the result of metamorphism by nepheline syenite intrusions, the feldspathoidal magma generating the fluids necessary to nephelinize its own skarns. Such fluids, being water-saturated, might also render pyroxene unstable and generate hornblende which is the reaction universally seen in these rocks.

Nepheline pegmatites

Nepheline pegmatites are a unique feature of the Haliburton-Bancroft area. They are composed essentially of nepheline and feldspar with lesser amounts of biotite and accessory

TABLE XXXII

SiO_2	66.53	Norm (wt.%)	
TiO_2	nil	Or	9.79
Al_2O_3	21.29	Ab	87.14
Fe_2O_3	0.19	Ne	0.43
FeO		Cor	2.39
MnO	nil	Ct	0.09
MgO	0.06	Hem	0.19
CaO	0.05	Fo	0.11
Na_2O	10.40	Rest	0.18
K_2O	1.66		100.32
P_2O_5	nil		
CO_2	0.04		
H_2O^+	0.08		
H_2O^-	0.10		
	100.40		

Albitite (C. 85072) with accessory biotite and calcite; Frazer quarry, Glamorgan Township. The presence of normatite corundum is interesting in view of the presence of corundum in one part of the quarry.

Analyst. J. Gittins.

apatite, zircon, calcite, tourmeline, sodalite cancrinite and magnetite. Rare earth and radioactive minerals are noteably absent as are the rarer silicates such as eudialyte found in similar rocks in other parts of the world. Grain size varies from less than one inch to as much as six feet. Crystals 2-3 feet across are very common. Crystal outline is rare but suggestions of it are occasionally present.

Two types of pegmatite may be distinguished: cross-cutting bodies which have intruded country rocks such as calcareous paragneiss and may cut across the foliation of nepheline gneisses as well; patchy pegmatites with gradational borders within the nepheline gneiss.

The feldspar is usually albite but is sometimes potassic oligoclase; the Gill pegmatite (Glamorgan Township) is rich in coarsely perthitic alkali feldspar. Partial analyses of two feldspars (expressed in terms of orthoclase, albite and anorthite) and one nepheline (expressed as nepheline and kaliophilite) are given in Table XXXIII.

Biotite is always an iron rich lepidomelane and an analysis from Mackay pegmatite is given in Table XXXIV.

As far as can be ascertained from the weathered surfaces of outcrops the amount of nepheline varies from 10 to 50% and biotite from 1 to 5%, the remainder being feldspar. The rocks appear to be leucocratic but this is partly an illusion because, although the biotite is widely scattered it is in fairly large

TABLE XXXIII

	1	2	3
Na_2O	8.98	11.20	15.58
K_2O	2.53	0.13	4.97
Or	15.0	0.8	
Ab	77.0	94.8	
An	8.0	4.4	
Ne			86.1
Kp			13.9

Analyst: J. Gittins

1. Feldspar from McKay property, lot. 14, Con. VI, Monmouth Township.

2. Feldspar from Lot. 31, Con. IV, Glamorgan Township.

3. Nepheline from McKay property, lot. 14, Con. VI, Monmouth Township.

TABLE XXXIV

		Metal atoms to 24 (O, OH)		
SiO_2	33.21	Si	5.19	
Al_2O_3	17.49	Al	2.81	
Fe_2O_3	3.17	Al	0.40	
FeO	23.10	Fe^{3+}	0.37	
MnO	0.51	Fe^{2+}	3.02	
MgO	7.45	Mn	0.07	5.86
TiO_2	2.21	Mg	1.74	
CaO	0.06	Ti	0.26	
Na_2O	0.54	Ca	0.01	
K_2O	8.96	Na	0.16	1.96
H_2O^+	3.67	K	1.79	
	100.37	OH	3.83	

Biotite from nepheline-albite pegmatite, Mackay property, Lot 14, Con. VI, Monmouth Township (C. 85073).

Analyst. J. Gittins

books often 2-3 inches across and as thick. If this were distributed even as small flakes the rock would appear much darker. The overall composition of the pegmatites is probably not much different from the more leucocratic varieties of nepheline rocks such as those at Esson Creek (p.) and Blue Mountains, Methuen Township.

A variety of modes of origin for these pegmatites have been appealed to in the past: to some people they are the result of remobilization and to others they are extreme products of nephelinization. So long as there is clear evidence of the existence of a feldspathoidal magma there seems to be little reason why the pegmatites should not be considered as the final product of the differentiation of such a magma. Indeed there is evidence that fluids emanating from the pegmatite have produced metasomatic effects in the country rocks. For example at the Frazer quarry in Glamorgan Township the development of a medium-grained, sugary albitite between the pegmatite and the host-rock limestone has already been described and an analysis was given in Table XXXII.

In some places, at least, the emplacement of pegmatites appears to have been structurally controlled. Satterly (1943) illustrates a part of the Frazer pegmatite that is clearly a saddle-reef in the apex of an anticline.

While the larger bodies of pegmatite may best be considered as simple differentiates of the feldspathoidal magma the

small pegmatitic stringers, at most a few inches wide and often cutting obliquely across the foliation of the nepheline gneisses, demand a different explanation. Their cross-cutting nature puts them later than the regional metamorphism which produced the foliation in the surrounding gneisses and effectively rules out an origin from the original feldspathoidal magma. They are probably due to partial melting of nepheline rocks, of whatever manner of origin, during the regional metamorphism and represent the injection of the liquid into fractures developed during the waning of the metamorphic stresses. Significantly this type of minor pegmatite is generally leucocratic, as the liquid formed at the beginning of melting would be.

Metamorphism of the nepheline rocks

All the nepheline rocks have been metamorphosed to some extent. Even the original igneous-textured rocks show the effects of thermal metamorphism and therest have been recrystallized during regional metamorphism to gneisses. Some of these gneisses were originally igneous rocks and some were metasomatic rocks that might have inherited some degree of foliation.

This regional metamorphism was not recognized by Adams and Barlow (1910). Nowhere in their memoir do they use "gneiss" to describe these rocks. It is curious why this should be. A few extracts illustrate their thinking:

> "The foliation is not such as would be produced by the direct crushing of a massive

> rock. Cataclastic structure is seen only in one or two places, and the rock very rarely shows any distinct evidence of pressure". (1910, p. 330).

> "Evidences of pressure, even in some of the most pronouncedly foliated or schistose varieties, are extremely rare" (1910, p. 231).

The majority of the nepheline-bearing rocks are gneisses and although generalization is difficult, for they are characterized by an extreme variability, the commonest types are nepheline-plagioclase-biotite gneiss and nepheline-plagioclase-hornblende gneiss. Garnet is often an accessory and occasionally even a major constituent. The proportions of these minerals vary enormously so that a typical sequence might display frequent alternation of mafic-rich bands that in places are amphibolite or biotite rock, and nepheline rich bands with only occasional albite and biotite or hornblende, interspersed with gneisses of less extreme variability than two types initially mentioned. In many of these types accessory or minor minerals are calcite, scapolite, garnet, sphene, zircon, magnetite and apatite. In addition to variation across the strike there is often an equally striking change along strike, leucocratic varieties becoming more mafic and vice versa. Individual bands may persist for hundreds of feet or may be very short as in the case of pods and lenses of nepheline a few feet in length.

Variability of nepheline content is also due in many places to the later intrusion of granite and syenite producing widespread assimilation hybrids but this is a separate problem and is discussed later.

A very fine exposure of nepheline gneisses is to be seen in the road cut on highway 500 immediately west of Esson Creek. The exposures also illustrate the complex intrusive relations of later syenite and the generation of hybrid rocks. In all about 240 feet of rock face is exposed. The nepheline rock appears to be an easterly dipping body which was originally at least 220 feet thick; it is now cut by a number of faults. It is a coarse-grained, white rock composed of nepheline, albite, microcline and microperthite with coarse magnetite and black biotite. There is a fairly pronounced foliation in the outcrop where biotite is sufficiently abundant to indicate it.

The nepheline and potash feldspar contents are very variable. Nepheline rarely exceeds 10% and in some specimens is absent so that the rock becomes an albite-(magnetite)-biotite gneiss $\pm$ microcline. The nepheline is always fresh, except where it is adjacent to the red syenite, and may contain small inclusions of microcline and albite, but it is otherwise clear.

Albite is the most abundant feldspar. Potash feldspar occurs as all gradations between microcline and microcline perthite. Biotite is the deep chestnut brown, intensely pleochroic iron-rich variety. In occasional specimens it is

greenish brown with extremely rare alteration to chlorite. Calcite is a constant accessory and reaches 10% in places. It is not uncommon to see fingers of plagioclase protruding into grains of calcite.

An analysis of a fairly typical rock is given in Table XXXV. Hewitt (1946) believed that the rocks are part of a sill displaying gravitative accumulation of magnetite toward its base. There seems no reason to doubt its intrusive nature and the rock appears to be an igneous gneiss but in the excellent exposures now available there is no clear evidence of settling.

Further information on the nature of regional metamorphic changes in these rocks is provided by a study of a gneiss that outcrops one quarter mile east of the igneous textured nepheline syenites of Lot 3, Con. III Monmouth. It is a medium-grained microcline-albite-nepheline-biotite-hornblende-(calcite) rock with strong foliation. An analysis of the rock is given in Table XXXVI. The rock is assumed to be the regionally metamorphosed equivalent of the igneous one-feldspar nepheline syenites as it lies on the same differentiation curves and although its iron content is somewhat lower than in these rocks its composition is close enough to illustrate the metamorphic changes.

The first changes involve the unmixing of alkali feldspar and recrystallization to separate grains of albite and microcline accompanied by reaction with nepheline to produce a more potassic nepheline free of pyroxene inclusions and which

TABLE XXXV

SiO_2	47.58	Norm	
TiO_2	0.24	Or	30.9
Al_2O_3	21.01	Ab	24.1
Fe_2O_3	4.65	Ne	21.7
FeO	4.21	An	0.6
MnO	0.17	Cor	2.7
MgO	0.77	Ct	7.2
CaO	4.48	Fo	1.3
Na_2O	7.62	Fa	3.0
K_2O	5.23	Mt	6.7
P_2O_5	0.24	Ilm	0.5
CO_2	3.17	Ap	0.7
H_2O^+	0.91	Rest	0.9
H_2O^-	nil		100.3
	100.28		

Microcline-albite-nepheline-biotite-magnetite gneiss (C. 82685)

Esson Creek Road Cut, Highway 121, Lot 23, Con XI.

Monmouth Twp.

Analyst. J. Gittins

approximates to the Morozewicz normal nepheline composition. Analyses of the constituent minerals of the rock are given in Table XXXVII. It can be seen that the feldspar has a low orthoclase content compared to the igneous rock feldspars but if the potash content of the biotite is recalculated as potash feldspar the bulk composition is similar to the igneous feldspars. An exact calculation can not be made because of the increased potash content of the nepheline and the small amount in the hornblende.

Both biotite and hornblende are characteristically iron-rich varieties and there is no magnetite in the rock. Biotite and hornblende have formed by reaction of microcline, magnetite, olivine, clinopyroxene and water, and the process was terminated when the magnetite was used up. Clearly the reaction could also be terminated by microcline, magnetite or water being used up.

In the nepheline gneiss exposed at Esson Creek on highway Monmouth Township biotite coexists with microcline and magnetite, and this appears to be an example of the further formation of biotite being prevented by the exhaustion of the water supply. Any obvious reaction texture would be obliterated by continued recrystallization after the exhaustion of available water.

It is not suggested that biotite in all the nepheline gneisses formed in this way but it appears likely that at least

TABLE XXXVI

	1		2		3
SiO_2	50.70	Or	32.19	Microcline	21.0
TiO_2	0.22	Ab	23.11	Plagioclase	29.3
Al_2O_3	22.89	Ne	23.91	Nepheline	25.4
Fe_2O_3	4.86	An	8.31	Hornblende	13.6
FeO	2.33	Cor	0.86	Biotite	8.3
MnO	0.14	Fo	0.52	Calcite	2.4
MgO	0.30	Ilm	0.43	Apatite	Tr
CaO	3.25	Mt	6.86		100.0
Na_2O	7.95	Hem	0.13		
K_2O	5.45	Ct	2.68		
P_2O_5	0.05	Rest	0.87		
H_2O+	0.83		99.87		
H_2O-	0.04				
CO_2	1.18				
	100.19				

1. Microcline-albite-nepheline-biotite-hornblende-(calcite) gneiss (C. 82468), Lot 6, Con. IV, Monmouth Township.
2. Norm of C. 82468
3. Weight per cent mode of C. 82468.

TABLE XXXVII

	1	2	3	4	5	6		7		8	
SiO_2	42.21	65.62	65.38	63.85	31.18	40.94	Si	5.09	8.00	6.51	8.00
TiO_2	0.08	nil	nil	nil	2.10	0.34	Al	2.91		1.49	
Al_2O_3	33.40	20.12	19.73	20.79	16.90	17.23	Al	0.34	5.61	3.87	
Fe_2O_3	0.46	0.15	0.08	0.55	6.55	5.92	Fe^{3+}	0.80		0.71	
FeO					27.95	23.44	Fe^{2+}	3.80		3.12	
MnO	nil	nil	nil	nil	0.14	0.33	Mn	0.02		0.05	
MgO	0.20	0.12	0.08	0.01	1.61	0.77	Ti	0.26		0.04	
CaO	0.27	0.78	0.49	0.14	0.02	4.85	Mg	0.39		0.18	
Na_2O	16.59	7.19	5.77	6.30	0.66	2.48	Ca	-		0.82	
K_2O	6.24	6.07	8.16	7.49	8.73	1.83	Na	0.21	2.03	0.77	
H_2O+	0.94	0.10	0.28	0.30	3.66	1.59	K	1.82		0.56	
H_2O-			0.03	0.02	0.29	nil	OH	3.99		0.32	
	100.39	100.15	100.00	100.00	99.79	99.72					

Or	35.8	48.4	44.9	
Ab	60.3	49.2	54.0	= 1.691
An	3.9	2.5	1.1	

1. Nepheline from microcline-albite-nepheline-biotite-hornblende-(calcite) gneiss (C.82468), Lot 6, Con. IV, Monmouth Township.
2. Bulk feldspar (microcline + albite) from same rock (C.82468)
3. and 4. Alkali feldspar from C.82461 and C.82464 of Table XVII for comparison.
5. Biotite from C.82468
6. Hornblende from C.82468
7. Cations to 24 (O, OH) in biotite
8. Cations to 24 (O, OH) in hornblende.

Analyst: J. Gittins

some did. The reaction potash feldspar + magnetite $\longrightarrow$ biotite is well known experimentally.

The one-feldspar igneous nepheline syenites have survived regional metamorphism possibly through being cushioned by marble that would likely have been plastic during the regional metamorphism thus protecting the nepheline syenite from any shearing stress. Thermal metamorphic effects can be seen, however. These are principally the appearance of a "dust" of minute opaque inclusions in the feldspar and of minute rods of magnetite in the pyroxene that are so abundant in some grains as to render the pyroxene almost opaque. The identity of the magnetite was confirmed by X-ray oscillation photographs. It probably represents partial oxidation of an originally iron-rich pyroxene during metamorphism.

Another common feature is the development of hornblende-plagioclase coronas around pyroxene grains (Fig. 15). They form wherever pyroxene adjoins nepheline but never between pyroxene and feldspar. Where pyroxene is in contact with feldspar and nepheline the corona ends abruptly at the feldspar (Fig. 16). The coronas consist of an inner zone of plagioclase and an outer zone of dark green hornblende.

With the complete recrystallization of the rock to form a metamorphic gneiss exsolution of perthitic feldspar proceeds to the development of separate grains of microcline and albite and many rocks display all three forms of alkali feldspar. At

the same time the rod-like inclusions of pyroxene that are so characteristic of the nepheline in the igneous rocks are completely expelled so that no nepheline in a gneissic rock has inclusions. The inclusions, by contrast, are found in igneous nepheline rocks from many parts of the world.

Ijolites and urtites are not likely to undergo much change other than recrystallization in most cases. If sufficient water is available, of course, hornblende may be formed from the pyroxene. Much of the garnet in the nepheline rocks is probably of metamorphic origin, either inherited from skarns that have been nephelinized as on Lot 3, Con. III, Monmouth Township or derived from pyroxene during reginnal metamorphism. Examples of this latter type can be seen in very coarse titanaugite in the ijolite pegmatitic rock that cuts the nepheline gneisses of Lot 3, Con. III, Monmouth Township (p.). The cleavages of the pyroxene are marked by trains of minute garnet granules and the pyroxene is partly altered to amphibole. This same feature has been observed in the metamorphosed essexite from the same locality. Complete recrystallization presumably leads to the garnet separating as larger discrete grains. Such garnet formation would require the more aluminous pyroxenes of the igneous rocks. It could not form from the relatively low-alumina clinopyroxenes that might be inherited from metasedimentary rocks. None of the garnet appears to be a product of direct magmatic crystallization. Such garnet elsewhere in the world is titaniferous (melanite) whereas all the garnets in this region are essentially grossularites.

There are some nepheline rocks principally ijolite that have not developed a gneissic character. They are well exposed in partly overgrown fields on Lot Con. , Monmouth Township. They are principally nepheline pyroxene rocks (ijolites) with lesser amounts of nepheline-feldspar rocks (urtites). In some of these the pyroxene is partly altered to hornblende but most of the pyroxene is a fresh green clinopyroxene. The rock is massive and very dark in appearance with a grain size of about one quarter inch. This changes within a few feet to very much finer grained varieties with no sharp or obviously intrusive contacts between them and is a feature repeated in the igneous textured phases of the Glamorgan gabbro where it is interpreted as the intrusion of magma into a crystal mush still containing interstitial liquid. It appears likely that this rapid textural variation in the nepheline rocks derives from a similar process and has been preserved in metamorphism.

Assimilation of nepheline rocks by granitic and syenitic intrusives

It is clear from the field mapping that nepheline bearing rocks were at one time more extensive than at present and that they have been assimilated on a large scale by the intrusion of granitic and syenitic magma and by the metasomatic activity of fluids derived from these magmas. Remnants of fresh nepheline gneiss within hybrid non-feldspathoidal syenite are

well illustrated by Hewitt (1960, p. 51). A description of another well-displayed example is given on p. 57 of this report.

In the road cuts at Esson Creek the alteration along fractures which have presumably acted as channelways for magmatic fluids is very clearly portrayed with a zonal arrangement of the greenish "gieseckite" and the brick red "hydronephelite". At this same locality the hybrid syenites developed by assimilation can be studied very readily. No general chemical study of the assimilation has yet been undertaken but one analysis of the pink intrusive syenite is presented in Table XXXVIII. It is not clear to what extent this syenite is a granitic derivative but it seems highly likely that it has originated by the assimilation of nepheline gneiss into granite. The particular example analyzed is a leucocratic rock but most appear to have retained the iron-rich biotite of the nepheline gneiss.

METAMORPHISM

The metamorphism of some of the rocks, principally the gabbros, has already been discussed. A brief attempt is made here to summarize the metamorphic history of the region.

A valuable contribution to the geological history of the Haliburton Bancroft district was the recognition of a two-fold division into the Haliburton and Hasting Highland Gneiss complex of higher metamorphic grade and the Hastings Basin of lower metamorphic grade by Hewitt (1957) and Hewitt and James (1955). Although Hewitt refers to the grade in the Haliburton

TABLE XXXVIII

		Norm	
SiO_2	65.52	Or	30.69
TiO_2	nil	Ab	64.77
Al_2O_3	20.09	Ne	-
Fe_2O_3	0.41	An	1.89
FeO	-	Cor	1.16
MnO	nil	Ct	0.32
MgO	0.28	Hyp	0.47
CaO	0.56	Fo	0.16
Na_2O	7.66	Fa	-
K_2O	5.20	Hem	0.42
P_2O_5	nil	Rest	0.14
CO_2	0.14		100.02
H_2O+	0.14		
H_2O-	nil		
	100.00		

Leucocratic pink syenite (non-feldspathoidal). (C.82675)
Otter Creek road cut. Highway 500. Lot 23, Con. XI, Monmouth Township.

Analyst: J. Gittins

and Hastings Highland Gneiss complex as "amphibolite-granulite facies" the highest grade characterized by the mineral assemblages described is the almandine - amphibolite facies, and although "pyroxene granulites" are described they are granulites only in the textural connotation.

It becomes clear from the present work, however, that the region did reach granulite facies metamorphism, although possibly for only a relatively short time. This is clear from the presence of hypersthene (orthopyroxene) in the gabbros (see pp. 28, 33). There is then something of an anomaly in that the remainder of the two townships exhibits almandine amphibolite facies metamorphism. Apparently disequilibrium is widespread.

At the same time one might reasonably enquire why evidence of granulite facies metamorphism is so limited. The answer might well lie as much in the chemical composition of the rocks as in the grade of metamorphism. In the gabbros the reaction

forsteritic olivine + plagioclase $\rightleftharpoons$ orthopyroxene

is particularly sensitive to granulite facies conditions and the crystal chemistry of the phases favours the reaction. Thus orthopyroxene is formed fairly readily.

Most of the other rocks however are lime rich or alkalic or both and it is entirely likely that rocks of such composition which have extensively adjusted toward the amphibolite facies will survive unaltered in the hornblende granulite facies. Only

in the pyroxene granulite facies, which was not reached, might calcic hornblendes be expected to break down. Far too little is known as yet about the stability of either calcic amphiboles or epidotes, particularly in the complex coupled reactions involved, to permit any categorical statement that they would not survive to higher grade essentially unaltered. It is possible, however, that the hornblendes might reflect the grade of metamorphism in their chemical composition and a study of the hornblendes might be one of the more rewarding investigations that remain to be carried out on the rocks of the area.

Another striking feature of the metamorphic history of the region is the very widespread appearance of scapolite in rocks of almost all compositions. It occurs in the igneous-textured gabbros as minute veinlets replacing plagioclase, in the amphibolitic gneisses and metagabbros as discrete grains, and is common in the nepheline rocks even forming scapolite gneisses in some instances. Evidence of a replacement origin is clear in some rocks but equally there is evidence of formation under the near magmatic conditions that must have accompanied the metamorphism of the Grenville orogeny for in places the scapolite forms pegmatitic patches with crystals up to several inches across.

The compositions range from fairly sodic to highly calcic, a number of analyses being given in Table XXXIX in addition to those already given in Tables XXIX and XXXI.

TABLE XXXIX

	1	2	3	4
SiO_2	54.84	54.73	57.89	47.6
CO_2	1.50	1.69	1.11	3.3
SO_3	0.05	0.39	0.03	nil
Al_2O_3	22.81	22.85	21.62	26.7
Fe_2O_3	0.10	0.08	0.07	0.53*
TiO_2	0.02	0.01	0.01	---
MgO	0.08	0.03	0.03	0.43
MnO	nil	nil	0.01	---
CaO	8.33	8.29	4.81	14.3
Na_2O	8.83	8.55	10.50	4.7
K_2O	1.06	1.08	1.16	1.13
H_2O+	0.26	0.13	0.44	0.72
H_2O-	---	---	0.06	---
CL	2.48	2.19	2.96	0.56
	100.46	100.02	100.70	99.97
less O=CL	0.56	0.49	.67	
	99.80	99.53	100.03	

*FeO

1. Scapolite (coarse pegmatic crystals) from calcareous gneiss, Lot 32, Con. XVII, Monmouth Township. (Ingmells and Gittins, 1968). For trace element data see Shaw (1960b, p. 270, specimen ON7).
2. Scapolite from pegmatitic skarn, Lot 13, Con. XVI, Monmouth Township in highway roadcut (Shaw, 1960a, p. 241).
3. Scapolite (blue grey) from syenitic pegmatite containing scapolite, feldspars, biotite and altered nepheline. (Shaw 1960a, p. 241).
4. Scapolite from scapolite-andesine-biotite-(calcite) gneiss C82592, Lot 3, Con. III, Monmouth Township (Shaw 1960a).

Analyst: 1,2,3. C.O. Ingamells: 4, J. Gittins.

Too little is known yet of either scapolite stability or the reactions by which it forms to allow any reasonable assessment of its significance in Grenville regional metamorphism. It is equally clear, however, that it offers one of the most fruitful avenues of study for the future elucidation of Grenville geology, and that its varied mineral associations imply a number of reactions by which it has originated.

There can be no reasonable doubt that partial melting has been widespread during the regional metamorphism which affected the area. Experimental studies of natural rocks and synthetic melts establish this point beyond dispute. The uncertainty lies in the extent to which melting can have occurred for we have no way of estimating either the geothermal gradient that existed a billion years ago or the amount of water that the rocks contained and which was therefore available for solution in a silicate melt. That the rocks were not dry, however, is abundantly clear from the prevalence of hydrous minerals in almost all the rocks of the area.

A basic problem in the geological history of the region is the number of major metamorphic episodes that have deformed the rocks. In the past it has been general to speak of "the Grenville metamorphism" on the assumption that only one major episode was involved. More recently certain structural features such as cross-folding have been described from various parts of the Grenville province and have been interpreted as

evidence of separate metamorphic episodes as have certain petrofabric stud es. Of course such data do not seem to say anything conclusive about the time interval separating the episodes.

There are, however, a number of petrological factors that might suggest polymetamorphism. There are distinct differences between the large granitic gneiss bodies such as the Cheddar and Anstruther granites and the smaller, massive, discordant intrusions such as the Hadley granite and the syenites intrusive into the Otter Creek nepheline gneiss band, and these differences seem to merit the designation of Older Granites and Younger Granites. Since the older granites are regionally metamorphosed and the younger ones appear to be very late-kinematic if not post-kinematic there appears to be a considerable time separation between their relative periods of emplacement. So far, however, geochronological studies have been unable to confirm this grouping.

STRUCTURAL GEOLOGY

No structural study of the area has been attempted and the only structural element that were measured during the field mapping was the attitude of foliation in gneissic rocks. It has already been pointed out that what appears to be bedding in the metasediments is actually foliation or cleavage. No faults have been shown on the map because although faults can

be recognized in the field there is nothing to indicate that displacement is other than minor in extent.

In the Glamorgan granite mass many linear features can be recognized in the outcrop patterns so well displayed on the airial photographs. Some of this may be jointing and some may be faulting but no analysis of it has been carried out.

Folding is readily observed in many rocks particularly where it is marked by the deformation of quartzite or pegmatite bands in limestone and its careful study could be expected to elucidate the deformational history of the region. However, no major folds of mappable proportions have been recognized.

ECONOMIC GEOLOGY

The principal mineral occurrences which have been actively prospected are summarized in the following pages. Since the radioactive mineral occurrences were the subject of a special study by Satterly (1956) while the mapping was in progress no special attention was devoted to them by us and Satterly's accounts are reproduced in slightly modified form here. Similarly a summary of Satterlys' notes on the other mineral localities taken from his earlier report on the mineral occurrences of Haliburton County (1943) is also reproduced since the original report is out of print.

A few generalizations can be made on the economic geology

of the region. Despite extensive prospecting activity no mine has been brought into commercial production lasting more than a year or two.

The greatest possibility seems to lie in non-metallic mineral deposits, of which the nepheline rocks offer the greatest promise. All considerations of nepheline rocks appear to be in terms of ceramic use and for this purpose the Glamorgan and Monmouth rocks contain too much iron to be profitably exploited in the forseeable future. It is, however, only a matter of time until diminishing bauxite supplies force the use of nepheline syenite as a source of aluminum and it is entirely conceivable that the nepheline rocks of the region may ultimately be quarried for this purpose.

APATITE

MONMOUTH TOWNSHIP

Concession XI, Lot 15

Old workings for apatite on lot 15, concession XI, Monmouth township, are situated north and south of the road that parallels the south boundary of the lot. In the south-west corner of the lot are several pits and an adit, all of which are overgrown. The adit is driven north into the side of a hill for a length of 30 feet. White carbonate veins containing pale-green apatite crystals are exposed in these workings.

Ten chains north of the road, near the top of a hill, a trench was put down on a carbonate vein cutting a graphic granite-pegmatite. Remnants of carbonate on the walls of the trench indicate that the vein may have been from 2 to 5 feet wide, trending N. 40° W. The vein can be traced northwest for 60 feet beyond the trench. The walls of the trench are covered with pink feldspar crystals from 3 to 6 inches in diameter. Dump material shows books of dark mica with a maximum diameter of 9 inches, minor amounts of titanite, and crystals of green apatite from 1 to 4 inches in diameter.

This deposit is described as Millar's phospate mine by Adams and Barlow (1910, p. 201, 383). There is no recorded production.

FELDSPAR

Concession VI, Lot 31, Glamorgan Township

A large area has been stripped and trenched on a granite pegmatite and quartz syenite pegmatite body intrusive into a larger area of syenite along the southern boundary of the Glamorgan granite mass.

In places the pegmatite is highly feldspathic (red microcline) with a very low quartz content but for the most part it contains green to black hornblende. The more hornblendic parts tend to be plagioclase-rich. An inclusion of coarse-grained syenite within the pegmatite has a marginal concentration of hornblende.

In 1965 a small mill was being erected for the concentration of feldspar but work subsequently lapsed.

MONMOUTH TOWNSHIP

Concession XI, Lot 26

A trench 45 feet long, 10 feet wide, and 3 feet deep, now full of leaves, has been put down on a syenite-pegmatite in lot 26, concession XI, Monmouth township, about 13 chains north from the road at a point 0.7 miles east from Otter creek. The pegmatite consists of pink feldspar, most of which is less than 12 inches and none greater than 18 inches in diameter; black biotite books as much as 4 inches in diameter; black tourmaline crystals with a cross-section of 3 inches; and, rarely fluorite. The country rock is a biotite syenite.

Concession XV, Lot 30

On lot 30, concession XV, Monmouth township, at 1 chain west of the fence between lots 30 and 31, an open cut 30 by 50 feet extends two-thirds of the way down the southwest face of a ridge 50 feet high. The rock is a graphic granite-pegmatite containing 25 per cent or more quartz. Rare accessory minerals are titanite, tourmaline, and calcite. Crystalline limestone, which may be an inclusion, occurs just southeast of the open cut, in contact with the pegmatite.

Industrial Minerals Corporation of Canada, Limited is reported to have operated this property from 1921 to 1924 with a production of 534 tons of second-grade spar.

GRAPHITE

MONMOUTH TOWNSHIP

Concession XIII, Lot 32

An open cut, 20 by 15 feet and 10 feet deep, on the south face of a hill just below its crest on lot 32, concession XIII, Monmouth township, exposes impure, white to grey crystalline limestone striking N. 55° E. and dipping 30 degrees or less to the south. The limestone contains one-half to one per-cent of disseminated graphite in flakes one-twentieth of an inch in diameter, but locally on joints and slips cutting across the bedding the graphite forms 10 per cent. In the back of the pit lenticular pegmatite stringers contain graphite flakes as much as one-quarter of an inch in diameter.

The crest of the hill is composed of pegmatite, and to the west pegmatite and biotite-hornblende gneiss are exposed. Another patch of crystalline limestone containing a few flakes of graphite occurs on the south slope of the hill to the south-east of the pit. These two occurrences of limestone are remnants or inclusions in the pegmatite or gneiss. The deposit is of no importance.

Concession XIV, Lot 35, North Half

Old workings occur at the base and top of a hill about four-tenths of a mile, at N. 50° W., from the farm-house. Two

pits, 10 by 10 feet and 10 feet deep and 10 by 10 feet and 3 feet deep, at the base of the hill expose a well-bedded crystalline limestone containing lenses of graphite-rich limestone, which is exposed only in the pits and not on the hill slope above. The foliation of the limestone is vertical and varies in strike from N. 45° W. at the base, to N. 25° W. on the slope, to N. 5° W. on the top of the hill. On the top of the hill three small pits, 11 chains from the two pits at the base, expose disseminated graphite in crystalline limestone. Phlogopite is present in varying amounts in different beds.

At the base of the hill the occurrence is lenticular and graphite distribution is spotty.

Concession XIV, Lot 35, South Half

The occurrence is near the line between lots 34 and 35, on both slopes of an east and west valley between hills just north of Wilbermere lake.

From broken float and a few outcrops a graphite gneiss has been traced for a possible width of 200 feet in an east-west direction, being bounded on the east and west by coarse pegmatite. The trend of the gneissic structure varies from N. 75° W., with a dip of 45° S., on the hill south of the valley to N. 5° W., with a vertical (?) dip, on the north

slope of the valley. This variation may be due to the influence of the two adjacent pegmatite masses.

The graphite flakes in the exposures on the south side of the valley range from one-twentieth to one-quarter of an inch in diameter and form on the average 8 to 10 per cent of the rock. To the north the percentage of graphite is lower, and it is doubtful from float samples if it would average 5 per cent. Present exposures do not permit a satisfactory estimate of the percentage of graphite present.

Concession XV, Lot 35, South Half

Old workings for graphite are to be found on the east face of the hill mentioned above in the north half of lot 35, concession XIV, and are 17 chains north from the base of that hill. The workings consist of a pit 40 by 25 feet and 20 feet deep and another adjacent but to the south of it, which is 25 by 20 feet and 7 feet deep. The rock exposed is a white crystalline limestone with the foliation marked by disseminated graphite flakes from one-tenth to one-eighth of an inch in diameter, and the graphite-bearing beds range from mere seams to beds 4 inches in thickness. The foliation strikes N. 35° W. and dips vertically. On the dump were found a few masses of solid amorphous graphite cut by stringers of flake graphite from one-twentieth to one-fifth of an inch in width.

Hand-picked material would average 10 per cent graphite. Several small dumps of such material lie adjacent to the pits. It is apparent from the size of the waste dump that only a small percentage of the limestone graded 10 per cent.

Concession XVI, Lots 34 and 35

The workings seen on lot 34, concession XVI, Monmouth township, consist of an inclined adit on the side of a hill just southwest of the dam on the creek about a quarter of a mile east of Wilberforce station on the Canadian National railway. The country rock is a crystalline limestone with interbeds of paragneiss. Disseminated graphite is present, the maximum amount being 10 per cent. Spence (1920, p. 27) reports that the inclined adit was 8 by 15 feet, and 100 feet long. The site of the old mill erected by the original owners in 1910 is just above this adit.

On lot 35, concession XVI, Monmouth township, about 30 chains by trail from the above location, there are four pits. The largest is an oval pit, 40 by 75 feet and 30 feet to the water level, in a clearing just to the east of the bush in which the three other pits occur. Spence states that this pit is reported to be 100 feet deep. The walls of the pit expose a contorted complex of grey to white crystalline limestone with inclusions of paragneiss. Some of the limestone contains no graphite or phlogopite, and the maximum content is 5 and 25 per cent, respectively. There is no well-defined graphite-bearing zone, and most

of the rock quarried was waste, judging from the size of the dump. Spence states that "the ore is comparatively low grade, probably averaging about 5 per cent of graphite". This must have been the material that was fed to the mill.

The Virginia Graphite Company operated the property from 1910 to 1913 and was succeeded by the Tonkin-Dupont Graphite Company, Limited. The mill was closed down in May, 1914 and was subsequently dismantled. Most of the ore fed to the mill probably came from the latter company's deposit at Maynooth in Hastings county.

IRON

Concession XV, Lot 27

On lot 27, concession XV, Glamorgan township, according to Adams and Barlow there "are several well-developed veins, one of which can be traced on its strike for over 60 yards, reaching in places a width of 4 feet. The vein matter is coarsely crystalline, and consists of pale pink calcite, with apatite, sphene, biotite, hornblende, orthoclase, and magnetite" (Adams and Barlow, 1910, p. 200). The magnetite constitutes about 50 per cent of the vein.

This is the so-called New York mine, on which a pit was sunk by C.J. Pusey about 1880.

Concession IV, Lot 35

Several pits were sunk on magnetite-titanaugite rocks

in the southwest corner of the lot and were probably reopened during the 1940's when the area was prospected for the Steel Company of Canada Ltd. The rock is described in detail on p. 82. The field relations of the rock are quite obscure. The Monmouth metagabbro lies to the east and a series of amphibolite gneisses underlie the pits but the rock in the pits is believed to be related to the basic nepheline rocks. Adams and Barlow (1910, pp. 155-156) grossly overestimated the size. Magnetite-rich rock is by no means abundant but the area would have to be stripped for an accurate estimate to be made. It clearly has no economic potential. The pits have become known in the literature as the "Pusey Iron Mine".

MICA

GLAMORGAN TOWNSHIP

Concession XV, Lot 28

The workings in lot 28, concession XV, Glamorgan township, 10 chains south of the schoolhouse, consist of 2 pits 1½ chains apart. The northeast pit is 7 by 7 feet and 6 feet deep; the southeast pit is 7 by 7 feet and 12 feet deep in an area of stripping 10 by 20 feet. These pits expose a calcite vein, which strikes N. 30°E., dips 70°NW., and is 7 feet wide in the northeast pit and from 5 to 7 feet wide in

the southwest pit. The walls of the calcite vein consist of an aggregate about 9 inches thick of books of dark mica ranging in size from less than 3 by 3 inches to as much as 5 by 7 inches. The mica is crossed by three sets of closely spaced fractures at 60 degrees to one another. Away from the walls the calcite contains a few books of mica, small crystals of apatite, and irregular stringers of pink to mauve fluorite. The country rock is a pink biotite granite gneiss with an aggregate of hornblende crystals from 3 to 6 inches in width developed adjacent to the vein.

The mica in this deposit is worthless, and the amount of fluorite present is negligible from an economic standpoint.

MONMOUTH TOWNSHIP

Concession X, Lot 13

The occurrence is on lot 13, concession X, Monmouth township, about 15 chains north of the abandoned railway right-of-way and 1 chain west of the boundary line between lots 13 and 14 and is an old pit, 10 by 15 feet, now partly filled with rock and overgrown with moss. The north wall of the pit is composed of an aggregate of hornblende, pyroxene, calcite, apatite, peristerite, and amber mica. The south wall exposes pink granite pegmatite. On the mica dump sheets as much as 10 by 14 inches show cross-checking and wrinkling, but some flawless mica is present.

Concession X, Lot 16

Old workings for mica occur in the northwest corner of lot 16, concession X, Monmouth township, northwest of McCue lake. The main working is a curved trench 95 feet long, 20 feet wide, and from 5 to 10 feet deep with a pit 25 feet in diameter and 15 feet deep. Several small pits occur to the northwest. The work was carried out about 1900, and the trench and pits are now overgrown. Rocks present are rusty syenite gneiss, crystalline serpentine limestone and pegmatite. Small books of amber mica and apatite occur in coarse white calcite vein material. Books as much as 16 inches in diameter are reported to have been found in the bottom of the pit.

Concession XII, Lot 23

There is an amber mica occurrence on the south side of the abandoned railway right-of-way, 1½ miles east of Tory Hill. The mica occurs in a flat vein, 4 inches thick, composed of amber mica, hornblende, and apatite. The country rock is a pink chloritized biotite granite.

Concession XII, Lot 23

An old pit 12 by 15 feet in diameter, now almost completely overgrown is 2 chains south of the abandoned railway right-of-way near the east boundary of the lot. Weathered books of amber mica are present in a gravelly soil. The largest

book found measured 4 by 5 inches. The country rocks are hornblende gneiss and biotite gneiss.

Apparently mica from this deposit was sold during the 1914-18 war.

Concession XV, Lot 35

On the western slope of a rock ridge in lot 35, concession XV, Monmouth township, several trenches have been put down on veins carrying mica. The largest trench trends N. 85° E. and is 70 feet long, 10 feet wide, and from 6 to 10 feet deep. Some 100 feet north of it there is another trench 25 feet long, from 12 to 30 feet wide, and 20 feet deep.

The country rock is a white-, pink-, or brown-weathering biotite-poor gneiss striking N. 30° W. to N. 5° E. and dipping 80° E. The trenches expose a series of veins of irregular strike and dip, composed of phlogopite, pyroxene, calcite and green apatite. In places the veins are wholly composed of a crushed aggregate of phlogopite in books as much as 10 inches in diameter, but mainly less than 3 inches and sometimes a quarter of an inch in diameter.

MOLYBDENITE

GLAMORGAN TOWNSHIP

Concession V, Lot 32

A molybdenite prospect, acquired by British Molybdenite,

Limited, in 1919 is 17 chains north of the road on the boundary line between concessions IV and V. The workings consist of an open cut 30 feet long with a 10- to 12-foot face and a stripping extending 70 feet from the open cut to some test pits. The rock exposed is a very pale greenish-white, siliceous rock showing no trace of bedding. No other rocks are exposed in the adjacent fields. It may be an intrusive. Irregular stringers, lenses and grains of glassy quartz occur in the rock. Pyrite is present in splashes as much as 1 inch in diameter. A few molybdenite flakes of one-eighth of an inch in diameter were seen at one place.

Concession XIII, Lot 34

A shallow pit, 15 by 25 feet, 10 chains north of Little Bear Lake (Little Glamor Lake) exposes rusty quartzitic gneiss and a pegmatite containing pyrite and pyrrhotite.

Tory Hill Marble and Mica Company, Limited mined mica from the same lot.

MONMOUTH TOWNSHIP

Concession XII, Lot 14

The old Lillico mine is situated in lot 14, concession XII, Monmouth township, 16 chains S. 15° W. from the northeast corner of the lot. The main workings consist of

one open cut 200 feet long, 100 feet wide, and 5 to 10 feet deep and another to the southeast 60 by 50 feet and 10 feet deep, nearly filled with water.

In the large open cut the floor exposes granite gneiss and hornblende gneiss. No molybdenite was seen. The shaft marked on the sketch in Eardley-Wilmot's report (1925, p. 113) was not found and must be filled in. On a 5-foot face at the southeast side of this open cut tourmaline pegmatite containing coarse pyrite, a little molybdenite, and pyrrhotite cuts flat-lying brownish granite gneiss.

At the northwest edge of the smaller open cut, pyrite and molybdenite were found in pegmatite. On the dump here pyrite was found in masses as much as 5 inches in diameter.

The deposit was apparently a flat-lying body, which has been largely mined out.

R.J. Lillico for the Ontario Molybdenum Company, Limited, shipped in 1917 55 tons of 1.01 per cent MoS_2 ore, from which 1,117 pounds of molybdenite was recovered; and in 1918, 102 tons of 0.533 per cent MoS_2 ore, from which 680 pounds of molybdenite was recovered. About 3,000 tons of ore and rock were mined to obtain the above amounts of shipping ore. Work ceased in August, 1918.

Concession XIII, Lot 13

In 1916 a quarry face 50 feet long and about 10 feet high was opened and a shipment of 1,300 pounds of hand- picked ore, running 3.85 per cent MoS_2 sent to the Mines Branch, Ottawa.

The quarry, which is 2 chains north of the south boundary of the lot and 4 chains east of the west boundary, now has a length of 130 feet from east to west and a width of 120 feet from north to south. One pit in the northwestern part of the quarry floor measures 25 by 30 feet and 15 feet in depth; another in the southeastern part measures 40 by 25 feet and from 1 to 4 feet in depth. The enlargement of the quarry was made by Canadian Molybdenite Mines, Limited, in 1939.

The country rock is a flat-lying hornblende-feldspar gneiss with a few lit par lit stringers of hornblende pegmatite. The gneissic structure trends N 80° W. and dips 10° S. The hornblende gneiss is slightly mineralized with large flakes of molybdenite, coarse pyrite, and pyrrhotite occuring in part in flat sulphide veinlets parallel to the gneissosity. The mineralization is very spotty, some bands of gneiss several feet thick showing none. Cutting the gneiss are several 1- to 4-foot wide pink pegmatite dikes.

A small stock pile adjacent to the pits actually shows very little molybdenite.

Concession XV, Lot 11

The occurrence was first opened in 1916 and a shipment of 55.6 tons of hand-picked ore, grading 1.4 per cent MoS_2 sent to the Mines Branch, Ottawa, from which 1,268 pounds of molybdenite was recovered; in 1917 62 tons of 1.0 per cent MoS_2 was shipped to the International Molybdenum Company's concentrator at Renfrew.

Additional development on this property and the lot to the south was by Canadian Molybdenite Mines, Limited, in 1940. On the site of the old workings there is now a pit, which trends N. 20° W. and is 150 feet long, 10 to 50 feet wide, and from 1 to 10 feet deep. The south end of the pit is 1 chain north of the Essonville road at the south side of the lot. This pit exposes cream, pink, green, and white banded crystalline limestone containing some bands rich in phlogopite or diopside and inclusions of hornblende gneiss. About the centre of the pit there is a mass of rusty basic pegmatite, perhaps 10 by 3 feet in size, which contains much pyrite and a few large flakes of molybdenite. The limestones dip gently to the south.

A new excavation, circular in shape, 4 feet deep and 30 feet across, was put down 16 chains north of the south boundary of the lot and 3 chains east of the west boundary. It exposes green, grey, and white diopside-phlogopite crystalline

limestone containing accessory graphite and cut by pegmatite dikelets. No molybdenite was seen.

Two trenches were put down by the same company in the lot to the south, that is, lot 11, concession XIV. The trenches extend eastward from the west boundary of the lot and are 15 and 17 chains south of the north boundary of the lot. The north trench, trending N. 65° E., was 80 feet long, from 2 to 3 feet wide, and 4 feet deep. It is now caved in, and exposes a decomposed crystalline limestone. The south trench, trending N. 75° E., was 85 feet long, from 5 to 10 feet wide, and from 4 to 6 feet deep. It exposes crystalline limestone with phlogopite, diopside, and accessory grains of pyrite and is cut by granite and pegmatite dikes. No molybdenite was seen in these trenches.

It would appear that in 1916 and 1917 a small body of ore was mined out and that later exploration has failed to reveal any commercial bodies of molybdenite.

Concession XV, Lot 17

The occurrence is 6 chains north of the Essonville road. A pit 20 by 12 feet and 4 feet deep exposes a hornblende gneiss injected <u>lit par lit</u> by pegmatite. At the bottom of the south side of the pit a rusty sulphide-bearing band, which is 1 foot thick and carries pyrite and a few large flakes of molybdenite, is exposed. The dip is 20° S.

Concession XV, Lot 33

The prospect was opened up by the Wilberforce Molybdenite Company, Limited, in 1917.[1] The workings are on a bare knoll just west and south of some farm buildings. At 2½ chains north of a side road there is a trench trending N. 65° E., which is 100 feet long, 10 feet wide, and 10 feet deep and has a pit at the west end 20 feet deep. At 5 chains north of the road stripping and small pits expose rusty-weathering mica-pyroxene gneisses. The trench exposes a complex of banded gneisses containing bands rich in phlogopite and pale-green pyroxene; one band consists of calcite, actinolite, and minor quantities of fluorite and sphene. The gneisses are cut by a dikelet of feldspar-apatite-pyroxene rock. Rusty gneisses contain pyrrhotite, and one 1-inch flake of molybdenite was found.

It is reported locally that some additional pitting in the trench was carried out in recent years, but little or no molybdenite was found.

Concession XVI, Lot 31

In 1942 work consisting of stripping and shallow test pits or trenches was done on a low ridge trending N. 10° E.

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[1] The reference in Ont. Bur. Mines, Vol. XXVII, 1918, pt. 1, p. 143, has Cardiff township in error.

The showings are reached by going west from Wilberforce for three-quarters of a mile, north on a bush road for one-quarter of a mile, and then 12 chains northeast to the top of the ridge. The rocks exposed are pyroxene crystalline limestones showing a pronounced banding and injected by narrow sills of albite-smoky quartz pegmatite. Stringers of calcite-apatite-pyroxene rock cut these rocks. A few flakes of molybdenite and pyrite occur in the pyroxene-calcite rock. Lower down the ridge graphic granite-pegmatite is exposed. Since the pyroxene crystalline limestones are flat-lying, it would appear that the pyroxene-calcite rock is a contact zone developed adjacent to a mass of graphic graphite-pegmatite and is possibly not more than 20 feet thick at this locality.

This property was trenched and drilled quite extensively as a uranium property in the 1950's (see Homer Yellowknife Mines, Ltd., and Desmont Mining Corporation, Ltd., pp. 45-48). It was subsequently drilled for molybdenum again in 1966 and later abandoned.

Concession XVI, Lot 32

The stripped and trenched areas lie 7 chains south of the abandoned railway right-of-way and four-tenths of a mile west of the highway at Wilberforce. Two shafts reputed to be 30 and 40 feet deep now lie in swamp and are filled with water. The ruins of an old mill can be seen. The rock is a peculiar pyroxene-feldspar assemblage with disseminated molybdenite and is described

more completely on pages 17-18. Molybdenite flakes up to an inch across are to be seen but there is neither aerial nor apparently vertical extent to the body. Exploration was in 1917 and again in 1965 when fresh trenches were sunk and a pair of scissor holes drilled. Shipments in 1917 to the Mines Branch in Ottawa were 58.6 tons of 0.205 per cent ore from which 168 pounds of molybdenite was extracted; in addition 27.2 tons of 0.39 per cent ore was sent to Renfrew and 152 pounds of molybdenum recovered.

Concession XVII, Lot 32

The workings are reported to be near the middle of the east boundary of lot 32, concession XVII, Monmouth township, about 1¼ miles northwest of Wilberforce on the abandoned railway right-of-way. On the west side of the bush-covered ridge two excavations were made in 1921, and some further work was done on one of these in 1940. No surface work was carried out, but a few short holes were drilled in the autumn of 1942.

The north opening, near the north end of the ridge, consists of a pit 7 feet wide, 8 feet long, and from 5 to 8 feet deep at the base of a cliff face. From the top of the cliff to the bottom on the pit is about 25 feet. A drift 6 feet wide and 7 feet high has been driven 10 feet into the base of the cliff from the bottom of the pit. A few chains south there is a shallow open cut on the same cliff.

The pit and drift at the north end of the ridge expose a medium- to coarse-grained, light-green pyroxenite very sparsely mineralized with large flakes of molybdenite, pyrite, and pyrrhotite. In the pit crumbly crystalline limestone and pegmatite occur. These rocks may be the footwall of the pyroxenite band. Overlying the pyroxenite band and exposed in the cliff face are interbedded rusty pyroxene and biotite paragneiss trending N. 25° W. and dipping 45°E.

The open cut to the south shows rusty paragneiss underlain by pyroxenite with an exposed thickness of 4 feet. Scattered molybdenite flakes were found.

NEPHELINE

The principal occurrences of nepheline are described on pages 38-68.

RADIOACTIVE MINERALS

The descriptions of these occurrences have been condensed from the report by Satterly (1957, pp. 77-107). Locations of the various occurrences are shown on the coloured geological maps that accompany this report. Except for a few modifications, the descriptions are of the properties as they appeared in 1956 and allowance should be made by the reader for inevitable slumping of trench walls and re-growth of the bush. No work has been done on any of these properties since 1956 except for one which has been re-examined for molybdenum (pp. 45-48).

GLAMORGAN TOWNSHIP

CASSIAR RAINBOW GOLD MINES, LIMITED

In 1955 the property of Cassiar Rainbow Gold Mines, Limited, comprised 10 lots in the southeast corner of Glamorgan township, 4½ miles by road from Gooderham.

Exploration

A scintillometer survey of the property was completed in July, 1955. This indicated six radioactive anomalies. In 1955 and 1956 granite pegmatite bodies were explored by one drill-hole 731 feet in length[1], and by six packsack drill-holes totalling 288 feet[2].

General Geology

The property is underlain by paragneiss, marble, metagabbro, nepheline gneiss, syenite, granite, and granite pegmatite. The metasediments strike N. 30°E. and dip 40°SE.

Economic Geology

A granite pegmatite in the southern third of lot 35, concession I, has been explored by one drill-hole, 731 feet long. This hole intersected 26 dikes of pegmatite, only 6 of which were over 5 feet in core length. The log does not record any radio-

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[1] Ont. Dept. of Mines, File No. 17179.

[2] Ont. Dept. of Mines, File No. 109220.

activity in the pegmatites; allanite is noted as an accessory in one biotite granite pegmatite dike.

In the north part of lot 34, concession II, a weakly radioactive, pink, coarse leucogranite pegmatite with patches of graphic granite has been explored by four packsack drill-holes. The pegmatite body is about 100 by 300 feet in dimensions, and gave geiger readings of 3x-6x, with rare spot-highs to a maximum of 10x. No radioactive minerals were seen.

In the south half of lot 34, concession III, a small exposure of leucogranite pegmatite has been explored by two packsack drill-holes. Geiger readings were 1x-5x. Tourmaline and biotite are recorded as accessories in the diamond-drill logs.

NU-CYCLE URANIUM MINES, LIMITED

In 1955, Nu-Cycle Uranium Mines, Limited, held lots 25 and 26 in concession III, and lots 25-28 in concession II, Glamorgan twonship, Haliburton country. The property is 1.6 miles south of Gooderham.

Exploration

Radioactive granite, pegmatitic granite or granite pegmatite, occurs on these lots as bodies cutting metagabbro. The company explored these occurrences by 16 pits and trenches and by 21 drill-holes totalling 4,309 feet. The showings are in lots 26-28, concession II.

General Geology

The property lies within a large body of metagabbro to the south of the Glamorgan granite. Cutting the metagabbro are a large number of small-to-large dikes or irregular bodies of granite, pegmatitic granite, or granite pegmatite.

Economic Geology

The bodies of granite and granite pegmatite contain erratically distributed radioactive minerals. The uranium-bearing mineral observed in uranothorite, which occurs in feldspar, but more frequently within or closely associated with magnetite, biotite, or pyroxene. The very spotty distribution of these three minerals in the granite bodies may account for the erratic distribution of uranium in the showings. Geiger readings average 10 times the background.

Description of Showings

No. 1 is an open-pit, possibly 70 by 140 feet in dimensions; rock has been blasted, but not removed, from an area 150 by 250 feet. The rock is a red leucogranite pegmatite with rarely magnetite, biotite and pyroxene.

Accessory minerals are allanite, zircon, and black and orange uranothorite. Geiger readings were 7x-12x over the broken rock, and might average 10x.

No. 2 is a 30-foot trench and exposes red leucogranite pegmatite, in part graphic granite, with black quartz, spotty distributed coarse magnetite, and accessory zircon and black uranothorite. Geiger readings were 4x-7x, and might average 6x.

No. 3 is a 40-foot trench in red-to-pink leucogranite and leucogranite pegmatite with, rarely, a little biotite. Geiger readings on the adjoining outcrop were 4x-6x and, in the trench, 4x-9x, with a spot-high of 17x. At the spot-high, magnetite, allanite, zircon, and rarely, uranothorite were noted. No. 4 is a 50-foot trench on an irregular east-west dike 25 feet wide of leucogranite pegmatite with accessory biotite, magnetite, allanite, zircon, and uranothorite. A little yellow uranium stain is present. Geiger readings across the dike averaged 8x with spot-highs, on fractures, up to 17x.

No. 5 is a 20-foot trench in leucogranite pegmatite that contains accessory magnetite, biotite, zircon, allanite, pyrite, and uranothorite.

No. 6 is a series of workings on an outcrop slope. Geiger readings on the exposure were 5x-8x with spot-highs to 17x on a fracture. The rock is a leucogranite or pegmatite with accessory biotite, magnetite, allanite, and zircon. In an old trench containing allanite, a geiger reading of 9x, and spot-highs to 15x were obtained.

Nos. 7 and 8 are shallow trenches in pink leucogranite or leucogranite pegmatite with peristerite, smoky quartz, and yellow uranium stain on fractures. Accessory minerals are magnetite, allanite, and yellow-green-to-orange uranothorite. Geiger readings on the outcrop area were 2x-5x and might average 4x. One spot-high of 8x was found. Trench No. 7 gave readings of 5x-8x with a spot-high of 15x and trench No. 8, 5x-10x with a spot-high of 15x.

No. 9 is a 15-foot wide open-pit, with blasted rock filling the pit. It exposes red, shattered or sheared, leucogranite with black quartz, locally much magnetite, altered pyroxene, and inclusions of amphibolite. Accessory minerals are zircon and uranothorite. Geiger readings over the broken rock were 10x-12x with a spot-high of 40x. Outside the area of the pit geiger readings were 4x-8x.

No. 10 is a trench on leucogranite with streaks of mafic minerals. The colouring is patchy, from red to buff,

following a gneissic structure. Inclusions of amphibolite are present. Geiger readings were 12x-25x. There is no rock exposure around the trench.

No. 11 is a 20-foot-long trench in a 20-foot dike striking N. 60° E., and dipping 45° S. of purple-red leucogranite with bands of grey quartz, and red patches of pegmatite. The country rock is a coarse amphibolite or metagabbro. Accessory minerals in the dike are magnetite, allanite, zircon, pyrite, and uranothorite in the magnetite. Geiger readings were 10x-25x with a spot-high of 30x.

No. 12 is a 40-foot long trench exposing leucogranite with bands of grey quartz and patches of pegmatite. Accessories are rare, and include magnetite, biotite, allanite, uranothorite, and the secondary mineral, uranophane. Geiger readings were 7x-12x with spot-highs to 20x.

No. 13 is a 20-foot long trench wholly in leucogranite like No. 12. Accessory minerals noted are magnetite, allanite, zircon, and uranothorite. Geiger readings were 12x-28x.

Nos. 14 and 15 are two 10-foot-long trenches, 50 feet,apart, exposing red leucogranite with pegmatitic patches, black quartz, and accessory allanite, magnetite, zircon, and, very rarely, black and orange uranothorite.

No. 16 is an open-cut in a ridge of granite pegmatite and leucogranite. The exposed width of the sill of pegmatite is 80 feet, the south contact with metagabbro being exposed. This contact strikes S. 45° E. The ridge is 50 feet high and continues southeast for 250 feet. The pegmatite contains grey-to-black quartz, peristerite, spotty bunches of pyroxene grains, and accessory allanite and magnetite. No uranium mineral was found. Geiger readings were 7x-12x with spot-highs to 15x.

NU-WORLD URANIUM MINES, LIMITED

In 1955, Nu-World Uranium Mines, Limited, held by staking or under option, 18 claims, in concession I-III, and patented lot 20, concession II, in the southern part of Glamorgan township 3.7 miles by road south of Gooderham.

Exploration

Bodies of granite pegmatite in marble have been explored by bulldozed strippings, trenches, and diamond-drilling. In 1955 the main showing, in the south half of lot 19, concession II, was explored by 12 drill-holes totalling 1,506 feet. Drilling amounting to 419 feet in

10 short holes was carried out in the north halves of lots 15 and 16, concession III, in late 1955.

General Geology

The property is underlain by paragneiss, marble, metagabbro, nepheline gneiss, syenite, and granite pegmatite. The metasediments and syenitic and granitic rocks form an embayment in the northwest contact of the Greens Mountain metagabbro mass, which is exposed on the southern part of the property or to the east of it.

Economic Geology

Radioactive occurrences in granite pegmatite dikes have been exposed by trenches on the east slope of a hill in an old clearing along a line approximately N. 80° W.

The pegmatite bodies in the surface workings range from 20 to 130 feet in width over a length of 725 feet. Diamond-drill intersections were from ½ to a maximum of 52 feet, but most of the intersections were 10 feet or less, much narrower than those found on surface.

The geiger readings on these pegmatite bodies were low, ranging from 7-10x count to occasional spot-highs of 15-30x.

Description of Showings

In the following description the trenches have been numbered from east to west. The distances between the trenches were measured by pacing.

Trench No. 1, the most easterly, is in the south half of lot 19, concession II. Pink leucogranite pegmatite and coarse graphic granite are exposed for 20 feet in contact, at the south end of the trench, with marble. Lenses of calcite up to 6 inches in length are present in the pegmatite. Uranothorite is a rare accessory mineral in grains 1/16--1/4 inch across. Allanite occurs in 1-inch plates at the boundaries of the calcite lens. A few flakes of molybdenite were noted in the marble. Geiger readings on the dike were 7x-10x, being highest at the contacts.

Trench No. 2, 75 feet west of No. 1, exposes a similar dike for 52 feet, also in contact with marble at the south end. The marble strikes N. 85° E., and dips 20° S. In the dike uranothorite is a rare accessory in black grains; black tourmaline occurs with quartz, and sphene was noted in the pyroxene phases of the pegmatite. Geiger readings were 7x-15x, with a spot-high of 30x, 7 feet from the south contact.

Trench No. 3, 100 feet west of No. 2, exposes a similar dike for a width of 46 feet, only the south contact with marble being exposed. Most of the dike is a very pale pink leucogranite pegmatite or graphic granite. Calcite is present as pods or lenses, or coating vugs. Coarse pyroxene up to 3 inches across is associated with the calcite, Geiger readings are low, mainly 3x, with readings of 7x for 12 feet at the south end of the trench.

Trench No. 4, 100 feet west of No. 3, is 90 feet long. From the south end it exposes 0-48 feet of marble and 48-90 feet of pegmatite, which continues beyond the trench to 110 feet. Beyond a 10-foot gap, marble is exposed. The banding in the marble strikes N. 85° E. and dips 40° S. The possible width of the dike is, therefore, 70 feet. The pegmatite is similar to that in the other trenches, and contains calcite pods or lenses up to ½ by 2 feet. Black uranothorite is a rare accessory, and occasional flakes of molybdenite up to 1 inch were noted in small masses of metapyroxenite adjacent to pegmatite. Geiger readings on the dike rock were 8x-16x, with two spot-highs of 20x.

Trench No. 5 and stripping is 100 feet west of No. 4. From south to north it exposes 0-82 feet in a stripping (marble), 82-117 feet in a trench (pegmatite),

and 117-410 feet in a stripping (marble). The pegmatite is the same as above, with geiger readings of 6x-10x.

Trench No. 6 and stripping is 150 feet west of No. 5. From south to north it exposes 0-180 feet in a stripping (marble), 180-200 feet in a trench (pegmatite), and 200-300 feet in a stripping (marble with interbeds of rusty-weathering sand gneiss). The granite pegmatite is quartz-rich, grey-to-brown in colour, and gave geiger readings of 6x-10x with a spot-high of 16x.

Trench No. 7 and strippings is 200 feet west of No. 6. From north to south it exposes 0-54 feet in a trench (pegmatite with geiger readings of 6x-20x with a 20-foot section of 27x-30x), 54-65 in a stripping (pegmatite), 65-76 feet in a pit (pegmatite with geiger readings of 8x-15x), 76-130 feet in a stripping (pegmatite), and 130-170 feet in a stripping (marble). The dike rock is a grey or pink leucogranite pegmatite with pyroxene grains, ½-2 inches across, as an accessory. The quartz is smoky grey in colour. Uranothorite is a rare accessory, and a few flakes of molybdenite were noted.

The last showing, No. 8, is a 350-foot stripping 200 feet west of No. 7. It exposes marble with rusty sandy gneiss interbeds. The banding strikes N. 80° E. and dips 50° S.

MONMOUTH TOWNSHIP

ACMAC MINING CORPORATION, LIMITED

Exploration

A pyroxenite mass in marble has been examined by an open cut 56 feet long, and an adit 34 feet long, in a direction S. 50° E. In a clearing on a hill about 50 feet above the adit a graphic granite mass has been explored by two trenches and three open cuts, totalling 425 lineal feet.

General Geology

The property is underlain by marble, metamorphic pyroxenite, and amphibolite, intruded by a mass of graphic granite.

Economic Geology

The workings are in the north part of lot 33, concession XIV. The adit is near the base of a hill about 50 feet in height. The adit and open cut expose mica pyroxenite and diopside rock, containing patches of calcite and albite, for an exposed thickness of 10 feet. These rocks strike N. 50° W., and dip 55° S.W. Overlying this band is a layer of grey marble about 10 feet thick. This marble, as a marble tectonic breccia, is exposed in the adit at the face,

the banding dipping 45° S.W. On the hill slope above the adit portal a shallow trench or stripping exposes granitized amphibolite cut by an irregular granite pegmatite dikelet ½-2 feet thick. Geiger readings were very low, 1x-2x, with a spot-high of 4x on mica pyroxenite. No radioactive minerals were found. The silicated marble contains diopside, augite, phlogopite, and sometimes a pale-green apatite. In the skarn material, which consists of coarsely crystalline calcite-augite, the accessories are sphene, apatite, phlogopite, pyrrhotite, and pyrite.

The hilltop workings above the adit expose a mass of graphic granite about 200 feet across overlying a limy amphibolite, which dips 25°-35° S. and strikes N. 75°-90° E. Areas of marble with abundant pyroxene and phlogopite exposed in the trenches may be remnants of the rock overlying the graphic granite. The maximum exposed thickness of the granite is about 15 feet.

The pale-pink graphic granite has low radioactivity with geiger readings of 2x-10x, the background count on marble being 300-700 counts per minute. The contact zone of the granite mass is a pyroxene-poor granite with altered pyroxene crystals, 1/8-1/2 inch across, accompanied by abundant accessory sphene. This material in the open cuts

gave geiger readings of 20x-80x. The radioactive mineral observed is uranothorite. In the second open cut to the east abundant amber grains of uranothorite accompany small crystals of sphene in a quartz-feldspar aggregate around large, 1-4 inch, pyroxene crystals. In the most westerly open cut a highly fractured zone, 1 foot thick, with a platy parting, is present at the contact with the underlying limy amphibolite. This zone contains abundant altered, earthy-red, crystals of thorite, 1/16-1/4 inch across, replaced by amber grains of uranothorite, quartz, and other minerals. Minute black grains of uranothorite accompany the thorite crystals.

CANADIAN ALL METALS EXPLORATIONS, LIMITED

In 1955, Canadian All Metals Explorations, Limited, held a group of eight claims, being lots 5-8 and patented lot 9, concession IX, and lot 6, concession VIII, Monmouth township. The adit can be reached by driving along the abandoned railway right-of-way from the Tory Hill-Gooderham road.

Exploration

Radioactive showings were explored in 1955 by bulldozing, trenching, diamond-drilling, and an adit. The diamond-drill program comprised 38 surface holes, totalling

5,040 feet, and 4 underground holes, totalling 531 feet. The underground development in the adit amounted to 642 feet of crosscuts and 490 feet of drifts.

General Geology

The property is underlain by a complex of marble,[1] quartzite, paragneiss, and granite gneiss being on the southeast border of the Glamorgan granite gneiss mass. The prevailing strike of the metasediments is N. 50° E., and the dip 30° S.E.

Economic Geology

Radioactive mineral showings are found in zones in silicated marble containing tremolite, pyroxene, mica, serpentine, and stringers, lenses, and pods of salmon-pink calcite. The radioactive minerals are uraninite (thorian) and pyrochlore disseminated somewhat erratically.

North Showing.-- The North showing has been explored by 13 bulldozed strippings and some trenching over a length of 1,300 feet in a direction N. 40° E. These workings expose silicated marble with erratically distributed lenses and stringers of salmon-pink calcite and lesser amounts of quartzite and paragneiss. Accessory minerals in the marble include pyroxene, phlogopite, uraninite, and pyrochlore.

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[1] Heinrich (1966, p. 379) leaves the misleading impression that this is a carbonatite complex; it is not.

Geiger readings were 5x-12x, with erratic spot-highs of 17x-55x usually either on lenses of salmon-pink calcite or on mica-rich bands in the marble. Uraninite and pyrochlore were noted at some of these spot-high locations. Apatite was noted in coarsely crystalline white calcite near the north end of these workings.

The main showing, which is undercut by the adit workings, is in a bulldozed area about 40 by 120 feet. A 20-foot long trench in this exposes a 4-foot band of silicated marble, overlain by quartzite and underlain by a lime-silicate rock with mica gneiss interbeds. These rocks strike N. 45° E. and dip 40° S.E. The silicated marble contains pyroxene, mica, salmon-pink calcite, and rarely, grains or cubes of uraninite. Geiger readings were 25x-50x, the higher readings being on mica-rich sections. The footwall of the marble band is a rusty mica gneiss, 1-3 inches wide and dipping 30° S.E. In the bulldozed area outside the trench geiger readings were 4x-12x on marble. Towards the southwest end of this area a single round grain, ¼ inch across, of pyrochlore[1] has been found.

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[1] Identified by S.C. Robinson of the Geological Survey of Canada.

A partial analysis of this pyrochlore is given below (quoted from Satterly (1957, p. 20)).

Na_2O	0.2
CaO	6.7
MnO	0.4
PbO	2.5
MgO	2.2
La_2O_3	0.1
U_3O_8	13
ZrO_2	0.1
SnO_2	0.2
ThO_2	0.6
SiO_2	5.1
Al_2O_3	0.6
Fe_2O_3	5.3
TiO_2	12
Nb_2O_5	36
	85.0

Analyst: W.O. Taylor, Provincial Assay Office; spectrographic analysis.

The adit[1] crosscut intersects interbedded marble, diopside rock, well-banded diopside-tremolite rock, quartzite, and bands of salmon-pink calcite. A pink leucogranite sill

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[1] A plan of the adit is given by J. Satterly, (1957, Fig. 12).

intrudes one of the quartzite bands. The metasediments strike northeast and dip 30°-75° S.E., but in places, are flat-lying. The marble ranges from a coarsely crystalline white rock, to pale green, to a banded rock with silicate minerals such as serpentine, diopside, phlogopite, and talc (?). The diopside rocks contain numerous gash veins or stringers of calcite-hornblende, and accessory pyrite, pyrrhotite, and molybdenite.

The radioactive zones are discontinuous lenses that consist of coarsely crystalline salmon-pink calcite with accessory diopside, tremolite, phlogopite, pyrite, and pyrrhotite. The strike, dip, and thickness of the zones intersected by the crosscut are very variable. It parallels the strike and dip of the enclosing metasediments. The dip is 25°-65° S.E. and may average 45° S.E. The uranium minerals are pyrochlore in brownish grains 1/16-1/4 inch across, sometimes showing hexagonal outlines in cross-section and, more rarely, grains of uraninite. The uranium minerals are disseminated sparsely or in bands 1 inch or less in thickness parallel to the dip of the zone and country rock.

Track Showing.--The Track showing is in the south half of lot 6, concession IX, just north of the Canadian National railway right-of way. In 1955 this showing was

explored by three pits, bulldozed strippings, and diamond-drilling. One pit, 130 feet north of the railway track, exposed a micaceous serpentine marble with occasional stringers of salmon-pink calcite and rare accessory uraninite in cubes 1/16-1/4 inch across. The serpentine contains relict forsterite.

Geiger readings were 5x-100x and averaged 25x across 12 feet north-and-south. A second pit, 100 feet north of the railway track, exposed marble containing pale-green pyroxene, phlogopite, streaks or patches of pink calcite, and accessory uraninite as grains, and cubes or interpenetration twins of from 1/16 to a maximum of 1/2 inch across. The bedding strikes N. 65° E. and dips 45° S.E. Geiger readings averaged 10x with spot-highs of 30x. A small stripping and test hold, 40 feet east of the last, exposed silicated marble.

CORDELL GOLD MINES, LIMITED

The Monmouth property of Cordell Gold Mines, Limited, comprised nine claims to the northeast of Esson Lake and 2.1 miles by car and tractor road west of Wilberforce.

Exploration

Two showings have been explored by shallow stripping and trenching and by six drill-holes totalling 541 feet. The

main showing on the north side of a small lake in the south half of lot 27, concession XVI, was explored in early 1955 by five holes. A second showing, in the north half of lot 28, concession XVI, had one vertical hole drilled on it.

General Geology

The claims are largely underlain by marble, lime-silicate rocks, and metamorphic pyroxenite cut by small bodies of granite.

Economic Geology

The main showing at the north side of the small lake is an exposure of medium-grained, pale-green, diopside rock about 50 feet long and 15 feet wide. Patches of mica are present, and the accessory minerals are sphene, pale-green apatite, phlogopite (?), pyrrhotite, and pyrite. Fracture planes are coated with scattered grains of sphene and, more rarely, uraninite. The diopside rock is cut by veins of white albite and one fissure vein of salmon-pink calcite in which the walls are lined with albite and mica. Geiger readings were 4x-10x with occasional spot-highs on uraninite grains. The shallow holes below this exposure cut diopside rock with high radioactivity over widths of 1-2 feet at depths up to 25 feet.[1]

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[1] Ont. Dept. Mines, File No. 52324.

A second showing is ½ mile east of the small lake beside the drill road and was explored by one drill-hole. A pit through 4 feet of overburden exposes tremolite-phlogopite marble. Geiger readings in the pit were 25x-30x with a spot-high of 40x. At the spot-high a few grains, 1/60/1/30 inch, of uraninite surrounded by a red halo were found. The disintegrated marble with much mica thrown out around the pit gave geiger readings of 10x-20x with a spot-high of 40x. There are no other rock exposures in the immediate vicinity of this pit.

T. CUDNEY

The T. Cudney property comprises lots 29 and 30, concession XVI, Monmouth township, Haliburton country. Mountain and Cockle lakes occupy parts of the lots.

Exploration

In 1955 lots 29 and 30 were prospected by over 20 bulldozed strippings.

General Geology

The property is underlain by marble, lime-silicate rocks, and minor pegmatite.

Economic Geology

In lot 29, concession XVI, the bulldozed strippings expose mainly disintegrated or decomposed marble containing various silicates, such as mica, pyroxene, and scapolite; diopside rock; mica metamorphic pyroxenite; amphibolite; and rarely, pegmatite. Geiger readings on the bulldozed strippings were 1x-3x with spot-highs to 12x, and rarely, to 20x. The average is probably about 3x. At the 20x location a pale-green diopside rock contains a few minute black grains of what is possibly uraninite-thorianite.

On lot 30, concession XVI, a syenite pegmatite outcrop has been further exposed by a bulldozed stripping. Geiger readins were 2x except on a fracture in the pyroxene syenite pegmatite giveing a count greater than 100x. In this fracture a rusty filling, possibly 1 inch wide, consists of abundant zircon crystals, orange grains of uranothorite, yellow-to-orange kasolite, and pyrite. Four additional bulldozed strippings on this lot expose disintegrated marble with mica-rich bands and silicated marbles. Geiger readings were 1x-3x, with spot-highs of 6x and one of 30x on mica-rich areas. Banding in the mica marble strikes N. 35° E. and dips 45° S.E.

DESMONT MINING CORPORATION, LIMITED
(FORMERLY HOMER YELLOWKNIFE MINES, LIMITED)

The property comprised the following lots and claims in Monmouth township, just west of Wilberforce: lots 29, 30, and 32, concession XVII; lot 31, concession XVI; seven claims, parts of lots 25-28, concession XVII, and three claims, lot 31, concession XVII.

Exploration

In 1954 the main showing in lot 31, concession XVII, was explored by bulldozed strippings and cross-trenches at intervals over a north-south length of 2,700 feet, and by 17 drill-holes totalling 2,810 feet; and the West showing, in lot 30, by trenching and bulldozed strippings.

In 1955 exploration was carried out on the east showing in lot 31, concession XVII, by bulldozed strippings and four cross-trenches, and on an old molybdenite showing in lot 32, concession XVI.

In 1965 and 1966 further drilling was carried out by in a search for molybdenum.

General Geology[1]

The property is underlain by marble containing interbands of diopside rock lime-silicate rock, and rusty mica gneisses. These rocks strike north-northwest and dip 45°-60° E. They are cut by irregular masses or dikes of granite pegmatite.

Economic Geology

Radioactive mineral occurrences of two types have been found on the property. The first type is in the bands of pale-green diopside rock or diopside-calcite rock in the marble. These bands contain erratic and sparse disseminations of uranothorite. This type is represented by the main and east showings. The second type consists of sparse disseminations of uraninite in lime-silicate bands in marble or in micaceous marble as at the west showings.

These occurrences are described in detail below.

The main showing is on a high ridge on lot 31, concession XVII. Along this ridge bulldozed areas and trenches expose a sugary pale-green diopside rock or diopside-calcite rock as an interbed in marble at intervals for 2,700 feet. This assemblage is cut in places by dikes

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[1] A geological map of the trenches accompanies the report by J. Satterly, (1957, Fig. 13.)

of granite pegmatite. Geiger readings on the diopside band were 5x-7x, with spot-highs of 25x-40x.

The workings indicate a series of disconnected bands of diopside rock containing irregular lenses and stringers of salmon-pink calcite. Accessory minerals are uranothorite, molybdenite, pyrite, and pyrrhotite.

The west showing is on the east slope of a ridge in lot 30, concession XVII, and has been explored by trenches and bulldozed strippings. These trenches expose deeply weathered micaceous marble, rusty paragneiss, and a vertical lime-silicate band about four feet wide trending N. 20° W. over a length of 200 feet. Geiger readings on the micaceous marble were slightly above background. On the silicate horizon spot-high readings of 3x to 4x were recorded and a little uraninite in irregular grains, ¼ to ½ inch across, was found in one trench.

Farther south of this showing, near a small lake, two bulldozed strippings and two test holes expose a disintegrated, micaceous marble. Geiger readings on the bulldozed strippings were barely above normal background count, but in the test holes, 1 and 3 feet across and 2 feet deep, readings of 20x were recorded. Samples from these pits yielded a concentrate pyrite and uraninite.

The east showing, in lot 31, concession XVII, was explored in 1955 by four trenches in a bulldozed clearing about 75 feet wide and 350 feet long in a north-south direction. The trenches expose a pale-green diopside rock with lenses of salmon-pink calcite, minor amounts of very black glassy quartz, and accessory uranothorite, pyrite, pyrrhotite, and molybdenite. Geiger readings might average 10x with spot-highs of 25x-40x. Where the uranothorite occurs in the calcite it may be in long narrow prisms. Accessory green apatite was noted in the calcite.

FAIRLEY RED LAKE GOLD MINES, LIMITED

In 1955-56, Fairley Red Lake Gold Mines, Limited held 11 claims in the southwestern part of Monmouth township.

Exploration

Radioactive showings in granite were explored by trenching and eight packsack drill-holes totalling 483 feet.[1]

General Geology

The property is underlain largely by amphibolite and metagabbro, with minor amounts of marble and nepheline rocks. The amphibolite, part of the metagabbro body, is

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[1] Ont. Dept. Mines, File No. 154551.

cut by a number of dikes and bodies of pink leucogranite, some of which are radioactive.

Economic Geology

A weakly radioactive leucogranite just north of a small pond in the north half of lot 4, concession III, has been explored by seven packsack drill-holes, and a 20-foot trench. The trench is in a band of granite with an exposed width of 200 feet that has been traced for a length of 800 feet to the northeast.

The rock is a pink, slightly gneissic leucogranite with occasional pegmatitic patches, and contains sparse-to-frequent black hornblende crystals. The quartz is black. The foliation strikes N. 80° W. and dips vertically. In the trench, accessory minerals present are zircon, allanite, orange uranothorite, and secondary uranophane coating fractures. Geiger readings in the trench were 20x-30x with lows of 10x-14x in the leached zone near the surface. In the area surrounding the trench and for 200 feet to the lake, the granite gave readings of 3x-4x with erratic spot-highs rarely to 6x and 7x and dropping to a low of 2x near the pond. A narrow sheared zone of leucogranite, 2-4 inches thick, near the trench strikes N. 60° E. and dips 50° S.E. It is exposed for a

length of 50 feet and gave geiger readings of 8x-14x. Accessory minerals present are zircon, allanite, and orange uranothorite. The quartz is glassy white.

The country rock amphibolite gave geiger readings of 300-400 counts per minute.

JESKO URANIUM MINES, LIMITED

In 1954-55, Jesko Uranium Mines, Limited, held a block of 27 claims, in lots 6-16, concessions III and IV, and patented lots 13 and 14, concession IV, in the southwestern part of Monmouth township.

Exploration

Three radioactive showings on and to the northeast of Hadlington Lake were explored in 1954 by surface trenches and 13 diamond-drill holes totalling 1,998 feet.[1]

General Geology

The property lies to the northwest of the north end of the Anstruther mass of granite gneiss, which underlies the eastern part of the property. To the northwest the Anstruther mass interbedded metasediments by olivine gabbro

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[1] Ont. Dept. Mines, Files Nos. 140893, 140955.

and peridotite west of Hadlington Lake and by a band of syenite containing a few small lenticular bodies of nepheline gneiss. The metasediments strike northeast and dip 60°-70° S.E.

Economic Geology

Radioactive granite and granite pegmatite dikes and bodies occur in the paragneiss-amphibolite group on, and to the northeast of, Hadlington Lake.

The most southerly showing on the north side of Hadlington Lake is here called No. 1 showing. A lenticular leucogranite pegmatite at the south point of an island in the swamp at the mouth of the northeast bay of the lake has an exposed length of 150 feet and a maximum width of 50 feet. It pinches out to the north and disappears under the lake to the south striking N. 20° E. The pegmatite varies from medium- to coarse-grained and in parts is graphic with feldspar crystals up to 1 foot across. Three trenches gave geiger readings of 3x to 10x.

The country rock is a calcareous paragneiss striking N. 20° E., and dipping 60° E. Geiger readings on the pegmatite between the trenches were 1x-3x. The only uranium mineral noted at this showing is uranothorite.

It was noted with zircon, magnetite, and allanite, in the pegmatite in one trench and closely associated with purple fluorite stringers in another. Four samples from the south part of this showing were reported to average 0.108 percent U_3O_8.

No. 2 showing 700 feet north of No. 1, is a shore-line exposure on the west side of the northeast bay of Hadlington Lake. A fine- to coarse-grained. leucogranite pegmatite is exposed for a length of 200 feet, and has an exposed width of 50 feet. Accessory minerals are magnetite, purple fluorite, allanite, and uranothorite. Five shallow pits gave 6x. Four samples from this showing were reported to average 0.09 percent U_3O_8.

No. 3 showing is 31 chains by picket line (N. 20° E.) and trail from No. 2 showing at Hadlington Lake. It is a dike or sill of leucogranite pegmatite striking about N. 30° E., which has been explored by three trenches and a number of shallow pits over a length of about 450 feet. The pegmatite has exposed widths of 50-90 feet and has intruded biotite or hornblende gneisses striking N. 30°.E. and dipping 60°-70° E. Horses of paragneiss are present in the pegmatite. Magnetite is, in much as 10-15. Other minerals are zircon and uranothorite and the company reports, in addition, a

minor amount of uraninite. Geiger readings on the granite pegmatite were 5x-12x with, rarely, a few spot-high readings of 18x where magnetite is abundant. Eleven samples of freshly-blasted pegmatite taken at 25- to 50-foot intervals over a length of 20 feet in the north part of the showing were reported to average 0.198 percent U_3O_8 and three samples from the southern 250 feet of this showing to have averaged 0.05 percent U_3O_8.

LONG RIDGE URANIUM MINES, LIMITED

A uraninite showing in marble in lot 13, concession XII, was explored by a bulldozed area 100 by 400 feet and by eight drill-holes (up to June 14, 1956) totalling, 1,295 feet. The bulldozed area is 3,100 feet south of the concession XII-concession XIII line.

The property lies within the southeast margin of the Glamorgan granite gneiss mass. In lot 13, concession XII, the rocks exposed are marble and diopside rock cut by granite and granite pegmatite. In drill core hornblende-plagioclase gneiss and granitized hornblende gneiss were also noted.

An east-west bulldozed clearing, 100 feet wide and 400 feet long, has scattered rock exposures of marble, banded diopside rock with <u>lit par lit</u> pegmatite, mica

metamorphic pyroxenite, granite, and granite pegmatite. The banding in the diopside rock strikes N. 75° W. and dips 20° N. At the contact between the marble and diopside rock there is a vertical fissure filling of metamorphic pyroxenite containing a lens of coarse white calcite 3 feet across. The marble band has a maximum exposed width of 50 feet and consists of white and salmon-pink calcite, pale-green diopside, and phlogopite. Spot-high geiger readings of 11x, 20x, and 29x were recorded. At these places small uraninite cubes, 1/40-1/20 inch across, were observed.

NU-AGE URANIUM MINES, LIMITED (OLD SMOKEY PROPERTY)

In 1955 the Old Smokey property of Nu-Age Uranium Mines, Limited, consisted of 14 claims, lots 7,8, and 11, concession X, and lots 9, 10, 11, and 12, concession XI, Monmouth township.

Exploration

In 1955 radioactive anomalies in the south half of lot 7, concession X, were explored by eight diamond-drill holes totalling 2,126 feet,[1] and by pitting and trenching on a number of calcite veins. In November, 1955, six

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[1] Ont. Dept. Mines, File No. 4413.

short holes totalling 240 feet[1] were drilled in the southwest corner of the south half of lot 11, concession XI.

General Geology

This property is situated in the southeast border zone of the Glamorgan granite gneiss mass and is underlain mainly by amphibolite and granite with minor amounts of marble. These rocks have a variable strike of N. 50° W.-N. 10° E., and dip 20°-60° N.E. or east.

Economic Geology

The eight drill-holes intersected a complex of amphibolite, pyroxene marble, granite pegmatite, pink granite, and calcite veins, the latter containing various amounts of biotite, pyroxene, hornblende, and apatite. In the eight holes nearly 50 veins are from less than 1 foot to a maximum of 25 feet, although most of the veins average less than 2 feet wide.

Miscellaneous occurrences of calcite veins containing apatite and mica have been explored by pits and trenches. These calcite veins or pods range from less than 1 foot to 12 feet in width, the better defined ones

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[1] Ont. Dept. Mines, File No. 22134.

striking N. 85° E. and therefore cutting across the gneisses, which strike N. 10° W. and dip 65° E. In some occurrences the vein material has the appearance of a pyroxene marble and contains accessory apatite and, rarely, uranothorite in small black grains. It is doubtful if any of the calcite occurrences are parts of one single continuous vein. Geiger readings on the calcite bodies ranged from barely above background count to spot-highs of 20x on mica-rich areas.

AMALGAMATED RARE EARTH MINES, LIMITED

The company held 36 claims and 4 patented lots south of Tory Hill. The present name has derived from a series of amalgamations involving Lead Ura Mines, Limited; Rare Earth Mining Corporation of Canada, Limited; Blue Rock Cerium Mines, Limited; and Rare Earth Mining Company, Limited. The properties were explored by two shafts and two adits. No. 1 shaft (the Rare Earth property) has five levels to 657 feet depth, and No. 2 shaft has three levels to 420 feet depth. Total underground development was 6,358 feet of drifts, 3,862 feet of crosscuts, and 1,562 feet of raises.[1] The shaft areas are readily accessible by deteriorating roads from the Hotspur road which leaves highway 500 just east of Tory Hill.

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[1] The company's annual report for 1956, estimated 541,820 tons grading 0.116 percent U_3O_8 to the present shaft depths of 650 feet at No. 1 shaft, and 420 feet at No. 2 shaft.

NO. 1 SHAFT

(FORMERLY RARE EARTH MINING CORPORATION OF CANADA, LIMITED)

Exploration

The surface exploration by Lead Ura Mines, Limited, in 1948 has been described by Wolfe and Hogg, (1948, pp. 10-12, Fig. 7).

Amalgamated Rare Earth Mines, Limited, has explored six radioactive showings, designated as zones, by stripping, bulldozing, trenching, diamond-drilling, and underground development on the Main zone, which comprises three of the surface showings. The Main zone includes showings in the Spence cut, the Zircon trench and pit, and the Poker showing. Other showings have been named the Monck zone, Northeast zone, Cliff zone, Otter Creek zone and Pyroxenite zone.

Underground development consists of an adit, shaft, and five levels. The No. 1 shaft, in lot 20, concession VIII, is a vertical, three-compartment shaft sunk to a depth of 657 feet with five levels established at 120, 240, 360, 480, and 630 feet. Underground diamond-drilling to the end of 1956 totalled 12,258 feet.

The surface diamond-drilling on the various zones on the property was reported by the company as follows:

Zone	Total to end of 1956
	feet
Main.....	9,260
Otter.....	16,181
Cliff.....	6,744
Pyroxenite.....	912
Lake.....	3,337
Total	36,434

General Geology

The property is underlain by bands of amphibolite, quartzite, and marble intruded by syenite, granite, and granite pegmatite. The metasediments strike north-northeast and dip 45° E. Uranium-bearing ore shoots are found in granite or granite pegmatite bodies intruding diopside quartzite.

Economic Geology

The Main zone, including the Spence cut, Zircon trench and pit, and Pker showing, has been explored by an adit, and from No. 1 shaft by lateral work on five levels.

The country rock underground is a phlogopite-diopside quartzite with narrow-to-wide interbeds of white and sometimes

black marble, vesuvianite marble, and marble tectonic breccia. Many of the marble areas are extremely irregular in shape. The quartzites strike north-to-northeast and dip 15°-55° E. A number of old faults, sealed with a chocolate-coloured aphanite strike east-west and dip 45°-86° S. Late fractures or narrow breccia zones have calcite-marcasite fillings.

Uraniferous granite or granite pegmatite bodies intrude these metasediments forming elongate lenticular bodies or narrow dikes from a few to several hundred feet in length. A series of ore shoots, occurring en echelon, have been exposed on four levels underground, a number of these being similar petrographically. They are granite pegmatite bodies that show a footwall enrichment. Where best developed the hanging-wall non-ore section of a body has pale-pink or red-veined white feldspar, minor quartz, and scattered pyroxene grains. In the footwall ore section the feldspar is a bright brick-red, the colour becoming more intense towards the footwall and the quartz content is often greater. Altered pyroxene crystals are sparsely distributed throughout. Clusters of allanite appear and increase in amount towards the footwall. They consist of allanite in black platy crystals up to ¼ by 1½ inches, uranothorite in yellow, orange, or black

grains intimately associated with allanite, zircon in minute crystals, pyrite, and more rarely, pyrrhotite and molybdenite. Gash veins of grey quartz and minor calcite are present in places 2-4 feet above the footwall. Fractures with chlorite coatings are common. Rock with high radioactivity contains allanite clusters and shows closely-spaced parallel fractures 1/8 inch or less apart. This footwall enrichment is erratic.

A slightly different type of granite forms an ore shoot on the 4th level. This ore shoot consists of grey biotite granite gneiss, white-to-greenish pyroxene-poor granite pegmatite, red biotite granite, grey quartz-rich granite, and pink, gneissic, biotite, porphyroblastic granite pegmatite. The high-grade material is the grey, shattered, quartz-rich chloritized pyroxene granite, which is present as patches up to 1 foot thick at or near the footwall. This rock contains accessory zircon, allanite, and both black and yellow uranothorite. It grades rapidly towards the hanging wall into a red biotite granite that has half the radioactivity of an adjoining footwall section.

A third type is represented by the pegmatitic material in the Spence cut, which is exposed in the third drift of the adit. It is a yellow-brown syenite pegmatite

For plans see J. Satterly, (1957, Figs. 13 and 14.)

with patches rich in allanite and uranothorite. Biotite and calcite are also present.

Wall-rock alteration is not common. In places the diopside quartzite is slightly coarsened and feldspathized for ½-1 inch from the hanging wall of the main pegmatite body in the adit. At the footwall of the same body where it transgresses the dip the quartzite may be seen in various stages of assimilation resulting in the formation of pyroxene grains intthe pegmatite.

The pegmatite bodies may occupy local folds in the regional structure. This is most apparent on the second level where the strikes and dips of the quartzite around the pegmatite body swing from the prevailing north-to-northeast strike and 45° E. dip.

The other showings on the property are described in the following paragraphs:

The Poker showing, an extension of the Main zone, is exposed by bulldozed strippings at the north end of lot 19, concession VII. Biotite paragneiss strikes N. 30° E. and dips 50° S.E. Within the paragneiss a discontinuous lenticular biotite granite pegmatite sill has been exposed for 200 feet ranging from 3 inches to 2 feet in width, and possibly averaging 1 foot. The sill contains small tubular crystals of allanite ¼-½ inch in length and, rarely, altered uranothorite

in minute grains. Geiger readings on the sill were 4x-10x, the north half reading 5x-10x, and the south half 4x-6x.

The Monck zone is in the southeast corner of lot 20, concession VIII, and has been explored by bulldozing and stripping. Adjacent to the road, drag-folded rusty-weathering diopside-biotite gneiss with interbeds of marble, 1-3 feet thick, is exposed. In the gneisses are sills of pyroxene syenite pegmatite rich in small zircon crystals. The sills are from 3 inches to 3 feet thick, but of no great lateral extent. Geiger readings were about 25x, the best areas being rich in disseminated pyrite. Spot-high readings of 55x were recorded. Drilling here failed to intersect any pegmatite below the outcrop. Bulldozed strippings or trenches on the hill above the showing described also expose rusty-weathering sugary, fine-grained diopside-biotite gneiss with numerous lenticular discontinuous sills of coarse hornblende pegmatite of from a few inches to 5 feet across.

The Northeast zone is in the southwest part of lot 21, concession VIII, and has been exposed in three cross-trenches over a length of 140 feet and by a bulldozed-stripped area. It is a lenticular granite pegmatite sill or dike striking N. 20° E., dipping 45° E., and conforming

more or less to the gneissosity of the biotite or hornblende-plagioclase gneisses. It ranges from 6 inches to 20 feet wide, may average 5 feet, and pinches and swells at frequent intervals. Much of it is a leucogranite pegmatite, but parts of it are rich in mafic minerals--pyroxene with accessory allanite and titanite. Geiger readings averaged 3x. The bulldozed-stripped area is 250 feet north of the three trenches and is 220 feet long by 40-70 feet wide. The dike can be traced an additional 50 feet northeast of this area. In the bulldozed-stripped area the dike is mainly a leucogranite pegmatite. Pyroxene-rich parts of the dike, with accessory purple fluorite, sphene and apatite, are very similar to some of the dikes at the Bicroft (Centre Lake) property,[1] and give geiger readings of 3x. The best readings (15x with spot-highs of 20x) were recorded on a shear zone in leucogranite pegmatite ½-4 feet wide (averaging less than 2 feet) and 80 feet in length near the north end of the area. The coarse leucogranite pegmatite at the north end read 3x, increasing to 5x at the contacts of the dike over a length of 30 feet.

The Cliff zone is exposed as a high ridge above Esson Creek in the south part of lot 20, concession VII. This zone is reported to be traceable north through lot 21 into lot 22, concession VII, but in the present survey it

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[1] Cardiff Township, Haliburton County.

was examined only in lot 20. It is a pink granite pegmatite sill in hornblende-plagioclase gneisses, which strikes N. 20° E. and dips 50° E. Where examined there is a cliff face of pegmatite 20 feet high. Geiger readings at the footwall contact averaged 18x over a length of 50 feet with spot-high readings of 45x and 55x. North of this contact zone only recorded 6x on the ratemeter. Blasted allanite, and very rarely, minute grains of orange-brown uranothorite. On the top of the ridge the rock is mainly a leucogranite pegmatite with numerous inclusions of paragneiss, and rarely, contains a few patches of pyroxene-rich rock. No uranium minerals were found. Geiger readings were 2x-8x, and might average 3x.

The Otter Creek zone was found by drilling and lies beneath (Otter) Creek in lots 19 and 20, concession VII. This zone is in a grey pegmatite and has been indicated by ten diamond-drill holes to be 1,200 feet long, 8.6 feet wide, to dip 50° E., and to average 0.11 percent U_3O_8, according to the company.

The Pyroxenite zone is in the southern part of lot 24, concession VIII, and has been exposed by trenching and stripping on the slope of a ridge in a clearing adjacent to the Irondale River. The northern working is a bulldozed-

stripped area, 50 feet wide and 80 feet long, which exposes pyroxene skarns in rusty-weathering gneisses striking N. 20° E. and dipping 65° E. An irregular bed, 1-3 feet wide, of grey marble is interbedded with hornblende gneiss and contains patches of salmon-pink calcite. Uranothorite was found in a pyroxene-calcite rock from the north end of this area. A cross-trench, 75 feet south of the above, is 80 feet long. It exposes a variety of gneisses with two interbeds of mica pyroxenite 3 and 5 feet wide and a marble band 6 inches wide. The pyroxenite bands are slightly radioactive. A second cross-trench, 100 feet south of the above, is 200 feet long. It is partly filled in with sand but exposes gneisses and marble. The marble is slightly pink and has a very low pyroxene content. There is possibly a second marble band, ½-3 feet wide, 15 feet east of the above. Loose mica debris may indicate that mica pyroxenite bands are present.

NO. 2 SHAFT
(FORMERLY BLUE ROCK CERIUM MINES, LIMITED)

Exploration

The original property comprised 18 claims south of the Rare Earth property. A number of radioactive anomalies, were designated as zones A, B, C, etc.

The initial radioactive showing on the property is in the south halves of lots 18 and 19, concession VI. This is now known as zone A. In 1952 this showing was explored by trenching and seven diamond-drill holes and in 1954 by additional trenching in overburden and bedrock and by seven additional drill-holes (six vertical), totalling 201 feet, in the immediate vicinity of the main showing.

Zone C is in the north halves of lots 18 and 19, concession V, and the south halves of lots 19 and 20, concession VI, where exposures are scattered and few, and initial exploration by stripping and trenching was followed by bulldozed strippings and trenchings in overburden or bedrock. By November, 1954, 3,500 feet of trenching at 50- and 200-foot intervals over a strike length of 1,400 feet in the south half of lot 19, concession VI, and the north half of lot 19, concession V, respectively, had exposed a coarse metagabbro intruded by granite pegmatites that contain radioactive ore-shoots.

These granite and granite pegmatite bodies were further explored in 1955 and 1956 by diamond-drilling, an adit, a shaft, and lateral work on three levels.

A summary of the diamond-drilling and underground development follows:

Diamond-drilling	Total to End of 1956
SURFACE:	feet
C zone.....	53,949
A zone.....	2,812
UNDERGROUND:	
No. 1 shaft.....	16,817

The underground development is from No. 2 shaft, a vertical, three-compartment shaft, 440 feet deep with three levels at 100, 250, and 400 feet. The shaft is s tuated in the southeast corner of lot 19, concession VI. The adit portal is near the west boundary of lot 20, concession VI, and corresponds to the 100-foot level in the shaft. The headframe was removed in 1965 and the shaft closed with a concrete slab.

General Geology

The property is traversed by bands of amphibolite and marble striking east to northeast and dipping 50-85 degrees south to southeast by metagabbro and by granite and granite pegmatite.

Economic Geology

Zone C or Main zone.--In the mine workings the prevailing country rocks are metagabbro and amphibolite. Some of the amphibolite is probably derived from metagabbro, but some well-banded light and dark amphibolite probably belongs to the paragneiss-amphibolite group and may represent inclusions within the metagabbro body. Owing to the abundance of granite and granite pegmatite in the workings it is difficult to determine the prevailing strike and dip of the gneissic structure in the metagabbro. It appears to be about N. 35° E. with dips of 45°-80° S.E.

The radioactive granite-granite pegmatite that intruded and feldspathized the metagabbro forms small-to-large lenticular bodies that closely parallel the gneissosity of the metagabbro and parallel or transgress the dip at all angles. The youngest intrusive is a black, fine-grained amphibolite occurring as dikelets that cut both the metagabbro and granite pegmatite.

Uranium-bearing ore shoots which are confined to the granite-granite pegmatite bodies, range from a few feet to 20 feet wide, and are 10-200 feet long. They occur: (1) as hanging-wall concentrations, (2) in the central part of a granite body, or (3) as the tail section of a body.

Wall-rock alteration in the metagabbro adjacent to the granite is marked by (1) coarsening of the grain size of the metagabbro, (2) hematitization of the feldspars, as indicated by red discolouration, and (3) development of peristerite (blue sheen) in metagabbro.

Petrography of Granite Bodies.--The granite that does not make ore is typically very variable in colour and grain size. It is buff, pink or grey in colour, giving a patchy appearance to the leucogranite or leucogranite pegmatite containing sparsely distributed altered pyroxene. Smoky black quartz is very obvious in the coarser phases. Both potash and soda feldspars are present, a grey soda feldspar being peristerite. Patches of graphic granite up to 1 foot across are not uncommon. Wall boundaries are sometimes scalloped and are suggestive of a replacement origin. In one drift the granite body is zoned, having a distinct grey feldspar (peristerite) border zone about 3 inches thick, followed by a wall zone of pink feldspar and black smoky quartz 9-12 inches thick. These two zones do not make ore, but the central part, which is a deep brick-red granite, does.

The rock of the ore shoots is a deep brick-red, medium-grained, leucogranite with scattered, sparse-to-common, small crystals of altered pyroxene. Quartz is smoky, often

black in colour. Much of the feldspar is peristerite. Accessory minerals in the better-grade sections are abundant zircon and allanite, and to a lesser extent, sphene, uranothorite as orange grains often in or with altered pyroxene, fergusonite as black resinous grains or crystals, uraninite, and uranophane. Structurally the better-grade zones are marked by widely spaced chlorite-coated strike fractures and very closely spaced fractures due to shearing producing a platy structure. Some of the rock in the ore shoots is more variable in graine size and composition; in one drift it is patchy pink and grey from the colours of the feldspars and ranges from granite to granite pegmatite.

Zone A.--Zone A is in the south halves of lots 18 and 19, concession VI, just west of a small lake.

A company map indicates a granite pegmatite about 900 feet long and 140-350 feet wide striking N. 50° E. intrusive into limy amphibolite. At the southwest end of the pegmatite and at one other point small irregular bodies of a syenite pegmatite are exposed by outcrops or by trenching and pitting; these are 60-240 feet long. The main radioactive showing is at the northeast end of one of these syenite pegmatites. This body is about 180 feet long and has a maximum width of 90 feet. Stripping and pits in an area 50 by 90 feet expose the northeast nose of this

syenite pegmatite. It is in contact, to the northeast, with a coarse, pink leucogranite pegmatite and, to the southeast, with a medium-grained pyroxene-plagioclase rock with accessory sphene believed to be a skarn. The syenite pegmatite is a very coarse-grained rock composed of yellow-brown plagioclase, dark-green pyroxene, abundant deep purple fluorite, and accessory molybdenite in flakes up to ½ inch across.

The radioactive showings are in fractures in the syenite pegmatite. The main fracture curves sinuously across the stripping and pits for a length of 30 feet in a direction N. 35° W. and dips 55° N. in the main pit. Additional irregular fractures or slips in the workings have nearly flat dips, and branch off from the main fracture. The filling in these fractures is a sheared rock or breccia composed of fragments or schlieren of a fine-grained brick-red leucogranite containing abundant uranothorite in orange-brown grains in a sheared matrix of altered pyroxene, chlorite, and fine-grained purple fluorite. One example was 3 inches or less thick, but is reported to have been up to 1 foot in thickness in the drill-holes. Geiger readings on the uranothorite-bearing material gave spot-highs of 33x, 50x, and 95x, in the main pit.

Lake Zone.-- The Lake zone is in the central part of lot 20, concession VI. Diamond-drilling over a length

of 400 feet indicates radioactive granite pegmatite bodies cutting silicated marble and interbedded lime-silicate rocks. The marble contains one or more of the following silicates: phlogopite, diopside, tremolite, serpentine, or chondrodite, as well as accessory graphite and pyrrhotite. The ore shoots are in a yellow-brown pyroxene granite pegmatite, the highest geiger readings being obtained where the accessories include zircon, allanite, sphene, pyrrhotite, pyrite, uranothorite (black or orange), and uraninite. Purple fluorite is a rare accessory.

RED BARK MINES, LIMITED (MONMOUTH PROPERTY)

In 1954, Red Bark Mines, Limited, held under option patented lots 5 and 6, concession XI, Monmouth township.

Exploration

In 1954 radioactive showings were explored by bulldozing and by 11 short drill-holes, totalling 1,847 feet.

General Geology

The property lies within the southeast border of the Glamorgan granite gneiss mass. The rock exposed is marble, representing a large inclusion, cut by granite pegmatite bodies.

Economic Geology

The surface showing is on the road allowance between lots 5 and 6 adjacent to a dry creek. North and south of this creek an area has been partially cleared for 100 feet north of the creek and 50 feet east, and 150 feet south and 80 feet east. Through the overburden of sand and boulders the bulldozing has exposed scattered outcrops of marble containing pyroxene, mica, and salmon-pink calcite. Geiger readings was 5x-10x. Minor occurrences of mica pyroxenite give spot-high readings. Towards the south end of the bulldozed area debris or exposures indicate the presence of mica pyroxenite, pink granite pegmatite, and a rusty-weathering pegmatite with inclusions of rusty biotite paragneiss. The latter pergmatite gave geiger readings of 10x and spot-highs of 20x. On the pink granite pegmatite the reading was 2x. Uraninite in grains about 1/16 inch across is a rare accessory in the mica-pyroxene marble.

Vertical sections through the 11 drill-holes by the company indicate that a north-south mass of marble is underlain by granite pegmatite, cut by dikes or sills of granite pegmatite, and intruded from the east by a wedge or tongue of syenite. Drill-holes at the north and south ends of the drilled area show that the mass is not greater than 200 feet in length. The maximum thickness is about 80 feet.

The east-west dimension of the marble was not determined by the drilling. The dikes or sills of granite pegmatite might dip 30°-50° E. Uranium mineralization is confined to the marble. According to the management, assay results on 19 samples from the drill-holes were all low, mostly below 0.05 percent U_3O_8 (radiometric).

ROFORD MINES, LIMITED

In 1955, Roford Mines, Limited, held four groups of claims in the northwestern part of Monmouth township.

Exploration

Radioactive mineral showings on two of the groups were explored by stripping, pitting, and trenching in 1955. Six holes, totalling 1,667 feet, were drilled in the north half of lot 13, concession XIII, in March, 1955.[1]

General Geology

The two groups of claims lie within the southeast border zone of the Glamorgan granite gneiss mass. The claims are underlain by a complex of hybrid granite gneiss, granite gneiss, granite, marble, and paragneiss, with various strikes and dips.

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[1] Ont. Dept. Mines, File No. 11649

Economic Geology

The main showing of the east group of claims is in the north half of lot 13, concession XIII. Exposures here indicate a gently-dipping sill of graphic granite or granite gneiss overlying biotite-feldspar gneiss containing interbeds of pyroxene marble. The banding in the gneiss strikes N. 50° W. and dips 30°-50° S.W. The uranium mineralization is uranothorite in grains or long tetragonal crystals, usually black in colour but also orange-brown. It is found with pyroxene concentrations in the granite or granite gneiss. Such concentrations may be more common or confined to the footwall zone of the sill. Pyroxene concentrations may also occur along fractures. Uranothorite or thorite is also found in small pods of pyroxene marble or as tetragonal crystals in salmon-pink lenses or masses of calcite in the marble.

In the southwest group of claims radioactive showings in the south half of lot 2, concession X, are exposed by four pits. Uraninite or uranothorite are found in mica-pyroxene marble or mica metamorphic pyroxenite adjacent to sills or sheets of granite pegmatite or granite. More detailed descriptions of these showings follow.

East Group.--The main showing is in the north half of lot 13, concession XIII. Here, about 2,800 feet

by road north of the concession road, a clearing and bulldozed area, 200 feet wide and 300 feet long, exposes a sill or sheet of pink granite, which has been explored by trenches on radioactive mineral occurrences.

The first working is a trench 80-95 feet southeast of the northwest side of the clearing. Biotite-feldspar gneiss (4x) is overlain by 1 foot of skarn (15x), and in turn by 2 feet of graphic granite (7x). The gneiss dips 30° S.E.

The second working, 130-135 feet southeast, is a trench exposing fine- to medium-grained pink granite gneiss (7x) with patches or streaks from a few inches to a few feet in size, rich in pyroxene giving spot-highs up to 40x. Uranothorite was noted here.

The third working, 165-190 feet southeast, is a trench exposing pink granite gneiss with grey-to-black quartz (7x-12x).

The fourth working is a trench 120 feet east of a point 230 feet southeast. It exposes biotite-feldspar gneiss with at least two interbeds of pyroxene marble containing streaks or pods of salmon-pink calcite, with accessory sphene, and thorite in tetragonal crystals

1/16-1/4 inch across. The interbeds of marble have exposed widths of 2-3 feet, strike N. 50° W., and dip 40°-50° S.W. (25x-110x).

The fifth working is a pit 180 feet at S. 20° E. from the last. It exposes pink granite (6x) with pyroxene-rich patches (50x-75x) containing uranothorite in grains or prisms up to ½ by 1½ inches in length. The relationship of the pyroxene material to the main granite was obscured by muck when the pit was examined. To the south of the pit, granite is exposed for 80 feet. It appears to be a 3- to 4-foot sill, dipping gently southeast or south, overlying crumbly-weathering biotite-feldspar gneiss. Geiger readings on the top of the granite are low at 2x, and on the footwall a spot-high reading of 7x was found.

Another showing is across a small creek in a bulldozed stripping 30 by 100 feet. It exposes a smooth glaciated surface of pink graphic granite (2x-5x) with streaks or bands ½-12 inches at S. 70° E. rich in pyroxene, giving spot-high readings up to 25x. A remnant band of biotite-feldspar gneiss, 3 feet wide, crosses the granite at S. 35° E. A shallow pit, 5 by 12 by 2 feet deep, has been put into a pyroxene granite pegmatite patch adjacent to the biotite-feldspar gneiss. A fracture containing a pyroxene-rich 1-inch stringer with orange-brown grains of uranothorite

gives a spot-high of 15x. The fracture has an exposed length of 6 feet.

The south showing is in an abandoned pasture about 1,000 feet by truck road from the concession line. A bulldozed area, 70 by 150 feet, poorly exposes grey biotite granite gneiss cut by irregular stringers or narrow dikelets or leucogranite and pyroxene granite pegmatite in widths up to 2 feet (2x-15x). The original showing here is a 3-inch pegmatite stringer with a spot-high of 20x.

Southwest Group.--Pit No. 1 is in lot 2, 2,550 feet south of the concession X-concession XI line and 300 feet east of the road on the Monmouth-Glamorgan boundary. It exposes mica-pyroxene marble overlain to the east by a flat-lying mass, 1-3 feet thick, of leucogranite or granite pegmatite with or without pyroxene. The marble may contain inclusions of pyroxenite or mica metamorphic pyroxenite from a few inches to a foot across, stringers of coarser calcite, and patches of grey feldspar. Geiger readings were 5x-12x with spot-highs of 20x-30x, the maximum reading being found on the more micaceous sections of the rock. No radioactive mineral was observed. In a clearing just south of this pit a complex of granite, pegmatite, and marble is exposed. The granite gives a geiger reading of 4x.

Pit No. 2 is 130 feet east of No. 1, and exposes a sheet, 1-2 feet thick, of buff leucogranite or pegmatite overlying mica-pyroxene marble. Geiger readings on the granite were 4x-7x and spot-highs of 12x and 15x at cavities in the marble possibly representing eroded mica masses.

Pits Nos. 3 and 4 are 300 feet north of No. 1. These pits expose a complex of leucogranite gneiss, grey siliceous metasediment, and granite pegmatite overlying mica-pyroxene marble and mica metamorphic pyroxenite. The contact between the granite complex and the marble complex is very irregular with minor rolls but is apparently at a low dip to the east. Geiger readings gave spot-highs in the marble complex of 25x-50x. No uranium minerals were found by the author, but he was shown a sample containing ½-inch grain of grey uranothorite.

SARANAC URANIUM MINES, LIMITED

In 1954-56, Saranac Uranium Mines, Limited, held a group of 14 claims adjacent to Esson Creek and south of highway No. 500 in Monmouth township. The company carried out exploration on a zircon occurrence and radioactive granite pegmatite bodies.

General Geology

The property is underlain by amphibolite and marble intruded by metagabbro, syenite, nepheline syenite, and granite pegmatite. These rocks strike northeast and lie midway between the Cheddar granite mass to the southeast and the Glamorgan granite gneiss complex to the northwest.

Zircon Showing

The zircon showing is in the south half of lot 24, concession X, 0.4 miles south of highway No. 500. The zircons are in a thorite-zircon-albite leucogranite pegmatite and associated skarn rocks.

Exploration.--The zircon occurrences were explored by stripping and trenching, by an open-cut 150 feet long in a bulldozed area 600 feet long, and by ten drill-holes totalling 1,212 feet.

Economic Geology.--A zircon granite sill is exposed for 100 feet in length in the open cut. It is up to 4 feet thick and is concordant with the marble. The marble strikes north and dips 28°-35° E. This sill pinches out in the east wall of the open cut. Another sill, possibly 150 feet long and dipping 35° E., was traced from the top of the open cut to the south. Geiger readings were 25x-50x with spot-highs to

100x. The high radioactivity is due almost entirely to the thorite content of the granite.

The thorite-zircon leucogranite is white to grey, the grey variety being shattered or sheeted parallel to the contact and forming the lower half or footwall zone of the sill. It contains abundant dark-brown zircons in small crystals of from less than 1/10 inch to a maximum of 3/4 inch in length, and highly altered, earthy-brown thorite in doubly-terminated pyramidal crystals up to ½ inch across.

Additional zircon showings have been trenched to the north and south of the above. About 100 feet south of the open cut a small trench exposes a thorite-zircon leucogranite band, 0.5 feet thick, dipping 25° E. Geiger readings were 25x-45x with a spot-high of 75x. About 300 feet north of the open cut two trenches expose two skarn bands 0.1-0.9 feet thick in marble. These pinch and swell both along strike and down dip. The marble strikes N. 10°-15° E. and dips 30°-40° E. The skarn bands consist of an aggregate of zircon, thorite, sphene, pyroxene, scapolite, and calcite. Adjacent to these bands the marble contains bands rich in pyroxene, rarely mica, and sometimes purple fluorite. Geiger readings on the skarns were 25x-100x with spot-highs greater than 125x. The radioactivity is due to thorite. In the eight bulldozed strippings to the north of these

trenches zircons with sphene were found only in the first stripping 400 feet to the north. Geiger readings were 2x-5x with a spot high of 30x.

The 10 drill-holes, both inclined and vertical, were planned to intersect the zircon-bearing sills below the open cut over a length of 150 feet. Four of these holes intersected albite granite pegmatite but not the others, and it is apparent that the zone is discontinuous down dip from the open cut. The zircon content in the narrow intersections of pegmatite was erratic and sparse.

East Pegmatite Showing

The east pegmatite showing is in the south halves of lots 23 and 24, concession IX, and is reached by a motor road east from the Hadlington road and south from highway 500.

Exploration.--The showing has been explored by an open cut 150 feet long, and over a 1,200-foot length, by 32 drill-holes totalling 7,286 feet.

General Geology.--On this section of the property the country rock is a biotite amphibolite or hornblende gneiss and metagabbro. Garnets are common in these rocks as seen in the core. Some of the amphibolite is probably

metagabbro, but much of it may be a metasediment. These rocks have been intruded by a series of lenticular bodies of granite, parts of which are radioactive.

Economic Geology.-- An open cut, 30 feet above the level of the swamp along which the holes were drilled exposes a granite sill in contact with biotite-hornblende gneiss striking N. 35° E. and dipping 45°-52° S.E. The open cut, 150 feet long, strikes N. 25° E. and exposes a medium-grained, pale-pink biotite-hornblende granite. The exposed thickness of the granite sill is 7 feet. Pegmatitic patches are present. The hornblende is present as bladed crystals from less than 1-3 inches in length. They are partly altered to biotite and chlorite. Accessory minerals are zircon, allanite, sphene, pyrite, uranothorite, and uranophane. Geiger readings were 5x-10x, with a 10-foot-long section reading 25x with spot-highs up to 40x, characterized by fracturing, rusty-staining from pyrite, and uranophane. The readings in this section increased towards the footwall. As indicated by the diamond-drill intersections the sill plunges to the northeast, and at the horizon of the holes has a length of 250 feet. Several other lenticular bodies of granite were found by the drilling program, but none as large as the above.

SCADDORE GOLD MINES, LIMITED

In 1955, Scaddore Gold Mines, Limited, held 13 claims in the southwest corner of Monmouth township and drilled one hole, 520 feet in length in lot 2, concession I.[1]

The property is underlain by paragneiss, amphibolite, and marble intruded by syenite, minor nepheline syenite, and granite pegmatite. The southeastern part of the property is just within the north part of the Anstruther granite gneiss mass. The metasediments strike northeast and dip 30°-70° S.E.

The one drill-hole is reported to have intersected quartzite, hornblende-biotite schist, and seven dikes of granite pegmatite 2-34 feet in core length.

SILANCO MINING AND REFINING COMPANY, LIMITED (TORY HILL PROPERTY)

In 1955, the Tory Hill property of Silanco Mining and Refining Company, Limited, comprised a group of 18 claims, on the east boundary of Monmouth township, four of the claims being in adjoining Cardiff township.

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1 Ont. Dept. Mines, File No. 23518.

Exploration

Radioactive showings in granite pegmatite dikes were explored by strippings and trenches. Exploration was concentrated on No. 2 showing, mainly in the south half of lot 32, concession VI, Monmouth township where five holes totalling 498 feet[1] were drilled.

General Geology

The property lies wholly within the Cheddar granite mass, the main showing being about 1½ miles from the main northwest contact of the mass.

Economic Geology

Nearly twenty radioactive showings in pegmatite dikes were reported by the company.[1] Trenches in the south half of lot 32, concession VI expose a complex of amphibolite, with bands of pyroxene-scapolite skarn, and minor paragneiss cut by numerous irregular dikes and masses of granite pegmatite, leucogranite, hybrid granite gneiss, and minor syenite pegmatite. The gneissic structure strikes N. 45° E. and dips 50° S.E. The workings are described below.

Trench A.1 is intersected by two cross-trenches, A.2 and A.

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[1] Ont. Dept. Mines, File No. 55900.

Trench A.1 follows a skarn band cut by minor dikelets of granite or granite pegmatite. The skarn is a pyroxene-calcite rock with patches of pyroxene-scapolite. In trench A.1 to the southwest of trench A, geiger readings were 2x-6x, but to the northeast they were 5x-10x with two high streaks at the trench A.2 intersection. These streaks are about ½ foot wide, one is 19 feet long reading 10z-45x (average 25x), and the other 7 feet long reading 12x-47x (average 30x). No radioactive mineral was recognized.

Trenches A and A.2 expose biotite paragneiss, amphibolite, pyroxene-scapolite skarn, minor coarse calcite and bands of granite, granite pegmatite, and rarely syenite pegmatite. Radioactivity is on the whole quite low, geiger readings being mostly below 2x with, rarely, spot-highs near trench A.1 up to 7x and 12x. The metasediments strike N. 45° E. and dip 50° S.E. The pegmatite or granite frequently have pyroxene at contacts with skarn rock. Bands of pyroxene within pegmatite or granite probably represent remnant bands or digested inclusions of limy metasediments.

Trench B.1 follows a 1½-foot band of pyroxene-rich syenite pegmatite within granite or granite pegmatite. It contains patches of calcite with which large grains of uranothorite up to ¼ by 1 inch occur. Uranothorite and calcite appear to be the last minerals to be deposited.

This band showed a range of 11x to 50x and might average 22x. The pyroxene-rich syenite pegmatite grades westward into syenite pegmatite, which in turn, where the dike widens, becomes a pale-pink leucogranite pegmatite.

In trench C.1 the main showing is at a pit. The pegmatite is very variable in character. It is a hornblende-calcite syenite pegmatite with abundant accessory pyrite and, rarely, blebs or large ovoid grains, ¼ by ½ inch, or reddish-brown uranothorite. The feldspar varies in colour from pale brick-red to brownish and greyish-green. Hornblende is patchy in distribution often in irregular strings of crystals or in clusters, sometimes intergrown with calcite. The calcite occurs in lenses or stringers or interstitially to the feldspar or hornblende. It is mostly grey but may be cream in colour. Pyrite is more abundant in the hornblende-rich sections of the pegmatite. All the pegmatite exhibits a marked fracturing in the feldspar roughly along parallel lines. Some of the calcite is late, filling narrow fissures. The uranothorite blebs are surrounded by strong radiation cracks in the feldspar. Geiger readings in the pit were 5x-12x with spot-highs of 15x-30x. In the trench to the north and south of the pit on the syenite pegmatite, readings were 5x-17x with spot-highs of 25x-50x. To the south of the pit, over leucogranite and pegmatite, readings were 2x-5x with a spot-high of 20x.

UROTOMIC MINES, LIMITED

The property lay south of Tory Hill and west of the Hadlington Road near its southern limit.

Exploration

During 1955 and 1956 eleven holes were drilled totalling 2,249 feet.

General Geology

The east section of the property is traversed by a band of marble lying between amphibolite with a band of syenite to the north, and syenitized amphibolite and granite to the south. The bands strike northeast. The west section is underlain by metagabbro, nepheline syenite, syenite, and granite.

Economic Geology

The main showing is in the north half of lot 19, concession IV, 1.1 miles west from the Hadlington road. A small bulldozed area, 50 by 200 feet, exposes the contact between marble to the south and feldspathized hornblende gneiss to the north. The gneiss strikes N. 57° E. and dips 65° S. Three small pits have been put down on the contact, the largest being 6 by 10 feet by 3-7 feet deep.

At the contact is a hornblende-calcite rock 1-7 feet wide on which the geiger count was 2x-20x, with spot-highs of 30x and 50x at the marble-hornblende-calcite rock contact.

The hornblende-calcite rocks contain dark-green hornblende crystals to 4 inches long, white-to-salmon-pink calcite, accessory sphene, pyrite, green apatite, and minute grains (1/40 inch) of uraninite surrounded by a purple-red halo.

The marble ranges in composition from a grey rock without silicate minerals to one with much phlogopite, diopside, or tremolite with or without salmon-pink calcite. A little red-staining in the marble was noted around minute grains of uraninite and uranothorite. Purple fluorite is quite rare and was noted as small grains in two places. The background count on the marble was 500-700 counts per minute. Near the hornblende-calcite zone the count increased to 20x-30x.

WADASA GOLD MINES, LIMITED

Exploration

A uranium showing in the north half of lot 5, concession VI, on a ridge near the Irondale River, was explored in 1954 by trenching and by seven diamond-drill holes totalling 1,813 feet.

General Geology

The claims are underlain by paragneiss, marble, metagabbro (in the south only), nepheline gneiss, syenite, and granite or granite pegmatite. These rocks are in a belt lying between the Glamorgan granite gneiss mass to the northwest and the Anstruther granite gneiss to the southeast. The metasediments in this belt strike northeast and dip 30° S.E.

Economic Geology

A long trench (No. 1) exposes marble on the slope of the hill and granite pegmatite near the bottom. This trench is 1-3 feet wide and, for the first 80 feet up the hill, exposes a pink, coarse, graphic leucogranite pegmatite on which geiger readings were 2x-6x and might average 4x. The next 40 feet is in sand overburden, which is exposed for a depth of 10 feet. The upper section, 75 feet in length, exposes a micaceous silicated marble, which gave readings of 7x-25x and might average 17x. The minerals present in the marble include phlogopite, tremolite, diopside, and pink calcite. Uraninite is present as blebs or cubes, mainly in the silicated marble proper, but occasionally in salmon-pink calcite. The uraninite crystals range from 1/8 to, rarely, ¼ inch across.

The company reported that a bulk sample, weighing about 80 pounds, was taken in this trench for a length of 35 feet and assayed 0.14 percent U_3O_8. Samples from three pits blasted 4-5 feet deep were reported to assay 0.002-0.163 percent U_3O_8 (radiometric). A hole drilled 100 feet to the northwest of the main showing was reported to have cut 6 feet assaying 0.011 percent U_3O_8 (radiometric.

BUILDING STONE

GLAMORGAN TOWNSHIP

Concession IV, Lot 23

In 1941, a small quarry for test shipments was opened up by the Ritchie Cut-Stone Company, Limited, in a black massive gabbro on lot 23, concession IV, Glamorgan township. The quarry operations show that the rock breaks with a very irregular fracture. A well-defined jointing is absent. A mill block lying in the quarry, despite the fact it was drilled at closely spaced intervals, had broken irregularly. The rock took a very good polish and would make a good decorative stone if it could be quarried in suitable sizes.

Concession VI, Lot 2

Marble was obtained about the year 1890 for monumental purposes from a quarry in lot 2, concession VI, Glamorgan township, but the output was very small. The marble occurs along the north edge of a hill, forming a belt about 20 feet wide. The rock is a white crystalline dolomite containing flakes of mica or disseminated brown spots (Parks, 1912, p. 319).

Tombstones made from this marble may be seen in the cemetery at Gelert (Adams and Barlow, 1910, p. 195).

MONMOUTH TOWNSHIP

Concession VIII, Lot 7

(The Hadley Granite)

In 1935 a small quarry, which was first operated in 1912, was reopened in a fine-grained, pink granite, adjacent to the south side of the old Gooderham-Tory Hill road. The quarry is 40 feet by 50 to 75 feet and from 15 to 20 feet deep. Jointing occurs at intervals from 2 to 6 feet deep. Jointing occurs at intervals from 2 to 6 feet apart trending N. 20° E. and dipping 80° W. Joints were also observed trending N. 50° E. and N. 65° W. The rock is cut by irregular stringers of pegmatite and black seams of quartz and biotite. Some pyrite was observed. Owing to the uneven splitting and the presence of stringers, much of the rock quarried was waste but selected material was

shipped to monument-makers in Toronto, and a shipment was made for granite paving stones. Total shipments were about 150 tons. Tombstones of this material may be seen at St. John's cemetery, Toronto, and in the cemetery at Gooderham.

A 300 LB sample from this quarry was developed as the Geochemical Standard H1 a series of Analyses of which have been given in Table IA.

Water Supply

All water supplies come from individual wells except for occasional cases where a house draws water from a lake. The supplies appear to be adequate for the present population.

A potential hazard exists in Glamorgan Township, however, with the proliferation of cottages on Koshlong, Stormy, Glamor and Gooderham Lakes. These summer residences rely on the lakes for their drinking water and there exists a considerable potential for water pollution from the sewage. The lakes do not have a heavy flow of water through them to prevent a toxic build-up of pollution. Furthermore, great care should be exercised in the event of future uranium development in the area. For example the plans of Amalgamated Rare Earth Mines, Ltd. in the late 1950's to use Lowry Lake as a tailings pond would have caused radioactive pollution of the Irondale River. Radioactive pollution of lakes farther to the east in the Bancroft area which was the

subject of a separate report in the early 1960's should serve ad adequate warning of this preventable hazard.

Sand and Gravel

Sand and gravel pits are too numerous throughout the area to mention or map individually. Reserves appear to be perfectly adequate for local use which is primarily road building and road repair work. Some of the pits show clear bedding and other features indicative of glacio-fluvial and lacustrine deposition.

Appendix I

Age determinations on nepheline rocks

Three age determinations by the K/Ar method have been carried out on rocks from Glamorgan and Monmouth Townships. Two from Dungannon Township are included for comparison.

TABLE XL

K-Ar data on nepheline, biotite, feldspar and pyroxene

	Mineral	K(%)	Ar^{40} (p.p.m.)	Age (m.y.)
PEGMATITE	nepheline	4.83	0.4494	992
Gill Quarry,			0.4456	1003
Lot 34, Con, IV,				
Glamorgan	biotite	6.99	0.5422	859
			0.5410	858
PEGMATITE				
Lot 11, Con. VI,	nepheline	4.67	0.3914	914
Monmouth			0.3857	904
IJOLITE				
Central Monmouth	nepheline	3.11	0.2265	817
Complex	pyroxene	0.46	0.0433	1008
			0.0420	978
BIOTITE-				
NEPHELINE GNEISS	nepheline	4.85	0.4011	904
Princess Quarry				
Lot 25, Con. XIV,	biotite	7.55	0.6205	900
Dungannon				
PEGMATITE				
Golding-Keene	nepheline	4.76	0.3927	903
Quarry, Lot 12,	biotite	7.66	0.5904	855
Con. XI			0.5742	830
Dungannon	biotite	5.96	0.4658	865
	feldspar	0.49	0.0318	743

Bibliography

Adams, F.D., and Barlow, A.E.,

1910: Geology of the Haliburton and Bancroft area, Province of Ontario; accompanied by G.S.C. Map No. 708, (Haliburton sheet); Geol. Surv. Canada, Mem. 6.

1913: Excursion A2. Haliburton-Bancroft area of central Ontario; XII Intern. Geol. Congr. (Canada). Guide Book 2.

Baragar, W.R.,

1953: Nepheline gneisses of York River, Ontario; Proc. Geol. Assoc. Canada, vol. 6, p. 82-115.

Barlow, A.E.,

1915: Corundum, its occurrence, distribution, exploitation and uses; Geol. Surv. Canada, Mem. 57.

Chesworth, W.,

1966: The origin of certain granitic rocks occurring in Glamorgan Township, Southeastern Ontario; Ph.D. thesis, McMaster University.

Derry, D.R.,

1951: The Lakefield nepheline syenite; Evidence of a non-intrusive origin: Trans. Roy. Soc. Canada, v. 45, sec. IV, p. 31-39.

Derry, D.R., and Phipps, C.V.G.,

1957: Nepheline syenite deposit, Blue Mountain, Ontario: In Geology of Canadian Industrial Mineral Deposits, 6th Commonwealth Mining and Metallurgical Congress, Canada, p. 190-195.

Eardley-Wilmot, V.L.,

1925: Molybdenum; Mines Branch, Canada Dept. Mines, No. 592.

Eckermann, H. von.,

1942: Ett preliminärt meddelande om nya forskningsron inom Alnö alkalina omrade; G.F.F., v. 64, p. 399-455.

Foye, W.G.,

1915: Nepheline syenites of Haliburton County, Ontario; Am. Jour. Sci., v. 40, p. 413-436.

1916: The relation of the titaniferous magnetite ores of Glamorgan Township, Haliburton County, Ontario to the associated scapolitic gabbros; Econ. Geol., v. 11, p. 662-680.

Friedlaender, C.,

1952: Alkaligesteine von Blue Mountains, Ontario; Schweiz. Min. Pet. Mitt., v. 32, p. 213-242.

Gittins, J.,

1961: Nephelinization in the Haliburton-Bancroft district, Ontario, Canada; Jour. Geol. v. 69, p. 291-308.

Goldich, S.S.,

1939: Perthite from Tory Hill, Ontario; American Mineral., v. 24, p. 407-427.

Grieve, R.A.F.,

1967: The petrology of a basic-ultrabasic complex in Monmouth Township, Ontario; M.Sc. thesis, University of Toronto.

Gummer, W.K., and Burr, S.V.,

1943: The nephelinized paragneisses of the Bancroft region, Ontario; Science, v. 97, p. 286-287.

1946: Nephelinized paragneisses in the Bancroft area, Ontario: Jour. Geol. v. 54, p. 137-168.

Harrison, W.G.,

1953: Unpublished B.Sc. thesis, McMaster University.

Heinrich, E.Wm.

1966: The Geology of carbonatites: Rand McNally and Co., Chicago.

Hewitt, D.F.,

1946: A petrologic study of alkaline intrusives in Haliburton County, Ontario; M.Sc. thesis, University of Wisconsin.

1954: Geology of the Brudenell-Raglan area; Ont. Dept. Mines, 62nd. Ann. Rept. v. 62, pt. 5.

1957: Geology of Cardiff and Faraday Townships; Ont. Dept. of Mines, 66th Ann. Rept., v. 66, pt. 3.

Hewitt, D.F.,

1960: Nepheline syenite deposits of southern Ontario; O_nt. Dept. of Mines, 69th Ann. Rept., v. 69, pt. 8.

Hewitt, D.F., and James, W.,

1956: Geology of Dungannon and Mayo Townships; Ont. Dept. of Mines, 64th Ann. Rept. v. 64, pt. 8.

Ingamells, C.O. and Gittins, J.,

1967: The Stoichiometry of scapolite; Canadian Mineral., v. 9, pp. 214-236.

Johannsen, A.,

1938: A descriptive petrography of the igneous rocks; vol. IV, p. 58, 298, 317.

Kinser, J.H.,

1937: A petrographic study of the Tory Hill stock, Haliburton County, Ontario; M.Sc. thesis, University of Minnesota.

Moyd, L.,

1949: Petrology of the nepheline and corundum rocks of southeastern Ontario; American Mineral, v. 34, p. 736-751.

Ontario Dept. of Mines

1957b: Haliburton-Bancroft area

Parks, W.A.,

1912: Report on the building and ornamental stones of Canada; vol. 1, Mines Branch, Canada Dept. of Mines, no. 100.

Satterly, J.,

1943: Mineral occurrences in the Haliburton area; Ont. Dept. of Mines, 52nd Ann. Rept. v. 52, pt. 2.

1944: Mineral occurrences in the Renfrew area; Ont. Dept. of Mines, 53rd Ann. Rept., v. 53, pt. 3.

1956: Radioactive Mineral occurrences in the Bancroft area; Ont. Dept. of Mines, 65th Ann. Rept. v. 65, pt. 6.

Satterly, J. and Hewitt, D.F.,

1955: Some radioactive mineral occurrences in the Bancroft area; Ont. Dept. of Mines Geol. Circular No. 2.

Shaw, D.M.,

1960a: The geochemistry of scapolite. Part I. Previous work and general mineralogy; Jour. Petrology, v. 3, pp. 218-260.

1960b: The geochemistry of scapolite. Part II. Trace elements, petrology and general geochemistry; Jour. Petrology, v. 3, pp. 261-285.

Spence, H.S.,

1932: Feldspar; Mines Branch, Canada Dept. Mines, no. 731.

Thomson, J.E.,

1943: Mineral occurrences in the North Hastings area; Ont. Dept. of Mines, 52nd Ann. Rept., v. 52, pt. 3.

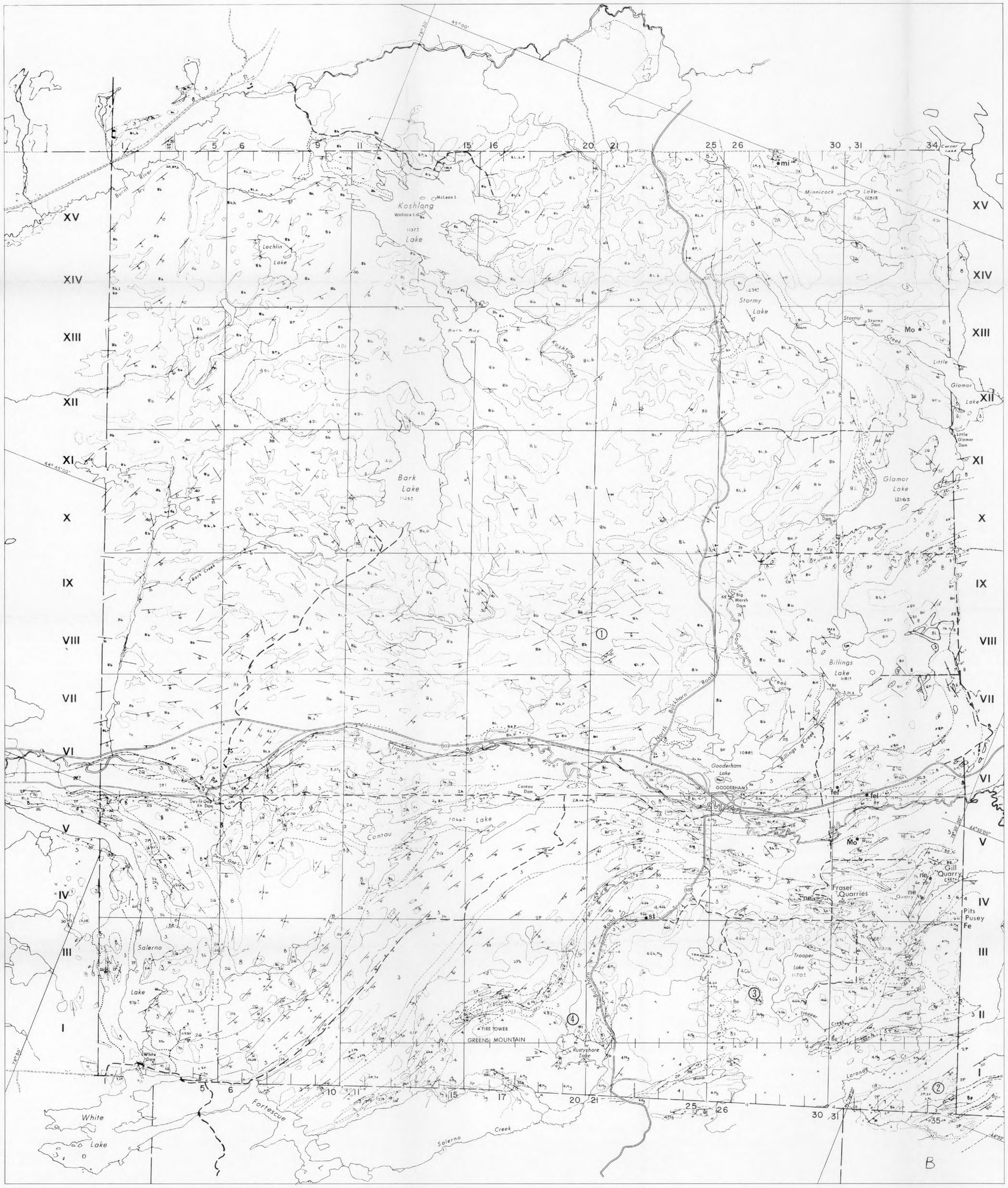
Tilley, C.E.,

1958: Problems of alkali rock genesis; Geol. Soc. London, Quart. Jour., v. 113, pp. 323-360.

Tilley, C.E. and Gittins, J.,

Wenban-Smith, A.K.,

1967: The petrology of part of the Glamorgan Gabbro, Ontario; M.Sc. thesis, University of Toronto.



ONTARIO DEPARTMENT OF MINES

PRELIMINARY GEOLOGICAL MAP No. P.59 (Revised)

GLAMORGAN TOWNSHIP

HALIBURTON COUNTY

Scale 1 inch to 1/2 mile

N.T.S. Reference: 31 D/15, 31 D/16, 31 E/1
G.S.C. Aeromagnetic Maps: 99G, 146G, 110G

LEGEND

CENOZOIC
PLEISTOCENE AND RECENT
Sand, gravel and clay

UNCONFORMITY

PRECAMBRIAN
PLUTONIC ROCKS

8 — GRANITIC ROCKS
- 8L Pink and white leucogranite; granite gneiss
- 8b Biotite granite; biotite granite gneiss
- 8h Hornblende granite; hornblende granite gneiss
- 8H Hybrid granite gneiss, (interbanded granite gneiss and metasediment); granitized gneiss
- 8P Granite pegmatite; pegmatitic granite

7 — SYENITIC ROCKS
- 7L Pink and white leucosyenite; syenite gneiss
- 7b Biotite syenite; biotite syenite gneiss
- 7h Hornblende syenite; hornblende syenite gneiss
- 7H Hybrid syenite gneiss, (interbanded syenite gneiss and metasediment); feldspathized gneiss
- 7P Syenite pegmatite

6 — NEPHELINE-BEARING ROCKS
- 6Sy Hypersolvus nepheline syenite with igneous texture
- 6b Biotite nepheline gneiss
- 6h Hornblende nepheline gneiss
- 6i Ijolite; massive nepheline-pyroxene rock
- 6e Nepheline-poor gneiss
- 6P Nepheline pegmatite
- 6Th Theralitic canadite (nepheline gabbro)

4 — MAFIC AND ULTRAMAFIC INTRUSIVE ROCKS
- 4Di Diorite
- 4Gb Gabbro
- 4Tr Troctolite
- 4Per Peridotite
- 4Px Pyroxenite
- 4Mg Metagabbro
- 4Am Amphibolite
- 4Db Diabase

METASEDIMENTS
MARBLE

3
- 3 Crystalline limestone; dolomite; marble
- 3d Diopside marble
- 3p Phlogopite marble
- 3g Graphite marble
- 3Ch Chondrodite marble
- 3S Calc-silicate rock; calc-silicate - calcite rock

PARAGNEISS-AMPHIBOLITE GROUP

2
- 2A Para-amphibolite; hornblende - rich gneiss; hornblende-plagioclase gneiss
- 2F Feldspathic paragneiss; quartzo-feldspathic paragneiss
- 2P Paragneiss; 2Pc, calcareous paragneiss; 2Ph hornblende paragneiss (less hornblende than 2A); 2Pg, garnet paragneiss
- 2Q Quartzite; 2Qp, pyroxene quartzite; 2Q Act, actinolite quartzite

GEOLOGICAL AND MINING SYMBOLS

- Small bedrock outcrop.
- Area of bedrock outcrop.
- Bedding, top unknown; (inclined, vertical).
- Gneissosity, (horizontal, (inclined, vertical).
- Geological boundary, observed.
- Geological boundary, position interpreted.
- Anticline, syncline, with plunge.

MINERAL OCCURRENCES REFERENCE*

Fe	Iron	Mo	Molybdenum
fel	Feldspar	ne	Nepheline
mi	Mica	st	Building stone

* Locations approximate, mostly from Satterly (1943).

LIST OF URANIUM PROPERTIES
(as of 1956)

*1 Bancroft Uranium Mines Ltd.
2 Cassiar Rainbow Gold Mines Ltd.
3 Nu-Cycle Uranium Mines Ltd.
4 Nu-World Uranium Mines Ltd.

* Not described in Open File Report 5021 (see Satterly 1956)

REFERENCES

Adams, F.D., and Barlow, A.E.
1910: Geology of the Haliburton and Bancroft area, Province of Ontario; accompanied by Map No.708, Haliburton sheet; Geol. Surv. Canada, Mem.6.

Hewitt, D.F.
1960: Nepheline syenite deposits of southern Ontario; Ontario Dept. Mines, Vol.69, pt.8.

Satterly, J.
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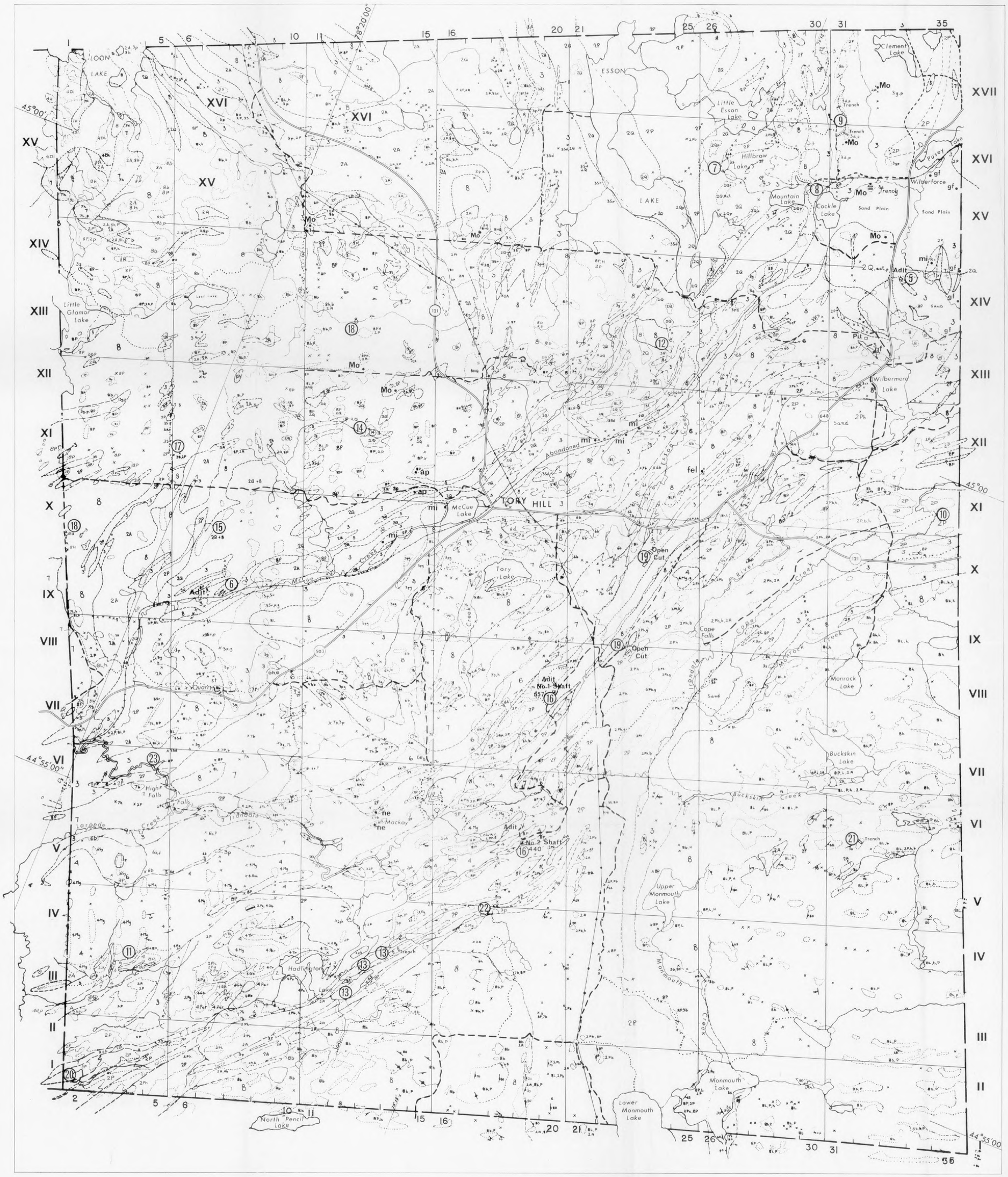
Base map derived from maps of the Forest Resources Inventory, Ontario Department of Lands and Forests with additional information by J. Gittins from recent air photographs.

Lot and concession lines very approximate.

Geology not tied to surveyed lines.

Magnetic declination approx. 9°30'W, 1965.

Issued 1960. Revised edition issued 1968.



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mi	Mica		

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(as of 1956)

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6 Canadian All Metals Explorations Ltd.
7 Cordell Gold Mines Ltd.
8 Cudney, T.
9 Desmont Mining Corp. Ltd. (formerly Homer Yellowknife Mines Ltd.)
*10 Empire Oil and Minerals Incorp.
11 Fairley Red Lake Gold Mines Ltd.
*12 Gould, B.
13 Jesko Uranium Mines Ltd.
14 Long Ridge Uranium Mines Ltd.
15 Nu-Age Uranium Mines Ltd., Old Smokey property
**16 Rare Earth Mining Co. Ltd.
17 Red Bark Mines Ltd., Monmouth property
18 Roford Mines Ltd.
19 Saranac Uranium Mines Ltd.
20 Scaddore Gold Mines Ltd.
21 Silanco Mining and Refining Co. Ltd., Tory Hill property
22 Urotomic Mines Ltd.
23 Wadasa Gold Mines Ltd.

* Not described in Open File Report 5021 (see Satterly 1956)
** Name changed to Amalgamated Rare Earth Mines Ltd., March 1957.

REFERENCES

Adams, F.D., and Barlow, A.E.
1910: Geology of the Haliburton and Bancroft areas, Province of Ontario; accompanied by Map No.708, Haliburton sheet; Geol. Surv. Canada, Mem.6.

Eardley-Wilmot, V.L.
1925: Molybdenum; Mines Branch, Canada Dept. Mines, No.592, p. 73-76.

Hewitt, D.F.
1960: Nepheline syenite deposits of southern Ontario; Ontario Dept. Mines, Vol.69, pt.8.

1967: Phosphate in Ontario; Ontario Dept. Mines, Mineral Resources Circular No.6, p.42.

Johnston, F.J.
1968: Molybdenum deposits of Ontario; Ontario Dept. Mines, Mineral Resources Circular No.7, p. 29-34.

Satterly, J.
1943: Mineral occurrences in the Haliburton area; Ontario Dept. Mines, Vol.52, pt.2.

1956: Radioactive mineral occurrences in the Bancroft area, Ontario Dept. Mines, Vol.65, pt.6.

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