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Pegmatite Mineral Resources of Ontario

By

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ABSTRACT

This report describes the pegmatite mineral resources of Ontario under the headings feldspar, quartz, mica, beryllium, lithium, uranium, rare earth minerals, molybdenum, tin, nepheline, and corundum. Tables are given listing 616 pegmatite deposits that have been opened in Ontario. The principal pegmatite mineral deposits are described. A classification of pegmatite mineral deposits is given with a discussion of internal pegmatite structure.

Pegmatite mineral production in Ontario up to 1965 has amounted to over $116,000,000, principally uranium, with small feldspar, mica, and corundum production, and minor beryl, nepheline, quartz, rare earths, and molybdenum.

There is a section on determination of grade and reserves of pegmatites.

Pegmatite Mineral Resources of Ontario

By

D. F. HEWITT[1]

INTRODUCTION

Pegmatites are igneous intrusive rocks, generally occurring as dikes or sills, characterized by coarse grain size. The most common type of pegmatite in Ontario is the *granite pegmatite*, composed predominantly of quartz and alkalic feldspars with a variety of accessory minerals. *Syenite pegmatite* and *nepheline syenite pegmatite* are also fairly common in Ontario and both types have been worked commercially. The common economic minerals found in pegmatites include feldspar, quartz, mica, beryl, columbite-tantalite, lithium minerals, corundum, cassiterite, molybdenite, uranium minerals, rare earth minerals, pollucite, zircon, nepheline, tourmaline, and gem stones.

Pegmatite mineral production in Ontario is given in Table 1.

Table 1 | *Pegmatite mineral production in Ontario to end of 1965*

PRODUCT	QUANTITY OR VALUE
Feldspar	$4,205,604
Mica	$4,561,193
Beryl	$8,057
Uranium	$105,503,124
Nepheline	$171,770
Quartz	$71,794
Corundum	$2,465,409*
Rare Earths	minor production of cerium concentrates
Molybdenum	a few hundred tons of concentrates

*In part pegmatite, in part syenite.

The pegmatites of one area are often all of the same age and have originated from the same source magma. For this reason, they usually have certain distinctive characteristics, such as their content of uranium or rare earth minerals, the presence of minerals such as beryl or spodumene, or the prevalence of muscovite mica, etc., which separate one group of pegmatites from another. Such a group of pegmatites, all genetically related, belong to a *pegmatite province*. Examples of pegmatite provinces in Ontario are the pegmatites of the following areas: Bancroft, Hybla, Verona, Perth, Madawaska, Sudbury, Mattawa, Parry Sound, Georgia Lake, and Crescent Lake.

A large number of Ontario pegmatite deposits have been opened up, and Table 2 gives the number of pegmatite mineral deposits in Ontario that are listed in this report.

Table 2 | *Number of pegmatite deposits opened in Ontario*

COMMODITY	NUMBER OF DEPOSITS
Feldspar	197
Lithium	46
Uranium	105
Rare Earths	128
Muscovite	63
Beryllium	23
Molybdenum	34
Columbite	8
Tin	3
Nepheline	9
Total	616

Some of these pegmatites contain more than one commodity, such as uranium and rare earths so that there is some duplication of listing.

CLASSIFICATION OF PEGMATITES

Pegmatites are classified on the basis of mineral composition as *granite pegmatite*, *syenite pegmatite*, or *nepheline syenite pegmatite*. Occasionally *basic pegmatites* are found, but they have not proven to be commercially important. The phlogopite-apatite-pyroxene-scapolite deposits of eastern Ontario are not classified here as pegmatites. They are carbonate replacement or contact metamorphic bodies in, or closely associated with, marble.

On the basis of structural type, pegmatites are classified into four groups:

Unzoned or *homogeneous pegmatites* in which the component minerals are more or less evenly distributed throughout the dike and show only minor textural variations. Such granite

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pegmatites have been mined for feldspar in Maine and North Carolina (Norton and Page 1956).

The nepheline pegmatites are unzoned, as are the corundum-bearing syenite pegmatites.

Zoned or *heterogeneous pegmatites* in which the component minerals are segregated into recognizable lithologic units or zones on the basis of texture and mineralogy. Most of the feldspar, beryl, spodumene, and mica-bearing pegmatites are of this type.

Cameron *et al* (1949) have given detailed descriptions of zoning in zoned pegmatites.

Complex replacement-type pegmatites in which the component minerals are segregated into recognizable lithologic units of varied mineralogy and texture, and in which replacement of country rocks of varied lithology is a predominant feature. Textures vary from granitic and porphyroblastic to pegmatitic. The uranium-bearing dikes of the Bancroft area are of this type, and these are therefore important commercially.

Xenoblastic patch pegmatites which are replacement pegmatites produced by recrystallization and mobilization of the constituent minerals in a gneissic environment of similar composition to the pegmatite. This replacement is usually accompanied by the introduction of hydrothermal solutions along certain zones or fractures in the rock. These pegmatitic patches are irregular in shape and have rather indefinite or gradational boundaries with the enclosing gneiss. Nepheline pegmatites in nepheline gneiss, syenite pegmatites in syenite gneiss and granite pegmatites in granitized gneiss are all examples of this type of pegmatite.

Corundum syenite pegmatites and some nepheline pegmatites of this type have been worked commercially.

Other Classifications

In some pegmatite provinces, the pegmatites appear to be spatially and genetically related to batholiths or stocks. In this case the pegmatites are often classified as to their spatial relationship to the batholith. *Interior pegmatites* occur within the batholith itself, *marginal pegmatites* occur along the batholith margins, and *exterior pegmatites* occur in the country rocks surrounding the batholith.

COMPOSITION AND TEXTURE

The granite pegmatites are composed predominantly of quartz, microcline microperthite and soda plagioclase. Common accessory minerals are biotite, muscovite, hornblende, pyroxene, and tourmaline, with minor or major accessory minerals occasionally present being beryl, spodumene, lepidolite amblygonite, uraninite, uranothorite, uranophane, allanite, monazite, fergusonite, euxenite, ellsworthite, columbite, zircon, apatite, garnet, pyrite, pyrrhotite, pollucite, chlorite, titanite, magnetite, hematite, calcite, fluorspar, cassiterite, molybdenite, and sericite.

The syenite pegmatites are composed predominantly of microcline microperthite, with minor soda plagioclase. The syenite pegmatites of the eastern Ontario corundum ranges commonly carry muscovite, corundum, biotite, and magnetite as important accessories. Allanite is occasionally present.

The nepheline pegmatites are composed predominantly of nepheline, albite, and microcline with abundant accessory biotite and magnetite. Minor accessories are calcite, zircon, sodalite, cancrinite, hydronephelite, zeolites, corundum, muscovite, apatite, hackmanite, galena, tourmaline, and allanite.

Texturally, pegmatites are distinguished by the large size of their constituent crystals compared to the normal grain size of the plutonic rocks with which they are usually associated. Grain size classification for pegmatites (after Cameron *et al* 1949, p.16) is given in Table 3.

Table 3 | *Grain size classification for pegmatites (after Cameron et al 1949, p.16)*

Texture	Grain Size
Fine-grained	Less than one inch
Medium-grained	1 to 4 inches
Coarse-grained	4 to 12 inches
Very coarse-grained	Greater than 12 inches

In normal granite, syenite, and nepheline pegmatites, the grain size ranges from 1 inch to about 1 foot. In pegmatites that are operated commercially for feldspar, mica, or nepheline, the crystal size is generally very coarse-grained being up to several feet in diameter. Very large crystals are not infrequently found in the larger commercial pegmatites. The author measured one microcline crystal at the Canadian Beryllium Mines and Alloys feldspar mine on lot 30, concession XV, Lyndoch township, Renfrew county, which measured 20 feet long, 8 feet wide, and 6 to 7 feet deep. The single crystal yielded over 75 tons of commercial feldspar worth about $750. Feldspar and nepheline crystals 10 feet in diameter are not unusual.

The Purdy mica mine near Mattawa, Ontario, in 1942 yielded a muscovite crystal measuring 9½ by 7 feet in diameter and nearly 3 feet thick. This single crystal yielded over 7 tons of trimmed mica valued at over $100,000. This 9½ foot crystal came from a dike not exceeding 15 feet in width.

The largest beryl crystal reported in Ontario was 8 inches in diameter and 3 feet long from the Canadian Beryllium Mines and Alloys property in lot 30, concession XV, Lyndoch township, Renfrew county. A beryl crystal measuring 14 by 16 inches has been reported from the N.M.W. pegmatite in the Georgia Lake area (Pye 1965, p.29). These beryl crystals are by no means of record size; "logs" of beryl 18 feet long and 4 to 6 feet in diameter are reported in U.S.A. from the Black Hills of South Dakota, from Maine, and from New Hampshire (Bates 1960, p.236).

The spodumene crystals in the spodumene pegmatite provinces of the Georgia Lake and Crescent Lake areas of Ontario reach 5 feet in size in rare occurrences (Pye 1965, p.33), but crystals a few inches across are the rule. Log-shaped spodumene crystals up to 47 feet long and 3 feet to 6 feet in cross section have been mined in U.S.A. at the Etta mine in the Black Hills of South Dakota (Bates 1960, p.236).

SIZE AND SHAPE

Pegmatites commonly occur as dikes or sills, which vary greatly in size and shape. The pegmatites range in length from a few feet to over a mile, and in width from a few inches to 500 feet. The dikes and sills are frequently tabular in shape, the average dike being 5 to 25 feet wide and up to 2,000 feet long.

The best feldspar pegmatites mined in Ontario have been wide and pod-shaped. The Richardson mine in Frontenac county, which produced 228,690 tons of feldspar, was just over 500 feet long, 200 feet wide, and the workings were 150 feet deep. The lowermost workings were still in feldspar. The second largest producer of feldspar, the Bathurst mine, which produced over 100,000 tons, was 350 feet long, 50 to 75 feet wide and was worked to a depth of 150 feet. The muscovite-bearing dikes at the Purdy mica mine were 8 to 15 feet wide, 200 to 400 feet long, and were opened to 150 feet in depth. The largest of the lithium pegmatites in the Georgia Lake area is the Newkirk dike with a maximum width of 25 feet and a length of 2900 feet (Pye 1965, p.27). The shape and attitude of the uranium-bearing ore shoots in the Bicroft pegmatites of the Bancroft area is interesting. The J and K orebodies were approximately 300 feet long, 10 feet wide, and extended to a vertical depth of over 1,350 feet with a plunge of 70°S. These pipe-like ore shoots extend to great depths compared to their lateral extent. Other ore shoots of smaller size were similar in shape.

Many pegmatites are irregular in shape and often branching. They frequently pinch and swell along strike. Regular tabular pegmatites are more common in schist of dark gneiss country rocks where there does not seem to be the tendency to ready dispersal into the country rocks.

INTERNAL STRUCTURE

The homogeneous pegmatites and the xenoblastic patch pegmatites show no internal zoning. In the zoned and complex replacement-type pegmatites the mineral constituents of the dikes are segregated into recognizable lithologic units. The classification of the internal units of a zoned pegmatite, which has been worked out and adopted by the U.S. Geological Survey, is as follows (Jahns 1955, p.1042):

1. Zones: successive shells, complete or incomplete, that reflect to varying degrees the shape or gross structure of the pegmatite body.
    - a: Border zone (the outermost zone).
    - b: Wall zone.
    - c: Intermediate zone or zones.
    - d: Core or innermost zone.
2. Fracture fillings: units, generally tabular in form, that fill fractures in previously consolidated pegmatite.
3. Replacement bodies: units formed essentially by replacement of pre-existing pegmatite, with or without obvious structural control.

Contacts between zones may be sharp or gradational. Two or more zones may merge or telescope along their length to form a single telescoped zone. The general features of zones are reviewed by Cameron *et al* (1949, p.16); these features are summarized here. Zones may be incomplete or discontinuous. Zones vary greatly in distinctness. In some cases zonal structure is evident only after detailed mapping and structural analysis.

Border or outermost zones are relatively fine-grained selvages that are not more than a few inches thick in most pegmatites. Wall zones, next inside the border zones, generally are coarser and much thicker. Although they are actually the second zones from the margins of pegmatite bodies, they are designated as "wall zones" in recognition of a terminology

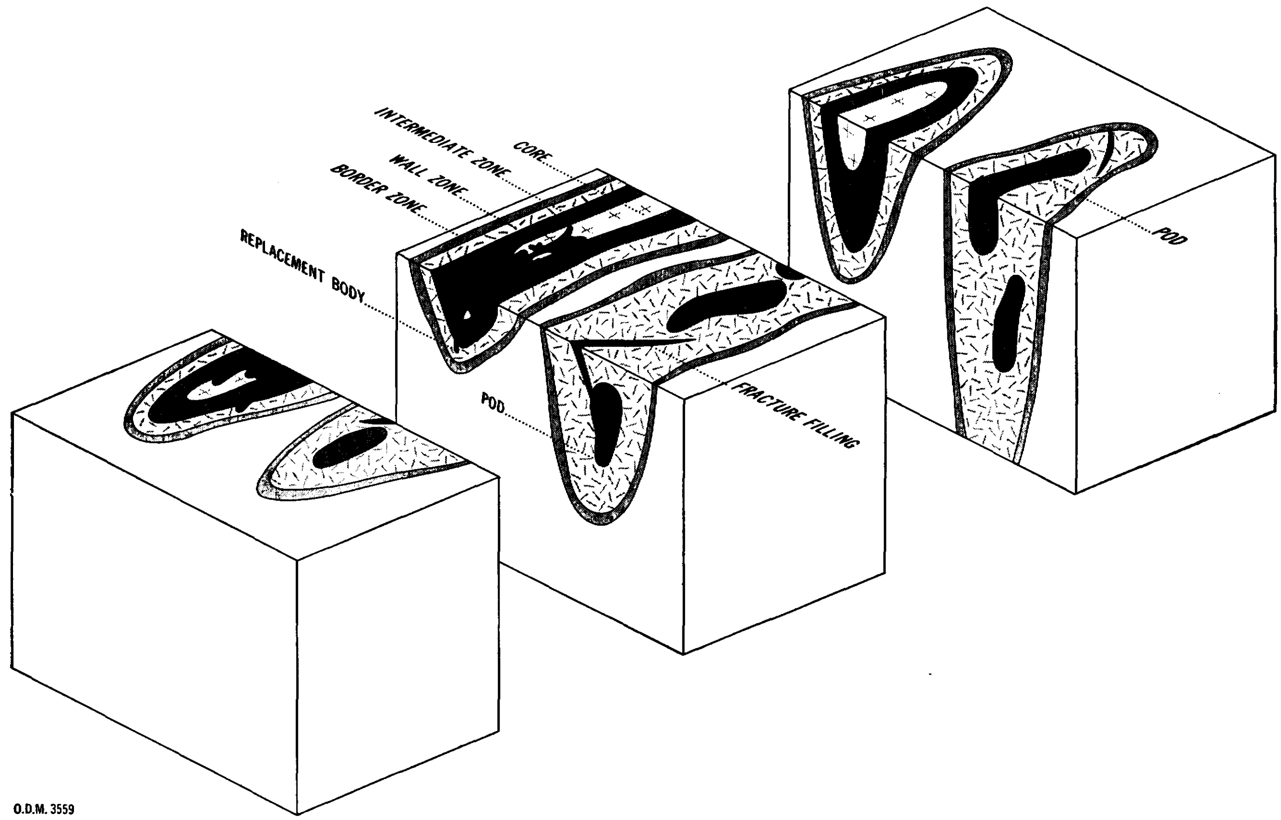

Figure 1—Idealized block diagram showing internal structural units in zoned pegmatite bodies. (After R. B. Rowe 1953, p.701)

firmly established in the domestic pegmatite mining industry. Most border zones are of little economic significance, and hence in the industry they have not been distinguished from the adjoining wall zones. The innermost zone, or core, generally occurs at or near the centre of a pegmatite body, commonly as an elongate lens or series of disconnected segments. Any zone between the core and the wall zone is an intermediate zone. There is no theoretical limit to the number of intermediate zones, but few pegmatites contain more than three mappable intermediate zones . . . Zones, as well as other units, are designated by names that express composition in terms of essential minerals, e.g. perthite-quartz pegmatite, plagioclase-quartz perthite pegmatite (Cameron *et al* 1949, p.20,21).

Cameron *et al* (1949, p.59) have found that pegmatites studied in U.S.A. frequently show similar sequences of assemblages of essential minerals from the walls inward. Few pegmatites contain all the assemblages, but those present usually occur in the order given below:

1. Plagioclase-quartz-muscovite
2. Plagioclase-quartz
3. Quartz-perthite-plagioclase ± muscovite ± biotite
4. Perthite-quartz
5. Perthite-quartz-plagioclase-amblygonite-spodumene
6. Plagioclase-quartz-spodumene
7. Quartz-spodumene
8. Lepidolite-plagioclase-quartz
9. Quartz-microcline
10. Microcline-plagioclase-lithia micas-quartz
11. Quartz

Fracture fillings are most commonly quartz, but may consist of two or more minerals. Replacement bodies are lithologic units formed by replacement of pre-existing pegmatite material.

In the complex replacement-type pegmatites, such as those at the Bicroft and Faraday uranium mines at Bancroft, recognizable lithologic units can be mapped. Many of these units are modified by replacement and assimilation of various types of country rock. The most common lithologic units are pink granite gneiss; pink leucogranite frequently magnetite-rich; pegmatitic granite, often peristeritic; pyroxene granite and syenite; pyroxene granite and syenite pegmatite; and cataclastic quartz-rich granite pegmatite. Inclusions and relict schlieren in all stages of assimilation may occur in the dikes. Lithologically the dikes range from granite to syenite.

ORIGIN AND MODE OF EMPLACEMENT OF PEGMATITES

Pegmatites have two modes of origin. First, they may occur as the by-product of the crystallization of granite batholiths, as late fissure-filling dikes representing the final crystallization of the magma. These dikes may occur within the batholith itself or within the adjacent country rocks. Secondly, pegmatites may originate by metasomatic replacement of the country rock by hydrothermal solutions or by anatexis and(or) rheomorphism of granitic gneisses, syenitic gneisses or nepheline gneisses.

Most homogeneous and zoned granite pegmatites originate by crystallization of a pegmatitic magma. Three principal modes of origin and emplacement are outlined by Cameron *et al* (1949, p.99):

1. Crystallization of a pegmatitic magma *in situ* with the injection of the magma into an open fissure. Zones may develop in a restricted system in which no new material is injected, but some material may escape during crystallization, and some reaction may take place between pegmatite and wall rock.
2. Zoned pegmatites may form by successive deposition in an open system in which there may be changes in pressure, temperature and composition of magmatic solutions supplied.
3. Zoned pegmatites may develop in two stages, a magmatic stage in which the pegmatitic magma was injected and crystallized in a more or less restricted system, followed by a hydrothermal stage in which solutions passing through the pegmatite effected replacement in an open system. This late stage hydrothermal replacement is responsible for many replacement units found in homogeneous and zoned pegmatites.

The complex replacement type of granite and syenite pegmatites characteristic of the Bancroft uranium camp are apparently formed by a complex process of injection of granitic and syenitic pegmatite magma, widespread assimilation and reaction of the pegmatite magma with the country rocks, and extensive hydrothermal replacement of the pegmatite by solutions in an open system.

The xenoblastic patch pegmatites are formed in granitic, syenitic and nepheline gneisses by anatexis and rheomorphism. This type of pegmatite and the complex replacement type of pegmatite of the Bancroft area are characteristic of the catazone or zone of deep burial within the earth's crust, and are frequently associated with anatectic granites and syenites.

The homogeneous and zoned granite pegmatites are most frequently associated with granite batholiths emplaced in the epizone or mesozone of the earth's crust.

REGIONAL DISTRIBUTION

By far the major part of Ontario pegmatite mineral production has come from the Grenville Province of the Canadian shield, including all the uranium, rare earth, nepheline, beryl and corundum production, and most of the feldspar, mica, quartz, and molybdenum production. The principal pegmatite deposits of economic interest so far found in the Superior Province are the lithium pegmatites of Georgia Lake and Crescent Lake areas, Thunder Bay district.

The more prominent pegmatite provinces of Ontario are the following: The *Perth area*, a feldspar mining district centred in Bathurst township; the *Verona area*, a feldspar mining district centred in Bedford and Portland townships; the *Hybla area*, a feldspar mining district centred in Monteagle township in which the dikes are characterized by their content of rare earth and radioactive minerals; the *Bancroft area*, a uranium mining district whose dikes contain uranium, thorium and rare earth minerals; the *Madawaska area*, a feldspar mining district centred in Murchison and Dickens townships in which the dikes are characterized by rare element minerals; the *Parry Sound area*, a feldspar mining district centred in Conger township where the dikes carry uranium and rare earth minerals; the *Mattawa area*, famous for its muscovite mica mines in Mattawan and Olrig townships; the *Sudbury area*, a feldspar mining district centred in Dill and Cleland townships; the *Georgia Lake area*, Thunder Bay district well-known for its spodumene pegmatites; and the *Crescent Lake area*, Thunder Bay district, also a spodumene pegmatite province.

AGE OF PEGMATITES

Numerous age determinations have been made of minerals from pegmatites in the Grenville Province. These ages range from about 900 million years to 1,100 million years, and are associated with the Grenville orogeny.

A limited number of age determinations have been made in the pegmatites of the Superior Province. The lithium granite pegmatites at Georgia Lake are associated in age with the local granite stocks, one of which has been dated at 2,455 million years.

DETERMINATION OF GRADE AND RESERVES OF PEGMATITES

The determination of grade and reserves of pegmatites depends upon the economic mineral sought and the type of pegmatite being investigated. If the pegmatite is sufficiently well stripped and exposed, detailed mapping of the body can be carried out. It can be determined whether the pegmatite is homogeneous with a fairly uniform distribution of economically recoverable minerals or whether the pegmatite is zoned. If zoned it is necessary to map and delineate the various mineralogical assemblages forming the contrasting zones and determine their extent, shape and structure by drilling.

The percentage of economic minerals present should be determined, and also the percentage of recoverable minerals present. In cases where hand cobbing is carried out, there is a limitation on the size of recoverable mica, feldspar, beryl, spodumene, etc. In the case of mica, the total percentage of mica present may not be significant, because mica smaller than 2 inches by 2 inches is not of commercial interest.

Sampling of a pegmatite body is normally carried out by grain measurements, channel sampling, bulk sampling, or diamond-drilling. Sampling of pegmatites is discussed by Rowe (1953, p.702–704). He gives the procedure for making a grain count of a valuable mineral directly on the pegmatite exposure as follows:

> The diameters of the area occupied by each exposed crystal of the valuable mineral are measured, and the area occupied by each crystal is computed. The sum of the areas of the individual crystals gives the total area occupied by these crystals. This sum is divided by the total surface area of the exposures on which the measurements were made and the result is multiplied by one hundred. The resultant figure is the percentage by volume of the mineral. If the mineral has a different specific gravity than the remainder of the pegmatite, further calculation is necessary before the percentage by weight is known. This calculation can be explained best by means of the following formula, where A is the percentage by volume of the valuable mineral, B is the specific gravity of the mineral, C is the percentage by volume of the remainder of the pegmatite, D is the specific gravity of the remainder of the pegmatite and W is the percentage by weight of the valuable mineral:
>
> $$W = \frac{AB}{AB + CD} \times 100$$
>
> This method of sampling has been very successful in calculating the percentage of beryl in pegmatites.

Norton and Page (1956, p.407) have suggested that for rocks with an average grain size of 2 inches or less, 100 square feet should be measured; for an average grain size of 6 inches, 1,000 square feet should be measured, and for 12-inch grain size, 5,000 square feet should be measured.

Channel sampling may be used in the evaluation of pegmatite mineral deposits. Channels are normally taken across the width of the mineralized zone normal to the strike of the dike. Bulk samples are useful where mill tests must be run.

Diamond-drilling is very useful to determine the size, shape and disposition of ore shoots within the pegmatite body. Zones may be delineated. Assays of drillcore are used to estimate grade. At Bancroft the uranium mines used diamond-drilling very extensively to outline the uranium-bearing ore shoots. Bullis (1965, p.721), describing the Faraday mine, states:

> The irregular nature of the ore zones was such that no other method of exploration would have been satisfactory and some 2,998 holes were drilled for a footage of 457,365 feet to May 1, 1964. If the production is added to the present reserve, it can be shown that the 2,998 holes have outlined 3,258,891 tons containing 7,337,253 lbs. of U_3O_8. The ratio of pounds of U_3O_8 outlined to feet of drilling is 16.04 lbs. per foot of hole; or conversely, 0.062 feet of hole has outlined 1.0 lb. of U_3O_8.

FELDSPAR

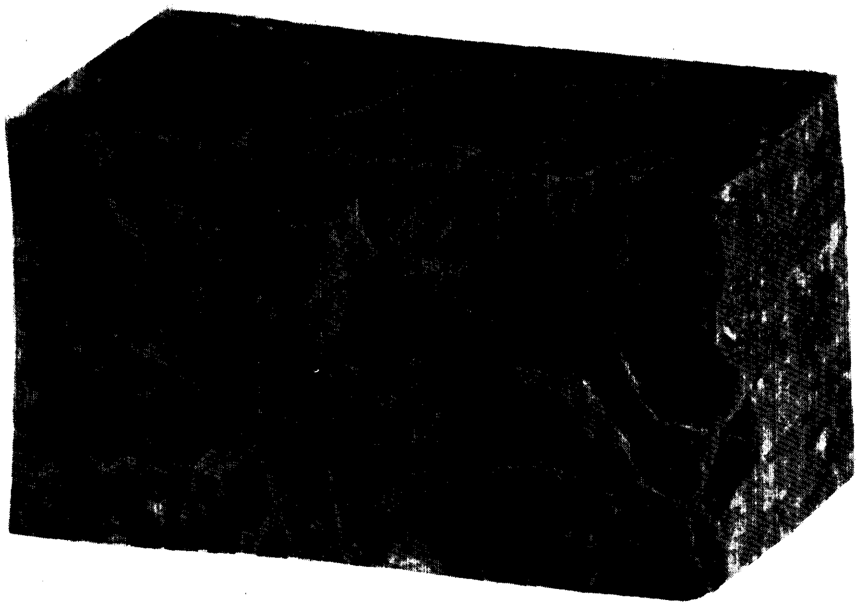

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Photo 1—Orthoclase feldspar. (Photo courtesy of Geological Survey of Canada)

Feldspar, used in the manufacture of glass, pottery and enamels, has been mined in Ontario from Precambrian pegmatite dikes since 1900, when the Richardson mine began production in Bedford township, Frontenac county. Over 200 feldspar mines operated in Ontario in the past 60 years, chiefly in eastern Ontario, with quarry centres at Verona, Perth, Hybla, Madawaska, Mattawa, Parry Sound, and Sudbury. Most of these have been small operations, but two mines in Ontario have each produced over 100,000 tons of feldspar.

Since 1954 there has been virtually no feldspar production in Ontario, principally due to the replacement of feldspar in the glass and ceramic trades by nepheline syenite. The only feldspar grinding plant in Canada in operation is the Buckingham, Quebec, mill of International Minerals and Chemical Corporation (Canada) Limited, which supplies Canadian requirements. Canadian feldspar production has declined from 16,096 tons in 1954 to 8,608 tons in 1963.

Composition and Properties

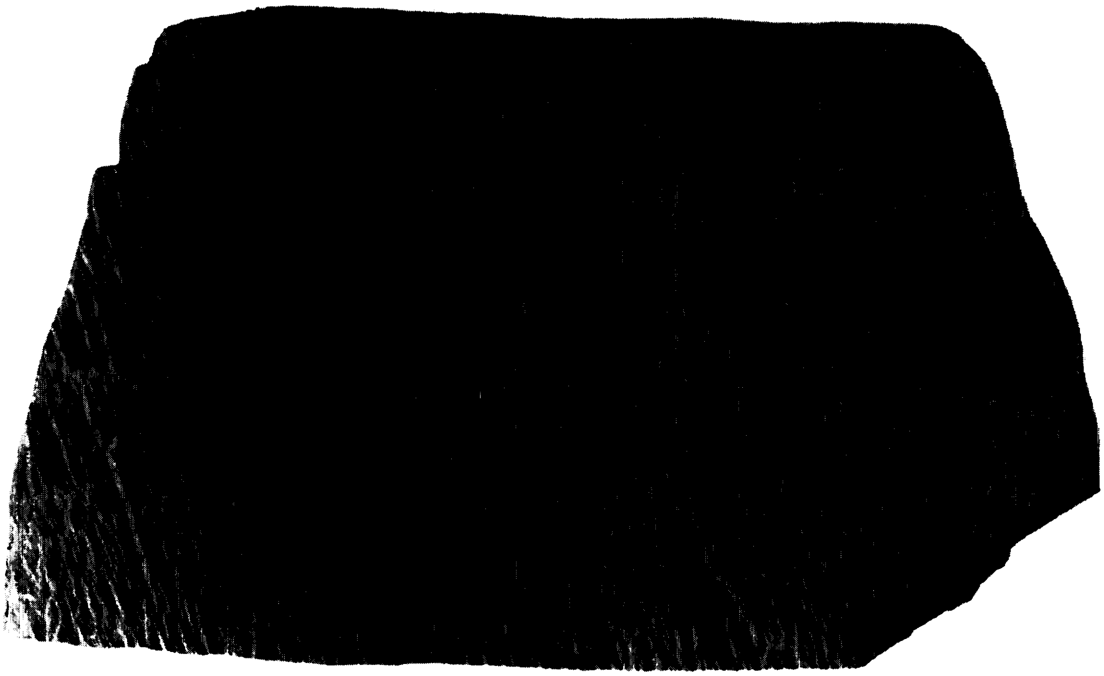
The name *feldspar* is given to a series of important rock-forming minerals that are aluminium polysilicates of potash, soda, and lime. Commercially the most important of the feldspar group are the *potash spars*, orthoclase and microcline, and the *soda spar*, albite.

ORTHOCLASE AND MICROCLINE

Orthoclase and microcline are both potash feldspars, identical in chemical composition, but differing in their crystal system; orthoclase is monoclinic, microcline is triclinic. Potash feldspars found in Ontario are usually dark-brick-red to pink, but may be white, green, or grey. The green variety is amazonstone, prized for lapidary work. Feldspar has excellent cleavage, splits well in two directions and rather poorly in a third direction, all nearly at right angles to one another. The lustre is from vitreous to pearly on cleavage surfaces. Fracture is uneven. The feldspars have a hardness of 6.0 to 6.5 and can only be scratched by a knife with difficulty. The streak is white.

PERTHITE

Potash feldspars are frequently intergrown with a very fine intergrowth of albite feldspar. This type of intergrowth is called *perthite*, after the town of Perth, Ontario, where it was first recognized. All the commercial feldspar commonly produced in Ontario is perthite and therefore contains some soda



VBM-1-H2

Photo 2—Microcline microperthite. (Photo courtesy of V. B. Meen)

VBM-2-H2

Photo 3—Albite feldspar. (Photo courtesy of V. B. Meen)

spar. Perthite can be recognized in hand specimen by careful examination of the cleavage face, where thin lamellae and blades of albite can be seen intergrown in a regular network with the microcline that makes up the main part of the perthite. In 28 analyses of commercial feldspar from Ontario mines (Spence 1932, p.102, 103), the perthites range in albite content from 12 to 25 percent. Anorthite is generally absent, and microcline makes up the remainder of the perthite. All the potash feldspars analyzed are perthite.

GRAPHIC GRANITE OR CORDUROY SPAR

Feldspar and quartz may occur intimately intergrown, with small blebs and blades of white to colourless quartz distributed in a fairly regular manner throughout the crystals of feldspar. This intergrowth is known as *graphic granite* or *corduroy spar*.

ALBITE

The soda spar, albite, is a white, grey, green-grey, or pinkish feldspar with good cleavage in two directions, nearly at right angles, and poor cleavage in a third direction. It is similar in physical properties to the potash feldspars, but can be distinguished from them by its twinning. If one of the good cleavage surfaces is carefully examined, the twinning shows up as a series of very fine parallel lines running across the cleavage surface at right angles to the cleavage edge. These twinning lines will often show up best when the feldspar is rotated slightly in reflected light.

ANORTHITE

Albite, the soda feldspar, and anorthite, the lime feldspar, make up an isomorphous solid solution series known as the *plagioclase* feldspars. Plagioclase may range in composition from the high-soda albite member to the high-lime anorthite member. The lime plagioclases are uncommon in pegmatites and do not constitute a commercial source of feldspar.

Grades, Specifications, and Uses

Feldspar is used chiefly in the manufacture of glass, whitewares, glazes, and enamels. The fusion point of a feldspar depends on the alkalis present, and becomes lower as the percentage of potash decreases and the percentage of soda increases. Most feldspars used in the ceramic industry fuse at cone 8 to 9; some, however, fuse as low as cone 4 or as high as cone 10.

When added to the glass batch, feldspar is primarily a source of alumina. The addition of two percent alumina strengthens the glass and results in increased resistance to breakage, scratching and a tendency to devitrify. Feldspar is also a source of alkalis and decreases the amount of soda ash required in the batch. Purchases of feldspar, nepheline syenite or aplite by the glass industry is based on the total units of alumina, soda, and potash contributed to the batch. A given tonnage of each contributed the following total alumina, soda, and potash: nepheline syenite 39, aplite 32, soda feldspar 31, potash feldspar 35. Because freight cost is also an important factor, the decision to use one material instead of another is based on the *value index:*

$$\text{Value index} = \frac{\text{f.o.b. cost} + \text{freight cost}}{\text{total chemical units}}$$

From 10 to 50 percent of feldspar is used in pottery bodies such as chinaware, electrical porcelains, and floor and wall tile. Feldspar is one of the most commonly used fluxes for all types of ceramic bodies. The softening range of the body and its refractoriness is increased with increased potash, at the expense of soda and lime in the feldspar used.

Soda spar is not used alone in pottery bodies because of its tendency to readily deform and cause warpage of the ware. However, a mixture of potash and soda spar yields a body whose firing behaviour varies slightly from the straight potash body. Both

Table 4 *Principal types of feldspar*

	ORTHOCLASE $KAlSi_3O_8$	MICROCLINE $KAlSi_3O_8$	ALBITE $NaAlSi_3O_8$	ANORTHITE $CaAl_2Si_2O_8$
COMPOSITION				
SiO_2	64.7	64.7	68.7	43.2
Al_2O_3	18.4	18.4	19.5	36.7
K_2O	16.9	16.9	—	—
Na_2O	—	—	11.8	—
CaO	—	—	—	20.1
CRYSTAL SYSTEM	monoclinic	triclinic	triclinic	triclinic
SPECIFIC GRAVITY	2.56	2.56	2.60	2.76
MELTING POINT	1200°C	1200°C	1110°C	1532°C
USUAL COLOUR	red, pink	red, pink	white, grey	grey, white

soda and potash spar are used in glazes, but the potash spar makes a more durable glaze.

Feldspar is also used for scouring powders and cleansers, artificial teeth, stucco dash, artificial stone, coating precast concrete building panels and poultry grit.

Selling Crude Feldspar in Ontario

Feldspar deposits in Ontario have been operated principally by independent jobbers selling crude lump feldspar, hand-cobbed and sorted in the pit, in carload lots, to a custom grinding mill. With the closing of the Rochester, New York, grinding mill of Consolidated Feldspar Corporation in the early 1950s, one of the most important markets for Ontario feldspar disappeared. A large percentage of the feldspar requirements are now met by feldspar produced by flotation mills in U.S.A., and there has been no feldspar production in Ontario since 1954.

No. 1 potash spar consists of carefully sorted pure feldspar containing less than 10 percent quartz and free from impurities such as pyrite, hornblende, mica, chlorite, iron staining, tourmaline, and garnet. Any minerals containing iron are undesirable. The crude is shipped as lump feldspar, from ½ inch and larger in size. The fines are wasted because soil and other impurities are concentrated in the fines.

No. 2 spar is not as well sorted as No. 1 spar and may contain more than 10 percent quartz. Iron staining and iron-bearing impurities present in a shipment of crude feldspar may take it out of the No. 1 grade class. There is very little demand for No. 2 grade spar, which is only suitable for lower grades of glass and pottery bodies. The demand for No. 1 soda spar is light.

It is customary to make a trial carload shipment of crude feldspar to the grinding mill for grading and valuation. Crude feldspar is largely bought by carload sample, and it is difficult to lay down exact specifications. The ultimate test of whether a ground feldspar is suitable for glass and pottery depends on its behaviour on firing. Deformation temperature, rate and range of fusion, and colour of the fused material are of primary importance and cannot be determined from a bulk chemical analysis of the crude feldspar. Crude feldspar is not, therefore, usually sold on the basis of chemical analysis.

Ground Feldspar

Glass grade feldspar is primarily a source of alumina, and either soda or potash spar is generally acceptable. Glass spar is used in the granular rather than the powdered state and is usually of minus-20-mesh size. Chemical specifications usually require at least 17 percent alumina, 11 to 12 percent alkalis (soda plus potash), and not more than 0.1 percent iron oxides.

Pottery grade feldspar is very finely ground, commonly 98 percent minus-200-mesh. High potash spar is preferable and the following composition is common: silica 65 to 67 percent; potash 10.5 to 12.5 percent; soda 1.5 to 3.0 percent; iron oxide 0.05 to 0.10 percent. The content of free silica and iron must be low.

Ground feldspar suitable for porcelain enamels should have 99 percent minus-100-mesh and 95 percent minus-200-mesh. The chemical analysis should be within the following ranges: silica, 65 to 66.5 percent; alumina, 18.75 to 19.75 percent; potash, 12 to 13 percent; soda, 2 to 3 percent; iron oxide, less than 0.10 percent; lime, less than 0.50 percent; magnesia, less than 0.10 percent. Impurities such as hornblende, garnet, biotite mica and tourmaline should not be present, because they do not fuse and show up as black flaws in the enamelled surface.

In 1930 U.S.A. producers and consumers of feldspar adopted a commercial standard classification for feldspar. This classification, Commercial Standard CS 23–30, may be obtained from the Bureau of Standards, U.S. Department of Commerce, Washington, but does not apply to Canadian production.

Origin and Mode of Occurrence

Feldspars are the most common rock-forming minerals; potash and soda spar occur as major constituents of such common igneous rocks as pegmatite, granite, syenite, alaskite, aplite and granodiorite. In most of these igneous rocks the feldspars are fine-grained and intimately associated with ferromagnesian minerals and quartz. Flotation is being successfully applied in U.S.A. to separate commercial feldspar from pegmatites too small in crystal grain size to allow hand sorting.

Pegmatite dikes have been the chief source of commercial feldspar in Ontario. These dikes are considered to be the offshoots of a granitic magma or molten rock mass lying at some depth beneath the earth's surface. In eastern Ontario these dikes are found cutting granite gneiss, hybrid gneiss, paragneiss, amphibolite, quartzite and marble. Some of the deposits appear to have been formed by injection of molten magma along fissures and cracks in the country rocks, others by the process of replacement of wall rocks.

The chief minerals of the granite pegmatites are microcline, perthite, albite, quartz, biotite, and

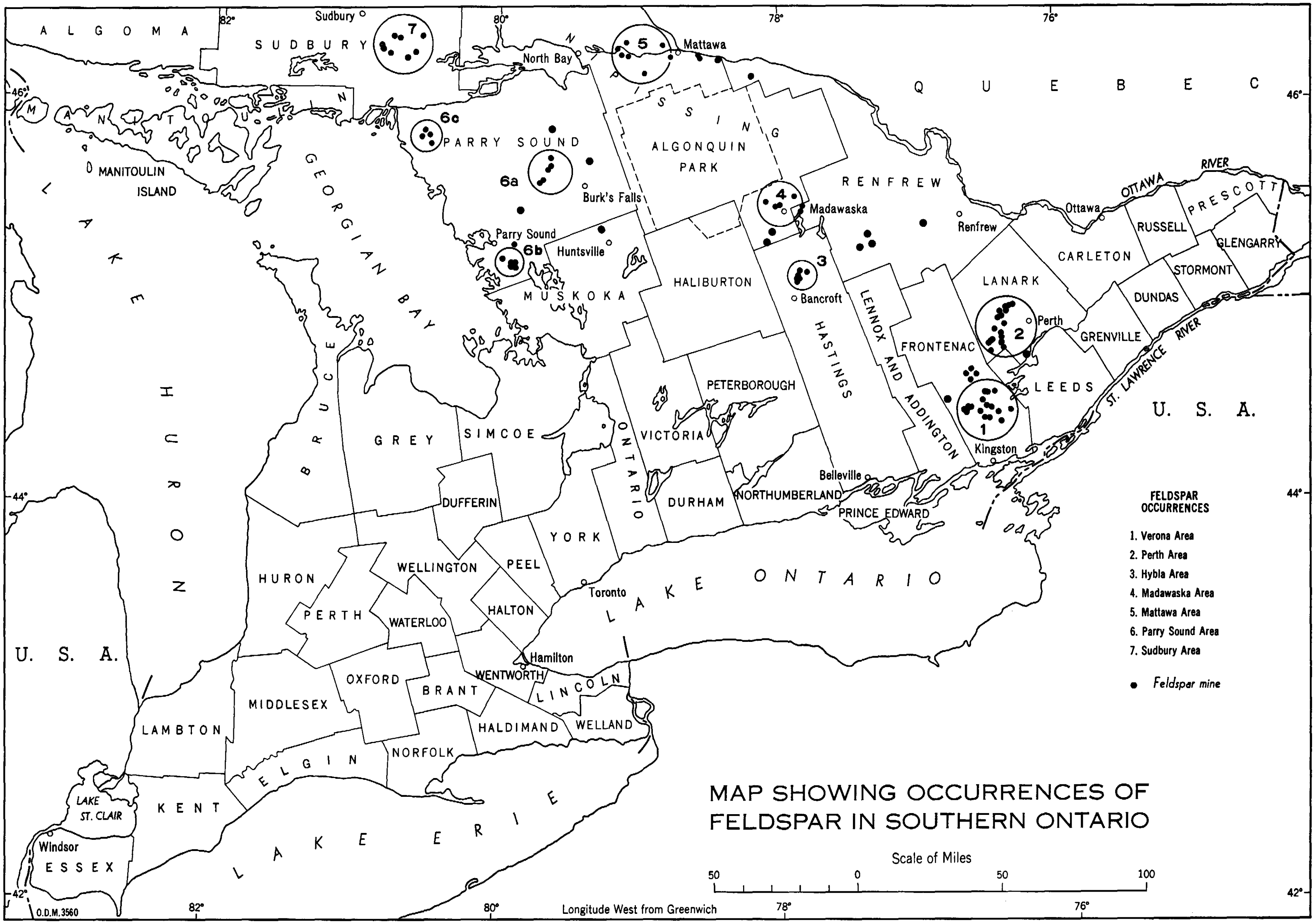


Figure 2—Map showing occurrences of feldspar in southern Ontario. (From O.D.M. Industrial Mineral Circular No. 3, p.4)

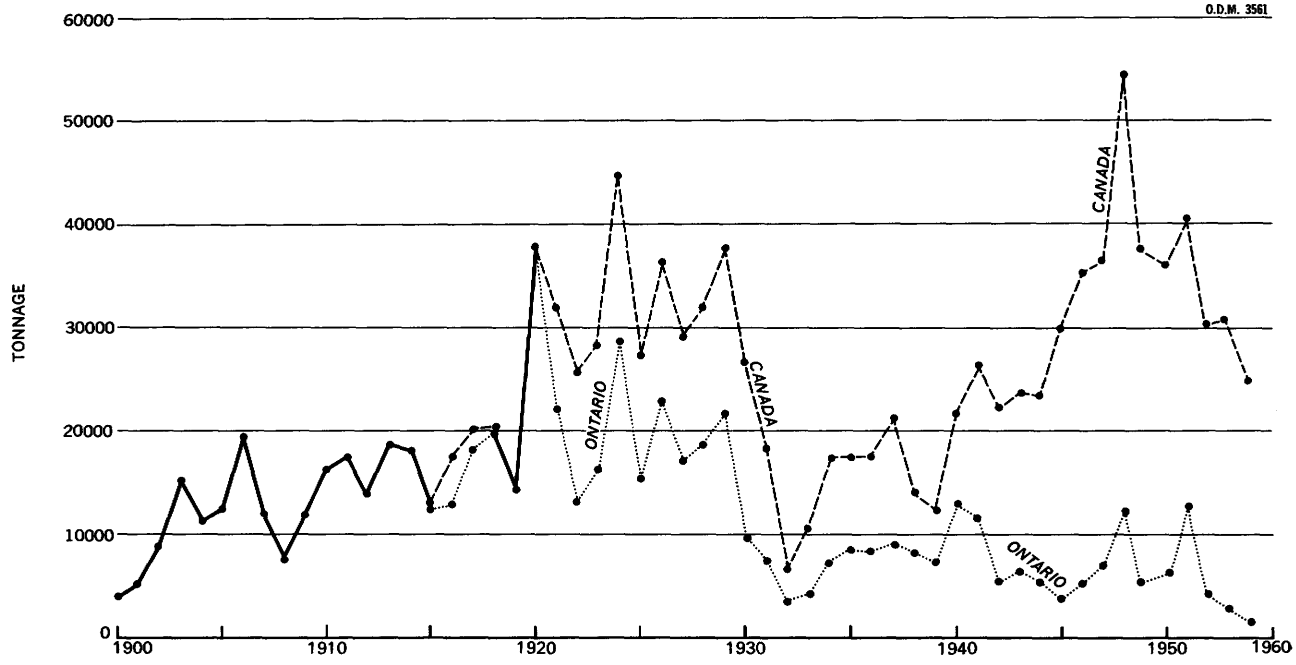


Figure 3—Feldspar production to 1960. (From O.D.M. Industrial Mineral Circular No. 3, p.5)

hornblende. Muscovite mica is often an accessory. Zircon, tourmaline, pyrite, sericite, garnet, chlorite, beryl, apatite, and rare-element and radioactive minerals occur as accessories. Graphic granite or *corduroy spar* is common.

Pegmatite dikes are often quite irregular in size and shape; many of them are branching. In general they are lenticular, tabular, or pod-shaped. Very few exceed 200 feet in width; the length may range from 100 feet for small dikes, to over 1,000 feet. The dikes often pinch and swell and send offshoots into the surrounding country rock. Many of the commercial pegmatite dikes in eastern Ontario are vertical or nearly vertical, but flatly-dipping dikes are not uncommon.

Zoning is frequently present in pegmatite dikes operated for feldspar in Ontario. The central core of the pegmatite is usually quartz. The border zone, or outer shell of the pegmatite next to the country rock, is often graphic in texture. Mica and plagioclase may be concentrated near the dike walls next to the border zone. The intermediate zone, between border zone and core, usually contains the large pure segregated crystals of feldspar, often with abundant quartz.

Pegmatite dikes that have cooled rapidly may have had little chance to develop a zonal character, and in some cases the entire dike may be graphic granite, an intimate intergrowth of quartz and feldspar.

History of Feldspar Production in Ontario

Feldspar production began in Ontario in 1900 when the Richardson mine was opened in Bedford township, Frontenac county. Figure 3 shows the Canadian and Ontario feldspar production from 1900 to 1960. From 1900 to 1920 almost the entire Canadian production came from the Verona area, with the Richardson mine being the major producer. During this period feldspar production ranged from 10,000 to 20,000 tons a year.

Table 5 *Canadian feldspar production 1941–1964*

	Ontario		Quebec		Canada	
Year	Tons	$	Tons	$	Tons	$
1941	11,822	107,124	14,218	137,160	26,040	244,284
1942	5,468	49,353	16,802	164,588	22,270	213,941
1943	6,659	61,549	17,199	176,222	23,858	237,771
1944	5,667	50,361	17,842	177,271	23,509	227,632
1945	3,857	35,414	26,389	247,242	30,246	282,656
1946	5,485	53,696	29,758	330,981	35,243	384,677
1947	6,958	60,396	29,146	320,964	36,104	381,360
1948	12,051	99,511	42,800	464,926	54,851	564,437
1949	5,100	43,610	31,848	384,892	36,948	428,502
1950	5,760	49,619	29,788	378,782	35,548	428,401
1951	12,749	125,727	28,000	425,370	40,749	551,097
1952	3,622	37,628	16,645	293,007	20,267	330,635
1953	2,655	28,018	18,591	319,146	21,246	347,164
1954	1,791	22,143	14,007	292,733	15,798	314,876
1955			18,152	355,879	18,152	355,879
1956			18,153	364,849	18,153	364,849
1957			20,450	393,284	20,450	393,284
1958			20,387	359,966	20,387	359,966
1959			17,953	301,372	17,953	301,372
1960			13,862	239,273	13,862	239,273
1961			10,507	229,626	10,507	229,626
1962			9,994	222,460	9,994	222,460
1963			8,608	197,031	8,608	197,031
1964			8,615	205,420	8,615	205,420

Table 6 *Group classification of feldspar production*

Group	Production	Number of Properties in Ontario
1	Over 100,000 tons	2
2	25,000–100,000 tons	2
3	10,000–25,000 tons	3
4	1,000–10,000 tons	41
5	Under 1,000 tons	85
P	Prospect	64
	Total	197

Table 7 *Consumption of feldspar in Canada*

	1962	1963
Whiteware	5,662 tons	4,800 tons
Porcelain enamel	260 tons	191 tons
Cleaning compounds	459 tons	411 tons
Other uses	437 tons	607 tons
Total	6,818 tons	6,009 tons

In the 1920s deposits in the Perth, Hybla, Mattawa, Parry Sound, and Sudbury areas were opened, and there were a large number of small producers active in these districts. In 1920 feldspar production reached a peak of 37,224 tons, a figure not since equalled. Since 1920, when the important deposits in the Buckingham and Gatineau districts of Quebec began to produce, Quebec feldspar production has made up an increasingly important part of Canadian production and at present accounts for the entire Canadian production.

Total Ontario production from 1900 to 1954 has amounted to 661,990 tons valued at $4,205,604. Of this total amount, the Richardson mine in Bedford township and the Bathurst mine in Bathurst township together produced a total of 334,708 tons or 50.5 percent of total feldspar production. These two large mines have dominated Ontario feldspar production.

Table 8 lists 197 feldspar pegmatite deposits in Ontario, giving location, name of mine, operators, years of operation, approximate production, reference, and short description. For detailed descriptions of the various properties, the references should be consulted.

Ontario feldspar deposits have been grouped, according to production, on the basis of Table 6.

Only seven Ontario feldspar mines have had a total production exceeding 10,000 tons.

Grade and Evaluation of Feldspar Deposits

Because of the irregularities in size, shape and mineral distribution in pegmatites, it is often difficult to determine the grade and tonnage available in a deposit. In general, the factors to be considered in evaluating a feldspar deposit concern its location and the character of the dike, and can be grouped under the following headings:

LOCATION

A. Access by road.
B. Proximity to rail transportation.
C. Trucking and freight charges.
D. Availability of experienced miners.

CHARACTER OF THE DEPOSIT.

A. Size of dike: width, length, depth.
B. Attitude of dike: strike and dip.
C. Shape or regularity of the dike: tendency to pinch and swell; lenticular, pod-shaped, etc.
D. Site: depth of overburden; potentialities of the site for quarry operation.
E. Mineral constituents of the dike:
   - (i) Degree of segregation or zoning of minerals within the dike.
   - (ii) Size, purity and abundance of large feldspar crystals.
   - (iii) Character of the feldspar itself; colour, purity, potash to soda ratio.
   - (iv) Presence of objectionable impurities and staining.
   - (v) Presence of marketable accessories such as beryl, columbite, mica, etc.
   - (vi) Spar to waste ratio, percentage of quartz and graphic granite.

LOCATION

Access:

Most feldspar deposits in eastern Ontario are situated within a mile of county or township roads, and it is seldom that more than a mile of road need be built for access to feldspar prospects. It is rarely that the size or productive capacity of a feldspar deposit would warrant construction and maintenance of a new mine road over a mile in length.

Proximity to rail transportation, and
Trucking and freight charges:

The length of truck haul from mine to rail transportation is a very important factor in evaluating operating costs. Truck costs will vary, depending on the loading and unloading facilities available, road maintenance costs, time of round trip, quality of roads, etc. In general trucking costs are between 10 and 20 cents per ton-mile and should not normally exceed $1.00 per ton.

It has been customary in eastern Ontario for buyers of crude feldspar to pay prices for feldspar f.o.b. cars, depending on the differential in freight rates for various localities. Mines close to a custom grinding mill may receive preferential prices.

Availability of experienced labour:

The operation of a feldspar quarry requires some knowledge of mining, and hand sorting of spar and waste in the pit requires some knowledge of feldspar in order to distinguish potash spar from soda spar. For these reasons experienced labour is desirable.

CHARACTER OF THE DEPOSIT

Size of dike,
Attitude of dike, and
Shape and regularity of dike:

The largest pegmatite dike mined in Ontario is the Richardson property, in Bedford township, Frontenac county. Here the dike was mined for a length of over 500 feet to a depth of 100 to 150 feet. The total width of the dike, including the central core of quartz which was not mined, is 200 feet.

The best commercial dikes have mining faces not less than 30 feet wide. Dikes are likely to persist in depth; several Ontario mines exceed 100 feet in depth. The deepest feldspar workings are about 150 feet deep. Feldspar mining in Ontario has been of the open-cut quarry type and 150 feet is just about the economic depth limit for this type of working due to safety restrictions in narrow openings.

Pegmatites are notably irregular in size and shape and it is difficult to predict whether the dike is likely to widen or narrow vertically or laterally. Diamond-drilling is of great value in determining the size and continuity of the dike, but few operators can afford expensive exploratory development of feldspar-bearing dikes.

Mining site:

The potentialities of the site should be carefully considered with a view to mining problems to be encountered. For open-pit mining, the overburden must be stripped off, and the surface cleaned. Dirt and soil are objectionable impurities in the product. Where the mining site is on a hill the dike should be developed, if possible, by a lateral cut rather than by sinking, so that there can be truck haulage in and out of the cut from the working face.

Mineral constituents of the dike:

To be of commercial value for hand cobbing, the pegmatite minerals in the dike should show a high degree of segregation; experience has shown that dikes in which there is pronounced zoning of mineral constituents have the best commercial potentialities.

Large, clean feldspar crystals at least 5 feet in diameter making up 50 percent or more of the mineable portion of the dike, are desirable. The colour of the feldspar itself is not important and is no indication of its iron content. Both white and red potash feldspars are marketable. A chemical analysis will give the potash to soda ratio of the feldspar. The percentage of quartz in the product should not exceed 10 percent. Graphic intergrowths of finely disseminated quartz in the feldspar are objectionable, as are inclusions of such minerals as hornblende, biotite, magnetite, pyrite, garnet, epidote, hematite and tourmaline. The feldspar should be free of chlorite seams and iron staining. Iron staining is frequently more common near the surface of the deposit.

If such minerals as muscovite, beryl, columbite or spodumene are present in the dike, they may be sorted out during the course of mining and provide an additional source of income.

If the dike runs 50 percent mineable feldspar, the recovery or spar to waste ratio may be 1 to 1. If the recovery falls below 1 ton spar to 2 tons waste, the mining is not likely to be economic.

Mining

In eastern Ontario feldspar mining has been done entirely by open-cut methods. Stripping is done by bulldozer and hand shovel. Equipment necessary for mining includes a compressor, air drills, drill steel and bits, dynamite, caps, and fuse.

Selective mining of the face is done as much as possible, so that one round is fired in pure feldspar, the next round in waste, etc. to cut down on sorting. After blasting, spar and waste are sorted by hand and loaded into trays, mine cars, or directly onto trucks by hand shovels or large tined forks. The use of large tined forks rids the spar of fines and facilitates sorting.

Where the mining face is advanced laterally along the dike on a hillside site, trucks can be driven to the working face and loaded directly. Where the mining site does not permit access to the working face by truck, the spar is loaded into trays and raised by derrick and hoist. Boom derricks may be of wood or steel. A sump and pump are required where there is no drainage.

During the late 1940s and early 1950s when feldspar mining was active in eastern Ontario, the average operator produced about 100 tons of spar a week with a crew of 10 men, averaging between 1 and 2 tons per man-day. Spar to waste ratio varied from 1:1 to 1:2.

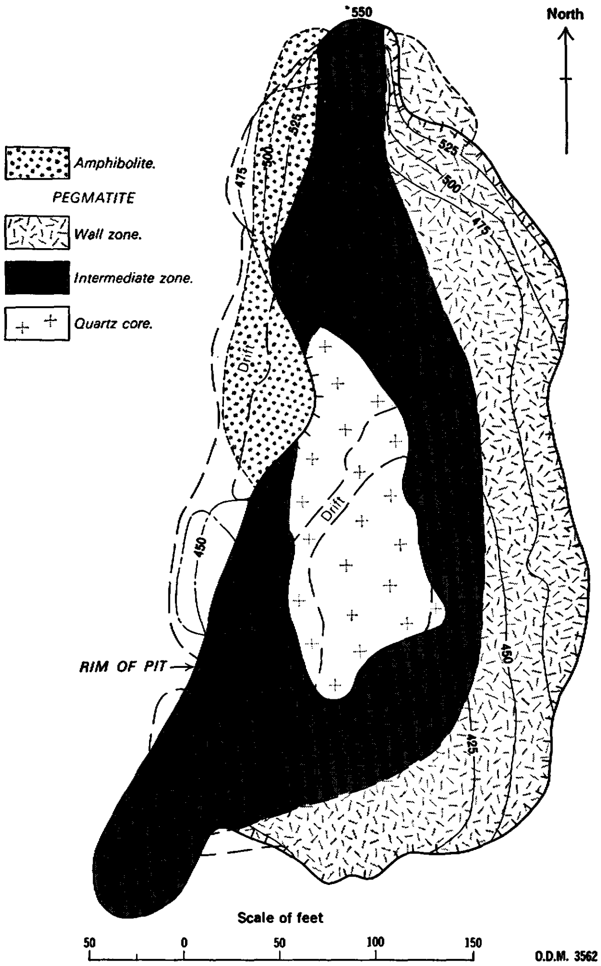


Figure 4—Richardson feldspar mine, lot 1, Con. II, Bedford twp. (Published by permission of N. B. Davis, Consulting Engineer, Ottawa)

Major Feldspar Deposits

Some of the major feldspar deposits of Ontario are described in the following section.

RICHARDSON FELDSPAR MINE

The Richardson feldspar mine is on lot 1, concession II, Bedford township, Frontenac county, just east of the Desert Lake road. It lies between Thirteen Island Lake and Desert Lake. This is the largest feldspar mine in Ontario, having produced 228,690 tons between 1900 and 1951. The mine was opened in 1900 by the Kingston Feldspar and Mining Company of Kingston and operated until 1916, when the mine was taken over by Feldspar Limited of Toronto who operated until 1918. The mine was idle until 1928 when it was leased to the Genesee Feldspar Company of Rochester, New York, and operated until 1931. In 1941 the mine was leased by E. H. Storms and S. A. Price of Toronto under the name Federal Feldspar Company. This company produced 414 tons of feldspar. In 1945 the mine was purchased by Canadian Flint and Spar Company of Ottawa who mined the dike in 1947 and 1948, and in 1950 and 1951. The property has been inactive since then.

The granite pegmatite dike strikes north-northeast and dips steeply to the west. The dike cuts metagabbro and paragneiss, which make up the west wall of the dike. On the east side of the pit, 150 feet from the pit, marble is exposed. Near the margins of the dike there are horses of hornblende gneiss country rock in the pegmatite. The workings are 500 feet in length, 200 feet in width, and 150 feet deep. The dike is zoned with a central core of quartz. The intermediate zone consisted predominantly of brick-red microcline perthite, with

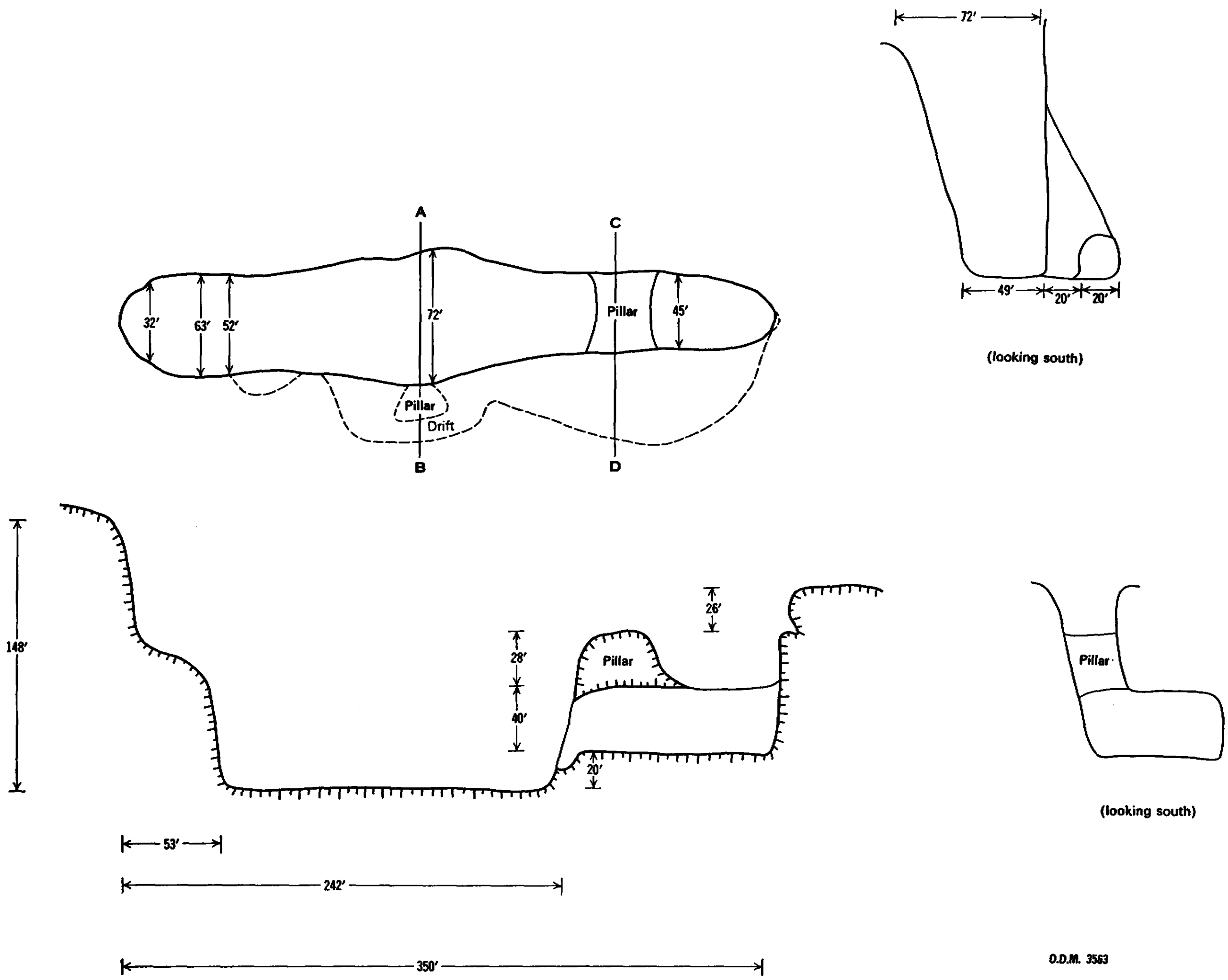


Figure 5—Bathurst feldspar mine, lot 16, Con. VIII, Bathurst twp. (Published by permission of N. B. Davis, Consulting Engineer, Ottawa)

some quartz. The wall zone consisted of graphic granite, microcline perthite, quartz and albite. Some accessory hornblende, biotite and sulphides are present with minor titanite, magnetite, calcite, apatite and tourmaline. When examined by the author in 1948, graphic granite was present in the bottom of the pit on the east side of the quartz core. Some potash feldspar was obtained from a drift driven west of the quartz core (Figure 4).

BATHURST FELDSPAR MINE

The Bathurst feldspar mine is on the S½, lot 16, and the N½, lot 15, concession VIII, Bathurst township, Lanark county, near Perth, Ontario. This is the second largest feldspar mine in Ontario, having produced 106,018 tons of feldspar between 1926 and 1953. The mine was operated by Bathurst Feldspar Mines Limited.

The granite pegmatite dike strikes north-south and dips steeply west. It has been traced alongstrike for over 600 feet and pinches out in both directions. The dike has been opened over a length of 350 feet. At the north end the pit is 32 feet wide, in the central part 72 feet wide and at the south end 45 feet wide. The pit has a maximum depth of 148 feet. There is a pillar at the south end. The west face overhangs.

The dike is composed largely of microcline, microperthite, and quartz, with some albite, accessory tourmaline, pyrite, hornblende, and biotite.

Feldspar crystals are 10 to 15 feet in diameter. The north end of the pit was abandoned because of the overhanging wall on the west side. No noteworthy zoning of the dike was observed.

MACDONALD FELDSPAR MINE

The MacDonald mine was the largest feldspar mine in the Hybla area, and the third largest feldspar producer in Ontario. It is well known for its interesting assemblage of radioactive minerals.

The main workings of the MacDonald mine are located on lot 18, concession VII, Monteagle township, Hastings county, two miles by road east of Hybla station, which is on the Canadian National railway, 10 miles north of Bancroft. Three smaller open cuts are located on lot 19, concession VII, just west of the main workings.

The MacDonald mine was opened in 1919 by the Pennsylvania Feldspar Company under lease from Peter MacDonald. This company, and its successors, the Verona Mining Company and the Genesee Feldspar Company, operated the mine until 1928. From 1929 to 1935 some production was reported by Peter MacDonald from the dumps, and from the pits on lot 19. Total production from 1919 to 1935 amounted to 35,048 tons of feldspar. The mine was optioned and examined for radioactive minerals during the Bancroft uranium rush in the 1950s.

The workings are shown on Figure 6 (facing p.76). The main dike strikes west and dips 60°–70°N. The main workings have a length of 550 feet, a maximum width of 70 feet and a depth of 120 feet. The dike is exposed on the side of an east-facing hill and was originally developed by an open cut that was driven westward along the dike into the hillside. At the west end of this open cut, the dike narrows to 15 feet in width and gradually pinches out. Subsequently, a second open cut was driven westward on the dike at an elevation 40 feet below the original cut. As seen on the accompanying map the portal of this cut was 120 feet east of the portal of the upper cut.

The lower cut was run a distance of 110 feet westward on the dike and then extended 175 feet as an adit. The lower part of the dike was removed by stoping upward from the lower level to break out into the upper open cut, and the two levels are now joined by a large open stope along the central part of the dike. The vertical elevation of the lip of the open cut at the west end of the workings is 113 feet above the elevation of the floor of the lower cut at the portal of the open stope.

Northwest and west of the main workings, there are three other small open cuts on parallel granite pegmatite dikes. These are the southwest, northeast, and northwest cuts.

Southwest cut: a hundred feet west of the main workings a small cut, 110 feet long, 25 feet wide, and 20 feet deep has been opened up on a small granite pegmatite dike that cuts amphibolite, metapyroxenite, syenite, and granite gneiss country rocks.

Northeast cut: a hundred and fifty feet north of the southwest cut is a shallow cut, 20 by 50 by 8 feet deep, on a small graphic granite pegmatite.

Northwest cut: a hundred feet west of the northeast cut, there is a large, water-filled open cut 250 feet long, 40 feet wide, and 25 to 30 feet deep. This cut opens to the west. The granite pegmatite dike strokes N70°E and dips steeply to the north.

Geology

The following is taken from Hewitt (1954, p.45,46):

The country rocks in the vicinity of the MacDonald mine consist of highly syenitized and granitized Grenville metasediments, syenite gneiss, granite gneiss, and pegmatite. The Grenville metasediments consist of paragneiss, amphibolite, and crystalline limestone. These original sediments have been intruded and replaced by the late acid plutonic rocks that are represented in this vicinity by the syenite and leuco-granite gneisses. The sediments now consist of feldspathic paragneiss, scapolitic and pyroxenic amphibolite, lime metapyroxenite, silicated limestone, lime silicate skarn, and hybrid granite and syenite gneisses. These are intruded by fine-grained, black lamprophyre dikelets, which may be related in age to the late granite pegmatite.

The late granite pegmatite dikes occupy east-west fractures that cut the country rocks. The main granite pegmatite dike strikes east-west and dips 60°–70°N. The smaller granite pegmatites to the northwest and west strike N.70E. and dip steeply to the north. The structure of the country rock gneisses in the vicinity of the MacDonald pegmatites is extremely variable, and it is difficult to determine their general trend because of local folding. The granite pegmatites are definitely crosscutting and have sharp though irregular contacts with the country rock. The wall rocks in the immediate vicinity of the granite pegmatite dikes may have been feldspathized to some extent, but the author attributes most of the granitization and metasomatism to an earlier widespread period of acid plutonic activity, which affected the whole region.

Shape

The main dike is lens-shaped. At its western end it has a width of 5 feet and rapidly widens to the east and with depth, until a maximum width of about 70 feet is reached towards the centre of the workings. At the eastern end in the lower cut the dike is not well exposed but does not appear to exceed about 25 feet in width.

Internal Structure

The main dike shows a zonal arrangement of internal units. The units usually present include: (1) a fine-grained graphic granite border zone; (2) a wall zone of medium-grained albite-microcline-quartz pegmatite; (3) an intermediate zone of coarsely crystalline quartz and microcline perthite; and (4) a central core and segregated patches of massive quartz, sometimes containing microcline. The coarsely crystalline salmon-pink to white calcite pods that occur within the dike may have formed about the same time as the latest quartz of the core towards the end of pegmatite stage.

General Description

Entering the mine from the lower or easternmost cut, the north wall is seen to consist of pink leuco-granite gneiss and calcite-amphibole-pyroxene gneiss intruded by pegmatitic stringers. The pegmatite-wall rock contact is exposed, and the border zone of the pegmatite is fine-grained graphic granite pegmatite underlain by a medium-grained quartz-albite-microcline pegmatite with crystals 8–10 inches in size. At the mouth of the stope a good section is exposed on the west wall. Here the gneiss-pegmatite contact is exposed. It is irregular, and pendants of gneiss extend down into the pegmatite. There is a graphic granite pegmatite zone at the contact followed by medium-grained quartz-albite-microcline, quartz-microcline, and massive quartz towards the south wall near the core of the pegmatite. On entering the stope, pink and white calcite can be seen in the pillar in massive quartz. The open stope has a maximum height of 25 feet from floor to back at a point 30 feet west of the portal. The south wall of the stope consists of coarse-grained quartz and microcline and minor soda spar in crystals 5–6 feet in diameter. The north wall and the back of the stope expose medium-grained granite pegmatite, microcline, quartz, and soda spar, in crystals 1–2 feet in diameter, with some graphically intergrown quartz and soda spar. Some gneiss is exposed at the base of the south wall and in the back 60 feet west of the portal. Radioactive minerals with shatter haloes, and massive sulphides, occur in the granite pegmatite towards the west end of the stope and in the pillars between the stope and the upper open cut.

In the upper open cut the hanging-wall country-rock gneiss is exposed continuously. For 10–15 feet below the contact the pegmatite is medium-grained, and finally coarse-grained in the intermediate and central portions of the dike. In places large pendants of gneiss extend down into the pegmatite. Towards the west end of the upper cut the quartz core is well exposed along the foot of the south wall.

Northeast Cut. The country rocks exposed along the margins of this pegmatite are grey hornblende-plagioclase-scapolite gneiss, pyroxenic amphibolite, hornblende syenite, granite gneiss, and interbanded earlier granite pegmatite. The pegmatite is composed largely of medium-grained graphic granite, microcline perthite, plagioclase, and quartz. There appears to be too much graphic intergrowth of soda spar and quartz for the deposit to be of commercial interest. The dike is about 15 feet wide at the west end of the cut, where both walls are exposed and appears to dip to the south.

Northwest Cut. The wall-rock gneisses are well exposed along the north wall of the cut and consist of scapolitic and pyroxenic amphibolite, silicated limestone, hornblende syenite, granite gneiss, and pegmatite. The dike-wall rock contact is sharp but irregular. Tongues of pegmatite extend into the amphibolite. The granite pegmatite of the dike is younger than most of the granite pegmatite that occurs interbanded with the amphibolite. At the contact there is a 2- to 3-foot wall zone of graphic granite pegmatite, followed by an intermediate zone of coarse microcline and quartz in crystals up to 6 feet in size. Three feet below the contact within the pegmatite there are several large allanite crystals, averaging 12 inches in diameter, surrounded by marked radial shattering.

Southwest Cut. At its eastern end the granite pegmatite is 4–5 feet wide, strikes east, and dips steeply north. The wall rocks are silicated limestone, skarn, metapyroxenite, scapolitic and pyroxenic amphibolite, hornblende syenite, granite gneiss, and pegmatite. The pegmatite has a fine-grained wall zone, 2–3 feet wide, and an intermediate zone consisting of microcline perthite and quartz in crystals up to 3 feet in size. The cut is water-filled, and the central part of the dike is not exposed.

Mineralogy

The following is taken from Hewitt (1954, p.46,47):

The main minerals of the dike are quartz, microcline perthite, and plagioclase. Some of the largest feldspar crystals measure 15 feet across. Quartz masses up to 30 feet occur. The quartz is milky, glassy, or smoky. The plagioclase ranges from 10 to 20 percent anorthite content. Hornblende, pyroxene, biotite, and chlorite occur in the outer zones of the pegmatite. Scapolite is found near the contacts, and abundant dark, red-brown garnet occurs near the walls. Magnetite is the most common metallic oxide; some ilmenite also occurs. Masses of pyrite and pyrrhotite are present on the dump, and minor amounts of chalcopyrite and molybdenite were reported by Ellsworth [(Ellsworth 1932, p.203)].

Titanite and zircon are common. The MacDonald mine is well known for its cyrtolite, a radioactive variety of zircon. The cyrtolite occurs in single crystals or masses of crystals that are up to 1 inch in size and frequently covered with hematite. These crystals show elongated double prisms and shorter pyramidal faces. The cyrtolite often occurs in feldspar or in pink or salmon-coloured calcite, which occurs as pods within the quartz of the dike. Associated with the cyrtolite is the radioactive mineral ellsworthite, a hydrous uranium, calcium, iron titano-tantalo-columbate of the pyrochlore-microlite series. This mineral is waxy yellow-brown to shiny black in colour and commonly occurs in calcite or feldspar. Allanite, in masses up to 1 foot in diameter, also occurs in the dike, and allanite, cyrtolite, and ellsworthite are all frequently surrounded by radial shatter patterns in the adjacent quartz, feldspar, or calcite.

Ellsworth [(Ellsworth 1932)] also reports purple fluorite, uranothorite, and galena. Uraninite is reported by P. A. Peach [(Peach 1950)].

In the Northwest Cut on lot 19, concession VII, the granite pegmatite consists of microcline perthite, quartz, and soda spar with allanite, biotite, hornblende, zircon, titanite, magnetite, ilmenite, and pyrite. The allanite crystals along the hanging-wall side of the dike in the wall zone are particularly common. They are up to 2 feet in length and are surrounded by pronounced radial shatter zones.

Table 8 *Ontario feldspar deposits*

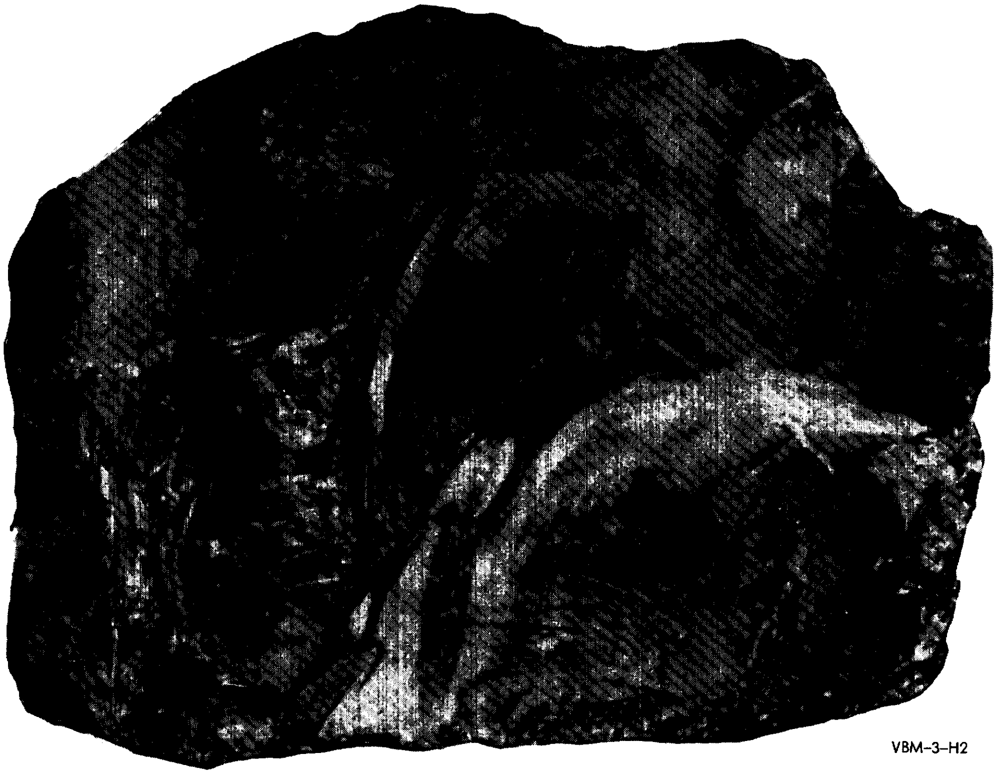
County or District	Township	Location	Name of Mine	Operators	Years of Operation	Approximate Production	Reference	Descriptive Remarks
Carleton	Huntley	Lot 21, Con. II	Chas. Humphreys	Chas. Humphreys of Carp	1901	Few tons	de Schmid 1916, p. 11	30 foot dike of grey perthite and quartz.
	March	Lot 6, Con. II & III		O'Brien and Fowler	1919-21	2538 tons	Spence 1932, p. 36	50 foot dike of pink microcline, quartz, graphic granite; some biotite, tourmaline, specularite; pyrite and albite in wall zones.
Frontenac	Bedford	Lot 1, Con. II	Richardson	Kingston Feldspar & Mining Co.	1900-1918	228,690 tons	Spence 1932, p. 38,	See description, page 15; Pit 400' by 200'; zoned dike with quartz core.
				Genesee Feldspar Corp. Canadian Flint & Spar Co.	1928-31, 1941, 1947-48, 1950-51		Harding 1947, p. 50,51	Largest feldspar producer in Ontario; pink microcline perthite, quartz, oligoclase, hornblende, pyroxene, biotite, muscovite, titanite, magnetite, pyrite, calcite, apatite, tourmaline; graphic granite.
		Lot 3, Con. II		E. Martin	1924	38 tons		
		Lot 30, Con. II	Robinson	T. Craig	1927-30	Prospect	Harding 1947, p. 51	Pink microcline, quartz, a little hornblende.
		Lot 2, Con. III	Hoppins	International Feldspar Co. Ltd.	1919-21	1940 tons	Harding 1947, p. 52	Pink and white feldspar, quartz, pyroxene, biotite, minor pyrite in walls.
		Lot 3, Con. III	Jenkins or Harris	C. Jenkins	1902-1905	2884 tons	Harding 1947, p. 52	Pink microcline, quartz, biotite, hornblende, pyroxene, magnetite.
		Lot 25, Con. III	Federal	Federal Feldspar Co.	1920-21	4420 tons	Harding 1947, p. 52	Pink and white feldspar, much quartz, minor biotite, muscovite, tourmaline; some graphic granite.
		Lot 27, Con. III	Steele	Gardner Feldspar Co.	1920	Small	Harding 1947, p. 53	Pink feldspar, quartz, biotite, hornblende; some graphic granite.
		Lot 32, Con. III		J. M. Stoness	1915-16	3 cars	Harding 1947, p. 54	Parallel pegmatite dikes principally graphic granite. Some biotite.
		Lot 4, Con. IV		Dick Wilson		Small	Harding 1947, p. 54	Pink microcline, soda spar, quartz and biotite.
		Lot 5, Con. IV	Wilson	E. M. Chisholm	1904, 1918	300 tons	Harding 1947, p. 54	Quartz and feldspar shipped.
		Lot 28, Con. IV	Kennedy	W. Kennedy		Prospect	Harding 1947, p. 55	Pink potash feldspar, quartz, biotite, tourmaline intimately intergrown.
		Lot 28, Con. V	Bobs Lake	Dominion Feldspars Ltd.	1919	145 tons	Harding 1947, p. 55	Pink microcline and quartz; some graphic granite.
		Lot 34, Con. V	Patterson	Stoness and Kent		Prospect	Harding 1947, p. 55	Pink microcline intergrown with quartz; biotite, hornblende, tourmaline, pyrite, magnetite.
		Lot 11, Con. VII	Noonan	L. E. Austin; G. Hurlbut	1915-18	Small	Harding 1947, p. 55	
		Lot 17, Con. VIII		A. Botting		Prospect	Harding 1947, p. 56	
	Hinchinbrooke	Lot 4, Con. III		A. Kenehan	1915	Small	Harding 1947, p. 48	Pegmatite lenses too small to be commercial.
		Lot 20, Con. IV	York		1920	Prospect	Harding 1947, p. 49	5 to 15 foot dike of granite pegmatite, much biotite and tourmaline.
		Lot 19, Con. VII	Cronk		1918 to 1922	Prospect	Harding 1947, p. 49	Pink microcline, albite, quartz, mica, tourmaline, magnetite, epidote.
		Lot 3, Con. X		Eureka Flint & Spar Co.	1920	Small	Harding 1947, p. 49	Graphic granite dike.
		Lot 6, Con. XII	Dwyer	J. Dwyer		Prospect	Harding 1947, p. 49	8 foot dike with microcline, quartz, muscovite, hornblende and epidote.
	Loughborough	Lot 11, Con. IX	Foxton	O'Brien & Fowler, S. Orser	1920-21	1250 tons	Spence 1932, p. 39 Rose, 1960, p. 24	2 pegmatite dikes; 30 foot dike strikes N 30°E, zoned. Euxenite, allanite, gadolinite.
		Lots 1 & 2, Con. X		T. H. Craig	1926	Small	Spence, 1932, p. 83	
		Lot 1, Con. XI		Gardner Feldspar Co.	1920-22, 1925	2080 tons	Spence, 1932, p. 39	Dike of pink spar carrying considerable impurities.
		Lot 9, Con. XI		S. Orser	1921	100 tons	Spence, 1932, p. 39	
		Lots 1 & 2, Con. XII	Freeman or Imperial	Verona Mining Co.; Dillon and Mills; Feldspar Quarries Ltd.; T. H. Craig	1902-3; 1922-26	9660 tons	Spence 1932, p. 39	Dike of pink spar carrying biotite.
		Lot 3, Con. XII		Cronk and Van Luven	1925	500 tons	Spence 1932, p. 39	
		Lot 5, Con. XII	Reynolds	Kingston Feldspar & Mining Co.	1913-14	8000 tons	de Schmid, 1916, p. 17	40 foot dike carrying microcline and quartz.
		Lot 1, Con. XIII	Mink Lake	Verona Quarries Ltd., Canadian Flint & Spar Co.	1925-29, 1949-50 1954-55	14000 tons	Spence 1932, p. 40	Large dike of pink microcline and quartz.
	Miller	Lot 15 SW range						50' zoned granite pegmatite dike, contains pyrochlore.
	Olden	Lot 17, Con. XI		MacPherson and Bragg	1920	Prospect	Harding 1947, p. 48	5 foot dike with pink potash spar and grey soda spar.
	Oso	Lot 10, Con. V		Mills and Cunningham	1904	Prospect	Harding 1947, p. 48	
	Portland	Lots 1 & 2, Con. X	Walker	Pennsylvania Feldspar Co.	1902-3	Small	de Schmid 1916, p. 17	50 foot dike with red potash spar.
		Lot 3, Con. X	Burnham	T. H. Craig	1922-25	1500 tons	Spence 1932, p. 39	40 foot dike of pink potash spar, peristerite, some calcite.
		Lot 16, Con. X		Feldspar Quarries Ltd.	1915-19	6000 tons	Spence 1932, p. 40	
		W½ Lot 16, Con. XI		Eureka Flint & Spar Co.	1915, 1917-21	25099 tons	Spence 1932, p. 40	
		E½ Lot 16, Con. XI	Card		1905-11, 1917-18, 1920	384 tons	Spence 1932, p. 84	
		Lot 17, Con. XI		Feldspar Quarries Ltd.	1920-21	Small	Spence 1932, p. 40	
		Lots 18&19, Con. XI	Bellrock	T. H. Craig	1907, 1927	600 tons	Spence 1932, p. 84	Narrow dike with pink spar.
		Lots 3 & 4, Con. XII	Huffman	McDonald Feldspar Co.	1911, 1919-20		de Schmid 1916, p. 19	Quartz, potash feldspar and abundant pyrite.
		Lots 5 & 6, Con. XII	Gamey	McDonald Feldspar Co.	1902, 1906-7, 1920	6000 tons	de Schmid 1916, p. 19	25 foot dike of pink spar with quartz ledges. Produced quartz & feldspar.
		Lot 11, Con. XII		G & M Feldspar Mining Co.	1911, 1914	Small	de Schmid 1916, p. 20	Quartz, feldspar, yellowish mica.
		Lot 15, Con. XIII		Canadian Feldspar Corp.	1913	Few tons	Spence 1932, p. 85	
	Storrington	Lots 7-9, Con. XIII	Rock Lake	Coon & Walton, Storrington Fel. Co.	1921-26	2500 tons	Spence 1932, p. 40	50 foot dike of grey spar with muscovite, calcite, diopside, titanite.

County or District	Township	Location	Name of Mine	Operators	Years of Operation	Approximate Production	Reference	Descriptive Remarks
Haliburton	Cardiff	Lot 9, Con. XII		Canada Radium Mines	1941-2	Prospect	Hewitt 1957, p. 61	Pink graphic granite pegmatite.
	Glamorgan	Lot 31, Con. VI		P. J. Dwyer	1918	1 car	Satterly 1943, p. 29	Small pegmatitic granite dike.
		Lot 32, Con. VI				Prospect	Satterly 1943, p 29	5 foot pegmatite dike.
	Monmouth	Lot 22, Con. VI			1920	990 tons		
		Lot 26, Con. XI		Ontario Feldspars Ltd.	1922	Prospect	Satterly 1943, p. 30	Syenite pegmatite with biotite, tourmaline, fluorspar.
		Lot 30, Con. XV	Holmes	Industrial Minerals Corp. of Canada	1921-22; 1924-26	534 tons	Satterly 1943, p. 30	Graphic granite pegmatite with titanite, tourmaline, calcite, pyroxene.
Hastings	Dungannon	Lot 24, Con. IX	Tait			Prospect	Hewitt 1955, p. 45	50 foot graphic granite pegmatite. Accessory hornblende and biotite.
		Lot 20, Con. X				Prospect	Hewitt 1955, p. 45	Pink potash feldspar, quartz, biotite.
	Faraday	Lot 6, Con. XII		W. Morrison; Dillon and Mills	1920-22	Small	Spence 1932, p. 44	100 foot dike of graphic granite pegmatite with biotite, hornblende, pyrite.
		Lots 8-10, Con. XII	Woods	W. A. Woods	1940, 1942	90 tons		
		Lot 31, Con. XV			1944	178 tons		
	McClure	Lot 14, Con. XII	Gunter		1930	Prospect	Thomson 1943, p. 25	40 foot pegmatite dike.
	Monteagle	Lot 20, Con. VI	Plunkett	American Molybdenite Co., S. Orser	1921, 1927	2 cars	Hewitt, 1954, p. 40	Graphic granite pegmatite; pegmatite with ellsworthite, euxenite.
		Lot 21, Con. VI	Watson No. 1	P. J. Dwyer, Consolidated Feldspar Co.	1919-1926		Hewitt, 1954, p. 40	10 foot granite pegmatite; some allanite, titanite, hornblende, pyrite.
		Lot 22, Con. VI	Watson No. 2, 3	P. J. Dwyer, Consolidated Feldspar Co.	1919-26, 1932	528 tons	Hewitt 1954, p. 41	15 foot dike, microcline, albite, quartz, graphic granite; biotite, hornblende.
		N½ Lot 24, Con. VI	McCormack N.	P. J. Dwyer	1926	Prospect	Hewitt, 1954, p. 42	12 foot dike with amazonite, allanite, ellsworthite, peristerite.
		S½ Lot 24, Con. VI	McCormack S.	P. J. Dwyer, Dillon and Mills	1920, 1926	150 tons	Hewitt, 1954, p. 42	12 foot granite pegmatite dike; microcline, albite, quartz, graphic granite.
		Lot 25, Con. VI				Prospect	Hewitt 1954, p. 42	Microcline perthite, quartz, minor allanite, biotite, hornblende, titanite.
		W½ Lot 11, Con. VII	Thompson	Feldspar Mines Corp.	1923-25, 1927	2715 tons	Hewitt 1954, p. 43	Microcline perthite, albite, quartz, epidote, allanite, hornblende, titanite.
		Lots 18&19, Con. VII	MacDonald	Verona Mining Co., Genesee Feld. Corp.	1919-35	35048 tons	Hewitt 1954, p. 43	Zoned granite pegmatite with ellsworthite, cyrtolite, allanite, uranorthorite.
		Lot 21, Con. VII	Cairns	Dillon and Mills, P. J. Dwyer	1920-24	2 cars	Hewitt 1954, p. 47	Microcline perthite, albite, quartz, ellsworthite, titanite, hornblende.
		Lot 25, Con. VII				Prospect	Hewitt 1954, p. 48	10 foot granite pegmatite dike with feldspar to six inches in size.
		Lot 12, Con. VIII		Consolidated Feldspar Mines Ltd.	1926	Prospect	Osborne 1930, p. 43	20 foot dike of graphic granite.
		Lot 13, Con. VIII	Taylor	P. J. Dwyer, Consol. Feldspar Mines Ltd.	1925-6	1 car	Hewitt 1954, p. 48	20 foot pegmatite dike primarily graphic granite.
		S½ Lot 14, Con. VIII	Genesee No. 2	Genesee Feld. Co., D. Vardy, W. Jessup	1926-31, 1948-50	2846 tons	Hewitt 1954, p.48,49	Pink microcline, quartz, albite, minor ellsworthite, pyrite, sericite.
		N½ Lot 14 Con. VIII				Prospect	Hewitt 1954, p. 49	Pegmatite with microcline, albite, quartz, rare allanite.
		Lot 15, Con. VIII	Bartlett	P. J. Dwyer, K. Bowser	1926, 1951	Prospect	Hewitt 1954, p. 49,50	80 foot pegmatite dike, microcline, quartz, graphic granite, hornblende, allanite.
		Lot 17, Con. VIII	Woodcox	Feldspar Mines Corp.	1921-23	4087 tons	Hewitt 1954, p. 50,51	30 foot dike; amazonstone, hatchettolite, columbite, cyrtolite, calciosamarskite.
		Lot 25, Con. VIII		P. J. Dwyer		Prospect	Hewitt, 1954, p. 51	Small granite pegmatite.
		Lot 13, Con. IX		Genesee Feldspar Co.	1924	2 cars	Spence 1932, p. 49	
		S½ Lot 30, Con. IX	Hickey	W. Jessup	1949	166 tons	Hewitt 1954, p. 51,52	20 foot granite pegmatite; microcline, quartz, graphic granite.
		Lot 6, Con. XII	Reeves	Bancroft Feldspar Mines	1945-46	1162 tons	Hewitt, 1954, p. 39	Pink microcline, albite, quartz, biotite, hematite, pyrite, allanite, magnetite.
Kenora	L.of the Woods	Falcon Is.		Winnipeg Roofing Co.	1926-27	few hundred tons	Spence 1932, p. 61	Feldspar and mica produced.
Lanark	Bathurst	Lot 1, Con. I	Mendels		1918	312 tons		
		Lot 1, Con. II	O'Halloran	Feldspar Quarries Ltd.	1920-21	few cars	Spence 1932, p. 41	Red feldspar, much biotite, tourmaline, quartz.
		Lot 2, Con. III	Burns	S. Orser	1920-22	Small	Spence 1932, p. 41	Small dike of low grade spar.
		Lot 5, Con. III	Palmer	Orser-Kraft Feldspar Ltd.	1922	Prospect	ODM 1923; p. 83	
		Lot 4, Con. IV		S. Orser	1921-22	Small	Spence, 1932, p. 41	Shipped quartz.
		Lot 10, Con. VI	Truelove	Rock Products Co.	1920	618 tons		
		Lots 3 & 4, Con. VII	Kirkham	R. McConnell	1919-21	3140 tons	Spence 1932, p. 41	Small dike of low grade spar with biotite, tourmaline, garnet, pyrite.
		Lot 9, Con. VIII	Charles	S. Orser, National Feldspar, T. H. Craig	1928-29, 1943, 1947	974 tons	Spence 1932, p. 41	Small dike with much massive quartz.
		Lot 12, Con. VIII	Foster	Feldspar Quarries Ltd.	1929			
		Lots 15&16, Con. VIII	Bathurst	Bathurst Feldspar Mines Ltd.	1926-1953	106018 tons	Spence 1932, p. 41,42	Large productive pegmatite dike; microcline, quartz, albite, hornblende, tourmaline, pyrite.
		E½ Lot 16, Con. VIII	Bowes	Feldspar Quarries Ltd., T. H. Craig	1929-30, 1944		Spence 1932, p. 42	Dike principally graphic granite.
		W½ Lot 12, Con. IX	McDonald	T. H. Craig, Can. Flint & Spar Co.	1928-38, 1940-41, 1950-51	23872 tons	Spence 1932, p. 42	100 foot dike of pegmatite.
	Bathurst	Lot 16, Con. IX	Furlong	Feldspar Quarries Ltd.	1929-30	1238 tons		
		Lot 18, Con. IX	Noonan	Rock Products Ltd.	1921	few cars		

		E½ Lot 19, Con. IX		Perth Feldspar & Mining Co.	1922-23	2000 tons	Spence 1932, p. 43	Large pegmatite, mainly graphic granite.
		N½ Lots 20 & 21, Con. IX	Keays	Rock Products Co.	1921-27	20841 tons	Spence 1932, p. 43	Large dike with red potash spar.
		S½ Lots 20 & 21, Con. IX	Perth	Gleason-Campbell Quarries	1922-26	4685 tons		
		Lot 22, Con. IX		W. Ennis	1922	Prospect	Rose 1960, p. 20,21	Euxenite, tourmaline in granite pegmatite.
	N. Burgess	E½ Lot 13, Con. V	Silver Queen	E. Smith	1911-14	2990 tons	de Schmid 1916, p. 21	Bluish white microcline, smoky quartz, titanite, pyrite, pyrrhotite, apatite, diopside, green tourmaline, muscovite.
	S. Sherbrooke	Lot 10, Con. IV	Morrow	R. McConnell	1919-20	Small		
		Lots 12 & 13, Con. V & VI	Orser-Kraft	S. Orser	1916-23	2836 tons		Zoned granite pegmatite carries euxenite, tourmaline.
		Lot 15, Con. VI	Patterson	Universal Silicates Ltd.	1920	100 tons	ODM 1921, p. 130	
		Lot 17, Con. VI		S. Orser	1916	Prospect	ODM 1917, p. 141	
		Lot 11, Con. VIII	Munroe	J. H. Mendels	1920	Small	ODM 1920, p. 113	
Muskoka	Brunel	Lots 7&8, Con. X			1953	Prospect		
		Lot 16, Con. XIV				Prospect	Satterly 1942, p. 61	Pink microcline, plagioclase, quartz, muscovite, biotite.
	Chaffey	Lot 23, Con. V		International Ceramic Mining Co.		Prospect		40 foot zoned granite pegmatite dike.
		Lot 13, Con. X				Prospect	Satterly 1942, p. 61	3 foot dike of muscovite granite pegmatite.
	Stephenson	Lots 26&27, Con. II		S. W. Hall	1915	1 car	Satterly 1942, p. 30	
		Lot 24, Con. XIV		F. C. Hammond and A. McKay	1941	Prospect	Satterly 1942, p. 61	25 foot granite pegmatite dike with microcline, quartz, graphic granite, biotite, magnetite.
Nipissing	Calvin	Lot 9, Con. I		Mattawa Feldspar Co.	1926-27	250 tons	Spence 1932, p. 51	Dark coloured potash spar, white soda spar.
		Lot 14, Con. VII		G. Purdy	1926-27	1000 tons	Spence 1932, p. 49, 51	15 foot dike of pink spar carrying beryl and biotite.
		Lot 22, Con. VIII		O'Brien and Fowler, Mo. Corp. of Amer.	1925-26	250 tons	Spence 1932, p. 51	Dike carrying pink spar, euxenite, columbite.
		Lot 16, Con. IX		O'Brien and Fowler	1926	Prospect	Spence 1932, p. 51	Two narrow dikes with rusty spar.
		Lot 21, Con. IX		Harcourt and Patterson	1925	Prospect	Spence 1932, p. 51	Small pegmatite dike with abundant quartz.
		Lots 22 & 23, Con. IX & X		O'Brien & Fowler	1925-6	Prospect	{ Spence 1932, p. 51 Rose 1960, p. 21 }	Euxenite, allanite and columbite in granite pegmatite.
	Cameron	Lot 4, Con. A		Turcotte	1927	1 car	Spence 1932, p. 51	Narrow pegmatite dike with considerable biotite.
		Lot 6, Con. A					Miller 1900, p. 193	Amazonstone reported.
		Lot 31, Con. A		J. Norreno	1925	200 tons	Spence 1932, p. 51	
		Lot 7, Con. B				Prospect	Barlow 1897, p. 159	Amazonite and perthite in granite pegmatite.
		Lot 30, Con. B		Turcotte	1927	2 cars	Spence 1932, p. 51,52	Pegmatite dike carries biotite, garnet.
	Dickens	Lot 19, Con. I	Lake	W. B. Cameron	1948-49			20 foot pegmatite dike with microcline, albite, quartz biotite, magnetite, monazite.
		Lot 14, Con. III		Can. Non-Metallic Minerals Ltd.	1922-23	500 tons	Spence 1932, p. 52	Dike carries reddish spar, quartz, mica.
		Lot 27, Con. V		Can. Flint & Spar Co. Ltd.	1943		Satterly 1944, p. 122	Pegmatite sheet carries microcline, peristerite, quartz, muscovite, euxenite, monazite.
		Lot 17, Con. VII	Five Mile	Keystone Contractors, W. Cameron	1947-8, 1951	5116 tons		Zoned granite pegmatite with microcline, albite, quartz, muscovite, biotite, hornblende.
	Mattawan	Lot 6, Con. II	Purdy	Purdy Mica Mine	1943	197 tons		Muscovite granite pegmatite.
		Lot 29, Con. III		O'Brien & Fowler	1926	3084 tons	Spence 1932, p. 52	Large dike of pink spar with biotite and euxenite.
	Murchison	Lot 11, Con. IV		J. A. Cameron	1924	18 tons		
		Lots 14&15, Con.IV	J. G. Gole	J. G. Gole, D. L. Ross	1937-44	9643 tons	Satterly 1944, p. 120	Granite pegmatite with allanite, fergusonite, sunstone. Shipped quartz.
		Lot 13, Con. V			1943	51 tons		
		Lot 17, Con. VI	Cameron & Aleck	Cameron & Aleck	1949-51, 1953	1869 tons		Granite pegmatite with allanite, fergusonite.
		Lot 22, Con. VII		Wallace B. Cameron	1953	1361 tons		
		Lot 22, Con. VIII	Cameron	W. Cameron, Keystone Contractors	1940-45, 1950-51	6027 tons	Satterly 1944, p. 121	Granite pegmatite with allanite, euxenite.
	Papineau	Lot 10, Con. IX			1925	few cars		
		Lot 18, Con. X		Morin and Neault	1926	250 tons	Spence 1932, p. 52	10 foot dike of pink spar with much biotite.
	Sabine	Lots 28, 29, Con. I		Mahoney and Morin	1924-25	200 tons	Spence 1932, p. 53	20 foot dike of pink spar with biotite, euxenite, magnetite.
		Lots 26 & 27, Con. VIII		Prince & Prince	1936-39	228 tons		
		Lot 27, Hastings Rd. W.	Gunter		1934-37	2428 tons	Spence 1932, p. 53	60 foot dike with large pink feldspar crystals.
Parry Sound	Burton	Lot 37, Con. XIV		Magnetawan Feldspar Syndicate	1940-41, 1943	46 tons		
	Chapman	Lots 20, 21, Con. I	Macdonald	J. Bell	1948	2 cars		Graphic granite pegmatite.
		S½ Lot 13, Con. II		W. E. Brandt	1949	Prospect		Large graphic granite pegmatite.
		Lot 26, Con. II		Wheeling Feldspar Co.	1920-23	868 tons	Satterly 1942, p. 56	Granite pegmatite with biotite, used for stucco.
		Lot 18, Con. IV	Hungry Lake	T. B. Tough	1941	Prospect	Satterly 1942, p. 56	5 foot dike of microcline and quartz.
		Lot 10, Con. VIII			1942	Prospect		25 foot pegmatite dike with K spar, peristerite, quartz, muscovite.
	Christie	Lot 27, Con. VI		Industrial Minerals Corp.	1923-24	200 tons	Satterly 1942, p. 56	15 foot granite pegmatite with biotite.
	Conger	Lot 5, Con. VIII		Standard Feldspar and Silica Co.	1911-12	Prospect	Satterly 1942, p. 56	Small dike with pink microcline, quartz, biotite.
		Lot 4, Con. IX		Ojaipee Silica-Feldspar Ltd.	1910-12	3890 tons	Satterly 1942, p. 57	12 foot pegmatite dike with microcline, quartz, plagioclase, allanite, biotite.
		Lot 10, Con. IX	McQuire	McQuire & Robinson	1925	618 tons	Satterly 1942, p. 57	Pegmatite dike with uraninite, calciosarmarskite, thucolite, cyrtolite.
		N½ Lot 6, Con. X		Conger Feldspar Mining Co.	1945	1000 tons		
		Lot 7, Con. X	Brignall	McQuire & Robinson	1923-25	4239 tons	{ Satterly 1942, p. 57 Rose 1960, p. 22 }	Pegmatite with euxenite, monazite, columbite.
		Lot 8, Con. X		Conger Feldspar Mining Co.	1946	417 tons		
	Foley	Lot 10, Con. III				Prospect	Satterly 1942, p. 57	8 foot pegmatite dike of microcline, quartz, plagioclase.

County or District	Township	Location	Name of Mine	Operators	Years of Operation	Approximate Production	Reference	Descriptive Remarks
Parry Sound	Harrison	Lots 38 & 39, Con. XIII		General Mica Mining Co.	1927	Prospect	Spence 1932, p. 55	Pink microcline, plagioclase, quartz, biotite, magnetite.
	Henvey	Lot 3, Con. A	Ambeau	Wanup Feldspar Mines Ltd.	1926-27	1000 tons	Satterly 1942, p. 58; Rose 1960, p. 18,19	Pegmatite carries euxenite.
		Lot 5, Con. B	Besner	Wanup Feldspar Mines Ltd.	1926-29	2500 tons	Satterly 1942, p. 58; Rose 1960, p. 19	60 foot dike carries cyrtolite, beryl, thucolite, uraninite, allanite.
		Lots 5 & 6, Con. IV		D. H. Hooey	1929-30	Prospect	Spence 1932, p. 56	2 narrow dikes of impure pegmatitic granite.
	Lount	Lot 137, Con. B		T. R. Russell	1953	Prospect	Satterly 1955, p. 42	6 foot pegmatite dike carries microcline, quartz, biotite.
		Lot 3, Con. V		J. Bell	1941	Prospect	Satterly 1955, p. 41	20 foot pegmatite dike carrying muscovite.
	Machar	S½ Lot 30, Con. VI		T. B. Tough	1942	Prospect		Graphic granite pegmatite.
	McConkey	Lot 11, Con. II				Prospect	Satterly 1942, p. 58	30 foot pegmatite dike with microcline, quartz, plagioclase, muscovite.
		Lot 20, Con. V		General Mica Mining Co.	1919	Prospect	Satterly 1942, p. 58	Coarse granite pegmatite with muscovite.
		Lot 22, Con. V		J. W. Keenan	1940	Prospect	Satterly 1942, p. 59	100 foot pegmatite dike with quartz, microcline, plagioclase, biotite.
		Lot 17, Con. VI				Prospect	Satterly 1942, p. 59	
	McDougall	Lot 5, Con. X			1926	Prospect	Satterly 1942, p. 59	3 pegmatite dikes with microcline, quartz, allanite, biotite.
		Lot 3, Con. XI				Prospect	Satterly 1942, p. 59	3 pegmatite dikes with microcline, quartz, allanite, biotite.
	McKellar	Lot 4, Con. VI		C. F. McQuire	1937-38	600 tons	Satterly 1942, p. 60	12 foot dike with pink microcline, quartz, rare biotite, garnet.
	Nipissing	Lot 30, Con. X		Holden & Waltenbury	1941	Prospect	Satterly 1942, p. 60	Coarse granite pegmatite with microcline to 1 foot in size.
	Ryerson	Lot 18, Con. XIII		T. B. Tough	1941	190 tons	Satterly 1942, p. 61	Zoned granite pegmatite with microcline, quartz, plagioclase, muscovite.
	Strong	Lot 19, Con. I		T. B. Tough	1942	Prospect		10 foot granite pegmatite.
		Lot 19, Con. III		T. B. Tough	1942	Prospect		5 foot granite pegmatite with microcline, amazonite, quartz.
	Wallbridge	Mill Site A		D. H. Hooey	1930	few cars	Spence, 1932, p. 57	Small dike of pink spar and quartz.
Renfrew	Brudenell	Lots 22&23, Con. II		T. H. Craig	1942	30 tons	Hewitt, 1953, p. 66,67	Graphic granite, microcline, albite, biotite, hornblende.
	Clara	Lot 28, Con. VI		Dewar & Gibson	1924	1 car	Spence 1932, p. 89	30 foot dike of pink spar.
	Fraser	N½ Lot 24, Con. XVI		W. J. Barr	1934-36	1107 tons	Satterly 1944, p. 37	30 foot pegmatite dike with microcline, quartz.
		S½ Lot 24, Con. XVI		J. Collins		Prospect	Satterly 1944, p. 38	40 foot dike of biotite graphic granite pegmatite.
	Grattan	Lot 22, Con. VIII	Keyfortmore	G. Colautti	1943	1174 tons	Satterly 1944, p. 38	Pink graphic granite pegmatite with tourmaline.
	Head	Lot 14, Con. A	Carey	Wanup Feldspar Mines Ltd.	1924-28	3000 tons	Spence 1932, p. 49	Large dike of pink microcline, quartz, muscovite, biotite.
	Jones	Lot 10, Con. XI		F. Raymond & L. Sawyer	1937	121 tons	Satterly 1944, p. 39	
		Lot 117, Range BN	Causeway	G. Colautti	1942	260 tons	Satterly 1944, p. 39	30′ granite pegmatite with quartz, microcline, albite, hornblende, muscovite.
	Lyndoch	Lot 23, Con. XV		Can. Beryllium Mines & Alloys Ltd.	1926, 1939		Hewitt 1953, p. 36-42	Granite pegmatite with beryl, euxenite, columbite, monazite.
		Lot 30, Con. XV		Can. Beryllium Mines & Alloys Ltd.	1935-36, 1949	675 tons	Hewitt 1953, p. 42-46	Large granite pegmatite with beryl, euxenite, columbite.
	Radcliffe	Lot 240, Range BN				Prospect	Hewitt 1953, p. 67,68	Pink microcline, grey albite.
	S. Algona	Lot 19, Con. IX		A. Lauzon	1922	Prospect	Satterly 1944, p. 39	25 foot pegmatite dike with fine grained microcline.
Sudbury	Awrey	Lot 6, Con. V		Donnen Feldspar Company	1923-4	few cars	Spence 1932, p. 57	35 foot pegmatite dike with biotite; little pure feldspar.
	Burwash	Lot 1, Con. III	Mt. Pleasant	S. Charette	1928, 1934-7, 1949	555 tons	Spence 1932, p. 57	140 foot pegmatite dike with orthoclase, quartz, biotite, albite, fluorite.
	Cleland	Lot 12, Con. II			1928	1 car	Spence 1932, p. 92	20 foot dike of pink spar carrying black and white mica.
		Lots 11&12, Con. IV		Weisman Feldspar Company	1922-24	20 cars	Spence 1932, p. 59	35 foot dike of coarse granite with biotite and muscovite.
	Davis	Lot 1, Con. I		Wanup Feldspar Mines Ltd.	1924-25	600 tons	Spence 1932, p. 59	Dike carrying pink spar.
	Dill	Lot 2, Con. II		Northern Feldspar Mines Ltd., Cubar UML	1924-25	800 tons	Spence 1932, p. 59	25 foot dike of pink spar with biotite and muscovite, beafite, allanite, euxenite, ellsworthite, pyrochlore-microlite.
		Lot 2, Con. III		Wanup Feldspar Mines Ltd.	1925-28	9914 tons	Spence 1932, p. 59	Large dike of granite pegmatite with muscovite.
		Lots 1 & 2, Con. III & IV	Elizabeth	Elizabeth Feldspar Mines Ltd.	1925-26	5090 tons	Spence 1932, p. 60	50 foot dike of pegmatite with biotite and muscovite.
	Dryden	Lot 9, Con. II		Industrial Minerals Corp.	1922-25	5985 tons	Spence 1932, p. 60	Large dike of microcline, quartz, biotite.
	Hagar	Lot 9, Con. IV		Donnen Feldspar Co.	1918	1 car	Spence 1932, p. 93	30 foot dike.
	Hawley	S½ Lot 6, Con. II	Nepawassi L.	Can. Flint & Spar Co.	1947-8	150 tons		Pegmatite with orthoclase, albite, quartz, biotite.
	Hendrie	Lot 11, Con. III		S. Charette	1949	Prospect		
	Loughrin	Lot 13, Con. VI		Industrial Minerals Corp.	1923-4; 1926-27	8000 tons	Spence 1932, p. 61	30 foot dike with microcline, quartz, albite, biotite.
	Ratter	Lot 1, Con. II		Consolidated Feldspar Ltd.	1926-28	905 tons	Spence 1932, p. 61	Dike of pink spar rather heavily iron stained.
Thunder Bay	Goldie		Buda	Bland & Blank				60 foot dike of white microcline feldspar.

QUARTZ



VBM-3-H2

Photo 4—Quartz. (Photo courtesy of V. B. Meen)

During the course of operation of many granite pegmatites for feldspar, considerable tonnages of quartz have also been mined. This massive pegmatitic quartz is sometimes sold as lump silica for use as flux, or ground to produce pottery flint. The quantity produced is relatively small and many of the feldspar operations are situated so far from markets that it is not economical to ship such a low priced commodity as quartz to the consumers. Between 1917 and 1953 a total of 21,465 tons of quartz valued at $71,794 was shipped by pegmatite mines. This averages $3.34 per ton.

Recently interest has been shown in pegmatitic quartz for crushed aggregate for facing precast concrete slabs used in building construction. Opaque and translucent quartz for this purpose is quarried and crushed by Industrial Garnet Company Limited near River Valley, Ontario, and Rideau Aggregate Company at Verona, Ontario. Several other properties have been recently opened for quartz. Crushed to the proper size, this quartz is priced at $20 to $36 per ton at the quarry depending on size and quality.

MICA

Photo 5—Muscovite mica.

Muscovite and phlogopite mica are widely used in the electric and electronics industries, especially as bridges and spacers in radio and television tubes and as the dielectric in capacitors. Records on mica production in Ontario indicate production from 1886 to the present, but mica was produced commercially in Ontario before 1886. Total Ontario mica production from 1886 to 1964 has amounted to 96,906,290 pounds valued at $4,567,610. Records indicate 63 muscovite mines and 159 phlogopite mines in the province. Of the muscovite mines, the Purdy mica mine at Mattawa was by far the largest, producing $1,577,326 worth of muscovite between 1941 and 1953. This represents 34.5 percent of Ontario mica production. A large percentage of the Ontario phlogopite production came from the famous Lacey mica mine, near Sydenham, which began operations about 1880 and produced intermittently until 1948. It is said to have been one of the world's largest mica producers. Crystals up to 9 feet in diameter were produced. The principal phlogopite producing areas were the Sydenham area of Frontenac county and the Perth area of Lanark and Leeds counties. At the present time mica production has fallen off: in 1965 production amounted to 400,000 pounds valued at $6,000, mainly phlogopite mica.

Phlogopite mica occurs in calcite-diopside-apatite bodies associated with metamorphic pyroxenites and silicated marbles and are therefore not pegmatites. For this reason this report deals principally with muscovite mica.

Composition and Properties

The mica group are hydrous aluminium orthosilicates of potassium, magnesium, soda, iron, and lithium. Principal members of the mica group with their approximate chemical compositions are given in Table 9.

Table 9 *Principal members of the mica group, and approximate chemical composition*

Muscovite	$H_2KAl_3(SiO_4)_3$	white mica
Phlogopite	$H_2KMg_3Al(SiO_4)_3$	amber mica
Biotite	$H_2K(Mg,Fe)_3Al(SiO_4)_3$	black mica
Lepidolite	$(OH,F)_2KLiAl_2Si_3O_{10}$	lithia mica
Paragonite	$H_2NaAl_3(SiO_4)_3$	soda mica

These formulae represent the pure mica end members and there can be considerable ionic substitution.

The micas crystallize in the monoclinic system, but with the inclination of the *a* axis close to 90°, the crystals are often pseudo-hexagonal or diamond-shaped. Micas are characterized by perfect basal cleavage and can be split into very thin flexible elastic sheets.

MUSCOVITE

Muscovite is known as white mica or potash mica. It is monoclinic with prismatic habit occurring in tabular crystals with a prominent base. Basal cleavage (001) is perfect. Thin cleavage sheets are flexible and elastic. Parting parallel to (010) and (110) sometimes occurs. This parting when present in a muscovite crystal may extend only part way through the crystal. Mica exhibiting parting is called "ruled mica". The hardness of muscovite ranges from 2.5 on cleavage surfaces, to 4 across the cleavage. Specific gravity is 2.8 to 2.9. In thin sheets muscovite is colourless, but in thick books muscovite may be reddish, brown, olive, or green. The colour classification of muscovite mica by the U.S. Geological Survey is shown in Table 10.

A comparison of the properties of muscovite and phlogopite is given in Table 11 by Montague (1960, p.551), from the Mica Handbook of the Mica Fabricators Association.

Table 10 *Muscovite mica, colour classification by U.S. Geol. Surv. (Skow 1962, p.3)*

MAIN COLOUR CATEGORIES	COMMERCIAL GROUPS
Pinkish buff and drab Cinnamon brown Brown	Ruby
Brown Brownish olive Yellowish olive	Rum
Yellowish olive Yellowish green Green	Green

PHLOGOPITE

Phlogopite or amber mica is the potassium-magnesium mica. It is monoclinic with cleavage, parting, and hardness similar to that of muscovite. The specific gravity is 2.8 to 3.4 increasing with iron content. Phlogopite grades to biotite with increasing iron content. Colour is pale-yellow to brown or brownish-black.

Biotite

Biotite, the black iron-bearing mica is an end-member of the phlogopite-biotite series. It is generally not of commercial value due to its poor dielectric strength.

Lepidolite

The lithium mica, lepidolite, usually occurs in fine-grained crystalline aggregates of lilac, yellow, or grey colour. Its specific gravity is 2.8 to 2.9. Its composition is variable with K being replaced by Na, Rb and Cs and the amounts of Li and Al being variable. It occurs in granite pegmatites, often with spodumene, and is an ore of lithium.

Paragonite

The soda mica, paragonite, is a rare mineral and can be distinguished from muscovite with difficulty.

Physical Defects Affecting Value

The value of mica is dependent on the quality of the mica, which is affected by various physical defects in the mica crystals. The properties affecting the value of muscovite are well described by Jahns and Lancaster (1950, p.6–16).

Table 11 *Properties of muscovite and phlogopite, from the Mica Handbook of the Mica Fabricators Association (Montague 1960, p.551)*

CHARACTERISTICS	MUSCOVITE	PHLOGOPITE
Chemical composition	$H_2KAl_3(SiO_4)_3$	$H_2KMg_3Al(SiO_4)_3$
PROPERTIES		
Colour	brown, ruby, green	amber to dark green
Specific gravity	2.6 to 3.2	2.6 to 3.2
Average specific gravity	average 2.83	average 2.83
Specific heat	0.207	0.207
Mohs hardness	2.8 to 3.2	2.5 to 3.0
Shore hardness	80 to 150	70 to 100
Optical axial angle	50 to 75	5 to 25
Volume resistivity Ohms/Cm^3	2×10^{13} to 1×10^{17}	somewhat less
Dielectric strength (1 to 3 mils thick in air) volts/mil	clear ruby, 3000 to 6000	3000 to 4200
Dielectric constant	6.5 to 8.7	5 to 6
Power factor (I/Q) for qualities classed as stained or better	0.0001 to 0.0004	0.004 to 0.07
Modulus of elasticity (10 mils thick) lb/sq. in.	about 25×10^6	about 25×10^6
Maximum coefficient of expansion per °C	0.000036	0.0552
Water of constitution, percent	4.5	3.0
Water of constitution driven off at °C	500 to 600°	800 to 1000°
Maximum temperature of use	600°C	1000°C
Flexibility	less	more
Transparency	more	less
Acid reaction	affected only by HF	decomposed by H_2SO_4

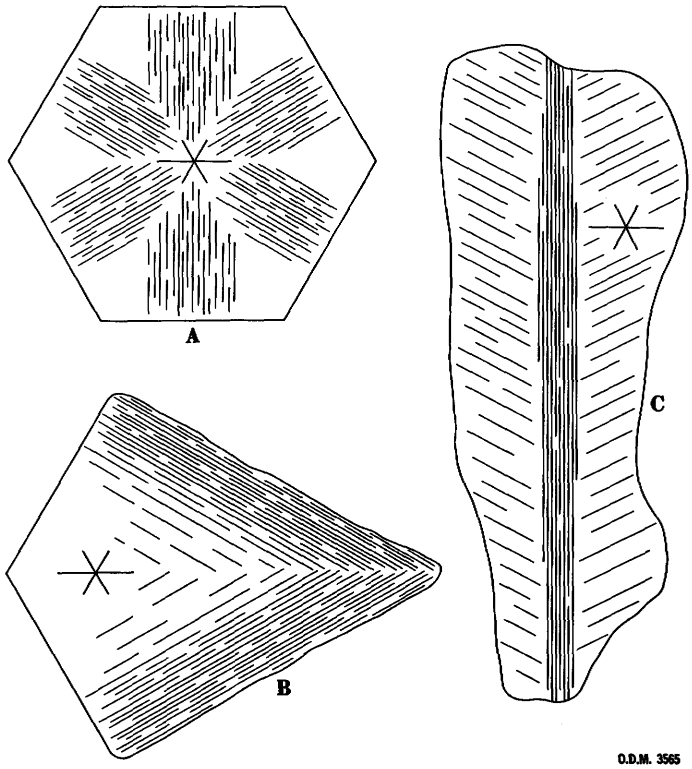


Figure 7—Relation of reeves to crystal directions in muscovite. Orientations are shown by percussion figures. A: Complete directional development of "A" reeves in crystal. B: Typical development of "A" reeves. C: Typical herringbone reeves. (From Johns and Lancaster 1950, p.9)

STRUCTURAL IMPERFECTIONS

Any structural imperfections which affect the flatness and ready cleavability of mica are objectionable. Reeves, wedge structure, warping, and ruling are the principal structural defects in mica.

Thomson (1955, p.2,3) describes structural imperfections in mica as follows:

Reeves, also known as cross-grains, are lines, striations, corrugations or folds arising from innumerable partings across the basal cleavage. Reeves can be simple, closely spaced folds or complex, broadly spaced corrugations. If the distance between the lines or the space between the missing laminae is small (narrow), the reeves appear as fine lines; if laminae are missing over a greater space, reeves are a combination of corrugations and edges of incomplete laminae. "A" mica contains two series of rulings or striations intersecting at an angle of about 60°. The third series of striations necessary to form the letter A are not present, and the intersecting reeves form a V. Typical "A" mica will have the reeves extending across the entire sheet and the apex near one edge. The area between the rulings of the "A" is frequently of good physical quality. Herringbones (fishbones, fishbacks, horsetails and feathers) are numerous reeves that intersect to form a series of V's, the legs making an angle of 120° at the apex. These reeves usually flank a central reeve to form a pattern resembling a fish skeleton.

Buckles, waves and ridges are terms used to describe the degree of warping. A buckle is a single concave depression in the middle of the sheet; waves are a series of alternate elevations and depressions; and ridges or ribs are parallel crenulations in the form of steps.

Wedge mica is, as the name implies, wedge-shaped, and on splitting yields pieces of mica thicker on one side than the other. This structure is caused by the interlayering of laminae of unequal size. Wedge mica commonly has "A" or herringbone imperfections and is referred to as "wedge-A" compared to "flat-A". Wedge mica is not satisfactory for use as sheet mica and usually can be used only as scrap mica.

Ruled or ribboned mica has parallel fractures or parting planes intersecting the basal cleavage plane at about 60°. These planes cause the mica to break into narrow strips. Books of mica can have one or more sets of fracture planes, which may pass completely or only partly through the mica.

CLEAVAGE

Cleavage sheets of uniform thickness are desirable, and mica that splits easily into thin sheets is known as free-splitting. Due to discontinuity of cleavage, some mica does not split freely but tears into irregular sheets. Such mica is said to be "locky", "gummy" or "tangled".

IMPURITIES AND STAINING

Mineral inclusions, vegetable stains and air inclusions reduce the quality of mica. ASTM specification D351-57T gives a quality classification for mica described below (after Montague 1960, p.560).

Verbal Descriptions of Visual Quality Classifications

V-1, Clear:
Hard, of uniform colour, flat, free from all stains and foreign inclusions, waves, cracks, buckles, and other similar defects.

V-2, Clear and Slightly Stained:
Hard, of uniform colour, fairly flat, free from all vegetable and mineral stains, cracks, buckles and other similar defects, and foreign inclusions except for a few tiny air inclusions in not more than one-fourth of the usable area.

V-3, Fair Stained:
Hard, of uniform colour, free from all vegetable and mineral stains, cracks, buckles and other similar defects and foreign inclusions, except may be slightly wavy and may contain slight air inclusion in not more than one-half of the usable area.

V-4, Good Stained:
Hard, free from vegetable or mineral stains, cracks, buckles and other similar defects and foreign inclusions, except may be somewhat wavy but not rippled and may contain medium air inclusions in not more than two-thirds of the usable area, but may not have heavily concentrated air inclusions in any of the usable area.

V-5, Stained A Quality:
Hard, free from cracks and other similar defects, and foreign inclusions, except may be wavy with slight buckles and may contain medium vegetable stains, and the entire area may have air inclusions if not heavily concentrated.

V-6, Stained B Quality:
Hard, free from cracks and other similar defects and foreign inclusions, except may be wavy and slightly buckled and may contain heavy air inclusions, medium vegetable, clay and mineral stains.

V-7, Heavily Stained:
Hard, free from cracks and other similar defects and foreign inclusions, except may be wavy and buckled and may contain heavy air inclusions, heavy vegetable, and medium mineral stains.

V-8, Black Dotted:
Same as Heavily Stained except may contain black dots.

V-9, Black Spotted:
Hard, free from cracks or similar defects and foreign inclusions, except may be medium wavy and contain slight buckles and vegetable stains, black or red spotted mineral stains, and heavy air inclusions.

V-10, Black Stained:
V-9 quality, except may be soft and have black lines and(or) short red bars or connecting stains.

TRIMMING AND MARKETING

After mining the mica crystals from the dike, the books are hand-cobbed to remove any adhering minerals. The books are then split down by knife into sheets $\frac{1}{16}$ inch or less in thickness. These sheets are knife-trimmed to remove inclusions and imperfections along the edges to produce commercial block mica.

Montague (1960, p.558) states:

> The proper trimming of mica so as to obtain the largest-possible area of sound mica and at the same time to remove all cracks and other physical imperfections is an operation requiring the exercise of skill and judgements and is acquired only through experience. Inexperienced workers can almost completely ruin the usable value to be obtained from crude mica. The trimming is done with the knife held at a sharp angle to the surface of the mica, since done this way the knife cuts the mica readily, whereas if the knife is held at a right angle to the surface of the mica the laminations will tear. This produces finished sheets or blocks with a beveled edge which facilitates the further splitting of mica in fabricating operations. There are several different methods of trimming. "Full-trimmed" mica is trimmed all the way around leaving no natural edges and all cracks and physical imperfections are removed.

"Half-trimmed" mica is knife trimmed on two sides with the natural edge on the other sides. "Three-quarter trimmed" mica is more fully trimmed than "half-trimmed" but still has a natural edge. "Thumb-trimmed" mica is trimmed by breaking off ragged edges by hand.

In Ontario it is customary to send rough-trimmed mica samples to a mica buyer for appraisal. Sale is based on lot-by-lot appraisal.

GRADING

Details on the grading of mica as to size are given by Thomson (1955, p.5–7) and by Jahns and Lancaster (1950, p.17–20). The ASTM publishes a size grading chart for muscovite mica.

Size grades of muscovite block mica are shown in Table 12.

Table 12 *Size grades of muscovite block mica*

Area of minimum rectangle, square inches	ASTM	U.S. domestic	Malagasy Republic	India	Minimum dimension on one side in inches
100	OOEE Special	8x12	0000	OOEE Special	4
80	OEE Special	8x10	000	OEE Special	4
60	EE Special	6x10	00	EE Special	4
48	E Special	6x8	0	E Special	4
36	A1 Special	6x6	A1	Special	3½
24	1	4x6	1	1	3
15	2	3x5	2	2	2
10	3	3x3, 3x4	3	3	2
6	4	2x3	4	4	1½
3	5	1½x2, 2x2	5	5	1
2¼	5½	circle	6	5½	⅞
1	6	punch	6	6	¾

Uses of Mica

SHEET MICA

Due to its unique combination of physical, chemical, and electrical properties, mica is widely used in the electronic and electrical industries. Mica has perfect basal cleavage, elasticity, flexibility, physical strength, heat resistance, non-inflammability, chemical inertness, low electrical conductivity, high dielectric strength and low dielectric loss. It is commonly used as tube spacers or bridges in electronic tubes. It is also used as the dielectric in capacitors.

Lower quality mica is used in the electrical industry as an insulator in household appliances, transformers, rheostats, fuse plugs, spark plugs, and heater elements.

Sheet mica was an important strategic mineral during World War II.

BUILT-UP MICA

Built-up mica in various forms is used in electric motors, generators and transformers. It is used as insulation between copper commutator segments of motors and generators, as V-rings at each end of a commutator to insulate the copper segments from the steel shaft, and as slot liners for armatures and stators. Built-up mica is used as heater plate for insulating the electrical resistance windings of toasters, irons, kettles, etc.

GROUND MICA

Scrap mica is wet or dry ground for use in manufacture of rolled asphalt roofing and asphalt shingles. It is also used in cement, oil drilling muds, paint, and rubber goods. It is a filler in plastics and a coating for wall-paper and welding rods.

Prices

Prices for mica are extremely variable depending on size and quality. Lots should be shipped to a buyer for appraisal. E & M J Minerals and Metals Markets for 21 March 1966 gives the following approximate prices:

North Carolina clear sheet mica
Size 1½ x 2 in., $0.70 to $1.10 per pound.
2 x 2 in., $1.10 to $1.60
2 x 3 in., $1.60 to $2.00
3 x 3 in., $1.80 to $2.30
3 x 4 in., $2.00 to $2.60
3 x 5 in., $2.60 to $3.00
4 x 6 in., $2.75 to $4.00
6 x 8 in., $4.00 to $8.00
Punch mica, 7¢ to 12¢ per pound.
Scrap mica, $30.00 to $40.00 per ton.

Madagascar sheet mica:
Grade 7 (below 1 sq. in.), 50¢ per pound.
6 (1 to 1½ sq. in.), 85¢
5 (3 to 6 sq. in.), $1.20
4 (6 to 10 sq. in.), $1.50
3 (10 to 14 sq. in.), $1.90

Major Muscovite Properties

The major muscovite producing mine in Ontario was the Purdy mica mine near Eau Claire, District of Nipissing. In the 1950s there was some muscovite production from the Caribou Lake mica mine in McConkey township, District of Parry Sound.

A listing of 63 muscovite mica properties in Ontario is given in Table 13.

Table 13 *Ontario muscovite mica deposits*

County or District	Township	Location	Name of Mine	Operators	Years of Operation	Approximate Production	Reference	Descriptive Remarks
Algoma	Scholfield	Mattawitchewan R.			1902		Maynard 1900, p. 125	Muscovite to 4 inches abundant in pegmatite dikes.
Frontenac	Clarendon	Lot 24, Con. II			Before 1912		de Schmid 1912, p. 202	Mica somewhat iron stained.
	Miller	Lots 4 & 5, Con. XI					de Schmid 1912, p. 202	Some iron staining.
	Palmerston	Lot 24, Con. II	Fred Maly		1954		Smith 1956, p. 44	3 foot dike with muscovite to 4 inches.
Haliburton	McClintock	Lot 15, Con. VII		Mr. Mills			Thomson, 1943, p. 59	Muscovite in pegmatite.
Hastings	Elzevir	Lot 29, Con. XI		D. E. K. Stewart of Madoc			Thomson 1943, p. 61	Mica plates are small with many iron oxide inclusions.
	Wollaston	Lot 25, Con. I		Herbert Moore				Muscovite to 15 inches in a pegmatite dike. Mica sparse.
Kenora	L. of the Woods	Falcon Island	Falcon Island	Falcon Mica Mining Co. Ltd.	1926			Largest muscovite crystals measured 18 x 16 inches. Mica in wall zones of a 10 foot pegmatite dike.
Lanark	N. Burgess	Lot 16, Con. IX		New York Mica Co.	1869	2 tons	de Schmid 1912, p. 201	15 foot pegmatite dike carries muscovite to 12 inches in 6 foot hanging wall zone; dike length 1500 feet. Pits on General Electric property said to be 80 to 90 feet deep. Shaft sunk to 67 feet, with level at 50 feet in 1944 by Marston Minerals.
Lennox & Addington	Effingham	Lot 8, Con. VI	Orser mine	S. H. Orser, Marston Minerals, General Electric Co.	1938-42, 1944, 1950	51 tons	Hoadley 1960, p. 86	
Muskoka	Kaladar	SW¼ Lot 9, Con. I		M. F. Johnson	1953	3½ tons	Satterly 1942, p. 61	Muscovite to 3 inches in pegmatite.
	Brunel	Lot 16, Con. XIV					Satterly 1942, p. 74	Muscovite books average 2 inches, occur in 1-2 foot aggregates.
	Chaffey	Lot 13, Con. X						Muscovite to 10″ in granite pegmatite 10′ wide, 80′ long.
Nipissing	Ballantyne	Lot 34, Con. XIV		Otto Frederick	1943	2000 pounds		Muscovite to 12″ in granite pegmatite 2-8′ wide.
	Boyd	Lot 4, Con. XVI		A. Joanise, J. Montreuil	1942-43			Muscovite 8-10″ in size in granite pegmatite.
	Butt	Lots 11&12, Con. VI		H. L. Barber	1899		Ellsworth 1932, p. 187	5-6 inch muscovite in granite pegmatite.
		Lot 13, Con. VII		Wm. Elliot	1919		Hoadley, 1960, p. 85	3 foot pegmatite dike carries greenish muscovite up to 10 inches; two old pits.
	Calvin	Lot 9, Con. I	Graff showing	J. McKay	1893, 1943		de Schmid 1912, p. 202	Six parallel veins of muscovite pegmatite.
		Lot 16, Con. I & II		F. B. Hayes of Ottawa	1893		Hoadley 1960, p. 85	Two dikes with muscovite crystals up to 7 inches.
		Lot 15, Con. VIII			1943		de Schmid 1912, p. 202	Small muscovite crystals in large pegmatite dike.
		Lot 19, Con. IX					Hoadley 1960, p. 86	Large pegmatite carrying much muscovite up to 6 inches in diameter.
	Chisholm	Lot 24, Con. III	Campbell					Muscovite in granite pegmatite.
	Clancy	Lot 3, Con. XIV	Peter Foy mine	Peter Foy of Bonnechere	1911	100 pounds	Satterly 1944, p. 121	6 foot dike carries good quality muscovite up to 5 inches in size.
		Lot 4, Con. XIV	Boudreau	Frank Foy			Satterly 1944, p. 122	4 foot dike with muscovite to 4 inches in size.
	Deacon	N½ Lot 10, Con. XIV	Foy mine	Huntley McDonald	1942, 1950-1		Hoadley 1960, p. 86	15 foot dike with 6 inch books of green muscovite.
		Lot 12, Con. XII	Brent deposit	Huntley McDonald	1942, 1950-1		Hoadley 1960, p. 86	5 to 6 inch muscovite in pegmatite dikes.
		Lot 10, Con. XV	Brent deposit	Canadian Flint & Spar Co. Ltd.	1943	690 pounds	Satterly 1944, p. 122	8 foot pegmatite carries brownish muscovite.
	Dickens	Lot 27, Con. V		Bonfield Mica Syndicate	1943	1 ton	Satterly 1944, p. 123	15 foot pegmatite sill carries pale green muscovite.
		Lot 9, Con. X	Aylen Lake mine	Algonquin Mica Mining Syndicate	1919-20, 1944	65 tons	Satterly 1944, p. 123	6 foot pegmatite sill carries 6 inch muscovite.
	Mattawan	Lots 9-11, Con. XIII		Mattarig Mica Mining Syndicate	1942	several hundred pounds	Harding 1944, p. 28	8 foot pegmatite carries muscovite up to 4 inches in size.
		Lot 1, Con. II & III	Mattarig mine	Mica Co. of Canada Ltd.	1942-3	150 tons	Harding 1944, p. 29	Several pegmatite dikes up to 8 feet wide carry muscovite.
		Lots 3-4, Con. II		Purdy Mica Mines Ltd.	1941-1945	2,942,786 pounds	Hoadley 1960, p. 71	Excellent large sheets of good quality muscovite in pegmatite dikes.
		Lots 6 & 7, Con. II	Purdy mine	North Bay Mica Company	1949-1953		Harding 1944, p. 33	Canada's largest muscovite producer. See description. p. 31.
		Lots 2 & 3, Con. VII	Croteau-Lipsett	Inspiration Mining & Development Co.	1942-3	6 tons	Harding 1944, p. 27	Pegmatite 10-18 feet wide carries muscovite up to 5 inches.
				George Chaput	1943		Harding 1944, p. 27	5 foot pegmatite dike with small books of muscovite.
	Murchison	Lot 14, Con. VII		J. D. Cameron	1931	630 pounds		Muscovite in pegmatite.
		N½ Lot 18, Con. VIII		W. B. Kinney	1953-54			
	Phelps	Lot 6, Con. I		M. Elliott	1921	43 pounds		
Parry Sound	Butt	Lot 13, Con. VI & VII					Hoadley 1960, p. 87	50 foot dike with excellent light green muscovite.
	Chapman	Lots 17 & 18 Con. XIII	Jeffry property				Hoadley 1960, p. 87	6 inch books of stained muscovite.
	Christie	Lots 13 & 14, Con. XIV	Armstrong property	H. F. McQuire			Spence 1929, p. 83	Mottled muscovite in sheets up to 8 inches.
	Conger	Lot 10, Con. IX	Harris	Georgian Bay Mining Co.	1894		de Schmid 1902, p. 203	
	Ferguson	Lot 18, Con. II						
	Hagerman	Lots 17 & 18, Con. XIII	Duggan & Auld	Wm. Duggan	1958, 1961	25 pounds	Satterly 1955, p. 41	5 foot pegmatite sill with 3 inch muscovite books.
	Lount	Lot 10, Con. III		N. Hoffman	1918		Satterly 1955, p. 41	Muscovite books 2 to 3 inches in diameter, in 20 foot dike.
		Lot 3, Con. V		J. Bell, T. B. Tough	1941	225 pounds		
	McConkey	Lot 11, Con. I	Kelcey mine	E. H. Kelcey	1904	4300 pounds		
		S½ Lot 15, Con. VI		General Mica Mining Co.	1920			
		Lots 17-19, Con. V & VI	Caribou Lake	Inspiration Mining & Dev. Co.	1952	10 tons	Hoadley 1960, p. 78	Muscovite books from 4 to 18 inches in size.

	McDougall	Lot 12, Con. X	Valentine		1894		de Schmid 1912, p. 203	
		Lot 8, Con. XII	Oak Ridge	F. P. Leushner	1894	Small	Satterly 1942, p. 73	6 foot pegmatite dike carries muscovite.
		Lot 12, Con. XII	Land		1900	1 ton		
	Proudfoot	Lot 28, Con. V		L. J. Lahay	1941			Clear muscovite up to several inches in diameter.
	Ryerson	Lot 18, Con. XIII		T. B. Tough	1937-38, 1941		Satterly 1942, p. 60.	Stained and spotted muscovite up to 12 inches in size.
	Strong	Lot 21, Con. II		M. McAvoy			Satterly 1942, p. 74	25 foot pegmatite dike with 2-inch muscovite books.
Peterborough	Methuen	Lot 14, Con. VIII					Hewitt 1960, p. 160	3 inch muscovite books in narrow syenite pegmatite dikes.
		Lot 15, Con. VIII		J. E. Ayrhart	1941		Hewitt 1960, p. 160	6 inch muscovite books in syenite pegmatite.
		Lot 16, Con. VIII					Hewitt 1960, p. 160	5 inch muscovite books in syenite.
		Lot 14, Con. IX	Bennett's mine	White Mica Mining Syndicate	1899, 1940-42		Hewitt 1960, p. 161	Muscovite to 5 inches in syenite pegmatite.
Renfrew	Admaston	Lot 1, Con. VIII		P. Shannahan	1922		Satterly 1944, p. 69	Muscovite crystals 2 to 4 inches in size.
Sudbury	Davis	Lot 7, Con. I	Finlan mine	Finlan & Clarke	1918	300 pounds	Hoadley 1960, p. 86	5 inch muscovite crystals in pegmatite.
	Dill	Lot 2, Con. II		Northern Feldspar Mines Ltd.	1924-25		Spence 1932, p. 59	Muscovite suitable for grinding scrap.
		Lot 2, Con. III		Wanup Feldspar Mines Ltd.	1925-28		Spence 1932, p. 59	Shipped mica for grinding scrap.
	Loughrin	Lots 8 & 9, Con. VI		Laughrin Prospecting Syndicate	1943	3 tons		

THE PURDY MICA MINE

Introduction

The Purdy mica mine has been the largest producer of muscovite mica in Canada, and is one of the outstanding muscovite deposits in this continent. The mine workings are on the N½, lot 6, concession II, Mattawan township, District of Nipissing, about 2 miles north of the village of Eau Claire, which is on Highway 17 between North Bay and Mattawa, Ontario.

Mica was discovered on the property in November 1941 by Justin Purdy of Eau Claire. The original find was in what is now termed the No. 9 dike, which is about 400 feet east of the present No. 3 workings. Here the dike is from 10 to 18 feet wide, and the mica is badly stained. This dike was never worked extensively, since a second dike (No. 3) was very soon discovered. The No. 3 dike was from 8 to 12 feet wide and contained large books of clear mica. Purdy immediately began development of this dike by hand steeling, and rough cobbed mica valued at about $800 was shipped to buyers in Ottawa and Hull in 1941.

Early in 1942 Purdy discovered a third dike, now known as No. 1 dike, about 1,000 feet south of No. 3 dike. This dike was larger than No. 3 dike and contained many clear muscovite crystals of unusual size, including one record crystal measuring 9½ by 7 feet by nearly 3 feet thick. This single crystal, when later mined, yielded about 7 tons of trimmed sheet mica. Purdy operated No. 1 dike until his death in June 1942. The Purdy estate continued operating until the property was sold in November 1942 to Purdy Mica Mines Limited, a subsidiary of Inspiration Mining & Development Company Limited. Under this company's management the property was developed rapidly and successfully.

By the summer of 1942, the importance of this find of high grade strategic quality muscovite to the war effort was appreciated, and the U.S. government through its agents, the Colonial Mica Corporation, contracted to take the entire mica output of the Purdy mine, under a special price schedule that allowed for the unusual percentage of large sheet.

Purdy Mica Mines Limited continued operation of the Purdy mine throughout 1943, 1944 and 1945. As indicated on the accompanying table of production (Table 14), the major production was during 1943 and 1944. On 31 December 1944, the wartime supply emergency being over, the Colonial Mica Corporation terminated its contract with the company. The mine was operated until December 1945, when the property was closed down. The main production during this period came from

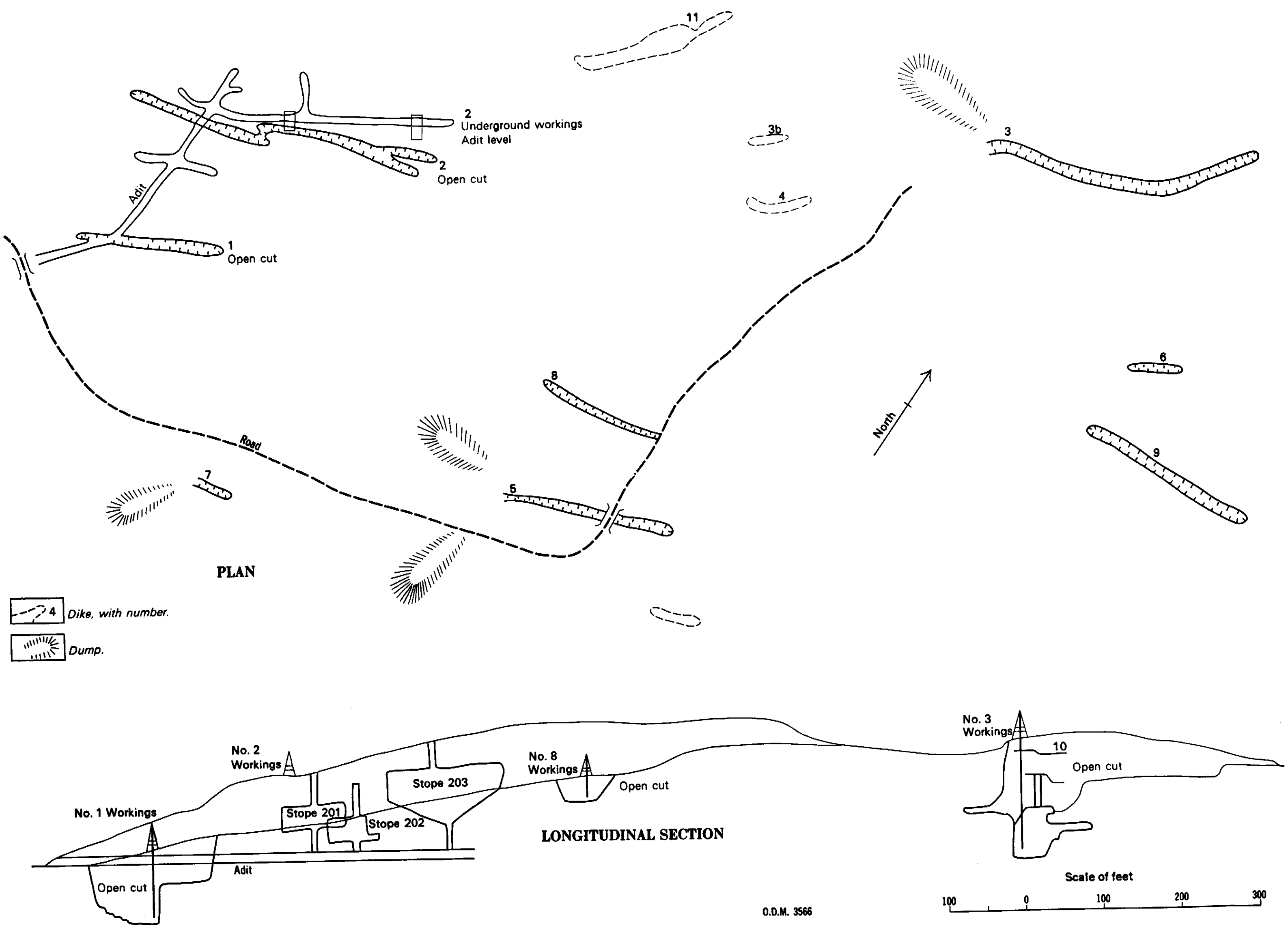


Figure 8—Purdy mica mine, lot 6, Con. II, Mattawan twp. (From D. F. Hewitt *in* The Geology of Canadian Industrial Mineral Deposits, 6th C.M.M.C., p.183)

No. 1, No. 2, and No. 3 dikes. No. 2 dike, lying 300 feet northwest of No. 1 dike, was opened in late 1942. A minor amount of production came from dikes 4, 5, 6, 7, and 9 on the Purdy property, and dikes 12 and 13 on the Croteau showing about ½ mile northwest of the Purdy workings.

In 1945 the management of Purdy Mica Mines carried out 5,000 feet of diamond-drilling on the property in an effort to prove up further reserves of mica-bearing pegmatite. However, the results were discouraging and the property was closed down, the dikes being considered exhausted.

In 1949 James J. Kenmey and associates formed the Northern Mica Company, of North Bay, and leased, and later bought, the Purdy mica mine. Mining began in June 1949, and continued until September 1953, when the property was again closed. In 1950 the company was reorganized as the North Bay Mica Company. As indicated in the accompanying table of production (Table 14), there was a very substantial amount of mica produced during this period: 2,253,507 pounds of mica, valued at $657,916. The total production of the Purdy mine to date amounts to 2,942,786 pounds of mica, valued at $1,577,326.

During this second period of operation production came almost entirely from No. 1, No. 2, and No. 3 dikes and extensive underground development was carried out.

General Geology and Structural Relations

The Purdy mine workings are on the top of an upland of granite gneiss that stands 500 to 600 feet above the valley of the Mattawa River, a mile to the south. The pegmatite dikes occur in a zone 400 to 500 feet wide and 1,600 feet long, extending in a northeasterly direction. The dikes strike northeast and dip from vertical to about 80°NW. They vary in width from 6 to 20 feet, averaging 10 to 15 feet wide, and from 200 to 400 feet long. Two of the dikes, No. 2 and No. 3, have been opened up to a depth of 150 feet. The dikes are frequently arcuate or S-shaped.

The main zone of dikes occurs in an irregular roof pendant of dark-coloured Grenville gneisses of early Precambrian age. These gneisses consist of amphibolite, garnet amphibolite, biotite amphibolite and paragneiss which are intruded and replaced by the underlying pink alaskite granite gneiss. The pink granite gneiss consists predominantly of quartz and microcline.

Structurally the granite pegmatite dikes are fissure-filling, and appear to occupy a set of northeast-trending tension fractures cutting the Grenville gneisses and granite. The dikes usually have sharp regular contacts and sometimes slickensides are seen giving evidence of movement along the fractures. Some of the movement is apparently post-dike. A geological study of the area led James J. Kenmey to suggest (personal communication) that the northeast fracture system occupied by the dikes represents a series of tension fractures developed by horizontal movement along two major northwest-trending faults lying northeast and southwest of the Purdy mine. These major faults are more than 1½ miles apart; the easterly one passes through the west end of Kearney Lake, the westerly one passes roughly down the creek that empties into the Mattawa River near Des Roches Rapids.

Character of the Pegmatite Dikes

As indicated on the accompanying diagram (Figure 8), 11 pegmatite dikes were located on the Purdy mica property. The granite pegmatite dikes consist primarily of quartz, pink potash feldspar, and albite, with muscovite and biotite as characterizing accessories. Epidote, chlorite, garnet, tourmaline, pyrite, euxenite, uraninite, beryl, monazite and allanite have been reported as minor accessories (Lang 1943), (Spence 1947), (Harding 1944).

The following general features of the deposits are noteworthy:

The pegmatite dikes are generally narrow, averaging 10 to 15 feet wide, with sharp, regular contacts.

The dikes are generally medium-grained with the quartz and feldspar crystals rarely exceeding 1 foot in diameter. In contrast to the general medium-grain size of the quartz and feldspar are the large books of muscovite in the dikes; frequently these books exceed 1 foot in diameter. The giant 7-foot by 9-foot mica crystal occurred in a relatively narrow dike.

The dikes are occasionally zoned, with a core of quartz and a wall zone rich in albite feldspar. Muscovite crystals often occur in the hanging-wall wall zone of the dike. Muscovite also occurs in the unzoned dikes. Most of the mica was sound and free from imperfections.

Individual dikes are small in size ranging from 200 to 400 feet long and not exceeding 200 feet in vertical depth. The dikes cut a roof pendant of dark Grenville gneisses that has been caught up in granite gneiss. At depth dikes No. 1 and No. 3 pinch out in granite gneiss. Dikes cutting the granite gneiss rarely contain mineable mica.

Mica is most abundant in dikes carrying abundant soda feldspar, and occurs in shoots or segregations within the dike.

Table 14 | *Muscovite production from Purdy Mica Mine: 1941–1945, 1949–1953 (Data from statistical files, Ontario Dept. Mines)*

	Rough cobbed and trimmed Mica		Scrap Mica		Total	
	Quantity lbs.	Value $	Quantity lbs.	Value $	Quantity lbs.	Value $
1941		800				800
1942	56,359	55,336	21,565	1,294	77,924	56,630
1943	88,171	214,808	283,900	2,626	372,071	217,434
1944	219,517	572,290			219,517	572,290
1945	19,767	73,056			19,767	73,056
1949	43,967	10,341	38,300	440	82,267	10,781
1950	164,950	125,498	86,400	1,095	251,350	126,593
1951	999,182	354,557	400,000	4,000	1,399,182	358,557
1952	202,010	106,934	202,000	3,030	404,010	109,964
1953	74,698	51,393	42,000	630	116,698	52,023
Total	1,868,621	1,565,013	1,074,156	13,115	2,942,786	1,578,128

Development of the Dikes

Although the original muscovite discovery was in dike No. 9, initial production was from dike No. 3 on top of the hill. Early production at the property came from dikes No. 1 and No. 3, with No. 2 coming in as a producer late in 1942.

No. 3 dike was exposed over a length of about 350 feet. The width averages from 8 to 10 feet. The dike strikes northeast, dips 75 degrees northwest, and is concave to the west. At its northeast end the dike ends against banded hybrid granite gneiss; at its southwest end it narrows and pinches out in two tails in the hybrid gneiss. Open pit operations were begun and the dike was opened to a depth of about 40 feet throughout its length. Soon the limit for hand tramming was reached and hoisting began on the No. 1 (north) skidway. The dike was opened to a depth of about 130 feet by Purdy Mica Mines Limited.

In 1949 when Kenmey reopened the property a large percentage of the production came from No. 3 dike. A second skidway, 60 feet south of No. 1 skidway, became the main production opening on No. 3 dike. It was found that No. 3 dike consisted of two lenses: the main dike or north lens that had been extensively worked by the Purdy company, and a second or south lens occurring on the hangingwall side of the north lens and separated from it by 4 to 5 feet of waste rock. This south lens had a length of about 40 feet on surface, but lengthened to over 100 feet at depth. It was worked to a depth of 160 feet. The average width of this lens was about 8 feet. A good 100-ton pocket of mica was mined from this dike in 1951. At depth this lens pinched out into two narrow leads.

No. 1 and No. 2 dikes were opened in 1942 and were worked by Purdy Mica Mines Limited by open cut benches driven northeast into the face of the hill. No. 1 dike, which also strikes northeast and dips 75° northwest, was exposed over a length of about 250 feet, and had an average width of 8 to 12 feet. At the southwest end the dike branched into two parts. To the northeast the dike narrows and splits into several narrow veins that pinch out in amphibolite gneiss. This dike was opened over a length of 200 feet to a depth of 40 feet by open cut methods. Purdy Mica Mines then sunk a shaft near the south end of No. 1 dike and mined it to a depth of about 60 feet.

No. 2 dike, which lies about 300 feet northwest of No. 1 dike, was also operated by open cut benching to the northeast into the hillside. The Purdy company carried the workings to a depth of 35 feet over a length of 440 feet. In his paper Spence (1947) gives details on the operation of Purdy Mica Mines.

During the operation of the mine by North Bay Mica Company, No. 2 dike was developed by underground methods. In 1951 a long adit was run into the hillside from the base of the hill and intersected No. 2 dike at a point about 300 feet from the mouth of the adit. Drifting was carried out over a length of 350 feet along No. 2 dike and mining of the dike was carried out by stoping. Three stopes, No. 201, No. 202, and No. 203, were opened and raises were carried through from 201 and 203 to surface, a maximum distance of about 150 feet. Although these methods resulted in lower mining costs than underhand stoping, the amount of mica located was disappointing and the mine closed in September 1953.

An interesting statistical summery of production during operations by the Purdy Mica Mines is given by Spence (1947). During this period the yield of sheet mica was 18.1 percent of the mica produced. The yield of rough mica per ton of rock was 2.5 percent, giving a yield of sheet mica per ton of rock of 0.45 percent. Average mining costs ran $1.42 per pound of sheet mica. The average grade was $23.06 per ton of rock. This compares with $7.56 to $17.52 per ton for mines operating in New Hampshire during the same period.

CARIBOU LAKE MICA MINE

In 1952 Inspiration Mining and Development Company took over the Caribou Lake Mica Mine in McConkey township, District of Parry Sound. The company held 12 claims on the north side of Caribou Lake comprising lots 17, 18, and 19, concessions V and VI, McConkey township. The property is located 6 miles west of the village of Loring, and, when visited by the author, was reached by boat from the Caribou wharf on Caribou Lake.

The property was taken over by Inspiration Mining and Development Company on 15 May 1952, and prospecting and exploration on the property proceeded throughout the summer. Work was done on four showings. In the fall of 1952 work was concentrated on No. 3 showing and muscovite was being produced at the rate of 3,000 pounds per week. Total production in 1952 was reported to be about ten tons of marketable mica.

The area surrounding Caribou Lake is underlain by a norite-metagabbro body which has an areal extent of at least four square miles. This norite and metagabbro is the country rock for the granite pegmatite dikes which carry the muscovite mica. The granite pegmatites average from 4 to 15 feet wide with an occasional large dike up to 100 feet or more in width. Mineralogically the dikes consist predominantly of albite, microcline, and quartz. Biotite, muscovite, and garnet are common accessory minerals. At No. 2 showing, biotite crystals were rimmed with muscovite indicating a later age for the latter.

Muscovite books observed by the author ranged from 4 to 18 inches in diameter. Commercial grade green, rum, and rum-ruby mica was produced at No. 3 showing.

No. 3 Showing

No. 3 showing consists of a granite pegmatite dike, striking N15°W to N15°E, dipping 40° to 60° west, cutting metagabbro. The pegmatite dike is somewhat irregular and the footwall is not exposed in the main pit, but it appears to have an average width of about 12 feet. On this dike a pit 27 feet long, 10 feet wide, and 8 feet deep has been sunk. Along the hangingwall side of this dike books of muscovite are concentrated in a zone 3 to 5 feet wide. The books range in size from 3 to 10 inches, with the bulk of the stockpiled mica running 4 to 6 inches in size. The muscovite appears to be good quality green, rum, and rum-ruby. Some of the mica is stained, but would be suitable for electrical grade mica.

Fifteen feet to the north of the main pit a second pit measuring 10 feet by 6 feet by 4 feet deep has been sunk on the dike.

Branching off the main dike at the main pit is another granite pegmatite dike which runs westward from the main pit, striking S80°W. This dike has an average width of about 4 feet and is exposed by stripping for a short distance from the main pit. Good muscovite books up to 6 or 8 inches occur in this dike. One hundred feet west of the main pit along-strike of this subsidiary dike another pit measuring 8 feet by 5 feet by 4 feet has been sunk. The 4-foot dike strikes N80°E, dips 60°S and contains good books of ruby to rum-ruby muscovite up to 8 inches in diameter. Forty feet west of this pit another small pit has again uncovered the dike and muscovite is again in evidence. This subsidiary dike has been traced for a distance of 170 feet west from the main pit and appears to have a reasonably good content of muscovite.

A second west-trending branch dike has been uncovered in strippings extending west from the northerly pit on the main dike. This dike strikes almost east-west, has a width of 4 feet and carries numerous books of muscovite. It is stripped for a distance of 55 feet from its intersection with the main dike.

Four hundred feet northeast of the main pit a new stripping has exposed another pegmatite dike containing small 4-inch books of clear-green muscovite.

No. 1 Showing

No. 1 showing, which is situated one claim northeast of No. 3 showing, consists of a large granite pegmatite exposure measuring 40 by 400 feet. The walls are not exposed and the attitude of the dike cannot be ascertained. The main working on this showing consists of a pit 30 feet by 12 feet by 8 feet deep in white graphic granite pegmatite. Some books of muscovite up to 10 inches in diameter occur in the dike, but are sparsely distributed throughout the dike and the mica does not appear to be sufficiently well concentrated to be commercial. At the eastern end of the exposure, biotite is the predominant mica. Garnets up to ¼ inch in size are present.

No. 2 Showing

No. 2 showing is one claim north of No. 3 showing. The granite pegmatite dike strikes N10°E, dips 82° east, and cuts metagabbro. The dike has a width of 13 feet. The dike is zoned, with a distinct quartz core and albite-microcline-quartz-muscovite intermediate zone. The muscovite mica occur in high concentration along the hangingwall side of the core of the dike. The books are up to 18 inches in diameter, but are of poor quality apparently due to some movement in this dike after their formation.

The dike is exposed for a length of 120 feet and the workings consist of an open cut 30 feet by 10 feet by six feet deep, and two pits.

ORSER MINE

The Orser mica mine at Mazinaw Lake is on lots 8 and 9, concession VI, Effingham township, County of Lennox and Addington. This mine adjoins the General Electric mica mine on the extension of the same granite pegmatite dike. The mine was worked by Sydney Orser from 1938 to 1942, by Marston Minerals Limited in 1943 and 1944, and by C. Orser and son in 1950.

The granite pegmatite dike is approximately 15 feet wide and contains a concentration of books of muscovite up to 12 inches in diameter in a 6-foot hangingwall zone. There is an open pit 100 feet long, 15 feet wide, and 15 to 20 feet deep. In 1944 a shaft was sunk to a depth of 67 feet, a level was established at 50 feet, and 55 feet of drifting was done. The combined length of workings on the Orser and General Electric properties is at least 1,500 feet. The two main pits on the General Electric property are said to be 80 to 90 feet deep (Hoadley 1960, p.87).

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Photo 6—Beryl crystal in feldspar. (Photo courtesy of Geological Survey of Canada)

The mineral *beryl*, $Be_3Al_2Si_6O_{18}$, is the chief ore mineral of beryllium, a light metal somewhat similar to magnesium and aluminium. There are 24 known granite pegmatite occurrences in Ontario carrying beryl, only one of which has produced commercially. The beryl pegmatite dike on lot 30, concession XV, Lyndoch township, Renfrew county, operated by Canadian Beryllium Mines and Alloys Limited produced 28 tons of beryl valued at $8,057.

Beryllium Minerals

Table 15 lists the principal beryllium minerals.

Table 15 *Principal beryllium minerals*

Mineral	Composition	BeO percent
Beryl	$Be_3Al_2Si_6O_{18}$	10–14
Phenacite	Be_2SiO_4	44–45.6
Bertrandite	$Be_4Si_2O_7(OH)_2$	39.6–42.6
Chrysoberyl	$BeAl_2O_4$	16.9–19.7
Barylite	$BaBe_2Si_2O_7$	15.4–15.8
Gadolinite	$Be_2FeY_2Si_2O_{10}$	10.7
Helvite group*	$R_4Be_3Si_3O_{12}.S$	10–15

*The helvite group is an isomorphous series consisting of the end members *helvite* $Mn_4Be_3Si_3O_{12}.S$, *danalite* $Fe_4Be_3Si_3O_{12}.S$, and *genthelvite* $Zn_4Be_3Si_3O_{12}.S$.

BERYL

Beryl is generally found in hexagonal crystals that may be up to a foot in diameter and several feet in length. It may be green, aquamarine, straw-yellow, or colourless. The beryl found in eastern Ontario is yellow-green to blue-green in colour and usually opaque to translucent. Emerald and aquamarine are gemstone varieties of beryl. Beryl has a hardness of 7.5 to 8 and a specific gravity of 2.6 to 2.8. It has imperfect basal and prismatic cleavage, and conchoidal to uneven fracture. It can be distinguished from apatite by its superior hardness. Beryl commonly occurs as an accessory mineral in granites and granite pegmatites.

PHENACITE

Phenacite looks very much like quartz. It occurs in rhombohedral crystals and has conchoidal fracture. The hardness is 7.5 to 8 and the specific gravity is 3. It is colourless, yellow, pale-rose, or brown. It is the richest ore of beryllium, containing 44 to 45.6 percent BeO. It commonly occurs in granite pegmatites.

BERTRANDITE

Bertrandite occurs in small tabular or prismatic crystals and in granular form. It has perfect (110)

Table 16 | *Ontario pegmatites with beryllium minerals*

County or District	Township	Location	Name of Mine	Operators or Owners	Years of Operation	Approximate Production	Reference	Descriptive Remarks
Frontenac	Loughborough	Lot 11, Con. IX	Foxton	O'Brien & Fowler, S. Orser	1920-21		Rose 1960, p. 24	Pegmatite carries gadolinite.
Kenora	50¼°N 94½°W	English River					Wright 1932, p. 127	Few small crystals of beryl in large pegmatite dike on east shore of English R. 2 miles NW of Separation Rapids in a small dike cutting sediments 3 miles west of Oneman Lake.
		Sandy Creek	Red Lake Road	Madsen Red Lake Gold Mines	1963			Pegmatite dike 12′ wide with white beryl crystals 2″ long; dike exposed for 180′.
	Tustin	Medicine Lake		E. Sobiski	1949			Beryl crystals 2″ in diameter and several inches long in granite pegmatite.
	Zealand	Lot 17, Con. VII, VIII		J. G. Taylor			Satterly, 1941, p. 55	Tourmaline pegmatite with small green beryl crystals.
Nipissing	Butt	S½ Lot 15, Con. XIV		D. Sheenan of Kearney				Beryl crystals ¼ to 2″ in diameter in granite pegmatite.
	Calvin	Lot 13, Con. IV					Ellsworth 1932, p. 188	Beryl with cleavelandite in dike 6-10′ wide.
		Lot 14, Con. VII		G. Purdy			Spence 1932, p. 49	Beryl in granite pegmatite.
Parry Sound	Ferrie						D. Sullivan, pers. comm.	Beryl in 3′ granite pegmatite.
	Henvey	Lot 5, Con. B	Besner	Wanup Feldspar Mines Ltd.	1926-29		Rose 1960, p. 19	Granite pegmatite worked for feldspar carries minor beryl, uraninite.
Rainy River		Turtle Lake					Tanton 1925, p. 10	Beryl crystals 2 inches long in pegmatite.
	Quetico Park	48°24′N91°48′W		P. Carrignan			Port Arthur files	Beryl crystals to 6″ long in granite pegmatite 150′ long.
		48°24′N91°48′W		J. Cyr			Port Arthur files	Beryl crystals to ¾″ diameter in granite pegmatite; grade low.
Renfrew	Lyndoch	Lot 23, Con. XV		Can. Beryllium Mines & Alloys	1926, 1939		Hewitt 1953, p. 36	Beryl up to 8″ long in granite pegmatite.
		Lot 30, Con. XV		Can. Beryllium Mines & Alloys	1936, 1939	28 tons	Hewitt 1953, p. 42	Beryl in granite pegmatite.
Sudbury	Whalen	On CNR		Redore Mining Co.	1940			Beryl reported in granite pegmatite.
Thunder Bay		L. St. Joseph					Bruce 1923, p. 20	Minor beryl in pegmatites cutting gneiss along south margin of granite.
		Linklater Lake		San Antonio Gold Mines	1948		Gussow 1942, p. 5	Pegmatite dikes carry minor beryl.
		Saga Lake					Moore 1931, p. 82	Beryl occurs sparsely in pegmatite dikes, near Saga Lake.
		Cresent L. area	N. Aubry deposit		1957		Pye, pers. comm.	Beryl and spodumene in granite pegmatite.
		Crescent L. area	S. Aubry deposit		1957		Pye, pers. comm.	Beryl and spodumene in granite pegmatite.
		Georgia L. area	Swanson	Goldale Mines Ltd.	1957		Pye 1965, p. 103	Beryl crystals to 7 inches in length, with spodumene in pegmatite.
		Georgia L. area 49°00′N 89°37′W	MNW deposit	Cons. Mining & Smelting	1956		Pye 1965, p. 84	Beryl, spodumene, amblygonite in granite pegmatite.
							Jolliffe 1933, p. 152	Beryl in albite pegmatite.

cleavage. The hardness is 6 to 7 and the specific gravity is 2.6. It is colourless, white, grey, or yellow, and generally very fine-grained. It frequently replaces beryl or phenacite in granite pegmatites.

CHRYSOBERYL

Chrysoberyl occurs in tabular orthorhombic crystals, which may be twinned to form pseudo-hexagonal crystals. It has distinct (011) cleavage, uneven to conchoidal fracture. It is brittle and has a hardness of 8.5 and a specific gravity of 3.5–3.8. The lustre is vitreous. It is green, yellow, greenish-white, brown, or red. Alexandrite is an emerald-green gem variety that is red in transmitted light. Cat's eye is a green variety exhibiting a chatoyant effect. It is commonly found in granite pegmatites.

BARYLITE

Barylite is a barium beryllium silicate occurring in colourless to white platy crystals. Its hardness is 6 to 7 and its specific gravity is 4. It has recently been discovered in some quantity at Seal Lake, Labrador.

GADOLINITE

Gadolinite is a beryllium iron rare earth silicate. It is frequently massive, sometimes in prismatic crystals. It lacks cleavage and has conchoidal to splintery fracture. It is brittle with a hardness of 6.5 to 7 and a specific gravity of 4.0 to 4.5. Its lustre is vitreous to greasy. Its colour is black, greenish-black, or brown. It occurs in granite pegmatites but is a rare mineral.

HELVITE GROUP

The helvite group, an isomorphous series with end members helvite, danalite and genthelvite, is noted for its resemblance to the garnet group. They occur in octahedral and tetrahedral crystals. They have poor octahedral cleavage, and uneven to conchoidal fracture. They are vitreous to resinous in lustre and yellow, red, or brown in colour. They occur generally in granite pegmatite.

Occurrence of Beryllium Minerals

The most common occurrence of beryllium minerals is in granite pegmatites where beryl can be hand-cobbed during pegmatite mining operations. Beryl may also occur disseminated in granite, but the segregations have not yet proven commercial. Beryl may also occur in quartz veins but not in commercial quantities. The wallrock adjacent to beryl-bearing quartz veins is occasionally replaced by beryl, phenacite and bertrandite. Some large replacement bodies of bertrandite in rhyolite tuff occur in southwest Utah, U.S.A. Beryllium minerals including helvite occur in contact metamorphic skarn deposits in New Mexico, U.S.A. Beryl has also been found in contact metamorphic deposits.

Exploration Methods

Beryl and chrysoberyl are the only beryllium minerals that are easily recognizable. Phenacite and bertrandite resemble quartz, and the helvite group resemble garnet.

Beryllium minerals can be detected by the beryl-ometer, a geophysical instrument manufactured by Nuclear Enterprises Limited in Winnipeg. The instrument is heavy and cumbersome to carry, and is not well suited to field prospecting but can be effectively used on outcrop areas, samples, drill core, etc.

Beryllium can be detected by various chemical field tests which are described by R. B. Rowe in a publication entitled "Beryllium—Information for Prospectors", published as contribution No. 45 of the Research department, Dow Chemical of Canada Limited, Sarnia. The principal tests are the modified morin fluorescence test for beryllium, the quinizarin fluorescence test for beryllium, the Gruner helvite test, and the Barlow beryl-quartz test.

Uses of Beryllium

One of the important uses of beryllium is in the production of beryllium-copper alloys, which possess physical and electrical properties that make them very valuable for particular uses. J. W. Clark (1949, p.1296) gives the following information on beryllium-copper alloys:

> The beryllium-copper alloys are of great commercial and strategic significance, having no peer when shaped into parts that must simultaneously perform a mechanical function and conduct electric current at moderately elevated temperatures. The ease with which beryllium-copper may be formed and subsequently age-hardened is a factor of immeasurable importance in its utility; the rapidly quenched alloys are ductile (Brinell 100) and readily machinable or castable into complex shapes which then may be very substantially hardened (Brinell 350–400) and otherwise strengthened by the fabricator with a simple heat treatment. Both ductile and mill-hardened stock is available commercially, with the mill hardened forms becoming increasingly important. Beryllium-copper alloys used in commercial practice range in beryllium content from about 0.25 to 2.85 percent according to properties desired.

Among the common uses for beryllium-copper alloys are the following: springs, bellows, electrical contacts, aircraft engine parts, cams, bearings, resistance welding electrodes; current carrying springs and switch parts where good electrical and thermal conductivity are desired at moderately elevated temperatures; and high-conductivity casting alloys used for switches, circuit breakers, switch gear, welding jaws, resistance welding dies, electrode holders, and other current-carrying members where strength, conductivity, and resistance to wear at moderately elevated temperatures are important (Clark 1949, p.1297).

Beryllium oxide is widely used in the ceramic industry in porcelain bodies used for aircraft spark plugs and insulators. Beryllium metal is used in some nuclear reactors because of its moderating effect on fast neutrons emitted by the fission of U-235 and plutonium. Beryllium is used in heat shields for space capsules. Beryllium-nickel alloys are used for surgical instruments, matrix for diamond drill bits, parts for fuel pumps and business machines, and dies for shaping aluminium channels, necks of bottles, stainless steel dinnerware, and plastics (Eilertsen 1965, p.5).

Prices

Eilertsen (1965, p.7,8) states that prices for domestic and imported hand-cobbed beryl are negotiated between buyer and seller. The average price for imported beryl containing approximately 11 percent BeO at ports of exportation for 1964 was $253 per short ton, or about $23 per short ton unit of BeO.

Ontario Deposits

A list of 24 occurrences of beryl in Ontario pegmatites is given in Table 16. The only commercial beryl deposits operated in Ontario were those in Lyndoch township, Renfrew county, which are described in the following sections (from Hewitt 1953, p.36–45).

LYNDOCH TOWNSHIP
CONCESSION XV, LOT 23, (CANADIAN BERYLLIUM MINES AND ALLOYS, LIMITED)

Location and Access

The beryl-bearing pegmatite dike on lot 23, concession XV, is on the south slope of Casey Hill, a prominent north-eastward-trending ridge of granite and hybrid gneiss. The property can be reached by road; from Quadeville Village corners it is 1.4 miles north on the Letterkenny road to the entrance to the mine property. The mine is ¼ mile east of the Letterkenny road. (Hewitt 1953, p.36).

History of Development

The dike was first described by Willet G. Miller (Miller 1898, p.235), who first reported the occurrence of beryl and columbite in this area as follows:

The deposit is situated well down the face of a high hill, which faces the Quodville road on lot 23 in the fifteenth concession of Lyndoch . . . The part of the face of the hill where the outcrop occurs is covered for the most part to a considerable depth with a layer of soil and boulders. The outcrop itself as now exposed is of small size, being about 15 yards in length. The rock matter on the western end of the outcrop consists of large masses of green felspar or amazonstone and quartz. These minerals show a rather sharp contact, and the masses of them have a diameter of some feet. Associated with these minerals is some black mica and beryl which is imbedded in the quartz. The beryl crystals are of different sizes, being generally much elongated but with imperfect terminations. Some of the crystals have a diameter of six inches. One crystal was seen imbedded in the quartz which had a length of over 30 inches and a diameter of three inches. On the eastern end of the deposit the felspar has a pink or reddish colour, and was found on microscopical examination to possess a microcline base through which is set plagioclase, thus making it a microcline microperthite. The surface of this part of the deposit is much broken up, the felspar and associated quartz, which is generally smoky in appearance, being in loose fragments. It is in this part of the deposit that the mineral occurs which has been determined to belong to the rare columbite group.

On making an examination of the deposit, my attention was at once attracted to this dark coloured mineral. It is black in colour, possesses a sub-metallic lustre, and occurs imbedded in the felspar. The plates conform somewhat closely to the cleavage planes of the felspar and in some cases are of considerable size. In one specimen obtained the diameter of the plate was about six inches, and its thickness one-sixteenth of an inch. The plates in some cases at points on one of their surfaces expand into nodules, which thus possess one rounded and one plane surface.

The deposit was later examined by H. V. Ellsworth of the Geological Survey of Canada, who described it (Ellsworth 1932, p.228,229), in part, as follows:

The dyke was almost entirely covered by soil, brush, etc., only a few square yards being exposed, until the summer of 1926 when Mr. T. B. Caldwell of Perth opened it up in the hope of obtaining beryl in commercial quantities. It is variously estimated that from 2 to 4 tons of beryl crystals were obtained. The dyke was more or less opened up over a length of 100 feet, a width of 5 to 10 feet, and a depth of 3 to 6 feet, but it is even not yet fully exposed. The strike in a general way appears to be about north 60 degrees east magnetic.

The openings show crystal masses up to 6 feet in diameter of pink microcline and beautiful green amazonstone, a moderate amount, perhaps not over 10 percent of the whole, of white, smoky, and pale rose quartz; platy albite (variety cleavelandite), with some more or less albitized pink microcline. Accessory rare minerals that have been identified are: beryl, columbite, lyndochite, cyrtolite, monazite. A few red garnets in good crystals up to 2 inches in diameter occur and also a small amount of fluorite. Magnetite is abundant in the finer grained parts of the dyke. Triangular black tourmaline crystals up to 6 inches in diameter are not uncommon, more especially in the albite. There is reason to believe that bismuthinite was also found, as this mineral is recorded [(Hoffman 1897, p.14R)] as occurring in a dyke with beryl in the same township and Mr. John Sullivan, the discoverer of the dyke some years ago informed the writer that he had found in earlier years a mineral answering to the description of bismuthinite.

Present Workings

The following is taken from Hewitt (1953, p.37):

In 1939 Canadian Beryllium Mines and Alloys, Limited, reopened the property for beryl, and the main development of the property took place at this time. The dike was opened for

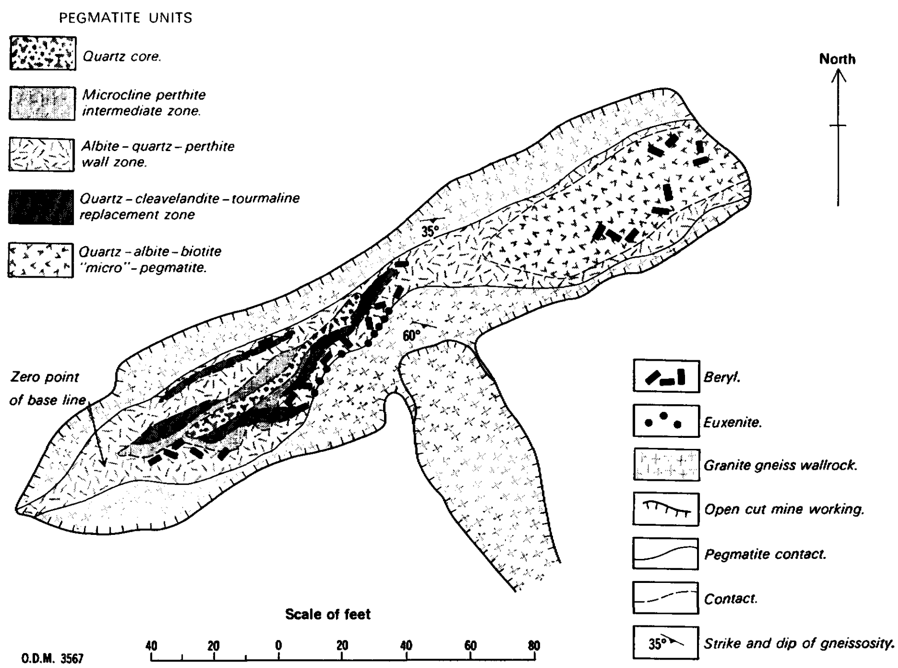

Figure 9—Geological map of beryl pegmatite, lot 23, Con. XV, Lyndoch twp. (From Hewitt 1953, p.38)

a length of 245 feet along strike by a single open cut. Along the north face of the cut, the depth to the bottom of the pit is 20–25 feet; along the south face, the depth is 6–15 feet. The width of the cut from rim to rim averages 45–50 feet. The floor of the cut is relatively level; it measures 210 feet in length along the strike of the dike and averages 30 feet in width. A hundred and twenty feet from the west end of the cut, the south wall has been breached, and there is a cut 20 feet wide and 90 feet long running southward to the mine buildings. Tracks are laid in this cut, and it provides access for small ore cars. This cut is 12 feet below the floor of the main workings and is filled with water.

Stripping and trenching has been carried out on strike of the dike both to the east and west of the main cut, but the dike appears to pinch out along strike.

Geology

The following is taken from Hewitt (1953, p.37):

The country rock exposed on lot 23, concession XV, is interbanded pink hornblende granite gneiss and pink leucogranite gneiss. These gneisses strike from N30°E to N70°E and dip 20°–60°SE. In the vicinity of the pit the granite gneisses strike N30°–50°E and dip 20°–30°SE. Interbanded with these gneisses are flat-lying lenses of pink allanite-titanite granite pegmatite, very similar to those occurring on the Hatch property on lot 25, concession XV. These granite pegmatite stringers appear to be cut by the beryl-bearing granite pegmatite. Some layers of biotite schist occur in the granite gneiss; one such mass of biotite schist occurs in the south wall of the dike at the centre of the cut.

As shown in the accompanying sketch map of the property, the beryl-bearing granite pegmatite is exposed in the floor and north wall throughout the 245-foot length of the cut. The strike of the dike is N59°E, and it appears to dip vertically. The dike is irregular in shape; on the rim at the west end of the cut, it has a width of 4 feet and widens to 10 feet at the floor of the cut;[3] 50 feet eastward, along strike, the dike widens to 34 feet and, at the 120-foot mark, again narrows to 10 feet; at 160 feet, it widens again to 32 feet and continues to have a width of 28–32 feet to the east end of the cut.

Thus, the dike is constricted at the centre and is divided into two pods that are quite different in structure and texture. The western pod shows pronounced zoning and coarse crystallization: the eastern pod is largely undifferentiated and relatively fine-grained, with average grain size from ½ to 1 inch. The primary zones present in the western pod are: (a) a central core of quartz; (b) an intermediate zone of microcline-perthite; and (c) a wall zone of medium to coarse-grained albite-quartz-microcline-perthite. Replacing these zones and cutting them irregularly is a later age of quartz-cleavelandite-tourmaline.

The quartz core extends from the 20-foot mark to the 100-foot mark and has a maximum width of 5 feet; it is composed of massive, milky to smoky, quartz. The microcline-perthite zone consists of massive, coarsely-crystallized, 1- to

[3]For convenience of reference, a base line was laid down along the floor of the cut, parallel to the dike strike, using the point on the floor of the cut at the west end as zero: these base line measurements are used in the following descriptions.

3-foot crystals of pink microcline-perthite and extends from the 20- to the 80-foot marks. This zone envelops the quartz core. In some places along the contact between the quartz and microcline-perthite zones, there is a narrow 1-inch band of ¼- to ½-inch tourmaline crystals in the border of the quartz zone. Stringers of quartz cut this band and penetrate the microcline-perthite zone, apparently indicating a later age for some of the quartz. The wall zone, which is most prominent in the western end of the dike, is medium-grained, being 1-inch to 1-foot grain size, and is composed predominantly of quartz, pink albite, and microcline-perthite. Beryl, biotite, muscovite, magnetite, allanite, and euxenite also occur in this zone. Cutting across, and replacing all three of these primary zones, is a secondary zone of quartz-tourmaline-cleavelandite. The cleavelandite and tourmaline occur in platy rosettes in the quartz and are up to 6 inches in diameter.

The east end of the dike, from the 120- to the 220-foot marks, is composed of only two zones. A wall zone, varying in width from 1 to 4 feet, composed of 1- to 6-inch crystals of pink albite, quartz, and microcline-perthite, with some biotite and magnetite is usually present. The greater part of the dike is made up of a "fine-grained" or "micro" -pegmatite of 1-inch grain size, which has not differentiated into zones. Mineralogically it is composed predominantly of pink albite, microcline, quartz, biotite, beryl, muscovite, and magnetite.

Mineralogy

BERYL

The following is taken from Hewitt (1953, p.39):

Well-formed, euhedral, six-sided, blue-green beryl crystals occur throughout the dike but are especially common in the south-wall zone adjacent to the intermediate zone of microcline-perthite. This band of beryl-rich albite-quartz rock extends from the 20- to the 120-foot mark and has a maximum width of about 10 feet. The beryl crystals are from 1 inch to 4 inches in diameter and up to 8 inches long. Beryl also occurs, as shown in the accompanying sketch map, at the east end of the dike in the "micro"-pegmatite. Here, however, instead of occurring in well-formed euhderal crystals, the small ½-inch crystals of beryl occur intergrown with quartz and feldspar interstitially and show no crystal form. This mode of occurrence lends support to the view that the east end of the dike cooled rapidly without allowing time for growth of good euhedral crystals.

In his description of the above property, H. V. Ellsworth (Ellsworth 1932, p.229) notes that:

A few [beryl] crystals with well-developed terminations have been found, but they are exceptional . . . Some of the beryl crystals have been considerably bent without breaking, showing that the dyke has been subjected to severe stress.

The deposit was sampled by H. M. Butterfield in June 1943; his statement, excerpted from a memorandum of the Canadian Department of Munitions and Supply, was reported by Hewitt (1953, p.39), as follows:

Beryl was seen pretty well throughout the floor of the quarry, but was badly scattered except in a zone 95 feet long and from 3 to 10 feet wide, which is fairly well mineralized with beryl varying from a quarter of an inch or less to 3 or 4 inches in diameter. It may be significant that this is at a constricted section of the dike. This area contains 932 square feet or 78 tons per vertical foot and is estimated to average 1.24 percent beryl or 0.130 percent BeO. At $12.00 per unit of BeO, the value in place would be $1.56 per ton, in U.S. funds, and the total beryl contained in each vertical foot would be 0.936 tons, which, estimating an average depth of 13 feet already removed from this part of the quarry, would account for 12 of the approximately 18 tons which have probably been taken out, leaving only 6 tons for the rest of the quarry. Of the total amount, probably not over 8 to 10 tons have been recovered as clean crystals, the balance being made up of beryl contained in the rock in the ore storage bin, which amounts to about 180 tons. A 250-pound sample from the bin assayed 6.82 percent beryl, but was probably slightly heavier than the average of the bin, which may be 5 to 6 percent.

The area of the quarry floor is 7,040 square feet, and the average depth of rock removed is 16.3 feet, so that the total weight of rock excavated is 9,560 tons. From the above figures, it is apparent that whether the smaller richer area be taken, or the entire area of the quarry, the operation could not be carried on at a cost within the value of the contained beryl at the present price.

An analysis of beryl from this property and partial analysis of beryl from this property and from lot 30, concession XV, are given in Table 17.

Table 17 *Analyses, beryl deposits, Lyndoch township (Hewitt 1953, p.40)*

	Sample No. 1	Sample No. 2	Sample No. 3
	percent	percent	percent
BeO	14.38	13.41	12.51
SiO_2	64.40	64.34	62.94
Al_2O_3	18.08	16.82	17.18
Fe_2O_3	0.97	1.16	0.94
CaO	0.18		
MgO	0.33		
MnO	0.04		
K_2O	0.18		
Li_2O	0.18		
Na_2O	0.35		
H_2O	1.08		
Total	100.17		
Specific gravity	2.726		

Sample No. 1—Blue-green beryl from lot 23, concession XV, Lyndoch township, analysed by H. C. Rickaby [(Walker and Parsons 1927, p. 13)].
Sample No. 2—Blue-green, glassy beryl from lot 23, concession XV, Lyndoch township; partial analysis by the Provincial Assayer [now Laboratory Branch], Ontario Department of Mines, 1951.
Sample No. 3—Asparagus-green, opaque, altered beryl from lot 30, concession XV, Lyndoch township; partial analysis by Provincial Assayer [now Laboratory Branch], Ontario Department of Mines, 1951.

EUXENITE, VAR. LYNDOCHITE

The following is taken from Hewitt (1953, p.40).

The rare element minerals lyndochite, columbite, monazite, cyrtolite, and allanite are recorded as occurring in this pegmatite. Lyndochite is the low-uranium end member of the euxenite group and was described from this locality by Ellsworth [(Ellsworth 1932, p.49)]. It is a titano-tantalo-columbite of rare earths, uranium, thorium, iron, and calcium.

An analysis of this mineral is given in Table 18.

Ellsworth (1932, p.229) described lyndochite as follows:

The mineral is brilliant black en masse, reddish brown and translucent by strong illumination of thin edges or splinters or in a powder under the microscope. Powder, pale yellow; lustre, vitreous; perfect conchoidal fracture; cleavage, none; hardness, 6.5; sp.gr., 4.909 at 17.88 degrees; infusible.

Hewitt (1953, p.40) continued:

Ellsworth's microscopic examination discloses that the lyndochite contains inclusions of columbite, and that the columbite has apparently been replaced by lyndochite.

Lyndochite and magnetite, intergrown, form a narrow border zone between the wall zone and the wall rock on the south side of the dike between the 80- and 110-foot marks.

COLUMBITE

The following is taken from Hewitt (1953, p.40):

No columbite in place was seen by the writer and must have been more common in the upper parts of the dike which have been mined out.

Ellsworth (1932, p.230) described its occurrence as follows:

Columbite occurs as thin, flat, disk-shaped masses, with concentric markings on cleavages or partings of feldspar. The masses may vary in size from less than an inch in diameter to as much as a foot or more across. The large ones are comparatively thin, seldom more than ½ inch thick, whereas the smaller ones less than an inch in diameter may be almost hemispherical.

MONAZITE

One rough wedge-shaped crystal [of monazite] about 2 inches square by ½ inch thick, and a few much smaller ones were found by the writer embedded in red, microcline near a lyndochite crystal and a small cyrtolite mass. The monazite is a dull brown colour and has lost its transparency by alteration. (Ellsworth 1932, p.230)

CYRTOLITE

Cyrtolite, a variety of zircon, is reported by Ellsworth to occur in masses up to the size of a man's fist. The writer noted numerous small zircons up to ¼ inch in size in albite feldspar along the north wall of the cut. (Hewitt 1953, p.41)

COLUMBIAN ANATASE

A. D. Graham [(Graham 1952)] has identified columbian anatase from this property by X-ray study. (Hewitt 1953, p.41)

ALLANITE

Allanite occurs in vitreous, black, platy crystals with lyndochite in the border zone and in the north wall of the dike. (Hewitt 1953, p.41)

MICROCLINE AND MICROCLINE-PERTHITE

The intermediate zone is composed of coarsely crystalline pink microcline and microcline-perthite. Green amazonstone also occurs in the dike, and appears to be replaced by pink microcline microperthite. (Hewitt 1953, p.41)

ALBITE

Pink, and mottled pink and white albite feldspar makes up a large part of the wall zone of the dike. In the "micro"-pegmatite of the eastern end of the dike, albite is the predominant feldspar. Platy curved sheaves of cleavelandite make up an important part of the late quartz-cleavelandite-tourmaline zone. (Hewitt 1953, p.41)

QUARTZ

Both smoky and clear glassy quartz are present. There appear to be two ages of quartz, as indicated earlier. (Hewitt 1953, p.41)

TOURMALINE

Tourmaline in shiny black triangular prismatic crystals up to 1 inch in diameter and 6 inches in length occur with cleavelandite and quartz in the latest zones of the dike. (Hewitt 1953, p.41)

BIOTITE AND MUSCOVITE

Both biotite and muscovite occur, particularly in the east end of the dike, where books up to 2 inches in diameter occur. Some of the biotite is rimmed with muscovite. (Hewitt 1953, p.41)

MAGNETITE

Magnetite is a common accessory in the dike and often occurs with euxenite. (Hewitt 1953, p.41)

GARNET

Occasional crystals of reddish-brown garnet up to ½ inch were observed in feldspar. (Hewitt 1953, p.41)

FLUORITE AND APATITE

Massive purple fluorite and green glassy apatite up to ¼ inch occur with biotite and albite in the north wall of the dike at the east end. One occurrence noted by the writer was along the border of the dike adjacent to schlieren of mica schist. (Hewitt 1953, p.41)

Table 18 | *Analyses of lyndochite and columbite from lot 23, concession XV, Lyndoch township (Hewitt 1953, p.42)*

	Sample No. 1	Sample No. 2	Sample No. 3
	percent	percent	percent
SiO_2	0.07		1.28
TiO_2	16.39		5.19
BeO } Al_2O_3 }	0.13		
Fe_2O_3	1.32		
FeO	0.77	11.14	10.90
CuO		0.03	
CaO	4.86		0.15
MgO	0.13		
MnO	0.59	10.22	10.24
ZrO_2	0.04		
SnO_2	0.12	0.92	0.56
Cb_2O_5	41.43 }	75.75	{ 55.79
Ta_2O_5	3.84 }		{ 15.21
PbO	0.37		
UO_2	0.67		
UO_3	0.04		
ThO_2	4.95		
$(Ce, La, Di)_2O_3$	4.34		
$(Yt, Er)_2O_3$	18.22		
Rare earths		2.00	9.82
H_2O (−110°)	0.06		
H_2O (+110°)	1.90		
Ignition loss	(1.76)		
Total	100.24	100.06	100.14
Specific gravity	4.909		5.431

Sample No. 1—Lyndochite, lot 23, concession XV, Lyndoch township. Analyst, H. V. Ellsworth [(Ellsworth 1932, p. 264)]; analysis No. XXVIII.

Sample No. 2—Columbite, lot 23, concession XV, Lyndoch township. H. V. Ellsworth [(Ellsworth 1932, p. 260)]. Analyst, W. L. Goodwin, analysis XII.

Sample No. 3—Columbite, lot 23, concession XV, Lyndoch township. H. V. Ellsworth [(Ellsworth 1932, p. 260)], analysis No. XIII. Analyst, E. W. Todd. Specific gravity, T. L. Walker and A. L. Parsons [(Walker and Parsons 1934, p. 34)].

Table 18, taken from Hewitt (1953, p.42), gives analyses of lyndochite and columbite from lot 23, concession XV, Lyndoch township.

LYNDOCH TOWNSHIP
CONCESSION XV, LOTS 30 AND 31
(CANADIAN BERYLLIUM MINES AND ALLOYS, LIMITED)

Location and Access

A second beryl-bearing, granite pegmatite worked by Canadian Beryllium Mines and Alloys, Limited, for beryl and feldspar is located on lots 30 and 31, concession XV. This property can be reached by road from Quadeville by driving west 1½ miles on the Quadeville-Palmer Rapids road, turning north off the road at the west end of Eneas (Cameron) Lake, and proceeding 1¼ miles by gravel road to the mine property. (Hewitt 1953, p.42)

History and Development

The occurrence of beryl and radioactive minerals in this granite pegmatite dike is described by Ellsworth [(Ellsworth 1932, p.230)]. The dike was opened up in 1935 and 1936 by Renfrew Minerals, Limited, and 675 tons of feldspar were produced. During this period of development the east and central workings, [shown on Figure 10] shown on the accompanying sketch map of the property, were opened. In 1950, 57,100 pounds of beryl concentrates, valued at $7,882, were sold from the ore stockpile from this property. In 1948 and 1949 Canadian Beryllium Mines and Alloys, Limited, opened the west workings and produced approximately 300 tons of feldspar, which is stockpiled at the property. (Hewitt 1953, p. 42)

Present Workings

The following is taken from Hewitt (1953, p.44):

The west workings consists of a T-shaped cut, 8 feet deep, extending 75 feet in a north-south direction and 80 feet in an east-west direction. No beryl occurs in this workings.

The central workings, 100 feet to the east, is irregular in shape, as shown in the accompanying sketch, and extends for 130 feet in an east-west direction and 80 feet in a north-south direction.

The east workings, which lies 50 feet to the northeast of the central workings has a length of 200 feet in an east-west direction and 75 feet in a north-south direction. The main pit, at the western end of this workings, has a face of 25 feet. The main deposit of beryl occurred in this cut. A small boom derrick used for hoisting is mounted on the south side of this workings.

Geology

The following is taken from Hewitt (1953, p.44):

The beryl-bearing granite pegmatite is exposed on a low hill surrounded by spruce-tamarack-cedar swamp. The pegmatite is exposed for a length of 600 feet in an east-west direction and has an exposed width of 100 to 150 feet. The walls of the pegmatite are not exposed, so its size and attitude are not known. At the eastern end of the workings, a coarse-grained granite or "micro" pegmatite is exposed on a knoll just north of the workings. This may be the footwall country rock of the dike; if so, it appears to be closely associated in age and genesis with the pegmatite, as it is similar mineralogically and contains interstitial anhedral beryl in portions of it. Patches of this rock are pegmatitic. It is very similar to the "micro" pegmatite occurring at the east end of the dike on lot 23 and may represent an undifferentiated facies of the pegmatite. The contact between this "micro" pegmatite and the mineralogically similar coarser facies of the pegmatite is indefinite.

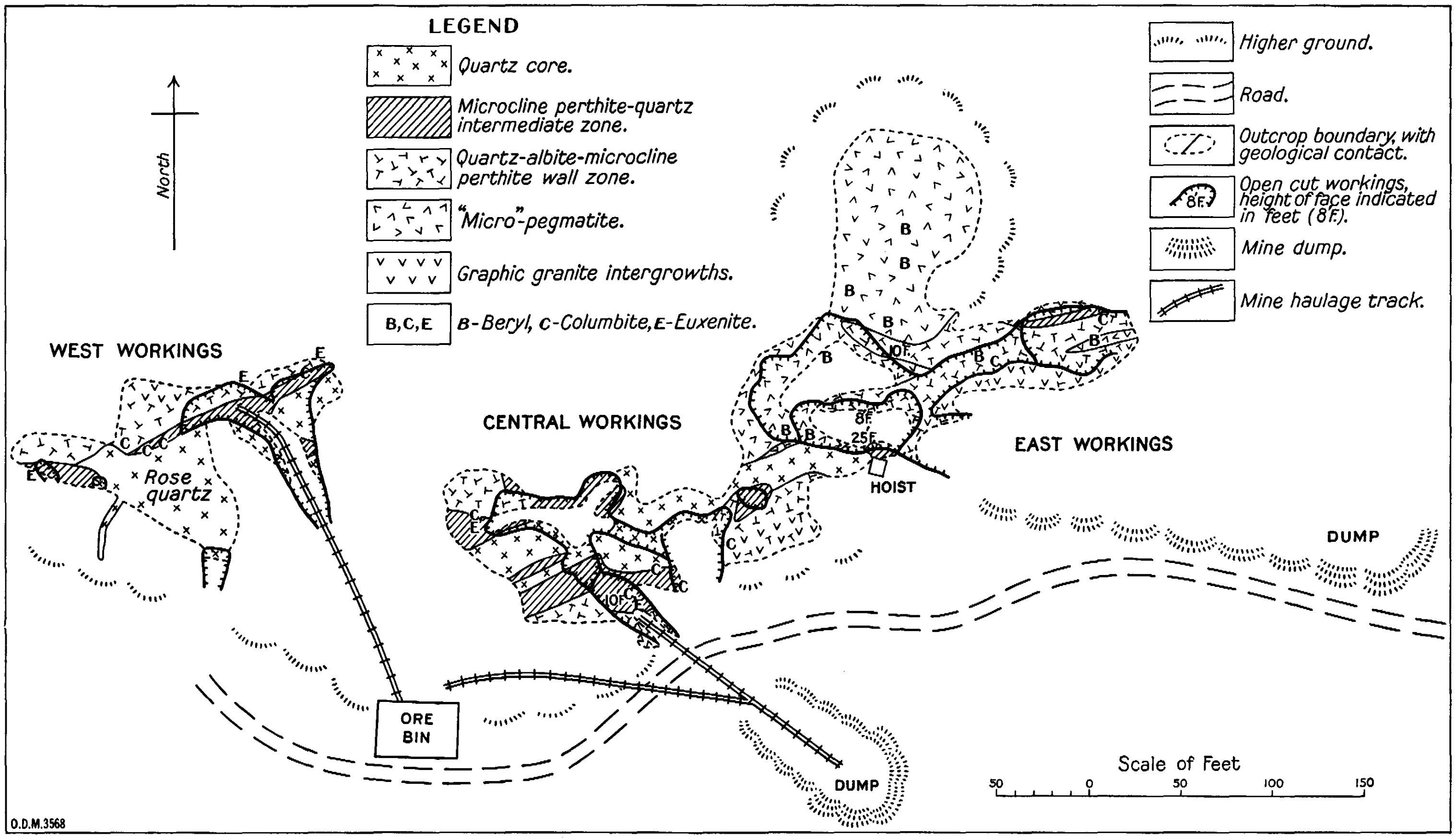

Figure 10—Geological map of beryl pegmatite, lot 30, Con. XV, Lyndoch twp. From Hewitt 1953, p.43)

The pegmatite appears to strike approximately N70°E and to form a flat sheet, dipping gently to the south. Since the wall rock contacts are not exposed, it is difficult to determine the true structural picture, and this estimate of its attitude is based on the trend of zones in the pegmatite, as shown in [Figure 10].

There are three recognizable zones in the pegmatite: (a) an inner zone or core of massive glassy white, smoky, or rose quartz; (b) an intermediate zone of pink microcline-perthite feldspar with some quartz; and (c) an outer-zone of albite and microcline-perthite, with quartz. At the western end of the property the pegmatite is very coarsely crystalline. One area of massive, white to rose quartz measures 75 by 30 feet. Before mining began at the west workings, the writer noted a single crystal of pink microcline-perthite measuring approximately 20 by 8 by 6 feet, containing perhaps 80 tons of feldspar. In the outer zone there is some graphic intergrowth of feldspar and quartz. In the west workings, quartz and feldspar are the main constitutents, and impurities are rare. A little sericite, kaolin, columbite, and magnetite were observed.

In the central workings, the quartz, albite,and microcline-perthite do not show such coarse crystallization. Some graphic granite occurs on the south side of the workings. Euxenite and magnetite are common.

In the east workings, beryl crystals are exposed in the feldspar on the south wall of the main pit, in the floor of this pit, and at the other places indicated on the sketch map. One beryl crystal from this pit was reported by the foreman to have measured 8 feet in length with a diameter of 18 inches. Radiating plates of columbite-tantalite occur in pink microcline-perthite along the south face of these cuts, adjacent to a zone of graphic granite pegmatite, which forms the outer or hanging-wall zone of the pegmatite in this section. On the north side of the east workings, graphic granite and "micro" pegmatite consisting of quartz, albite, and microcline in ½- to 2-inch crystals are exposed. Hornblende and magnetite are common in the east workings.

Mineralogy

The following minerals were found in this pegmatite; white and pink albite; pink microcline-perthite; rose, smoky, and white quartz; hornblende; biotite; muscovite; magnetite; columbite-tantalite; euxenite; beryl; fluorite; cyrtolite; molybdenite; specularite; pyrite; and calcite. (Hewitt 1953, p.45)

BERYL

Occurrences of beryl, in place, are confined to the east workings. Some beryl crystals up to 8 inches in diameter were seen, but most of the crystals now exposed are about 2 inches in diameter. An analysis of the opaque, asparagus-green beryl from this locality is given in a previous section. Beryl occurring in the "micro" pegmatite is anhedral and apparently interstitial to quartz and feldspar. (Hewitt 1953, p.45)

COLUMBITE

Plates of columbite up to 3 inches in diameter and ¼ inch in width occur in radiating clusters in pink microcline-perthite in the west, central, and east workings. Columbite sometimes occurs with magnetite. (Hewitt 1953, p.45)

EUXENITE

Dark-brown to black euxenite with a waxy resinous lustre occurs with magnetite in pink microcline-perthite. (Hewitt 1953, p.45)

BIOTITE, MUSCOVITE, HORNBLENDE

Hornblende and biotite occur in the more sodic zone of the central and east workings. Biotite is common in the "micro" pegmatite. Sericite occurs on slickensides slip faces of feldspar in the east workings. (Hewitt 1953, p.45)

FLUORITE

Fluorite occurs in the central workings, in vugs in potash and soda spar associated with euxenite and bladed columbite. (Hewitt 1953, p.45)

The principal minerals mined for lithium are spodumene, amblygonite, lepidolite, and petalite, all of which occur in pegmatites. At the present time spodumene is the most important lithium ore mineral. In U.S.A. at Searles Lake in California, lithium is recovered from brines carrying dilithium sodium phosphate.

The estimated lithium reserves of U.S.A. and Canada are given in Table 19.

Table 19 *Estimated and inferred lithium reserves of U.S.A. and Canada (Hale 1940, p.640)*

Locality	Principal Lithium Mineral	Millions of pounds of Equivalent Li_2CO_3
U.S.A.		
North and South Carolina	Spodumene	6,400
Black Hills, S. Dakota	Amblygonite	80
New England, Colorado, Arizona, New Mexico, and California	Amblygonite	10
Searles Lake, California	Brine	450
U.S. Total		6,940
CANADA		
Manitoba	Spodumene	1,000
Northwest Territories	Spodumene	284
Ontario	Spodumene	734
Quebec	Spodumene	1,150
Canadian Total		3,168
Grand Total		10,108

Principal Lithium Minerals

The composition, and content of lithium oxide, of the 4 principal lithium minerals is given in Table 20.

Table 20 *Principal lithium minerals and their composition*

Mineral	Composition	Percent Li_2O
Spodumene	$LiAlSi_2O_6$	4–8
Amblygonite	$LiAlFPO_4$	8–10
Lepidolite	$KLi_2AlSi_4O_{10}(OH)_2$*	2.5–7.5
Petalite	$LiAlSi_4O_{10}$	3–4.9

*Polylithionite end member of the lepidolite group.

SPODUMENE

Spodumene, the lithium pyroxene, occurs in prismatic crystals or platy masses. It has perfect prismatic cleavage and splintery fracture. Its hardness is 6.5 and specific gravity is 3.1 to 3.2. Its colour is white, pink, grey, greyish-green, or yellow. The theoretical lithia content of spodumene is 8 percent, but it readily alters to albite and muscovite and the lithia content rarely exceeds 7.5 percent. Where spodumene is highly altered the lithia content may fall below 1.0 percent. Spodumene is readily recognizable due to its crystal habit, cleavage, and red lithium flame test.

AMBLYGONITE

Amblygonite, a lithium aluminium fluophosphate, is triclinic and occurs in rough crystals and large columnar or compact cleavable masses. It has excellent (100) cleavage, and good prismatic cleavage. Its fracture is uneven and brittle; its hardness 5.5 to 6; and its specific gravity 3.0 to 3.1. It is white, creamy, yellowish, pink, green, blue, grey, or colourless. Amblygonite is variable in composition with Na substituting for Li and OH for F. It readily alters to clay minerals and may be mistaken for albite with which it often occurs. The theoretical lithia content is 10.1 percent, but commercial concentrates average 8 to 9 percent.

LEPIDOLITE

Lepidolite, the lithium mica, is a complex fluosilicate of potassium, lithium and aluminium. It usually occurs in fine-grained micaceous aggregates with perfect basal micaceous cleavage. Its hardness is 2.5 and its specific gravity is 2.8 to 2.9. It is commonly lilac in colour, but may be colourless, yellow, pink, or violet-grey. Its lilac colour is usually diagnostic. The lithium micas form a complex series including polylithionite (lithium-rich mica), protolithionite and zinnwaldite (iron-rich varieties) and taeniolite (magnesium-lithium mica). Although lithium-rich mica grades up to 7.5 percent lithia, commercial concentrates average 3 to 4 percent lithia.

PETALITE

Petalite, the lithium aluminium silicate, usually occurs in massive or foliated form. It has perfect basal cleavage, conchoidal fracture. It is brittle with a hardness of 6 to 6.5 and a specific gravity of 2.4 to 2.5. It is colourless, white, grey, or reddish- to

Table 21 *Ontario lithium-bearing pegmatites*

County or District	Township	Location	Name of Mine	Operators or Owners	Years of Operation	Reference	Descriptive Remarks
Cochrane	Lowther	Lot 7, Con. IV		A. Villeneuve, I. Topaloff	1939, 1955		Granite pegmatite with spodumene and lepidote.
	Steele	Lot 5, Con. V				Lumbers 1962, p. 30	Zoned granite pegmatite 825′ long, up to 100′ wide, carries 10-15% spodumene in crystals to 3′. Also columbite-tantalite.
Kenora	Brownridge	Mavis Lake		Milestone Mines Limited	drilled 1956	Kenora files	Granite pegmatite 700′ long, 15 to 60′ wide contains up to 20% spodumene.
		Mavis Lake		Lun Echo Gold Mines Ltd.	drilled 1957	Kenora files	Granite pegmatite traced 2100′, carries spodumene.
Fort Hope Area		Lily Pad Lakes		Campbell claims	drilled 1962	Kenora files	Spodumene granite pegmatite with minor amblygonite, lepidolite.
	Webb	2½ mi. E. of Gullwing L.		Kozowy-Leduchowski	drilled 1964	Kenora files	Spodumene granite pegmatite with minor pollucite.
Kenora-Patricia		Root Lake Area		Consolidated Morrison Explorations Ltd.	drilled 1955	Kenora files	Spodumene granite pegmatites.
		Root Lake Area	McCombe	Capital Lithium Mines Ltd.	drilled 1955	Kenora files	One inch spodumene crystals in granite pegmatite, 35′ wide, 1200′ long.
Rainy River		Lac La Croix		Lexindin Gold Mines Ltd.			Spodumene in granite pegmatite.
		Lac La Croix	Wheeler	International Lithium Mining Corp.	drilled 1955	Port Arthur files	1,100,000 tons of spodumene ore outlined to 1100′ depth running 1.3% Li_2O.
	Quetico Park	Lac La Croix	Hanberg		1955	Port Arthur files	Spodumene in granite pegmatite.
		Twin Falls	Twin Falls			Port Arthur files	Spodumene in granite pegmatite.
		Maligne River	R. C. Wager			Port Arthur files	20-25% spodumene in granite pegmatite sill.
Thunder Bay		Crescent Lake Area	North Aubry	Anaconda Co. (Canada) Ltd.	drilled 1957	Pye, pers. comm.	Spodumene granite pegmatite with beryl; spodumene up to 24 inches in size; grade 1.5% Li_2O.
		Crescent Lake Area	South Aubry	Anaconda Co. (Canada) Ltd.	drilled 1957	Pye, pers. comm.	Spodumene granite pegmatite; some altered spodumene; grade ½ to 1% Li_2O.
		Crescent Lake Area	Chappais Lake	Dempster Explorations Ltd.	1959	Pye, pers. comm.	Spodumene to 8 inches in granite pegmatite.
		Crescent Lake Area	Despard Li Deposit	Sogemines Ltd., Ventures Ltd.	1958, drilled 1959	Pye, pers. comm.	Spodumene granite pegmatite; lithia content 1.3% at west end, spodumene altered at east end.
		Crescent Lake Area	Seymour Lake			Pye, pers. comm.	Spodumene granite pegmatite with low lithia content.
		Crescent Lake Area	Falcon Lake	British Canadian Lithium Mines	drilled 1956	Pye, pers. comm.	4 groups of spodumene granite pegmatites with 15-20% spodumene.
		Crescent Lake Area	Zigzag Lake	Dempster Explorations Ltd.		Pye, pers. comm.	5 groups of spodumene granite pegmatites with minor beryl.
		Georgia Lake Area	Aumacho River	Aumacho River Mines Ltd.	drilled 1955, 1956	Pye 1965, p. 62	Spodumene granite pegmatites with up to 25% spodumene; 759,475 tons of pegmatite averaging 1.65% Li_2O outlined in 1 deposit. Spodumene crystals up to 42 inches in size. Minor amblygonite.
		Georgia Lake Area	Camp	Jean Lake Lithium Mines Ltd.	1955, 1956	Pye, 1965, p. 65	A small spodumene granite pegmatite carrying 25 to 30% spodumene.
		Georgia Lake Area	Caral	Caral Mining Co. Ltd.	drilled 1956	Pye 1965, p. 65	Spodumene in ½ to 1 inch crystals in granite pegmatite; grade low.
		Georgia Lake Area	Carrot Lake	Ontario Lithium Co. Ltd.		Pye 1965, p. 66	Flat erosional remnant of pegmatite with 20% spodumene to 18 inches size.
		Georgia Lake Area	E. S. Conway	Leitch Gold Mines Ltd.	drilled 1957, 1958	Pye 1965, p. 66	4 spodumene granite pegmatites; 1,830,000 tons of pegmatite averaging 0.96% Li_2O outlined in Conway dike.
		Georgia Lake Area	Dunning			Pye 1965, p. 69	2 small spodumene granite pegmatites 4 to 5 feet wide.
		Georgia Lake Area	Foster	Towagmac Exploration Co.	drilled 1956	Pye 1965, p. 69	10-15% fine to medium grained spodumene in granite pegmatite.
		Georgia Lake Area	Georgia	Georgia Lake Lithium Mines	drilled 1956	Pye 1965, p. 70	Glacial erratics only.
		Georgia Lake Area	Giles	Towagmac Exploration Co. Ltd.	drilled 1956	Pye 1965, p. 71	Spodumene crystals to 6 inches in granite pegmatite.
		Georgia Lake Area	Harricana	New Highridge Mining Co., New Harricana Mines Ltd., Nama Creek Mines Ltd.	drilled 1955	Pye 1965, p. 72	Severe alteration of spodumene results in grades of less than 0.5% Li_2O. Dike traced for 1600 feet.
		Georgia Lake Area	Jean Lake	Jean Lake Lithium Mines Ltd.	drilled 1955, 1956	Pye 1965, p. 73	5 spodumene granite pegmatite deposits; Parole Lake or No. 4 deposit reported to contain 1,689,000 tons of 1.3% Li_2O to 1100′ depth.
	Kilkenny	Georgia Lake Area	Kenogamisis	Kenogamisis Gold Mines Ltd.	drilled 1955	Pye 1965, p. 77	Spodumene granite pegmatite 13′ wide, 650′ long.
		Georgia Lake Area	Lew	Towagmac Exploration Co. Ltd.		Pye 1965, p. 78	8-10′ spodumene granite pegmatite traced on surface for 108′.
		Georgia Lake Area	Line 60	Nana Creek Mines, New Highridge	drilled 1955	Pye 1965, p. 79	Spodumene granite pegmatite with low lithia content due to alteration.
		Georgia Lake Area	Pine Portage	Lun-Echo Gold Mines Ltd.	drilled 1955	Pye 1965, p. 80	6 spodumene granite dikes tested; some columbite present; Spodumene altered by underlying diabase at shallow depths.
		Georgia Lake Area	MNW deposit	Consolidated Mining & Smelting Co.	drilled 1956	Pye 1965, p. 84	Granite pegmatite carries spodumene, minor beryl, amblygonite, columbite, cassiterite.
		Georgia Lake Area	McVittie	Noranda, Anglo-Huronian, Mining Corp.	drilled 1956	Pye 1965, p. 87	Spodumene granite pegmatite, some sections average 1.03% Li_2O.
	Kilkenny	Georgia Lake Area	Nama Creek	Nama Creek Mines Ltd.	drilled 1955, 1956	Pye 1965, p. 90	Drilling on North and South zones indicated 4,292,332 tons of 1.06% Li_2O to 1000′ depth. Shaft sunk to 503′ in 1956, 1957.
Thunder Bay		Georgia Lake Area	Newkirk	Newkirk Mining Corp. Ltd.	drilled 1955	Pye 1965, p. 96	Low grade spodumene granite pegmatite.
		Georgia Lake Area	Niemi	Lun-Echo Gold Mines Ltd.	drilled 1955	Pye 1965, p. 97	Spodumene granite pegmatite traced for 420′.
		Georgia Lake Area	Ontario Lithium	Ontario Lithium Company Ltd.	drilled 1955	Pye 1965, p. 97	Drilling outlined 2,000,000 tons of ore grading 1.09% Li_2O in the Jackpot deposit; 3 other deposits also drilled.
		Georgia Lake Area	Trans	Goldale Mines Ltd.	1956	Pye 1965, p. 103	Spodumene granite pegmatite 500′ long, 7′ wide.
		Georgia Lake Area	Vegan	Vegan Lithium Mines Ltd.	drilled 1955-56	Pye 1965, p. 104	750,000 tons of 1.38% Li_2O ore outlined in one deposit.
		Georgia Lake Area	West	New Highridge, New Harricana, Nama Creek Mines Ltd.	drilled 1955	Pye 1965, p. 105	Spodumene granite pegmatite; spodumene to 4 inches; much alteration.
		Trapnarrows L. Area	Koshman		drilled 1957		Spodumene granite pegmatite.
		Trapnarrows L. Area	Stancan	Stancan Lithium Corp.	drilled 1955		Spodumene granite pegmatite of low grade.

greenish-white. It may sometimes be mistaken for quartz but gives the lithium flame test. Its maximum lithia content is 4.9 with commercial concentrates averaging 3.5 to 4.5 percent lithia.

Uses

The manufacture of lubricating greases, which employ lithium hydroxide monohydrate, is one of the largest uses of lithium. Lithium greases have the ability to resist water and perform satisfactorily over wide temperature ranges, from minus-60°F to plus-320°F.

Another principal consumer of lithium is the ceramics industry. Lithium carbonate is used in porcelain enamels, glass, refractories, and glazes. For use as a flux in ceramic materials, the lithia is added as spodumene, lepidolite and petalite concentrates. Lithia lowers the maturing temperatures and increases the fluidity and gloss of glasses, glazes, and enamels (Reeves 1965, p.358).

Lithium chloride and lithium bromide are extremely hygroscopic and are used in air conditioning. Lithium bromide is used in absorption refrigeration systems that have water as the refrigerant and employ bromide solutions as the absorbent. Lithium chloride is used primarily to dehumidify rather than cool the air in air conditioning systems (Hale 1962, p.307).

In metallurgy lithium metal is used as a scavenger and degasser. It has an affinity for oxygen, nitrogen, and sulphur. Lithium finds minor use as an alloying metal with aluminium and magnesium. Lithium is also used in brazing alloys. Due to their reducing action lithium chloride and fluoride are added to welding and brazing fluxes (Hale 1962, p.307).

Lithium hydroxide monohydrate is added to the electrolyte in nickel-iron alkaline storage batteries to increase their life and output. A newly developing use for lithium compounds is as an additive to the electrolyte in the Hall cell of aluminium smelters. The strong fluxing action of lithia would reduce power requirements (Reeves 1965, p.359).

Lithium is also used in the production of synthetic rubber, in the synthesis of antihistamines and vitamins, and by the Atomic Energy Commission for unstated use. The U.S.A. Atomic Energy Commission was a large buyer of lithium compounds during the late 1950s. This demand for millions of pounds of lithium hydroxide over a short period led to a large expansion of lithium production and then to a subsequent depression of the industry.

Prices

Prices of the principal lithium chemicals quoted from Oil, Paint and Drug Reporter for 28 December 1964 were as follows, per pound:

Lithium carbonate	$0.58
Lithium hydroxide monohydrate	$0.54
Lithium chloride	$1.23½
Lithium fluoride	$1.55
Lithium stearate	$0.47½
Lithium hydride	$9.50

Canadian Production and Milling

Quebec Lithium Corporation in Lacorne township, Quebec, is the sole Canadian lithium producer. It is a wholly integrated operation mining spodumene-bearing pegmatite dikes, producing spodumene concentrates by flotation, and producing lithium chemicals. The company's chemical plant is reported to have a capacity of three million pounds of lithium carbonate and one and a half million pounds of lithium hydroxide monohydrate per year. The mill began operations in November 1955.

Ontario Deposits

Because of the increased demand for lithium in the late 1950s, a concentrated search for spodumene deposits in north-western Ontario was carried on from about 1955 to 1958. Forty-six lithium-bearing pegmatites, mainly found during this prospecting rush, are listed in Table 21. The two principal areas of spodumene pegmatites are at Crescent Lake and Georgia Lake in the district of Thunder Bay. These deposits have been thoroughly described by Pye (1965; and personal communication) and the following descriptive matter is largely abstracted from Pye's reports.

GEORGIA LAKE AREA

The Georgia Lake spodumene pegmatites were discovered in 1955 and 1956 following the discovery of a spodumene granite pegmatite reef in Georgia Lake by E. W. Hadley. Over 50 occurrences of spodumene pegmatite were discovered in the Georgia Lake area and 24 properties are listed in the accompanying table. Work on the deposits was confined mainly to surface trenching and diamond-drilling, but a 503-foot shaft was sunk on the property of Nama Creek Mines Limited. Based on exploration work to date, reserves of 11,700,000 tons of spodumene ore grading 1.14 percent lithia have been outlined on nine properties as detailed in Table 22 (Pye 1965, p.26).

Table 22 | *Estimated reserves of lithium pegmatites, Georgia Lake Area of Ontario*

Company or Owner	Deposit	Estimated Reserves	Average Lithia Content
Aumacho River Mines Ltd.	No. 1 (Brink)	759,475	1.65
	No. 3	96,000	1.50
E. S. Conway	Conway	1,830,000	0.96
Jean Lake Lithium Mines Ltd.	No. 4 (Parole)	1,689,000	1.30
Open for staking	McVittie	261,000	1.03
Nama Creek Mines Ltd.	North Zone	2,784,000	1.11
	South Zone	1,508,332	0.96
Ontario Lithium Co. Ltd.	Jackpot	2,000,000	1.09
Vegan Lithium Mines Ltd.	No. 2 (Newkirk)	750,000	1.38
Total		11,677,807	
Average Grade			1.14

Spodumene Pegmatites

The Georgia Lake pegmatites range in width from a few inches to 50 feet and in length from a few feet to 2,900 feet in the case of the Newkirk dike whose width averages 25 feet. The pegmatites pinch and swell in size and terminate by wedging out rapidly, gradually tapering, or breaking into branches. In attitude the dikes vary from steeply dipping to gently dipping. The steeply dipping pegmatites are frequently sill-like and lie parallel to the foliation of the paragneiss country rocks. Most of the dikes are in paragneiss country rock near the granite intrusion, which was apparently their source. The spodumene dikes seem to be concentrated off the ends of prominent westward- and upward-projecting tongues and satellitic bodies of the main granite mass.

Mineralogy

The common minerals in the spodumene granite pegmatities of Georgia Lake, in order of abundance, are: white microcline perthite, white albite, quartz, spodumene, and muscovite. Accessory minerals sometimes present are apatite, beryl, bityite, cassiterite, cleavelandite, columbite, garnet, hühnerkobelite, molybdenite, purpurite, sericite, talc, and tourmaline. Lepidolite was reported from the Vegan deposit in minor amounts and a little amblygonite is present in the M.N.W. and Brink pegmatites. Lithium minerals other than spodumene are rare.

In many cases the spodumene is altered to muscovite or sericite, resulting in a much reduced lithia content. This alteration is more widespread in the proximity of diabase dikes and appears to be due to hydrothermal solutions from these dikes. Some alteration is due to late hydrothermal solutions associated with the pegmatite emplacement itself. The largest spodumene crystals at Georgia Lake measure about 5 feet long. The colour of the spodumene is chalk-white, grey, or greenish-white.

Internal Features of the Pegmatites

Zoning

The Georgia Lake spodumene granite pegmatites generally have a thin well-defined border zone ¼ to ½ inch thick. Apart from this they generally exhibit no zoning. There is only one well-zoned spodumene pegmatite in the Georgia Lake area: the M.N.W. pegmatite. This pegmatite has a well-defined spodumene and quartz core; an inner intermediate zone of quartz, muscovite and feldspar; outer intermediate zones of cleavelandite, quartz, muscovite, beryl, and tourmaline; and wall zones of feldspar, quartz, muscovite, and tourmaline.

Orientation of Spodumene and Microcline Crystals

In many of the Georgia Lake pegmatite dikes, the crystals of microcline perthite and spodumene are oriented with their long axes normal to the pegmatite contacts.

Aplites

Thin veins of aplite frequently cut the spodumene granite pegmatites. They are similar in composition to the pegmatites, but of fine-grain size. Pye (1965, p.42) believes most of the aplites to be of replacement origin. Irregular-shaped aplite patches are also sometimes present.

Quartz Veins

The spodumene granite pegmatites of the northern part of the Georgia Lake area are cut by narrow quartz and quartz-muscovite veins. They are commonly found in transverse or oblique post-aplite fractures, and seldom exceed 12 inches in thickness.

Regional Zoning

Pye (1965, p.46, 47) notes that there is a regional zoning of the pegmatites of the Georgia Lake area. Within and close to the main mass of granitic rocks, there are numerous mica-quartz-feldspar pegmatites without spodumene and beryl. Within the metasediments and sometimes in the granitic sills and stocks the pegmatites contain spodumene and sometimes beryl. The lithium pegmatites themselves can be divided into three geographic groups with distinctive characteristics.

Origin of the Pegmatites

Pye (1965, p.49–54) gives evidence indicating that the spodumene granite pegmatites are fluid-emplaced and of magmatic origin, and postulates that they are associated in age and origin with the granitic rocks of the area.

CRESCENT LAKE AREA[1]

The spodumene granite pegmatites of the Crescent Lake area, District of Thunder Bay, were mainly discovered in 1956 and 1957, and considerable drilling was carried out. About 20 pegmatites carrying spodumene and some beryl were located and exploration was carried out on seven properties. The pegmatite dikes are for the most part lenticular or tabular-shaped and consist of microcline perthite, albite, quartz, spodumene, and muscovite, with minor apatite, garnet, and tourmaline. Spodumene content is up to 30 percent and muscovite content from 5 to 10 percent.

The Despard deposit is the only zoned pegmatite, with fine-grained wall zones and a central spodumene-rich zone. Spodumene and microcline crystals show an orientation with their long axes normal to the dike walls. Aplites are present in the pegmatites. Spodumene shows alteration to sericite in places. Regional zoning is not evident. The pegmatites appear to have a magmatic origin and were apparently emplaced in a magmatic state as fissure-filling deposits.

[1]Personal communication with E. G. Pye, Geologist, Ontario Department of Mines, 1965.

During the uranium rush of 1950 to 1958 a large number of uranium-bearing pegmatites were discovered in Ontario, mainly in the Grenville province of southeastern Ontario. Table 24 lists 105 uranium-bearing pegmatites that were discovered and explored in Ontario. There was production from 4 of these properties which amounted to $105,503,124. The principal producers were Bicroft mine and Faraday mine, both at Bancroft. Large reserves of uranium exist in the Bancroft area and await favourable market conditions for development.

Uranium was produced in the Bancroft area, from 1956 to 1964, as follows:

Faraday Uranium Mines Limited	$51,726,126
Bicroft Uranium Mines Limited	44,149,778
Canadian Dyno Mines Limited	8,792,331
Greyhawk Uranium Mines Limited	834,889

Mineralogy

The principal uranium minerals of the pegmatites are uraninite, uranothorite, and uranophane. Thorianite and thorite are also present. Other uranium-bearing minerals are pyrochlore-microlite, betafite, fergusonite-formanite, euxenite-polycrase and allanite.

URANINITE-THORIANITE

Uraninite (UO_2) and thorianite (ThO_2) form a complete solid solution series, with the division between uraninite and thorianite being U:Th = 1:1. Uraninite and thorianite crystallize in the isometric system and occur in steel-grey to black cubes and octahedrons. Lustre is submetallic; hardness is 5 to 6 and specific gravity 8 to 10.5. Uraninite is distinguished from magnetite by its lack of magnetism and by its radioactivity.

Table 23 is from Satterly (1957, p.16) and gives uraninite analyses from granite and syenite pegmatites of the Bancroft area (after Robinson and Sabina).

Thorite $ThO_2 . SiO_2$

Thorite is tetragonal and occurs in square prismatic crystals similar to those of zircon. In colour it is black, brown or yellow, with a vitreous to glassy lustre. Hardness is 4.5 to 5, and specific gravity is 4.1 to 6.4. It is difficult to identify in hand specimen and may be confused with zircon and uranothorite. Assured identification requires x-ray and chemical work. In the Bancroft area thorite has been identified in some leucogranite pegmatites and skarns.

Thorite has been identified at the Kemp property, the Saranac property, Silver Crater Crystal Lake property and Faraday mine (Satterly 1957, p.17).

Uranothorite $(Th,U)O_2 . SiO_2$

Uranothorite is one of the most common uranium minerals in the Bancroft area. It occurs in small tetragonal crystals or irregular masses having a vitreous to glassy lustre, conchoidal fracture, and yellow, orange, brown, or black colour. Uranothorite is common in the pegmatite dikes of the Bancroft region and forms an important ore mineral. Analyses of uranothorites given by Satterly (1957, p.18) after Robinson and Abbey, indicate a wide range of uranium and thorium contents. The average specific gravity is 4.3.

Uranophane $CaO . 2UO_3 . 2SiO_2 . 6H_2O$

Uranophane is the most common yellow secondary alteration product of the primary uranium

Table 23 *Uraninite and thorianite from Ontario (Satterly 1957, p.16)*

Group 1—Uraninites containing 10 percent ThO_2 or less; granitic and syenitic bodies with accessory titanite, zircon, apatite, and fluorite.

Sample No.	Location (township, concession and lot)	Property	U:Th	Composition		
				U_3O_8 percent	ThO_2 percent	PbO percent
1	Cardiff; XX; 7		9.2	73.0	7.7	10.75
2	Faraday; XI; 16, 17	Faraday Uranium Mines, Ltd.	8.8	70.0	7.7	13.7
4	Cardiff; XI, XII; 27, 28	Bicroft Uranium Mines, Ltd.	8.1	65.0	7.7	11.9
5	Cardiff; XV; 6	Halo Uranium Mines, Ltd.	7.59	66.7	8.5	11.4
6	Cardiff; XI, XII; 27, 28	Bicroft Uranium Mines, Ltd.	6.79	64.5	9.2	11.9
7	Cardiff; XXI; 9	Montgomery property	6.43	66.7	10.0	8.4

Table 24 Ontario uranium-bearing pegmatites

County or District	Township	Location	Name of Mine	Operators	Years of Operation	Approximate Production	Reference	Descriptive Remarks
Carleton	March	Lot 6, Con. II		M. J. O'Brien			Lang et al 1962, p. 268	Uraninite in granite pegmatite.
Frontenac	Palmerston	Lot 9, Con. III		J. Eastman			Lang et al 1962, p. 275	Uraninite in pegmatite.
		Lots 2 & 3, Con. V		J. Eastman			Lang et al 1962, p. 275	Uraninite in pegmatite.
Haliburton	Cardiff	Lot 9, Con. I, II	Triton	Triton Uranium Mines Ltd.	1955		Satterly 1956, p. 75	Allanite and uranothorite in leucogranite pegmatite.
		Lot 10, Con. II	R. Doubt	R. Doubt	1955-56		Satterly 1956, p. 53	Allanite and uranothorite in granitic dikes.
		Lots 10, 11, Con. V	Milhol	Milhol Exploration & Dev. Ltd.	1953-55		Satterly 1956, p. 67	Allanite and uranothorite in leucogranite pegmatite.
		S½ Lot 6, Con. VI		Consol. Thor Mines Ltd.	1954-56		Satterly 1956, p. 50	Allanite and uranothorite in granitic pegmatite.
		Lot 9, Con. VII	J. Gilbert	J. Gilbert	1955-56		Satterly 1956, p. 58	Uranothorite in granite pegmatite.
		Lot 12, Con. VIII	Dyno	Canadian Dyno Mines Ltd.	1954-60	$8,792,331	Satterly 1956, p. 43	Pegmatitic granite dikes with uraninite, uranothorite, allanite, cyrtolite, hatchettolite.
		Lot 22, Con. IX		Aumacho River Mines Ltd.	1954-55		Satterly 1956, p. 28	Allanite, uraninite, uranothorite, in pyroxene granite pegmatite.
		Lot 27, Con. X		Fab Metal Mines Ltd.	1953-54		Satterly 1956, p. 56	Uraninite in granite pegmatite.
		N½ Lot 11, Con. XI		Molybdenum Corp. of America	1953-55		Satterly 1956, p. 68	Uranothorite and allanite in leucogranite pegmatite.
		Lots 11-13, Con. X	Tomlinson	Pickering Metal Mines Ltd.	1955		Satterly 1956, p. 74	Uranothorite, allanite in leucogranite pegmatite.
		S½ Lot 11, con. XI		Climax Molybdenum Co.	1955		Satterly 1956, p. 50	Uranothorite, allanite in leucogranite pegmatite.
		Lots 27-28, Con. XI	Bicroft	Bicroft Uranium Mines Ltd.	1953-63	$44,149,778	Satterly 1956, p. 30	Uraninite, uranothorite, allanite, pyrochlore, betafite in complex pegmatitic granite dikes.
		Lots 7-11, Con. XII		Canada Radium Corp. Ltd.	1932-36, 1940-42		Satterly 1956, p. 41	Uraninite, uranothorite, ellsworthite in leucogranite pegmatite.
		Lot 9, Con. XIII		West Lake Mining Co. Ltd.	1955		Satterly 1956, p. 76	Uranothorite in pyroxene granite pegmatite.
		Lot 31, Con. XIII		Cons. Tungsten Mining Corp. of Can.	1954-55		Satterly 1956, p. 52	Uraninite, uranothorite in hornblende granite and syenite pegmatite.
		Lots 6, 7, Con. XIV	Kenmac	Kenmac Chibougamau Mines Ltd.	1955		Satterly 1956, p. 64	Uranothorite, allanite in granite pegmatite.
		S½ Lot 11, Con. XIV		Mindus Corp. Ltd.	1953-56		Satterly 1956, p. 67	Uraninite, uranothorite, allanite, ellsworthite in pegmatite
		Lots 6, 7, Con. XV	Halo	Amalgamated Rare Earth Min. Co.	1953-56		Satterly 1956, p. 62	Uraninite, uranothorite, betafite in granitic dikes.
		S½ Lot 20, Con. XV		D. E. Foster	1956		Satterly 1956, p. 58	Uranothorite, zircon, allanite in granitic pegmatite dikes.
		Lot 32, Con. XV	Croft	Bicroft Uranium Mines Ltd.	1953-55		Satterly 1956, p. 37	Monazite, allanite, cyrtolite, uraninite, uranothorite in pegmatite.
		Lot 7, Con. XX		Burma Shore Uranium Mines Ltd.	1955		Satterly 1956, p. 40	Uraninite, uranothorite in pyroxene syenite pegmatite.
		Lots 4-6, Con. XXI	Richardson	Fission Mines Ltd.	1929-32, 1946-48, 1955		Satterly 1956, p. 56	Uraninite, uranothorite, allanite, zircon in pyroxene syenite pegmatite.
		Lot 8, Con. XXI	Tripp	Nu-Age Uranium Mines Ltd.	1954-56		Satterly 1956, p. 69	Uraninite, uranothorite in pegmatite.
		Lot 5, Con. XXII		Bancroft Uranium Mines Ltd.	1955-56		Satterly 1956, p. 29	Allanite, uranothorite in pyroxene syenite pegmatite.
	Glamorgan	S½ Lot 19, Con. II		Nu-World Uranium Mines Ltd.	1955		Satterly 1956, p. 80	Uraninite, allanite, uranothorite, cyrtolite in granitic pegmatite.
		Lots 26-28, Con. II		Nu-Cycle Uranium Mines Ltd.	1955		Satterly 1956, p. 78	Uranothorite, allanite, zircon in granitic pegmatite.
	Harcourt	N½ Lot 6, Con. IV		P. J. McLean			Satterly, pers. comm.	Uranothorite in red leucogranite dikes.
	Lutterworth	Lot 11, con. VIII		E. T. Hogan			Lang et al 1962, p. 266	Allanite, thorite, uranothorite in pegmatite.
	Monmouth	Lot 4, Con. III		Fairley Red Lake Gold Mines Ltd.	1955-56		Satterly 1956, p. 88	Allanite, uranothorite in pegmatitic leucogranite.
		Lots 3-5, Con. III; Lots 2-4, Con. IV		Cassiar Rainbow Gold Mines			Lang et al 1962, p. 270	Euxenite, allanite, uranothorite in granitic dikes.
		Lot 14, Con. IV		Jesko Uranium Mines Ltd.	1954		Satterly 1956, p. 89	Uranothorite, allanite in granitic pegmatite dikes.
		Lot 19, Con. VI	Blue Rock Cerium	Amal. Rare Earth Mining Corp.	1954-56		Satterly 1956, p. 96	Fergusonite, allanite, uraninite, uranothorite in granitic dikes.
		Lot 32, Con. VI		Silanco Mining & Refining Co.	1955		Satterly 1956, p. 104	Uranothorite in syenite pegmatite.
		Lot 20, Con. VIII	Rare Earth	Amal. Rare Earth Mining Corp.	1948-56		Satterly 1956, p. 92	Fergusonite, cyrtolite, uraninite, uranothorite in granitic dikes.
		S½ Lot 24, Con. X	Saranac	Saranac Uranium Mines Ltd.	1954-56		Satterly 1956, p. 102	Zircon, thorite, allanite, uranothorite in granitic sill.
		Lot 35, Con. XI		Empire Oil & Minerals Inc.	1954-55		Satterly 1956, p. 54	Uraninite, uranothorite, allanite, zircon in leucogranite pegmatite.
	Snowdon	Lot 11, Con. II		C. Giles			Lang et al 1962, p. 278	Uraninite, thorite in granitic pegmatite.
Hastings	Carlow	Lots 2-4, Con. V; Lot 2, Con. IV		Mentor Exp. & Dev. Co.			Lang et al 1962, p. 255	Allanite, uranothorite in granitic dikes.
		S½ Lot 17, Con. XII		H. Sundstrom	1957		Satterly, pers. comm.	Uranothorite in pyroxene granite and pegmatite.
	Dungannon	Lots 69-71 Hast. Rd. E.	Mountain zone	Eagle Nest Mines	1957		Satterly, pers. comm.	Uraninite and uranothorite in red leucogranite.
		Lot 69, Hast. Rd. W.	Mountain zone	Eagle Nest Mines	1957		Satterly, pers. comm.	Uraninite and uranothorite in red leucogranite.
		Lot 18, Con. XI		Gordon Card	1957		Satterly, pers. comm.	Uranothorite in leucogranite pegmatite.
		Lot 29, Con. XVI	Field zone	Eagle Nest Mines	1957		Satterly pers. comm.	Uranothorite in leucogranite.
	Faraday	Lots 21-24, Con. A		Bonville Gold Mines Ltd.	1954		Satterly 1956, p. 107	Ellsworthite, uranothorite in granitic pegmatite dikes.
		Lot 28, Con. B	Kerr	Silver Crater Mines Ltd.			Lang et al 1962, p. 260	Allanite, uranothorite in granitic dikes.
		Lots 16-18, Con. XI	Faraday	Faraday Uranium Mines Ltd.	1952-64	$51,726,126	Satterly 1956, p. 108	Allanite, uraninite, uranothorite, cyrtolite, uranophane in pegmatitic granite dikes.
		Lots 9-11, Con. XII	Greyhawk	Greyhawk Uranium Mines Ltd.	1953-58	$834,889	Satterly 1956, p. 117	Pyrochlore, uraninite, uranothorite, zircon, allanite in granite pegmatite.
		S½ Lot 6, Con. XV		York River Uranium Mines Ltd.	1957		Satterly, pers. comm.	Uranothorite in pyroxene granite pegmatite.
		Lots 27-29 Con. XV	Baumhour	Silver Crater Mines Ltd.	1954-56		Satterly 1956, p. 132	Uranothorite, allanite in syenite and granite pegmatites.
		Lots 31-32, Con. XVI	Reasor	Gerald L. Reasor	1954-55		Satterly 1956, p. 122	Pyrochlore, uraninite, uranothorite in pyroxene syenite pegmatite.
	Herschel	Lot 26, Con. V	Baptiste L.	Standard Ore & Alloys Corp.	1955		Satterly 1956, p. 135	Uranothorite in granite pegmatite.
		Lot 39, Con. VIII		Peter Rock Mining Co.	1955		Satterly 1956, p. 135	Pyrochlore, euxenite, uranothorite, allanite in granite pegmatite.

	Monteagle	S½ lot 5, Con. I		Carr, Quirk, Mellish	1955	Satterly 1956, p. 136	Allanite, uranothorite, zircon in granite pegmatite.
		Lot 3, Con. III	Goddard L.	B. C. Robson	1955	Satterly 1956, p. 141	Uraninite in syenite pegmatite.
		Lots 2-3, Con. V		Carr, Quirk, Robson	1955	Satterly 1956, p. 136	Allanite, uranothorite in granitic gneiss.
		Lots 7-8, Con. III		S. J. Carr		Hewitt 1954, p. 69	Allanite, uranothorite in granite pegmatite.
		Lots 11-12, Con. IV		J. Quirk	1955	Satterly 1956, p. 140	Ellsworthite, uranothorite, thorite in granite pegmatite.
		Lot 4, Con. VII		Mrs. W. M. Thompson	1954	Satterly 1956, p. 142	Uranothorite in granite pegmatite.
		Lots 18-19, Con. VII	MacDonald	Verona Mining Co., Genesee Feldspar Corp.	1919-35	Satterly 1956, p. 138	Ellsworthite, cyrtolite, allanite, uraninite, uranothorite in zoned granite pegmatite dike.
		S½ Lot 29, Con. VIII		Peter Rock Mining Co. Ltd.	1955	Satterly 1956, p. 140	Allanite, uranothorite in granitic pegmatite.
Kenora		Vermilion Lake	Cameron	M. Y. Cameron of Kenora		Lang et al 1962, p. 251	Granitic dike with monazite, uraninite, molybdenite.
	MacNicol	Richard Lake		Campbell Is. Mines & Exp. Ltd.		Lang et al 1962, p. 267	Allanite, uraninite, uranothorite in granitic rock.
Lanark	S. Sherbrooke	N½ Lot 18, con. III		Christie Lake Mines Ltd.		Lang et al 1962, p. 278	Brannerite, uraninite, thorite in granitic pegmatite.
Nipissing	Butt	Lot 13, Con. VII		Wm. Elliot	1919	Ellsworth 1932, p. 187	Uraninite, allanite in granite pegmatite.
	Mattawan	Lots 6-7, Con. II	Purdy	Purdy Mica Mines Ltd.		Lang et al 1962, p. 268	Uraninite in granite pegmatite.
Parry Sound	Conger	Lots 9-10, Con. IX	McQuire	McQuire & Robinson	1925	Lang et al 1962, p. 256	Uraninite, calciosamarskite, thucolite, cyrtolite, allanite in granite pegmatite.
	Henvey	Lot 5, Con. B	Besner	Wanup Feldspar Mines Ltd.	1926-29	Lang et al 1962, p. 248	Uraninite, cyrtolite, thucolite, allanite in granite pegmatite.
	McDougall	Lot 12, Con. A		Ascot Metals Corp.	1954		Uraninite in granite pegmatite.
		Lot 15, Con. A		Ascot Metals Corp.	1954		Uraninite in granite pegmatite.
		Lot 27, Con. IX		J. A. Fenn		Lang et al 1962, p. 269	Uraninite in pegmatite.
		Off Sandy Island		T. W. Keating	1956		Uraninite, allanite, thucolite in granite pegmatite.
Peterborough	Anstruther	Lots 17-18, Con. I		Zenmac Metal Mines Ltd.	1955	Satterly 1956, p. 154	Uranothorite in granite pegmatite.
		Lots 26-27, Con. I				Lang et al 1962, p. 247	Uraninite, allanite, uranothorite, zircon in granitic dikes.
		Lots 22-28, Con. III; S½ Lots 23-27, Con. IV		Farcroft Mines Ltd.	1954-55	Satterly 1956;p. 148	Uraninite, allanite, uranothorite in leucogranite pegmatite.
		N½ Lots 26-27, Con. IV		Brunsman Mines Ltd.	1954-55	Satterly 1956, p. 146	Uranothorite in granite pegmatite.
		Lots 2-3, Con. IX	Stony Creek	Gray Wolf Exploration Co. Ltd.	1955-56	Satterly 1956, p. 151	Allanite, zircon, uranothorite in leucogranite pegmatite.
		Lot 2, Con. X		Higgins Uranium Mines Co. Ltd.	1955	Satterly 1956, p. 152	Uranothorite in granite pegmatite.
		Lots 32-33, Con. XVII		A. L. Kemp	1957	Satterly, pers. comm.	Uranothorite in granite and syenite pegmatite.
		Lots 5-6, Con. XVIII		Garland Mining & Dev. Co.	1955	Satterly 1956, p. 150	Uraninite, allanite, uranothorite, cyrtolite in granite pegmatite.
	Burleigh	Lot 25, Con. XII		Pole Star Mines Ltd.	1954	Satterly 1956, p. 158	Uraninite, uranothorite in granite pegmatite.
	Cavendish	Lot 3, Con. III	Windover	Silanco Mining & Refining Co.	1955	Satterly 1956, p. 167	Fergusonite, zircon, uranothorite in granite pegmatite.
		N½ Lot 16, Con. III	Buckhorn Rd.	Drude Uranium Mines Ltd.	1955	Satterly 1956, p. 164	Allanite, uranothorite in granite pegmatite.
		S½ Lots 5, 7, Con. IV		Macfie Explorations Ltd.	1955-56	Satterly 1956, p. 166	Allanite, uranothorite in leucogranite pegmatite.
		Lot 14, Con. V; Lot 13, Con. VI		Cromwell Uranium & Dev. Co.	1955	Satterly 1956, p. 162	Uranothorite in pegmatitic leucogranite.
		S½ Lot 14, Con. VII	Cavendish	Amalgamated Rare Earth Mining Co.	1954-57	Satterly 1956, p. 159	Uraninite, uranothorite, thorite, allanite, cyrtolite in granitic pegmatite.
		Lot 15, Con. IX		D. J. Smith		Lang et al 1962, p. 255	Uranothorite in granite pegmatite.
		S½ Lot 16, con. IX	Higgins L.	Drude Uranium Mines Ltd.	1955	Satterly 1956, p. 162	Allanite, zircon, uranothorite in granitic pegmatite.
		S½ Lot 14, Con. XI	Picard Lake	Drude Uranium Mines Ltd.	1955	Satterly 1956, p. 163	Allanite, uranothorite in granitic rock.
		N½ Lot 21, Con. XI	Pencil Ck.	Silanco Mining & Refining Co.	1955	Satterly 1956, p. 167	Allanite, zircon, uraninite in granitic pegmatite.
		Lots 24-25, Con. XIV		Kelbee Rare Metals Corp. Ltd.	1955-56	Satterly 1956, p. 165	Uraninite, uranothorite, allanite, zircon in granite pegmatite.
	Chandos	S½ Lot 9, con. XVI		Cons. Uranium Corp. Ltd.	1954	Satterly 1956, p. 170	Allanite, uranothorite, bastnaesite in leucogranite pegmatite.
	Galway	Lots 23, 25, Con. X	Crystal Lake	Silver Crater Mines Ltd.	1955	Satterly 1956, p. 172	Allanite, thorite, uranothorite in granitic pegmatite.
		Lots 23, 24, con. XI; Lot 24, Con. XII	Crystal Lake	W. Blott, Kenmac Chibougamau Mines Ltd.	1954-55	Satterly 1956, p. 171	Uraninite, uranothorite in leucogranite pegmatite.
		Lot 7, Con. XIII		J. Tait	1957	Satterly, pers. comm.	Uraninite in pyroxene granite pegmatite.
	Harvey	Lot 18, Con. XII	Cavendish	R. Kennedy	1954-55	Satterly 1956, p. 176	Uranothorite in leucogranite pegmatite.
		Lot 26, Con. XVI		R. Kennedy	1954	Satterly 1956, p. 175	Uranothorite in leucogranite pegmatite.
Rainy River		Mainville L.–Otter Bay		Rainy Lake Mining Ltd.	1955	Port Arthur files	Uraninite in granite pegmatite.
Renfrew	Horton	Lot 1, Con. III		J. Dempsey		Lang et al 1962, p. 264	Uranothorite, allanite in pegmatite.
	Raglan	Lot 32, Con. V		Marquardt Bros.	1955-56	Satterly, pers. comm.	Uraninite, uranothorite in granite pegmatite.
		Lots 3&4, Con. XVIII	Craigmont			Lang et al 1962, p. 277	Allanite, uraninite, euxenite in syenite pegmatite.
Thunder Bay		Charon Lake		Sandy Stone Exp. & Dev. Co.	1955, 57	Port Arthur files	Uraninite in pegmatite dike.
	Hele	Black Sturgeon R.		J. Tessier	1955	Port Arthur files	Uranium mineralization in granite pegmatite.

minerals in the Bancroft area. It frequently occurs as yellow coatings on fractures in uranium ore, or replacing uranium minerals. Uranophane is orthorhombic and occasionally forms groups of minute radiating crystals. The hardness is 2 to 3 and the specific gravity 3.8 to 3.9.

Other Radioactive Minerals

Other radioactive minerals such as pyrochlore-microlite, betafite, fergusonite-formanite, euxenite-polycrase, and allanite are discussed in the section on rare-element minerals.

Uranium Pegmatites

The most important uranium deposits of the Bancroft area, including those of Bicroft, Dyno, Halo, Faraday and Greyhawk mines, are in pegmatitic granite dikes. Disseminated metasomatic replacement deposits of uraninite and uranothorite occur in marble, metamorphic pyroxenite, and occasionally in granite or syenite. Hydrothermal calcite-fluorite veins also may carry uraninite and uranothorite.

The mode of occurrence and history of uranium deposition in the area is complex; there appears to have been three stages in the sequence of deposition, and these may overlap even in a single deposit. These stages are: 1. Pegmatitic granite stage: dilatant injection accompanied by assimilation and replacement; 2. Metasomatic replacement stage; 3. Hydrothermal vein stage, usually of the calcite-fluorite-apatite vein type.

The pegmatites do not show the usual characteristics of granite pegmatite dikes of the segregated zoned type. They are complex composite granitic bodies usually occurring as dikes or irregular pod-shaped, branching bodies cutting and replacing the country rocks. Their contacts vary from sharp to gradational depending to some extent on the type of wall rock. Grain size is variable ranging from coarse to fine-grained. In some cases magmatic stoping has taken place and large inclusions of country rocks are caught up in the dikes. The dikes vary in size from 300 to 3,000 feet or more in length and from 10 to 150 feet wide. Some dikes have been traced down dip for over 1,000 feet.

LITHOLOGY

The pegmatite bodies often consist of multiple facies, with the different lithologic units being quite irregular in size, shape, and position. Marked changes in lithology and texture frequently occur along the dikes and may often be related to the type of wall rocks. The most common lithologic types are: pink granite gneiss; pink leucogranite, frequently magnetite-rich; pegmatite granite, usually peristeritic; pyroxene granite and syenite; pyroxene granite and syenite pegmatite and cataclastic quartz-rich granite pegmatite. The dikes lack the regular zoning of the dike into lithologic units from wall to core as in the normal zoned magmatic granite pegmatite. Inclusions and relict schlieren in all stages of assimilation occur in the dikes. Lithologically the bodies grade from syenite to granite.

MINERALOGY

The essential minerals are quartz, peristerite, and microcline microperthite. Characterizing accessories are pyroxene, hornblende, chlorite, biotite and magnetite. Varietal accessories include purple fluorite, allanite, zircon, titanite, tourmaline, apatite, hematite, calcite, pyrite, pyrrhotite, molybdenite, chalcopyrite, and rarely anatase, melanocerite, bastnaesite, and umangite. The uranium minerals in order of importance are uranothorite, uraninite, uranophane, and occasionally thorite, pyrochlore, fergusonite, davidite, beta-uranophane, and kasolite.

OCCURRENCE AND GENESIS

The following is taken from Hewitt (1957, p.54):

> The mode of occurrence and the characteristics of these dikes indicate that they belong to the pegmatite line of descent. However, they are not emplaced solely by simple dilatant injection; there is abundant evidence of assimilation of wall-rocks, metasomatic replacement, and reaction of earlier facies with later gaseous or hydrothermal elements in the pegmatite sequence. Assimilation, digestion, and reconstitution of wall-rocks, and wall-rock inclusions are features. Evidence that these bodies are not formed by simple dilatant fissure-filling is found in the lack of offset of beds, and in the frequent well-marked lithologic changes in the dike where the wall-rocks change in lithology. Pyroxene, for example, is frequently present in the dikes where limy amphibolites, pyroxene granulites, or metamorphic pyroxenites have been assimilated or replaced by the dike rocks, as at the Bicroft mine.
>
> This type of pegmatitic granite body is regarded by the author as typical of deep-zone ultrametamorphism; the tectonic association of these bodies in the Highland gneiss terrane in hybrid mixed gneiss zones marginal to major batholithic complexes or intrusive sheets such as the Cheddar batholith, the Cardiff plutonic complex, and the Faraday granite, is significant. This is apparently a favourable structural position and a characteristic metamorphic environment for their occurrence. This should therefore be a guide to prospecting.

COUNTRY ROCKS OR HOST ROCKS

The following is taken from Hewitt (1957, p.54):

> The uranium deposition is influenced by the chemical and physical properties of the host rocks in which the granitic dikes occur. Host rocks, rich in magnetite and calcium-magnesium-iron silicates such as pyroxene and hornblende, are favourable. In the Bancroft area the Faraday, Greyhawk, and Blue Rock Cerium dikes are in metagabbro (essentially an ortho-amphibolite or pyroxene amphibolite). The Bicroft, Dyno, and Halo dikes occur in limy para-amphibolite carrying

interbeds of pyroxene-scapolite granulite and garnet-sillimanite paragneiss.

Pyroxene and magnetite seem to act as chemical precipitants for the uranium minerals. Where pyroxene and magnetite are assimilated from the wall-rocks and recrystallized in the dike, these patches or shoots are frequently enriched in uraninite and uranothorite. Thus the presence of limy, iron-rich wall-rocks such as amphibolite or pyroxenite appears to have a favourable influence on uranium deposition in the dike. Pyroxene- and magnetite-rich ore shoots are a characteristic feature of the granitic dikes at both the Bicroft and Faraday mines.

Amphibolite and metagabbro also appear to be favourable host rocks from a structural viewpoint, being fairly competent and not too easily permeable, so that the dike material is reasonably confined physically. These physical attributes of amphibolite and metagabbro contrast with conditions in sandy paragneisses, where the uranium-bearing granitic material seems to become widely injected as migmatitic veinlets and is dissipated over a large area rather than being confined to a discrete dike. Although uranium mineralization is often present in dikes in sandy paragneisses, it is usually diffuse.

The physical incompetence of marble may account for the lack of important uranium-bearing granite dikes in marble in the Bancroft area. However, metasomatic-replacement-types of uranium deposits do occur in marble.

SHEARING AND CATACLASIS

The following is taken from Hewitt (1953, p.54,55):

Another rather noteworthy and important feature of the uranium-bearing granitic dikes of the area is the prevalence of cataclastic structures in some enriched portions of the dikes. Movement and "action" in the dikes during the late stages of emplacement is favourable to uranium deposition. Where shearing has fractured and crushed the crystallizing pegmatitic granite dike at a time when late-stage uranium-bearing solutions are available, these cataclastic zones will localize late-uranium mineralization. Glassy, quartz-rich cataclastic pegmatites rich in uranium occur at the Bicroft, Greyhawk, and Halo mines.

At the Bicroft mine, L. Kelly [(Kelly 1956, p.87)] has pointed out that many ore shoots are found where the granitic dikes transect the garnet-sillimanite band, and that evidence of shearing is often shown in dikes cutting the garnet-sillimanite gneiss at high angles. These dikes may be shattered throughout the intersection and may be highly radioactive. This garnet-sillimanite gneiss band is thought to be a broad incompetent zone in which shearing adjustments have taken place parallel to the contacts of the band. The helicitic structure of the garnets in the garnet-sillimanite gneiss gives evidence of this shearing.

OTHER FEATURES OF THE DIKES

The following is taken from Hewitt (1957, p.55):

Uranium minerals occur in shoots within the dikes, but they are not confined to any particular lithologic unit. There may be hanging-wall or footwall enrichment, or enrichment close to inclusions within the dike at competency boundaries. Fracturing and cataclasis may play an important part in localizing the ore. These features all suggest structural rather than genetic controls for the ore.

Hematitization and red colouration of feldspars and quartz usually accompany uranium mineralization. Purple fluorite, zircon, peristerite, and allanite are common. The uranium minerals in these dikes are commonly uranothorite and uraninite, whereas in the zoned magmatic type of pegmatite dike, such as those at Hybla, Quadeville, and Madawaska, the uranium minerals are more commonly the complex oxides of rare earths, titanium, columbium, and tantalum.

Principal Uranium Deposits

BICROFT MINE

Bicroft Uranium Mines Limited was formed by the amalgamation in 1955 of Centre Lake Uranium Mines Limited and Croft Uranium Mines Limited. In 1961 the name was changed to Macassa Gold Mines Limited (Bicroft division). In 1955 the company received a contract for the purchase of $35,805,000 worth of uranium precipitates from Eldorado Mining and Refining Company Limited. The company completed the installation of a 1,000 ton-per-day mine plant and mill in 1956. Milling began in October, 1956 and continued until mid-1963.

The mine and mill are on lots 27 and 28, concession XI, Cardiff township, on the Centre Lake portion of the property. Two shafts were sunk, No. 1 shaft to a depth of 234 feet and No. 2 shaft to a depth of 1,843 feet. Thirteen levels were developed before the mine closed due to lack of markets for uranium.

A north-south striking zone of radioactive pegmatitic granite and syenite dikes occurs in a band of syenitized amphibolite and paragneiss, which lies between marble on the east and the east-dipping Centre Lake granite sheet on the west. This band of metasediments dips 50°–60°E. This dike-bearing zone has a strike length of 16,000 feet on the Centre Lake property. About 4,000 feet of this length was developed.

Within the favourable zone the metasediments consist mainly of amphibolite, garnet-sillimanite-biotite paragneiss (often graphitic), and a narrow band of silicated marble. This series of metasediments was intruded and replaced first by grey albite syenite and granite; secondly by yellow-brown to red sodic syenite and granite often characterized by alkaline hornblende and pyroxene, purple fluorite, and abundant titanite; and thirdly by pink potassic syenite and granite. Pegmatitic facies of all three types of granite and syenite occur, and radioactive minerals appear to be most common in the yellow-brown and red sodic pegmatitic granite and syenite dikes.

The following is from Hewitt (1957, p.60):

Surface and underground mapping shows that the granitic bodies strike north, and cut across the metasediments, which strike northeast. These bodies dip 40°–70°E. They form lenticular bodies with many minor offshoots, fingering, pinching, and swelling in a very irregular manner; some are pipe-like. They range in length from a few to 400 feet, and in width from a few to 80 feet.

The general characteristics of the dikes have already been described in the introduction. The dikes in the Centre Lake workings consist of various lithologic units such as pegmatitic syenite and granite, leucogranite gneiss, and pyroxene granite pegmatite. Boundaries between units are transitional along strike but are often sharply defined across strike. Evidence of assimilation and replacement of the country rocks is shown by the presence of residual bands of amphibolite and streaks of mafic minerals near the contacts of the granitic dikes.

The main lithologic units present in the dikes are pegmatitic pyroxene syenite and granite, porphyroblastic granite pegmatite, leucogranite gneiss, and cataclastic quartz-rich pegmatite. Essential minerals are peristerite, microcline, microcline microperthite, and quartz, with pyroxene sometimes present as a characterizing accessory. Uranothorite and uraninite are the common radioactive accessories. Biotite, pyrrhotite, pyrite, apatite, purple fluorite, calcite, zircon, titanite, molybdenite, allanite, and occasionally pyrochlore, betafite, anatase, and umangite, are accessories.

Ore shoots within the granitic dikes range from a few to 300 feet in length and vary greatly in width, with a maximum of about 30 feet.

Hewitt (1957, p.60) continued:

Several ore shoots may occur along the length of a granitic body with barren or low-grade sections between them. Often ore shoots are confined to the footwall or hanging-wall sections of the bodies, but in other cases the whole width of the dike may make ore. As pointed out in the introduction, sections of the dike, rich in pyroxene and magnetite and sheared sections, frequently make ore; the dikes lying within the 100-foot band of sillimanite-garnet gneiss are likely to run better than those outside this favourable band.

The J and K orebodies, which were among the largest at Bicroft mine, were approximately 300 feet long, 10 feet wide and extended to a vertical depth of over 1,350 feet with a plunge of 70° south. These pipe-like ore shoots extend to great depths compared to their lateral extent. Other oreshoots of smaller size were of similar shape. Forty-nine ore shoots were outlined on the first level, having a combined length of 4,143 feet and an average width of 6 feet.

Hewitt (1957, p.60) continued:

Where the granitic dikes cut the sillimanite-garnet gneiss band there is frequently a border zone of 1–25 feet wide of *lit par lit* pegmatitic injection in the sillimanite-garnet gneiss band.

There is widespread syenitization of amphibolite and paragneiss throughout the whole metasedimentary band. Peristerite (albite) feldspar has been introduced. Yellow-brown hornblende or biotite peristerite gneiss occurs as inclusions within the granitic dikes, adjacent to some of the dike contacts, or as bands removed from the granitic dikes. Detailed mapping by the company geologists shows that although some of the peristerite syenite bands are spatially related to the granitic dikes, many of them are not. Syenitization of this type is a widespread phenomenon throughout the area within and flanking the Cardiff plutonic complex; the author believes that the syenitization is a widespread regional feature associated with the emplacement of the Deer Lake syenite and associated alkalic bodies. The dikes and the syenitization may have had a common origin, but the syenitization cannot generally be referred to as a wall-rock alteration associated with the emplacement of the dikes, although a limited syenitization of wall-rock may take place.

Some epidotization, tourmalinization, and scapolitization of the wall-rocks occur in the vicinity of the dikes.

FARADAY MINE

The Faraday uranium mine was operated from 1957 to 1964 by Faraday Uranium Mines Limited and its successor, Metal Mines Limited (Bancroft division). The property consists of 25 lots and parts of four other lots in north-central Faraday township. The mine and plant are on lots 16 and 17, concession XI, Faraday township, just north of No. 28 highway, 5 miles southwest of Bancroft. The property was originally discovered and staked by Arthur Shore, a Bancroft prospector, in 1948 and 1949.

Exploration and Development

Prior to 1953 exploration comprised trenching and 25 diamond-drillholes totalling 3,087 feet. In 1953 the property was covered by geological mapping, an airborne scintillometer survey, a ground ratemeter survey, and a resistivity ground survey. Diamond-drilling amounted to 41 holes totalling 10,787 feet.

The work in 1954 entailed stripping and trenching the hillside above the A zone, diamond-drilling on surface of 54 holes totalling 20,621 feet, and underground diamond-drilling of 60 holes totalling 3,024 feet. Underground work was commenced in 1954 by driving two adits, the east and west, 1,240 feet apart, to explore the A and E zones of granite bodies. The east adit (now No. 1) is in lot 16, concession XI, with drifting in lot 16 and into lot 17. The west adit (now No. 2) is in lot 17, concession XI with some drifting on the E zone being in lot 18. In 1954 the underground development from the east adit amounted to 821 feet of crosscutting and 796 feet of drifting, and underground development from the west adit amounted to 398 feet of crosscutting and 595 feet of drifting.

In 1955 diamond-drill exploration comprised 60 holes, totalling 38,116 feet, and 235 underground holes totalling 21,250 feet. The total of all drilling to the end of 1955 was 96,885 feet. Two vertical shafts were sunk; No. 1 shaft was 78 feet in depth, and No. 2 275 feet in depth, with a level 150 feet below the adit level. After completing the 1955 exploration, the mine manager estimated ore reserves to be 1,660,980 tons grading 0.112 percent U_3O_8, according to the company's annual report. In January 1956 it was announced that the company had negotiated a contract covering the sale of $29,754,800 worth of uranium precipitates with Eldorado Mining and Refining Limited. Following receipt of the contract, plans were completed for bringing the mine and mill into production in 1957 and production began in April 1957. The original mill was laid out for 750 tons per day, with provision for an increase to 1,000 tons per day.

By the time the mine closed in 1964, No. 1 shaft was 1,455 feet deep and No. 2 shaft was 196 feet deep. There were nine levels: adit, 150-foot, 300-foot, 450-foot, 600-foot, 750-foot, 900-foot, 1,050-foot, and 1,200-foot. Production to 1 May 1964 amounted to 2,805,641 tons with an average grade of 0.1074 percent U_3O_8 and a metal content of 6,025,955 pounds of U_3O_8 (Bullis 1965, p.720).

Bullis states that the various levels have contributed the tonnages shown in Table 25.

Table 25 | *Faraday mine, uranium production, tonnages, and grades (Bullis 1965)*

LEVEL	TONS	GRADE	LBS. U_3O_8
Adit	487,084	0.1105	1,076,826.4
150	410,235	0.1037	850,598.8
300	433,865	0.0989	857,999.0
450	548,430	0.1040	1,141,221.8
600	541,338	0.1055	1,141,837.0
750	231,679	0.1254	581,008.0
900	135,709	0.1261	342,267.4
1050	17,078	0.0988	33,756.6
1200	223	0.0986	439.6

Bullis gives the ore reserves at 15 July, 1964 as 453,250 tons grading 0.144 percent U_3O_8 containing 1,311,298 pounds U_3O_8 He states:

During the life of the mine it was necessary to explore and outline the orebodies with diamond drills. The irregular nature of the ore zones was such that no other method of exploration would have been satisfactory, and some 2,998 holes were drilled for a footage of 457,365 feet to May 1, 1964. If the production is added to the present reserve, it can be shown that 2,998 holes have outlined 3,258,891 tons containing 7,337,253 lbs. of U_3O_8. The ratio of pounds U_3O_8 outlined to feet of drilling is 16.04 lbs. per foot of hole.

General Geology

The radioactive minerals occur in bodies of leucogranite, leucogranite pegmatite and pyroxene hornblende granite or syenite pegmatite cutting metagabbro, gabbroic amphibolite and paragneiss. The metagabbro and amphibolite form the western part of the Faraday metagabbro, a metamorphosed basic intrusive body about 6 miles long and up to ¾ of a mile wide, which cuts the Grenville paragneiss and marble in this area. In the mine area, there is an anticline to the north and a syncline to the south, both pitching southwest. The Grenville metasediments and the Faraday metagabbro are intruded by nepheline syenite, syenite, and granite. This assemblage forms a zone of mixed hybrid gneisses lying on the south margin of the Hastings Highland gneiss complex. This zone is transitional from the granite gneiss to the north and the lower grade metasediments of the Hastings Basin to the south. Several south-dipping normal fault zones trending east to northeast form prominent zones of mylonite and cataclastic breccia to the north and south of the metagabbro; the metagabbro itself is strongly sheared.

To the north of the Monck road the south-dipping sheet of Faraday granite extends from Albion Lake in Faraday township eastward to Clark Lake in Dungannon township. This sheet forms the footwall of the mixed hybrid gneiss zone in which the Faraday mine occurs.

Granitic Bodies at Surface

The following is taken from Hewitt (1957, p.72):

The A zone is exposed on a cliff and may be examined in three cuts along the face of the cliff, called the Top, Middle, and Lower cuts. The face of the cliff trends about N5°W. Granite and pegmatite is exposed along the top cut for a distance of 192 feet. It intrudes a fine-grained hornblende-plagioclase gneiss, part of a metagabbro body, the gneissic structure of which at the south contact strikes N65°E. and dips vertically. The granite body consists of both leucocratic and mafic types. The leucocratic type is a leucogranite or leucogranite pegmatite ranging from medium- to coarse-grained, pink, yellow-brown, or blotchy red and yellow-brown in colour. One variety of the leucocratic type is a pale pink-to-purplish-red graphic granite with very variable grain size. Allanite and zircon are present as accessory minerals. The mafic type is a dark red, pyroxene granite pegmatite with pyroxene crystals from ¼ to 4 inches across. Accessory minerals are titanite, zircon, allanite, uranothorite, molybdenite, and, very rarely, fluorite. Allanite occurs as thin tabular crystals up to 1¼ inches across.

Granitic Bodies at the Adit Level

The following is taken from Hewitt (1957, p.72):

Underground development on the adit level has explored a large number of granitic bodies, and the following general description is based on the examination of twelve of these bodies, some of which are described in more detail later in this report.

The granitic bodies may be lenticular, pod-shaped, or irregularly branching with a long axis usually parallel to the gneissic structure. The dip of the bodies closely approximates that of the metagabbro, but transgresses it at small-to-large angles in some places. Ore shoots within these bodies range from less than 50 to as much as 300 feet in length, and from less than 1 to a maximum of 35 feet in width. These shoots may occupy the whole width of a granitic body, be confined to footwall or hanging-wall zones, or sometimes occur medially.

The granitic bodies are made up of a number of lithologic units such as aplitic leucogranite, leucogranite, pyroxene granite (or syenite) pegmatite, and magnetite or magnetite-pyroxene pods. A few of the bodies are multiple intrusions, for example No. 22. The oldest intrusive of the series is an aplitic leucogranite which may be seen as cognate inclusions in later units. The leucogranite unit is also an intrusive. The distribution and arrangement of the pyroxene in the granite (or syenite) pegmatite is clearly related to the replacement or assimilation of amphibolite (metagabbro). Magnetite or magnetite-pyroxene pods, for example No. 3, appear to be late segregations in the granitic bodies and show transition into normal granite pegmatite. Much of the magnetite occurs as narrow bands parallel to the strike and dip of the granitic bodies and appears to have followed a system of late fractures parallel to the body's walls.

The rock types of the ore shoots may be conveniently grouped into three varieties: (1) leucogranite, (2) pyroxene granite (or syenite) pegmatite, and (3) magnetite or magnetite pyroxene pods, lenses, or bodies in pegmatite. Peristerite, an albite feldspar with a blue sheen, is a characteristic feldspar in these rocks. The dark-green pyroxene, when present, is usually highly altered. The accessory minerals are similar in the three types but vary considerably in amount within one ore shoot and from one ore shoot to another. They include zircon, allanite, titanite, magnetite, and hematite. Sulphides are not common, although both pyrite and marcasite are present. The uranium-bearing accessory minerals are uranothorite, thorite, uraninite, and the secondary uranium mineral uranophane. Crystals of secondary calcite are common in vugs. Parts of the ore shoots have been intensely leached and oxidized, and there has been much deposition of secondary carbonate and hematite.

The better-grade material in the ore shoots is usually indicated by one or more of the following:

1. Abundant magnetite.
2. Abundant pyroxene.
3. Reddening of the feldspar by hematitization.
4. Red flecking or staining of quartz.
5. Fracturing or platy sheeting parallel to the walls.
6. Granitic rather than pegmatitic texture.

It should be noted that the presence of magnetite, pyroxene, and hematitization is not necessarily indicative of ore, but rather of an increase in the relative amounts of the minerals.

The rock of the non-ore sections of the granitic body is also leucogranite and leucogranite pegmatite, but includes a sugary white and red blotched or streaked aplitic leucogranite, which appears as relict masses throughout the other rock types. This aplitic rock has the lowest geiger count of the granitic rocks. All the non-ore granitic rocks are distinguished by a paler colour due to less or no hematitization. Tourmaline-quartz intergrowths were noted in a few places in these rocks.

Some of the granitic bodies with ore shoots on the adit level are described below to illustrate the variations in structure, petrography, and mineralogy.

Mineralogy of the Granitic Bodies

The following is taken from Hewitt (1957, p.73–75):

The granitic bodies consist of feldspars, microcline and peristerite, quartz, pyroxene in some, and accessory magnetite, zircon, titanite, pyrite, marcasite, hematite, and calcite. The radioactive accessory minerals are uraninite, uranothorite, thorite, and allanite. Secondary uranium minerals are uranophane and beta-uranophane.

Microcline and microcline perthite are the common pink feldspars of the granitic bodies, usually stained a deep brick-red in the ore shoots owing to hematitization.

Albite, the variety peristerite with an iridescent blue sheen, is characteristic of the radioactive granitic bodies. It forms crystals up to several inches across in some bodies.

Pyroxene forms small-to-large crystals in the granitic bodies, especially adjacent to the footwall or hanging-wall contacts, or in strings of crystals or parallel zones within the bodies indicating its origin from assimilation of metagabbro or mafic metasediments.

Quartz is clear, white, smoky-grey to black, often stained rusty or jasper red. The latter is especially indicative of the better-grade radioactive occurrences.

Magnetite is frequently present in leucogranite or leucogranite pegmatite bodies as grains, blobs, lenses, or discontinuous bands. Although it is indicative of uranium mineralization it does not necessarily indicate that the rock will be of ore grade. Magnetite is also an important constituent of the magnetite-pyroxene mass, which forms the E-1 west No. 3 orebody.

Zircon is a consistent accessory mineral occurring as minute brown, doubly-terminated prisms. When present in magnetite it is usually bleached to a pale-blue-grey or white.

Titanite is a fairly common accessory in minute red-brown crystals, rhomb-shaped in cross-section.

Pyrite and marcasite are not common and were noted in only a few places in the granitic bodies.

Hematite is widespread throughout the granitic bodies mostly in such minute form that only the deep-red colour of the granitic rock indicates its presence. In some ore shoots it coats the inside of vugs in minute botryoidal forms and coats calcite crystals. In some of the larger vugs it is only earthy in character.

Calcite is not uncommon in vugs as honey-yellow crystals. In a large vug in No. E-1 west drift scalenohedrons of calcite terminated with the basal pinacoid were found. These crystals ranged from 1 to 5 inches in length. They were coated with a shiny black film of botryoidal hematite.

Uraninite is with difficulty recognized underground since it occurs in minute cubes of grains, those observed being all less than 1/20 inch across. It is found in red-stained quartz, but is most abundant as rough grains in coarse magnetite occurrences such as No. 3 orebody in the E-1 west body. An analysis of uraninite concentrated from this material by S. C. Robinson and A. P. Sabina [(Robinson and Sabina 1955, p.631)] is as follows: U_3O_8, 70.0; ThO_2, 7.7; and PbO, 13.7 percent.

Uranothorite occurs in small grains, which may be black, greenish-black, greenish-orange, orange, brown, or red in colour. The grains have a conchoidal fracture, and a greasy vitreous, or resinous lustre. Black grains may often be observed altered to shades of green, orange, or brown. Orange grains from the A-east (north limb) body are tentatively identified as uranothorite. An analysis (Provincial Assay Office, Ont. Dept. Mines) of this material gave the following results: U_3O_8, 11.4 (chemical); and Ce, 3.7 percent (spectrographic). No analyses of black grains were made. Uranothorite is visually the commonest uranium-bearing mineral on the Faraday property.

Thorite, as well-developed, small zircon-type orange crystals, are found in the A east (north limb) at 28 feet east of station No. 117 in a leached and oxidized pyroxene syenite pegmatite. An X-ray powder pattern photograph on the unheated mineral gave a weak but distinct thorite pattern, and on the heated mineral a very dark thorite pattern was obtained. A spectrographic analysis gave the following results: U_3O_8, 11.5; ThO_2, 54; and SiO_2, 21 percent. U_3O_8 by chemical analysis was found to be 9.17 percent. The mineral is therefore a uranium thorite. In another sample from this working, taken by the author in 1954, a yellow grain bounded by a black rim (magnetite?) in square crossections was identified as thorite and uranophane.

Allanite is often abundant, especially in the footwall and hanging-wall parts of some ore shoots. It forms black, platy crystals from less than 1 inch to a maximum of 3 inches across. In some places uranothorite, as minute grains, is plastered on the allanite plates.

Uranophane is a common and often abundant secondary uranium mineral found as a lemon-yellow stain, coating fractures or around primary uranium minerals and zircon. More rarely it is found in fibrous clusters lining minute vugs. Some uranium minerals have been completely replaced by uranophane.

Beta-uranophane is rare. It was found in diamond-drill core as radiating clusters of acicular crystals in a ⅛-inch vug in feldspar and identified by E. W. Nuffield [(Gorman and Nuffield 1955, p.641, 642)].

As the mine was developed it was found that many of the large pegmatites had vuggy cores containing crystals of calcite, selenite, pyrite, goethite, hematite, uranophane, fluorite and chalcopyrite. In places there has been brecciation of the pegmatites and the breccia fillings are usually gypsum and anhydrite.

Bullis (1965, p.720) states that "the youngest deposits found underground are 'veins' or fracture fillings of purple to green coarse-crystallized anhydrite with some gypsum, augite and occasionally pyrite."

RARE EARTH MINERALS

The rare earth minerals are commonly found in granite pegmatites, mainly in the Grenville Province. Table 28 lists 128 pegmatites in Ontario carrying rare earth minerals as accessories. The rare earths consists of a group of 16 metallic elements that are divided into the cerium group of light rare earths including cerium, lanthanum, praseodymium, neodymium, promethium, samarium, and europium; and the yttrium group of heavy rare earths including gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, lutecium, and yttrium.

Table 26 gives the atomic number and weight of the rare earth metals (after Rose 1960, p.3).

Table 26 *Rare earth elements (Rose 1960, p.3)*

Element	Symbol	Atomic No.	Atomic weight
Cerium group of light rare earths			
Lanthanum	La	57	138.92
Cerium	Ce	58	140.13
Praseodymium	Pr	59	140.92
Neodymium	Nd	60	144.27
Promethium (illinium)[1]	Pm	61	145.?
Samarium	Sm	62	150.43
Europium	Eu	63	152.0
Yttrium group of heavy rare earths			
Gadolinium	Gd	64	156.9
Terbium	Tb	65	159.2
Dysprosium	Dy	66	162.46
Holmium	Ho	67	164.94
Erbium	Er	68	167.2
Thulium	Tm	69	169.4
Ytterbium	Yb	70	173.04
Lutecium	Lu	71	174.99
Yttrium	Y	39	88.92

[1]Not found in nature.

Monazite and bastnaesite are the principal ore minerals of the rare earths, with some being produced from euxenite. The term *misch metal* is used for combinations of rare earth metals, and usually contains abundant cerium. Rio Algom Mines Limited at Blind River has commenced production of yttrium oxide at the rate of 100,000 pounds annually from their uranium and thorium ores.

Uses

Yttrium oxide is used with europium oxide to form the red phosphors for colour television tubes. Europium is the active ingredient that gives greater colour fidelity to the television picture, while yttrium oxide is efficient in collecting energy for the europium. Yttrium oxide is also used in the electronics industry in solid state devices for microwave applications (Northern Miner, 10 March 1966).

The oxides of the cerium group of light rare earths are used for polishing lenses, mirrors, plate glass and television tubes. Cerium oxide in small quantities acts as a glass decolourizer. In larger quantities cerium and neodymium oxides opacify glass to ultraviolet light. There are many other uses for rare earths in the glass industry. Rare earth fluorides and oxides are used in carbons for arc lighting. Misch metal is used for pyrophoric alloys such as ferrocerium lighter flints. In ferrous metallurgy rare earth metals and compounds act as deoxidizers, desulfurizers and grain refiners. Other uses for the rare earths have been found in nonferrous metallurgy. Many other uses are outlined by Parker (1965, p.9–10).

Principal Rare Earth Minerals

Table 27 shows the principal minerals containing rare earths in Ontario pegmatites.

URANINITE-THORIANITE

The uraninite-thorianite series of minerals carry from 8 to 12 percent rare earths, and are a source of thorium and yttrium at the Blind River mines.

PYROCHLORE-MICROLITE

Pyrochlore and microlite form a complete solid solution series from the niobian member, pyrochlore, to the tantalum member, microlite. They are complex oxides of Ca, Na, Nb, and Ta with hydroxyl and fluorine. There is considerable substitution of Fe, Ti, Mn, U, Th, Zr, and the rare earths. The rare earth content of betafite, a variety of pyrochlore, reaches 23 percent, but pyrochlore and microlite do not usually contain more than 10 percent rare earths.

Pyrochlore and microlite are isometric and may be found in good octahedral crystals or in irregular grains with a yellow-brown, brown or black colour and a bright vitreous lustre. Hardness is 5 to 6 and specific gravity is 4.2 to 6.4 increasing with the Ta content. Fracture is subconchoidal and uneven.

Betafite is a variety of uranium pyrochlore containing more Ti, U, Th and rare earths than normal pyrochlore. From chemical analyses, Satterly (1956, p.21,22) indicates that *ellsworthite* and *hatchettolite* are varieties of betafite.

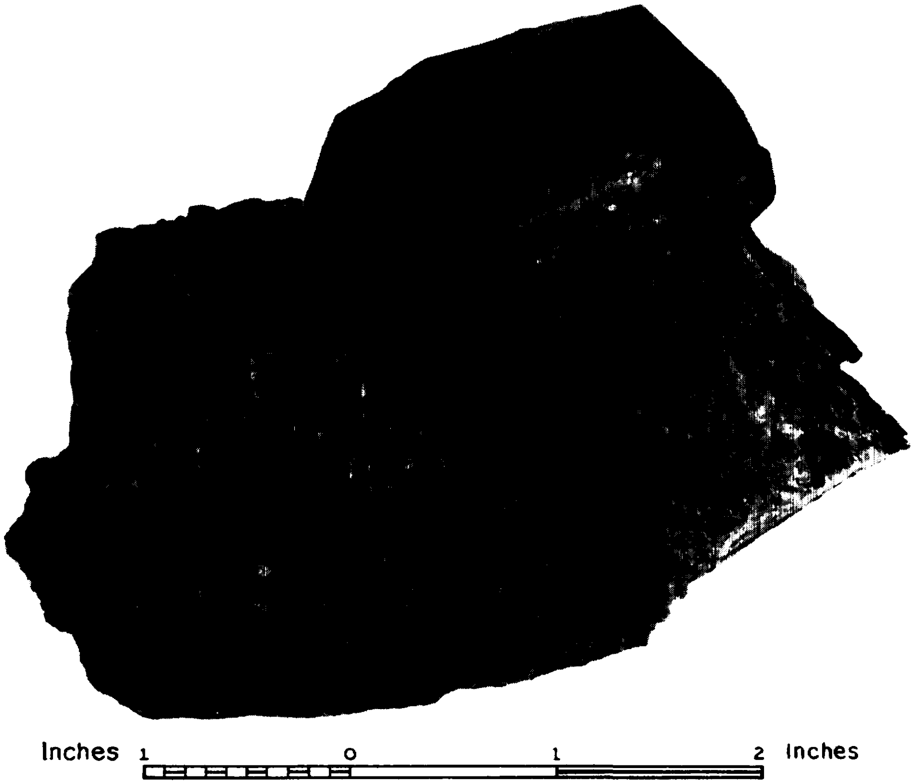

Photo 7—Betafite crystal.

Good betafite crystals are found at the Silver Crater Basin property in Faraday township, Hastings county. Ellsworthite is abundant at the MacDonald mine near Hybla, in Monteagle township, Hastings county.

FERGUSONITE-FORMANITE

Fergusonite and formanite are columbates and tantalates of yttrium and erbium with lesser amounts of other rare earths, uranium, thorium, calcium, iron, titanium, and water. They form an isomorphous series from the niobate (fergusonite) to the tantalate (formanite). Fergusonite is more common than formanite. The minerals are tetragonal and crystallize in tapering prismatic crystals. The colour is brown to black with a bright vitreous lustre. Fracture is subconchoidal. Hardness is 5.5 to 6.5 and specific gravity is 4.2 to 5.8 depending on the Ta content.

Good tapered prismatic crystals of fergusonite occur at the Gole pegmatite near Madawaska, Ontario.

EUXENITE-POLYCRASE

The following is taken from Satterly (1956, p.23):

> Euxenite and polycrase are the end members of an isomorphous series of minerals that are multiple oxides of niobium, tantalum, titanium and the yttrium group rare earths, and usually contain uranium, thorium and the cerium group rare earths. The minerals are orthorhombic and rarely form stout prismatic crystals. More often they occur as jet-black to brown or yellow irregular patches in zoned granite pegmatite dikes. The lustre is glassy to vitreous; hardness, 5.5 to 6.5; and specific gravity 4 to 5.8.
>
> In the Grenville subprovince euxenite-polycrase, next to allanite, is one of the commonest radioactive minerals found in zoned granite pegmatite dikes. So far, it has not been

Table 27 | *Principal minerals containing rare earths in Ontario pegmatites*

Mineral	Composition	Maximum percent rare earths
Simple Oxides		
Uraninite	UO_2	12
Thorianite	ThO_2	8
Multiple Oxides		
Pyrochlore	$(Na, Ca)\ Nb_2O_6F$	18
Microlite	$(Na, Ca)\ _2Ta_2O_6(O, OH,F)$	10
Betafite	$(U,Ca)\ (Nb,Ti,Ta)_3O_9.nH_2O$	23
Ellsworthite	$(U,Ca)\ (Fe,Ti,Nb,Ta)_3O_9.nH_2O$	1.6
Hatchettolite	$(U,Ca,Mn)\ (Nb,Ti,Ta)_3O_9.nH_2O$	1
Fergusonite	$(Y,Er)NbO_4$	40
Formanite	$(Y,Er)TaO_4$	32
Euxenite	$(Y,Ce)\ (Nb,Ti,Ta)_2O_6$ niobian	31
Polycrase	$(Y,Ce)\ (Ti,Nb,Ta)_2O_6$ titanian	29
Eschynite	$(Ce,Th)\ (Ti,Nb,Ta)_2O_6$	27
Priorite	$(Y,U,Er)\ (Ti,Nb,Ta)_2O_6$	31
Samarskite	$(Y,Er,U,Fe)\ (Nb,Ta)_2O_6$	23
Silicates		
Thorite	$ThO_2.SiO_2$	1.5
Uranothorite	$(Th,U)O_2.SiO_2$	4
Allanite	$4(Ca,Fe)0.3(Fe,Al,Ce)_2O_3.6SiO_2.H_2O$	51
Gadolinite	$Be_2FeY_2Si_2O_{10}$	49
Cyrtolite	$(Zr,Fe,U,Th,Y)SiO_4$	11
Phosphates		
Xenotime	YPO_4	65
Monazite	$(Ce,La)PO_4$	74
Fluo-carbonate		
Bastnaesite	$(La,Ce,F)CO_3$	76

found in the unzoned granite and syenite pegmatites of the Bancroft area.

Lyndochite, so-named after Lyndoch township, Renfrew county, is a high lime euxenite found in the Quadeville beryl pegmatites.

ESCHYNITE-PRIORITE

Eschynite and priorite are complex oxides of niobium, titanium and tantalum, with rare earths, thorium and uranium. These minerals form an isomorphous series with the Ce, Th end member being *eschynite* and the Y, Ur, Er end member being *priorite*. The minerals are orthorhombic but generally occur massive. The colour is black, brown or yellow-brown; lustre is vitreous to resinous; fracture is conchoidal; hardness is 5 to 6 and specific gravity is 4.7 to 5.3. These minerals are rather rare in Ontario pegmatites.

SAMARSKITE

Samarskite is a columbate and tantalate of the yttrium group of rare earths, also containing Ur and Fe. It is orthorhombic and forms prismatic crystals. The colour is black, brown or yellow-brown; lustre is glassy to vitreous; fracture is conchoidal; hardness is 5 to 6 and specific gravity 4.1 to 6.2. The mineral is rare in Ontario but occurs in the MacDonald mine near Hybla.

THORITE-URANOTHORITE

Thorite and uranothorite described earlier under uranium carry small percentages of rare earths ranging up to about 4 percent.

Table 28 *Ontario pegmatites containing rare earth minerals*

County or District	Township	Location	Name of Mine	Operators	Years of Operation	Reference	Descriptive Remarks
Cochrane	Pitt	Otter Rapids		Mosher		Lang et al 1962, p. 276	Monazite in pegmatite.
Frontenac	Loughborough	Lot 11, Con. IX	Foxton	O'Brien & Fowler; S. Orser	1920-21	Rose 1960, p. 24	Euxenite, gadolinite in zoned granite pegmatite.
	Miller	Lot 15, SW Range					Pyrochlore in zoned granite pegmatite.
Haliburton	Cardiff	Lot 9, Con. I, II		Triton Uranium Mines Ltd.	1955	Satterly 1956, p. 75,76	Allanite, uranothorite in leucogranite pegmatite.
		Lot 10, Con. II		R. Doubt	1955-6	Satterly 1956, p. 53	Allanite, uranothorite in pegmatitic granite dikes.
		Lots 10, 11, Con. V		Milhol Exp. & Dev. Co.	1953-5	Satterly 1956, p. 67	Allanite, uranothorite in leucogranite pegmatite.
		S½ Lot 6, Con. VI		Consol. Thor Mines Ltd.	1954-6	Satterly 1956, p. 50	Allanite, uranothorite in granite pegmatite.
		Lot 12, Con. VIII	Dyno	Canadian Dyno Mines Ltd.	1954-60	Satterly 1956, p. 43	Allanite, hatchettolite, uraninite, uranothorite, cyrtolite in pegmatitic granite.
		Lot 22, Con. IX		Aumacho River Mines Ltd.	1954-5	Satterly 1956, p. 252	Allanite, uraninite, uranothorite in pyroxene granite pegmatite
		Lots 11-13, Con. X	Tomlinson & Mulliette	Pickering Metal Mines Ltd.	1955	Satterly 1956, p. 74	Allanite, uranothorite, zircon in granite pegmatite.
		N½ Lot 11, Con. XI		Molybdenum Corp. of America	1953-5	Satterly 1956, p. 68	Allanite, uranothorite in leucogranite pegmatite.
		S½ Lot 11, Con. XI		Climax Molybdenum Co.	1955	Satterly 1956, p. 50	Allanite, uranothorite, zircon in pegmatitic leucogranite dikes.
		Lots 27, 28, Con. XI	Bicroft	Bicroft Uranium Mines Ltd.	1953-63	Satterly 1956, p. 30	Allanite, pyrochlore, betafite, uraninite, uranothorite in pegmatitic granite dikes.
		Lot 9, Con. XII		Canada Radium Corp. Ltd.	1932-6, 1940-42	Satterly 1956, p. 41	Ellsworthite, uraninite, uranothorite in leucogranite pegmatite.
		Lots 6, 7, Con. XIV	Kenmac	Kenmac Chibougamau Mines Ltd.	1955	Satterly 1956, p. 64	Allanite, uranothorite in pegmatitic granite dikes.
		S½ Lot 11, Con. XIV		Mindus Corp. Ltd.	1953-6	Lang et al 1962, p. 253	Ellsworthite, allanite, uraninite, uranothorite in granite pegmatite.
		Lots 6 & 7, Con. XV	Halo	Amalgamated Rare Earth Mining Co.	1953-6	Satterly 1956, p. 62	Betafite, uraninite, uranothorite in pyroxene syenite pegmatite.
		S½ Lot 20, Con. XV		D. E. Foster	1956	Satterly 1956, p. 58	Allanite, zircon, uranothorite in granite pegmatite dike.
		Lot 32, Con. XV	Croft	Bicroft Uranium Mines Ltd.	1953-5	Satterly 1956, p. 37	Monazite, allanite, cyrtolite, uraninite, uranothorite in pegmatitic granite dikes.
		Lot 2, Con. XVI	Allanite	Atlin Ruffner Mines (BC) Ltd.	1953-5	Satterly 1956, p. 38	Allanite syenite pegmatite.
		Lots 4-6, Con. XXI	Richardson	Fission Mines Ltd.	1929-32, 1946-8, 1955	Satterly 1956, p. 56	Allanite, uraninite, uranothorite, zircon in syenite pegmatite.
		Lot 5, Con. XXII		Bancroft Uranium Mines Ltd.	1955-6	Satterly 1956, p. 29	Allanite, uranothorite in pyroxene syenite pegmatite.
	Clyde	S½ Lot 21, Con. XI	Malcovitch		1955-56		Allanite in pink leucocratic granite.
	Glamorgan	S½ Lot 19, Con. II		Nu-World Uranium Mines Ltd.	1955	Satterly 1956, p. 80	Allanite, uraninite, uranothorite, cyrtolite in granitic pegmatite.
		Lots 26-28, Con. II		Nu-Cycle Uranium Mines Ltd.	1955	Satterly 1956, p. 78	Allanite, uranothorite, zircon in granitic pegmatite.
	Livingstone	Lots 17, 18, Con. V, VI		W. H. Robillard		Lang et al 1962, p. 266	Allanite in granite pegmatite.
	Lutterworth	Lot 11, Con. VIII		E. T. Hogan		Lang et al 1962, p. 266	Allanite, thorite, uranothorite in pegmatite.
	Monmouth	Lot 4, Con. III		Fairley Red Lake Gold Mines Ltd.	1955-6	Satterly 1956, p. 88	Allanite, zircon, uranothorite in pegmatitic leucogranite.
		Lots 3-5, Con. III } Lots 2-4, Con. IV }		Cassiar Rainbow Gold Mines Ltd.		Lang et al 1962, p. 270	Euxenite, allanite, uranothorite in granitic pegmatite dikes.
		Lot 14, Con. IV	Jesko	Jesko Uranium Mines Ltd.	1954	Satterly 1956, p. 89	Allanite, uranothorite in granite pegmatite dikes.
		Lot 19, Con. VI	Blue Rock Cerium	Amalgamated Rare Earth Min. Corp.	1954-6	Satterly 1956, p. 96	Fergusonite, allanite, uranothorite, uraninite in pegmatitic granite dikes.
		Lot 20, Con. VIII	Rare Earth	Amalgamated Rare Earth Min. Corp.	1948-56	Satterly1956, p. 92	Fergusonite, cyrtolite, uranothorite, uraninite in pegmatitic granite dikes.
		S½ Lot 24, Con. X		Saranac Ur. Mines Ltd.	1954-56	Satterly 1956, p. 102	Allanite, zircon, thorite, uranothorite in granitic pegmatite sill.
		Lot 35, Con. XI		Empire Oil & Minerals Inc.	1954-55	Satterly 1956, p. 54	Allanite, zircon, uranothorite, uraninite in leucogranite pegmatite.
Hastings	Carlow	Lots 2-4, Con. V		Mentor Exp. & Dev. Co.		Lang et al 1962, p. 255	Allanite, uranothorite in granitic pegmatite.
		N½ Lot 18, Con. XII		H. Sundstrom	1957		Allanite in pink leucogranite.
	Faraday	Lots 21-4, Con. A		Bonville Gold Mines Ltd.		Lang et al 1962, p. 260	Ellsworthite, uranothorite in granitic dikes.
		N½ Lot 4, Con. B		York River Uranium Mines	1957		Pyrochlore in syenite pegmatite.
		Lot 28, Con. B	Kerr	Silver Crater Mines Ltd.		Lang et al 1962, p. 260	Allanite, uranothorite in granitic pegmatite dikes.
		Lots 16-18, Con. XI	Faraday	Faraday Uranium Mines Ltd.	1952-1964	Satterly 1956, p. 108	Allanite, cyrtolite, uraninite, uranothorite in granitic pegmatite.
		Lots 9-11, Con. XII	Greyhawk	Greyhawk Uranium Mines Ltd.	1953-58	Satterly 1956, p. 117	Pyrochlore, uraninite, uranothorite, zircon, allanite in granite.
		Lots 27-29, Con. XV	Baumhour	Silver Crater Mines Ltd.	1954-6	Satterly 1956, p. 132	Allanite, uranothorite in syenite and granite pegmatites.
		Lots 31-32, Con. XVI	Reasor	G. L. Reasor	1954-5	Satterly 1956, p. 122	Pyrochlore, uraninite, uranothorite in pyroxene syenite pegmatite.
	Herschel	Lot 39, Con. VIII		Peter Rock Mining Co.	1955	Satterly 1956, p. 135	Pyrochlore, euxenite, uranothorite, allanite in pegmatite.
		Lots 17, 18, Con. XVI		F. Patterson		Lang et al 1962, p. 264	Eschynite, euxenite in granitic pegmatite.
	Monteagle	S½ Lot 5, Con. I	Carr, Quirk, Mellish		1955	Satterly 1956, p. 136	Allanite, uranothorite in granite pegmatite.
		Lots 2, 3, Con. V	Carr, Quirk, Robson	Mentor Exp. & Dev. Co.	1955	Satterly 1956, p. 136	Allanite, uranothorite in granite pegmatite.
		Lots 7, 8, Con. III	S. J. Carr			Hewitt 1954, p. 69	Allanite, uranothorite in pegmatite.
		Lots 27, 28, Con. III	J. F. Ferril			Lang et al 1962, p. 272	Allanite in pegmatite.
		Lots 11, 12, Con. IV	Quirk	J. Quirk		Lang et al 1962, p. 272	Ellsworthite, uranothorite, thorite in granitic pegmatite dikes
		Lot 20, Con. VI	Plunkett	S. Orser	1921, 1927	Hewitt 1954, p. 40	Ellsworthite, euxenite in granite pegmatite.
		Lot 21, Con. VI	Watson No. 1	P. J. Dwyer	1919-26	Hewitt 1954, p. 69	Allanite in granite pegmatite.
		N½ Lot 24, Con. VI	McCormack	P. J. Dwyer	1926	Hewitt 1954, p. 42	Ellsworthite, allanite in granite pegmatite.
		Lot 25, Con. VI				Hewitt 1954, p. 69	Allanite in granite pegmatite.
		Lot 11, Con. VII	Thompson	Feldspar Mines Corp.	1923-25, 1927	Hewitt 1954, p. 43	Allanite in granite pegmatite.
		Lots 18, 19, Con. VII	MacDonald	Verona Mining Co.	1919-35	Hewitt 1954, p. 43	Ellsworthite, cyrtolite, allanite, uraninite, uranothorite in zoned granite pegmatite.
		Lot 21, Con. VII	Cairns	Dillon & Mills, P. J. Dwyer	1920-24	Hewitt, 1954, p. 47	Ellsworthite in granite pegmatite.

		Lot 14, Con. VIII	Genesee No. 2	Genesee Feldspar Corp.	1926-31, 1948-50	Hewitt, 1954, p. 69	Euxenite in granite pegmatite.
		Lot 15, Con. VIII	Bartlett	P. J. Dwyer, K. Bowser	1926, 1951	Hewitt 1954, p. 69	Allanite in granite pegmatite.
		Lot 17, Con. VIII	Woodcox	Feldspar Mines Corp.	1922-23	Hewitt 1954, p. 50	Hatchettolite, ellsworthite, calciosamarskite, betafite, allanite columbite in granite pegmatite.
		S½ Lot 29, Con. VIII		Peter Rock Mining Co.	1955	Satterly 1956, p. 140	Allanite, uranothorite in granite pegmatite.
		Lot 8, Con. X		Welsh		Hewitt 1954, p. 70	Allanite in granite pegmatite.
		Lot 6, Con. XII	Reeves	Bancroft Feldspar Co.	1945-46	Lang et al 1962, p. 273	Allanite in pegmatite.
Kenora		Vermilion Lake	Cameron	M. Y. Cameron		Lang et al 1962, p. 251	Monazite, uraninite in 9 foot granite dike.
		Vermilion Lake		S. Stevenson		Lang et al 1962, p. 283	Monazite, uraninite in granite pegmatite.
	MacNicol					Lang et al 1962, p. 267	Allanite, uraninite, uranothorite in granite pegmatite.
Lanark	Bathurst	Lot 22, Con. IX		W. Ennis	1922	Lang et al 1962, p. 248	Euxenite, fergusonite, cyrtolite in granite pegmatite.
	S. Sherbrooke	Lot 13, Con. V	Orser-Kraft	S. Orser	1916-23	Rose 1960, p. 26	Euxenite in granite pegmatite.
Manitoulin	Carlyle	Philip Edward Is.		L. R. Bousquet	1957		Monazite and uranophane in granite pegmatite.
		Philip Edward Is.		D. Schaffer	1956		Monazite and uranium minerals in granite pegmatite.
Muskoka	Chaffey	Lot 23, Con. V		Int. Ceramic Mining Co.	1948		Pyrochlore in granite pegmatite.
Nipissing	Butt	Lots 1-3, Con. VI		W. Ryan, R. Mann, D. Sheehan	1921	Ellsworth 1921, p. 65	Allanite in 8′ zoned granite pegmatite dike.
		Lot 4, Con. VI		Napoleon Dault	1921	Ellsworth 1921, p. 64	Allanite in lens shaped zoned granite pegmatite 6′ wide.
		Lot 10, Con. VI		F. Watson	1921	Ellsworth 1921, p. 64	Allanite in granite pegmatite 2′ wide.
		Lot 11, Con. VII		A. E. Trafford	1921	Ellsworth 1921, p. 63	Allanite & radioactives in 8-10′ granite pegmatite 70′ long.
		Lot 13, Con. VII		Wm. Elliot	1919	Ellsworth 1932, p. 187	Allanite, uraninite in muscovite pegmatite.
		Lot 7, Con. IX		C. W. Beaton	1921	Ellsworth 1921, p. 64	Allanite in granite pegmatite 1-2′ wide.
		Lot 8, Con. IX		F. H. Armstrong	1921	Ellsworth 1921, p. 64	Allanite in 3-4′ zoned granite pegmatite dikes 40′ long.
	Calvin	Lot 22, Con. IV				Lang et al 1962, p. 251	Euxenite in granite pegmatite.
		Lots 21, 22, Con. VIII Lots 19-21, Con. X		Molybdenum Corp. of America	1955	Rose 1960, p. 21	Euxenite, columbite in granite pegmatite.
	Dickens	Lot 19, Con. I	Lake	Opeongo Mining Co.	1948-9	Lang et al 1962, p. 258	Monazite in granite pegmatite.
		Lot 27, Con. V		Can. Flint & Spar Co.	1943	Satterly 1944, p. 122	Euxenite, monazite in granite pegmatite.
		Lot 9, Con. XIII				Lang et al 1962, p. 258	Monazite in granite pegmatite.
	Mattawan	Lot 29, Con. II		C. Palangio		Lang et al 1962, p. 268	Euxenite-polycrase in granite pegmatite.
		Lot 29, Con. III		O'Brien & Fowler	1925-6	Rose 1960, p. 28,29	Euxenite in granite pegmatite.
	Murchison	Lots 14, 15, Con. IV	J. G. Gole	J. G. Gole, D. L. Ross	1937-44	Satterly 1944, p. 120	Fergusonite, allanite in granite pegmatite.
		Lot 17, Con. VI		Cameron & Aleck	1949-53		Fergusonite, allanite in granite pegmatite.
		Lot 22, Con. VIII		Wallace B. Cameron		Lang et al 1962, p. 275	Allanite, euxenite in granite pegmatite.
	Peck	Lot 6, Con. III & IV		J. G. McLennan	1956		Pyrochlore in granite pegmatite.
	Sabine	Lots 28, 29, Con. I			1924-25	Lang et al 1962, p. 277	Euxenite in granite pegmatite.
		S½ Lot 32, Con. XV		Galwood Mines Ltd.	1956		Euxenite in granite pegmatite.
Parry Sound	Chapman	Lots 20, 21, Con. I	Macdonald	J. Bell	1948		Allanite in granite pegmatite.
		Lot 3, Con. VIII		W. Raney		Lang et al 1962, p. 256	Pyrochlore and columbite in granite pegmatite.
	Conger	Lots 9 & 10, Con. IX	McQuire			Lang et al 1962, p. 256	Allanite, calciosamarskite, uraninite, thucolite, cyrtolite in pegmatite.
		Lot 7, Con. X	Brignall	McQuire & Robinson	1923-25	Rose 1960, p. 22	Euxenite, monazite, columbite in granite pegmatite.
		Fifteen Mile Island		Atlin Ruffner Mines (BC) Ltd.	1955	Hewitt 1960, p. 186	Allanite in syenite pegmatite.
	Henvey	Lot 3, Con. A	Ambeau	Wanup Feldspar Mines Ltd.	1926-27	Rose 1960, p. 18	Euxenite in granite pegmatite.
		Lot 5, Con. B	Besner	Wanup Feldspar Mines Ltd.	1926-29	Lang et al 1962, p. 248	Allanite, uraninite, cyrtolite, thucolite in granite pegmatite.
	Key Harbour	Dokis Island		C. Lyte			Xenotime in granite pegmatite.
	Monteith	Lot 21, Con. B				Lang et al 1962, p 273	Allanite in pegmatite.
		Wall Island		G. Macbeth	1954		Pyrochlore and uranophane in granite pegmatite.
		Off Sandy Is.		T. W. Keating	1956		Uraninite, allanite, thucolite in granite pegmatite.
Peterborough	Anstruther	Lots 26, 27, Con. I				Lang et al 1962, p. 247	Allanite, melanocerite, uraninite, uranothoirite, zircon in granitic dikes.
		Lots 22-28, Con. III Lots 23-27, Con. IV		Farcroft Mines Ltd.		Satterly 1956, p. 148	Allanite, uraninite, uranothorite in granite pegmatite.
		Lots 2-3, Con. IX		Grey Wolf Exp. Co. Ltd.	1955-6	Satterly 1956, p. 151	Allanite, zircon, uranothorite in leucogranite pegmatite.
		Lots 5, 6, Con. XVIII		Garland Mining & Dev. Co.	1955	Satterly 1956, p. 150	Allanite, uraninite, uranothorite, cyrtolite in granite pegmatite.
	Cavendish	Lot 3, Con. III		Silanco Mining & Ref. Co.	1955	Satterly 1956, p. 167	Fergusonite, zircon, uranothorite in granite pegmatite.
		Lot 16, Con. III		Drude Uranium Mines	1955-6	Satterly 1956, p. 162	Allanite, zircon, uranothorite in leucogranite pegmatite.
		Lot 8, Con. IV		Macfie Explorations Ltd.	1955-56	Satterly 1956, p. 166	Allanite, uranothorite in leucogranite pegmatite.
		Lot 13, Con. VI		Cromwell Ur. & Dev. Co.	1955	Satterly 1956, p. 162	Allanite, zircon, uranothorite in pegmatitic leucogranite.
		S½ Lot 14, Con. VII	Cavendish	Amalgamated Rare Earth Min. Corp.	1954-57	Satterly 1956, p. 159	Allanite, uraninite, uranothorite, thorite, cyrtolite in pegmatitic granite.
		Lot 16, Con. IX		Drude Uranium Mines	1955-56	Satterly 1956, p. 162	Allanite, zircon, uranothorite in leucogranite pegmatite.
		N½ Lot 21, Con. XI		Silanco Mining & Ref. Co.			Allanite zircon, uraninite in pegmatitic granite.
		Lot 24, 25, Con. XIV		Kelbee Rare Metals Corp. Ltd.	1955-56	Satterly 1956, p. 165	Allanite, uraninite, uranothorite, zircon in granitic pegmatite.
	Chandos	S½ Lot 9, Con. XVI		Cons. Uranium Corp. Ltd.	1954	Satterly 1956, p. 170	Allanite, uranothorite, bastnaesite in leucogranite pegmatite.
	Galway	Lots 23, 25, Con. X	Crystal Lake	Silver Crater Mines Ltd.	1955	Satterly 1956, p. 172	Allanite, zircon, thorite, uranothorite in granitic dikes.
Renfrew	Alice	Lot 13, Con. XV		R. McCoshen		Lang et al 1962, p. 136	Euxenite in pegmatite.
	Brudenell	Lot 34, Con. IV				Hewitt 1953, p. 83	Allanite in syenite pigmatite.
		Lot 21, Con. X	Gorman Lake			Hewitt 1953, p. 83	Allanite in granite pegmatite.
	Hagarty	Lot 13, Con. A				Lang et al 1962, p. 262	Allanite in granite pegmatite.
	Horton	Lot 1, Con. III		J. Dempsey, N. Harvey		Lang et al 1962, p. 264	Allanite, uranothorite in pegmatite.
	Lyndoch	Lot 23, Con. XV		Can. Beryllium Mines & Alloys	1926, 1939	Hewitt 1953, p. 36	Euxenite, monazite, columbite in granite pegmatite.
		Lot 25, Con. XV		Universal Light Metals		Hewitt 1953, p. 83	Allanite in pegmatite.
		Lot 30, Con. XV		Can. Beryllium Mines & Alloys	1935-6, 1949	Hewitt 1953, p. 42	Euxenite, beryl, columbite in granite pegmatite.
	Raglan	Lots 3 & 4, Con. XVIII				Lang et al 1962, p. 277	Allanite, euxenite, uraninite in syenite pegmatites.
Sudbury	Dill	Lot 2, Con. II		Cubar Uranium Mines		Lang et al 1962, p. 258	Betafite, euxenite, ellsworthite, pyrochlore in granite pegmatite.
	Servos	Lot 6, Con. VI		Graham L. Mining Synd.		Lang et al 1962, p. 277	Eschynite-priorite in granitic dikes.
Victoria	Dalton	Lot 25, Con. XII				Lang et al 1962, p. 257	Allanite in pegmatite.

ALLANITE

Allanite is a cerium-bearing epidote whose rare earth content may be up to 51 percent. It is monoclinic and frequently occurs in flat tabular crystals or radiating blades. It is often massive. The colour is black to dark-brown; lustre is vitreous to resinous; hardness is 5.5 to 6; and specific gravity 2.7 to 4.2. It is one of the most common rare earth minerals found in Ontario pegmatites.

GADOLINITE

Gadolinite is a silicate of beryllium, iron, and the yttrium group of rare earths. It has been described under beryllium minerals. The rare earth content is up to 49 percent. It is a rare mineral in Ontario pegmatites.

CYRTOLITE

Cyrtolite is a radioactive variety of zircon containing Fe, U, Th and rare earths. Rare earth content is up to 7 percent. Cyrtolite is tetragonal and forms excellent prismatic crystals. It is brown, reddish-brown or black in colour; lustre is glassy to subvitreous; hardness is 7.5; specific gravity is 4.6 to 4.7. Zircon and cyrtolite are common in Ontario granite pegmatites.

XENOTIME

Xenotime is a rare earth phosphate containing principally yttrium and erbium, with minor cerium, thorium, uranium, and iron. The mineral is tetragonal and occurs in prismatic crystals similar to zircon. The colour is yellow-brown, red-brown, brown, pink, yellow, or green. Lustre is resinous; fracture is uneven; (110) cleavage is good; hardness 4 to 5; and specific gravity is 4.4 to 4.6. Xenotime is a rare mineral in Ontario pegmatites, but was found by the author in a pegmatite on Dokis Island in Georgian Bay.

MONAZITE

Monazite is a phosphate of cerium and lanthanum with some thorium and yttrium earths. It occurs in monoclinic crystals whose colours are reddish-brown, brown, or yellow. Lustre is resinous; it has good cleavage and uneven fracture. Its hardness is 5 to 5.5, and its specific gravity is 4.6 to 5.3. Monazite is found in a number of Ontario granite pegmatites and is an ore mineral at the Blind River uranium mines where it is a source of yttrium.

BASTNAESITE

Bastnaesite is a barium, cerium fluo-carbonate, which contains up to 69 percent rare earths. It occurs in hexagonal prismatic crystals with basal parting. It has a yellow to reddish-brown colour; hardness is 4.5; and specific gravity is 4.9. It is a rare mineral in Ontario pegmatites but has been identified at a pegmatite in Chandos township.

Rare Earth Exploration

The uranium deposits of the Blind River and Bancroft areas appear to be good sources of rare earth metals as a by-product of uranium mining. Few of the zoned pegmatite dikes offer economic possibilities. The pyrochlore-bearing carbonatite complexes of northern Ontario also offer good possibilities for the production of niobium and rare earth metals.

At the present time monazite and bastnaesite are the chief world sources of rare earth metals. There are adequate reserves of monazite sands, and the Mountain Pass, California, bastnaesite mine of the Molybdenum Corporation of America is said to contain reserves of over 5 million tons of rare earth oxides.

COLUMBIUM (NIOBIUM)

Columbium occurs in all of the rare earth columbates listed in the previous section and many of these are columbium ore minerals. Among the rare earth columbates of economic interest are pyrochlore, betafite, fergusonite, euxenite, eschynite, and samarskite.

In addition to these minerals, columbite-tantalite and columbian perovskite are also of economic interest. Columbite-tantalite from granite pegmatites was formerly a major source of columbium, but with the development of pyrochlore-bearing alkaline complexes and carbonatites, these are now the main source. Columbium is being produced at Oka, Quebec, from alkaline complexes and large reserves of columbium ores have been proven at Nemegos, Nemegosenda Lake, and Lake Nipissing in Ontario. These, however, are not pegmatite deposits.

Mineralogy

COLUMBITE-TANTALITE

Columbite (Fe,Mn) $(Cb,Ta)_2O_6$
Tantalite (Fe,Mn) $(Ta,Cb)_2O_6$

Columbite and tantalite form a complete solid solution series from the columbian columbite to the tantalan tantalite. These minerals are orthorhombic, and form short prismatic crystals, or often bladed crystals. There is good (010) cleavage; fracture is uneven; hardness is 6 for columbite and 6 to 6.5 for tantalite; specific gravity is 5.2 for columbite and 7.9 for tantalite. The colour is black to brownish-black. Columbite-tantalite frequently occurs in pegmatites.

Uses

The major use for columbium and tantalum is as an alloy for certain types of steel. Columbium is used as a getter and electron emitter in electronic tubes. It is also used as a fuel alloying element in some nuclear reactors.

Ontario Deposits

Ontario pegmatites containing pyrochlore and other rare earth columbates are listed under rare earth pegmatites (Table 28). A list of 8 columbite-bearing pegmatites are given in Table 29.

Table 29 *Composition of principal tantalum-columbium minerals* (after R. H. Jahns 1951)*

MINERAL	SIMPLIFIED FORMULA	THEORETICAL CONTENT OF Ta_2O_5 OR Cb_2O_5, PERCENT	PROPORTION OF Ta_2O_5 OR Cb_2O_5 IN HIGH-GRADE CONCENTRATES, PERCENT
Tantalite**	$(Fe,Mn)Ta_2O_6$	86.12 Ta_2O_5***	>70 Ta_2O_5
Columbite**	$(Fe,Mn)Cb_2O_6$	78.88 Cb_2O_5***	>65 Cb_2O_5
Microlite**	$(Na,Ca)_2Ta_2O_6(O,OH,F)$	>82 Ta_2O_5	>70 Ta_2O_5
Pyrochlore**	$NaCaCb_2O_6F$	73.05 Cb_2O_5	>60 Cb_2O_5
Hatchettolite	$(Na,Ca,U)_2(Ta,Cb)_2O_6(O,OH,F)$	>65 $Ta_2O_5+Cb_2O_5$	>60 $Ta_2O_5+Cb_2O_5$
Samarskite	$(Y,Er,Ce,U,Ca,Fe,Th)(Cb,Ta)_2O_6$	>55 $Cb_2O_5+Ta_2O_5$	>45 $Cb_2O_5+Ta_2O_5$
Tapiolite****	$(Fe,Mn)(Ta,Cb)_2O_6$	86.01 Ta_2O_5	>70 Ta_2O_5
Fergusonite**	$(Y,Er,Ce,Fe)CbO_4$	>54 Cb_2O_5	>50 $Cb_2O_5+Ta_2O_5$
Formanite**	$(Y,Er,Ce,Fe)TaO_4$	>66 Ta_2O_5	
Euxenite*****	$(Y,Ca,Ce,U,Th)(Cb,Ta,Ti)_2O_6$	>55 $Cb_2O_5+Ta_2O_5$	

*Includes minerals of present and potential commercial importance.
**End member of a tantalian-columbian mineral series.
***For material with Fe:Mn ratio of 1:1.
****Tantalum-columbium mineral series that include high-tantalum members but probably no corresponding high-columbium members.
*****General name for members of a columbium-tantalum-titanium mineral series that are relatively rich in Ta and Cb.

Table 30 *Columbite-bearing pegmatites*

County or District	Township	Location	Name of Mine	Operators	Years of Operation	Reference	Descriptive Remarks
Cochrane	Steele	Lot 5, Con. V				Lumbers 1962	Columbite-tantalite in granite pegmatite.
Hastings	Monteagle	Lot 17, Con. VIII	Woodcox		1921-23	Hewitt 1954, p. 50	Columbite in granite pegmatite.
Nipissing	Calvin	Lots 21-22, Con. VIII Lots 19-22 Con. IX		Molybdenum Corp. of America		Rose 1960, p. 21	Columbite, euxenite in granite pegmatite.
Parry Sound	Chapman	Lot 3, Con. VIII		W. Raney Sr.		Lang et al 1962, p. 256	Columbite, pyrochlore in granitic deposit.
	Conger	Lot 7, Con. X	Brignall	McQuire & Robinson	1923-25	Lang et al 1962, p. 257	Euxenite, columbite, monazite in granite pegmatite.
Renfrew	Lyndoch	Lot 23, Con. XV		Can. Beryllium Mines & Alloys		Hewitt 1953, p. 36	Columbite in granite pegmatite.
		Lot 30, Con. XV		Can. Beryllium Mines & Alloys	1935-36, 1939	Hewitt 1953, p. 42	Columbite in granite pegmatite.
Sudbury	Whalen			Redore Mining Co.	1940		Columbite-tantalite reported in granite pegmatite.

MOLYBDENUM

Thirty-four molybdenite-bearing pegmatites are listed in Table 31. Thirteen of these pegmatites have produced molybdenite, the largest producer being the Zenith mine in Renfrew county.

Mineralogy

MOLYBDENITE

Molybdenite is the principal ore mineral of molybdenum. It contains approximately 60 percent Mo and 40 percent S. Molybdenite is hexagonal and the crystals are tabular in shape; generally it occurs massive, foliated or in flakes. The colour is blue-grey; the lustre is metallic; hardness is 1 to 1.5; specific gravity 4.7 to 4.8. It has excellent basal cleavage with flexible laminae. It is sectile.

Occurrence

Molybdenite is one of the more common sulphide minerals found in pegmatites. It is especially prevalent in granite pegmatites in Haliburton and Renfrew counties where a number of small mines have been opened. The grade of ore is usually erratic and no substantial production has resulted.

Uses

The principal use of molybdenum is in alloy steels. Molybdenum is added to cast iron to improve its tensile and impact strength. It is used in the electrical industry.

Table 31 — *Ontario molybdenite-bearing pegmatites*

County or District	Township	Location	Name of Mine	Operators or Owners	Years of Operation	Approximate Production	Reference	Descriptive Remarks
Algoma		Molybdenite Lake					Vokes 1963, p. 81	Molybdenite in coarse grained quartz rich pegmatite.
Frontenac	Hinchinbrooke	Lot 26, Con. VIII		S. Sills			Harding 1947, p. 90	Molybdenite in pink granite pegmatite.
		Lot 18, Con. X		H. Drader			Harding 1947, p. 90	Molybdenite in pegmatite lens of mineralogical interest only.
	Kennebec	Lots 14&15, Con. I					Harding 1942, p. 74	Molybdenite in quartz lenses in pegmatite.
Haliburton	Cardiff	Lot 11, Con. V	Orr-Kidd		1914-15	50 pounds	Satterly 1943, p. 60	Large molybdenite flakes in pegmatite.
		Lot 6, Con. IX	Powell-Anderson				Satterly 1943, p. 61	Two parallel pegmatite dikes with molybdenite.
		Lot 18, Con. IX		Paudash Lake Molybdenite Mines Ltd.	1917	Several tons	Satterly 1943, p. 61	Large molybdenite flakes in coarse pegmatite.
		Lot 14, Con. X		Brough Lake Molybdenite Ltd.	1937		Satterly 1943, p. 61	Molybdenite in pegmatite.
		Lot 12, Con. XI	Mathews-McMahon		1915	60 pounds	Satterly 1943, p. 63	50 foot pegmatite carries molybdenite.
		Lot 27, Con. XI	Dixon				Satterly 1943, p. 63	2 foot sill of pink pegmatite with molybdenite.
		Lot 3, Con. XX	Joiner	Cardiff Molybdenite Mines Ltd., Ventures Ltd., Shallberg Mo. Co.	1917, 1920, 1935-6	30 tons	Satterly 1943, p. 63	Molybdenite in syenite pegmatite.
	Monmouth	Lot 14, Con. XII	Lillico	Ontario Molybdenum Co. Ltd.	1917-18	157 tons	Satterly 1943, p. 66	Molybdenite in tourmaline pegmatite.
		Lot 11, Con. XV	Padwell	Canadian Molybdenite Mines Ltd.	1916, 1940	118 tons	Satterly 1943, p. 67	Molybdenite in rusty pegmatite.
Kenora		Upper Manitou L.	Pidgeon		1920	200 pounds	Vokes 1963, p. 72	Molybdenite and bismuthinite in granite pegmatite.
	Echo			Pidgeon Molybdenum Mines Ltd.	1957		Vokes 1963, p. 73	Molybdenite in quartz pegmatites.
Renfrew	Admaston	Lot 8, Con. XIII		M. P. Kiley			Satterly 1944, p. 71	3 foot dike of rusty pegmatite carries molybdenite.
	Bagot	Lot 28, Con. IV	Zenith	Zenith Molybdenite Corp. Ltd.	1914-17, 1924-37, 1942	8660 tons	Satterly 1944, p. 73	Molybdenite in granite pegmatite.
		Lot 29, Con. IV		Bagot Mo. Mining Syndicate Ltd.	1939		Satterly 1944, p. 75	Molybdenite in granite pegmatite.
		Lot 11, Con. V					Satterly 1944, p. 76	Molybdenite in pegmatite stringers.
		Lot 15, Con. X		S. Hunter	1890	100 pounds	Satterly 1944, p. 76	Pink pegmatite with molybdenite.
	Brougham	Lot 15, Con. XI		J. Charron	1910 to 1916		Satterly 1944, p. 79	Molybdenite in rusty granite pegmatite.
	Burns	S½ Lot 13, Con. II		J. Brotton	1940		Satterly 1944, p. 82	Scattered molybdenite in pegmatite.
	Grattan	Lot 11, Con. XI		J. Wren	1918		Satterly 1944, p. 82	Minor molybdenite in pegmatite.
	Griffith	Lot 31, Con. IV	Spain	N. American Molybdenum Corp.	1912, 1918-19, 1939-40	105 tons	Satterly 1944, p. 83	Molybdenite in pegmatite and pyroxenite.
	Lyndoch	S½ Lot 34, Con. II	McCoy	McCoy Molybdenite Ltd.	1917, 1937-38	10 tons	Satterly 1944, p. 84	Molybdenite in syenite pegmatite.
		Lot 4, Con. VIII					Hewitt 1953, p. 74	Molybdenite in pegmatite.
	Raglan	Lot 27, Con. IX&X		Edgemont Molybdenite Mines Ltd.	1939-42	27 tons	Hewitt 1953, p. 76	Molybdenite in graphic granite pegmatite.
	Ross	Lot 22, Con. II	Rose	Maple Leaf Exploration Co.	1916-17	18 tons	Satterly 1944, p. 87	1 to 3 inch molybdenite in granite pegmatite.
	Sebastopol	Lots 14&15, Con. II		W. Felhaber			Satterly 1944, p. 88	Molybdenite in rusty pegmatite.
Sudbury	Des Rosiers			Jonsmith Mines Ltd.				Molybdenite in pegmatite.
Thunder Bay		Owl Lake	Jackfish-Pritchard				Vokes 1963, p. 81	Plug of granite pegmatite carries molybdenite.
	McTavish	Loon Lake		Lindsay Exploration Co.	1959			Diamond drilling, molybdenite in granite pegmatite 2500' long.
Timiskaming	Bompas		Biederman	Greenlee Mines Ltd.	1939-40		Vokes 1963, p. 85	Quartz-rich pegmatite with molybdenite.
	Terry		Biederman		1908, 1914		Vokes 1963, p. 85	Molybdenite in granite pegmatite.

Table 32 — *Tin-bearing pegmatites*

County or District	Township	Location	Name of Mine	Operators	Years of Operation	Reference	Descriptive Remarks
Sudbury	Whalen			Redore Mining Co.	1940		Cassiterite reported but not definitely confirmed in granite pegmatite.
Thunder Bay		Linklater Lake		San Antonio Gold Mines	1948		Cassiterite in aplite to pegmatite dikes.
		Georgia Lake	MNW deposit	Cons. Min. & Smelting Co.	1956		Cassiterite in granite pegmatite, minor occurrence only.

TIN

Three cassiterite-bearing pegmatites have been recorded in Ontario; however, none of these appears to have commercial potentialities (see Table 32).

Mineralogy

The chief tin ore mineral is *cassiterite*. It occurs in short prismatic crystals or massive. Cleavage (100) is good. The colour is yellow, red-brown or brownish-black. Lustre is adamantine. Its hardness is 6 to 7, and specific gravity 6.8 to 7.1. Its composition is SnO_2, with 78.6 percent tin. It is distinguished by its crystal form, hardness, and high specific gravity. A large percentage of tin ore comes from alluvial deposits.

Table 33 *Nepheline pegmatites*

County or District	Township	Location	Name of Mine	Operators	Years of Operation	Reference	Descriptive Remarks
Haliburton	Glamorgan	Lots 32-33, Con. III			1941	Hewitt 1960, p. 42	Nepheline pegmatite with carbonate inclusions.
		Lots 29-31, Con. IV	Fraser	Gooderham Nepheline	1937-38	Hewitt, 1960, p. 39	Produced 3178 tons of nepheline pegmatite.
		Lot 34, Con. IV	Gill	Gooderham Nepheline		Hewitt 1960, p. 41	Produced 6 cars of nepheline pegmatite.
	Monmouth	Lots 10 & 11, Con. VI		Alex McColl	1941	Satterly 1943, p. 75	Nepheline pegmatite.
		Lot 14, Con. VI	Mackay	F. B. Brower & A. H. Simpson	1941	Satterly 1943, p. 77	Nepheline pegmatite.
Hastings	Dungannon	Lot 12, Con. XI	Golding-Keene	Golding-Keene Co.	1937-39	Hewitt 1960, p. 75	Shipped 11092 tons of nepheline pegmatite.
		Lot 10, Con. XIII	Morrison	Temagami Development Co.	1939-40	Hewitt 1960, p. 76	Shipped 1663 tons of nepheline pegmatite.
		Lot 27, Con. XIII	Robbins	Wm. Robbins		Hewitt 1960, p. 68	Nepheline pegmatite.
		Lot 9, Con. XIV	Davis	Can. Flint & Spar Co.	1940	Hewitt 1960, p. 77	Shipped 944 tons of nepheline pegmatite.

NEPHELINE

Between 1937 and 1941 nine nepheline pegmatites were opened up in Ontario as a source of soda feldspar and nepheline for the glass and ceramic industries (see Table 33). Several thousand tons were shipped from 5 of these properties. In most cases the iron and calcite content was high and shipments were not continued. Production was valued at $171,770.

Most of the nepheline pegmatites are of small size and consist merely of patches of nepheline and albite a few feet in diameter in a matrix of nepheline gneiss. However, some giant nepheline pegmatites measuring 50 to 100 feet wide and several hundred feet in length do occur, in which nepheline and albite crystals, 1 foot to 6 feet or more in diameter, may be found. The Fraser and Gill pegmatites in Glamorgan township, the Mackay pegmatite in Monmouth township, and the Golding-Keene, Morrison, Davis, and Robbins pegmatites in Dungannon township are of the giant type.

These nepheline pegmatites consist primarily of nepheline and albite, with biotite, hornblende, zircon, calcite, apatite, sodalite, cancrinite, magnetite, galena, tourmaline, microcline, and allanite as accessories.

Small irregular patches of pegmatite nepheline and albite are termed xenoblastic patch pegmatites, and are interpreted as replacement pegmatites produced by recrystallization and mobilization (rheomorphism) of the nepheline and albite of the gneisses. They appear to be endogeneous to the nepheline gneiss units and rarely occur elsewhere. Some of the nepheline pegmatites show sharp contacts and intrusive relations with the enclosing nepheline gneisses indicating that some mobilization, migration, and injection took place. The replacement origin of some of these pegmatitic patches is indicated by the sieve textures with relict granoblastic albite grains of the original gneiss in the pegmatitic nepheline.

CORUNDUM

GSC112810J-H2

Photo 8—Corundum crystal. (Photo courtesy of Geological Survey of Canada)

Corundum ranks second only to diamond in hardness and was widely used as an abrasive until it was gradually supplanted by the artificial abrasives, silicon carbide and alundum. During World War II, when there was a pressing demand for grain corundum for snagging wheels used in the production of forgings and castings, and for corundum flour used in grinding optical lenses, this mineral became of strategic importance. The United States has used from 3,000 to 5,000 tons of corundum annually, mainly from South Africa.

During the period from 1900 to 1921 there was a large production of corundum in Ontario from the Craigmont, Burgess and Jewellville mines. There was further production in 1944 to 1946 at Craigmont. Total corundum production was valued at $2,465,409.

Mineralogy

Corundum has the formula Al_2O_3 and consists of 52.9 percent aluminium and 47.1 percent oxygen, together with small amounts of such impurities as silica, iron, lime, magnesia, and water. Corundum occurs in barrel-shaped hexagonal crystals, sometimes tapered at the ends, and in massive subhedral crystalline masses. Corundum found in Ontario may be bronze, brown, greenish-bronze, blue, blue-grey, grey, or white, and often shows zonal structure. Lustre is vitreous to adamantine. Corundum has uneven conchoidal fracture and breaks to form sharp angular fragments; it has excellent basal parting which resembles basal cleavage. On these parting planes, a cross-hatch pattern of striations is often seen. The hardness of corundum is 9, and its specific gravity from 3.95 to 4.10. Emery is granular corundum that is intimately intermixed with magnetite.

Uses

Corundum was formerly widely used for many types of abrasive, but, as noted, the present use of corundum is restricted to specialized uses, such as snagging wheels and optical flour in which it surpasses artificial abrasives. In snagging wheels the natural corundum gives a higher rate of production than artificial abrasive because of the way in which natural corundum grains break down to expose new sharp, angular cutting edges as the wheels wear. Artificial abrasive grains, although tougher, wear down to smooth, rounded edges and lose their bite. For optical grinding, corundum flour is superior for the same reason.

Mode of Occurrence

In Ontario corundum occurs in nepheline and scapolite gneisses, and in the pink and grey alkaline syenites and their pegmatitic equivalents. The main production from Craigmont, Burgess and Jewellville mines came from corundum syenite and corundum syenite pegmatite. At the Klondike cuts, there is considerable corundum in the nepheline syenites and pegmatites, and there was some production from this source. Corundum syenite, in which the corundum occurs in grains ranging from microscopic size up to one inch in diameter, forms narrow bands up to 10 feet wide in the syenitic gneiss sequence. The richest corundum deposits are in syenite pegmatite pods and lenses, which often lie parallel to the gneissosity of the country rock. These corundum pegmatite lenses range from 1 foot to 15 feet wide, and some of the more persistent zones can be traced for 100 feet or more. Corundum crystals range from 1 inch to over 8 inches in diameter. One corundum crystal weighing 60 pounds is reported to have been found at Craigmont by the early manager, H. E. T. Haultain.

The average grade of corundum ore at Craigmont was about 8.5 percent. Recovery was by gravity concentration.

A description of individual corundum deposits may be found in Hewitt (1954).

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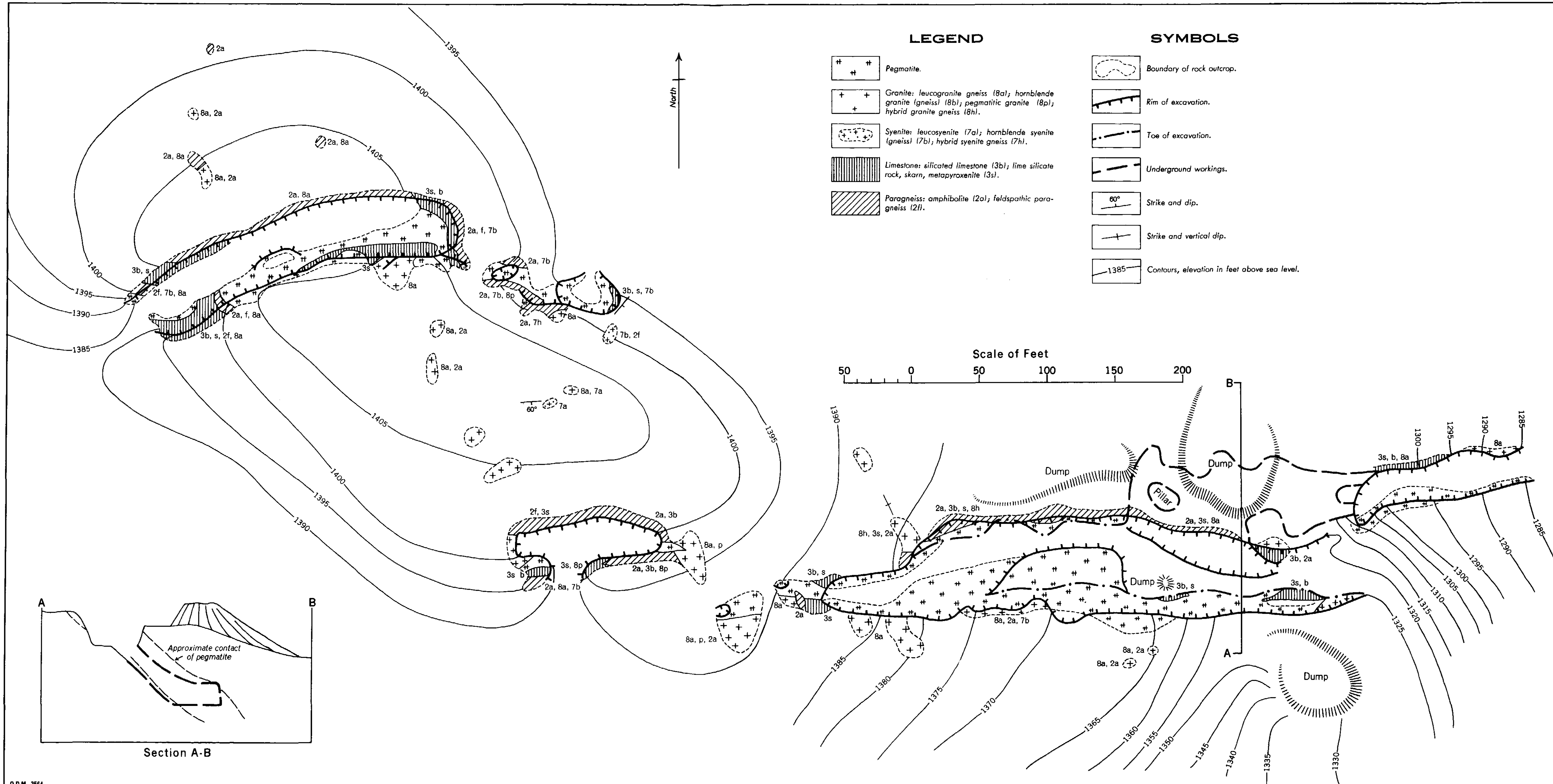

Figure 6—Geological Sketch Map of the MacDonald Feldspar Mine, Monteagle Township.

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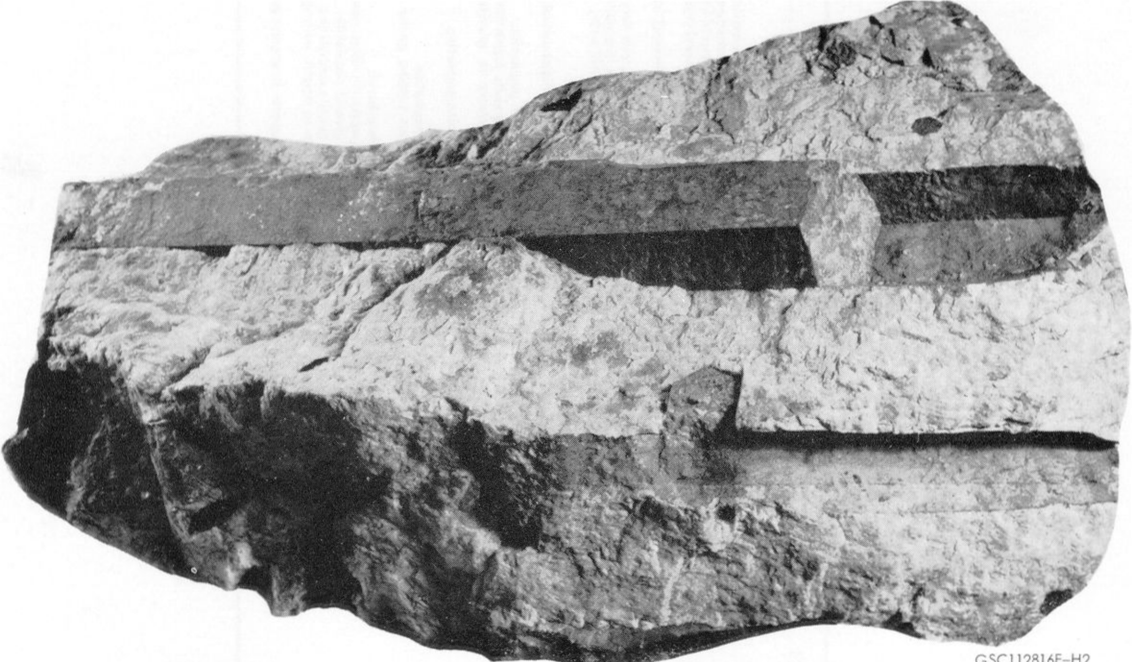

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