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GEOLOGY OF THE ST. AGNES LAKE DISTRICT, ALBERTA

by

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GEOLOGY OF THE ST. AGNES LAKE DISTRICT, ALBERTA

Abstract

The geology of a 74 square-mile area in the Precambrian Shield of northeastern Alberta is shown on a colored map of scale 2 inches to 1 mile.

The western part of the map-area is underlain by a granite gneiss complex containing bands and patches of high-grade metasedimentary rocks; the eastern part is underlain by a group of porphyroblastic biotite granites with massive biotite and leucocratic granites. Ten rock types are described with regard to hand specimen characteristics, field occurrence, contact relations, and chemical and modal analyses.

Schistosity and foliation are well developed in most of the rock-units, and small-scale folds and shear zones are common. A system of north-northwest-trending faults cut the prevailing northerly strike of the major rock units.

INTRODUCTION

General Statement

This publication constitutes part of a series of reports and maps dealing with the geology of a portion of the Precambrian Shield in northeastern Alberta, north of Lake Athabasca.

This report and accompanying map present preliminary information on the general geology and on mineralization in the district of St. Agnes Lake. Field aspects of the geology are emphasized, and mention of laboratory studies is made only where it has a bearing on the field geology as in mineral identification or rock classification.

Considerable use is made of vertical aerial photographs in present-day methods of prospecting, exploration, and geological mapping. Two complete sets covering the study area are available, both on a scale of 1:40,000. The more recent set of photographs (1955) can be obtained from the National Air Photographic Library, Topographic Survey, Ottawa, Ontario. Another set of photographs (1949) is available from the Technical Division, Department of Lands and Forests, Government of Alberta, Edmonton, Alberta.

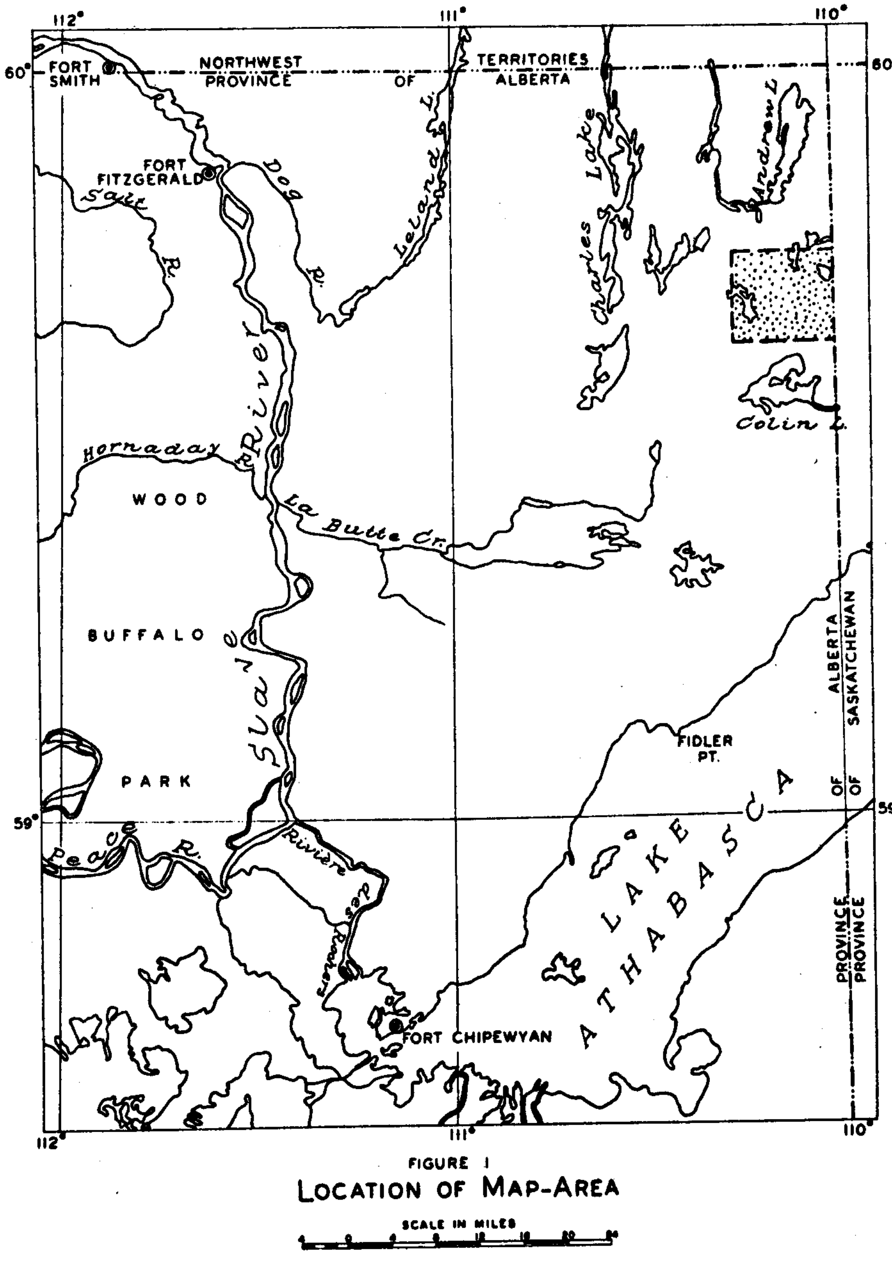

FIGURE 1

LOCATION OF MAP-AREA

Location and Access of District

The St. Agnes Lake district is situated in northeast Alberta, adjoining the Province of Saskatchewan to the east (Fig. 1). It lies between longitudes 110 degrees and 110 degrees 15 minutes west, and between latitudes 59 degrees 37 minutes 30 seconds and 59 degrees 45 minutes north.

Uranium City, Saskatchewan, is situated 45 miles east of St. Agnes Lake, and has regularly scheduled commercial airline flights from and to Edmonton, Alberta, via Fort Smith. Pontoon-equipped planes may be chartered from either Uranium City or Fort Smith into the map-area, where many scattered lakes are suitable for landing these craft.

St. Agnes Lake is 26 miles north of Lake Athabasca, the nearest commercially utilized water route. Tugs and barges of the Northern Transportation Co. Ltd. operate along this route from Fort McMurray, Alberta, to supply settlements towards the east end of Lake Athabasca, principally Uranium City, Fond du Lac, and Stony Rapids, Saskatchewan.

Physiography

The peneplained surface of the area is typical of the Precambrian Shield where Pleistocene glacial scouring has left numerous rock-basin lakes, low rounded hills, and a locally rugged surface with a maximum relief of about 250 feet. Striae and giant glacial grooves are the most obvious ice-erosional features. The general elevation is from 1,000 to 1,250 feet above sea level. More than two thirds of the land surface of the map-area is bedrock with a small proportion of muskeg. Sandy plains of glacial origin, such as on the east side of St. Agnes Lake, have few low bushes and present an open parkland-type appearance. The lakes are mainly either disconnected or poorly connected, and cross-country canoe travel involves portaging. The principal drainage is southeast through Colin Lake to Lake Athabasca.

The distribution and shapes of lakes are controlled by factors of structure and lithology with modification by ice erosion. Narrow elongate bays are associated with the erosion of fault zones and straight shorelines suggest faultline features. Fractured zones or structurally weak rocks have been plucked out by ice erosion, particularly on the west and southwest lake-shores, giving rise to irregular shorelines. At one or two localities exceptionally clean, fresh, water-washed, bedrock surfaces form low, wide aprons bordering rock-basin lakes.

Previous Work

Tyrrell (1896) made the initial canoe traverse along the north shore of Lake Athabasca in 1892 and 1893 and was followed by Alcock (1915, 1917). In 1929 and 1930 Cameron and Hicks (Cameron, 1930; Cameron and Hicks, 1931; Hicks, 1930, 1932) conducted a reconnaissance survey of the Shield area north of Lake Athabasca, though none of their canoe traverses passed through the map-area.

After gold was discovered at Goldfields, Saskatchewan, Alcock mapped the Precambrian Shield in the northwest Saskatchewan, including the district to the east of St. Agnes Lake, on a scale of 1 inch to 4 miles (Alcock, 1936). Mapping of the Fort Smith, N.W.T., area, which adjoins Alberta to the north, was completed by Wilson in 1938 (Wilson, 1941), on a scale of 1 inch to 4 miles.

Uranium prospecting activities spread to the Precambrian Shield of Alberta from Saskatchewan, and in 1953 Collins and Swan (1954) spent several weeks examining mineralization in the northeast corner of the province. Low-grade uranium mineralization only was found in the course of this period of prospecting and exploratory activity (e.g. Ferguson, 1953).

In 1959 the Geological Survey of Canada carried out a reconnaissance survey of the Precambrian Shield in Alberta north of Lake Athabasca and published a map on a scale of 1 inch to 4 miles, with marginal notes (Riley, 1960).

In 1960, 1961 and 1962, the Saskatchewan Department of Mineral Resources conducted a mapping program on a scale of 1 inch to 1 mile in an area northeast and east of the St. Agnes Lake district (Koster, 1961).

The geology of the two map-areas north of the St. Agnes Lake district has been previously described (Godfrey, 1961, 1963).

Present Study

The map-area (74 square miles) covered in this report was examined during the field season of 1958.

The accompanying map (62-1A) is based on parallel pace and compass traverses generally spaced at one-quarter to one-third mile intervals. Anomalous compass readings were noted in places, mainly in the vicinity of hornblende granite gneisses and amphibolites. Magnetite concentrations somewhat above those in the surrounding rocks account for some of these magnetic anomalies. The regional structures and distribution of rock groups as indicated on map 62-1A show a clear correlation with the pattern of magnetic anomalies and contours on an aeromagnetic map of the Geological Survey of Canada (1958). Both porphyroblastic biotite granites, and massive biotite and leucocratic granites have a uniform low aeromagnetic response, whereas granite gneiss and metasedimentary rocks have a linear ridge and valley aeromagnetic contour pattern, the latter of low relief and the former of high relief. Regional faults such as the Bonny fault have a low aeromagnetic response which contrasts with the response from rocks of the granite gneiss terrain.

Acknowledgments

The field party was composed of J. M. McLelland, E. W. Peikert, D. Clements, R. Jull, J. G. Tansey, and G. P. Wysocki.

The helpful cooperation of the staff and pilots of McMurray Air Service Ltd. contributed greatly towards an effective field operation.

GENERAL GEOLOGY

The St. Agnes Lake district is underlain by Precambrian[1] igneous, metamorphic, and sedimentary rocks that owe many of their present characteristics to an extensive history of metamorphism and deformation.

The map-area consists of two approximately equal, contrasting parts: a granite gneiss complex underlies the western portion of the area and porphyroblastic biotite granites the eastern portion. These rock divisions are part of northerly trending bands many miles in length (Riley, 1960). The contact between the two divisions is irregular in this map-area with a large "embayment" of porphyroblastic biotite granites extending into the granite gneiss terrain near Lister Lake, and an isolated mass of granite gneiss dividing the porphyroblastic biotite granite band in the vicinity of Governor Lake. Massive granitic rocks are present in all parts of the map-area, but the largest and most abundant bodies lie in the northern one third of the area. The regional foliation strikes north 0 to 30 degrees east, but complicated folding near St. Agnes and Lister Lakes has produced many local attitudes that do not conform to the regional strike. The areas underlain by the principal rock groups, their constituent rock types, and the general field associations of the rock types are summarised in table 1.

The major faults are concentrated in the relatively homogeneous band of porphyroblastic biotite granites. The predominant series of faults

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[1] The potassium-argon dates of biotite and muscovite from several of the principal rock types in this and adjoining map-areas are 1.8 billion years (Godfrey and Baadsgaard, 1962).

Table 1. Principal Rock Groups, Constituent Rock Types, and their Field Associations

<table>
<tr><th>Granite gneiss (17.5%)*</th><th>Metasedimentary and associated rocks (1.0%)</th><th>Massive to foliated granites and pegmatites (7.5%)</th><th>Porphyroblastic biotite granites (38.5%)</th></tr>
<tr><td rowspan="3">Biotite granite gneiss

Hornblende granite gneiss</td><td rowspan="2">Quartzite

Biotite schist</td><td>Sheared leucocratic granite</td><td>Biotite granite C

Gneissic biotite granite C

Biotite granite D

Gneissic biotite granite D

Quartz diorite</td></tr>
<tr><td colspan="2">Leucocratic granite - - - - - - -</td></tr>
<tr><td colspan="3">- - - - - - - - - - Muscovite granite and pegmatite - - - - - - - - -</td></tr>
<tr><td colspan="4">- - - - - - - - - - - - - - - - - Massive biotite granite, biotite 'p' granite and granite pegmatite - - - - -</td></tr>
<tr><td colspan="4">- - - - - - - - Amphibolite** -</td></tr>
</table>

* Per cent outcrop of total map-area.

** Outcrop area included with each rock group as appropriate.

trending north 15 to 30 degrees west are connected by short easterly trending cross faults. Faults striking north 15 to 20 degrees east are present north of Weekes Lake, and faults striking north 70 to 90 degrees west are prevalent near Governor Lake. Shear and mylonitic zones are common in the homogeneous rocks, but plastic flow structures are prevalent in the areas of granite gneiss and gneissic porphyroblastic biotite granites C and D.

Geological History

Following is a tentative outline of the geological history of the area. The well-defined granite gneiss complex was developed initially, consisting of biotite and hornblende granite gneisses with associated high-grade metasedimentary rocks and amphibolite. The original materials were probably sedimentary and volcanic rocks transformed into granite gneisses during extensive and perhaps repeated periods of metamorphism. The still recognizable metasedimentary rocks and some of the amphibolites represent materials that have survived the transformation to granite gneiss, either because of their structural position, their chemical composition, or the late time of their incorporation into the granite gneiss terrain.

The large band of relatively homogeneous porphyroblastic biotite granites overlies the granite gneiss complex. These rocks have been shown to be metamorphic equivalents of highly deformed, low-grade metasedimentary and metavolcanic rocks in the Waugh Lake area (Peikert, 1961; Godfrey, 1963). The rocks of the Waugh Lake area probably represent a sedimentary and volcanic cycle much younger than that represented by the high-grade metasedimentary rocks in the granite gneiss complex. The impure quartzitic rocks and the abundance of volcanic material in the Waugh Lake band suggest geosynclinal sedimentation. Both the granite gneiss complex and the porphyroblastic biotite granites are cut by massive to slightly foliated granite and pegmatite of varied size, shape, and texture. In addition, two large amphibolite bodies and a number of small basic dykes cut the porphyroblastic biotite granites. Faulting, with the associated development of breccias, mylonites, shear zones, and hydrothermal alteration zones, postdates the formation of all rock types.

Rock-Type Classification

Some aspects of the field geology have necessitated the use of certain techniques in the map presentation. For example, the definition of some lithologic boundaries is not always clear in view of serial changes in mineralogy and texture between some rock types. In this case an arbitrary "boundary" within the gradation was chosen, and is represented by the gradational boundary symbol. In addition, metamorphism, intrusion, and deformation have resulted in mixed rock assemblages in much of the area. In such cases only the predominant rock type is shown on the map. Many small rock bodies are indicated as lenses and though this is their predominant shape, their representation is diagrammatic rather than precise in actual dimensions.

To assist in the definition of individual map-units, chemical and modal analyses were made of certain hand specimens called "standard reference samples" selected from the major rock-units, and these are given in table 3; their locations are indicated on the accompanying map 62-1A.

The density of foliation, gneissosity, and schistosity data permits ready extrapolation between adjacent field traverses to provide continuous structural lines; the interpreted structural forms represented on the map are conservative in their complexity. The density of foliation lines on map 62-1A can be used as a rough measure of the degree of foliation in a particular rock type or rock body.

MAP-UNITS

Metasedimentary and Associated Rocks

Most of the metasedimentary rocks in the St. Agnes Lake district form part of the granite gneiss complex; however, because of their distinct lithology and for conformity with previous usage (Godfrey, 19[illegible] 1963), they are presented as a separate group.

Bands of metasedimentary rocks from a few feet up to one-half mile wide are scattered throughout the granite gneiss complex. Similar-appearing rocks also form small (up to 50 feet wide) lenses in the porphyroblastic biotite granites near their contact with granite gneiss. As indicated in table 1, metasedimentary rocks make up one per cent of the outcrop area, but because they are the least resistant to erosion, they may underlie a larger percentage of the unexposed areas. The widest metasedimentary bands are located at the south edge, north edge, and northwest corner of the map-area, and another major band appears to underlie the west portion of St. Agnes Lake where metasedimentary rocks are exposed in scattered islands (Secs. 11, 14, Tp. 123, R. 2). The metasedimentary bands are lenticular and pinch out rapidly along strike.

The metasedimentary rocks have a banding produced by interlayering of contrasting rock types that is interpreted as relict sedimentary structure. These layers, typically of alternating quartzite and biotite schist or phyllite, are laterally persistent although not of great thickness (most commonly from 1/2 to 4 inches).

Each major band of metasedimentary rocks is a mixture of rock types generally including pure to impure quartzite, biotite schist and phyllite, minor sericite schist, phyllonite, hornblende schist, and amphibolite as primary constituents, and variable amounts of feldspar megacrysts, pegmatite, granite, microgranite, and milky quartz as late-formed constituents.

Granitic constituents generally comprise up to 50 per cent of the metasedimentary bands. Metamorphic feldspar is present as small, disseminated crystals, as augen from 1/4 to 1/2 inch in length, and as feldspathic stringers and pegmatites crudely parallel to foliation in the enclosing rocks. Pegmatites with quartz-feldspar intergrowths up to four inches in length are common and are indicated on the map where especially abundant. They are present as patches and bodies of irregular shape with dimensions of a few inches to 100 feet or more. Contacts of these bodies with the metasedimentary rocks are irregular in outline, but are commonly sharp.

Granite dykes and stringers and milky quartz lenses and veins are present in smaller amounts and as more regularly shaped bodies, commonly with straight sides and sharp contacts. In the metasedimentary rocks east of St. Agnes Lake a number of small, lenticular basic concentrations are found, 2 inches to 3 feet in length, and composed essentially of light to dark green amphibole, or pyroxene or both. Their occurrence is restricted to the metasedimentary rocks.

Internal structures in the metasedimentary bands exhibit features commonly associated with plastic flow - small folds and crenulations ranging from 1 to 2 inches to several feet in amplitude - but more pronounced and smaller in scale than those in the surrounding granite gneiss. Bands rich in granitic materials have a migmatitic structure. Structures associated with the deformation of brittle rocks, such as fracture cleavage, are uncommon in the metasedimentary rocks.

Contacts of metasedimentary rocks with other rock types are gradational and concordant except those with younger massive granitic rocks. Many contacts are unexposed because of the soft nature of the metasedimentary rocks. A typical contact with granite gneiss is exposed west of Lister Lake (Sec. 30, Tp. 123, R. 1, southernmost of the three metasedimentary lenses) where a band of impure quartzite and feldspathic biotite schist grades through a transition zone of alternating 1/4- to 1-inch wide bands of biotite schist and feldspathic pegmatite into granite gneiss in 25 feet across strike. Away from the metasedimentary band the biotite schist layers are disrupted to form discontinuous lenses, and the pegmatite layers are reduced in grain size as the rock grades to a typical granite gneiss. Other contact zones range from 1 to more than 100 feet in width.

The same band of metasedimentary rocks west of Lister Lake grades in the opposite direction into porphyroblastic biotite granite C within a distance of 250 feet across strike. In this gradation, first, one-quarter of an inch feldspar porphyroblasts are present in discrete bands in the metasedimentary rocks, then the porphyroblasts are distributed throughout the rocks, but contorted banding is still discernible. With the disappearance of banding the rock is classed as porphyroblastic biotite granite C. A similar contact was observed southwest of Hair Lake (Sec. 16, Tp. 123, R. 1).

The presence of small amounts of garnet in some metasedimentary rocks throughout the map-area indicates that they have attained at least the garnet zone, and the presence of microscopic sillimanite and cordierite in a few specimens suggests an even higher grade of metamorphism in some areas.

Quartzite

Metasedimentary rocks are divided into two map-units; where a quartzitic lithology predominates they are mapped as quartzite and where a schistose or phyllitic lithology is prevalent the rocks are mapped as biotite schist. The contacts between these rock units are gradational both parallel and normal to the strike of the foliation and both rocks are present in several of the larger metasedimentary bands.

The pure to impure quartzites are white, grey, green, pink, or blue where fresh with color banding visible in the thicker layers. Weathered surfaces are commonly lighter and may possess a yellowish-brown stain. Less resistant minerals, such as amphibole, pyroxene, or garnet, form pits in weathered surfaces.

The typical impure quartzite contains up to 50 per cent biotite plus feldspar, with minor garnet, amphibole, and pyroxene at some localities. The quartzitic bands north and east of St. Agnes Lake, in particular, are characterized by garnet. North and west of St. Agnes Lake, white quartzite containing small amounts of pale green pyroxene or amphibole or both is present in association with hornblende-bearing schist and granite pegmatite. The quartzites have a fine- to medium-grained, sugary texture with foliation produced by biotite and color banding.

Biotite schist, hornblende schist, and amphibolite are present in minor amounts in the quartzite unit and small amounts of sericite schist and phyllonite are presen. in sheared areas.

Biotite Schist

The typical biotite schist comprising the main rock type of this map-unit is dark brown on fresh surfaces with bands and patches of white feldspar and colorless quartz. Weathered outcrop surfaces are commonly characterized by a yellow to yellowish-brown stain. Though the general appearance of the rock is largely influenced by the biotite which may comprise as little as 30 per cent of the rock the abundant quartz and feldspar are clearly visible. Small amounts of garnet are present in some bands. The biotite schist locally shows mineralogical banding on a minute scale with concentrations of quartzo-feldspathic constituents. The grain size of the biotite schists ranges from fine to medium.

A number of bands of biotite schist with minor granitic constituents present in porphyroblastic biotite granites C and D are very narrow (2 to 30 feet wide) and have only a crude layering. Though these bands are grouped with schists of metasedimentary origin, on lithological grounds they may actually represent sheared and altered porphyroblastic biotite granites or basic dykes. Impure quartzite, amphibolite, sericite schist, and phyllonite are additional rock types present in minor amounts in this map-unit.

The internal structures in the biotite schist are similar to those in the quartzite except that the folds and crenulations tend to have a smaller amplitude.

Porphyroblastic Biotite Granites and Associated Rocks

The eastern portion of the map-area is underlain by a band of foliated porphyroblastic biotite granites[1] that exhibit a high degree of textural and mineralogical uniformity. This rock group underlies 38.5 per cent of the map-area (Table 1).

The presence of feldspar megacrysts in two size ranges, 1/4 to 1/3 inch (plagioclase) and 1 1/2 to 3 inches (microcline), characterizes these rocks. The small megacrysts are present throughout the group, whereas the large megacrysts are confined to the biotite granite D. Although there is some mineralogical gradation between rock types, a change of rock type is indicated by abrupt textural differences. The majority of rocks in the porphyroblastic biotite granite band are foliated, and mineralogical banding is present only in small, restricted areas that have been subject to special conditions of deformation. As shown in table 3 the porphyroblastic biotite granites are more basic in composition than the granite gneiss or massive granites. The average content of mafic minerals (biotite, hornblende, and chlorite) ranges from 15 to 30 per cent for the various rock types in this group. Members of the younger massive granitic rock group are more restricted in type and volume within the porphyroblastic biotite

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1 In order to emphasize the common textural characters which embrace the genetically related members of the porphyroblastic biotite granite group, it has been necessary to include rock types which do not conform to the strict petrographic definition of the term "granite". Thus, the porphyroblastic biotite granite group includes biotite granites C and D, the gneissic equivalents, and the quartz diorite. Precise petrological nomenclature for these rock types is used in the section dealing with chemical and modal analyses.

granite band than in the granite gneiss; rocks of undoubted sedimentary origin are absent, and the few small amphibolite bodies are highly sheared.

Table 1 shows the rock types in the porphyroblastic biotite granite band within this map-area. Additional members of this group are recognized in the extensions of the band on adjacent map sheets both to the north and to the south. A summary of petrographic properties of all granitic and pegmatitic rock types present in the map-area is given in table 2. The contact between quartz diorite and biotite granite C is marked by the presence of abundant visible (5 to 7 per cent) hornblende in the former, which is still subordinate to biotite. The first appearance of microcline megacrysts in biotite granite D marks its contact with biotite granite C. This contact can be accurately placed traversing across strike because the megacrysts attain considerable abundance (10 to 15 per cent) within 50 to 100 feet of their first appearance. Gneissic porphyroblastic biotite granites C and D are distinguished from the normal types by mineralogical banding and by their complex structure. The gradation from the normal porphyroblastic biotite granites to the gneissic phases takes place over hundreds of feet and the contacts are appropriately indicated on the map. Chemical and modal analyses of these rock types are shown in table 3.

Several large bodies of massive granitic rock are located at the boundaries of the band of porphyroblastic biotite granites, and the largest bodies within the band are located in the gneissic parts of biotite granites C and D. Elsewhere in the porphyroblastic band, massive granite is commonly present in intersecting dykes from 3 inches to 6 feet wide and as small irregularly shaped bodies. The contacts of these younger massive granitic rocks with the porphyroblastic biotite granites are typically sharp with little mineralogical or textural similarity between them; the following features were observed at a few localities: (1) the foliation, where present on each side of the contact, is parallel, (2) the presence of feldspar porphyroblasts both granite and country rock, (3) concentrations of large feldspars merging to form pegmatites, and (4) dilation of earlier dykes by later ones. These relations suggest diverse origins and ages of formation for individual dykes, even though they may be of similar textural and mineralogical character.

The presence of small basic lenses composed primarily of biotite and feldspar in equal amounts is restricted to the porphyroblastic biotite granites. These lenses range from 1/2 inch to 3 feet in length and are parallel to the foliation of the country rock. They are generally fine grained, but locally contain a few, white porphyroblasts, commonly from 1/4 to 1/2 inches in length and more rarely up to 2 inches. These lenses are present in many outcrops in the eastern part of the area, but except in the quartz diorite are less common in the western portion of the porphyroblastic biotite granite band.

The major contact of porphyroblastic biotite granite with granite gneiss and contacts with the younger massive granitic rocks are discussed

Table 2. Systematized Description of Petrographic Properties of the Porphyroblastic Biotite Granite, and Massive Granite and Pegmatite Groups

Rock Unit		Color	Texture	Composition[1] Porphyroblasts[2]	Matrix
Biotite granite C		porphyroblasts: white to grey matrix: medium grey	porphyroblastic (1/4 to 1/2"), foliated, fine to medium grained	plagioclase (40 to 65%)	quartz, biotite, plagioclase, minor microcline, epidote, hornblende.
Gneissic biotite granite C		porphyroblasts: white to grey general: light to medium grey	gneissic, porphyroblastic (1/4 to 1/2"), fine to medium grained	plagioclase (20 to 45%)	quartz, biotite, plagioclase, minor microcline, epidote, hornblende.
Biotite granite D		porphyroblasts: grey to pink matrix: medium to light grey	porphyroblastic (1 1/2 to 3"), foliated to massive, medium to coarse grained	microcline perthite (35 to 55%)	quartz, biotite, plagioclase, minor hornblende, epidote, microcline.
Gneissic biotite granite D		porphyroblasts: grey to pink general: medium to light grey	gneissic, porphyroblastic (1 1/2 to 3"), medium to coarse grained	microcline perthite (15 to 40%)	quartz, biotite, plagioclase, minor hornblende, epidote, microcline.
Quartz diorite		porphyroblasts: white to pink matrix: medium to dark green-grey	porphyroblastic (1/4 to 3/4"), foliated, medium grained	plagioclase (30 to 50%)	quartz, plagioclase, biotite, hornblende, minor epidote.
Massive granite	equigranular biotite phase	pink to reddish	massive, equigranular, typically medium grained	none	quartz, microcline, perthite, plagioclase, biotite, minor muscovite, chlorite, locally garnet, hornblende.
	muscovite phase	white to light grey	massive, equigranular, medium to coarse grained	none	quartz, perthite, plagioclase, muscovite, minor biotite, chlorite, locally garnet.
	biotite 'p' phase	pink to reddish to grey	massive, medium grained, porphyroblastic (1/4 to 1/3")	microcline, perthite (25 to 55%)	quartz, plagioclase, microcline perthite, biotite, minor chlorite, muscovite.
Pegmatite	equigranular granite phase	pink to red	massive, equigranular, coarse grained	none	quartz, microcline perthite, plagioclase, minor biotite, chlorite.
	muscovite phase	white to light grey	massive, equigranular, very coarse grained	none	quartz, plagioclase, microcline, muscovite, locally garnet.
Leucocratic granite		pink	massive, fine to medium grained	none	quartz, microcline perthite, plagioclase.
Sheared leucocratic granite		light grey to pink	foliated, crushed, equigranular, fine to medium grained	none	quartz, microcline perthite, plagioclase, minor sericite, biotite, chlorite.

1 It has been found that color is not a reliable guide for the identification of feldspars in the field and reporting of a specific feldspar indicates that laboratory studies have been made.

2 Percentages refer to amount of porphyroblasts in rock.

under their respective headings.

Detailed study of field and laboratory evidence (Peikert, 1961) has shown that the porphyroblastic biotite granites have developed from a mixed assemblage of metasedimentary and metavolcanic rocks similar to those at Waugh Lake, four miles to the north of the map-area. Extensive recrystallization and homogenization under conditions of medium- to high-grade metamorphism were involved in this transformation.

The gneissic biotite granites C and D have clear textural and mineralogical affiliations with porphyroblastic biotite granites C and D, but have large- and small-scale plastic deformation structures closely allied to those of the granite gneiss terrain. Gneissic porphyroblastic biotite granites C and D are phases of granites C and D in which mineralogical banding, considerable plastic deformation, and emplacement of massive biotite granites have taken place. These features of migmatization indicate a formational environment compatible with that of the granite gneiss terrain, and it seems likely that the gneissic phases represent basal biotite granites C and D which rest on the granite gneiss complex. A close field association of gneissic biotite granites C and D with granite gneiss is evident from the map, and their similar structural forms and characteristics suggest a common origin and age of their deformations. Massive biotite granites within granites C and D are found mainly close to the granite gneiss. This relationship suggests that massive biotite granites either are derived directly from the intensely metamorphosed granite gneiss terrain or are generated as a result of metamorphism in the contact zone.

It may be significant that at a number of places biotite granite C lies between biotite granite D and the underlying granite gneiss. An original stratigraphic relationship may be implied here where primary biotite granite C materials were laid down closer to the older granite gneiss and grade outwards into the biotite granite D lithology. To the south, quartz diorite interfingers with the biotite granite C and it may have been a stratigraphic equivalent.

Biotite Granite C

Its major development is east of Cherry Lake and in the vicinity of Governor Lake, but it is present as narrow bands at scattered localities along the gneiss-porphyroblastic biotite granite contact. A few lenses are also present in biotite granite D and in phases of the massive biotite granite.

A general petrographic description is listed in table 2, and in addition it should be noted that dispersed subhedral to anhedral, tabular, white feldspar megacrysts are normally prominent on weathered surfaces.

Younger massive granites and pegmatites make up large percentages of some outcrops and comprise approximately 10 per cent of biotite granite C. Pink, quartz-feldspar pegmatite is most abundant and is present in tabular bodies ranging from a few inches to 100 feet in width, which commonly cut the foliation in the country rock at small angles. A number of these pegmatite bodies west of Cherry Lake are foliated parallel to their walls. In the northern portion of biotite granite C the pegmatites are muscovite-bearing, whereas toward the south they contain a few flakes and clots of biotite, chlorite, or both. Pink to white, sugary aplite is present in many places, generally appearing to be a textural variation of the pegmatite with which it is associated. Small bodies of massive biotite granite were found mainly in the southern part of the map-area.

The foliation of biotite granite C is a result of deformation prior to recrystallization as indicated by the undeformed nature of individual grains and by the manner in which many of the feldspar megacrysts cut the matrix foliation. Subsequently this rock has been sheared in some places, particularly towards the south edge of the map-area. In outcrops the trends of both the primary foliation and the secondary shear structures are simple straight lines, but compilation of these trends reveals a number of folds in the primary foliation, particularly east of Governor Lake.

Biotite granite C is typically interlensed with biotite granite D near Cherry Lake. Toward the south these rock types have a simple contact where biotite granite C is always situated between granite gneiss and biotite granite D. Biotite granite C and quartz diorite also have an interlensing relationship which is particularly well shown east of St. Agnes Lake (Sec. 6, 7, Tp. 123, R. 1). However, because of the subtle differences between the biotite granite C and quartz diorite this contact and its geological nature are difficult to determine.

Gneissic Biotite Granite C

North of Governor Lake is a gneissic phase of biotite granite C consisting of sheared biotite granite C but which also contains smaller amounts of microgranite, sheared pegmatite, and a sheared basic rock of biotite and feldspar present in bands from 1/2 inch to 3 feet wide arranged parallel to the foliation, giving the rock a gneissic structure. The rock is plastically deformed in the manner of the granite gneiss with sweeping folds and contortions visible in outcrop.

Several large bodies of massive to slightly foliated granite are present in addition to the large amounts of granitic constituents dispersed in layers throughout the gneissic biotite granite C.

Biotite Granite D

This map-unit is the most abundant of all rock types in the map-area. It makes up the interior part of the band of porphyroblastic biotite granites and extends beyond the boundaries of the map-area to the north, east and south. The rock is strikingly uniform over large areas and textural and mineralogical varieties can be traced through a continuous series of intermediate stages.

The majority of the feldspar megacrysts are oriented with (010) in the plane of foliation and are divided into two fairly equal parts by a Carlsbad twin. The megacrysts have sharp contacts with the matrix, a few are partly surrounded by a selvage of biotite, and many have a rim of fine-grained red feldspar, but as a rule, the blunt ends of the megacrysts cut the matrix foliation. Inclusions of biotite (or chlorite) and quartz are commonly irregularly distributed in the large crystals, but a few megacrysts exhibit zones of inclusions parallel to the crystal faces suggesting distinct stages of growth. The megacrysts are evenly distributed in most outcrops, but show slight concentrations in highly sheared areas. Petrographic evidence indicates that the large crystals are porphyroblasts that have formed at a late stage in the history of the rock. The porphyroblasts are set in a slightly foliated matrix that is essentially biotite granite C but with slightly more quartz and less biotite. Along the same line of argument used for biotite granite C, the foliation in this rock unit is related to a deformation that is primarily prerecrystallization in origin.

Although nearly every type of the younger massive granites is present at some locality within biotite granite D, the most common are leucocratic granite and pegmatite, either of which may contain sericite or muscovite. Small amounts of leucocratic granite are present in many outcrops east of a northerly line drawn through Cherry Lake, with a concentration of small bodies west of Chain Lake.

In a given outcrop of biotite granite D internal structure is expressed as a straight foliation, but compilation of all foliation data shows the presence of many isoclinal folds. Shear zones from 1 to 6 inches wide which cross the foliation at small angles in many outcrops are commonly chloritized. Shearing on an extensive scale has affected the rocks south of the fault which passes beneath Governor Lake where the feldspar porphyroblasts are aligned in the foliation of the schistose matrix.

Gneissic Biotite Granite D

This rock type is found mainly north of Lister Lake; however, minor amounts are also present east of Hair Lake and east of Governor Lake. The same features as gneissic biotite granite C are shown, but in relation to biotite granite D. In the formation of gneissic banding many of the large feldspars have been drawn into augen whereas others have remained undeformed. Outcrops typically exhibit large numbers of small folds with variously oriented axes. The large gneissic mass primarily bounded by the two faults north of Lister Lake may represent a block brought up from a lower level in the crust where plastic deformation was dominant.

Quartz Diorite

West of Governor Lake quartz diorite forms a band which probably represents a mass folded into the granite gneiss. Megacrysts are interlocked in a complex manner to form aggregates of irregular outline and are dispersed in a slightly foliated matrix. The quartz diorite resembles biotite granite C in hand specimen; however, the abundant (5 to 10 per cent) hornblende results in a less pronounced foliation and the interlocking hornblende and feldspar crystals reduces the sharp contrast between megacrysts and matrix as observed in biotite granite C.

Except for bodies large enough to be indicated on the map, granitic rocks comprise only a small percentage of this unit. Granite pegmatite, aplite, and quartz veins are most abundant amongst these materials. Elongate lenses of biotite-feldspar schist, typical of the porphyroblastic biotite granites, are common. Although quartz diorite is more basic than the other types of porphyroblastic biotite granite its close relation to these rocks in the field and its gradual transition to biotite granite C indicate that it is genetically related to this group.

Granite Gneiss

The western portion of the map-area is underlain by granite gneiss which is subdivided into biotite and hornblende varieties. This area also contains amphibolite and metasedimentary rocks as well as younger massive granitic rocks including biotite granite, leucocratic granite, and pegmatite, any of which may contain feldspar megacrysts. Plastic deformation expressed as swirls, ptygmatic folds, and complex contortions is characteristic of much of the granite gneiss terrain. Mixed rock types on a small scale account for great variation in texture and composition both within and between outcrops and this presents difficulties in defining areas of a given rock type. It is therefore emphasized that map-units in this area represent several rock types in mixed assemblages.

The granite gneiss is characterized by distinct alternating 1/4- to 4-inch wide mafic-rich and mafic-poor layers. Generally the mafic bands are sharply defined and laterally continuous, but locally they are only faint, discontinuous lenses. In some outcrops, banding gives way to a general foliation defined by biotite wisps and quartz lenses scattered throughout the rock.

The presence of appreciable visible hornblende (greater than 5 per cent) is used as the field criterion for the distinction of biotite and hornblende granite gneisses shown on the map. In addition, biotite-rich and leucocratic varieties can be recognized but the differences are insufficient to justify separation into distinct map-units. All types of gneiss are completely intergradational in texture and in mineralogy.

As a rule a narrow band of metasedimentary rocks separates granite gneiss and porphyroblastic biotite granites at a major contact. West and south of Lister Lake the foliation in the granite gneiss dips steeply beneath that in the porphyroblastic biotite granites C and D, whereas a shallower dip is suggested by the saddle-like structure north of Governor Lake.

The large bodies of younger massive granite are partially conformable to the structure in the granite gneiss in that the foliation in the gneiss is commonly diverted around these bodies. The margins of these younger granites are sheared parallel to their contacts with the gneiss at several localities north of St. Agnes Lake. Blocks and lenses of granite gneiss are common in the massive granitic rocks, but the borders of these blocks range from sharp to completely gradational. The complicated structural trends in the granite gneiss make it very difficult to determine whether or not these remnants of gneiss have been transported or rotated from their original positions. Contact relations establish that the massive granitic rocks are younger than the granite gneiss, but the origin of these rocks is uncertain.

Although the quartzo-feldspathic mineral assemblage of the gneiss itself is not particularly definitive of the conditions of formation, some minerals of the associated metasedimentary rocks suggest medium- to high-grade metamorphism (p. 10). The common association of granite gneiss with metasedimentary rocks and the complete structural and mineralogical gradation between the two suggests that large portions of the granite gneiss terrain are derived from metasedimentary rocks.

Biotite Granite Gneiss

Biotite granite gneiss is the most abundant rock type in the granite gneiss terrain and is also present in minor amounts within other rock types of this terrain.

On fresh and weathered surfaces biotite granite gneiss is generally pink to red. Dark brown, biotite-rich streaks and lenses give the rock its characteristic color banding.

The typical biotite granite gneiss contains less than 10 per cent biotite, approximately 30 per cent quartz, with pink feldspar comprising the remainder of the rock. Chlorite, amphibole, garnet, epidote (commonly in 1/16 to 1/8 inch thick cross-cutting veins), hematite, magnetite, and allanite are locally present in small amounts. Feldspathic varieties are present locally, some containing only 2 to 3 per cent of biotite, whereas other varieties have abundant, sharply defined, biotite-rich bands. Modal and chemical analyses of granite gneiss are shown in table 2 (48, 50, and 51). Most of the granite gneiss is medium grained, but pegmatitic and porphyroblastic textures with 1/4- to 1/3-inch feldspar augen are locally combined with the basic layered structure.

Numerous narrow bands and lenses of hornblende granite gneiss, amphibolite, and metasedimentary rocks in the biotite granite gneiss are too small to be shown on the map. The first two rock types are most common and generally have completely gradational contacts with the biotite granite gneiss. Small, discontinuous bodies of foliated granite which do not have a distinct layered structure are present, mainly in the northern portion of the granite gneiss area. Their penetrative foliation distinguishes them from the younger massive granitic rocks.

In addition to the major bodies of younger massive granitic rocks shown on the map similar rocks are distributed in small amounts throughout the biotite and hornblende granite gneisses. Quartzo-feldspathic pegmatite is the most common of these rock types being present in almost every outcrop of granite gneiss and comprising the major portion of some. The pegmatite bodies are irregular in size, shape, and texture although generally conforming to the foliation of the gneiss. Some bodies of pegmatite appear to be genetically related to the gneiss rather than to be of external origin. Other types of younger massive granitic rocks (biotite granite, leucocratic granite, and porphyroblastic phases) are also present in minor veins and dykes, particularly in the vicinity of the larger massive granite masses.

The banded structure in the granite gneiss is typically swirled and ptygmatically folded with the most extreme forms indicated by the symbols ( ) and ( ) on the map.

Hornblende Granite Gneiss

Small patches of hornblende granite gneiss are found throughout the granite gneiss mass and one major body lies to the east of St. Agnes Lake. Two principal types are recognised: one with hornblende present as disseminated crystals, and in the other amphibolite and quartzo-feldspathic bands from 1/2 to 2 inches thick alternate.

The first type resembles parts of the biotite granite gneiss with hornblende taking the place of some of the biotite. Small hornblende crystals (making up 5 or more per cent of the rock) are oriented in the plane of foliation and commonly form indistinct bands. The remainder of the rock is composed of quartz and pink feldspar.

The other type of hornblende granite gneiss consists of alternating dark green and white or pink bands. In spite of the banding the rock splits with the same irregular fracture as the biotite granite gneiss. The dark-colored bands are composed of hornblende and some feldspar and quartz. The light-colored bands consist of quartz and feldspar with a medium-grained granoblastic texture. The alternation of bands is regular, and with an increase in the grain size and proportion of amphibolite layers the rock grades into banded amphibolite.

Hornblende granite gneiss contains amphibolite, metasedimentary rocks, and younger massive granitic materials as does the biotite granite gneiss, and also shows the deformation which is characteristic of the gneissic terrain.

Amphibolite and Basic Dykes

The bodies of amphibolite in the area represent a great variety of textural and mineralogical types which are present in a number of lithologic associations. Characteristically they are associated with the granite gneiss, but small bodies are present in the porphyroblastic biotite granites and two large bodies cut several rock types north of Weekes Lake. The general properties of the group will be described first, followed by notes on particular types and associations.

Amphibolites[1] are dark green on fresh surfaces with some varieties composed of alternating green and white or pink bands. The green colors weather to greenish-grey tones.

The principal minerals are hornblende and feldspar, with quartz, biotite, and epidote present in certain types. As the proportion of hornblende to feldspar plus quartz varies the rock ranges from hornblendite to amphibolite to hornblende granite gneiss or amphibolitic metasedimentary rocks as a continuous series. These amphibolitic metasedimentary rocks appear to be hornblendic equivalents of the impure biotite quartzites. Examples of such gradations are present in the area. The grain size varies from fine to coarse, with one-quarter inch and larger hornblende crystals common in hornblende-rich varieties. The texture ranges from massive, to foliated, to banded, with regularly alternating 1/2- to 1-inch wide bands of hornblende and white feldspar.

With the exception of the two large bodies near Weekes Lake, amphibolites rarely exceed 200 feet in width, most being in the range from 5 to 25 feet. Many of the amphibolites are represented diagrammatically on the map and many others are too small to be shown.

All types of amphibolite, particularly those rich in hornblende,

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1 In general reference "amphibolite" is used to include the two petrological terms "amphibolite" and "hornblendite". Shaw's (1957) definition 6A is preferred for amphibolite, i.e. "a metamorphic rock of medium to coarse grain, containing essential amphibole and plagioclase", whereas hornblendite is simply "a rock containing more than 90 per cent hornblende". Both rock types are found in the map-area, but amphibolite is more common.

are associated with granite pegmatite which is present in veins and discontinuous patches that comprise up to 30 per cent of some outcrops. Contacts of the amphibolite with this pegmatite appear sharp because of the color contrast, but are typically gradational in detail. Other varieties of massive granitic rock are not commonly found with amphibolites.

The internal structures of the amphibolites conform to those in the surrounding rocks. The banded varieties in the granite gneiss and metasedimentary rocks show a high degree of contortion, whereas some of the hornblende-rich type and those in the porphyroblastic biotite granites have only a simple foliation.

Contacts of the amphibolites with biotite granite gneiss and porphyroblastic biotite granites tend to be sharp, but those with hornblende granite gneiss and metasedimentary rocks are commonly gradational, particularly where the amphibolite is of the layered type.

Some of the metasedimentary bands near St. Agnes Lake, particularly those to the west (Sec. 15, Tp. 123, R. 2), contain banded amphibolite associated with quartzite, biotite schist, and granite pegmatite. These amphibolites contain abundant quartz in addition to hornblende and feldspar.

The granite gneiss contains both layered and slightly foliated, hornblende-rich amphibolites associated with granite pegmatite. The layered-type amphibolite is similar to that in the metasedimentary rocks except for a lower quartz percentage, and in many places grades into hornblende granite gneiss. Slightly foliated amphibolite composed almost entirely of blocky crystals of green amphibole is present west of St. Agnes Lake (Secs. 3, 10, Tp. 123, R. 2). These rocks have a coarse, variable texture and are accompanied by large amounts of granite pegmatite. Similar rocks of more feldspathic composition are present throughout the granite gneiss area.

The two large bodies of amphibolite at Weekes Lake have a sharp contact with porphyroblastic biotite granite D to the west. The rock is foliated and has a uniform grain-size and mineralogy throughout with hornblende and feldspar in approximately equal amounts and minor biotite. Minor pegmatite and aplite are present. West of Weekes Lake (Sec. 35, Tp. 123, R. 1) lenses mapped as amphibolite in porphyroblastic biotite granite D are hornblende-feldspar-biotite chlorite rocks which may represent altered diabase dykes.

It is apparent from the varied characteristics and lithologic associations that these amphibolites are not of a common origin. Both igneous and sedimentary amphibolites are present and all bear the mark of deformation and metamorphism.

Several basic dykes are present in the northern portion of biotite granite D, east of Hair Lake (Sec. 16, 22, Tp. 123, R. 1) and west of

Weekes Lake (Sec. 35, Tp. 123, R. 1). These dykes are dark grey on a fresh surface but weather to a reddish-brown color. The texture is aphanitic. The dykes are from 3 to 9 feet in width and are either parallel to, or approximately normal to, the foliation of the country rock. The dykes parallel to the foliation commonly have one or both borders of chlorite schist resultant upon shearing. Although these rocks appear to be the youngest in the map-area they are so restricted in occurrence that their relation to the granite gneiss and to the massive granitic rocks is not known, although one dyke intruding the sheared leucocratic granite was noted (Sec. 36, Tp. 123, R. 1).

Massive to Foliated Granites and Pegmatites

Distinct bodies of massive to foliated granitic rock of varied size, shape, texture, and composition are present in all parts of the map-area in addition to the more dispersed small granitic aggregates within other map-units. The largest masses of these rocks are in the northeast corner of the map-area, within the granite gneiss north of St. Agnes Lake, and in the gneissic biotite granites C and D.

Some of these bodies cut the foliation in the surrounding rocks; generally, they have a lower percentage of mafic minerals (0 to 8 per cent) so that they contrast sharply and appear to be younger than the surrounding rocks. Many of the granitic rocks are massive, others have a local foliation due to late shearing, and only a few have the penetrative foliation that characterizes the older rocks. Textures range from fine grained to pegmatitic and from even grained to porphyroblastic.

The massive granitic rocks are subdivided in the manner shown in table 2. Characteristics and associations of each type are discussed under the specific rock types and chemical and modal analyses of several rocks are given in table 3.

The general type of contact these bodies have with their surrounding rocks consists of a zone from a few feet up to hundreds of feet in width composed of dykes and irregularly shaped bodies of massive granitic rock that enclose remnants of country rock oriented with the regional trend. Any foliation in these young massive granitic rocks is generally best developed parallel to the contacts.

The diversity of texture, mineralogy, and association displayed by this rock group suggests that the constituent rock types may not be of a common origin, and even those rocks of similar petrographic characteristics, e.g. biotite granites, appear likely to include rocks of different origins and ages.

Biotite Granite

The three phases of massive granite differentiated on the map include an equigranular biotite granite, a megacrystic phase referred to as biotite 'p' granite, and an equigranular muscovite granite.

Equigranular massive biotite granite with up to 5 per cent biotite locally contains muscovite or hornblende. This granite is present in small, scattered bodies concentrated in a northerly trending zone through the central one third of the map, but also in a large mass around the north end of Cherry Lake. Biotite granite is especially common in the gneissic phases of biotite granites C and D.

The rock is characterized by a high degree of variability, and texture ranges to a pegmatitic grain-size in patches of some areas. On the one hand these rocks are transitional to biotite 'p' granite and on the other they grade into leucocratic granite.

Though a slight foliation is present in some areas, it is either confined to discrete shear planes or is near contacts. Crushed and granulated grains, chloritization of biotite, and the development of sericite in foliated areas suggest that the foliation is produced by post-crystalline deformation.

Hornblende granite is present in two areas: south of Weekes Lake and south of Governor Lake. This granite is similar to biotite granite except that the place of biotite is taken by 2 to 3 per cent of short, blocky hornblende crystals disseminated throughout the rock. The southern body (Sec. 29, Tp. 122, R. 1) consists of both hornblende and biotite granite whereas the body south of Weekes Lake (Sec. 24, 25, Tp. 123, R. 1) appears to be composed entirely of hornblende granite.

Muscovite Granite

A small body is present near a fault zone southeast of Cherry Lake (Sec. 27, Tp. 123, R. 1). It is much like the biotite granite except that a small percentage of muscovite has taken the place of biotite, particularly in the coarser-grained portions of the body.

Biotite 'p' Granite

This granite is the most abundant amongst the massive granites and it also forms the largest bodies. It is especially abundant north of St. Agnes Lake, and in the northeast and northwest corners of the map-area. This rock contains from 5 to 10 per cent biotite, thus it is more mafic than the equigranular biotite granite.

Just north of St. Agnes Lake abundant microscopic magnetite in some outcrops makes the rock appear darker. The rock is mostly massive, but has a foliated texture near some of its contacts. Foliation is usually produced by the preferred orientation of undeformed grains and is therefore pre- rather than post-recrystallization in origin. Within a single mass the massive biotite 'p' granite is uniform, but the size and abundance of the large feldspars, the biotite content, and the grain size vary between bodies.

West of Lister Lake (Sec. 30, Tp. 123, R. 1) a gradational contact between massive biotite 'p' granite and biotite granite C was observed. The biotite granite C grades into massive biotite 'p' granite by the addition of 1/4- to 1/3-inch microcline megacrysts, reduction in biotite content, and the subsequent loss of foliation. In a 100-foot wide transition zone, rocks intermediate between the same two rock types have been observed south of Waugh Lake (Godfrey, 1963). Although such relations suggest that massive biotite 'p' granite is derived from the replacement of biotite granite C, most of the massive biotite 'p' granite bodies are not so related, and many are surrounded by granite gneiss and enclose blocks and lenses of gneiss. This rock type appears to be another example where a similar end product may have formed by diverse lines of development.

Granite Pegmatite

Although only a few bodies of granite pegmatite are of sufficient size to be indicated on the map it forms a minor component in all of the map-units.

This rock is typically coarse grained, and in two areas - at the west shore of St. Agnes Lake (Sec. 14, Tp. 123, R. 2) and near the metasedimentary band west of Cherry Lake (Sec. 6, Tp. 124, R. 1) - white feldspar crystals from 4 to 5 inches diameter are developed in the pegmatite.

Pegmatite bodies are of varied size and shape and commonly cut the foliation in the surrounding rocks where the pegmatite contacts range from complete gradation to extreme sharpness. Examples were noted of an older pegmatite displaced by a younger one as though by dilation.

Muscovite Pegmatite

This rock is similar to granite pegmatite except that it contains 1/4- to 1/2-inch diameter flakes and books of muscovite rather than biotite or chlorite (Table 2). This pegmatite outcrops in the porphyroblastic biotite granite band, particularly along a northerly trending zone east of Cherry Lake and also in the vicinity of Chain Lake. The muscovite pegmatites are associated with leucocratic granites and are apparently genetically related to them.

Leucocratic Granite

Massive leucocratic granites contain less than 3 per cent mafic minerals. Two subdivisions were recognized, one which contains small amounts of biotite, chlorite, or both, and a second, mafic-free variety. Both types of leucocratic granites are associated with the porphyroblastic biotite granites C and D, the first type having a general distribution, and the mafic-free type being restricted to the eastern part of the map-area.

The leucocratic granite with a small amount of mafic minerals is essentially the same as the massive equigranular biotite granite, but with a lower percentage of mafic minerals. Though commonly massive a foliation may be locally expressed by lenticular quartz grains and patches. Leucocratic granite forms dykes and irregularly shaped bodies that range from a few inches to several hundred feet in width. These bodies include many oriented blocks of country rock, their contacts vary from sharp to gradational and are typical of contacts of younger massive granitic rocks.

Leucocratic granite with sericite (S) forms several small bodies in biotite granite D east of Governor Lake. This granite is generally sheared where sericite is present as a coating on minor shear surfaces as well as being distributed throughout the rock. In all the fine- to medium-grained granitic rocks sericite appears to be a secondary, rather than a primary, constituent.

Sheared Leucocratic Granite

The northeast corner of the map-area is occupied by a granite which is distinguished by a low content of mafic minerals (2 to 3 per cent biotite), a well-developed foliation, and a crushed appearance. Sericite coats many of the shear planes and 1/4- to 1/3-inch feldspar megacrysts are present locally in an equigranular matrix. To the north this rock is transitional on strike into massive biotite 'p' granite to which it may be related in origin (Godfrey, 1963).

CHEMICAL AND MODAL ANALYSES

The 13 chemical and modal analyses given in table 3 were obtained from the standard reference samples representing the major rock types mapped.

In the porphyroblastic biotite granite group, with respect to silica content both biotite granite C(43) and quartz diorite (54) are less acidic than biotite granite D and they fall in the intermediate range. These two rocks have a high (CaO + MgO) total corresponding to a high mafic mineral content of predominant biotite with hornblende up to 8 per cent. They are

Table 3. Chemical and Modal Analyses of Standard Rock Type Samples
Chemical analyses by H. A. Wagenbauer

Sample	43	44	49	53	45	54*	48	51	50	42	46	52	47
SiO_2	64.71	66.22	66.04	73.72	72.76	62.66	69.21	73.96	67.93	71.59	70.95	75.10	74.50
TiO_2	0.59	0.59	0.61	0.29	0.19	0.64	0.46	0.14	0.80	0.10	0.17	0.05	0.10
Al_2O_3	13.85	15.14	15.21	13.68	14.12	15.63	14.66	13.41	14.47	15.13	14.58	13.79	13.90
Fe_2O_3	6.40	4.76	4.72	2.41	2.04	5.65	3.71	1.17	3.46	1.08	1.65	0.75	1.30
MgO	3.65	1.90	2.13	1.24	0.80	3.41	0.70	0.35	0.95	0.44	0.67	0.39	0.37
CaO	2.86	3.36	3.29	1.44	1.71	4.23	1.54	1.01	2.16	0.70	1.36	0.31	0.73
Na_2O	2.27	2.73	3.01	2.94	3.02	2.94	3.05	2.57	3.61	3.47	3.55	3.17	3.90
K_2O	3.12	4.01	3.54	3.37	4.40	2.64	4.57	5.08	4.93	6.72	5.20	5.42	4.42
L.O.I.	0.81	0.61	0.94	0.69	0.32	0.52	0.48	0.50	0.08	0.25	0.37	0.45	0.37
P_2O_5	0.15	0.15	0.17	0.08	0.07	0.20	0.11	0.07	0.14	0.03	0.09	0.03	0.02
Total	98.41	99.47	99.66	99.86	99.43	98.52	98.49	98.26	98.53	99.51	98.59	99.46	99.61
Quartz	19.7	16.0	30.6	23.0	22.3	23.3	25.8	31.8	23.7	28.1	28.9	31.6	28.8
Potash Feldspar	3.6	20.3	18.7	32.6	32.4	2.5	38.1	47.4	37.7	42.0	26.4	36.4	25.5
Plagioclase	52.6	41.6	34.0	36.6	33.6	38.1	21.0	15.8	24.5	27.4	34.1	29.9	40.1
Biotite	23.1	19.4	12.7	7.0	10.9	24.6	13.2	3.1	5.8	0.0	8.3	0.0	4.6
Chlorite	0.0	0.0	0.0	0.3	0.0	0.2	0.5	1.3	0.0	1.6	0.4	1.3	0.0
Hornblende	0.5	0.0	1.5	0.0	0.0	7.8	0.0	0.0	5.4	0.0	0.5	0.0	0.0
Epidote	0.2	0.0	1.9	0.1	0.2	2.2	0.4	0.0	0.7	0.0	0.7	0.0	0.0
Muscovite	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.4	0.0	0.9	0.2	0.7	1.0
Garnet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Calcite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Accessories	0.3	1.7	0.6	0.5	0.4	1.4	0.7	0.2	2.2	0.0	0.5	0.1	0.0
Number of points	2000	4000	3500	3000	2000	2000	3000	2000	2000	2000	2000	2000	2000

43 Biotite granite C
44 Biotite granite D
49 Biotite granite D
53 Biotite granite D
45 Gneissic biotite granite D
54 Quartz diorite
48 Biotite granite gneiss
51 Biotite granite gneiss
50 Hornblende granite gneiss
42 Massive biotite granite
46 Massive biotite 'p' granite
52 Leucocratic granite
47 Sheared leucocratic granite

* Sample located one-half mile south of map-area, 6 1/4 miles west of the Saskatchewan boundary.

placed in the "porphyroblastic" quartz diorite field of Moorhouse (1959, p. 154). Biotite granite D (44, 49, 53, and 45) is in the high-silica range and has a high to moderate (CaO+ MgO) total. Biotite is by far the most abundant mafic mineral, and since both plagioclase and potash feldspar are common, this rock is placed in the porphyroblastic quartz monzonite field (Moorhouse, ibid).

Biotite granite gneiss (48 and 51) and hornblende granite gneiss (50) are both high with respect to silica content; the slightly higher (CaO+ MgO) total in sample 50 accounts for the presence of hornblende. Total alkalis, iron, and (CaO+ MgO) are typical for these rock types. The mineralogy of sample 51 corresponds to that of a true granite, and samples 48 and 50 fall in the field of quartz monzonite.

The two samples of massive biotite granite (42 and 46), representing the equigranular and 'p' phases respectively, along with leucocratic granite (52) and sheared, leucocratic granite (47) show the expected high silica and total alkalis values, and the corresponding low iron and (CaO+ MgO) values. In thin section these rocks show abundant quartz with both feldspars in such ratios to place them in the field of quartz monzonite.

The modal analyses reported for the granitoid rocks of this map-area and adjoining map-areas point to an overwhelming predominance of the quartz monzonite type in the Precambrian Shield of Alberta.

STRUCTURAL GEOLOGY

Faults trending north-northwest and a complimentary system of easterly fractures, probably tensional, constitute the principal structural features of this map-area. On a regional scale the longitudinal faults striking north 10 to 30 degrees west make up part of a series of horsetail faults related to the southeast extension of the Bonny fault system. The main section of the Bonny fault was established on the adjoining maps to the north. Direct field evidence for these faults, as in many other cases, consisted of scattered occurrences of breccia, sheeting, vein quartz, and rock alteration expressed as chloritization and hematization. However, well-defined topographic linears invariably link together several of these features to present substantial evidence for the existence of a continuous fault. In a few places map-units are terminated and contacts are displaced along fault-lines.

The longitudinal faults involve some major contacts such as granite gneiss against biotite granite D and massive biotite granite; and gneissic biotite granite D against massive biotite granite and normal biotite granite D. The related transverse tension faults do not bring rocks together from contrasting terrains but account for the termination of some small bodies of leucocratic and massive biotite granites within the main body of biotite granite D.

Separation along the faults can only be measured in a horizontal plane by the displacement of recognizable contacts. For example, on the east side of Governor Lake along the fault striking north 70 degrees west the contact of biotite granite C with granite D is separated by 1 1/4 miles. Farther west, a narrow metasedimentary band shows a separation of one quarter of a mile in the opposite direction along the same fault. Most of the major faults pass through biotite granite D where the absence of marker beds prevents the estimation of horizontal separations. An indication of substantial vertical movement is given by the repetition of biotite granite C intertonguing with biotite granite D on the easterly fault southeast of Cherry Lake, (Sec. 27, Tp. 123, R. 1). According to the attitude of the associated mylonites most of the faults dip steeply.

Northeasterly-trending faults passing through Weekes Lake partly truncate both the amphibolite and the sheared leucocratic granite. Easterly-trending faults near Governor Lake displace bands of granite gneiss, quartz diorite, metasedimentary rocks, and biotite granite C.

Though regional folds have not been established in this map-area, complex large folds may be present though masked in the highly deformed granite gneiss terrain. One such fold can be visualized at the south end of St. Agnes Lake where a synclinorial axis trends and plunges to the north.

A planar structure can be measured in most rock types of the map-area. Two types of foliation are recognized, though no distinction is made on the accompanying map: (1) penetrative foliation which affects all the major mineral components and which is present throughout the body of the rock to some extent, such as in the biotite granites C and D, and (2) restrictive foliation which appears as parallel shear surfaces and which have not resulted in an orientation of the major mineral components, such as in the massive biotite granites.

An examination of the foliation patterns on map 62-1A reveals structures such as drag folds, isoclinal folds, crenulations, and other forms indicative of plastic deformation in the granite gneiss. These types of structures were also observed on a smaller scale in the outcrops.

Reconstruction of the structure in the granite gneiss area to the east and south of St. Agnes Lake, shows a series of saddle folds where northerly and easterly axes are combined. Saddle-style folding accommodates the rapid changes of strike and the alternating steep and shallow, and possibly reversed, dips noted around St. Agnes Lake. Shallow dips are confined to this area of granite gneiss and their absence elsewhere would suggest the localization of saddle folding. The existence of saddle folding may depend upon the presence of two or three large folds which encompass the illustrated folds to constitute several anticlinoria and synclinoria.

East of Governor Lake there is a suggestion of saddle folding in the biotite granite C adjoining granite gneiss. However, northerly axes generally predominate over easterly axes, which is the opposite to the granite gneiss. No inference is made with regard to the sequence of folding: these 'combination folds' are due to synchronous or separate periods of deformation, and the different expressions of saddle folding may only indicate a change in the relative importance of the two directions of stress. Granite gneiss to the east of the quartz diorite in the south of the map-area may indicate a syncline which has been upfaulted.

In outcrop, biotite granites C and D and quartz diorite display a penetrative foliation of simple straight lines, and compilation of this structural data over the map-area shows the presence of a few folds. These rocks have similar structural features on both large and small scales, however, a general increase in the number of folds to the south indicates an increase in the degree of plastic deformation in that direction, which coincides with the general increase of intensity of metamorphism in the porphyroblastic biotite granites, as mentioned by Godfrey (1963, p. 8).

Metasedimentary rocks are plastically deformed on both large and small scales and form an integral part of the complicated structural picture both in the granite gneiss terrain and in association with biotite granite C and quartz diorite.

The massive biotite and leucocratic granites in both the granite gneiss and the porphyroblastic biotite granites conform to the contortions of the foliation in the host rocks and many are positioned in the cores of folds. Their emplacement is largely post-deformational in that they generally lack a readily recognisable foliation.

The lack of three-dimensional exposures, the smooth-surfaced outcrops, and the sparcity of acicular minerals makes the measurement of lineations difficult though they were noted in a few places. The long axes of the large feldspars in the porphyroblastic biotite granites are arranged in a vertical or near vertical direction in the plan of foliation. Since the feldspars are tabular in habit, lineation is difficult to observe, although lineations may not be of general distribution. In hornblende-bearing rocks, where lineation should be best expressed, lineation is rarely measured because of the small size of the hornblende crystals.

A number of small-scale megascopic structural features representing both plastic and cataclastic phenomena may be summarized here. Mullion and rod structures are rare and are found mostly in the metasedimentary rocks. Joints and sheeting are common to all rocks. Other cataclastic structures observed include crushed augen, mortar structure, flaser structure, and mylonite. Slaty and fracture cleavage are commonly found in the fine-grained metasedimentary rocks, especially the phyllonites and biotite-sericite schists. Breccias are commonly a well-cemented stockwork of quartz veins enclosing and cutting hematized, chloritized, and epidotized, country rock fragments.

Migmatite structures found in the basic granite gneisses, at granite gneiss-metasedimentary rock contacts, and in highly feldspathized metasedimentary rocks include tight isoclinal or chevron folds, drag folds, and other more complicated forms illustrative of plastic flowage are indicated ( ) on map 62-1A, and more open folds and swirls are indicated ( ). These symbols on the map are oriented parallel to structural trends in the outcrop. Boudinage structures were observed in amphibolite bodies within the granite gneiss.

MINERAL OCCURRENCES

Mapping in the Precambrian Shield in northeastern Alberta has shown that the most favorable association for the presence of sulfide mineralization is in the metasedimentary rocks. These rocks occupy about one per cent of the present map-area, considerably less than in previously described adjoining areas. Consequently, as can be expected, only minor mineralization was noted in the metasedimentary rocks, consisting of pyrite and arsenopyrite. Minor radioactivity greater than 3X background was recorded in granites and pegmatites in the north and northwestern portion of the map-area.

REFERENCES CITED

Alcock, F. J. (1915): Geology of the north shore of Lake Athabasca, Alberta and Saskatchewan; Geol. Surv. Can. Summ. Rept. 1914, p. 60-61.

__________ (1917): Black Bay and Beaverlodge Lake areas, Saskatchewan; Geol. Surv. Can., Summ. Rept. 1916, p. 152-156.

__________ (1936): Geology of Lake Athabasca region, Saskatchewan; Geol. Surv. Can. Mem. 196, 41 pages.

Cameron, A. E. (1930): Report of progress on mineral explorations in the Precambrian; Res. Coun. Alberta, Tenth Annual Rept., 1929, p. 34-39.

Cameron, A. E. and Hicks, H. S. (1931): The Precambrian area of northeastern Alberta; Res. Coun. Alberta, Eleventh Annual Rept., 1930, p. 32-40.

Canada. Geological Survey (1958): Colin Lake; Geophysics Paper 716.

Collins, G. A. and Swan, A. G. (1954): Preliminary report of geological field work, northeastern Alberta; Res. Coun. Alberta Mimeo. Circ. 18, 8 pages.

Ferguson, A. B. (1953): First Alberta uranium discovery; Western Miner Oil Rev., Vol. 26, 1953, p. 43.

Godfrey, J. D. (1958): Aerial photographic interpretation of Precambrian structures, north of Lake Athabasca; Res. Coun. Alberta Bull. 1, 19 pages.

____________ (1961): Geology of the Andrew Lake, North district; Res. Coun. Alberta Prelim. Rept. 58-3, 32 pages.

____________ (1963): Geology of the Andrew Lake, South district; Res. Coun. Alberta Prelim. Rept. 61-2, 30 pages.

Godfrey, J. D. and Baadsgaard, H. (1962): Structural pattern of the Precambrian Shield in northeastern Alberta and mica age-dates from the Andrew Lake district; Roy. Soc. Can., Spec. Publ. IV, p. 30-39.

Hicks, H. S. (1930): A petrographic study of Precambrian rocks in northeastern Alberta; unpublished M.Sc. thesis, Univ. of Alberta, 47 pages.

____________ (1932): The geology of the Fitzgerald and northern portion of the Chipewyan map areas, northern Alberta, Canada; unpublished Ph.D. thesis, Univ. of Minnesota, 82 pages.

Koster, F. (1961): The geology of the Thainka Lake area (west half) Saskatchewan; Saskatchewan. Dept. Mineral Resources, Mines Br., Geol. Div., Rept. No. 61, 28 pages.

Moorhouse, W. W. (1959): The study of rocks in thin section; Harper and Brothers, New York, 514 pages.

Peikert, E. W. (1961): Petrological study of a group of porphyroblastic rocks in the Precambrian of northeastern Alberta; unpublished Ph.D. thesis, Univ. of Illinois, 151 pages.

Riley, G. C. (1960): Geology, Fort Fitzgerald, Alberta; Geol. Surv. Can. Map 12-1960.

Shaw, D. M. (1957): Some recommendations regarding metamorphic nomenclature; Proc. Geol. Assoc. Can., Vol. 9, p. 69-81.

Tyrrell, J. B. (1896): Report on country between Athabasca Lake and Churchill River, N.W.T.; Geol. Surv. Can. Ann. Rept. (n.s.), Vol. 8, Pt. D, 1895, 117 pages.

Wilson, J. T. (1941): Fort Smith, District of Mackenzie, Northwest Territories; Geol. Surv. Can. Map 607A.

RESEARCH COUNCIL OF ALBERTA

LEGEND

PRECAMBRIAN*

Quartzite, *pure and impure, white, grey, green, pink and blue; including biotite sericite schist, minor milky quartz pods, feldspar augen, granite and pegmatite lenses, ferruginous and garnetiferous zones.*

Biotite schist, *with abundant quartz, some sericite; including phyllite, phyllonite, quartzite, minor milky quartz pods, feldspar augen, granite and pegmatite lenses, ferruginous and garnetiferous zones.*

Biotite granite C, *with white to grey subhedral to anhedral feldspar megacrysts, one-quarter to one-half inch in size, in a foliated matrix; including minor aplite, microgranite and pegmatite.*

Gneissic biotite granite C, *with white to grey feldspar augen, one-quarter to one-half inch in size, in a well-foliated to banded matrix, including microgranite bands, with minor aplite and pegmatite.*

Biotite granite D, *with grey to pink to red euhedral feldspar megacrysts, one and one-half to three inches in size, in a foliated to massive matrix; including minor aplite, microgranite and pegmatite.*

Gneissic biotite granite D, *with grey to pink feldspar augen, one and one-half to three inches in size, in a well-foliated to banded matrix; including microgranite bands, with minor aplite and pegmatite.*

Quartz diorite, *with white to pink feldspar megacrysts, one-quarter to three-quarters inch in size, abundant hornblende, minor biotite (locally biotite rich and hornblende poor); in a foliated matrix; including minor aplite, microgranite.*

Biotite granite gneiss, *with some hornblende, chlorite; including minor massive granite, porphyritic granite, granodiorite, alaskite, lenses of biotite, quartzite, amphibolite; garnetiferous zones.*

Hornblende granite gneiss, *with some biotite, chlorite; including minor massive granite, porphyritic granite, granodiorite and amphibolite.*

Amphibolite, *including biotite amphibolite, hornblendite; banded to massive.*

Biotite granite, *with white, to pink to red feldspars, minor sericite; including leucocratic phases; massive. Muscovite granite (m), with abundant white to pink feldspars, minor biotite; massive. Phases with abundant feldspar megacrysts (p), one-quarter to one-third inch in size. Hornblende bearing phases (H).*

Granite pegmatite, *with white, to pink to red feldspars, sparse biotite and/or chlorite; massive. Muscovite pegmatite (m), with abundant white to pink feldspars, quartz; massive.*

Leucocratic granite, *with pink to red anhedral feldspars, equigranular; massive, locally foliated; including minor microgranite and pegmatite. Sericite bearing phases (S).*

Sheared leucocratic granite, *with white to pink feldspars; medium to fine grain, typically sheared; minor biotite, muscovite, sericite.*

Basic dyke, *massive, locally sheared with chlorite.*

**Note: Rock units are not arranged chronologically*

Geological boundary (defined, approximate, assumed)
Geological boundary, gradational
Schistosity, gneissosity, foliation (defined, assumed)
Schistosity, gneissosity, foliation (dip-inclined, vertical, horizontal) 75
Extreme contortion (structural trend)
Tight folds (structural trend)
Fault (defined, approximate, assumed)
Shear, shear zone
Breccia
Mylonite
Gossan
Joint
Sample location 43 o
Glacial striae (direction of ice movement known)
Radioactivity
Garnet G
Chlorite, abundant C

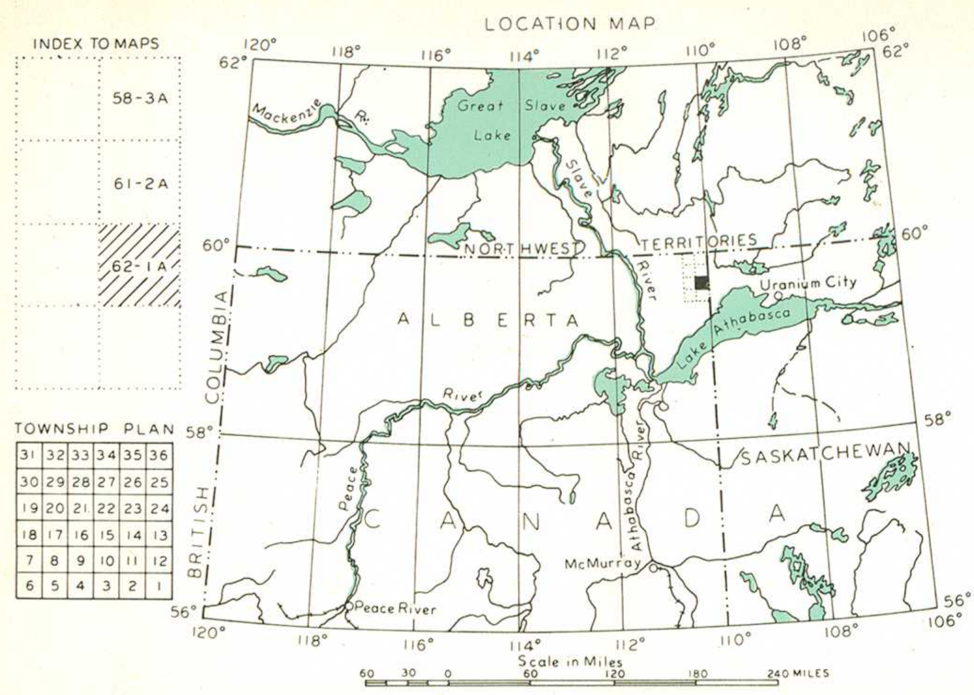
Geology by John D. Godfrey and E. W. Peikert, 1958

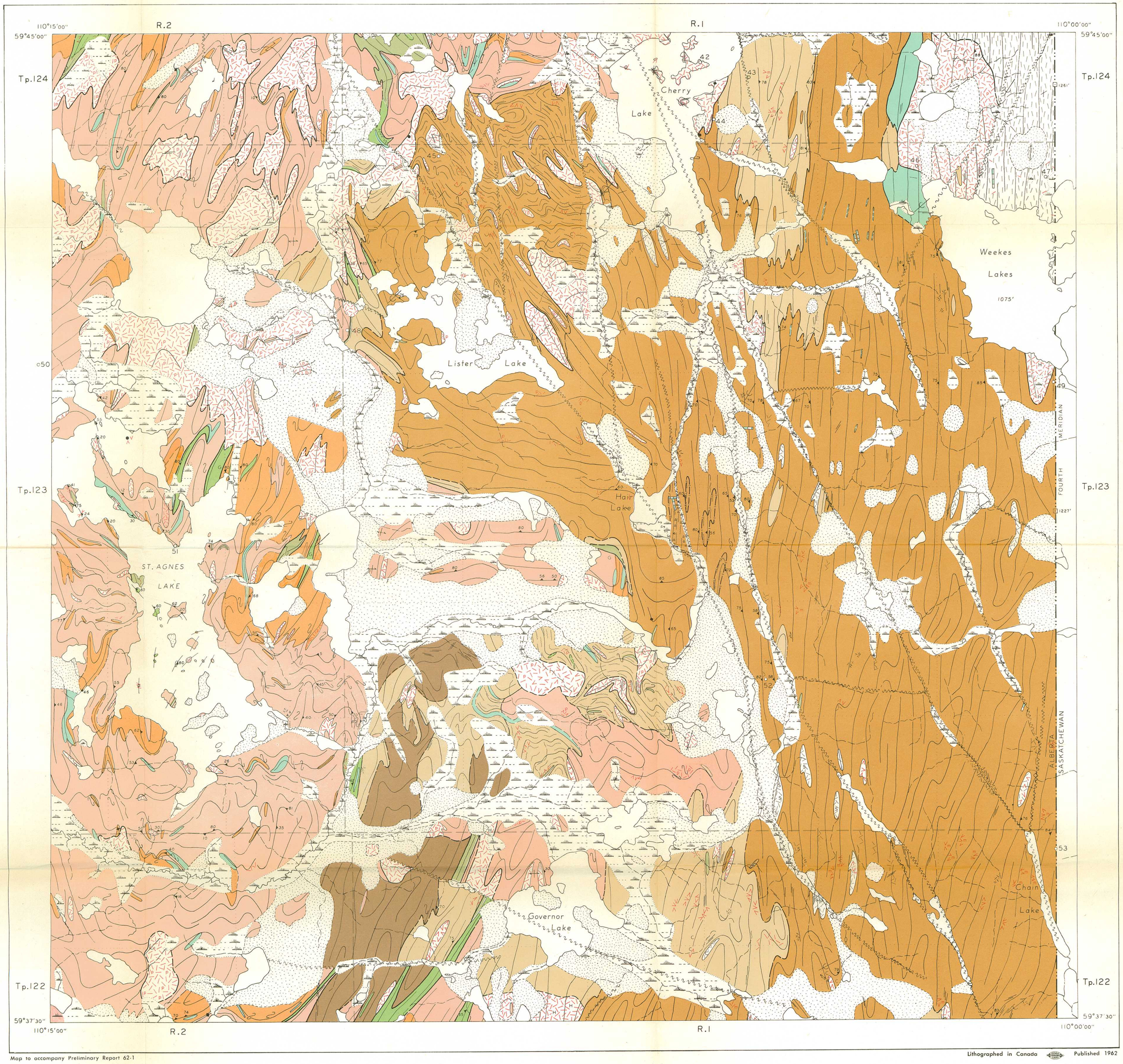
Drainage (permanent, intermittent)
Muskeg
Sand-covered area
Spot elevation, height in feet above mean sea-level 1261′
Provincial boundary
Township boundary
Section line

Base map compiled from planimetric sheet 74 $\frac{M}{9}$ NE. quarter, published by Government of Alberta, Department of Lands and Forests, Edmonton.

Air photographs covering this area are obtainable from the Technical Division, Department of Lands and Forests, Government of Alberta, Edmonton, and the National Air Photographic Library, Topographical Survey, Ottawa.

Approximate magnetic declination 25° 58′ East in 1962, decreasing 6′ annually.





Map to accompany Preliminary Report 62-1

Lithographed in Canada Published 1962

MAP 62-1A

ST. AGNES LAKE

WEST OF FOURTH MERIDIAN

Scale: Two Inches to One Mile = $\frac{1}{31,680}$

½ ⅜ ¼ ⅛ 0 ½ 1 1½ 2