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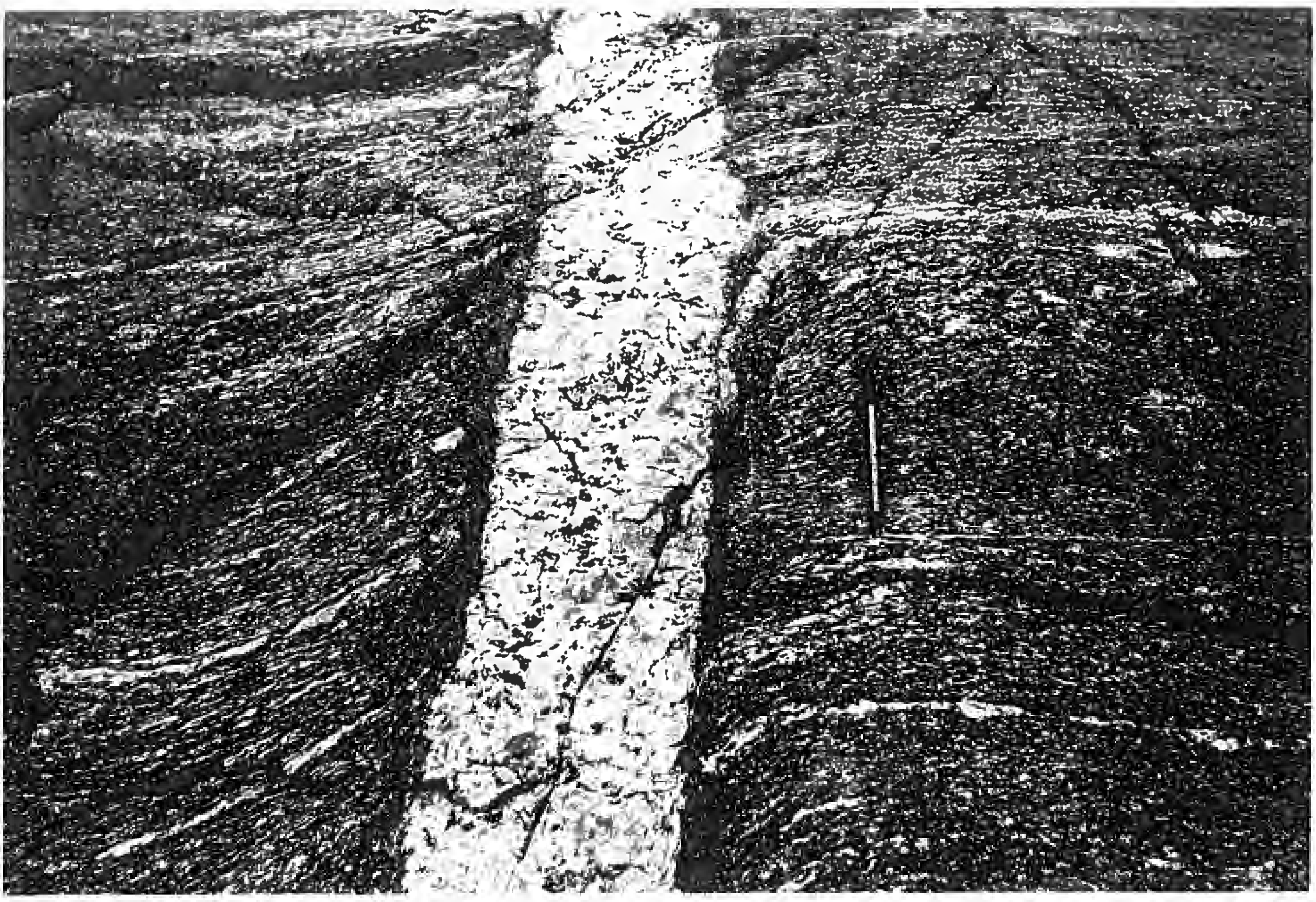
Geology of the
Bocquene-Turtle Lakes district, Alberta

J.D. Godfrey



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Cover photo: Shear drag along pegmatite dyke margin in stretched gneissoid phase of Slave Granite.

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The field party in 1973 included Dr. John D. Godfrey, chief geologist; Geoffrey Hodgson and Godfrey Walton, assistant geologists; Laurence Andriashek, Wayne Dwyer, Po Geh, David Kornder and Gregory McGrath, field assistants; and Charles Sedgwick, camp cook. The contributions of these people to the field program are acknowledged and appreciated, especially insofar as persistent rains made camp life miserable and the task at hand much more difficult than usual. The logistical support and ready help in the field and camp by the pilots and staff of Noralta Flights Ltd., Fort Chipewyan, is gratefully acknowledged.

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Abstract

The bedrock geology of the study area consists of a north-trending belt of Archean granite gneisses in the east intruded by an Aphebian granitoid complex in the west. The migmatitic gneissic belt consists of classic granitic gneisses with minor components of granitoid bodies, high-grade metasediments, and amphibolite. The granitoid complex is dominated by the Slave Granitoids group, and there are minor components of Arch Lake and La Butte Granitoids. Screens and a ghost stratigraphy of high-grade metasediments and granite gneiss are fairly common within the granitoid complex. The internal structure of the granitoids reveals a series of imperfect basins and domes. The granitoids appear to be ultrametamorphic partial-melt derivatives from the protolithic granite gneisses. The major contact between the granitoids and the gneissic belt is intrusive with gneissic wall wedges and tongues projecting into the granitoids.

Most of the rocks have undergone a two-cycle polyphase metamorphism. Geochronology and electron microprobe mineral analyses show that an Archean high-pressure granulite facies metamorphism was followed by an Aphebian moderate-pressure facies metamorphism. Mineral assemblages show that the latter retrogressed through amphibolite facies and greenschist facies conditions. From Rb-Sr isochron analyses, the moderate-pressure granulite event was dated at 1900 Ma. K-Ar dates on biotite and hornblende of approximately 1800 Ma reveal that the greenschist facies event occurred at the end of a widespread severe thermal event that reset all of the K-Ar isotopic ratios. The metamorphic foliation has a regional northerly trend, but a wide range of variations exists locally, within both the granitoids and the gneissic belt.

The map area is crossed by regional faults of two principal orientations, north to northeasterly and west to west northwesterly. The latter is the more common orientation. The Allan Fault, represented by a prominent mylonite zone and localized fault surfaces, trends northerly. It principally cuts the granite gneiss belt.

A continental ice sheet of Pleistocene Age has scoured the region, leaving abundant erosional and depositional evidence of recent glaciation. The Classical Wisconsin ice advance came from almost due east. Aeolian reworking of the typically sandy glacial deposits by southeasterly storm winds resulted in the formation of sand sheets and dunes. Associated wind polish and abrasion can be commonly found on bedrock surfaces.

Scattered minor mineralization is present in the high-grade metasediments and Slave Granitoids, and less commonly in the gneisses and other granitoids. Of particular note are minor uranium stains, copper, and dispersed magnetite.

Introduction

This report deals with 1523 km² (588 mi²) of exposed Precambrian Shield in northeastern Alberta. The map area is situated between latitudes 59°15′ and 59°30′N, and longitudes 110°30′ and 111°30′W (figure 1).

The surface of the Precambrian Shield has a general gentle downslope toward the west. Elevations range from 204 m (670 ft) at the Slave River up to about 320 m (1050 ft) eastwards in the interior of the map area. Drainage is essentially westward to the Slave River lowlands and thence north to the Arctic Ocean.

Previous reconnaissance geological work in the Alberta portion of the Canadian Shield was done by Cameron and Hicks (Cameron, 1930; Cameron and Hicks, 1931; Hicks, 1930, 1932). Collins and Swan (1954) spent several weeks examining mineral prospects in the Alberta Shield. In 1959, the Geological Survey of Canada (Riley, 1960) conducted a reconnaissance geological survey of the Shield north of Lake Athabasca. Results were published on a 1:250 000-scale uncolored map accompanied by notes.

Bostock (1982), of the Geological Survey of Canada, mapped the Fort Smith area, which adjoins to the north. His information is available in an Open File Report of the Geological Survey of Canada and includes an uncolored 1:125 000-scale map.

In 1957, the Alberta Research Council initiated a Shield mapping program and has since published several district maps and reports in the current series (Godfrey, 1958b, 1961, 1963, 1966, 1980a, 1980b, 1984; Godfrey and Peikert, 1963, 1964; see figure 1). The field work is now complete, and the remainder of the maps and reports are in press (Godfrey and Langenberg, 1986, in press).

A number of Alberta Research Council bulletins have syntheses of several aspects of the Shield geology. In particular, the metamorphic history is summarized by Langenberg and Nielsen (1982), and the structural conditions are discussed by Langenberg (1983). The geophysical properties of the Alberta Shield have been summarized by Sprenke, et al. (1986) whereas the geochemical character and petrogenetic implications are presented by Goff et al. (1986).

Several university theses on various aspects of the bedrock geology have been completed in the course of the Alberta Research Council's Precambrian Shield program (Peikert, 1961, 1963; Watanabe, 1961, 1965; Klewchuk, 1972; Kuo, 1972; Day, 1975; Sprenke, 1982).

Microprobe mineral analyses by Nielsen (1979) established the metamorphic conditions under which various mineral assemblages have developed and petrogenetic processes have taken place.

An ongoing geochronological program with the University of Alberta, under the direction of Dr. H. Baadsgaard, has yielded numerous age dates and allowed identification of significant metamorphic-igneous events in the evolution of the Shield in Alberta (Godfrey and Baadsgaard, 1962; Baadsgaard et al., 1964, 1967; Baadsgaard and Godfrey, 1967, 1972; Nielsen et al., 1981; Langenberg and Nielsen, 1982).

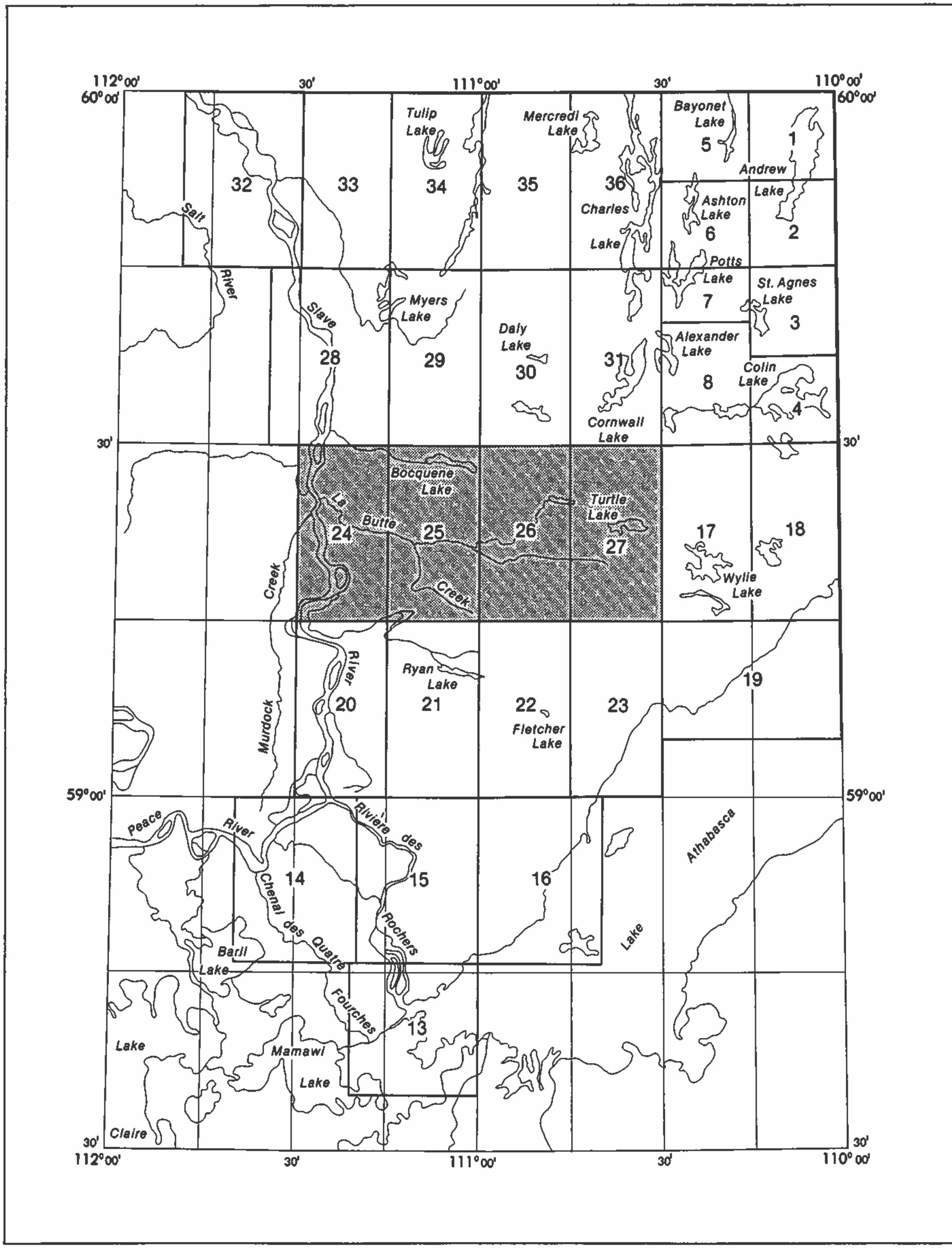


Figure 1. Location of study area, maps 24, 25, 26, 27, the Bocquene-Turtle Lakes district, Alberta, and index to map sheets.

General geology

The Shield terrain in this map area is a northward continuation of the litho-structural trends and patterns present in the Ryan-Fletcher Lakes district (Godfrey, 1984).

The study area is underlain by a Precambrian Shield complex of igneous and metamorphic rocks that lie within the Churchill Structural Province. Two distinct Shield terrains—the Granite Gneiss belt and the Slave Granitoids—are evident in the map area (table 1 and figure 2). The map area is dominated by the Slave Granitoids, which, including the minor variations of the La Butte and Arch Lake Granitoids components, occupy over 80 percent of the map area (table 2). The balance of the map area is made up of two zones: a marginal phase of the pluton, composed of mixed granitoids (primarily Arch Lake Granitoids) and the Archean granite gneiss belt. The mixed granitoid marginal phase of the Slave Granitoids is more clearly defined and the regional significance of the gneissic belt is more apparent from the combined map areas of

Table 1. Geological terrains (figure 2) and their constituent rocks for the Bocquene-Turtle Lakes district, Alberta. Minor component [ ].

Constituent Rocks		Geologic Terrain
granite gneiss mylonitic rocks [high-grade metasediments]	A	Granite Gneiss belt partly migmatitic and mylonitic
mixed granitoids [high-grade metasediments]	S_2	Slave Granitoids (a) Marginal Phase
Slave Granitoids [granitoids] [high-grade metasediments]	S_1	(b) Core Phase

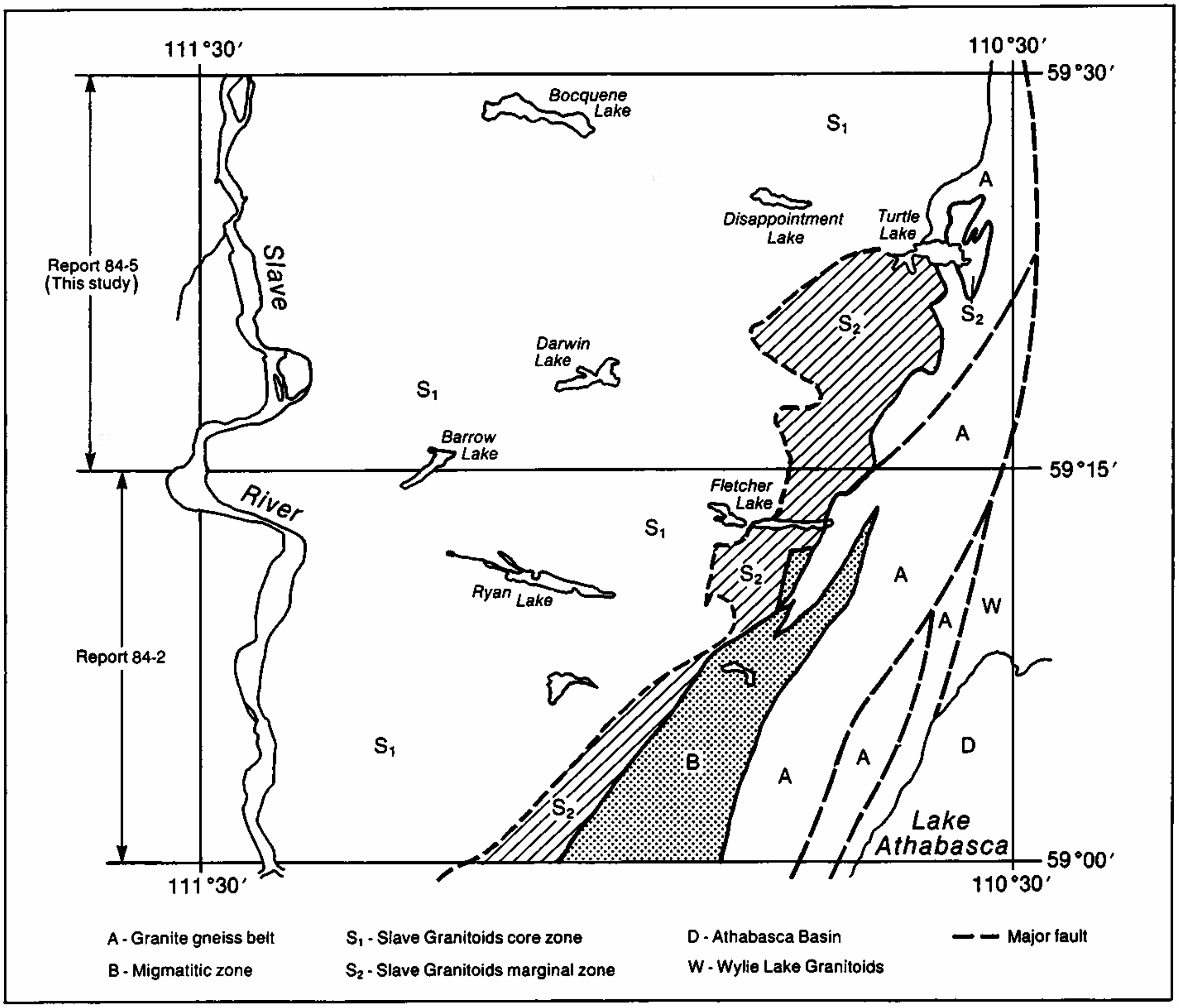


Figure 2. Sketch map of principal geologic terrains.

Table 2. Percentage areal composition of the Bocquene-Turtle Lakes district by rock type and rock group.
(For this table, covered ground within the map area is interpreted on the basis of an aeromagnetic survey.)

Granite gneiss	4.0
Slave Granitoids	68.0
Wylie Lake Granitoids	trace
La Butte Granodiorite	6.5
Arch Lake Granitoids	17.0
High-grade metasediments	2.5
Mylonitic rocks	2.0

this report and that in Godfrey (1984) (see figure 2). The constituent map units within each rock group and the possible genetic relationships are presented in table 3.

Geologic history

The geologic history of this map area is summarized in the form of a stratigraphic column in table 4. The Archean granite gneiss belt, covering five percent of the map area, is located in the east of the study area. This gneissic belt is intruded by a granitoid complex that occupies the remaining 95 percent of the area.

The oldest group of rocks, the basement granite gneiss complex, consists of orthogneiss with subordinate amounts of paragneiss, granitoids, high-grade metasediments, and amphibolites. The formation of these gneisses likely entailed multicycled sedimentation, polyphase metamorphism, extensive plutonic intrusion and deformation. Primary magmatic material was introduced in the form of granitoid masses and basic dykes, probably during several phases of magmatic activity. Deep-seated events led to major parts of the gneissic belt being migmatized, remobilized and subsequently mylonitized. Metamorphic mineral assemblages within the high-grade metasediments of the basement gneiss complex contain hypersthene, green spinel, corundum and sillimanite. The temperature and pressure estimated for this mineral assemblage is 900±100°C and 7.5±2 kbar (M_1 of Nielsen et al., 1981). These peak conditions, equivalent to moderate- to high-pressure granulite facies metamorphism, existed during development of the para-ortho-gneissic complex.

The Archean age (2.5 Ga) of the Charles Lake gneisses (Godfrey and Langenberg, 1985a, 1985b) and their involvement in the Kenoran Orogeny has been established by a Rb-Sr whole-rock isochron on pegmatites cutting the granitoids in the gneissic belt at Charles Lake (Baadsgaard and Godfrey, 1972).

In thin section, cordierite and almandine either enclose or replace the granulite facies mineral assemblage referred to earlier, showing that the rocks were subsequently subjected to lower grade metamorphic conditions (Godfrey and Langenberg, 1978a). Emplacement of the Slave Granitoids, La Butte Granodiorite, and the Arch Lake Granitoids is associated and coincident with prevailing moderate-pressure granulite facies metamorphic conditions ($M_{2.1}$ of Nielsen et al., 1981) during the Hudsonian Orogeny.

Emplacement of the combined Slave-Arch Lake Granitoid masses resulted in a granitoid body that was probably mantled and walled by basement gneisses. All of the granitoid masses probably originated as remobilized infrastructure materials. The conditions of formation and emplacement are estimated by Nielsen et al. (1981) to have been 740±30°C and 5.0±0.7 kbar (i.e., under moderate-pressure granulite-facies conditions). These conditions are interpreted as a second phase of metamorphism, rather than as retrograde effects of the first metamorphic phase ($M_{2.1}$ of Nielsen et al., 1981).

Mineral assemblages in various rocks of the region have recorded a retrograde metamorphism through

Table 3. Principal Precambrian rock groups, constituent rock units and their field associations, Bocquene-Turtle Lakes district, Alberta

Mylonitic Rocks	Granite Gneisses		High-Grade Metasedimentary Rocks		Granitoid Rocks
	Amphibolite ↑		Amphibolite ↑		Amphibolite ↑
	Granite Gneiss	+	Granitic Metasedimentary Rocks Metasedimentary Rocks	→	Arch Lake Granitoids La Butte Granodiorite
Derived from all other rock groups					
	[Granite Gneiss]	+	Granitic Metasedimentary Rocks Metasedimentary Rocks	→	Fishing Creek Quartz Diorite Slave Granitoids

↑ Intrusive relationship.
→ Close field, and possible genetic, relationships.
[ ] Less significant component.

Table 4. Summary of geologic history of the Shield in the Bocquene-Turtle Lakes district, Alberta

Geologic Age	Rock Units/Groups	Predominant Rock Type(s)	Process/Event	
Recent	Fluvial, lacustrine deposits	Sand, silt, mud	Sedimentation	
Pleistocene	Glacial/fluvial/lacustrine	Till, sand, silt	Continental glaciation	
Devonian	Elk Point Group and older	Carbonates	Marine and evaporitic sedimentation	
Aphebian			Regional Faults (e.g. Allan Fault) and mylonitization Metamorphism $M_{2.3}$ (greenschist facies)	Hudsonian Event
	La Butte Granodiorite	Granodiorite, (quartz diorite)		
	Fishing Creek Quartz Diorite	Quartz diorite (granodiorite)	Basic dykes Metamorphism $M_{2.1,2}$	
	Arch Lake Granitoids	Granite (granodiorite)	(granulite-amph.facies) Remobilization	
	Slave Granitoids	Granite (granodiorite)	Migmatization Plutonic intrusion	
Archean	Basement Gneiss Complex	Amphibolite Metasedimentary Rocks Hornblende Gr. Gneiss Biotite Granite Gneiss	Basic dykes Plutonic intrusion Granitization Metamorphism M_1 (granulite facies) Sedimentation	Kenoran Event

low-pressure amphibolite facies (estimated to be 550 ± 55°C and 3.0 ± 0.3 kbar, i.e. $M_{2.2}$ of Nielsen et al., 1981) and a greenschist facies ($M_{2.3}$ of Nielsen et al., 1981).

The moderate-pressure granulite conditions represent the culmination of the Hudsonian Orogeny, and have been dated with Rb-Sr at 1900 Ma (Godfrey and Baadsgaard, 1962; Baadsgaard et al., 1964, 1967; Baadsgaard and Godfrey, 1967; Nielsen et al., 1981). Formation of the granitoid bodies is linked with intense metamorphism and partial melting of the combined granite gneiss and high-grade metasedimentary rock belt. Large portions of the resultant crystal-liquid granitic product were mobilized and separated from the granite gneiss-metasedimentary belt to form plutons and batholiths. Small amounts of segregated granitic material remain within the parent migmatitic belt as either minutely dispersed or larger mappable masses. In places, the close spatial relationship is an intimate mixture of parent metamorphic material and the derived granitic material.

The lithology of the plutonic-complex core is characterized by Slave Granitoids plus minor amounts of small bodies of La Butte Granodiorite, Francis Granite, Arch Lake Granitoids, granite gneiss and high-grade metasediments. The internal structure of the core consists of partly closed foliations around imperfect domes and basins. Some distortion of the structures has occurred, in part due to drag along late faults. These data strongly suggest deformation of the Slave-Arch Lake Granitoids, possibly towards the roofal section of the pluton. A clearer geometric definition of the internal structures within the Arch Lake Granitoids pluton has been preserved to the north, in the Mercredi Lake map district (Godfrey and Langenberg, 1986) where there is less structural distortion.

In the Bocquene-Turtle Lakes map area some screen materials that have been caught up and dragged during emplacement of the granitoids help to define the internal structures. Ghost stratigraphy is also present as bands and lenses of granite gneiss and high-grade metasediments, especially evident within the Slave Granitoids component of the pluton. Furthermore, the screens and ghost stratigraphy provide a direct petrogenetic link to the parent materials of the granitoids, the Archean granite gneisses and high-grade metasediments. An example is provided by the isoclinal folds outlined by a combination of foliation and lithology at Disappointment Lake.

An east-west trending concentration of minor granitoid bodies—Francis Granite, and minor La Butte Granodiorite and Arch Lake Granitoids—and high-grade metasediments forms an unusual, discontinuous westerly extension in alignment with a major westerly projection of the Arch Lake Granitoids mass at the east margin of the Slave Granitoids pluton (geology maps in pocket). This zone of granitoids and metasedimentary rock masses may demarcate an interface or discontinuity between two adjacent major intrusive cells or phases of Slave Granitoids, i.e. it separates the northern and southern sections of the plutonic complex. The south border of the major Arch Lake Granitoids mass is parallel and lies some 8 km to the north of this fragmentary zone. It should also be noted that the zone of fragmentary granitoid bodies coincides and is aligned with a well-developed set of east to west transverse faults. Some lateral movement of the fragmentary bodies is related to displacements along these faults.

Further speculation on the origin of the zone of fragmentary granitoid bodies suggests that they could very well be remnants of pluton roof pendants. This explanation requires that Arch Lake Granitoids envelope the Slave Granitoids, which is in keeping with their regional structural arrangement (figure 2). Structural data from Langenberg (1983) supports this concept, in that the zone of fragmentary granitoid blocks coincides with an east-west basinal axis. Domes are appropriately positioned to the north and south.

The contact of the Slave Granitoids pluton with the Granite Gneiss belt is characterized by a mixture of granitoid rock units (Slave and Arch Lake Granitoids) and high-grade metasediments. This zoned granitoid margin is continuous to the south in the Ryan-Fletcher Lakes map area (figure 2, and Godfrey, 1984), but it is not so evident to the north. This zoned pluton margin is perhaps an intermediate petrogenetic phase between the parent gneisses and the Slave Granitoids pluton.

Subsequent to the formation of the crystalline basement gneissic complex and Aphebian granitoids, there were at least four periods of sedimentation in the region—1) Aphebian-Proterozoic low-grade Burntwood Group, 2) Proterozoic Athabasca Group, 3) Devonian carbonates, and 4) Pleistocene glacial sediments. The first one, and possibly the second, of these periods are not represented in the outcrop of this immediate map area.

Rocks of the low-grade metasediments (equivalents of the Burntwood Group) are absent in this map area. A period of prolonged uplift and erosion preceded deposition of the second set of sediments, the Athabasca Group. The largely continental Athabasca Group (Ramaekers, 1980; Wilson, 1985) has not been seen in outcrop in the map area. However, as discussed in the section on glacial history, it is suggested that outliers of Athabasca Group sandstone may be closely associated with, and in part underlie, the extensive glacial sandy areas. Those sandy areas associated with the north to south aligned glacio-fluvial-lacustrine deposits just west of Esker Lake are excluded from this speculation.

Another extensive period of uplift and erosional stripping of much of the Athabasca Group rocks preceded subsidence and transgression by the Devonian seas. Middle Devonian carbonates unconformably overlie the crystalline basement complex in the extreme westerly portion of the map area. Exposures in the banks of the Slave River show flat to gently warped beds, with solution-collapse breccias locally cemented with bitumen. These Devonian strata thicken to the west where they underlie Wood Buffalo National Park.

Yet another long period of uplift and erosion preceded the Pleistocene continental glaciation. This glaciation is the most significant recent geological event in the region, and has left a generally high proportion of bedrock outcrop and minor scattered glacial deposits, with the exception of the lowlands along the Slave River.

A recent (postglacial) pronounced change of channel position is indicated for the Slave River where an abandoned channel (now partly occupied by La Butte Creek) projects a maximum of 10 km easterly of the present channel. It should be noted that this unusual deviation coincides with widespread surficial sandy sediment, i.e. marking a possible buried Athabasca Group sandstone outlier in a graben structure.

Map units

Rock unit classification

Most of the primary structures and textures of sedimentary and igneous rocks in the crystalline basement complex have been obscured or lost entirely in the course of high-grade metamorphism, partial melting, intrusion, and deformation. Mixed rock assemblages, and wide, gradational contact zones, are evident in both outcrop and on a regional scale. This is true in terms of both pluton/pluton and pluton/granite gneiss contacts. The principal map units shown in the accompanying colored geological maps depict only the predominant rock unit within a given outcrop area. Of necessity, the smaller-scale variations of minor lithologies are largely not represented on the maps.

To permit petrological, geochemical and geophysical comparison, and classification of map units, certain hand specimens are designated as standard reference samples. These standard samples represent as nearly as possible the typical lithology of each map unit as observed in the field. Standard samples of granitoid, gneissic, mylonitic, and metasedimentary rock are listed in tables 5 to 9 (appendix) along with their modal and major element analyses. Field locations of these standard samples are shown on the accompanying four geological maps.

Granite Gneisses[1] (11)[2]

The Granite Gneisses are characteristically banded in outcrop. However, the banding ranges widely in quality from distinct to indistinct, and on a small scale is locally absent. This metamorphic banding can be planar in geometry or wavy to contorted, as in migmatitically associated structures. Individual bands can be fairly continuous, or discontinuous to streaky, and either well or poorly defined (as in the case of mafic-poor, felsic orthogneisses). In appropriate cases, by looking

[1]The incidence of Hornblende Granite Gneiss is sufficiently low that it has not been separated as a mappable unit on these map sheets, and, therefore, it is included as a minor component within the more broadly defined Biotite Granite Gneiss.

[2]Numbers in parentheses refer to map unit designations used on the accompanying geological maps.

at very low angles of incidence along the outcrop surface, it is possible to discern the continuity of an individual band from long, attenuated plastic flow folds where the limbs commonly lie in direct contact and can extend together for a metre or more in length.

The granite gneiss terrain typically contains subordinate small granitoid masses. The composition and texture of the small granitoid masses are similar to the principal granitoid rock units of the region (Slave, Arch Lake and Wylie Lake). Where large enough, the masses of granitoid rocks are mapped as the appropriate rock unit.

The Granite Gneisses are typically composed of quartz-feldspar layers alternating with mafic-rich layers of foliae, which are usually (chloritic) biotite, and which locally contain hornblende. The gneisses are typically medium grained overall, with the felsic mineral layers being noticeably more abundant and coarser grained than the intervening mafic-rich layers. Chloritization of biotite is usual, and epidote veinlets are present locally. Quartz veins, pods, and pegmatite masses are fairly common. Isolated grains of allanite and concentrations of magnetite in streaks parallel to the foliation have been noted (table 5).

Amphibolite and metasedimentary rocks are commonly present as minor components of the granite gneiss terrain. Usually they occur as small lenses or bands parallel to foliation.

A large part of the Archean granite gneiss terrain has been subjected to mylonitization within the wide Allan Fault Shear Zone. These regional mylonite zones of deep-seated origin show the effects of extensive recrystallization in both outcrop and thin section (table 9).

Amphibolite (20)

Amphibolite is present in a variety of host rocks. These rocks are found within each of the major geologic terrains and rock groups—granite gneiss, high-grade metasediments, and granitoid rocks. The widespread distribution and range of rock associations of amphibolites in this igneous-metamorphic terrain suggests that they were emplaced and/or generated under a range of geologic conditions and times. Amphibolites do not show any marked regional or local pattern of distribution or concentration. Furthermore, major bodies of amphibolite have not been found in the map area, and nowhere do they develop thicknesses indicative of either a volcanic association or a major plutonic mass. Their origins probably involve both metamorphic and igneous processes. Chilled contacts have not been observed; however, such features could have been obliterated through subsequent deformation, metamorphism, and recrystallization.

Amphibolite lenses and narrow bands are common in the granite gneisses, typically ranging from 0.7 to 3 m (2 to 10 ft) thick and from 2 to 6 + m (6.5 to 20 + ft) long. They usually trend parallel to the metamorphic foliation and show ductile to plastic deformation. Most amphibolite bodies tend to be discontinuous and probably represent either boudinaged basic dykes and sills, a fragmented restite accumulation, or an agmatitic pegmatite complex within granite gneiss or metasedimentary rocks. Amphibolites are relatively uncommon in the major granitoids of the map area.

Massive amphibolites are dark green on a freshly broken surface, weathering to a greenish gray. Gneissic banded varieties weather to alternating green and white to pink layers. Feldspars stand out selectively in high relief on a weathered surface, giving the amphibolite the false appearance of being a much more felsic rock. Hornblende and feldspar are the principal minerals with minor amounts of biotite and chlorite. Veinlets of epidote and quartz are locally present. As the proportion of hornblende decreases, amphibolite grades to either hornblende granite gneiss or to metasedimentary rock. The grain size of amphibolite generally ranges from fine to coarse, although hornblende crystals greater than 5 mm are relatively uncommon. The texture ranges from massive to foliated to banded, the latter two textures being most common. Many of the banded varieties consist of bands from 10 to 15 mm thick, in which alternating layers differ in their hornblende to feldspar ratio.

Many of the amphibolites, particularly in the granite gneiss and high-grade metasedimentary rock terrains, have a rusty weathering surface. This phenomenon is probably related in part to the decomposition of small amounts of pyrite.

The less-recrystallized, less-deformed amphibolites (particularly those that have dyke-like relationships to the granitoid host rocks) are probably the youngest igneous rocks in the map area.

High-Grade metasedimentary rocks (31)

The high-grade metasedimentary rocks are found as relatively minor lenses and bands within the granite gneiss and the graintoid terrains. The largest band and concentration of metasediments is situated in the granitoid/granite gneiss contact zone.

The high-grade metasedimentary rock bodies tend to be elongated in plan view. Their long axes are aligned with the regional structural trend (mostly northerly). In outcrop, the metasedimentary rock structures show intricate, generally steeply dipping isoclinal folds that are locally crenulated and chaotic (due to flow folding), particularly in migmatitic associations. The enclosing gneisses or granitoids are invariably much less deformed. Such structural relationships indicate greater mobility (plasticity) of the metasedimentary rocks, compared with the host gneisses or granitoids, in the course of deformation.

The metasedimentary rocks are typically quartzofeldspathic with subordinate amounts of schist, phyllite and amphibolite (table 5). These rocks are of high metamorphic grade. Almandine is commonly identifiable in outcrop, and hypersthene, green spinel, sillimanite and cordierite are visible under the microscope. The metasedimentary rocks are typically pyritic, and commonly have a rusty appearance in weathered outcrop. Locally, the rust may be sufficiently extensive to be termed a rusty zone, or in the extreme case a gossan.

The outstanding structural feature of high-grade metasedimentary rocks in outcrop is the fairly regular (relict?) compositional banding. However, this banding becomes more disrupted and therefore less continuous as the amount of metamorphic quartz and feldspar increases. At the same time, the rock becomes less sedimentary and more granitoid in appearance. Where the granitic component is not prominent, the metasedimentary rocks are typically well foliated, color banded, or both.

Prograde metamorphism of the metasediments reaches a maximum of granulite facies conditions, as indicated by the presence of hypersthene, green spinel, and sillimanite (Godfrey and Langenberg, 1978a). The associated granitization (possibly including some igneous material) is expressed in a variety of ways:

- isolated feldspar porphyroblasts;
- quartzo-feldspathic concentrations as clusters, pods, and irregular patches;
- pegmatites with either conformable or cross-cutting relationships;
- migmatitic to gneissic phases; and
- minor granitoid bodies.

Schlieren of either biotite concentrations or granitized metasedimentary rock may be present. The end products cover a lithologic range which is gradational from regularly banded metamorphic rocks of obvious sedimentary parentage to rocks that contain a high proportion of metamorphic quartz and feldspar. In outcrop, these rocks are classified as migmatites and granitic or pegmatitic masses.

Amphibolite bands, 0.5 to 2 m (1.5 to 6 ft) thick, are fairly common in the metasediments and generally parallel the metamorphic foliation.

Sulfide mineralization is common in the metasedimentary rocks. Pyrite, by far the most abundant sulfide mineral, is associated with rusty zones. Minor copper (chalcopyrite), molybdenite, graphite, and uranium have been noted in adjacent map areas; they can also be expected to be found here if these metasedimentary rocks are thoroughly prospected. Narrow, milky white quartz veins and pods, singly or in groups, are usually barren of sulfide mineralization.

The granitoid rocks

This group of crystalline rocks includes all of the granitoid[3] rock units. Together, granitoids make up more than 91 percent of the map area. There are essentially two broad groupings based on genetic affinities—the Slave and Arch Lake Granitoids. The individual plutonic complexes range in size from more than 40 km to less than 1 km across and in this map area probably have a limited range of Hudsonian ages.

[3]The term granitoid is used as a general field term, insofar as the granitoid plutons and rock units collectively, and in some cases individually, represent a range in composition. Some plutons and rock units range from granite to quartz diorite or to granodiorite; others have a more restricted compositional range. See figure 3 for compositional details of individual rock units.

Slave Granitoids

The Slave Granitoids dominate the western part of the map area and represent the most abundant rock unit in the exposed Shield of Alberta. The lithologic and structural characters of the granitoids are relatively simple compared with those of the Granite Gneiss belt. Nonetheless, the Slave Granitoids contain numerous fragments and masses that are gradational to Arch Lake Granitoids and metasedimentary rocks. The eastern margin and a central 'east to west' zone in the Slave Granitoids, in particular, have a concentration of these masses. Furthermore, the internal structure of the granitoids is not simple in detail. The foliation reveals several domes and basins, (e.g. Disappointment Lake area [maps in pocket, Langenberg, 1983]).

Slave Granite Phase (101)

The Slave Granite Phase has a relatively limited textural and compositional range. It has a fairly light overall color in outcrop, commonly gray to white, but ranging to pink or mauve pink. The characteristically massive, medium-grained texture locally displays fine- and coarse-grained variations. The typically uniform grain size is locally megacrystic, with 15 to 30 mm long white feldspars making up to 15 percent of the rock. The rock is typically garnetiferous, with a chloritic-biotite envelope around garnet cores (tables 5 and 6). These mafic knots (clots) are about 5 mm in diameter and are dispersed through the rock masses (up to an abundance of 4 percent). Green spinel (and hypersthene, corundum, elsewhere in the Slave Granitoids) seen under the microscope places this rock unit in the granulite facies.

Mafic Slave Granite Phase (102)

The Mafic Slave Granite Phase is similar and gradational to the typical Slave Granite (101). It is distinguished by a higher dispersed biotite content (table 7).

Subordinate masses of Arch Lake Granitoids and high-grade metasedimentary rocks are common in the Slave Granitoids. Derivation of the Slave Granitoids by partial melting of the granite gneisses followed by segregation of infrastructure materials (possibly dominated in composition by metasedimentary rock) seems most plausible from the mapped field relationships and the geochemical study of Goff et al. (1986).

Red Slave Granite Phase (103)

This rock type is similar to Slave Granite Phase in mineralogical and textural features, but has a distinct pinkish red appearance. It is seen to be gradational to gray, pink, and mauve phases. It may be locally mixed with Slave Granite Phase, making up a minor component of about 10 to 20 percent of an outcrop. Typically leucocratic, garnets in mafic knots make up from 1 to 5 percent abundance; porphyroblastic feldspar from 20 to 30 mm across makes up 5 to 20 percent abundance (table 7). The matrix is medium- to coarse-grained with a typically weak foliation, though quartz is commonly rodded. Although (chloritic) biotite forms typically less than 1 percent of the rock, locally higher concentrations provide a better defined foliation. Intimate mixtures with aplo-pegmatite are local. The principal rock type is granite with minor variations to granodiorite.

Red Slave Granite generally has gradational and locally intrusive contacts with a number of other rocks, including granitoids, aplites, high-grade metasedimentary rocks, and granite gneiss. Migmatitic blocks of metasedimentary rock and granite gneiss have also been seen in Red Slave Granite. It is possible that Red Slave Granite is a late magmatic phase of the Slave Granitoids, it has injected and intruded earlier-formed granitoid phases, and it may have facilitated massive intrusion as a minor (20 ± percent) magmatic component. Its transitional (intermediate) composition between Slave Granite and Arch Lake Granite, looking very similar to Arch Lake Transitional Granite, emphasizes a genetic link between the Slave and Arch Lake Granitoids.

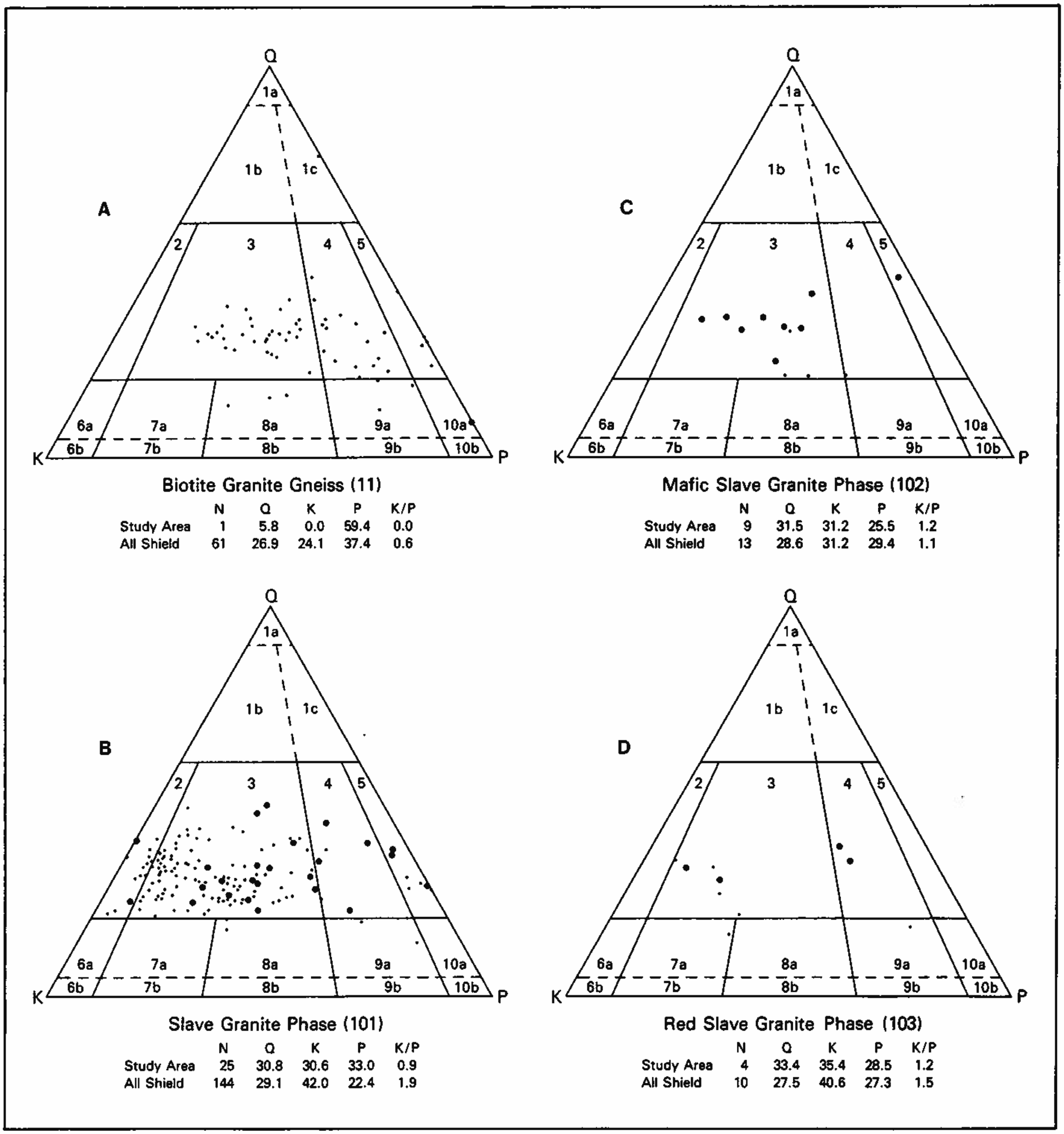
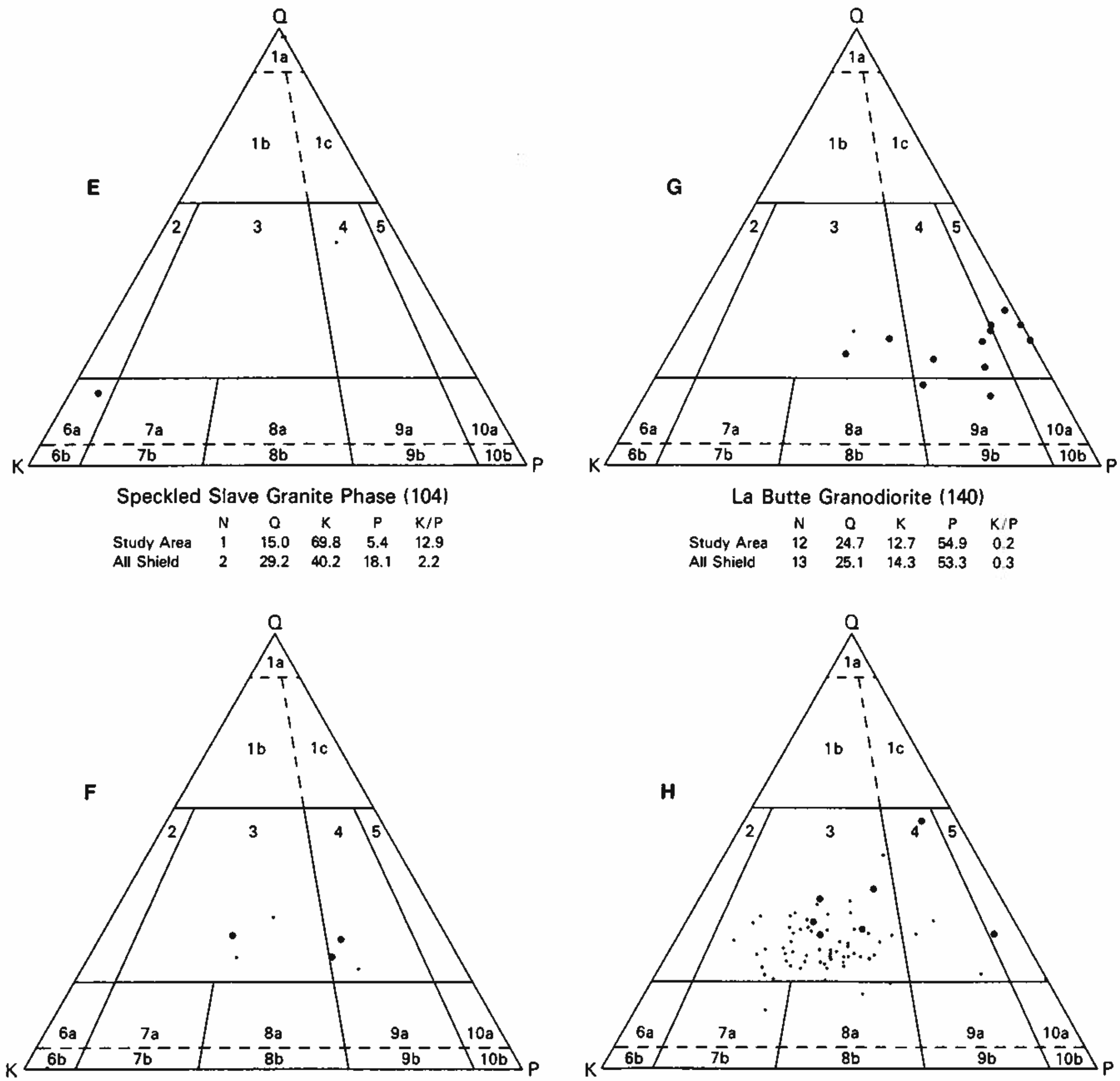


Figure 3. Ternary quartz-alkali feldspar-plagioclase feldspar (Q-K-P) plots for granitoids and gneisses in the study area.



Speckled Slave Granite Phase (104)

	N	Q	K	P	K/P
Study Area	1	15.0	69.8	5.4	12.9
All Shield	2	29.2	40.2	18.1	2.2

La Butte Granodiorite (140)

	N	Q	K	P	K/P
Study Area	12	24.7	12.7	54.9	0.2
All Shield	13	25.1	14.3	53.3	0.3

Slave PQ Granite Phase (105)

	N	Q	K	P	K/P
Study Area	3	26.4	27.7	38.0	0.7
All Shield	7	21.6	34.6	30.8	1.1

Arch Lake Granite Phase (161)

	N	Q	K	P	K/P
Study Area	7	34.3	24.1	32.2	0.7
All Shield	70	27.1	36.3	29.5	1.2

Figure 3. (continued)

Speckled Slave Granite Phase (104)

This phase of the Slave Granitoids is similar to the Slave Granite Phase (101) in most textural and structural aspects. It differs in having an overall reddish and mottled appearance due to the presence of red and white feldspars. The matrix of feldspar, quartz, (chloritic) biotite and sericite is typically foliated and can be mildly crushed. Two samples on the Q-K-P plot (figure 3) show a wide variation in composition, from a quartz-bearing alkali syenite to granodiorite (table 7). Speckled Slave Granite Phase is an extremely minor component of the Slave Granitoids and generally bears a genetic relationship similar to other minor components such as Red Slave Granite Phase and Slave Granite PQ Phase.

Slave PQ Granite Phase (105)

A member of the Slave Granitoids, Slave PQ Granite is noted primarily for its reddish pink to pink color and the presence of red feldspar megacrysts from 6 to 12 mm

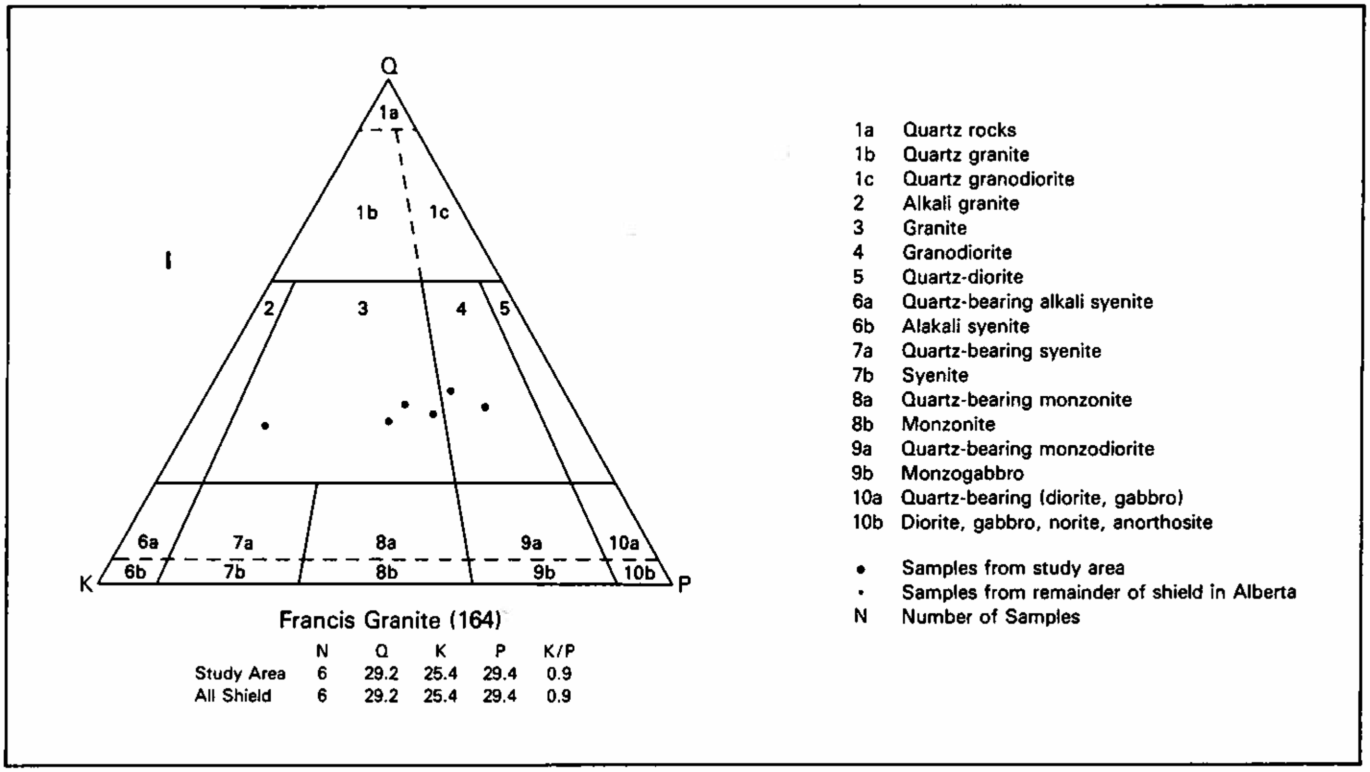


Figure 3. (continued)

across. Biotite, at 3 to 5 percent abundance, contributes to a foliated and even gneissic matrix, although there are also locally massive phases (table 8). Small lenses and bands of metasedimentary rock appearance are typical of this rock unit. The predominant rock type is granite with gradations to granodiorite. In the field, Slave PQ Granite exhibits gradational and intrusive contacts with other granitoids, and it contains blocks of other granitoids, such as Arch Lake Granite. Thus, Slave PQ Granite could be a late magmatic phase of the Slave Granitoids. It also shows a tendency to be migmatitic, and even gneissic, to the point where a small outcrop could be mistaken for a felsic or migmatitic granite gneiss. This latter observation suggests that Slave PQ Granite is the product of partial melting from the parent Archean granite gneisses, and locally still shows textural evidence of the protolithic gneiss.

Wylie Lake Granitoids

This group of granitoids was first described in the Wylie Lake district (Godfrey, 1980a) where these rocks are especially abundant. Although the map units have been extended into the Bocquene-Turtle Lakes map area, a strict stratigraphic correlation is not intended at this time. Field associations of the Wylie Lake Granitoids and granitized, high-grade metasedimentary rocks are similar and they appear to have close genetic relationships.

Granodiorite E (132)

Granodiorite E is most abundant in the Wylie and the Colin Lake map areas. Typically, it is intimately associated with other Wylie Lake Granitoids, especially Fishing Creek Quartz Diorite and Wylie Lake Granodiorite Phase. Granodiorite E has an overall greenish or brownish color in outcrop and can appear finely mottled in hand specimen. Pink to red subhedral feldspars from 6 to 8 mm long appear slightly megacrystic in an equigranular, medium-grained, massive to poorly foliated matrix of feldspar, quartz and (chloritic) biotite. Although of very small proportion, larger megacrystic feldspars from 10 to 15 mm long, making up less than 1 percent, are nevertheless characteristic of the rock unit. The common granodioritic composition of Granodiorite E extends marginally into the granite field. Chemical and modal analyses appear in Godfrey and Peikert (1964).

Based on close field relationships and similar mineral compositions, a genetic link is indicated between Granodiorite E, Wylie Lake Granodiorite Phase, possibly Fishing Creek Quartz Diorite and high-grade metasediments. Differences in feldspar megacryst formation (a late-stage petrogenetic feature) among these granitoids may reflect local variations in mineral distribution and potassium metasomatism.

Fishing Creek Quartz Diorite (133)

Fishing Creek Quartz Diorite is lithologically equivalent to the same map unit in the Wylie Lake area to the east (Godfrey, 1980a). It is light gray overall, and in hand specimen is mottled grayish white on a medium gray background. The typical texture is almost megacrystic, and locally ranges from distinctly megacrystic to equigranular. Although typically foliated, it can be locally either gneissic (with biotite-rich schlieren or metasedimentary rocks) or massive. Megacrystic white feldspars range from 7 to 10 mm in length within the greenish-gray matrix of feldspar, quartz and (chloritic) biotite. Separate small, irregularly shaped, leucocratic granitic masses are common. They are white, fine grained and composed of massive aplite to microgranite, and may be locally pegmatitic.

La Butte Granodiorite (140)
This rock unit is characterized by a generally uniform color and texture. The color ranges from a light-medium gray through brownish gray to mauve (blue quartz plus pinkish gray feldspar). It is typically medium grained with feldspar megacrysts from 8 to 20 mm long that are rare to 5 percent abundant (table 8). The matrix is typically massive to uncommonly poorly foliated or locally gneissic, consisting principally of feldspar, quartz, and biotite. Rock types range from granite to granodiorite, quartz diorite, and quartz monzodiorite, with a mean composition of granodiorite.

La Butte Granodiorite crops out almost exclusively within the Bocquene-Turtle Lakes map area of the Shield in northeastern Alberta. It is intimately associated with the major Slave Granitoids and is confined to an east to west belt through the northern half of the map area (maps in pocket). Outcrops of La Butte Granodiorite commonly show the presence of other minor phases of the Slave Granitoids (e.g. 10 percent of Red Slave Granite); they could be minor magmatic phases that facilitated emplacement of the La Butte Granodiorite. Aeromagnetic survey data, along with the distribution pattern of large-scale 'xenolithic' blocks of Arch Lake Granite, Arch Lake Transitional Granite and Francis Granite, and the proximity to the southern margin of the major Arch lake Granitoids to the north (Godfrey and Langenberg, 1986, in press), suggest a unique regional setting for the La Butte Granodiorite. It appears that the belt containing masses of La Butte Granodiorite and Arch Lake Granite represents a zone of disruption of the Arch Lake Granitoids in the margin of the Slave Granitoids (figure 4 and maps in pocket). If the numerous large blocks of Arch Lake Granitoids are indeed xenoliths or boudins, then their distribution and that of the La Butte Granodiorite are in harmony with an east to west bulk displacement (ductile flow) for the Arch Lake Granitoids major pluton. Such an event also explains the gap in the Arch Lake Granitoids zone that is peripheral to the Slave Granitoids (i.e. adjacent to the granite gneiss wall rock). Large-scale (regional) flow of a mixture of granitoids, including a minor viscous magma component, could account for the rock unit distributions observed today.

Boudins of metasedimentary rock are seen within the La Butte Granodiorite phase. Numerous dykes of La Butte Granodiorite 15 cm thick and up to 6 m long are seen to intrude Francis Granite parallel to the metamorphic foliation. The dyke walls are sharp, straight and unsheared. There is no sign of ductile deformation near the dykes.

The contacts between major bodies of La Butte Granodiorite and Francis Granite exhibit ductile flow features. Zones from 20 to 30 m wide of shear-flow contain oval-shaped boudins of La Butte Granodiorite, basic material, and gneissic banding that locally becomes chaotic. The boudins are from 0.3 to 1 m wide with their long axes aligned and parallel to the foliation. At a major contact, the La Butte Granodiorite is generally gneissic and shows flow folds. These ductile deformation features at the contacts are interpreted as adjustments to imposed stress while still in a plastic state, but nonetheless allow the intrusion or introduction of basic material from a separate source.

Hematitic staining is characteristic along fractures within La Butte Granodiorite and is interpreted as a late-stage alteration feature.

Arch Lake Granitoids
Arch Lake Granitoids masses are found exclusively in association with the Slave Granitoids plutonic complex in the western granitoid terrain of the map area. Arch Lake Granitoids blocks and bands of major and minor dimensions are scattered within the pluton, but with two notable concentrations: 1) towards the eastern margin of the pluton adjacent to the granite gneiss belt; and 2) in an east to west zone through the center of the map area (figure 4).

Arch Lake Granite Phase (161)
The Arch Lake Granite Phase is overall reddish in outcrop and is distinctly foliated, both in outcrop and in hand specimen. This penetrative foliation is accompanied by a mild mylonitization. The rock texture is fairly homogeneous, and typically medium-grained, but locally coarse, with up to 25 percent feldspar megacrysts ranging from 15 to 30 mm long (table 9). The megacrysts are commonly aligned in the foliation, giving an augen texture. The matrix consists of pink to red feldspar, biotite, and typically blue quartz. The rock composition is dominantly granite with minor variations to granodiorite and quartz diorite (figure 3).

Arch Lake Granite Transitional Phase (162)
Arch Lake Granite Transitional Phase is a sub-unit of the Arch Lake Granite Phase and it is distinguished by the absence of large (15 to 30 mm long) potassium feldspar megacrysts (table 9). However, a smaller size range of potassium feldspar megacrysts about 15 mm long and up to 5 percent of the rock is usually present.

Francis Granite (164)
This rock unit has an overall brownish gray color. Its outstanding textural feature is the presence of pink to reddish euhedral, tabular-shaped megacrystic feldspars from 25 to 40 mm long, typically forming 5 to 15 percent of the rock. The texture is commonly medium grained, massive or locally poorly foliated, and comprises feldspar, quartz, and biotite. The abundant sharply angular feldspar megacrysts are typically random to sub-parallel oriented. Locally, the feldspar megacrysts may be rare or even absent. The composition of Francis Granite is granitic but ranges to granodiorite (figure 3).

Local concentrations of feldspar megacrysts form pegmatitic masses, otherwise pegmatites and aplites are not typical of this melanocratic granite. Basic

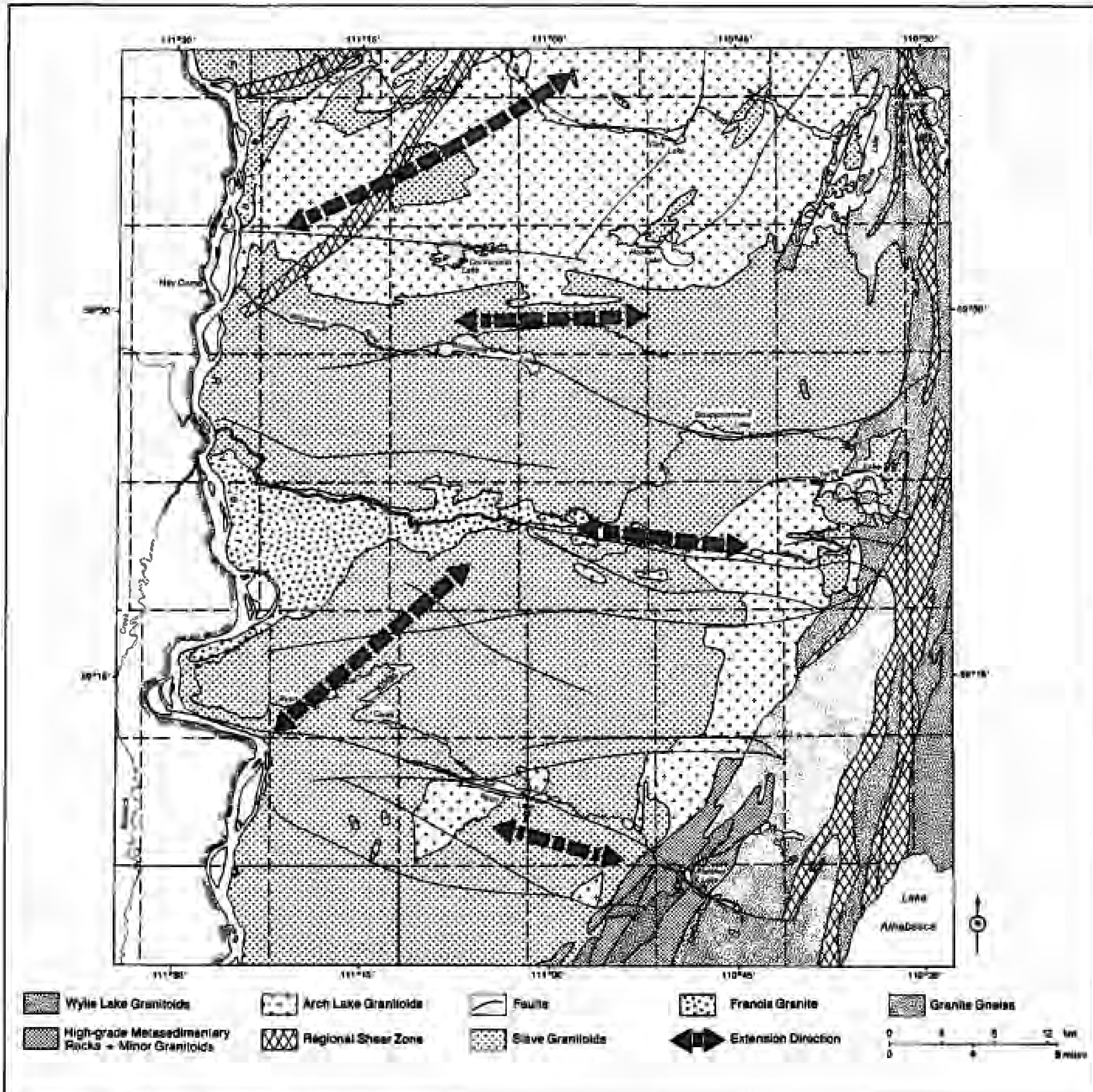


Figure 4. Regional deformation of the Arch Lake Granitoids marginal zone.

schlieren are present in minor amounts. This rock unit is regarded as a member of the Arch Lake Granitoids group by virtue of its composition, textural similarities, and field distribution and associations. Mixtures of this rock unit with minor (10 percent) Slave Granitoids are common. Intrusive relationships with La Butte Granodiorite show that the latter is younger.

Regional Shear Zones

Shear zones with mylonitization, principally affecting the belt of granite gneisses in the eastern part of the map area, are an expression of the 8 km wide Allan Fault Zone (Godfrey, 1958). Within this shear zone mylonitization has produced deformational products ranging from ultramylonite to less-crushed phases of flaser gneiss and mylonite. All of these crushed rocks have been affected by recrystallization to some extent, resulting in the formation of blastomylonites and the commonly observed porphyroclastic-augen feldspars. Rocks of the mylonitic group underlie two percent of the map area.

Mapping indicates that the parent materials for the mylonitic rocks are dominantly gneisses, with lesser amounts of high-grade metasedimentary rocks, Slave and Arch Lake Granitoids.

The compositional and textural fabric in these mylonitized zones tends to be planar in form. The planar geometry is seen over a range of scales, from hand specimen to outcrop, and to belts several kilometres along the strike (as viewed on aerial photographs).

The regional mylonitic shear zones have been studied by Watanabe (1965), and some aspects have been discussed by Godfrey (1966, 1980b), and Langenberg (1983). It is evident that these structures are associated with deep-seated shear zones, and the mylonitic deformation is essentially of a ductile character. Subsequent to erosional unroofing, further deformation was of a localized brittle nature, involving brecciation and quartz-vein filling. The mylonitic shear zones have been fixed by K-Ar dating at 1790 ± 40 Ma (Baadsgaard and Godfrey, 1972) and are characterized by greenschist facies minerals (Langenberg and Nielsen, 1982).

The color and megascopic texture of the mylonites, together with gradational contacts to less-deformed phases of the rocks, were used to develop a field classification of mylonitic rocks that is both descriptive and genetically meaningful in terms of parental relationships. In a few cases only, distinctions between the mylonites have not been clear. The parental materials themselves, at least in the gneissic terrain, are already mixtures of rock units on a fairly detailed scale, and mylonitization has introduced further blending. An overlap or gradation of geologic character among these mylonites in outcrop or hand specimens is inevitable, but the concern is a very minor one.

The mylonitic group is subdivided on the basis of their protolithic equivalents as follows:

- Mylonitic Rock 221 has largely granite gneiss parent material
- Mylonitic Rock 222 has largely high-grade metasediment parent material
- Mylonitic Rock 223 has largely granitoid parent material

Recrystallized Mylonitic Rock (221)

Recrystallized Mylonitic Rock (221) is pale pink to red or dark greenish on both fresh and weathered surfaces. White to pink feldspar porphyroclasts from 6 to 18 mm long make up to a maximum of about 5 percent of the rock. The augen-shaped porphyroclasts may have trails of smaller feldspar crystals and fragments that are enclosed in a foliated aphanitic, finely banded matrix. Metamorphic foliation has a generally simple geometry in outcrop, but on the regional scale, folds can be clearly demonstrated.

Small amounts of other rock units in the mylonitic group are mixed in this map unit on a scale too fine to be distinguished separately on the present scale of mapping. As the bodies become smaller, distinctions among map units are less evident.

Recrystallized Mylonitic Rock (221) is always enclosed by, and associated with, a rock assemblage typical of the granite gneiss terrain. The contact with these rocks—gneisses, metasedimentary rocks and amphibolite—is commonly gradational. It is obvious that granite gneiss was the predominant parent material from which Recrystallized Mylonitic Rock (221) was developed.

Recrystallized Mylonitic Rock (222)

Fresh and weathered surfaces are dark green to gray to black, and freshly broken surfaces can be vitreous. Minor porphyroclasts of feldspar, and more rarely of quartz, are enclosed in a siliceous, banded, massive to foliated, aphanitic to schistose or phyllitic matrix, with chlorite, biotite, and sericite.

Geometrically simple metamorphic foliation structures and gradational crushed and sheared contacts follow the pattern described for other mylonites of granite gneiss and granitoid rock associations. It is apparent that quartzo-feldspathic metasedimentary rocks with minor schistose and basic rocks were the parent materials for the Recrystallized Mylonitic Rock (222).

Recrystallized Mylonitic Rock (223)

Fresh and weathered surfaces are medium to dark gray. White to gray feldspar augen and euhedral porphyroblasts from 1 to 7 cm in size form 5 to 15 percent of the rock. The matrix is typically aphanitic and foliated, and locally medium grained and gneissose. Minor aplites and pegmatites are present as small bodies that conform generally to the main structural trend.

Foliation patterns have a typically simple geometry in outcrop, but on a regional scale they grade from simple forms in the north to distinctly folded and more complex forms in the south. The mylonite contact with quartzo-feldspathic metasedimentary rock is commonly interlensed and is gradational both texturally and mineralogically over a short distance. Recrystallized Mylonitic Rock (223) surrounds, and is completely gradational to, uncrushed cores of Biotite Granite F. Granite gneiss in contact with Recrystallized Mylonitic Rock (223) becomes less contorted and more mylonitic, and the size of feldspar porphyroclasts gradually increases from 1 to 7 cm as the mylonite is approached. Bands of granite gneiss from 0.3 to 3 m wide can be recognized in the contact zone, where felsic and mafic layers of the parent gneiss remain distinct in the mylonitic granite gneiss.

Devonian carbonate rocks (252, 253, 254)

Middle Devonian and/or earlier age carbonates rest with profound unconformity on the weathered surface of the Precambrian crystalline basement complex. Carbonate rocks which crop out along the Slave River at the extreme western margin of the map area have been described in detail by both Norris (1963) and Richmond (1965). Where the unconformity is to be seen in the adjacent map area to the north, the basal regolith grades upwards through a conglomeratic, sandy granite wash into a sandy dolostone. Rubbly bedding lower down in the carbonate section gives way upwards to well-bedded, flat to warped, gently westward dipping strata consisting of sandy and argillaceous dolostone, fine-grained vuggy dolostone and dolomitic limestone, and laminated gypsiferous lithographic dolostone. In the north bank at the mouth of Murdock Creek, collapsed brecciated limestone, presumably related to either evaporite or carbonate solution below water level, has been subsequently impregnated and cemented with bitumen.

Modal and chemical analyses

Mineralogical and chemical data on rock units in the map area are presented in tables 5 to 9 (appendix). Representative specimens were chosen from all of the major groups—the gneissic, granitoid, mylonitic, and high-grade metasedimentary rock map units. Selection of the standard hand specimens for detailed analyses were based on the representative character of their features as seen in outcrop. The gneissic and granitoid standard samples are represented by individual hand specimens. However, because of the typically wide lithological variations encountered within the metasedimentary rock bands, each standard sample for the high-grade metasedimentary rocks is represented by a combined group of 5 to 10 specimens. Metasedimentary standard rock samples were ideally collected on traverses approximately perpendicular to the regional strike of the compositional banding (see geology maps in pocket).

Modal analyses for the gneissic and granitoid rock units are plotted on a series of Q-K-P diagrams (figure 3). Modal data plotted from the present study area are distinguished from those of the same rock unit in other parts of the exposed Shield in Alberta. Rock type boundaries in these diagrams are plotted according to the recommendations of Streckeisen (1967).

Field work, and geochemical (Goff et al., 1986) and geochronological studies, strongly suggest that the Archean basement gneiss complex was the source from which the younger Aphebian granitoids were derived. High-grade regional metamorphism of these gneisses led to partial melting and mobilization of the granitoid constituents.

The range in modal composition of the granite gneisses and high-grade metasediments does not include the plagioclase poor-to-absent area corresponding to the alkali feldspar granite members of the Slave Granite (101) (figure 3). Hence, complete melting does not appear to be a likely genetic mechanism for these compositions. However, partial melting of the assumed parent materials would be expected to generate end products of potassium-rich composition similar to those of the Slave Granite (Lameyre and Bowden, 1982).

Based on the compositional norms for the abundant rock units (granite gneiss, Slave and Arch Lake Granitoids) the diagrams (figure 3) indicate divergent lines of granitoid evolution and segregation from the parent granite gneisses. The intimate relationships of minor granitoid masses within the granite gneiss/high-grade metasedimentary belt supports the petrogenetic concept of the parent gneissic material and derived granitoids. The mobilized granitoids are likely to consist of a dominant mobilizate component with minor restite in a solids-dominated, crystal-melt mush during intrusion. Much of the restite component produced by the partial melting of the gneiss could form a solids phase within the melt. The restite would be represented by calcic plagioclase cores enclosed by a mafic/mineral-rich zone. Intrusive relationships (irregular dykes and screens next to large-scale blocks) have been observed. Although compositions are similar, the magmatic components tend to be more leucocratic than the blocks.

Mafic Slave Granite is part of the continuous compositional gradation from Slave Granite to Arch Lake and Arch Lake Transitional Granites. In terms of our present geochemical view of the petrogenesis of the granitoids, this rock unit could contain more of the restite from partial melting of the granite gneisses than the abundant Slave Granite unit. In the Arch Lake Granitoids, the melanocratic Francis Granite is likewise a possible restite-rich component.

The intimate field relationships of minor leucocratic components as irregular dykes and patches within the granitoids (Slave Granite, Mafic Slave Granite, Arch Lake Granite Phase and Arch Lake Granite Transitional Phase) is a product of late-stage leucosome (magmatic) segregation and mobilization. Such widespread occurrence of a leucosome phase in each of the granitoid complexes points to a common petrogenetic history of the granitoids.

Minor amounts of scattered, small bodies of amphibolite are believed to be derived by metamorphism, structural extension, and dislocation of diabase dykes and metamorphic basic segregations. The high-grade metasedimentary rocks (table 3) are quartzitic granulites that correspond to starting compositions of arkosic graywackes.

The chemical composition of the metasedimentary rocks tends to be low in CaO, MgO and Na_2O, and high in K_2O, relative to worldwide averages for graywackes. These differences, at least in part, are probably reflected in the locally high K_2O content of the major granitoid bodies of Slave and Arch Lake affinity in the Shield of northeastern Alberta.

In summary, it is apparent that the basement gneiss complex has been partially molten, mobilized, segregated, and recrystallized during the formation of the Slave and Mafic Slave Granites.

Metamorphism

Metamorphic grades are estimated to be generally high, ranging from high-pressure granulite to amphibolite facies conditions (Godfrey and Langenberg, 1978a, 1978b; Nielsen et al., 1981; Langenberg and Nielsen, 1982). Hypersthene is present in the Slave Granite, whereas spinel, hypersthene, and sillimanite are typical of the high-grade metasedimentary rock bands. The above minerals indicate the attainment of regional granulite facies conditions.

Metamorphic events in the Shield of northeastern Alberta have been identified and dated by geochronology using a variety of radioactive systems and isotopes (Godfrey and Baadsgaard, 1962; Baadsgaard et al., 1964; Baadsgaard and Godfrey, 1967, 1972). Two principal metamorphic events have been defined (Langenberg and Nielsen, 1982):

1. An Archean high-pressure granulite facies metamorphism, M_1, is indicated by relic hypersthene, sillimanite, green spinel, and corundum in the Slave Granitoids and high-grade metasediments.
2. An Aphebian moderate-pressure granulite facies metamorphism, M_2, which affected all the crystalline Shield rocks of Alberta, coincided with the intrusion of most of the granitoids.

No remnant of an Archean metamorphism (M_1) has been found in the Arch Lake Granitoids. The Aphebian M_2 Event is associated with an assemblage of almandine, hornblende, cordierite, and andalusite. The moderate-pressure granulite maxima of the M_2 Event has been traced by electron microprobe mineral analysis to retrogress through the amphibolite facies, and ultimately, to the greenschist facies.

Retrograde greenschist facies conditions are expressed by the widespread and common occurrence of chlorite, muscovite, and epidote. Chlorite is usually seen as an alteration product of biotite, hornblende, or garnet, wheras epidote typically occurs as veinlets.

Development of the regional mylonitic shear zones—the Allan and Warren Fault Zones—is related to greenschist facies conditions, presumably a late stage of the Hudsonian Orogeny.

Structural geology

An overview of the structural geology of the Shield in northeastern Alberta has been published by the Alberta Research Council (Langenberg, 1983).

The regional structure involves a steep west- to northwest-dipping foliation. It appears that immature diapirs of Slave Granitoids have intruded and domed the older supercrustal gneisses to form mantled gneissic domes. Erosion has subsequently stripped much of the gneissic cover to reveal internal large-scale dome and basin features in the Slave Granitoids of the Bocquene-Turtle Lakes District map area. Similarly, dome and basin structures have been found on a regional scale within all of the major granitoid plutonic masses of the Shield in northeastern Alberta.

The granitoids of this map area display a substantial disruption of the typical north to south lithostructural regional trend. Some north to south trend of the granitoids is evident, but there are also east to west, random, and even non-elongated or -aligned bodies and fabrics.

The major Arch Lake Granitoids zone, which to the south is typically a phase that is marginal to the Slave Granitoids at its eastern contact with the granite gneiss belt (Godfrey, 1984), terminates in this map area (S_2 in figure 2). This termination and several offset (stepped) contacts of the north-trending bands of Slave Granitoids/Arch Lake Granitoids/granite gneiss belt (figure 4) coincide with a concentration of east to west striking transverse faults. Horizontal separations of these easily recognizable contacts are in the order of 2 to 4 km. The system of west to west-northwesterly striking regional faults extends throughout the map area and beyond to the north and south. To the east they do not cross the Allan Fault Zone. The western extension of these faults cannot be traced across the Slave River because Precambrian basement features are obscured by the Phanerozoic cover (Devonian and Recent).

A further coincidence at this locality is that the Arch Lake Granitoids marginal phase has an unusual westward elongation as a nose, plus a train of large-scale blocks of Arch Lake Granite, Francis Granite, and high-grade metasediments towards the west (figure 4). Lastly, the south end of the Arch Lake Granitoids to the north (and just off this map area) has a pronounced distortion or projection to the west (figure 4), indicating an extension similar in direction to that noted above.

Taken together, these observations present a uniform picture of a regional deformation that was active at a time when the Slave Granitoids and Arch Lake Granitoids were in a ductile state. The axis of maximum horizontal extension is in an east-west direction.

The southwest extension of the Arch Lake Granitoids at B (figure 4) cannot be fully assessed in view of the lack of Precambrian outcrop west of the Slave River. Thus, direct observation of the Arch Lake Granitoids margin plus a predictable train of 'xenolithic' blocks is prevented. However, aeromagnetic survey data over the carbonate-covered Shield at this latitude suggests that scattered large blocks of Arch Lake Granitoids are enclosed within the Slave Granitoids terrain.

An alternate structural explanation is offered for the distribution of granitoid lithologies in this region and in adjoining map areas to the north and south. Two domal structures in the roof of the Slave Granitoids to the north and south of the east-west fragmentary granitoid block zone would leave an intermediate east-west structural low (i.e. a basin). Post-uplift erosion can be expected to have removed much of the gneisses and Arch Lake Granitoids that are presumed to have mantled the Slave Granitoids. Today, only pendant root segments are now retained in the structural low between the two domes (i.e. the fragmentary granitoid block zone). Support for this concept can be found in the detailed geological maps and particularly in the structural overview of basins and domes presented in Langenberg (1983).

An unusual aeromagnetically disturbed zone that is regionally scaled east to west (10 km wide), coincides with the disruption of the typically north to south litho-structural trend. In outcrop this disruption is represented by: (1) a gap in the Arch Lake Granitoids which is marginal to the Slave Granitoids, and (2) the east-west concentration of La Butte Granodiorite bodies. The bird's eye aeromagnetic anomaly pattern in this zone of disruption, described by Sprenke et al. (1986), is interpreted as due to the minor bodies of high susceptibility La Butte Granodiorite within Slave Granitoids.

Two sets of major orthogonal faults dissect the map area along north to north-easterly and west to west-northwesterly directions. The principal regional fault structure is the Allan Fault (Godfrey 1958a; Watanabe, 1965) although little is seen of it in this map area and an expression of its full width is restricted to the southeast corner of the map area. The Allan Fault is represented by a steeply dipping shear and mylonitic zone up to a total of 8 km wide. Flow folded structures in the mylonitic shear zone signify a deep-seated origin for these regional shear zones. The sense of horizontal displacement along the Allan Fault appears to be sinistral (figure 5) which is in agreement with that proposed by Gibb (1978).

In outcrop, deformation of the mylonitic rocks is seen as a ductile-shear phenomenon rather than brittle fracture, and is contained principally within the granite gneisses. Recrystallization has affected all rocks of the area, and in the mylonitic zones, in particular, these processes have combined to produce a range of comminuted rock textures, including mylonite, ultramylonite, blastomylonite, and less-deformed phases such as flaser gneiss. Minor local megabrecciation of the mylonites has occurred during a later stage of brittle deformation, producing quartz-filled fractures and quartz-lined vugs.

The Allan Fault Zone is one of two major structural breaks in northeastern Alberta. It can be traced 300 km farther north to the aulacogen of the east arm of Great Slave Lake. Movements along this fault zone were likely intermittent over geologic time. The period of main development of mylonitic shear zones probably took place during the late Hudsonian Event.

The Allan Fault forms part of a system of regional mylonitic shear zones that extend east into Saskatchewan and north into the Northwest Territories. The widespread distribution of such mylonitic zones is of considerable interest and may relate to regional plate tectonic movements.

The Slave and Arch Lake Granitoid bodies appear to have formed by the partial melting (Goff et al., 1986) of the Archean gneissic infrastructure that was mobilized and emplaced higher in the crust. It seems most likely that the various granitoid plutons overlapped in the time of their emplacement. Structural details within the batholithic granitoid masses, especially beyond the map area to the north (Godfrey and Langenberg, 1985b), show a pattern of closely spaced, small-scale dome and basin features. This latter structural character suggests proximity to the roofal section of the major plutonic complex mass.

Some transverse faults are tangential to the dome and basin structures, whereas others cut through these internal structures of the Slave Granitoids. It is evident that doming mostly preceded faulting, but the parallel versus tangential relationships of these fault and fold structures suggest that, in part, these processes occurred simultaneously.

Along with dome and basin features that are found on a range of scales (Langenberg, 1983) in the granitoid masses, isoclinal folds have been mapped within the larger domes as at Disappointment Lake (figure 6). The concentric arrangements of narrow bands of granite gneiss, Arch Lake Granitoids, and high-grade metasedimentary rock strongly suggest ghost stratigraphy. Development of the major diapiric granitoid masses probably entailed the mobilization of quartzofeldspathic material, possibly facilitated by 20 to 30 percent partial melt, all derived from the Archean granite gneisses. Incorporation of granite gneiss (restite) masses could take place in conjunction with intrusion of the Slave Granitoids. Thereby, less-altered segments of the gneisses could be preserved, which now appear as ghost stratigraphy within the granitoid masses. Ghost stratigraphy in other areas of the Slave and Arch Lake Granitoids may be expressed by remnant metasedimentary rock lenses and bands.

All rock units mapped have a foliation. It is typically well developed in the gneissic belt and more varied in quality in the granitoids. These foliations show a variety of ductile-plastic deformational styles in all of the rock units. Migmatitic structures are characteristic of the metasedimentary rock and granite gneiss belt. In outcrop, the foliation fold patterns are generally simpler in form within the Slave and Arch Lake Granitoids, and although less well developed, are nevertheless clearly evident.

The present configuration of the foliation in the various granitoid bodies is a reflection of the large-scale ductile deformation and extension to which the individual granitoid masses have been subjected. The foliation development and pattern in the granitoids results from a combination of metamorphism and plutonism during ultrametamorphism, partial melting, and intrusion.

The granite gneiss terrain is characterized by a layered to foliated metamorphic fabric with minor, local lineation. The deformational structures are commonly complex and represent several phases of deformation, possibly including Archean structures. The fabric can be planar, but is typically folded and locally migmatitic. Tight, collapsed, extension flow folds can be recognized in a few instances. They are probably more common than has been observed to date and establish the extreme ductile deformation of the gneisses. Within the gneissic belt, minor pegmatites can either crosscut or parallel the metamorphic structure and can be either deformed or undeformed. The style and degree of pegmatite deformation reflects the relative timing of pegmatite emplacement and deformation of the host

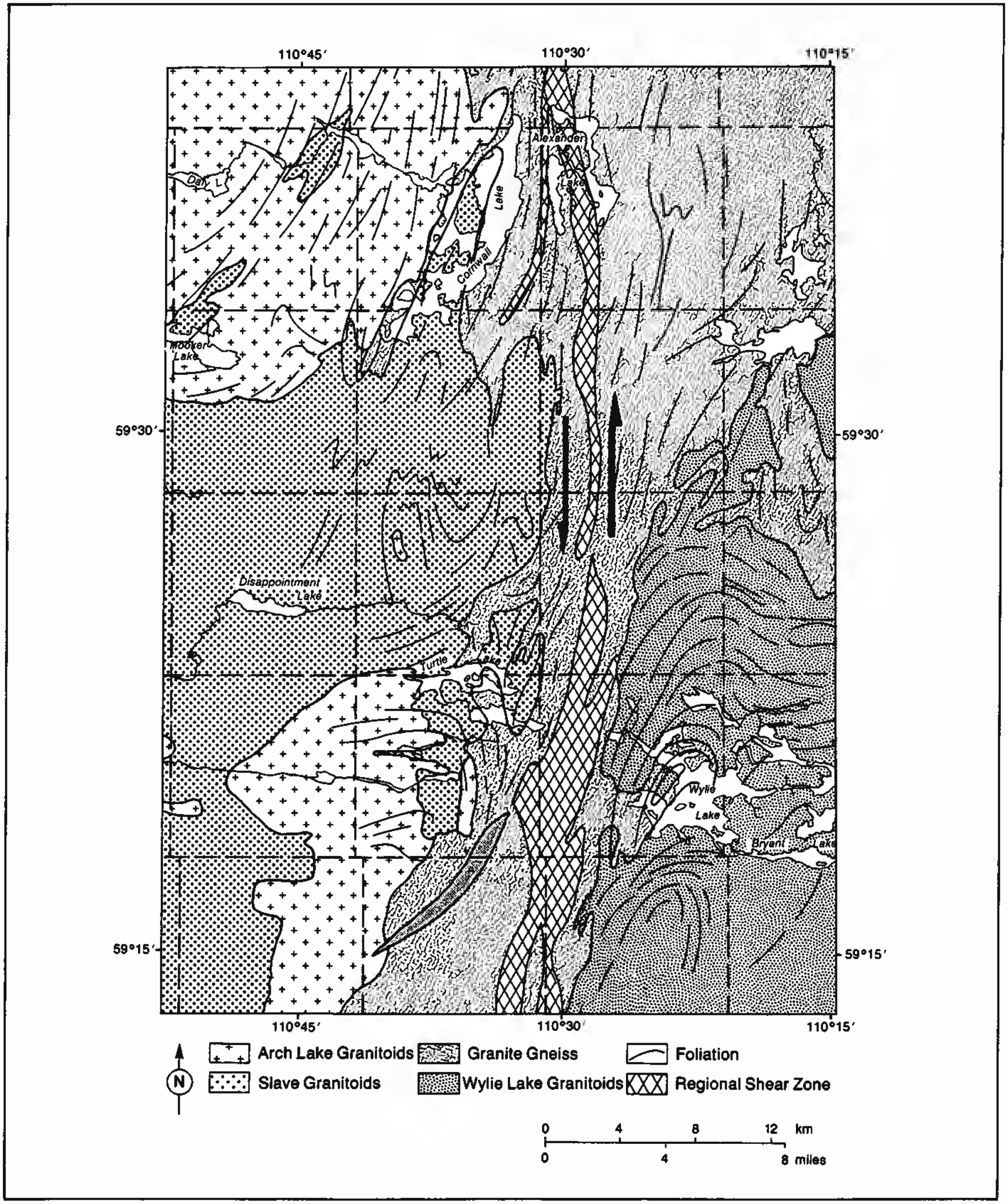


Figure 5. The Allan Fault Zone. Relative direction of horizontal component of displacement shown.

gneisses.

Amphibolites within the granite gneiss terrain illustrate a variety of structural conditions. Boudinage structures are common. Folded structures are seen mostly in association with the thinly banded amphibolites, and uncommon agmatites are developed where pegmatites enclose concentrations of mafic (amphibolitic) blocks.

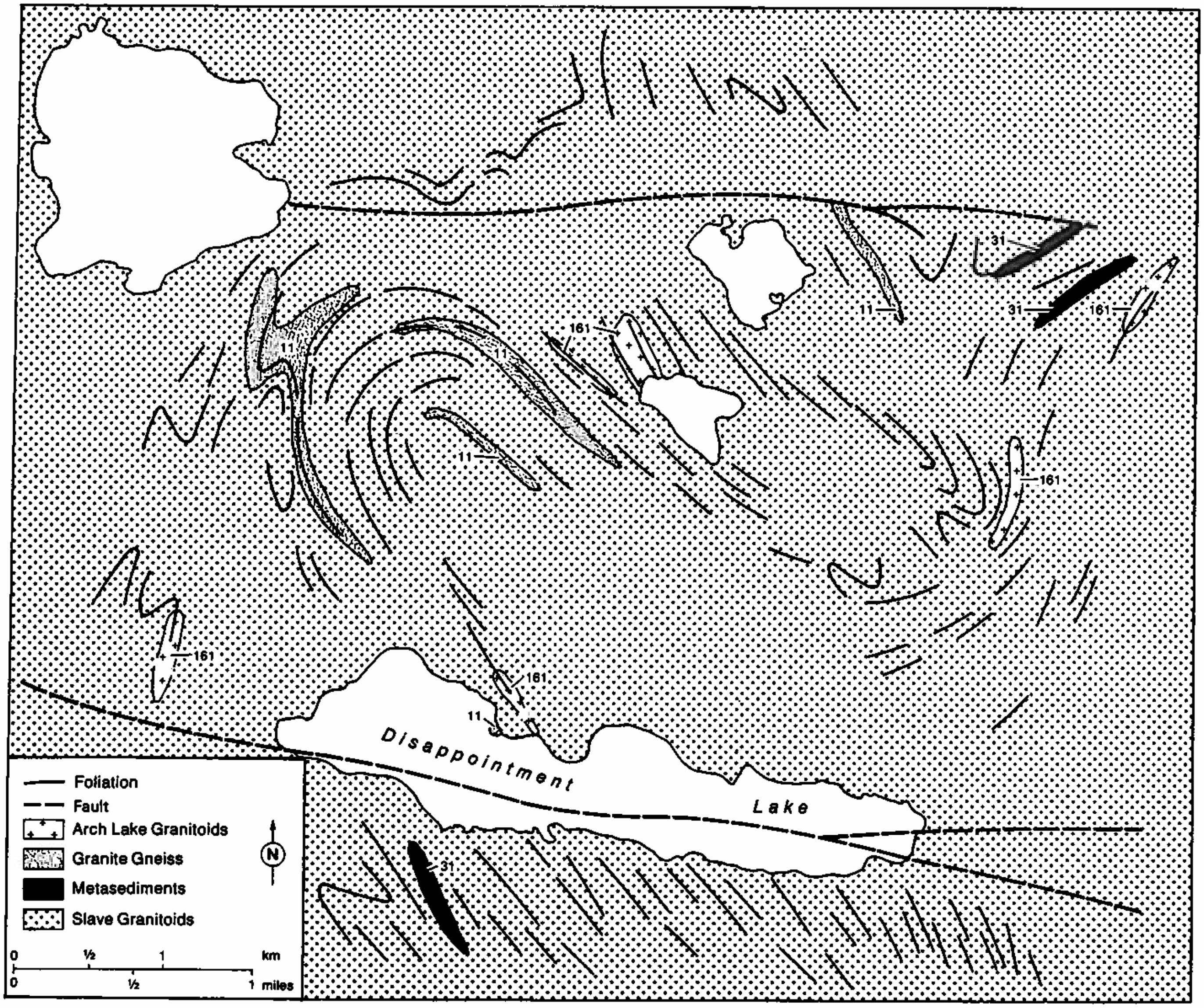


Figure 6. Ghost stratigraphy in Slave Granitoids at Disappointment Lake.

Minor high-grade metasedimentary rock bands within the granite gneiss terrain tend to exhibit a gneissic and color-banded structure. Migmatitic styled flow folds are fairly typical of these bands.

The fabric expression is variable within each granitoid body. Texturally massive phases can grade locally to a foliation or lineation. The margins of plutonic complexes tend to preferentially develop a better-defined foliation, whereas the interior remains more massive. Such variations of fabric within a single body suggest a heterogenous distribution of stress, the principal surfaces of relief being along lithologic and folded structural boundaries. Differences in metamorphic fabric between plutons suggest that emplacement took place over a period of time, especially with respect to the main pulses of tectonic activity.

A fairly representative selection of joints is given on the accompanying geological maps. The dominant orientation is north to south, with subordinate orientations of east to west, northeast and northwest (Langenberg, 1983). Some of these joints are of tectonic origin; they parallel and lie adjacent to shear zones. Other joints are decompressional in origin and formed as a consequence of unloading during erosional stripping of the cover rocks. Decompressional unloading accounts for the formation of both steeply dipping fracture sets and particularly the flat-lying to gently dipping fractures that parallel the overlying topographic slopes.

Economic geology

Experience on the Shield of northeastern Alberta has generally been that minor amounts of metallic minerals are found most commonly in the high-grade metasedimentary rocks. Pyrite is widely distributed in amphibolites and metasedimentary rocks, and uncommonly in the gneisses and granitoids.

Many scattered occurrences of minor uranium mineralization (indicated by secondary yellow stains and confirmed by geiger counter) are known in the Shield of northeastern Alberta, especially in the high-grade metasediments and Slave Granitoids. Minor occurrences of yellow mineral stain and radioactive anomalies were noted in this map area. However, the majority of the high-grade metasediments have not been explored; systematic prospecting of these bands should yield additional anomalies.

Although not observed within the map area, minor occurrences of molybdenite can be expected in this terrain, and its yellow bloom (powellite) could be mistaken for a secondary uranium mineral stain if not checked by a geiger counter or scintillometer. Minor copper (chalcopyrite) showings are associated with some gossans or rusty zones within the high-grade metasediments. Dispersed magnetite is locally present in only low concentrations within the granite gneisses, but is sufficiently abundant to cause problems in the use of a magnetic compass.

The greatest potential for metallic minerals lies within the high-grade metasedimentary rock bands, although the overall economic potential for the map area appears to be low. Faults and shear zones also merit closer examination.

The range of textures and colors available in the granitoids of the map area make this a prospective area for a variety of building stones. The typical local relief of up to 10 to 20 m would make for an easy side-hill quarry operation. Areas of widely spaced, and orthogonally oriented joint sets within the granitoids should be found in the course of surficial exploration. A combination of these favorable factors could yield some very good prospects for obtaining a range of granitic ornamental building stones.

The various types of glacial deposits in this region have a predominant sandy lithology. The well-defined and mapped fluvial channel deposits in the north-trending ice-contact deposits should contain gravel, and therefore offer the best possibility for granular construction materials in the map area.

A keyworded index to assessment reports describing the results of metallic minerals exploration programs has been compiled and is available from the Alberta Research Council (Poruks and Hamilton, 1976).

Glacial history

A variety of glacial deposits are scattered throughout the map area, and polished, scoured, fluted and striated bedrock surfaces attest to a recent continental glaciation. The direction of the Classical Wisconsin ice advance was from the east. The glacial sediments are dominantly sandy and occur as glaciolacustrine, glaciofluvial, and crevasse-fill deposits. A centrally located north to south aligned system of glaciofluvial channel deposits is dotted with interconnected glaciolacustrine deposits. Many of the latter show a stacked series of abandoned beaches that may have developed within nunatak, ice-marginal, meltwater lakes. Some of the abandoned beaches are developed on both flanks of the elevated ridge of glacial sediments. This entire glacio-fluvial-lacustrine system, passing just west of Esker Lake, may have formed in an ice-contact environment and, in a regional context, may represent a recessional moraine.

Stagnant ice-block wasting is recorded as a late phase of deglaciation in the form of kettle holes and depressions in the glacio-lacustrine-fluvial deposits, notably in the northeast of the map area. Here, the large areas of sandy deposits form part of the extensive Colin Lake outwash plain stretching farther to the east. Evidence of aeolian activity is widespread in the map area. It takes the form of depositional sand sheets and sand dunes along with polish and grooves cut into the bedrock by wind-blown sand. The orientation of dunes and sand-cut grooves on low, southeast-facing steep surfaces of outcrop, indicates that the prevailing storm winds came from the southeast. Wind-polished and -facetted outcrop faces are generally found to the northwest and adjacent to extensive sand sheets.

The widespread dominance of a uniform sandy lithology (lacking in notable amounts of boulders, pebbles or clay) indicates a possible nearby Athabasca sandstone bedrock source for this glacial sediment. The westerly trend of the major surficial sandy deposits strongly suggests their origin by down-ice glacial transport from the east. The further possibility of the major east to west glacial sand deposits overlying and obscuring Athabasca Group outliers should not be discounted. Some of the sand deposits appear to be highly localized concentrations of sand, which do not appear to be markedly reworked and dispersed by either late glacial or Recent processes into the surrounding region. Therefore, they may be of local origin—in fact, possibly related to underlying Athabasca Group outliers. The surficial sand concentrations along an east to west trend coincide with a zone of closely spaced easterly striking faults. The possible Athabasca Group sandstone outliers could be basal remnants preserved in an easterly oriented graben structure. The implication of this possibility is that the Athabasca Basin was formerly far more extensive than the present-day outcrop distribution indicates. Athabasca Group outliers have been reported at Burstall Lake, by Wilson (1985). This suggestion in turn presents further ramifications for prospective uranium exploration in the map area.

As suggested above, Athabasca Group sandstone outliers may prove to be the underlying source of the east to west trending belt of glacial sands in the La Butte Creek basin. The latter, in turn, could be the immediate source of the sediment distributed by meltwaters along the prominent north to south ice-contact front. Local reversals of topographic slope along these interconnected meltwater deposits indicate that the pattern of flow direction may not have been entirely simple and unidirectional. These north to south trending ice-contact deposits are a late-stage deglaciation feature, as witnessed by the occasional stagnant ice-block related kettle depressions. Therefore, although ice topography was probably a contributing factor in the localization of these glacio-fluvial-lacustrine deposits, it is believed that ice cover was not sufficiently extensive or continuous to make the deposits supraglacial in origin.

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Appendix. Modal and chemical analyses of standard samples

Table 5. Modal and chemical analyses of standard samples for Biotite Granite Gneiss (11), Slave Granite Phase (101), and Metasedimentary Rock Bands (31) in percent

Standard	(11)	Slave Granite Phase (101)										
sample number	407	312	314	315	317	318	322	337	338	339	340	341
Quartz	5.8	23.7	32.2	36.0	36.6	24.1	20.7	37.6	42.5	35.9	22.2	29.5
K-Feldspar	0.0	66.8	20.2	3.4	23.4	40.4	20.0	8.0	14.7	4.6	49.8	24.3
Plagioclase	59.4	6.4	40.4	56.0	32.5	31.1	53.5	50.3	39.0	58.7	18.9	41.6
Biotite	1.9	0.0	4.2	3.7	2.9	3.4	0.9	2.4	2.1	0.7	0.7	2.5
Chlorite	0.0	0.2	0.8	0.0	0.7	0.2	0.3	0.7	0.9	0.0	1.0	1.1
Hornblende	30.5	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0
Epidote	1.0	0.0	trace	trace	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Muscovite	0.0	1.6	2.0	0.1	4.0	0.5	0.0	0.0	0.0	0.0	7.3	0.6
Spinel	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Garnet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.7	0.1	0.0	0.4
Pyroxene	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0	0.0	0.0	0.0	0.0
Cordierite	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Andalusite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sillimanite	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	1.4	0.3	0.0	0.7	0.0	0.0	0.1	0.0	0.1	0.0	0.0	trace
Number of points	1000	2000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
SiO_2	57.34	72.64	72.82	73.45	73.84	72.42	70.81	76.04	74.91	73.99	74.28	74.32
TiO_2	0.78	0.13	0.23	0.18	0.14	0.21	0.26	0.08	0.11	0.10	0.07	0.14
Al_2O_3	16.70	14.19	13.45	14.23	14.16	14.78	14.77	13.88	13.83	14.24	14.32	13.96
Fe_2O_3	7.96	0.54	1.71	1.43	0.89	1.44	1.62	0.88	0.89	0.54	0.54	1.52
MgO	3.39	0.18	0.70	0.43	0.33	0.55	0.96	0.21	0.32	0.15	0.26	0.46
CaO	6.69	0.65	1.08	1.37	0.59	0.93	1.16	1.08	1.35	1.39	0.63	0.93
Na_2O	4.34	3.03	3.90	4.27	3.31	3.80	3.52	3.89	4.01	4.15	3.22	3.43
K_2O	1.19	5.96	3.60	2.65	4.92	4.14	4.33	3.82	3.05	2.52	4.57	3.98
MnO	0.15	0.01	0.05	0.03	0.01	0.03	0.03	0.04	0.02	0.04	0.03	0.05
P_2O_5	0.10	0.48	0.30	0.22	0.06	0.06	0.12	0.00	0.05	0.23	0.11	0.05
L.O.I.	0.69	0.51	0.37	0.24	0.55	0.36	0.71	0.09	0.10	0.36	0.33	0.46
H_2O	0.00	0.00	0.02	0.06	0.00	0.09	0.16	0.00	0.00	0.04	0.11	0.06
Total	99.33	98.32	98.23	98.56	98.80	98.82	98.45	100.01	98.64	97.75	98.47	99.36

Chemical analyses by J.R. Nelson, Alberta Research Council Chemistry Laboratory.

Table 5 (continued).

Standard sample number	Metasedimentary Rock Bands (31)					
	43	54	55	56	66	67
Quartz	45.5	30.8	41.4	17.3	41.3	41.8
K-Feldspar	1.8	6.7	22.1	20.9	11.2	8.3
Plagioclase	15.6	18.8	15.2	47.2	17.5	20.6
Biotite	11.8	5.2	6.5	7.2	9.7	10.8
Chlorite	5.9	2.2	0.1	0.0	1.3	0.2
Hornblende	0.0	4.0	0.7	1.3	0.8	0.0
Epidote	0.7	0.0	0.2	0.0	3.0	0.0
Muscovite	13.8	21.1	4.4	0.0	5.1	9.7
Spinel	0.0	0.1	0.1	0.0	0.1	0.1
Garnet	2.6	7.8	5.8	0.0	2.6	4.9
Pyroxene	0.0	0.1	0.0	6.0	0.0	0.0
Cordierite	0.0	1.5	2.0	0.0	2.0	2.7
Andalusite	trace	0.0	0.5	0.0	0.0	0.0
Sillimanite	0.6	1.0	0.0	0.0	2.5	0.0
Accessories	1.7	0.7	1.0	0.1	2.9	0.9
Number of points	1875	2500	4500	2500	1825	2400

Table 5 (continued).

Standard sample number	Metasedimentary Rock Bands (31)					
	43	54	55	56	66	67
SiO_2	71.89	61.45	71.27	63.04	66.41	72.04
TiO_2	0.59	0.62	0.72	0.64	0.65	0.55
Al_2O_3	12.18	16.80	16.69	15.00	16.44	12.75
Fe_2O_3	5.96	8.77	5.19	5.32	5.61	6.11
MgO	1.52	3.57	0.07	3.03	1.85	1.18
CaO	0.57	1.87	0.12	3.49	3.23	1.33
Na_2O	1.92	1.17	1.43	2.40	1.90	1.53
K_2O	3.27	3.24	3.50	4.35	3.25	3.46
MnO	0.05	0.12	0.11	0.07	0.06	0.07
P_2O_5	0.15	0.17	0.10	0.27	0.04	0.03
L.O.I.	2.23	1.72	0.67	0.98	0.94	1.09
H_2O	0.14	0.00	0.03	0.15	0.07	0.05
Total	100.47	99.50	99.90	98.74	100.45	100.19

Chemical analyses by J.R. Nelson, Alberta Research Council Chemistry Laboratory.

Appendix (continued)

Table 6. Modal and chemical analyses of standard samples for Slave Granite Phase (101) in percent

Standard sample number	Slave Granite Phase (101)													
	342	**343**	**344**	**345**	**347**	**381**	**382**	**397**	**399**	**400**	**401**	**402**	**403**	**625**
Quartz	43.6	39.0	31.8	28.4	21.0	26.3	26.5	30.1	32.1	24.9	27.3	44.9	27.0	26.9
K-Feldspar	27.0	58.4	34.0	43.7	38.9	0.9	25.4	30.6	44.5	44.3	34.8	23.8	48.9	35.3
Plagioclase	22.0	0.0	28.6	23.6	34.2	66.0	45.6	30.6	18.3	26.7	28.8	22.7	20.0	30.2
Biotite	0.0	1.3	1.7	1.6	3.5	1.4	0.0	0.5	0.7	0.3	4.8	2.8	1.1	0.0
Chlorite	1.2	0.0	1.0	0.0	0.0	0.2	0.0	1.6	0.3	0.0	0.0	1.4	0.2	5.7
Hornblende	0.0	0.0	0.0	0.0	0.0	0.1	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Epidote	0.0	0.0	0.0	trace	0.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Muscovite	0.9	0.0	1.3	0.0	0.0	3.3	0.0	6.5	0.6	3.5	4.1	0.9	0.0	0.7
Spinel	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Garnet	5.2	1.4	1.7	2.7	1.2	0.0	0.0	0.0	0.0	0.0	0.0	3.5	1.7	0.0
Pyroxene	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cordierite	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	2.8	0.0	0.0	0.0	1.2	0.0
Andalusite	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	0.0
Sillimanite	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
Accessories	0.0	0.0	0.1	trace	0.3	0.2	0.7	0.1	0.5	0.4	0.2	0.0	0.0	1.2
Number of points	1000	1000	1000	1000	1009	1000	1000	2103	1000	2079	2050	2069	2008	2000
SiO_2	75.44	72.93	72.94	71.12	72.26	73.46	70.19	72.91	73.67	74.13	73.85	75.07	72.00	74.04
TiO_2	0.08	0.11	0.18	0.17	0.19	0.19	0.16	0.09	0.11	0.06	0.16	0.24	0.10	0.24
Al_2O_3	13.68	15.79	14.51	15.93	15.28	15.90	16.30	15.64	14.77	14.76	14.66	13.40	15.28	15.02
Fe_2O_3	0.88	0.62	0.89	2.51	1.52	1.22	1.27	0.68	0.75	0.22	0.75	1.57	0.69	0.71
MgO	0.19	0.24	0.31	0.52	0.33	0.52	0.33	0.20	0.26	0.20	0.34	0.34	0.30	0.74
CaO	0.75	0.68	0.68	0.90	0.86	0.98	1.40	0.88	0.74	0.51	0.95	1.10	0.53	0.24
Na_2O	3.19	3.51	2.96	3.36	3.37	4.84	4.81	3.27	3.47	3.28	3.32	2.67	3.14	7.82
K_2O	4.69	5.25	5.57	5.20	4.59	2.29	3.98	5.22	4.77	6.21	5.27	4.75	6.72	0.43
MnO	0.02	0.00	0.10	0.02	0.11	0.03	0.06	0.03	0.02	0.02	0.02	0.04	0.03	0.01
P_2O_5	0.15	0.12	0.10	0.13	0.11	0.04	0.37	0.17	0.33	0.09	0.11	0.06	0.10	0.07
L.O.I.	0.36	0.74	0.60	0.31	0.38	0.66	0.17	0.49	0.41	0.23	0.24	0.18	0.27	0.82
H_2O	0.07	0.10	0.04	0.09	0.11	0.00	0.00	0.01	0.10	0.04	0.21	0.02	0.00	0.28
Total	99.50	100.09	98.88	100.26	99.11	100.13	99.04	99.59	99.40	99.75	99.88	99.44	99.16	100.42

Chemical analyses by J.R. Nelson, Alberta Research Council Chemistry Laboratory.

Appendix (continued)

Table 7. Modal and chemical analyses of standard samples for Mafic Slave Granite Phase (102), Red Slave Granite Phase (103) and Speckled Slave Granite Phase (104) in percent

Standard sample number	Mafic Slave Granite Phase (102)									Red Slave Granite Phase (103)				(104)
	383	384	385	389	390	392	394	629	630	313	316	323	324	388
Quartz	29.7	33.4	32.2	22.3	28.4	35.7	38.8	32.9	30.1	37.2	33.6	29.7	33.1	15.0
K-Feldspar	40.1	35.0	46.2	36.1	26.4	2.2	22.0	42.2	30.8	18.6	18.0	49.6	55.7	69.8
Plagioclase	20.4	24.0	10.8	30.2	30.5	39.0	30.8	15.8	28.2	40.1	44.3	19.3	10.2	5.4
Biotite	2.1	5.4	2.9	1.2	0.0	22.2	7.6	1.8	6.5	0.8	1.2	0.0	0.1	3.5
Chlorite	0.6	0.5	0.3	3.4	0.0	0.0	0.0	0.0	2.1	0.2	2.3	0.2	0.7	2.1
Hornblende	6.4	0.0	6.4	0.0	10.0	0.0	0.0	6.5	0.0	0.0	0.0	0.0	0.0	0.0
Epidote	0.1	0.5	1.2	0.3	trace	0.8	0.2	0.0	0.5	0.0	trace	trace	0.0	0.0
Muscovite	0.0	0.1	0.0	0.9	0.1	trace	0.4	0.1	0.2	1.3	0.1	0.6	0.0	4.1
Spinel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0
Garnet	0.0	0.0	0.0	0.0	1.7	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pyroxene	0.0	0.0	0.0	0.9	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cordierite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0
Andalusite	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	0.0
Sillimanite	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	0.0
Accessories	0.6	1.1	0.1	5.3	0.6	trace	trace	0.5	1.8	0.5	0.5	0.7	0.2	0.1
Number of points	1000	1000	1000	2061	1000	1000	1000	1996	2003	1000	1000	1000	1000	1000
SiO_2	68.28	73.59	71.58	64.56	71.57	64.54	74.21	72.28	71.00	73.41	74.08	75.95	75.23	72.44
TiO_2	0.78	0.32	0.23	0.75	0.31	1.36	0.31	0.24	0.54	0.11	0.11	0.07	0.07	0.20
Al_2O_3	14.08	13.34	14.08	16.84	12.73	16.28	2.91	12.98	13.73	14.78	13.75	12.90	12.92	14.16
Fe_2O_3	4.64	2.36	2.64	5.13	4.27	4.86	2.52	2.76	3.38	0.53	0.98	0.80	0.71	1.81
MgO	0.93	0.26	0.28	0.45	0.88	2.41	0.54	0.23	0.55	0.11	0.34	0.09	0.19	0.48
CaO	1.54	0.76	0.97	2.10	1.86	3.12	1.27	0.76	1.01	0.76	0.95	0.59	0.53	0.36
Na_2O	3.04	2.86	3.08	3.19	2.21	2.20	2.19	3.70	3.28	3.45	3.91	3.61	3.64	3.06
K_2O	5.06	6.13	6.49	5.94	5.09	3.66	4.79	5.89	5.07	5.17	4.03	4.66	4.95	6.18
MnO	0.08	0.04	0.04	0.07	0.07	0.08	0.04	0.06	0.04	0.00	0.02	0.01	0.02	0.03
P_2O_5	0.23	0.05	0.03	0.19	0.05	0.08	0.07	0.02	0.08	0.07	0.08	0.13	0.31	0.18
L.O.I.	0.38	0.31	0.71	0.16	0.37	0.73	0.50	0.58	0.92	0.32	0.31	0.14	0.16	0.50
H_2O	0.00	0.00	0.01	0.18	0.08	0.00	0.00	0.08	0.23	0.04	0.00	0.18	0.08	0.00
Total	99.04	100.02	100.14	99.56	99.49	99.32	99.35	99.58	99.83	98.75	98.56	99.13	98.81	99.40

Chemical analyses by J.R. Nelson, Alberta Research Council Chemistry Laboratory.

Appendix (continued)

Table 8. Modal and chemical analyses of standard samples for Slave PQ Granite Phase (105) and La Butte Granodiorite (140) in percent

	Slave PQ Granite Phase (105)			La Butte Granodiorite (140)											
Standard sample number	**408**	**627**	**628**	**320**	**325**	**326**	**327**	**328**	**331**	**333**	**346**	**387**	**391**	**398**	**626**
Quartz	27.9	22.9	28.3	26.5	14.6	33.6	28.6	27.4	30.0	22.4	23.6	18.0	28.5	23.2	20.6
K-Feldspar	20.2	23.7	39.2	9.5	13.2	1.9	0.0	0.0	6.7	20.0	23.0	25.9	5.8	35.2	11.4
Plagioclase	44.8	45.1	24.2	58.7	64.7	59.4	60.2	68.4	60.8	50.5	34.7	53.2	55.1	33.0	60.8
Biotite	3.8	5.5	4.2	0.2	1.3	1.5	6.8	2.7	1.3	3.6	14.5	1.4	0.7	5.7	4.3
Chlorite	0.6	0.9	0.6	3.5	0.4	2.5	0.6	0.4	0.3	1.2	2.0	0.9	0.7	2.0	1.6
Hornblende	0.0	0.0	0.0	1.0	4.9	0.0	0.0	0.0	0.2	0.0	0.9	0.0	6.7	0.0	0.0
Epidote	0.2	0.0	0.9	0.0	0.1	0.2	2.2	0.0	0.3	0.3	0.1	trace	0.0	0.3	0.0
Muscovite	0.5	0.4	0.8	0.2	0.0	0.0	0.0	0.2	0.0	0.2	0.3	0.2	0.0	0.4	0.0
Spinel	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	0.0	0.0
Garnet	0.1	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	0.0
Pyroxene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0
Cordierite	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	0.0	0.0
Andalusite	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	0.0	0.0
Sillimanite	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	0.0	0.0
Accessories	1.3	1.6	1.8	0.5	0.8	0.9	1.0	0.9	0.6	1.3	0.9	0.4	1.5	0.2	1.1
Number of points	901	2000	2000	1000	1000	1003	1000	1000	1000	1000	1000	1000	1000	1000	2000
SiO_2	72.79	65.97	71.07	66.12	68.58	68.80	64.39	67.99	70.03	70.02	64.39	68.60	65.48	69.02	66.88
TiO_2	0.19	0.36	0.37	0.34	0.26	0.21	0.37	0.31	0.26	0.16	1.31	0.34	0.41	0.38	0.32
Al_2O_3	14.50	16.98	14.03	16.80	15.73	17.02	19.08	16.92	15.26	16.04	15.16	16.31	17.69	15.20	16.54
Fe_2O_3	1.47	3.59	2.52	3.06	2.43	1.97	3.03	2.42	1.95	1.95	5.37	2.26	3.64	2.25	3.23
MgO	0.64	1.10	0.59	1.09	0.81	0.50	1.18	0.89	0.50	0.57	1.63	0.64	1.03	1.91	1.36
CaO	0.77	2.39	0.90	3.11	2.82	3.48	3.48	2.82	2.93	3.53	2.46	1.31	3.39	2.33	3.17
Na_2O	2.53	4.80	3.05	4.37	4.76	4.89	4.35	4.56	4.42	4.71	2.21	3.74	4.84	2.96	4.58
K_2O	6.52	3.56	6.25	3.32	2.31	1.95	3.04	2.01	2.34	1.84	5.06	5.63	2.63	4.27	2.08
MnO	0.03	0.05	0.06	0.04	0.08	0.10	0.06	0.11	0.04	0.09	0.04	0.02	0.09	0.03	0.05
P_2O_5	0.07	0.15	0.07	0.15	0.13	0.12	0.20	0.11	1.15	0.29	0.67	0.31	0.21	0.17	0.14
L.O.I.	0.62	0.83	0.85	0.47	0.13	0.16	0.34	0.74	0.23	0.23	0.69	0.31	0.18	0.53	0.50
H_2O	0.20	0.12	0.17	0.12	0.08	0.00	0.06	0.12	0.00	0.00	0.10	0.03	0.11	0.29	0.03
Total	100.33	99.90	99.93	98.99	98.12	99.20	99.58	99.00	99.11	99.43	99.09	99.50	99.70	99.34	98.88

Chemical analyses by J.R. Nelson, Alberta Research Council Chemistry Laboratory.

Appendix (continued)

Table 9. Modal and chemical analyses of standard samples for Arch Lake Granite Phase (161), Arch Lake Transitional Granite Phase (162), Francis Granite (164) and Recrystallized Mylonitic Rock (221 and 223) in percent

Standard sample number	Arch Lake Granite Phase (161)						(162)	Francis Granite (164)						(221)	(223)
	393	395	396	404	405	406	513	329	330	332	334	335	336	386	319
Quartz	33.1	50.9	35.1	29.6	28.8	29.8	32.7	30.0	27.7	27.5	27.5	34.5	27.7	30.2	36.8
K-Feldspar	30.9	6.0	20.8	28.7	37.9	5.1	39.3	52.6	11.8	20.0	22.0	17.4	28.4	9.9	0.0
Plagioclase	20.6	31.9	28.6	32.9	26.7	60.0	24.8	12.3	38.0	32.9	26.8	36.9	29.0	50.5	60.5
Biotite	10.7	8.9	6.0	8.3	5.4	0.0	0.9	3.9	20.0	18.4	22.6	10.4	10.3	8.9	1.3
Chlorite	0.6	0.7	6.5	0.2	0.5	2.2	0.7	0.2	0.2	0.0	0.6	0.1	0.0	0.1	0.1
Hornblende	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	0.0	0.0
Epidote	1.2	0.2	0.3	0.3	0.4	2.0	0.0	0.1	0.3	0.3	0.0	0.0	trace	0.2	0.2
Muscovite	1.1	1.0	2.0	0.0	0.2	0.5	1.0	0.9	0.3	0.7	0.2	0.1	0.2	0.2	0.8
Spinel	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	0.0	0.0
Garnet	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.1	0.0	3.8	0.0	0.0
Pyroxene	0.0	0.0	0.0	0.0	trace	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cordierite	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	0.0	0.0
Andalusite	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	0.0	0.0
Sillimanite	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	0.0	0.0
Accessories	1.7	0.3	0.6	trace	trace	0.4	0.4	trace	1.3	trace	0.2	0.6	1.3	0.0	0.3
Number of points	2114	1000	2024	1000	1000	1000	2000	1000	1000	1000	1000	1000	1000	1000	1000
SiO_2	71.34	73.80	69.79	69.72	71.07	71.62	74.04	72.10	64.42	64.48	64.35	69.85	67.23	70.76	70.27
TiO_2	0.39	0.39	0.47	0.40	0.55	0.40	1.29	0.35	0.98	1.14	1.10	0.80	0.93	0.38	0.21
Al_2O_3	14.32	13.32	14.51	15.17	14.05	15.37	13.44	13.65	15.17	14.57	15.03	14.21	14.29	14.40	15.23
Fe_2O_3	2.59	2.41	2.80	2.30	3.43	1.55	0.54	1.97	5.88	5.43	5.78	3.66	5.10	2.64	2.32
MgO	1.06	0.77	1.49	0.71	0.89	0.82	0.18	0.49	1.42	2.30	2.24	1.06	1.17	1.64	0.72
CaO	0.43	0.89	0.29	1.04	1.43	0.84	0.80	1.06	3.10	2.65	2.72	2.05	1.76	1.69	1.86
Na_2O	1.94	1.77	1.60	1.97	1.88	6.27	3.76	2.53	2.12	1.92	2.01	2.27	2.06	3.94	5.83
K_2O	6.23	5.93	7.76	7.20	5.06	1.90	5.96	6.07	4.47	4.83	5.02	5.08	5.25	3.28	0.95
MnO	0.03	0.03	0.03	0.03	0.04	0.03	0.00	0.03	0.07	0.06	0.08	0.07	0.10	0.08	0.10
P_2O_5	0.07	0.09	0.14	0.15	0.13	0.08	0.06	0.10	0.45	0.43	0.43	0.34	0.47	0.10	0.28
L.O.I.	1.29	0.71	1.07	0.38	0.88	0.43	0.41	0.21	0.52	0.64	0.93	0.22	0.07	0.24	0.33
H_2O	0.20	0.03	0.13	0.01	0.00	0.15	0.05	0.04	0.01	0.03	0.00	0.00	0.01	0.43	0.00
Total	99.89	100.14	100.08	99.08	99.41	99.46	100.53	98.60	98.61	98.48	99.69	99.61	98.44	99.58	98.10

Chemical analyses by J.R. Nelson, Alberta Research Council Chemistry Laboratory.

TURTLE LAKE LEGEND

PRECAMBRIAN**

REGIONAL SHEAR ZONES

Zones of regional shearing and recrystallization have principally affected granite gneisses and metasedimentary rocks to produce: ultramylonite, mylonite, cataclasite, blastomylonite, and flaser gneiss; megastructure is typically streaky; may contain rounded or augen rock clasts or feldspar porphyroclasts (0).

223 — RECRYSTALLIZED MYLONITIC ROCK: dark colored, with white to gray anhedral feldspar porphyroclasts and euhedral feldspar porphyroblasts 10 to 50 mm long; foliated, locally gneissose; aphanitic matrix, locally medium-grained; minor aplite and pegmatite. Parent material largely Slave Granitoids and Arch Lake Granitoids.

222 — RECRYSTALLIZED MYLONITIC ROCK: green to black; granulose (siliceous) to schistose, with biotite, chlorite, sericite; feldspar and minor quartz porphyroclasts in a massive to foliated, finely banded, aphanitic matrix. Parent material largely metasedimentary rock.

221 — RECRYSTALLIZED MYLONITIC ROCK: mostly light colored, with white to pink feldspar porphyroclasts 5 to 20 mm long making up 2 to 5 percent of the rock, in a foliated, finely banded, aphanitic matrix. Parent material largely granite gneiss.

GRANITOID ROCKS

ARCH LAKE GRANITOIDS

161 — ARCH LAKE GRANITE PHASE: typically reddish overall; 20 to 40 percent red, subhedral, elongate to tabular feldspar megacrysts, from 15 to 30 mm long, aligned subparallel in a medium-grained (locally coarse-grained) usually well-foliated matrix of feldspar, blue quartz and biotite. Locally reduced amounts of feldspar megacrysts. Mafic mineral content 6 to 14 percent. Commonly mildly cataclastic, with crushed matrix and augen megacrysts.

162 — ARCH LAKE TRANSITIONAL GRANITE PHASE: (transitional to Slave Granitoids); typically reddish overall; up to 10 percent white to pink subhedral, elongate to tabular feldspar megacrysts, from 10 to 15 mm long, aligned subparallel in a medium-grained (locally coarse-grained) usually well-foliated matrix of feldspar, blue quartz, and biotite. Quartz content locally reduced from 25 to 10 percent. Commonly mildly cataclastic.

164 — FRANCIS GRANITE: typically pink spots on a medium gray background. Commonly medium-grained, locally fine- to medium-grained, large pink to reddish pink tabular feldspar megacrysts 25 to 35 mm long, from 5 to 15 percent abundance, contrast texturally with a finer matrix of feldspar, quartz, and biotite. Commonly massive, locally poorly foliated; megacrysts typically random to subparallel oriented. Rock type is predominantly granite, but ranges to granodiorite.

LA BUTTE GRANODIORITE

140 — Generally light gray to brownish gray to mauve (bluish quartz combined with pink-gray feldspar), of uniform color and texture; in hand specimen specks and aggregates of dark mafic mineral in a lighter gray background. Medium grained but ranging to fine-and coarse-grained, with 8 to 20 mm long feldspar megacrysts from rare to 5 percent abundance in a quartz, feldspar, biotite matrix. Typically massive to uncommonly poorly foliated or locally gneissic. Rock types range from granite to granodiorite, quartz diorite, and quartz monzodiorite, with a mean composition of granodiorite.

WYLIE LAKE GRANITOIDS

133 — FISHING CREEK QUARTZ DIORITE: medium gray overall; mottled grayish white on a medium- to dark-gray background in hand specimen; medium-grained, typically almost megacrystic but locally distinctly megacrystic or equigranular; megacrystic white to gray to pale green feldspars 5 to 10 mm long in a greenish gray matrix of feldspar, quartz and biotite; typically poorly foliated, locally massive or gneissic. Rock type is predominantly quartz diorite but composition ranges to quartz-bearing diorite and granodiorite. Schlieren of biotite or metasedimentary rocks may be present.

132 — GRANODIORITE E: generally greenish or brownish overall; may be finely mottled; pink to red subhedral feldspars (6 to 8mm) tend to be megacrystic with occasional megacrysts (10 to 15 mm) in an essentially equigranular, massive to poorly foliated matrix of feldspar, quartz, and biotite (chloritic). Composition ranges to granite.

SLAVE GRANITOIDS

101 — SLAVE GRANITE PHASE: typically whitish gray (locally white to greenish gray to pink feldspar mottled on a darker background); medium- to coarse-grained (locally fine-grained); up to 5 percent white feldspar megacrysts, 7 to 15 mm long, in a matrix of white feldspars, quartz and biotite (< 1 to 5 percent); massive to more commonly foliated (increase in biotite content tends to better define foliation); typically garnetiferous, in knots 5 ± mm across with a biotite envelope; may be locally gneissic; includes minor small-scale mafelsic lenses of metasedimentary appearance; minor gray white, fine- to medium-grained felsic dykes and quartz veins.

102 — MAFIC SLAVE GRANITE PHASE: similar to Slave Granite but with a notably higher biotite content (up to 10 percent); distinctly foliated.

MEGACRYSTIC COMPONENT: up to 15 percent white feldspar megacrysts 15 to 50 mm long, either randomly oriented or aligned with the foliation of map units 101 and 102 (⧸).

103 — RED SLAVE GRANITE PHASE: similar to Slave Granite Phase but with a distinct pinkish red color.

104 — SPECKLED SLAVE GRANITE PHASE: similar to Slave Granite Phase, but reddish to mottled overall; red and white feldspars in a medium-grained matrix of feldspar, quartz, chloritic biotite, and sericite; mildly crushed and foliated matrix.

105 — SLAVE PQ GRANITE PHASE: typically reddish pink to pink; commonly medium-grained; abundant white to pink to red feldspar megacrysts 6 to 12 mm across in a medium-grained matrix of feldspar, quartz, biotite (4 to 5 percent) and minor sericite; massive to foliated matrix, locally gneissic. The predominant rock type is granite with a gradation towards granodiorite; includes minor small-scale mafelsic lenses of metasedimentary appearance; minor fine- to medium-grained felsic dykes and quartz veins.

METASEDIMENTARY ROCKS

31 — METASEDIMENTARY ROCKS: the high-grade metasedimentary rock types included in this map unit are lithologically and texturally gradational, and in part intermixed on outcrop scale. Typically impure quartzite; dark greenish (bluish) gray (fresh surface); fine-grained; layered, with ferruginous and garnetiferous zones, locally scattered pyrite, gossans, and milky to bluish gray quartz pods and veins. Minor amphibolite may be present. Common local lithologic gradational variations to: (1) fine- to medium-grained, metamorphic quartzo-feldspathic (granitic and minor pegmatitic) phase ranging from individual white feldspar porphyroblasts 5 to 15 mm long, to nebulous or distinct aggregations and masses; commonly foliated to locally gneissic; (2) fine-grained, retrograde phyllite and schist (biotite, chlorite, sericite, and uncommonly hornblende), and phyllonite.

AMPHIBOLITE

20 — Dark brownish green (fresh surface) to grayish green; typically medium grained; biotite may be common; composition ranges from essentially amphibole pure or amphibole rich to a feldspathic biotite amphibolite; commonly foliated but may be banded where feldspar rich; minor pyrite common.

GRANITE GNEISS

11 — BIOTITE GRANITE GNEISS: typically pink to reddish; quartz-feldspar bands interlayered with mafic-rich bands (biotite, possibly with subordinate hornblende; generally chloritic) on hand-specimen scale; fine- to medium-grained, generally equigranular, rarely megacrystic; commonly well banded but may be locally poorly banded to foliated, and leucocratic phases may be nearly massive. Composition is predominantly granite, with minor granodiorite, quartz diorite, and quartz monzodiorite. Large areas are migmatitic, particularly where intimately associated with minor lenses, pods, and bands of metasedimentary rocks, pegmatite, or amphibolite. Minor hornblende granite gneiss.

**NOTE: Rock groups are arranged in approximate chronological sequence. Nomenclature follows Strekeisen (1967): Classification and nomenclature of igneous rocks; Neues Jahrbuch für Mineralogie, Abhandlungen, 107, No. 2, p. 144-240.

- Geological boundary (defined, approximate)
- Foliation (defined: dip known, dip vertical; foliation assumed) — 69
- Foliation trend*
- Lineation (combined with foliation) — 76, 73
- Extreme contortion (structural trend shown)
- Tight folds (structural trends shown)
- Local gneissosity in generally massive to foliated rock
- Joint (dip known, vertical, unknown) — 76
- Fault (defined: dip known, fault assumed) — 79
- Shear (dip known) — 79
- Breccia
- Mylonite (local)
- Rock alteration — A
- Quartz vein
- Crystalline standard sample — 329
- Metasedimentary rock band standard sample — 55
- Yellow mineral stain — Y
- Chlorite — C
- Garnet — G
- Isotopic age (million years); biotite (b); K-Ar (k); University of Alberta — Δ bk 1751
- Glacial stria (direction of ice movement shown)
- Crevasse filling* (ridge shown)
- Dune*
- Esker* (direction known, unknown)
- Kettle
- Raised beach* (downslope indicated)
- Wind-cut groove (wind direction shown)
- Sand-covered area*
- Small outcrop (map unit shown) — 31
- Muskeg
- Drainage (intermittent, permanent)
- Township boundary
- National Park Boundary
- Trail

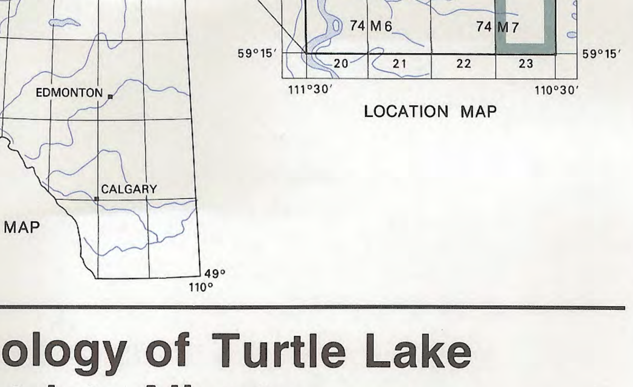
*Aerial photographic interpretation

Approximate magnetic declination 25°25′ East in 1984 decreasing approximately 4.2′ annually for the Turtle Lake map area.

SCALE 1:31,680

Miles 1 — 0 — 1 Miles

Kilometres 1 — 0 — 1 Kilometres



Geology of Turtle Lake District, Alberta

Sheet No. 27

John D. Godfrey, Godfrey J. Walton and Geoffrey Hodgson, 1973

Published 1984
Map to accompany Earth Sciences Report 84-5

Any revisions or additional geological information would be welcomed by the Alberta Research Council.

Base maps compiled from planimetric sheets published by Alberta Energy and Natural Resources, Edmonton.
Aerial photographs for the area obtainable from Alberta Energy and Natural Resources, Edmonton; or the Surveys and Mapping Branch of Energy, Mines and Resources, Ottawa.
Cartography by Alberta Research Council, Graphic Services, Richard J. Buck.

ALBERTA RESEARCH COUNCIL
Natural Resources Division
Alberta Geological Survey

TURTLE LAKE LEGEND

PRECAMBRIAN**

REGIONAL SHEAR ZONES

Zones of regional shearing and recrystallization have principally affected granite gneisses and metasedimentary rocks to produce: ultramylonite, mylonite, cataclasite, blastomylonite, and flaser gneiss; megastructure is typically streaky; may contain rounded or augen rock clasts or feldspar porphyroclasts (0).

223 RECRYSTALLIZED MYLONITIC ROCK: dark colored, with white to gray anhedral feldspar porphyroclasts and euhedral feldspar porphyroblasts 10 to 50 mm long; foliated, locally gneissose; aphanitic matrix, locally medium-grained; minor aplite and pegmatite. Parent material largely Slave Granitoids and Arch Lake Granitoids.

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221 RECRYSTALLIZED MYLONITIC ROCK: mostly light colored, with white to pink feldspar porphyroclasts 5 to 20 mm long making up 2 to 5 percent of the rock, in a foliated, finely banded, aphanitic matrix. Parent material largely granite gneiss.

GRANITOID ROCKS

ARCH LAKE GRANITOIDS

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162 ARCH LAKE TRANSITIONAL GRANITE PHASE: (transitional to Slave Granitoids); typically reddish overall; up to 10 percent white to pink subhedral, elongate to tabular feldspar megacrysts, from 10 to 15 mm long, aligned subparallel in a medium-grained (locally coarse-grained) usually well-foliated matrix of feldspar, blue quartz, and biotite. Quartz content locally reduced from 25 to 10 percent. Commonly mildly cataclastic.

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SLAVE GRANITOIDS

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**NOTE: Rock groups are arranged in approximate chronological sequence. Nomenclature follows Streckeisen (1967): Classification and nomenclature of Igneous rocks; Neues Jahrbuch für Mineralogie, Abhandlungen, 107, No. 2, p. 144-240.

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Lineation (combined with foliation)
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Rock alteration
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Crystalline standard sample
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Yellow mineral stain
Chlorite
Garnet
Isotopic age (million years); biotite (b); K-Ar (k); University of Alberta
Glacial stria (direction of ice movement shown)
Crevasse filling* (ridge shown)
Dune*
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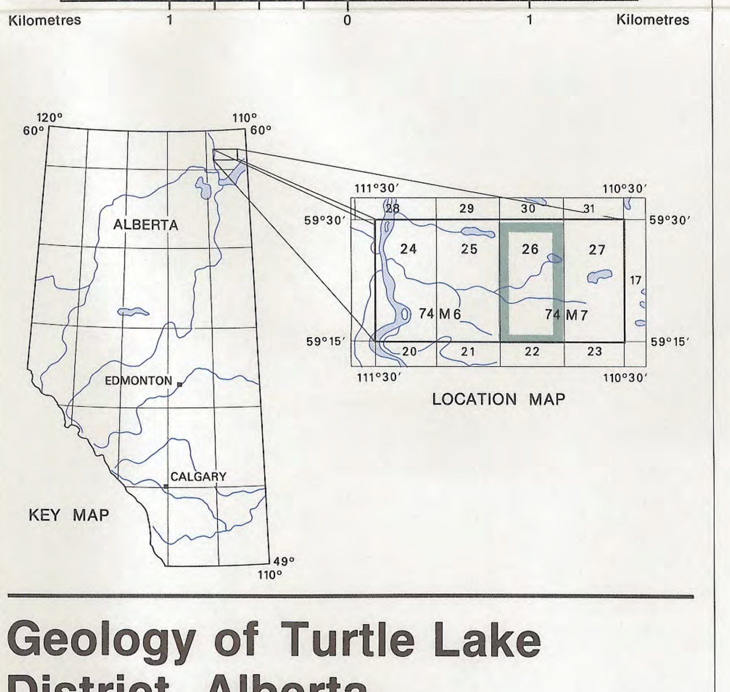
Kettle
Raised beach* (downslope indicated)
Wind-cut groove (wind direction shown)
Sand-covered area*
Small outcrop (map unit shown)
Muskeg
Drainage (intermittent, permanent)
Township boundary
National Park Boundary
Trail

*Aerial photographic interpretation

Approximate magnetic declination 23°25′ East in 1984 decreasing approximately 4.2′ annually for the Turtle Lake map area.

SCALE 1:31,680

Miles 1 0 1 Miles
Kilometres 1 0 1 Kilometres



Geology of Turtle Lake District, Alberta

Sheet No. 26

John D. Godfrey, Godfrey J. Walton and Geoffrey Hodgson, 1973

Published 1984
Map to accompany Earth Sciences Report No. 84-5

Any revisions or additional geological information would be welcomed by the Alberta Research Council.

ALBERTA RESEARCH COUNCIL
Natural Resources Division
Alberta Geological Survey

BOCQUENE LAKE LEGEND

DEVONIAN

254 — LA BUTTE FORMATION: light to medium, brownish gray, thin- to thick-bedded to massive, fossiliferous, bioclastic argillaceous fine-grained limestone, with laminations of brownish gray shale.

253 — HAY CAMP FORMATION: light brown to orange brown, generally (collapse) brecciated limestones and dolomitic limestones, containing laminated, lithographic dolostone, partly gypsiferous, and light gray fossiliferous, argillaceous limestone, with light gray, calcareous shale laminations.

252 — FITZGERALD FORMATION: pale brown, weathering light orange brown, thin to rubbly bedded to massive, fine grained, vuggy, dolostone and dolomitic limestone. Carbonaceous dolostone locally; transitional through sandy and argillaceous dolostone to underlying La Loche Formation. Locally bitumen impregnated.
(subdivision based on Norris, A.W, 1963, G.S.C., Bulletin 313)

PRECAMBRIAN**

REGIONAL SHEAR ZONES

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GRANITOID ROCKS

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105 — SLAVE PQ GRANITE PHASE: typically reddish pink to pink; commonly medium-grained; abundant white to pink to red feldspar megacrysts 6 to 12 mm across in a medium-grained matrix of feldspar, quartz, biotite (4 to 5 percent) and minor sericite; massive to foliated matrix, locally gneissic. The predominant rock type is granite with a gradation towards granodiorite; includes minor small-scale mafelsic lenses of metasedimentary appearance; minor fine- to medium-grained felsic dykes and quartz veins.

METASEDIMENTARY ROCKS

31 — METASEDIMENTARY ROCKS: the high-grade metasedimentary rock types included in this map unit are lithologically and texturally gradational, and in part intermixed on outcrop scale. Typically impure quartzite; dark greenish (bluish) gray (fresh surface); fine-grained; layered, with ferruginous and garnetiferous zones, locally scattered pyrite, gossans, and milky to bluish gray quartz pods and veins. Minor amphibolite may be present. Common local lithologic gradational variations to: (1) fine- to medium-grained, metamorphic quartzo-feldspathic (granitic and minor pegmatitic) phase ranging from individual white feldspar porphyroblasts 5 to 15 mm long, to nebulous or distinct aggregations and masses; commonly foliated to locally gneissic ( ); (2) fine-grained, retrograde phyllite and schist (biotite, chlorite, sericite, and uncommonly hornblende), and phyllonite.

AMPHIBOLITE

20 — Dark brownish green (fresh surface) to grayish green; typically medium grained; biotite may be common; composition ranges from essentially amphibole pure or amphibole rich to a feldspathic biotite amphibolite; commonly foliated but may be banded where feldspar rich; minor pyrite common.

GRANITE GNEISS

11 — BIOTITE GRANITE GNEISS: typically pink to reddish; quartz-feldspar bands interlayered with mafic-rich bands (biotite, possibly with subordinate hornblende; generally chloritic) on hand-specimen scale; fine- to medium-grained, generally equigranular, rarely megacrystic; commonly well banded but may be locally poorly banded to foliated, and leucocratic phases may be nearly massive. Composition is predominantly granite, with minor granodiorite, quartz diorite, and quartz monzodiorite. Large areas are migmatitic, particularly where intimately associated with minor lenses, pods, and bands of metasedimentary rocks, pegmatite, or amphibolite. Minor hornblende granite gneiss.

**NOTE: Rock groups are arranged in approximate chronological sequence. Nomenclature follows Strekeisen (1967): Classification and nomenclature of igneous rocks; Neues Jahrbuch für Mineralogie, Abhandlungen, 107, No. 2, p. 144-240.

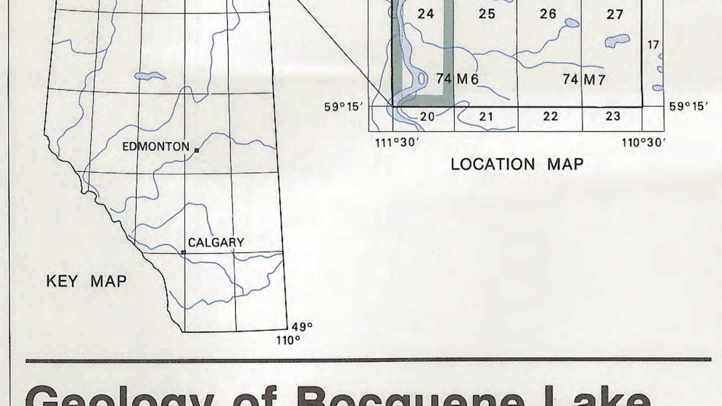
Geological boundary (defined, approximate)
Foliation (defined: dip known, dip vertical; foliation assumed) — 82
Foliation trend*
Lineation (combined with foliation) — 76 73
Extreme contortion (structural trend shown)
Tight folds (structural trends shown)
Local gneissosity in generally massive to foliated rock
Joint (dip known, vertical, unknown) — 76
Fault (defined: dip known, fault assumed) — 79
Shear (dip known) — 79
Breccia
Mylonite (local)
Rock alteration — A
Quartz vein
Crystalline standard sample — 329
Metasedimentary rock band standard sample — 55
Yellow mineral stain — Y
Chlorite — C
Garnet — G
Isotopic age (million years); biotite (b); K-Ar (k); University of Alberta — bk 1751
Glacial stria (direction of ice movement shown)
Crevasse filling* (ridge shown)
Dune*
Esker* (direction known, unknown)
Kettle
Raised beach* (downslope indicated)
Wind-cut groove (wind direction shown)
Sand-covered area*
Small outcrop (map unit shown) — 31
Muskeg
Drainage (intermittent, permanent)
Township boundary
National Park Boundary
Trail

*Aerial photographic interpretation

Approximate magnetic declination 25°55′ East in 1984 decreasing approximately 4.3′ annually for the Bocquene Lake map area.

SCALE 1:31,680

Miles 1 — 0 — 1 Miles
Kilometres 1 — 0 — 1 Kilometres



Geology of Bocquene Lake District, Alberta

Sheet No. 24

John D. Godfrey, Godfrey J. Walton and Geoffrey Hodgson, 1973

Published 1984
Map to accompany Earth Sciences Report No. 84-5

Any revisions or additional geological information would be welcomed by the Alberta Research Council.

Base maps compiled from planimetric sheets published by Alberta Energy and Natural Resources, Edmonton.
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Cartography by Alberta Research Council, Graphic Services, Richard J. Buck.

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Natural Resources Division
Alberta Geological Survey

Adjoining Sheet No. 29

Adjoining Sheet No. 24

Adjoining Sheet No. 26

Adjoining Sheet No. 21

BOCQUENE LAKE LEGEND

DEVONIAN

254 LA BUTTE FORMATION: light to medium, brownish gray, thin- to thick-bedded to massive, fossiliferous, bioclastic argillaceous fine-grained limestone, with laminations of brownish gray shale.

253 HAY CAMP FORMATION: light brown to orange brown, generally (collapse) brecciated limestones and dolomitic limestones, containing laminated, lithographic dolostone, partly gypsiferous, and light gray fossiliferous, argillaceous limestone, with light gray, calcareous shale laminations.

252 FITZGERALD FORMATION: pale brown, weathering light orange brown, thin to rubbly bedded to massive, fine grained, vuggy, dolostone and dolomitic limestone. Carbonaceous dolostone locally; transitional through sandy and argillaceous dolostone to underlying La Loche Formation. Locally bitumen impregnated.
(subdivision based on Norris, A.W, 1963, G.S.C., Bulletin 313)

PRECAMBRIAN**

REGIONAL SHEAR ZONES

Zones of regional shearing and recrystallization have principally affected granite gneisses and metasedimentary rocks to produce: ultramylonite, mylonite, cataclasite, blastomylonite, and flaser gneiss; megastructure is typically streaky; may contain rounded or augen rock clasts or feldspar porphyroclasts (θ).

223 RECRYSTALLIZED MYLONITIC ROCK: dark colored, with white to gray anhedral feldspar porphyroclasts and euhedral feldspar porphyroblasts 10 to 50 mm long; foliated, locally gneissose; aphanitic matrix, locally medium-grained; minor aplite and pegmatite. Parent material largely Slave Granitoids and Arch Lake Granitoids.

222 RECRYSTALLIZED MYLONITIC ROCK: green to black; granulose (siliceous) to schistose, with biotite, chlorite, sericite; feldspar and minor quartz porphyroclasts in a massive to foliated, finely banded, aphanitic matrix. Parent material largely metasedimentary rock.

221 RECRYSTALLIZED MYLONITIC ROCK: mostly light colored, with white to pink feldspar porphyroclasts 5 to 20 mm long making up 2 to 5 percent of the rock, in a foliated, finely banded, aphanitic matrix. Parent material largely granite gneiss.

GRANITOID ROCKS

ARCH LAKE GRANITOIDS

161 ARCH LAKE GRANITE PHASE: typically reddish overall; 20 to 40 percent red, subhedral, elongate to tabular feldspar megacrysts, from 15 to 30 mm long, aligned subparallel in a medium-grained (locally coarse-grained) usually well-foliated matrix of feldspar, blue quartz and biotite. Locally reduced amounts of feldspar megacrysts. Mafic mineral content 6 to 14 percent. Commonly mildly cataclastic, with crushed matrix and augen megacrysts.

162 ARCH LAKE TRANSITIONAL GRANITE PHASE: (transitional to Slave Granitoids); typically reddish overall; up to 10 percent white to pink subhedral, elongate to tabular feldspar megacrysts, from 10 to 15 mm long, aligned subparallel in a medium-grained (locally coarse-grained) usually well-foliated matrix of feldspar, blue quartz, and biotite. Quartz content locally reduced from 25 to 10 percent. Commonly mildly cataclastic.

164 FRANCIS GRANITE: typically pink spots on a medium gray background. Commonly medium-grained, locally fine- to medium-grained, large pink to reddish pink tabular feldspar megacrysts 25 to 35 mm long, from 5 to 15 percent abundance, contrast texturally with a finer matrix of feldspar, quartz, and biotite. Commonly massive, locally poorly foliated; megacrysts typically random to subparallel oriented. Rock type is predominantly granite, but ranges to granodiorite.

LA BUTTE GRANODIORITE

140 Generally light gray to brownish gray to mauve (bluish quartz combined with pink-gray feldspar), of uniform color and texture; in hand specimen specks and aggregates of dark mafic mineral in a lighter gray background. Medium grained but ranging to fine-and coarse-grained, with 8 to 20 mm long feldspar megacrysts from rare to 5 percent abundance in a quartz, feldspar, biotite matrix. Typically massive to uncommonly poorly foliated or locally gneissic. Rock types range from granite to granodiorite, quartz diorite, and quartz monzodiorite, with a mean composition of granodiorite.

WYLIE LAKE GRANITOIDS

133 FISHING CREEK QUARTZ DIORITE: medium gray overall; mottled grayish white on a medium- to dark-gray background in hand specimen; medium-grained, typically almost megacrystic but locally distinctly megacrystic or equigranular; megacrystic white to gray to pale green feldspars 5 to 10 mm long in a greenish gray matrix of feldspar, quartz and biotite; typically poorly foliated, locally massive or gneissic. Rock type is predominantly quartz diorite but composition ranges to quartz-bearing diorite and granodiorite. Schlieren of biotite or metasedimentary rocks may be present.

132 GRANODIORITE E: generally greenish or brownish overall; may be finely mottled; pink to red subhedral feldspars (6 to 8mm) tend to be megacrystic with occasional megacrysts (10 to 15 mm) in an essentially equigranular, massive to poorly foliated matrix of feldspar, quartz, and biotite (chloritic). Composition ranges to granite.

SLAVE GRANITOIDS

101 SLAVE GRANITE PHASE: typically whitish gray (locally white to greenish gray to pink feldspar mottled on a darker background); medium- to coarse-grained (locally fine-grained); up to 5 percent white feldspar megacrysts, 7 to 15 mm long, in a matrix of white feldspars, quartz and biotite (< 1 to 5 percent); massive to more commonly foliated (increase in biotite content tends to better define foliation); typically garnetiferous, in knots 5 ± mm across with a biotite envelope; may be locally gneissic; includes minor small-scale mafelsic lenses of metasedimentary appearance; minor gray white, fine- to medium-grained felsic dykes and quartz veins.

102 MAFIC SLAVE GRANITE PHASE: similar to Slave Granite but with a notably higher biotite content (up to 10 percent); distinctly foliated.

MEGACRYSTIC COMPONENT: up to 15 percent white feldspar megacrysts 15 to 50 mm long, either randomly oriented or aligned with the foliation of map units 101 and 102.

103 RED SLAVE GRANITE PHASE: similar to Slave Granite Phase but with a distinct pinkish red color.

104 SPECKLED SLAVE GRANITE PHASE: similar to Slave Granite Phase, but reddish to mottled overall; red and white feldspars in a medium-grained matrix of feldspar, quartz, chloritic biotite, and sericite; mildly crushed and foliated matrix.

105 SLAVE PQ GRANITE PHASE: typically reddish pink to pink; commonly medium-grained; abundant white to pink to red feldspar megacrysts 6 to 12 mm across in a medium-grained matrix of feldspar, quartz, biotite (4 to 5 percent) and minor sericite; massive to foliated matrix, locally gneissic. The predominant rock type is granite with a gradation towards granodiorite; includes minor small-scale mafelsic lenses of metasedimentary appearance; minor fine- to medium-grained felsic dykes and quartz veins.

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- Foliation trend*
- Lineation (combined with foliation) — 76, 73
- Extreme contortion (structural trend shown)
- Tight folds (structural trends shown)
- Local gneissosity in generally massive to foliated rock
- Joint (dip known, vertical, unknown) — 76
- Fault (defined: dip known, fault assumed) — 79
- Shear (dip known) — 79
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- Mylonite (local)
- Rock alteration — A
- Quartz vein
- Crystalline standard sample — 329
- Metasedimentary rock band standard sample — 55
- Yellow mineral stain — Y
- Chlorite — C
- Garnet — G
- Isotopic age (million years); biotite (b); K-Ar (k); University of Alberta — Δ bk 1751
- Glacial stria (direction of ice movement shown)
- Crevasse filling* (ridge shown)
- Dune*
- Esker* (direction known, unknown) — <<<< ><><
- Kettle
- Raised beach* (downslope indicated)
- Wind-cut groove (wind direction shown)
- Sand-covered area*
- Small outcrop (map unit shown) — 31 x
- Muskeg
- Drainage (intermittent, permanent)
- Township boundary
- National Park Boundary
- Trail

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SCALE 1:31,680

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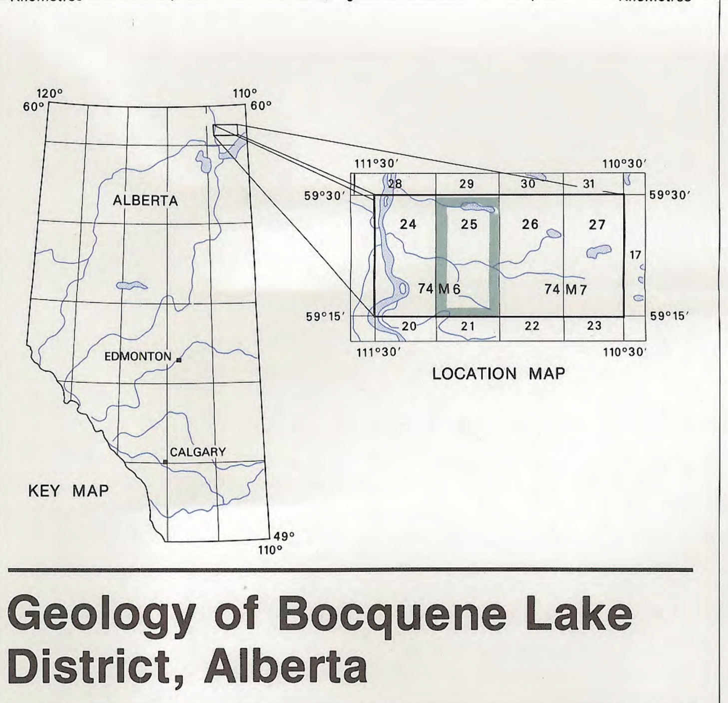
Kilometres 1 — 0 — 1 Kilometres



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Sheet No. 25

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Published 1984
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