Earth Sciences Report 84-2

Geology of the Ryan-Fletcher Lakes district, Alberta

John D. Godfrey

ALBERTA
RESEARCH
COUNCIL
Natural Resources Division
Alberta Geological Survey

Geology of the

Ryan-Fletcher Lakes district, Alberta

John D. Godfrey

GEOLOGICAL SURVEY DEPARTMENT, ALBERTA RESEARCH COUNCIL
EDMONTON, ALBERTA, CANADA 1984

Acknowledgments

The field party mapping in 1972 consisted of M. Dusseault, Assistant Geologist, and L. Andriashek, D. Sinclair, and G. Walton, field assistants. Their contributions in the field and support of the mapping program are acknowledged and appreciated. The support and generous help offered by the pilots and staff of Noralta Flights Ltd., Fort Chipewyan, is gratefully acknowledged.

Subsequent to the field work, ongoing useful technical discussions have been held with my colleagues C.W. Langenberg and Stephen Goff.

Copies of this report are available from:

Alberta Research Council
Editing & Publications Sales Department
5th Floor, Terrace Plaza
4445 Calgary Trail South
Edmonton, Alberta
T6H 5R7
phone: 438-1666

Alberta Research Council
Industrial Development Department
Suite 250
Foothills Professional Building
1620-29th Street N.W.
Calgary, Alberta, T2N 4L7
phone: 282-9136

Table of contents

page

Figures

Maps

Tables

Abstract

The bedrock geology in the study area consists of three major belts, from west to east: the granitoids, a migmatite zone, and a granite gneiss belt adjacent to Lake Athabasca. The granitoid terrain is dominated by the Slave Granitoids accompanied by subordinate amounts of Arch Lake Granitoids and high-grade metasedimentary rocks. The migmatite zone consists of major belts of high-grade metasediments interspersed with granitoid masses, principally Wylie Lake Granitoids and Chipewyan Red Granite. The granite gneiss belt is represented by biotite and hornblende granite gneisses with minor amounts of high-grade metasediments, amphibolite, and granitoids.

All the above crystalline rocks show the effects of an amphibolite to granulite facies metamorphism with subsequent regional retrogressive greenschist facies metamorphism. The regional trend of the foliation is north to north-northeasterly. A narrow band of prograde greenschist facies metasedimentary rock lies in fault contact with the granite gneisses along the shoreline of Lake Athabasca.

The bedrock has been affected by faults that trend either parallel or perpendicular to the regional foliation. A prominent, regional mylonitic zone trends north-northeast through the granite gneiss belt. Biotite and hornblende K-Ar age dates show that the region was subjected to an intensive thermal event connected with the Hudsonian Orogeny.

A Pleistocene continental glaciation has scoured the map region, leaving widespread evidence of glacial erosion and deposits typical of the Canadian Shield. Ice advance was from the east. Aeolian reworking of some of the glacial sands by storm winds from the southeast caused the formation of dunes accompanied by wind polish and abrasion on the bedrock surface. Mineralization is scattered, consisting of minor uranium mineral stains and chalcopyrite in association with the high-grade metasedimentary rock.

Introduction

This report deals with 1378 km^2 (532 sq mi) of exposed Precambrian Shield in northeastern Alberta. The map area is situated between latitude 59°00′ and 59°15′N and longitudes 110°30′W and 111°30′W (figure 1).

In the study area, the Precambrian Shield surface slopes gently toward the west. Elevations range from 210 m (700 ft) at the Slave River to about 320 m (1050 ft) in the interior. Drainage is either east to Lake Athabasca or west to the Slave River with extensive muskeg lowlands adjacent to the Slave River. Near the Slave River, Shield rocks are overlapped by middle Devonian carbonate rocks, which thicken farther to the west.

Evidence of a recent continental glaciation is widespread in the form of polished, scoured, and striated bedrock surfaces. Glacial deposits are dominantly sandy and occur as glaciolacustrine and glaciofluvial deposits, drumlins and crevasse fillings. A string of discontinuously interconnected glaciolacustrine and glaciofluvial deposits probably developed in an ice-contact environment. Aeolian reworking of the sandy deposits during deglaciation resulted in the formation of complex, longitudinal dunes, that were again modified by shifting winds. Wind erosion led to sand polishing of exposed, steeply sloping, southeast-facing Precambrian bedrock surfaces both within and downwind of major sources of sand.

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

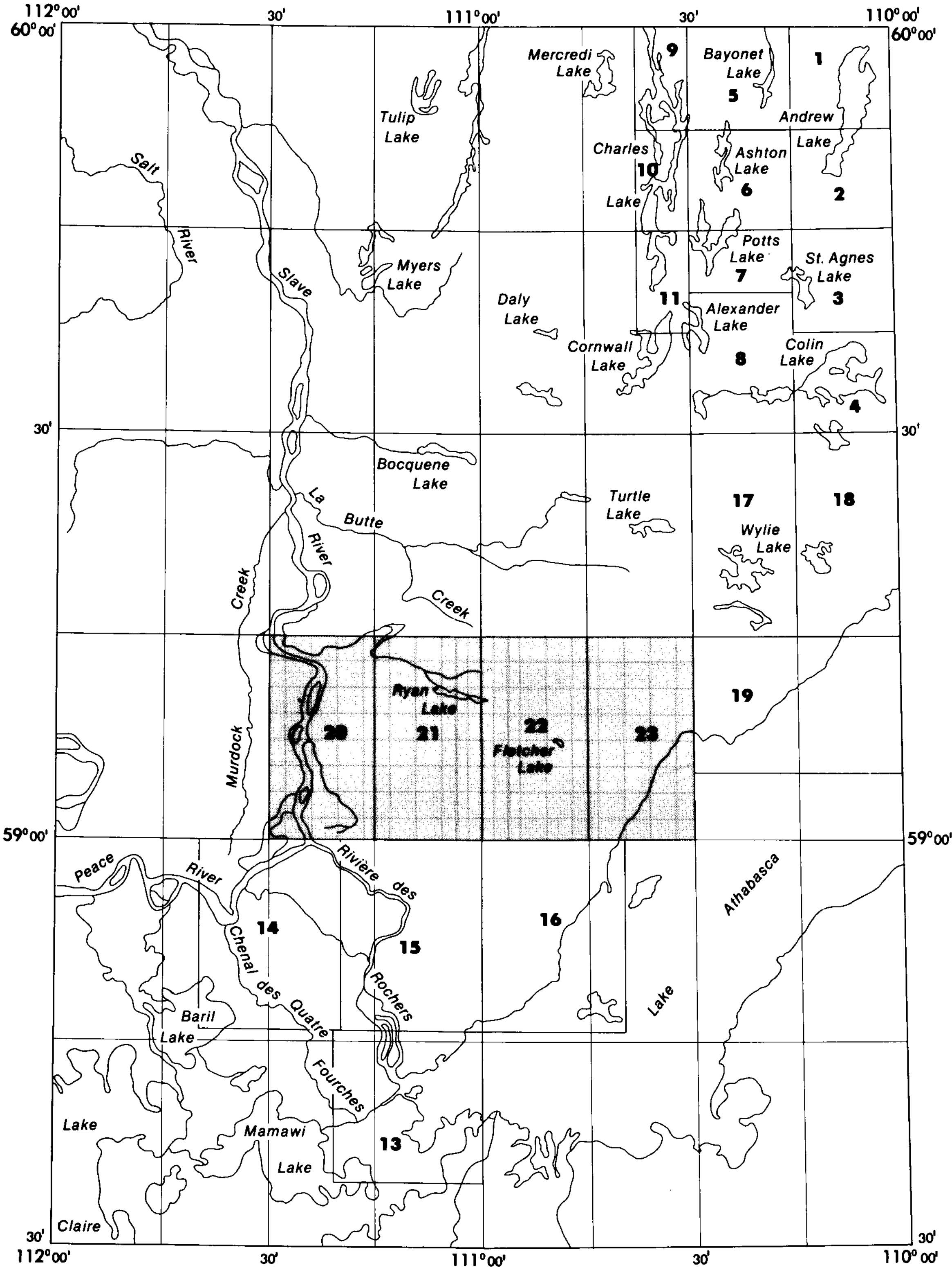


Figure 1. Location of study area, maps 20, 21, 22, 23, the Ryan-Fletcher Lakes district, Alberta, and index to previously published map sheets

mineral prospects on 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 map accompanied by marginal notes.

In 1957, the Alberta Research Council initiated a Shield mapping program and has since published several maps and reports in the current series, (Godfrey, 1958b, 1961, 1963, 1966, 1980a, 1980b; Godfrey and Peikert, 1963, 1964; see figure 1). The fieldwork is complete, and the balance of the maps and reports are to be published.

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

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 certain significant 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; and Langenberg and Nielsen, 1982).

General geology

The Shield terrain in this map area is a northward continuation of the geologic structural trends and lithologic distribution patterns described for the Fort Chipewyan district (Godfrey, 1980b).

The study area is underlain by a Precambrian Shield complex of igneous and metamorphic rocks that lie within the Churchill Structural Province (Godfrey and Langenberg, 1978b). Three distinct Shield terrains (plus the Athabasca Group, largely under water) are evident in the map area (table 1, figure 2). From west to east, these are the Slave Granitoid pluton; the migmatite zone of mixed lithologies; and the granite gneiss belt, partly migmatized and extensively mylonitic. The constituent rock types within each rock group and their possible genetic relationships are presented in table 2.

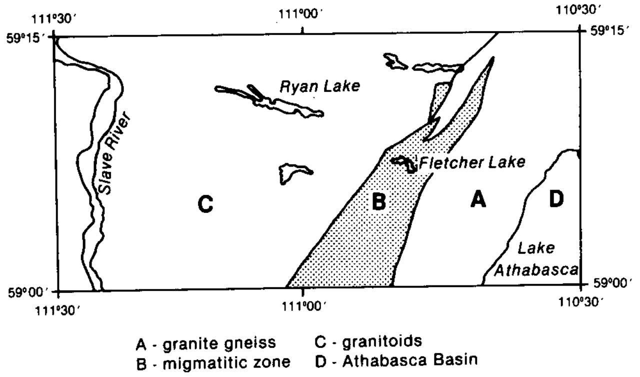


Figure 2. Sketchmap of principal geologic terrains

Subsequent to the formation of the basement gneissic complex, there were at least two cycles of Aphebian-Proterozoic sedimentation (marine then continental) that left sediments now confined to the Lake Athabasca region in this map area. Devonian carbonates onlap the Shield from the west in the vicinity of the Slave River. The last major event, a Pleistocene continental glaciation, left a discontinuous veneer of deposits representing a combination of diverse modes of origin.

Geologic history

The geologic history of this part of the Canadian Shield is summarized in table 3.

The oldest group of rocks, the basement granite gneiss complex, consists of para- and orthogneisses with subordinate amounts of granitoids, high-grade metasediments, and amphibolites. The formation of these gneisses likely entailed multicycle sedimentation along with polyphase metamorphism and deformation. Primary magmatic material was added in the form of granitoid masses and basic dykes, probably during several phases of intrusion. As a consequence of such deep-seated events, major parts of the gneissic belt were migmatized, remobilized and subsequently mylonitized. Metamorphic mineral assemblages in high-grade metasediments of the basement gneiss complex contain hypersthene, green spinel, corundum and

Table 1. Principal rock groups and the geological terrains in which they are found, Ryan-Fletcher Lakes District, Alberta (figure 2)

Rock Group			Geologic Terrain	Distribution In Map Area
(1) granite gneisses (2) cataclastic rocks		A	Granite gneiss belt, partly migmatized and mylonitic;	East
(3) high-grade metasedimentary rocks (4) granitoid rocks	minor masses	B	intervening migmatitic zone of mixed lithologies, including granitized metasedimentary rocks and small plutons	Central
(4) granitoid rocks	major masses	C	major Slave Granitoid pluton	West
(5) low-grade metasedimentary rocks (Burntwood Group)		D	Athabasca Basin	East

Table 2. Principal rock groups, constituent rock units and their field associations, Ryan-Fletcher Lakes district, Alberta

Rock Groups

(2) Cataclastic Rocks	Basement Complex				(4) Granitoid Rocks	(5) Low-Grade Metasedimentary and Sedimentary Rocks
	(1) Granite Gneisses		(3) High-Grade Metasedimentary Rocks			
	Amphibolite				Amphibolite	Athabasca Group[1] Burntwood Group
Derived mainly from rock groups 1, 3, 4	Hornblende Granite Gneiss Biotite Granite Gneiss	+	Granitic Metasedimentary Rocks Metasedimentary Rocks	--->	Arch Lake Granitoids Chipewyan Red Granite	
	[Granite Gneisses]	+	Granitic Metasedimentary Rocks Metasedimentary Rocks	--->	Wylie Lake Granodiorite Fishing Creek Quartz Diorite Granodiorite E Slave Granitoids	

[1] Believed to be locally present beneath surficial cover

---> Close field, and possible genetic, relationships

[] Minor component of parent materials

Table 3. Summary of geologic history of the Shield in the Ryan-Fletcher 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	
Helikian	Athabasca Group[1]	Sandstone	Continental sedimentation	
Aphebian	Burntwood Group	Arkose, phyllitic argillite Sandstone, shale	Regional Faults (eg - Allan Fault) and mylonitization Metamorphism (greenschist facies) Sedimentation	Hudsonian Event
	Wylie Lake Granodiorite	Granodiorite, (quartz diorite)	Basic dykes Metamorphism (granulite-amph. f.) Remobilization Granitization Migmatization Plutonic intrusion	
	Granodiorite E	Granodiorite (granite)		
	Fishing Creek Quartz Diorite	Quartz diorite		
	Chipewyan Red Granite	Granite		
	Arch Lake Granitoids	Granite (granodiorite)		
	Slave Granitoids	Granite		
Archean	Basement Gneiss Complex	Amphibolite Metasedimentary Rocks Hornblende Granite Gneiss Biotite Granite Gneiss	Basic dykes Plutonic intrusion Granitization Metamorphism (granulite facies) Sedimentation	Kenoran Event

---

[1] Believed to be locally present beneath surficial cover

sillimanite. The temperature and pressure for this mineral assemblage are generally estimated at 900 ± 100°C and 7.5 ± 2 kbar (Nielsen *et al.*, 1981), indicating that peak conditions of moderate- to high-pressure granulite facies metamorphism existed during development of this para- and ortho-gneissic complex.

The Archean age (2.5 b.y.) and involvement by the basement gneiss complex in the Kenoran Orogeny is established by the Rb-Sr whole rock pegmatite isochrons from the gneissic belt in the Charles Lake district (Baadsgaard and Godfrey, 1972).

Cordierite and almandine typically either enclose or replace the above granulite facies mineral assemblage, showing that the rocks were subsequently subjected to lower grade metamorphic conditions (Godfrey and Langenberg, 1978a). Emplacement of the granitoids — Slave Granitoids, Wylie Lake Granitoids, Chipewyan Red Granite, and the Arch Lake Granitoids — is associated and coincident with prevailing moderate-pressure, granulite facies metamorphic conditions. Emplacement of the major Slave Granitoid pluton resulted in a diapir that is mantled and walled by basement gneisses. All the diapiric granitoid masses probably originated as remobilized infrastructure crystalline materials. The conditions of emplacement are estimated by Nielsen *et al.* (1981) to have been 740 ± 30°C and 5.0 ± 0.7 kbar (within the moderate-pressure granulite facies field). These conditions are thought to reflect a renewed second phase of metamorphism, rather than retrograde effects of the first metamorphic phase. The region was later subjected to lower grade metamorphic conditions, 550 ± 55°C and 3.0 ± 0.3 kbar (low-pressure amphibolite facies). The moderate-pressure granulite conditions represent the culmination of the Hudsonian Orogeny, and have been dated by Rb-Sr at 1900 m.y. (Godfrey and Baadsgaard, 1962; Baadsgaard *et al.*, 1964, 1967; Baadsgaard and Godfrey, 1967; Nielsen *et al.*, 1981).

Formation of the regional migmatitic zone (intermediate in position between the granite gneiss belt and the major Slave Granite pluton) is linked in gross terms with intense metamorphism and granitization of high-grade metasedimentary rock concentrations within the granite gneisses. Metasedimentary rocks provided much of the parent material from which crystalline granitic products were derived. Large portions of the granitic product were mobilized and separated from the migmatitic metasediment to form plutons and batholiths. Smaller amounts of granitic material remained within the parent migmatitic belt as either minutely dispersed or mappable distinctive masses. The resultant intimate mixture and therefore close spatial association of parent metamorphic and the derived granitic materials together make up the migmatitic character of this central belt.

Three scattered areas of low-grade metasedimentary rocks rest uncomformably on high-grade basement gneisses and granitoids in northeastern Alberta and adjoining northwestern Saskatchewan. These low-grade rocks occupying similar stratigraphic positions relative to the basement suggest similar periods of formation. They are the only metasediments of the region that exhibit primary structures.

In the present map area, the Burntwood Group (table 2, informal name given by Godfrey, 1980b) of low-grade metasediments occupies a narrow band along the shoreline of Lake Athabasca. Although mapped in fault contact with the granite gneiss complex, it is assumed to have been originally unconformably underlain by the gneisses. The Burntwood Group has achieved greenschist facies grade metamorphism only. Therefore, it must have been unconformably deposited on the gneissic-granitoid basement floor after extensive uplift and erosion of the latter. The Burntwood Group outcrops fringe the present Athabasca Basin, suggesting a history of tectonism and sedimentation in this basin preceding deposition of the widespread Athabasca Group. Since the Hudsonian Event, northeastern Alberta appears to have formed part of a structurally stable cratonic block.

Possible stratigraphic equivalents of the Burntwood Group, mapped in northwestern Saskatchewan by Scott (1978), are known as the Thluicho Lake Group. Likewise, the Waugh Lake Group in extreme northeastern Alberta, which has a significant volcanic/volcaniclastic component, has been informally named and described by Godfrey (1963).

These three occurrences of low-grade metasediments suggest tectonic activity in the region accompanied by sedimentation and localized volcanism. One or more of these late Aphebian basins (1970 m.y. for Waugh Lake metamorphic biotite, Baadsgaard and Godfrey, 1972) may have been a forerunner of the Proterozoic Athabasca Basin. The Athabasca Group outcrop area could be underlain in part by rocks of the Burntwood-Waugh Lake-Thluicho Lake Groups or Martin Lake Formation (Fahrig, 1961; Tremblay, 1972; Scott, 1978; Ramaekers, 1981). The continental Athabasca Group has been seen in outcrop in the map area. It is presumed, however, to be present as outliers beneath both extensive areas of glacial sandy cover and Lake Athabasca.

Prolonged uplift of the region has led to erosional stripping of the surface, particularly the removal of considerable amounts of Athabasca Group rocks.

Pleistocene continental glaciation, the most significant recent regional event, has left a terrain with a high proportion of bedrock outcrop and only minor amounts of glacial cover.

Rock type classification

Most of the primary structures and textures of sedimentary and igneous rocks in the crystalline basement complex have been obscured or lost in the course of intense metamorphism, recrystallization, remobilization, intrusion, and deformation. Mixed rock assemblages, and wide, gradational contact zones are evident both in outcrop scale and on the larger regional scale. The principal map units shown on the accompanying geological maps depict the predominant rock type within an outcrop area. Of necessity, the minor, smaller-scale variations in lithology are omitted.

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 seen in the field. Granitoid, gneissic and metasedimentary rock standard samples are listed in tables 4, 5, 6, 7, 8 and 9 along with their modal and chemical analyses. Field locations of these standard samples are shown on the accompanying geological maps.

Map units

The granite gneisses

Biotite and hornblende granite gneisses are characteristically banded in outcrop. The quality of the banding, however, ranges widely from distinct to indistinct, and is locally essentially absent. The metamorphic banding can be planar, or wavy to contorted as in migmatically related structures. Individual bands may be discontinuous or streaky, and well developed or poorly developed (as in the case of mafic-poor, felsic phases and ortho-gneisses).

The granite gneiss terrain contains subordinate amounts of small plutonic masses. Their composition and texture is in part similar to the principal granitoid rock types of the region (Chipewyan Red, Fishing Creek, and Wylie Lake) or intermediate between the granitoids and granite gneisses.

Biotite granite gneiss (11)[1]

Biotite granite gneisses are typically composed of felsic (quartz-feldspar) layers alternating with mafic layers or foliae which are biotite-rich and locally contain minor amounts of hornblende (table 4). The gneisses are typically medium-grained overall, with the felsic mineral layers noticeably coarser-grained than intervening mafic-rich layers. Chloritization of biotite is usual, and epidote veinlets are locally present. Quartz

---

[1] Numbers refer to map unit designations used on the accompanying geological maps.

Table 4. Modal and chemical analyses of standard samples for Biotite Granite Gneiss (11) and Amphibolite (20) in percent

	Biotite Granite Gneiss (11)										Amphibolite (20)
Standard sample number	416	417	420	422	423	429	430	435	437	439	438
Quartz	26.2	28.4	29.1	28.3	26.1	14.5	18.2	11.4	22.4	20.0	0.0
K-Feldspar	0.0	48.6	37.4	40.3	14.7	40.1	25.1	44.9	14.5	5.1	0.0
Plagioclase	59.4	18.3	26.1	19.4	33.1	40.2	26.0	29.2	59.0	50.7	34.9
Biotite	14.0	3.2	6.7	6.7	14.0	0.7	16.1	13.7	3.2	17.6	1.1
Chlorite	0.1	0.3	0.2	0.0	0.0	3.0	Tr	0.0	0.0	0.2	0.0
Hornblende	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.8	55.7
Epidote	Tr	0.7	0.1	0.0	1.3	0.9	9.8	0.6	Tr	5.3	7.0
Muscovite	0.2	0.0	0.0	2.7	10.2	0.6	1.3	0.0	0.0	0.0	Tr
Spinel	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	0.0	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
Cordierite	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
Sillimanite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Accessories	0.1	0.5	0.4	2.6	0.6	0.0	3.5	0.2	0.2	0.3	1.3
Number of points	1030	2000	1001	2176	2052	1027	2160	1014	999	991	1000
SiO_2	68.40	70.69	74.35	70.55	67.35	70.25	59.18	64.97	68.98	60.46	46.81
TiO_2	0.44	0.29	0.22	0.30	0.42	0.25	1.38	1.62	1.08	2.92	2.27
Al_2O_3	15.22	14.92	12.00	15.58	16.80	13.29	16.03	13.69	15.96	13.25	24.34
Fe_2O_3	3.75	2.47	2.11	1.11	3.38	2.65	8.30	5.61	1.50	7.66	2.89
MgO	2.20	0.65	0.92	0.79	1.08	0.78	2.12	1.49	0.98	2.66	6.78
CaO	2.16	0.88	1.21	0.85	2.72	1.82	3.44	2.59	2.76	4.62	10.78
Na_2O	3.65	2.74	2.78	2.13	3.71	4.31	3.08	3.39	4.34	3.30	2.40
K_2O	2.87	6.34	4.89	7.53	3.51	5.05	4.47	4.72	3.09	3.22	1.40
MnO	0.07	0.03	0.11	0.02	0.04	0.05	0.02	0.11	0.08	0.12	0.21
P_2O_5	0.09	0.11	0.10	0.02	0.17	0.18	0.52	0.23	0.17	0.06	0.23
L.O.I.	1.04	0.45	0.34	0.66	0.81	0.89	0.68	1.07	0.37	1.36	1.49
H_2O	0.11	0.16	0.05	0.00	0.05	0.08	0.03	0.08	0.07	0.05	0.10
Total	100.00	99.73	99.08	99.54	100.04	99.60	99.25	99.57	99.38	99.70	99.70

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

Table 5. Modal and chemical analyses of standard samples for Slave Granite Phase (101) in percent

Standard sample number	349	350	352	353	354	355	356	357	358	359	360	361	364	365	369	371
Quartz	30.1	26.6	28.7	20.0	24.8	26.1	23.6	29.5	35.3	27.4	25.4	36.3	30.8	23.6	20.2	27.0
K-Feldspar	35.4	61.6	32.2	52.0	49.5	4.8	60.5	49.5	39.6	42.9	42.7	31.8	57.5	43.5	54.8	32.6
Plagioclase	25.0	9.0	30.7	18.9	21.4	64.0	8.1	11.2	11.2	27.0	18.2	28.7	9.5	31.1	16.0	37.6
Biotite	1.9	0.4	0.0	0.1	2.8	0.8	0.3	1.9	1.4	0.0	0.5	2.7	0.5	0.4	0.3	1.0
Chlorite	0.1	0.0	0.0	1.2	0.2	0.0	4.5	0.6	0.1	0.0	0.0	0.4	0.0	0.2	1.5	0.0
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	0.0
Epidote	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Tr	0.0	0.0	0.1	0.0
Muscovite	0.0	2.4	0.6	7.6	1.3	3.3	3.0	4.5	2.7	2.4	0.2	0.1	0.1	0.7	1.4	1.8
Spinel	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Garnet	7.5	0.0	2.9	0.0	0.0	0.3	0.0	1.4	5.5	0.0	13.0	0.0	1.0	0.5	4.8	0.0
Pyroxene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cordierite	0.0	0.0	4.4	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
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	0.0
Sillimanite	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0
Accessories	0.0	0.0	0.3	0.3	0.0	0.0	0.0	1.4	0.0	Tr	0.0	Tr	0.0	0.0	0.9	Tr
Number of points	1000	1000	1049	912	1000	1000	1010	999	1000	1000	998	1000	999	1037	1000	1010
SiO_2	71.33	74.62	71.95	73.99	72.35	72.62	73.17	71.43	73.28	73.56	69.94	75.16	73.11	72.84	70.56	73.67
TiO_2	0.24	0.08	0.29	0.13	0.13	0.12	0.24	0.19	0.12	0.11	0.12	0.17	0.10	0.10	0.17	0.13
Al_2O_3	14.99	14.27	13.26	12.76	14.21	13.59	9.00	15.91	14.56	14.46	14.78	13.88	13.04	15.07	15.45	15.30
Fe_2O_3	1.44	0.55	2.66	1.00	0.82	1.55	5.61	0.84	1.25	0.24	0.89	0.60	1.79	0.49	1.65	0.72
MgO	0.46	0.10	0.43	0.61	0.44	0.22	0.38	0.24	0.29	0.09	0.26	0.27	0.23	0.14	0.32	0.32
CaO	1.10	0.90	1.29	0.28	0.83	0.81	0.61	1.13	0.95	0.65	0.96	1.11	0.87	0.56	0.78	1.34
Na_2O	3.99	3.79	3.98	2.29	2.72	4.68	2.94	3.47	2.90	2.98	3.52	3.03	3.38	4.06	3.22	3.41
K_2O	5.73	4.77	5.08	8.60	6.77	5.09	7.24	5.59	5.32	6.77	8.81	5.28	6.73	5.94	6.60	3.95
MnO	0.01	0.01	0.04	0.02	0.02	0.02	0.03	0.01	0.03	0.01	0.02	0.01	0.02	0.00	0.04	0.01
P_2O_5	0.09	0.03	0.10	0.09	0.09	0.07	0.10	0.07	0.06	0.05	0.11	0.00	0.10	0.10	0.09	0.06
L.O.I.	0.03	0.00	0.35	0.92	0.68	0.45	0.69	0.42	0.24	0.37	0.44	0.30	0.47	0.50	0.25	0.61
H_2O	0.07	0.08	0.05	0.08	0.05	0.03	0.06	0.17	0.28	0.10	0.05	0.04	0.04	0.07	0.10	0.03
Total	99.48	99.20	99.48	100.77	99.11	99.25	100.07	99.47	99.28	99.39	99.90	99.85	99.88	99.87	99.23	99.55

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

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

Standard sample number	372	373	374	375	376	409	410	411	412	413	434	441
Quartz	16.8	24.1	23.5	36.2	26.0	31.9	32.2	36.7	33.6	27.8	24.5	26.2
K-Feldspar	49.8	47.6	35.7	27.5	38.1	58.8	24.2	21.0	45.6	33.6	45.0	0.0
Plagioclase	31.0	25.8	37.3	29.0	31.7	4.9	42.6	33.0	8.8	28.2	29.3	69.2
Biotite	0.3	0.0	3.2	5.3	3.8	0.5	0.2	0.2	0.4	1.9	0.9	2.7
Chlorite	0.1	0.0	0.3	1.5	0.1	0.0	0.0	0.0	0.4	0.0	0.3	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
Epidote	0.0	0.0	0.0	0.1	0.0	0.2	0.0	0.0	Tr	0.0	Tr	0.0
Muscovite	0.2	1.9	0.0	0.2	0.2	0.7	0.8	9.0	2.7	7.9	0.0	1.8
Spinel	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Garnet	1.8	0.0	0.0	0.1	0.0	0.2	0.0	0.0	8.2	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
Cordierite	0.0	0.1	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0
Andalusite	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sillimanite	0.0	0.1	0.0	0.0	0.0	1.1	0.0	0.1	0.0	0.0	0.0	0.0
Accessories	0.0	0.0	0.0	0.1	0.1	1.2	0.0	Tr	0.3	0.6	Tr	0.0
Number of points	1044	1011	1000	999	1000	2000	1000	1800	1000	2144	1000	999
SiO_2	72.10	74.71	71.48	75.11	71.38	73.51	74.46	73.97	73.95	73.52	72.91	74.61
TiO_2	0.23	0.11	0.17	0.13	0.27	0.16	0.09	0.09	0.12	0.10	0.11	0.16
Al_2O_3	12.67	13.72	14.70	13.49	14.88	15.33	13.88	15.05	14.51	15.46	14.17	15.07
Fe_2O_3	2.56	0.35	1.27	0.95	1.23	0.60	0.85	0.42	1.13	0.70	0.81	0.64
MgO	0.31	0.12	0.51	0.49	0.69	0.24	0.06	0.18	0.20	0.26	0.63	0.36
CaO	1.19	0.96	1.26	0.83	1.30	0.62	0.88	0.55	0.66	0.57	1.05	0.38
Na_2O	3.91	3.64	3.81	2.94	3.35	2.97	3.63	3.45	3.11	3.98	2.32	6.40
K_2O	5.90	6.06	5.05	4.95	5.77	4.95	4.95	5.16	5.67	4.29	6.58	0.94
MnO	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.04	0.01	0.02	0.00
P_2O_5	0.07	0.11	0.06	0.08	0.15	0.07	0.09	0.13	0.13	0.11	0.04	0.08
L.O.I.	0.67	0.36	0.40	0.51	0.50	0.97	0.42	0.53	0.33	0.61	0.48	0.66
H_2O	0.09	0.10	0.07	0.10	0.07	0.12	0.14	0.04	0.06	0.01	0.03	0.06
Total	99.72	100.26	98.80	99.60	99.61	99.55	99.46	99.58	99.91	99.62	99.15	99.36

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

Table 7. Modal and chemical analyses of standard samples for Mafic Slave Granite Phase (102), Wylie Lake Granodiorite Phase (131) and Fishing Creek Quartz Diorite (133) in percent

	Mafic Slave Granite Phase (102)							Wylie Lake Granodiorite Phase (131)	Fishing Creek Quartz Diorite (133)			
Standard sample number	348	351	366	368	370	377	379	421	215	424	431	440
Quartz	30.6	19.0	21.1	26.7	29.1	22.7	20.0	32.1	38.1	27.7	16.7	25.9
K-Feldspar	54.1	36.2	13.7	41.1	14.3	29.8	25.3	9.2	21.9	17.8	0.7	10.9
Plagioclase	0.3	34.1	52.8	23.5	33.9	36.8	48.6	31.1	37.5	27.6	49.2	43.7
Biotite	8.8	6.2	12.4	8.0	14.4	8.8	5.9	26.6	0.0	13.4	30.1	16.2
Chlorite	0.3	Tr	0.0	0.3	1.3	1.9	0.1	0.0	0.9	0.3	0.3	0.2
Hornblende	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8
Epidote	0.0	0.1	0.0	0.1	0.4	0.0	Tr	0.2	0.6	5.7	1.6	0.3
Muscovite	0.0	0.1	Tr.	0.0	0.0	0.0	0.0	0.0	0.2	7.2	0.2	0.0
Spinel	1.6	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	4.3	0.0	0.0	6.2	0.0	0.0	0.0	0.2	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
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
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	3.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Accessories	0.4	0.0	Tr	0.3	0.4	0.0	0.1	0.8	0.6	0.3	1.2	Tr
Number of points	900	1025	999	910	1000	1000	1000	2074	2000	2125	1728	1000
SiO_2	71.78	67.07	67.31	71.57	72.90	70.37	69.11	65.04	74.91	68.71	62.67	61.33
TiO_2	0.10	2.26	0.81	0.24	0.17	0.35	0.78	0.53	0.05	0.43	0.64	0.61
Al_2O_3	15.99	10.83	9.07	15.16	14.52	16.27	14.84	15.72	13.47	15.37	17.02	15.07
Fe_2O_3	0.64	7.27	7.81	0.74	1.53	1.42	2.41	5.19	0.89	3.36	5.21	6.72
MgO	0.22	1.19	2.76	0.37	0.71	0.69	1.14	3.06	0.20	1.62	2.72	4.42
CaO	0.72	1.92	3.32	0.83	1.42	1.36	1.69	2.36	1.26	2.30	3.01	3.51
Na_2O	3.72	3.76	2.87	3.57	3.04	3.47	3.35	2.65	3.18	3.03	2.63	2.15
K_2O	5.37	5.69	4.05	6.15	4.99	4.67	5.08	3.74	4.32	4.25	3.50	3.97
MnO	0.01	0.07	0.08	0.01	0.02	0.02	0.02	0.08	0.05	0.03	0.09	0.11
P_2O_5	0.10	0.18	0.37	0.09	0.06	0.02	0.23	0.14	0.06	0.11	0.19	0.16
L.O.I.	0.37	0.29	0.98	0.37	0.40	0.44	0.72	1.04	0.34	1.09	1.49	1.02
H_2O	0.12	0.04	0.04	0.11	0.14	0.08	0.07	0.12	0.24	0.05	0.05	0.09
Total	99.14	100.57	99.47	99.21	99.90	99.16	99.44	99.67	98.97	100.35	99.22	99.16

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

Table 8. Modal and chemical analyses of standard samples for Chipewyan Red Granite (150), Arch Lake Granite (161) and Arch Lake Transitional Granite Phase (162) in percent

Standard sample number	Chipewyan Red Granite (150)				Arch Lake Granite (161)								Arch Lake Transitional Granite Phase (162)	
	427	428	433	436	362	363	380	414	415	419	426	432	367	378
Quartz	19.0	24.3	30.0	20.6	19.7	29.9	26.6	24.5	24.2	18.7	16.5	24.4	28.5	18.7
K-Feldspar	29.3	33.9	32.0	72.6	11.4	14.0	18.1	37.2	24.2	30.1	36.2	32.8	20.0	31.1
Plagioclase	50.2	40.1	36.2	4.4	58.5	43.2	40.7	30.1	33.9	45.5	41.2	36.8	43.1	42.7
Biotite	0.9	1.4	1.6	1.5	7.0	5.7	14.3	5.7	14.0	5.7	1.1	5.8	4.0	6.3
Chlorite	0.3	0.1	0.1	0.5	2.9	0.9	0.0	0.4	1.4	0.0	3.7	Tr.	0.1	0.2
Hornblende	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0
Epidote	0.1	0.0	Tr	0.2	0.3	0.3	0.2	0.3	0.8	0.0	Tr	0.0	0.0	0.0
Muscovite	0.0	0.1	0.1	0.0	Tr	0.1	0.0	0.1	0.0	0.0	1.4	0.2	0.0	0.1
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
Garnet	0.0	0.0	0.0	0.0	0.0	5.8	0.0	1.4	0.0	0.0	0.0	0.0	4.3	0.9
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	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
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	0.2	0.1	0.0	0.1	0.2	0.1	0.1	0.3	0.9	0.0	0.0	0.0	Tr	0.0
Number of points	1004	1000	1000	1034	1000	1000	1002	1001	2102	1000	1031	1000	1006	993
SiO_2	72.76	75.31	75.67	74.45	66.03	68.16	69.53	69.33	67.07	71.19	70.51	70.77	70.88	70.23
TiO_2	0.32	0.13	0.09	0.12	0.62	1.12	0.83	0.51	0.47	0.69	0.32	0.29	0.34	0.78
Al_2O_3	14.39	13.25	13.64	13.28	18.53	10.88	13.91	15.24	14.55	15.28	15.35	14.45	15.16	11.31
Fe_2O_3	0.62	0.32	0.49	0.35	0.79	7.15	4.85	3.52	3.43	0.86	2.12	2.13	1.91	4.71
MgO	0.51	0.28	0.22	0.20	1.56	1.19	1.26	0.75	2.10	0.79	0.98	1.01	1.03	0.99
CaO	1.58	0.82	1.23	0.34	3.74	2.38	2.16	2.25	2.62	1.56	0.61	1.06	1.01	1.77
Na_2O	3.79	3.55	3.46	2.69	3.56	4.13	2.35	2.53	2.48	3.86	3.47	3.31	3.58	4.40
K_2O	4.90	5.67	4.62	7.98	2.50	3.54	3.60	5.11	5.36	5.03	5.42	5.24	4.82	4.48
MnO	0.04	0.05	0.02	0.04	0.03	0.05	0.04	0.08	0.03	0.05	0.02	0.03	0.02	0.05
P_2O_5	0.12	0.12	0.06	0.12	0.22	0.17	0.21	0.04	0.22	0.15	0.04	0.15	0.07	0.10
L.O.I.	0.55	0.42	0.38	0.21	1.32	1.72	0.64	0.32	1.09	0.48	1.00	0.87	1.01	0.36
H_2O	0.08	0.04	0.07	0.02	0.06	0.16	0.07	0.07	0.02	0.04	0.06	0.11	0.01	0.06
Total	99.66	99.96	99.95	99.18	98.96	100.65	99.45	99.75	99.44	99.98	99.90	99.42	99.84	99.24

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

Table 9. Modal and chemical analyses of standard samples for Mylonite (221), Mylonite (222), and Metasedimentary Bands 48, 49, 50, 51, 52, 53 and 69 in percent

	Mylonite (221)	Mylonite (222)	Metasedimentary Rock Bands (31)						
Standard sample number	442	418	48	49	50	51	52	53	69
Quartz	12.5	34.4	36.8	43.4	28.7	39.5	38.5	35.8	42.1
K-Feldspar	13.2	22.4	11.1	7.1	23.5	7.1	5.9	18.0	0.1
Plagioclase	64.8	30.4	30.2	25.3	31.1	19.0	24.2	28.4	10.2
Biotite	5.3	0.0	3.4	6.1	5.9	17.0	11.2	7.4	23.6
Chlorite	0.0	0.2	4.1	2.8	1.1	0.2	5.0	0.1	4.6
Hornblende	0.0	0.0	0.0	3.3	0.0	0.0	0.5	0.0	0.0
Epidote	3.4	0.5	0.0	0.1	Tr	0.0	Tr	Tr	0.0
Muscovite	0.6	9.2	8.6	6.7	6.8	11.1	14.1	3.2	18.2
Spinel	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Garnet	0.0	0.0	4.1	4.9	2.8	1.7	0.1	3.7	0.0
Pyroxene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Tr	0.0
Cordierite	0.0	0.0	1.4	0.0	0.0	3.6	0.2	3.3	0.0
Andalusite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sillimanite	0.0	0.0	0.1	0.0	0.0	0.5	Tr	0.1	0.0
Accessories	0.2	2.9	0.1	0.3	0.1	0.3	0.3	Tr	1.2
Number of points	1022	1000	2500	1600	2000	2400	2400	2500	1200
SiO_2	70.08	73.20	69.48	73.75	71.26	69.56	69.41	68.57	71.55
TiO_2	0.50	0.17	0.68	0.62	0.48	0.70	0.56	0.67	0.46
Al_2O_3	10.93	14.56	13.55	12.09	14.71	15.00	14.53	14.70	14.40
Fe_2O_3	5.87	1.24	5.64	4.93	3.61	4.47	5.00	5.22	4.30
MgO	1.20	0.53	1.71	1.25	0.92	1.15	1.58	1.58	0.10
CaO	1.08	0.72	0.75	1.26	1.35	1.25	1.41	1.13	0.37
Na_2O	4.57	3.04	1.55	1.67	3.17	2.01	1.92	2.08	0.34
K_2O	3.89	5.05	4.16	3.42	3.52	4.23	3.62	3.89	3.30
MnO	0.08	0.03	0.07	0.06	0.05	0.04	0.05	0.03	0.02
P_2O_5	0.11	0.03	0.07	0.10	0.10	0.02	0.03	0.08	0.16
L.O.I.	1.09	0.44	1.06	1.03	0.72	1.33	1.75	1.03	4.11
H_2O	0.08	0.10	0.06	0.11	0.11	0.06	0.06	0.07	0.16
Total	99.48	99.11	98.81	100.29	100.00	99.92	99.92	99.05	99.27

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

veins, pods, and pegmatites are fairly common. Isolated grains of allanite and concentrations of magnetite in streaks parallel to the foliation have been noted.

Hornblende granite gneiss (12)
Hornblende granite gneisses are much less abundant than their biotite counterparts. These two rock units are similar in petrologic character. Mafic layers in the hornblende-bearing gneisses are rarely without some biotite, although the reverse is not necessarily the case. Magnetite is more common in the hornblende gneisses than in the biotite gneisses. Chemical and modal analyses of typical samples appear in table 4.

Amphibolite and metasedimentary rocks are commonly present as minor components, usually small masses, within the granite gneiss terrain.

A large part of the granite gneiss terrain has been subjected to cataclastic deformation on a regional scale and subsequently recrystallized.

Amphibolite (20)

Amphibolite is present in a variety of host rocks which in turn represent different ages and environments of formation. Amphibolites are found within each of the major geologic terrains and rock groups — granite gneiss, high-grade metasediments, and granitoid rocks. The widespread occurrence of amphibolites in this igneous-metamorphic terrain suggests that they were emplaced or generated under a range of geologic conditions and times. They do not show any marked regional or local pattern of distribution or concentration. Major bodies of amphibolite have not been found in the map area, and nowhere have amphibolites developed thicknesses indicative of a volcanic association or a major plutonic mass. The amphibolites are probably of varied origin, involving both igneous and metamorphic processes. Chilled contacts have not been observed; they may have been obliterated through subsequent deformation, metamorphism and recrystallization.

Amphibolite lenses and 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 (5 to 20+ ft) long. They are usually aligned parallel to the metamorphic foliation and show the effects of ductile to plastic deformation. Most amphibolite bodies are discontinuous and probably represent either boudinaged basic dykes and sills, fragmented restite, or an agmatitic pegmatite complex within granite gneiss or metasedimentary rocks. Amphibolites are relatively uncommon in the major granitoids in the western part of the map area.

Massive amphibolites are dark green on a freshly broken surface, weathering to 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 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. Chemical and modal analyses of a typical amphibolite appear in table 4.

As the proportion of hornblende decreases, amphibolite grades to either hornblende granite gneiss or 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. Some of the banded varieties consist of 10 to 25 mm thick bands, in which alternating layers contrast in their hornblende to feldspar ratio.

Many of the amphibolites, particularly in the granite gneiss and high-grade metasedimentary rock terrains, weather noticeably rusty. This phenomenon is probably related in part to the decomposition of pyrite, commonly present, but usually in small amounts.

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

High-grade metasedimentary rocks (31)

The high-grade metasedimentary rocks have two principal modes of distribution:

1. as a major rock type in the central migmatitic zone, occurring along with a variety of small-scale granitoid bodies; and,
2. as relatively minor lenses and bands within both the granite gneiss and Slave Granite terrains.

All the high-grade metasedimentary rock bodies tend to be elongated in a plane view. Their long axes are aligned parallel to the regional structural trend (north to northeast). In outcrop, the metasedimentary rocks show intricate, steeply dipping isoclinal folds, locally crenulated and chaotic (due to flow folding) in migmatitic associations. The enclosing gneisses or granitoids are much less deformed. These structural relationships indicate greater mobility (plasticity) of the metasedimentary rocks compared to the host gneisses or granitoids. This increased mobility is possibly a consequence of water released preferentially from the metasediments — as compared to the drier adjacent crystalline host rocks — in the course of prograde metamorphism.

The metasedimentary rocks are typically quartzitic with subordinate amounts of schist, phyllite and amphibolite. 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 weathered appearance. Locally, the rust may be sufficiently extensive in outcrop to be termed a rusty zone, or in the extreme case a gossan. Chemical and modal analyses of typical samples appear in table 9.

The outstanding structural feature of high-grade metasedimentary rocks in outcrop is the fairly regular banding. This banding, however, becomes more disrupted and less continuous as the amount of metamorphically recrystallized quartzo-feldspathic material increases, and the rock becomes more granitoid in appearance. Where the granitic component is not prominent, the metasedimentary rocks are typically well foliated or color banded or both.

Prograde metamorphism of the metasediments to a maxima in the granulite facies is indicated by the presence of hypersthene, green spinel and sillimanite (Godfrey and Langenberg, 1978a). The resulting granitization is expressed in outcrop in a variety of ways: isolated feldspar porphyroblasts; quartzo-feldspathic concentrations as clusters, pods and irregular patches; conformable and cross-cutting pegmatites; migmatitic to gneissic phases; and minor granitoid bodies with or without schlieren of either biotite concentrations or granitized metasedimentary rock. The end products cover a lithologic range gradational from regularly banded metamorphic rocks of obvious sedimentary parentage to rocks that contain a high proportion of metamorphically generated quartzo-feldspathic material. These latter rocks are classified as gneissoid-migmatites and granitic-pegmatic masses in outcrop.

The larger bands of metasediments are situated in the central migmatitic zone. This is the northern continuation of the major band described at Loutit Lake in the Fort Chipewyan map area (Godfrey, 1980b). These bands are structurally complex, and consist of quartzite with subordinate amounts of schist and phyllite. These metasediments contain significant proportions of dispersed metamorphic quartzo-feldspathic material. A high proportion of discrete granitoid bodies are also present.

Amphibolite bands from 0.5 to 2 m (3 to 6 ft) across 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 typically associated with rusty zones. Minor copper (chalcopyrite) mineralization is locally present. Molybdenite, graphite and uranium have been noted in adjacent map areas and can be expected if these metasedimentary rocks are thoroughly prospected. Narrow, milky white quartz veins and pods, single or in groups, are usually barren of sulfides.

The granitoid rocks

This group of rocks includes all of the granitoid[1] rock units. The plutons range in size from more than 30 km to less than 1 km across. These plutons probably represent a range of ages. They all, however, tend to be elongated parallel to the north-northeasterly trend, suggesting a continuing influence of the regional tectonic stress orientation. The smaller plutons are scattered through the central migmatitic zone and in the granite gneiss belt.

Slave Granitoids

The Slave Granitoid pluton dominates the western part of the map area and is the most abundant rock type in the Shield of Alberta. The lithologic and structural character of the pluton is relatively simple compared to that of either the granite gneiss or the central metasedimentary-migmatite zone. Nonetheless, the Slave Granitoid pluton contains numerous xenoliths and gradations to Arch Lake Granitoids and metasedimentary rocks. The eastern margin of the Slave Granite pluton in particular has a concentration of these xenoliths.

Slave Granite Phase (101)

The Slave Granite Phase has a relatively limited textural and compositional range. It has a fairly light overall color, 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 comprising up to 15 percent of the rock. The rock is typically garnetiferous, with chloritic biotite wrapped around garnet cores and dispersed through the rock masses (up to a total of 4 percent). The mafic knots are about 5 mm in diameter. Green spinel (and hypersthene elsewhere in the Slave Granitoids), seen under the microscope, places this rock in the high-grade granulite facies. Chemical and modal analyses of typical samples are presented in tables 5 and 6.

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 of up to 10 percent. Chemical and modal analyses of representative samples are given in table 7.

Subordinate masses of Arch Lake Granitoids and high-grade metasedimentary rocks are common in the Slave Granitoid pluton. Derivation of the Slave Granitoids by partial melting of infrastructure materials possibly dominated by metasedimentary rock, seems most plausible from the mapped field relationships.

Wylie Lake Granitoids

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

Wylie Lake Granodiorite Phase (131)

The Wylie Lake Granodiorite Phase is overall dark in color, either a greenish or brownish-red, and can display a mottled pattern in hand specimen. The rock is typically of medium grain size and equigranular except for rare pink to red potassium feldspar megacrysts about 13 mm long. The texture is massive to poorly foliated. The principal minerals are pink to red feldspar, quartz, and biotite. The feldspar coloration is due to minute hematite inclusions. One chemical and modal analysis of a typical sample appears in table 7.

Wylie Lake Granodiorite occurs in field association with Fishing Creek Quartz Diorite. They occur together within the granite gneiss belt and in the high-grade metasedimentary migmatite zone.

Granodiorite E (132)

Granodiorite E is most abundant in the Wylie Lake and Colin Lake map areas. In all areas it is intimately associated with other Wylie Lake Granitoids, especially Fishing Creek Quartz Diorite and Wylie Lake Granodiorite Phase.

---

[1] 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 restricted compositional range. See figures 2 and 3 for details.

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. Rare larger megacrystic feldspars from 10 to 15 mm long are present, and although of small proportion (< 1 percent), they are nevertheless characteristic of the rock type. The typical granodioritic composition of Granodiorite E extends marginally into the granite field. Chemical and modal analyses appear in Godfrey and Peikert (1964).

A genetic link is indicated between Granodiorite E, Wylie Lake Granodiorite Phase, and possibly Fishing Creek Quartz Diorite, based on close field relationships and similar mineral compositions. Differences in feldspar megacryst formation (a late-stage feature of petrogenesis) 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 poorly foliated, it can be locally either gneissic (with wisps of biotite concentration or metasedimentary rocks) or massive. Megacrystic white feldspars range from 7 to 10 mm in length within a 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. Chemical and modal analyses of this rock type are presented in table 7.

Undifferentiated Granitoids (136)

Undifferentiated Granitoids are local areas within the Wylie Lake Granitoids that lack sufficient traverse data to allow further subdivision into individual granitoid rock types. Traverses through areas underlain by Wylie Lake Granitoids have indicated such complex, small-scale mixtures of lithologies, that it is deemed unwise to extrapolate rock type boundaries beyond the zones where reliable ground data exist.

The principal rock types within the areas of undifferentiated granitoids are expected to be: Fishing Creek Quartz Diorite and Wylie Lake Granodiorite Phase, along with minor amounts of Granodiorite E. Leucocratic Granite, a minor component which accompanies all of the above granitoids, would therefore also be a subordinate constituent of the Undifferentiated Granitoids.

Chipewyan Red Granite (150)

This rock is of a distinctive red color with variations to a paler, almost pink shade. The typically medium-grained texture is locally fine-grained, and is massive to faintly lineated (shown by quartz rods) with pink to red feldspars, quartz, minor chloritic biotite, and locally minor amounts of garnet. Chemical and modal analyses of standard samples are presented in table 8.

Variable ghostlike streaks and gneissose schlieren (xenolithic) of mafic composition are aligned in the regional northeasterly foliation. Minor quartz veins and pegmatites up to 7 to 10 cm (3 to 4 in) thick cut the Chipewyan Red Granite. Small-scale amphibolite dykes cut many of the granite bodies; some are related to shear zones and others parallel the regional foliation.

Many small masses of Chipewyan Red Granite are concentrated in the central metasedimentary migmatite zone. Several others are scattered in the granite gneiss belt to the east and a few are in the main Slave Granite pluton to the west. The main concentration within bands of high-grade metasediments in the migmatite zone suggests, however, either injection along regional lines of weakness or a genetic association, or possibly a combination of the two.

Arch Lake Granitoids

Arch Lake Granitoid masses are situated exclusively within the Slave Granitoid pluton in the western part of the map area. Arch Lake Granitoid blocks and bands, of major and minor dimensions, are scattered throughout the pluton, but with notable concentration towards the eastern margin adjacent to the metasedimentary-migmatite belt.

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 cataclasis. The rock texture is fairly homogeneous, typically of medium grain size, but locally coarse, with up to 25 percent feldspar megacrysts ranging from 15 to 30 mm in length. The matrix consists of pink to red feldspar, biotite, and blue quartz. Chemical and modal analyses of this rock type are given in table 8. The rock composition is dominantly granite with minor variations to granodiorite and quartz diorite.

Arch Lake Granite Transition Phase (162)

Arch Lake Granite Transition Phase is a sub-type of the Arch Lake Granite Phase and is distinguished by the absence of large 15 to 30 mm long potassium feldspar megacrysts. However, a smaller size range of potassium feldspar megacrysts about 15 mm long and up to 5 percent of the rock can be present. Chemical and modal analyses of standard samples are given in table 8.

Low-grade metasedimentary rocks

Burntwood Group rocks occur discontinuously as a narrow band of outcrops along the shore of Lake Athabasca for a strike length of 6.5 km (4 mi). These outcrops are the most extensive and best exposures of Burntwood Group rocks in the Shield of northeastern Alberta. These rocks have been subjected to low-grade metamorphism and have been cataclastically deformed, most likely in response to late movements along the Allan Fault zone.

The principal rock types are dark gray-green, chloritic, phyllitic to argillitic beds about 25 mm (1 in) thick, interbedded with mauve, arkosic sandstone in beds that average about 100 m (4 in) thick. The primary sedimentary rocks appear to have been silty shales and arkosic sandstones with minor pebble bands resembling a flysch or turbidite sequence. Primary bedding, most prominent in the sandy phases, strikes northeasterly and dips steeply to the northwest. Small, milky white gash quartz veins are numerous locally. The principal outcrop of Burntwood Group rocks forms a prominent steep escarpment along the shores of Lake Athabasca in which sea arches and caves have been developed near lake level.

The only other extensive area of prograde greenschist facies rocks in the Shield of Alberta is to be found at Waugh Lake, in the extreme northeastern corner of the province (Godfrey, 1963). The low-grade Waugh Lake metasedimentary rocks include a significant metavolcanigenic component by way of flows and probably pyroclastics (Watanabe, 1961; Godfrey, 1963). Primary bedding and graded bedding commonly seen at Waugh Lake are also evident in the Burntwood Group. These two areas of greenschist metasedimentary rocks occupy similar stratigraphic positions relative to the crystalline basement and display similar styles of deformation. It is suggested that the metasedimentary rocks of Waugh Lake and those of the Burntwood Group could be stratigraphically equivalent.

Unlike the high-grade metasediments in the rest of the map area, the Burntwood Group rocks lack any metamorphically generated quartzofeldspathic segregations. It is apparent that metamorphic conditions were inadequate either to promote granitization or to destroy the primary sedimentary structures.

The contrast in metamorphic grade, lithologies and deformational style, supports the concept of a significant time break and unconformity between the Burntwood Groups rocks and the presumed underlying basement gneisses. If the Waugh Lake and the Burntwood Group are approximate time equivalents, then the K-Ar metamorphic biotite age date of 1.78 b.y. on Waugh Lake lavas (Godfrey and Baadsgaard, 1962) places a minimum age on the Burntwood Group. Thus, the Burntwood Group rocks were metamorphically and structurally affected by the Hudsonian Event, probably during a late stage of that orogenic episode.

In Saskatchewan, low-grade metasedimentary rocks have been described by Hale (1954), Fahrig (1961), Koster (1961), and Scott (1978). Scott renamed a sequence of basal conglomerate, graywacke, arkose and banded argillite (showing graded bedding) situated between Thluicho and Gulo Lakes as the "Thluicho Lake Group." The Burntwood Group rocks of Alberta appear to be lithological equivalents of the banded argillite in the Thluicho Lake Group.

Distribution of Burntwood Group rocks along the shores of Lake Athabasca suggests that this lake basin was a structurally (tectonically) controlled basin as far back as the late Hudsonian. The coexistence of tectonically influenced depositional basins would support independent sedimentation of the Waugh Lake and Thluicho Lake Groups. However, extensions of the early "Athabasca Basin" into these outlying areas cannot be ruled out. Intermittent sedimentation in an early Athabasca Basin and sub-basins might be represented by the following sequence of deposits:

Athabasca Group	1.35 b.y. (min.)[1]
Martin Lake Series	1.65 b.y. (1.83 b.y. max.)[2]
Burntwood Group (Waugh Lake Group, Thluicho Lake Group)	~1.78 b.y. (min.)

Regional cataclastic zones

Wide zones of cataclasis, principally affecting the belt of granite gneisses in the eastern part of the map area, are an expression of the Allan Fault zone (Godfrey, 1958). Varied cataclasis within the zone produced a range of deformational products from ultramylonite to less-crushed phases — flaser gneiss and mylonite. All of these cataclastic rocks have been affected by recrystallization to some extent, resulting in the formation of blastomylonites and the commonly observed porphyroclastic-augen feldspars.

Mapping indicates that the parent materials for the cataclastic rocks are dominantly gneisses, with lesser amounts of high-grade metasedimentary rocks, Wylie Lake Granitoids, and Chipewyan Red Granite.

The compositional and textural layering 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 long in strike (as viewed on aerial photographs).

The wide mylonitic zone (up to 8 km) which forms the principal outcrop expression of the north-trending Allan Fault, swings through an angle of about 40 degrees toward the southwest as it nears the shoreline of Lake Athabasca. Both geological mapping and aeromagnetic survey data suggest that the full width of the Allan Fault makes this swing (Godfrey, 1958a, 1980b; GSC, 1964). The possibility, however, of a branching fault remains open if a direct southern continuation of the fault underlies the waters of Lake Athabasca.

Modal and chemical analyses

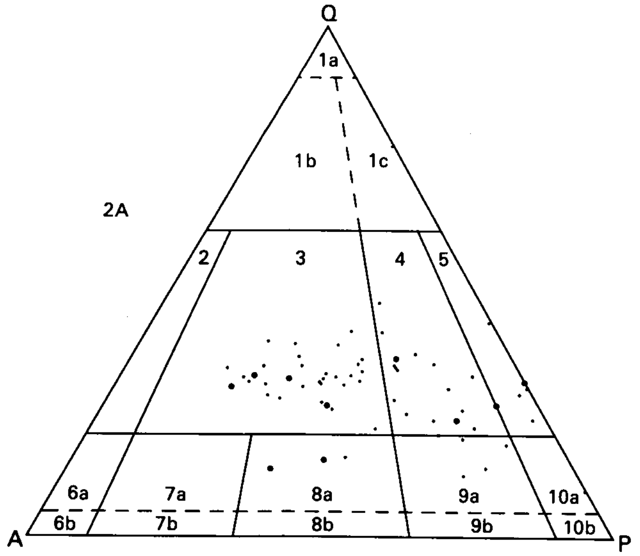
Mineralogical and chemical data on rock types in the map area are presented in tables 4, 5, 6, 7, 8 and 9. Representative hand specimens have been chosen from both the gneissic-granitoid map units and the high-grade metasedimentary rock group. Selection of the standard hand specimens was based on the representative character of their megascopic features. The gneissic and granitoid map unit standard samples are represented by single hand specimens, but standard samples for the high-grade metasedimentary rocks are each represented by a group of five to ten specimens because of the typically wide lithological variation within metasedimentary rock bands. Metasedimentary standard rock samples were 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 ternary Q-A-P diagrams, shown in figure 3. On these diagrams, modal data plots for rock types from the present study area are distinguished from those of the same rock type from other parts of the Shield in Alberta. Rock type boundaries are incorporated into these diagrams according to the recommendations of Streckeisen (1967).

---

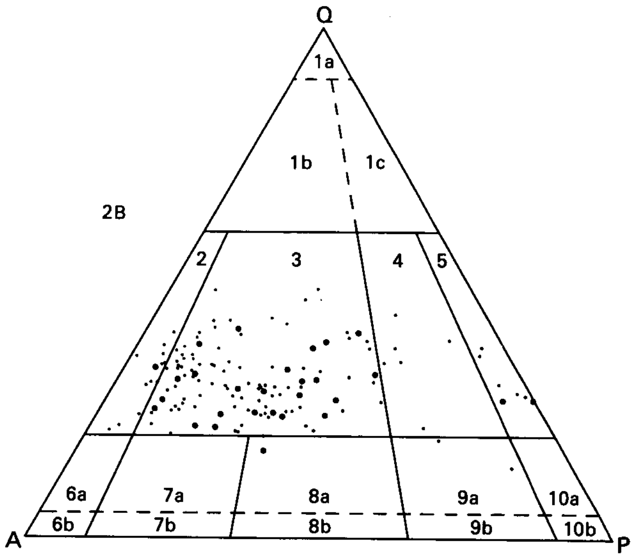
[1] Ramaekers (1980)

[2] Tremblay (1972)



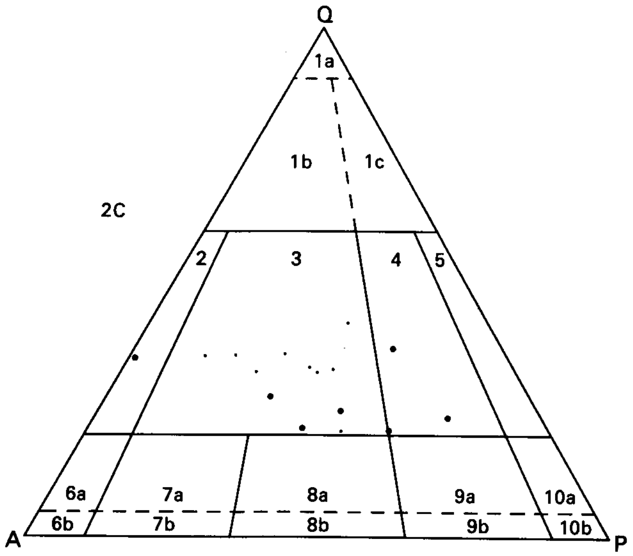
Biotite Granite Gneiss (11)

	N	Q	K	P	K/P
Study Area	10	22.5	27.1	36.1	0.75
All Shield	63	26.6	23.7	38.1	0.6



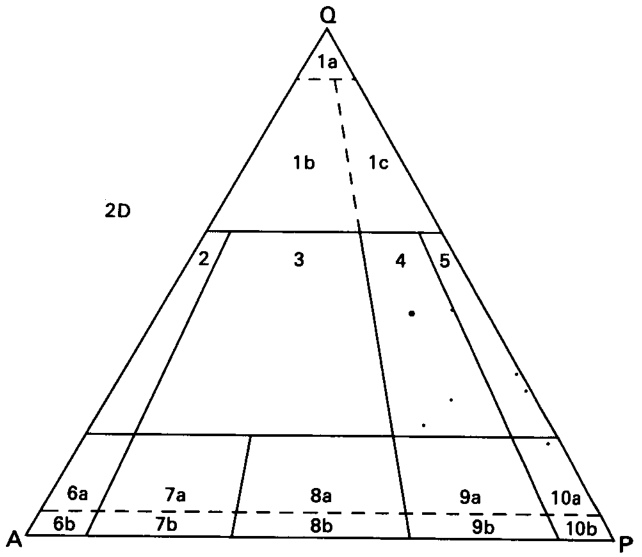
Slave Granite (101)

	N	Q	K	P	K/P
Study Area	28	27.7	39.9	26.4	1.5
All Shield	144	29.1	42.0	22.5	1.9



Mafic Slave Granite (102)

	N	Q	K	P	K/P
Study Area	7	19.8	30.6	32.9	0.9
All Shield	17	25.5	32.1	30.0	1.1

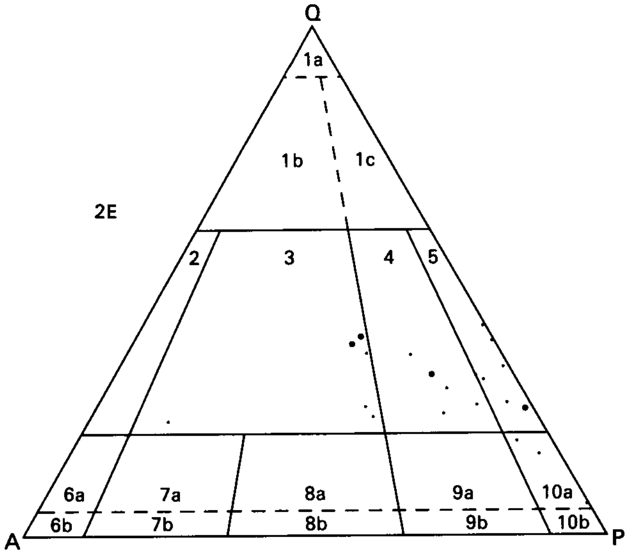


Wylie Lake Granodiorite Phase (131)

	N	Q	K	P	K/P
Study Area	1	32.1	9.2	31.1	0.3
All Shield	7	24.2	6.3	47.9	0.1

Figure 3. Ternary Quartz-Alkali Feldspar-Plagioclase Feldspar (Q-A-P) plots for granitoids and gneisses in the study area, and for the remainder of the Shield in Alberta. Ternary field boundaries based on Streckeisen (1967).

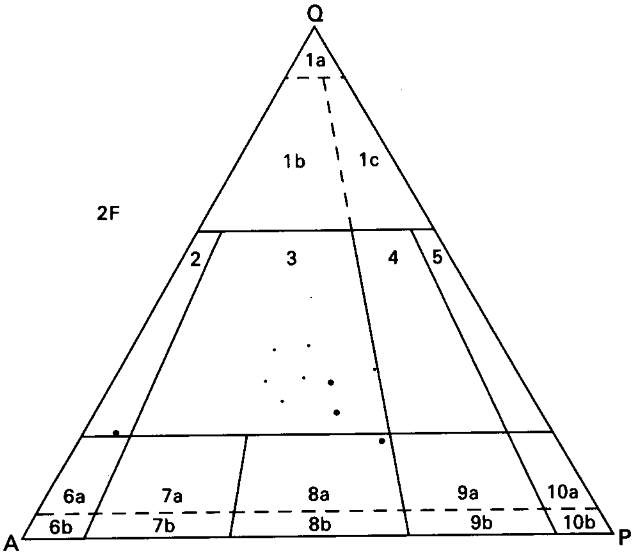
2E



Fishing Creek Quartz Diorite (133)

	N	Q	K	P	K/P
Study Area	4	27.1	10.3	39.5	0.26
All Shield	20	23.4	9.8	50.9	0.19

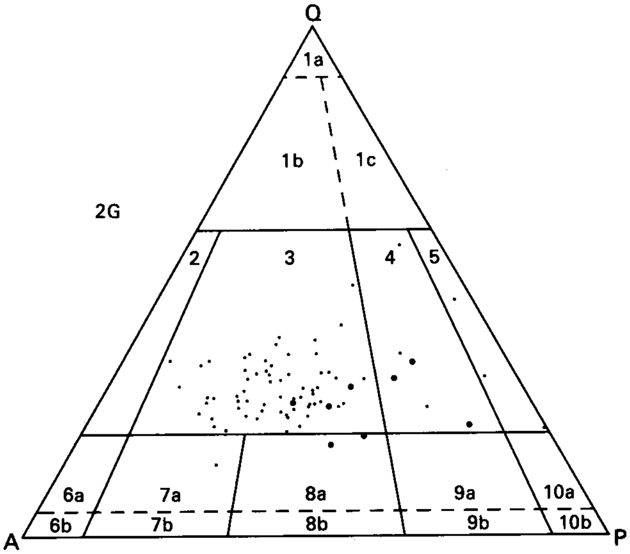
2F



Chipewyan Red Granite (150)

	N	Q	K	P	K/P
Study Area	4	23.7	42.6	32.8	1.3
All Shield	10	28.2	37.7	30.7	1.2

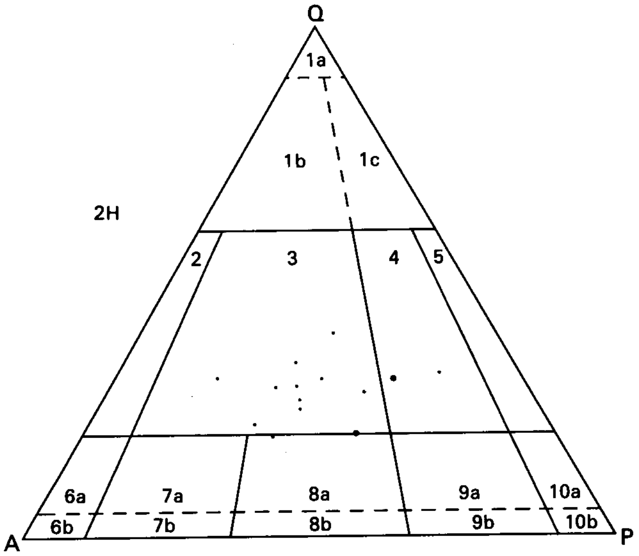
2G



Arch Lake Granite Phase (161)

	N	Q	K	P	K/P
Study Area	8	11.5	25.5	41.2	0.6
All Shield	79	27.2	36.1	29.6	1.2

2H



Arch Lake Transitional Granite Phase (162)

	N	Q	K	P	K/P
Study Area	2	23.6	25.6	42.9	0.6
All Shield	14	26.3	33.7	32.1	1.0

Legend
1a Quartz rocks, **1b** Quartz granite, **1c** Quartz granodiorite, **2** Alkali granite, **3** Granite, **4** Granodiorite, **5** Quartz-diorite, **6a** Quartz-bearing alkali syenite, **6b** Alkali syenite, **7a** Quartz-bearing syenite, **7b** Syenite, **8a** Quartz-bearing monzonite, **8b** Monzonite, **9a** Quartz-bearing monzodiorite, **9b** Monzogabbro, **10a** Quartz-bearing (diorite, gabbro), **10b** Diorite, gabbro, norite, anorthosite,

● Samples from study area • Samples from remainder of shield in Alberta N Number of Samples

Fieldwork and geochronological studies strongly suggest that the basement gneiss complex is of Archean age and supplied the parent materials from which the younger granitoids were derived. High-grade regional metamorphism of gneisses led to partial melting, segregation, and mobilization of granitoid constituents. The ternary diagrams indicate divergent lines of granitoid evolution and segregation.

In a mass-balance type of calculation, the weighted average composition of all the separated products should approximate that of the parent materials if isochemical changes predominated. The intimate relationships of minor granitoid masses in the gneisses and high-grade metasedimentary belt points to the latter as parent materials. Insofar as the segregated granitoids were mobilized from within the gneissic belt, the latter is most likely to contain the complementary restite, at least in part. The widely distributed amphibolites, found mostly in the gneisses but also in the granitoids, may well qualify, at least in part, as restites.

Viewing the granite gneisses and high-grade metasediments as the parent materials, it is immediately apparent that their compositional range does not include the plagioclase poor-to-absent area which corresponds to the alkali feldspar granite members of the Slave Granite. Partial melting of the assumed gneissic and high-grade metasedimentary parent materials would be expected to generate end products of potassium-rich compositions similar to those of the Slave Granite.

Mafic Slave Granite is part of the continuous compositional gradation from Slave Granite to Arch Lake and Arch Lake Transitional Granites, and ultimately to Wylie Lake Granodiorite and Fishing Creek Quartz Diorite. Petrologically, this range extends from alkali granite through granite and granodiorite to quartz diorite.

In summary, it is apparent that the basement gneiss complex has been partially molten, mobilized, segregated, and recrystalized in the process of formation of the Slave and Mafic Slave Granites. Other granite gneisses of intermediate and plagioclase-rich composition were recrystallized, mobilized, and segregated to give rise to the complementary suite of granitoids — Arch Lake and Arch Lake Transitional Granites, Wylie Lake Granodiorite and Fishing Creek Quartz Diorite.

The range of compositions of the granite gneisses of the Ryan-Fletcher Lakes map area corresponds to that of the granitoids collectively in extending from granite to quartz diorite, that is, with a notable exception of the alkali feldspar granite field. This latter limitation in compositional range can be accounted for by partial melting or possibly potassium metasomatism of the basement, in the production of alkali feldspar phases of the Slave Granites.

The intimate field relationships of minor leucocratic components as irregular dykes and patches within the granitoids (Slave Granite, Mafic Slave Granite, Wylie Lake Granodiorite Phase, Fishing Creek Quartz Diorite, Arch Lake Granite Phase and Arch Lake Transitional Granite Phase) is a product of late stage leucosome segregation and mobilization. Such widespread occurrence of a leucosome phase in each of the granitoid complexes points to a common petrogenetic history of the host granitoids, at least during the latter stages of their development.

Chipewyan Red Granite represents a limited compositional range within the granite field and is probably related to anatexis-recrystallization and remobilization of intermediate to potassium-rich phases of the parent gneisses.

Chipewyan Red Granite is contradistinctive from other granitoids in that it completely lacks the leucocratic segregations. Its history may have involved plutonic intrusion of magmatic material (as opposed to being metamorphically derived) into the superstructure sufficiently late to have missed the metamorphically triggered leucosome segregation event. Overall, magmatic processes may have played a more significant role in the formation of Chipewyan Red Granite than in the genesis of other granitoids in the map area.

Minor (cumulative) amounts of scattered, small bodies of amphibolite are believed to be derived by metamorphism, structural extension and dislocation of diabasic dykes and metamorphic basic segregations. The high-grade metasedimentary rocks (table 2) are retrograde quartzitic granulites that correspond to initial compositions of arkosic graywackes. The low-grade metasediments of prograde greenschist facies (Burntwood Group) contain almost 50 percent micaceous minerals, which reflects both the metamorphic facies and an initial graywacke composition.

The chemical composition of all 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, probably reflect the locally high K_2O content of the major bodies of Slave and Arch Lake Granites in the Shield of northeastern Alberta.

Metamorphism

Metamorphic maxima are high, ranging from high-pressure granulite to amphibolite facies conditions (Godfrey and Langenberg, 1978; 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; all of these minerals indicate attainment of regional granulite facies conditions.

Almandine and/or hornblende are widely scattered in the Arch Lake and Fishing Creek granitoids and in most metasedimentary bands, the latter also being commonly characterized by cordierite. Therefore, these rocks units are placed in the amphibolite facies.

Retrograde greenschist conditions are expressed by the commonly widespread occurrence of chlorite, muscovite, and epidote. Chlorite is usually seen as an alteration product of biotite, hornblende, or garnet, whereas epidote typically occurs as veinlets. The prograde greenschist metasediments are characterized by a similar mineral suite of chlorite, muscovite and, less commonly, epidote.

The regional metamorphic history involving granulite and amphibolite facies conditions retrograding through greenschist facies is summarized in Nielsen *et al.* (1981) and Langenberg and Nielsen (1982).

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 metamorphic fabric, which is present in all three major lithologic zones. It appears that a bulbous- or mushroom-shaped Slave Granite pluton has diapirically intruded and domed the overlying supercrustal gneisses and migmatites to form a mantled gneissic dome. Erosion has subsequently stripped the gneissic cover to reveal internal large-scale dome and basin features in the Slave Granitoid of the Ryan-Fletcher Lakes district map area. A north-south elongated dome trends south from Ryan Lake, and a north-south basin trends north from Ryan Lake. These two structures are separated by a regional easterly striking fault that trends through Ryan Lake (figure 28, Langenberg, 1983). The Shield of northeastern Alberta shows similar regionally scaled dome and basin structures within all of the major granitoid plutonic masses.

Two sets of major orthogonal faults dissect the map area along north to north-easterly and west to west-northwesterly directions. The principal fault structure is the Allan Fault, represented by a wide regional mylonitic zone that enters at the northeast corner of the map area.

A wedge-shaped zone from 10 to 2.5 km (6 to 1.5 mi) wide, passing through Reef and Fletcher

Lakes, contains a concentration of northeasterly trending faults associated with mixed migmatitic metasedimentary and granitoid rock types.

Major fault movement probably occurred late in the geological history of the map area. Initiation of faulting was, however, likely early, because the north to northeasterly set parallels both the regional foliation and the alignment of major lensoid bodies. All of these structural features were probably influenced by persistent long-term regional stresses.

The Slave and Arch Lake Granitoid plutons appear to arise from recrystallized and remobilised infrastructure material that has been diapirically emplaced higher in the crust. It is most likely that the various granitoid plutons overlapped in the time of their emplacement. Furthermore, structural details within the batholithic granitoid masses beyond the map area to the north show a pattern of "nested" small-scale domal features. This latter structural character indicates that at least the major plutonic masses were intruded in a piecemeal fashion. That is, the major granitoid plutonic masses developed by the aggregation of small, individual, discrete masses (rather than as a single intrusive event), which accumulated to ultimately attain batholithic proportions.

All of the rock types have a metamorphic foliation, typically well developed in the gneissic and migmatitic belts, and more varied in quality in the granitoids. These foliations show a variety of ductile-plastic deformational styles in all rock types with the exception of the low-grade metasedimentary Burntwood Group. Migmatitic structures are characteristic of the central migmatitic metasedimentary belt and less common in granite gneisses. The foliation fold patterns are simpler in the Slave Granite batholith, and although less well developed, are nevertheless clearly evident. Movement along the major westerly faults within the Slave Granite is seen where the regional northerly foliation is extensively deflected along the strike of some of these faults. Such deflections are evident along faults west of Ryan Lake. The widespread deflection of foliation, as in this case, must be accounted for other than by normal fault drag. The suggestion is that fault movement took place while the granitoid was in a ductile state, after the formation of the foliation, or alternatively, that the curved foliation represents the (flattened) sheared margin of small internal domes within the main Slave Granite batholithic mass.

The Allan Fault mylonite zone (Watanabe, 1965) occupies a belt up to 10 km (6 mi) wide within the easterly granite gneisses. On entering the northeast corner of the map area, this fault swings from a southerly to a southwesterly strike. It therefore parallels and controls the orientation and position of this part of the Lake Athabasca shoreline. The low-grade Burntwood Group metasediments crop out along the shoreline of Lake Athabasca and abut against the Allan Fault. These metasediments were involved in post-depositional movement showing increasing intensity of shear northwestward toward the fault zone.

The Allan Fault zone is one of two major structural breaks in northeastern Alberta and can be traced 300 km (200 mi) north to the aulacogen at the East Arm of Great Slave Lake. Movements along this fault zone were probably intermittent and span a wide range of geologic time. The following history of major fault movement is suggested:

1. Kenoran (2560 m.y. +) — possible initiation of major faults, principally affecting the basement granite gneisses; it is doubtful whether any specific expression has survived to the present;
2. Hudsonian (1800 m.y −) — main development of mylonitic belts, probably associated with batholithic emplacement, followed by plastic deformation of the mylonitized rock in a deep-seated crustal environment;
3. Elsonian (1400 m.y. +) — reactivation, resulting in brittle fracture along the fault zone at higher crustal levels.

The Allan Fault forms part of a system of regional mylonitic faults that extend into Saskatchewan and the Northwest Territories. The distribution of such mylonitic zones is of considerable interest and a regionally scaled study may indicate that they are related to a plate tectonic suture or shear.

In outcrop, the deformation in the mylonitic rocks is seen as a ductile shear phenomenon of varied intensity rather than brittle shear, and is principally contained within the granite gneisses. Recrystallization has affected all rocks of the area and in the mylonitic zones this has produced a range of comminuted rocks — mylonites, ultramylonites, blastomylonites, and less crushed phases such as flaser gneisses. Minor local megabrecciation of the mylonites has occurred producing quartz-filled fractures and quartz-lined vugs.

The granite gneiss terrain is characterized by a layered to foliated metamorphic fabric with a minor, locally present lineation. 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 plastic deformation of the gneisses. Within the gneissic belt, minor pegmatites crosscut or parallel the structure and can be either deformed or undeformed. The style and degree of deformation reflects the relative timing of pegmatite emplacement and deformation of the host gneisses.

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

Minor high-grade metasedimentary bands within the granite gneiss terrain tend to have an internal gneiss- and color-banded structure. Migmatitic style flow folds are fairly typical of these bands, which generally tend to be more highly deformed (more mobile) than the adjacent enclosing gneisses.

The metamorphic fabric generally varies within each plutonic granitoid body. Locally massive phases grade into foliated or lineated textures. Margins of the plutons tend to develop preferentially a parallel metamorphic foliation texture, whereas in the interior more massive phases are found. Such variation in fabric within a single body suggest a heterogeneous distribution of stress, with principal zones of relief situated along lithological boundaries. Differences in metamorphic fabric between plutons suggest that emplacement of the plutons took place over a significant period of time especially with respect to the main pulse of tectonic activity.

A fairly representative selection of joints is given on the accompanying maps. The dominant directions are WNW and N to NNE, with subordinate orientations of WNW and ENE. Some of these joints are of tectonic origin; they parallel and lie adjacent to shear zones. Others are decompressional and are 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 those flat-lying to gently dipping fractures that parallel the overlying topographic slopes.

Economic geology

Minor amounts of metallic minerals are found most commonly in the high-grade metasedimentary rocks. Pyrite is widely distributed in the amphibolite and metasedimentary rocks, with uncommon occurrences in the gneisses and granitoids.

Scattered uranium mineralization (indicated by secondary yellow stains and confirmed by geiger counter) is known in the Shield of northeastern Alberta, especially in the high-grade metasediments. Minor occurrences of yellow mineral stain and radioactive anomalies were noted in the map area. However, major portions of the high-grade metasediments have not been explored and systematic prospecting of those bands could 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. Minor copper (chalcopyrite) showings are associated with some gossans or rusty zones within the high-grade metasediments. Dispersed magnetite is locally present in small percentages within the granite gneisses, but is sufficiently abundant to cause problems with the normal use of a magnetic compass.

Overall, the greatest possibility for metallic minerals lies within the high-grade metasedimentary rock bands, although the economic potential appears to be low. Faults and shear zones also merit close examination.

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

References

Baadsgaard, H., G.L. Cumming, R.E. Folinsbee and J.D. Godfrey (1964): Limitations of radiometric dating; Royal Society of Canada Special Publication No. 8, p. 22-38.

Baadsgaard, H. and J.D. Godfrey (1967): Geochronology of the Canadian Shield in northeastern Alberta: I. Andrew Lake Area; Canadian Journal of Earth Sciences, Vol. 4, No. 3, p. 541-563.

———(1972): Geochronology of the Canadian Shield in northeastern Alberta: II. Charles-Andrew-Colin Lakes Area; Canadian Journal of Earth Sciences, Vol. 9, No. 7, p. 863-881.

Baadsgaard, H., J.D. Godfrey and G.L. Cumming (1967): Precambrian geochronology in northeastern Alberta: II. Rb-Sr isochrons in the Andrew Lake-Colin Lake area; Abstract, Geochronology of Precambrian Stratified Rocks: Conference, University of Alberta, June 1967.

Cameron, A.E. (1930): Report of progress on mineral explorations in the Precambrian; Scientific and Industrial Research Council of Alberta Report 25, Tenth Annual Report, 1929, p. 34-39.

Cameron, A.E. and H.S. Hicks (1931): The Precambrian area of northeastern Alberta; Research Council of Alberta Report 26, Eleventh Annual Report, 1930, p. 32-40.

Collins, G.A. and A.G. Swan (1954): Preliminary report of geological field work, northeastern Alberta; Research Council of Alberta Mimeographed Circular No. 18, 8 pages.

Day, L.W.(1975): Zircon geochronology of northeastern Alberta; unpublished M.Sc. thesis, University of Alberta, 72 pages.

Fahrig, W.F. (1961): The geology of the Athabasca Formation; Geological Survey of Canada Bulletin 68, 41 pages.

Geological Survey of Canada (1964a): Fitzgerald, 74M, aeromagnetic map No. 7161G, scale 1:250 000.

———(1964b): Fort Chipewyan, 74L, aeromagnetic map No. 7159G, scale 1:250 000.

Godfrey, J.D. (1958a): Aerial photographic interpretation of Precambrian structures, north of Lake Athabasca; Research Council of Alberta Bulletin 1, 19 pages.

———(1958b): Mineralization in the Andrew, Waugh and Johnson Lakes area, northeastern Alberta: Research Council of Alberta Preliminary Report 58-4, 17 pages.

———(1961): Geology of the Andrew Lake, north district, Alberta; Research Council of Alberta Preliminary Report 58-3, 32 pages.

———(1963): Geology of the Andrew Lake, south district, Alberta; Research Council of Alberta Preliminary Report 61-2, 30 pages.

———(1966): Geology of the Bayonet, Ashton, Potts and Charles Lake districts, Alberta; Research Council of Alberta Preliminary Report 65-6, 45 pages.

———(1979): Chipewyan granite — a building-stone prospect in Alberta; CIM Bulletin, Vol. 72, No. 805, p. 105-109.

———(1980a): Geology of the Alexander-Wylie Lakes district, Alberta; Alberta Geological Survey, Alberta Research Council, Earth Sciences Report 78-1, 26 pages.

———(1980b): Geology of the Fort Chipewyan district, Alberta Geological Survey, Alberta Research Council, Earth Sciences Report 78-3, 20 pages.

Godfrey, J.D. and H. Baadsgaard (1962): Structural pattern of the Precambrian Shield in northeastern Alberta and mica age-dates from the Andrew Lake district; Royal Society of Canada Special Publication 4. p. 30-39.

Godfrey, J.D. and E.W. Peikert (1963): Geology of the St. Agnes Lake district, Alberta; Research Council of Alberta Preliminary Report 62-1, 31 pages.

———(1964): Geology of the Colin Lake district, Alberta; Research Council of Alberta Preliminary Report 62-2, 28 pages.

Godfrey, J.D. and C.W. Langenberg (1978a): Metamorphism in the Canadian Shield of northeastern Alberta; *in* Metamorphism in the Canadian Shield, Geological Survey of Canada Paper 78-10, p. 129-138.

———(1978b): Alberta contribution to Metamorphic map of the Canadian Shield, Geological Survey of Canada Map 1475A.

Hale, W.E. (1954): Gulo Lake, Saskatchewan; Geology Survey of Canada, Paper 54-6, map scale 1 inch to 1 mile, with marginal notes.

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

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

Klewchuk, P. (1972): Mineralogy and petrology of some granitic rocks in the Canadian shield north of Fort Chipewyan, Alberta; unpublished M.Sc. thesis, University of Calgary, 138 pages.

Koster, F. (1961): The geology of the Thainka Lake area (west half); Saskatchewan Department of Mineral Resources, Mines Branch, Geology Division Report No. 61, 28 pages.

Kuo, S.L. (1972): Uranium-lead geochronology of Kenoran rocks and minerals of the Charles Lake area, Alberta; unpublished M.Sc. thesis, University of Alberta, 126 pages.

Langenberg, C.W. and P.A. Nielsen (1982): Polyphase metamorphism in the Canadian Shield of northeastern Alberta; Alberta Research Council, Bulletin 42, 80 pages.

Langenberg, C.W. (1983): Polyphase deformation in the Canadian Shield of northeastern Alberta; Alberta Research Council, Bulletin 45, 33 pages.

Nielsen, P.A., C.W. Langenberg, H. Baadsgaard and J.D. Godfrey (1981): Precambrian metamorphic conditions and crustal evolution, northeastern Alberta, Canada; Precambrian Research, Vol. 16, p. 171-193.

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

———(1963): Biotite variation as a guide to petrogenesis of granite rocks in the Precambrian of northeastern Alberta; Journal of Petrology, Vol. 4, No. 3, p. 432-459.

Poruks, M. and W.N. Hamilton (1976): Index to uranium assessment reports for quartz mineral exploration permits, northeastern Alberta; Alberta Research Council, Report 76-6, 81 pages.

Ramaekers, Paul (1979): Stratigraphy of the Athabasca Basin; Summary of Investigations 1979; Saskatchewan Geological Survey, Miscellaneous Report 79-10, p. 154-160.

———(1980): Stratigraphy and tectonic history of the Athabasca Group (Helikian) of Northern Saskatchewan; Summary of Investigations 1980, Saskatchewan Geological Survey, Miscellaneous Report 80-4, p. 99-106.

———(1981): Hudsonian and Helikian basins of the Athabasca region, northern Saskatchewan; *in* Geological Survey of Canada symposium, Paper 81-10, *edited by* F.H.A. Campbell "Proterozoic basins of Canada"; p. 219-233; 444 pages.

Riley, G.C. (1960): Geology, Fort Fitzgerald, Alberta; Geological Survey of Canada Map 12-1960.

Scott, B.P. (1978): The geology of an area east of Thluicho Lake, Saskatchewan, (Part of NTS area 74N-11); Saskatchewan Department of Mineral Resources, Report No. 167, 52 pages.

Streckeisen, A.L. (1967): Classification and nomenclature of igneous rocks; Neues Jahrbuch für Mineralogie Abhandlungen, Band 107, p. 144-240.

Tremblay, L.P. (1972): Geology of the Beaverlodge mining area, Saskatchewan; Geological Survey of Canada, Memoir 367, 265 pages.

Watanabe, R.Y. (1961): Geology of the Waugh Lake Metasedimentary Complex, northeastern Alberta; unpublished M.Sc. thesis, University of Alberta, 89 pages.

———(1965): Petrology of cataclastic rocks of northeastern Alberta; unpublished Ph.D. thesis, University of Alberta, 219 pages.

LOCATION MAP

KEY MAP

RYAN—FLETCHER LAKES LEGEND

PRECAMBRIAN*

REGIONAL CATACLASTIC ZONES

Zones of regional cataclasis and recrystallization have affected granite gneisses, granitoids 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 (*O*).

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

221 — RECRYSTALLIZED CATACLASTIC ROCK: mostly light colored, with white to pink feldspar porphyroclasts from 5 to 20 mm long comprising 2 to 5 percent of the rock, in a foliated, finely banded, cataclastic, aphanitic matrix. Largely granite gneiss parent materials.

223 — RECRYSTALLIZED CATACLASTIC 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. Largely Fishing Creek Quartz Diorite and Wylie Lake Granodiorite Phase parent materials.

METASEDIMENTARY ROCKS (LOW-GRADE)

201 — BURNTWOOD GROUP: reddish arkosic sandstone with minor grit and pebble bands interbedded with subordinate thin green (chloritic) phyllonitic argillite bands; milky gash quartz veins locally numerous.

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. Mafic mineral content 6 to 15 percent. Minor textural variations include reduced amounts of feldspar megacrysts or augen in characteristically crushed matrix.

162 — ARCH LAKE TRANSITIONAL GRANITE PHASE: similar to Arch Lake Granite but essentially lacking larger feldspar megacrysts, the remaining 10 percent smaller feldspar megacrysts are 10 to 15 mm long.

150 — CHIPEWYAN RED GRANITE: typically red to pink, equigranular, medium grained but locally fine grained; massive to poorly foliated, biotite (chloritic) content generally increases with degree of foliation; fairly homogeneous lithology with very few small-scale xenoliths, locally gneissic; minor pegmatites and quartz veins.

WYLIE LAKE GRANITOIDS

LEUCOCRATIC GRANITE: commonly found as small bodies intimately mixed with other Wylie Lake Granitoid rocks. Present in widely ranging proportions in outcrop; only concentrations over 50 percent are shown. White to pink to reddish leucocratic masses of varied texture, typically equigranular, medium grained but ranging to coarse- and fine-grained, massive; borders sharp or gradational, simple or complex in outline (∠\7).

136 — UNDIFFERENTIATED GRANITOIDS: lack of local field data does not allow better definition and subdivision of these areas; this broadly defined unit is composed principally of Fishing Creek Quartz Diorite and Wylie Lake Granodiorite Phase; Granodiorite D and Granodiorite E are subordinate.

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 may be distinctly megacrystic or equigranular; megacrystic white to gray to pale green feldspars from 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 ranges to quartz-bearing diorite and granodiorite. Schlieren of biotite concentrations or metasedimentary rocks may be present.

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

131 — WYLIE LAKE GRANODIORITE PHASE: generally dark greenish or brownish red; may appear finely mottled; medium grained, typically equigranular except for rare 15 mm pink feldspar megacrysts in a feldspar, quartz, biotite matrix; typically poorly foliated to massive. Rock types are predominantly granodiorite with minor quartz diorite.

SLAVE GRANITOIDS

105 — SLAVE PQ GRANITE PHASE: overall pink to red mottled color pattern; abundant white to pink to red coarse feldspars 8 mm ± across in a medium- to coarse-grained, massive to poorly foliated, matrix of quartz, feldspar and biotite (chloritic) with minor muscovite. Rock composition is dominantly granite with variation into the granodiorite field.

101 — SLAVE GRANITE PHASE: typically whitish gray to pink; medium- to coarse-grained (locally fine-grained); up to 5 percent white to pink feldspar megacrysts, from 15 to 40 mm long, in a matrix of feldspar, quartz, and biotite (<1 to 5 percent); massive to more commonly foliated (foliation better defined by higher biotite content); typically garnetiferous, may be locally gneissic; includes minor small-scale mafelsic xenolithic lenses of metasedimentary rock.

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

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

METASEDIMENTARY ROCKS (HIGH-GRADE)

31 — METASEDIMENTARY ROCKS: the high-grade metasedimentary rock types included in this map unit are lithologically and texturally gradational, and in part intermixed on a small scale in outcrop. Typically impure quartzite; fresh surface is dark greenish (bluish) gray; fine grained, layered, with ferruginous and garnetiferous zones, locally scattered pyrite, gossans, and milky or bluish gray quartz pods and veins. Minor amphibolite present locally. Minor, common lithologic gradational variations to: (1) fine- to medium-grained, metamorphic quartzofeldspathic (granitic) phase ranging from individual feldspar megacrysts to nebulous or distinct aggregations and masses; locally gneissic; (∠\7)(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 amphibolite, to a feldspathic biotite amphibolite; commonly foliated but may be banded where feldspar rich; minor pyrite common.

GRANITE GNEISS

12 — HORNBLENDE GRANITE GNEISS: typically pink to reddish with dark green bands; quartz-feldspar bands interlayered with mafic-rich bands (hornblende, with biotite; generally chloritic) on hand specimen scale; fine- to medium-grained, typically equigranular, uncommonly megacrystic; typically well banded, uncommonly poorly banded, and rarely foliated. Composition is predominantly granite, with minor granodiorite, and quartz diorite. Large areas are migmatitic, particularly where intimately associated with minor lenses, pods, or bands of metasedimentary rocks, pegmatite, or amphibolite.

11 — BIOTITE GRANITE GNEISS: typically pink to reddish; quartz-feldspar bands interlayered with mafic-rich bands (biotite, possibly with subordinate hornblende; may be 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 quartz monzonite, granodiorite, quartz diorite, and monzodiorite. Large areas are migmatitic, particularly where intimately associated with minor lenses, pods, and bands of metasedimentary rocks, pegmatite, or amphibolite.

NOTE: Rock groups are arranged in approximate chronological sequence. Nomenclature follows Streckeisen (1967): Classification and Nomenclature of Igneous Rocks; Neues Jahrbuch für Mineralogie, Abhandlungen.

Base maps compiled from planimetric sheets published by Alberta Energy and Natural Resources, Resource and Evaluation and Planning Division, Edmonton.

Aerial Photographs covering this area are obtainable from the Bureau of Surveys and Mapping, Alberta Energy and Natural Resources, Edmonton, and the National Air Photographic Library, Ottawa.

Approximate magnetic declination 25°59′ E and 25°31′ E for the Ryan Lake and Fletcher Lake respectively, decreasing 4′ annually.

Geology by John D. Godfrey, Maurice B. Dusseault, 1972.

Map drawn by C.A. Parent

Published 1982.

GEOLOGY OF THE FLETCHER LAKE DISTRICT, ALBERTA

Sheet No. 23

SCALE 1:31,680

Miles 1 0 1 2 Miles

Kilometres 1 0 1 2 3 Kilometres

Geological boundary (defined, approximate)	
Foliation (defined: dip known, dip vertical; foliation assumed)	68
Foliation trend*	— — —
Lineation (combined with dip of foliation)	76 68
Extreme contortion (structural trend)	
Tight fold (structural trend)	
Local gneissosity in generally massive to foliated rock	
Joint (dip known, vertical; unknown)	69
Fault (defined, dip known, assumed)	79
Shear (with dip)	64
Breccia	◁△▽
Mylonite (local)	
Quartz vein	▬
Granitoid standard sample	259 ○
Metasedimentary band standard sample	49 ⊙
Mineral occurrence (magnetite)	×M
Yellow stain, mineral	Y
Garnet	G
Chlorite (abundant)	C
Epidote (abundant)	E
Graphite	R
Isotopic age (millions of years); biotite (b), muscovite (m); K-Ar (k); U.of A	Δbk1740
Glacial stria (direction of ice movement indicated)	
Wind-cut groove (wind direction indicated)	
Raised beach (downslope direction indicated)*	
Dune*	
Esker*	<<<<
Drumlin	○
Kettle	
Crevasse filling (ridge shown)*	
Sand covered area	
Drainage	
Muskeg	
Township boundary	▬
National Park boundary	▨

*Primarily aerial photographic interpretation

RESEARCH COUNCIL
Natural Resources Division

Alberta Geological Survey

GEOLOGY OF THE RYAN-FLETCHER LAKE DISTRICT, ALBERTA

Sheet No. 20

Alberta
RESEARCH COUNCIL
Natural Resources Division

Alberta Geological Survey

9

SCALE 1:31,680

Miles 1 0 1 2 Miles

Kilometres 1 0 1 2 3 Kilometres

GEOLOGY OF THE RYAN LAKE DISTRICT, ALBERTA

Sheet No. 21

Alberta
RESEARCH COUNCIL
Natural Resources Division

Alberta Geological Survey

GEOLOGY OF THE FLETCHER LAKE DISTRICT, ALBERTA

Sheet No. 22

RESEARCH COUNCIL
Natural Resources Division

Alberta Geological Survey