GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

PAPER 64-52

FLAT RIVER, GLACIER LAKE, AND WRIGLEY LAKE, DISTRICT OF MACKENZIE AND YUKON TERRITORY

95E, 95L, and 95M

(Report and maps 35-1964, 36-1964, 37-1964)

H. Gabrielse, J. A. Roddick, and S. L. Blusson

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ABSTRACT

The area includes parts of Mackenzie Mountains, Logan Mountains and the Hyland and Liard Plateaus. Well defined stratigraphic units of Ordovician and Devonian rocks, mainly carbonates, are exposed throughout the northern and eastern parts of the area, these units have strong lateral persistence, but eventually change southwesterly into calcareous shales, black shales, and siltstones. Proterozoic strata exceeding 20,000 feet in thickness underlie the Palaeozoic sequence. Copper, silver, lead, zinc, tin, and tungsten minerals have been reported and placer gold has been found on several creeks. The area has a reasonable potential for oil and gas.

FLAT RIVER, GLACIER LAKE, AND WRIGLEY LAKE MAP-AREAS, DISTRICT OF MACKENZIE AND YUKON TERRITORY

INTRODUCTION

Flat River (lat. 61 to 62°, long. 126 to 128°), Glacier Lake (lat. 62 to 63°, long. 126 to 128°), and Wrigley Lake (lat. 63 to 64°, long. 126 to 128°) map-areas were mapped during the 1963 field season in a project referred to as 'Operation Nahanni'. Wrigley Lake map-area received limited ground examination and the accompanying geological map was compiled mainly from air photos and reconnaissance flights by helicopter and fixed-wing aircraft.

Able assistance in the field was given by M.E. Atchison, T.M. Gordon, R.C. Handfield, P.J. Street, and U. Upitis. B.S. Norford of the Geological Survey measured two sections during the field season. Some observations by E.F. Roots in 1953 have been used, mainly near Grizzly Bear Lake in Glacier Lake map-area and in the western part of Flat River map-area. Transportation in the field was provided by a Hiller 12 E helicopter supplied by Klondike Helicopters, Ltd. of Whitehorse; Beaver aircraft supplied by Harrison's Flying Service and B.C. - Yukon Air Service Ltd., of Watson Lake; and by Cessna 180 and Piper Family Cruiser aircraft supplied by Watson Lake Flying Service of Watson Lake. Otter and Beaver aircraft supplied by Northwest Territorial Airways Ltd. of Yellowknife were used to cache aviation gasoline before the field season. To these companies and their crews the writers extend their appreciation for excellent air support. The writers also wish to acknowledge the cooperation and many kindnesses received from the management and personnel of Redstone Mines, Ltd. and Canada Tungsten Mining Corporation, Ltd.

Watson Lake was used as the base for supplies and communication. During the 1963 season a road extending about 200 miles northerly from Watson Lake to Canada Tungsten on Flat River provided access to the Logan Mountains region. A branch road leads to lakes in the divide near the head of Flat River. Work in Wrigley Lake map-area might well be supported from a base at Wrigley on Mackenzie River.

PHYSICAL FEATURES

The area investigated includes parts of Mackenzie Mountains, Logan Mountains, Hyland Plateau and Liard Plateau (Bostock, 1948)[1]. Canyon Ranges of Mackenzie Mountains in northeastern Wrigley Lake map-area consist of relatively subdued, bare, north to northwesterly trending ridges of resistant strata, attaining maximum elevations of just over 5,000 feet, separated by broad, low-lying, forested areas underlain by relatively soft, shales.

Backbone Ranges of Mackenzie Mountains include moderately rugged mountain groups attaining a maximum elevation of 8,900 feet, separated by narrow to broad, flat-bottomed valleys many of which display classic examples of braided streams. Many of the north to northwesterly trending valleys have been cut into synclines of easily eroded shales which are flanked by 'flat-irons' of more resistant strata. Much of north-central Glacier Lake and southwest Wrigley Lake map-areas is a high dissected plateau formed in gently dipping or flat-lying strata.

The Ragged Range, part of Logan Mountains in southwestern Glacier Lake and northwestern Flat River map-areas, is a region of extremely rugged topography with maximum elevations of more than 9,000 feet and a relief locally as much as 6,000 feet. The ruggedness and great relief are the result of extensive alpine glaciation of a resistant terrain that includes widespread, granitic and metamorphic rocks. Several large snow fields and numerous small glaciers contribute to the spectacular scenery of the range.

The remainder of Logan Mountains southwest of Flat River is a relatively rugged area although less so than Ragged Range. The northern part contains many well-developed rock glaciers.

Hyland and Liard Plateaux include isolated, bare-topped mountain groups and ridges separated by wide areas of low-lying, forested valleys. In the valleys outcrops are restricted mainly to stream channels.

Most of the northern part of the area lies within the drainage system of Redstone River and most of the southern part is drained by South Nahanni River and its tributaries. Northwesternmost Wrigley Lake map-area is drained by Natla and Keele Rivers and eastern Glacier Lake map-area contains the headwaters of Root and North Nahanni Rivers.

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[1] Names and dates in parentheses refer to publications listed in the references.

GLACIATION

The entire region has been glaciated by alpine and valley glaciers and two or more ice-sheets. The large moraine on the east side of Wrigley Lake is believed to be related to the front of Laurentide ice from the east. Debris near the moraine includes boulders of pink- and orange-weathering granitic gneiss and leucocratic granitic rock characteristic of material derived from the Canadian Shield. Similar material also occurs at an elevation of about 4,300 feet near the peak (elevation 5,410 ± feet) south of North Redstone River opposite the southeast end of Tigonankweine Range.

East of Little Dal Lake glacial erratics presumably derived from the south or southwest occur up to elevations of about 6,000 feet. Glacial deposits are abundant in the bottoms of major valleys. Ice moved southeasterly down the valley of South Nahanni River northeast of Ragged Range and down Flat River. Conspicuous kame terraces along Flat River and the head of Irvine Creek slope southeasterly.

The distribution of glacial erratics and the form of drumlinoid ridges indicate that an ice-sheet advanced easterly and northeasterly over the southern part of Flat River map-area. Locally, southeast of Skinboat Lakes conflicting evidence provided by glacial erratics indicates a southerly movement. Aligned and parallel sequences of abandoned drainage channels in southwesternmost Flat River map-area indicate a southwesterly retreat of the ice.

GENERAL GEOLOGY

Throughout the northern and eastern parts of the project area well-defined map-units of Ordovician to late Devonian and possibly Mississippian ages show remarkable lateral persistence although varying considerably in thickness. Seemingly abrupt changes in thickness occur locally across pronounced northwest-trending faults. These units are a continuation of those mapped and described by Douglas and Norris (1960, 1961, 1963) in map-areas to the east.

Near a line running from northeast of Clearwater Creek to Grizzly Bear Lake carbonate rocks of Ordovician to Devonian ages change facies southwesterly into calcareous shales, black shales, and siltstones. Middle Ordovician carbonate strata, however, persist into Ragged Range where they change to graptolitic shales. Significant facies changes also take place in Cambrian and Proterozoic strata in Ragged Range and coupled with a prominent pre-Middle Cambrian unconformity make correlations difficult.

TABLE OF FORMATIONS*

Era	Period or Epoch	Formation	Map-unit	Lithology	Thickness (feet)
Cenozoic	Pleistocene and Recent		36	Unconsolidated glacial and alluvial deposits	
Mesozoic	Cretaceous (?)		35	Quartz monzonite, granodiorite, diorite; minor granite	
PALAEOZOIC	Devonian and (?) Mississippian		34	Shale, black, pyritic; minor black limestone	
	Devonian — Middle	Nahanni	33	Limestone, fine- to medium-grained, grey weathering	0-275
			32	Limestone and dolomite, well banded, light and dark grey	1,500-2,000
		Headless	31	Limestone, buff-brown, platy, argillaceous; calcareous shale	425-990
		Landry	30	Limestone, crypto-grained to medium-grained, grey, commonly banded	100-690
		Manetoe	29	Dolomite, coarse-grained, cream and light grey; limestone and dolomite, crypto-grained	0-200
		Arnica	28	Dolomite, banded, medium and dark grey; dolomite breccia	550-2,600
	Devonian — Lower	Sombre	27	Dolomite, banded, light and medium grey	615-2,350
		Camsell	26	Limestone breccia, buff and orange; dolomite, well bedded	540-1,200
	Silurian and (?) Devonian	Delorme	25	Dolomite and limestone, buff, grey, cinnamon; limestone breccia	150-2,300
	Ordovician and Silurian	Whittaker	24	Dolomite and limestone, dark and light grey, cherty	990-2,337
	Ordovician and younger		23	Shale, pyritic, black, locally slaty and phyllitic; chert; siltstone; dolomite and limestone, thin-bedded and black	0-2,169+
	Ordovician — Middle		22	Dolomite, dark and light grey; limestone; sandstone; volcanic flows, vesicular	2,346-2,800
	Cambrian and Ordovician		21	Limestone, grey and orange weathering; dolomite	2,800-3,480
			20	Limestone, well banded and argillaceous; slate, calcareous	550
	Lower to Upper		19	Sandstone, red, buff, yellow, grey; limestone; siltstone	5,500-

TABLE OF FORMATIONS (cont'd)

Era	Period or Epoch	Formation	Map-unit	Lithology	Thickness (feet)
PALAEOZOIC	Middle and (?) Upper Cambrian		18	Limestone, wavy banded, silty; siltstone; shale, calcareous	4,000+
			17	Siltstone, dolomitic, orange weathering; shale, dark grey; sandstone, calcareous; dolomite, grey	1,349
	Lower and/or Middle		16	Dolomite, silty and sandy, buff and orange weathering limestone	1,150
	Lower		15	Limestone; siltstone, calcareous; dolomite; argillite, shale; quartzite	3,500+
	Cambrian and/or Precambrian		14	Carbonate, shaly, brown, dark grey, orange weathering	0-1,000
			13	Quartzite, sandstone, white, pink, purple, red; limestone and dolomite, crypto-grained, mottled, mauve, pink; shale; minor conglomerate	7,000+
PROTEROZOIC			12	Phyllite, slate, quartzite, siltstone, argillite, agglomerate, conglomerate, volcanic rocks, schist	10,000
			11	Shale and slate, dark weathering, red and green weathering; quartzite; calcarenite; quartz-pebble conglomerate; siltstone; minor limestone; phyllite	10,000
			10	Carbonate, platy, sandy, orange weathering	1,000
			9	Shale and siltstone, dark grey, recessive	3,185
			8	Sandstone, dolomitic, orange weathering; dolomite, sandy; mafic flow	2,500
			7	Mudstone, siltstone, conglomerate, slate, iron-formation, volcanic rocks	4,500+
			6	Limestone, fetid, dark grey; slate; limestone conglomerate	675
			5	Siltstone, pink, slaty; gabbro	1,500
			4	Dolomite, grey, buff, orange, sandy; minor siltstone slate, conglomerate	4,350
			3	Limestone, well bedded, grey, stromatolitic; dolomite, minor slate, diorite, mafic volcanic rocks	1,468-2,400
			2	Quartzite, white, pink, purple; minor slate and dolomite	4,300
			1	Shale, olive-green; slate, quartzite; minor dolomite	1,600

*Relative position of map-units in this table does not necessarily imply relative stratigraphic position.

More than 20,000 feet of Proterozoic strata are exposed south-southeast and west of Little Dal Lake. Correlation of these rocks with Proterozoic rocks in Logan Mountains and Hyland Plateau is not attempted.

DESCRIPTION OF MAP-UNITS

Proterozoic

Map-Unit 1 (Glacier Lake)[1]

Map-unit 1 includes about 1,600 feet of recessive-weathering, dark grey and green shale, light grey and green, fine- to medium-grained quartzite, and interbeds of orange to buff weathering sandy dolomite, ranging from one inch to several feet in thickness. Most of the quartzite occurs in one prominent resistant member about 200 feet thick that lies roughly between 700 and 500 feet below the top of the section. The base of the map-unit is cut off by a westerly dipping thrust fault.

Map-Unit 2 (Glacier Lake, Wrigley Lake)

This unit is about 4,300 feet thick south-southeast of Little Dal Lake and comprises pink, white, and purple quartzite in beds a few inches to several feet thick. The base of map-unit 2, consists of 100 feet of thinly laminated, purple weathering shale apparently conformably overlying map-unit 1. Minor purple weathering slate and orange-buff and brown weathering dolomite occur in higher beds. Interbedded olive-grey and grey slate and ochre to orange weathering dolomite about 350 feet thick form a conspicuous marker bed 900 feet below the top of the formation.

In southeastern Wrigley Lake map-area the top of map-unit 2a locally consists of orange and buff weathering dolomite, calcareous slaty, siltstone, and red and green shale. These rocks may be much younger than map-unit 2 and could possibly include Cambrian strata (map-unit 17c).

Map-Unit 3 (Glacier Lake, Wrigley Lake)

Stromatolitic and oolitic, grey and dark grey, fine-grained to medium-grained limestones and dolomites of map-unit 3 conformably overlie strata of map-unit 2. Southeast of Little Dal Lake, where the unit is 2,400

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[1]Map-areas in which unit appears, if not present in all three map-areas.

feet thick, the basal beds consist of bright yellow and buff weathering, thin-bedded, dolomitic siltstones 100 feet thick. At the north end of Thundercloud Range the basal member is 84 feet thick and consists of greyish red, greyish green, and pale reddish brown, recessive mudstone, dark grey argillaceous dolomite, and quartz siltstones. There, the total thickness of map-unit 3 is 1,468 feet, of which the lower half is mainly limestone and the upper half dolomite. Southeast of Little Dal Lake map-unit 3 includes a dark green to black weathering amygdaloidal mafic flow or sill (map-unit 3a). A plug of fine- to medium-grained hornblende diorite (map-unit 3b) outcrops in the same area. A thin band of dark green- to black-weathering rock in map-unit 3 east of Keele River is believed to be a flow or sill but was not examined on the ground and is not shown on the map.

Map-Unit 4 (Glacier Lake, Wrigley Lake)

Map-unit 4 is 4,350 feet thick south-southeast of Little Dal Lake but in many areas has been removed by erosion preceding deposition of map-unit 7. The formation is characterized by buff-orange and reddish orange weathering dolomites and sandy dolomites, but also includes thinly bedded and laminated siltstone, slate, and mudstone. A sequence of sandy and cherty dolomite 200 feet thick with two interbeds of dolomite conglomerate less than 20 feet thick occurs near the middle of the orange-dolomite unit south-southeast of Dal Lake. The strata appear to overlie map-unit 3 conformably.

Map-Unit 5 (Glacier Lake, Wrigley Lake)

Map-unit 5 outcrops near Keele River, near Little Dal Lake, and possibly locally in the wide valley south of Little Dal Lake. Elsewhere the rocks are believed to have been removed prior to deposition of map-unit 7. On the east face of the mountain east of Little Dal Lake the map-unit is more than 1,500 feet thick and comprises conspicuous, pink weathering, locally calcareous siltstone. Small-scale crossbedding is fairly common. From three to seven zones of greenish weathering slightly dolomitic siltstone occur near the top of the formation and contain disseminated copper minerals. Map-unit 5 is underlain by a westerly dipping thrust fault east of Little Dal Lake. The base of the sequence was not examined elsewhere.

Black, medium-grained gabbro (map-unit 5a) intrudes the siltstones near a fault zone in the valley north of Little Dal Lake. A band of creamy white, laminated anhydrite also outcrops along the fault and is intruded by the gabbro.

Map-Unit 6 (Glacier Lake, Wrigley Lake)

Map-unit 6 is believed to overlie map-unit 5 east of Keele River but was examined only on the east face of the mountain east of Little Dal Lake where it is 675 feet thick. There it is separated from the underlying map-unit 5 by a fault. The basal 175 feet comprise buff weathering, platy, silty limestone and calcareous siltstone in beds 1/2 inch to 3 inches thick. This member is overlain by 225 feet of dark grey to black, fine-grained, fetid limestone and recessive black, buff, and grey calcareous slate. The upper 275 feet consist of resistant, fine-grained dark grey to black, light grey weathering limestone. Locally the uppermost limestone beds are fragmental.

Map-Unit 7 (Glacier Lake, Wrigley Lake)

Strata of map-unit 7 are widespread in Wrigley Lake and north-central Glacier Lake map-areas. The lower part comprises a distinct maroon weathering sequence of maroon and green siltstone, slate, sandstone, iron-formation, and conglomerate. The upper and thickest part consists of green, green-brown, and greenish grey, platy, locally ripple-marked, siltstone, slate, sandstone, and conglomeratic mudstone. Pebbles, cobbles, and boulders in the conglomerate, ranging up to 2 1/2 feet in diameter, are subangular to well rounded and include fine-grained greenstone, buff-orange weathering silty and sandy dolomite, quartzite, black and grey chert, white quartz, black crypto-grained limestone, hornblende diorite, and muscovite-biotite gneiss.

East of Little Dal Lake an iron-formation containing steely grey hematite and reddish orange jasper is about 100 feet thick. There and on the mountain to the south, the lower, maroon weathering member of map-unit 7 is more than 2,000 feet thick. North of Redstone River the combined thickness of the lower and upper units is more than 4,500 feet.

The base of map-unit 7 is marked by a regional unconformity perhaps best observed in south-central Wrigley Lake map-area. A significant angular unconformity occurs at the base of the upper member so that locally the lower member is missing.

Map-Unit 8 (Glacier Lake, Wrigley Lake)

Well-bedded, resistant, orange weathering, dolomitic sandstone, sandy dolomite, and minor limestone of map-unit 8 locally attain a thickness of about 2,500 feet but in places are considerably thinner. A buff-weathering, dolomite member that forms the top of the unit is an

excellent horizon marker. East of Grizzly Bear Lake the top of an aphanitic basalt flow, 70 feet thick, outcrops just below the top of the unit.

Map-Unit 9 (Glacier Lake, Wrigley Lake)

Map-unit 9 consists of a distinctly recessive sequence of non-calcareous, shale, siltstone, and sandstone that weathers medium to dark grey and brown and commonly produces a glistening talus. Near the headwaters of South Redstone River the upper part of the sequence is more resistant than elsewhere and the rocks are probably coarser grained. A section measured east of Grizzly Bear Lake near the peak, elevation 8,217 feet, is 3,185 feet thick.

Map-Unit 10 (Glacier Lake, Wrigley Lake)

This unit comprises orange and brown weathering platy sandy carbonate rocks that outcrop between the headwaters of Redstone and South Redstone Rivers. Little is known of their relations to enclosing strata. The maximum thickness appears to be about 1,000 feet but the sequence disappears abruptly to the north and south either by primary thinning or beneath an unconformity at the base of map-unit 13a.

Map-Unit 11 (Flat River)

This unit consists mainly of interbedded quartzose and argillaceous rocks in about equal proportion. Owing, however, to their greater resistance to erosion, the quartzose rocks form more than half of the outcrops. Limestone beds make up from 5 to 10 per cent of the formation. Minor phyllite is present locally.

The main rock types in the formation in decreasing order of abundance are black and dark green shale and slate, quartzite (commonly gritty), calcarenite, quartz-pebble conglomerate, sandstone, brightly coloured maroon, green, and buff shale and slate, and limestone. Although not the most abundant, the maroon and green shales are the most conspicuous strata in the unit, being commonly recognizable from the air. Also distinctive are the quartz-pebble conglomerates and gritty quartzites which contain prominent bluish grey quartz grains. The quartz-pebble conglomerate forms competent beds, generally 50 to 100 feet thick, and breaks into large blocks resembling granite from a distance. These rocks are widespread in Frances Lake and Nahanni map-areas to the west where Green and Roddick (1961) estimated them to be more than 10,000 feet thick.

Map-Unit 12 (Flat River, Glacier Lake)

This unit consists of an undivided sequence of dark weathering, fine-grained clastic rocks, possibly as much as 10,000 feet thick, that may locally contain equivalents to map-unit 11. West of Mount Ida in Glacier Lake map-area the uppermost rocks comprise a distinctive assemblage of green and maroon weathering volcanic rocks and chlorite schist at least 200 feet thick. The volcanic strata were either deposited over a small area or were removed prior to deposition of map-unit 16a because they were not observed to the north near the head of Brintnell Creek or west of Rabbitkettle River.

Cambrian and/or Precambrian

Map-Unit 13

A reddish weathering quartzite unit (map-unit 13c) is exposed in an anticline crossing South Nahanni River and is about 4,000 feet thick. It is underlain by about 500 feet of buff weathering dolomite (Green and Roddick, 1961). The correlation of units 13c and 13d with units 13a and 13b, respectively, is tentative. In the major anticline northeast of South Nahanni River the assemblage of quartzites, slates, and calcareous sandstones (13a) overlying the carbonate unit (13b) is 6,700 feet thick. The lowermost member of the upper quartzite unit (13a) is a basal conglomerate, one foot thick, consisting of angular fragments of the underlying dolomite (13b) set in a matrix of quartz sandstone and pebble conglomerate.

Much of map-unit 13b is crypto-grained, mauve, pink, and buff, mottled dolomite weathering ochre, yellow, buff-orange, and grey. East of Grizzly Bear Lake these rocks are 755 feet thick. There the upper part of the sequence weathers to shales of pink and orange and the lower part weathers cream to buff.

In the anticline northeast of South Nahanni River the carbonate rocks (map-unit 13b) are 1,150 feet thick. There, and east of Grizzly Bear Lake quartzites (13a) underlying the carbonate units (13b) are mainly fine-grained and are greenish grey weathering.

The local distribution of map-unit 10 and a resistant upper member of map-unit 9 below quartzites of map-unit 13a in northwestern-most Glacier Lake map-area suggests the presence of an unconformity at the base of the lower quartzite member of map-unit 13a. An alternative explanation involving facies changes within map-units 9 and 13a seems improbable.

Map-Unit 14 (Glacier Lake, Wrigley Lake)

Brown and grey weathering strata, possibly more than 1,000 feet thick locally, outcrop in northwestern Glacier Lake and southwestern Wrigley Lake map-areas. The rocks were not examined in the field but appear to be dominantly carbonates. This map-unit (14) may be partly or entirely equivalent to shales of map-unit 17b which outcrop farther north in Wrigley Lake map-area.

Cambrian

Map-Unit 15 (Flat River)

Map-units 15a and 15b outcrop in northwesternmost Flat River map-area. The lower, carbonate member of unit 15a, 200 feet thick, comprises irregularly interbanded calcareous siltstone and impure limestone. Pods and lenses of limestone on weathering impart a "Swiss-cheese" texture to the rock. The overlying upper member, also about 200 feet thick, consists of blue-grey, fine-grained limestone and coarsely crystalline limestone. The base of map-unit 15a may be marked by an unconformity but evidence obtained is not conclusive.

Map-unit 15b is about 2,000 feet thick southwest of Rabbitkettle River and consists of sandstone, sandy and silty dolomite, dolomite, argillite, minor quartzite and impure limestone. Fossils identified by B.S. Norford include Olenellus gilberti which demonstrates a Lower Cambrian age. Sandy carbonate rocks of map-unit 15c outcrop in south-central Flat River map-area where they are more than 1,100 feet thick. These rocks yielded one poorly preserved archaeocyathid.

Map-Unit 16 (Flat River, Glacier Lake)

This unit outcrops southwest of Rabbitkettle River and rocks believed to be correlative to the lower member were mapped west of Mount Ida. The sequence consists of two members—the lower (16a), about 150 feet thick, comprising bright yellow and orange weathering, silty and sandy dolomite and the upper (16b), about 1,000 feet thick, comprising dolomite, partly silty and sandy, and minor sandstone and shale. Near Mount Ida strata believed equivalent to map-unit 16a are about 200 feet thick and are similar to those southwest of Rabbitkettle River except that they include interbeds of grey limestone. At the base of the Mount Ida occurrence an unconformity is possible (see discussion of map-unit 12). The stratigraphic position of map-unit 16 suggests a Lower and/or Middle Cambrian age.

Map-Unit 17

Buff and orange weathering dolomitic siltstones, silty dolomites, calcareous sandstones, and stromatolitic dolomites of Middle and (?) Upper Cambrian age form a distinctive sequence, particularly well exposed in Glacier Lake map-area. A section measured by Norford 12 miles northeast of the mouth of Broken Skull River is 1,349 feet thick. There, and in two localities north of Redstone River in Wrigley Lake map-area basal beds of map-unit 17 have yielded early Middle Cambrian trilobites.

In southwest Wrigley Lake map-area the unit has been separated, only locally, from overlying and underlying rocks. There, map-unit 17a consists of a lower silver-grey weathering carbonate unit and an upper orange-buff weathering unit. Farther north unit 17a has been mapped as part of unit 17b together with an underlying recessive dark grey, shale that may be in part, or entirely equivalent to map-unit 14.

Map-unit 17c southwest of Tigonankweine Range was not examined and its age is uncertain. Strata included in map-unit 2a in south-eastern Wrigley Lake map-area occur at the same stratigraphic position and have similar weathering characteristics.

The base of map-unit 17 is a regional unconformity. Near the headwaters of Clearwater Creek in Glacier Lake map-area map-units 13 and 9 appear to be bevelled down-section to the southeast. Locally, in south-central Wrigley Lake map-area, unit 17 lies directly on strata of map-unit 7. The situation north of North Nahanni River is similar.

Map-Unit 18 (Flat River, Glacier Lake)

Intercalated platy, impure limestone, and siltstone of map-unit 18 is widespread in southwest Glacier Lake and Flat River map-areas. Locally the map-unit probably includes equivalents of map-units 16 and 17. The strata are more than 4,000 feet thick in northwestern Flat River map-area. Siltstone and silty limestone are more common in the lower beds. The unit is characterized by its resistant, well-bedded to massive appearance and southwest of Flat River by its light grey colour which contrasts markedly to the dark weathering of the underlying rocks (mainly unit 12). In outcrops a distinctive feature of the unit is the wavy banding of silty layers, and, in the lower beds, a "Swiss-cheese" texture resulting from the weathering of limestone pods and lenses in a more resistant silty matrix.

A regional unconformity, locally markedly angular, underlies map-unit 18 in Flat River map-area. No fossils were collected from these rocks within the map-areas but a Middle and possibly Upper Cambrian age is suggested by lithological correlation with fossiliferous strata exposed in the anticline crossing South Nahanni River near latitude 62°23' and a fossil collection west of Flat River map-area near latitude 61°45'. An upper member, unit 18b, consisting of light grey weathering, dark fissile argillaceous limestone and calcareous shale, occurs southwest of Rabbitkettle River, where it appears to be sharply bevelled by the unconformity at the base of Ordovician and Silurian shales (map-unit 23).

Map-Unit 19 (Glacier Lake)

Map-unit 19 comprises an undivided sequence of red, buff, yellow, and grey weathering dolomite, siltstone, sandstone, and limestone that outcrops in the Ragged Range in southwestern Glacier Lake map-area. In Nahanni map-area to the northwest (Green and Roddick, 1961) this sequence is about 5,500 feet thick and contains Lower, Middle, and possibly Upper Cambrian fossils. The thickness is probably considerably less in Glacier Lake map-area because of a marked angular unconformity, separating it from the overlying rocks of map-unit 22b.

Buff-weathering, calcareous sandstone exposed in the anticline immediately northeast of South Nahanni River may be correlative with the sandstones of Lower Cambrian age included in map-unit 19. Farther northeast, Lower Cambrian strata have either been removed beneath the unconformity at the base of Middle Cambrian strata or are represented by the upper part of the quartzite sequence (map-unit 13a).

Cambrian and Ordovician

Map-Unit 20 (Flat River, Glacier Lake)

Map-unit 20 is best exposed west and southwest of Rabbitkettle Lake in Flat River map-area. Similar rocks outcrop farther north but have been mapped only in part or included with map-unit 18. The lower unit (map-unit 20a) comprises grey, slaty, argillaceous limestone and buff calcareous slate possibly 300 feet thick. The stratigraphic position and lithology of this unit are similar to that of map-unit 18b exposed about 10 miles to the west. The upper unit (20b) includes banded, buff and grey weathering, blocky, dark grey, crypto-grained limestone about 250 feet thick. Locally, rocks of map-unit 20b display buff, pink, and wine mottling and in this respect resemble some of the strata of map-unit 22. Unit 20 has not been subdivided in Glacier Lake map-area.

Map-Unit 21

Well-bedded to massive limestones and dolomites of map-unit 21 were mapped in the southwestern part of Wrigley Lake map-area, Glacier Lake map-area, and northernmost Flat River map-area. The unit is present also in the undivided map-unit 22b. In Flat River map-area, north of South Nahanni River, the sequence is characterized by craggy weathering, distinctly bedded, light grey, crypto-grained limestone that locally weathers vivid orange. Dolomite and sandy, laminated limestone are also present.

In a section measured by Norford, 12 miles northeast of the mouth of Broken Skull River in Glacier Lake map-area, crypto-grained to fine-grained, locally oolitic, light grey weathering, dark grey limestone is dominant in the lower part of the unit whereas very fine-grained, dark grey dolomite is dominant in the upper part. In places the dolomites contain chert nodules and some beds are pisolitic. The map-unit in this area is 3,480 feet thick and appears to overlie map-unit 17 conformably. Immediately northeast of South Nahanni River the unit is about 2,800 feet thick.

Norford collected Upper Cambrian (late Franconian) trilobites from these rocks 566 feet above the base. The succeeding strata contain Lower Ordovician fossils.

Ordovician

Map-Unit 22 (Flat River, Glacier Lake)

Map-unit 22, well exposed in Flat River and Glacier Lake map-areas, comprises a conspicuously banded sequence of dark grey, light grey, and cream weathering dolomites, pink and grey mottled limestone and one prominent member of orange-brown sandstone. The section measured by Norford northeast of South Nahanni River is 2,346 feet thick and another measured on the ridge northeast of South Nahanni River is about 2,800 feet thick. There, limestones are dominant in the upper 1,000 feet of the map-unit. Near the headwaters of Flood Creek the basal member is homogeneous, dark grey weathering, fetid dolomite about 300 feet thick. This member is overlain by about 200 feet of banded, light and dark grey weathering dolomites the upper beds of which weather creamy grey. Overlying the banded dolomites are platy, light grey and buff weathering, pink-mottled, crypto- to fine-grained limestones 500 to 600 feet thick. Upwards in the succession are thick-bedded, dark grey, crypto- to fine-grained limestones containing lenses and stringers of chert, 200 feet thick; buff, brown, and reddish brown weathering sandy dolomite,

dolomite and sandstone, 100 feet thick; and interbedded light and dark grey weathering dolomites about 1,000 feet thick. The uppermost beds comprise mottled, blue-grey limestone and platy, shaly, bioclastic limestones containing abundant fossils. The basal dark weathering dolomite member and the overlying silver-grey weathering, banded dolomite member are conspicuous throughout the area. The overlying member northeast of Clearwater Creek contains much sand and weathers shades of orange and buff. These rocks include a prominent andesite or basalt flow, or locally, two flows with an aggregate thickness of as much as 150 feet (map-unit 22a). West of Grizzly Bear Lake the base of map-unit 22 is not well defined but the section appears to be about 2,500 feet thick. Four distinct members from the base up are as follows: resistant, buff weathering, medium-grained, medium to light grey dolomite, 800 feet thick; interbedded light grey to creamy buff weathering and dark grey weathering crypto- to fine-grained dolomite, 558 feet thick; crypto-grained to fine-grained, light grey and cream weathering limestone, 130 feet thick, and a conspicuous unit of cherty, dark grey to black dolomite, 1,045 feet thick.

Map-unit 22 overlies strata of map-unit 21 conformably.

Abundant fossil collections were examined by Norford and indicate a Middle to possibly early Upper Ordovician age. As described in this report map-unit 22 probably is mainly equivalent to part of the Sunblood Formation which outcrops farther east in Mackenzie Mountains (Douglas and Norris, 1960; 1961).

Ordovician, Silurian, and Later

Map-Unit 23 (Flat River, Glacier Lake)

Fissile, thin-bedded, pyritic, black and grey shales, siltstones, crypto-grained black limestones, and bedded chert are widespread in the southern part of Glacier Lake map-area and in Flat River map-area. In northeasternmost part of Flat River map-area these rocks contain more limestone than elsewhere and are a continuation of strata in Virginia Falls map-area (map-unit 5 and upper part of map-unit 3, Douglas and Norris, 1960). The light buff, tan, and pale olive-grey weathering there is unique.

Near a line trending northwesterly from northeast of Clearwater Creek to, and beyond, Grizzly Bear Lake, strata of the Whittaker, Delorme, Sombre, and Arnica Formations change facies rather abruptly from carbonates in the northeast to shaly rocks of map-unit 23. Fourteen miles northwest of the mouth of Broken Skull River the Arnica and Sombre Formations can be observed to grade northwesterly into shale, whereas the facies change of the Delorme Formation occurs a few miles farther to the northeast.

Near Clearwater and Flood Creeks the lowermost strata of map-unit 23 are recessive; platy, thin-bedded, argillaceous limestones, calcareous shales, and minor black chert that produce a characteristic silver-grey talus. Farther west and southwest the rocks are more graphitic and weather dark grey to black.

A section measured by Norford, 13 miles northeast of the mouth of Broken Skull River includes a lower, recessive, graptolitic, calcareous shale and argillaceous limestone unit, 297 feet thick; a middle, thin-bedded, olive, grey, pale yellow, and dark grey weathering cherty and silty dolomite unit containing abundant beds, lenses, and nodules of grey and black chert, 476 feet thick; and an upper, recessive, dark grey, calcareous, graptolitic shale unit, more than 1,396 feet thick. The lower unit contains graptolites of Middle (Caradoc) to Upper Ordovician age and strata near the base of the upper unit contain graptolites of Lower Silurian (late Llandovery) and possibly later age. West of the mouth of Broken Skull River late Silurian (early Ludlow) graptolites were collected. Fossils of Upper Silurian or Lower Devonian age were collected from the uppermost strata in Virginia Falls map-area (map-unit 5 of Douglas and Norris, 1960) and equivalent rocks are probably included in map-unit 23.

On the limbs of the syncline a few miles east of the mouth of Broken Skull River, a conspicuous member of buff weathering calcareous slate and argillaceous limestone assigned to map-unit 31a overlies strata of map-unit 23. This is the only area in which map-unit 23 can be readily separated from the shales of map-unit 34.

Near Flat River strata of map-unit 23 contain graptolites of Middle and (?) Upper Ordovician age and directly overlie those of map-unit 18. An unconformity may separate the two assemblages. Farther north in Ragged Range the underlying strata are those of map-unit 20 near Glacier Lake and southeast of Mount Sidney Dobson, whereas still farther north, the underlying strata are included in map-unit 22b.

It is apparent from the relationships described above that the carbonate facies of Middle Ordovician and possibly early Upper Ordovician age persist somewhat farther southwest than the younger carbonates. The facies change to shale in the Middle Ordovician carbonates of map-unit 22b may take place near Mount Sir James MacBrien the equivalents being included in map-unit 23. On the other hand, the occurrence of an Upper Ordovician or Lower Silurian fauna near the base of map-unit 23 south of Rabbitkettle River, suggests that at least part of the disappearance of map-unit 22b to the southwest is the result of pre-Upper Ordovician erosion.

In Flat River map-area relatively resistant rocks (map-unit 23a) occur near the granitic intrusives (map-unit 35). Northeast of Seaplane Lake the beds are highly deformed and locally the shales and slates possess a distinct phyllitic sheen.

Whittaker Formation, map-unit 24 (Glacier Lake, Wrigley Lake)

The Whittaker Formation comprises well-bedded, dark grey weathering, dolomite and limestone. It outcrops in eastern Glacier Lake map-area and is widespread in Wrigley Lake map-area. In southwest Wrigley Lake map-area the rocks have not been studied in detail and strata correlative with map-units 17, 21, and 22 may be included locally. In southeastern Glacier Lake map-area the relationship between map-unit 22 and the Whittaker Formation is not yet understood as fossil control is limited and accordingly the distribution shown is uncertain.

North of North Nahanni River in Thundercloud Range the Whittaker Formation consists of a lower, light grey weathering limestone member and a dark grey upper dolomite member, both commonly cherty. At least locally the dolomite is porous and contains coarse vugs generally lined with dolomite crystals. The Whittaker Formation is 1,500 feet thick near North Nahanni River (thickness of limestone member 750 feet); about 1,100 feet thick near latitude 62°30' (limestone member 450 feet); 1,369 feet thick (limestone member, 102 feet) in a section measured by Norford at the northern end of Thundercloud Range; 2,337 feet in northeastern Glacier Lake map-area; 1,340 feet thick 6 miles west of South Redstone River near lat. 63°; and 990 feet thick about 8 miles north-northwest of Dal Lake.

A regional unconformity occurs at the base of the Whittaker Formation but the apparent magnitude of the unconformity also reflects the cumulative effects of the unconformity at the base of map-unit 17. An apparent angular discordance of about 15 degrees between strata of the Whittaker Formation and underlying rocks of map-unit 7 is strikingly displayed in Thundercloud Range near lat. 62°30'. There, the upper and lower divisions of map-unit 7 are bevelled progressively down-section to the east so that the Whittaker Formation farther east lies directly on strata of map-unit 4.

The Whittaker Formation includes fossils of Upper Ordovician and Silurian age. According to Norford the Ordovician - Silurian boundary in the section at the northern end of Thundercloud Range lies within the interval between 287 and 551 feet above the base of the map-unit.

Silurian and (?) Devonian

Delorme Formation, map-unit 25 (Glacier Lake, Wrigley Lake)

The Delorme Formation, generally recessive, buff, grey, cream, and cinnamon weathering, platy, mottled dolomites and limestones, forms a distinctive map-unit in Glacier Lake and Wrigley Lake map-areas. The rocks are commonly crypto-grained to fine-grained, thin-bedded, and in many places, delicately laminated. They contain nodules of pink and orange-pink weathering dolomite. Alternating dark and light weathering members with somewhat diffuse boundaries owing to talus creep impart a characteristic banded or striped appearance easily recognizable in outcrops and on air photographs.

The Delorme Formation is 2,300 feet thick south of North Nahanni River; about 2,000 feet thick at the north end of Thundercloud Range; 835 feet thick 6 miles west of South Redstone River near lat. 63°; 1,060 feet thick 8 miles north-northwest of Dal Lake; and between 150 and 200 feet thick southwest of Tigonankweine Range.

Ostracoderm fragments collected by Norford, 178 feet above the base of the unit, were examined by D.L. Dineley, University of Ottawa and are of Upper Silurian or Lower Devonian age.

Devonian

Camsell Formation, map-unit 26 (Glacier Lake, Wrigley Lake)

Strata assigned to the Camsell Formation include grey, yellow and orange weathering limestone breccia, crypto-grained grey limestone, and alternating beds of grey and buff weathering dolomite. The basal beds are generally recessive weathering and outcrop poorly.

Near North Nahanni River a sequence of well-bedded, alternating grey and buff weathering dolomites, 1,200 feet thick, is transitional between the Delorme Formation below and the Sombre Formation above. There the entire assemblage is relatively resistant.

A poorly exposed section 6 1/2 miles southeast of Dal Lake includes abundant breccia that locally weathers into hoodoos, and subordinate, laminated, crypto-grained dolomite and banded limestone. This assemblage is 540 feet thick.

In part of Thundercloud Range rocks mapped as Delorme Formation include brecciated rocks at the top that may be equivalent to the Camsell Formation. The formation is absent in sections measured northwest and southwest of Dal Lake and southwest of Tigonankweine Range, where rocks typical of the Delorme and Sombre Formations appear to be in conformable contact.

Sombre Formation, map-unit 27 (Glacier Lake, Wrigley Lake)

The Sombre Formation, well-exposed in Glacier Lake and Wrigley Lake map-areas, comprises a cliff-forming assemblage of well-bedded, commonly laminated, alternating light grey and medium to dark grey weathering crypto-grained to medium-grained dolomites. In many places the formation can be divided into a lower, medium to dark grey banded unit, a conspicuous dark grey weathering middle unit, and a silver-grey weathering slightly recessive upper unit.

East of Little Dal Lake in Thundercloud Range the lower, middle, and upper divisions of the Sombre Formation are 415, 140, and 1,135 feet thick, respectively. Elsewhere, thicknesses of the Sombre Formation are as follows: south of North Nahanni River, 2,350 feet; 6 miles west of South Redstone River near lat. 63°, 615 feet, 6 1/2 miles southeast of Dal Lake, 1,620 feet; and 8 miles northwest of Dal Lake, 750 feet.

Locally, where the map-unit is thin, it has been included in the overlying Arnica Formation (map-unit 28a). On the northeast flank of the anticline southwest of Grizzly Bear Lake 2,154 feet of resistant dolomite (map-unit 27b) includes a thin-bedded, dark and light grey weathering crypto-grained to fine-grained lower unit and a light grey weathering thick-bedded to massive upper unit. On the southwest limb, however, the strata are dominantly argillaceous and dark grey weathering, and have been included, in part, in map-unit 23.

Near lat. 63°22' and long. 127° the Sombre Formation appears to be bevelled down-section to the southeast eventually to disappearance below the Arnica Formation. Part of the disappearance of the Sombre Formation, however, is attributable to a facies change of its lower part into argillaceous strata of map-unit 23.

Arnica Formation, map-unit 28 (Glacier Lake, Wrigley Lake)

In Glacier Lake and Wrigley Lake map-areas the Arnica Formation comprises a distinctive assemblage of dark grey weathering,

fine- to medium-grained dolomite. Alternating medium grey and dark grey beds, generally ranging from 6 inches to 4 feet in thickness, result in a conspicuous banding, particularly well displayed in Thundercloud Range. The dolomites are locally porous and contain vugs as much as 1 1/2 inches long and 3/4 inch across lined with white weathering dolomite crystals. 'Spaghetti-stone' consisting of rod-like, white weathering remains of fossils in a dark weathering matrix is common. Intraformational breccia is characteristic, particularly in the upper part of the formation in Thundercloud Range, and appears to become relatively more abundant in north Wrigley Lake map-area.

Thicknesses of the Arnica Formation are as follows: south of North Nahanni River - 2,600 feet; east of Little Dal Lake - 1,540 feet; 6 miles west of South Redstone River near lat. 63°-795 feet (in this section map-unit 28a includes the Sombre Formation and the uppermost 70 feet is coarsely crystalline dolomite similar to the Manetoe Formation, map-unit 29); 6 miles southeast of Dal Lake - 1,105 feet; and 8 miles north-northwest of Dal Lake - 550 feet, which there includes much intraformational breccia.

East and southeast of Grizzly Bear Lake thicknesses vary considerably and the formation is locally thin, owing in part at least to a change of facies to shaly strata of the overlying map-unit 31a, which are relatively thick in this area.

The Arnica Formation contains few well preserved fossils but one collection from beds relatively high in the formation north of North Nahanni River was identified by A.W. Norris of the Geological Survey as of Middle Devonian age.

Manetoe Formation, map-unit 29 (Glacier Lake)

The Manetoe Formation outcrops in Thundercloud Range and near Grizzly Bear Lake. In Thundercloud Range, where a thickness of 200 feet was measured, the dominant rock type is an extremely porous, light grey to creamy white, very coarse-grained dolomite. The unit is characteristically thick-bedded to massive and includes interbeds of medium grey, dark grey to black, crypto-grained limestone as much as 4 feet thick. Coarse breccia occurs locally.

Vuggy, light grey to white, coarse-grained dolomite southeast of Grizzly Bear Lake is about 60 feet thick north of the peak, elevation 8,202 feet.

West of Grizzly Bear Lake a section of very coarse-grained, porous limestone 150 feet thick overlying map-unit 27b is assigned to the Manetoe Formation. The succeeding strata, 695 feet thick, are mainly crypto-grained, light and medium grey weathering, fairly massive limestones that may be correlative to the Landry Formation (map-unit 30).

In Thundercloud Range the contact between the Manetoe and underlying Arnica Formations is distinct but gradational.

Landry Formation, map-unit 30 (Glacier Lake, Wrigley Lake)

Poorly fossiliferous, medium-bedded, crypto-grained, light grey and medium grey weathering limestone, of the Landry Formation overlies rocks of the Manetoe Formation in Thundercloud Range and overlies rocks of the Arnica Formation to the north in northern Glacier Lake and Wrigley Lake map-areas. In Wrigley Lake map-area alternations of light grey weathering and buff grey weathering beds impart a distinctive banded appearance to the outcrops.

The Landry Formation is 400 feet thick in Thundercloud Range east of Little Dal Lake; 665 feet thick near lat. 63°, 6 1/2 miles west of South Redstone River; 690 feet thick 6 miles southeast of Dal Lake; 505 feet thick one mile northeast of Dal Lake; 580 feet thick 8 1/2 miles northeast of Dal Lake; and about 100 feet thick southwest of Tigonankweine Range.

Headless Formation, map-unit 31 (Glacier Lake, Wrigley Lake)

Highly fossiliferous, buff-brown weathering, thin-bedded recessive, fine-grained, argillaceous limestones of map-unit 31 are assigned to the Headless Formation. Locally the formation includes minor calcareous siltstone and shale. Generally the unit forms a conspicuous recessive interval between the underlying Landry Formation and overlying Nahanni Formation. Near Grizzly Lake and in the section measured east of Little Dal Lake the formation includes one conspicuous, resistant limestone member. East of Little Dal Lake this member is 190 feet thick and is separated from the overlying Nahanni Formation by 195 feet of platy, recessive, argillaceous limestone.

In southwestern Glacier Lake map-area in the general area of Grizzly Bear Lake map-unit 31a contains strata correlative with the Headless Formation in its upper part but includes older rocks of similar lithology that may be in part equivalent to the upper part of map-unit 27 and to map-unit 30. Part of this assemblage is similar to the Funeral

Formation which outcrops farther east in Mackenzie Mountains (Douglas and Norris, 1960; 1961). Near Grizzly Bear Lake map-unit 31a is 2,025 feet thick.

Thicknesses of the Headless Formation are as follows: east of Little Dal Lake in Thundercloud Range - 990 feet; near lat. 63° and 6 1/2 miles west of South Redstone River - 425 feet; 6 miles southeast of Dal Lake - 845 feet; one mile northeast of Dal Lake - 535 feet; and 665 feet thick 9 miles northwest of Dal Lake.

According to A.W. Norris the Headless Formation is of Middle Devonian (early Givetian) age.

Map-Unit 32 (Wrigley Lake)

Two units with an aggregate thickness of 1,500 to 2,000 feet comprise map-unit 32, in the restricted area in which it outcrops in southwestern Wrigley Lake map-area. The lower unit (32a) consists of light grey weathering carbonate and the upper unit (32b) of dark grey weathering carbonate. The strata were not examined in the field. They appear to overlie rocks that weather like those of the Landry Formation and may be in part equivalent to map-unit 31a.

Nahanni Formation, map-unit 33 (Glacier Lake, Wrigley Lake)

The youngest prominent carbonate formation in this part of Mackenzie Mountains is the Nahanni Formation. It comprises resistant, grey weathering, well-bedded, fine- to medium-grained limestones that commonly form flat-irons on the sides of synclinal valleys underlain by shales of map-unit 34. The map-unit persists with a remarkably consistent character and general thickness throughout the northern part of Glacier Lake and most of Wrigley Lake map-area. West of Broken Skull River the strata thin southeasterly along the outcrops and appear to be replaced by argillaceous limestones included in map-unit 31a.

Thicknesses are as follows: Grizzly Bear Lake - 200 feet; east of Little Dal Lake in Thundercloud Range - 220 feet; 6 miles west of South Redstone River near lat. 63° - 115 feet; 6 miles southeast of Dal Lake - 225 feet; east side of Dal Lake - 265 feet; and southwest of Tigonankweine Range - 250 to 275 feet.

The Nahanni Formation contains an abundant Middle Devonian (Givetian) fauna, according to A.W. Norris.

Devonian and (?) Mississippian

Map-Unit 34 (Glacier Lake, Wrigley Lake)

Map-unit 34 consists of recessive, thin-bedded pyritic slaty shale and minor interbedded black, argillaceous limestone and black chert. Only where the Nahanni Formation or strata of map-unit 31a are present can these rocks be readily separated from those of map-unit 23. In southwestern Glacier Lake map-area and in Flat River map-area the equivalent strata are included in map-unit 23.

On Caribou River in southeastern Flat River map-area well-bedded, calcareous shales interbedded with black, argillaceous limestone contain Ordovician and Silurian graptolites. A thick section of generally non-calcareous slate and argillite overlying these rocks is believed to be, in part, of Devono-Mississippian age.

Fossils collected by J. Coates of Redstone Mines, Ltd., 2 1/2 miles east of Little Dal Lake are, according to D.J. McLaren of the Geological Survey, of Late Devonian (Famennian) age. Although the contact is sharp, strata of map-unit 34 appear to overlie the Nahanni Formation conformably. The basal beds may be of late Middle Devonian age.

Mesozoic

Map-Unit 35 (Flat River, Glacier Lake)

About one-quarter of Flat River map-area is underlain by medium- to coarse-grained granitic rocks that form two batholiths and numerous stocks. In Glacier Lake map-area three granitic stocks outcrop southwest of South Nahanni River. W. Mackenzie of Redstone Mines, Ltd. (personal communication, 1963) reported three small bodies of leucocratic, biotite granite near lat. 62°17 1/2' and long. 127°17'.

The granitic rocks are mainly quartz monzonites and granodiorites. They commonly contain from 15 to 40 per cent megacrysts of euhedral to subhedral potash feldspar, ranging from 1/2 inch to 2 1/2 inches long, in a medium- to coarse-grained matrix of feldspar, quartz, biotite, and/or hornblende. Near Hole-in-the-Wall Lake, Roots (unpublished notes, Geological Survey, 1953) reported the presence of black tourmaline as a relatively abundant accessory mineral. There, locally, quartz-tourmaline clots are conspicuous and aligned in zones.

East of Irvine Creek the granitic rocks include a border zone of light to medium grey weathering, coarse-grained hornblende diorite

(map-unit 35a). Northwest of Dome Peak an area of rusty weathering, medium-grained biotite-hornblende granodiorite (map-unit 35b) outcrops within the larger mass of grey weathering, coarse-grained quartz monzonite. Contacts of the rock types outlined above are known in only a general way.

Although the plutonic rocks cannot be dated by stratigraphic means within the project area, one K/Ar age determined on a sample of quartz monzonite in northwesternmost Flat River map-area indicates a Cretaceous age (110 m.y.). This age is consistent with several others obtained for similar rocks in southeastern Yukon Territory.

STRUCTURAL GEOLOGY

Northerly to northwesterly trending folds with moderately steep limbs, are the most widespread structures in the three map-areas. The structures are locally broken by thrust faults that generally dip westerly, except in eastern Wrigley Lake and eastern Glacier Lake map-areas where they dip easterly.

Three major anticlinal areas flanked by synclinoria are present in northeastern and southeastern Wrigley Lake map-area. Douglas and Norris (1963) have shown that the structure of Redstone Range is essentially an anticline broken near the crest by a major east-dipping thrust, the Redstone Fault. The anticlinal structure trends north-northwesterly through Wrigley map-area northeast of Wrigley Lake but was not examined on Operation Nahanni. A study of air photos suggests, however, that a possible continuation of the Redstone Fault northeast of Wrigley Lake is westerly dipping and that thrusting was directed to the east.

A synclinal area southwest of Redstone Range is flanked on the southwest by an anticline that underlies Rouge Range and which is broken by two easterly dipping thrust faults.

Tigonankweine Range and the range underlain by quartzites of map-unit 2a in southeasternmost Wrigley Lake map-area are anticlinal areas separated along trend by a depression that preserves younger strata. Tigonankweine Range is bordered to the southwest by tightly folded rocks that lie in front of a major, southwesterly dipping thrust fault or faults. In northeasternmost Glacier Lake map-area the quartzite range is bordered to the west and southwest by a major, easterly dipping thrust fault. Northeast of this fault are two other easterly dipping thrust faults, the most important of which is a northwesterly continuation of the Painted Mountain fault (Douglas and Norris, 1961).

South of North Redstone River an area of extremely complicated structure is bounded on the west by a major, westerly dipping thrust fault which maintains a uniform stratigraphic position for many miles. The eastern boundary of this area is also marked by a major westerly dipping thrust fault that bounds the prominent quartzite range between lat. 63°30' and Redstone River. North of Redstone River the wedge of strata between the westernmost major thrust fault and a major fault that crosses Redstone River near long. 126°38 1/2' is folded along west-northwesterly trending axes.

North of South Redstone River (Glacier Lake map-area) a prominent southwesterly dipping thrust fault appears to swing southwesterly suggesting an upward and outward movement of the block to the west. A major northeasterly trending fault farther southwest along trend may be a continuation of the structure described above.

Near long. 126° the northeast side of Thundercloud Range is marked by several faults along which rocks to the southwest have been relatively uplifted. Farther northwest these structures appear to die out in a prominent syncline where, at least locally, the northeast limb is broken by a northeasterly dipping thrust fault.

A conspicuous, westerly dipping thrust fault east of Little Dal Lake has brought siltstones of map-unit 5 in contact with overturned Devonian rocks. The detailed structure of the mountain south-southeast of Little Dal Lake is complex. The dominant features appear to be westerly dipping thrust faults interrupted by a major cross-fault along which strata to the south have been relatively down-dropped. South of the most prominent cross-fault, the general structure appears to be that of a northeasterly overturned anticline broken along its fore-limb by a west dipping thrust fault. Displacement along the thrust fault appears to decrease rapidly to the south.

The abrupt northward disappearance of map-units 1, 2, 3 and 4 and the southward disappearance of map-units 5 and 6 in the valley south of Little Dal Lake, the latter presumably the result of erosion prior to deposition of map-unit 7, strongly suggests the presence of a cross-fault in the valley. Also, unless large transcurrent movements have taken place, displacement along a cross-fault must have occurred in Proterozoic time before deposition of map-unit 7.

The southwest side of Thundercloud Range is bounded by one major northeasterly dipping thrust fault and at least two similarly directed thrusts of lesser importance. The relationship of this major thrust to the westerly dipping thrust farther north is not clear.

Except for folded and faulted strata near its boundaries, Thundercloud Range is underlain essentially by flat lying to gently warped strata. Another extensive area of nearly flat lying strata occupies north-central Glacier Lake map-area and a large part of western Wrigley Lake map-area southwest and west of a prominent bounding thrust fault. Several conspicuous, northeasterly trending faults along which displacements have been mainly parallel with the dip are exposed in north-central Glacier Lake map-area.

A major southwesterly dipping thrust fault repeats the Palaeozoic succession in southwestern Wrigley Lake map-area. Locally, this fault is marked by a remarkably straight scarp in the alluvium.

The remaining western and southern parts of Glacier Lake map-area are dominated by gently to moderately plunging folds and associated thrust faults. Some of the major structures appear to be linked en échelon. Many folds involving argillaceous strata are tightly compressed and local overturning of beds to the northeast or east is not uncommon.

Southeasterly plunging folds are well displayed southwest of Rabbitkettle Lake and tight folds are characteristic of the Ragged Range farther northwest. Elsewhere in Logan Mountains and Hyland Plateau the major structures are evident only from the general map pattern. The upper part of Flat River valley lies essentially along the axis of a syncline.

Throughout much of Flat River map-area, structures trend north-south. In the eastern part of the map-area, between Caribou and South Nahanni Rivers, uniform folds involving gently to moderately dipping beds are common. Elsewhere beds dip much more steeply and are disrupted by faults and granitic intrusions.

ECONOMIC GEOLOGY

Oil and Gas

The widespread Mesozoic (probably mainly Cretaceous) granitic intrusions eliminates much of Flat River and southwesternmost Glacier Lake map-areas as potentially productive areas for oil and gas. Farther north in Glacier Lake and Wrigley Lake map-areas restricted synclinal areas underlain by Devono-Mississippian shales have some prospects for oil and gas, but most potential reservoir rocks are exposed in the adjacent mountains.

The two best reservoir rocks appear to be the porous, vuggy dolomites of the Manetoe Formation and the less porous but locally vuggy dolomites of the Whittaker Formation. These formations are probably present in the synclinal structures at Grizzly Bear Lake and east of Little Dal Lake. The Arnica Formation also is porous. The Arnica and Whittaker Formations are widespread in Wrigley Lake map-area where locally they are probably buried deeply enough to constitute potential reservoirs.

In general the structure of the synclinal areas appears very complex and the apparent simplicity in some cases is due to the lack of structural data in the incompetent Devono-Mississippian shales. Thus anticlinal closures and structural traps may exist within the synclinoria.

Metallic Minerals

Copper, Silver

Chalcopyrite, bornite, chalcocite, malachite, and azurite occur in bleached zones in the uppermost part of map-unit 5 east and north of Little Dal Lake. Redstone Mines Limited have carried out exploration work including trenching and drilling on the property east of Little Dal Lake. Strata of map-unit 5 also outcrop near Keele River and, as the distribution of copper minerals near Little Dal Lake may be stratigraphically controlled, these siltstones also merit careful prospecting.

Several showings of argentiferous tetrahedrite with some chalcopyrite, bornite, and chalcocite occur in the dolomite breccias of map-units 3, 4, and 24, west and southwest of Dal Lake between Redstone and South Redstone Rivers. The breccias are cemented by crystalline calcite, ankerite, or dolomite and commonly the metallic minerals occur as blebs and masses in the calcite or as disseminations in the breccia. More complete descriptions of these occurrences are given by Baragar and Hornbrook (1963) and Green and Godwin (1963).

Malachite occurs locally along the contact between maroon weathering strata of map-unit 7 and overlying rocks of the Whittaker Formation in Thundercloud Range on a southeasterly trending spur 5 miles northeast of the peak reaching an elevation of 8,230 feet.

Lead, Zinc

Extensive gossans immediately south of North Nahanni River occur in thin-bedded grey limestones near the base of the Delorme

Formation. The easternmost gossan contains coarse crystals of galena, whereas a sulphide body farther west contains pyrite, galena, and sphalerite.

Considerable zinkenite float was noted on a ridge 4 miles west of the mouth of Broken Skull River. The mineral occurs in carbonate rocks of map-unit 22b.

Tin

Tin-bearing minerals occur near lat. 61°24' and long. 126°19' in Flat River map-area. There, a trench in rusty argillite exposes a narrow vein that includes pyrite, galena, sphalerite, stannite, franckeite, and possibly geocronite in a matrix of calcite (Evans, 1957). The adjacent country rock has been pyritized.

Gold (Placer)

Some placer gold has been obtained from Bennett Creek and workings were noted on McLeod and Grizzly Creeks. Little is known, however, about the nature and occurrence of the gold or of the quantity mined.

Tungsten

Minor amounts of scheelite occur along the contact between a granitic stock and rocks of map-units 16 and 18 northeast of Flat River in northwesternmost Flat River map-area. The upper member of map-unit 15a is the host rock for the scheelite deposit at the Canada Tungsten Mine near Flat River in northeasternmost Frances Lake map-area.

Prospecting Possibilities

Gossans are abundant in rocks near granitic plutons in Logan Mountains and merit careful prospecting. In view of the occurrence of a high-grade scheelite deposit in the upper member of map-unit 15a at Canada Tungsten Mine, particular attention might be given to areas where these rocks occur near granitic intrusions.

Numerous morainal deposits are associated with glaciers in Logan Mountains and these afford excellent opportunities for study of

materials that have been derived from bedrock along the course of the glaciers.

Springs

Springs that have in most cases deposited large amounts of tufa are conspicuous in the northern part of Flat River map-area. Warm springs were examined 7 miles east-northeast of Seaplane Lake where a maximum water temperature of 79°F was recorded and at Rabbitkettle Hotsprings where a temperature of 69°F was recorded. Warm springs that have deposited negligible material occur in the valley immediately west of Hole-in-the-Wall Lake. Cold springs were examined near latitude 61°24' in westernmost Flat River map-area and immediately southwest of Flat River near the mouth of Pass Creek. The former has produced a terraced deposit of tufa about 400 feet long and 240 feet wide.

The largest pools of warm water are associated with the springs near Seaplane Lake. There three pools - an upper pool about 250 feet by 100 feet and averaging 8 feet deep; a middle pool about 575 feet long and ranging in width from 50 to 125 feet, with an average depth of 6 feet; and a lower pool about 110 feet by 40 feet with an average depth of 4 feet - are dammed by arcuate deposits of tufa that have grown upwards and inwards. Temperatures range from 64°F in the lowest pool to 79°F in the upper pool. A lush vegetation grows in the bottom of the pools.

Rabbitkettle Hotsprings forms a spectacular, terraced, flat-topped deposit of tufa, roughly circular in plan, with a diameter of about 225 feet and rises 90 feet above the level of Rabbitkettle River. Successive terraces ranging from 6 inches to 12 feet produce the appearance of a giant layer cake. The main spring issues from a pool about 12 feet in diameter near the center of the uppermost terrace.

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