GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

MEMOIR 365

GEOLOGY OF BEECHEY LAKE MAP-AREA, DISTRICT OF MACKENZIE

A part of the Western Canadian Precambrian Shield

L. P. Tremblay

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PREFACE

Beechey Lake map-area was mapped as part of a program designed to obtain a broader knowledge of the relatively unmetamorphosed Precambrian sedimentary and volcanic rocks of the Western Canadian Shield.

The area is part of the Slave and the Churchill Structural Provinces of the Canadian Shield and reflects several periods of orogenesis. Two main groups of sedimentary rocks were recognized: the older Yellowknife Group has been intruded by a variety of granitic rocks, whereas the younger Goulburn Group lies unconformably on the intrusive rocks.

Small amounts of arsenopyrite, chalcopyrite, gold, hematite, magnetite, pyrrhotite, and pyrite were seen in various parts of the region, but no significant mineral deposits were discovered.

Y. O. FORTIER,
Director, Geological Survey of Canada

OTTAWA, June 18, 1968

MEMOIR 365 — Die Geologie des dem westkanadischen Präkambrischen Schild zugehörigen Kartenblatts Beechey Lake (Mackenzie-Distrikt)

Von L. P. Tremblay

In dieser geologischen Betrachtung des dem westkanadischen Präkambrischen Schild zugehőrigen Kartenblatts Beechey Lake (Mackenzie-Distrikt) werden präkambrische sedimentäre Gesteine und Eruptivgesteine beschrieben, die relativ wenig metamorphosiert sind.

МЕМУАР 365 — Геология картографированного участка озера Бичи, район Макензи; часть Западно-Канадского докембрийского щита.

Л. П. Тремблей

Описываются сравнительно не метаморфизованные докембрийские осадочные и вулканические породы.

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GEOLOGY OF BEECHEY LAKE MAP-AREA, DISTRICT OF MACKENZIE: A PART OF THE WESTERN CANADIAN PRECAMBRIAN SHIELD

Abstract

Yellowknife-type sedimentary rocks underlie the central part of Beechey Lake map-area. They are mainly argillite, slate, and greywacke and grade into nodular schists and granitoid gneisses near the margins of the map-area. Numerous bodies of biotite–muscovite granite are abundant in the nodular schists and granitoid rocks. All these rocks are Archean and most of them are part of the Slave Structural Province. The granitoid rocks along the eastern margin of the map-area, however, give an Aphebian age and are placed within the Churchill Structural Province. They appear to be Slave rocks affected by the Hudsonian Orogeny. Extensive areas of Goulburn rocks overlie Slave rocks in the north-central part of the map-area, and within Bathurst Trench the Tinney Cove Formation overlies Goulburn rocks. The Ellice Formation overlies rocks affected by the Hudsonian Orogeny and is correlated with the Tinney Cove Formation. The Goulburn rocks are probably Aphebian as they are cut by gabbro sills dated at 1,215 m.y. Late gabbro dykes dated at 1,050 m.y. cut Goulburn rocks, the Ellice Formation and their underlying rocks. The gabbro sills and dykes are probably Helikian.

Bathurst Trench is a structure of crustal dimension with an apparent horizontal offset of 20 miles. It traverses the northeast corner of the map-area in a north-northwesterly direction.

Gold, iron, and copper showings are known from the area.

Résumé

Le centre de la région du lac Beechey est recouvert de roches sédimentaires du type Yellowknife. Ces roches sont surtout des argilites, des ardoises et des grauwackes, et près de la périphérie de la région elles se transforment graduellement en schistes cristallins nodulaires et en gneiss granitoïdes. Il y a dans les schistes nodulaires et dans les gneiss granitoïdes plusieurs masses de granite à biotite et muscovite. Toutes ces roches sont de l'Archéen et la plupart d'entre elles font partie de la province tectonique des Esclaves. Cependant, les roches granitoïdes, le long de la limite est de la région qui datent de l'Aphébien, sont placées dans la province tectonique de Churchill. Elles semblent être des roches de la province des Esclaves affectées par l'orogenèse hudsonienne. Il y a dans la

partie centrale nord de la région de grandes étendues de roches du groupe de Goulburn; ces roches reposent en discordance sur celles de la province des Esclaves et dans le fossé de Bathurst, elles sont recouvertes par la formation de Tinney Cove. La formation d'Ellice recouvre des roches qui ont été affectées par l'orogenèse hudsonienne, et elle est mise en corrélation avec la formation de Tinney Cove. Les roches du groupe de Goulburn datent probablement de l'Aphébien vu qu'elles sont coupées par des filons-couches de gabbro âgés de 1,215 millions d'années. Les dykes récents de gabbro ont été datés à 1,050 m.a.; ils coupent les roches du groupe de Goulburn, la formation d'Ellice et les roches qui en sont sous-jacentes. Les filons-couches et les dykes de gabbro sont probablement de l'Hélikien.

Le fossé de Bathurst est une structure de grande dimension, son déplacement horizontal apparent est de 20 milles. Le fossé coupe l'angle nord-est de la région en direction nord-nord-ouest.

Il y a dans la région des indices d'or, de fer et de cuivre.

INTRODUCTION

Beechey Lake area occupies 4,000 square miles in the Northwest Territories between 65° and 66°N and 106° and 108°W. The northeast and farthest corner of the map-area is 350 miles northeast of Yellowknife; the north boundary is less than 25 miles south of Bathurst Inlet on the Arctic coast or about 40 miles south of the Arctic Circle. The area is reached by chartered aircraft from Yellowknife. Churchill is 600 miles to the southeast and Uranium City 470 miles to the south. All land or water routes from these various centres are long, tedious, and impractical.

Travel in the area is difficult (Figs. 1, 2): roads are non-existent and water routes are not good. Back and Western Rivers could possibly be used in the spring at high water, but this is not advisable because the water is too cold and too swift. In July and August their use is not recommended as water is low with an almost continuous succession of all but impassable rocky rapids. Beechey Lake is the only part of Back River that provides easy access to a large tract of land in the centre of the map-area.

The area is of little economic value. No mineral deposits of any significance are known, but gold, copper, and iron showings were found at a few places.

The writer was ably assisted in the field by Raymond Mongeau, R. S. Sylyski, J. W. Tedford, and A. Sisonenko in 1962 and by Maurice Séguin in 1963.

G. M. Wright first mapped the area in 1955 as part of a helicopter-supported project. Results of this study were published at 8 miles to 1 inch (Wright, 1957). In 1962 and 1963 the writer restudied the area. On the whole the geological boundaries have remained the same. During this study emphasis was placed on the stratigraphy of the basal units of the Goulburn Group, which was mapped at 1 mile to 1 inch; on the nature of Bathurst Trench and its extension to the south; on the boundary between the Churchill and Slave Provinces; on the unusual concentration of basic rocks near the Trench and the boundary; and on a re-evaluation of the geology of the basement. Air photographs were used extensively to check the geological boundaries; this work was supplemented by ground traverses in the northwest corner of the map-area, in the south half of Beechey Lake, and around Regan Lake. Most geological boundaries, particularly those between massive granite and bedded sediments, show well on air photographs.

The area is in the tundra region north of the treeline and vegetation consists mainly of moss, lichen, and grass. Small bushes, 3 to 4 feet high, are rare and were seen generally along the main rivers, on the shores of some of the lakes, and on a few south-facing slopes.

Wildlife is fairly abundant in June when the caribou are moving north and in late July or early August when they are migrating south. Herds of possibly two thousand were seen. Grey and white wolves, foxes, ptarmigans, partridges, barren ground hare, and numerous varieties of birds were seen. Fish are abundant in most of the larger lakes and rivers. Tracks of the barren ground grizzly bear were seen on some sandy plains.

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FIGURE 1

Terrain of low relief typical of areas underlain by Yellowknife-type sedimentary rocks. These rocks are heavily frost-heaved along bedding and joint planes. The frost-heaved blocks are slabs elongated parallel to bedding planes. Many outcrop areas are made entirely of these frost-heaved slabs piercing through a thin mantle of gravel or morainic material. Hammer on slab for scale.

154912

FIGURE 2

Looking southeast towards a gabbro dyke in background. The angular equant blocks in foreground are frost-heaved blocks from massive Yellowknife-type sedimentary rocks. These blocks generally occur in large chaotic accumulations covering wide areas. Such accumulations generally include occasional glacial erratics.

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The climate is subarctic; summers are cool with frequent mist and light rain. Break-up of ice on most lakes generally takes place in the first ten days of July, and ice starts to form late in August. Snow storms are not unusual during August, and strong wind makes walking difficult and tiring.

Rock exposures are abundant and fairly clean in granite and granitized areas, except along the east boundary of the map-area. The Yellowknife-type sediments are well exposed along some lakeshores or along abandoned river channels where all growth and gravel were removed by run-off from the melting ice. Both shores of Beechey Lake were cleaned of gravel up to at least 150 feet above present lake level. Several abandoned channels were seen east of Beechey Lake and west of Ellice River; on such channels rock exposures are continuous and clean and many of them are true cross-sections.

Elevations vary from less than 500 feet along Western River near the northern boundary of the map-area to more than 1,600 feet along the southern margin of Goulburn rocks. Relief is about 1,000 feet along the northern part of Western River and about 600 feet near the edge of the area of Goulburn rocks, but in general it is around 200 to 300 feet. The area is fairly rugged as variations in elevation are abrupt and common. Along the west boundary elevations locally reach 1,600 feet but most are 1,400 to 1,500 feet. Stretches along Back and Western Rivers and in the northeast corner of the map-area lie at approximately 900 to 1,000 feet elevation and are the lowest parts of the Beechey Lake area.

Drainage is through three main rivers, Back, Ellice, and Western. All waters drain eventually into the Arctic Ocean. The drainage is rough, as it is either through a succession of small lakes connected by bouldery streams or along fairly wide rivers which are also an irregular succession of rocky shallow rapids. The southern two thirds of the area is drained by Back River, the northeast corner by Ellice River, and the north–central part by Western River. The head of Western River appears to be advancing south and may eventually capture some of the Back and Ellice Rivers drainage.

The area was entirely glaciated. There are definite indications of variations in the directions of movement of the ice, some of which suggest possible multiple glaciation (Fig. 3). Most of the glacial features observed in the field and recognized on air photographs are the results of only one glaciation. These features are drumlinoid ridges and glacial striae or grooves. West of a line passing through Casey Lake and the chain of lakes that extends southeast from latitude 65°44′N, longitude 108°W, drumlinoid ridges trend slightly south of west, whereas east of this line similar hills trend northwesterly. The change in direction occurs over a short distance and rather abruptly. Such a sudden change of direction in the movement of the ice mass is difficult to explain, but it may be due to stagnant ice over the area of Goulburn outcrops. The glacial striae follow the same pattern. Near the north boundary of the map-area, however, at least two main directions of glacial striae were measured: one is indicated by occasional readings and seems to suggest an older southerly ice advance; the other readings are almost entirely between northwesterly and westerly and are probably due to the same ice mass as that responsible for the drumlinoid ridges trending in that direction. Minor variations in the directions of the glacial striae measured indicate local variations in the movement of ice.

Numerous abandoned river channels occur from Beechey Lake northeastward to Western and Ellice Rivers. These channels were probably used when Beechey Lake was much larger and its waters (about 150 feet higher than now) flowed north into Western River valley. At that time an arm of the sea (Bird, 1961; Craig, 1964, p. 27) extended slightly beyond the sharp bend at the south end of the valley. The thick deposits of sand, clay, and gravel, about 150 feet, on both sides of the valley were probably

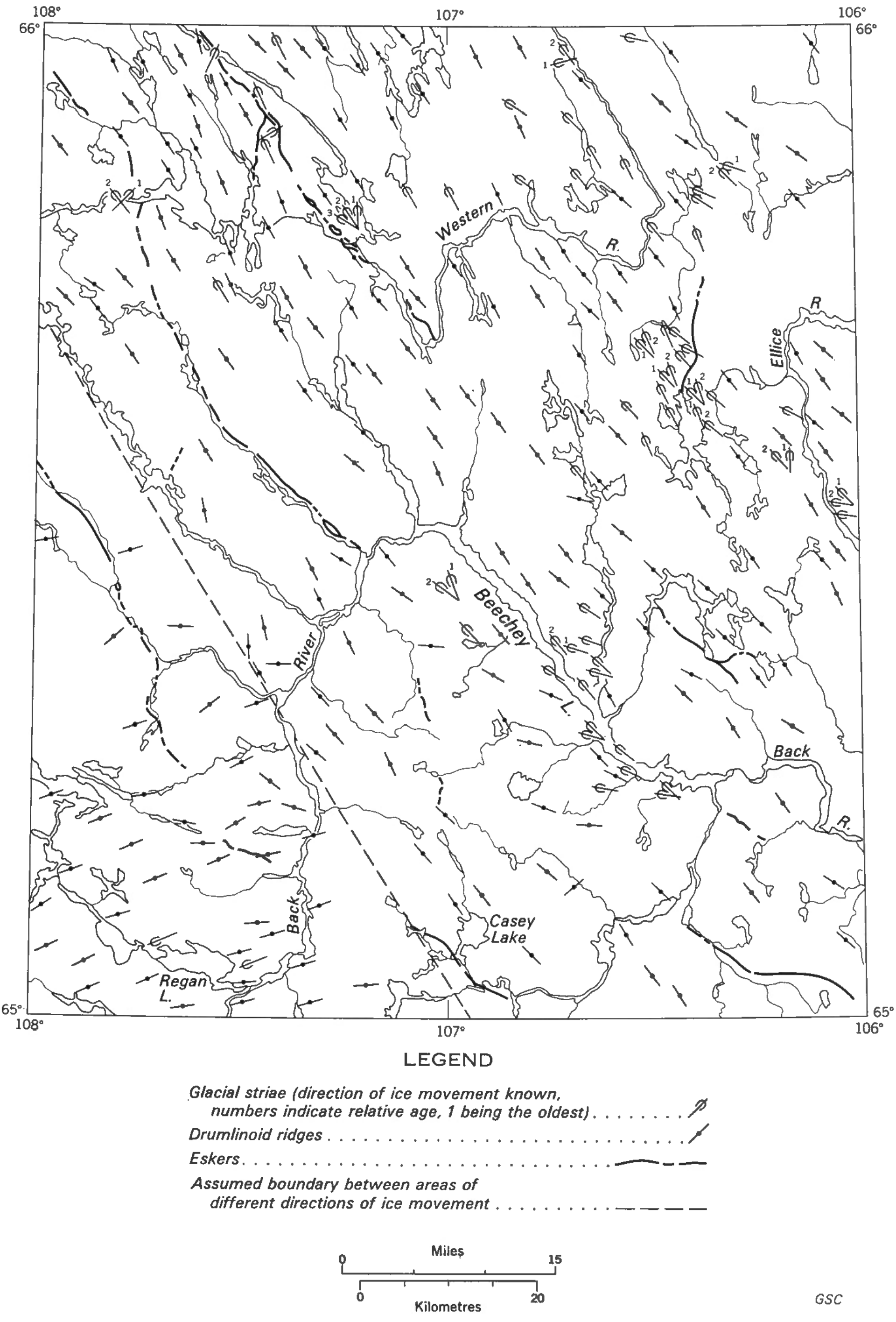

FIGURE 3. Directions of ice movements in Beechey Lake area, mainly from interpretation of air photographs.

deposited in this arm of the sea from northward-flowing rivers. At one time these deposits probably covered the floor of this valley up to the thickness mentioned above—at least in the part of the valley south of the northern boundary of the map-area. These deposits have been extensively eroded by Western River. Four stages of terrace development including the present bottom of Western River valley were recognized, which suggests either repeated land uplifts, or a gradual lowering of the sea level interrupted by stillstands.

GENERAL GEOLOGY

All rocks of Beechey Lake area are Precambrian, and consist mainly of an intermixture of thinly bedded argillite, slate, greywacke, and impure quartzite. These are probably of Archean age and are Yellowknife-type.[1] Along the eastern, southern, and western margins of the map-area the Yellowknife-type sedimentary rocks were metamorphosed during the Kenoran Orogeny to phyllites, nodular cordierite–andalusite–staurolite schist and gneiss, and possibly to granitoid and granitized gneiss. Near the eastern and southern margins, these metamorphic rocks, although regarded as Archean, appear to have been affected slightly by the much younger Hudsonian Orogeny as they give an Aphebian isotopic age. Their granitoid appearance may date from Hudsonian metamorphism. Intrusive into the Yellowknife-type sedimentary and metamorphic rocks are numerous bodies of massive to porphyritic biotite–muscovite granite and occasional dykes and sills of an old altered gabbroic rock.

Overlying unconformably all these rocks and outcropping in a triangular-shaped area near the northern boundary of the map-area is the Goulburn Group of younger sedimentary rocks of probable Aphebian age. These younger rocks comprise a thick succession of argillites, quartzites, and dolomites known as the Western River Formation, which is overlain conformably by up to at least 9,000 feet of pink quartzite and conglomerate, the Burnside River Formation. These successions are overlain unconformably by the Tinney Cove Formation in Bathurst Trench. The Ellice Formation, mainly sandstones, is correlated with the Tinney Cove Formation.

Older and younger rocks are cut by gabbro dykes and sills of Helikian (Middle Proterozoic) age.

Yellowknife-type Rocks

Sedimentary Rocks

Sedimentary rocks of the Yellowknife Group underlie about half of Beechey Lake area and are the most common rocks. Abundant outcrops extend from Beechey Lake northward to Western River, eastward to the eastern boundary of the map-area, and westward almost to its western boundary, occurring in the northwest corner of the map-area and beyond Regan Lake in the southwest corner. South of Beechey Lake they grade into metamorphic equivalents, which are mapped separately. These sedimentary rocks are all fresh looking and relatively unmetamorphosed, and grade to the east, south, and west, near the edges of the map-area, into nodular schists and granitoid or granitized rocks. They are mostly fine grained to dense. Weathered surfaces are grey to black and light brown. As seen in hand specimens they are composed of tiny clastic quartz and feldspar grains in a dense matrix wherein tiny mica flakes can be discerned. Four main

[1] Similar in appearance and deformation to the sedimentary rocks of the Yellowknife Group of the Yellowknife area, which is regarded as the type area.

Table of Formations

Time			Group, Formation, Member	Lithology
Cenozoic				Morainic material: gravel, sand, clay, silt
Unconformity				
Precambrian	Proterozoic	Helikian		Gabbro dykes and sills
			Intrusive contact	
				Gabbro sill
			Intrusive contact	
			Tinney Cove Formation: Ellice Formation	Sandstone, conglomerate; sandstone, conglomerate, shale and carbonate
		Unconformity (?)		
		Aphebian	Goulburn Group Brown Sound or Kuuvik Formation (?)	Shale, dolomite, sandstone and conglomerate
			Burnside River Formation	Quartzite, conglomerate, minor shale and slate
			Western River Formation Upper Argillite Member	Grey and red argillites, white and pink quartzites
			Quartzite Member	White quartzite; buff, massive, siliceous dolomite
			Red Siltstone Member	Red argillite, minor grey argillite
			Lower Argillite Member	Grey argillite, minor quartzite and dolomite
			Basal Conglomerate Member	Quartz-pebble conglomerate
	Unconformity			
	Archean			Granite and pegmatite dykes and sills Old altered gabbro and diorite (dykes and sills) Gneiss derived from Yellowknife-type rocks: nodular cordierite–andalusite–staurolite schist and gneiss; Granodiorite and granitized gneiss; minor amphibolite and hornblende schist and gneiss, and younger granite Biotite granite, biotite-muscovite granite; porphyritic
			Intrusive contact	
			Yellowknife Group	Yellowknife-type sedimentary and volcanic rocks: mainly greywacke, impure quartzite, argillite and slate; minor agglomerate, tuffs, basic and acidic volcanic rocks

rock types were recognized: greywacke, argillite, slate, and quartzite. There are also some agglomerate, tuff, and basic volcanic rocks in the southwest corner. Iron-formation and carbonate beds were recognized in very small or trace amount. The greywacke, argillite, slate, and quartzite occur in thin beds and are closely interbedded with one another. In places they are traversed by small, thin lenses and veins of milky white to grey and black quartz. These veins and lenses are mostly less than 3 inches thick but may locally be a foot; the thickest lenses carry some white feldspar.

Greywacke is the most abundant constituent of this sedimentary succession, probably forming about 65 per cent. In some local outcrop areas, however, argillite, slate, and quartzite are more abundant. Nevertheless, argillite and slate form only about 30 per cent of the whole succession, and quartzite does not constitute more than 5 per cent.

The greywacke is ordinarily massive, fine grained, and grey to dark grey. It consists of abundant tiny clastic quartz and probable feldspar grains in a dark dense matrix wherein small amounts of tiny mica flakes can be seen with the naked eye. Beds are generally 6 inches to a foot thick, but locally reach 15 feet. A few beds are visibly arenaceous. In general beds of greywacke are lighter grey, coarser grained, and thicker than those of argillite and slate, but they are darker grey and of about the same grain size and thickness as the quartzite beds. They are closely interbedded with argillite and quartzite beds. Because of their massive nature and siliceous composition, the greywacke beds stand out in relief in relation to the argillite beds.

The following variations in beds of greywacke were noted: Some weather lighter grey, are more siliceous, and have fewer mica flakes; these are probably gradational to the quartzite beds. Some are slightly more schistose, less massive, and darker grey to black at least in part on weathered surface; these are probably related to the argillite of the succession and may be argillaceous greywacke. Some weather light brown, are coarser grained, and appear to contain a greater number of mica flakes. They are probably of slightly different composition or have been slightly more metamorphosed. Some are coarser grained, carry a fair amount of a dark green mineral, and have a dioritic appearance on polished outcrops. This variety is slightly gneissic or schistose and is various shades of grey, blue, and green. It is probably rich in CaO. Some have lenticular to irregular dioritic patches. These are zoned, elongated parallel to the bedding, and were probably calcareous concretions now recrystallized to a chlorite- or amphibole-bearing rock. The patches have a narrow yellowish white zone on the outside enclosing either a uniformly or an irregularly zoned core.

The argillite weathers black, grey-black to dark grey, is fine grained to dense, and is chiefly schistose although some is massive. The massive argillite grades into greywacke and phyllite. Where cleavage is pronounced, the argillite is a slate and there is complete gradation between argillite and slate. Argillite beds are generally less than 3 inches thick, most are an inch or less. They occur either in groups forming fairly thick layers or successions, or as individual beds or pairs of beds, separating the much thicker greywacke or quartzite beds. Some of the beds contain syngenetic pyrite or pyrrhotite and are rusty. The argillite differs from the greywacke in that it is generally black instead of grey, schistose instead of massive, and has few tiny quartz or feldspar grains in an abundant black dense matrix where mica flakes are more apparent and more abundant than in the matrix of the greywacke. Its beds are also thinner.

In contrast, the quartzite is grey-white, white and yellowish white, has a dense siliceous appearance and does not exhibit on fresh surface readily visible clastic quartz grains and abundant mica flakes in a dense base. It is a massive, thickly bedded rock with beds comparable in thickness to those of the greywacke; they reach 35 feet as measured in well-exposed sections. It is interbedded with greywacke and argillite. Locally it seems to grade into greywacke through transitional facies, which are darker grey and contain a few tiny clastic quartz grains in a dense siliceous base and some mafic minerals. This variety was generally mapped as an 'impure' quartzite. Another variety was noted near the western boundary of the exposures of Ellice Formation. This quartzite is glassy white to transparent, massive, and intensely fractured; it weathers glassy grey to white and shows neither bedding nor any other sedimentary structures. At one place the white variety is schistose and to the south and east seems to pass into a schistose quartz-pebble conglomerate. Occasional beds of feldspathic quartzite were seen throughout the area. They are medium to coarse grained and granitoid, and like the other quartzite beds are white to light grey where weathered.

In thin sections the greywacke, argillite, and quartzite members all display pronounced clastic textures, are stratified and interstratified to various degrees, and are composed of the same minerals although in slightly different proportions. Because of these similarities and their close relationship in the field they are described together to emphasize their distinctive features in thin sections.

The clastic texture is represented by quartz and feldspar fragments in a fine-grained matrix of quartz, feldspar, sericite, and chlorite. The fragments are subrounded to subangular, average 0.4 mm in greywacke, are slightly larger in quartzite, but are only 0.04 mm in argillite. The matrix averages 0.01 mm or less. In greywacke, fragments constitute about 50 per cent of the rock, whereas in argillite they are less than 20 per cent. In quartzite there is very little matrix. The estimate for argillite may be incorrect as it is commonly difficult to distinguish fragments from matrix. The fragments are almost entirely quartz, feldspar, or a mixture of quartz and feldspar. The matrix is made up of various amounts of quartz, feldspar, sericite, chlorite, and biotite.

Stratification can be seen in most thin sections. It is crude and not always visible in thin sections of greywacke or quartzite, but it is sharp and common in those of argillite. It is marked by variations in the amount of fragments or matrix, in the size of the fragments from layer to layer, and in composition or mineral content. This stratification is also accentuated by an elongation and an orientation of the fragments and flakes of mica and chlorite in the direction of the stratification.

Greywacke has more quartz and feldspars than the argillite (Table I) but less micas and chlorite. There is probably a complete gradation from greywacke to argillite. In general the greywacke has 60 per cent felsic minerals, 35 per cent mica, chlorite, and amphibole, and 5 per cent opaque minerals. In the argillite the content of opaque minerals is the same or slightly larger, the felsic minerals represent only 35 per cent of the rock, whereas the mafic minerals such as micas, chlorite, and others represent 60 per cent. The quartzites have more quartz and feldspar than the greywacke and less dark minerals and sericite.

Quartz and feldspar are generally present in about the same amount and occur both as fragments and in the matrix. The quartz is usually in somewhat larger grains or fragments than the feldspars although a few feldspar grains are as large as those of quartz. The feldspar is mainly oligoclase and albite. Some potassic feldspar was noted and also some myrmekite.

Biotite is reddish brown and occurs mainly in large poikiloblastic and ragged flakes. It is found also in small amounts in the matrix. All of it appears to be late and to be recrystallized material. The larger flakes are oriented at right angles to the stratification and are responsible for the spotted appearance of some of the argillites. Chlorite and sericite form irregular aggregates in the matrix; sericite is by far the more abundant and common and in some slides is the only one present. Epidote is locally found with chlorite and sericite. The amphibole is needle-like actinolite that occurs as rosettes. In some slides it represents 20 to 25 per cent of the rock. The opaque material is uniformly distributed mainly as fragments slightly larger than the grains of the matrix but smaller than the fragments of quartz and feldspar. Apatite, sphene, and bluish green tourmaline are present in small amounts.

Interbedded with these sedimentary rocks are narrow zones of banded iron-formation. These rocks are rare and were recognized at only two localities. One is at the north end of the lake with elevation 900 feet west of Ellice River, where the banded iron-formation was traced for 2 miles and the zone is at least 4,000 feet wide. This zone appears to be cut by a small granite body. The other occurrence is about 8 miles northeast of the unnamed lake, elevation 1,080 feet, in the northwest of the map-area, a short distance west of the unconformity between Goulburn- and Yellowknife-type sediments. Aeromagnetic data were not available to check the extent of this banded iron-formation.

The iron-formation north of the unnamed lake with elevation 900 feet west of Ellice River is well layered and very fine grained. Several rock types were recognized. All layers are thin, and average less than an inch. Their composition varies from almost pure magnetite layers to cherty or quartzitic rocks free from magnetite. There are white, red or pink, and black layers of chert, green layers rich in chlorite or amphibole, magnetite layers, and layers with varying amounts of magnetite—either disseminated, or in streaks, lines, and spots in other material, generally chert. The iron-bearing layers are irregularly distributed over the width of this zone. Garnet was noted in some of the amphibole-bearing layers. The iron-formation west of the unconformity occurs as a thin formation about 50 feet wide, and is not so well layered as that to the east. Its layers also appear to be thicker. Some siliceous layers are white, dense, and may carry up to 15 per cent pyrite. Other layers are dark green to black, chlorite-bearing and, in general, much serpentinized; they may also carry magnetite. Other black layers are rusty, deeply weathered and generally magnetite-bearing. This lenticular zone of banded iron-formation was traced for a mile along strike.

As seen in thin section the banded iron-formation is extremely well layered, resembles a clastic rock, and is made up mainly of quartz, magnetite, sericite, and varying amounts of chlorite or amphibole. Layers are generally less than a fraction of an inch wide; grain size varies from 0.1 to 0.005 mm and probably averages around 0.05 mm. Of the several types of layers, some are quartzose, some are magnetite-rich, and others are amphibolitic. The quartzose layer has about 80 per cent quartz, 10 per cent sericite, 5 per cent chlorite, and 5 per cent opaque minerals. The magnetite-rich type is made up of about 40 per cent magnetite, 25 per cent quartz, 25 per cent sericite, and 10 per cent chlorite. Locally this type has hornblende instead of sericite and chlorite, and biotite is usually present in small amounts. The amphibolitic layers, which are not too common, are made up of large red garnet (cell-edge: 11.570) metacrysts in a base of amphibole, quartz, and some reddish brown biotite. The garnet metacrysts, however, are not present in all amphibolite layers. Chlorite occurs generally in small amounts.

Occasional narrow carbonate layers noted at two places trend parallel to the bedding of interbedded greywacke, argillite, and phyllite. The rock of these layers is massive and reddish brown on weathered surface and appears to be entirely carbonate.

Volcanic Rocks

Two southeasterly trending belts of agglomerate, tuffs, and acidic to basic volcanic

TABLE I — *Estimated mineral compositions in per cent of the sedimentary rocks, nodular schists, and granitoid gneisses of the Beechey Lake area*

Rock types:	Sedimentary Rocks		Nodular Schists		Granitoid Gneisses[1] along east margin of map-area
	Greywacke	Argillite	West of unnamed lake[2] (65°30′N, 107°35′W)	South of Beechey Lake[3]	
Number of specimens	7	8	3	4	7
Quartz	60 (quartz, plagioclase and potassic feldspar together)	35 (quartz, plagioclase and potassic feldspar together)	20–30	25–30	25–30
Plagioclase			15–20	10–15	35
Potassic feldspar			some	some	5(0–25)
Mafic minerals	35 (mafic minerals and muscovite together)	60 (mafic minerals and muscovite together)	25	35	15
Muscovite			5	10	10
Opaque material	5	5	2	2	2
Porphyroblasts or nodules			15	5	

Mineral assemblages:

[1]In the granitoid gneisses (7 thin sections): all have plagioclase, quartz and chlorite; other minerals present: muscovite, biotite, garnet, staurolite (1 T.S.); muscovite, biotite (2 T.S.); biotite, muscovite, microcline (2 T.S.); biotite, garnet (1 T.S.); muscovite (1 T.S.).

[2]In the nodular schists, west (3 thin sections): all have plagioclase, quartz, biotite, staurolite; other minerals present: muscovite, chlorite (1 T.S.); sericite, chlorite, andalusite (?) entirely altered to sericite (1 T.S.); sericite, micrographic intergrowth, cordierite in part altered to chlorite, andalusite (?) entirely altered to sericite (1 T.S.).

[3]In the nodular schists, south (4 thin sections): all have plagioclase, quartz, biotite, andalusite, chlorite; other minerals present: muscovite, cordierite, sericite from andalusite (1 T.S.); muscovite (1 T.S.); muscovite, sericite and sillimanite from andalusite (1 T.S.); staurolite, sericite and sillimanite from andalusite (1 T.S.).

rocks were mapped west and south of Regan Lake in the southwest corner of the map-area. These rocks are in part interbedded or interlayered with the greywacke and argillite already described. Grey acidic volcanic rocks, tuffs, and agglomerates are the main rocks of these two belts, but there are also some dense to fine-grained, massive greenstone and basic volcanic rocks. The greenstone and the basic volcanic rocks appear to be flows. The tuffs are distinguished from the Yellowknife-type sediments by their layering, which is much different from the bedding of the argillite and greywacke; by their fine-grained texture where weathered, which resembles volcanic ash; and by their seemingly high feldspar content. Their association with rocks that are regarded as agglomerate and that are probably acidic or basic flows is also indicative that these belts are mainly volcanic material. Finally, these tuffaceous rocks do not contain the tiny clastic quartz grains visible to the naked eye that are so typical of the greywacke and argillite.

Four thin sections were cut from the volcanic rocks: three from the grey weathering tuffs or agglomerate and rhyolitic rocks, and one from the dark green basic rock. One of the grey rocks is probably a tuff as in thin section it exhibits fragments of feldspars, quartz and chert, or fine-grained felsic rock and is crudely to strongly layered. The base to the fragments is fine grained and made up of chlorite, sericite, and felsic material. The chlorite and sericite occur as tiny grains forming long lenticular streaks and bands separated from one another by the felsic material. This is probably a relict depositional feature. The other two sections may be rhyolite or intermediate volcanic rocks. One has large oligoclase (about An_{25}) crystals and large lenticular chloritic agglomerations in a base made up of tiny feldspar laths (about An_{25}), blebs of carbonate and sericite needles, all set in a dense homogeneous acidic mass. The other shows amygdules of quartz or carbonate or both in a base of tiny feldspar laths, sericite flakes, and quartz in abundant chlorite. The opaque material represents 5 to 10 per cent of these rocks. The thin section from the basic rock is from a gabbroic rock. It is made up of large completely altered pyroxene crystals in a base of much altered feldspar laths and fresh micrographic intergrowths. There are also large irregular patches of leucoxene and probably ilmenite. Most of the feldspar laths are altered to chlorite, epidote, and carbonate, whereas the pyroxene is altered to chlorite and amphiboles.

Nodular Schists and Granitoid Gneisses

Near the margins of the map-area, the group of sedimentary rocks passes gradually into nodular schists on the west and south and into granitoid gneisses on the east. East of Bathurst Trench the area is underlain entirely by granitoid gneisses and granitized rocks. On the map these are placed with the granitoid gneisses that are known to grade into the Yellowknife-type sedimentary rocks, and are described with them, as they are thought to be derived from the same sedimentary rocks even though locally they are superimposed on the nodular schists, which are themselves derived from Yellowknife-type sedimentary rocks.

The nodular schists occur in the northwestern part of the map-area and south of the south half of Beechey Lake. Their probable extent is shown on the accompanying geological map. This distribution is based on Wright's helicopter work (1957) and on a few traverses done by the writer in critical areas.

West of 65°30′N, 107°35′W, gradation from relatively fresh sedimentary rocks to nodular schists is gradual. They are separated by a zone where biotite forms spots and large flakes, which was mapped with the relatively fresh sedimentary rocks. It is followed by a zone where nodules are abundant, and prominent on weathered surface. The first appearance of nodules in the biotite zone marks the beginning of the nodular schists. The nodular zone could be called the cordierite zone, as the nodules are generally made up of poikiloblastic grains of cordierite. This passes to another zone where staurolite crystals are abundant and are the characteristic feature of the weathered surface. The crystals are typically brown, prismatic, and square to six-sided in cross-section. In this zone the cordierite nodules are still present but they are not so obvious and seemingly not so abundant as they are in the nodular zone. Andalusite also occurs locally. Farther west the staurolite zone probably passes to a zone where the rock is granitoid or almost so; this was not recognized or mapped by the writer. However, the westernmost outcrops visited west of 65°30′N, 107°35′W indicate that the rock becomes coarser grained and more granitized with granitoid blebs and pegmatite dykes occurring locally.

Rock of the biotite zone is light brown, sandy, and resembles greywacke. It is a fine-grained, quartz–feldspar–biotite granoblastic rock with a faint gneissic structure. As the size of biotite flakes increases the foliation becomes more pronounced. The matrix or base to the cordierite and andalusite nodules in the nodular zone and to the staurolite crystals in the staurolite zone is a rock similar to the granoblastic rock of the biotite zone, but its grain size is slightly larger and its foliation much better developed.

In all three zones bedding was recognized and measured. It is much better preserved in the biotite and nodular zones than in the staurolite zone and farther west. In the biotite and nodular zones it is accentuated locally by concentration of large biotite flakes or nodules in some beds or parts of beds.

South of the south half of Beechey Lake the nodular schists are similar to those of other parts of the map-area. They are characterized as usual by abundant nodules in a fine-grained granoblastic matrix. However, the three distinct zones of increasing metamorphism indicated west of 65°30′N, 107°35′W cannot be recognized south of Beechey Lake, and present work suggests that if they do occur they are of very irregular outline. Staurolite appears to be missing, or if present its occurrence is not so striking as it is west of the lake at 65°30′N, 107°35′W. Andalusite and cordierite are the main metamorphic minerals. They constitute the nodules or the porphyroblasts. The schists are strongly nodular on weathered surface, they weather black and dark rusty brown, and are fine-grained quartz–feldspar–biotite granoblastic rock with abundant cordierite nodules and andalusite porphyroblasts. The andalusite occurs as pink, prismatic grains with vitreous luster. The prisms are up to 3 inches long by an inch wide. Where the rock is coarser grained, the mica flakes are larger and the rock more schistose. In general, formation of these nodular schists was not related to the granite bodies for where schists are in contact with the granite they have not been affected by it and the contact zone between relatively fresh sedimentary rocks and nodular schists seems to cut across the granite bodies. This relationship also appears to be true in the area west of 65°30′N, 107°35′W, but there it could not be checked in the field.

The gneisses along the east boundary of the map-area and east of Bathurst Trench are not nodular, but are granitoid and resemble granitized rock. They are generally coarser grained than the average nodular schist and where weathered are much lighter in colour. Their content of dark minerals is generally much less than that of the nodular schists. Their apparent composition on weathered surfaces is that of granite or granodiorite, and the large cordierite, andalusite, and staurolite grains recognized in the nodular schists were never seen here except in the immediate vicinity of the nodular schist zone in the southeast corner of the map-area where remnants of cordierite nodules were recognized in the granitoid gneiss a short distance from the contact. This suggests that a phase of metamorphism was superimposed on nodular schists changing the schists into granitoid gneiss. However, locally throughout these granitoid gneisses a few large augen-like porphyroblasts of white feldspar or quartz or both and a few discrete crystals of garnet were noted.

On the outcrops the granitoid gneisses are white, rusty white, and brownish white; some are red and reddish white. A few outcrops are brown with white spots. These gneisses are massive to foliated. The massive variety is coarse grained, granitoid, granodioritic, and white to reddish white. The foliated variety is generally red and brown or rusty brown; it seems to be made up of layers of the massive granitoid variety and of layers that are finer grained, granoblastic to locally faintly schistose and higher in dark mineral content. Dark mineral-rich layers generally have garnet, whereas in the white massive granitoid layers garnet is missing. Throughout these gneisses locally large areas with gradational contacts are made up of a finer grained rock that resembles sedimentary rocks similar to those from which the nodular schists are believed to have been derived. These areas may represent remnants of these sedimentary rocks not completely changed to granitoid rocks, and may suggest not only variation of composition but also different degree and type of metamorphism accounting for the formation of granitoid gneiss instead of nodular schist.

In thin sections the nodular schists and the granitoid gneisses are seen to differ in mineral composition and texture. The nodular schists have andalusite, cordierite, and staurolite which do not occur in the granitoid gneisses. Apart from the above-noted metamorphic minerals, both rock types are composed of about the same suite of minerals: quartz, feldspars, biotite, muscovite, chlorite and opaque material, in different, or slightly different, amounts. The minerals andalusite, cordierite, and staurolite occur in the nodular schists in large nodules or irregular porphyroblasts and account for the nodular appearance of these schists. The granitoid gneisses are ordinarily not nodular, but they may be locally crudely porphyroblastic and now and then contain large blebs of feldspar or quartz or both. In two thin sections of the granitoid gneiss, large cordierite nodules were recognized not far from the contact with nodular schists and are interpreted as relicts of nodular schists within granitoid gneiss (*see* Table I).

The nodules have irregular outlines and enclose many tiny quartz and biotite grains or inclusions. Most of the andalusite and cordierite nodules are altered, the cordierite to chlorite and the andalusite to sericite and sillimanite. The staurolite is fairly fresh, but in a few places south of Beechey Lake it appears to be replaced by andalusite altered to sericite and sillimanite. The nodules are set in a very fine grained matrix composed of granoblastic quartz and plagioclase with many scattered biotite flakes. The reddish brown, oriented biotite flakes are larger than the quartz and feldspar grains. The plagioclase is mainly an andesine more sodic than An_{40} and some of it appears to be a calcic oligoclase (about An_{26}). In the granitoid gneisses the quartz and feldspars are interlocked as in granite and have interstitial biotite, muscovite, and chlorite. Their grain size is larger than that of the quartz and feldspar grains in the nodular schists. The biotite flakes, however, are about the same size as those in the schists, but they are not so uniformly distributed, they are in clusters or are interstitial, and surround the quartz and feldspar grains. At one locality about 12 miles east of the Bathurst Trench, the plagioclase is almost a labradorite but in general it is an andesine less than An_{40} or a calcic oligoclase. Near and along Bathurst Trench, it is locally much less calcic. In a few places the K-feldspar may constitute up to 25 per cent of the granitoid gneisses; in others it is almost absent. These rocks are much brecciated and mylonitized along and on both sides of Bathurst Trench.

The nodular schists and the granitoid gneisses have about the same amount of opaque material, quartz, and muscovite, but they show marked differences in their biotite, chlorite, plagioclase, and potassic feldspar contents. The granitoid gneisses have about 35 per cent plagioclase, 15 per cent biotite and chlorite, and as much as 25 per cent potassic feldspar, whereas the nodular schists have less than 15 per cent plagioclase, as much as 30 per cent biotite and chlorite, and no potassic feldspar. Their mineral composition is that of a quartz monzonite or a quartz diorite. The nodules in the nodular schists represent about 10 per cent of the rock. These mineral contents suggest that the nodular schists are derived from the argillite and argillaceous greywacke of the sedimentary suite already described, whereas the granitoid gneisses appear to be derived from the same sedimentary suite but from slightly different rock types, probably from more siliceous rocks such as siliceous greywacke and impure quartzite. However, a short distance east of Beechey Lake, the Yellowknife-type sedimentary suite grades into quartzofeldspathic gneisses and nodular schists. Thus it seems that the development of a type depends on factors other than composition.

Hornblende schist and hornblende-feldspar gneiss were recognized at several places east of Bathurst Trench and were mapped locally. The northern extension of a wide belt in the northeast corner is outside the map-area, but its southern extent is not fully known as the extension of this zone was not entirely mapped. However, it appears to pinch out in that direction. Other occurrences seen during the few ground traverses made were too small to map. These gneisses were not recognized west of Bathurst Trench; it is likely that they are present but not extensive. Not enough work was done in the nodular schist areas south of Beechey Lake and west of 65°30′N, 107°35′W to ascertain the presence of similar rock.

The wide zone that was partly outlined in the northeast corner of the map-area is a mixture of thinly bedded hornblende schist, biotite–hornblende schist, quartz–feldspar–biotite schist and abundant masses, sills and dykes of a coarse-grained white granite or pegmatite. There are also beds of argillite, greywacke, and quartzite, which are not granitized or recrystallized to the extent and intensity of the granitoid gneiss.

The hornblende schist consists almost entirely of green hornblende and plagioclases with minor amounts of quartz, sphene, and opaque material. A few apatite grains occur. Late chlorite veins were also noted.

Granite

Granite underlies 20 per cent of the map-area, mostly in Slave Structural Province and west of Bathurst Trench. Some granite also occurs east of the trench and along the eastern boundary of the map-area south of the Ellice Formation in Churchill Structural Province. In Churchill Province and east of the trench its extent is not known and is difficult to assess as the granite occurs in diffuse irregular masses and in dykes and sills of various sizes mainly in quartzofeldspathic gneisses. These masses and dykes are intimately mixed with the gneisses, and in most places they could not be mapped separately at this scale. The diffuse masses are normally red and vary in grain size and texture, whereas the dykes and sills are mainly white, coarse grained, and pegmatitic. The diffuse masses probably represent metasomatic granite. Petrographic description of this granite is given elsewhere in this section together with description of the granite in the Slave Province.

The granite in Slave Structural Province and west of Bathurst Trench is intrusive. Most of it is in the south half of the map-area where it occurs in large irregular bodies. These bodies are concentrated along and near the southern and the western boundaries, and they are probably interconnected at depth for they are closely spaced on the surface and many of the masses appear to be cupolas of a much larger body. In the north half of the area of Slave Province rocks, west of Bathurst Trench, only 2 per cent of the area is underlain by granite. There the granite forms small discrete irregular masses, most of them transgressive, in relatively fresh Yellowknife-type sedimentary rocks. Ten such small masses were mapped in the vicinity of 65°35′N, 106°25′W. Another mass occurs north of Western River near the unconformity at the base of the Goulburn Group. Three masses were mapped south of 65°50′N, 107°35′W near the western boundary of the map-area. One of them, about 8 miles long by 4 miles wide, is much larger than the other two. On aeromagnetic maps, most of these granite masses cannot be distinguished from the sediments.

All granite masses in Slave Province and west of Bathurst Trench do not appear to have metamorphic aureoles. Also, they do not seem to be connected with the general pattern and trend of the easily mapped metamorphic isograds, such as the contact of the nodular schist with fresh sedimentary rocks and the contact of the quartzofeldspathic gneisses with nodular schists. Some of the granite masses seem to cut across these metamorphic isograds and to bear no relation to them. The granite masses also appear to be unaffected by the metamorphism of the rocks nearby, so they are probably later. If contemporaneous, then their lack of relationship with the metamorphic isograds would suggest that their shape is different at depth than at surface, which could be the reason for this cutting relationship.

Most of the granite masses in Slave Province show transgressive relationships with the country rocks along some of their contacts. Thus the bedding has been truncated by the granite masses in a few places at the southeast end of Beechey Lake, along the northern contact of the large granite mass south of 65°50′N, 107°35′W, and along several of the small masses in the vicinity of 65°35′N, 106°25′W. However, some of the contacts are locally parallel to the foliation of the country rocks. This was noted in the southwest corner of the map-area near the southern boundary and also about the southeast end of Beechey Lake. Where the contacts are transgressive, some of the granitic material has been injected into the country rocks to produce migmatitic rocks over narrow widths near the contacts. This is a rare feature. Augen structures are present in areas where migmatites have developed, suggesting some metasomatism or granitization of the country rocks. Near such areas, inclusions of the country rocks can mostly be observed in granite a short distance from the contact. In general, however, most granite contacts are sharp rather than gradational, and the granites are coarse grained at the contacts. They seem also to have produced no metamorphic effects on the country rocks as these rocks are not strikingly more metamorphosed at the contact than at some distance from the granite mass.

In Slave Province the granites are mainly white and grey. Locally they are spotty pink. Most granites are massive, homogeneous, coarse grained, and widely porphyritic. They are also locally pegmatitic. Fine-grained phases occur in a few places; these are generally gneissic and richer in dark minerals, mainly biotite, than the coarse-grained granite. The biotite occurs in streaks or clusters and is responsible for the apparent gneissic structure of the rock. Where the granite is porphyritic, the phenocrysts are generally white feldspar. These are locally 1½ inches by 1 inch, but they are nowhere very abundant. This structure is normally not a spectacular feature of the outcrops. The pegmatitic phases are gradational into the coarse-grained granite, are not of great extent, and their distribution appears to be irregular. In hand specimen all granites are composed of the following main minerals: grey glassy quartz, white to buff feldspar, biotite and muscovite, the amounts of biotite and muscovite varying from place to place within a mass and also from mass to mass.

Fifteen thin sections of all granites from the area were studied. They show that the

TABLE II *Estimated mineral composition of the granites of the Beechey Lake area in per cent*

	South of lake at 65°50′N, 107°35′W		Central and Southern				Diffuse masses	Dykes
		South end of Beechey Lake	Lake at 65°35′N, 106°25′W			Average Beechey and lake at 65°35′N, 106°25′W		
Number of specimens:	1	4	3	2	5	9	1	1
Quartz	36	30	24	30	27	29	35	26
Plagioclase	32	46	38	50	43	44	28	65
Potassic feldspar	25	10	17	2	11	10	33	3
Muscovite	1	2	18	4	12	7	X	6
Biotite	6	10		12	5	7	3	
Chlorite	X		3	2	2	2		
Epidote		2				1		X
Apatite, opaque micrographic intergrowth	X	X	X	X	X	X	1	X
Rock name:	Quartz monzonite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Quartz monzonite	Granodiorite

granites are coarse, granitoid, and fairly homogeneous; that they are composed mainly of quartz and plagioclase with minor amount of microcline; that these three minerals are interlocked with one another; and that there are various amounts of muscovite, biotite, and hornblende. Chlorite and epidote are present as alteration products after biotite and hornblende or as introduced material. Apatite, zircon, opaque material, tourmaline, and sphene occur as accessories. Table II gives the estimated mineral content of the granites of this area as determined by crude point counting.

In most thin sections the plagioclase is seen to be albite or oligoclase (An_4–An_{12}) and is altered to sericite. It is also commonly twinned but occasionally it is faintly zoned. Its grains are round to irregular, and many of them are elongated parallel to the twinning. Generally it represents more than 25 per cent of the rock and most of it is of early formation, but some is probably late as it occurs in tiny round grains within quartz and microcline or at the junction of these minerals. The phenocrysts, probably plagioclase, were not studied in thin sections. Quartz, which accounts for about 20 per cent of the rock, is in small to large grains forming large areas or lenses elongated parallel to one another and producing a crude foliation which is also locally caused by alignment of mica flakes.

Microcline is normally fresh, perthitic, and in irregular grains. It represents less than 15 per cent of the rock and averages about 10 per cent except in a few places where it is much more abundant and is the main feldspar of the rock. A thin section showed that some granite of the diffuse granite masses in the quartzofeldspathic gneisses east of Bathurst Trench is microcline-rich. Two other sections from granite west of Bathurst Trench have more than 25 per cent microcline. This suggests that the microcline content of the granite in general may be quite variable. This variation may be due to metasomatism.

Myrmekite seems to be more common where microcline is abundant. It is found between microcline grains or at the junction of microcline and plagioclase.

Muscovite, biotite, and hornblende form generally about 15 per cent of the rocks. Locally, the main mineral of this group is muscovite, elsewhere it is biotite, rarely it is hornblende. In some rocks biotite and muscovite occur in equal amounts. Hornblende was noted in only one slide and may be a relict mineral.

Goulburn Group

History and Definition

The term Goulburn was first used in 1924 by J. J. O'Neill (1924, pp. 23A and 47A–51A) as a formational name for a succession of about 4,000 feet of quartzite and conglomerates outcropping on Goulburn Peninsula on the western side of Bathurst Inlet. If O'Neill included rocks other than quartzite in the Goulburn Formation he did not state so in his text.

Wright (1957) correlated quartzite that outcrops near Western River with O'Neill's Goulburn quartzite, as he interpreted it to be the southern extension of O'Neill's Goulburn. Fraser in 1962 established the continuity of quartzite outcrops between Wright's Western River and O'Neill's Goulburn. Wright elevated the term Goulburn from formation to group because the area near Western River included not only the distinctive quartzite but also great thicknesses of argillite, slate, dolomite, and sandstone conformable with and below the quartzite in this succession. Fraser (1964) extended the Goulburn rocks north of this area as far as the Arctic coast, including the original exposures described by O'Neill. He included great thicknesses of conformable slates, argillite, and dolomite found above the original Goulburn quartzite of O'Neill. Thus, in the type area the Goulburn is a much more complex succession than first described by O'Neill.

The name Goulburn is retained here and used as a group name as used by Wright and Fraser. In this area the group has been subdivided into formations.

Quartzite with conglomeratic layers, described by O'Neill as pink quartzite and by Wright as pink quartzite and conglomerate, is named the Burnside River Formation. The rocks below it are named the Western River Formation. The succession above the quartzite does not outcrop in this area and so is not discussed here. A more complete account of the Goulburn Group is given elsewhere (Tremblay, 1968).

Location and Extent

The Goulburn rocks are found entirely within the north half of the map-area where they underlie about 300 square miles. This area is about 25 miles wide along the northern boundary, and extends slightly south and past Western River. Its western boundary is a string of long narrow lakes trending for 16 miles in a southeasterly direction from the northern boundary as far south as the lake at 65°50'N, 107°08'W.

Basal Relationships

The Goulburn rocks rest unconformably on Yellowknife-like sediments, granitic rocks, and gabbro. In the east half of the area the plane of unconformity is sharp, dips gently northward, and is characterized by a thin layer of quartz-pebble conglomerate almost flat lying and unconformable on steeply dipping sedimentary rocks. In the west half of the area, the unconformity plane is not so sharp but is readily recognized as it is characterized by a regolith. The steeply dipping Yellowknife-type sediments seem to have been so much jointed along their old erosional surface that the jointed blocks were slightly moved or slightly separated from one another and that at the beginning of Goulburn time they were cemented together with a light brown weathering dolomitic material. Locally the fractures separating the blocks were fairly wide and conglomeratic material was deposited with the dolomite cement. This regolith is overlain by almost flat lying light green to grey argillite and slate, or by quartzite.

Western River Formation

This formation is that part of the Goulburn Group that extends from the unconformity at the base of the group to the overlying Burnside River Formation. It includes all rocks below the formation mapped as quartzite by Wright (1957). The Western River Formation is conformable with the Burnside River Formation, but there is a marked change in lithology upwards from the argillites and white to buff quartzites of the Western River Formation to the pink quartzite of the Burnside River Formation. Locally there is a conglomerate at the base of the pink quartzite, elsewhere it is a layer of red argillite. Thus, both the bottom and top of the Western River Formation are well defined and in general can be located fairly readily and accurately.

The Western River Formation is relatively well exposed around the periphery of the outcrop area of the Goulburn Group. Several sections were measured, the best ones are given in Table III. These sections are composite and represent data collected at many places within an area of a few thousand square feet. The sections (Fig. 4) show that the thickness of the formation increases eastward and northward, that thicknesses of some of the lower units vary locally, possibly due to irregularities on the old erosional surface on which these units were deposited, and that some units are thicker locally in basin-like depressions as shown by some units above the Basal Conglomerate.

TABLE III | *Composite sections, Western River Formation, Beechey Lake area*

	Along the western contact of area of Goulburn rocks near north boundary of map-area (area 1 on Fig. 4)		Near southernmost part of area of Goulburn rocks east of Western River (area 3 on Fig. 4)		A short distance west of Bathurst Trench and north of Western River (area 5 on Fig. 4)	
Member	Lithology	Thickness (feet)	Lithology	Thickness (feet)	Lithology	Thickness (feet)
Upper Argillite	Red siltstone		Argillite and red siltstone		Red siltstone	10
					Argillite	940
	Quartzite	60	Argillite,		Red slate	10
	Argillite		quartzite	700	Pink quartzite	240
	Buff quartzite		Pink quartzite		Argillite	150
			Argillite		White quartzite	100
	Grey argillite	100			Gabbro	450
	Red siltstone				Argillite	250
Quartzite	White quartzite	60	Dolomite and quartzite	300	Dolomite and quartzite	550
	Dolomite	40				
	Quartzite (white, blue, and green)	30				
Red Siltstone	Argillite	30	Red siltstone	200		
	Dolomite	5	Argillite, quartzite, and dolomite	200		
	Red siltstone	250				
	Argillite	5				
			Red siltstone	300	Red siltstone	450
Lower Argillite	Dolomite	5	Argillite and quartzite	700		
	White quartzite	30				
	Grey argillite	250	Red siltstone	200		
			White quartzite	200	White quartzite	800
Basal Conglomerate	Regolith (dolomitic)	5	Conglomerate	5	Conglomerate	20
Angle of dip of beds at section site	10°E		15°W		30°E	
Total thickness of section	870		2,800+		4,000± (includes gabbro sill)	

For mapping purposes, the formation has been subdivided into five members; each, except the Basal Conglomerate, includes several rock types. These members can be readily distinguished from one another as they have fairly definite upper and lower limits. The Basal Conglomerate is generally thin and on the map is placed with the Lower Argillite Member. The members mapped are from bottom to top: Basal Conglomerate, Lower Argillite, Red Siltstone, Quartzite, and Upper Argillite.

Regolith and Basal Conglomerate Member

A regolith was noted on the unconformity at the base of the Goulburn Group along

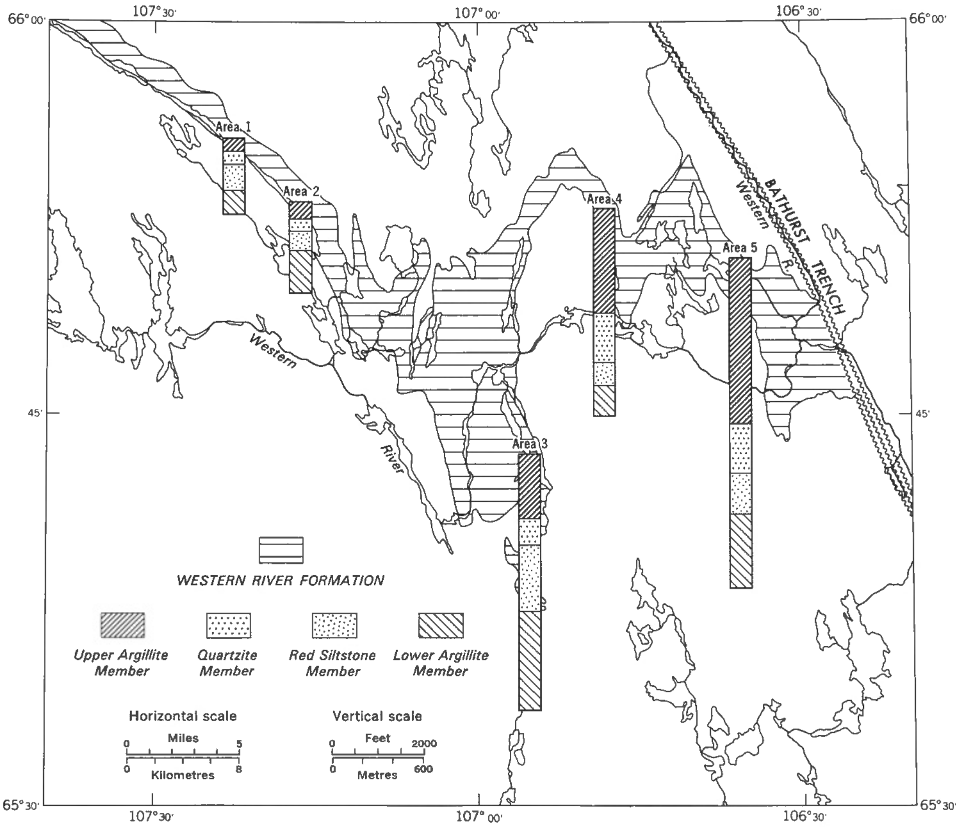

FIGURE 4. Columnar sections of the Western River Formation. Each section is composite and represents data collected at several closely spaced localities in the vicinity of the areas shown on this figure.

its western contact from the northern boundary of the map-area southeasterly to near Western River. This regolith resembles a breccia with a dolomitic cement. It is made up of fragments of Yellowknife-type sediments. The fragments are angular, of various sizes, and are in their original positions, or moved only very slightly. The dolomitic cement envelops the fragments and cements them together, fills joints, fractures, or openings in these blocks, or filled holes on the erosional surface. Locally some of the holes are filled with a mixture of dolomitic cement and occasional well-rounded, white quartz pebbles, or with patches and pockets of quartz-pebble conglomerate resting on or mixed with the dolomitic material. Where conglomerate patches are missing, the regolith is overlain by a grey to green argillite and slate or by a white quartzite. In general where the regolith was seen, continuous basal conglomerate layer was not noted. Where basal conglomerate is present, it was seen only in patches or pockets, scattered irregularly over or within the regolith. Conglomeratic patches or pockets seem to be more common near Western River than near the northern boundary of the map-area. This distribution suggests a transition zone between regolith in the west and basal conglomerate in the east, that is, a zone where the regolith occurs with occasional patches of basal conglomerate passing to an area where the patches are more common, and finally to an area where the basal conglomerate forms a continuous layer. In the region east of Western River no regolith was observed but the Basal Conglomerate was seen everywhere the unconformity was exposed. This transition zone occurs west and east of the lake at 65°47′N, 107°07′W, and probably marks the outline of the first basin of sedimentation.

In the area east of the above-mentioned lake, the Basal Conglomerate forms a continuous layer of variable thickness directly above the unconformity eastward to Bathurst Trench. The conglomerate layer is up to 20 feet thick, but in most places it is between 5 and 10 feet. It is a quartz-pebble conglomerate in which the fragments are about 98 per cent white quartz, and the rest glassy grey quartz and rare red quartzose rocks, all in a sandy matrix. The fragments are in general well rounded but size-sorted, and vary from 2 feet to less than ¼ inch in diameter. Pebbles between 1 inch and 2 inches are most common. The matrix is fine-grained quartzite or sandstone and is made up mainly of quartz grains all less than 1 mm in a sericitic or clayish cement. Where the amount of sericitic cement is appreciable the conglomerate is roughly schistose. There are also grains of magnetite. No sulphide mineralization was noted. The ratio of fragments to matrix is of the order of 3 or 4 to 1. Locally white quartzite beds produce a crude layering in an otherwise massive and homogeneous conglomerate.

Lower Argillite Member

This member forms a continuous belt of variable thickness along the southern and western edges of the area of Goulburn rocks and in the west occurs directly above the regolith; elsewhere it overlies Basal Conglomerate. Its upper limit is the Red Siltstone Member. Its contacts with the regolith and the Basal Conglomerate are sharp, but those with the Red Siltstone are gradational over about 10 feet, red siltstone being thinly interbedded with grey argillite. The best and the largest exposures are those forming parts of the large tongue-like mass of Goulburn rocks outcropping in the central part of the map-area and extending south past Western River. At the southern extremity of this mass, much of the member has been removed by erosion as erosional remnants were mapped south of this tongue-like mass and as truncation of the various units of this member was indicated by the mapping.

Along the western boundary of the area of Goulburn rocks, from the northern boundary of the map-area to as far south as Basalt Lake, the rocks of this member are mainly grey argillite, about 300 feet thick, and fairly well exposed in a westerly facing steep slope. There are about 30 feet of massive fine-grained white quartzite at the top, a few beds of red siltstone near the base, and a few thin layers of dolomitic material or calcareous argillite at various levels in the grey argillite but mainly near the base. Together these calcareous and dolomitic layers are less than 6 feet thick. Some of the dolomitic material occurs as boudins or lenses cemented with grey argillaceous material.

South and east of the lake at 65°50′N, 107°08′W, much of the area of Goulburn rocks is underlain by this member. South of the lake, the white quartzite still occurs near the top and above a great thickness of grey argillite. The quartzite forms a much thicker deposit which covers a much larger area. Southeast of the lake, the red siltstone at the base is more abundant and around the small area, or window, of older sediments the red siltstone forms a belt a few hundred feet wide that was mapped separately.

In the central part of the area around the tongue-like wedge, the thick succession of grey argillite that formed the base elsewhere occurs near the top of the sequence and is underlain by a fairly thick succession of white quartzite and red siltstone. There seems to be a facies change from the northwest towards the south and southeast. In this area the white quartzite is directly above the Basal Conglomerate and the contact seems to be gradational over a few feet.

FIGURE 5

Southward along the western margin of the area of Goulburn rocks, thinly laminated grey argillite of the Lower Argillite Member, Western River Formation. Thick bed of white quartzite at upper left is near the top of this unit. Dip is about 10°E.

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Near the lake at 65°52′N, 106°50′W, somewhat east and north of the area of the tongue-like mass, the grey argillite has almost disappeared, the white quartzite is the dominant constituent and as a whole the Lower Argillite Member seems somewhat thinner than it is at the south end of the tongue-like mass.

From Bathurst Trench west to the first main bend of Western River, the main rock type of this member is white quartzite overlain by a fairly thick succession of thinly bedded carbonate rocks, grey argillite, and red siltstone. This suggests a facies change, as carbonate material was not found so abundantly elsewhere to the west. The carbonate rock is different from the one higher in the succession as it is thinly bedded, shaly, and locally brecciated, contorted and much deformed. It exhibits also some domical algae-like structures.

At one place west and south of the lake at 65°50′N, 107°08′W a conglomerate was observed that contains fragments of red siltstone, grey argillite, and quartzite or rocks found below the conglomerate in the succession. This suggests that there are local unconformities within the Lower Argillite Member.

On the outcrop the argillite is, in general, various shades of grey, dense to very fine grained, and thinly bedded (Fig. 5). A few beds are buff or buff peppered on grey background due to a small content of carbonate. Other beds throughout the succession are reddish grey. They carry some iron oxide and resemble the rocks of the Red Siltstone Member. The grey argillite is varve-like. Near the unconformity chlorite and large muscovite flakes occur in noticeable amounts along some bedding planes; they are probably mainly clastic, although in part they may be recrystallized material. The origin of these muscovite flakes is discussed under metamorphism. A K/Ar age of 2,380 m.y.[1] on a concentrate of this muscovite is regarded as a maximum age for the Goulburn rocks. It probably represents the age of the metamorphism of the rocks underlying the Goulburn Group.

Thin sections show that the argillite is distinctly layered, clastic, and partly recrystallized. Some of the layers may be only a few millimetres thick. Some are made up mainly of clastic grains (averaging 0.1 mm) cemented with sericite and chlorite flakes.

Alternate layers are made up of sparse clastic grains (averaging 0.04 mm) in a dense, abundant, felted mass of sericite and chlorite. The grains are subangular to subrounded, mainly undulatory quartz and the matrix or cement is recrystallized clay material. About 15 per cent of the grains are feldspar. An occasional tiny grain of sphene and zircon and a few granules of iron oxides were observed. Biotite is present locally in very small quantity. Most seems to have altered to chlorite because locally chlorite is pseudomorphic after biotite and has zircon grains with haloes as in biotite. A few grains of bluish green, possibly detrital, tourmaline were noted.

The quartzites vary from massive to distinctly or faintly bedded, well-jointed, fine-grained rocks. They are generally white but partly greenish, bluish, or even buff and faintly pink. The bluish and greenish colours are due to disseminated chlorite, the buff to carbonate, and the pink to iron oxide. Locally the carbonate specks appear as tiny rusty brown dots on weathered surface.

In thin sections the quartzites display a clastic texture, are massive to faintly stratified, and are made up of clastic grains closely packed and cemented together with a small amount of chloritic-sericitic cement. In general, there is very little matrix. The main grains of the quartzites are well rounded to subrounded and average 0.5 mm ranging between 2.0 mm and the matrix grain size (less than 0.05 mm). The ratio of clasts to matrix is approximately 85 to 15. Most clasts are undulatory quartz and many show a slight silica regrowth. Feldspars, both plagioclase and potassic feldspar (microcline and perthite), constitute about 15 per cent of the clasts. There are also a few clasts of chert and rock fragments. Other minerals, noted only in traces, are zircon, magnetite, biotite, muscovite, leucoxene, limonite, sphene, and tourmaline.

A thick gabbro sill intrudes this member from Bathurst Trench 8 miles west to a large syncline, and also south of the lake at 65°50′N, 107°08′W in the west half of the area of the Goulburn Group.

[1] All dates in this report are potassium-argon ages determined in the Isotope Laboratory of the Geological Survey of Canada and published in the annual "Age Determinations and Geological Studies" series of the Survey's Paper Series reports.

Red Siltstone Member

This member outcrops as an almost continuous belt above the Lower Argillite Member, circling the area of Goulburn rocks near its southern and western limits. It seems to be missing for slightly more than a mile at a point about 3 miles southwest of 65°52′N, 106°50′W, where quartzite of the Lower Argillite Member appears to be in direct contact with the Quartzite Member above. Near the west margin of the area of Goulburn rocks and towards the northern boundary of the map-area, the Red Siltstone Member is about 250 feet thick and includes minor scattered beds of greenish grey argillite and rare thin dolomite beds. South of 65°50′N, 107°08′W and to the southeast past Western River in the central part of the map-area, this member is interbedded with some grey argillite and white quartzite (Fig. 6), which becomes more abundant in the south. At the southern tip of the area of Goulburn rocks near the centre of the map-area and east of Western River, the member is about 700 feet thick. There it was subdivided into a lower red siltstone layer separated from an upper one by a thick (200 feet) succession of interbedded grey argillite and white quartzite beds.

FIGURE 6

Small anticline in white quartzite about 3 miles west of Bathurst Trench and 4 miles north of Western River. The white quartzite is part of the Red Siltstone Member and occurs as a lens at the nose of a major anticline. It is overlain by gabbro. In left background the tops of hills are capped with the Burnside River pink quartzite.

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South and east of Western River near the Bathurst Trench, the Red Siltstone Member is a mixture of closely interbedded red siltstone, sandstones, and calcareous sandstones, the red siltstone forming about half of the succession. There the total thickness of the unit is also about 250 feet, comparable to that along the western edge of the outcrop area of Goulburn rocks.

The lower contact of this member is usually transitional over a few feet. Grey argillite and red siltstone of the Lower Argillite Member are thinly interbedded, the red siltstone being the characteristic rock of the transition zone. The lower contact is usually placed where the red siltstone becomes readily noticeable in the outcrop. The upper contact is generally indicated by an increase in the number of grey argillite beds. If the red siltstone is overlain by grey argillite, as is common near the western margin of the area of Goulburn rocks, the contact is gradational over a few feet. Where the overlying unit is quartzite, the contact is sharp but the red siltstone contains interbedded grey argillite in greater abundance than usual. Near Bathurst Trench, abundance of calcareous sandstones and red to white sandstones near the top of this member requires that the contact be placed where red siltstone is lacking in the succession.

The rocks of this member are dark chocolate-red, very fine grained, and thinly bedded. Abundant mud-cracks were noted in loose slabs. In many places beds seem to be made up of two fractions: those near the base are thicker, slightly lighter red, and probably slightly coarser grained than those near the top of the layer; they pass gradually upward into dense, dark red, thinner upper parts. Beds are generally less than an inch thick and are in part varve-like. In thin sections the red siltstone is seen to be layered due to variation of grain size representing probable stratification. The grains are below 0.08 mm and average 0.01 mm. Some layers are made up of abundant tiny quartz and feldspar grains in a felted mass of sericite and chlorite; others have only a few sparse clastic grains in a similar felted mass; others are made up entirely of a felted mass of sericite and chlorite. Only a few layers are sandy as their grains average 0.5 mm and are less than 1 mm. Many layers are claystone as the clasts average less than 0.005 mm. The sericite and chlorite flakes and rods of all layers are oriented parallel to the layered structure of the rocks or deviate only slightly from it. A few of the flakes are characteristically at right angle to this main trend and may be related to a crude cleavage noted locally. A few tiny specks of opaque substance were noted. These form about 5 per cent of the rock and are either carbon or magnetite. Carbonate, biotite, and limonite are present in small amounts.

A chemical analysis[1] of this rock made on a composite sample is given here. For comparison, *see* other chemical analyses on page 30.

	Weight %		Weight %
SiO_2	63.5	K_2O	5.3
Al_2O_3	15.4	H_2O	2.9
FeO	1.8	TiO_2	0.69
Fe_2O_3	4.2	MnO	0.05
MgO	2.7	P_2O_5	0.13
CaO	0.7	CO_2	1.0
Na_2O	0.6	total	99.0

Quartzite Member

This member occurs stratigraphically immediately above the Red Siltstone Member. As stated, the underlying Red Siltstone Member contains increasing amounts of grey argillite interbeds near its contact with the Quartzite Member. At the contact the argillite is replaced entirely by quartzite; ordinarily this contact is fairly sharp. The upper contact of the Quartzite Member is gradational, and is placed at the appearance of grey argillite in some abundance in the succession and at the disappearance of dolomite.

[1] In the chemical analyses of this report, MgO, Al_2O_3, SiO_2, K_2O, CaO, TiO_2, and MnO were determined by X-ray fluorescence using the fusion method. Na_2O, P_2O_5, CO_2, FeO were determined by the rapid method of chemical analysis and Fe_2O_3 by difference. All analyses by S. Courville.

Outcrops of the Quartzite Member were traced in a continuous belt from Bathurst Trench around the area of Goulburn rocks as far as the northern boundary of the map-area. The belt is about 500 feet wide along the western boundary but locally reaches almost 4,000 feet in the east half of the area. It is more than 2,000 feet wide near Bathurst Trench where it is truncated. The member is about 150 feet thick in the west and at least 600 feet in the east.

This member is the only good marker in the Western River Formation of this area. It is marked by abundant white glassy quartzite immediately above the Red Siltstone Member, by dolomitic rocks with a characteristic light brown weathered surface, and by the lenticular nature of a large number of these dolomitic rocks.

In the area near Bathurst Trench, a zone of dolomitic rocks occurs in the Lower Argillite Member that could possibly be mistaken for the dolomitic rocks of the Quartzite Member, but their thinly bedded nature, their light green to grey colour, and their lack of abundant interbedded white quartzite beds distinguish them from the carbonate rocks of the Quartzite Member, which are generally coarsely bedded, light brown where weathered, and interbedded with abundant white quartzite. All other zones of dolomitic rocks noted at various levels in the Western River Formation of this area are less than 6 feet thick, are not associated with white quartzite, and in general are discontinuous along strike. In appearance, however, the dolomites of these other zones resemble the dolomites of the Quartzite Member.

The Quartzite Member consists of a variety of quartzites or sandstones, of many kinds of dolomitic rocks, and in places of some grey argillite. Quartzites or sandstones are generally more abundant than dolomites, and the ratio of the thickness of quartzites or sandstones to that of the dolomites is 8 to 1 in the east and 2 to 1 in the west (*see* detailed sections in Table IV and the main sections in Table III). In the east near Bathurst Trench the Quartzite Member comprises the succession quartzite–dolomite repeated four times starting with quartzites or sandstones and ending with dolomites whereas in the west towards the northern boundary of the map-area there is only one layer of dolomite separating two quartzite layers. Thicknesses of these quartzite and dolomite layers vary greatly from place to place, and also in the west the quartzites are more glassy-looking than in the east where they are commonly carbonate-bearing and sandy. Argillite is generally missing or occurs in small amounts except in a few places where it may be fairly abundant as in the area southeast of 65°50′N, 107°08′W where grey argillite similar to the type found in the Lower and Upper Argillite Members occurs interbedded with the quartzite and represents a fair thickness of the Quartzite Member rock succession. In other places, as in the apex area of the main anticline about 4 miles west of Bathurst Trench, it occurs in small quantity mainly as lenses within the quartzite.

The quartzite is a well-consolidated homogeneous glassy rock, generally white to grey, medium grained, massive to thickly bedded, and closely jointed. The sandstones are not so well consolidated, their weathered surfaces are strikingly more gritty, and they occur anywhere in this member but are found mainly in the east near Bathurst Trench where their sandy texture is more apparent as they are there extensively calcareous. Some of the quartzite or sandstone is pink, purple, or red due to disseminated hematite and in a few places the rock is a ferruginous quartzite or sandstone. In some areas the weathered surface of the quartzite or sandstone is pitted and speckled light to dark rusty brown due to the weathering out of disseminated carbonate in a white sandy mass. Other quartzite or sandstone masses have tiny disseminated grains of white kaolinized feldspar in a mass of medium quartz grains. Others have large concentrations of tiny green grains (probably chlorite, amphibole, and epidote) and are greenish. Most quartzites and sandstones of

TABLE IV | *Detailed sections of the Quartzite Member in the area near Bathurst Trench (east half)*

Almost same locality as area 5 of Fig. 4 about 3 miles west of Bathurst Trench north of Western River	Thickness (feet)	About a mile west of Bathurst Trench south of Western River	Thickness (feet)
Dolomite, pink sandstone	50	Dolomite	15+
Dolomite, purple calcareous sandstone, limestone	360	Sandstone	20
Calcareous sandstone, dolomite	50	Dolomite, in part arenaceous	10
Purple sandstone	40	Sandstone	110
Calcareous sandstone, siliceous dolomite	55	Dolomite	20
Purple sandstone, dolomite	45	Dolomite, in part arenaceous	10
		Sandstone	200+

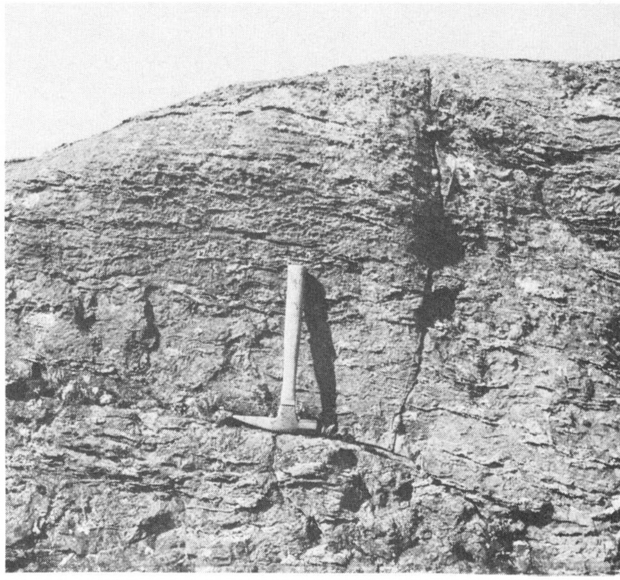
this member have tiny black grains of iron oxide. Finally a few have dark rusty brown dolomitic or limy pockets and layers, locally these pockets and layers are so abundant that the quartzite or sandstone becomes a limy or dolomitic rock. The pattern of distribution of these many quartzite or sandstone varieties is not known.

The dolomite or dolomitic rock is one of the diagnostic rock types of this member in this area. However, these rocks vary greatly in composition and texture and are irregularly bedded (Fig. 7). Most of the common dolomites are fine grained, gritty, and massive, have a muddy-looking characteristically light chocolate-brown weathered surface, and on outcrops have tiny irregular blebs and seams of siliceous material. The muddy-looking, massive dolomite, particularly where it is almost free of siliceous material, exhibits locally a rough 'elephant skin' or conchoidal fracturing appearance; in other places it is characterized by pronounced markings (Fig. 8) which are regarded as stromatolites. These markings are spherical on the outcrops and conical or columnar in section. They show a concentric structure and occur generally in groups or colonies, locally accounting for more than 50 per cent of an outcrop. In plan most of them are less than 6 inches in diameter; in section the same structure may extend for several feet. The long axis of the structure seems to be at right angle to the stratification. Vertical sections up to 50 feet thick that exhibit these markings were noted in some localities, particularly in the area about a mile east of Bathurst Trench and in the small isolated area of dolomitic rocks southwest of 65°52′N, 106°50′W. Along the western outcrop areas of the Quartzite Member, that is, from the northern boundary of the map-area to almost the southern extremity of the area of Goulburn rocks, such markings were rare or non-existent. These markings seem to occur in and to be associated with the thickest section of the Goulburn Group, which is the outcrop area that extends from Bathurst Trench west to the southernmost extension of the group in the central part of the area. The form of their deposits may suggest their origin. Similar markings were also noted in the thinly bedded dolomitic layer in the Lower Argillite Member near Bathurst Trench, but there they are more dome shaped.

In some outcrop areas, the blebs and seams of siliceous material in the dolomites

FIGURE 7

Crudely stratified dolomite in the Quartzite Member of the Western River Formation. Seams, patches, and irregular networks of dense siliceous material can be seen in a dense base of light brown dolomite. About same locality as Figure 6.



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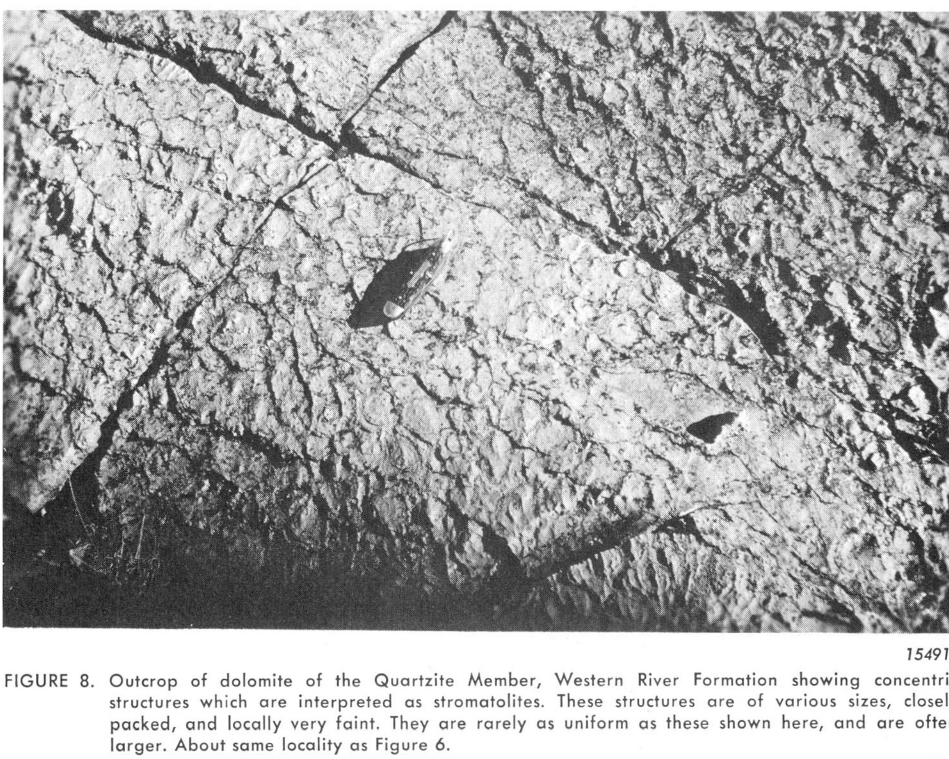

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FIGURE 8. Outcrop of dolomite of the Quartzite Member, Western River Formation showing concentric structures which are interpreted as stromatolites. These structures are of various sizes, closely packed, and locally very faint. They are rarely as uniform as these shown here, and are often larger. About same locality as Figure 6.

are almost missing; in others they are a major constituent of the dolomites. In the field all gradations from an almost silica-free dolomite to a siliceous dolomite of the type mentioned previously were noted within and mapped with this member. This represents their main variation in composition and texture. This siliceous material is either cherty or sandy, and in most outcrops is pink or purple. On weathered surfaces it stands out in relief as tiny irregular ridges of various shapes and forms, as lines, streaks, blebs, and irregular patches (Fig. 7). It explains the roughness of the weathered surface of much of the dolomitic outcrops. Their shapes suggest that much of the silica is depositional as the lines, streaks, lenses, and many of the blebs occur along probable bedding planes. Some of the irregular patches or blebs scattered throughout the mass are probably depositional, but the streaks and lines along vertical fractures may represent cleavages or other types of fractures filled with silica or argillite from material from above. These are in places faintly schistose.

Breccias were also noted amongst the rocks mapped with the dolomites. Some are made up of fragments of fine-grained, muddy-looking light chocolate-brown dolomite in a matrix of sand grains and carbonate cement; others have sandy siliceous fragments in a light brown muddy-looking limy matrix; others are made up of patches and irregular masses of light green to grey argillite in a dolomitic or limy matrix where mud-cracks are suggested locally by the distribution of the argillaceous fragments and the dolomitic material. In general, however, these are true breccia.

A few thin beds or lenses of massive limestone were recognized. They weather dark brown, are grey to white on fresh surface, and are fine to medium grained. The argillite already mentioned as forming part of this unit in a few places is very much the same as that of the Lower and Upper Argillite Members and is not described here.

In thin sections all gradations can be seen from a clastic rock with about 5 per cent carbonate cement to a carbonate rock with about 5 per cent clastic grains or silica material filling cavities. The clastic rocks are either sandstones or quartzites, as some of their quartz grains show silica regrowth. The sandstones or quartzites are composed of about 80 per cent quartz grains, 15 per cent feldspar, some chert and rock, and about 5 per cent carbonate as cement. There is generally very little matrix or none at all. Iron oxide, sericite, and chlorite occur in trace amounts and are part of the cement; tourmaline and sphene occurs occasionally. The grains are subrounded to rounded, average about 0.5 mm in diameter, but vary between 2.0 mm and 0.2 mm; grains in the matrix are somewhat smaller. A few grains are stained red and altered. The quartz shows undulatory extinction and some of the feldspar is perthitic. Where the amount of carbonate is greater than 5 per cent, tiny clastic grains averaging 0.01 mm probably form part of the matrix. In the carbonate rock where the clastic grain content is low, a rough layering can ordinarily be seen and is represented by coarse-grained, clear, recrystallized carbonate layers alternating with fine- to medium-grained dirty looking carbonate material. Some of the quartz in the carbonate may be later, as it seems to fill cracks or cavities. It may be the result of percolating or circulating solutions.

Upper Argillite Member

This member closely resembles the Lower Argillite Member and is separated from it by the fairly characteristic and readily recognizable Quartzite Member. The Upper Argillite Member represents a succession about 200 feet thick in the west and more than 2,000 feet thick in the east near Bathurst Trench.

The main rock types are argillites, quartzites, and red siltstones, all coarsely interstratified and locally thinly interbedded, argillite being the main and characteristic rock type of the succession. Quartzite forms about 20 per cent of the succession in the east and about 10 per cent in the west. Red ferruginous siltstone is a minor constituent, occurring only as thin layers.

Variation in width of outcrop belt is due to differences in thickness and dip of the rocks. Belt is very wide in the east near Bathurst Trench, very narrow west and north of the lake at 65°50′N, 107°08′W, and covers a large area in the central part of the map-area.

This member lies immediately below the pink quartzite of the Burnside River Formation and above the Quartzite Member. The upper contact is sharp and is marked either by a thin layer of red siltstone, or by a thin band of quartz-pebble conglomerate in the Burnside River pink quartzite, or by pronounced ripple-marks at the base of the Burnside River Formation. The lower contact is generally placed at the first appearance of argillite in some quantity above the interstratified mixture of quartzite and dolomite of the Quartzite Member.

A gabbro sill intrudes this member in the area of the lake at 65°50′N, 107°08′W. In the east the same gabbro mass occurs in the Lower Argillite Member.

Argillite is the most abundant rock type of this member. It is generally massive and dense or fine grained, but some beds are slaty. The rock is buff to various shades of grey; a few of the beds, including some slate, are light green. Beds are mainly less than 2 inches thick and occur as successions resembling varves. A few beds reach 2 feet. Beds of grey argillite are locally closely interbedded with a few thin red siltstone beds and a few fairly thick ones of buff to white and pink quartzite. In thin section, the argillite is seen to be crudely layered due to concentration of clastic grains of slightly different grain size or in various quantity in adjoining layers, or due to various composition in alternating layers. Some layers are a felted mass of sericite flakes or a mixture of sericite and chlorite flakes. Others have various amounts of clastic grains averaging about 0.02 mm in a felted mass of sericite and chlorite; grains may be of two sizes, the larger are not so common and average about 0.4 mm. Other layers are made up mainly of clastic grains cemented with a faint coating of sericite and chlorite. The sericite and chlorite flakes may be oriented; they probably represent recrystallized clay matrix. The clastic grains are subangular to subrounded, mainly quartz although a few appear to be feldspar or chert. Quartz has an undulatory extinction and some is stained red with iron oxide. The opaque grains are pyrite and magnetite or carbon. A few flakes of biotite, noted in one slide, may be detrital.

The following chemical analysis (column 1) is on a composite sample of this argillite. Column 2 is an average of 33 Precambrian slates (Nanz, 1953, p. 57).

	Weight %			Weight %	
	1	2		1	2
SiO_2	64.5	60.4	K_2O	4.6	4.1
Al_2O_3	15.9	18.5	H_2O	2.9	
FeO	2.8	6.7	TiO_2	0.66	0.8
Fe_2O_3	2.1	4.1	MnO	0.02	0.1
MgO	2.9	2.7	P_2O_5	0.09	0.2
CaO	< 0.1	1.1	CO_2	0.01	
Na_2O	1.6	1.3	total	98.2	

Next to argillite, quartzite is most abundant. It is generally massive and fine grained with a characteristic clastic texture in the hand specimen; sandstone locally closely jointed; white, buff, and pink. Some of the thicker beds are pink and closely resemble the pink quartzite of the Burnside River Formation. Bedding is coarse and not easily recognized. In thin section, the quartzite shows abundant closely packed clastic grains in a base of smaller clastic grains and a chlorite-sericite cement. The grains are rounded to subrounded; the largest average 0.3 mm and represent about 65 per cent of the rock, others in the base average 0.02 mm. Most of the grains are quartz, some are feldspar, a few are cherty. Locally they are red. Feldspar grains are altered to sericite; quartz grains do not show silica regrowth and are undulatory. An occasional tourmaline (?) grain was noted; magnetite is the main opaque substance.

Red siltstone occurs in very small amounts, and is similar to that of the Red Siltstone Member. It is found at the base of this member interbedded in thin beds with the grey argillite; near the top as a thinly bedded layer; and throughout as rare laminae; and is missing in some sections. It is dark chocolate-red, dense and massive. In thin section, this rock is seen to resemble rocks of the Red Siltstone Member, consisting of closely packed clastic grains in sparse matrix and iron oxide cement encircling and filling the interstices between grains. The grains average 0.05 mm; are subangular to subrounded, mainly quartz with no silica regrowth; those stained red and altered to chlorite and sericite are probably feldspar or rock grains. The opaque grains representing about 3 per cent of the rock are in part pyrite, but most of them are probably carbon or an iron oxide.

Burnside River Formation

The name of this formation is derived from Burnside River, which appears to cut an entire section from top to bottom through this unit. The formation is a thick succession of pink quartzites and quartz-pebble conglomerate overlying the Western River Formation. Its lower limit is generally easily recognized by a marked change in lithology; the upper limit does not outcrop in this area but is probably exposed along Burnside River in the area to the north mapped in 1962 by Fraser (1964). The upper limit is probably also indicated by a pronounced change in the lithology. The formation is O'Neill's Goulburn quartzite.

This formation makes up about 75 per cent of Goulburn rocks in this area. It occurs only north of the Western River Formation and extends east to Bathurst Trench, where it is truncated and in contact with the older granitic gneisses, and north to the northern boundary of the map-area. Its total thickness cannot be calculated as the upper parts of the formation are beyond the map-area. It is also difficult to accurately determine thickness of the formation within the area, as the rocks are gently and openly folded and an average dip cannot be easily determined. However, near the northern boundary of the map-area and northeasterly from a point along the western contact of this formation, the dip is fairly uniform at about 10 degrees for a distance of at least 9 miles, indicating a minimum thickness of more than 9,000 feet. Farther east, near Bathurst Trench, the quartzite is folded in gentle continuous rolls, making it almost impossible to avoid repetition of part of the succession in the calculations; therefore, no measurements were attempted in the east. However, it is possible and even probable that the succession is thicker there, as the underlying Western River Formation is much thicker near Bathurst Trench than in the northwest corner of the map-area.

Quartzite or sandstone is the most common rock constituent, and represents more than 90 per cent of the total succession. The quartz-pebble conglomerate is next in abundance and occurs in beds up to 10 feet thick but mainly less than 5 feet. Minor amounts of green and red argillite and slate were noted locally.

The quartzite is generally pink, red, or reddish white; massive, well consolidated, and locally well jointed; and exhibits a pronounced clastic texture. Bedding was seen locally but in general is not conspicuous on outcrops because either the outcrops are dirty, or the bedding planes not sufficiently pronounced, or the beds too thick to be discernible in small outcrops. Crossbeds and ripple-marks were also noted. The attitudes of a few crossbeds were measured, and they suggest a northwesterly direction of transport of the material forming the quartzite. In hand specimen this quartzite is composed almost wholly of grains of glassy quartz, with a few deep red grains (possibly also quartz), and a few grains of a black mineral, possibly magnetite. The quartz and other grains average 0.5 mm, varying between 0.1 mm and 1 mm; locally, they may be slightly larger or smaller. In this quartzite, as previously stated, there are occasional white quartz pebbles, generally less than 2 inches wide.

In thin section the quartzite is seen to consist almost entirely of quartz grains together with a minor quantity of interstitial sericite flakes. There is practically no matrix. Grains are well rounded to subrounded, rarely show regrowth of silica, and are fairly well sorted. The grain size ranges from about 0.1 mm to slightly over 1 mm; larger grains are rare. A few feldspar, chert, and rock fragments were recognized. Trace amounts of dirty bluish green tourmaline, zircon in minute grains and of some opaque minerals (black to white in reflected light) were noted in every thin section studied.

A chemical analysis on a composite sample of this pink quartzite is given below. It is fairly similar to the orthoquartzite of Pettijohn.

	Beechey Lake area	Orthoquartzite (Pettijohn, 1949)			
	Weight %			Weight %	
	1	2		1	2
SiO_2	93.9	92.5	K_2O	1.6	0.1
Al_2O_3	2.5	1.4	H_2O	0.5	
FeO	0.2	0.3	TiO_2	0.11	
Fe_2O_3	1.5	0.2	MnO	<0.02	
MgO	<0.5	0.1	P_2O_5	<0.02	
CaO	<0.1	3.0	CO_2	0.1	2.3
Na_2O	0.1	0.1	total	100.5	

The quartz-pebble conglomerate occurs mainly as beds in the pink quartzite. Some of the beds are lenticular. Pebbles, which form about 55 per cent of this conglomerate, are 98 per cent white quartz. A few small fragments of ferruginous quartzite, grey quartz, and glassy grey rocks with a clastic texture were recognized. Near the base of the pink quartzite succession a conglomerate layer carries a few fragments related to rocks of the underlying Western River Formation. In general, however, the fragments of all conglomerate layers are unsorted ranging from very small to 6 inches in diameter, are fairly well rounded, and are set in a matrix of pink sandy quartzite, 1 mm in grain size. The pebbles show some orientation in their elongation and locally some crude depositional layering.

Argillite and slate in the pink quartzite commonly occur as layers or beds less than 2 inches thick and as narrow zones, thinly bedded, up to 2 feet thick. These rocks represent a very small part of the total succession of the formation, and are only rarely seen on the outcrops. Where seen they were used to determine the attitudes of the bedding.

Tinney Cove Formation

In the valley of Western River, a conglomerate unit was mapped at two places in Bathurst Trench, near the northern boundary of the map-area. One outcrop is 3 miles south of the boundary, the other only a few hundred feet south. The latter extends northwesterly for at least 6,000 feet outside the map-area along the valley. These outcrops probably represent the southernmost extension of map-unit 16 of the Bathurst Inlet area mapped in 1962 by Fraser (1964). It is named here the Tinney Cove Formation. These outcrops are somewhat lithologically similar to the Ellice Formation and related rocks mapped by the author about 25 miles farther to the southeast along the possible extension of the Bathurst Trench. It is probable that rocks of these two outcrops and the area of the Ellice Formation should be related, as both areas are elongated in the same direction, and trend into each other.

The southern outcrop of Tinney Cove Formation in Bathurst Trench is a high, poorly exposed, knob on the east edge of Western River valley. It consists mainly of conglomerate which is at least 300 feet thick, well consolidated, and coarsely bedded with a high fragment-matrix ratio. The fragments are well rounded, unsorted up to 2 feet in diameter, and mainly milky white quartz and pink quartzite. The matrix is deep red, arkosic, and ferruginous.

In the northern outcrop the conglomerate is at least 400 feet thick, is found mainly on the eastern side of the valley, and forms a long high ridge parallel to the valley trend. On the bottom of the valley floor, approximately at the level of Western River, it was mapped almost to the western side of the valley. At the base of this ridge or on the bottom of the valley floor, the conglomerate is similar to the one at the southern outcrop. Near the top of the ridge it is interbedded with much crossbedded, ferruginous, and grey sandstone, and northward along the ridge the amount of sandstone in the outcrop increases, the sandstone becomes mainly grey with a clay or silica white cement, and the conglomerate interbeds near the top contain fewer fragments than near the base. The fragments are mainly white quartz and pink quartzite with occasional gneiss, granite, pegmatite, blue quartz, and fine-grained ferruginous quartzite fragments. The pink quartzite fragments are the largest and may be related to the pink quartzite (Burnside River Formation) of the Goulburn Group. The white quartz fragments, however, are more abundant, and granite and gneiss fragments seem more plentiful near the eastern edge of this conglomerate outcrop than in the western part. The few readings that could be obtained on the crossbeds in the northern outcrop suggest a westerly direction of transport.

Ellice Formation and Associated Rocks

A thick succession of sandstones and some associated rocks outcrop over an area of about 20 square miles in the headwater region of Ellice River. The area is about 24 miles long in a northwest-southeast direction by as much as 3 miles wide at its widest point. The sandstone succession, which is the main mappable rock unit of this area, covers about 19 square miles. Its associated rocks cover the remaining square mile and are exposed at the northwestern extremity of the area underlain by the sandstone succession. These rocks were mapped by helicopter in 1955 (Wright, 1957), and remapped by the writer in 1962 and 1963.

The term Ellice Formation is here proposed for the thick successions of white to pink sandstones; it does not include the associated rocks. The term is derived from Ellice River, which traverses this sandstone area from the southeast to the northwest. The most complete and best exposed section is at the northwest end of this outcrop area. It indicates that about 6,000 feet of sediments were deposited in this area, the Ellice Formation and the underlying conglomerate accounting for more than 95 per cent of the estimated thickness. A composite section based on at least five closely spaced west-east traverses is given in Table V. All figures are estimates and probably represent maxima.

TABLE V | *Composite section for area underlain by Ellice Formation and associated rocks*

Rock types		Estimated thickness (feet)
Ellice Formation: Sandstone		3,000 – 6,000
Conglomerate		1,100
	possible unconformity	
Red Unit	shale and carbonate rocks	50
	sandstone and carbonate rocks	50
	carbonate rocks and shale	50
Grey Unit	grey sandstone	50
	conglomerate	100

Figure 9 shows the distributions of the Ellice Formation and other main units mapped.

The Ellice Formation and associated rocks are in contact with Yellowknife-type sediment on the west and with granite and gneiss on the west and east. Contacts are generally not exposed; they are covered with overburden and are along deep and wide gulleys. At one place, however, near the western edge of the northwestern extremity of this area, the contact is exposed on the side of a high hill; it is sharp, dips steeply east, and is an unconformity. Elsewhere contacts are probably the loci of faults.

The Ellice Formation and associated rocks are not overlain by younger rocks and are not in contact with any of them except that the formation is cut by a northwesterly trending gabbro dyke which may be related to the young gabbro described in section on gabbro. The upper contact or limit of this succession is not known.

Rocks of this outcrop area were subdivided for purposes of mapping and description into four main units (*see* Table V). The Grey and Red Units are grouped together on the main geological map as both outcrop on a steeply sloping, west-facing cliff where it is impossible to show them separately at this scale of mapping; they are shown separately on Figure 9. These two units appear to pinch out over a short distance to the south and north; to the north it is possible that they grade not only laterally but also vertically and

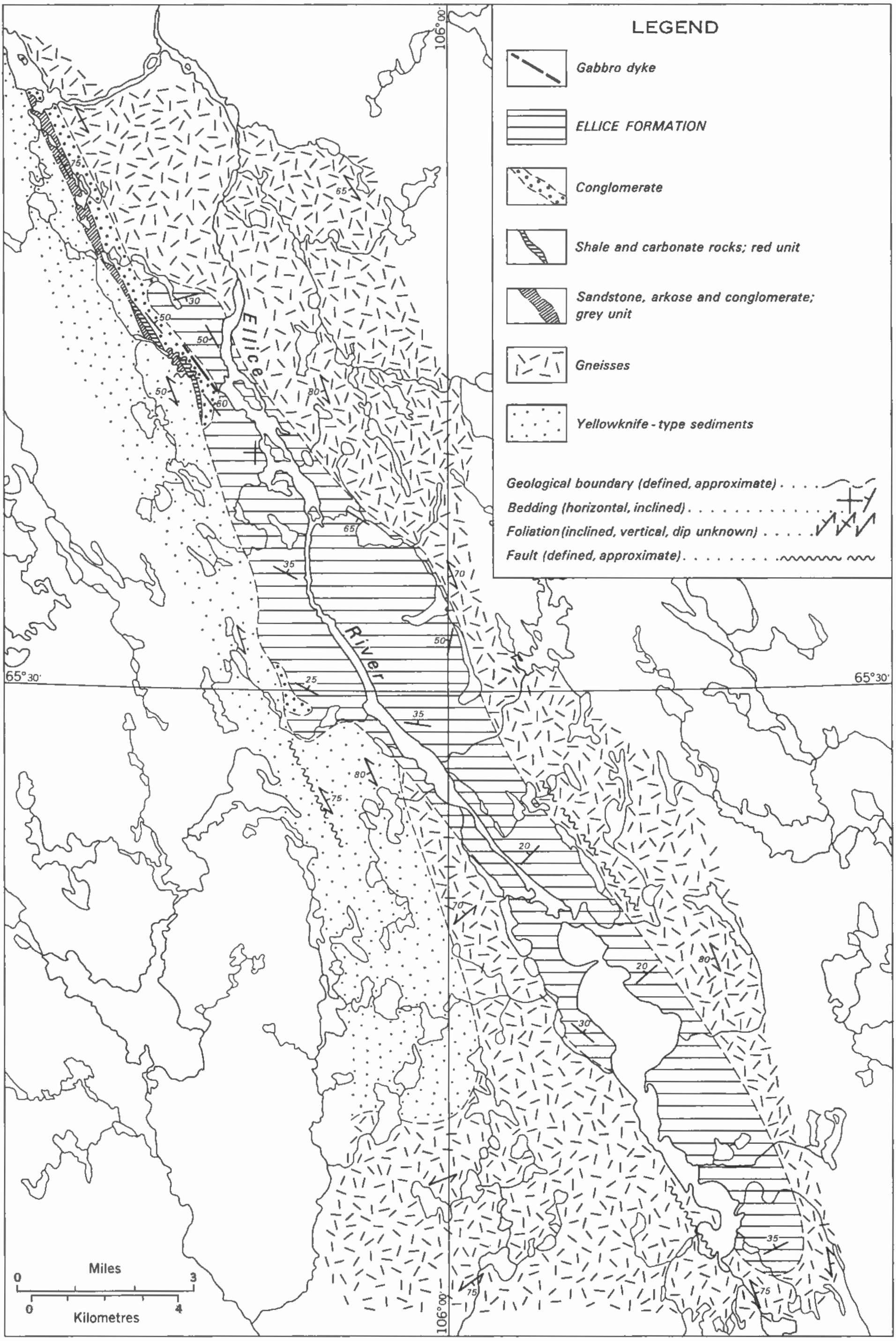

FIGURE 9. Geological map of area underlain by the Ellice Formation and associated rocks.

upward into a mixture of red sandstone and conglomerate which has been mapped on the main geological map with the thick conglomerate unit below the Ellice Formation, as the mixture of sandstone and conglomerate appears also to grade laterally southeasterly into the same thick conglomerate below the Ellice Formation. The surface extent of these two lower units is very small, and their outcrop area suggests that these units are restricted on surface to this small area, extending possibly a short distance east underneath the thick conglomerate unit below the Ellice Formation.

Grey Unit

The Grey Unit, a sandstone or quartzite with a white silica or clay cement, is locally conglomeratic and pebbly. In one traverse, about 100 feet of conglomerate noted below the grey sandstone was mapped with it. Elsewhere the conglomerate was not observed; either it was missing or the section did not extend into conglomerate. The sandstone is a well-consolidated rock with grain size averaging about 0.5 mm. Grains are rounded to subangular, closely packed, and fairly well sorted compositionally, being mainly quartz. Chert and feldspar (microcline) represent less than 5 per cent of the grains. The matrix and the cement together are less than 30 per cent. The cement is partly silica as some silica overgrowths occur on quartz grains, and partly iron oxide, carbonate, and sericite shreds. The matrix is represented mainly by quartz grains much smaller than the main grains of the sandstone, and contains a few tiny grains of tourmaline and zircon.

The fragments in the conglomerate are mainly grey quartzite and white quartz. The grey quartzite fragments have a clastic texture and a silica or clay cement similar to that of the overlying grey sandstone of the Grey Unit.

Red Unit

The Red Unit is thinly laminated; deep red to light brown. Laminae are generally less than a quarter of an inch thick; locally their pattern and distribution suggest stromatolites (Fig. 10). In places, particularly towards the central part of the succession, they are thicker. A few of the thicker laminae are composed of sandstone and conglomerate. All rocks of the unit—shale, carbonate, sandstone and conglomerate—are interlayered and carbonate-bearing. The carbonate may be either the main constituent of the rock or a part of the cement. Most of the carbonate-rich rocks contain many quartz grains and sericite flakes as impurities. These impurities average less than 0.1 mm and are generally concentrated along parallel lines, which probably accounts for some of the layering of these rocks. The sandstone layers are grey to red and consist mainly of quartz with rare chert. Silica overgrowth on quartz grains is fairly common. The grain size of the sandstone averages 0.5 mm. In this unit, carbonate rocks are common near the base and the succession is more shaly near the top and more sandy towards the centre (*see* Table V).

The upper contact may be an unconformity, as the basal few feet of the overlying conglomerate carries abundant angular fragments of the Red Unit.

Conglomerate

This unit is found at the north end of the area underlain by the Ellice Formation. Stratigraphically it occurs below the Ellice Formation and above the Red Unit. It seems to pass gradually northwestward into a pebbly sandstone that is in part conglomeratic

154914

FIGURE 10

Outcrop of part of the Red Unit in the associated rocks below the Ellice Formation. This outcrop is exposed in a westward-facing cliff about a mile south and slightly west of the northern extremity of the Ellice sandstone. Its fine lamination is interpreted as possibly of stromatolitic origin.

and which may be part of the Grey Unit and the Red Unit. Southward it dies out gradually over a short distance or fingers out into the Ellice Formation.

This conglomerate is a well-consolidated, grey to red rock. It is deep red for 200 to 300 feet immediately above the Red Unit and near its base carries fragments of this underlying unit. These fragments are angular, up to 2 feet in diameter, and are found a few feet above the Red Unit. They suggest an unconformity, the importance of which is not definitely known. A conglomerate boulder reported in this conglomerate by Wright (1957, p. 11) probably came from one of the conglomeratic layers of the underlying Red Unit; no such boulders were observed by the writer. The transition from red to grey conglomerate is generally gradual, that is, there is a zone where both grey and red conglomerates are interlayered. The conglomerate is not a massive homogeneous layer, but is coarsely stratified and contains intercalated sandstone beds. Some of these conglomerate layers are true conglomerate, others are pebbly sandstone (Fig. 11). Many of the sandstone beds are crossbedded. The fragments, except those derived from the underlying Red Unit near the base of the conglomerate, are well rounded to subrounded and in general unsorted as to size and composition. Their amount in relation to matrix decreases eastward or upward in the conglomerate. White quartz fragments predominate at the top. Other fragments recognized are red feldspar, red alaskitic granite, coarse-grained white gneisses, red granitized gneisses with a high content of dark minerals, red dense siliceous rock, and mica-rich schistose rock. The matrix is coarse grained, sandy, and has little or much red iron oxide. The grains of the matrix average 0.5 mm, are mostly quartz, and many have silica regrowth. Some sericite and tourmaline are also present.

Ellice Formation

The Ellice Formation is the most widespread unit of this succession. Outcrops are widely scattered and occur mainly as large, high, well-exposed hills; a few, however, are accumulations of loose frost-heaved blocks. This sandstone is grey to pink and may be patchy purple or light red. An occasional bed may be red; locally, as along Ellice River, beds may alternate red and grey. The rock is massive, coarsely (but faintly) bedded, and locally well jointed. Crossbeds are common. Ripple-marks were noted. A few beds are conglomeratic or shaly. The grains are fine to coarse and in hand specimens are coated with white silica, kaolin, or clay material. The texture is clastic and sandy. Fragments, up to 6 inches in diameter, subrounded and constituting less than 5 per cent of the sandstone, are common. They are widely scattered, unsorted as to size, and most are grey to milky white quartz. A few are red feldspar, red granitoid rocks, thinly bedded quartzite, and grey sandstone.

154919

FIGURE 11

Northward view of interbedded mixture of red sandstone and conglomerate near the base of Ellice Formation but above associated rocks. Fragments are well rounded and mainly quartz, granite and granite gneiss. Dip is about 30°E.

Thin sections show that the Ellice Formation is made up of closely packed clastic grains, in a matrix of fine clastic material cemented with carbonate, iron oxide, sericite (clay?), and silica. The grains are subrounded, well sorted compositionally and vary in size from 15.0 mm to less than 0.1 mm, averaging about 0.3 mm. In most thin sections, however, the grain size is within a narrower range. In composition, they are 95 per cent quartz grains, 4 per cent chert or fine-grained quartz rock, and 1 per cent accessory minerals such as tourmaline, zircon, chlorite, and sericite. Feldspar grains are missing or rare and were observed in only one section. Silica regrowth on quartz grains was observed in most thin sections, but it is not a spectacular or dominant feature; it may be responsible

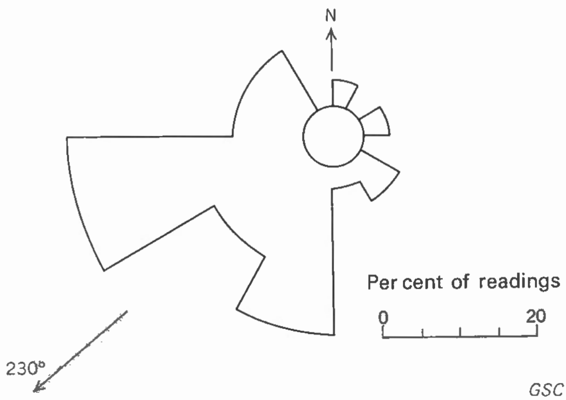

FIGURE 12

Histogram summarizing crossbed dip azimuths in the Ellice Formation. Arrow indicates vector mean, based on 35 readings.

for the quartzitic appearance of some parts of this sandstone. The few narrow quartz veins that were noted may be related to the silica overgrowth and may indicate mobilization of silica. The matrix may be missing or may represent about 50 per cent of the rock; it increases in amount with an increase in the size of the grains and may be half of the rock where the grain averages 1.0 mm.

Thirty-five readings on crossbeds in the south half of the sandstone outcrop area show a southwesterly direction (Fig. 12) of material transport. This is at right angles to the long dimension of the outcrop area, suggesting that the elongation is a structural feature.

Two other rocks studied in thin section, one from the Thelon Formation (Wright's Dubawnt sandstone) and one from the small mass of sandstone southeast of the Ellice Formation area and northwest of the main mass of the Thelon sandstone, show characteristics similar to those of the Ellice Formation. Lithologically the rocks of these three areas might be correlated.

Gabbro

Gabbro is widespread but not abundant in the map-area and is commonly represented by a dyke or a sill, or by a cluster of three or four dykes and sills. In a few places, as in the vicinity of the lake at 65°35'N, 106°25'W and on a narrow zone bordering Bathurst Trench, it is strikingly more abundant. East of the lake, gabbro represents 25 per cent of the rock succession and west of the lake 10 per cent. Within a narrow zone bordering Bathurst Trench on the east, it constitutes somewhat more than 5 per cent of the rock.

Gabbro dykes and sills vary in thickness from a few inches to at least 200 feet; most are less than 70 feet. Locally, where two dykes or a dyke and a sill intersect, a much larger, somewhat irregular mass has been formed. In such areas large blocks of the country rocks may be enclosed in the gabbro and several apophyses, small dykes and sills, may be connected to the mass.

Along strike, sills and dykes may grade into one another. Only a few were followed for any distance. One, northeast of the lake at 65°50'N, 107°35'W, was traced for 10 miles. It is probable that several extend as a unit or as several *en échelon* units across the entire width of the map-area. The gabbro appears to form mainly sills near Bathurst Trench and dykes away from it.

Dykes and sills trend almost entirely northwesterly; a few trend northeasterly and northerly. East and west of Bathurst Trench, the trend is mainly N20°W (Fig. 13) except where the gabbro crosses from sediments into granite when it becomes N70°W. In the vicinity of 65°50′N, 107°35′W, the trend is around N50°W and near Regan Lake in the southwest corner of the map-area it is N60°W. In summary the trend of the sills and dykes seems to change gradually from N20°W in the northeast corner of the map-area to N60°W in the southwest corner. This is very apparent on aeromagnetic maps.

The gabbro is a fine- to coarse-grained rock. The grain size varies with size of the gabbro mass and position in it. It is usually fine at the margins, increasing towards the centre. It is green to black on fresh surfaces and brown to green on weathered surfaces.

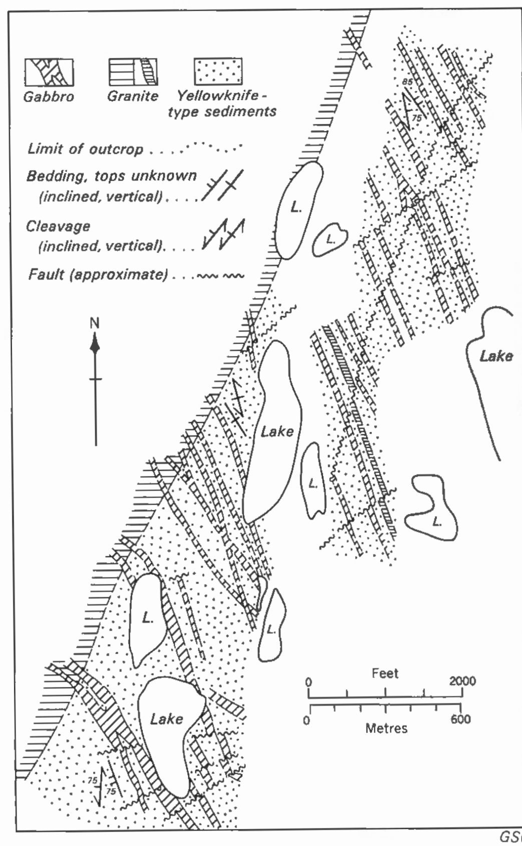

FIGURE 13

Geological map of two outcrop areas showing the abundance of gabbro dykes and sills in the area from west of Ellice River to Bathurst Trench.

Outcrops are massive and generally well jointed. Some of the gabbro masses near Bathurst Trench are sheared or faintly schistose, others are brecciated, and some are faintly granitized and cut by granitic seams.

Three ages of gabbro are present in the map-area. The oldest occurs mainly near Bathurst Trench and trends northwesterly. In hand specimens and in fresh cuts it is altered looking and dark green to greenish black, whereas outcrops are dark brown to dark green. The youngest gabbro trends in the same direction and also occurs as sills and dykes everywhere in the area even near Bathurst Trench. It is grey-black on fresh cut and

TABLE VI — *Estimated mineral composition in per cent of the gabbro of the Beechey Lake area*

	Old Gabbro	Gabbro Sill	Young Gabbro
Number of specimens	4	1	5
Plagioclase	30	50	55
Quartz–feldspar intergrowth	7	5	5
Pyroxene	10	40	30
Alteration products after pyroxene	45		5
Opaque material	8	5	5

light rusty to reddish brown on weathered surface. Its mafic minerals show as shiny specks on a fresh surface. The intermediate gabbro is represented by only one mass: the large gabbro sill within the Goulburn Group. This sill is cut by the younger gabbro dykes but appears to be later than the oldest gabbro as the oldest gabbro does not seem to cut the Goulburn rocks. This sill is light green on fresh cut surface and light brown to green where weathered. Its thickness is variable and although possibly near 450 feet locally it does not appear to be differentiated. The mass pinches out locally along strike. Its field relationship to the Goulburn Group helps to distinguish it from other gabbros of the area. In the Goulburn rocks it is near the base of the succession in the east near Bathurst Trench and much higher in the succession near 65°50′N, 107°08′W near the west margin. Although this gabbro mass is mainly a sill, the relationship described suggests that it is locally transgressive and possibly a dyke. North of the lake at 65°50′N, 107°08′W it possibly passes northward into an ordinary dyke in the Burnside River quartzite. The oldest and youngest gabbros cut the granite masses on the west side of Bathurst Trench. East of the trench, however, the oldest gabbro seems to have been locally slightly granitized and much altered to amphibolite. A few of these amphibolitized dykes are cut by pegmatite and invaded by granitic material, suggesting that the granite east of Bathurst Trench is younger than that west of it.

Thin sections show that the gabbro is composed of plagioclase, pyroxene, opaque material, and some interstitial quartz of quartz-feldspar micrographic intergrowth. The plagioclase is in unoriented laths and these occur mixed with large to small blocky pyroxene masses. All minerals are fairly uniformly distributed; Table VI gives the estimated mineral composition of the gabbros of the area. The plagioclase and pyroxene may be fresh to almost completely altered.

In the oldest gabbro the plagioclase is now a dense mass of dark dusty material and sericite, or of sericite, epidote, and carbonate, and appears to have been a very calcic plagioclase. However, traces of unaltered plagioclase were determined as oligoclase. The pyroxene is generally almost entirely altered to a mixture of amphibole and some chlorite and biotite. In some sections the alteration is so intense that the rock is now a mass of altered material.

The gabbro sill in the Goulburn rocks and the youngest gabbro dykes and sills appear to be similar type of rocks. They are all fresh looking and their estimated mineral composition is about the same (*see* Table VI). Feldspar is unaltered, is a labradorite or locally an even more calcic plagioclase, and in general is more abundant in these rocks than in the oldest gabbro. Pyroxene is also very fresh, in sharp contrast to the pyroxene of the old gabbro, and is a light brown augite. Alteration where developed is similar to the alteration of the pyroxene of the old gabbro but is spotty or peripheral.

Opaque material seems to be slightly more abundant in the old gabbro and also in the altered variety, and closely associated with the pyroxene or its alteration products.

The quartz-feldspar intergrowth is of the myrmekitic type. In general it is more abundant in the gabbros that contain most feldspar. The old gabbro locally has quartz as discrete interstitial grains instead of intergrowths.

STRUCTURE

The amount of structural information on the Beechey Lake map-area available to the writer was highly variable. Most of the areas underlain by Yellowknife-type sediments, nodular schists, granitoid gneisses, and granites were not traversed systematically, and consequently the structure of these rocks is known only in a very general way, mainly by comparison with that of similar rocks. Areas underlain by the Goulburn Group, the Tinney Cove Formation, and the Ellice Formation were traversed more regularly, and their structure is better known.

Bedding

Bedding or stratification was recognized in most rocks except in the massive granite and the granitoid gneisses where the foliation may be in part relict bedding. In the Yellowknife-type sediments bedding is sharp and is defined by rocks of slightly different composition, colour, and grain size such as greywacke, argillite, and quartzite. It is generally easily measured. Locally, however, because the outcrops are lichen-covered or small, because of very little variation in composition, colour, and grain size between adjoining beds, and because of abundant fractures or more intense deformation, it may be almost impossible to measure the attitude of beds. Thickness of beds varies from less than an inch in the argillites to about a foot in the greywacke and to several feet in the quartzites. Beds 35 feet thick were measured in quartzites.

In rocks of the Goulburn Group bedding is varve-like and sharp in the argillites and siltstone of the Western River Formation as these rocks are thinly bedded and colour laminated. Their beds are less than an inch thick and have defined boundaries. In the carbonate rocks of the Western River Formation bedding is crude to faint and in part is represented by threads, lenses, and irregular masses of siliceous material in parallel orientation within carbonate rocks. Quartzites are thickly bedded but the beds are difficult to discern on the outcrops.

In the Tinney Cove Formation bedding is obscure as exposures are deeply weathered and poor.

In the Ellice Formation bedding is also generally obscure. In rocks associated with this sandstone, it is sharp in the Red Unit, rare in the Conglomerate Unit, and obscure or missing in the Grey Unit.

Minor Primary Structures

No minor primary sedimentary structures except variation in grain size and some gradation from coarse grained at the bottom to fine at top of beds were recognized in the Yellowknife-type sediments. The rare examples of gradation in grain size indicate much repetition of the formations and tight folding.

In rocks of the Goulburn Group, however, minor structures such as mud-cracks, ripple-marks, and crossbeds were recognized at many places. In general these structures suggest that beds are not overturned. Mud-cracks were rarely seen on the outcrops but were noted at several places on loose slabs of the Lower Argillite and Red Siltstone Members. Ripple-marks were noted on many sandy beds at several horizons over large areas of the Lower Argillite Member. They are small to very large, up to 15 inches from crest to crest. Crossbeds occur in the pink quartzite of the Burnside River Formation, in some of the white quartzites of the Western River Formation, in the Ellice Formation, and in the Tinney Cove Formation. Measurements of a few of these structures indicate a direction of transport between northwest and southwest. It is southwesterly in the Ellice Formation and westerly to northwesterly in the Burnside River quartzite. Variation of grain size was noted in most quartzites and sandstones, but in general grain size appears to be of the irregular variation type and not coarse at the bottom to fine at the top.

Minor Secondary Structures

In the relatively fresh sediments of the Yellowknife-type and particularly in the argillaceous phases, at least three distinct directions of cleavage were noted. As these rocks were not mapped in a systematic way, the significance of these cleavages is not known, however, their directions appear to be uniform throughout the area. Everywhere they were observed their relationship to the bedding was the same. Two of the cleavages are of the slaty type and are referred to as bedding cleavages even if they are not essentially parallel to the stratification. However, although these two directions are almost parallel to the bedding, their trends are slightly different and they rarely occur together. The older of these two cleavages trends generally west to northwesterly, whereas the younger trends more northerly to northwesterly. The third direction of cleavage is a fracture cleavage, very different from the other two, and ordinarily oriented at a high angle to the bedding direction.

A cleavage was also noted in some of the rocks of the Goulburn Group. It is generally not well developed and occurs in widely spaced areas, mainly within rocks of the Western River Formation. In this formation it was recognized almost entirely in the argillites of the Lower Argillite Member and was seen mainly in the area extending from 65°50′N, 107°08′W to Bathurst Trench. Locally it is so faint that an accurate measurement is almost impossible. It is best developed where rocks are intensely folded, and in a few beds near the base of the succession. In folded areas it strikes north, about parallel to the trend of the fold axes of the area. It dips steeply east. This cleavage is probably related to the folding of the Goulburn Group. Near the base of the succession cleavage is either an incipient stratification or a load effect, as it is almost flat lying and parallel in strike to beds.

In the Burnside River Formation cleavage is restricted to a few thin beds of argillite intercalated in massive thick pink quartzite beds. It is faint, parallel to bedding, and accounts for the schistose appearance of some of these beds. It is probably due to movements along these beds between thick beds of the pink quartzite, and it may be partly a load effect.

A foliation could be measured in most gneisses of the area. In the nodular schist it is probably relict bedding and appears to have been accentuated locally by orientation of some of the metamorphic minerals, in some beds by an increase in size of some of these minerals, and locally in some parts of beds by the concentration of nodules. In the granitoid gneisses of the southeast corner of the map-area and east of Bathurst Trench, it is a gneissosity, a layered structure, and even in places a schistosity. Some of the layering is probably relict bedding as it occurs in rocks that resemble sediments or tuffs, but some of it is probably a metamorphic effect as it seems to be associated with a larger concentration of dark minerals. The schistosity appears to be best developed near Bathurst Trench. It occurs in rocks that are rich in minerals such as chlorite, sericite, and biotite.

Many lineations were seen in the Yellowknife-type sediments. Most are mere streaks on the bedding planes, and are probably the result of the intersection of bedding and cleavage. At least two lineations, represented by streaks, were recognized and both plunge steeply or almost vertically. Other lineations that seem to be the result of movement of beds on the bedding planes were also seen. These are rolls and their plunge is generally not so steep as that of the streaks. The exact significance of these lineations is not known but the steeply plunging ones are probably related to the folds of the Yellowknife-type sediments which are probably steeply plunging.

Only rarely were lineations noted in the Goulburn rocks. In the argillites near the base of the Lower Argillite Member they are of the streaky type. If they occur in other sections of the succession they were not seen. The occurrence noted appears to be related to folds in the Goulburn rocks.

Folds

The Yellowknife-type sediments trend mainly northwesterly. Locally they trend in different directions; these areas are probably the locations of Z-shaped type of drag-folds. In general, dips on beds are steep. The plunge of drag-folds is also steep and mainly southward. These sedimentary rocks must be isoclinally folded. The folds are tight; they appear to trend mainly northwestward and plunge steeply. The older of the two directions of flow cleavage previously mentioned is probably related to these isoclinal folds as it seems to be parallel to the main trend of folds. The vertical lineation seen almost everywhere in Yellowknife-type sediments is probably also related to these isoclinal folds, and may represent the plunge of these folds.

Rocks of the Goulburn Group, the Ellice Formation and its associated rocks, and the Tinney Cove Formation have all been folded, but not so intensely as the Yellowknife-type sediments. Some of the Goulburn rocks are almost flat lying or exhibit gentle rolls with dips of less than 15 degrees, and in many places it is almost impossible to recognize these rolls on the outcrops. Their fold axes are almost horizontal or plunge very gently. Other areas of Goulburn rocks have steeply inclined beds with dips of 60 degrees or more. The argillites and siltstones are generally more intensely deformed than the quartzites and sandstones. In the argillites and siltstones, the folds are tighter, the fold axes closer, and the dips of beds steeper, whereas the thick succession of quartzites and sandstones has more open and wider folds, more widely spaced fold axes, and in many places is characterized by folds that are gentle rolls only. In other words, the folds mapped in some argillites and siltstones below a thick succession of quartzite may not be so obvious or may not occur in the quartzites above. The folding is of the disharmonious type. The folds in the Goulburn rocks trend northerly and their axial planes are vertical to steeply east. No overturning was recognized. Examples of disharmonious folding are common. In the area extending from the lake at 65°50′N, 107°08′W, east to Bathurst Trench—an area of about 15 miles wide where both argillites and quartzites are involved—eight main synclines separated by anticlines were mapped in the quartzites of the Burnside River Formation. In the argillites of Western River Formation below and within an area only a mile wide east of Crooked Lake six fold axes were recognized.

In the north outcrop of the Tinney Cove Formation bedding attitudes suggest a syncline trending about parallel with the trend of the valley and plunging northwesterly.

The area underlain by the Ellice Formation and its associated rocks is seven times as long as it is wide and seems to be a basin elongated in a northwest-southeast direction. Bedding readings at both extremities of the area suggest a closed basin, but the basin is not symmetrical as its centre is near its northern end. Nowhere is the plunge steep and in the south it is about 30 degrees northwest. Dips are up to 50 degrees in the north and below 30 degrees in the south. Bedding readings near the northeast and southwest margins are few; however, a couple in the northern part suggest that the sides of this basin may have been truncated by faults. Although this truncation is not apparent everywhere, the present shape of this basin may well be a tectonic feature, as may the asymmetry mentioned above, although the location of the centre of the basin is probably a depositional feature.

Faults

Very few faults were recognized in Beechey Lake map-area. Those mapped generally offset the rocks of the Goulburn Group, the Ellice Formation and its associated rocks, and the Tinney Cove Formation. No faults, except possibly those on the southern extension of Bathurst Trench, occur in pre-Goulburn rocks. The mapping of these rocks was too spotty to give much information on the probable faults.

The few faults mapped were all recognized by offset of formations. These offsets seem to indicate large horizontal displacements. In general the nature of the faults, their direction, and amount of movement are not known. They are all steeply dipping. However, none is sufficiently known to describe in detail.

Several faults were mapped along the valley of Western River, two of which outline the valley itself. The pronounced depression that marks this valley, the Bathurst Trench, is regarded as a major tectonic feature—probably a graben. It was traced from the northern boundary of the map-area to where the Ellice Formation outcrops near the eastern boundary. The faults that limit this trench seem to dip steeply in towards each other. The younger Tinney Cove Formation was mapped within the trench. These younger rocks appear to have been down-faulted in relation to the rocks on both sides of the valley. The Goulburn rocks are truncated on the east along the trench as delineated by one of the faults and are found along the western side of the trench in contact with the rocks of the Tinney Cove Formation, the Yellowknife-type sediments, and the granitoid gneisses. It is not known if the western edge of this trench has moved at all, but the central part has definitely moved down and the eastern edge up relative to each other and to the western edge. Southward the deep gully dies out before reaching the Ellice Formation, suggesting that the faults that define the trench may also die out at the Ellice Formation. The movement on the faults bordering the trench is not known, but the apparent offset is about 20 miles as indicated by the Goulburn rocks on both sides of the trench, one of these contacts (Fraser, 1964) being north of the map-area.

This trench or graben is a well-defined topographical feature in the area northwest of the Ellice Formation and north of the map-area as far as the Arctic Coast (Fraser, 1964). Southeast of the Ellice Formation there is no such topographical feature, and if this tectonic feature does extend south of the Ellice Formation, its position is not readily apparent. However, on the possible extension of this trench some mylonite and brecciated rocks were recognized locally. These are in granitoid gneisses and Yellowknife-type sediments. They occur over wide zones and seem to be fairly continuous, but as they were not mapped in detail, their pattern, width, and trend are not yet known. On the other hand the faults that border and define the trench are sharp features with very little or no associated mylonite and brecciated rocks. This would suggest that the mylonite zones and brecciated rocks in the gneisses and Yellowknife-type sediments are old structures whereas the faults on both sides of the trench are younger superimposed structures. They are probably related, as both occur along the same zone of deformation.

The Bathurst Trench appears to represent a deep crustal element because: (1) gabbro dykes and sills are abundant in the gneisses and Yellowknife-type sediments on both sides of the trench; (2) the trench extends 150 miles northward to the Arctic Coast, making the feature at least 200 miles long; and (3) southward it seems to represent the extension of abundant mylonitic and brecciated rocks. The development of a faint schistose structure with the formation of sericite and muscovite on both sides of this trench in Beechey Lake area is probably related to its formation.

CONDITIONS OF DEPOSITION

The Yellowknife-type sediments are mainly clastic. They are fine grained, thinly bedded, and grey to black. Beds are continuous. They are alternately argillite, greywacke, and sandy or argillaceous phases of these rocks. Altogether they are a monotonous succession, lacking good marker beds. Shallow-water features are generally absent. Even if these rocks are not generally limy, they are assumed to be of flysch-type and to have formed in water at depth below wave action under probably marine conditions of deposition, that is, in a geosynclinal trough.

The Goulburn rocks are predominantly clastic. Argillites and siltstones are the characteristic rocks of Western River Formation whereas sandstones or quartzites, which become progressively more abundant near the top of this formation, are the characteristic rock types of the overlying Burnside River Formation. Carbonate rocks represent only about 5 per cent of Western River Formation and most of them are stromatolitic; they are missing in the Burnside River Formation. This gradual upward change of rock types within the succession suggests a gradual change in the relief of the adjoining land area and also changing conditions of deposition.

The basal conglomerate is a mature rock. The good sorting of its components as to size and composition suggests long transportation. Its sheet-like occurrence suggests transgressive beach conditions over a surface of low relief and a basin area becoming larger as the transgression progresses. The preservation of the regolith in the west and its destruction and replacement by conglomerate in the east suggest a transgression from west to east. As none of the fragments in the conglomerate is greywacke or argillite or rocks related to the Yellowknife-type sediments outcropping south and west of the Goulburn rocks in Beechey Lake area, and as none is gneiss or granite or rocks related to the granitoid gneisses east of Bathurst Trench, these two areas do not appear to be the source areas for this conglomerate. If the dominant quartz fragments are vein quartz the source area could be practically anywhere. If the source area was a gneissic and granitic terrane, it is very likely that fragments of these rocks would also be common, as granite and gneiss are almost as resistant to erosion as quartz. As they are not present the source of the quartz fragments is still not known.

The feldspar content of the argillites and siltstones of the Goulburn Group, their locally high clay content, and their widespread mixture of clastic grains and clay matrix suggest short transportation and rapid deposition in a quiet basin. Shallow water is indicated by mud-cracks, crossbeds, and ripple-marks. The thinly interbedded mixture of argillite, siltstone, and quartzite suggests rapid changes in the tectonic activity of the source area and in the conditions of deposition of the basin.

The good sorting of the sandstones as to size and nature of their grains, the roundness of most of their grains, and their small clay content suggest long transportation, quiet environment of deposition, and a mature, tectonically inactive source area. Their crossbeds suggest shallow water.

Most dolomites are widely stromatolitic. Some are massive and not stromatolitic. Stromatolites are generally regarded as formed by algae in shallow warm waters. Their environment could have been marine or continental. The few tourmaline grains observed in these and other rocks of the Goulburn Group may indicate marine conditions.

Shallow-water condition is also suggested by interformational conglomerate and breccias associated with mud-cracks.

The lenticular masses of carbonate rocks in clean sandstones (Quartzite Member) suggest closed-in basins of deposition. When these basins were being filled with carbonate, detrital sedimentation continued as the sandstones are carbonaceous to various degrees and the dolomite is partly detrital. This association, dolomite and clean sandstone, suggests for the source area a stable land of fairly low relief.

From the foregoing, it is clear that it is not possible to determine the source rock and the source area for these Goulburn rocks. The source rock was probably quartzose, as most rocks are high in quartz, and the source area was likely to the east, as no Yellowknife-type argillite or greywacke fragments were recognized in the conglomerates of this succession and as the direction of transport from crossbed measurements in some sandstones is to the northwest. It is also likely, from the nature of the fragments of the conglomerate layers and the good sorting and roundness of the sandstone grains, that the source rock was an old sedimentary terrane to the east and southeast. The conditions of deposition were variable, but generally in a fairly quiet and shallow basin. This deposition was greatest in the east, as there the thickness of the sediments deposited was greater and the basin was sinking at a faster rate than in the west (Fig. 4).

The Ellice Formation and associated rocks underwent conditions of deposition similar to the Goulburn rocks. Most of the rocks are clastic, even the carbonate rocks have appreciable amounts of clastic grains. Conglomerate and carbonate rock are of local extent only. The roundness of the grains of sandstone and of most fragments of conglomerate, the good sorting of grains in the sandstone as to size and composition, and the high quartz content of these rocks suggest long transportation. This is also suggested by the absence of feldspar and chlorite, and the low clay content of most sandstone. Shallow water is indicated by ripple-marks, crossbeds, stromatolites, and occasional large subrounded fragments in a fairly well sorted rock. There are also indications that some of the associated rocks were subjected to erosion for short periods between periods of deposition, as fragments near the base of some of the conglomerate lenses are angular and related in composition to the rocks below.

The source area for the Ellice Formation and associated rocks was to the northeast as suggested by: (1) the fragments in the conglomerate, which are gneisses and granitoid rocks related to the red gneisses and granite to the northeast; (2) the readings on the crossbeds in the Ellice sandstone, which indicate a direction of transport to the southwest; and (3) the iron oxide in some of the rocks in the north half of their outcrop area. This iron oxide came probably from the weathering of the red gneisses to the northeast. If it was hydrothermal it should be restricted or concentrated along zones of deformation and fractures. If it was a surficial effect it should be at surface everywhere in the area.

The conditions of deposition and the source area for the rocks of the Tinney Cove Formation were probably the same as for those of the Ellice Formation as both rocks are correlated (*see* section on correlation).

ORIGIN OF BASINS

The area underlain by Goulburn rocks in Beechey Lake map-area is only a small part of that known to be covered by Goulburn rocks. The total area as mapped at 8 miles to 1 inch (Fraser, 1964; Wright, 1957) is represented by four separate basins. The Beechey Lake area of Goulburn rocks is on the rim, near the southern tip, of the largest of the four basins, that is, the basin in the immediate vicinity of Bathurst Inlet. Mapping of the Goulburn rocks in the Beechey Lake area gave very little information on the nature of this large sedimentary basin, but has shown that its base is folded to various degrees, that it is elongated in a northerly direction, that the folds trend roughly parallel to the length of the basin, and that the thickness of the deposited sediment increases from west to east.

The thickness of the sediments in the area of the Ellice Formation has been estimated at about 5,000 feet. This figure suggests that the basin became deeper as filling proceeded. However, its present shape and outline is probably mainly tectonic. It is unlikely that the dips of some of the beds are depositional as they range up to 50 degrees. These sediments were probably also folded. Folding may have been the result of movement on the faults along the margins of the basin; that is, as the rocks of the basin were down faulted, they were compressed in an east-west direction.

The area underlain by the Tinney Cove Formation is also believed to be a tectonic feature, as it is a slice bordered by faults and preserved because of down faulting along these faults. However, as some of the dips are very low and suggest depositional features they are probably relicts of the original basins before the emplacement of the slice by faulting.

AGES

The oldest (absolute ages) rocks in Beechey Lake area are probably the Yellowknife-type sediments. Their time of deposition is not known, but in the northwest corner of the map-area they are cut by granites dated at 2,390 m.y. and 2,550 m.y. (both on biotite). In the same corner the sedimentary rocks are locally metamorphosed into nodular schists dated at 2,490 m.y. (biotite). In the southeast corner, that is, in the area near or in the border zone between the older Slave Structural Province on the west and the younger Churchill Structural Province on the east, similar types of granites and nodular schists gave ages of 1,950 m.y. and 2,030 m.y. for the granites and 2,100 m.y. and 2,140 m.y. for the nodular schists (all on biotite). The granitoid gneisses east of Bathurst Trench have been dated at 1,920 m.y. and 1,990 m.y. (also on biotite). The significance of these younger dates is not known, but they may indicate a younger period of granite intrusion or they may represent old dates that have been updated by the Hudsonian Orogeny. In summary these dates suggest that the rocks are Archean or early Aphebian. They suggest also that the sediments are probably pre-Kenoran, that most of the granites are Kenoran, and that some of the granites are possibly post-Kenoran. No geological evidence has been recognized in this area to support the presence of a younger granite. However, about

150 miles west of Beechey Lake map-area a young granite cuts and metamorphoses Epworth rocks (Fraser, 1966), which are correlated with Goulburn rocks (*see* Correlation). The Goulburn rocks rest unconformably on the old sediments and granites mentioned previously. An age of 2,380 m.y. on clastic muscovite from argillites at the base of the Goulburn rocks suggests that these rocks were derived from these old granite and meta-sediments. The Goulburn rocks are then younger than 2,480 m.y. (average of 2,390, 2,550, and 2,490).

A partly transgressive gabbro sill was mapped in the two formations of the Goulburn Group that occur in this area. This sill was dated at 1,215 m.y. by the K/Ar whole rock method from a sample collected near Bathurst Trench where it is in the lower of the two formations. A hundred miles farther west, in Rocking Horse Lake area (Bostock, 1967), a similar and related sill in the same lower formation was dated at 1,555 m.y. by the same method (Wanless, 1967, p. 59). This would suggest that the Goulburn rocks of this area are probably Aphebian although they could be in part Helikian.

One of the late gabbro dykes trending northwesterly and cutting Archean rocks, Goulburn rocks, and a gabbro sill in the Goulburn rocks was dated 1,050 m.y. (whole rock). This dyke probably represents the youngest rock of the area.

SLAVE–CHURCHILL BOUNDARY

The boundary between the Slave and the Churchill Structural Provinces has been placed in the east half of Beechey Lake area (Stockwell, 1964). In the northern part of this region it follows the Bathurst Trench from the northern boundary of the map-area to the Ellice Formation near the eastern boundary. This part of the boundary, being a fault, is sharp, straight, and well defined. The rocks on the western side of the boundary are lithologically different from those on the eastern side. But their ages, at least those on rocks older than those of the Goulburn Group, are all of about the same order of magnitude. Thus, a biotite age of 2,030 m.y. was obtained from a small granite body (about 8 miles west of the northern end of the Ellice Formation) west of the Bathurst Trench and almost similar ages were obtained on biotite from two granitoid gneisses east of the trench; one of these ages is 1,990 m.y., the other 1,920 m.y. These three ages are high if compared to the mean age (1,735 m.y. Stockwell, 1964) for the Churchill Province. The boundary between the two provinces may not be at Bathurst Trench but at some distance east of the trench if absolute ages alone are considered. If the position of this boundary is based on the nature of the rock types, their degree of metamorphism, and their structural trend, then its present position, as located by Stockwell, is probably correct, as this position is based on differences of rock types, differences in the degree of metamorphism, and some differences in the trends of structural elements on both sides of the boundary.

In the southern part of the east half of the map-area the boundary was placed at a granitization front and is arbitrary as it is a gradational contact. On the eastern side of this boundary the rocks are granitoid gneisses; on the western side they are fine-grained nodular schists and gneisses. This front of granitization appears to be transgressive in relation to the nodular schists as the granitoid gneisses are superimposed on the nodular schists. This boundary then marks the western limits of the granitization effects associated with the Hudsonian Orogeny of the Churchill Province. As the rocks on both sides of the boundary give relatively similar ages (on the west: 1,950, 2,030, 2,100 and 2,140 m.y.; on the east: 1,920 and 1,990 m.y.), they all were probably once parts of the same structural province, in this case the Slave Province, as these ages are regarded as Slave ages updated by the Hudsonian Orogeny. The updating effect has been operative for some distance west of this boundary, and, being progressive, it could possibly mark the boundary. If so, the actual boundary would have to be moved west. However, its present position was placed where the visible effect of the granitization front on the outcrop ends as this is a fairly easy recognizable feature.

In summary, this boundary probably should be moved farther eastward outside this map-area if absolute ages alone in relation to the mean age of 1,735 m.y. are used, or westward if the updating effect is used. But if its position is determined by metamorphic effects (in this instance the granitization front) of the Hudsonian Orogeny, then the boundary is probably properly located where it is placed on the accompanying map. However, this position could be changed slightly as more detailed mapping is done but in general it would not change greatly; in this work it was changed slightly from Stockwell's position. The granitization effects related to the Hudsonian Orogeny are the only safe diagnostic features to determine the position of this boundary in the south half of this area; structural features cannot be used as they were obscured by the granitization.

CORRELATION

The Yellowknife-type sediments of Beechey Lake area are correlated with the sediments of the Yellowknife Group on similarities of lithology, texture, deformation, and metamorphism. Their rock types are similar to those of the Yellowknife Group, except that in Beechey Lake area they are in general slightly more argillaceous, somewhat finer grained, and seemingly more thinly bedded. The Yellowknife-type sediments of this area are tightly and isoclinally folded similar to the sediments of the Yellowknife Group. They have reacted similarly to the effects of metamorphism; wide zones of nodular schists have formed. They are cut by similar types of granites; however, the granites of this area seem to occur in discrete masses with little apparent metamorphic effects on the intruded rocks whereas those in the Yellowknife area have wide migmatite zones around them. The discrete granite masses from the Beechey Lake area date between 1,950 m.y. and 2,550 m.y. No younger dates are known on granites. So, as in Yellowknife area, no younger granite has been found cutting the Yellowknife-type sediments in Beechey Lake area except east of Bathurst Trench where the granitization recognized is locally represented by a younger granite. Dates on pegmatites east of Bathurst Trench average 1,800 m.y. This date is almost the average for the Churchill Province.

The Tinney Cove Formation is correlated with the Ellice Formation. Although both successions differ appreciably in thickness in this area—the Tinney Cove Formation is estimated at 200 feet whereas the Ellice Formation is several thousand feet thick—both are correlated on similarity of lithology, proximity of outcrops, and location on the same structure, the Bathurst Trench, or its likely extension. The Tinney Cove Formation is within the trench; the Ellice Formation is on its possible extension to the south. The sandstones of both successions have conglomerate towards the base, have a clay kaolinitic cement throughout, are composed mainly of subrounded to rounded quartz grains, and have grains that average 0.5 mm in diameter and that show common silica overgrowth.

This correlation is extended for similar reasons to the Thelon Formation (Donaldson, 1965) to the east southeast—a correlation recognized as possible by Wright (1957) and accepted by Douglas (1963). Readings on crossbeds in the Ellice Formation (Fig. 12) and the Tinney Cove Formation support this correlation, suggesting a west-southwest direction of transport similar to that within the Thelon Formation (Donaldson, 1965).

Rocks below the conglomerate unit at the base of the Ellice Formation cannot be correlated with rocks in this area, but it is possible that they should be correlated with one of the uppermost formations (Brown Sound or Kuuvik) of the Goulburn Group (Tremblay, 1968; Fraser and Tremblay, 1969). If so the contact between the Red Unit and the conglomerate below the Ellice Formation would be an unconformity.

A correlation also is suggested between the Goulburn Group and the Epworth Group; this has already been proposed by Fraser (1964, p. 17). Both groups rest unconformably on older sediments and granite and both have a white sandstone succession (the Tinney Cove Formation in the Goulburn area and the Hornby Bay Sandstone in the Epworth area) with a kaolinitic cement overlying them unconformably. The basal units of both successions are similar lithologically and in outcrop areas are at one point less than 20 miles apart. However, no pink quartzite comparable in thickness to the Burnside River pink quartzite of the Goulburn Group has been found in the Epworth Group. Instead a thick succession of dolomite was mapped at about the equivalent level in the Epworth Group. The correlation between both groups is proposed nevertheless and this difference may represent only slightly different environments of deposition. There are also similarities of lithology in the upper parts of the successions of both groups (Fraser and Tremblay, 1969).

The large gabbro sill in the Goulburn rocks and the late gabbro dykes are probably interrelated events even if the dykes cut the sill. The sill and the dykes were probably derived from the same gabbroic mass but injected at different intervals. Whole rock K-Ar ages on this sill (1,215 m.y.) and one of the dykes (1,050 m.y.) cutting the sill support this hypothesis so both dates are of about the same order of magnitude.

METAMORPHISM

It is not possible to present a thorough description of the metamorphism of the area, as the geological information is not sufficient and chemical data are not available. Only a few very general remarks can be offered, some of which have been partly expressed under other headings.

Relatively unmetamorphosed Yellowknife-type sediments cover the central part of Beechey Lake area and grade outward into a wide zone of nodular schists and gneisses. This regionally important nodular zone shows a broad relationship to the main granite masses of the area and is entirely within the Slave Structural Province. East of Bathurst Trench and in the southeast corner of the map-area, on the side of the Churchill Structural Province, the rocks are almost entirely granitoid gneisses and granites. Garnet is common, but these granitoid rocks lack andalusite, cordierite, and staurolite which constitute the nodules of the nodular schists. The geological implications of these differences in the types of gneisses on both sides of the boundary between the Slave and the Churchill Structural Provinces may be as follows:

(1) They may indicate rocks of different compositions. This was suggested by grain count in thin sections of rocks of both groups. It seems that the granitoid gneisses were probably derived from more siliceous rocks than the nodular schists and gneisses (*see* Table I).

(2) They may indicate different periods of metamorphism. This is suggested by the absolute ages obtained on both groups of gneisses and by the alteration of some of the nodules in the nodular schists, which suggests that the metamorphism of the Churchill Structural Province is superimposed on the earlier metamorphism of the Slave Structural Province.

(3) They may indicate different domains of metamorphism. The metamorphism of the

Churchill Province is of the type implying widespread granitization and probably belongs to the domain of anatexis. The metamorphism of the Slave Province is of the type characterized by the development of andalusite, staurolite, and cordierite nodules in a rock where widespread granitization is missing. This metamorphism could be referred to as a regional metamorphism of the low pressure intermediate type (Miyashiro, 1961).

(4) Finally they may indicate different crustal depths. On the Churchill Province side of the boundary, the granites are diffuse bodies with gradational contacts and they were involved in the type of cataclasis characterized by fine layering and not coarse breccia. The fine layering of mylonite is regarded as a deeper phenomenon. On the Slave Structural Province side of the boundary, the granites are in discrete masses and mainly in the nodular schist zones. The Slave rocks seem to represent a higher level of the crust, the Churchill ones a deeper level. There is then the possibility that the Churchill rocks lie stratigraphically underneath the Slave rocks, particularly when the 20-mile horizontal offset along the Bathurst Trench is taken into consideration. If so they will be older than the Slave rocks even if their absolute ages are younger than those of the rocks of the Slave Province.

ECONOMIC GEOLOGY

As Beechey Lake map-area was not entirely mapped its mineral potential cannot be fully assessed with accuracy. However, the following known mineral occurrences are good indications of the possibilities of the area.

(1) Grains of arsenopyrite about a quarter of an inch across were noted in a narrow carbonate vein along Ellice River a short distance north of the northernmost outcrops of the Ellice Formation. This vein could be traced for only a few feet and where seen was less than 3 inches wide. It is in granitoid gneiss near an amphibolite mass probably representing an old gabbro sill. Arsenopyrite was also reported from the gold prospects mentioned below and described by Lord (1951).

(2) Chalcopyrite mainly as individual grains but also as masses up to 3 inches wide was noted in several of the old gabbro sills within Bathurst Trench near the southernmost outcrops of Goulburn rocks along the trench. A few chalcopyrite grains were also noted in some of the gabbro dykes and sills.

(3) Magnetite in grains less than 0.1 mm occurs in iron-formations at two localities. These occurrences are described in the section on *General Geology*. Their iron oxide content is probably less than 40 per cent. At one locality magnetite is associated with red garnet (cell edge 11.57), at the other with abundant pyrite.

(4) Pyrite was recognized in many rock units. It occurs in tiny grains sparingly distributed with pyrrhotite in most gabbro dykes and sills. In Yellowknife-type sediments it and pyrrhotite cause the occasional rusty outcrop. It occurs as tiny concretion-like blebs in greywacke or is finely disseminated locally in argillite and slate. It constitutes about 15 per cent of some quartzose rocks closely associated with one of the known occurrences of iron-formations and its outcrops are deeply weathered and rusty black. Along the probable extension of Bathurst Trench in schistose quartz-pebble conglomerate and grit, pyrite is bright yellow, sparingly distributed, and abundant enough to produce rusty outcrops. Traces of gold were apparently panned from this conglomerate.

(5) Gold showings have been reported from the southwest corner of the map-area in

the general vicinity of Regan Lake. None of these gold showings was visited by the writer. However, their geological settings, the exploratory work done on most of them, and some of their results have been described and published (Lord, 1951; Schiller and Hornbrook, 1964 and 1965). The gold is found associated with quartz veins in Yellowknife-type sediments in an area where these sedimentary rocks are interbanded with tuffs, agglomerate, and basic volcanic rocks. Arsenopyrite in abundant elongated needles was found in both the veins and wall-rocks.

(6) Hematite or specularite occurs as seams with carbonate and quartz in gabbro sill or dykes and disseminated throughout some of the Goulburn rocks.

Other features that may have some bearing on possible mineral occurrences in the area are veins, seams, and irregular masses of quartz or carbonate. Quartz veins and veinlets were noted in all rock types. They cut pegmatites, some of the late gabbro dykes and sills, and in granite are locally masses and blebs. There may be several ages of quartz veins. The carbonate veins and seams are generally closely associated with the gabbro dykes and sills. Locally these quartz and carbonate veins and seams are mineralized with some of the minerals mentioned but generally they are unmineralized or have only traces of minerals. Many of the quartz veins and blebs contain small amounts of white feldspar.

Garnet was found in some of the rocks associated with the iron-formation and also in some of the gneisses and pegmatites throughout the area but mainly east of the Bathurst Trench.

No mineralization of any type except for hematite was noted in Goulburn rocks, the Tinney Cove Formation, and the Ellice Formation and its associated rocks. The conglomerate at the base of the Goulburn succession appears to be entirely free of sulphide and oxide mineralization. Smoky quartz was noted in some quartz veins in the Burnside River Formation.

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