GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

PAPER 60-8

PRECAMBRIAN GEOLOGY OF ARCTIC CANADA, A SUMMARY ACCOUNT

R. G. Blackadar and J. A. Fraser

Price 50 cents

1960

CANADA

GEOLOGICAL SURVEY

OF CANADA

PAPER 60-8

PRECAMBRIAN GEOLOGY OF ARCTIC CANADA, A SUMMARY ACCOUNT

Part I -- The Precambrian of the Arctic Archipelago
by R.G. Blackadar

Part II -- The Precambrian of the Arctic Mainland
by J.A. Fraser

DEPARTMENT OF

MINES AND TECHNICAL SURVEYS

CANADA

This paper is one of several summary papers prepared by officers of the Geological Survey of Canada and presented at the First International Symposium on Arctic Geology, Calgary, Alberta, 1960. Preliminary publication is by arrangement with the organizing committee of the symposium.

Part I -- The Precambrian of the Arctic Archipelago

CONTENTS

Part I

THE PRECAMBRIAN OF THE ARCTIC ARCHIPELAGO

by R.G. Blackadar

Introduction

The Arctic Archipelago is merely the flooded northern part of the North American Continent and for this reason it is no surprise that geological features found on the mainland are continued on the islands.

With minor exceptions the rocks in the Archipelago are progressively younger from the southeast to the northwest, and if Baffin Island were excluded, the Precambrian outcrop areas would be restricted to structural highs on Boothia Peninsula, Somerset Island, and Victoria Island. Outcrops of Precambrian rocks are not known in the Queen Elizabeth Islands except along the eastern coasts of Ellesmere and Devon islands, and metamorphic rocks of possible Precambrian age in northern Ellesmere Island. A specimen from the latter complex has recently been dated at 545 million years, suggesting a late Precambrian or early Palaeozoic age for the most recent metamorphism in this area. Magnetic data suggest that the Shield lies at no great depth in the area between eastern Victoria Island and eastern Prince of Wales Island, a fact in accord with the progressive thickening toward the northwest, of the post-Precambrian rocks mentioned above.

The broad division of the Precambrian rocks on the Shield—into gneisses, granitic rocks, and lesser amounts of highly deformed and metamorphosed sedimentary material, and less deformed and only slightly metamorphosed strata which in many places include basic intrusive rocks—is equally applicable in the Arctic Archipelago.

The absolute ages of these rocks are mainly unknown, but in many places the less metamorphosed sedimentary strata rest unconformably on granitic or gneissic rocks and they are tentatively considered to be Proterozoic in age, whereas the gneissic rocks are thought to be Archaean; however, when absolute age determinations become available, some gneissic rocks may be found to be younger than less deformed strata presently considered of Proterozoic age.

Archaean

With the exception of widely distributed late Precambrian strata in northern and northwestern Baffin Island, the Precambrian rocks mapped on this island consist of heterogeneous, complexly folded granitic gneisses. Here and there throughout this complex, and interbanded with it, are belts and bands of limestone, graphitic schist, quartzite, and mafic schists.

The gneisses of southern Baffin Island, roughly those outcropping S66°N, are more variable than those farther north. In addition to the ubiquitous granite-gneisses there are widely distributed gneisses, granulites and massive granitic rocks, all of which vary in composition from felsic to mafic and which contain hypersthene and commonly hornblende.

In the Cumberland Sound area these rocks form a complex of differing metamorphic facies (Riley, 1959)[1]. The highest grade of metamorphism is represented by charnockite or hypersthene gneiss outcropping at the head of the sound. The metamorphic grade decreases to the southwest through amphibole-bearing granitic gneiss to epidote-biotite granitic gneiss. Although many of the groups within the complex appear conformable, one to the other, Riley noted a group of biotite-, garnet-, and scapolite-bearing schists and gneisses lying unconformably above the granitic amphibole-bearing Chidliak gneiss.

Similarly along the south coast of Baffin Island, well-stratified, buff-coloured, quartz feldspar granulites, commonly hypersthene-bearing, are found associated with lower-grade, hornblende-biotite-chlorite granitic gneisses. Common to all parts of Baffin Island are fine- to medium-grained granitic gneisses that in many places are interbanded with biotite granitic gneiss and biotite-garnet granitic gneiss. The latter association is widespread along the coasts of southern Baffin Island. A specimen of granite-gneiss from Cape Dorset was dated by the Isotope and Nuclear Research Section of the Geological Survey as 1,685 million years. These rocks contain interbedded marble belts (Blackadar, 1959) and other metasedimentary strata, and some authors had suggested a Grenville or even Proterozoic age for them. The physical age obtained appears incompatible with such correlation.

In the coastal region near Clyde on the east coast of Baffin Island, granitic gneisses with biotite or less commonly hornblende, are associated with widespread lenses, bands, and patches of amphibolite thought to be derived from dykes and sills. Throughout this area, near-horizontal foliation prevails and recumbent folds have been detected locally (Kranck, 1955).

Lithology similar to the Clyde area prevails farther north in the Admiralty Inlet (Arctic Bay) and Eclipse Sound (Pond Inlet) areas. At Admiralty Inlet the Archaean rocks include biotite-gneiss, banded biotite and granitic gneiss, biotite-garnet gneiss and small irregular masses of biotite-granite which cut the gneissic rocks. Little is known of the northward extension of the Archaean rocks of Baffin Island. Similar rocks are known to outcrop on eastern Devon Island and on eastern Ellesmere Island south of Bache Peninsula. Granite, granitic and layered garnetiferous gneisses, and gneissoid quartzites are found on Devon Island; and along the central part of the east coast of Ellesmere Island, acid and basic rocks containing hvpersthene are found associated with paragneisses and granites, as well as other features reminiscent of southern Baffin Island.

---

[1]Names and dates in parentheses refer to publications listed in the References, p. 8.

Outcropping in northern Foxe Basin area at the eastern entrance to Fury and Hecla Strait, is an assemblage of amphibole schist, biotite schist and chlorite schist (Blackadar, 1958a). Here and there are relics of pillowed lava flows and coarse-grained diabasic layers which may be the centres of flows. These rocks are intruded by granite but the relationship of this granite to the granitic gneisses which comprise much of the exposed Precambrian in this region is unknown.

Two similar assemblages occur on Baffin Island southeast of Steensby Inlet and north of Piling Bay (Blackadar, 1958b). The first comprises amphibole schist, micaceous quartzite and iron-formation, and the second, some 20 miles farther south, is mainly quartzite, conglomerate, and dark greenish grey micaceous quartzite. Sills of granite occur only within the first, or mafic, group. Similar strata are reported to outcrop farther south along the little-explored east coast of Foxe Basin.

Crystalline limestone and biotite, garnet and sillimanite schists and gneisses, amphibole schist and gneiss, quartzite and quartz-mica schist are bedded with the granitic gneisses and mixed with granitic rocks of southern Baffin Island (Blackadar, 1959; Davison, 1959a, b). Quartzite has been mapped in substantial amounts in the southwestern part of Baffin Island. Northeast of Cape Dorset, gradations from quartzite to biotite granitic gneiss have been observed, and the evidence suggests widespread granitization of the original sedimentary rock.

The gneisses inland from Clyde contain a belt of crystalline limestone with metamorphic derivatives, and a belt of quartzite with lesser carbonates, meta-argillaceous strata, and a bed of banded quartz-magnetite rock probably derived from an iron-formation.

A few areas in the Cumberland Sound region contain crystalline limestone. Riley (1959) reports that "Bands of crystalline limestone from 2 inches to about 40 feet wide occur singly or grouped together in zones up to 200 feet wide. They can be traced up to several hundred yards along strike."

The Precambrian granitic rocks, gneisses and schists, of northeastern Southampton Island, Melville and Boothia peninsulas, and western Somerset and eastern Prince of Wales islands, have not been differentiated. Crystalline limestone, argillite, quartzite, slate, garnet-mica schist and paragneiss are known to occur in northeasterly trending folds midway up the eastern part of Melville Peninsula.

Proterozoic

Relatively undeformed and unmetamorphosed sedimentary strata outcrop on Bache Peninsula, Ellesmere Island (Troelsen, 1950) and some 45 miles north at Copes Bay (Thorsteinsson, 1956). The former locality has long been correlated with the Thule group of northwest Greenland, thought to be of Proterozoic age. It includes sandstone overlain by dolomite. At Copes Bay, similar rocks are thrust over

Silurian beds. In ascending order, they comprise dolomite, conglomerate, sandstone, shale and dolomite. This succession is overlain by Middle Cambrian limestone. These Proterozoic strata extend northeasterly to Dobbins Bay and thence northward past Scoresby Bay to about latitude 80°45'N.

Similar rocks are known on southeastern Ellesmere Island from the vicinity of Fram, Grise, and Harbour fiords and at Craig Harbour (Bentham, 1941; Wordie, 1938).

More than 11,450 feet of sedimentary and volcanic rocks similar in lithology to the Thule group outcrops along the eastern shores of Admiralty Inlet, northwestern Baffin Island (Blackadar, 1956).

More detailed studies have been made here, and the stratigraphic succession is shown in Figure 1. The rocks can be divided into a lower, sandstone-volcanic assemblage—the Eqalulik group—and an upper succession of shale, dolomite, dolomitic siltstone, siltstone, and sandstone—the Uluksan group. These groups have been further subdivided.

Sedimentation on an eroded gneissic terrain commenced with the deposition of a nearly pure sandstone that now varies in thickness between 10 and 100 feet. A period of volcanic activity followed, resulting in the deposition of an assemblage of massive basalts, amygdaloidal basalts, basaltic flows with well-formed pillow structures, andesites, and thin tuffaceous beds. This assemblage is about 1,000 feet thick and is overlain by further quartzitic sandstones. Here and there, there seems to be some interbedding of sandstone and volcanic rock but the bulk of the upper quartzite unit comprises a pale-orange to dark reddish brown succession of pure quartzitic sandstone with minor beds of quartz-pebble conglomerate. Crossbedding is common throughout, and ripple-marked bedding planes are present at some levels. This member forms castellated cliffs which rise more than 1,000 feet above adjacent valleys. It appears probable that this quartzitic sandstone was deposited under moderately shallow conditions, and from the observed rounded form of the quartz grains and the virtual absence of any other mineral grains, it is assumed that a prolonged period of abrasion and winnowing occurred prior to the deposition of the sands.

The contact between the Eqalulik and Uluksan groups appears gradational but may be marked by an erosional unconformity. A transition zone marked by alternating bands of argillaceous sandstone, and sandstone, separates the pure sandstone of the lower group from the shales of the Arctic Bay formation. This could represent material derived from the reworking of the top beds of the older rocks or possibly a decrease in the source of supply during continuous deposition. The absence of conglomerate and the fact that the lowest beds of the Arctic Bay formation are not indicative of shallow-water deposition, suggest that there was no erosional break.

The shale, dolomite, alternating argillaceous dolomite and dolomite, siltstone and shale formations of the Uluksan group suggest a varied history of deposition. Abundant clastic material was available when the period opened but towards the close of Arctic Bay time this decreased and carbonate deposition was initiated. Carbonate deposition persisted through much of Society Cliffs time, but came to an abrupt halt with the incursion of argillaceous material. The Victor Bay formation, containing as it does edgewise conglomerates in finely laminated dolomite and limestone beds that commonly contain pyrite, indicates deposition under quiet and relatively deep water conditions probably with stagnant conditions prevailing on the sea bottom. The edgewise fragments may have formed in a shallow shelf area undergoing periodic emergence and desiccation.

The monotonous succession of dark grey to dusky red siltstones of the Strathcona Sound formation, 1,500 to 2,000 feet thick, indicates prolonged and uniform deposition. They appear to have been deposited rapidly in a subsiding basin which held the level of deposition constant. The alternating succession of thick quartzitic sandstones, silty quartzitic sandstone and micaceous shales, 5,000 to 6,000 feet thick, that comprise the Elwin formation, is indicative of a cyclical advance and recession of near-shore conditions.

A period of erosion followed deposition of the Elwin formation, and the next strata encountered, which lie above an erosional unconformity, are thought to be Palaeozoic in age although the first fossils, of Upper Ordovician age, are found more than 500 feet above the unconformity.

Both the Eqalulik and Uluksan groups are cut by gabbro dykes which in turn are truncated by the erosional unconformity and both groups are but slightly folded. Similar rocks are reported from the head of Milne Inlet and Tay Sound southeast of Admiralty Inlet.

Along both shores of Fury and Hecla Strait the Archaean rocks are overlain unconformably by a succession of sandstone, conglomerate and grit with a possible thickness exceeding 10,000 feet. This in turn is overlain here and there by black slate, siltstone, dolomite and limestone (Blackadar, 1958a). Like the similar strata in northern Baffin Island these rocks are intruded by gabbroic rocks in the form of both sills and dykes. They were first observed by Lieutenant Reid in 1822 (Parry, 1824, p. 348) and appear to lie in a gently dipping syncline whose axis is roughly parallel to the trend of Fury and Hecla Strait.

South of Aston Bay on northwestern Somerset Island, non-fossiliferous and relatively undeformed sedimentary strata have here and there been mapped. These comprise two units: a lower unit, the Aston formation, is about 7,000 feet thick and consists of quartzite and minor amounts of siltstone, slate, shale, and conglomerate, and about 1,400 feet of gabbro sills; the upper unit, the Hunting formation which conformably overlies the quartzitic rocks, is comprised of 2,250 feet of dolomite (see Blackadar, 1957; Fortier et al., 1959).

Here and there along the east coast of Prince of Wales Island there are strata similar to those previously described, thought to be Proterozoic in age.

The similarities in lithology between Greenland and eastern Canadian Arctic localities led to correlation between the Thule group of northwest Greenland and the section at Bache Peninsula (Troelsen, 1950; Blackadar, 1957; Fortier et al., 1959). This correlation was later extended to include the succession at Copes Bay, Ellesmere Island; similarities between the depositional history of the Thule group, the Eqalulik and Uluksan groups, and the Hunting and Aston formations were also pointed out (Blackadar, 1957). Some of the lithological similarities are illustrated by Figure 2.

The problems of correlation between these various areas are as yet unsolved but it is probable that sedimentation took place in many relatively restricted basins rather than in a single basin extending from Greenland to the central Canadian Arctic.

On Victoria Island, Proterozoic-type rocks have been known for some years and have been tentatively correlated with the Coppermine series of the adjacent mainland. Field work carried out in 1959 by the Geological Survey of Canada has clarified some of the stratigraphical relationships in this area.

On the southwest shores of Hadley Bay, granitic rocks are overlain unconformably by a series of folded quartzites and greywackes. These in turn are overlain unconformably by a succession of sedimentary and volcanic rocks at least 10,300 feet thick that extends northward from Minto Inlet and Prince Albert Sound. This succession is similar to the Coppermine series. Six units have been recognized:

Unit		Thickness (feet)
6	volcanic flows and pyroclastics	1,000
5	red sandstone, shale, gypsum	1,500
4	limestone, minor dolomite, shale	2,000
3	gypsum, and red and green shale, sandstone	800
2	limestone, minor sandstone	2,000
1	red sandstone, limestone, shale	3,000

Beds similar to unit 1 outcrop north of Wellington Bay on the south coast of Victoria Island, and on southern Banks Island.

The structure of the main sedimentary succession is a northeast-trending syncline in which the strata are gently inclined.

All sedimentary units in this upper succession contain numerous gabbro sills.

Diabase Series

A system of unaltered basic dykes, partly with a diabasic texture, cuts all rocks older than the Palaeozoic. The exact age of this "Diabase Series" (Fortier, 1957) is unknown; on southern Devon

Island they lie beneath an erosion surface above which Lower Cambrian beds were deposited, and at Admiralty Inlet, the dykes are truncated by an erosional unconformity of pre-Richmond (Upper Ordovician) age.

These dykes are found from the south coast of Baffin Island to Boothia Peninsula and Peel Sound and have a predominantly north-west trend. They are particularly abundant between Arctic Bay and Tay Sound (west of Pond Inlet) but elsewhere throughout the area, single dykes or groups of a few units are found.

Economic Geology

Mineral production from Precambrian areas of the Arctic Archipelago has been scanty. A small tonnage of graphite was mined in the Cumberland Sound area in the latter part of the nineteenth century, and garnet, mica, and graphite were mined near Lake Harbour during and just after World War I.

Magnetite was reported from the vicinity of Chorkbak Inlet, some 50 miles east of Cape Dorset, southern Baffin Island, following field studies carried out by W.L. Davison of the Geological Survey in 1951 and 1953; more than 500 claims were staked in 1956 and 1957. Most of these were held by Ultra-Shawkey Mines, Ltd., and in a report dated September 1957, this company stated that five ore zones had been outlined with a total estimated tonnage exceeding 350 million tons. Unfortunately, a diamond-drilling program in 1958 did not substantiate the ore grade of much of this tonnage and the company discontinued further efforts in the area. The deposits are close to tidewater, but the prevailing high tidal range and the innumerable reefs and shallows along this coast make shipping difficult in the area.

The magnetite is largely confined to narrow belts and is associate with meta-sedimentary and mafic rocks. The longest belt extends from near Amadjuak Bay to Keltie Inlet, a distance exceeding 25 miles. This belt contains one or more magnetite-rich quartzitic bands with a thickne of 4 to 15 feet. The belt is about 400 feet wide and is associated with bands of garnet-amphibolite that contain disseminated magnetite.

Magnetite is also known from northeastern Foxe Basin where massive magnetite is associated with banded iron-formation. Bands of quartzite containing up to 40 per cent magnetite and bands of grunerite with 25 per cent magnetite are also present (Blackadar, 1958b).

Iron-formation has been reported from the Clyde district of eastern Baffin Island (Kranck, 1951). Here the deposits consist of banded chert and magnetite associated with garnet, anthophyllite, and cummingtonite schists.

In northwestern Baffin Island, sphalerite, galena and pyrite were discovered by Bernier in 1910 near Arctic Bay, and in 1954 a reconnaissance examination of the area was carried out (Blackadar, 1956). Massive, deeply weathered pyrite is exposed across an area some 500 feet by 2 miles, and sphalerite and galena are locally abundant. The mineralized area seems to be tabular and occurs in dolomites of Proterozoic age. The deposit was staked by Ecstall Mining Company and some exploratory work has been reported.

References

Bentham, R.
1941: Structure and Glaciers of Southern Ellesmere Island; Geog. J., vol. 97, No. 1, p. 37.

Blackadar, R.G.
1956: Geological Reconnaissance, Admiralty Inlet, Northwestern Baffin Island; Geol. Surv., Canada, Paper 55-6.

1957: Proterozoic Stratigraphy of the Canadian Arctic Archipelago and Northwestern Greenland; In the Proterozoic in Canada; Roy. Soc. Can., Special Paper 2.

1958a: Fury and Hecla Strait, Northwest Territories; Geol. Surv., Canada, Map 3-1958.

1958b: Foxe Basin North, Northwest Territories; Geol. Surv., Canada, Map 4-1958.

1959: Cape Dorset, Northwest Territories; Geol. Surv., Canada, Map 11-1959.

Davison, W.L.
1959a: Foxe Peninsula (Eastern Part), Northwest Territories; Geol. Surv., Canada, Map 4-1959.

1959b: Lake Harbour, Northwest Territories; Geol. Surv., Canada, Map 29-1958.

Fortier, Y.O.
1957: The Arctic Archipelago; In Geology and Economic Minerals of Canada (4th ed.); Geol. Surv., Canada, pp. 417-418.

Fortier, Y.O., et al. (officers of G.S.C. on Operation Franklin)
1959: Northern Prince of Wales, Somerset and Northwesternmost Baffin Islands, District of Franklin, Northwest Territories; Geol. Surv., Canada, Prel. Map 19-1959.

Kranck, E.H.
1951: Mineral Possibilities of Baffin Island; Bull. Can. Inst. Min. Met., vol. 44, pp. 682-683.

1955: The Bedrock Geology of the Clyde Area in Northeastern Baffin Island; Acta Geographica, No. 14, pp. 226-238.

Parry, W.E.
1824: Journal for a Second Voyage for the Discovery of a North-west Passage, 1821-22-23; London, John Murray.

Riley, G.C.
1959: Cumberland Sound, Northwest Territories; Geol. Surv., Canada, Map 1061A.

Thorsteinsson, R.
1956: Geology of Eastern Ellesmere Island; Geol. Surv., Canada, manuscript report. See also Blackadar, 1957.

Troelsen, J.C.
1950: Contributions to the geology of Northwest Greenland, Ellesmere Island and Axel Heiberg Island; Medd. om Grønland, Bd. 149, Nr. 7.

Wordie, J.M.
1938: An Expedition to Northwest Greenland and the Canadian Arctic in 1937; Geog. J., vol. 92, p. 399.

Figure 1

Table of Formations

Proterozoic and/or Early Cambrian, Admiralty Inlet

(after Blackadar, 1956)

Group and Approximate Thickness (feet)	Formation and Approximate Thickness (feet)	Lithology
Uluksan group + 6,850	Elwin formation + 2,500	Sandstone, siltstone, shale
	Strathcona Sound formation ± 2,500	Mudstone, siltstone
	Victor Bay formation + 600	Dolomite, minor limestone, mudstone, edgewise conglomerate
	Society Cliffs formation + 900	Dolomite
	Arctic Bay formation + 350	Calcareous shale
Erosional disconformity (?)		
Eqalulik group + 5,500	Upper quartzite + 4,000	Quartzite; minor shale, conglomerate
	Volcanic member ± 1,000	Andesite and basalt flows, tuff
	Lower quartzite ± 50	Quartzite
Angular unconformity		

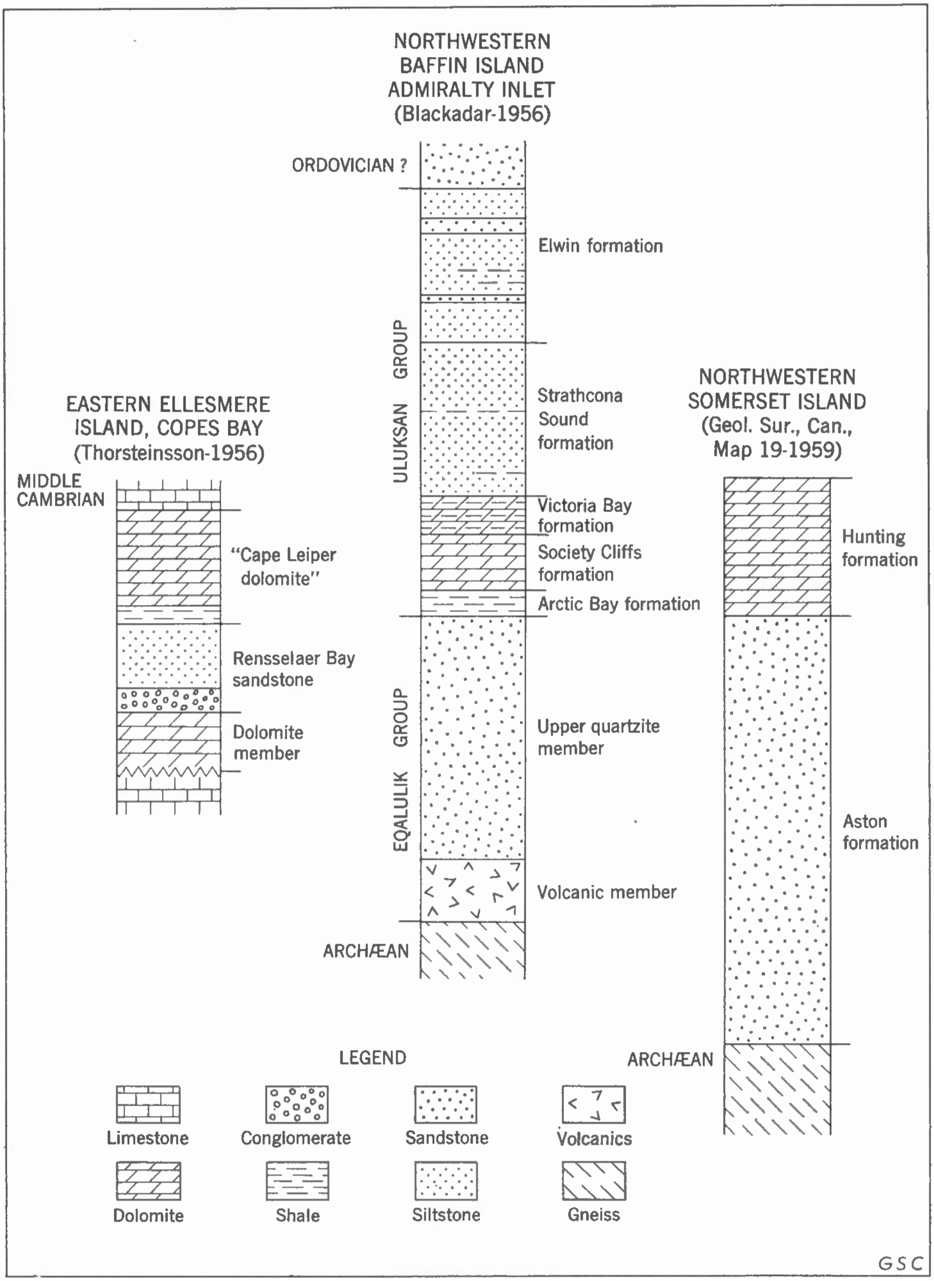

Figure 2. Diagram showing stratigraphic sections of Proterozoic formations, Eastern Canadian Arctic

Part II - - The Precambrian of the Arctic Mainland

CONTENTS

Illustrations

Part II

THE PRECAMBRIAN OF THE ARCTIC MAINLAND

by J.A. Fraser

Introduction

This paper summarizes the Precambrian geology of the District of Keewatin and the District of Mackenzie east of longitude 124°. The greater part of this region has been mapped by helicopter reconnaissance within the past 10 years. Still largely unmapped is the area between Bathurst Inlet and Contwoyto Lake, and the coastal area, 100 miles or more in width, that extends east from Bathurst Inlet to Hudson Bay.

The results of geological investigations in the District of Mackenzie prior to 1950 have been described by Lord (1951)[1]. References to the earlier literature, not included by the present writer, may be found in Lord's report. The main features of the Proterozoic rocks of the Northwest Territories have also been reviewed by Brown and Wright (1957).

Except for two small Palaeozoic outliers in the region drained by the Thelon River system (Wright, 1955, 1957), the area between Hudson Bay and the Precambrian-Palaeozoic boundary that extends from Great Slave Lake through Great Bear Lake to Coronation Gulf is underlain by a varied assemblage of granitic rocks and by strata of volcanic and sedimentary origin. Some of this strata exhibits a high degree of metamorphism and structural deformation, and has been granitized or intruded by granite. To these rocks it is customary to apply the term Archaean. Unconformably overlying the upturned strata and granites or granite-gneisses, are groups of younger strata that show a lesser degree of deformation and metamorphism; few bear evidence of intrusion by granite. These are the so-called Proterozoic rocks.

Age relationships between groups, based on stratigraphic successions in selected localities, are shown in Figure 1. Correlations from region to region can only be speculative until more absolute age determinations are available for the intervening granites and more is known of the nature of the contacts between the granites and the sedimentary or volcanic strata.

Archaean

Among the oldest rocks exposed in the Northwest Territories are those of the Yellowknife group, a term applied to all Archaean

---

[1]Dates or names and dates in parentheses refer to publications listed in the References, p. 2 .

Figure 1

Precambrian Correlation Chart

Arctic Mainland

(Exact correlation between regions is not implied.)

Region	Nonacho Lake - Taltson River	Great Slave Lake	Coppermine River	Great Bear Lake - Arctic Coast	Bathurst Inlet	Baker Lake - Thelon River
Proterozoic	Diabase dykes and sills	Diabase dykes and sills	Diabase dykes and sills	Diabase dykes and sills	Diabase dykes and sills	Diabase dykes and sills
		Et-then group	Coppermine River series Hornby Bay group	Coppermine River series Hornby Bay group	Coppermine River series Goulburn group Kanuyak formation	Dubawnt group
		Unconformity	Unconformity	Granite, granodiorite, and allied rocks	Unconformity	Unconformity
	Granite and allied rocks	Great Slave group	Epworth formation	Cameron Bay group	Epworth formation	Hurwitz group
	Nonacho group			Disconformity		
Archaean	Granite and allied rocks	Granite, granodiorite, and allied rocks	Granite and allied rocks	Echo Bay group	Granite and allied rocks	Granite and allied rocks
	Tazin group	Yellowknife group	Yellowknife group			Metamorphosed sediments and volcanic rocks

volcanic and sedimentary rocks north of Great Slave Lake. From Yellowknife they extend 300 miles northeast to Beechey Lake (Wright, 1957), and 250 miles north to Point and Hepburn lakes. A sequence of greenstones or amphibolites derived from andesitic and basaltic flows with associated minor dacites, rhyolites, and pyroclastic beds, is estimated at Yellowknife Bay to be about 33, 000 feet thick. This is succeeded conformably by a great thickness of well-bedded greywacke, arkose, impure quartzite, slate, and argillite, with minor conglomerate near the base. Near contacts with granitic bodies the sediments may be metamorphosed to mica-quartz schist and knotted schist. The Yellowknife strata have been folded during two stages of deformation. Dips of beds are commonly vertical and folds may plunge 90 degrees.

Rocks of the Snare group are exposed in long narrow basins that extend in a northerly direction from Great Slave Lake almost to Great Bear Lake. Recently, this group has been shown to comprise two separate groups (Ross and McGlynn, 1958). The older is pre-granite and consists mainly of metamorphosed quartzites and dolomites interpreted as a shelf facies of the Yellowknife group. The younger group is post-granite and consists of quartzite, dolomite, and argillite, overlain by sandstone and massive or pillowed andesitic, basaltic, and dacitic flows with minor pyroclastic rocks. This group has been assigned the name Basler Lake.

On Wilson Island in Great Slave Lake, the Wilson Island group comprises more than 11, 000 feet of acidic lava flows interlayered with conglomerate and arkose, and overlain by quartzite, dolomite, schist, and phyllite. Quartzose paragneiss and iron-formation are exposed locally. The strata may dip 45 degrees or more and are commonly overturned. The oldest exposed members are in contact with intrusive granitic rocks or are separated by faults from younger strata.

The Tazin group exposed along Hill Island Lake southeast of Great Slave Lake comprises moderately to steeply dipping quartzites, argillaceous sediments, and minor, hornblende schist or chloritic schists and gneisses.

In the District of Keewatin the oldest rocks are pillowed andesitic and dacitic lavas, derived greenstones or amphibolites, and schistose greywackes (Lord, 1953; Wright, 1955).

Granitic Rocks

Large areas of the Arctic mainland are underlain by granitic rocks that exhibit a great diversity in composition, texture, and structure.

Massive, medium- and coarse-grained granite and granodiorite carrying biotite and hornblende, is exposed near Point Lake and east of Takiyuak Lake (Fraser, 1960). Massive, medium- or coarse-grained, pink granite outcrops over a large area northeast of Baker Lake (Wright, 1955). Very coarse-grained porphyritic granite is found at Nueltin Lake in central District of Keewatin (Lord, 1953). Pink, coarsely porphyritic granite and granodiorite with a low mafic content of biotite or chlorite, observed west of Point Lake, contains scattered inclusions of amphibolite. Similar granite, extending south for 100 miles or more beyond Winter and Carp lakes (Moore et al., 1951; Fraser, 1958b), has been determined by the potassium-argon method to be 2,115 million years old. A massive, inclusion-free granodiorite body southeast of Winter Lake (Fraser, 1958b), dated also by the potassium-argon method, is 1,790 million years old.

Massive granite that outcrops in rugged hills east and southeast of Great Bear Lake (Lord and Parsons, 1953; Fraser, 1958a, 1960) grades into very coarse-grained, porphyritic, granite, quartz monzonite, and granodiorite. Intimately associated with the granitic rocks are bodies of quartz-feldspar porphyry which occur apparently in extrusive and intrusive form. These may be genetically related to the feldspar porphyry interlayered with sediments of the Echo Bay group, believed to be Proterozoic. Pitchblende in veins cutting the Echo Bay strata is about 1,400 million years old (Cumming et al., 1955). Granite with associated quartz-feldspar porphyry is also exposed in windows in sandstone of the Hornby Bay group southwest of the Dismal Lakes (Fraser, 1960).

Granitic intrusions of two ages, the younger characterized by muscovite, have been mapped at many localities including Prosperous Lake, Braulie River, MacKay Lake, Lac de Gras, Aylmer Lake (Lord, 1951) and Winter Lake (Fraser, 1958b). Muscovite granite intrudes the Nonacho group and dolomite of the Great Slave group. Massive granite containing muscovite and biotite, found between Artillery and Beechey lakes, has been shown by the potassium-argon method to have an age in the order of 2,500 million years (Wright, personal cummunication).

Granitic gneisses are, in general, associated spatially with older, metamorphosed, sedimentary and volcanic rocks. In many instances, Archaean strata show progressive granitization into migmatites and layered gneisses that may carry relict structures of former sedimentary or volcanic units commonly marked by the presence of minerals such as garnet, hornblende, andalusite, cordierite, and sillimanite. Garnetiferous paragneisses and pyroxene granulites have been mapped north of Baker Lake and along Chesterfield Inlet (Wright, 1955), and in several other localities.

From the few absolute age determinations now available it appears that granites north of Great Slave Lake range in age from approximately 1,800 to 2,500 million years. Granitic rocks farther east, in the vicinity of Baker Lake, are younger (Wright, personal communication).

Proterozoic

In describing the Proterozoic groups it is convenient to divide the area into six regions (Fig. 1) in which stratigraphic relations can be established between groups. In general, groups in different regions are separated by areas underlain by granitic rocks.

Nonacho Lake - Taltson River

The Nonacho group lies in a narrow basin trending northeast through Nonacho Lake. A possible extension of the group extends northeast from Tent to Whitefish lakes (Wright, 1957). Up to 2, 000 feet of conglomerate is overlain by slates, greywackes, arkoses, and quartzites. The strata lie in open folds with dips on the limbs from 45 to 65 degrees, but they are more intensely folded near granitic intrusions or where cut by faults. They rest unconformably on older granitic rocks and Tazin rocks and have been correlated with the lower part of the Great Slave group.

Great Slave Lake

The Great Slave group, exposed along the east arm of Great Slave Lake, comprises six formations, totalling about 7, 000 feet. The Sosan formation at the base, consisting of about 3, 000 feet of sandstone, quartzite, arkose, and conglomerate, is overlain by about 1, 000 feet of shale, limestone, iron-formation, and volcanic flows with associated pyroclastic rocks of the Kahochella formation. These are followed by the Pethei formation, comprising about 1, 500 feet of limestone and dolomite that contains algal structures in some beds; and the Stark formation, approximately 1, 000 feet thick, made up of dolomite, shale, and limestone. Above the Stark formation is about 300 feet of shaly sediments and sandstone of the Tochatwi formation. This is overlain by the Pearson formation consisting of 70 to 150 feet of andesitic, basaltic, and trachytic lava flows, and interbedded argillite. Strata of the Great Slave group form an easterly-trending synclinorium 150 miles long. The beds on the north limb dip 5 to 10 degrees south; strata on the south limb have been folded into a series of easterly-trending anticlines and synclines with limbs dipping between 30 and 70 degrees. The group lies unconformably on granitic rocks or on Yellowknife-type rocks.

The Et-then group lies almost horizontally on granites and folded strata of the Great Slave group at Great Slave Lake. It comprises the Murky formation, of conglomerate that may be several thousand feet thick but is missing locally; and, in the upper part, the Preble formation of coarsely feldspathic sandstone and quartzite.

Coppermine River

Rocks of the Epworth formation extend from Port Epworth on the Arctic coast, southwest to Point Lake, and west to the Coppermine River or beyond it (Fraser, 1960). Andesite or dacite is overlain by quartzite, sandstone and minor conglomerate, followed by brown, buff, and grey cherty dolomite that commonly contains, in some beds, abundant algal-like structures, or stromatolites. Succeeding the dolomite is thick-bedded greywacke interlayered with black and red argillites, slate and minor quartzite. The total thickness of this formation may reach several thousand feet but accurate estimates of thickness are rendered difficult by the rapid change of dips across strike, and the possibility of repetition of beds by faulting. At Point Lake and along Tree River, Epworth strata lie unconformably on granite or Yellowknife rocks with dips of not more than 25 degrees. Farther north and west, Epworth strata have been folded around northerly-trending axes, and vertical dips are common.

South of Coronation Gulf, folded greywacke and dolomite of the Epworth formation is overlain by almost flat-lying dolomite of the Hornby Bay group (Fraser, 1960), which in turn, is overlain conformably by basalt and sediments of the Coppermine River series interlayered with diabase sills. The terms 'Epworth formation' and 'Coppermine River series' are retained in this paper in compliance with former usage, although each assemblage includes at least two mappable rock units.

Great Bear Lake - Arctic Coast

Rocks of the Echo Bay group, occurring east and southeast of McTavish Arm, Great Bear Lake, consist of pyroclastic beds, cherty sediments containing algal-like structures, and minor limestone and conglomerate. These are interlayered with intrusive feldspar porphyry and feldspar-hornblende porphyry overlain by porphyritic and amygdaloidal lava flows with interstratified massive tuff. A reddish alteration is characteristic of the Echo Bay rocks. The strata display moderate dips that steepen locally. At least 9,300 feet of the section has been observed; the base is cut off by younger granite.

Strata of the Cameron Bay group exposed along the east side of Great Bear Lake are gently inclined with beds parallelling those of the Echo Bay rocks nearby. Loosely consolidated conglomerate contains pebbles and cobbles, mainly of volcanic rocks typical of the Echo Bay group. In the upper part of the Cameron Bay group, arkose, sandstone, argillites, and tuffs, are interlayered with trachytic and andesitic lava flows. The group is intruded by granitic rocks (Feniak, 1952).

The age of the Echo Bay and Cameron Bay groups, relative to the Epworth formation, is unknown.

The Hornby Bay group comprises several thousand feet of interlayered sandstones, quartzites, and conglomerates, that are well exposed north of Hornby Bay, Great Bear Lake. They are overlain conformably by about 4,000 feet of dolomite with shaly dolomite at the base (Fraser, 1960). The sandstone-dolomite contact extends from Dease Arm, north and east, passing north of the Dismal Lakes, and eastward beyond the Coppermine River. The conglomerate consists of pebbles and cobbles of white quartzite, and in one or two places, of quartz-feldspar porphyry, in a matrix of coarse-grained, white or grey, sandstone. The sandstone and quartzite are coarse grained, commonly quartzose, with a scattering of flakes of clay-like material. The sandstone and quartzite is predominantly white, but a purplish mottling that may cut across bedding surfaces is characteristic. Near contacts with underlying granitic rocks, the sandstone may be purplish or reddish, coarse grained, friable and arkosic. The dolomite is buff and grey with brownish or reddish dolomite at the base. Stromatolites are abundant in some beds. The Hornby Bay strata are, nearly everywhere flat-lying or gently inclined. Steep dips, observed locally, as for example north of Dease Arm, may be associated with faults. Contacts between the Hornby Bay and Cameron Bay rocks have not been observed, but the Hornby Bay strata are believed to overlie those of the Cameron Bay group with angular unconformity.

Sediments and flows of the Coppermine River series are exposed in a broad belt, 30 or more miles wide, that extends west from Coronation Gulf to the region north of Dease Arm, Great Bear Lake, where it is overlain unconformably by Palaeozoic strata (Fraser, 1960).

The lower part of the series consists of about 11,000 feet of dark brown or purplish, fine-grained, basaltic flows, in part amygdaloidal. North of the Dismal Lakes where flows lie conformably on dolomite of the Hornby Bay group, the dip is about 10°N. Farther north the attitudes are less steep. Sediments outcropping north of the basalts and apparently conformable with them, belong to the upper part of the Coppermine River series. They comprise red and white sandstone, white or grey quartzite, black or variegated argillites, buff, grey, and brown dolomite, and minor limestone. These are commonly interlayered with sills of diabase. The total thickness may be about 15,000 feet.

Lithologically similar sediments outcrop along the Arctic coast between Darnley Bay and Tinney Point and extend south into the Hornaday River basin (Fraser, 1960). Like the Proterozoic rocks north of Dease Arm, they are overlain unconformably by sandstone, presumably of Palaeozoic age, and are intruded by dykes and sills of diabase which have not been observed to pass upward into the overlying rocks. Layers of gypsum from 10 to 65 feet or more in thickness have been mapped east of Clinton Point on the Arctic coast where they underlie limestone and diabase, and in the valley of the Hornaday River, where they are interstratified with dolomite and diabase. Black limestone with associated black argillite or shale is exposed east of Clinton Point and west of Deas Thompson Point on the Arctic coast. In the latter occurrence are bun-shaped structures up to 15 feet in diameter. These are composed of closely-packed stromatolitic, conical forms up to 8 inches long, oriented vertically with the apices down. Black limestone observed north of the Rae River contains similar structures. The possible stratigraphic equivalence of these limestones suggests that the Coppermine River strata lie in a broad, shallow, synclinal basin with an easterly-trending axis.

Bathurst Inlet

The Kanuyak formation has been mapped only at Bathurst Inlet where it rests unconformably on dolomite believed to belong to the Epworth formation (O'Neill, 1924). It consists of more than 100 feet of calcareous tuff and tuff conglomerates that resemble sandstone, shales, and sandy limestones. The beds strike northeast and are gently inclined to the southeast.

The Goulburn group, recognized only at Bathurst Inlet, is made up of more than 4,000 feet of coarse-grained orthoquartzites intercalated with conglomerate that contains pebbles, cobbles, and boulders of quartz and rounded and angular fragments of dolomite, probably all derived by erosion from Kanuyak and Epworth strata. At the south end of Bathurst Inlet is slate, dolomite, or limestone, massive arkosic quartzite, and pebbly quartzite or conglomerate (Wright, 1957).

About 900 feet of amygdaloidal lava flows of the Coppermine River series is exposed at Bathurst Inlet, lying on an eroded surface of conglomerate of the Kanuyak formation.

Baker Lake - Thelon River

Rocks of the Hurwitz group form basin structures in several areas near Nueltin Lake and northeast to Rankin Inlet, and between Baker and Garry lakes (Lord, 1953; Wright, 1955). In a composite section, greywacke with conglomerate is succeeded by white quartzite, dolomite, greywacke, and impure quartzite. Of these, the most prominent is the white quartzite which may be several thousand feet thick and forms long, narrow, in some places, sinuous, topographic ridges. Some of the sediments in the group have been converted to schist and hornfels. Direct evidence of intrusion by younger granite is lacking.

Units of the Dubawnt group are widely exposed south and west of Baker Lake (Wright, 1955). A basal conglomerate at the east end of Baker Lake may rest directly on granitic basement rocks; it is overlain by at least 400 feet of white or mottled sandstone similar in appearance to the sandstone of the Hornby Bay group. Conglomerate intercalated with sandstone in the vicinity of Aberdeen and Dubawnt lakes, contains cobbles of distinctive Dubawnt-type porphyry, sandstone, and white quartzite, presumably of Hurwitz age. Flat-lying dolomite occurs in the upper part of the Dubawnt group near Thelon River. Dubawnt porphyritic rocks, mainly quartz-feldspar porphyry, are chiefly flows but may also occur as sills or plugs. Although contacts between the Dubawnt and the Hurwitz groups are, in general, not well exposed, it is clear from the differences in lithology and structural expression of the two groups that Dubawnt strata must overlie Hurwitz strata unconformably.

Mafic and Ultramafic Rocks

Dykes of diabase cut all exposed Precambrian rocks and show a preferred orientation of N 30° W, although dykes trending north and northeast are also common. Sills of diabase are abundant in the upper part of the Coppermine River series and are also found intruding strata of the Cameron Bay and Et-then groups. The presence of diabase in the Proterozoic rocks north of Great Bear Lake has proved a useful criterion in distinguishing them from the overlying Palaeozoic strata (Fraser, 1960).

Mafic and ultramafic rocks other than diabase, are, in general, exposed as small bodies whose ages in many cases are either uncertain or unknown.

Many small bodies mapped as diorite may be recrystallized flows; others appear to be of intrusive origin. Dioritic and syenitic stocks occur along the east arm of Great Slave Lake near the McDonald fault. Some of these at least, are known to intrude Great Slave strata. Hornblende diorite is exposed along the Bathurst trench (Wright, 1957). Sills of this rock intrude the folded strata of the lower part of the Goulburn group. Biotite-hornblende diorite forms large hilly outcrops south of Regan Lake, southwest of Bathurst Inlet. Other small bodies of diorite and gabbro, and minor anorthosite and hornblendite, appear to intrude gneissic granites in the District of Keewatin (Lord, 1953; Wright, 1955) and in the eastern part of the District of Mackenzie (Wright, 1957).

A body of anorthosite, more than 10 miles long, outcrops in rugged hills at the east end of Baker Lake (Wright, 1955). Smaller bodies of anorthosite are found south of Baker Lake near Tulemalu Lake (Wright, 1955), and in southern District of Keewatin (Lord, 1953).

Peridotite occurs west of Ennadai Lake in association with a diorite plug (Lord, 1953). A body of serpentinized dunite has been mapped north of Baker Lake lying along the margin of a mass of white quartzite of Hurwitz type (Wright, 1955). An ultramafic body, possibly related in age to the late diabase, is exposed east of the big bend in the Coppermine River. It trends north for about 30 miles and has a maximum exposed width of 3 to 4 miles. Compositional variations of this body include dunite, peridotite, pyroxenite, gabbro, and granophyre (Smith, C.H., personal communication).

Correlation

Many additional absolute age determinations will be required before a satisfactory correlation can be established between strata in regions separated by large areas underlain by plutonic rocks. As earlier writers have pointed out, however, certain obvious similarities in structure and lithology do exist between the various Proterozoic groups (Harrison, 1957; Brown and Wright, 1957). The oldest Proterozoic rocks are highly deformed; some, such as the Nonacho, Echo Bay, and Cameron Bay groups, have clearly been intruded by granite. Other structurally deformed groups, the Great Slave, Epworth, and Hurwitz, may be older than nearby granite but the evidence is inconclusive. In nearly all regions, relatively undeformed and unmetamorphosed strata overlie the older, folded Proterozoic rocks unconformably. White, quartzose sandstones, or quartzites and quartz-pebble conglomerates are prominent constituents of the younger rocks which are represented by the Et-then, Hornby Bay, Coppermine River, Goulburn, and Dubawnt groups.

Faults

Faults cut all the exposed Precambrian rocks including the late diabase dykes. Commonly these strike northeast, or north to northwest. The northeast faults are, in general, pre-diabase, and have right-hand offsets. Faults striking north to northwest are commonly post-diabase and have left-hand offsets.

The McDonald fault extends northeast from Great Slave Lake for a distance of 200 miles and cuts rocks of the Great Slave and Etthen groups. Right-hand movement of several miles may have occurred along it; most of the movement appears to be pre-diabase. North of Point Lake, strata of the Epworth group are displaced along several northeast faults in right-hand offsets (Fraser, 1960). The Fault River fault that trends northeast from Hornby Bay, Great Bear Lake, separates Hornby Bay strata on the north from older granitic rocks on the south. Farther north, near Teshierpi Mountain, a dolomite-basalt contact is displaced about 5 miles in a left-hand offset along a northeast fault.

Faults striking north to northwest are common from Yellowknife north to Indin Lake. A prominent example is the West Bay fault along which the west block moved more than 3 miles south, and more than 1/4 mile down, relative to the east block. The Wopmay River is the locus of a mylonite zone that has been interpreted as a thrust fault zone in which the older basement gneisses on the east have been thrust up to the west against younger massive granites (Ross and McGlynn, 1958). East of Great Bear Lake, strong topographic lineaments that trend north can be followed for many miles, and probably represent faults (Fraser, 1960).

The Bathurst trench, extending in a southeasterly direction from Bathurst Inlet, is almost certainly the locus of a major fault which may die out at Back River or run under the flat-lying Dubawnt rocks exposed to the south (Wright, 1957). It separates Goulburn strata from older granites to the northeast and strikes parallel with the granite-gneiss. The gneissosity of the granites swings south and west in a great arc from Bathurst Inlet and parallels the McDonald fault in the vicinity of Great Slave Lake.

Economic Geology

Gold is produced at three mines in the Yellowknife district. Two of these are in shear zones that transect andesitic lava flows; in the third, the ore is at the crest of a drag-fold in highly contorted greywacke of the Yellowknife group. Nearly all known gold deposits in the Northwest Territories are associated with sedimentary and volcanic rocks of the Yellowknife group. Most of them occur north of Great Slave Lake and east of a line extending north from the north arm of Great Slave Lake through Basler, Arseno, and Rocknest lakes.

Uranium is mined at Port Radium on Great Bear Lake. Pitchblende with silver and a variety of associated minerals are found in faults that cut sediments and porphyry of the Echo Bay group. Pitchblende is also found in giant quartz veins and stockworks east of Great Bear Lake that commonly follow northeast faults cutting granitic rocks and quartz-feldspar porphyry.

Nickel is mined with copper at Rankin Inlet on the west shore of Hudson Bay from a sill of serpentinized pyroxenite (Lord, 1953). Nickel-bearing sulphides are also found at Ferguson Lake south of Baker Lake in sill-like bodies of hornblendite associated with a complex of impure granite-gneiss (Wright, 1955). Nickeliferous sulphides occur along the margins of the ultramafic complex mapped east of the big bend in the Coppermine River (Fraser, 1960).

Copper is recovered from the uranium ore mined at Port Radium. Copper had also been mined at one time with gold and tungsten from a deposit on the east arm of Great Slave Lake. Copper sulphides occur east of Great Bear Lake in giant quartz veins with a little bornite, chalcopyrite, and chalcocite. Disseminated chalcopyrite is found in large quartz veins along the Tree River northeast of Inulik Lake (Fraser, 1960). Native copper has been reported to occur in basaltic flows of the Coppermine River series near the Dismal Lakes, and at Bathurst Inlet; it occurs as flakes in amygdules or in massive basalt, or in thin seams with chalcocite, bornite, and covellite, traversing the basalt. Chalcocite concretions up to 2 inches in diameter are enclosed in grey shale of the Coppermine River series 2 miles south of Escape Rapids on the Coppermine River (Fraser, 1960).

Manganese mineralization is associated with a quartz stockwork that intersects the Fault River fault northeast of Hornby Bay, Great Bear Lake (Fraser, 1960).

Minerals carrying lithium, tantalum, columbium, tin, and beryllium, are known to occur in pegmatite dykes or sills associated with muscovite-biotite granite. These are common in the Yellowknife and Beaulieu River areas and are also found in the Lac de Gras and Aylmer Lake areas 210 miles northeast of Yellowknife.

References

Brown, I.C., and Wright, G.M.
1957: Proterozoic Rocks of the Northwest Territories and Saskatchewan; Roy. Soc. Can., Special Publication, No. 2, pp. 79-92.

Cumming, G.L., Wilson, J.T., Farquahar, R.M., and Russell, R.D.
1955: Some Dates and Subdivisions of the Canadian Shield; Proc. Geol. Assoc. Can., vol. 7, pt. 2, pp. 27-79.

Feniak, M.
1952: MacAlpine Channel, Northwest Territories; Geol. Surv., Canada, Map 1011A, descr. notes.

Fraser, J.A.
1958a: Hardisty Lake (West Half), Northwest Territories; Geol. Surv., Canada, Map 2-1958, notes.

1958b: Fort Enterprise, Northwest Territories; Geol. Surv., Canada, Map 16-1958, descr. notes.

1960: North-central District of Mackenzie, Northwest Territories; Geol. Surv., Canada, Map with descriptive notes (in preparation).

Harrison, J.M.
1957: The Canadian Shield Mainland; In Geology and Economic Minerals of Canada (4th ed.), pp. 19-122.

Lord, C.S.
1951: Mineral Industry of District of Mackenzie, Northwest Territories; Geol. Surv., Canada, Mem. 261.

1953: Geological Notes on Southern District of Keewatin; Geol. Surv., Canada, Paper 53-22.

Lord, C.S., and Parsons, W.H.
1953: Camsell River, Northwest Territories; Geol. Surv., Canada, Map 1014A, descr. notes.

Moore, J.C.G., Miller, M.L., and Barnes, F.Q.
1951: Carp Lake, Northwest Territories; Geol. Surv., Canada, Paper 51-8, second prel. map, descr. notes.

O'Neill, J.J.
1924: The Geology of the Arctic Coast of Canada, West of the Kent Peninsula; Report of the Canadian Arctic Expedition, 1913-18; Ottawa, Queen's Printer, vol. 11 (Geology and Geography), pt. A, p. 22A.

Ross, J.V., and McGlynn, J.C.
1958: Speculations on the Structure and Stratigraphy of the Central Portion of the District of Mackenzie, Northwest Territories; Abs. in Trans. Can. Inst. Mining Met., April 1958.

Wright, G.M.
1955: Geological Notes on Central District of Keewatin; Geol. Surv., Canada, Paper 55-17.

1957: Geological Notes on Eastern District of Mackenzie; Geol. Surv., Canada, Paper 56-10.