BROCK RIVER MAP-AREA,

DISTRICT OF MACKENZIE (97D)

H. R. Balkwill and C. J. Yorath

ABSTRACT

Gently folded, unmetamorphosed Upper Proterozoic (Hadrynian or Neohelikian) sedimentary rocks, with a total exposed thickness of about 6,000 feet, underlie most of the map-area; gabbro sills and dikes locally intrude the strata. Paleozoic marine sedimentary rocks, ranging from Cambrian to Middle Devonian, unconformably overlie the Proterozoic rocks. Exposed thickness of Paleozoic strata is about 1,700 feet. A regional hiatus separates the Paleozoic rocks and a sequence, about 700 feet thick, of Lower Cretaceous quartz sandstones, siltstones, shale, and coal. Thick, topographically prominent Pleistocene glacial deposits obscure bedrock throughout wide areas.

Northwesterly trending Coppermine Arch dominates the regional geologic structure. Proterozoic and Phanerozoic epeirogenesis is indicated by unconformities along and adjacent to the arch.

CONTENTS

Illustrations

BROCK RIVER MAP-AREA
DISTRICT OF MACKENZIE (97D)

INTRODUCTION

Geological field studies of Brock River map-area were conducted in 1968 as part of Operation Norman, a regional mapping program of the lower Mackenzie River and Anderson River areas (Aitken and others, 1969 and 1970; Yorath and others, 1969).

H. R. Balkwill mapped the distribution of Proterozoic and Paleozoic rocks, and C. J. Yorath studied the distribution and lithostratigraphy of Cretaceous strata. R. W. Macqueen investigated ~~sections~~ exposures of Paleozoic rocks along Hornaday River, and R. W. Klassen carried out studies of Quaternary deposits and physiography. L. A. Love, A. J. M. Elliot, and D. Turner were able and resourceful assistants, and T. Samuel was a superb cook.

Observations on the geology of the coasts of Darnley Bay and Amundsen Gulf were made during the 1913-18 Canadian Arctic Expedition (O'Neill, 1924). Mackay (1958) studied the physio-

graphy of the region; his memoir is also an outstanding source of information on the human geography and history of exploration. Brock River map-area was included in reconnaissance studies by Fraser and others (1960) of the north-central part of the District of Mackenzie. Unpublished reports by oil companies and consultants on parts of the area are on file with the Department of Indian Affairs and Northern Development.

A Department of Transport radar station is maintained at Tysoe Point; the Eskimo community of Paulatuk is a few miles west of the map-area on the south shore of Darhley Bay.

PHYSIOGRAPHY

Brock River map-area is bounded on the north by Amundsen Gulf (Arctic Ocean), and is thus at the northern limit of the Interior Plains physiographic province (Bostock, 1970). Klassen (in Yorath and others, 1969) modified and extended physiographic divisions in the region after Mackay (1958) and Bostock (1964). Klassen (op. cit.) recognized three physiographic divisions (Fig. 1); these are: (1) Brock Upland, which includes almost all of the region east of Hornaday River, and which is a moderately well dissected highland underlain by gently dipping

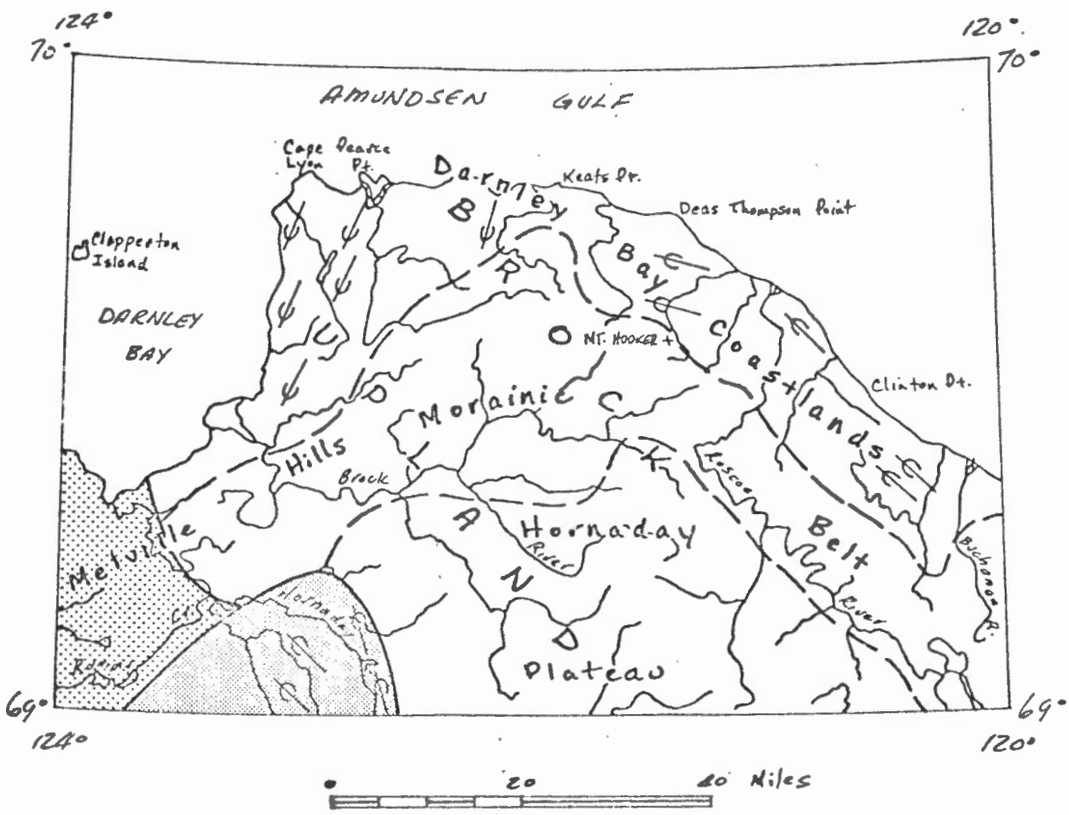

Figure 1. Physiographic divisions, Brock River map-area

LEGEND

Physiographic boundary (major, minor) .... ———— ———

Generalized direction of glacial flow .... ⟶

Brock Upland

Horton Plateau

Anderson Plain

(After Klassen, *in* Yorath *et al.*, 1969)

Proterozoic rocks; it is the physiographic manifestation of the Coppermine Arch structural province (Fig. 2); the Melville Hills Morainic Belt, a distinctive region of moraine ridges and kames, extends across Brock Upland as a convex-northward arc and separates the Upland into the Darnley Bay Coastlands, adjoining Amundsen Gulf, and Hornaday Plateau, in the south-central part of the area; (2) Horton Plateau, a barren upland south of Hornaday River and Rummy Creek, which is sculptured from gently tilted Paleozoic and Cretaceous rocks; and (3) Anderson Plain, which in the map-area is dominated by the westward extension of the Melville Hills Morainic Belt.

Continental glaciation by the Amundsen Gulf and Great Bear Lake ice lobes (Fig. 1) profoundly affected geomorphic processes and physiographic development in parts of the area. The Melville Hills Morainic Belt is a constructional feature where topography is quite irregular (kames and ridges range in elevation from 500 to 2,000 feet: Fig. 3) and small lakes are abundant. Glacial drift is relatively thin over the Darnley Bay Coastlands, but the region is strongly fluted and crag and tail landforms are conspicuous.

Post-glacial marine processes have apparently had little effect on modifying the physiography of the coast. There are

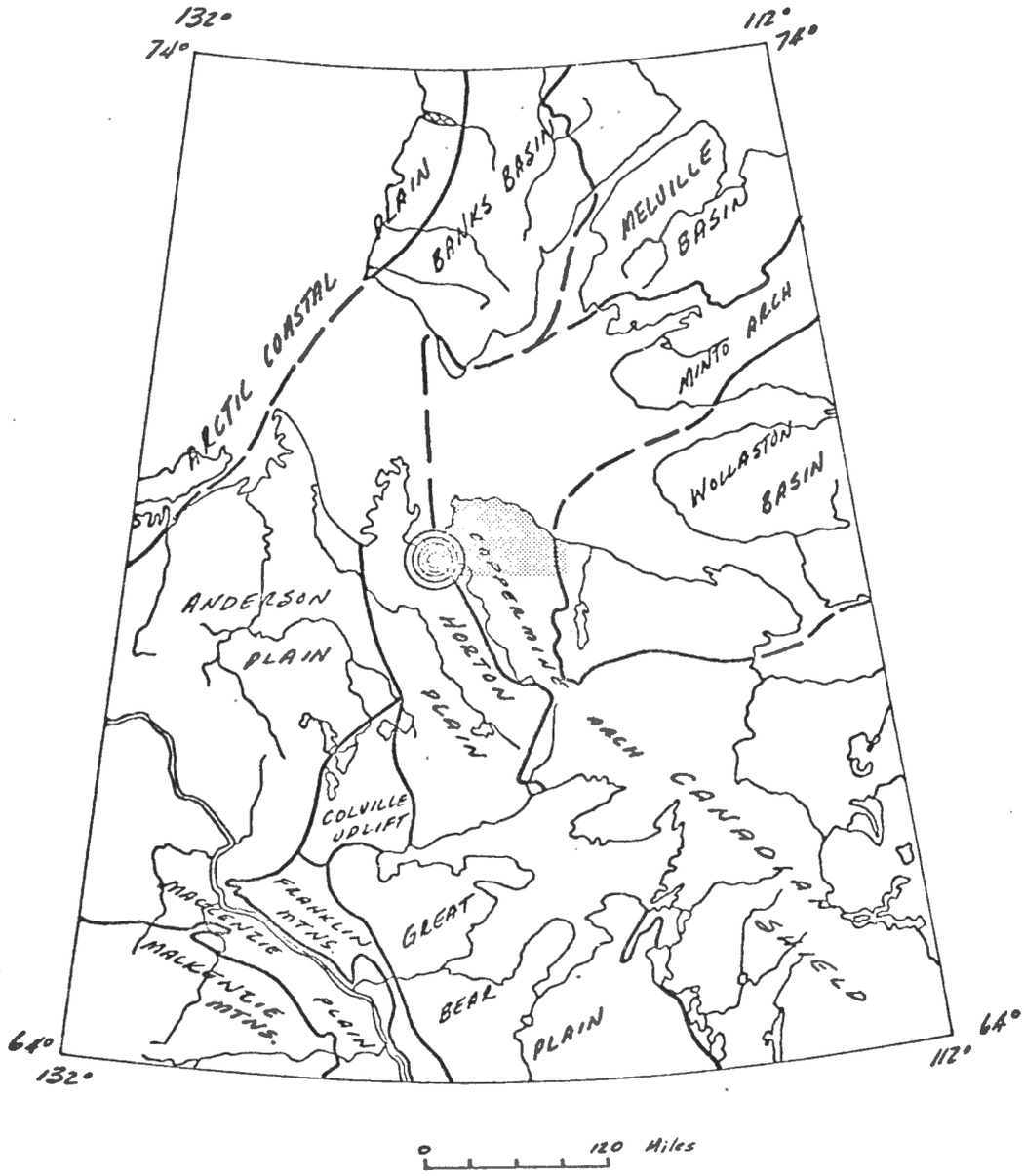

Figure 2. Structural provinces of the northern Interior Plains and environs

LEGEND

Structural provinces

Brock River map-area

Positive gravity anomaly

(Slightly modified from Douglas et al., 1963)

USGS-430

Figure 3. Westward view of Mount Hooker (elev. 1,500'), a prominent kame in the Melville Hills Morainic Belt.

poorly developed marine terraces, about 200 feet above sea level, near the mouths of Hornaday and Brock Rivers, but as Mackay (1958, p. 38) notes, there are:

> ... none of the remarkable flights of raised beaches rising to 500 or 600 feet above sea level that are such conspicuous features throughout much of the Arctic.

RLC-1

Large lobate deltas are presently being constructed at the mouths of Brock and Hornaday Rivers.

Bedrock is well exposed in most parts of Brock Upland and Horton Plateau, but outcrops are quite rare in the Melville Hills Morainic Belt. There are nearly continuous exposures along Hornaday, Brock, and Roscoe Rivers, and along the shoreline from Brock Lagoon to Buchanan River. Parts of the lower courses of Hornaday and Roscoe Rivers, and especially Brock River, are characterized by narrow, spectacular canyons (Fig. 4). Mackay's (1958, p. 58) description of Brock Canyon is apt:

> In places, the buff to rusty-brown canyon walls rise 350 feet above the swift-flowing river. Spired 100-foot high pinnacles with precariously balanced rocks rise like minarets along the banks. Talus deposits apron the bases of the pinnacles and often extend down to river level. The colourful Brock River gorge has the scenic attraction of some canyons in the southwestern United States.

If the canyons are post-glacial, as field evidence favours, they are striking examples of the inordinate amount of erosion that has been accomplished by streams in some periglacial regions.

RLC 2

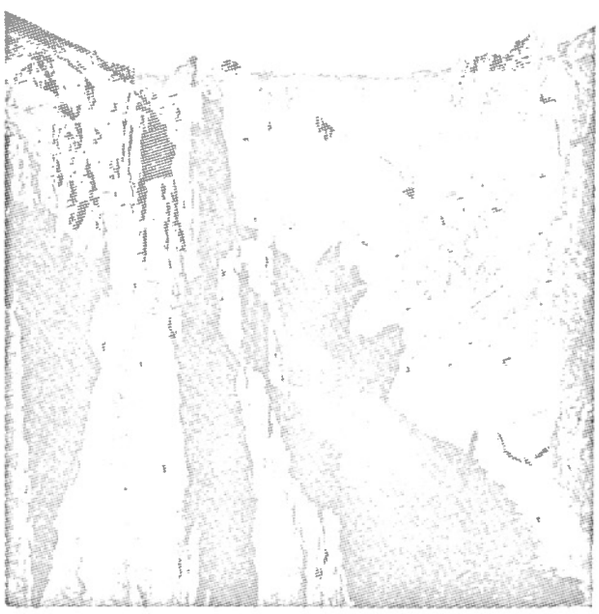

Figure 4. Brock Canyon, viewed easterly; here the canyon is about 350 feet deep. Delicate pinnacles are sculptured from Proterozoic dolomite (map-unit P_2) chiefly by rockfall along systematic joints.

STRATIGRAPHY

Gently tilted, unmetamorphosed, Upper Proterozoic (Hadrynian or Neohelikian) sedimentary rocks, locally intruded by gabbro sills and dikes, underlie most of Brock Upland. The sequence, which has a total exposed thickness of at least 6,000 feet, is tentatively correlated with the Shaler Group of nearby Victoria Island.(Table 1).

Cambrian quartz sandstones unconformably overlie the Proterozoic strata and are succeeded by about 1,500 feet of Lower and Middle Paleozoic clastic and carbonate rocks. A regional hiatus separates the Paleozoic rocks from Lower Cretaceous quartz sandstones, siltstones, shale, and coal; approximate thickness of the Cretaceous rocks is about 700 feet.

Unconsolidated Quaternary glacial deposits and Recent alluvium form a widespread mantle on the older rocks.

Proterozoic

Shaler Group (Thorsteinsson and Tozer, 1962; Cook and Aitken, 1969)

All of Brock Upland, except for an area near the headwaters of Roscoe and Buchanan Rivers, is underlain by a se-

Table 1.

Table of Map-units

System or Series	Map-unit and estimated maximum thickness (feet)	Lithology
Quaternary	Recent alluvial and deltaic deposits (Qad) ?	Unconsolidated gravel, sand, silt, and clay.
	Unconformity	
	Moraines, glacio-fluvial, and glacio-lacustrine deposits (Qm) 500	Unconsolidated gravel, sand, silt, and clay; locally bedded; till.
Unconformity		
Lower Cretaceous	"Bentonitic zone" (Kb) 300	Black, soft, plastic shale with fossiliferous orange, concretionary limestone.
	"Silty zone" (Ks) 400	Light to dark grey shale and mudstone; light grey, friable sandstone; local coal; local limestone concretions.
Unconformity		
(?)Lower and Middle Devonian	Bear Rock Formation (Dbr) 260	Dolomite: light brown grey and light green grey; fine crystalline; calcareous; interbeds of pale green, pink, and maroon shale near base; local dolomite-pebble conglomerate at base.
Unconformity		
Upper Cambrian and Lower Ordovician	"Ronning Group" — Unit 2b (COr_{2b}) ~~300~~ 400	Dolomite: pale yellow brown to pale grey; mainly medium crystalline; abundant white and yellowish-grey, stromatolitic and locally oolitic chert; abundant drusy quartz.
	"Ronning Group" — Unit 2a (COr2a) ~~300~~ 500	Dolomite: pale brownish grey; fine- to coarse-crystalline; interbedded with greyish-orange dolomite; partly laminated.
	"Ronning Group" — Unit 1 (COr1) 65	Dolomite and rare limestone; cyclic repetitions of laminated beds, oolitic beds, conglomeratic beds, stromatolitic beds, and thin beds of dolomitic shale.
Cambrian	Saline River Formation (Cs) 120	Red and green shales; gypsum; halite; siltstone; flaggy dolomite with salt-crystal casts.

~~Mount Cap Formation~~

Table of map-units, continued

System or Series	Map-unit and estimated maximum thickness (feet)	Lithology
Cambrian	Mount Cap Formation (Ccp) ~~120~~ 200	Green, grey, and minor red shales; glauconitic sandstone and siltstone.
	Old Fort Island Formation (Co) 200	Sandstone: white, grey, locally red and green; quartzose; fine to very coarse grained and conglomeratic; cross-bedded; locally friable.
Unconformity		
Neohelikian or Hadrynian	Unit P_6	Gabbro sills and dikes
	Intrusive contact	
	Unit P_5 500	Maroon and green dolomite, siltstone, and orthoquartzite; local gypsum.
	Possible unconformity	
	Unit P_4 500	Pink and buff dolomite; green shale; dark grey limestone; large domal stromatolites.
	Unit P_3 1,500	Pink, grey, buff, and maroon orthoquartzite; minor shale near top.
	Unit P_2 800	Buff, pink, and grey dolomite; fine- to coarse-crystalline; partly cherty.
	Unconformity	
	Unit P_1 3,000 (base not exposed)	Dark grey-green shale, argillite, and siltstone.

quence of unmetamorphosed, largely or entirely marine clastic and carbonate strata, which are intruded by diabasic sills and dikes. The sedimentary and intrusive rocks are truncated by a regional unconformity beneath Cambrian strata (Cook and Aitken, 1969); furthermore, the intrusive rocks have yielded radiometric ages of 705 and 770 m.y., based on whole-rock, K-Ar determinations (Wanless and others, 1965, p. 48), although it was later suggested (Wanless and others, 1968, p. 66) that the intrusions may be older than this and that the 'young' ages may have resulted from loss of argon during a Late Proterozoic tectonic event. In any case, the stratified rocks and their attendent intrusions are Precambrian, and likely Hadrynian or Neohelikian (Upper Proterozoic).

In the past the Proterozoic rocks were correlated with the Coppermine River Series (O'Neill, 1924; Fraser and others, 1960; Yorath and others, 1969), however they are in mappable continuity with rocks that Cook and Aitken (1969) referred to as the Shaler Group, inasmuch as:

> ... they lie on trend with that Group (Shaler Group) at its type locality on Victoria Island, and are similar in lithology and stratigraphic position.

RLC-1

Barager and Donaldson (1970, p. 122) mapped an unnamed succession of post-Coppermine River Group Proterozoic rocks west of Coronation Gulf, which may correspond to rocks herein referred to as

the Shaler Group.

Five informal lithostratigraphic units in the Shaler Group were mapped in the Brock River map-area, as were the sills and dikes that locally intrude them. Stratigraphic sections were not measured in the Proterozoic rocks, nor were the rocks examined in detail; estimates of unit thicknesses are based on regional structure.

The oldest Proterozoic strata (map-unit P_1) consist of dark grey-green, slightly calcareous shale, argillite, and siltstone. These rocks form low sea cliffs along the eastern shore of Darnley Bay, and locally crop out along Brock River at the approximate axis of the Coppermine Arch. The base of the unit is not exposed; the uppermost beds are abruptly and unconformably overlain by dolomite assigned to unit P_2. Map-unit P_1 is estimated to be at least 3,000 feet thick, based on exposures near Cape Lyon.

Lowermost rocks assigned to unit P_2 are composed of thin-bedded, maroon and buff,[1] fine-crystalline, arenaceous dolomite. These strata are overlain by thick- to very thick-bedded, resistant dolomite that forms headlands at Pearce Point but which is best exposed in the narrow gorge of Brock River (Fig. 4). Dolomite

1 In this report buff is used for colors in the range - yellowish grey to very pale orange (5Y7/2 to 10YR8/2 in the Rock Color Chart (Goddard and others, 1963). Tan is used for colors in the range - light brown to moderate brown (5YR6/4 to 5YR4/4).

in the upper part of the unit is light buff, light pink, and light grey; it is very fine- to medium-crystalline, and there are abundant reticulate masses of tan-weathering chert, as well as laminations of chert. The upper part of the sequence has local poor porosity in the form of disconnected small vugs. Map-unit P_2 is estimated to be about 800 feet thick at Brock River, and may be thicker than this at Pearce Point. The unit is conformably overlain by orthoquartzite assigned to unit P_3.

Light pink, maroon, light grey, and light buff orthoquartzites (P_3) are widely exposed on Hornaday Plateau and in the Darnley Bay Coastlands near Keats Point. These rocks are fine to coarse grained, very well cemented, thick bedded, and resistant. There are a few thin zones of recessive, maroon and dark green shale in the upper part of the sequence. Map-unit P_3 is estimated to be about 1,500 feet thick; it is conformably overlain by strata assigned to unit P_4.

The lowermost beds assigned to unit P_4 consist of light pinkish buff, buff- to orange-weathering, fine-crystalline dolomite with small reticulate masses of chert. These thin- to medium-bedded rocks are exposed along the Arctic Coast at Keats Point, at Hornaday River, and southwest of Roscoe River where they are overlain by about 100 feet of medium to dark green and maroon shale and thin-bedded, medium green siltstone. The

remainder of unit P_4 is composed of buff and pinkish-buff, fine-grained fine-crystalline dolomite, with beds of large, domal stromatolites and one zone (about 100 feet thick) of dark grey, microcrystalline, thin-bedded limestone near Deas Thompson Point. Complete sections of unit P_4 are not exposed but the unit is estimated to be about 500 feet thick.

The uppermost Proterozoic sedimentary rocks in the area, consisting of maroon and light green dolomite, siltstone, orthoquartzite and thin beds of gypsum, (unit P_5), are poorly exposed eastward from Clinton Point and along the unnamed river immediately west of Buchanan River. Dolomite in this equence is very finely crystalline and thin bedded. Orthoquartzites are thin bedded and cross laminated. The lower and upper contacts of unit P_5 were not observed. Cook and Aitken (1969) reported a possible unconformity at the base of the unit in the Erly Lake map-area (97A), and also that the unit is there unconformably overlain by Cambrian sandstone. Owing to pre-Paleozoic erosion the sequence is absent in the western part of the Coppermine Arch, however it is at least 500 feet thick near Buchanan River.

Diabase sills and dikes (P_6)

The Proterozoic sedimentary rocks are intruded by sills and dikes of dark green to dark grey, diabasic gabbro. The dikes range in width from a few tens of feet to about 400 feet; the longest, near Deas Thompson Point, is exposed for about 5 miles. All observed dikes are nearly vertical and trend northwesterly, parallel to the regional trend of the Coppermine Arch.

Sills are most conspicuously developed in map-units P_1, P_2, and P_4; except for a thin sill near the southern border of the map-area, the very thick sequence of orthoquartzites designated as unit P_3 appear to be free of sills. Some sills are nearly 100 feet thick and are continuously exposed over wide areas, particularly between Hornaday and Roscoe Rivers.

Argillaceous rocks adjacent to the dikes, and above and below sills, are altered to pelitic hornfels, whereas carbonate rocks are bleached and recrystallized; orthoquartzite beds appear to be unaffected. The zones of alteration are, at most, a few tens of feet wide.

As previously noted, radiometric age determinations (705 and 770 m.y.) of the intrusions may be misleading, however similar intrusions in the Shaler Group on Banks and Victoria Islands have yielded radiometric ages of 635m.y. and 640 m.y. (Christie, 1964).

Paleozoic

Paleozoic marine sedimentary rocks, ranging from Cambrian to Middle Devonian, flank the eastern and western limbs of the Coppermine Arch and unconformably overlie Proterozoic sedimentary and intrusive rocks. Cumulative thickness of Paleozoic strata is estimated to be about 1,400 feet.

The Paleozoic succession is homotaxial with the sequence of units elsewhere in the eastern part of the northern Interior Plains (see Aitken and others, 1969, 1970). Identifiable fossils are uncommon in the Paleozoic rocks; assignments of geologic age are principally based on occurrences elsewhere in the lower Mackenzie and Anderson River areas, and are consequently tentative. Stratigraphic nomenclature and assignments of geologic age (Table 1) are partly amended from an earlier publication (Yorath and others, 1969) for reasons that follow.

Old Fort Island Formation: Co (Norris, 1965)

A sequence of light grey, buff, and pink, medium- to coarse-grained quartz sandstones, about 200 feet thick, unconformably overlies Proterozoic dolomite (unit P_4) in

Hornaday Canyon. These friable, porous rocks are conspicuously cross stratified. There are a few thin beds of light green and maroon siltstone near the base of the succession.

Yorath and others (1969) informally referred to these rocks as 'basal Paleozoic sandstone'. The rocks are in mappable continuity with quartz sandstones in the Erly Lake map-area (97A) that Cook and Aitken (1969) tentatively correlated with the Mount Clark Formation of the Franklin Mountains, about 300 miles to the south (Fig. 2). It seems inadvisable to perpetuate the appelation of Mount Clark Formation to these rocks, as there is much uncertainty regarding the age and stratigraphic relationships of that formations as originally described (see Hume, 1954, pp. 9-13).

Norris (1965) mapped the distribution of basal Paleozoic quartz sandstones along the margin of the Precambrian Shield from Great Slave Lake northward to Latitude 64°; he proposed that these rocks be called the Old Fort Island Formation from

exposures in the North Arm of Great Slave Lake. Field work by Balkwill in 1969 demonstrated that rocks corresponding to the Old Fort Island Formation could be mapped as far north as Leith Peninsula (Great Bear Lake, Latitude 66°). Fraser and others (1960) mapped basal Paleozoic sandstones near the north shore of Great Bear Lake, and these rocks are in mappable continuity with the strata that Cook and Aitken (op. cit.) referred to the Mount Clark Formation.

In summary, friable, porous, conspicuously cross-bedded, quartz sandstones, which overlie a variety of Precambrian crystalline and sedimentary rocks, can be mapped from Great Slave Lake to the Arctic Ocean; Old Fort Island Formation is their most appropriate stratigraphic designation.

Except for trails and burrows, the formation is unfossiliferous, however its age in Hornaday Canyon is indicated by these conditions: it rests unconformably on rocks that Wanless et al. (1968, p. 66) suggest were mildly deformed as recently as 605 m.y.; and it is conformably overlain by rocks tentatively assigned to the Mount Cap Formation, from which Lower and Middle Cambrian fossils have been collected in the Mackenzie and Franklin Mountains (Cook and Aitken, in press).

Accordingly, the Old Fort Island Formation is tentatively considered Lower Cambrian in the map-area, however the unit is a disconnected, transgressive, basal clastic deposit, and its age likely differs from place to place along the margin of the Canadian Shield.

Mount Cap Formation: Ccp (Williams, 1923)

Maroon and green shale, with thick-bedded, glauconitic sandstone (Fig. 5) and thin beds of orange dolomite, are in mappable continuity with rocks that Cook and Aitken (1969) tentatively correlated with the Mount Cap Formation. The formation conformably overlies the Old Fort Island Formation and is conformably overlain by the Saline River Formation. An isolated outcrop of glauconitic sandstone on the eastern flank of the Coppermine Arch, near the headwaters of Roscoe River, is tentatively assigned to the formation.

The Mount Cap Formation is about 200 feet thick at La Ronciere Falls (Macqueen, pers. comm., 1969) where the thick sandstone beds form the lip of the falls (Fig. 5). Cook and Aitken (1969) report that the unit is about 230 feet thick in the southeastern part of Erly Lake map-area.

Fossils were not collected from the Mount Cap Formation in Brock River map-area. Middle Cambrian taxa were reported (Hume, 1954, pp. 10-11) at the type locality (Mount Cap in the Franklin Mountains) and recent collections from Mount

GS-3199-A-22

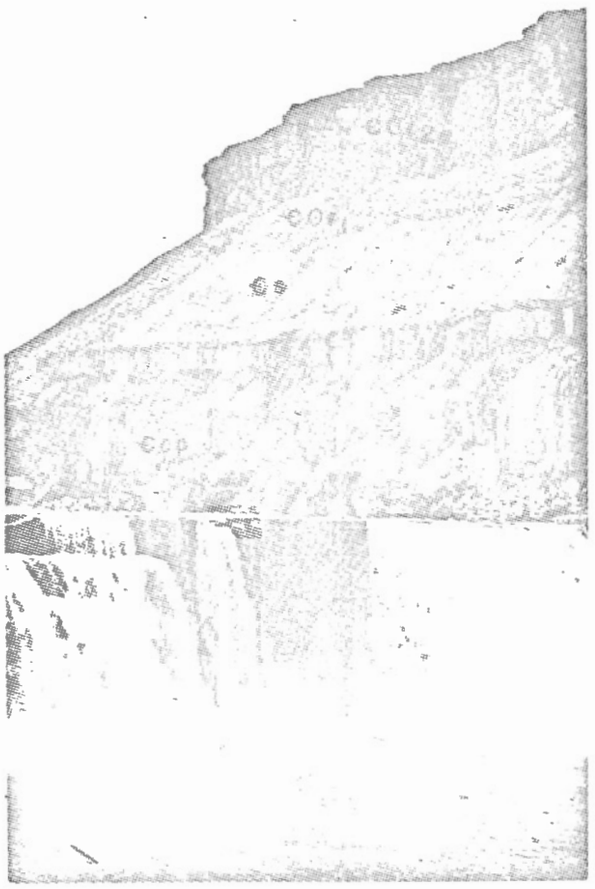

Figure 5. La Ronciere Falls, Hornaday River; height of the falls is about 70 feet. Resistant beds in the Mount Cap Formation (Ccp) form the lip of the falls and lower walls of the canyon; Saline River Formation (Cs) and the 'cyclic unit' (COr_1) of the 'Ronning Group' are poorly exposed in the recessive slope; the 'rhythmic unit' (COr_{2a}) of the 'Ronning Group' forms the upper cliff.

Clark, also in the Franklin Mountains, are late Early Cambrian (W. H. Fritz, G. S. C. Paleontology Section Report C-19-1969-WHF).

Saline River Formation: Cs (Williams, 1923)

The Saline River Formation conformably overlies the Mount Cap Formation in exposures along the upstream part of Hornaday Canyon. At La Ronciere Falls, where it is a recessive unit about 120 feet thick (Macqueen, pers. comm., 1969), the formation consists of maroon, green, and buff shale, and gypsiferous, very thin-bedded dolomite. Dessication polygons, salt casts, and ripple marks are common on many bedding surfaces.

Fossils collected near the type locality in the Franklin Mountains were referred to the Middle Cambrian (Hume, 1954, p. 11). Collections from Saline River strata in the Mackenzie Mountains (Fig. 2) were tentatively assigned to the Glossopleura Zone of the Middle Cambrian (W. H. Fritz, G. S. C. Paleontology Section Report C-19-1969-WHF).

'Ronning Group' (Hume and Link, 1945; Bell, 1959; Macqueen, 1970)

Macqueen (1970) used the term 'Ronning Group' in a reconnaissance sense to include four distinct, widespread,

Lower Paleozoic, shelf carbonate units in the plains east of the lower Mackenzie River. From the base these are the informal 'cyclic', 'rhythmic', and 'cherty' units, and the overlying Mount Kindle Formation. The 'cyclic', 'rhythmic', and 'cherty' units are present in the map-area, although the 'cyclic unit' is very thin; the Mount Kindle Formation is absent, presumably because of erosion associated with a sub-Devonian unconformity.

Sparse paleontologic evidence from 'Ronning' strata in the area of Operation Norman (Macqueen, 1970) indicates that the lower part of the 'rhythmic unit' is Upper Cambrian (possibly Franconian), and at least part of the 'cherty unit' is Lower Ordovician. With this control the following possibilities exist: the Middle Cambrian - Upper Cambrian boundary is near the top of the Saline River Formation or in the lower part of the cyclic unit'; and the Cambrian - Ordovician boundary is near the top of the 'rhythmic unit' or near the base of the 'cherty unit'.

The 'cyclic unit' (COr_1) of the 'Ronning Group' is in gradational contact with the underlying Saline River Formation along Hornaday Canyon. The base of the 'cyclic' unit' is marked by the appearance of distinctive, pale yellowish-

orange weathering dolomite, with alternations of finely laminated beds, oolitic beds, flat-pebble conglomerate (intraclast) beds, stromatolitic beds, and thin beds of dolomitic shale. According to Macqueen (pers. comm., 1969) this succession is 63 feet thick at La Ronciere Falls (Fig. 5).

A sequence of pale brownish grey, fine- to medium-crystalline dolomite, interbedded with pale greyish-orange, fine-crystalline dolomite, gradationally overlies the 'cyclic unit' and is assigned to Macqueen's informal 'rhythmic unit' (COr2a) of the 'Ronning Group'. A subtle banded appearance is locally imparted by the alternating colors of the beds. Unit COr2a has poor to fair pin-point vuggy and intercrystalline porosity. The base of the 'rhythmic unit' is marked by the absence of shale beds and partings that are characteristic of the underlying sequence. At Hornaday Canyon the unit is about 500 feet thick.

About 400 feet of light- to medium-grey, and buff, thick-bedded, fine- to predominantly medium- and coarse-crystalline dolomite (COr_{2b}) conformably overlies the 'rhythmic unit'. This succession is distinguished by drusy quartz that lines vugs, by beds of light grey and white chert, and by abundant stromatolites replaced by grey and white chert, prompting Macqueen's (1970) informal designation as the 'cherty unit'. There are zones with poor to fair vuggy porosity and some beds have poor to fair intercrystalline porosity. Unit COr_{2b} underlies much of Horton Plateau and is locally exposed

in the extensively drift-covered region in the southeastern part of the map-area. The cherty rocks also crop out on Clapperton Island in the western part of Darnley Bay.

Bear Rock Formation: Db (Hume and Link, 1945; Bassett, 1961; Tassonyi, 1969)

Thick-bedded 'Ronning' dolomites are disconformably overlain near the mouth of Hornaday Canyon by a variety of carbonate and clastic strata that are assigned to the Bear Rock Formation. Local relief on the disconformity is as great as 150 feet (Fig. 6), where thin-bedded dolomite, limestone, and light green and maroon shale, with some grey chert pebbles at the base, occupy depressions in the disconformity and are draped over knobs of nearly horizontal 'Ronning strata. The effect of this draping is to develop random folds in the Bear Rock Formation that are not expressed in the underlying rocks. Relief on the disconformity apparently decreases westward; along Horton River, in adjacent Simpson Lake map-area (Balkwill and Yorath, 1970) local relief is generally less than 50 feet.

Most of the Bear Rock sequence in Hornaday Canyon is buff and grey, calcareous and gypsiferous, fine-crystalline dolomite that is not brecciated in contrast to neighbouring regions (Balkwill and Yorath, op. cit.; Cook and Aitken, 1969),

68-BAA-A-18

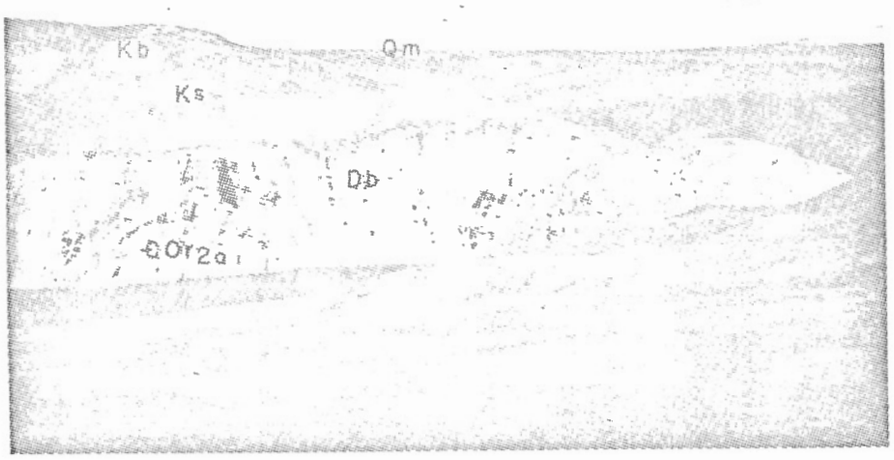

Figure 6. Mouth of Hornaday Canyon, viewed eastward: knobs of 'Ronning cherty unit' (COr_{2b}) disconformably overlain by Bear Rock Formation (Db); note supratenuous folds in latter. Cretaceous 'Silty zone' ~~and~~ 'Bentonitic zone' (Ks) and 'Bentonitic zone (Kb)' poorly exposed in recessive slope; upland surface overlain by glacial drift (Qm).

$\in Or_{2a}$ in photo.

owing to the insignificance of readily soluble evaporites in the sequence. The rocks have poor to fair intercrystalline porosity.

Fraser (1960) collected Middle Devonian fossils from the Bear Rock Formation in Hornaday Canyon. This is consistent with age determinations of the upper part of the formation elsewhere in the lower Mackenzie River region (Cook and Aitken, in press; Norris, 1968, p. 22). The age of the basal beds is uncertain; in the Mackenzie Valley the Bear Rock Formation is partly Lower Devonian and may locally be as old as Upper Silurian (Tassonyi, 1969).

Cretaceous

Principal exposures of Cretaceous rocks in Brock River map-area are scattered along the downstream parts of Hornaday and Brock Rivers, along the western part of the Darnley Bay Coastlands, and along the unnamed stream immediately west of Buchanan River. Cretaceous strata are believed to extend westward toward Anderson Plain but exposures are few and poor, owing to the extensive cover of glacial drift.

Four informal Cretaceous lithostratigraphic units have been mapped in the northernmost parts of the northern Interior Plains (Yorath, et al., 1969); of these, the lower two units

('Silty zone' and 'Bentonitic zone') were mapped in the Brock River area.

'Silty zone'

Proterozoic and Paleozoic rocks are overlain with pronounced unconformity by poorly to moderately well indurated clastic rocks assigned to the Lower Cretaceous 'Silty zone'. Along Hornaday and Brock Rivers the 'Silty zone' is divisable into two informal units: a lower, non-marine sandstone and coal division, and an upper siltstone and mudstone division; the combined thickness is about 400 feet. The lower division is best exposed in Rummy Creek and George Creek valleys where it consists of light grey and buff, fine- to very coarse-grained, porous and friable quartz sandstones with prominent planar cross beds, thin coal seams in its lower part, and large (one- to three-feet in diameter) orange weathering, calcareous concretions. Along Hornaday River, about four miles from the junction with George Creek, the low-grade lignites and sandstones form recessive slopes above resistant Paleozoic carbonates (Fig. 6). Here the lignites have burned and are red.

Along the downstream parts of Hornaday and Brock Rivers the lower sandstone and coal division grades upward to the upper siltstone and mudstone division. The latter is composed of dark grey, concretionary mudstones and interbedded grey brown siltstones. Coquinas containing very poorly preserved pelecypods and gastropods occur in the lower 80 feet of the unit on Brock River.

Two isolated occurences of the lower sandstone and coal

division are preserved in small grabens along Hornaday River near the southern boundary of the map-area. Exposures north of Brock River are poor, however all of the Cretaceous rocks in this area appear to belong to the lower sandstone and coal division.

Rocks with lithologies typical of the lower division of the 'Silty zone' occur in the vicinity of Buchanan River, on the east side of Brock Peninsula. The seqence at Buchanan River is about 200 feet thick and unconformably overlies Proterozoic dolomites (unit P5).

'Bentonitic zone'

A thin veneer of strata assigned to the 'Bentonitic zone' conformably overlies the 'Silty zone' along Hornaday River and its tributaries First and Second Creeks. In adjacent map-areas (97B and 97C; see Yorath and others, 1969) the 'Bentonitic zone' consists of a basal cone-in-cone bed overlain by uniform black, plastic and concretionary shales. In the Brock River area only the lowermost few feet are exposed and these include the well defined cone-in-cone layer. A maximum thickness of about 300 feet is estimated for this unit in the map-area.

Age and Correlation of Cretaceous Rocks

Age assignments of Cretaceous strata are tentative, pending completion of micropaleontological studies. The units are tentatively correlated with formations of similar lithology and stratigraphic position on Banks Island (Yorath and others, 1969). The lower sandstone and coal division of the 'Silty zone' appears to

to be the lithologic equivalent of the Isachsen Formation (Lower Cretaceous: pre-Albian) as described by Thorsteinsson and Tozer (1962). The upper siltstone and mudstone division is probably correlative with the lower member of the Christopher Formation, which has yielded diagnostic Early to Middle Albian faunas. The upper member of the Christopher Formation has been dated as Middle to Late Albian (Thorsteinsson and Tozer, 1962), and is lithologically similar to the 'Bentonitic zone'. Chamney (personal communication, 1969) has identified Middle Albian glomospirellid foraminifera from the upper beds of the 'Bentonitic zone' in the Anderson River area. A few immature and fragmental ammonites were collected from the 'Bentonitic zone' on Horton River, west of the map-area. Jeletzky (GSC Paleontology Report No. Km-3-1969) tentatively suggested that they represent the late Lower or early Middle Albian Arcthoplites or Beudanticeras affine zone, but was unable to provide positive identifications due to the paucity, immaturity and fragmental nature of the specimins collected.

Quaternary

Thick, topographically prominent moraines and related glacial deposits (Qm) are mainly within the Melville Hills Morainic Belt (Fig. 1). The deposits are mostly coarse- to very coarse-grained, light grey to buff quartz sand, which appears to have been largely derived from the poorly indurated quartz sandstones of the lower sandstone and coal division of the Cretaceous 'Silty zone'. Thickness of the moraines is quite variable; in some places the deposits are at least several hundred feet thick.

Recent alluvium, consisting of unconsolidated gravel, sand, and silt, locally mantles the narrow floodplains of major streams. Large, lobate fan deltas, consisting of silt and fine-grained sand, are presently being constructed at the mouths of Brock and Hornaday Rivers.

STRUCTURAL GEOLOGY

Coppermine Arch, which dominates the structure of the map-area (Fig. 2), is a northwesterly trending cratonic salient of Proterozoic sedimentary rocks, (with minor intrusions), unconformably flanked on the east and west by easterly and westerly dipping homoclines of Lower and Middle Paleozoic and Cretaceous strata. The arch is asymmetrical, with a steeper southwest limb; the approximate axis is marked by outcrops of unit P_1 of the Shaler Group near the upstream portal of Brokk Canyon. Southwestward asymmetry of structures within the arch (including folds and reverse faults) were noted in adjacent Erly Lake map-area (Cook and Aitken, 1969).

Several epeirogenic events in the Coppermine Arch and environs are recorded by: (1) intra-Proterozoic unconformities between units P_1 and P_2, and between units P_4 and P_5; (2) widespread Late Proterozoic (about 700 m.y. or slightly older) intrusion of diabasic dikes and sills; (3) a sub-Paleozoic angular unconformity (Wanless et al., 1968, p. 66, suggest mild deformation about 605 m.y.); (4) pre-Devonian channelling of 'Ronning Group' carbonate rocks; (5) a regional unconformity beneath Lower Cretaceous rocks; and (6) faulted Lower Cretaceous

rocks and a hiatus between these strata and Pleistocene glacial deposits.

Where the stratigraphic record permits observation, these (and additional) indicators of epeirogenesis are widespread in the lower Mackenzie River region. Thus the importance of the Coppermine Arch as a singular tectonic feature is not readily apparent; however, two local considerations suggest that there were phases when the arch was a discretely positive structure: (1) local erosional relief in sub-Bear Rock carbonates ('Ronning Group') is much more pronounced on the flanks of the arch than elsewhere in the region, suggesting an Early Paleozoic (Caledonian) uplift; in this way the arch may have served as the northeastern boundary of the shallow Devonian basin that gave rise to the extensive Bear Rock evaporites; and (2) coarse quartz sandstones and conglomerates, probably fluvial in origin, in Simpson Lake map-area (Balkwill and Yorath, 1970, p. 5) appear to have been generated in the region of the Coppermine Arch during the Early Cretaceous (probably pre-Albian).

The relationships between the Coppermine Arch and structures involving similar Proterozoic rocks on Banks and Victoria Islands (Thorsteinsson and Tozer, 1962) are not readily apparent; 90-mile wide Amundsen Gulf separates the regions.

Dikes and significant faults consistently strike northwesterly, parallel to the approximate axis of the arch; this is parallel to the dominant trend of these features in other parts of the structure (Cook and Aitken, 1969). Most of the faults appear to be high-angle normal faults that were generated in response to broad crustal arching, although interpretation is sometimes difficult because of extensive drift cover, widespread felsenmeer, and low local relief.

The gentle, westward-dipping homocline on the western flank of the Coppermine Arch has been called the Horton Plain structural province (Yorath et al., 1969). Lower Paleozoic clastic and carbonate rocks, and poorly indurated Cretaceous strata are little deformed; random small folds in Bear Rock Formation, with amplitudes of a few tens of feet, are supratenuous on irregularities in the underlying 'Ronning' paleosurface.

The westernmost part of the Wollaston Structural Basin is contiguous with the eastern flank of the Coppermine Arch; at the boundary, the Paleozoic rocks dip eastward as a rather uniform homocline.

Nearly vertical systematic joints are very well developed in brittle rocks throughout the Coppermine Arch, Horton Plain, and westernmost Wollaston Basin. Predominant joints strike northwesterly and north-

easterly. The abrupt angularity of the courses of many streams and parts of the coastline (as at Halcro Point) is largely the result of erosion along master joints; rockfall, facilitated by joints, has developed spectacular gorges (Fig. 4).

A probable Proterozoic subsurface structure of great significance, but as yet undetermined relationships, is indicated by a spectacular gravity high, rising about 130 mgal above the regional field near the mouth of Hornaday River (Fig. 2). According to Hornal et al. (1970, p. 10):

> A good fit to the anomaly was obtained from a model shaped like an inverted cone of gabbroic composition (ρ = 3.0 g/cm^3) which intruded Precambrian rocks of density 2.7 g/cm^3 and which approached within 3 miles of the surface.

The feature may be comparable in genesis and age to layered ultrabasic intrusions, including the Muskox Complex (Smith, 1962), which are known in Proterozoic rocks in other parts of the northwest District of Mackenzie (Hornal, 1969).

ECONOMIC GEOLOGY

No metallic sulphides, other than pyrite or marcasite, were found in the rocks; however the Proterozoic rocks were not investigated in detail and the possibilities of mineralization, particularly along faults and intrusive contacts,

should not be discounted.

Prospects for significant accumulations of hydrocarbons in the Phanerozoic rocks appear to be poor. Some of the rock units have sufficient porosity and permeability to serve as potential hydrocarbon reservoirs, however permeability barriers or structural anomalies would be required for favorable reservoir conditions: where they are present, Cretaceous 'Silty zone' strata are generally at the surface and the unit can be disregarded as a possible reservoir in the map-area; Paleozoic rocks (including porous zones in the Bear Rock Formation, 'Ronning Group', and Old Fort Island Formation) dip westward in a gentle homocline that may have permitted up-dip migration and escape of hydrocarbons. Supratenuous folds developed in Bear Rock beds may provide local, small structural traps.

The thin coal seams of the lower sandstone and coal division of the 'Silty zone' have been used as a source of fuel by trappers and the mission at Paulatuk, but the deposits are not extensive.

REFERENCES

Aitken, J. D., and others
1969: Operation Norman, District of Mackenzie, Northwest Territories; in Report of activities, May to October, 1968, R. G. Blackadar, editor; Geol. Surv. Can., Paper 69-1A, pp. 223-229.

1970: Operation Norman, District of Mackenzie; in Report of activities, April to October, 1969, R. G. Blackadar, editor; Geol. Surv. Can., Paper 70-1A, pp. 202-206.

Balkwill, H. R., and Yorath, C. J.
1970: Simpson Lake map-area, District of Mackenzie (97B); Geol. Surv. Can., Paper 69-10.

Baragar, W. R. A., and Donaldson, J. A.
1970: Coppermine and Dismal Lakes map-areas, District of Mackenzie (86O and N); in Report of activities, April to October, 1969, R. G. Blackadar, editor; Geol. Surv. Can., Paper 70-1A, pp. 120-124.

Bassett, H. G.
1961: Devonian stratigraphy, central Mackenzie River region, Northwest Territories, Canada; in Geology of the Arctic, G. O. Raasch, editor; Alta. Soc. Petrol. Geol., Univ. Toronto Press, pp. 481-498.

Bell, W. A.
1959: Stratigraphy and sedimentation of Middle Ordovician and older sediments in the Wrigley-Fort Norman area, Mackenzie District, N.W.T.; Bull. Can. Inst. Min. Met., vol. 52, pp. 3-18.

Bostock, H. S.
1964: A provisional physiographic map of Canada; Geol. Surv. Can., Paper 64-35.

~~Bostock, H. S.~~
~~1967:~~ 1970: Physiographic regions of Canada; Geol. Surv. Can., Map 1254A

Christie, R. L.
1964: Diabase - gabbro sills and related rocks of Banks and Vistoria Islands, Arctic Archipelago; Geol. Surv. Can., Bull. 105

Cook, D. G., and Aitken, J. D.
1969: Erly Lake, District of Mackenzie (97A); Geol. Surv. Can., Map 5-1969.

in press: Geology, Colville Lake map-area and part of Ermine map-area (96NW and NE, part of 86NW) Northwest Territories; Geol. Surv. Can.

Douglas, R. J. W., and others
1963: Geology and petroleum potentialities of northern Canada; Geol. Surv. Can., Paper 63-31.

Fraser, J. A., and others
1960: North-central District of Mackenzie, Northwest Territories; Geol. Surv. Can., Map 18-1960.

Goddard, E. N., and others
1963: Rock-color chart; the Rock-Color Chart Committee, E. N. Goddard, Chairman; distributed by the Geol. Soc. Amer., Boulder, Colo.

Hornal, R. W.
1969: The gravity field over the northwestern Canadian Shield (abstract); Trans. Am. Geophys. Un., vol. 50, p. 321.

Hornal, R. W., and others
1970: Preliminary results of gravity surveys over the Mackenzie Basin and Beaufort Sea; Dept. Energy, Mines and Res., Earth Physics Branch, Gravity Map Series Nos. 117-119.

Hume, G. S.
1954: The lower Mackenzie River area, Northwest Territories and Yukon; Geol. Surv. Can., Memoir 273.

Hume, G. S., and Link, T. A.
1945: Canol geological investigations in the Mackenzie River area, Northwest Territories and Yukon; Geol. Surv. Can., Paper 45-16

Mackay, J. R.
1958: The Anderson River map-area, N.W.T.; Geograph. Branch, Can.; Memoir 5.

Macqueen, R. W.
1970: Lower Paleozoic stratigraphy and sedimentology; eastern Mackenzie Mountains, northern Franklin Mountains (96C,D,E,F; 106 G, H); in Report of activities, April to October, 1969, R. G. Blackadar, editor; Geol. Surv. Can., Paper 70-1A, pp. 225-230.

Norris, A. W.
1965: Stratigraphy of Middle Devonian and older Paleozoic rocks of the Great Slave Lake region, Northwest Territories; Geol. Surv. Can., Memoir 322.

1968: Reconnaissance Devonian stratigraphy of northern Yukon Territory and northwestern District of Mackenzie; Geol. Surv. Can., Paper 67-53.

O'Neill, J. J.
1924: The geology of the Arctic Coast of Canada, west of the Kent Peninsula; in Report of the Canadian Arctic Expedition (1913-1918), vol. XI, Arctic Publ. Comm., Kings Printer, Ottawa.

Stevens, R. D.
1968: K-Ar Isotopic ages, District of Mackenzie; in

Smith, C. H.
1962: Notes on the Muskox Intrusion, Coppermine River area, District of Mackenzie (86J and 86O, Parts of); Geol. Surv. Can., Paper 61-25.

Tassonyi, E. J.
1969: Subsurface geology, lower Mackenzie River and Anderson River area, District of Mackenzie; Geol. Surv. Can., Paper 68-25.

Thorsteinsson, R., and Tozer, E. T.
1962: Banks, Victoria and Stefansson Islands, Arctic Archipelago; Geol. Surv. Can., Memoir 330

Wanless, R. K., and others
1965: Age determinations and geological studies, Part 1- isotopic ages, Report 5; Geol. Surv. Can., Paper 64-17 (Part 1), p. 48.

1968: Age determinations and geological studies, K-Ar isotopic ages, Report 8; Geol. Surv. Can., Paper 67-2 (Part A), p. 66.

Williams, M. Y.
1923: Reconnaissance across northeastern British Columbia and the geology of the northern extension of Franklin Mountains, N.W.T.; Geol. Surv. Can., Sum. Rept. 1922, pt. B, pp. 65-87.

Yorath, C. J., Balkwill, H. R., and Klassen, R. W.
1969: Geology of the eastern part of the northern Interior and Arctic Coastal Plains, Northwest Territories; Geol. Surv. Can., Paper 68-27.