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RECONNAISSANCE GEOLOGY OF A PART OF THE CANADIAN SHIELD, NORTHERN QUEBEC AND NORTHWEST TERRITORIES

F.C. TAYLOR

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W.R.A. Baragar

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PREFACE

The coastal portions of the most northern and remote part of Quebec were first examined by Robert Bell and A.P. Low of the Geological Survey near the turn of the century, but it was not until the 1950s, when extensive prospecting by industry geologists and regional mapping by the Quebec Department of Mines revealed the existence of base metal and asbestos deposits, that this stark and barren region received the geological attention it deserves. The entire region, however, had not been examined until the present study. Almost all work prior to 1973 was confined to the Cape Smith Fold Belt, where the expense of exploration and detailed investigation was justified economically.

One of the major objectives of the Geological Survey of Canada is to delimit the mineral resources of our country and to furnish the geoscientific data required to facilitate their discovery. Geological maps and reports resulting from regional studies such as Dr. Taylor's are important in establishing an adequate data base from which to attain these objectives.

The 50 000 km^2 covered by this study are underlain entirely by rocks of Precambrian age. As similar rocks are and have been the source of much of Canada's mineral wealth, adequate mapping of all parts of this area was essential in order to allow a meaningful assessment of its mineral potential. This report and the accompanying multicoloured maps are the result of helicopter-supported fieldwork in 1973 and later office and laboratory work.

Archean rocks underlie about 12 000 km^2 of the area; the rest of the area is made up of Aphebian rocks with the exception of a few Hadrynian diabase dykes. This report describes these rocks, and their structural and metamorphic history. The Aphebian layered rocks of the Cape Smith Fold Belt, which contain a producing asbestos mine and several nickel-copper deposits, offer the best prospects for further discoveries.

D.J. McLaren
Director General
Geological Survey of Canada

Ottawa, April 1980

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Abstract

The area comprises 50 000 km^2 of the northern mainland Precambrian Shield of Quebec. The land surface, which was completely covered by ice during the Pleistocene, is variously plateau and ridge and valley type.

Parts of two structural provinces are present, the Superior underlying most of the southern part of the area, and the Churchill comprising the remainder. Most of the boundary between the two is clearly defined by an unconformity between Archean and Aphebian rocks.

The Superior Province consists of minor metasedimentary and metavolcanic rocks within a terrane dominated by granitic gneisses, migmatite and silicic intrusive rocks of Archean age. Late Archean diabase dykes are abundant in the eastern part.

The Churchill Province contains well preserved sedimentary and volcanic rocks, the latter forming about 80 per cent, almost entirely of mafic elements. Intrusions of gabbro, pyroxenite and ultrabasic rocks are numerous within these layered rocks and together they comprise the Cape Smith Fold Belt. Farther north this province consists of granitic gneisses, paragneiss, hornblende-plagioclase gneiss, granulite and granitic intrusive rocks. A few Hadrynian diabase dykes cut the older rocks.

Metamorphism in the Cape Smith Fold Belt is in the greenschist facies, which has also overprinted earlier amphibolite facies metamorphism in the Archean rocks to the south. Rocks immediately north of the fold belt are in the amphibolite facies and farther north are in the granulite facies, which in part has been overprinted by the amphibolite facies metamorphism.

Structures in the Superior Province trend northward in general, whereas those in the Churchill Province are chiefly east-northeasterly. A second, younger fold direction in the Cape Smith Fold Belt trends northwest and a third trends northward. Both refold the major east-northeast folds. Steeply dipping strike faults are prominent within the fold belt.

Asbestos is mined at Asbestos Hill and several nickel-copper deposits have been located in and associated with the ultrabasic intrusive rocks of the Cape Smith Fold Belt. The geology of the region indicates excellent potential for further metallic mineral discoveries.

Resumé

La région comprend 50 000 km^2 du nord du bouclier précambrien du Québec. La surface terrestre, que était entièrement recouverte par les glaces pendant le Pléistocène, présente tantôt une topographie de plateau, tantôt un aspect vallonné.

Deux provinces structurales y sont représentées, la province du lac Supérieur, qui englobe la majeure partie du sud de la région, et la province de Churchill qui comprend le reste. La limite entre les deux est en général clairement définie par une discordance entre les roches aphébiennes et archéennes.

La province du lac Supérieur contient une quantité mineure de roches métavolcaniques et métasédimentaires, dans un terrain dominé par des gneiss granitiques, des migmatites et des roches intrusives siliseuses d'âge archéen. Les dykes de diabase d'âge archéen supérieur sont abondants dans la partie est.

La province de Churchill contient des roches sédimentaires et volcaniques bien conservées; les secondes, presque entièrement constituées d'éléments mafiques, représentent à peu près 80% du total. De nombreuses intrusions de gabbro, de pyroxénite et de roches ultrabasiques traversent ces roches stratifiées; ensemble, elles constituent la zone de plissements de Cape Smith. Plus au nord, cette province contient des gneiss granitiques, des paragneiss, des gneiss à hornblende et plagioclase, des granulites et des roches granitiques intrusives. Quelques dykes de diabase de l'Hadrynien recoupent les roches les plus anciennes.

Dans la zone de plissements de Cape Smith, le métamorphisme est celui du faciès schistes verts; il est aussi surimposé au métamorphisme plus ancien du faciès amphibolite, dans les roches archéennes situées au sud. Les roches situées immédiatement au nord de la zone de plissements se situent dans le faciès amphibolite, celles plus au nord dans le faciès granulite, en partie modifié par le faciès amphibolite.

Dans la province du lac Supérieur, les structures ont en général une orientation nord, mais dans la province de Churchill, surtout une orientation est nord-est. Dans la zone de plissements de Cape Smith, une seconde orientation nord-ouest de plissement est apparue plus récemment, et une troisième en direction nord. Ces deux dernières ont remanié les plis principaux d'orientation est nord-est. Des failles longitudinales de fort pendage apparaissent très nettement dans la zone de plissements.

On exploite l'amiante de Asbestos Hill; d'autre part, on a localisé plusieurs gîtes de cuivre et de nickel dans les roches ultrabasiques intrusives de la zone de plissements de Cape Smith; les minéralisations sont associées à ces roches. La géologie de la région indique que celle-ci possède un excellent potentiel et contient sans dout d'autres minéralisations métallifères.

INTRODUCTION

Location and access

The map area covered by this study occupies all the northernmost part of the Province of Quebec (north of latitude 61°N) and offshore islands that are part of the Districts of Franklin and Keewatin (Fig. 1). This region, which embraces approximately 50 000 km^2, is served by Nordair Ltd. from Montreal via Fort Chimo once or twice a week, depending on the season, with landings at either Deception Bay or Asbestos Hill airstrips. Heavy freight can be shipped by sea to Deception Bay and to native communities during the late summer months.

Rapid travel within the map area is in general restricted to aircraft, except during the winter months when snowmobiles are practical. Besides the airstrips at Deception Bay (35 J)* and Asbestos Hill, (35H), two smaller strips are available, one at Spartan Lake (35G) and the other at the property of New Quebec Raglan Mines Limited (35H). The former requires some repair work before being used by heavy equipment, but the latter was in excellent condition in 1973.

Many lakes are unsuitable for float-equipped aircraft because water is shallow and the ice-free period is generally brief in most summers. Aircraft equipped with low-pressure, oversize tires can be landed in many places, particularly within the fold belt. This type of machine is not hampered by breakup and is able to provide ready access to Deception Bay and Asbestos Hill scheduled flights. In the spring and winter ski-equipped machines are unquestionably useful. However, helicopters are the most reliable and practical air transport in this treeless region.

Road travel is limited to areas of mine development and exploration. A 65 km all-weather gravel road joins Asbestos Hill and Deception Bay. Another extends from Cross Lake (35G) past the shaft site of the MacDonald Mine towards Douglas Harbour (35H). Most of this road is suitable for regular wheeled vehicles, but toward the east end it is passable only with four-wheel drive machines. Short side roads to drill sites occur erratically. In many places in the fold belt tracked vehicles such as Bombardiers, and wheeled vehicles such as balloon-tired Honda motorcycles can provide rapid transport.

Waterways are marked by numerous rapids and small waterfalls, so that canoe or boat travel is on the whole restricted to large lakes such as the Nuvilik Lakes and Lac Françoys-Malherbe (35G). Only the lower 40 km of the Kovik River (35F) provide suitable passage.

Settlements

Several native villages are along the coast. From east to west they are Koartak, Maricourt (Wakeham), Saglouc and Ivujivik (see Fig. 1). Although each has a general store, none is sufficiently supplied to support an exploration program of any reasonable size. The major habitation point is at Asbestos Hill, where mine employees live. A smaller service group are quartered at Deception Bay. Populations at these two locations fluctuate with the shipping season and midwinter mine shutdown.

Climate and vegetation

About half the map area lies in the zone of continuous permafrost, which at Asbestos Hill extends to a depth of more than 540 m (Stewart, 1976). The -7°C mean annual air temperature isotherm passes through the eastern end of the region near Wakeham Bay (Brown, 1967).

Deception Bay is ice-free from about the last week of June or the first week of July until November, or at the latest, early December when it is fully frozen over.

In June 1973 only the southwestern part of the map area was sufficiently free of snow for geological traversing and the higher ground in the east-central part was not suitable until after July 1. Snowbanks often remain throughout the summer, but in 1973 an unusually warm summer cleared many outcrops not normally free of snow.

The entire area is in the barrens and only a few small alders and willows grow in sheltered places. Ground cover consists of grasses, caribou moss and similar low-growing plants. Wildlife is scarce and no large animals such as caribou were seen. A few seals dwell along the coast.

Previous work

The exploration of the region commenced at the end of the 19th century with the examination of some coastal areas during extensive reconnaissance surveys of Hudson Bay, Hudson Strait and Ungava Bay. Bell (1885) observed gneisses with quartz veins at Cape Prince of Wales (25E) on the east coast and reported red gneiss with epidote veins and red pegmatite on Digges Island on the north coast (35K). A rusty amphibolite attracted the attention of Low (1899) on a voyage south from Douglas Harbour to Ungava Bay during the summer of 1897. Low (1902) also examined the west coast south from Cape Wolstenholme (35K), and noted the presence of 'diabase trap' southward from Kettlestone Knob (35F). This was the first record of the existence of the volcanic rocks of the fold belt. At this time Low also recognized granitic rocks in the map area and small amounts of nickel and copper in the rocks immediately south of the map area.

In the early 1930s on the basis of Low's work, the fold belt running inland from Cape Smith, which lies south of the present map area, was prospected for base metals well inland into the area, revealing several showings. Some of these were examined by Gunning (1934), who also reported briefly on the geology between the Korak River (35F) and the south boundary.

Following a renewed interest in sulphide mineralization in the 1950s Quebec provincial geologists mapped several areas, chiefly within the fold belt, covering approximately one third of the map area. The first work entailed a broad reconnaissance to delineate the fold belt and a mapped section across the fold belt at the longitude of Bilson Lake (35F) (Bergeron, 1957a). Bergeron's suggestion that a serious study of the fold belt was warranted led to several 1 inch to 1 mile mapping projects centred about the main nickel discoveries in the east-central part of the area. Bergeron (1959) continued his own work on a scale of 1 inch to 2 miles in the central part of the fold belt, where he divided the rocks into two groups, the Povungnituk and, unconformably above it, the Chukotat. Subsequently, Bergeron authored several papers on the whole fold belt, including its tectonics and deposition (Bergeron, 1958, 1957b; Bergeron et al., 1962; Dimroth et al., 1970). The more detailed mapping (Fig. 1) was done by Demontigny (1959), Beall (1959, 1960), Gélinas (1962) and Gold (1962).

Kretz (1960), accompanying a gravity survey party of the Dominion Observatory, briefly examined most of the region. Although lying outside the present map area, a study by Stam (1961) bears directly on the geology of the fold belt, as does Stevenson's (1968) mapping in the adjoining area to the south.

Isotopic age studies of samples from both within and without the fold belt were made by Beall et al. (1963) and scattered individual determinations have been made on rocks collected by Geological Survey of Canada geologists. Baragar (1974) mapped in detail and sampled two sections, chiefly of volcanic rocks, and part of a third between Carye Lake (35F) and Nuvilik Lakes.

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*Refers to NTS map sheet.

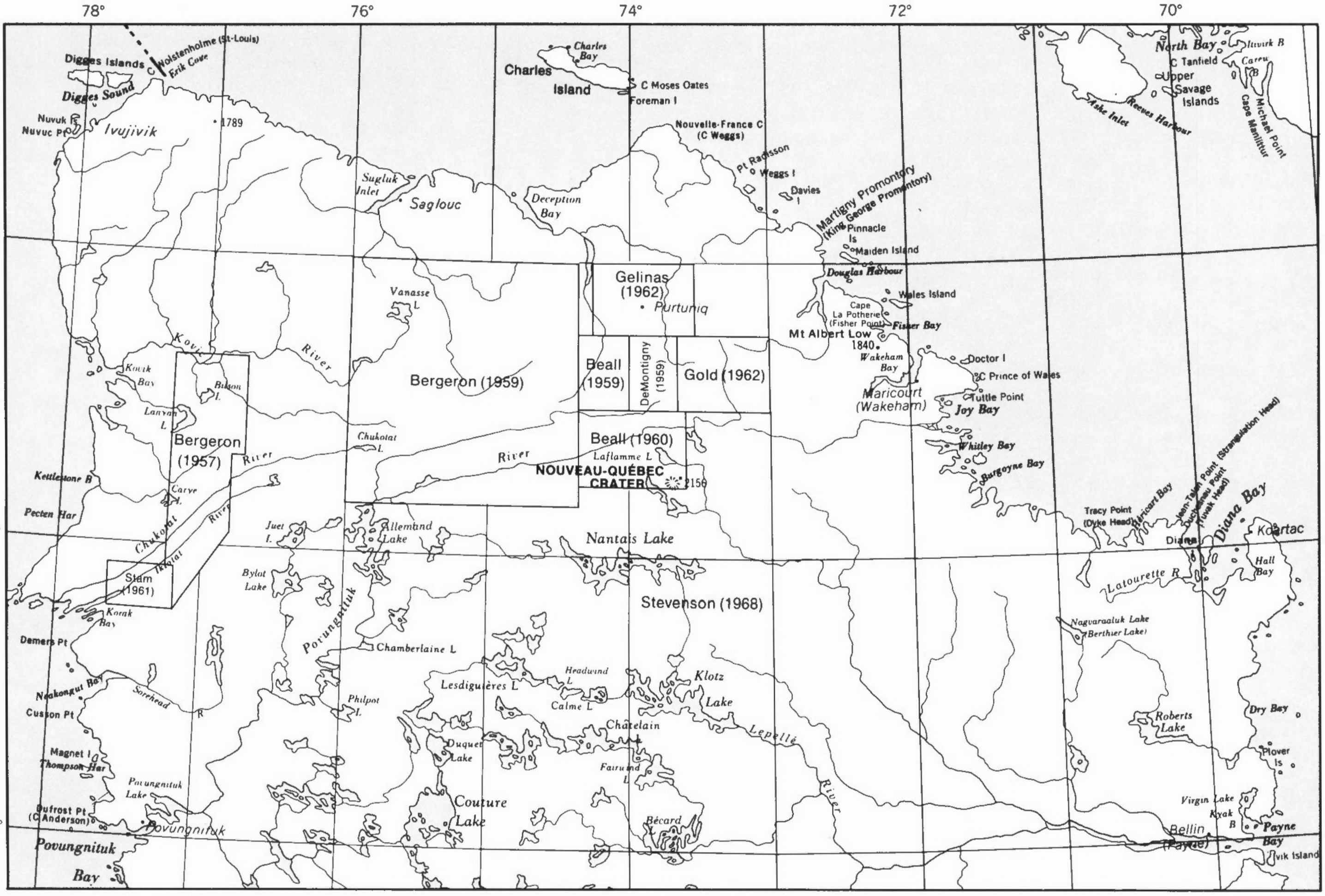

Figure 1. Location of the map area and previous mapping.

The Cratère du Nouveau-Québec (35H), which lies in the southeastern part of the map area, has been the site of several field studies since the United States Air Force discovered it in the 1940s. The first expeditions undertaken by Meen in 1950 and 1951 led to several papers (Meen, 1950, 1951, 1952, 1957), followed shortly after by those of Harrison (1954) and Millman (1956). Other researchers include Shoemaker (1961), Beall (1959), Currie (1966), and Currie and Dence (1963).

Published geophysical surveys consist only of gravity data and interpretation by Tanner and McConnell (1964) and further interpretation by Innes et al. (1967, 1968). Other geophysical techniques have been applied to much of the area for exploration purposes.

Field studies in Quaternary geology have been confined almost entirely to the north coast between Cape Wolstenholme and Deception Bay, where Matthews (1962, 1966, 1967) has investigated glacial lakes and marine submergence. Drinnan and Prior (1955) briefly visited the Diana Bay area (25F). Prest (1970) and Prest et al. (1968) compiled air photographic data and summarized limited data relating to the Quaternary geology.

A report and map preliminary to this memoir were issued in 1974 (Taylor, 1974).

Fieldwork

The present survey was carried out during the summer of 1973. Camp equipment and fuel were airlifted in April by Nordair's Lockheed Electra aircraft from Schefferville, Quebec, to the Asbestos Hill airstrip. Aviation gasoline and naphtha were both shipped in 10-gallon kegs for easy handling during the summer. Provisions purchased at Dorval Food Market, Dorval, which provided first-quality, well packed produce, meat and groceries, were flown to Asbestos Hill on scheduled flights. Three camps were established, the first on June 16 on the Kovik River, 34 km from the mouth, the second on the Rivière Foucault (35G) at about 61°44'N, and the third 5 km south-southeast of Lac Vicenza (35H). An Otter DHC3 with oversize wheels was used for this purpose and to haul provisions and gasoline from Deception Bay and Asbestos Hill. Landings at the campsites were on unprepared ground that was later marked out with signal cloth and empty fuel kegs. The Otter was also used to establish gasoline caches for use during traversing, in those areas most remote from the campsites.

Geological traverses were made using Bell G4A model helicopters on a four-mile spacing along north and south lines. Traverses were 180 km long at the maximum, so that sufficient time was available for ground observations, which averaged 32 per traverse. Spot checks were made where additional information was required to clarify data gathered during routine traversing, and much of the northeast and south boundary of the fold belt was traced along its length. Continuous observation from the air was maintained during traversing and these data are also incorporated on the accompanying maps.

Traversing started on June 19 and all fieldwork was concluded on August 18. The weather during the operation was unusually excellent. During this work 2154 individual ground observations were made. At least one rock sample was collected at each observation point, and two or more at many of them.

Acknowledgments

The successful field work of Operation Nuvilik was the result of the wholehearted co-operation of all members of the field party. The dedication of staff geologists T.M. Gordon and J.B. Henderson is greatly appreciated, particularly as the party was short-handed and they had an additional workload thrust upon them. The skill of the aircrews of Skyrotors Limited and Bradley Air Services Ltd., of helicopter pilots Nelson Bentley and Randy Brading, of Otter pilots Ken Lee and Harold Mordy, and of the engineering crew, consisting of Colin Munro and Gordon McDowel on helicopters and Lionel Whiteduck on the Otter, ensured the success of the operation. Thankless and varied chores were undertaken with good humour by student assistants Larry Lane and Robert Drysdale. Dennis Jones was radio operator, providing valuable communication with aircraft, Asbestos Corporation Limited at Asbestos Hill, and another field party within the region. Roland Senneville, our proficient cook, contributed greatly to the wellbeing of the crew.

The co-operation of the staff of Asbestos Corporation Limited in handling camp supplies and gasoline, and in providing accommodation for the crew is greatly appreciated. In particular, I wish to thank Sam Luciani, Manager at Asbestos Hill, and J. Scott, who made many logistic arrangements in the spring. Likewise, I wish to thank T. Bennett of Schefferville, Quebec, who oversaw the airlift of fuel and field equipment from Schefferville to Asbestos Hill in the spring.

I am grateful to Prof. Laszlo Westra of the Free University of Amsterdam, the Netherlands, who studied the metamorphic rocks of the northern part of the map area.

PHYSIOGRAPHY AND PLEISTOCENE GEOLOGY

The area covered by Operation Nuvilik embraces three physiographic divisions, the Povungnituk Hills, the Sugluk Plateau and the Larch Plateau (Bostock, 1970). The Povungnituk Hills transect the region in an east-northeasterly to easterly direction, forming a series of ridges and valleys in much of the area. However, in the eastern part the hills are subdued and the surface is almost a plain. Hilltop elevations range between 270 and 760 m above sea level and local relief is about 150 m. North of the Povungnituk Hills lies the Sugluk Plateau and to the south, the Larch Plateau. Although the three physiographic divisions are quite clearly separable in the west, they merge almost imperceptibly into one another in the east.

The Sugluk Plateau slopes gently southward from the north coast throughout much of the region. A few streams flowing north have cut steep-walled valleys into the plateau and these terminate along the coast as fiords, such as Sugluk Inlet (35J) and Douglas Harbour. The north coast consists in part of precipitous cliffs up to 335 m high, but maximum elevations of about 640 m occur inland.

The Larch Plateau presents a gently undulatory surface with elevations between 270 and 700 m. To the east, bordering Hudson Strait, an abrupt drop into the sea is characteristic and steep cliffs up to 335 m high are common. To the west, outside of this map area, this plateau slopes gradually to Hudson Bay. The generally even skyline is broken only by the rim of the Cratère du Nouveau-Québec, which reaches an altitude of 655 m.

Continental glaciers covered the entire map area during the Pleistocene and flowed outward to the sea from roughly the centre of the map area during the later stages of glaciation. Locally in the south-central part there is evidence in the form of striae, as shown by Prest et al. (1968), of what is probably an earlier southern flow in the central part of the map area. Rare boulders of rocks known to occur only in the fold belt are present in the drift covering Archean rocks to the south and these most probably were placed there by glacial ice. Matthews (1962) noted another area of aberrant ice flow southeast of Kugluk Cove (35K) on the north coast, where an east-southeast ice movement is indicated by roches moutonnées and striae. The major ice movement, however, was northward, as Archean rock detritus is common in drift well to the north of any Archean outcrops.

During the latter stages of glaciation, ice calved directly into the sea, leaving a series of DeGeer moraines (Prest, 1970) on the Hudson Bay coast. These moraines extend almost 80 km inland at Kovik River and form some of the islands in Kovik Bay (35F). Also present in this area and to the north are several short eskers, primarily oriented normal to the moraines and the coast.

The waning stages of glaciation saw the impoundment of melt-water between the ice front and high land near the Hudson Strait coast. Prest et al. (1968) showed that about 30 per cent of the map area had been covered by a glacial lake at its maximum extent. Drainage in the early stages was probably eastward into Joy Bay (25E), and later it was also northward via the Lac Watts - Lac Françoys-Malherbe valley (35G, 35J) and Rivière Foucault, the major stream emptying into Sugluk Inlet. In the Cape Wolstenholme and Sugluk areas Matthews (1962) measured several lake shorelines, the highest at 240 m. During the present survey this aspect was not studied but shorelines are prominent throughout much of the map area, particularly in the vicinity of Lac Nantais (35G), which is about 408 m. As some shorelines are 65 m above this lake level, the maximum glacial lake level may well have been as high 475 m.

As shown by Prest et al. (1968), the sea encroached shortly after glacial ice disappeared, and this marine advance is well displayed along the west coast and to a lesser degree elsewhere. The deep valleys along the north coast are the site of several marine terraces from which shells, peat, charcoal and bone have been dated by radiocarbon methods (Matthews, 1966, 1967). The highest marine level recorded is near Cape Wolstenholme, where Matthews (1962) located well formed, paired terraces at 176 m. Farther east maximum marine limit decreases to 152 m at Sugluk and 135 m at Deception Bay (Matthews, 1962, 1967). A similar decrease in maximum elevation occurs south along the Hudson Bay coast where Gunning (1934) measured the highest beach at 132 m. On the basis of the ^{14}C dates, Matthews (1967) concluded that the general deglaciation of northern Ungava occurred 7000 to 8000 years ago in coastal areas, and possibly as late as 6700 years ago in inland areas. Local areas may have been open to the sea 10 450 years ago.

GENERAL GEOLOGY

The map area embraces parts of the Superior and Churchill structural provinces (Stockwell, 1970), the former comprising a strip up to 46 km wide along most of the southern boundary that probably extends to the east coast south of Whitley Bay (25E).

In the Superior Province, structures characteristically trend northerly, although easterly orientations are local. For example, east-southeast trends occur west of Juet Lake (35F) and east to northeast trends are evident near the south boundary 35 km south of Grunerite Lake (35H). Posttectonic features include small outliers of undeformed Aphebian strata in the eastern part, post-Kenoran Orogeny diabase dykes and an impact structure, the Cratère du Nouveau-Québec.

The boundary between the Superior and Churchill structural provinces is clearly defined for the most part by an unconformity at the base of the Aphebian strata that embody the Cape Smith Fold Belt. Although this unconformity is traceable to the north boundary of the fold belt, to a point north of Lac Letendre (35H) the Churchill-Superior boundary maintains its easterly trend south of Whitley Bay because Archean rocks at the east end of the Cape Smith Belt were remobilized during the Hudsonian Orogeny. Several outliers of Aphebian rocks in the Whitley Bay - Burgoyne Bay (25E) area were folded during the Hudsonian Orogeny, so that the boundary lies south of these rocks. Stockwell (1970) showed that the area between Pointe Bégon and Diana Bay lies in the Churchill Province because Aphebian rocks to the south (Stevenson, 1968) are affected by the Hudsonian Orogeny. Since both the Kenoran and Hudsonian orogenies produced coincident north-northwesterly trends in this area, the precise location of the Churchill-Superior boundary is unknown. However, it probably trends south in the vicinity of Pointe Raudot (25E). The Archean rocks east of Pointe Raudot may not have been greatly reworked by the Hudsonian Orogeny, but the rocks in the vicinity of Cape Hopes Advance (25F), which are here considered to be Aphebian, were intensely metamorphosed and deformed during the Hudsonian Orogeny.

Within the Churchill Province folded rocks occur almost to the base of the fold belt along most of the length of the unconformity but locally an extremely narrow homocline is present at the unconformity. Axial planes, in general, dip moderately away from the unconformity but are also steep to vertical. Over most of the fold belt the layered rocks pass into more highly metamorphosed rocks to the north, but in part this transition is marked by a fault. In the southern part of the Churchill Province trends are primarily east-northeasterly to east, but in the gneissic rocks in the northern part trends are less consistent; they are chiefly easterly in the northwest, and commonly northerly in the northeast. However, in this gneissic terrain trends are diverse throughout. The Archean rocks north and east of the fold belt display variable orientations, depending principally on the degree of reworking during the Hudsonian Orogeny. Posttectonic rocks consist solely of rare diabase dykes.

Archean

The Archean rocks are chiefly in the Superior Structural Province and a few are in the Churchill Province north of the Cape Smith Fold Belt. They are dominantly quartzo-feldspathic gneisses and igneous rocks with limited gabbro, metasedimentary and metavolcanic strata.

Metasedimentary (Agk, Asc, Aqz, Acs) and *metavolcanic* (Aab, Atf, Ahb) *rocks*

The oldest rocks in the Archean terrane are probably the layered rocks that primarily form three separate bands at the north of Juet Lake, at Lac Allemand and between Lac Nantais and Lac Rouxel, the last of which are considered to be a continuation of those shown by Stevenson (1968) and extending from Lac Nantais to Klotz Lake in the map area to the south.

The Juet Lake rocks form a band 3 km wide bounded on both sides by light to medium grey, equigranular to locally cataclastic granitic gneiss. The layered rocks, which are metagreywacke with local amphibolite, are laminated or bedded to schistose with laminae ranging from 2 mm to 10 cm thick. They are more schistose and highly deformed in the southern part of this outcrop area than in the north. Bedding planes, for example, are highly contorted near Juet Lake. Medium to dark grey and grey-green, equigranular, fine-grained rocks are typical of the metasedimentary rocks. Bedding, where preserved, is parallel with schistosity. Contacts between amphibolite and metagreywacke are gradational. Outcrops show local rusty horizons due to pyritiferous laminae. Tourmaline-bearing pegmatite dykes up to 3 m thick are local in the south, but form less than 10 per cent of the rock. Irregular, white quartz veins, up to 15 cm thick, are also in the same area.

Thin section examination shows that these rocks are metagreywacke with from 10 to 20 per cent plagioclase and 40 to 50 per cent quartz. Although most samples show total recrystallization, original detrital grain boundaries are preserved in some samples, especially in somewhat coarser grained rocks. Detrital grains consist dominantly of quartz and plagioclase and rare quartzite amongst the coarser grained (0.2 mm) samples. These detrital grains range from angular to rounded but are chiefly subangular to subrounded. Detrital plagioclase ranges from An_{30} to An_{44}, whereas the recrystallized plagioclase, which is chiefly untwinned, ranges from An_{21} to An_{33}.

The matrix consists chiefly of quartz and plagioclase, and of variable amounts of chlorite, biotite, muscovite, epidote, hornblende and, less commonly, tourmaline, sphene, apatite, pyrite, pyrrhotite, magnetite and graphite.

Muscovite forms metacrysts up to 2 mm long, which lie athwart the foliation or schistosity, and at the south end of this outcrop area muscovite is associated with calcite metacrysts to 4 mm in diameter and cordierite to 1 mm. Whereas the calcite and muscovite metacrysts transect the schistosity, which is defined by abundant chlorite, cordierite lies within the foliation, is in part crenulated, and contains quartz and epidote inclusions that are aligned parallel with the schistosity. Chlorite grains partly 'flow' around the metacrysts even where the metacrysts are normal to the schistosity.

Amphibolite in this area is a dark greenish grey to greenish black, fine- to medium-grained, thinly laminated and foliate rock. Laminae are visible as clearly defined microscopic bedding planes with microcrossbeds or scour and fill. Quartz and less commonly plagioclase, which together form from 15 to 35 per cent of these rocks, are probably detrital, as a few grains display detrital textures. Amphibole, which forms up to 70 per cent of the rock, is variously hornblende or actinolite. A sample from the north end of this belt shows only actinolite, whereas one from 6 km to the south shows both actinolite and hornblende, some of the latter forming cores to actinolite. In the same thin section actinolite also forms discrete laminae. Biotite, epidote, tourmaline, apatite, sphene, pyrite, magnetite and hematite are present in small amounts. Tourmaline occurs in a few large poikilitic grains in one sample, with actinolite and quartz inclusions. These amphibolites are probably of tuffaceous origin in view of their fine lamination, the presence of microsedimentary structures and gradation into metagreywacke.

The Lac Rouxel - Lac Nantais band is 6 km wide at the south boundary but dies out near Lac Rouxel. Bordering rocks are partly granitic gneiss and partly massive granodiorite intruding the layered rocks. At the south boundary sills of granodiorite are common in amphibolite close to the granodiorite contact. Sills of granodiorite are also common on the west side of the layered rocks 2 km south of Lac Rouxel. Granodiorite dykes are fewer and only rarely do the intrusive rocks transect foliation or bedding planes; where they do they are chiefly at low angles. A white, medium-grained, equigranular, pyritiferous granodiorite forms a small stock within the layered rocks 3 km north of the boundary. Where the layered rocks are constricted, 7.5 km north of the map boundary, the contact between the belt and country rocks is probably a fault. In summary, the layered rocks of the Lac Rouxel - Lac Nantais band clearly predate the massive granitic rocks but their relationship to the gneissic granitic rocks is undefined.

The majority of these rocks are thinly layered, equigranular, fine-grained, dark green amphibolite, some of which is of volcanic derivation. Primary volcanic structures are rare but 5.5 km north of Lac Nantais a deformed fragmental rock with clasts up to 15 cm is well displayed. The dominant clasts consist of an acid porphyry not known elsewhere. Pillow margins are preserved in amphibolite 7.5 km north of the map boundary near where this sequence of layered rocks is constricted. However, some amphibolite is undoubtedly sedimentary as it grades into metagreywacke in some places, such as 2 km south of Lac Rouxel, where gradation is on both a megascopic and microscopic scale. However, much of this amphibolite is probably metatuff consisting of well laminated rocks with interbedded metasedimentary rocks.

The amphibolites in the Lac Rouxel - Lac Nantais area, although unquestionably volcanic in some places, are similar in general to those in the Juet Lake area, consisting dominantly of actinolite or hornblende with variable plagioclase and quartz content. A sample from 2 km northeast of Lac Nantais consists of 80 per cent actinolite and small amounts of plagioclase, quartz, epidote, calcite, magnetite, pyrrhotite and pyrite. Other amphibolites show the same general mineralogy, some with hornblende rather than actinolite, and some with biotite. However, proportions vary widely. An unusual sample of well foliated metatuff from north of Lac Nantais contains 5 per cent cummingtonite.

The metasedimentary rocks in this belt are primarily metagreywacke, commonly in bands less than 10 m thick, similar to those at Juet Lake. They include rare detrital grains of quartz, plagioclase and quartzite from 0.5 to 1 mm in diameter and also local, rare, metacrysts of muscovite and cordierite. Similarly, bedding planes are preserved in some places but replaced by a schistosity or foliation in others. Unlike the Juet Lake rocks, however, carbonate-bearing and calc-silicate rocks are represented. Calcite comprises up to 10 per cent in some of the metagreywacke outcrops. Calc-silicate rocks occur at the south border of the map area east of Lac Nantais and on the long peninsula at Lac Rouxel. These rocks are schistose to banded (1 to 3 cm), fine grained, greenish black and greyish green. The greyish green bands consist chiefly of diopside, clinozoisite and calcite in the southern occurrence, whereas at Lac Rouxel diopside, quartz and plagioclase predominate. The dark bands are amphibolite.

A feldspathic quartzite is associated with the calc-silicate rocks east of Lac Nantais. This fine-grained banded rock is composed of light grey bands up to 1 cm thick separated by black laminae 1 mm thick. The light bands consist of recrystallized quartz and about 15 per cent plagioclase with rare muscovite, biotite, epidote and tourmaline. The dark laminae consist of quartz and subhedral tourmaline in about equal amounts. In thin section the tourmaline is chiefly pleochroic, pale greenish yellow to moderate olive-brown, with local horizons of a pale greenish yellow to greyish olive variety. A few of the larger grains display zoning in which the greyish olive pleochroic variety forms the core.

The belt at Lac Allemand is narrow and poorly defined in comparison with the other occurrences. There, intercalated amphibolite and metamorphosed sedimentary rocks are extensively intruded by granodiorite and pegmatite. Whereas most of the layered rocks are similar to those at Lac Juet and Lac Nantais, some display a more varied mineralogy. Garnet is present in the north and central parts of this belt, where it is associated with a calcite-muscovite-quartz schist and a biotite-cummingtonite-quartz gneiss, respectively. Cordierite is found also in the northern part, but is almost entirely altered to muscovite and only shows relict outlines. Muscovite metacrysts identical to those seen elsewhere are also present.

The cummingtonite-bearing rock is a dark greenish grey, fine-grained, laminated and crenulated gneiss with subhedral to euhedral garnet up to 0.7 mm in diameter. The cummingtonite, which is subhedral to anhedral, is extensively twinned. Rare green chlorite is associated with some cummingtonite grains. Although this rock is completely recrystallized its general appearance and a high quartz content suggest a sedimentary origin.

Paragneiss (Apg)

Scattered outcrops of paragneiss occur erratically as discontinuous and poorly defined bands within quartzo-feldspathic gneisses. They are, in general, more highly deformed and recrystallized than the rocks at Juet Lake and Lac Rouxel, so that primary structures are scarce or absent. Contacts with the granitic gneiss are chiefly gradational, but with pegmatite and granodiorite they are sharp and these rocks are intrusive.

An outcrop west of Juet Lake is typical of these outcrops, consisting of equigranular, medium-grained, moderately foliated, variegated, medium to dark grey, biotite-quartz-feldspar-paragneiss. Garnet is present in a few places, notably southwest of Juet Lake and on Diana Island on the east coast. Hornblende accompanies biotite in a few outcrops and muscovite at one.

A couple of occurrences of impure marble (Amb) are associated with biotite-garnet-quartz-feldspar paragneiss and granitic gneiss, one near the south boundary 35 km south of Grunerite Lake and the other at Pointe Frontenac (25E) on the east coast. At the first locality the marble, which forms a lens 1 m thick and 7 m long in the paragneiss, is a mottled yellowish grey, medium-grained rock consisting of a calcite-quartz matrix with anhedral diopside up to 3 mm long and garnet to 1 mm in diameter. Diopside-rich nodules up to 7 cm in diameter are localized. The garnets, which are probably chiefly grossular, typically have cores of epidote and calcite, and some have only a thin skin of garnet. Sphene, some of which has overgrowths, is a common accessory. The paragneiss at this locality is not typical of this unit in that it is a brownish grey, porphyroblastic, medium-grained rock with pale red garnets up to 4 mm in diameter, forming 25 per cent of the rock.

At Pointe Frontenac, 35 cm of marble is associated with interlayered paragneiss, granitic gneiss and minor amphibolite.

Amphibolite (Aab)

Amphibolite outside the metasedimentary and metavolcanic belts is erratic throughout the gneiss terrain, chiefly forming narrow bands or angular blocks. Most contacts with the gneissic rocks are sharp and some outcrops are interlayered. Rock is typically dark greenish grey, fine to medium-grained, massive to weakly laminated, and less commonly well laminated. Besides the essential minerals, hornblende and plagioclase, garnet, biotite and clinopyroxene are found in a few outcrops.

Uncharacteristic of this unit, amphibolite on the east shore of Lac Nantais consists of interlaminated garnetite and amphibolite. Laminae, chiefly in the amphibolite, range from 2 mm to 5 cm thick. The garnetite contains a few patches of gossan.

The origin for these rocks is unclear and no doubt they are of several geneses. Some of the well laminated types may be of sedimentary origin, but the laminations may be a metamorphic phenomenon. Others, particularly the massive rocks, may be metavolcanic or old diabase dykes and sills.

A massive greenish black, aphanitic amphibolite outcrops 2 km northeast of Lac Nantais. Banding is well defined in much of the outcrop and one band is extensively brecciated. This rock, which is composed of 80 per cent actinolite with small amounts of plagioclase, quartz, epidote, pyrrhotite, pyrite and magnetite, probably has a volcanic origin.

Ultrabasic rocks (Aub, Apx)

Confined to two small occurrences, ultrabasic rocks are very limited in the Archean terrane. One occurrence consists of a 60 by 15 m pod in granitic gneiss 13 km north of Lac Letendre and the other is 5 km southwest of Joy Bay. The former is a massive, equigranular, medium-grained, dark grey-green, partly serpentinized peridotite with minor biotite and talc. A minor amount of amphibolite is also present. The Joy Bay ultrabasic occurrence is associated with a sizeable amphibolite body. There, a medium green, coarse-grained, massive, equigranular pyroxenite forms the major part of the ultrabasic rock, and a dark green, medium-grained peridotite comprises only about 10 per cent near the northeast end of the amphibolite.

Granitic gneiss (Agg)

Foliated granitic rocks form most of the Archean terrane south of the fold belt and substantially all of it to the north and east. They grade into both massive granitic rocks and paragneiss in most places, but local contacts with the latter are sharp or graded over only a metre or so. Foliation in these rocks is parallel with that in the paragneiss where both occur. It is also parallel to structures within the fold belt where close to it, especially at the eastern end and northern side of the belt, as these basement rocks have been redeformed during the Hudsonian Orogeny.

Inclusions of paragneiss and amphibolite occur locally as boudins, lens-shaped to irregularly shaped masses and thin layers. Amphibolite is particularly common in the region between Grunerite Lake and the south boundary, and also along the coast in the Pointe Raudot - Pointe de Tracy area. Both these areas contain up to 10 per cent amphibolite. In those few places where paragneiss or amphibolite form a significant proportion of the rock, the term migmatite has been applied (Amg).

Pegmatite dykes, chiefly small, irregular and invariably devoid of minerals of economic interest, are erratically distributed.

Lithologically these rocks consist primarily of an equigranular, medium-grained, pinkish, yellowish or medium grey, well foliated biotite granitic gneiss. Locally and rarely these rocks display feldspar augen or a cataclastic texture. Coarse-grained or fine-grained representatives are extremely rare, along with more common light grey, variegated grey or greyish orange-pink types.

Hornblende occurs with biotite, which is always present, in about 20 per cent of the samples and in some it is the dominant mafic mineral. Epidote, chlorite, muscovite, sphene, zircon, magnetite and pyrite are rare constituents.

Petrographically, these gneissic granites are similar to the massive rocks, ranging in composition from granite to tonalite, but most of them are granodiorite. Limited microscopic examination shows that plagioclase, which is variously fresh to completely sericitized, is oligoclase, whereas K-feldspar, microcline, is invariably fresh.

Although isotopic age determinations are lacking for the granitic gneisses south of the fold belt there is little doubt they are a product of the Kenoran Orogeny. A biotite age of 2575 ± 80 Ma was obtained from granite gneiss samples from 6 km north of the Sorehead River in the map area to the south (Stevens, in Wanless et al., 1966). North of the fold belt biotite and hornblende from a mafic gneiss (amphibolite) from Lac Lépine (35H) within the area shown as underlain by Archean rocks have ages of 1639 ± 40 and 1584 ± 48 Ma, respectively (Stockwell, in Wanless et al., 1974). This sample is only 9 km north of the fold belt and about the same distance south of granulites attributable to the Hudsonian Orogeny. Therefore, these ages are considered to be an imprint of the Hudsonian Orogeny on Archean rocks.

Farther west Beall et al. (1963) obtained a whole-rock Rb-Sr age of 2270 ± 66 Ma on a biotite quartzofeldspathic gneiss, which is undoubtedly part of this map unit although it plots within the fold belt on the most recent topographic map sheets. This age suggests that the Kenoran Orogeny was the prime controlling orogeny on these rocks, despite the proximity to the fold belt and the influence of the Hudsonian Orogeny.

Migmatite (Amg)

Migmatite forms a relatively small part of the quartzofeldspathic Archean rocks. The area between Grunerite Lake and the south boundary is the main site for rocks of this map unit. In this area amphibolite bands, which here and there form up to 50 per cent of the rock, are dominant. Paragneiss is present in a few places but is scarce in comparison with the amphibolite. In general, this unit consists of granitic gneiss with amphibolite or paragneiss or both, with or without pegmatite (Apm) or granodiorite (Agd) dykes or sills. The amphibolite and paragneiss paleosomes variously form well defined bands, angular blocks or irregularly shaped and contorted zones within the granitic gneiss. Lit-par-lit structures are fairly abundant where amphibolite is the paleosome and in these rocks contacts are customarily sharp, whereas gradational contacts are generally more characteristic, especially between paragneiss and the neosome (Figs. 2 and 3).

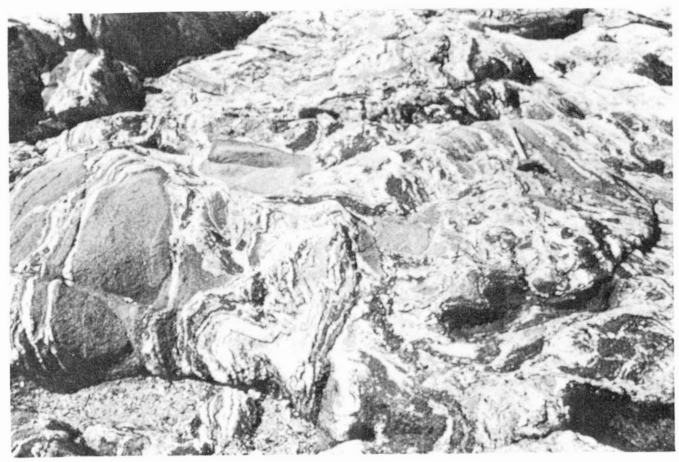

Figure 2. Biotite amphibolite fragments in Archean migmatite, Walrus Island. (25E; J.B. Henderson; GSC 178733)

Figure 3. Banded Archean gneiss in fault contact with Aphebian sedimentary rocks on the north side of Wakeham Bay at The Narrows. (35H; F.C. Taylor; GSC 178894)

Granite, granodiorite, tonalite (Agr, Agd, Atl)

Massive granitic rocks form about 20 per cent of the Archean terrane south of the fold belt. The largest area of these rocks, which is of batholithic proportions, is near Lac Nantais and there they extend from the south boundary to the unconformity. Smaller plutons occur near Lac Allemand, Lac Péloquin (35G) and south of Pointe Raudot. Contacts between these rocks and the bordering gneisses are poorly defined for the most part and are presumed to be gradational, whereas contacts with the layered rocks, as previously indicated, are intrusive. Wherever a foliation is discernible in these rocks its orientation generally is parallel with the regional trend. Local small areas of metasedimentary rocks and amphibolite are rare within these plutons. Only the pluton south of Pointe Raudot contains many inclusions and there up to 10 per cent amphibolite is present.

These massive granitic rocks are dominantly pinkish grey, but they have significant amounts of light or yellowish grey shades, and more rarely, medium grey, greyish orange-pink or white shades. A medium-grained, equigranular, massive rock is characterisitic, but a weak foliation is seen in some samples. A few erratically distributed rocks are porphyritic with plagioclase grains up to 2 cm long. Compositionally these rocks are primarily granodiorite with significant quantities of tonalite and relatively rare granite. Tonalite is possibly more than shown on the accompanying maps, because potash feldspar is indistinguishable in these rocks without microscopic examination or staining. At present no pattern of high or low potash feldspar distribution is evident. If granite or tonalite is known it is indicated. Mineralogically the rocks consist dominantly of plagioclase, quartz and potash feldspar. Plagioclase ranges from An_8 to An_{36} and averages An_{26}. However, plagioclase in the granite is An_{8-12} whereas in the granodiorite and tonalite it is chiefly about An_{32}, and albite-rich samples are rare. Much of the plagioclase is sericitized and in some samples alteration is complete. Potash feldspar, on the contrary, consists of microcline, and is invariably fresh. Some samples contain string-type perthite and rarely, a mesoperthite. Quartz produces biaxial interference figures in some samples.

Pleochroic biotite, in shades of pale greenish yellow to moderate olive-brown, is the most abundant varietal mineral and forms up to 10 per cent in some samples. Along with the biotite, muscovite occurs in about half the samples and common hornblende in 10 to 15 per cent. Neither muscovite nor hornblende generally comprises more than 5 per cent. Epidote, although invariably present, usually forms only one or two per cent, but in some samples forms 5 per cent. Sphene, some in euhedral crystals, is characteristic and in some hand samples it appears as discrete, subhedral to euhedral grains up to 5 mm in length. In thin section it also is seen as rims about ilmenite. Chlorite is present as a local and minor alteration of biotite and also forms crosscutting veins. Apatite, calcite, zircon, allanite, magnetite, pyrite and ilmenite are accessories. In one sample of tonalite a clinopyroxene not encountered elsewhere and highly altered to chlorite is present.

Until recently, age data of these granitic rocks within the map area consisted of a single K-Ar biotite age of 1750 Ma from near Lac Allemand (Kretz, in Lowdon, 1961) and two Rb-Sr whole-rock ages from samples collected near Lac Rouxel of 2760 and 2320 Ma (Beall et al., 1963). The biotite age of 1750 Ma is from close to the contact with the fold belt and is considered to show the influence of the Hudsonian Orogeny on the basement rocks, as suggested by Kretz. The older Rb-Sr ages, as advocated by Beall et al., more accurately portray the age of the granitic rocks, which are regarded as a product of the Kenoran Orogeny.

South of the map area, samples from granitic rocks similar to those from near Klotz Lake and 64 km southeast have K-Ar ages on biotite and hornblende ranging from 2530 Ma to 2690 Ma (Table 1) (Kretz, in Lowdon, 1961; Stevenson, 1968). These samples, far removed from the influence of the Hudsonian Orogeny, suggest, in agreement with the Rb-Sr determinations, a Kenoran orogenic origin for the massive granitic rocks.

A recent Rb-Sr isochron on samples from northeast of Lac Nantais (Taylor and Loveridge, 1981) gives an errorchron age of 2685 Ma, confirming an Archean age for these rocks. In view of their age and structural relationships with their host rocks, the massive granitic rocks are considered to be syntectonic plutons emplaced during the Kenoran Orogeny.

Lamprophyre (Alp)

Striking north-northeast, a dyke 0.3 m thick cuts massive granodiorite near the southern boundary of the map area. A dark greenish grey, medium-grained, equigranular, massive rock is typical. Microscopic examination shows it to consist of approximately equal parts of anhedral augite and biotite that is pleochroic from pale greenish yellow to light olive, with 2 per cent hornblende and 2 per cent chlorite, epidote, magnetite, calcite, apatite and sphene. This lamprophyre is probably related to the massive granitic rocks.

Gabbro (Agb)

Gabbro is present at three places: bordering the Povungnituk River 12 km southwest of Lac Beauparlant (35G), 13 km south of Grunerite Lake, and at Juet Lake as a small, evidently tabular body trending northeast. The first two are roughly equidimensional. Their relationship to the other rock units is not known. However, as they are massive, they are presumed to be posttectonic.

These gabbros are chiefly dark greenish grey, although locally mottled white and greenish black, medium and coarse grained, massive and equigranular to rarely subophitic. The largest pluton is a hornblende gabbro that in some parts is more correctly described as a metahornblende gabbro. This pluton is primarily composed of up to 70 per cent large hornblende grains, and smaller grains of interstitial plagioclase (An_{49-57}) that are variously fresh to mostly altered to sericite and epidote. Epidote is common in the matrix, also forming up to 7 per cent. Quartz, calcite, chlorite, sphene, ilmenite, pyrite, chalcopyrite and apatite are accessory. A pleochroic, nearly colourless to light brown biotite forms about 5 per cent in one sample. The pluton south of Grunerite Lake consists of equal parts of plagioclase (An_{48}) and augite. Whereas the plagioclase shows only local minor sericitization, about 60 per cent of the augite is altered to a fine-grained matte of nearly colourless chlorite and uralite, chiefly the former. Some augite grains are fresh, some partly altered and others fractured and the fractures filled with chlorite. Small amounts of pale green hornblende, light olive biotite and apatite are also present.

Diabase (Adb)

Archean diabase dykes are prevalent in the eastern quarter of the Archean terrane. They are a continuation of a large swarm of north-northwest-striking dykes mapped by Stevenson (1968) in the northeast part of the adjoining map area to the south. Although most of these dykes strike north-northwest, several form a conjugate set striking east-northeast. A few others strike almost due north or east. In the rare localities where intersecting dykes are exposed the northwesterly striking dykes are the younger of the two. However, it is probable that all are approximately the same age.

The age of these Archean dykes is apparent where they are in contact with the Aphebian rocks. There they are overlain unconformably, having been intruded subsequent to the Kenoran Orogeny and eroded prior to the deposition of the Aphebian strata. This relationship is well displayed west of Burgoyne Bay, 12 km east-northeast of Grunerite Lake and west of Whitley Bay. The same feature can also be used to disclose the precise location of the Aphebian-Archean unconformity where deformation has resulted in a parallelism of structures in both the Aphebian and Archean rocks.

Whereas the majority of these dykes are 25 or 30 m thick and a few kilometres long, a few are 60 m thick and up to 30 km long. On the other extreme are tiny pod-shaped plutons a metre or so in length and less in width. All are probably vertical.

Some contacts are sheared parallel to the dyke, either in the dyke or country rock or both, showing that at least some deformation occurred in these zones, probably chiefly after dyke emplacement.

The typical dull rusty brown weathered surface contrasts sharply with the country rocks. In many places a conspicuous rectangular joint pattern also enhances their prominence, as they are eroded well below the level of their hosts.

A medium-grained, greyish green, massive rock with an ophitic or hypidiomorphic texture is typical. Thicker dykes are coarse grained in the central parts. A well defined chill zone is common.

Aphebian

The Aphebian rocks, which are almost entirely in the Churchill Province, are approximately equally divided into those forming the Cape Smith Fold Belt and those lying to the north of it. The Cape Smith Fold Belt, which is part of the Circum-Ungava Fold Belt, extends across the map area from the southwestern quarter northeasterly and easterly to the Wakeham Bay area. At its widest, in the central part of the map area, it is 80 km wide, but toward the extremities it is only 30 to 50 km wide. Whereas the south boundary and the eastern part of the north boundary of the belt are clearly defined by an unconformity, most of the north boundary is a metamorphic contact and hence less definitive.

Several outliers of predominantly sedimentary rocks, forming part of the Cape Smith Fold Belt, are present in the eastern part of the map area. The most southerly of these is about 50 km north of the most northerly exposures of rocks forming part of the Kaniapiskau Supergroup (Stevenson, 1968). Stevenson's description of these strata shows them to be identical with the rocks in the outliers and eastern end of the Cape Smith Fold Belt. Undoubtedly the rocks comprising the Cape Smith Fold Belt are correlative with the Kaniapiskau Supergroup, as suggested by Dimroth, et al. (1970) and Bergeron (1957b).

The rocks comprising the Cape Smith Fold Belt were divided by Bergeron (1957a) into two groups, which he later named the Povungnituk at the base and, unconformably overlying it, the Chukotat (Bergeron, 1959).

According to Bergeron, the Povungnituk Group lies unconformably on the Archean terrane. The existence of this unconformity between the Aphebian and Archean rocks is indisputable as it is exposed in several places. However, the nature of this unconformity is highly variable. For example, 10 km northeast of Juet Lake the basal rocks are reddish to black limy iron-rich (hematite and limonite) quartzite with sandy layers that may be metachert. A few carbonate concretions are locally present and minor arkose. All the strata near the contact are lime-rich with up to 30 per cent calcite in some places. Some beds contain grunerite. Bedding in the sedimentary rocks is parallel to the contact with granodiorite, which is clean and free of any regolith.

At this locality it can also be seen that the old Archean land surface was probably very similar to the present one. To the east, north of Lac Allemand, quartzite overlain by grunerite schist and sandstone lies on a slightly weathered tonalite that contains small amounts of calcite. Five km east, a basalt flow lies directly on Archean granodiorite. The base of this flow, which dips northward about 30°, contains scattered granitic clasts up to 10 cm in diameter. About 2 km northeast of Lac Perron (35H) the basal Aphebian rock is a dark grey phyllite but there, in view of the fact that the Archean consists of sheared granodiorite, the unconformity may have been modified by a fault. In any event the overlying rocks are argillaceous at this point. East of Lac St-Germain (35H) southeast-trending sandstone overlies gneissic granite striking north. This sandstone, which dips 20 degrees northeast, is in turn overlain by grunerite schist and dolomite. In the area 12 km east of Lac Cournoyer (35H) iron formation commonly overlies granitic gneiss that in part is more extensively weathered than rocks to the west, although a deep regolith is lacking. The surface of the Archean rocks shows no weathering whatever in a stream valley 25 km east of Lac Cournoyer, where a few rounded granitic gneiss pebbles up to 5 cm in diameter are fixed to a clean Archean surface. The rocks at and near the base of the Aphebian sequence are chiefly black slate with minor red sandstone, iron formation and rare schistose mafic volcanic rocks. Farther east contact relationships, although locally well exposed, have been modified by orogenesis, which has resulted in a parallelism of structure on both sides of the unconformity and more intense metamorphic alteration. The unconformity can be recognized with certainty at the axis of folds, where the strike of the bedding in the Aphebian rocks is normal to the foliation in both the Aphebian and Archean rocks. It is also readily recognized where late Archean diabase dykes are present and can be seen to end abruptly at the unconformity, as for example, 27 km west of Pointe Frontenac.

The unconformity along the north edge of the fold belt from north of Lac Rinfret (35H) to the east coast has also been subjected to deformation and metamorphism. However, basal rock types, amphibolite and quartz-rich schist with and without iron formation, are metamorphic equivalents of those in some places on the south side of the fold belt (Fig. 4).

Figure 4. Contact between the Aphebian, chiefly amphibolite and Archean to the north, 3.3 km north of Wakeham village on the east side of Wakeham Bay. (25E; J.B. Henderson; GSC 178734)

In the westernmost part of the map area (35F), a gabbro may have been intruded along the unconformity. Drift cover is extensive in this area and although the accompanying map has been drawn to show argillaceous rocks at the contact, gabbro may extend to the Archean in a few places.

An unconformity is well defined at some of the Aphebian outliers west and south of Whitley Bay since these rocks are little deformed or metamorphosed. The basal rock unit in these outliers is commonly a sandy biotite schist but locally a thin (3 m thick) garnet amphibolite separates the schist from the underlying gneiss. At Pointe Bégon a tuff, ranging from less than 1 m to 15 m thick, occurs at the base. At the thin end it includes rare 2 cm quartz pebbles (Fig. 5).

In summation, the Archean rocks show only minor and local weathering effects beneath the Aphebian strata and the latter, although dominantly quartz-rich sedimentary rocks, display a variety of rock types at the contact.

Both Stam (1961) and Stevenson (1968) considered the Aphebian-Archean contact south of the map area to be a fault whereby the younger rocks have been thrust over the older. No evidence for a similar relationship was forthcoming in the present study and it is assumed the fault dies out outside the map area.

The division of the Cape Smith Fold Belt into two groups, the Povungnituk and the Chukotat, separated by an unconformity, was not confirmed because no evidence for an unconformity was found. Bergeron (1957a) reported a terrestrial conglomerate, interpreted as the base of the Chukotat Group, outcropping 400 feet above the level of the Chukotat River (35F). This conglomerate he described as follows:

> The conglomerate consists of rounded fragments of the lower series and of the basement complex cemented by silica and iron oxide. The conglomerate dips 20 degrees to the north, whereas the gabbro on which it rests contains intercalated lenses of sedimentary rock that dip 65 - 70 degrees to the north. Thus, a major unconformity between the two series is indicated.

A re-examination of the locality shows this conglomerate to contain fragments of twigs, probably from shrubs, in an iron oxide matrix. The conglomerate therefore is interpreted as being of interglacial or postglacial origin. The low dip is most probably the angle of repose. All the Proterozoic strata in this area dip northward at about 70° and no evidence of an unconformity within the sequence is indicated.

Figure 5. View looking south showing Aphebian strata lying unconformably on Archean. (J.B. Henderson; GSC 178745)

Bergeron (1959) shows an unconformity in many places on the Povungnituk Mountains area map sheet. One occurrence is based on a supposed basal conglomerate or breccia east of Chukotat Lake (35G). The breccia consists of angular to subangular fragments, up to 0.5 m but chiefly less than 7.5 cm long, of basic volcanic rocks, some of which are vesicular, and of dolomite. The area was examined carefully and it was concluded that the breccia is of explosion origin and is not basal. A crude layering parallel to the regional trend is apparent in some places and nowhere is there evidence of discordance.

A discordance between the layered rocks and metagabbro at Lac Beauparlant is shown by Bergeron (1959) but investigation of this contact showed a complete parallelism of structures and no evidence of an unconformity.

The validity of Bergeron's thesis regarding the existence of two distinct groups has also been questioned by Stam (1961), who mapped a small part of the Cape Smith Fold Belt south of the map area. He considered that a break in the sequence, seemingly the extension of Bergeron's unconformity, was a thrust fault similar to and parallel with the one he proposed to form the Aphebian-Archean contact.

Baragar (1974) mapped in detail three profiles across most of the belt without establishing the presence of an unconformity, even though a total of 27 450 m of stratigraphy is represented.

Similarly, detailed mapping by Schimann (1978a), of most of the rocks of this belt east of longitude 73°W showed no angular unconformity nor could he directly correlate the succession with Povungnituk and Chukotat groups.

As it appears that there is not a major break in the stratigraphic sequence from the base of the Aphebian layered rocks at the Archean boundary to the highest observed beds, the division into two groups is dispensed with and the use of the group names is discontinued.

Sedimentary rocks

Sedimentary rocks comprise between 15 and 20 per cent of the Cape Smith Fold Belt. They are most abundant at the base of the sequence but also are scattered throughout the volcanic rocks, notably in the form of thin interflow argillaceous, arenaceous or tuffaceous beds.

Argillaceous rocks (Ash, Asl, Aal, Asn, Amd, Apt, Asc)

Argillaceous rocks are the major sedimentary rock types throughout the entire stratigraphic sequence, although inconsistently. As well as forming a significant part of the sedimentary rocks of the sequence, and in places the major part, argillaceous rocks are intercalated with the volcanic rocks in many parts of the map area. The argillaceous rocks in general form thin interflow beds of little lateral continuity and are, for the most part, too small to show at the present map scale.

All the consolidated argillaceous sediments are represented in the Cape Smith Fold Belt along with their metamorphic equivalents. Slates are probably the most abundant and almost all the strata display some degree of metamorphism. On the accompanying maps these rocks are included with their higher metamorphic grade equivalents phyllite and micaceous schists (Figs. 6-9) because the present map scale precludes their separate delineation.

Contacts between various argillaceous rocks are commonly gradational but contacts with arenaceous rocks and carbonates are variously sharp or gradational. Those within the volcanic terrane show sharp contacts with the flow rocks but grade into tuffs in some places and are in abrupt contact with other rock types.

Figure 6. Frost-heaved phyllite 14 km east-southeast of Lac Bégin lying on the north side of the major strike fault. (35F; F.C. Taylor; GSC 178814)

Figure 8. Phyllitic siltstone 12 km northwest of Hubert Lake. (35F; T.M. Gordon; GSC 178446)

Figure 7. Slate with mudstone along the Chukotat River valley at 76°29'W. (35F; T.M. Gordon; GSC 178442)

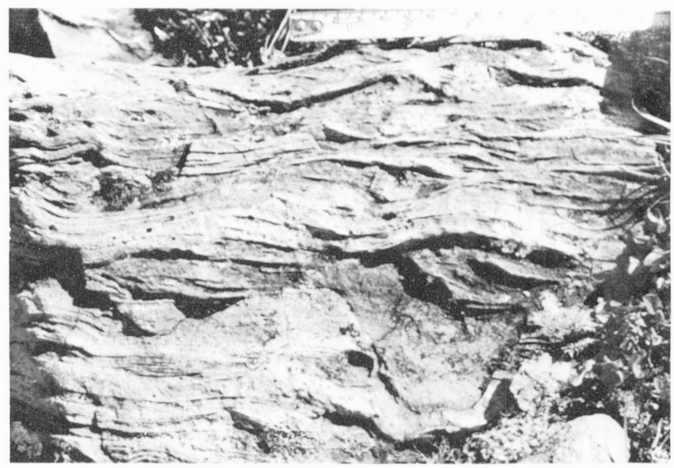

Figure 9. Ripple-laminated carbonated siltstone 2 km south of Esker Lake. (35G; J.B. Henderson; GSC 178631)

Individual argillaceous formations range in thickness from a few centimetres to hundreds of metres. Comprehensive thickness determinations are unreliable but the thickest formation is possibly south of the Povungnituk River, north of Lac Nantais (35G), where more than 2000 m is present, assuming no unforeseen repetitions due to faulting and folding. As these rocks are commonly phyllitic there may be strike faults in this area.

Some argillaceous rocks are characterized by the presence of graphite and some others by pyrite. The graphitic rocks are abundant in the volcanic terrane but are also well represented elsewhere. Carbonate is a common constituent in some places. For example most of the phyllites associated with fault zones contain some calcite and a few are almost entirely carbonatized.

The argillaceous rocks are typically dark and many are black, particularly those intercalated with volcanic rocks. Greys and greenish greys are most common. Reddish browns and browns are only rare and are fairly well confined to near the unconformity with the Archean and in some phyllites along fault zones. The same environments also are the loci of most of the lighter coloured rocks.

All degrees of fissility, lamination and cleavage are represented. In many places cleavage is so intense that recognition of bedding or laminations is impossible. Where visible, laminae range from less than 1 mm to about 1 cm. Some rocks are apparently massive, at least over short thicknesses.

An unusual medium dark grey, cellular, carbonaceous siltstone occurs within the volcanic sequence, where it underlies a gabbro intrusion 12 km southwest of Lac Lépine. This rock is presumed to have been baked by the hot gabbro magma that vaporized the enclosed water so as to produce the cellular structure. The degree of porosity suggests a high water content, which, if valid, infers emplacement of gabbro relatively soon after the sediment was deposited.

Arenaceous rocks (Ass, Aqz, Agk, Avs)

Erratically but widely distributed throughout the Cape Smith Fold Belt, arenaceous rocks show their greatest development in the Lac Beauparlant district. Thicknesses are mostly indeterminate but over 1000 m of orthoquartzite is exposed along the Povungnituk River at longitude 74°42'W.

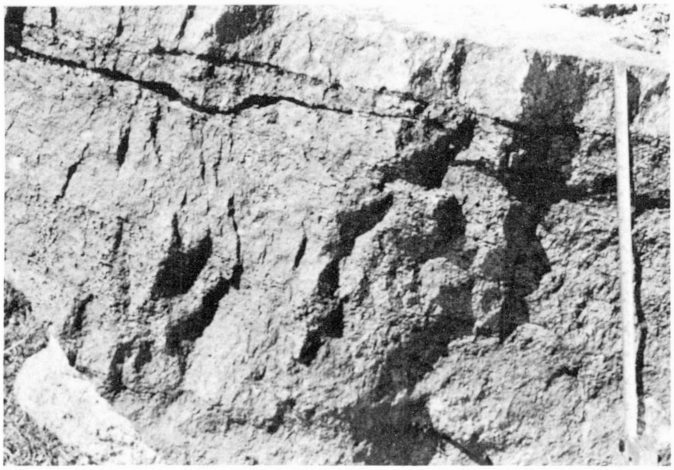

Figure 10. Weakly developed graded bedding in carbonate-rich sediments on Povungnituk River 5.5 km east of the outlet of Lac Allemand. (35G; J.B. Henderson; GSC 178622)

Figure 11. Conglomerate 0.7 km north of the Povungnituk River at 76°00'W. (35G; F.C. Taylor; GSC 178831)

Approximately 10 km northwest a calcareous quartzite may be equally thick. However, in most places the arenaceous horizons rarely exceed a few tens of metres before giving away to other rock types, ranging from orthoquartzite to mudstones and their metamorphic equivalents. Greywacke is more abundant within the volcanic rocks than in the lower part of the belt but is localized there also, especially north of Lac Allemand (Fig. 10).

Except for bedding, which may be obscure or even absent, primary structures are rare. Bedding is graded in a few places only and crossbedding is limited to the thick quartzite along the Povungnituk River, previously cited. Beds range from about 1 cm to 2 or 3 metres but many quartzite horizons, for example, are massive.

Quartzite just north of Lac Vicenza is characterized by widely scattered, well rounded, vein quartz pebbles of 2.5 cm. The quartzite south of the same lake contains dolomite in angular 3 m blocks.

In general quartzite is light grey, more rarely medium grey or white, and is fine grained, equigranular and massive. Medium-grained rocks occur locally.

Greywacke is typically medium grey to dark grey-green and is fine grained. Thick-bedded, massive greywacke turbidites are well exposed 3.5 km south of Lac Beauparlant, where beds reach a maximum thickness of 0.6 m. Beds in this area show an increase in both grain size and thickness toward the north. Good graded bedding with local sole markings are well displayed in this area.

Some arenaceous rocks are considered to have been derived directly from erosion of the volcanic strata.

Conglomerate and breccia (Acg, Abc)

Despite the existence of a major unconformity there is no basal conglomerate and in the stratigraphic sequence conglomerate is rare. The best exposure is just north of the Povungnituk River 6 km northwest of Lac Allemand, where approximately 6 m of polymictic conglomerate dip northward. It consists chiefly of well rounded cobbles less than 5 cm in diameter, of quartzite, dolomite and biotite-quartz-feldspar gneiss in a greywacke matrix. Scattered throughout are subangular to subrounded boulders of dolomite up to 0.5 m in greatest dimension. Intercalated with this conglomerate are several wedges of greywacke 10 to 15 cm thick resembling the rock to the south that underlies the conglomerate. Two other conglomerate outcrops lie south of the Povungnituk River, north of Lac Nantais. Both of these outcrops show deformation of the clasts, the easternmost at about 10:1. Clasts set in a phyllitic matrix are chiefly carbonate and volcanic rocks, ranging from 1 to 7.5 cm long in the western exposure. The easternmost outcrop is lithologically similar to the conglomerate described above but also includes sandstone clasts (Fig. 11).

Ten km west of Lac Vicenza a coarse-grained quartzite to pebble conglomerate forms a topographically prominent northwest-trending ridge. Well rounded, pebble-sized quartz grains are characteristic of this well bedded conglomerate. On the eastern edge of the Aphebian outlier at Pointe Bégon, tuff overlying the Archean gneiss contains rare rounded to subangular quartz cobbles up to 10 cm in diameter close to the contact.

Rare breccias with sedimentary matrices are from this unit. None are known to be extensive and they are erratically distributed. Sixteen kilometres west-northwest of Hubert Lake a limy siltstone breccia 1.2 m thick overlies a massive grey limy siltstone 9 m thick. This limy siltstone breccia contains volcanic fragments presumably derived from the overlying flow. A somewhat similar breccia occurs 3 km south of Esker Lake (35G), where angular to subangular fragments up to 60 cm in diameter are present in a carbonate matrix. At this locality clasts are mixed carbonate, limy siltstone, and mafic and silicic volcanic rocks.

Carbonates (Adm, Als)

Carbonates form a small but significant part of the sedimentary rock group. As they are rather erratic they were probably formed in semi-isolated environments. Carbonate horizons within the volcanic sequence are particularly useful in providing marker horizons, even if only for short distances.

Dolomite occurs throughout most of the sequence but is most common in the basal zone, particularly in the vicinity of the Povungnituk River southwest of Lac Beauparlant in the centre of the map area. There, possibly as much as 1500 m of dark grey, fine-grained, well bedded dolomite and associated rocks, chiefly siltstone, are present. The dolomite bedding in places is marked by siliceous and micaceous partings. Irregular white quartz veins are common. More typical, however, are dolomite beds ranging from 1 m to 3 m thick interbedded with sandstone, shale and siltstone. In some places dolomite beds die out along strike by both decreasing in thickness and breaking up into a series of discontinuous pods. For example, the dolomite horizon 18 km west-northwest of Grunerite Lake, although occurring in uncommonly thick 30 to 50 m beds, forms only discontinuous pods on the western end of the outcrop area. Whereas fresh surfaces are light to medium grey with rarer yellowish hues, the weathered surfaces are characteristically light brown to yellowish orange.

Much of the dolomite higher in the succession is associated with dark to black shale or slate, forming thin interflow beds. Exposures of these rocks are probably disproportionately few because they are primarily in valleys between erosion-resistant volcanic rocks and only in late summer when the snow has all melted are they visible. Undoubtedly there are many more dolomite occurrences than are shown on the accompanying maps (Fig. 12).

Limestone, unlike the dolomite, is of limited distribution and never attains any great thickness. It is probably most abundant in the sedimentary unit along the Chukotat River and even there is sporadic. The thickest limestone member is 14 km slightly south of east of Lac Bégin, (35F) where a 10 m thick, somewhat silty limestone is overlain by a carbonate-cemented breccia containing volcanic fragments. A grey, fine-grained, equigranular, moderately well bedded rock is typical. Bedding thickness, however, shows considerable variation. Bedding in the limestone 12 km north of Lac Cournoyer ranges from 0.5 to 2.5 cm with silicic partings, whereas in some outcrops along the Chukotat River most of the bedding ranges from 1 to 7.5 cm and a few beds up to 30 cm thick are interbedded with shale.

Chert (Ach)

Except in a small area east of Chukotat Lake, where it forms a distinct and laterally extensive part of the layered sequence, chert is rare. In most places chert occurs as very thin bands less than a metre thick, or as round to lensoid nodules in the sedimentary rocks. Nevertheless the thin chert bands can comprise as much as 5 per cent of the strata over short stratigraphic distances, such as along the Chukotat River 22 km west-southwest of Hubert Lake where medium grey chert is interbedded with a muscovite-chlorite schist. An example of the nodular chert also occurs along the Chukotat River in a strongly cleaved, black, carbonaceous mudstone 7 km west of Lac Vigneau (35F) (Fig. 13).

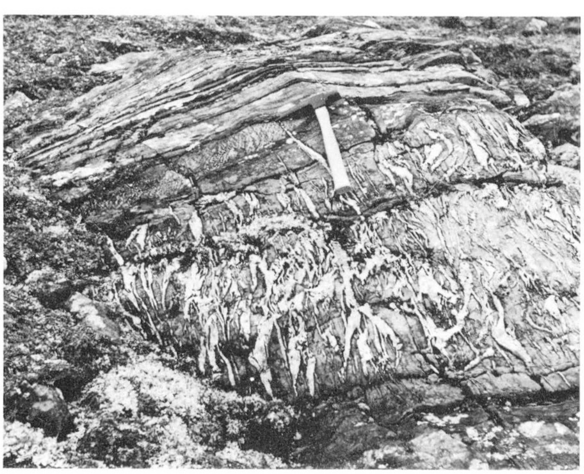

Figure 12. Dolomite with numerous quartz veins oriented normal to the bedding 5 km east of Chukotat Lake. (35G; F.C. Taylor; GSC 178845)

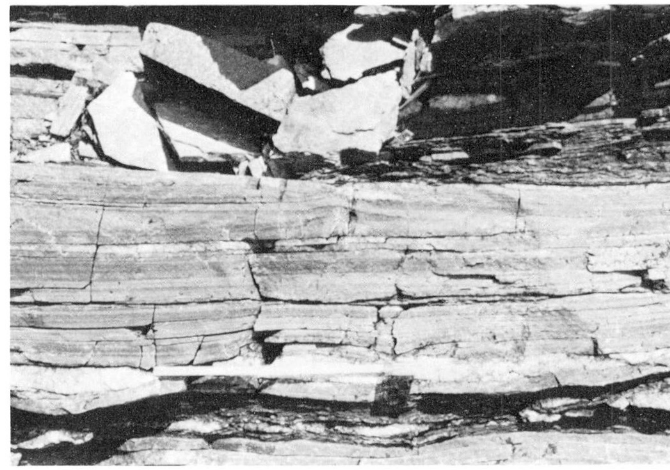

Figure 13. Metachert and mudstone beds 3.3 km north of Wakeham village. (25E; J.B. Henderson; GSC 178738)

The principal chert occurrence is 6 km east of Chukotat Lake where a 15 m thick dark red jasper bed is bordered on the north by a reddish brown weathering, light grey dolomite and on the south by a yellowish orange weathering coarse-grained dolomite. This jasper band may well extend another 4 km to the east because an outcrop there shows a similar 45 m thick jasper bed also bordered by dolomite. None is known to the west. South of the 15 m thick band of jasper, is a zone of mixed jasper, chert and dolomite with local pyrite, approximately 60 m thick. East or west extensions at this zone are not known.

Rare cobbles of dark red jasper in the drift along the major stream emptying Lac Parent (35G) at 61°50'N, which is not directly glacially downstream from the Chukotat Lake outcrops, suggest the presence of other jasper occurrences. Thin quartzose beds, especially in the more metamorphosed rocks, may be recrystallized chert.

Iron formation (Aif)

Iron formation is present near the unconformity along the eastern end of the south side of the fold belt, north of Lac Allemand, and in the outliers of Aphebian rocks near Whitley Bay, but in only a couple of places along the northern unconformity west of Wakeham Bay. As outcrop is reasonably abundant in the Wakeham Bay area the absence of iron formation there is real and not due to poor exposure. None is known west of longitude 76°W. Somewhat erratic, the iron formation has nowhere shown the great continuity characteristic of some well known iron formations such as those of the Labrador Trough.

Thickness of the iron formation has not been definitely established. Thickness is greatest near the southern unconformity southwest of Lac Vicenza, where about 35 m of iron formation consisting of 5 m of black ferruginous quartzite is overlain by 30 m of porous hematite-grunerite rock. A vague bedding is defined in the latter rock by zones of hematite nodules 1.2 to 7.5 thick separated by 15 to 20 cm of amphibole matrix. More common are thicknesses of 3 to 6 m (Fig. 14).

The iron formation is layered to massive. A laminated rock in which laminae range from 3m to 1 cm thick is the commonest. A typical laminated iron formation outcrops on a tiny island on the south side of Whitley Bay, where a 3 m thick band of iron formation consisting of laminated quartz-hematite rock contains a small zone of magnetite, laminated hematite-magnetite iron formation, pods of garnetiferous iron formation and grunerite. This iron

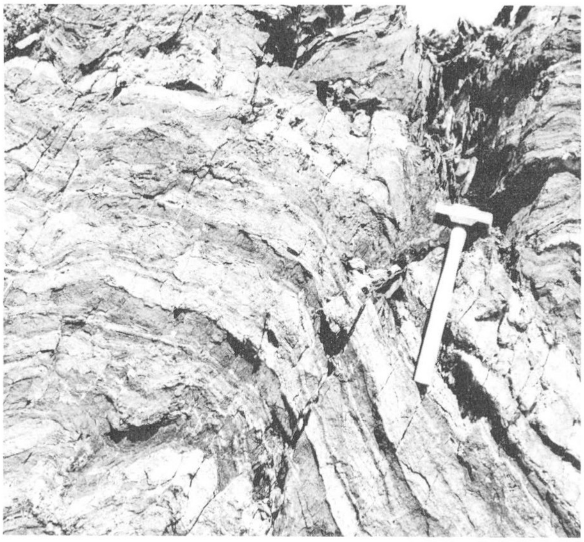

Figure 14. Well bedded and crenulated iron formation along the Povungnituk River valley 5 km west of the outlet of Lac Allemand. (35; F.C. Taylor; GSC 178837)

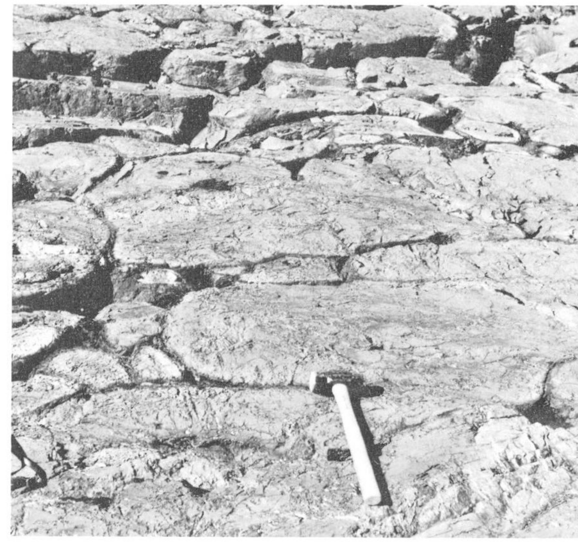

Figure 15. Pillowed basalt 7.5 km northwest of Lac Lahaye. (35F; F.C. Taylor; GSC 178800)

formation band is bordered on the north by 3 m of amphibolite and 60 m of black quartzite, and on the south by a similar thickness of black slate. Grain size is commonly coarse because of the development of pale reddish brown grunerite rosettes up to 2 cm in diameter, although some rocks are fine and medium grained, especially in the outliers. Typically these rocks are pale brown to reddish brown but a few that are marked by much magnetite are dark grey to bluish grey. Mineralogically they consist primarily of grunerite and quartz, with variable amounts of stilpnomelane, minnesotaite, iron chlorite, magnetite, hematite and carbonate, in part siderite. Garnet and biotite are local and a garnet-grunerite rock (Schimann, 1978a) is rare. Schimann divided the iron formation into silicate, carbonate and oxide members but these are not mappable units.

Volcanic rocks

The Cape Smith Fold Belt is characterized by an abundance of well preserved volcanic rocks and they form the major rock type. Baragar (1974), in traversing across the belt, reported over 15 000 m of mafic volcanic rocks. They are magnificently displayed along the river 6 km east of Lac des Deux-Îles (35G), which flows northward into Lac Watts. Several kilometres of mafic volcanic rocks are exposed in the canyon walls. Individual flows in this great volcanic display range in thickness from a metre or two to about 100 m. Primary structures include pillows, flow breccias, vesicles, amygdules and rare spherulites. Of these structures pillows are the most prominent and widespread and these rocks may well be the finest display of this structure in the entire Canadian Shield. Pillows are particularly well displayed in the western part of the belt, where hundreds of metres of well developed pillows are exposed between the Chukotat River and Lanyan Lake (35F) (Fig. 15).

Basalt, komatiite and andesite (Abl, Akt, Aad)

Whereas most of these rocks are basalts, or have been, a few are komatiites or andesites, and a few rare members are rhyolite and dacite. Many can suitably be described in the field only as greenstones because of their aphanitic texture and low-grade metamorphism, which is probably deuteric in part. Typically they are light to dark grey-green to dark green, and aphanitic. Although a massive rock is characteristic, a weak schistosity is present in many places and a few rocks display tiny phenocrysts of plagioclase. Rocks are fine to medium grained in some places, in particular in the centres of thick flows. Where these rocks form isolated outcrops they are indistinguishable from some of the gabbros (Agb).

Metamorphism in the northern part and the eastern end of the belt has converted these rocks to amphibolite. Rare chlorite schists (Acl) are probably due to local shearing.

Thin section examination shows that many of these rocks consist of a semiopaque matte of very finely divided alteration products of plagioclase and clinopyroxene. Plagioclase is almost invariably highly altered to epidote and sericite and where identifiable it is chiefly secondary and varying from albite to andesine, depending on metamorphic grade. A few samples contain local thin zoning. Augite is recognizable in some samples but most augite is altered to amphiboles, either tremolite-actinolite or hornblende. Interstitial chlorite, clinozoisite, epidote and calcite are common along with accessory or trace amounts of calcite, sphene, ilmenite, biotite and magnetite. Veinlets of chlorite and calcite are locally present. Pumpellyite is a rare constituent.

Of particular interest are the quench textures in some of the pillowed basalts from the central and particularly the western parts of the map area. This texture was not observed in samples from the eastern part of the map area. Examples of this texture are excellent in the rocks 10 to 15 km west of Carye Lake. Megascopically these rocks are medium grey-green and very fine grained. Pillows range from 15 cm to 2 m in diameter and have selvages 2.5 to 5 cm thick. Microscopically they characteristically show very elongate, locally swallowtail-shaped, plagioclase crystals, probably labradorite, 0.4 to 1 mm long, chiefly randomly oriented but locally preferentially oriented. Twinning may or may not be present. Plagioclase may be altered either wholly or in part to a mixture of sericite, epidote and chlorite. These crystals lie in a matrix of feathery amphibole or pyroxene, the latter probably also a quench product or devitrified glass. A few samples show both devitrified glass and poorly developed feathery clinopyroxene. A few moderately well formed lantern-shaped phenocrysts that are scattered through the matrix and composed of calcite or chlorite or both, and locally with rims of smectite (?), are probably olivine pseudomorphs. Epidote is a rare additional constituent of these pseudomorphs.

Some of the quench basalts display veinlets of calcite and stilpnomelane, and cavity fillings of calcite, chlorite and prehnite.

Komatiitic rocks were first recognized among the Cape Smith Belt rocks on Smith Island southwest of the map area by Schwarz and Fujiwara (1977), but some earlier analyses reported by Wilson et al. (1969) also show komatiitic affinities, depending upon definition used. More recently Moore (1977) and Francis and Hynes (1979) also have reported komatiitic rocks. These high-magnesia rocks were recognized from chemical analysis and they have not been identified with certainty in the field. Those shown on the accompanying maps were identified by thin section examination only and hence are subject to revision.

The distribution of komatiites in the volcanic rocks is unknown and they are possibly much more extensive than indicated. They are not readily distinguishable from the other volcanic rocks in the field on the present scale of mapping, although some have a more mafic appearance. Typical komatiite is similar to one 4 km northeast of Hubert Lake which is dark green, massive, equigranular, and fine to medium grained. Microscopically it consists of anhedral augite up to 0.6 mm lying in a matrix partly of devitrified glass and partly tremolite and chlorite, with rare clinozoisite. Some augite shows tremolite overgrowths. Tremolite also occurs with chlorite, quartz and clinozoisite in rare, presumed, olivine pseudomorphs. A few grains of calcite are present locally in augite of this rock.

Quench textures are also shown by some of the komatiites. For example, a sheared, pillowed komatiite from 6.5 km north of East Lake (35H) consists of pseudomorphs of olivine in a feathery clinopyroxene matrix, probably augite. The pseudomorphs consist of a nearly colourless to very pale green chlorite, or a mixture of chlorite, well formed clinozoisite or epidote, and locally, rare calcite. The clinopyroxene shows minor alteration to tremolite-actinolite along the rims of the crystal clusters. A trace of pyrite occurs in the matrix.

Another type of pillowed komatiite, outcropping 3 km east of Carye Lake, contains skeletal crystals of augite up to 3.5 mm long but mostly about 2 mm in a matrix of devitrified glass that contains a few tiny, poorly formed clinopyroxenes and minor amounts of feathery clinopyroxene. Also scattered throughout the matrix are euhedral olivine pseudomorphs up to 1 mm, now consisting of carbonate, tremolite, chlorite and smectite (?). A few smaller lantern-shaped, skeletal crystals of olivine are also present. In the same area south of the above occurrence another pillowed komatiite consists primarily of olivine pseudomorphs up to 0.3 mm, now tremolite and chlorite, with skeletal clinopyroxene crystals up to 1.4 mm in devitrified glass and tremolite. Tremolite also forms poor coronas around some skeletal pyroxenes.

Olivine pseudomorphs up to 0.25 mm in pillowed komatiite 2.5 km east-southeast of Hubert Lake contain two chlorites, one anomalous blue and the other green-blue, and quartz. These are similar to olivines described by Gélinas and Brooks (1974) from high Mg-metabasalt except that none is entirely quartz, although a few are entirely chlorite. The same rock has a matrix of feathery clinopyroxene up to 0.75 mm, rare skeletal clinopyroxene and devitrified glass.

Fine-grained feathery tremolite is characteristic of komatiite 3 km west of the Iktotat River (35F). It is probably a quench product after clinopyroxene, with interstitial clinozoisite, epidote, minor chlorite and devitrified glass and rare calcite. Tiny amygdules in this rock consist of calcite with rare epidote and pyrrhotite.

Tuffs (Atf)

Tuffs form only a small part of the Aphebian stratigraphic sequence. As previously indicated, they grade in places into other sedimentary rock types. They are apparently most common in a zone extending east-northeast of Chukotat Lake to east of Nuvilik Lakes. No great thickness of these rocks is known; the few mapped are less than 60 m thick. Lateral continuity is probably not extensive but pertinent data are not on hand.

Figure 16. Thinly laminated tuffs with soft sediment deformation 5 km east of Chukotat Lake. (35G; F.C. Taylor; GSC 178862)

Tuffs indicated on the accompanying maps are primarily mafic (Fig. 16). Felsic tuffs probably predominate, however, as much of the rhyolite (Arl) shown is of tuffaceous origin. Felsic tuffs have also been reported by Beall (1959) and Schimann (1978a) near Cross Lake (35G) and in the Wakeham Bay areas, respectively.

A tuff is well displayed at the Archean-Aphebian unconformity at Pointe Bégon. There a dark grey-green, partly well bedded, equigranular, fine-grained rock contains scattered vein quartz pebbles at its base. This tuff ranges from a few centimetres to 15 m thick and is overlain conformably by 20 m of light brown sandstone.

A crystal tuff 14 km south of Lac Belleau (35G), which appears in outcrop to be massive, shows distinct layering microscopically. This dark grey-green, fine-grained rock is characterized by partially to extensively altered, subhedral plagioclase and augite crystals plus angular, less commonly subrounded, rock fragments in a very fine grained matrix of rock fragments and devitrified glass. A few crystals display resorption embayments.

Most tuffs, however, are probably lithic tuffs because only rarely are crystals visible.

Rhyolite and dacite (Arl, Adc)

Rhyolite is most abundant in the central part of the fold belt. Outcrops are only scattered in the east and nonexistent in the west. Except for the area south of Nuvilik Lakes and west of Lac Watts, none of the rhyolite is very extensive and the extent of the Lac Watts occurrence is magnified somewhat by the topography and structure as it is probably not very thick (Figs. 17, 18).

As previously indicated, many of the rocks shown as rhyolite are of tuffaceous origin, and are either crystal or lithic tuffs. For example, most of the rhyolite south of Nuvilik Lakes is a light grey to grey, moderately well foliated to thinly bedded, equigranular silicic tuff with local angular fragments. These rocks are, in places, converted to felsic schists. Whereas they have all the megascopic characteristics of rhyolite, potash feldspar content is so low in most of those examined microscopically that petrographically they are predominantly dacitic.

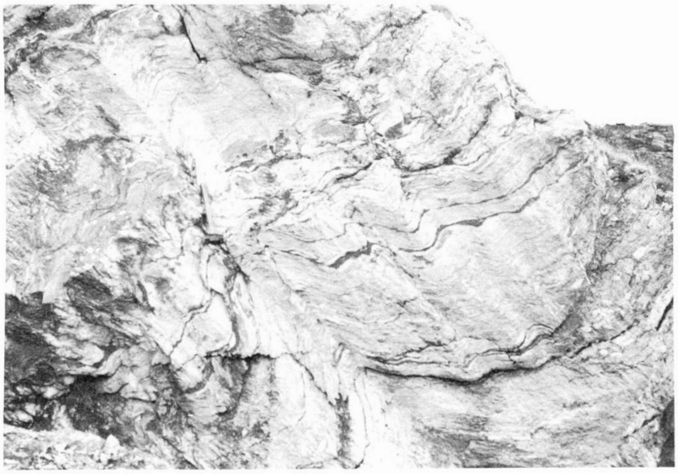

Figure 17. Crenulated rhyolitic schist with chlorite schist layers on the east side of Lac Watts. (35G; J.B. Henderson; GSC 178689)

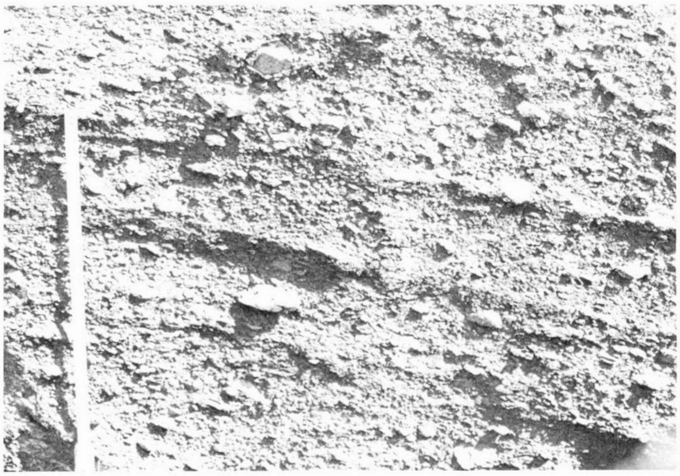

Figure 19. Crude layering in volcanic breccia 5 km east of Chukotat Lake. (35G; J.B. Henderson; GSC 178625)

Figure 18. Mafic layers in rhyolite 6.7 km south of the western part of Nuvilik Lakes. (35G; J.B. Henderson; GSC 178614)

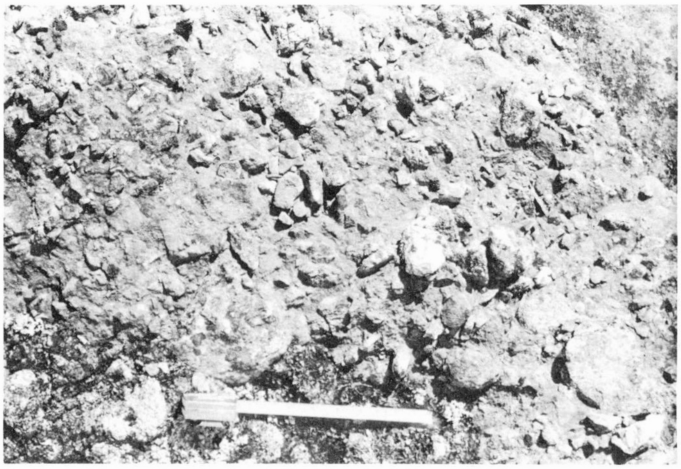

Figure 20. Felsic volcanic clasts in breccia 5 km east of Chukotat Lake. (35G; J.B. Henderson; GSC 178627)

Between Chukotat Lake and Lac Long (35G) numerous outcrops of volcanic breccias (Avb) are exposed (Figs. 19, 20). Although these are roughly on strike they are probably at different levels in the stratigraphy. Smaller outcrops are present elsewhere but are not abundant. In a valley 10 km west-southwest of Lac Long a section over 300 m thick is dominantly volcanic breccia. However, most breccia horizons are only about a few metres. Breccia fragments, which range from 3 mm to 15 cm, consist chiefly of mafic volcanic rocks but a few outcrops also contain silicic volcanic and carbonate clasts. Similarly, the matrix is commonly mafic volcanic composition but a few outcrops have a carbonate cement. One of these is 3 km south of Esker Lake. East of Chukotat Lake a coarse breccia, with many fragments up to 0.3 m, seems to be composed of air-shaped, closely packed bombs in a tuffaceous matrix.

Nonsedimentary carbonate rocks (Act)

Rocks with high carbonate contents, excluding the obviously sedimentary rocks such as limestone, occur in several places. They take several forms: some are distinctly dykes and sills and others are the result of a pervasive carbonatization of country rock. Some of the latter are spatially associated with faults whereas others show no obvious connection with geological parameters.

Typical carbonate dyke rocks occur 24 km northwest of Nuvilik Lakes, where three dykes 1, 2 and 3 m thick cut massive amphibolite (Fig. 21). Contacts are sharp in most places but the thicker dyke contacts are less well defined. In other places dykes become sills and follow foliation planes.

The dykes and sills are typically moderate brown to dark yellowish brown weathering, fine- to medium-grained, equigranular, massive, yellowish grey to light olive-grey rocks. Microscopic examination shows an erratic calcite content from about 10 to 50 per cent. Whereas the low-carbonate dykes contain major amounts of highly altered plagioclase, the others have virtually none. Muscovite and chlorite are common in the high-calcite types. Minor amounts of quartz and pyrite are commonly present. There is little doubt that these are intrusive rocks.

Pervasive carbonatization that displays no clearly defined limits or contacts is most prominent about 20 km north of Nuvilik Lakes. It is irregularly distributed in zones up to 30 m thick throughout this part of the map area. These zones are commonly parallel to the regional trend but partly lie athwart it. In some places, the part normal to the structure appears to join together those zones parallel to it as a feeder. In other places carbonatization of the volcanic rocks appears along minor shears, but in general no structures are evident and both carbonate zone and country rock are massive to weakly foliated.

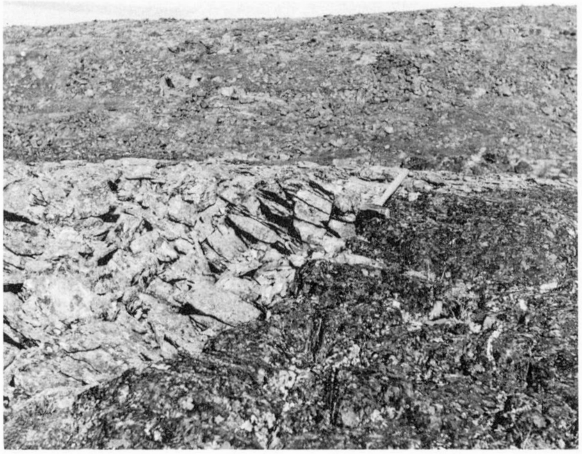

Figure 21. Carbonate dyke in amphibolite 24.5 km north-northwest of Nuvilik Lakes. (35G; F.C. Taylor; GSC 178867)

These fine-grained rocks are greyish green and weather to shades of light to moderate brown. Carbonate forms up to 50 per cent, and amounts of altered plagioclase, chlorite and minor pyrite are variable.

The other form of carbonatization is common near faults, in particular the more prominent strike faults. Although recognized in several rock types close to the fault zones, it is most prevalent in the phyllites. Undoubtedly this carbonatization is associated with the faults.

East of Chukotat Lake a breccia (Actb) with a thickness ranging from 13 to 200 m extends for about 6 km through several outcrops. Its relationship to the other rock units is not clear. A sheared breccia along the south edge of the gabbro and ultrabasic sill is presumed to be the same rock but the shearing has destroyed any age evidence. Elsewhere, this breccia occurs in isolated outcrops. It consists of a pale to dark yellowish brown weathering, yellowish to olive-grey, fine- to coarse-grained breccia containing erratically distributed biotite grains. These range from 1 mm to 5 cm in diameter. The fragments, which are predominantly 1 mm to 5 cm, are angular to rounded. A few fragments of dolomite up to 45 cm and rare volcanic fragments up to 15 cm are present locally. In the fine-grained samples the fragments consist of calcite, biotite, plagioclase, magnetite and rare chlorite in various proportions, but primarily with calcite and biotite dominant. Some fragments are entirely calcite, consisting of one or more calcite grains, and commonly have a thin biotite-magnetite rim. Rare plagioclase-dominant fragments show it to be generally fresh. Its composition is about An_{40}. The matrix consists of finely divided calcite and lesser biotite. The large biotite grains are fresh and undoubtedly phenocrysts. Fragments in the coarse-grained breccia include light grey argillite, dolomite, grey, weakly pyritiferous quartzite, dolomite, rare volcanic rocks and fragments of the breccia itself. One place has fragments of a biotite-carbonate similar to that occurring as a dyke at Chukotat Lake. All the rocks present as fragments are known to exist within the Aphebian volcanic-sedimentary sequence. The matrix consists chiefly of calcite, rare finely divided rock fragments and rarer quartz.

The presence of various sedimentary and volcanic fragments shows that this breccia postdates the sedimentary and volcanic rocks. The rounding of many fragments shows them to have been abraded. The many fragments of the breccia itself suggest violent and repetitive events. These facts, plus the existence of the large biotite phenocrysts, are consistent with an explosive origin for these deposits from as yet undiscovered diatremes.

Carbonate at the east end of Chukotat Lake differs from those previously described. There a vertical, east-striking carbonate dyke 8 m thick intrudes a dark grey, pyritiferous argillite and a greenish grey garnet-muscovite rock, probably a highly altered serpentinite, at a very low angle. This dyke is a fine-grained, medium dark grey rock with pyrite and biotite phenocrysts up to 1 cm and 0.5 cm, respectively. The matrix consists of finely divided green biotite (40%) and calcite (50%) and small amounts of plagioclase, pyrite, ilmenite and epidote. It may be genetically related to the explosion breccia described above, which outcrops a short distance to the east.

Mafic intrusive rocks

The layered rocks of the Cape Smith Fold Belt have been intruded by a suite of mafic rocks consisting chiefly of gabbro, but containing significant amounts of ultrabasic rocks. These intrusions are most abundant in the central part of the map area but also occur sporadically throughout the belt. Widely scattered mafic intrusions in the gneissic terrane north of the belt are presumed to belong to this unit. These intrusions occur primarily as sills, but also locally as low-angle dykes and small stocks.

The intrusions are very extensive laterally even where they are thin, and many are tens of kilometres long. For example, gabbro at the base of the layered sequence west of Juet Lake is over 35 km long within the map area and extends beyond. A sill 10 km north of Lac Allemand is 25 km long although only 100 m thick. Two ultrabasic sills south of Nuvilik Lakes are each over 15 km long, although rarely more than 100 m thick. Folding has deformed these rocks in many places, especially in the east-central part of the belt, resulting in thickening and thinning of the sills. The thickest ultrabasic rocks are those at Asbestos Hill, in part probably because of folding. In some places tiny ultrabasic intrusions about 1 metre long, either tabular or lens-shaped, occur within the volcanic rocks. These are most abundant in the region surrounding Lac Long.

Contacts with the host rocks are generally well defined, with narrow fine-grained borders. The ultrabasic contacts are particularly well marked by the colour contrast between the greyish green volcanic rocks and reddish brown weathering ultrabasic rocks. Some isolated outcrops mapped as gabbros may well be coarse-grained basalt that has cooled slowly enough to acquire textures similar to the intrusive rocks.

Beall (1977) divided these sills into three types: ultrabasic, gabbro and settled differentiate, the last being a combination of the first two. To avoid a genetic connotation, the third type is referred to here as mixed rather than settled differentiate.

Gabbro (Agb)

The most widespread of the mafic intrusive rocks is gabbro, which forms the largest plutons north of Juet Lake. Beall (1977) notes that the thicker gabbros in the Cross Lake - Lac Laflamme areas (35G, 35H) commonly grade from pyroxenite at the base through gabbro and diorite to quartz diorite at the top. This relationship was not apparent during the present survey, as any discrete gabbro sills examined are on the whole quite uniform petrographically, except for the fine-grained chill zones.

The gabbro sills consist of a medium- to coarse-grained, ophitic-textured, massive rock. Plagioclase, much of which is altered to chlorite and epidote, ranges from 30 to 60 per cent. Anorthite content ranges from 27 to 55 per cent but good determinations are rare because of the alteration. By electron microprobe analysis Miller (1977) found a plagioclase core of An_{33}. Clinopyroxene alteration to tremolitic amphibole is prevalent. Chlorite is present in almost all samples and abundant in many, and quartz occurs in approximately one third. Sphene, biotite, magnetite, apatite and calcite occur in accessory amounts in order of decreasing abundance.

Ultrabasic rocks (Aub, Apd, Ase)

Ultrabasic intrusions are best developed in the central part of the area, particularly near Lac Vaillant (35H). They are readily identified by their weathered surface, which is predominantly reddish brown. In the northern part of the Cape Smith Belt, some ultrabasic outcrops in the general vicinity of Lac Watts weather to a yellowish brown or less commonly, to a bright yellowish orange. The latter are deeply weathered and friable, and pebble-size fragments form the outcrop surface. A few serpentinite outcrops show a very light grey weathered surface.

The fresh rock is dark green to dark grey-green, massive and medium grained. A poikilitic texture is prevalent in the peridotite and subhedral to euhedral serpentinized olivine grains are up to 2 cm long in clinopyroxenes. Veinlets of brittle chrysotile and magnetite are abundant. Whereas the bulk of the ultrabasic rocks are peridotite in various stages of serpentinization, locally complete, some outcrops are relatively unaltered, especially in the south. Compositions approach dunite in a few places. (Fig. 22).

Beall (1977) noted a sheet jointing parallel with bedding in the adjacent rocks. Columnar joints are excellent in some outcrops such as those shown in Fig. 23. A few outcrops are partly schistose, such as 7 km west of Lac Vanasse (35G), where 5 per cent of the outcrop is schistose rock in which carbonate, talc and tremolite are extensively developed.

Amphibolite occurs along the base of a few sills that are "tens of feet in thickness", according the Beall (1977). More prevalent in the amphibolite metamorphic zone, it is chiefly about one or two metres, and is probably dominantly due to metamorphism.

Relatively minor amounts of pyroxenite are associated with these ultramafic sills. In a few places it forms discrete outcrops. However, much of the pyroxenite occurs in the mixed sills. For example, 12 km west of Lac Watts a couple of small pyroxenite plutons are present in and bordering the rhyolite. These show various degrees of serpentinization. A larger pyroxenite body, 3 km north of Lac Serpentine (35G), is extremely serpentinized and chloritized. An outcrop near the Povungnituk River north of Lac St-Germain consists of 90 per cent serpentinized peridotite and 10 per cent light grey-green, massive, equigranular, medium-grained pyroxenite, which is characteristic of this rock type. Minor amounts of carbonate occur in the pyroxenite.

Figure 22. Serpentinized peridotite with northward-dipping serpentine veinlets along the Chukotat River valley at 76° 27'W. (35F; T.M. Gordon; GSC 178445)

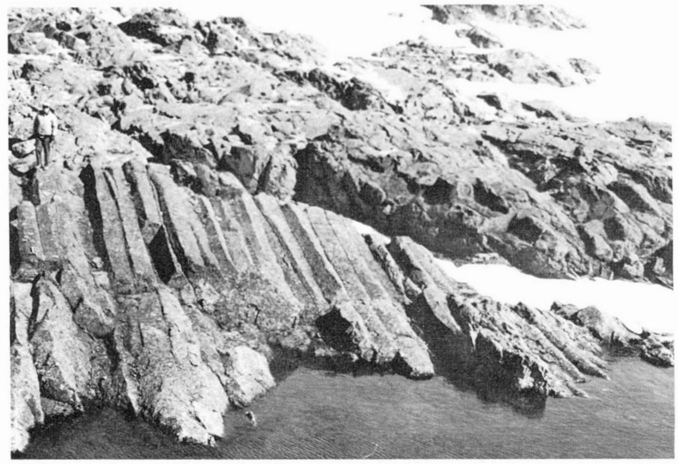

Figure 23. Columnar-jointed ultrabasic sill 0.5 km north of Chukotat River south of Hubert Lake. (35F; J.B. Henderson; GSC 178559)

Mixed sills (Agb, Apd, Apx)

The mixed sills consist of gabbro, peridotite and pyroxenite in various proportions. Pyroxenite is quantitatively the least of the three in most places, but Stewart (1976) reported that pyroxenite or pyroxene-rich rocks constitute 60 to 70 per cent of the sill in which the asbestos mine occurs.

An outcrop 7 km north-northeast of Lac Vicenza is typical of these sills, as it shows a thick gabbro layer on the north side grading through a thin pyroxenite layer, which in turn passes into a thick peridotite layer. At the southern contact is a thin gabbro layer similar to that on the north, which grades into the overlying peridotite.

These mixed sills typically are layered so that the major portion of the gabbro is stratigraphically at the top and the ultramafic near the base, as reported by Shepherd (1959) and Beall (1977). This relationship is determinable in exposures where tops in the host rocks are evident and Beall (1977) noted no exceptions in the Cross Lake and Lac Laflamme areas. Results from the present survey tend to confirm this observation. However, in detailed mapping of the '2-3 sill' 4 km east-northeast of East Lake, Miller (1977) found that the ultramafic rock stratigraphically overlies the gabbro. Thus the layering in the sills must be used with caution for structural analysis.

Francis and Hynes (1979) recently endorsed the crystal accumulation concept, with the provision of a magma of pyroxenitic komatiite composition.

The origin of these rocks is beyond the scope of this report, but those doing more detailed analyses have called upon several mechanisms to explain the petrogenesis of these sills, especially the mixed type.

Shepherd (1959) considered them to be composite sills formed from two separate magma injections, one ultramafic, the other gabbroic. Miller (1977) invoked differentiation by flow in the '2-3 utramafic sill', a mechanism also suggested by Wilson et al. (1969). All these processes involving the mafic intrusive rocks probably were in effect at various times and places and each sill must be examined on its own merit. Beall (1977), objecting for several reasons to this proposal, considered that the mixed sills were formed by rapid gravitational settling of the ultramafic portion immediately after injection, and that the upper gabbro portion was differentiated in place.

Gneisses

Gneissic rocks north of the Cape Smith Fold Belt, here considered to be Aphebian and deformed during the Hudsonian Orogeny, can be divided into two groups, the dominantly silicic rocks consisting of gneissic granitic rocks and migmatite, and those derived from, or probably derived from, sedimentary or volcanic rocks. Rocks have been assigned to less metamorphosed units when this could be done with a reasonable degree of certainty. An example is the rhyolite west of Watts Lake, even though it is extensively metamorphosed. Since contacts between the various gneissic rocks range from abrupt to gradational, contacts shown on the accompanying maps in some places are arbitrarily located.

Paragneiss (Apg)

Rocks assigned to this unit are considered to have had a sedimentary origin. Distinctive metasedimentary rock units, such as marble and rusty graphitic quartz-rich gneiss, have been segregated but small areas of these rocks probably occur within this unit. The rocks are most abundant in the northwestern part of the map area but are widely distributed from Cape Hopes Advance to the west coast. Although contacts are commonly gradational with gneissic granitic rocks (Agg), granulite (Agl) and schists (Asc), they are sharp or gradational with other rock units over short distances (Figs. 24 - 27).

Structure consists of a well developed foliation and less common banding, which is probably relict bedding. In general these are uniform over short distances; contorted or crenulated rocks are relatively rare and chiefly involve the finer grained representatives. Small amphibolite bands occur within this unit in many places and are particularly well displayed in coastal outcrops, possibly because exposure is good. Similarly, granitic gneiss forms a significant part of the unit as thin layers, either tabular or lensoid. Pegmatite dykes are common in some places, notably near Sugluk Inlet and 15 km north-northeast and 5 km north-northwest of Lac Amarurtuuq (35F).

Figure 24. Layered and foliated paragneiss on the west side of Peck Inlet. (35K; F.C. Taylor; GSC 178786)

Figure 25. Paragneiss along the north coast 3.5 km west of Cap Pachot. (35K; T.M. Gordon; GSC 178480)

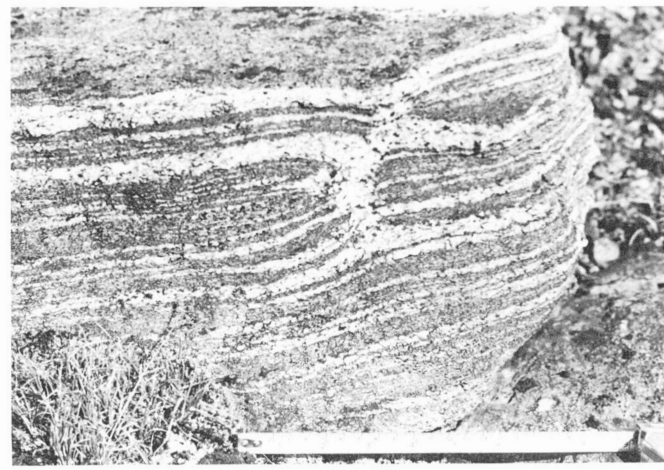

Figure 26. Paragneiss with thin granite layers and local boudins, 10 km east of Erik Cove. (35K; J.B. Henderson; GSC 178611)

Figure 27. Garnetiferous paragneiss 8.5 km west of Cap de Nouvelle-France. (35I; J.B. Henderson; GSC 178718)

Typically this paragneiss consists of an equigranular, medium-grained, variegated grey, well foliated, biotite-quartz-feldspar gneiss. However, some inequigranular rocks contain local porphyroblastic feldspar or large garnet metacrysts. Fine- and coarse-grained rocks are also prevalent. The former commonly form distinct bands in the coarser grained rocks and are probably relict beds. Although predominantly grey, rock similar to some gneissic granitic rocks is pinkish grey. A rusty- and soft-weathered surface is common in some areas and is particularly well developed along parts of the coastal cliffs and north of Wakeham Bay. Although biotite is by far the most abundant mafic mineral, hornblende occurs in some outcrops and in a few it forms the sole mafic mineral. Garnet up to 1 cm in diameter is sporadic. Confined to somewhat schistose parts of the paragneiss, sillimanite is rare. Kyanite, cordierite and sapphirine are extremely rare consituents.

Mineralogically this paragneiss is primarily a biotite-quartz-feldspar rock. Brown biotite content is mostly about 5 to 10 per cent but some samples have as much as 20 per cent and a few have none. Quartz content ranges from 10 to 50 per cent and averages 25 per cent. Feldspars are chiefly plagioclase although rare samples display a preponderance of potash feldspar. Plagioclase composition averages An_{21} and ranges from An_{15} to An_{32}. In content it ranges from 15 to 75 per cent and averages 45 per cent. Approximately 15 per cent of the plagioclase is antiperthitic. Potash feldspar, which is microcline and commonly perthitic, is absent from some samples and forms up to 45 per cent in others. Average content is 18 per cent. Green hornblende is present locally and in some samples forms as much as 15 per cent of the rock. Only rarely however does the hornblende content exceed the biotite content. Moderate red garnet is sporadic and in a few places makes up to 20 per cent of this rock. Aluminum silicates, sillimanite and kyanite are very limited, being in general confined to the more schistose parts of the paragneiss. Extremely rare, cordierite and sapphirine occur in only two localities each. Muscovite is common in a few outcrops. One or more of sphene, magnetite, ilmenite, apatite, zircon, calcite, scapolite and rutile occur in accessory amounts. Chlorite, muscovite and epidote are common alteration products of the major minerals.

Marble (Amb) *and calc-silicate rocks* (Acs)

These rocks are scarce and are found chiefly at Digges Island and 10 km south of Promontoire Longueuil (35K). Typically the rocks are associated with thin amphibolite, paragneiss and quartzite bands and some outcrops contain pegmatite dykes. The marble south of Promontoire Longueuil contains up to 40 per cent rounded and irregularly shaped masses of pegmatite and pyroxenite that superficially resemble a conglomerate or fault breccia. This fragmental rock was probably formed by tectonic destruction of pre-existing layers and flowage of the marble. Bedding is poorly preserved and has been obliterated by tectonism in some outcrops. The marble is a medium-grained, white to light brown, chiefly massive, equigranular rock composed primarily of calcite although some have a high dolomite content. Phlogopite is common and diopside is present in most samples. Garnet is present in the rock south of Promontoire Longueuil. Quartz and magnetite are rare. The calc-silicate rock is fine to medium grained, grey to grey-green and equigranular. Diopside, quartz, garnet and plagioclase are the essential minerals. Small amounts of free carbonate are present in most samples. Although not observed in outcrop these two rock types probably grade into one another.

Rusty graphitic quartz-rich paragneiss (Arc)

A distinctive rusty weathering quartz paragneiss, primarily located in the northwest part of the map area, is associated with paragneiss and granitic gneiss (Agg). Although thin bands of several tens of metres are characteristic, locally thick zones are present as displayed at Erik Cove (35K). This unit, because of the prominent weathering, is readily identifiable from the air. The thicker units contain elements of paragneiss, amphibolite, quartzite and possibly some carbonates.

A fine- to medium-grained, well foliated, equigranular rock that is white to very light grey on fresh surfaces, is typical. Quartz, plagioclase, biotite and graphite are the main components. Although comprising less than 2 per cent, the graphite is ubiquitous as medium-grained, metallic flakes. Pyrite is rarely visible megascopically but undoubtedly is responsible for the distinctive rusty-weathered surface.

Quartz forms at least half the content and plagioclase about one third. Brown biotite ranges from less than 5 per cent to approximately 20 per cent in a few samples. Tiny euhedral garnets are present locally. Accessory minerals are magnetite, zircon and muscovite.

Amphibolite (Aab)

A significant part of the northern and eastern part of the Cape Smith Belt is amphibolite, which is also widely distributed throughout the gneissic terrane. In the latter area, however, it consists chiefly of thin bands, most of them unmappable at the present scale, and lensoid to angular inclusions in the migmatite and granitic gneiss. Because most of the amphibolite within the gneiss is tabular and lies parallel to regional banding and foliation it is considered to have been derived from mafic layered rocks, probably primarily volcanic but possibly including some gabbroic intrusions. Locally angular amphibolite masses in the migmatite are possibly relicts of mafic dyke rocks. The large amphibolite masses on the north side and east end of the Cape Smith Belt are unquestionably of volcanic origin; in many places well defined volcanic strata can be traced into their metamorphic equals (Fig. 28).

Volcanic characteristics have been destroyed by metamorphism and tectonism even where volcanic derivation is beyond doubt. A possible exception occurs in the amphibolite, where there is secondary layering or lamination that can also be interpreted as a relict primary structure.

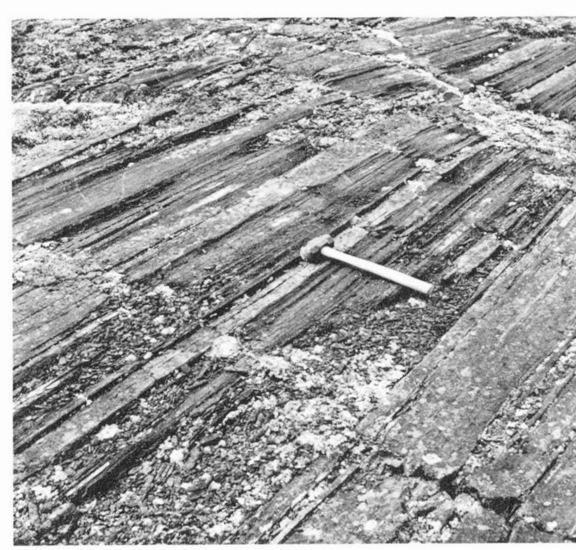

Figure 28. Banded amphibolite on the south side of Kovik Bay. (35F; F.C. Taylor; GSC 178767)

This layering is particularly common in the area between Pointe Bernier (35F) to a few tens of kilometres east of Lac Bégin. In the same area thin amphibolite layers of about 0.5 m or less are particularly abundant within the metasedimentary rocks (Asc). These thin amphibolite layers may be metamorphosed mafic tuffs because contacts with the metasedimentary rocks are gradational in many places. Some amphibolites, especially in the Lanyan Lake - Lac Bégin district, have a feathered texture and plumose hornblende grains, locally up to 2 cm long, lying parallel to or forming the foliation plane. These rocks may also be metatuffs. Elsewhere, layering not of primary origin may be the result of metamorphic differentiation.

A greenish grey to greenish black, medium-grained, equigranular, massive to weakly laminated or foliated rock is characteristic. Fine-grained, coarse-grained schistose, mottled and inequigranular rocks occur locally. A few display excellent mineral lamination. Hornblende and plagioclase (An_{30-35}) commonly form over 80 per cent of this rock and various amounts of biotite, quartz and garnet form most of the remainder. Epidote is locally abundant and may form as much as 15 per cent. An unaltered rock is typical but alteration, generally minor in amount, of plagioclase to sericite and epidote, and hornblende and biotite to chlorite, occurs locally. There may be accessory amounts of apatite, sphene, calcite, scapolite, pyrite and iron oxides.

Hornblende-plagioclase gneiss (Ahg)

A large area surrounding the Lac Vanasse - Lac Serpentine region is underlain by this rock unit. Although consisting almost entirely of hornblende and plagioclase and therefore similar to rocks mapped as amphibolite this rock unit is readily recognizable because it is lighter in colour, has a much higher plagioclase content and resembles a diorite. This is the same unit that Bergeron (1959) mapped and that he considered to grade into the amphibolite to the south. As outcrops are generally less abundant in this region the precise nature of the contact between this map unit and the surrounding rock types is not clear. However, a gradational contact is most likely. Along the northern contact local pink lenses suggest a gradation into the granitic gneiss (Agg) and in the south hornblende content increases near the margin. The small stocks of granodiorite, granite, diorite and tonalite (probably) postdate this gneiss, whereas the ultrabasic rocks near Lac Serpentine probably have been deformed with it. An outcrop 10 km east of Lac Serpentine shows a fine-grained metagabbro intrusive into the hornblende-plagioclase gneiss. Similarly, 9 km east-southeast of the same lake a massive, brown-weathering gabbro cuts the gneiss. About 3 km northeast of Lac Vanasse, however, metagabbro is interlayered with this gneiss in 3 to 30 m layers in approximately equal proportions, with no clear age relationship between them. North of this lake fine-grained amphibolitic schist is layered with the gneiss although at this locality the latter rock is more amphibolitic than normal. A fine-grained amphibolite breccia is interlayered with the gneiss 7.5 km east of Lac Vanasse but it forms less than 5 per cent of the outcrop.

Typically the hornblende-plagioclase gneiss is well foliated, equigranular, medium grained and variegated grey to grey-green. Locally a fine-grained rock or darker coloured rock is present. Subhedral plagioclase content averages 55 per cent but reaches 70 per cent in some samples and as little as 35 per cent less commonly in others. There are two types of plagioclase (An_{25-38}): crystals and anhedral aggregates, both of which range from fresh to extensively altered. Some samples contain antiperthite and myrmekite. Green hornblende, which variously occurs in large or small anhedral to subhedral crystals, forms an average of 25 per cent. Absent from many samples, reddish to light brown biotite forms as much as 10 per cent locally. It occurs chiefly as distinct anhedral to subhedral grains and as an alteration product of pyroxene with which it is intergrown.

Clinopyroxene, which is in half the samples examined microscopically, is erratic and typically only in trace amounts, although a few samples contain as much as 10 per cent. A light green limy clinopyroxene is most common but other clinopyroxenes are colourless. Local alteration to uralite, biotite and chlorite is characteristic. Very rare hypersthene is mostly altered to biotite. Chlorite, epidote, muscovite and carbonate are mainly in large secondary aggregates, some of which are after plagioclase and others hornblende. Some of the chlorite fills tiny fractures or veins. Apatite is present in accessory amounts in nearly all samples but magnetite, sphene and allanite are much scarcer.

The origin of this particular rock unit is in doubt. Many features, such as foliation, mineralogy, relationship to other rock units, and also its location, suggest it to be a metamorphic rock derived from mafic volcanic strata. However, the same features can equally well apply to an intrusive rock of diorite composition that has been deformed so as to develop a good foliation either during emplacement or later. Data at hand are insufficient to resolve this problem but impressions are that the hornblende-plagioclase rock is metamorphic and originates from mafic volcanic rocks.

Granulite (Agl)

Rocks of this map unit are primarily in the northwest and northeast parts of the map area but smaller occurrences are scattered from the extreme east to the extreme north on Charles Island (35I, 35J). Contacts with bordering rocks are gradational in general and intermixing of various other gneissic rocks in the border areas is common. Foliation is well defined and a banded rock is prevalent in some places, such as in the middle parts of the Durouvray River, where banding, which is well enough defined to be visible on air photographs, reveals folds within the granulite. This banding, like that in the paragneiss, is probably relict bedding. In some parts banding is accentuated by the amphibolite layers, which are a few to several tens of metres thick. A few localities, especially within the large area underlain by granulite in the northeast, display no structure; this suggests either a homogenization of the pre-existing strata or a pre-existing massive intrusive rock. Locally the granulite is intruded by granite, granodiorite or pegmatite. The latter rock type is quite common locally as thin dykes and sills (Fig. 29).

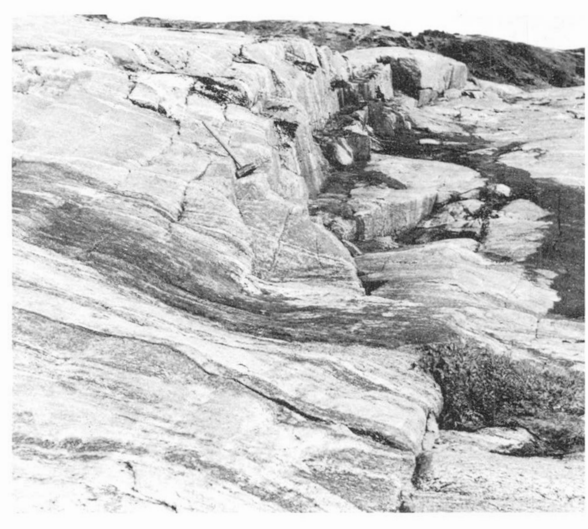

Figure 29. Banded granulite on Peak Island. Dark area in the background is gossan formed of pyrite-rich paragneiss. (35H; F.C. Taylor; GSC 178910)

Typical granulite is a medium-grained, granoblastic, equigranular, light to medium grey rock, much of which is a light rusty colour on weathered surfaces. Hypersthene is deeply weathered and the surface on many samples is covered with tiny pits. Rocks are coarse-grained locally but rarely are there porphyroblastic varieties where garnet is slightly larger than the other minerals. Foliation is marked by the orientation of platy quartz and biotite. Amphiboles rarely show any preferred direction. The darker coloured rocks of high ferromagnesian content are dark grey or grey-green to green. Pyroxenes in many of these rocks are not readily identifiable megascopically.

This granulite is composed primarily of quartz and plagioclase and of lesser and variable amounts of biotite, hornblende, clinopyroxene, orthopyroxene and garnet. Plagioclase (An_{20}-An_{60}), chiefly unaltered, averages An_{36} and in some places is antiperthitic. Most of the biotite, which forms up to 10 per cent, has a distinctive strong, pale yellow-orange to bright foxy red pleochroism not present in the lower grade gneisses. Green to olive-green hornblende attains as much as 25 per cent in some rocks but is absent from others. Clinopyroxene, probably a salite, is very pale green to colourless. In lime-bearing rocks the clinopyroxene is probably diopside. Commonly strongly pleochroic red to green hypersthene ranges from accessory amounts to 25 per cent but averages less than 10 per cent. Subhedral to euhedral dusky red garnet, locally present only, rarely exceeds 5 per cent. Ilmenite, magnetite, apatite and zircon is accessory and in a few places scapolite occurs with diopside. A few samples contain partly perthitic microcline. Alteration products in these granulites show plagioclase to sericite and epidote; hypersthene to iddingsite and uralite primarily, with some to biotite and chlorite and less commonly to cummingtonite with a hornblende rim (Westra, 1978); and clinopyroxene to uralite and chlorite.

Westra noted microscopic amounts of sapphirine in a hypersthene-diopside-garnet-kyanite assemblage in a specimen from Cape Hopes Advance. The same sample contains green spinel. Sapphirine, in megascopic quantities, also occurs on the northwest side of the northeast area of Lac Sirmiq (35K) where the granulite is associated with an amphibolite. The assemblage there is sapphirine-biotite-hypersthene-plagioclase.

Granite gneiss and granodiorite gneiss (Agg)

Underlying about 60 per cent of the Aphebian gneissic terrane north of the Cape Smith Fold Belt are gneissic rocks of granitoid composition. These rocks are characterized by a distinct foliation or banding defined primarily by biotite and rarely by hornblende orientation or concentration. A common, and in places the only, structural element is schlieren. These gneisses grade into most of the other rock units, most notably migmatite Amg) and paragneiss. Contacts are sharp where they border some marble, rusty graphitic gneiss and amphibolite. Inclusions are present in some areas; some are dominantly amphibolite (Agga) and others dominantly paragneiss Aggp). Small dykes and sills of granite, granodiorite and pegmatite are also included in this map unit (Figs. 30 - 32).

A pink to greyish pink, medium-grained, equigranular biotite granodiorite gneiss is typical. Grey to light red varieties are well represented. Whereas fine-grained rocks are sporadic, coarse-grained members are rare. A few localities display plagioclase augens up to 3 cm long. Although green to brown biotite, 4 to 17 per cent and averaging 9 per cent, is ubiquitous, green hornblende accompanies it in only about 25 per cent of the samples. Hornblende does not occur alone but forms up to 21 per cent. Microcline, which is in part perthitic, forms from less than 3 per cent to 60 per cent of the rock. Plagioclase (An_{20-42}), partly antiperthitic, ranges from 27 to 60 per cent. Plagioclase content exceeds potash in almost all rocks and a granodiorite composition is most characteristic but granite, quartz monzonite and tonalite are also represented. Fresh feldspars are typical and extensive sericitization and kaolinitization are only rare. Quartz content ranges fairly uniformly between 13 and 36 per cent. Accessory are apatite, chlorite, epidote, muscovite, calcite, magnetite, ilmenite, hematite, zircon and scapolite in decreasing order of abundance. Of these chlorite and epidote are primarily alteration products.

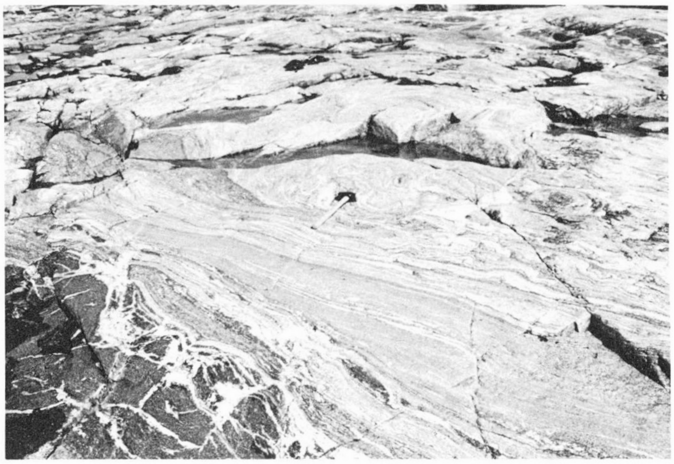

Figure 30. Broken amphibolite in the foreground with layered and contorted granitic gneiss on the west coast 23 km north of Pointe Bernier. (35F; T.M. Gordon; GSC 178426)

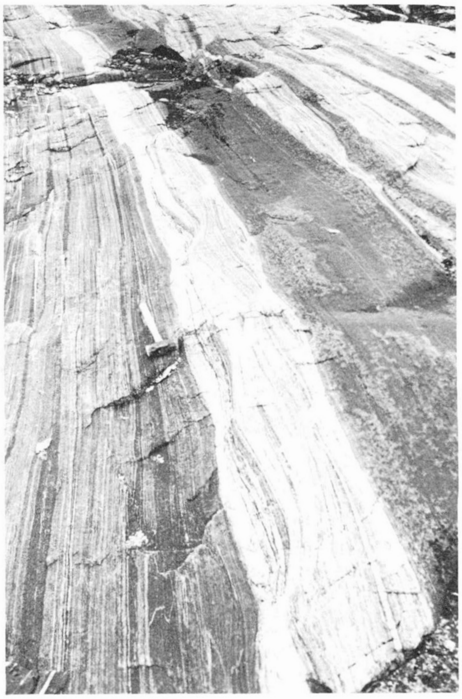

Figure 31. Layered amphibolite, paragneiss and granitic gneiss 2.5 km west of Cap Ennemond-Massé. (35J; J.B. Henderson; GSC 178703)

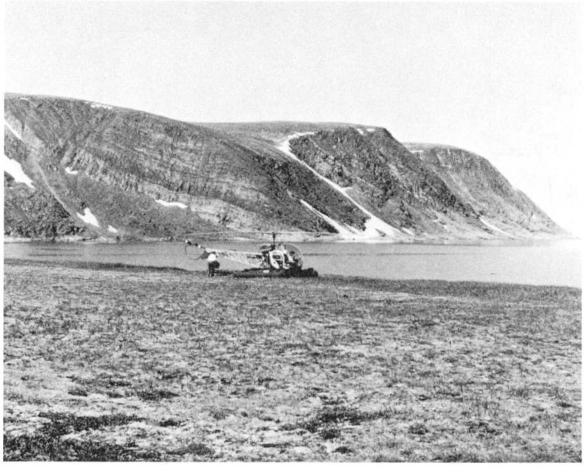

Figure 32. Well banded granitic gneiss west of Point Radisson. (35I; F.C. Taylor; GSC 178884)

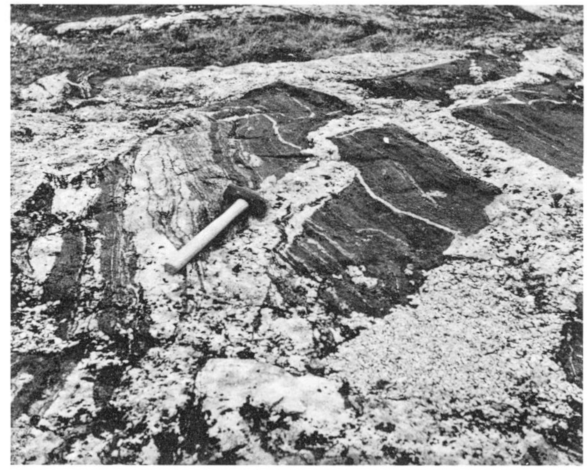

Figure 33. Migmatite on the east side of Nuvuk Islands. (35K; F.C. Taylor; GSC 178778)

This map unit is probably of more than one origin. Some parts, such as where it passes into paragneiss, may be of sedimentary origin. Elsewhere such as where it grades into massive granitic rocks (Agd), (Agr), it may have been intrusive. Although not examined in detail the areas underlain by inclusion-rich components are also considered to have had an intrusive origin.

Migmatite (Amg)

Rocks mapped as migmatite underline only small areas on the west coast and Digges Islands. Some areas shown as granodiorite and granite gneiss with inclusions could equally well be assigned to the unit although migmatite is generally more complex in that it contains more, and in places a greater variety of, inclusions and more intrusive rock. Boundaries between migmatite and granitic gneiss are arbitrarily drawn and those with the other rock types are poorly delineated because gradations between them cover broad zones (Fig. 33).

These Aphebian migmatites are essentially similar to those in the Archean and consist of a dominantly amphibolite and paragneiss paleosome fraction and a granitic neosome fraction. The paleosome, which also includes a granitic fraction in some places, consists of a vast array of shapes, chiefly angular or subangular, and sizes ranging from a few centimetres to several tens of metres in greatest dimension. Amphibolite boulders are prevalent in those parts of the migmatite that can be described as banded. Where a lit-par-lit structure is present the neosome fraction ranges from 30 to 70 per cent and bands range from less than a centimetre to a few metres thick. None of the lit-par-lit zones are known to be extensive either along or across strike. Dykes, sills and irregularly shaped masses comprise the neosome and in many places can be seen to intrude earlier neosome elements. Schlieren and feldspar augen occur in some of the granitic phases. Structures within the migmatite are inconsistent. On a regional scale foliation and banding conform to structures in less deformed rocks but in detail ptygmatic and convolute folding are abundant and attitudes of foliation and banding are random.

Included in this unit are small areas of agmatite in which angular mafic fragments, chiefly amphibolite, occur in a matrix of fine- to medium-grained, pink, equigranular granodiorite. Rare fragments generally a metre or less in greatest dimension are a pinkish grey gneissic granite.

The paleosome paragneiss is similar to that previously described and consists chiefly of medium-grained, biotite-quartz-feldspar gneiss with rare calc-silicate rock and rusty graphitic quartz-rich gneiss. Sillimanite and garnet are present in this paleosome paragneiss on the northwest end of Digges Islands. The paleosome amphibolite is similar to that in the amphibolite unit. Where the paleosome is granitic it is similar to elements of the granite and granodiorite gneiss. Paleosome fragments of granulite or hornblende-plagioclase gneiss are not known to occur in the migmatite.

The neosome consists primarily of a medium-grained, massive, pink to pinkish grey biotite granodiorite or granite. In some places hornblende is present instead of biotite and in others mafic minerals are scarce or absent. A pink to white biotite and/or muscovite pegmatite, which commonly forms crosscutting dykes, is the youngest neosome fraction in many outcrops. The neosome fraction is probably cogenetic with the granodiorite, granite and pegmatite (Agd, Agr, Apm).

Felsic intrusive rocks

Granodiorite, granite, tonalite, diorite and pegmatite (Agd, Agr, Atl, Adr, Apm)

Massive to weakly foliated granitic plutons occur erratically throughout the gneissic terrane north of the Cape Smith Fold Belt. The major occurrences are southeast of Digges Sound (35K). A few of these plutons are within or close to the fold belt strata, predominantly in the northern, more highly metamorphosed parts. The only sizeable pluton in the low-grade (greenschist facies) rocks is at Pecten Harbour (35F) on the west coast. Plutons range from small dykes, which are numerous within the areas underlain by gneissic granitic rocks and migmatite, to batholiths such as those west of the Durouvray River. Some of these plutons display intrusive relationships with rocks such as paragneiss in the form of apophyses into the paragneiss and paragneiss inclusions in the plutons. Contacts hence are not abrupt but rather are several metres or tens of metres wide. Contacts with migmatite and granitic gneiss are gradational. The contact between rocks to the west and the pluton at Lanyan Lake shows a gradational zone over a distance of 60 m in which the hornblende content in a garnet-biotite amphibolite drops until only biotite is present in a variegated grey-green, medium-grained, equigranular biotite- quartz feldspar gneiss. This rock in turn grades, in about 30 m, into a variegated, coarse-grained locally augen-bearing, weakly foliated to massive and well jointed biotite granite. The foliation in the amphibolite and granite are essentially parallel. The contact between tonalite and volcanic rocks outcrops 4 km east-northeast of Pecten Harbour, where foliated, medium-grained, augen biotite tonalite crosscuts and contains inclusions of metavolcanic rock, thereby establishing intrusive relationships with the low-grade metamorphic rock (Fig. 34).

Although intrusive relationships cannot be substantiated for all the plutons it is likely that these rocks postdate all rock types except diabase dykes. Their emplacement is probably late syntectonic because many are foliated along the margins but postdate the formation of the paragneiss and amphibolite.

Compositionally these rocks range from diorite to granite and contain as much as 30 per cent fresh microcline. Plagioclase (An_{20-25}), which is variously fresh to 90 per cent altered to sericite and epidote, forms up to 70 per cent. Brown biotite is the most ubiquitous varietal mineral, forming up to 8 per cent, but not the most abundant. Both hornblende and muscovite exceed the biotite content in some samples. In the dioritic members biotite is scarce and locally absent, and green hornblende is the dominant mineral. Epidote forms a significant proportion (up to 9 per cent) of some samples both as an alteration of plagioclase and as a primary constituent. Chlorite, which is an alteration product of biotite, is locally common. Apatite, iron oxides, sphene and zircon occur in accessory amounts.

The diorite shown southeast of Lac Vanasse differs from the others in that pyroxenes form a significant part (up to 35 per cent) of the rock instead of biotite and hornblende. Both clinopyroxenes and orthopyroxenes are present, and strongly pleochroic hypersthene constitutes about half. Biotite is less than 3 per cent; some of it is a bright foxy red, typical of biotite in granulite. The pyroxenes are partly rimmed with uralite and chlorite, and the chlorite also locally forms veinlets. About 5 per cent potash feldspar is also present. This particular pluton is only tentatively assigned to this unit, as it may be a metamorphic rock. However, in outcrop it is well jointed both vertically and horizontally and although foliation is well to poorly developed, it is inconsistent, so that on the whole the rock appears to be intrusive.

Pegmatite is scattered throughout the gneissic terrane and is locally present with these intrusive rocks. The greatest concentration of pegmatite dykes is near Sugluk Inlet and 15 km north-northwest, 5 km north-northeast and 15 km northwest, of Lac Amarurtuuq, where swarms of north-trending dykes, up to 10 m thick, comprise about 10 per cent of the outcrop. Biotite and less commonly muscovite are the only varietal minerals (Fig. 35).

Figure 34. Amphibolite on the right intruded by biotite granodiorite at Pecten Harbour. (35F; T.M. Gordon; GSC 178429)

Figure 35. Pegmatite in paragneiss 2 km east of Cap Jurie. (35J; J.B. Henderson; GSC 178647)

Diabase (Adb)

A few diabase dykes are erratically distributed within rocks of the Cape Smith Fold Belt and the gneisses to the north, primarily in the western part of the region. The most prominent occur at the Kovik River west of Lac Chassé (35F), 15 km southwest of Lac Ivitaarqiap Tasinga (35K), 12 km east-northeast of Lac Siurartuuq (35K) and at King George Sound (35H). These dykes chiefly have a predominantly northwest trend although the one southwest of Lac Ivitaarqiap Tasinga is distinctly north-northwest and one 4 km north of Lac Bégin is north-northeast. These dykes clearly postdate the gneissic rocks and elements of the Cape Smith Belt, such as the gabbro north of Juet Lake, but their age is not well defined. Their orientation indicates that they are unlikely to be a part of the Hadrynian Franklinian intrusions, which in this region trend west-northwest. Their field relationships show them to be post-Hudsonian Orogeny, and they are considered here to be late Aphebian although they are possibly younger (Helikian?).

These dykes are not nearly as continuous as the Archean or Hadrynian representatives, the longest being only about 8 km. However, the dyke that lies along the east coast at King George Sound outcrops intermittently from there to Charles Island, a distance of 100 km. The same dyke system is probably on strike at Mill Island (Blackadar, 1969) in Hudson Strait, giving a total length of 330 km for this fracture. The thickest dyke outcrops at the Kovik River; it is 60 m but most of them are 20 m or less. The dyke in gabbro north of Juet Lake is only 0.6 m thick. The King George Sound area dyke ranges from 15 to 30 m thick and commonly has several short, thin (less than 2 m) dykes parallel to it. All are vertical.

These dykes are grey-green with reddish brown weathered surfaces; they are fine to medium grained, massive, equigranular, and locally ophitic in texture. Plagioclase and clinopyroxene are fresh. The diabase near Pointe Bernier contains tiny amounts of pyrite.

A dyke sampled by Fahrig (in Wanless et al., 1968) at the south border of the map area has a K-Ar age of 1875 ± 240 Ma, indicative of an Aphebian emplacement. The northerly trending dyke north of this sample, shown as Archean, is possibly Aphebian.

Hadrynian

Diabase

The Hadrynian (**H**) is represented by several diabase dykes striking west-northwest in both the Churchill and Superior structural provinces. These, the youngest rocks, are part of the Franklin diabase dyke swarm (Fahrig et al., 1971), which is widespread in the District of Franklin. In the present map area they range from 15 to 60 m thick and the longest, near Lac Nantais, can be traced with minor breaks for about 20 km. All are vertical. Fahrig et al. (1971) analyzed 12 cores from these dykes paleomagnetically and these show good agreement with the great Franklin diabase swarm on Baffin Island and elsewhere. A whole-rock K-Ar age determination of chilled diabase gave an age of 534 ± 74 Ma and a similar analysis of a biotite-hornblende concentration gave 507 ± 85 Ma (Fahrig et al. 1971).

STRUCTURAL GEOLOGY

The present scale of mapping precludes more than general recognition of major structural elements. The more detailed mapping by Gélinas (1962), Beall (1977), Gold (1962), DeMontigny (1959), and particularly Schimann (1978a) provides additional structural data that show complexities not evident in this reconnaissance survey. The reader is referred to their reports for further information.

Structures in the area fall into two natural divisions, those formed during the Archean and those formed during the Aphebian. In the Archean, banding and foliation trend dominantly north although local exceptions exist. For example, a northwest trend is present northwest of Juet Lake, and an east and northeast foliation south of Grunerite Lake. The northerly trend of foliation in the Archean rocks contrasts sharply in many places in the western and central parts with the prevailing east-northeast to east orientation of the Aphebian structures. However, in other places, particularly in the easternmost part of the area, the Aphebian deformation has affected Archean as well as Aphebian rocks so that structures within them are parallel. This variation is primarily related to depth of erosion and degree of metamorphism. Discrete folds were not delineated anywhere in the Archean terrane. However, Gold (1962) reported an open, inclined anticline plunging west at about 40° in the Archean rocks 8 km north of Lac de la Tente Déchirée (35H). This fold is probably a product of the Hudsonian Orogeny.

Faults in the Archean are common in the eastern part of the map area, especially south of Pointe Bégon and south and west of Fisher Bay (35H). The profusion of faults in these areas as opposed to the western portion of the Archean is probably, in part at least, related to the plentiful outcrop south of Pointe Bégon and the Fisher Bay area where faults are more readily recognized. Some of the lineaments shown in the west and elsewhere may be loci of faults. These faults in the Archean rocks chiefly strike north-northwesterly and northeasterly, and are probably vertical. As some similarly oriented faults displace Aphebian rocks in the Whitley Bay district, some or all of them may be Aphebian or younger in age.

As previously indicated, the Aphebian rocks lie unconformably on the Archean rocks to the south. In the map area to the south Stevenson (1968) showed the same contact as a fault, as does Stam (1961), who mapped a small part of the same area. Stam considered the contact to consist of a thrust fault dipping northward at 40°. Both noted that the Archean rocks have a strongly developed gneissosity at the contact, which rapidly decreases to the south. The extension of this fault into the present map area could not be corroborated and it probably ends at approximately the present map area boundary.

Aphebian fold structures that include all the rocks of the Cape Smith Fold Belt and those to the north involve three major fold directions. The most prominent and oldest of the three is generally easterly and roughly parallel with the Archean-Proterozoic unconformity. The folds in this direction are of several types. They include isoclinal or nearly isoclinal folds that are variously upright or overturned. The overturned isoclinal folds are inclined both southward, as in the Laflamme Lake and Cross Lake areas (Beall, 1977), and northward, such as some of the folds in the Upper Deception River map area (DeMontigny, 1959). Schimann (1978a) recognized recumbent nearly isoclinal folds in the western part of his map area that have not been reported elsewhere. Open folds, both upright and inclined, are also well represented. The extensive syncline east of the Asbestos Hill mine, mapped by Gélinas (1962), is an excellent example of this fold type. Some of these folds open into very broad, basinlike structures, such as the syncline north of Lac Letendre, which plunges west-northwest at about 45° (Gold, 1962). Other folds show a variety of attitudes, such as one mapped by Gold (1962) which is overturned to the north, inclined in the centre and upright at its eastern end. East-striking open folds are also present in the Aphebian gneissic terrane. They are best displayed west of Lac Sirmiq. Plunge directions and amounts are not known for certain but many appear to be of low values and to both east and west.

The second major fold direction is northwest. The open folds trending northwest, which refold the easterly trending folds, are well displayed in the region northwest of Lac Laflamme but are present in many places in the southern part of the eastern third of the Cape Smith Fold Belt. Only rarely, such as near Kettlestone Knob, are they apparent elsewhere in the map area.

Folds in the third fold direction, which is north, are also later than the east-striking folds and refold them. An anticline at Cross Lake (35G) (Beall, 1977) is a good example, as this fold separates an east-plunging syncline east of Cross Lake and a westward-plunging series of folds to the west of the lake. The north-trending folds are prominent in the gneisses west of Deception Bay and to both south and north they can be seen to have refolded the east-striking structures. Less prominent are vertical, open folds with a northerly plunge, recognized by Schimann (1978a) in the western part of his map area through a study of planar and linear structures. In the same study Schimann was also able to recognize shallow, northeast-plunging open folds. Whereas it is well established that the northwest folds postdate the east-striking folds, it has been established only in Schimann's (1978a) area that the north-striking folds postdate the other two. The ages of the northeast folds relative to the northwest folds are not known. Schimann also noted that in the eastern part of his study some east-striking elements postdate the northeast folds and are contemporaneous with the southwest folds.

Faulting in the Aphebian rocks is dominated by a major strike fault system that extends from south of Lanyan Lake eastward to south of Asbestos Hill. A fault line scarp marks the locus of this break for much of its extent. This major fault has been described as a thrust fault by Bergeron (1957a) and Gélinas (1962) and a reverse fault by Beall (1959). Dips of about 70° and 80° north in the sheared and phyllitic rocks along the fault plane are characteristic along most of this fault, but Beall (1959) reported the dip to be 45° north along the river between Cross and Watts lakes. If this fault is indeed a thrust there is the implication of vertically directed force involvement because of the steep dips. Other faults are parallel with this major break, such as a reverse fault that dips 60° north, 2 km south of Lac des Deux-Îles. However, none are as prominent topographically. It may be that they are less continuous and structurally less disruptive so that their topographic expression is subdued.

West of Lac Françoys-Malherbe a strike fault, well expressed in many places, marks the contact between rocks of fold belt and paragneiss to the north. Some places have a shear zone up to 30 m thick whereas others have less than 3 m of fault gouge to show its location. The fault plane dips south at 35° to 50°.

Faults are relatively scarce in the eastern portion of the fold belt. Gold suggested two oblique faults in Brisebois and Rinfret lakes area (35H) and a right-hand strike slip fault through Lac du Bombardier (35H). Gélinas also mapped northwest- and northeast-striking oblique faults north of Asbestos Hill. In general, oblique faults are rare.

Cross faults, younger than the strike faults, are more common than oblique faults but are neither lengthy nor of great displacement. Both left- and right-hand dislocations are present.

METAMORPHISM

A comprehensive metamorphic study was undertaken by Professor L. Westra, using data and examples from the present survey, for inclusion in the volume entitled *Metamorphism* in the Canadian Shield (Westra, 1978). Interested readers are also referred to papers by Hashimoto and Béland (1968) and Schimann (1978a, b) covering metamorphism of silicate iron formation and regional metamorphism in the eastern end of the fold belt, respectively.

GEOCHRONOLOGY

Isotopic age determinations have been carried out on several minerals and rocks of different types, using K-Ar and Rb-Sr techniques (Tables 1 and 2). Geological Survey of Canada K-Ar ages are plotted on the accompanying maps, but those by Beall et al. (1963) are omitted because plotting of sample locations on new topographic maps fails to fit the geology in several instances. For analytical details and interpretations the original references should be consulted.

In the Superior Province K-Ar ages all show the influence of the Hudsonian Orogeny, which has reset the minerals concerned to give Aphebian ages. As Beall et al. (1963) pointed out, Rb-Sr techniques are required in this area to see through the Hudsonian overprinting and disclose the Archean age of the rocks. This has been accomplished, for example, by a GSC Rb-Sr errorchron of 2685 Ma on the granodiorite batholith in the Lac Nantais area and by analyses of Beall et al. (1963). The ~2600 Ma ages for the Archean are products of the Kenoran Orogeny and agree well with those farther south (Stevenson, 1968) in the Superior Province, which are beyond the influence of the Hudsonian Orogeny. K-Ar ages on diabase dykes in the Superior Province, presumably providing the approximate age of the intrusion, show an Aphebian age for a dyke southeast of Lac Péloquin at the south boundary and a Hadrynian age for one extending, with breaks, from Lac Nantais to near Lac Peltier (35G).

In the Churchill Province K-Ar ages for the most part indicate Aphebian metamorphism associated with the Hudsonian Orogeny. Some of the schist and slate determinations are slightly low (circa 1450 - 1500) but these are undoubtedly anomalous. The few ages in the northern gneisses are also Aphebian, showing that these rocks were metamorphosed during the Hudsonian but shedding no light on their primary age. An age of 507 ± 85 Ma on diabase shows it to be Hadrynian.

A single Rb-Sr determination on Archean gneiss north of the fold belt gave an age of 2270 ± 66 Ma (Beall et al., 1963) and is unquestionably on the low side, as it is from beneath the Aphebian-Archean unconformity.

In general these ages confirm relationships established in the field and provide absolute rather than relative age data. They have also disclosed the effect of the Hudsonian Orogeny on Archean rocks well below the unconformity.

Table 1. K-Ar age determinations

Map-area	Rock type and map unit	Mineral	Age (MA)
25E	Amphibolite (Aab)	Hornblende	1639 ± 109[1]
35F	Granite (Agr)	Biotite	1750[2]
35G	Diabase (Hdb)	Biotite	507 ± 85[3]
	Diabase (Adb)	Whole rock	1875 ± 240[4]
	Diabase (Hdb)	Whole rock	534 ± 74[4]
	Amphibolite (Apg)	Biotite	1628 ± 41[1]
	Amphibolite (Apg)	Hornblende	1658 ± 48[1]
	Slate	Whole rock	1430 ± 30[5]
	Schist	Muscovite	1430 ± 50[5]
	Schist	Muscovite	1570 ± 70[5]
	Schist	Whole rock	1550 ± 40[5]
	Biotite gneiss	Biotite	1800 ± 60[5]
35H	Migmatite (Apg)	Biotite	1715[2]
	Amphibolite (mafic gneiss) (Agg)	Hornblende	1548 ± 48[1]
	Amphibolite (mafic gneiss) (Agg)	Biotite	1639 ± 40[1]
	Slate	Whole rock	1490 ± 50[5]
	Schist	Muscovite	1460 ± 80[5]
	Schist	Biotite	1650 ± 30[5]
	Schist	Biotite	1570 ± 40[5]
	Schist	Biotite	1840 ± 40[5]
	Biotite gneiss	Biotite	1660 ± 30[5]
	Biotite gneiss	Biotite	1850 ± 30[5]
35J	Biotite-quartz-feldspar gneiss (Agg)	Biotite	1655[2]

[1]Wanless et al. (1974).
[2]Lowdon (1961).
[3]Wanless et al. (1966).
[4]Wanless et al. (1968).
[5]Beall et al. (1963).

Table 2. Rb-Sr age determinations

Map-area	Rock type	Age
35G	Granodiorite (Agd)	2685[1]
35H	Biotite-quartz-feldspar gneiss (Agg)	2270 ± 66[2]
	Granodiorite (Agd)	2320 ± 70[2]
	Granodiorite (Agd)	2760 ± 130[2]
	Quartz-biotite schist (Asc)	1430 ± 35[2]

[1] Errorchron; Taylor and Loveridge (1981).
[2] Beall et al. (1963).

REGIONAL SYNTHESIS

The geological history of the region commenced with Archean deposition, on a basement of unknown character, of a mixed assemblage of sedimentary and volcanic rocks that are now confined to narrow north-trending outcrop areas. The few structures preserved in these rocks offer only meagre data on which to deduce the conditions prevailing during their deposition. In the sedimentary rocks the variety and quantity of detrital grains are insufficient to furnish any meaningful information as to source rocks. Carbonate-bearing rocks and well sorted quartzite indicate a shallow water or shelf-type depositional environment and carbonate rocks may also indicate warm water. In the volcanic rocks rare pillows point to underwater extrusion and the tuffaceous elements support shallow water conditions. The depositional age of these layered rocks is unknown.

The Archean rocks were deformed, metamorphosed and intruded by granitic rocks during the Kenoran Orogeny. Deformation in this region, unlike that in the southern part of the Superior Province, was controlled by east-west compression in most places; this is now apparent in narrow northerly striking supracrustal belts. Concomitantly these rocks were uniformly metamorphosed to the amphibolite metamorphic facies. Intrusion of batholith-size plutons of granitic rocks, dominantly granodiorite but ranging from tonalite to granite, accompanied the deformation and metamorphism. Isotopic analyses of the intrusive rocks by K-Ar and Rb-Sr techniques established their age as ~2660 Ma. Local gabbro stocks postdate the granitic intrusions and are posttectonic.

At the conclusion of the mountain building, tensional forces replaced compressional and a swarm of diabase dykes striking dominantly north-northwest was emplaced in the eastern part of the area. This intrusion was followed by lengthy and deep erosion, which saw the surface reduced sufficiently to expose the amphibolite facies rocks and unroof the granitic batholiths. This erosion surface reached a peneplane stage similar to that extant. As the erosion surface beneath the Aphebian strata does not display a deep regolith anywhere and is commonly fresh rock, a temperate climate can be postulated.

During the lower Aphebian, seas once again inundated the region, probably chiefly from the north, overlapping the peneplane. This marine encroachment is part of the southern limit of the Baffin Geosyncline (Jackson and Taylor, 1972), which saw a great depositional area extend northward over Baffin Island. Whereas in most places sedimentary rocks form the basal elements of the Aphebian strata, locally volcanic rocks lie directly on the Archean surface, attesting to early volcanism once the region had changed from an erosional to a depositional site. The basal sedimentary rocks assemblage, which commonly includes iron formation in the central and eastern part of the region, suggests a shallow water marine environment. Although iron formation is not represented in the west, the assemblage shale-quartzite-dolomite with scattered conglomerate confirms a shallow and probably warm sea setting. Baragar (1974) reported about 500 m of the basal sedimentary rocks in a section south of Lac Beauparlant but, as previously indicated, volcanic rocks locally are present at the unconformity and also are interbedded, as north of Lac de l'Ours Blanc (35H). Whereas the seas were probably consistently shallow, the shelflike conditions varied along the depositional zone and were unstable because of volcanism. No current data are available and following the present survey there is some doubt that the sedimentary rocks contain sufficient parameters to provide a statistically significant result. Depression, however, must have been gradual until sedimentation was replaced by a great, dominantly submarine, outpouring of mafic volcanic rocks, including komatiitic types. During breaks in the volcanism, thin beds of rocks, chiefly argillaceous but locally carbonate and sandstone, were deposited with the volcanic rocks. Although the volcanism was overwhelmingly submarine and mafic, tuffaceous and silicic rocks were extruded locally; the latter were primarily explosive. Rapid cooling of some of the mafic rocks is indicated by quench textures in some basalts.

Penecontemporaneously with the volcanism, a great host of mafic rocks, ranging from gabbro to peridotite, were intruded. In places they may have intruded near the surface because some of the water-saturated sedimentary rocks show evidence of baking and are highly vesicular. The mafic intrusions display evidence of differentiation, both in place and in a magma chamber. Sills are both simple and compound; some are wholly gabbro or peridotite and others display a transition from gabbro through pyroxenite to peridotite. These intrusions, like the sedimentary rocks, are scarcer in the west than in the east.

In the general area of Chukotat Lake and to the east-northeast toward Nuvilik Lakes and beyond, an extensive zone of volcanic breccias attests to a change in the type of volcanic activity from relatively passive submarine flows to violent eruptions. Near Chukotat Lake a laterally extensive explosion breccia was formed at one stage following consolidation of some of the sedimentary and volcanic rocks, and possibly is related to this period of violent eruption. Accompanying these rocks are chemical sediments, jasper and chert, carbonates and detrital sediments. Stratigraphically higher volcanism resumed its earlier character.

Baragar's (1974) section shows about 1500 m of predominantly sedimentary rocks at about this level in the stratigraphy, but in many places this zone is not only much thinner but also contains fewer sedimentary rocks.

The gneissic area north of the western part of the Cape Smith Fold Belt is here interpreted as part of the Baffin Geosyncline and to have consisted chiefly of sedimentary strata presumably overlying the volcanic rocks. Since tops in the metamorphosed layered rocks in the northern parts of the belt have not been determined, their stratigraphic position is in doubt. A case can be made for extending the unconformity on the north side of the fold belt farther west, possibly as far as longitude 74°W. Hence the size of the area of Archean rocks north of the fold belt would be expanded from that shown (35H). However, there are no data at present supporting an extension of the unconformity west of longtitude 74°W.

The Aphebian layered rocks were deformed, metamorphosed and intruded during the Hudsonian Orogeny. Deformation at this time was primarily compressive from the north, resulting in extensive east-northeast folds and strike faults. These major reverse faults dip steeply north for the most part but a south-dipping thrust fault is well defined west of Lac Françoys-Malherbe.

A second deformation resulted in a series of northwest-striking folds that are well developed in the east-central part of the area. Related folds may be present east of Kovik Bay. The strike of these folds is parallel with those in the Labrador Trough, which suggests that the Labrador Trough deformation postdates the major easterly Cape Smith Belt folding.

Metamorphism of the Aphebian rocks ranges from greenschist to granulite facies, the former prevalent in the south and west with prograde effects to the north and east. This Hudsonian metamorphism also affected the underlying Archean rocks, retrograding them from amphibolite to greenschist throughout almost all the Archean terrane south of the fold belt (Westra, 1978). North of the fold belt most of the granulite facies rocks have been overprinted by amphibolite facies assemblages (ibid). Westra noted that this overprinting could be retrogradation due to hydration resulting from an increase in the partial pressure of water, which is not necessarily accompanied by a temperature drop.

This is the interpretation favoured here. However, as Westra pointed out, the granulite assemblages may be relicts of an older, probably Kenoran, event that was retrograded during the Hudsonian Orogeny.

Intrusive rocks ranging from diorite to granite emplaced during the Hudsonian Orogeny are for the most part within the gneissic terrane but a few plutons occur in the western part of the area within the area of greenschist metamorphism. Local zones of abundant pegmatite dykes are considered a late phase of this intrusive period.

Near the close of the Hudsonian Orogeny or following it, a few chiefly northwest-trending diabase dykes of probable Aphebian age were emplaced. Tensional forces were active again in the Hadrynian when west-northwest trending diabase dykes, members of the extensive Franklin swarm, were intruded.

Erosion has reduced the region to its present level. The closeness of Paleozoic carbonate rocks east and west of the area suggests that they may have covered this region at one time. Glacial and postglacial deposits shape much of the surface because it was covered by ice during the Pleistocene.

The linearity of the Cape Smith Fold Belt has promoted proponents of plate tectonics to apply that concept to this region. For example, Gibb and Walcott (1971) suggested the belt was part of a major suture peripheral to the Superior Province. Similarly, the region was also used by Burke and Dewey (1973) as an example of Precambrian collision and suturing. More recently, Thomas and Gibb (1977), primarily using gravity data, interpreted the basaltic rocks as remnants of oceanic crust tectonically emplaced by obduction on shelf deposits of the Superior Craton. However, Baer (1977) rejected the Thomas and Gibb model as a proof of plate tectonic activity, pointing out that an earlier gravity model of Tanner and McConnell (1964) applies equally well and that the geological data do not fit. The Tanner and McConnell model ascribed the positive Bouguer anomalies over the belt to the high-density volcanic and intrusive rocks, and the flanking negative anomalies to a regional negative anomaly explained by the existence of a root at the base of the crust.

Certain geological facts must be accounted for in any Aphebian mountain building concept. One critical factor is the absence at the east end of the belt, where the Archean basement is exposed on both sides and at the end, of any indication of a suture in the form of shearing or mylonitization. It is also worth noting that there is no evidence of a suture in the rocks at the north end of the Labrador Trough (Stevenson, 1968). Similarly, the major strike faults, either individually or collectively, do not extend for the length of the belt and in fact, although sometimes referred to as thrusts, may not be thrusts in the normal sense of the word, as dips on the fault planes are commonly about 70° to 80°.

ECONOMIC GEOLOGY

Mineral exploration of the Cape Smith Fold Belt was intensive during the 1950s following the discovery of nickel and other base metals. Numerous companies engaged in the search for base metals and this work led to the discovery of sizeable nickel deposits and an asbestos property, which has since become the only mine in the region. Search for base metals other than nickel has not been pursued with the same intensity but the geology is of sufficient diversity that zinc, copper and precious metals may well be present in economic quantities. A useful listing of mineral occurrences has been compiled by Dugas (1971).

Asbestos

Murray Watts discovered asbestos in 1957 following an aerial reconnaissance that revealed a major ultrabasic pluton in the northern part of the Cape Smith Belt. After detailed exploration of the property, which outlined 16 million tons of high-grade asbestos ore, the property was optioned in 1962 to Hudson Strait Asbestos Limited, a wholly owned subsidiary of Asbestos Corporation Limited. In 1964, Asbestos Corporation Limited exercised its option and acquired the property and consolidated assets of Murray Mining Corporation Limited.

Mining commenced in mid-1972 as an open pit operation feeding a 3000-ton-per-day mill to produce annually 300 000 tons of concentrate, approximately one-third fibre. By 1975 an underground development had been initiated so that probably by 1982 this mine will be an underground operation. The mine operates from February to December. Ore reserves are listed as 20 838 000 tons for 1979, 17 389 000 tons for 1978 and 18 185 000 tons for 1977 (Northern Miner Press, 1980-81). Concentrate is stored at Deception Bay, 67 km from the mine site by road, until the shipping season, when it is shipped to Nordenham, West Germany, for finishing.

The orebody lies in a large elliptical ultrabasic sill at least 1200 m thick forming part of a large syncline. The geology of the mine has been described by Stewart (1976) and the following summary is from his report. Three principal rock types, all extensively to entirely altered, dunite, peridotite and pyroxenite, occur in various individual layers throughout the sill. Altered pyroxenite or pyroxene-rich rocks constitute 60 to 70 per cent of the sill, but dunite and peridotite are more common than normal next to and south of the orebody. Layering is common; on a large scale alternating pyroxene-rich and olivine-rich layers vary from 6 to 300 m thick and average about 100 m, and within these layers similar minor layering and banding range from 6 to 60 cm. This banding or layering parallels the sill walls. Asbestos mineralization is primarily in the major serpentinized dunite layers, especially those parts lying within 30 to 45 m of adjacent pyroxene-rich layers.

Serpentinite is replaced by talc along faults and shears and also next to the quartzite north of the mine. Talc also forms veins within or close to fibre zones.

The orebody lies in a serpentinized dunite layer 150 to 180 m thick which in plan has a rough lenticular shape of 400 m by 30 to 60 m. It plunges northeast 25° to 30° to at least 360 m. A fairly sharp boundary exists between barren wall rock and ore. The ore is a cross-fibre deposit, principally of gash-type veins, which range from several centimetres to a few metres, chiefly oriented either parallel with or normal to the layering. Fibre veins are predominantly 4.5 to 6 mm thick, which is consistent throughout the orebody.

Stewart (1976) suggested that the chrysotile was formed during the second of two alteration periods, and was associated with regional metamorphism and tectonic activity.

The likelihood of discovering further economic asbestos deposits through surface prospecting is small. Undoubtedly, surface exposures of all large ultrabasics have by this time been examined so that prospecting in the future will have to rely on the discovery of any buried ultrabasic plutons or blind asbestos occurrences in exposed plutons. The large sill containing the present orebody is probably the best target, but large ultrabasic plutons to the west near Lac Watts may be worth investigating. Plutons in the southern part of the belt are well exposed and significant amounts of asbestos are rare, so that these rocks are not likely to be as rewarding as those in the north.

Nickel

Significant concentrations of nickel sulphides have been discovered in several places in the Cape Smith Fold Belt. These are almost invariably within or close to ultrabasic rocks, and in other rock types, chiefly in slate. New Quebec Raglan Mines Limited, which is 68.3 per cent owned by Falconbridge Nickel Limited, outlined a total of 15 050 000 tons grading 2.58 Ni and 0.71 Cu from four localities. An additional 10 050 000 tons averaging 1.55 Ni and 0.78 Cu were also discovered, but are not considered as potential ore because of metallurgical problems.

The above results led to the sinking of a shaft in 1967 and 1970 at the Donaldson property (35H) to a depth of 924 feet, with levels at 350, 525, 700 and 875 feet. Underground development included 4393 feet of drift and crosscuts, and 43 637 feet of diamond drilling. Over 56 km of road were constructed from the property to Douglas Harbour before the project was shut down in 1972 because of adverse economic conditions.

The nickel occurrences belong to the 'volcanic' type of Kilburn et al. (1969) in which ultrabasic bodies occur in concordant intrusions within a volcanic sequence. In this type of deposit mineralization is concentrated in the lower parts of the intrusive masses and commonly at the contact. For example, Kilburn et al. reported that in the Cross Lake occurrence nickel sulphide is concentrated in depressions or permanent flexures in the lower contact of the intrusion and in lenses of disseminated sulphide above the contacts. Similarly, Miller (1977) noted that both massive and interstitial sulphides in the '2-3 sill' lie in canoe-shaped troughs at the base of that sill. Other comparable sulphide concentrations have been reported by Beall (1977). Kilburn et al. reported that fractures in footwall quartzites are filled by massive sulphides in a few places. Sulphide and oxide minerals comprising these deposits are pyrrhotite, pentlandite, pyrite, chalcopyrite, magnetite, sphalerite and violarite.

Miller (1977) recognized that all significant nickel occurrences are associated with high-magnesium basalts, which form the lower part of the great volcanic sequence. On the basis of past discoveries, further nickel prospecting should be concentrated on the lower parts of the ultrabasic sills in the high-magnesium volcanic rocks.

Although gossans are numerous throughout the belt no other significant discoveries have been made as yet. Sulphide mineralization, chiefly pyrrhotite and pyrite, is common in the interflow sedimentary rocks, especially the dark-coloured slates.

Schimann (1978a) located two zones considered to be exhalites. A massive to banded, pyrite and pyrrhotite horizon 1 to 2 m thick lies within sedimentary rocks and tuffs 5.6 km northeast of Lac Félix (35H). Gossan along strike is traceable for 10 km. The second zone consists of 1 m of felsic tuff containing 5 per cent each of galena and sphalerite 12 km southeast of Lac Vicenza. Rocks in the areas east of Chukotat Lake, west of Lac Watts and south of Nuvilik Lakes are lithologically compatible with exhalative concepts of mineral deposition because chert, carbonates and felsic volcanics are commonly present. These areas are worthy, therefore, of careful examination for mineralization.

Gossans in the zones of carbonatized rocks south of Lac Serpentine should be examined, particularly for gold.

Stream sediments were analyzed for Cu, Zn, Pb, Ni, Co and Mn within the Cape Smith Fold Belt from longitude 72°30'W to 73°00'W by Schimann (1978a) and Ministère des Richesses Naturelles de Québec (undated). The analyses revealed several anomalous areas, some of which appear to be related to gossans. A strong Ni anomaly is present 8 km northeast and a Cu, Ni, Co anomaly 13 km east of Lac Vicenza.

Iron formation, although locally over 60 per cent iron oxide, is too thin and lean to be of economic interest at this time.

Allan (1973) studied metal dispersion in surficial materials of the permafrost areas in the vicinity of the Ni-Cu zones of Falconbridge Nickel Limited. His results indicate that geochemical techniques involving soil, drainage sediment, eskers, stream and lake water and snow may complement geological and geophysical methods in a total exploration program.

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