GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

MEMOIR 347

BACHE PENINSULA, ELLESMERE ISLAND, ARCTIC ARCHIPELAGO

R. L. Christie

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BACHE PENINSULA, ELLESMERE ISLAND,

ARCTIC ARCHIPELAGO

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PLATE I. Cape Camperdown and the south shore of Bache Peninsula; view west. The gneissic basement rocks and the overlying dark- and light-weathering Cambrian or older beds form the coastal cliffs.

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PREFACE

Lower Palaeozoic and underlying beds on Bache Peninsula, on the western side of Kane Basin, were first examined by the British Naval Expedition of 1875 under Captain Nares. These beds, on both sides of Kane Basin, have attracted the attention of numerous geologists in the nearly 90 years following, and certain sections have become well known from published descriptions. This report represents a reconnaissance study of sections of these beds exposed in the Bache Peninsula region.

Thin shoreward equivalents of thicker, basinal formations to the west are exposed on Bache Peninsula, and relationships recognized there may be used in evaluating the oil potential of the western beds.

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

OTTAWA, June 23, 1964

MEMOIR 347 — Bache Peninsula, Ellesmereland, Arktischer Archipel.
Von R. L. Christie

Beschreibung der klastischen und kalkigen Schichten des Unteren Paläozoikums und der präkambrischen Gneise im nordöstlichen Teil der kanadischen Arktis.

ТРУД 347 — Полуостров Бачи, Остров Эллсмира, Арктический Архипелаг.
Р. Л. Христи

Дается описание нижне-палеозойских кластических и известковых отложений и докембрийских гнейсов в северо-восточной канадской Арктике.

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Abstract

Bache Peninsula, which lies about the middle of the east coast of Ellesmere Island, is a plateau area in which faulted, homoclinal lower Palaeozoic strata overlie Precambrian gneisses and granite. The Palaeozoic section, some 4,000 feet thick, bears close affinities to that of Northwest Greenland, where the type localities for many of the formations are found.

Some unfossiliferous, basal clastic beds are of limited extent and may be of late Precambrian age. Other basal sandstone and dolomite formations are of wide distribution, and may be correlatives of known Cambrian and possible Cambrian beds in nearby areas of Ellesmere Island. Overlying dolomite and dolomitic limestone formations are correlatable, on faunal and stratigraphic grounds, with similar formations in Northwest Greenland. The youngest Palaeozoic beds are gypsum and dolomitic limestone, and faunal collections from them indicate a Lower Ordovician age.

Small areas of down-faulted Tertiary beds with thin coal seams overlie the Palaeozoic rocks.

The following significant stratigraphic breaks are inferred in the sequence of layered rocks: (a) a disconformity at the base of the Palaeozoic section, separating it from underlying beds of unknown age; (b) a disconformity separating Middle Cambrian and Lower Ordovician strata; and (c) a disconformity or unconformity separating Palaeozoic and Tertiary strata.

Marine shell fragments in surficial deposits well above the limit of post-glacial marine submergence represent a considerably older marine period and probably were transported to their present positions by glacial ice.

Résumé

La presqu'île Bache, qui se trouve à peu près au centre de la côte est de l'île Ellesmere, est un plateau où des strates faillées et homoclinales du Paléozoïque inférieur recouvrent des gneiss et des granites précambriens. La coupe paléozoïque de quelque 4,000 pieds d'épaisseur présente des affinités prononcées avec celle du Nord-Ouest du Groenland où l'on a trouvé les types locaux de plusieurs formations.

Quelques couches clastiques de base non fossilifères d'une étendue restreinte peuvent remonter au Précambrien supérieur. D'autres formations de base à grès et à dolomie sont très répandues et peuvent être mises en corrélation avec des couches cambriennes connues ou possibles dans les régions avoisinantes sur l'île Ellesmere. La dolomie sus-jacente et les formations de

calcaire dolomitique peuvent être mises en corrélation, du point de vue de la faune et de la stratigraphie, avec des formations semblables du Nord-Ouest du Groenland. Les couches paléozoïques les plus jeunes sont de gypse et de calcaire dolomitique, et la faune qui s'y trouve indique que la formation remonte à l'Ordovicien inférieur.

En des endroits de peu d'étendue, des couches du Tertiaire faillées par abaissement et comportant de minces filons de charbon recouvrent les roches du Paléozoïque.

Voici, d'après la séquence des strates, les principales lacunes stratigraphiques: (a) une discordance à la base de la partie paléozoïque la séparant des couches sous-jacentes d'âge inconnu; (b) une discordance qui sépare les strates du Cambrien moyen de celles de l'Ordovicien inférieur; et (c) une discordance qui sépare les strates du Paléozoïque de celles du Tertiaire.

Des fragments de coquillages marins dans les dépôts de surface, qui se trouvent bien au-dessus du niveau des terres submergées lors de la période postglaciaire, représentent une période pélagique beaucoup plus ancienne; ils ont probablement été transportés à cet endroit par les glaciers.

INTRODUCTION

Bache Peninsula lies at latitude 79°04'N on the east coast of Ellesmere Island. The peninsula projects into Kane Basin, with Inglefield Land, Greenland on the other side, only 50 miles away.

This report describes the geology of the sedimentary rocks of Bache Peninsula; field work was conducted here in 1961 during a reconnaissance survey based at Alexandra Fiord, a few miles south of the map-area, and until recently an R.C.M. Police detachment. The Precambrian gneissic 'basement' rocks are shown on a preliminary map (Christie, 1962)[1] already published by the Geological Survey of Canada; these rocks, to be described in a separate report, will not be considered in detail here.

Field work on Bache Peninsula began near the end of April, 1961, with a reconnaissance by dog team of the coasts of Flagler Bay and the lower parts of the valley of Sverdrup Pass. More detailed study was carried out on foot between June 18 and July 17, using dog teams and aircraft for transport of camps. Both Beaver and Piper Super-Cub aircraft were used, the machines in each case fitted with large, low-pressure tires for landings on unprepared terrain. Stratigraphic sections were measured at several places along the south coast of Bache Peninsula, at Bartlett Bay on the east coast, and on Sanddöla Creek[2], west of Bache Peninsula. Except for some data obtained on scattered foot traverses, the formational mapping was done from air photographs and from binocular study from vantage points in the area.

Settlements and Accessibility

There are no settlements in the map-area; the Alexandra Fiord R.C.M. Police post lies about 8 miles south, opposite the mouth of Flagler Fiord. In 1963 this station was abandoned, and some of the buildings removed.

An R.C.M. Police post stood formerly on the south shore of Bache Peninsula at the mouth of Flagler Bay. This well known post, Bache Peninsula, was established in 1926 and abandoned in 1933. Although the buildings have been removed (they presently stand at Alexandra Fiord) the site is well marked by their foundations, and will be referred to in the following text as 'the Police Post'.

[1] Names and/or dates in parentheses are those of *Bibliography* at end of report.

[2] The name is taken from the descriptive note, 'sanddöla', on Isachsen's map of Buchanan Bay and Bache Peninsula (*see* Sverdrup: New Land; Longmans, Green, and Co., London, 1904). The note is an old Norwegian form of 'sandy dale'.

Bache Peninsula is not readily accessible, because of the absence of settlements and regular shipping or air travel in the region. It can, however, be reached by ski-equipped aircraft and by icebreakers at suitable times of the year. Aircraft may land on the ice of the numerous fiords from late autumn until about the end of June; after about mid-June, light aircraft with oversize tires may land at selected sites, including the Alexandra Fiord Police Post. Icebreakers or ice-strengthened ships have little difficulty in navigating Kane Basin in August, but adverse conditions in Buchanan Bay have resulted in considerable delays in shipping. The Police Post was visited by ship in 1927, but ice conditions prevented further visits until 1931, and finally the detachment evacuated by sled to Craig Harbour, on the south coast of Ellesmere Island, in the spring of 1933. Modern icebreakers, however, have relatively little difficulty in the same waters.

Travel by dog team is feasible along the coasts, fiords, and major valleys, and Greenland Eskimos occasionally cross Smith Sound to visit Ellesmere Island. Open water due to strong tidal currents may be encountered at any time of year at certain narrows in fiords, and coastal ice often is removed from the capes by currents and storms. The island-studded narrows near the Police Post remains open the year round.

History of Exploration

Bache Peninsula is a crossroads of both prehistoric and historic polar travel. The well-travelled coastal route northward has been used by ship and by sledge since the early days of exploration, and Sverdrup Pass, to the west, has provided a low, relatively easy sledge route through the rugged east-coastal mountains to the rolling, game-rich western parts of Ellesmere Island.

The first European explorer to sight Bache Peninsula was Commander A. E. Inglefield, R.N., who explored northward into Smith Sound in 1852. Victoria Head and Cape Albert were sighted and named just before Inglefield's ship was driven southward from the entrance to Kane Basin by a severe storm. In 1854 the east coast of the peninsula was travelled by Dr. I. I. Hayes, the surgeon of Dr. E. K. Kane's expedition. Kane applied the names of Bache[1] and Henry, who were the principal patrons of his expedition, to capes earlier named by Inglefield. Hayes mapped the peninsula as two islands, using Kane's names 'Bache' and 'Henry', on a northward sledge journey during a later expedition led by himself (1860-61).

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[1] It is timely to recall that Alexander Dallas Bache, after whom the peninsula is named, occupies an important place in the history of research, particularly in the marine sciences, in the United States. Bache was Superintendent of the U.S. Coast Survey in 1846-47, when he placed a ship for marine research at the disposal of Louis Agassiz. In 1862, Bache, Joseph Henry, and one other were established by the U.S. Congress as a 'permanent commission' reporting to the Navy on scientific research that might be useful in war effort, and in 1863 Bache promoted and became first president of the National Academy of Sciences. These achievements have been taken to mark the beginning of efforts to secure government aid and encouragement for science in the United States (Lurie, 1960, p. 332).

The Royal Navy expedition of 1875-76 under Captain Sir George Nares navigated Buchanan Bay and the east coast of the peninsula, and landed at Victoria Head. Fossils collected at the landing and observations made by this expedition provided the first accurate knowledge of the geology and physiography of the Bache Peninsula region.

The expeditions of Captain C. F. Hall (1871-73) and of Lieutenant A. W. Greely (1881-83) passed Bache Peninsula but did not observe or add new information.

The Second Norwegian Expedition in the *Fram,* commanded by Captain Otto Sverdrup, wintered in Rice Strait just south of Buchanan Bay in 1898-99. From there, several parties explored and hunted along Flagler Bay and Bache Peninsula.

Commander R. E. Peary hunted and explored on and near Bache Peninsula in the course of his polar expeditions of 1898-99 and 1901-02. A depot, including coal, was landed on the north shore of Bartlett Bay in 1905. The remains of this depot are visible today.

Dr. F. A. Cook travelled westward through Sverdrup Pass on his purported journey to the North Pole in 1908.

D. B. MacMillan and E. Ekblaw passed through the Bache Peninsula region in the course of MacMillan's Crocker Land Expedition (1913-17).

In 1926 the R.C.M. Police Post, Bache Peninsula, was established. The buildings and men were brought in by Captain J. E. Bernier in the C.G.S. *Arctic,* and the post was erected on a small delta beneath high cliffs at the mouth of Flagler Bay. The German geologist-explorer Dr. H. K. E. Krueger and his two companions stopped at Bache Peninsula in 1930 on their westward and northward sledge journey. When the Krueger party failed to return, search trips from Bache Peninsula were made in 1932 by Corporal H. W. Stallworthy and Constable R. W. Hamilton.

Later visits to Bache Peninsula included: the Oxford University Ellesmere Land Expedition, which used the abandoned Police Post in 1935 as an advanced sledging base for exploration both locally and to the west and north; J. M. Wordie, who visited the Police Post briefly by ship in 1937; and the Danish Thule and Ellesmere Expedition in 1940 on its westward journey through Sverdrup Pass.

Previous Geological Investigations

The earliest observations on the geology of Bache Peninsula were made by the surgeons P. C. Sutherland and I. I. Hayes, of Inglefield's and Kane's Expeditions, respectively. Sutherland, from shipboard (south of Cape Sabine and in a rising storm), compared the terrain between Victoria Head and Cape Isabella to Cape Farewell (Greenland), and pessimistically added that 'any idea of fossiliferous strata may safely be excluded (*in* Inglefield, 1853, p. 147). Hayes, after his sledge journey down the west side of Kane Basin in 1854, described 'high cliffs of magnesian limestone as far down as Cape Sabine' (*in* Kane, 1856, Vol. II, p. 370).

Geological observations and collections on Bache Peninsula were made by Captain H. W. Feilden, naturalist on the Nares Expedition. Feilden published a geological map that included Bache Peninsula (Feilden and De Rance, 1878, Pl. XXIV) and described the coarse basal beds of the Silurian[1] of the south coast of Bache Island as 'resting on syenitic and granitoid rocks'[2] and 'overlain by mural cliffs of limestone rising to a height of more than 1,000 feet, dipping gently to the NNW.' The brief landing and small collection of fossils obtained from Victoria Head have been mentioned.

Per Schei, geologist of Sverdrup's Expedition, examined Bache Peninsula at several localities in 1899 and discovered the diabase sills in the basal beds that overlie the basement gneisses. He further identified certain higher dolomite beds as the source of Cambrian fossils. Schei's preliminary accounts (1903, 1904) were later amplified in reports by Bugge (1910) and by Holtedahl (1913, 1917). Holtedahl described the sequence of sedimentary rocks from Schei's notes, and described the Cambrian and Ordovician fossils collected by Schei along the east coast of the peninsula. Bugge studied and described specimens of the Precambrian metamorphic complex collected by Schei.

Robert Bentham, geologist of the Oxford University Ellesmere Land Expedition, made numerous fossil collections on Bache Peninsula and briefly described (Bentham, 1936, p. 427) the succession of sedimentary rocks. Bentham's collections, mostly from talus, contain the widest variety of Cambrian and Lower Ordovician fossils yet collected in the Canadian Arctic Archipelago. Bentham compared the red basal sandstone with the Thule Formation of Greenland, and identified certain overlying limestone beds as the source of Cambrian fossils.

J. M. Wordie visited the Police Post in 1937 to examine the relationships of the basal sandstone described by Schei and Bentham. Wordie found no break in succession, and concluded that the 'Thule beds' at Bache are merely basement lower Cambrian strata.

The Cambro-Ordovician fossils collected by Bentham were described by Chr. Poulsen (1946, p. 299), who also reassessed certain of Schei's earlier described fossils, and discussed the correlation of Cambrian and Lower Ordovician beds of Bache Peninsula and Northwest Greenland.

J. C. Troelsen, geologist of the Danish Thule and Ellesmere Land Expedition, sledged along Bache Peninsula in the early spring of 1940 and examined several localities, including the section at the Police Post. Troelsen's knowledge

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1 Feilden and De Rance regarded the beds as Lower Silurian. Their geological account preceded by one year Lapworth's introduction of the term 'Ordovician' for beds of this age.

2 Feilden's map, in a more accurate manner than the description, shows 'mica schists and altered rocks' on the south coast of Bache Peninsula.

of the lower Palaeozoic succession of northwestern Greenland enabled him to apply several Greenland formational names to the rocks of Bache Peninsula (*see* Troelsen, 1950).

Acknowledgments

The author thanks Superintendent W. J. Fraser, R.C.M. Police, for permission to use the post at Alexandra Fiord as a base, and Constables J. A. Armstrong and R. Siddle for their hospitality and help during the field season. N. E. Haimila of Canmore, Alberta, was an able assistant. The sledging services of Okoko and the late Pauloosie, both of Grise Fiord, are gratefully acknowledged also. For fossil identifications the author is indebted to G. Winston Sinclair, Geological Surveys of Canada, and to J. W. Cowie, Bristol University.

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PHYSIOGRAPHY AND GLACIATION

Bache and Knud Peninsulas are part of a small, relatively low, dissected plateau area in the mountainous east coast of Ellesmere Island. The plateau, joined by Sverdrup Pass to the western valley and plateau areas of Ellesmere Island, is one of several topographic breaks in the elevated eastern edge of the Canadian Arctic Archipelago. In addition, the plateau area forms a border zone between high mountain ranges of the Ellesmere-Greenland Fold Belt (*see* Fortier, McNair, and Thorsteinsson, 1954, p. 2078) to the north and equally high mountains of dissected crystalline rocks to the south. The latter ranges constitute the northernmost exposures of the Canadian Shield in the archipelago. Bache Peninsula is characterized by nearly horizontal beds and high relief, and is thus a true plateau region in the geomorphological sense. The upland surfaces of rolling hills are bounded over much of their perimeter by spectacular sea-cliffs. Short, small streams drain the upland and are entrenched in deep canyons near the coasts. Deep, ice-scoured major valleys passing into long fiords separate the peninsular plateau areas.

Active glaciers presently occupy the heads of certain valleys. Evidence of former, more widespread glaciation in the Bache Peninsula region includes such features as glacial striae, erratics, and ice-rounded bluffs and islands. The most striking glacial features are the deep, steep-walled valleys, many terminating in fiords. Glacial overdeepening of the inner parts of Flagler Bay and Hayes Fiord is indicated by the presence at their mouths of numerous islets, which suggest shallow thresholds. Glacial grooves may be found in many places on gneiss or granite surfaces; the direction of grooving, in general, conforms approximately to the local valley direction.

Glacial deposits, including the erratics already mentioned, are widespread. These deposits are complex, and additional uncertainty in interpretation is created by solifluction of the active surface layer. Marine shell material is widely distributed, and apparently represents two marine events of different ages; older shell debris is incorporated in the surficial deposits, which are themselves modified by post-glacial marine action and overlain by younger shells.

Glacial boulders and cobbles on the upland surfaces of Bache and Knud Peninsulas are composed, in usual order of frequency, of: (a) buff-weathering dolomite or dolomitic limestone, (b) black-weathering crumbling limestone, (c) dark grey quartzite or quartzose gneiss, (d) red quartzite or sandstone, (e) red granite, (f) grey gneiss, (g) white sandstone. The limestone, dolomite, and sandstone are undoubtedly derived largely from nearby exposures of Palaeozoic rocks. The white sandstone, also probably of local origin, may be more abundant than apparent; it is weakly cemented and therefore rapidly broken down to fines and, even when present as boulders, is inconspicuous among the dominantly light-weathering carbonate-rock debris.

The distribution of distinctive erratic material, especially red granite, indicates former streams of glacial ice conforming to the present valley directions but not limited by the valleys themselves. Thus, red granite forms a significant proportion of the debris on the uplands at the two places examined: east of Harmsworth Bay and in the vicinity of Bartlett Bay. Glacial ice apparently flowed out of uppermost Flagler Bay valley northeastward across the upland, and out of lower Flagler Bay eastward across the head of Bache Peninsula. The possibility that at least some of the granitic and other detritus has come from Greenland must be considered; certainly similar rocks are present on both sides of Kane Basin and the distances are not great. However, with only reconnaissance data presently available on either the bedrock or erratic material, it seems preferable to favour the nearer source.

The uplands are apparently largely covered by an unsorted, clayey material with a varying proportion of admixed rounded, subangular, and angular rock debris. This upland surficial deposit, presumably glacial till, is rarely well exposed and diagnostic structures have not been observed.

An interesting feature of the unconsolidated upland material is the presence of marine shell fragments, both on the surface and within the deposits. Shell fragments lie thinly scattered, more or less uniformly, on the upland surface and on the valley walls in the vicinity of Bartlett Bay, and were observed on the upland at the highest point examined (at about 1,500 feet elevation) and below. The marine material, consisting of rounded bits of carbonate shells, gives an impression of comminution or of great age. The fragments are most easily found in 'frost boils' in poorly sorted, clayey, till-like deposits. The inferred limit of marine submergence in the region is about 350 feet elevation; no evidence of marine action other than the shell fragments has been found at higher elevations.

It seems certain that the high marine shell fragments originated in the nearby fiords and bays and were glacially transported to their present positions. The evidence supporting this includes: the appearance of considerable age or comminution; the association with erratic boulders and a till-like deposit; the apparently uniform distribution on valley walls and uplands; and the complete absence of any other features that might indicate marine inundation to such heights in the recent geological past. The presence on Bache Peninsula of red granite erratics, probably derived from the extensive granite outcrops between lower Flagler Bay and Sverdrup Pass, indicates an eastward flow of ice from Flagler Bay over the easternmost part or 'head' of Bache Peninsula. The observed shell debris probably, therefore, originated in Flagler Bay. The only alternative source that appears reasonable is Kane Basin, from which bottom or shore deposits might have been carried up by west-flowing Greenland ice; as noted earlier, however, the nearness of Ellesmere Island glacial centres makes this appear to be an unlikely alternative.

The shell material of Bache Peninsula uplands must date from a marine period older than the most recent major glacial advance. Direct evidence of the probable age of these shells has been obtained elsewhere in the Arctic Archipelago of Canada, where shell fragments and, less commonly, whole shells from altitudes above the post-glacial marine limit have yielded radiocarbon dates ranging from 19,000 to 36,000 years (Fyles, 1962). These ages, which are considered minimal, are in marked contrast with the ages up to 8,000 years obtained for marine shells close to the post-glacial limit of marine submergence elsewhere on Ellesmere Island (Dyck and Fyles, 1964).

The high Bache Peninsula shells apparently, therefore, were derived from an interglacial (or preglacial?) marine deposit in Flagler Bay, and were incorporated with glacial detritus during the advance of the ice streams and sheets that retreated some 7,000 to 8,000 years ago.

Possibly related to the high, 'old' shells of the uplands are shell fragments found in surficial material of uncertain origin exposed in the walls of an icehouse at Alexandra Fiord Police Post, immediatly south of the map-area. The shell fragments occur both scattered and rudely sorted into discontinuous beds in a sandy, bouldery deposit, possibly a till. The shells, which are now very fragile or 'rotten', appear to have been deposited both as large pieces and whole. No paired valves were observed, however. The boulders in the deposit are of gneiss, are angular, and range in size up to 10 inches in diameter. The sandy matrix apparently contains very little material of clay size. The icehouse lies at the mouth of a glaciated valley tributary to Alexandra Fiord; the termini of twin glaciers in the tributary valley are now 2.5 miles away. The shell-laden deposit might be described as morainal material resulting from deposition in sea water of debris from melting ice. The foregoing account is offered only to indicate the prevalence in Bache Peninsula region of marine shell debris in deposits not necessarily related to post-glacial beaches, and apparently of various origins.

Unusually thick fluvioglacial and glacial deposits are present in the pass that cuts diagonally across Knud Peninsula to join Hayes Fiord and Flagler Bay. Associated with these deposits are numerous east-trending meltwater channels cut into the uplands to the west and a prominent kame terrace on the south side of Knud Peninsula. These features are slightly higher than the inferred local limit of marine inundation, although the kame terrace lies about the marine limit at its down-valley or eastward termination.

The surficial deposits in the Knud Peninsula pass are in part unsorted, bouldery material with an irregular, gullied, hummocky surface, and in part well-washed and sorted gravels. At the Hayes Fiord end of the pass, bouldery moraine-like deposits with gravels are continuous with the south-coastal kame terrace.

The surficial features of Knud Peninsula described above presumably mark a period of glacial retreat when fiord-valleys were filled by ice; meltwater apparently flowed southeastward through the pass and along the north wall of Hayes Fiord, terminating in a delta—probably marine—that now forms an elevated bench two miles west of the eastern extremity of the peninsula.

In contrast with the 'old' marine shell fragments of the plateau surfaces and valley walls, are 'young' shells and shell debris associated with other features characteristic of areas submerged during the widespread post-glacial marine inundation.

Marine beaches are present, but generally obscure, at elevations below about 250 feet in the Bache Peninsula region. The highest post-glacial shells collected (at Talbot Inlet, some miles south of the present map-area) were at an altitude of 200 feet; a wave-cut bench in bedrock in the same area was measured by aneroid altimeter at 270 feet. Determination of the limit of marine submergence is made difficult by the generally inconspicuous nature of the beaches, by a paucity of post-glacial shells, and by the presence of shell fragments above the marine limit. Rather prominent gravel benches at higher elevations, on the other hand, are presumably kame terraces, although probably many of these terminate in or are related to marine deposits. The higher or kame benches mostly lie above 350 feet. The limit of marine submergence, therefore, evidently lies between 200 and about 350 feet elevation. It seems probable that the retreating glacial margin was irregular and, at least in part, formed the coastline in this area, which even now is heavily glacierized; the author thus considers the higher figure to be a more reasonable choice for the local limit of marine submergence.

BEDROCK GEOLOGY

General Statement

Precambrian gneissic rocks are exposed as a narrow band along the southern part of Bache Peninsula, facing Buchanan Bay. The remainder of the peninsula is underlain by an essentially undeformed, conformable sequence of early Palaeozoic and Cenozoic sediments that dip gently to the north. The Palaeozoic rocks of Bache Peninsula form the northeasternmost part of the Arctic Lowlands, or areas of relatively undeformed 'shelf'-type sedimentary rocks, of the Canadian Arctic Archipelago. To the north and northwest of Bache Peninsula lies the Franklinian geosyncline, characterized in this region by thickened formations and by folds and major thrust faults.

The Precambrian basement rocks of Bache Peninsula are mainly biotite-quartz-feldspar gneiss, in part garnetiferous, with minor pegmatitic quartz-feldspar intrusions or segregations. The overlying conformable sequence of sedimentary rocks comprises carbonate, evaporite, and clastic sediments of Lower and Middle Cambrian and Lower Ordovician age. These rest unconformably on a peneplaned surface on the crystalline basement gneisses, and attain a total thickness of about 4,100 feet. The age of the lowermost clastic and carbonate rocks, into which are intruded two diabasic sills, is uncertain, although in the past they have generally been presumed to be Precambrian.

Cenozoic sandstone and shale with coal seams disconformably overlie the Palaeozoic rocks, preserved in down-faulted blocks.

Table of Formations

Era	Period or Epoch	Map-unit number	Formation, map-unit, member, and approximate thickness in feet	Lithology
Cenozoic	Quaternary to Recent	10		Till, gravel, sand, alluvium
	Tertiary (Paleocene or Eocene)	9	Eureka Sound Formation	Sandstone, shale, arkose, coal

Table of Formations *(Cont'd)*

Era	Period or Epoch	Map-unit number	Formation, map-unit, member, and approximate thickness in feet		Lithology
disconformity					
Palaeozoic	Lower Ordovician	8	Cornwallis[1] Formation	Member B	Dolomitic limestone, limestone
		7		Member A 750′	Gypsum, anhydrite, dolomitic limestone breccia
		6	Map-unit 6 300′		Dolomitic limestone, limestone, intraformational conglomerate
		5	Cape Clay Formation 250-300′		Dolomite
		4	Cass Fiord Formation 1200-1600′		Limestone, limy dolomite, intraformational conglomerate, gypsum, argillaceous carbonate-rock
	Middle Cambrian	3	Cape Wood Formation 130′		Dolomite, limestone, sandstone
	Lower Cambrian		Cape Kent Formation 50′		Dolomite, dolomitic limestone
			Police Post Formation 15′		Limestone, sandy limestone
	Cambrian (?)		Cape Ingersoll Formation 80′		Dolomite
			Cape Leiper Formation 100-150′		Dolomite, intraformational breccia
		3a	Rensselaer Bay Formation	Sverdrup Member/Formation 170-300′	Sandstone
		2		Bache Peninsula Member 0?-90′	Arkose, conglomerate
				Camperdown Member 0-260′	Sandstone, shale, dolomite

Table of Formations (Conc'd)

Era	Period or Epoch	Map-unit number	Formation, map-unit, member, and approximate thickness in feet	Lithology
		unconformity		
Precambrian		1		Gneiss, pegmatite, granite, crystalline limestone

1 Correlation with the Cornwallis Formation, presumed in the writing of this report, is no longer tenable in the light of data recently obtained by J. W. Kerr, Geological Survey of Canada, on Cornwallis and Ellesmere Islands. The problem is discussed more fully in a footnote to the section *Age and Correlation* of the Cornwallis Formation.

Precambrian

Map-unit 1

The distribution of crystalline 'basement' rocks on Bache and Knud Peninsulas has been obtained from both ground observations and air-photographic interpretation; the areas explored in the field include Sverdrup Pass, the head of Flagler Bay, outermost Knud Peninsula, and the south coast of Bache Peninsula (*see* Plate I). The crystalline Precambrian rocks include dark gneisses, massive red granite, and minor crystalline limestone. The massive granites underlie Sverdrup Pass and the head of Flagler Bay, and the dark gneisses are exposed at the mouth of Flagler Bay and along the south coast of Bache Peninsula. An area of mixed rocks separates the western granite region from the eastern gneiss region. A few irregular masses of crystalline limestone are exposed on the south coast of Knud Peninsula just west of the mouth of Flagler Bay. Continuations of the marble beds presumably represented by these masses may be exposed south of Hayes Fiord where light-coloured masses on the shore and high on the ridge were observed but not visited.

The gneisses of the eastern region are mainly medium- and coarse-grained, grey to greenish black quartz-feldspar-mafic rocks with distinct banding. Quartzose gneisses, generally garnetiferous, are common. The feldspar of the coarser, darker gneisses is characteristically grey to dark grey; the quartz commonly has a bluish cast, and in places is distinctly blue; the mafic minerals are hornblende or pyroxene and biotite. The lighter, quartz-rich rocks contain biotite alone. Metallic, sulphide minerals (pyrite and pyrrhotite?) occur disseminated in some quartz-feldspar-biotite gneiss bands; these are marked by rusty-weathering bands and patches up to some hundreds of feet wide on both the north and south shores of Buchanan Bay.

The granitic rocks of the western region are coarse grained, bright red to dark reddish grey, and variously massive to weakly foliated. Small, dark, chloritic inclusions are sparsely scattered, and larger, gneissic included bodies may be encountered near the contact zone with the gneisses.

Table I. *Correlation of Formations of Bache Peninsula, Ellesmere Island*

SYSTEM	SERIES	Inglefield & Washington Lands Northwest Greenland revised after Koch, 1929: Troelsen, 1950	BACHE PENINSULA	COPES BAY Thorsteinsson, 1963; Kerr, 1963	DUNDAS HARBOUR DEVON ISLAND Kurtz, McNair & Wales, 1952	CORNWALLIS ISLAND SOUTH HALF after Thorsteinsson, 1950	BOOTHIA PENINSULA Christie, unpublished ms
ORDOVICIAN	MIDDLE	Cape Calhoun Gonioceras Bay Cape Webster	Cornwallis: (top not exposed) Member B	Cornwallis: Unit iv Unit iii Unit ii	Croker Bay	Cornwallis	Unnamed dolomite
	?						
	LOWER	Nunatami — ? — — ? — Cape Weber Nygaard Bay Poulsen Cliff Cape Clay Cass Fiord	Cornwallis: Member A Map-unit 6 Cape Clay Cass Fiord	Cornwallis: Unit i Gypsum-anhydrite member Copes Bay	Nadlo Point Mingo River	Eleanor River (base not exposed)	
CAMBRIAN	UPPER	hiatus	hiatus	hiatus	hiatus ?		hiatus ?
	MIDDLE	Cape Wood	Cape Wood	Parrish Glacier	Ooyahgah Bear Point		Unnamed sand-stone & carbonate
	LOWER	Cape Kent Wulff River Cape Ingersoll Cape Leiper Rensselaer Bay	Cape Kent Police Post Cape Ingersoll Cape Leiper Rensselaer Bay	Scoresby Bay Unnamed conglomerate, ss, arkose	Rabbit Point		
PRE-CAMBRIAN	LATE	? ?		hiatus Unnamed carbonate-rocks (thrust fault)			
	EARLY	Crystalline rocks	Crystalline rocks		Crystalline rocks		Crystalline rocks

The border zone between the red granites and the dark gneisses, a few miles west of the mouth of Flagler Bay, is marked by a mingling of the two rock types and also by the presence of numerous light-coloured pegmatitic veins. The vein segregations or intrusions, with accompanying distortion of the gneissic banding, have produced a ptygmatic 'pudding'-rock.

The age relationships of the three rock types are not clear; the red granite appears to cut the gneisses in some places, but in others a gradation through dark granite-gneiss appears to be present. The light pegmatitic veins or segregations contain minerals, such as garnet and biotite, in common with the surrounding gneisses, and also have a close spatial association with the gneisses; these facts suggest a close relationship with the development of the gneissic structure and mineral phases.

The structural trends of the Precambrian rocks throughout the area examined are northeast to east-northeast. Numerous local exceptions to these trends occur, however. Dips of the gneiss bands are generally moderate to steep, except near Cape Camperdown, where the banding is apparently folded over into a fairly broad anticline and syncline with gentle to flat dips.

Cambrian (?)

Rensselaer Bay Formation (Map-units 2, 3a)

The Rensselaer Bay Formation of unfossiliferous beds, predominantly of clastic origin, unconformably overlies the basement gneisses of Bache Peninsula. The usage or terminology followed here is that of Troelsen (1950, p. 35), who described the basal clastic beds (specifically, the purple and yellow sandstones) of Inglefield Land as the 'Rensselaer Bay sandstone'. This basal formation of Bache Peninsula is herein divided into three members: the lowest, Camperdown Member; the Bache Peninsula Member; and the uppermost, Sverdrup Member. The lowest two members, which can apparently be correlated with the 'purple sandstones' of Inglefield Land, are restricted in distribution, while the uppermost, or Sverdrup Member—the 'yellow sandstone' of Inglefield Land—transgresses the others and is of wide distribution. Where the Sverdrup Member rests directly on the gneisses it is of formational rank. Although the Rensselaer Bay Formation might well be raised to group rank, the author prefers not to do this from a study only of sections outside the type area.

The Rensselaer Bay Formation is divided, on the accompanying map (in pocket), between map-units 2 and 3a. This is a consequence of the relative ease with which the darker, purple beds (2) are distinguished from the overlying lighter, yellow beds (3a) in air photographs. The yellow beds, on the other hand, are not easily separated in photographs from the overlying light-weathering dolomite and limestone formations, and are included in the generalized map-unit, 3.

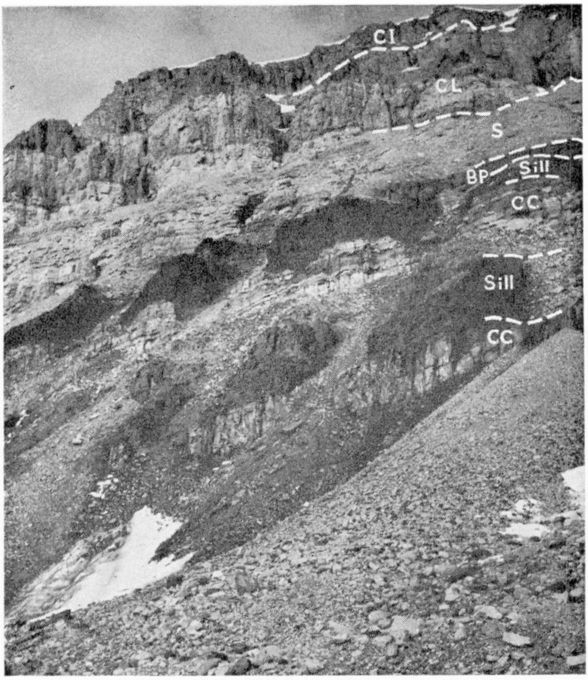

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PLATE II

A well-exposed section 4 miles west of Cape Camperdown, with the Cape Camperdown Member (CC) exposed in the lower slopes. Dark sill-rock and arkose (BP), and light sandstone (S), are evident in the slopes; the cliffs are dolomite of the Cape Leiper (CL) and Cape Ingersoll (CI) Formations.

Camperdown Member

Definition, Distribution, Thickness

The best exposures of the Camperdown Member are in the lower slopes of the well-bedded cliffs overlooking Buchanan Bay near Cape Camperdown, from which cape the name of the member is taken. The Camperdown Member thins westward from a maximum thickness of about 260 feet at Cape Camperdown, and apparently pinches out west of the Police Post, where it is thin and poorly exposed. Two diabase sills increase the thickest section to about 460 feet (*see* Pls. I, II).

Lithology

The Camperdown Member comprises mainly thin-bedded red and green shale, and white, greenish, and brownish sandstone. Present in minor amounts are calcareous beds including shaly and sandy limestone and algal limestone. Feldspar detritus is present, though not in conspicuous amounts, throughout the member. The Camperdown Member is represented by units 1 to 8 in the section tabulated below.

Four sub-members are recognizable in sections near Cape Camperdown; the sub-members, which pinch out at various places on the south coast of the peninsula, are described below in descending stratigraphic order:

D. Thin- to medium-bedded, white to purple sandstone; up to 100 feet

C. Interbedded, thin-bedded, fine-grained, red-weathering sandstone, sandy shale, and shale with abundant mud-cracks and ripple-marks; about 100 feet (Pl. III)

B. Medium- to fine-grained, medium-bedded sandstone, greenish to white in colour, with some crossbedding; 30 to 70 feet

A. A basal, impure thin-bedded sandstone unit with shaly green and red parting; 10 feet.

A section of the two basal members was measured by aneroid altimeter, and is tabulated below:

Section of the Camperdown and
Bache Peninsula Members
4 miles west of Cape Camperdown
(Localities 5, 6)[1]

Unit No.		Approximate Thickness (feet)
	Overlying, pale purple and white sandstone of map-unit 3a, Sverdrup Member	
9	Bache Peninsula Member: arkose; dark reddish brown, coarse-grained to conglomeratic, and weakly cemented beds 4 to 18 inches; pebbles up to 4 inches diameter, and rare sub-angular boulders of sandstone similar to matrix up to 8 inches diameter; pebbles are well rounded, mainly quartzite, with some black chert and rare jasper	90
	Sill; dark green-grey, diabasic	(40)
	Top of Camperdown Member	
8	Sandstone, pale purple to white, fine-grained to very fine grained; about 3 feet of shale and shaly sandstone near the underlying sill burned to a brick-red, porous rock	50
	Sill; andesitic to basaltic, dark blue-grey	(160)
7	Sandstone; purple to white, medium-grained	10
6	Sandstone; pale green to white, coarse-grained	10
5	Carbonate-rock with knobby algal-growth structure; greenish on the fresh surface, but white-weathering, probably due to gypsum; interbeds 6 to 10 inches thick of intraformational conglomerate—greenish carbonate-rock fragments in a matrix of dark red medium-grained sandstone	5
4	Interbedded fine-grained sandstone, grit, and shale, mainly red-weathering but with numerous green beds; sandstones compact, with tough, hematitic matrix; mud-cracks and ripple-marks abundant; minor intraformational conglomerate	100
3	Sandstone; white, medium-grained, with a pinkish cast due to feldspar grains	15
2	Sandstone; greenish and fine-grained, with well-rounded quartz grains; very slightly arkosic	15
1	Sandstone; thin-bedded, red and green, with shaly partings	10
	Total measured thickness of map-unit 2, including sills	505
	Underlying: gneiss	

[1] For location of the tabulated section refer to the locality numbers on the accompanying geological map (*in pocket*).

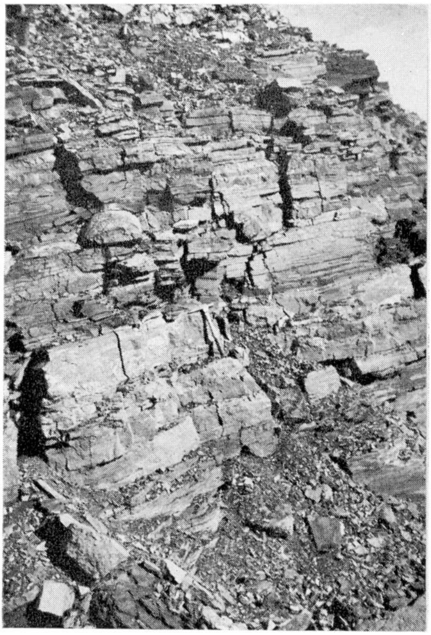

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PLATE III

Interbedded sandstone and red and green shales of the lower beds of the Rensselaer Bay Formation four miles west of Cape Camperdown.

Bache Peninsula Member

Definition, Distribution, Thickness

The Bache Peninsula Member overlies the Camperdown Member, apparently conformably and transgressively, and is itself conformably overlain by the Sverdrup Member (*see* Pl. II). The latter member in turn transgresses westward so that the Bache Peninsula Member is pinched out some 10 or 20 miles west of the Police Post. The greatest thickness measured, 30 feet, was at the type section west of Cape Camperdown. The Bache Peninsula Member is unit 9 in the section tabulated above.

Lithology

The Bache Peninsula Member is coarse-grained, thick-bedded, dark purple-brown, conglomeratic arkose. Feldspar is abundant, and the pebbles in conglomeratic beds are mostly brown-weathering, well-rounded quartzite, ranging up to 4 inches in diameter. Chert pebbles and some angular sandstone boulders up to 8 inches in diameter also are present. The sandstone of the boulders resembles the matrix of the conglomerate.

Sverdrup Member (Map-unit 3a)

Definition, Distribution, Thickness

The name 'Sverdrup Member' is here proposed for a sequence of yellowish weathering sandstone and conglomeratic sandstone beds that rests conformably on the Bache Peninsula Member east of the Police Post and nonconformably on

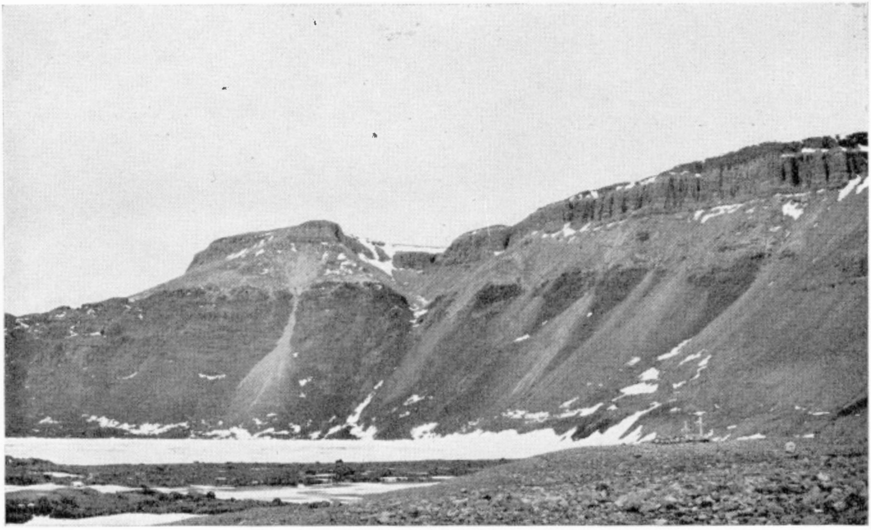

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PLATE IV. A view northwestward from the site of the Police Post, Bache Peninsula. Overlying the gneiss and visible are: the Sverdrup Member, the Cape Leiper Formation, and, along the skyline, the Cape Ingersoll Formation. The Bache Peninsula Member, here only a few feet thick, is obscured by talus.

the basement gneisses to the west. The name is taken from Sverdrup Pass, named by Ekblaw (1918, p. 342) after Captain Otto Sverdrup, who first crossed the pass and whose expedition in the *Fram* contributed greatly to knowledge of the Queen Elizabeth Islands.

The Sverdrup Member is overlain abruptly by the Cape Leiper Formation. The Sverdrup sandstone beds are exposed in light-coloured slopes along the south coast of Bache Peninsula (*see* Pls. I, II, IV), where the formation is 170 feet thick, and excellent exposures occur in and near Sverdrup Pass, where the thickness apparently increases to about 300 feet (*see* Pl. V).

Lithology

The Sverdrup Member comprises medium-bedded, medium- to coarse-grained white sandstone that weathers white, pale yellow, or pale purple. The sandstone is characteristically crossbedded (*see* Pl. V), and contains pebble-conglomerate layers with quartz pebbles up to about 5 mm in diameter. The sand grains are moderately rounded, the larger appearing frosted or pitted.

The sandstone in some places is characterized by scolithid-like, regular, sub-columnar structures in the form of sand tubes or pipes. The columns are about 2 to 5 mm in diameter, and are separated by distances equal to about twice their diameter. The columns are uniform and straight, and run from bottom to top of sandstone beds about 12 inches in thickness. In a variety of the columnar rock the columns are 10 to 15 mm in diameter, are less regular, and appear to intrude coarse sand into finer sand.

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PLATE V. The north wall of the valley of Sverdrup Pass, showing the basement gneiss, the basal sandstone or Sverdrup Formation, and the overlying, competent dolomite formations.

The basal beds of the Sverdrup Member rest with rather abrupt contact upon the Bache Peninsula Member. The two members contrast markedly, the lower being richly coloured, conglomeratic, and arkosic, the upper white to pale yellow, uniformly grained, crossbedded, and nearly pure quartz sand. An appearance of gradation or interfingering from arkose to quartz-sandstone is given in places by a distinct purple-and-white banding in the Sverdrup Member. This, however is a weathering phenomenon, the rock in all cases being uniformly white on the fresh surface.

The following section of the Sverdrup Member was measured:

Section of Map-unit 3a,
4 miles west of Cape
Camperdown
(Locality 6)

Unit No.		Approximate Thickness (feet)
	Overlying: Cape Leiper Formation	
14	Sandstone; fine-grained, compact, greenish to yellowish weathering	5
13	Sandstone; medium-grained, greenish, weakly lithified; perhaps in part carbonate-cemented	1
12	Sandstone; very coarse grained and porous	1.5

Unit No.		Approximate Thickness (feet)
11	Sandstone; medium- to coarse-grained, medium and distinctly bedded, with abundant crossbedding and scolithid-like sand pipe structures; quartz pebbles (5 mm) in thin layers	120
10	Sandstone; fine- to coarse-grained white sandstone, weathering pale purplish to white, banded, medium-bedded	40
	Total thickness of the Sverdrup Member	167.5
	Underlying: Bache Peninsula Member	

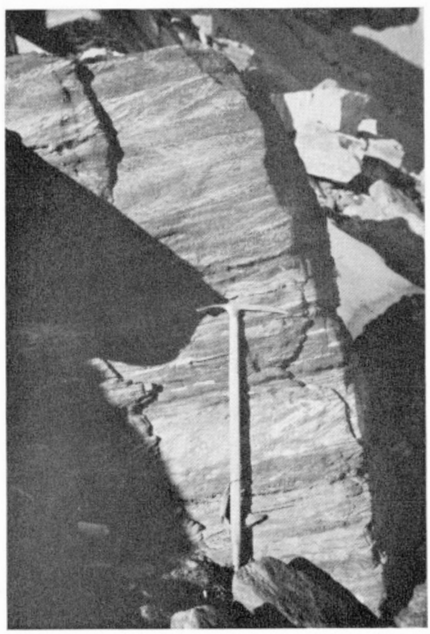
Age and Correlation of the Rensselaer Bay Formation

The Rensselaer Bay Formation was named by Troelsen (1950, p. 35); the type locality for the formation is Rensselaer Bay in Inglefield Land, Greenland. Troelsen followed Koch (1929b, p. 220) in correlating the basal clastic sequence of Inglefield Land with the basal part of the Thule Group, which was erected as the Thule Formation by Koch (1929b) in the Cape York and Thule districts of Greenland. Troelsen also correlated the basal clastic beds of Bache Peninsula with the Rensselaer Bay Formation and assigned to them an 'eo-Cambrian' (latest Precambrian?) age.

Troelsen's correlation between Bache Peninsula and Inglefield Land appears reasonable to the present author, and the formational nomenclature of Inglefield

PLATE VI

Crossbedded, yellow-and-purple sandstone at the base of the Sverdrup Member, four miles west of Cape Camperdown.



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Land is followed in this report. From recent work on Ellesmere Island, however, at least some of the basal clastic beds appear probably Cambrian in age, and for this and other reasons the Thule Group and eo-Cambrian or Precambrian terminology are not used herein. The age and correlation of Rensselaer Bay and overlying beds is fully discussed later.

Middle and Lower Cambrian and ? Older

Map-unit 3

Six relatively thin formations are included in map-unit 3 on the accompanying geological map. In descending stratigraphic order they are:

Cape Wood Formation	Middle Cambrian
Cape Kent Formation	Lower? Cambrian
Police Post Formation	Lower Cambrian
Cape Ingersoll Formation	
Cape Leiper Formation	
Sverdrup Member/Formation	

The Sverdrup Member, the uppermost member of the Rensselaer Bay Formation, is described in a preceding section; as stated there, where other members are absent the term Sverdrup Formation may be used.

Cape Leiper Formation (Cambrian?)

Yellow, fine-grained dolomite beds conformably overlying the Rensselaer Bay Formation were named the 'Cape Leiper dolomite' by Troelsen (1950, p. 35), the type locality presumably being Cape Leiper, Inglefield Land. At an earlier time Koch mentioned (1929b, p. 221) and described (1933, p. 20) the dolomite beds as part of the Thule Formation (so-called, in Inglefield Land, not in the type area of the Thule Formation) but did not name them. Troelsen correlated the yellow dolomite of Bache Peninsula with the Cape Leiper dolomite of Inglefield Land, describing the dolomite as being of equally universal distribution in the two regions.

The Cape Leiper Formation near Cape Camperdown abruptly overlies about 6 feet of greenish compact sandstone, and at the Police Post about 12 feet of grey and greenish impure sandstone. Overlying the formation, apparently conformably, is the relatively thin Cape Ingersoll Formation of massive dolomite.

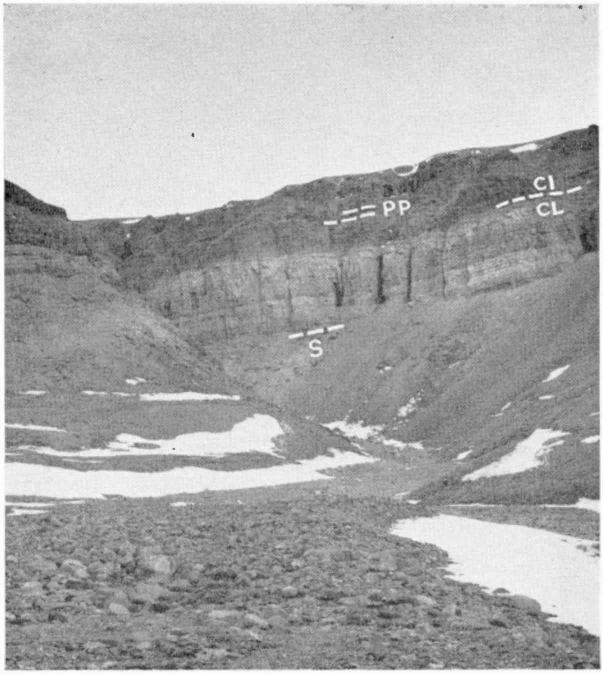

PLATE VII

The ravine behind the Police Post on Bache Peninsula. Visible are the yellow sandstone beds (S), the light, cliff-forming Cape Leiper Formation (CL), and the darker Cape Ingersoll (CI), Police Post (PP), Cape Kent, and Cape Wood Formations.

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Distribution and Thickness

The Cape Leiper Formation is widely exposed in the Bache Peninsula region. Being competent, it forms cliffs along the south coast of Bache Peninsula and underlies some of the upland areas of Knud Peninsula (*see* Pls. II, IV, VII, VIII) and those near Sverdrup Pass. Its thickness, measured at several localities, varies between 100 and 150 feet.

Lithology

The Cape Leiper Formation comprises competent, fine-grained, grey dolomite beds that weather very light grey, light brown, yellowish, or slightly violet. Bedding is variously spaced from 2 to 10 inches, and the bedding planes characteristically are strikingly distorted by stylolites. Beds of intraformational conglomerate[1], containing fragments up to 2 inches in largest diameter, are present in the upper, more yellow-weathering parts of the formation.

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[1] Intraformational conglomerate or breccia is exceedingly abundant in the Palaeozoic rocks of the Bache Peninsula region. The distinction between intraformational 'conglomerate' and 'breccia' is not easily made; in the present report the first term is applied where the fragments appear relatively well-rounded, the second where more angular. However, it should be understood that the rocks appear almost alike, and are fundamentally the same rock type.

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PLATE VIII. View westward of Knud Peninsula, Flagler Bay, and the south coast of Bache Peninsula. The sub-Palaeozoic unconformity is evident in the left half of the view. The irregular point at the head of the small bay at the centre of the photograph is the site of the abandoned Bache Peninsula Police Post.

The Cape Leiper Formation forms part of the section exposed in the ravine at the abandoned Police Post on Bache Peninsula; in the following tabulation the formation is represented by units 5 to 8, inclusive.

Section at the Police Post,
Bache Peninsula
(Locality 1)

Unit No.		Approximate Thickness (feet)
	Top of Section	
13	Cape Wood Formation: interbedded, thick-bedded limestone and dolomite; pale grey-brown on the fresh surface, weathering brown and grey; dolomite medium-crystalline and markedly vuggy, limestone very fine grained and compact	90
12	Sandstone; fine-grained, dark grey with carbonate matrix	5
11	Cape Kent Formation: dolomite; medium-grained, becoming coarser upward; pale brown, weathering reddish brown	50
10	Police Post Formation: limestone; medium-(?) grained, dark grey, becoming greenish (glauconite?) at top and bottom; arenaceous, with abundant worm-tube-like markings and sparse trilobites (*Olenellus* fauna; GSC loc. 47287); thin pyrite veins are present, and the rock is very slightly fetid when broken	16
9	Cape Ingersoll Formation: dolomite; coarsely crystalline and drusy, with coarse grey-white carbonate crystals lining the cavities; brown on fresh surface, red-brown-weathering with lighter patches and streaks; in places, sharply outlined, spheroidal to sub-cylindrical white patches up to 3 mm in diameter give the rock a pseudo-(remnant?) fossiliferous appearance	80
	Top of Cape Leiper Formation	
8	Dolomite; dark grey-weathering (contrasts with unit 7), becoming light yellow-grey near top; fine-grained, medium-bedded stylolitic	20
7	Dolomite; fine-grained, light grey, weathering light yellow and violet-grey; medium-bedded, with dark grey stylolites; near top of unit are beds, 6 to 10 inches thick, of intraformational conglomerate with fragments up to 2 inches diameter	25
6	Dolomite; very compact and fine-grained but with scattered coarse crystals and vuggy openings up to 5 mm long; violet-grey on fresh surface, weathering light yellow	35
5	Dolomite; compact, fine- to medium-grained, dark grey, weathering grey to slightly violet; medium- and thick-bedded, with stylolitic bedding-planes	25
	Base of Cape Leiper Formation	
	Contact not exposed	
4	Sandstone; fine-grained to poorly sorted and coarse-grained; grey, weathering light greenish grey; characterized by irregular, discontinuous dark grey argillaceous or carbonaceous? laminae	10
3	Sandstone; medium-grained, medium-bedded, uniform, clean white sandstone weathering light yellow; abundant crossbedding indicating a westerly source; the upper 15 feet of section is massive, fine-grained, and pale green-weathering	90

Unit No.		Approximate Thickness (feet)
2	Sandstone; medium-grained, with scattered quartz pebbles 5 mm in diameter; light yellow- to pale purple-weathering; of relatively pure quartz sand composition, medium-bedded; abundant crossbedding	70
1	Arkose; dark brown, conglomeratic, with pebbles up to 1 inch diameter	Estimate less than 50
	Base of section not exposed	
	Gneiss	

Age and Correlation

No fossils have been found in the Cape Leiper beds of Bache Peninsula or Inglefield Land, and the formation has previously been assigned an 'eo-Cambrian' (latest Precambrian?) age. The present author proposes a Cambrian age for the beds, the correlation of which is discussed later.

Cape Ingersoll Formation

Definition, Distribution, Thickness

The type area for the Cape Ingersoll Formation, which was named by Troelsen, is in Inglefield Land, Greenland. On Bache Peninsula the Cape Ingersoll Formation of brown-weathering dolomite succeeds the Cape Leiper with abrupt yet conformable contact, and is conformably overlain by the Police Post Formation (*see* Pls. IV, VII, IX). A thickness of about 80 feet was measured by tape at the Police Post.

The Cape Ingersoll Formation is widely exposed in cliff sections in the Bache Peninsula region, and may be identified in the field and in air photographs by its dark weathering colour, which contrasts with the light beds above and below (*see* Pls. IV, VII).

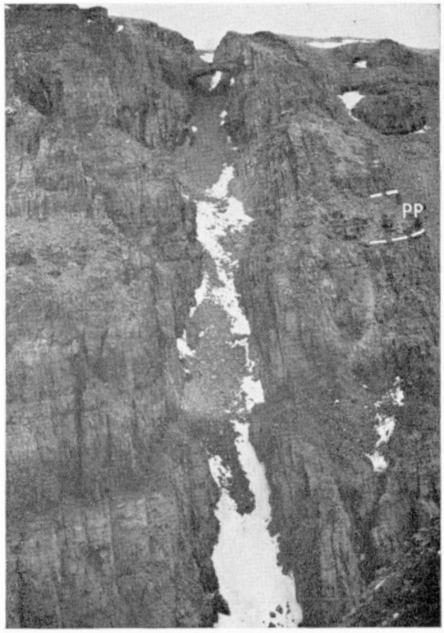
Lithology

The Cape Ingersoll Formation is thick-bedded, medium to coarsely crystalline, and characteristically vuggy to cavernous dolomite. The dolomite is grey-brown on the fresh surface, and weathers mottled reddish brown. Other than the lighter mottling, the rock seems nearly massive, although Troelsen (1950, p. 36) describes breccia (probably intraformational) as being conspicuous along the south coast of Bache Peninsula. Some spheroidal to sub-cylindrical white carbonate blebs in the dolomite are either remnant or pseudofossil forms.

The Cape Ingersoll dolomite is represented by unit 9 in the Police Post section (Locality 1).

PLATE IX

A gully on the east side of the ravine behind the Police Post. The platy-weathering Police Post Formation (PP) is in the middle of the photograph.



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Age and Correlation

The Cape Ingersoll Formation of Bache Peninsula is unfossiliferous, but has been correlated with the Cape Ingersoll beds of Inglefield Land by Troelsen on the basis of similar lithological characters and stratigraphic position. The Cape Ingersoll dolomite was assigned a Precambrian age by Troelsen, who considered the upper surface of the formation to be a significant disconformity. As is noted in the following section, the present author assigns a 'probably Cambrian' age to this formation.

Correlation of Cambrian and Sub-Cambrian Beds and of the So-called Thule Group

Unfossiliferous beds conformably or disconformably underlying fossiliferous Cambrian beds in Northwest Greenland and Ellesmere Island generally have been referred to the Thule Group, a term now well established in the literature of these regions (*see* Koch, 1929, 1933; Troelsen, 1950; Cowie, 1961; Thorsteinsson, 1963b; and others). In the present author's opinion, however, the basal beds of Bache Peninsula may not be correlatable with the Thule Group of the Thule district, and furthermore may be Cambrian in age; the term, Thule Group, is therefore not used in the present report.

The Thule Group was originally named the Thule Formation by Koch (1929b, p. 220; 1933, p. 14), who named the Cape York district (including the Thule region) of Greenland as the type area. Koch described the formation principally from beds exposed at Thule, but he also regarded the basal beds of Inglefield Land as belonging to the Thule Formation. Thus, the basal arkose and sandstone of Inglefield Land were correlated with the lowest part of the Thule Formation at Thule, although the two areas are separated by 140 miles in which basement rocks are widely exposed. Unfossiliferous dolomite beds overlying the sandstone and below fossiliferous Cambrian beds in Inglefield Land were also included in the Thule Formation by Koch. No fossiliferous beds have been discovered in the Thule district.

The basal, unfossiliferous beds of Inglefield Land were subsequently studied by Troelsen (1950, p. 35) who, retaining Koch's Thule name and raising it to group status, divided the beds into three formations: the Rensselaer Bay sandstone, Cape Leiper dolomite, and Cape Ingersoll dolomite. This stratigraphic nomenclature Troelsen carried across Kane Basin to Bache Peninsula. The Thule Formation in the type area, on the other hand, was examined by Kurtz and Wales (1951), who redescribed the beds and divided them into the Wolstenholme, Danish Village, and Narssarssuk Formations.

J. W. Cowie, who has recently studied certain sections in Inglefield Land, has remarked (1961, p. 16) that correlation between the Thule and Inglefield-Bache districts cannot be made in detail, and that there are differences in sedimentary type and thicknesses. Cowie also suggested (1961, p. 30), although speculatively, a lower Cambrian age for the Rensselaer Bay Formation from evidence in northeast Greenland. Wordie (1938) had earlier considered the basal sandstones of Bache Peninsula to be included in the Cambrian system from the apparent lack of stratigraphic break between the sandstone and Cambrian beds higher in the section.

The differences in sedimentary type and thicknesses between the Inglefield Land-Bache Peninsula and the Thule districts noted by Cowie are indeed considerable, as may readily be seen in Figure 2 (in pocket). Justification of the dual nomenclature of the Thule Group, at first glance a seeming duplication, is evident when the groups in the two areas are compared: in Inglefield Land, an aggregate thickness of less than 700 feet, while at Thule, more than 8,400 feet; in Inglefield Land, two thin dolomite formations, nowhere absent, while at Thule more than 6,800 feet of shale, siltstone, and dolomite of quite dissimilar stratigraphic character. Similarities in the two columns, such as red quartzite and arkose near the base and white quartzite and sandstone above, or the presence in both of diabase sills, seem insufficient alone to require the use of the Thule term outside the type area.

On the other hand, published descriptions of the formations on either side of Kane Basin suggest close similarities in lithology, sequence, and thicknesses, and Troelsen, who examined both regions, correlated across the 40-mile gap with confidence. Troelsen's formational nomenclature, therefore, with type sections in Inglefield Land, appears applicable to Bache Peninsula and is used in the present report, although the group name (Thule Group) is not.

Correlation of Bache Peninsula strata northwestward into the former Franklinian geosyncline is now possible, based on recent field work by J. W. Kerr, Geological Survey of Canada (*see* Kerr, 1963, and pers. com.). Cambrian fossils[1] have been collected from beds correlatable with the heretofore unfossiliferous and presumed Precambrian Cape Leiper and Cape Ingersoll Formations of Bache Peninsula; these formations, and at least part of the conformable clastic sequence underlying them, now appear very probably Cambrian in age. Suggested correlations are shown in Figure 2 (*and see* Table I).

Correlation from Bache Peninsula into the geosynclinal region to the north and west is based mainly on the apparent widespread occurrence of the sequence: (a) coarse, purple-weathering clastic beds; (b) overlying finer, cream- or yellow-weathering sandstone beds; (c) massive dolomites uppermost. This sequence bears, furthermore, a consistent underlying relationship with Lower and Middle Cambrian (Police Post–Cape Kent–Cape Wood) dolomite and limestone formations and with the easily recognized Lower Ordovician Cass Fiord–Copes Bay lithology. The sequence described is represented at Bache Peninsula by the Bache Peninsula and Sverdrup Members of the Rensselaer Bay Formation, the Cape Leiper Formation and the Cape Ingersoll Formation; in Kerr's sections the sequence embraces unnamed clastic formations (2, 3, and 4 of Fig. 2) and the lower part of an overlying, unnamed formation.[2] Kerr found animal trails (trilobite?) and burrows in formation 3 at Ella Bay (Fig. 2, col. 1) and J. W. Cowie assigned fossils from a bed near the top of formation 4 in both his Ella Bay and Scoresby Bay (Fig. 2, col. 2) sections to the 'lower *Olenellus* sub-zone'. The lowest fossil bed at Bache Peninsula, immediately overlying the Cape Ingersoll Formation, contains 'upper *Olenellus* sub-zone' fauna (Cowie, pers. com.); the 'lower *Olenellus* sub-zone' horizon presumably lies in the Cape Leiper Formation, perhaps near its base. The presence of trails and other evidence of marine life stratigraphically lower than the lowest *Olenellus* horizon suggests that much, if not all, of the bedded sequence on Bache Peninsula and in Inglefield Land probably is of Cambrian age.

Considerable thicknesses of dolomite (unit 1 in Fig. 2) low in Kerr's sections remain without apparent correlative formations; these beds, which according to Kerr and Thorsteinsson are separated from overlying units by a disconformity, are possibly related to the wedge of clastic and limy beds with stromatolite structures that forms the lowest (Camperdown) member of the Rensselaer Bay Formation on Bache Peninsula. Although the basal member is apparently conformable with overlying beds, a disconformity, or even a slight unconformity,

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[1] Cambrian collection from both regions have been examined by J. W. Cowie of Bristol University.

[2] The name, Scoresby Bay, has been suggested for this unnamed unit. The formation has not been formally described and the name is not yet approved.

could well be present and undetected in the few miles of exposure available. On the other hand, the Bache Peninsula wedge may be a remnant of a basin that lay separate from, but adjacent to, the Franklinian geosyncline, and which was more or less contemporaneous with it. It might also be suggested, speculatively, that these lowest beds are equivalent to the Thule Group of the Thule district.

Lower Cambrian

Police Post Formation

Definition, Distribution, Thickness

The name Police Post Limestone was given by Troelsen (1950, p. 38) to a formation discovered by Bentham[1] and described by Poulsen as the *Bonniopsis* horizon. The formation is only about 15 feet thick at the Police Post (Pl. IX), and has been found only on Bache Peninsula. Troelsen has added that "its absence from the section on Inglefield Land was definitely established".

Lithology

The Police Post Formation is thin-bedded, arenaceous, dark grey limestone, becoming green in the upper and lower parts. Abundant worm-tube-like markings and sparse trilobites and tribolite fragments are present. Thin pyrite stringers also were observed. The rock appears glauconitic and, unlike that of the beds below, emits a slightly fetid odour upon breaking.

The Police Post Formation is represented by unit 10 in the Police Post section (Locality 1).

Fauna and Correlation

The following forms were identified by Poulsen (1946, p. 301) from specimens collected by Bentham, and were referred to a *Bonniopsis* horizon:

Acrothele? *pulchra* Poulsen
Hyolithes (*Hyolithes*) sp.
Paedeumias? *borealis* sp. nov.
unnamed olenellid
Bonniopsis nasuta gen. et sp. nov.
B. rostrata sp. nov.

Poulsen referred the source beds to the Lower Cambrian.

[1] From Bentham's notes on the sequence of strata at the Police Post, quoted by Poulsen (1946, pp. 300, 301), it appears that Bentham succeeded only in establishing the *presence* of the Lower Cambrian trilobite-bearing bed. Wordie and Drever (Wordie, 1938, p. 399) found the fossil-yielding beds and closely examined the stratigraphic relationships a few years later.

Fossils collected from the Police Post Formation by the present author were submitted to J. W. Cowie, who reports as follows:

Bonniopsis rostrata Poulsen 1946
Bonniopsis sp.
Olenellus sp.
Hyolithes sp.
Circotheca sp.

Cowie states that the fauna is Lower Cambrian in age and suggests correlation with the 'upper *Olenellus* sub-zone'.

Poulsen (1946, pp. 301, 305) considered the fauna of the *Bonniopsis* horizon to be older than the Lower Cambrian Wulff River Formation of Inglefield Land on the grounds that a species from the former occurs in pebbles in the latter formation. Cowie (1961, p. 23) considered the two formations to be probably of slightly different age, but to be penecontemporaneous, and suggested that the glauconitic and arenaceous nature of the Wulff River beds indicates an association with 'an unconformity in the broadest sense' that is, a hiatus in which there was erosion and/or non-deposition of beds.

An 'Upper *Olenellus* sub-zone' fauna has been collected by Kerr at Irene Bay, about 80 miles west of Bache Peninsula. The Police Post Formation apparently, therefore, is equivalent to beds exposed there (*see* Fig. 2). The correlation of Cambrian beds has also been discussed in an earlier section.

Cape Kent Formation

Definition, Distribution, Thickness

The Cape Kent Formation in Inglefield Land was described as limestone by Poulsen, Koch, and Troelsen (Troelsen, 1950, p. 41) and was identified on Bache Peninsula by Troelsen on the basis of lithology and stratigraphic position; it conformably overlies the Police Post Formation, and it is exposed in cliffs on Bache Peninsula (Pls. VII, IX) and along the shores of Flagler Bay (Pl. X). Thicknesses measured range from 35 to 50 feet.

Lithology

The Cape Kent Formation on Bache Peninsula is a medium-grained, thick-bedded, dolomitic limestone or dolomite that weathers light brown to red-brown and is variably oölitic or mottled weathering. The formation is represented by unit 11 and perhaps also by unit 12 in the Police Post section (Locality 1).

Fauna, Age, and Correlation

No fossils have been collected from the Cape Kent beds in the Bache Peninsula region and, according to Troelsen, nearly all existing Greenland collections are from talus. Cowie (1961, p. 24) discussed the fauna and age of the

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PLATE X. The north shore of Flagler Bay near the head of the inlet. The lower competent beds are dolomites of the Cape Leiper, Cape Ingersoll, Cape Kent, and Cape Wood formations; the talus-covered slopes are Cass Fiord beds, and the cap-rock is orange-weathering dolomite of the Cape Clay Formation.

Cape Kent Limestone and considered the formation to be restricted to the Lower Cambrian. In the correlations proposed in the present report the Cape Kent Formation is correlated, from stratigraphic position and lithology, with certain of the unnamed beds[1] below the Parrish Glacier Formation at Copes Bay (*see* Thorsteinsson, 1963b, pp. 388, 389). These beds, earlier correlated with the Thule Group, have recently yielded fossils of Lower Cambrian age (Kerr, pers. com., and *see* Kerr, 1963).

Middle Cambrian

Cape Wood Formation

Definition, Distribution, Thickness

Descriptions of the Cape Wood Formation were published by Poulsen (1927, p. 242; 1946, p. 305) from Koch's collections and notes. Exposures in Inglefield Land were later studied by Troelsen, and the fauna of the Cape Wood Formation and other formations (Cape Frederik VII, Pemmican River)

[1] These beds were first mapped in 1955 by Thorsteinsson, who assigned them to the Precambrian and correlated them with the Thule Group of Greenland. Brief descriptions have been published by Blackadar (1957, pp. 96, 97) and by Kerr (1963).

proposed by Koch (1929b) was reconsidered by Poulsen (1946, p. 309). Troelsen and Poulsen concluded that the terms Cape Frederik VII and Pemmican River Formations could not be maintained, and Troelsen (1950, p. 42) redefined the Cape Wood Formation to 'include' the two discarded formations, which contained fauna and lithological characters representing beds in the Cape Wood Formation.

The Cape Wood Formation on Bache Peninsula comprises limestone and dolomite beds and overlies the Cape Kent conformably. It is exposed on uplands near the south coast of Bache Peninsula and in cliffs in the upper part of Flagler Bay (*see* Pls. VII, IX, X). A thickness of 130 feet was measured at the Police Post, where, however, the uppermost beds were not measured. The Cape Wood Formation is represented by units 12 and 13 in the Police Post section (Locality 1).

Lithology

On Bache Peninsula the Cape Wood Formation comprises medium-grained, grey-brown, brown-weathering dolomite and limestone that is variously massive, mottled, and cavernous. A network of dark films and patches in some beds suggests a former breccia structure. A five-foot bed of grey, limy sandstone at the Police Post is presumed to mark the base of the formation, although Troelsen (1950, p. 43) described the basal stratum as a fossiliferous limestone bed.

Fauna, Age, and Correlation

No fossils were found by the writer in beds herein assigned to the Cape Wood Formation, although a collection from talus was made by Bentham, and fossils were obtained from both the basal and upper strata by Troelsen. Poulsen (1946, p. 301) has identified the following forms in Bentham's collection:

Clavaspidella? sp.

Glossopleura cf. *expansa* Poulsen

Glossopleura longifrons Poulsen

Glossopleura walcotti Poulsen

Blainiopsis benthami gen. et sp. nov.

Blainiopsis scheii sp. nov.

Blainiopsis? sp.

Elrathia? sp.

Kochina arctica sp. nov.

Olenoides? *fallax* sp. nov.

The fauna was considered by Poulsen to include representatives of the lower (*Glossopleura*) and the upper (*Blainiopsis*) horizons of the Cape Wood Formation of Greenland. From faunal studies in Greenland, Poulsen (1946, pp. 305, 306) also distinguished an *Elrathiella* faunal zone between the *Glossopleura* and *Blainiopsis* horizons, but the *Elrathiella* horizon has not been found on Bache Peninsula. Poulsen dated the Cape Wood Formation as Middle Cambrian.

Troelsen (1950, pp. 43, 46) apparently collected both the *Glossopleura* and *Blainiopsis* faunas from the Cape Wood Formation at the Police Post.

Troelsen distinguished two members in the Cape Wood Formation: the lower, Cape Russell Member, and the upper, Blomsterbaek Member, separated from the lower by a thin conglomerate bed. The present author made no attempt in the field to sub-divide the Cape Wood beds.

The Cape Wood Formation may be correlated with impure limestone beds of the Parrish Glacier Formation, described by Thorsteinsson (1963b, p. 390) at Copes Bay, north of Bache Peninsula (*see* Fig. 4, col. 1). A trilobite probably related to *Clavaspidella* was collected from the Parrish Glacier Formation; *Clavaspidella* is known to occur within the *Glossopleura* zone of the Cape Wood Formation in Northwest Greenland (*see* Troelsen, 1950, p. 44). The Cape Wood and Parrish Glacier Formations are lithologically not closely similar. However, the Cape Wood Formation of Inglefield Land and Bache Peninsula is variable and includes numerous sandy beds; thus, it may be taken as a near-shore facies of the Parrish Glacier Formation, the shaly character of which suggests a geosynclinal association.

Lower Ordovician

Cass Fiord Formation (Map-unit 4)

Definition

The strata overlying the Cape Wood Formation are correlated with the Cass Fiord Formation, named and described by Koch (1929a, p. 9; 1929b, p. 229) in Washington Land, Northwest Greenland. Correlation of Cass Fiord beds of Washington Land, Inglefield Land, and Bache Peninsula was made by Troelsen (1950, p. 47) from their similarity in stratigraphic position and lithology. Both upper and lower contacts of the formation are conformable and abrupt on Bache Peninsula.

Distribution and Thickness

Exceptionally good exposures of the Cass Fiord Formation are found in the steep valley walls of upper Flagler Bay (Pl. X), where the overlying, resistant Cape Clay Formation forms a protective capping. Considerable areas of the upland of Bache Peninsula are underlain by Cass Fiord beds which, because of their recessive nature, are poorly exposed (*see* Pls. I, VIII). A completely exposed section of the Cass Fiord Formation was seen only at Flagler Bay, where about 1,600 feet of beds is present.

PLATE XI

An intraformational conglomerate bed of the Cass Fiord Formation. Note the characteristically platy nature of the overlying dolomitic limestone beds.

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Lithology

The Cass Fiord Formation comprises mostly grey-weathering, platy limestone, dolomitic limestone, and intraformational conglomerate (Pls. XI, XII). Algal and gypsiferous beds lie scattered in the upper half of the section (*see* Pls. XIII, XIV). Some beds emit a fetid or bituminous odour on breaking and certain of these contain small inarticulate brachiopod remains.

The general impression of the formation is one of thin, alternating or cyclical-bedded limestone, fragmental limestone, and massive dolomitic limestone, suggesting deposition in shallow waters. The formation forms recessive, grey-weathering slopes, mostly talus-covered. The basal few hundred feet of the formation in some places is reddish and greenish grey weathering. The uppermost 150 feet of beds, also in part fragmental, is dolomitic, grey to buff weathering, and competent. These beds, with the overlying orange-weathering Cape Clay dolomite, form prominent cliffs and steep slopes along Flagler Bay and elsewhere.

Although fragmental beds are common throughout the lower Palaeozoic section of Bache Peninsula, the dominantly fragmental and thin-bedded character of the Cass Fiord Formation is noteworthy. Evidently the Cass Fiord beds illustrate uniform and rapid or prolonged deposition in a basin in which sinking and deposition were closely balanced to produce a wide, shallow sea. Chemical deposition presumably was dominant, producing the massive, fine-grained limestone and the gypsum beds. It may be suggested, then, that the thin, rather coarsely fragmental, and very widely spread breccia and conglomerate beds represent redeposited debris from sea-bottom torn up by wave action and turbulence produced, say, by storm winds.

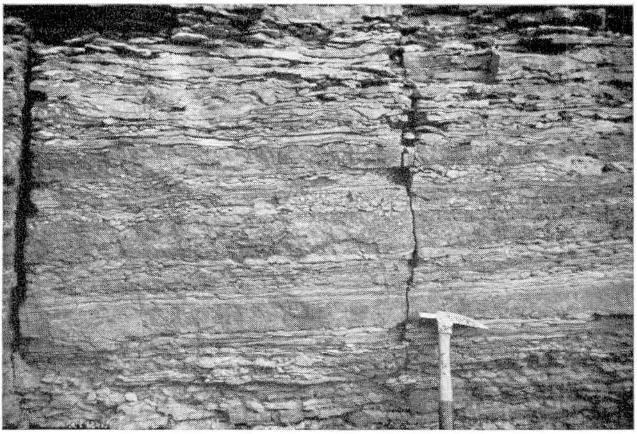

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PLATE XII

Thin-bedded, interbedded, intraformational conglomerate and conglomeratic dolomitic limestone near the top of the Cass Fiord Formation at Bartlett Bay. Note the characteristically wavy bedding surfaces.

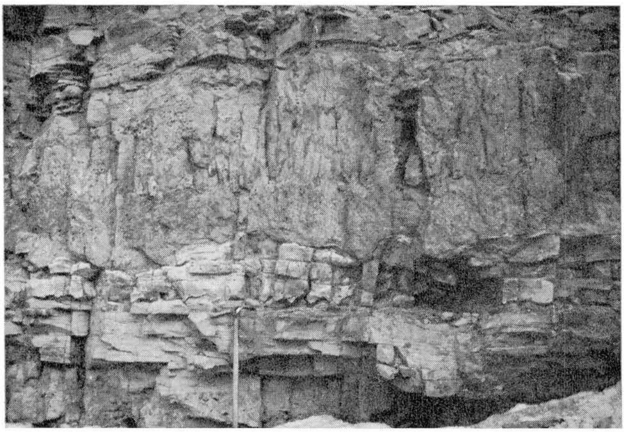

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PLATE XIII

A columnar algal bed about 5 feet thick resting, with a 'billowing' contact, on gypsiferous carbonate-rock. Intraformational carbonate breccia, in which a whole fossil brachiopod was found, fills the spaces between the algal columns. Cass Fiord Formation, exposed on the south shore of Flagler Bay.

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PLATE XIV

Base of the algal bed of Plate XIII.

The following section was measured by aneroid altimeter on the south wall of Flagler Bay, opposite the mouth of Sanddöla Creek; the Cass Fiord Formation is represented by beds of units 1 to 14 inclusive:

Section at the head of Flagler Bay
(Locality 7)

Unit No.		Approximate Thickness (feet)
	Top of section	
15	Cape Clay Formation: dolomite; medium-grained, porous, pale brownish yellow, orange-weathering; nearly massive, with widely spaced bedding joints; the uppermost 50 to 100 feet characterized by irregular tubes or lenses of a soft white mineral, perhaps leached siliceous material	250
	Top of Cass Fiord Formation	
14	Limestone; fine-grained, grey, weathering grey with a faint brown cast; thick-bedded, competent; patchy with siliceous material in the form of nets, strings, branching forms, lenses, tubes and pods, mainly oriented parallel with the bedding	150
13	Dolomitic limestone and interbedded intraformational breccia; limestone is fine-grained, grey, medium-bedded, nearly massive but with some grey and brown bands; some beds gypsiferous; intraformational breccia is grey-brown; at the base, limestone breaks with a pronounced fetid odour and contains tiny inarticulate brachiopod fossils; oölitic beds also present	450
12	Algal limestone; fine- to medium-grained, dark grey-brown, competent, thick-bedded; algal structure is columnar, forming slightly domed masses up to 8 feet in diameter; irregular algal columns measure up to 4 inches in diameter, and the intercolumnar space is filled with limestone breccia; interbeds include limestone intraformational breccia (some with a gypsiferous matrix) and thin-bedded gypsiferous dolomitic limestone; pink gypsum geodes, generally about one inch in diameter, observed in limestone	150
11	Dolomitic limestone and intraformational breccia; fragments up to 6 inches long, in part deposited on edge or sub-radiating; minor gypsiferous interbeds	85
10	Limy gypsum-rock; crumbling, grey-brown, with white fibrous gypsum veins up to 4 mm thick	15
9	Dolomite to limy dolomite; fine-grained, grey to brownish, weathering grey-brown; generally thick bedded and competent, but grey, thin-bedded limestone interbeds scattered throughout; columnar algal growth layer about middle of unit	200
8	Limestone; fine-grained, grey, thin-bedded, with argillaceous partings	15
7	Intraformational breccia; platy dolomite fragments up to 3 inches diameter in a dolomitic sandstone matrix	12
6	Sandstone; medium-grained, white	2
5	Dolomite; fine-grained, pale grey-brown, grey-weathering, medium-bedded; concretionary, siliceous, oölitic bed 6 inches thick also present	50
4	Limestone; fine-grained, thin-bedded (¼ inch to 2 inches), grey and grey-brown, with wavy bedding planes; numerous interbeds, 6 to 10 inches thick, of intraformational conglomerate with fragments 2 to 75 mm in diameter; bedding planes and matrix of conglomerate appear silty; inarticulate brachiopods sparsely scattered	250

Unit No.		Approximate Thickness (feet)
3	Covered interval; apparently thin-bedded, platy limestone with conspicuous amounts of intraformational conglomerate and breccia	140
2	Limestone; beds 4 to 8 inches thick; fine-grained, grey, with worm-tube-like structures on bedding planes; minor intraformational conglomerate	20
1	Covered interval; evidently grey-weathering, thin-bedded	40
	Total thickness of Cass Fiord Formation	1,600
	Underlying beds—Cape Wood Formation: dolomite; competent, near massive, vuggy, light brown; medium- to thick-bedded	

Fauna, Age, and Correlation

Koch (1929, p. 9) described the Cass Fiord Formation in Washington Land as limestone interstratified with limestone conglomerates, and assigned a thickness of at least 400 metres to the type section of the formation in Cass Fiord. A fauna collected from Cass Fiord beds by Koch was reported as including:

Lingulella? sp. ind.
Eoorthis? sp. ind.
Sinuopea? sp. ind.
Hystricurus ravni Poulsen
Hystricurus longicephalus Poulsen

Lingulella was described as the most common fossil, and as occurring throughout the formation. Poulsen (1927, p. 244), who identified the fossils, referred the formation to the Upper Ozarkian. Troelsen (1950, p. 47) dated the Cass Fiord Formation as Canadian.

Beds assigned to the Cass Fiord Formation on Ellesmere Island have not yielded diagnostic fossils, but are strikingly similar in lithology, thickness, and general appearance to Cass Fiord beds in Northwest Greenland. Lingulellid brachiopods and gastropod fragments were collected from three horizons near the head of Flagler Bay (*see* preceding section; GSC locs. 47282, 47284, 47285). Cass Fiord beds on the north shore of Bartlett Bay yielded the following forms, identified by J. W. Cowie (GSC locs. 47288, 47292, 47293, 47295, 47296): unidentifiable gastropod, horny brachiopod, a new genus cf. *Grinnellaspis,* unidentified bryozoan, and trilobite fragments. Cowie suggests a Lower Ordovician age for the collections.

A Lower Ordovician age may be tentatively accepted, from the available faunal and stratigraphic evidence, for the Cass Fiord Formation of Northwest Greenland and Bache Peninsula.

A formation in East Central Greenland with the distinctive Cass Fiord lithology has been named Cass Fiord Formation by Cowie and Adams (1957).

This formation has yielded a larger fauna of trilobites and graptolites, by which the authors (op. cit. p. 33) have dated it as Lower Ordovician. The upper beds of this formation possibly represent the Cape Clay Formation and part of the Poulsen Cliff Formation of Northwest Greenland. The Cass Fiord of East Central Greenland is overlain by the Lower Ordovician Cape Weber Formation.

It should be noted that the two regions in which Cass Fiord beds are identified (East Central Greenland and Bache Peninsula-Northwest Greenland) lie in different and widely separated structural provinces; it seems improbable that the two Cass Fiord Formations represent identical time intervals or were ever continuous.

The Cass Fiord Formation of Bache Peninsula is probably equivalent to the greater part of the Copes Bay Formation, which was defined by Thorsteinsson (1963b, p. 391) at Copes Bay, about 20 miles north of Bache Peninsula. The Copes Bay Formation was described as some 4,800 feet of mainly grey, medium- to thin-bedded limestone and argillaceous limestone with some shale, siltstone and gypsum. Ripple-marks and autobreccias are stated to be common bedding plane features. No fossils have yet been obtained from this formation, but it overlies the fossiliferous Middle Cambrian Parrish Glacier Formation, and underlies the Cornwallis Formation of Lower and Middle Ordovician age.

The upper part of the Copes Bay Formation contains thicker, more competent beds than the lower, and should include, from its stratigraphic position, equivalents of the Cape Clay Formation and map-unit 6 of Bache Peninsula. The lower beds, then, may be mainly equivalent to the Cass Fiord Formation.

It is interesting that unequivocally dated Upper Cambrian beds have not been found in the Canadian Arctic Archipelago. The abrupt contact between the tentatively Lower Ordovician Cass Fiord Formation and the underlying Middle Cambrian Cape Wood Formation is herein interpreted as a paraconformity.

Cape Clay Formation (Map-unit 5)

Definition, Distribution, Thickness

The Cape Clay Formation was defined by Koch (1929a, p. 14; 1929b, p. 230) in Washington Land, Greenland, where it conformably overlies the Cass Fiord Formation. On Bache Peninsula the Cape Clay Formation comprises about 300 feet of dolomite, usually competent and cliff-forming, and therefore well exposed throughout the region (*see* Pl. X).

The Cape Clay Formation is represented by unit 15 in the section measured at Locality 7, shown in the previous table.

Lithology

The Cape Clay Formation of Bache Peninsula is characteristically medium- to coarse-grained, porous to cavernous dolomite. The dolomite is pale brownish

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PLATE XV. Victoria Head viewed from the south. The usually competent dolomite of the Cape Clay Formation crumbles to form steep, light-coloured slopes below beds of map-unit 6, which form the uppermost cliffs.

yellow on the fresh surface, and weathers to a distinctive orange-brown that is easily identified even from great distances. The dolomite beds are thick and nearly massive, and in many places form long blocky cliffs. At Bartlett Bay, however, the formation is fractured and crumbling, and forms rubbly slopes (Pl. XV).

The Cape Clay dolomite is characteristically shot with siliceous material forming strings, nets, lenses, and branching forms up to about 10 mm thick, and oriented more or less in the bedding planes. The dolomite tends to be limy, and the siliceous network is white-weathering and particularly conspicuous in the uppermost 100 feet of the formation.

Fauna and Correlation

The present writer observed no fossils in the Cape Clay beds. Correlation with the Cape Clay Formation of Washington Land is made, however, from similarities in stratigraphic position and lithology. The Cape Clay Formation, as described by Koch, is yellowish to whitish compact and 'marble-like' limestone. Koch mentioned that "fossils are rather common" but that they are difficult to extract, and most of his collections are from loose debris. Poulsen (1927, p. 245) assigned an 'Upper Ozarkian' age to the fauna.

The writer agrees with Poulsen (1946, p. 331) that the 'light greyish white limestone' that Schei (1904, p. 457) described as occurring in a bed some 300 feet thick in the middle of the section at Victoria Head is identical with the beds herein classified as the Cape Clay Formation. These beds Schei referred to as the '*Orthoceras* limestone', and in a collection from them Holtedahl (1913, p. 7; Pl. 4, figs. 4, 5) identified trilobites as *Illaenurus* sp. and *Ptychoparia* sp. (?). Cephalopods and gastropods collected by Schei were figured and described by Foerste (1921) as:

cf. *Euconia quebecensis* Billings
Clarkoceras holtedahli Foerste
Ellesmeroceras scheii Foerste
cf. *Cameroceras tenuiseptum* (Hall)

In a restudy of Schei's collections, Poulsen (1946, p. 331) disagreed with Holtedahl's identifications, and offered the opinion that *'Illaenurus'* is, in fact, a closely related genus, *Symphysurina,* and that *'Ptychoparia'* is *Hystricurus.* In addition, Poulsen found the following in Schei's material: fragments of *Ophileta*? sp. indet.; *Clarkoceras* sp. identical with the species earlier described from the Cape Clay Formation of Northwest Greenland; *Symphysurina porifera* Poulsen; and *Hystricurus affinis* sp. nov.

Poulsen (1946, p. 302) also has examined talus collections brought back by Bentham, and in specimens presumed to come from a cephalopod-bearing 'mottled brown and white limestone' has noted forms that compare satisfactorily with *Clarkoceras* from the Cape Clay Formation of Greenland.

Thus, from both the lithological characters and the fauna it appears that the *Orthoceras* limestone, herein called Cape Clay, is identical with the Cape Clay Formation of Greenland.

From its stratigraphic position, the Cape Clay Formation appears correlative with beds in the upper part of the Copes Bay Formation at Copes and Scoresby Bays, respectively 20 miles north and 60 miles northeast of Bache Peninsula (*see* Fig. 4).

Map-unit 6

Definition, Distribution, Thickness

About 300 feet of beds lying conformably above the Cape Clay dolomite beds and below the gypsum member of the Cornwallis Formation are described herein but are not named. The beds of map-unit 6 underlie considerable areas of the uplands of Bache Peninsula (*see* Pl. XV).

Lithology

Map-unit 6 comprises fine-grained, grey- and brown-weathering, thin- to medium-bedded limestone and dolomitic limestone. Fragmental (intraformational conglomerate and breccia) and massive beds alternate repeatedly. Siliceous and sandy beds are common in the upper half of the formation.

The following, more or less typical, section of map-unit 6 was measured on a tributary of Sanddöla Creek, north of the head of Flagler Bay. Thicknesses were measured by an aneroid altimeter.

Section of Map-unit 6,
Sanddöla Creek
(Locality 9)

Unit No.		Approximate Thickness (feet)
	Overlying beds: gypsum and gypsiferous beds of the Cornwallis Formation	
2	Limy dolomite, breccia; lower beds are mainly medium-grained, light grey, sandy, limy dolomite and sandy dolomitic intraformational breccia; upper beds are fine-grained, grey-brown, grey-weathering dolomitic limestone with some chert nodules and a bituminous odour on breaking	210
1	Limestone; fine-grained, grey, thin-bedded; uppermost bed more massive, marked by siliceous networks and a bituminous odour on breaking; contains poorly preserved orthoceroconic cephalopod and gastropod fossils (GSC loc. 47280)	90
	Total thickness of map-unit 6	300
	Underlying beds: Cape Clay Formation; orange-weathering dolomite	

As the above descriptions reveal, quartz sand is an important component in the middle beds of the map-unit, although only a few minor beds are pure sandstone. Sandy beds occur only in the upper part of the unit at Bartlett Bay, where also some algal beds are present.

Fauna and Correlation

Only fragmentary, unidentifiable fossils were collected by the author from map-unit 6. Trilobite fragments in addition to the cephalopods and gastropods mentioned in the tabulation above, were found 130 feet above the Cape Clay dolomite at Bartlett Bay.

Map-unit 6, from its stratigraphic position, may be correlated with some or all of the Nunatami Formation of Koch (1929a, pp. 16-22) in Northwest Greenland, or the sequence Poulsen Cliff–Nygaard Bay–Cape Weber–Nunatami Formations of Troelsen[1] (1950, pp. 48-53).

From its stratigraphic position beneath the thick, basal gypsum member of the Cornwallis Formation, map-unit 6 appears probably equivalent to at least part of the thick-bedded, competent limestone member that forms the upper part of the Copes Bay Formation at Copes and Scoresby Bays (Fig. 4, cols. 1 and 2). This correlation is shared with the underlying Cape Clay Formation. For similar reasons, map-unit 6 and perhaps underlying beds may be correlatives of the Eleanor River Formation of Cornwallis Island (*see* Thorsteinsson, 1958, p. 32).

[1] The exact nature of the succession is somewhat contentious; Troelsen claimed to have identified three formations between Koch's (1929a, pp. 16-22; 1929b, p. 231) Cape Clay and Nunatami Formations, although the contact with the Cape Clay was not observed.

Lower and Middle Ordovician

Cornwallis Formation

Palaeontological and stratigraphic evidence indicates that the youngest formations (7, 8) of the conformable lower Palaeozoic sequence of Bache Peninsula are referrable to the lower part of the Cornwallis Formation, which was defined by Thorsteinsson and Fortier (1954, p. 8; *see also* Thorsteinsson, 1958, p. 33) on Cornwallis Island in the central-south part of the Queen Elizabeth Islands.[1]

In the type area on Cornwallis Island the Cornwallis Formation comprises mainly carbonate rocks with lesser clastic and evaporite strata, and was estimated to be about 5,000 feet thick. The formation is generally unfossiliferous except for the uppermost beds, in which fossils of Arctic Ordovician aspect are abundant.

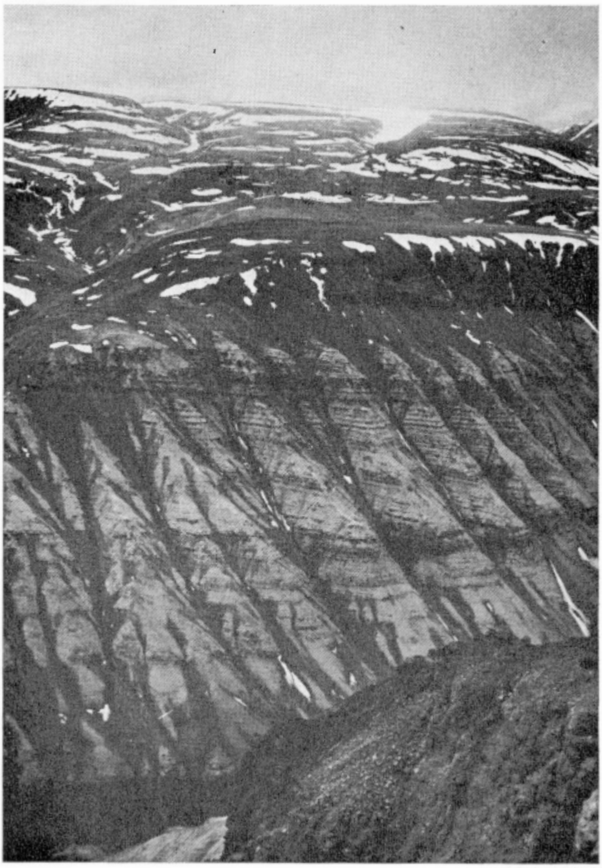

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PLATE XVI

A view southwest across Sanddöla Creek showing the gypsum beds. Competent beds of map-unit 6 are evident in the bottom of the photograph.

[1] *See* footnote, p. 49.

Mapping in recent years by the Geological Survey of Canada has shown the Cornwallis Formation to be widely exposed in both the miogeosynclinal region of the Franklinian geosyncline and in the Arctic Lowlands and plateaux region of Devon and Ellesmere Islands.

Two members are readily recognizable in the Cornwallis Formation of Bache Peninsula: Member A, the basal unit of the formation, consisting mainly of gypsum; and Member B, overlying, which is dolomitic limestone and intraformational conglomerate. These members have been mapped separately on the accompanying geological map.

Member A (Map-unit 7)

Member A comprises predominantly gypsiferous beds conformably overlying map-unit 6 of the Bache Peninsula region. The well-exposed section on Sanddöla Creek (*see* Pl. XVI) could serve as a reference section for the region. Member A is widely exposed in the vicinity of nearby Harmsworth Bay.

Distribution, Thickness

Member A underlies much of Bache Peninsula, and is prominent along the northern parts (*see* Pl. XVII); extensive exposures of gypsiferous measures occur also in the sea-cliffs between Bache Peninsula and Copes Bay (Thorsteinsson, 1963b, p. 392). The thickness was measured by aneroid altimeter as about 600 to 750 feet, the latter measurement at Sanddöla Creek.

Lithology

Member A is divisible into three units: a lower gypsum unit, a middle carbonate unit, and an upper gypsum unit. These divisions, which are of greatly disparate thicknesses, are described below in ascending order.

Lower gypsum beds: This unit, about 450 feet thick, comprises mainly thick beds of brownish white gypsum-anhydrite, with interbeds, especially at the base, of platy grey gypsiferous limestone. Competent interbeds up to 4 feet thick of dolomitic limestone breccia and algal-and-breccia-rock occur higher in the division.

Middle breccia beds: The gypsum units are separated by about 200 feet of competent, fine-grained, grey-brown dolomitic limestone breccia. At Bartlett Bay, where these beds are only about 100 feet thick, they consist predominantly of bioclastic material with thin upstanding algal fingers, and emit a petroliferous odour on breaking.

The breccia beds, contrasting markedly in competency with the gypsum beds above and below, stand out on the gently sloping uplands of northern Bache Peninsula and are easily identified in air photographs or from a distance (*see* Pl. XVII, extreme right).

PLATE XVII. A view westward of Bache Peninsula, with Bartlett Bay in the foreground. Note the conspicuous fault-lines and the dark hills of Tertiary coal-bearing beds.

Upper gypsum beds: This unit consists of about 100 feet of gypsum and gypsiferous beds. These beds are rarely exposed, lying as they do between thicker, relatively competent limestone-dolomite units.

Member A includes units 3 to 8 in the section described below:

Section of Member A of the Cornwallis Formation
on Sanddöla Creek
(Locality 9)

Unit No.		Approximate Thickness (feet)
	Overlying: Member B of the Cornwallis Formation	
	Covered interval	80
8	Upper gypsum unit: gypsum-anhydrite similar to unit 4	70
7	Middle carbonate unit: dolomitic limestone breccia; fine-grained, dark grey, brown-weathering, medium- to thick-bedded	150
	Top of lower gypsum unit	
6	Gypsum-anhydrite as unit 4	100
5	Interbedded gypsum, dolomitic limestone breccia, and breccia-algal rock; breccia beds are dark brown-weathering, thick, and competent; algal beds are of medium thickness and consist of columnar algal growths based on breccia strata	50

Unit No.		Approximate Thickness (feet)
4	Gypsum-anhydrite; variegated brown and white, thick-bedded, with bedding considerably distorted and brecciated; black chert as lenses, veins, and nodules abundant	200
3	Gypsum and gypsiferous carbonate-rock; thin-bedded, crumbling	100
	Base of lower gypsum unit	
	Total thickness of Member A	750
	Underlying beds: map-unit 6	

Fauna, Age

Fossil collections from the middle carbonate breccia division of Member A, exposed at Bartlett Bay (Locality 11), were identified by J. W. Cowie as follows:

Base of the unit (GSC locs. 47271, 47275)

Hormotoma sp.

Hystricurus sp.

Top of the unit (GSC loc. 47273)

Helicotoma sp.

Hormotoma sp.

?*Grinnellaspis* sp.

Member B (Map-unit 8)

Definition

Dolomitic limestone and limestone beds, described here as Member B of the Cornwallis Formation, abruptly but conformably overlie the upper gypsum beds of Member A (*see* Pl. XVI). Member B caps the hills along the northern part of Bache Peninsula; it is well exposed and has yielded numerous fossils at Harmsworth and Bartlett Bays. About 500 feet of this unit, the top of which is not defined, have been measured.

Lithology

Member B comprises interbedded grey-brown-weathering-dolomitic limestone, intraformational conglomerate, bioclastic limestone, and platy limestone. Bedding is thin to moderately thick. The rocks generally break into platy debris and weather with a scoriaceous, nodular, or hackly surface. The weathering character is due to the fragmental structure and perhaps to variation in grain and degree of dolomite replacement. A petroliferous odour may usually be detected on breaking the rocks. Numerous beds with abundant fossils, both whole and fragmental, are present. The following sections were measured using an aneroid altimeter; fossils in these sections were identified by G. W. Sinclair, Geological Survey of Canada.

Section of Member B of Cornwallis Formation[1]
at Bartlett Bay, South Side
(Locality 12)

Unit No.		Approximate Thickness (feet)
	Top of section; eroded	
8	Dolomitic limestone; alternating medium- and thin-bedded, brown-weathering; chert nodules evident and fossils numerous (GSC loc. 47291): *Cycloceras* sp. *Hormotoma* sp. *Pliomera* sp. *Polytoechia* sp.	130
7	Dolomitic limestone with breccia interbeds, generally thin-bedded; uppermost bed contains brachiopods in crinoid-fragment coquina	70
6	Dolomitic limestone breccia with fine-grained limestone and shaly limestone interbeds; some bioclastic (coquina) beds, with trilobite cheeks up to 3 inches long; thin- to medium-bedded, moderately competent	110
5	Limestone; fine-grained, brownish grey, weathering creamy brown, thin-bedded; some weakly developed ripple-marks	20
4	Dolomitic limestone breccia and dolomitic limestone, interbedded; thin- to thick-bedded, and competent; as units 1 and 2	70
3	Dolomitic limestone; thin-bedded, relatively incompetent, weathering with a sponge-like surface; fossils include (GSC loc. 47294): cf. *Maclurites* sponge trilobite	20
2	Dolomitic limestone; fine-grained, thin-bedded, with irregular, nodular bedding planes	20
1	Dolomitic limestone conglomerate or intraformational breccia; fine-grained, brownish to purplish grey, yellowish brown-weathering, thin- to thick-bedded; poorly preserved fossils present	40
	Total measured thickness of Member B	480
	Underlying beds: gypsum of Member A, Cornwallis Formation	

[1] *See* footnote, p. 49.

Section of Member B of Cornwallis Formation[1]
on Sanddöla Creek
(Locality 9)

Unit No.		Approximate Thickness (feet)
	Top of section; eroded	
12	Dolomitic limestone; grey, yellowish weathering, thin-bedded, uniform	500 ?
11	Limestone; light grey, thin-bedded, shaly, recessive; fossils described below (GSC loc. 47276) apparently lie on bedding plane at base of unit	20
10	Dolomitic limestone and interbedded breccia as below; several fossiliferous beds (GSC loc. 47289) from which were collected: *Spyroceras* sp. *Liospira* sp. *Hormotoma* sp. *Gyronema* sp. *Lophospira* sp. *Maclurites* sp. *Priscochiton* sp. *Ceratopea* sp. orthoceroconic cephalopod sponge crinoid fragments The uppermost bed yields (GSC loc. 47276): *Goniotelus* sp. crinoid fragments orthoid brachiopod asaphid trilobite	150
9	Dolomitic limestone and intraformational breccia; fine-grained, dark grey, grey-brown-weathering; medium-bedded and tough, forming a competent unit; siliceous networks in lighter weathering, variegated breccia beds; flint nodules up to 3 inches long, and irregular, worm-like forms ½ inch thick up to 8 inches long; strong petroliferous odour on breaking	100
	Underlying: poorly exposed gypsum beds of Member A, Cornwallis Formation	

Fauna

Fossil collections (GSC locs. 47294, 47291, 47289, 47276) from beds in the two measured sections tabulated above are listed there. Other collections, from equivalent beds in other sections examined but not described here, have been reported on by G. W. Sinclair and are listed below:

South side of Bartlett Bay (Locality 11), from beds equivalent to beds 3 and 4 in the Bartlett Bay section (Locality 12) tabulated above:

[1] *See* footnote, p. 49.

70 feet above the base of Member B, Cornwallis
Formation (GSC loc. 47278)

Pliomera sp.
Goniotelus sp.
Bathyurus sp.
orthoceroconic cephalopod
gastropods

About 100 feet above the base, and higher (GSC loc. 47277)

Maclurites sp.
Turritoma sp.
Plioceras sp.
'*Spyroceras*' sp.
orthoceroconic cephalopod
sponge

East side of pass between Harmsworth and Flagler Bays (Locality 13), from beds equivalent to beds 10 and 11 in the Sanddöla Creek section (Locality 9) tabulated above:

200 feet above the base of Member B,
Cornwallis Formation (GSC loc. 47272)

Goniotelus sp.
Pliomera sp.

300 feet above the base (at the base
of the shaly unit 11) (GSC loc. 47279)

Goniotelus sp.
Pliomera sp.
Hormotoma sp.
small bucanid gastropod
orthoid brachiopod
crinoid fragments

Age and Correlation of the Cornwallis Formation[1] of Bache Peninsula

A Lower Ordovician age is indicated, according to G. W. Sinclair, for all the fossils collected from the Cornwallis Formation of Bache Peninsula. Correlation with the type area of the Cornwallis Formation is made, however, from the presence of the thick, basal gypsiferous member (Member A of Bache Peninsula). The faunules are, nevertheless, of considerable interest because, until now, no part of the Cornwallis Formation has been known to be older than Middle Ordovician[1].

Three faunal zones heretofore have been tentatively recognized in the Cornwallis Formation of Cornwallis Island and surrounding islands (*see* Thorsteinsson, 1958, pp. 38-42; 1963a, pp. 38, 39). The oldest zone is characterized by the trilobites *Bathyurus* and *Isotelus,* and includes also such forms as: *Palaeocystites, Rhinidictya, Pachydicta, Hesperorthis, Rafinesquina, Plectorthis, Lophospira,* and *Goniurus.*

A middle zone typified by the cephalopod *Gonioceras* has been indicated by collections from talus apparently derived from beds below the uppermost zone, and is confirmed by the presence of *Gonioceras* in the Gonioceras Bay Formation of Northwest Greenland, which underlies the uppermost, or typical 'Arctic Ordovician' faunal zone. The upper zone is probably the most widespread and abundantly represented fossil zone in the Canadian Arctic Archipelago; this contains the so-called 'Arctic Ordovician' fauna, and appears in the upper few hundred feet of beds in the Cornwallis Formation. This zone is characterized by the cephalopod *Probillingsites,* and includes also: *Calapoecia, Catenipora, Palaeophyllum, Foerstephyllum, Streptelasma, Receptaculites, Dinorthis, Hebertella, Öpikina, Rhynchotrema, Trochonema, Maclurites, Hormotoma, Charactocerina, Cyrtogomphoceras, Aspidoceras, Cyclendoceras, Diestoceras, Charactoceras, Actinoceras, Vaginoceras, Lambeoceras, Westonoceras, Illaenus,* and *Bumastus.* The Arctic Ordovician fauna is also represented in the lower part of the Allen Bay–Cape Phillips Formations (facies equivalents), which overlie the Cornwallis Formation (Thorsteinsson, 1963a, pp. 41, 45).

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[1] Important changes in both stratigraphic correlation and in nomenclature have been made by J. W. Kerr (pers. com.) since this report was written. Kerr now recognizes two gypsum-bearing formations separated by the Eleanor River Formation; it appears that, in many places on Ellesmere Island, the lower gypsum unit has been wrongly identified as the basal gypsiferous member of the Cornwallis Formation. Contrary to statements in the text above, it now appears that a Middle Ordovician age for the entire Cornwallis Formation is correct, and that the Lower Ordovician gypsum and limestone beds of Bache Peninsula correlate with the Eleanor River and other units *underlying* the Cornwallis Formation. In addition, the Eleanor River Formation at Burnett Inlet on Devon Island (referred to in the text) now seems to have been correctly identified, although it remains to be discovered which beds, if any, represent the lower of the two gypsiferous units; the lower unit is represented, possibly, by part of the thin-bedded sequence below the *Piloceras* (?) horizon described by Glenister (1963, p. 181) as occurring about 1,000 feet above the base of the section.

All three of the previously known faunal zones have been dated as Middle Ordovician or younger[1]. Furthermore, a Middle Ordovician age has been inferred for the whole of the Cornwallis Formation, including the gypsiferous, lowermost member and the lower part of the overlying carbonate member, where no fossils have been found until the present study. The inferred age was based on a faunule collected by Glenister (1963, p. 181) at Burnett Inlet on Devon Island; the faunule was supposedly from the Eleanor River Formation, conformably underlying the Cornwallis Formation, and was provisionally dated Middle Ordovician. Provisionally dated Middle or Upper Ordovician and Middle Ordovician fossils from a limestone member overlying the basal gypsum member, with fossils from the lower part of the gypsum member identified as ?*Foerstephyllum* sp., apparently confirmed the inferred Middle Ordovician age for the entire Cornwallis Formation.

In view of the results from Burnett Inlet, the discovery of Lower Ordovician fossils in the lower beds of the Cornwallis Formation came as a surprise. If the identification and Middle Ordovician age of the Eleanor River Formation at Burnett Inlet were accepted, a greater age range would be implied for Cornwallis beds in the Bache Peninsula region than in other parts of the Canadian Arctic Archipelago. Such a variance in age range does not appear probable to the present writer for the following reasons: (a) The widespread presence of the basal gypsiferous member of the Cornwallis Formation in the Franklinian geosyncline and neighbouring regions has been confirmed by a recently completed reconnaissance study by J. W. Kerr (1963, and pers. com.). (b) Member A of the Cornwallis Formation, as described herein, is almost certainly lithologically equivalent to the basal gypsiferous member of the formation described by Thorsteinsson (1963b, p. 392) at Copes Bay, some 20 miles north of Bache Peninsula; in both areas the gypsiferous member is characterized by a distinctive three-fold lithologic division. (c) Lower Ordovician fossils also have been collected by Kerr from beds immediately above the gypsiferous member in the Cornwallis Formation. Although the Eleanor River Formation evidently has been misidentified at Burnett Inlet on Devon Island, the writer prefers tentatively to regard the basal gypsum member of the Cornwallis Formation as a time-stratigraphic unit and of Lower Ordovician age throughout the area of exposure. The alternate possibility of transgression of time and faunal boundaries by the formation will be confirmed or disproven, presumably, by further investigations on Devon Island and southern Ellesmere Island.

Correlation of the lower Cornwallis beds of Bache Peninsula with the Cape Webster Formation of Northwest Greenland is inviting from the stratigraphic position of the two formations. Exact correlation is not possible, however, until agreement on the formational and faunal boundaries of the formations above and below the Cape Webster Formation is reached (*see* Troelsen, 1950, pp. 48-58).

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[1] The age of the Arctic Ordovician faunal zone has been a subject of considerable dispute, and forms of the fauna have been referred to ages ranging from the Black Riveran to Richmondian epochs. Thorsteinsson (1958, p. 90; 1963a, p. 42), however, has tentatively drawn the Middle and Upper Ordovician boundary at the top of the Cornwallis Formation.

Lithological correlation of the lower Cornwallis beds with the Cape Webster Formation might be suggested; although gypsum is not mentioned by Koch, limestone breccias or conglomerates and incompetent weathering character are common to both formations. The recessive slopes of the Cape Webster Formation, evident in photographs by Koch (e.g., 1929a, pp. 19, 25), appear identical in nature to those of the lower Cornwallis Formation. Koch noted that only minor sections were exposed; gypsum layers might easily have been missed in reconnaissance journeys such as Koch undertook. In any case, the alternating light yellow compact limestone and dark shale described by Koch may well be a lateral facies equivalent of the interbedded gypsum, impure gypsum, and limestone that occurs at the same stratigraphic horizons to the west. If this correlation was correct, the suspected Chazyan or Canadian age of the Cape Webster Formations (*see* Koch, 1929a, pp. 24, 25) would be confirmed by the Lower Ordovician age now given to the lower parts of the Cornwallis Formation.

Tertiary

Eureka Sound Formation (Map-unit 9)

A coal-bearing, weakly consolidated sandstone formation is preserved in fault slices in the vicinity of Bartlett Bay, where it forms several dark-weathering hills (Pls. XVII, XVIII). No section was measured, but the thickness can be estimated as at least equal to the local relief, which is about 700 feet.

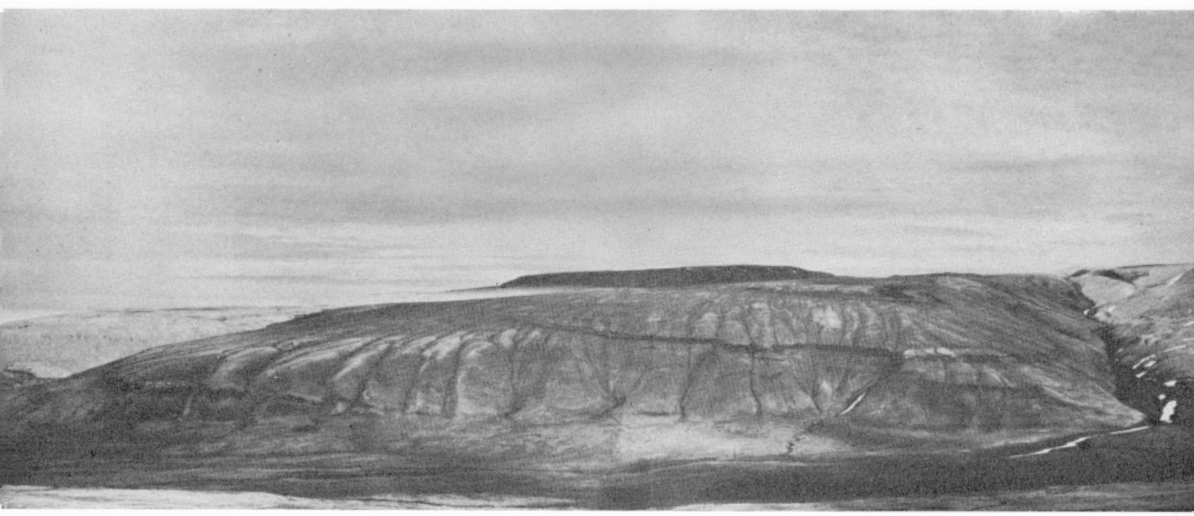

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PLATE XVIII. View eastward to Tertiary beds near Bartlett Bay. The dark bands are thin coal seams.

Lithology

The Tertiary beds at Bartlett Bay comprise quartz-carbonate sandstone, conglomerate, shaly sandstone, and shaly coal.

The conglomerate consists of poorly sorted but mostly well-rounded limestone and dolomite pebbles about 1 inch to 4 inches in diameter in a sand matrix. The sandstones are medium-grained, slightly cemented, light brown or yellowish white-weathering rocks. They typically comprise less than half angular quartz fragments and more than half dolomitic carbonate fragments. The sandstones contain scattered pebbles of limestone, dolomite, and chert.

Poorly consolidated green-grey and grey-brown shaly sandstone beds probably form most of the section but are rarely exposed, due to their rapid breakdown to muddy sand.

Shaly coal lenses and seams are abundant. Two seams (*see* Pl. XVIII) were estimated from their slumped exposures to be about 3 feet or more thick, and a third, exposed in a limited area near the junction of two streams, about 15 feet or more thick. A sample from the larger seam (Locality 14) was analyzed by W. J. Montgomery of the Mines Branch, Department of Energy, Mines and Resources, who reports as follows:

Table II

Analysis of Coal from Bartlett Bay Vicinity (Locality 14), Bache Peninsula

		Equilibrium at 97% relative humidity	Dry
Proximate analysis			
Moisture	%	21.9	0.0
Ash	%	35.4	45.2
Volatile matter	%	25.4	32.5
Fixed carbon (by difference)	%	17.4	22.3
Ultimate analysis			
Sulphur			2.0
Calorific value Btu/lb gross		4670	5680
Moist mineral matter free Btu		7220	

The coaly material may be described as lignitic, with a very high ash content.

Flora, Age, and Correlation

Plant microfossils were extracted from impure sandstone and coal specimens by the Palaeontology Section of the Geological Survey of Canada and identified by G. E. Rouse of the University of British Columbia as follows:

Sandstone, north bank of east-flowing creek emptying into Bartlett Bay (Loc. 15; GSC loc. 5845)

Pteridophytes:

Lycopodium sp. (same as in Manum, 1954)
Laevigatosporites albertensis Rouse
Osmundacidites sp.
Azolla sp. similar to *primaeva* (Penh) Arnold
Selaginella sp.
Spore of Polypodiaceae? (similar to Manum's Pl. I, figs. 3, 4).
Gleichenia concavisporites Rouse

Conifers:

Pinus strobipites Wodehouse
Picea grandivescipites Wodehouse
Sciadopitys sp. (larger than Manum's)
Taxodiaceae, cf. *Glyptostrobus* sp.

Angiosperms:

Betula sp. (same as Manum's)
Corylus sp. (same as Manum's)
Carya sp.
cf. *Salix* sp. (same as Manum's Pl. I, figs. 21 and 22)
Ericaceae tetrad (same as Manum's Pl. I, figs. 28 and 29)

Sandstone, hill southwest of Bartlett Bay (Loc. 16; GSC loc. 5844)

Pteridophytes:

Lycopodium sp.
Laevigatosporites ovatus Wilson and Webster
Osmundacidites primarius (Wolff) Potonié

Conifers:

Pinus strobipites Wodehouse
Taxodium hiatipites Wodehouse
Pinus sp., 50 mu.
cf. *Podocarpus* sp.
cf. *Picea* sp.
?*Pseudotsuga* sp. (may be a large *Larix*)

Angiosperms:

Betula sp. (identical with Manum's Pl. I, fig.10)
Corylus sp. (identical with Manum's Pl. I, fig. 11)
cf. *Myrica* sp. (similar to Manum's Pl. I, fig. 13)

Coal, canyon southwest of Bartlett Bay (Loc. 17; GSC loc. 5846)

Pteridophytes:

Osmundacidites primarius (Wolff) Potonié

Conifers:

Pinus strobipites Wodehouse
Larix sp.

Angiosperms:

Betula sp. (same as Manum's)
Corylus sp. (same as Manum's)
Myrica sp.

In Rouse's comments on the florule he states that there is a high degree of similarity to that described by Manum (1954) from Spitzbergen, and which was referred to either Paleocene or Eocene. He adds that the presence in one sample of *Gleichenia*, which in beds in British Columbia does not range into the Eocene, suggests an early (Paleocene) age, but that typical Paleocene spores and pollen (e.g., *Extratriporopollenites*) that are so abundant in the Siberian Paleocene are completely absent in the specimens from Bache Peninsula. Rouse suggests an age range of Paleocene to Eocene for the specimens.

The sandstone and coal beds of Bache Peninsula are similar in lithological character and stratigraphic position to the Eureka Sound Formation, which is widely exposed on the west side of Ellesmere Island (*see* Thorsteinsson and Tozer, 1957; Tozer, 1963, pp. 92-95). Rouse, in his report, remarks that the microfossils from Bache Peninsula are closely correlative with microfossils from a coal specimen recently collected by E. T. Tozer, Geological Survey of Canada, on Schei Peninsula, Axel Heiberg Island.

The Eureka Sound Formation, in regions to the west of Bache Peninsula, is known to lie with structural conformity upon beds ranging in age from Upper Cretaceous in the west to lower Palaeozoic in the east. The formation is interpreted as a transgressive deposit, overstepping progressively older formations to the east; the Eureka Sound beds predate and are folded by the Tertiary earth-movements that affected the region.

The angular relationship of the Tertiary beds of Bache Peninsula to the underlying lower Palaeozoic formations has not been determined because of insufficient exposures. The beds appear nearly conformable or displaced a few degrees. At least a small angular relationship and an irregular surface of unconformity might be expected from the composition of the sandstone and conglomerate exposed near Bartlett Bay; rock of the provenant terrane appears to have been the local Palaeozoic dolomitic limestone and sandstone, and it appears probable that the Tertiary beds were deposited in small basins in a region of moderate relief.

Diabase Sills

The two diabase sills in the lower part of the Rensselaer Bay Formation, noted by Schei and others, were not studied by the present author except to record their stratigraphic positions (*see* Pl. II). Little new information, therefore, can be contributed. The wide distribution and stratigraphic positions of the sill-rocks are of interest, however, and will be discussed briefly in the following paragraphs.

The age of the diabase is unknown, but is generally assumed to be Precambrian because of: (a) its association with unfossiliferous, sub-Cambrian beds; (b) its apparent absence in Cambrian and younger beds; and (c) the presence of diabase pebbles in a Cambrian formation in Inglefield Land. On Bache Peninsula the diabase sills are restricted to the lower part of the Rensselaer Bay Formation (*see* Fig. 1) and therefore apparently conform to these general relationships.

The highest horizon in which diabase sills are found varies from place to place. In Inglefield Land, Greenland, a sill lies between the uppermost 'cream to buff' sandstone (Sverdrup Member?) and the lowest buff-weathering dolomite (Cape Leiper Formation), according to Cowie (1961, p. 10), who added that no transgression into the dolomite has been observed. Koch (1933, pp. 22, 23) earlier described the sills of Inglefield Land as intruding the 'red sandstone' (Bache Peninsula Member?) but stated that the diabases erupted *after* the dolomites (Cape Leiper, Cape Ingersoll), and on his map (1933, Pl. XI) clearly showed a diabase dyke cutting the dolomite. Nowhere in his text, however, did Koch state that diabase cuts dolomite, and he might have been thinking of relationships in regions beyond Inglefield Land. The relationship shown on the map could easily be an error. On Bache Peninsula the highest sill has intruded along the basal surface of the Bache Peninsula Member, although at another locality, about 4 miles east of the Police Post, rubble seems to indicate dyke or sill rock near the top of that member, but not above it.

The ages of the sills and of the enclosing beds remain uncertain, still depending as they do on the identification and evaluation of disconformities and the correlation of unfossiliferous formations discontinuously exposed over wide areas. Even the presence of diabase pebbles in Cambrian beds cannot be taken as limiting the age, because some diabase dykes, widespread in the crystalline basement complex, almost certainly antedate the denudation of the complex and have contributed debris to such younger, detrital beds[1].

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[1] Diabase dykes apparently are truncated and overlain by probable Precambrian beds near Cape Combermere, 150 miles south of Bache Peninsula (*see* Christie, 1962, marginal notes).

STRUCTURAL GEOLOGY

The lower Palaeozoic beds of Bache Peninsula are part of the 'Bache homocline', an area of gently north-dipping strata resting on uplifted crystalline basement rocks. The homoclinal area lies on the southeastern margin of the central Ellesmere Fold Belt or zone of folded miogeosynclinal rocks of the Franklinian geosyncline (*see* GSC Mem. 320, Fig. 1). Only structures younger than the basement complex will be considered here.

The bedded rocks dip 5 degrees or less to the north and are exposed as east-trending bands or as caps on the hills of the peninsulas, thus providing the dominant structural pattern of the geological map.

Nearly flat or anomalous westward dips occur in the small areas of Tertiary beds; the true attitude of the Tertiary beds is difficult to evaluate, however, because of widespread distortion due to the bounding faults. Strong fault-lines and lineaments constitute a second prominent structural feature. The faults, trending mainly easterly and northeasterly, interrupt the outcrop bands and are expressed also by fiords and secondary valleys. Less prominent but still important faults trend northeast to north-northeast, and northwest.

Two major faults, parallel and trending east, underlie at least the eastern part of Flagler Bay and coincide with deep indentations on the east coast of Bache Peninsula. The preservation of Tertiary beds along both sides of the belt between the faults suggests a down-dropped or graben zone, but the Palaeozoic beds are displaced normally and it seems probable that the zone is complicated by branch faults resulting in 'slivers' or 'slices'. The amount of horizontal displacement is unknown, and may be considerable.

A prominent, east-northeast-trending zone of faulting coincides with Harmsworth Bay and the uppermost arm of Flagler Bay. Stratigraphic displacement in this zone is appreciable at Harmsworth Bay but apparently decreases to the southwest.

Tertiary fault movement is evident from dislocation of beds of that period. Earlier movement on the same faults may have occurred, at least one phase of this pre-Tertiary activity perhaps resulting in or influencing the location of the local Tertiary basins postulated in the previous section of this report. These possible, earlier periods of activity can only be dated as post-Lower Ordovician, pre-Tertiary, or early Tertiary. Widespread faulting, for example, could have accompanied the period of post-Lower Cretaceous, pre-Tertiary diabase intrusion that took place in the Sverdrup basin to the west (*see* Blackadar, 1963).

Faulting in the Bache Peninsula region might supposedly be related to the Tertiary orogeny that deformed the Sverdrup basin to the west (*see* Thorsteinsson and Tozer, 1960, p. 14). This hypothesis is based on the following facts: (a) the margins of the miogeosynclinal region (on which Bache Peninsula lies) and of the Sverdrup basin lie nearly parallel and only 50 or 60 miles apart; (b) Tertiary folding has been superimposed on earlier folding in the marginal areas, and Tertiary structures also have affected areas outside the region of Palaeozoic folding—e.g., Irene Bay at the head of Bay Fiord, some 40 miles west of Bache Peninsula (*see* Thorsteinsson and Tozer, 1957).

Thrust faults a few miles north of Bache Peninsula may be the result of a major compressional phase that deformed the Sverdrup basin, while normal and transcurrent faults of Bache Peninsula may have provided adjustment and relief of stresses during a late phase of the orogeny. Block-faulting of the cratonic basement and overlying sedimentary veneer, with slight basinward tilting of the blocks, also occurs on southern Ellesmere Island, southwestward along the fold-belt margin, and appears to be a characteristic structural feature of this province.

ECONOMIC GEOLOGY

Of minerals observed in the bedded rocks, only the Tertiary lignitic coal and the Ordovician gypsum could be considered of potential economic interest.

The coal of Bartlett Bay underlies a small area, is of uncertain thickness and continuity, and is of low physical and thermal quality (*see* Table II). It seems certain, therefore, that the coal will be used only locally if, indeed, any use can be made of it.

The gypsum deposits invite attention because of their widespread development and considerable thickness. These factors would provide a wide choice of mining sites and ample tonnage should gypsum be in demand at these latitudes.

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