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LOWER PALAEOZOIC SEDIMENTS OF NORTHWESTERN BAFFIN ISLAND, DISTRICT OF FRANKLIN

(Report and 10 Figures)

H. P. Trettin

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ABSTRACT

This is a summary description of the Lower Palaeozoic sediments of northern Baffin Island west of long. 80°, an area of some 50,000 square miles with local relief up to 4,000 feet. Here, Precambrian plutonic, metamorphic, sedimentary, hypabyssal, and volcanic rocks are unconformably overlain by Cambrian (?), Ordovician, and Silurian strata with a maximum thickness of nearly 6,000 feet.

The basal Lower Ordovician or Cambrian Admiralty Group comprises the largely non-marine Gallery sandstone (0-1,125 feet) and the shallow marine Turner Cliffs Formation, dolomitic and clastic sediments (0-1,008 feet). Isopachous maps indicate that the group was deposited in an easterly plunging basin or embayment confined to the northern half of the area, and paleocurrent studies show that the clastic sediments were derived from a northwestern source (Franklinian geosyncline?) and a southern source (craton). Regional relationships suggest that the group is upper Lower and Middle Cambrian, but diagnostic fossils are lacking. The Lower and lower Middle Ordovician Ship Point dolomite (150-900 feet) transgressed the entire area. In the southern third, the lower part of the formation shows near-shore features. The Ship Point is overlain disconformably by the Brodeur Group which comprises the upper Middle Ordovician to lower (?) Niagaran Baillarge Formation (1,600 feet)—mainly dolomitic limestone with some dolomite and shale in the lower member, and the Niagaran and (?) younger Cape Crauford (1,340 feet)—dolomitic limestone, calcareous dolomite, and evaporite solution breccias. The group represents a transgressive-regressive cycle with the deepest submergence mainly in the Late Ordovician and Early Silurian.

The influence of several Precambrian structural elements on Lower Palaeozoic sedimentation is apparent. Post-Silurian deformations produced the gentle, arcuate, northwesterly to southwesterly dipping Brodeur Homocline; northwesterly (about 300°) trending faults; and complicated fracture patterns that control the drainage.

The Turner Cliffs Formation locally contains oolitic iron (up to 40 per cent), but not in economic quantity.

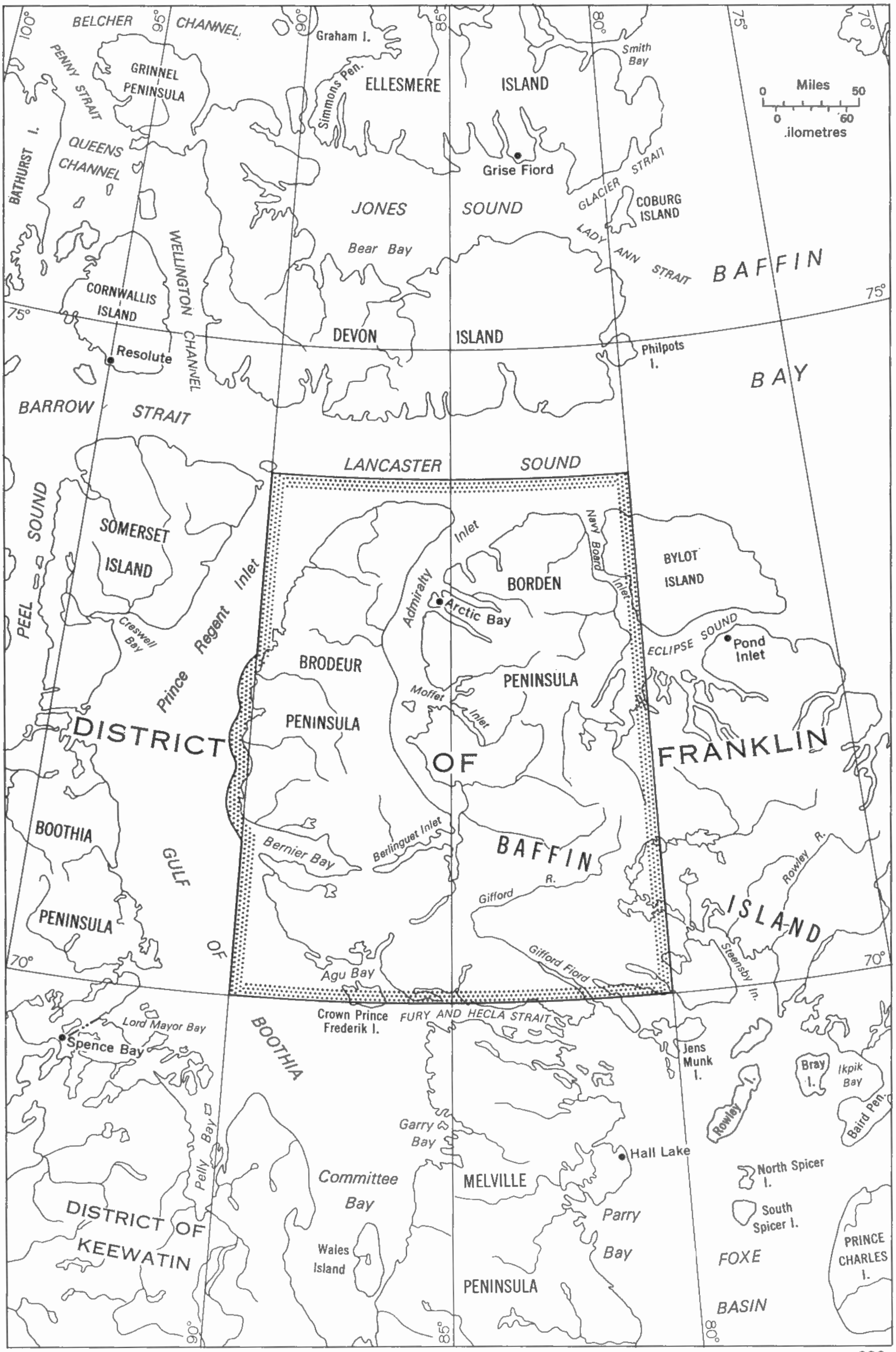


Figure 1. Location of map-area

LOWER PALAEOZOIC SEDIMENTS OF NORTHWESTERN BAFFIN ISLAND, DISTRICT OF FRANKLIN

INTRODUCTION

This report summarizes the Lower Palaeozoic stratigraphy and structural history of northern Baffin Island west of long. 80°, an area of about 55,000 square miles (see Fig. 1). Nearly horizontal, shelf-type Lower Palaeozoic sediments with a total maximum thickness of nearly 6,000 feet, resting unconformably on Precambrian rocks, cover about half the area (see Fig. 10)—mainly the western, northern, and southeastern parts.

The earliest geological information on the Lower Palaeozoic of the area is in the account of Parry's third Arctic voyage 1824-25 (Neill in Parry, 1826*, pp. 91-94; Jameson, ibid., pp. 145-151; Lee, 1912; Foerste and Savage, 1927); later important contributions were made by the Danish Fifth Thule Expedition (Mathiassen, 1933; Teichert, 1937). Reconnaissance work on Lower Palaeozoic strata in parts of the area was done by R.G. Blackadar in 1954 (Lemon and Blackadar, 1963) and in 1956 and 1957 (Blackadar, 1958a, 1958b and 1963), and by A.W. Norris in 1955 (Norris, 1963). In 1954, R.R.H. Lemon carried out detailed stratigraphic studies on the coasts of Admiralty Inlet (Lemon, 1956; Lemon and Blackadar, 1963).

In the summer of 1963 the Geological Survey of Canada completed the reconnaissance mapping of the area. R.G. Blackadar was responsible for organization and the mapping of Precambrian rocks, D.B. Craig for Pleistocene deposits, and the writer for the Lower Palaeozoic strata. W.L. Davison, who assisted Blackadar, completed earlier work in the adjacent Pond Inlet area. A map of the bedrock geology has been compiled by Blackadar and the writer, but its publication will be delayed until new topographic base maps are available. The accessibility, topography, and Precambrian geology are described by Blackadar (1965).

Acknowledgments

In the field the writer was ably assisted by A.A. Petryk, a graduate student at McGill University. Brachiopods from the Turner Cliffs Formation were identified by B. Rowell of the University of Nottingham, England, fossils of the Arctic Ordovician fauna by G.W. Sinclair, and Silurian fossils by T.E. Bolton, both of the Geological Survey. Examination of rock specimens by R.M. Thompson, W.R. Danner, and G.E. Rouse of the University of British Columbia is gratefully acknowledged. R.N. Delabio and J.A. Maxwell of the Geological Survey made several X-ray determinations and one chemical analysis. The pilots J. Bryant (Bradley Air Services Ltd.), G.R. Field and W. Thomas (Universal Helicopters Ltd.) performed their duties in a competent and cooperative manner.

*Names and/or dates in parentheses refer to publications listed in the References.

TABLE OF FORMATIONS

Age	Group	Formation and Thickness (feet)	Lithology
Middle Silurian and (?) younger	Brodeur	Cape Crauford (1,340)	Dolomitic limestone, calcareous dolomite, evaporite solution breccias
			-conformable contact
Late Middle Ordovician to Middle Silurian		Baillarge (1,600)	Dolomitic limestone, minor calcareous dolomite, shaly carbonates, shale
			-local or regional disconformity
Early and early Middle Ordovician		Ship Point (150-900)	Dolomite, in part shaly and silty; minor dolomitic intraformational conglomerate, siltstone, sandstone, and shale
			-contact relationships uncertain
Early Ordovician and/or Cambrian	Admiralty	Turner Cliffs (0-1,008)	Dolomite, mostly shaly and silty; sandstone, quartzose and dolomitic; intraformational conglomerate; minor siltstone, shale; a little oolitic iron "ore"
			-minor hiatus?
		Gallery (0-1,125)	Sandstone, quartzose, minor dolomitic; minor siltstone, shale, conglomerate, a little breccia, dolomite
			-angular unconformity
Precambrian			Igneous, metamorphic, sedimentary, and volcanic rocks

STRATIGRAPHY

ADMIRALTY GROUP

The name "Admiralty Group" was given by Lemon and Blackadar to the entire Lower Palaeozoic succession encountered by them in their 1954 work, namely the Gallery, Turner Cliffs, and Ship Point Formations, and the lower few hundred feet of the Baillarge. The Baillarge is here excluded from the Admiralty Group, because it is separated from the Ship Point by a local or regional disconformity, and the Ship Point because it may be separated from the Turner Cliffs by a major hiatus that involves the Upper Cambrian.

Gallery Formation

(Cambrian and/or Lower Ordovician)

The Gallery Formation was erected by Lemon and Blackadar (1963) and named for conspicuous cliffs on the east coast of central Admiralty Inlet. The type section is on the east coast of Victor Bay (see Fig. 4, loc. LB-7). The formation is exposed in the northern and southern parts of Borden Peninsula (see Fig. 2). Measured thicknesses (see Fig. 3) range between 1,125 and 0 feet. The formation consists mainly of quartzose sandstone, with some siltstone and shale, and breccia, conglomerate, and locally dolomite in the basal parts. The lower part of the formation is coloured predominantly in shades of red and orange, and the upper part is predominantly light grey, but greyish and reddish beds are commonly interstratified, and the distinction between red and uncoloured beds made on Fig. 5 is arbitrary. High-angle cross-lamination—mainly of the trough type and to minor extent of the planar type (terminology of McKee and Weir, 1953)—is the typical stratification of the formation, except for some uncoloured beds in its upper part. Sets of crossbedded strata are mostly a few feet thick. On the coasts of Admiralty Inlet the sandstone is mainly medium- to coarse-grained (Lemon and Blackadar, 1963). In the remaining parts of the area, medium to fine grades are predominant in all but the lowest beds. The sandstone consists mostly of quartz, not more than a few per cent of feldspar, and trace amounts of heavy minerals (see Lemon, 1956). The rounding varies from subangular to predominantly well rounded. The sorting is mostly good to moderate, except for conglomeratic beds. The sandstone is weakly cemented by quartz in optical continuity, iron oxides, and locally (Lemon and Blackadar, 1963), in the basal parts of the formation, by dolomite.

The Gallery Formation rests with very low angular discordance on the oldest to youngest Precambrian units of the area. The contact with the overlying Turner Cliffs Formation is structurally conformable, but marked by an abrupt change from sandy to dolomitic, shaly, and silty rocks with abundant worm markings, which may indicate a minor hiatus. The similarity of the sandstones of the Gallery and Turner Cliffs Formations, and the approximate coincidence of their isopachous trends and paleocurrent directions suggest that the two formations originated in a similar environment, and are not separated by a major disconformity.

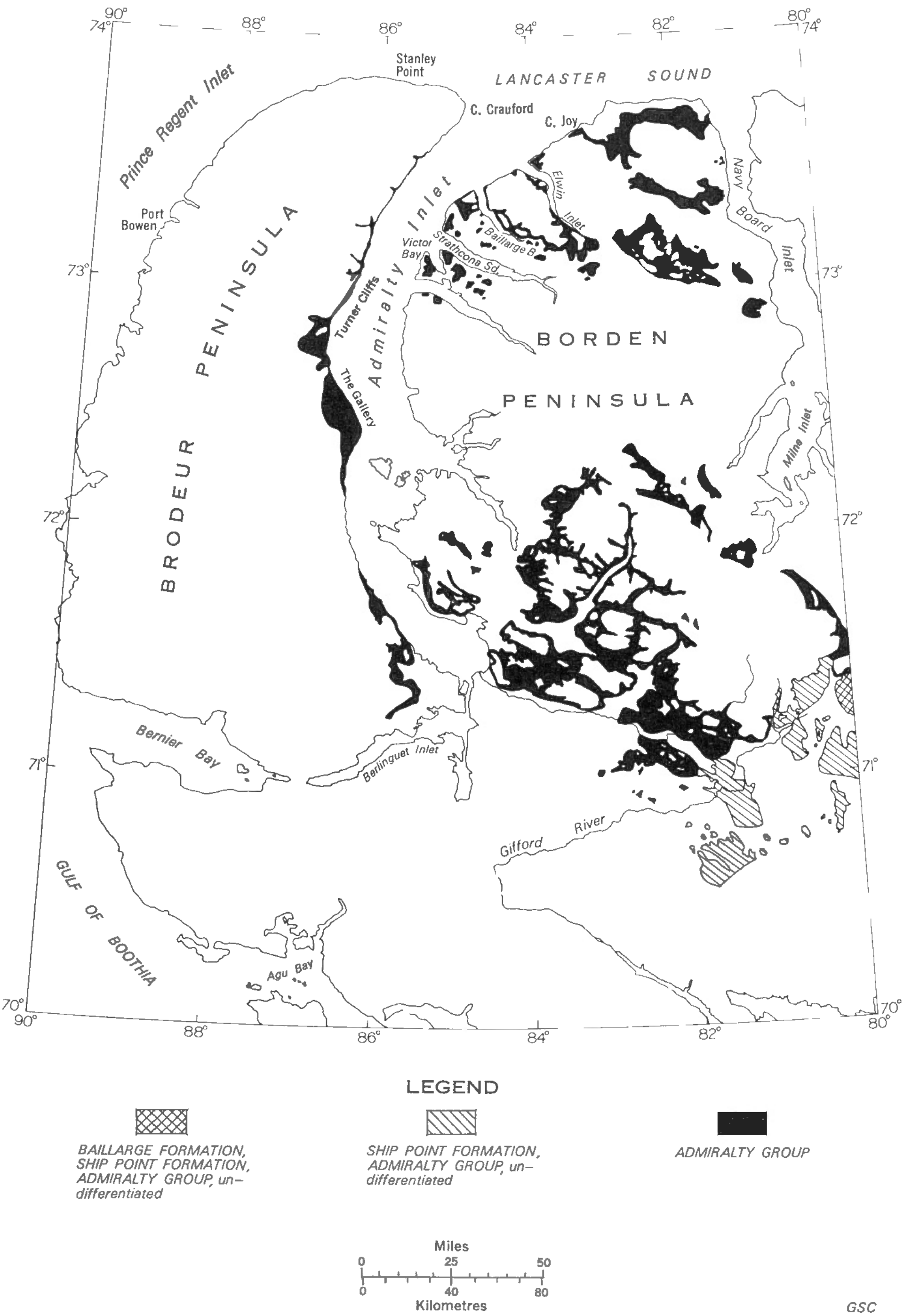
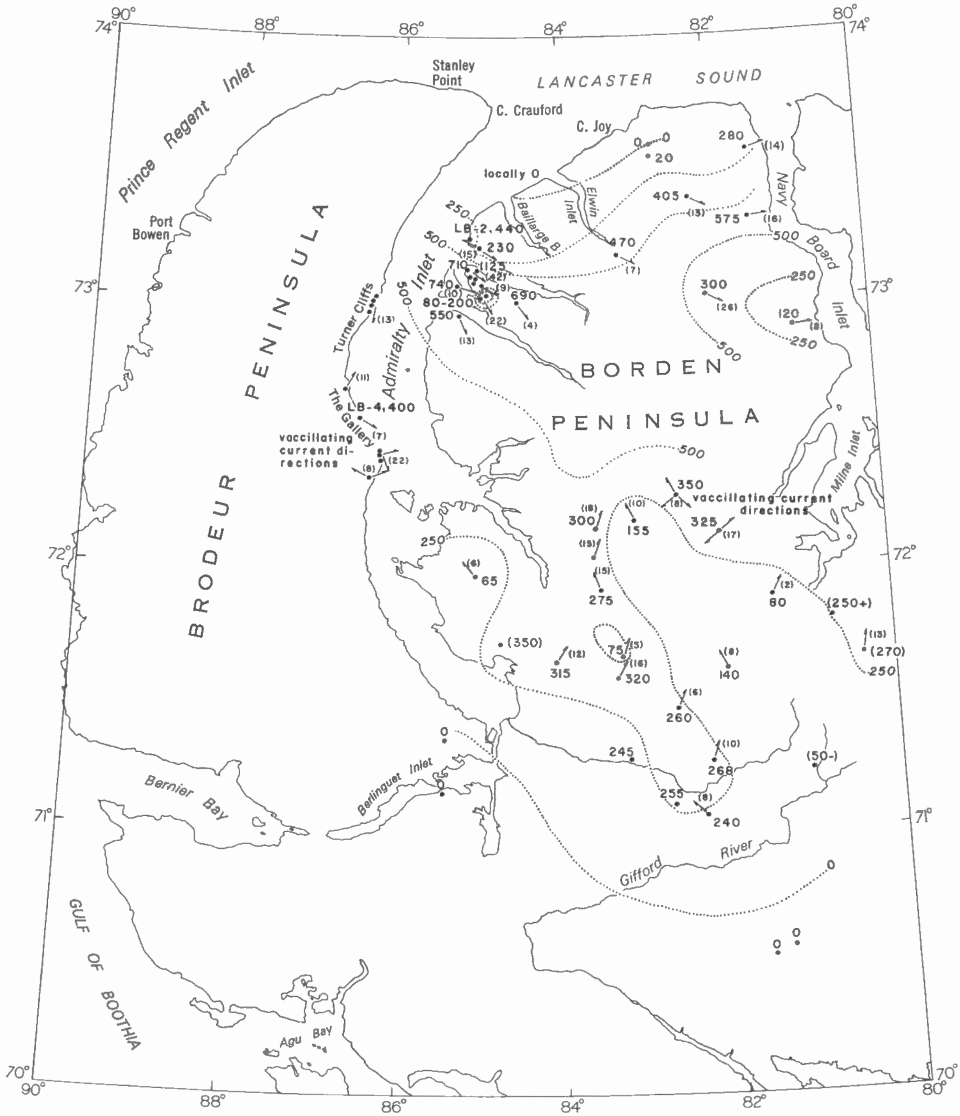


Figure 2. Outcrop areas, Admiralty Group, northwestern Baffin Island



LEGEND

Section or station, approximate thickness in feet, incomplete or poorly exposed . . •, 120, (270)

Locality number (from Lemon and Blackadar) thickness in feet LB4,400

Isopach, tentative and highly generalized . . 250

Crossbedding, mean azimuth of foreset dips . . . . . .

Number of readings . . . . (10)

Miles 0 25 50
Kilometres 0 40 80

GSC

Figure 3. Paleocurrent and isopachous map, Gallery Formation, northwestern Baffin Island

The Gallery Formation is probably mainly non-marine, but parts of it may represent marine portions of a delta. It seems to have been derived largely from quartzose sandstones, and was deposited by currents. In order to establish the directions of these currents a total of about 440 crossbedding determinations were made at 39 localities. The arrows on Figure 3 represent the arithmetical means of the means of the predominant dip-azimuths in stratigraphic intervals of 10 feet for a given locality or group of localities. Where more than one predominant direction was apparent, the individual maxima have been represented separately. The determinations were made with the Brunton compass, and the rather variable local declinations have been established by frequent bearings taken from the sun or topographic points. Figure 3 indicates that in the northern half of the area the currents came from the northwest and left in easterly directions. In the southern half, they came from the south. On the western coast of central Admiralty Inlet, where vacillating directions were obtained, the two drainage systems seem to have interfered with each other. On the steep cliffs bordering Admiralty Inlet between Cape Strathcona and Elwin Inlet it can be seen that local irregularities in the thickness of the formation are related to the relief of the erosion surface on which it was laid down. The major isopachous trends, on the other hand, tentatively outlined on Figure 3 are probably related to differential sinking during Gallery time as they are parallel, to some extent, to the isopachs of the Turner Cliffs Formation (Fig. 4). Continuous sinking during Turner Cliffs time is indicated by Figure 5.

No diagnostic fossils have been found in the formation. The age of the overlying Turner Cliffs Formation, and the lack of a recognizable major hiatus between these two formations suggests that the Gallery is Cambrian and/or Lower Ordovician. Lithology and stratigraphic position suggest that the Gallery may be correlative with the Rabbit Point Formation of Dundas Harbour, Devon Island, which is upper Lower Cambrian (Kurtz, McNair and Wales, 1952). The base of the formation is considered as the Palaeozoic-Precambrian boundary because the underlying strata are cut by basic dykes that have yielded K-Ar ages of 915 and 1,140 m.y. (Blackadar, 1964).

Turner Cliffs Formation

(Cambrian and/or Lower Ordovician)

The Turner Cliffs Formation was erected by Lemon and Blackadar (1963) and named for the type section on the east coast of Brodeur Peninsula (see Fig. 4, loc. LB-5). The outcrop areas of the Turner Cliffs Formation coincide approximately with those of the Gallery (see Fig. 2). Isopachous maps (Figs. 3, 4), however, indicate that the Turner Cliffs overlaps the Gallery—at least in the northwest and the southeast. Measured thicknesses range from 98 to 1,008 feet. In the plains south of Borden Peninsula and Berlinguet Inlet the Turner Cliffs Formation cannot be distinguished from a near-shore facies of the lower part of the Ship Point Formation, and here the two formations have been mapped as one unit. The isopachous map suggests that in this area the thickness of the Turner Cliffs Formation may range between 0 and 100 feet.

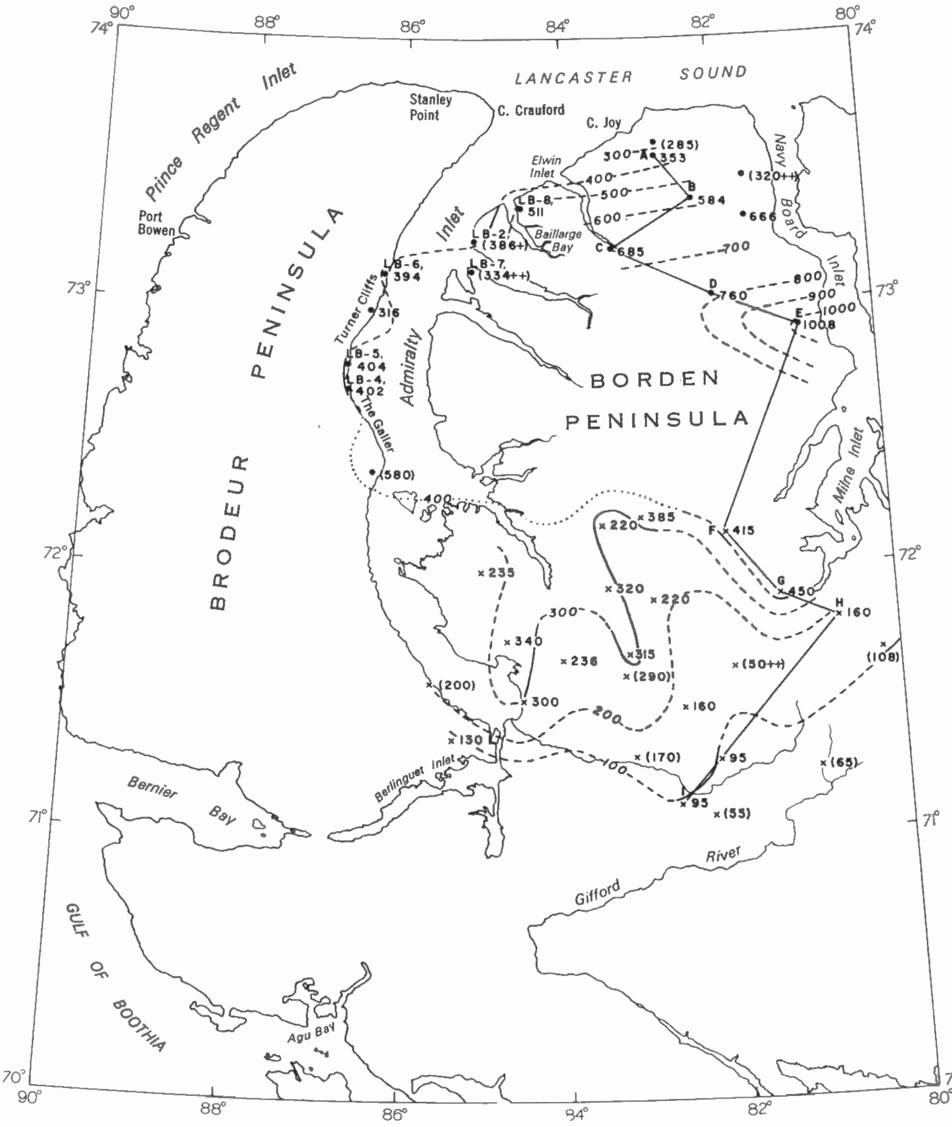
In order to simplify the representation and discussion of the stratigraphy, the various rock types of the formation have been assigned to two assemblages:

Assemblage 1, fairly resistant to weathering, composed of quartzose and dolomitic sandstone; and
Assemblage 2, recessive and generally poorly exposed, comprising dolomitic, shaly, and silty rocks.

Most strata of assemblage 1 are yellowish grey to greyish yellow, depending on their dolomite content, and slightly greenish when chloritic, but in member S1, there are also some bright to dusky-red beds. Cross-bedding is common, but not as abundant as in the Gallery Formation. As in the Gallery Formation, the typical forms are high-angle trough cross-lamination, and, to minor extent, high-angle planar cross-lamination (terminology of McKee and Weir, 1953) occurring in sets a few feet thick. Horizontal units are either well stratified and laminated to thin bedded or thick to very thick bedded and vaguely stratified. Rounded to well-rounded quartz is the main component of the sandstones, but microcrystalline dolomite may be present in any amount. Minor constituents are feldspar, heavy minerals, and locally glauconite. Quartzose, slightly dolomitic sandstone at locality E of Figures 4 and 5 contains oolites composed of very thin concentric shells of hematite and limonite (X-ray determination by R.N. Delabio), some with a quartz nucleus. The oolitic bed is about 3 feet thick, and has been traced for a few hundred feet, but may be more extensive. The oolite content varies from a few per cent to perhaps 50 per cent by volume. A grab sample, assayed by J.A. Maxwell, contains 40.7 per cent and 0.10 per cent of total S.

Assemblage 2 consists of thin bedded to thinly laminated, silty, shaly, sandy, and pure dolomite, dolomitic intraformational conglomerate, and dolomitic to pure shale, mudstone, and siltstone. Impure dolomite is by far the most abundant rock type in the sections measured by the writer in the interior of Borden Peninsula, but siltstone, mudstone, and shale seem to be more abundant on the margin of the basin of deposition studied by Lemon (1956). The strata show abundant mud-cracks, ripple-marks, and worm markings. Undulatory stromatolites (Donaldson, 1963) occur in the uppermost beds of the formation, and a few collections of linguloid brachiopods have been made from the lowest strata. The dolomite is microcrystalline, and mostly euhedral, but some very finely microcrystalline dolomite is anhedral to subhedral. The dolomite may contain varying amounts of generally poorly sorted sand and silt of quartz and minor feldspar, white mica, chlorite, microcrystalline authigenic pyrite, and locally a little glauconite. Most of the sand is well-rounded, but the very fine grained sand like the silt is more angular.

In the northern parts of the area, three sandy members (S1, S2, S3) and four dolomitic members have been recognized (D1, D2, D3, D4). In the southern half, only member S3 could be recognized. The lower and middle parts of the formation here consist mainly of assemblage 2 with several, relatively thin sandy units that cannot be correlated, with certainty, from one section to the next (see Fig. 5).



LEGEND

Section, northern facies, southern facies, approximate thickness in feet, incomplete or poorly exposed . . . . •,×,685,(205)

Line of section . . . . A——— ———I

Locality number (from Lemon and Blackadar), thickness in feet LB-6, 394

Isopach, approximately located, poorly controlled, assumed 200

Miles 0 25 50

Kilometres 0 40 80

Figure 4. Isopachous map, Turner Cliffs Formation, northwestern Baffin Island

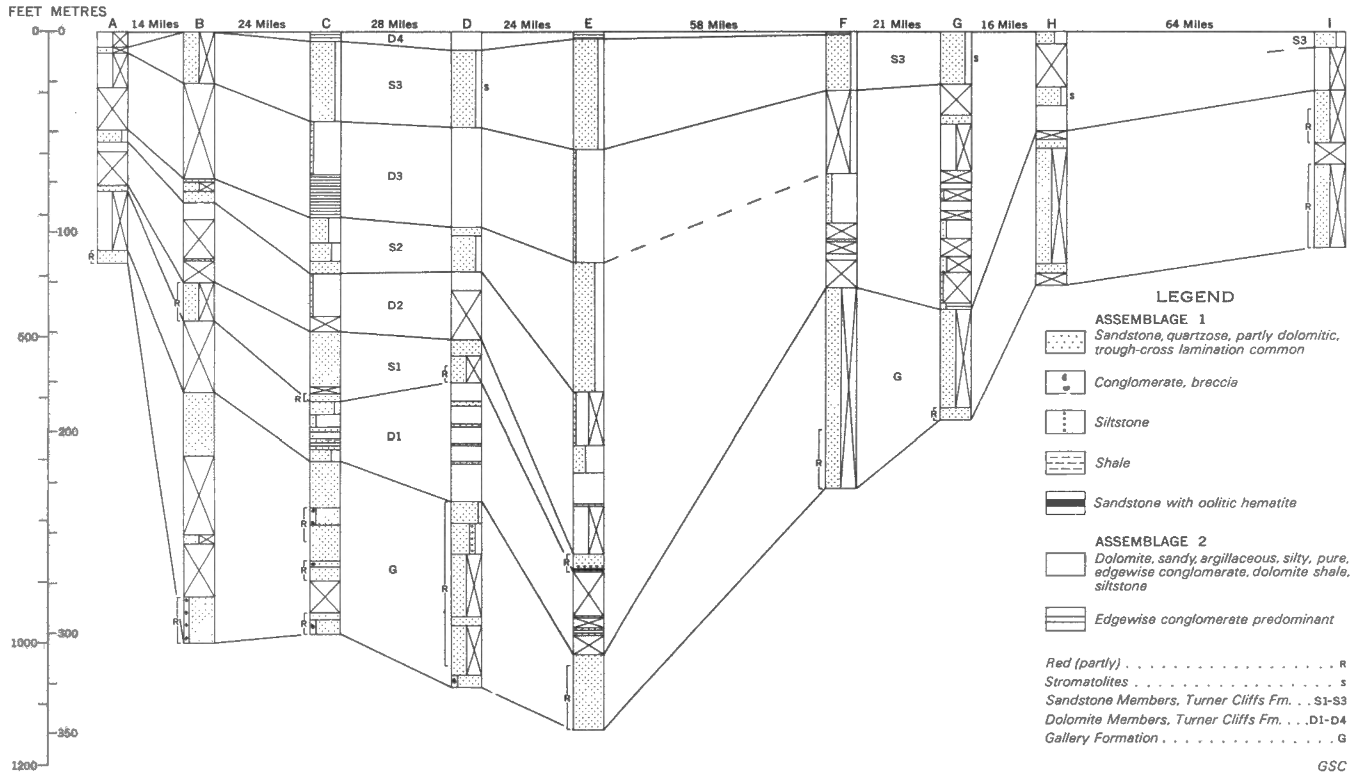


Figure 5. Columnar sections, Admiralty Group. (For line of section see Figure 4)

The Turner Cliffs Formation overlies the Gallery with a structurally conformable but abrupt contact that may represent a minor hiatus. The upper contact, with the Ship Point, is problematic. On the one hand, neither structural nor lithological evidence for a major disconformity has been discovered. In most localities the contact seems to be gradational through a few tens of feet. On the other hand, regional relationships suggest that a major hiatus may be present. It is possible that this hiatus is expressed by the local absence of member D4. It is also possible that the hiatus lies at the base of member S3, and not at the top of the formation. In this case members S3 and D4 should be included with the Ship Point.

Assemblage 2 and the dolomitic sandstone of assemblage 1 probably formed in very shallow marine waters, perhaps mainly in the intertidal zone. The trough cross-laminated, silica-cemented sandstones of assemblage 1 could be non-marine, but because of their association with the other rock types are judged to be tidal channel, or similar current-laid marine deposits. Petrographic criteria indicate that most of the dolomite was formed by replacement, but the finely microcrystalline, anhedral dolomite could be a chemical precipitate. The quartz sand was probably derived from quartzose sandstones. The isopachous map indicates that the formation was laid down in an easterly plunging embayment, and a stratigraphic cross-section (Fig. 5) shows that the basin sank more or less continuously throughout Turner Cliffs time. This cross-section, and a few crossbedding determinations, indicate that the sands of the Turner Cliffs Formation, as those of the Gallery, were derived from northwesterly and southerly directions, the northwest being the major source area.

Three collections of brachiopods, all from the lower part of member D1 have been identified as Lingulella (s.s.) by Rowell who states that it is not possible to restrict the age within the range of the genus, namely, Lower Cambrian to Middle Ordovician. Graptolites collected by Blackadar on Jens Munk Island, a few miles east of the southeastern extremity of the map-area, have been assigned by Thorsteinsson to the Arenigian (Blackadar, 1958a, 1963). The writer re-examined the fossil locality where impure and pure dolomitic strata overlie the crystalline Precambrian basement, and concluded that the fossils probably came from the lower part of the Ship Point. They could possibly have come from the upper part of the Turner Cliffs Formation but this does not seem likely. On the basis of these fossil collections, then, the Turner Cliffs is Lower Ordovician and/or Cambrian. Lithology and stratigraphic position suggest that it may be correlative with Middle Cambrian beds on Boothia Peninsula (Christie, 1963, p. 9) and with the combined Bear Point and Ooyagah Formations of Dundas Harbour which are also Middle Cambrian in age (Kurtz, McNair and Wales, 1952).

SHIP POINT FORMATION

(Lower and early Middle Ordovician)

The Ship Point Formation was named by Lemon and Blackadar (1963). The type section (see Fig. 6, loc. A) is on the east side of Baillarge Bay, opposite the point known as "Ship Point". The formation seems to have been deposited over the entire map-area, and scattered outcrops occur in all but the western and central-southern parts and in central Borden Peninsula.

At the type section the formation is 892 feet thick (Lemon and Blackadar, 1963). It thins very rapidly to the east, and gradually to the south. At locality F (Fig. 6) the formation is probably more than 300 feet thick, and at locality E, between 450 and 600 feet.

The formation consists mainly of thick to very thick bedded strata composed of, microcrystalline to very fine crystalline, subhedral to euhedral dolomite. These rocks weather in very light hues of grey, green, yellow, and orange. Interbedded with this resistant rock type are more recessive units of slightly silty and argillaceous dolomite, commonly with mud-cracks and worm markings. Intraformational conglomerates of laminated dolomite are common, with the flat pebbles stained brownish by secondary iron minerals. Oolites, partly replaced by chert, occur at a few localities.

Fossils, represented mainly by gastropods, are rare. In the lower part of the formation, locally undulatory and oncolitic stromatolites occur.

The Ship Point Formation overlies the Turner Cliffs with conformable and, in most localities, gradational contact. At localities B and C (Fig. 6) a disconformity between the Ship Point and Baillarge Formations is indicated by anomalously low thicknesses and a solution zone at the top of the Ship Point. A well-indurated, steeply dipping breccia, occurring within the formation at locality D (Fig. 6) is interpreted as the filling of a fracture or sink-hole, developed on the inferred Mid-Ordovician land surface. In the other parts of the area the contact between the Ship Point and Baillarge Formations is not well exposed. An apparently abrupt lithological change suggests a disconformable relationship, but reasonably normal thicknesses would seem to indicate that in these parts Mid-Ordovician erosion—if it really occurred—was not as pronounced as on the Navy Board High (comp. Fig. 10).

Petrographic criteria such as euhedral habit, inclusions, and occasional zoning suggest that most or all of the dolomite formed by replacement (see Pettijohn, 1957, pp. 421-424). Intraformational conglomerates and stromatolites indicate that parts of the formation originated in very shallow water. The southward increase of clastic material and intraformational conglomerate in the lower part of the section shows that a shore lay in that direction, and that the clastic sediments came from the craton. The decrease in these components upwards in the section, seems to indicate further southward transgression of the sea at a later time in the deposition of the Ship Point Formation.

Fossil collections from the general vicinity of the type section were assigned to early Middle Ordovician (Lemon and Blackadar, 1963). Arenigian graptolites found by Blackadar (1958a, 1963) on eastern Jens Munk Island came probably from the lower part of the Ship Point, although the possibility that they came from the Turner Cliffs cannot be excluded. On the basis of this evidence the formation is tentatively assigned to Early and early Middle Ordovician. The Ship Point Formation is correlative with the lower part of the Cornwallis Formation (Thorsteinsson, 1958), and in part, possibly also with underlying Lower Ordovician carbonate units such as the Copes Bay Formation (Thorsteinsson, 1963), and the Nadlo Point and Mingo River Formations (Kurtz, McNair and Wales, 1952).

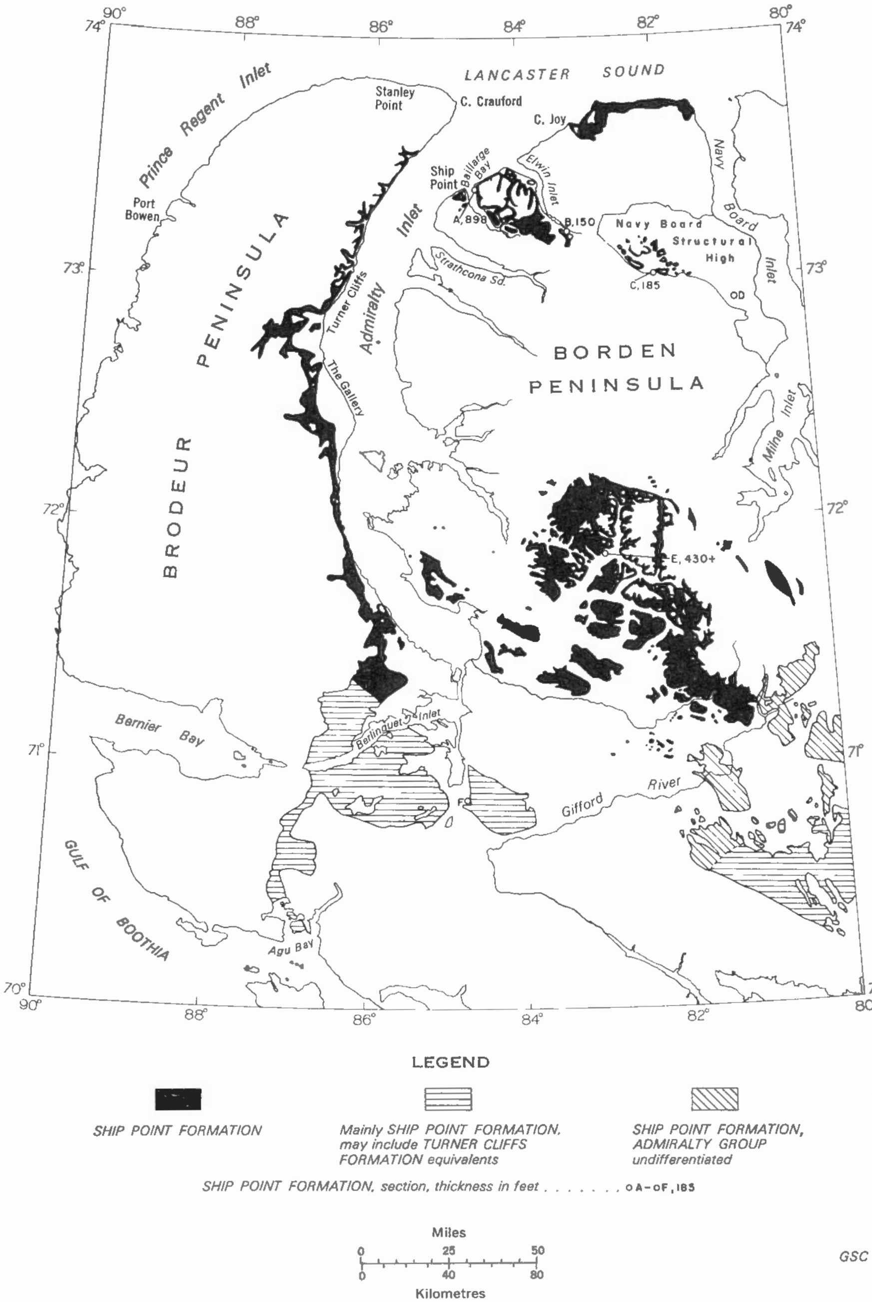


Figure 6. Outcrop areas and thicknesses, Ship Point Formation. (See Figure 2 for undifferentiated Baillarge Formation-Ship Point Formation-Admiralty Group), northwestern Baffin Island

BRODEUR GROUP

The name "Brodeur Group" is here given to a new unit comprising the (extended) Baillarge Formation, and the Cape Crauford Formation, also proposed in this report. The two formations are related in lithology, and represent a transgressive-regressive cycle. The group is named for Brodeur Peninsula, where it is best exposed.

Baillarge Formation

(Late Middle Ordovician to Niagaran)

The Baillarge Formation was erected by Lemon and Blackadar (1963) and named after Baillarge Bay on northwestern Borden Peninsula, the location of the type section (see Fig. 7, loc. E). It contained the youngest strata encountered by Lemon and Blackadar in 1954; bounded at the top by an erosion surface and poorly exposed in the lower part, the type section contains only 392 feet of strata. It was stated, however, that the thickness of the formation exceeds 460 feet (op. cit., p. 72). In the present mapping the formation has been extended upwards to the first significant and mappable change in lithology. A well-exposed complete composite section was found 16 to 17 miles south-southwest of Cape Crauford, on the east coast of Brodeur Peninsula, and is here used as a reference section (loc. D, Fig. 7). When traced around the northern coasts of Brodeur Peninsula the extended Baillarge Formation was found to include most of the strata assigned by Norris (1963) to the "lower limestone unit" of the Read Bay Formation. The Baillarge Formation outcrops in three main parts of the area (see Fig. 7): (1) in scattered areas of northwestern Borden Peninsula, mainly between Baillarge Bay and Elwin Inlet, and at Cape Joy; (2) in a belt extending from Cape Crauford to Agu Bay; and (3) in the central-southeastern parts of the area, south of the head of Milne Inlet. At the reference section on northeastern Brodeur Peninsula the formation is about 1,600 feet thick. Two members, informally named members A and B, are distinguished.

Member A has been recognized in all parts of the map-area where the Baillarge Formation is in contact with the Ship Point by dark talus and recessive slopes, but is generally poorly exposed. At the reference section it is about 460 feet thick and thickens rapidly to the west. Thicknesses of several hundred feet obtain between this area and Agu Bay. In the central and eastern parts of the map-area the member is thinner, ranging down to a few tens of feet.

At the reference section the poorly exposed, recessive lower 335 feet consists of thinly interstratified dark grey shale, and light grey to pale olive, microcrystalline limestone and dolomite (see Fig. 8). Desiccation breccias, low-angle cross-laminations, and authigenic microcrystalline pyrite are characteristic of these strata, part of which form rhythmic sequences—a few millimetres thick—grading from very finely microcrystalline, carbonaceous, and partly argillaceous limestone up to coarser-grained but still microcrystalline dolomite. The upper 125 feet of the member consists of ledge-forming, vaguely bedded, calcareous dolomite with "ghosts" of fossils and breccia texture, and of poorly exposed, recessive shaly carbonates. Strata similar to the lower 335 feet of the reference section have been observed at several localities between Cape Crauford and Agu Bay.

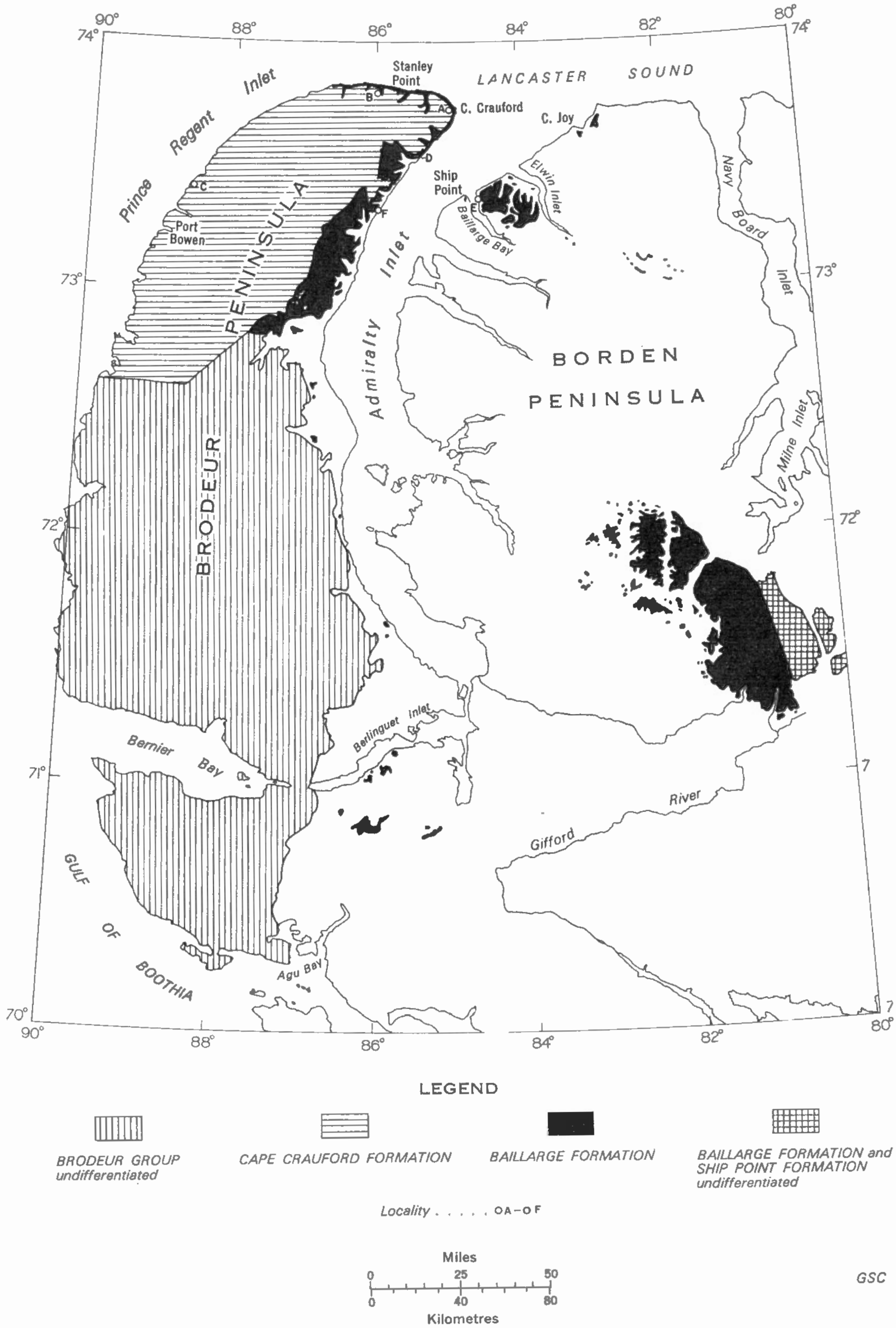


Figure 7. Outcrop areas, Brodeur Group. (See Figure 2 for undifferentiated Baillarge Formation-Ship Point Formation-Admiralty Group), northwestern Baffin Island

In the central and eastern parts of the map-area, only shaly limestone has been seen, but the member is here very poorly exposed. At the type section (Fig. 7, loc. E) the member is probably represented by the lower, mostly concealed, 130 or 277 feet.

Member B is about 1,140 feet thick at the reference section on northeastern Brodeur Peninsula. Rather uniform in lithology, it corresponds closely to Lemon and Blackadar's (1963) description of the formation. The typical rock is medium to dark yellowish brown, fossiliferous, cryptocrystalline, partly dolomitized limestone with finely divided carbonaceous matter and a pronounced fetid odour. Cliff-forming units of pure, vaguely bedded, dolomitic limestone are separated by ledge- or plateau-forming units of thinly bedded, argillaceous dolomitic limestone. The dolomite occurs in irregular stringers, mostly parallel with bedding, in irregular tubes or nests, or it may pervade the whole rock. The crystals are generally euhedral, full of minute inclusions, occasionally zoned, and fine crystalline to predominantly microcrystalline. A rich Arctic Ordovician fauna occurs in light-greenish-weathering argillaceous limestone 284 to 350 feet above the base of the member (see Fig. 8). Silurian brachiopods, corals, and stromatoporoids are abundant in the upper 500 feet. Most fossils are broken and seem to have been transported, but some are nearly in place.

A stratified breccia with fragments of microcrystalline, laminated limestone in a laminar matrix of clear, secondary calcite, 783 feet above the base of the member, seems to be a forerunner of the solution breccias of the Cape Crauford Formation.

The Baillarge Formation overlies the Ship Point with local or regional disconformity (see above). The contact with the Cape Crauford Formation is conformable and arbitrary and is placed at the base of the lowest unit of interstratified limestone and calcareous dolomite which occurs within 20 feet below a sequence of solution breccias.

Desiccation breccias, laminated dolomite with evidence of penecontemporaneous replacement of calcium carbonate, and authigenic pyrite, indicate a lagoonal environment of deposition for member A for at least the western parts of the area. The abundance of cryptocrystalline calcite matrix, and the scarcity or absence of secondary calcite cement, oolites, and reefs show that member B was laid down in an environment protected from vigorous waves and currents by reefs, bars, shoals, or a wide, shallow shelf (viz. Folk, 1962, p. 68f). The fairly rich fossil content, with at least some of the fossils in place, indicates waters of not excessively high salinity and greater depth than represented by any other rock unit of the area.

The most important biostratigraphic data are summarized on Figure 8. Mainly on the basis of fauna and stratigraphic position, and partly on the basis of lithology, the following correlations with rock units of the Franklinian miogeosyncline can be made:

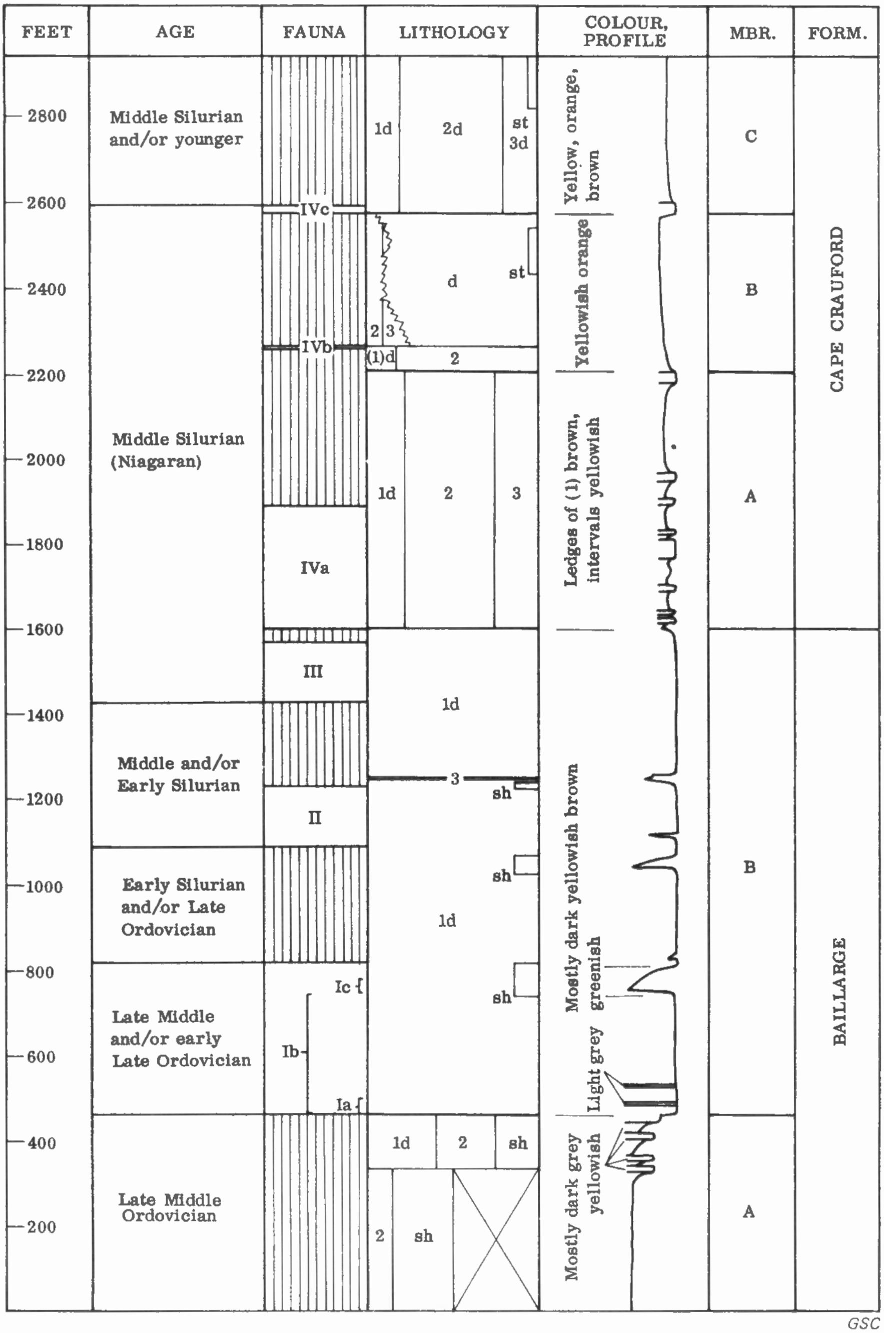


Figure 8. Stratigraphy, lithology and biostratigraphy of the Brodeur Group

TABLE I

LITHOLOGY

1: fossiliferous cryptocrystalline limestone
2: thinly interstratified microcrystalline limestone and dolomite
3: strata of type 2 brecciated by solution of evaporites, and associated undulatory stromatolites
sh: shale, shaly impurities
st: silty impurities
d: cross-cutting and thickly stratified dolomite

BIOSTRATIGRAPHY

ZONE IVc (1 coll., loc. A): stromatoporoids, Streptelasma kukense Teichert, Favosites cf. favosus (Goldfuss) from Stanley Point (Teichert, 1937, p. 129 f.), Halysites, Porpites aff. michiganensis (Bassler), orthoconitic cephalopod

ZONE IVb (1 coll., loc. B): Favosites cf. favosus (Goldfuss)

ZONE IVa (8 coll. at loc. B, 3 coll. at loc. C): stromatoporoids, Streptelasma kukense Teichert, Favosites cf. favosus (Goldfuss) from Stanley Point, Cystihalysites, Catenipora, Brachyprion aff. robustum Twenhovel, Stegerhynchus (?), strophomenid brachiopod, Clorinda (?) or Glassia (?), Pterinea, Holopea, Homortoma, Leperditia

Comments re Zone IV: Niagaran, pre-late Wenlockian, on the basis of absence of Atrypella

ZONE III (2 coll. at loc. D, 3 coll. near loc. A): stromatoporoids, Favosites same sp. as in Zone II, "Ptychophyllum" or "Naos", Rhipidium same sp. as in Zone II, strophomenid brachiopod, "Reticularia (?)" undulata Poulsen, Clorinda (?), Leperditia

Comments: "Reticularia (?)" undulata was described by Poulsen from the Cape Schuchert Fm. or NW Greenland. The formation is Middle Llandoverian or early Niagaran on the basis of Monograptus convolutus (Poulsen, 1934)

ZONE II (8 coll., loc. D): stromatoporoids, Favosites same sp. as in Zone III, Paleofavosites, Vacuopora n. sp., "Ptychophyllum" or "Naos", Rhipidium close to Conchidium arcticum from NW Devon Island (Holtedahl, 1914), Brachyprion cf. philomela Billings of Southampton Island (Teichert, 1937, p. 139 f.), Homortoma, some with large whorls

Comments: Zone II shares several elements with III and is considered by Bolton as probably Niagaran. The position of this zone, however, below "Reticularia (?)" undulata suggests that it may extend into the early Llandoverian

ZONE Ic (1 coll., loc. D): Receptaculites cf. arcticus Etheridge, Streptelasma, Grewingkia, Calapoecia, Plasmopora cf. lambei Schuchert, Catenipora, crinoid fragments incl. square columnals, Arthroclema cf. armata Ulrich, Helopora, Rhinidictya, Austinella, Leptaena, Triplesia, Beloitoceras, illaenid trilobite, Ceraurus (?), cf Lepidocoleus

Comments: Arctic Ordovician fauna, early Late Ordovician and slightly older

ZONE Ib (1 coll., loc. F): Receptaculites, Catenipora, Maclurites cf. manitobensis (Whiteaves)

Comments: Arctic Ordovician fauna, Red River representative

ZONE Ia (1 coll., about 2 mi. SW of loc. D): Catenipora, Calapoecia cf. canadensis Billings, Plasmopora, Batostoma

Comments: Arctic Ordovician fauna

Identification and correlation of Zone I: G.W. Sinclair, Zones II and III: T.E. Bolton

Baillarge		Correlative Unit
Feet Above Base of Formation	Member	
810 - 1,600	B	Allen Bay Formation of Cornwallis Island (Thorsteinsson, 1958, pp. 42-47), lower part; dolomite, minor dolomitic limestone, limestone
745 - 810	B	Cornwallis Formation of central Ellesmere Island (J.W. Kerr, unpub. ms.) uppermost sub-unit: limestone, shaly, greenish weathering, recessive, rich in Arctic Ordovician fauna
460 - 745	B	second sub-unit from top: limestone, thick bedded, partly dolomite, bluff-forming, slightly rusty weathering, sparsely fossiliferous, Arctic Ordovician fauna
0 - 460	A	middle sub-unit: limestone, thin bedded, silty, sandy, and shaly, in some sections gypsum is common, recessive

Cape Crauford Formation

(Niagaran and (?) younger)

The Cape Crauford Formation comprises all Lower Palaeozoic strata of northwestern Baffin Island overlying the Baillarge Formation. It is named after Cape Crauford, the northeastern point of Brodeur Peninsula, discovered by Parry in 1820. The Cape Crauford includes strata originally (Norris, 1963) assigned to the Read Bay Formation. A new formational name is here introduced for two reasons: (1) the Cape Crauford, containing solution breccias and a high proportion of dolomite, differs significantly in lithology from the Read Bay; and (2) at least parts of the Cape Crauford are possibly older than the Read Bay, as the index fossil Atrypella does not seem to be represented. The formation is exposed in the central and western parts of Brodeur Peninsula and the unnamed peninsula south of Bernier Bay. In the composite type section located between 1.5 miles south and 2 miles northwest of Cape Crauford (loc. A, Fig. 7) the formation is about 1,340 feet thick. Three informal members, A, B and C, are recognized.

The formation is composed of three genetic assemblages of rock types; in member B, however, the original lithology is partly obscured by secondary dolomitization. Assemblage 1 consists of the same rock types as most of member B of the Baillarge Formation: a yellowish brown, very-thin-bedded to massive, mostly vaguely bedded, cryptocrystalline limestone with sparse amounts of mostly broken fossils, varying, but small amounts of intraclasts (Folk, 1959), and still smaller amounts of fecal (?) pellets. Carbonaceous matter is finely divided throughout the rocks, which have a fetid odour. The limestone is replaced in varying proportions by fine crystalline to predominantly microcrystalline, generally euhedral, pale orange dolomite, occurrring in stringers, tubes, irregular patches, or pervading the whole rock. Some strata contain lenses or stringers of grey chert. Assemblage 2 comprises thin bedded to thinly laminated, commonly interlaminated limestone, dolomitic limestone, and calcareous dolomite. A few beds show low-angle cross-lamination. The limestone varies from pale to intermediate yellowish brown, and is composed of cryptocrystalline to predominantly microcrystalline, subequant, anhedral to subhedral calcite, varying greatly in crystal size, but not in habit and texture, within the area of a thin section. Fossils are absent except for fecal (?) pellets and concentric algal coatings. In crystal size and habit, the dolomite is identical with the dolomite of assemblage 1, but differs in being well stratified. Associated with the dolomite are varying amounts of finer-grained calcite. Both the crystal size of the dolomite and the dolomite-calcite ratio remain fairly constant within individual laminae of a hand specimen. Dolomite and limestone contain thinly laminated carbonaceous matter, and emit a fetid odour when struck. Locally, solution casts of coarse blades of gypsum (?) are present that cut across the stratification. Assemblage 3 consists of stratified, widely distributed breccias, and associated wavy beds. In mineralogy and texture the sediments are identical with assemblage 2. Individual units range from less than a foot to more than 80 feet in thickness, and some have been traced around the coasts of Brodeur Peninsula for more than 80 miles (see Fig. 9). The fragments of the breccias range from a small fraction of a millimetre to more than a foot in length. They are subequant to elongate or of vaguely defined, flowing outlines. The fragments are displaced little with respect to each other, and are in part tightly packed. They are cemented mainly by clear, secondary calcite with some microcrystalline calcite and dolomite derived from the brecciated strata. The secondary calcite may form layers parallel to bedding that range down to a small fraction of a millimetre in thickness. The interstices also contain bituminous matter and, locally, traces of malachite. The breccias are overlain by strata showing various kinds of soft-sediment deformations and intrusions, which grade upwards into undulating beds forming small domes usually a few inches in diameter. Viewed from a distance, the resistant breccia ledges are seen to form irregular, shallow folds, in the order of 100 feet or more in width and not more than a few tens of feet in height. Individual breccia units seem to have been folded separately, and intervenient ledges of assemblage 1 appear to be undisturbed. Locally the folds pass into steeply dipping fractures and faults with slight vertical displacements. Steeply dipping tension fractures are filled with boulder breccias composed mainly of assemblage 3 but involving underlying and overlying strata of the other assemblages as well.

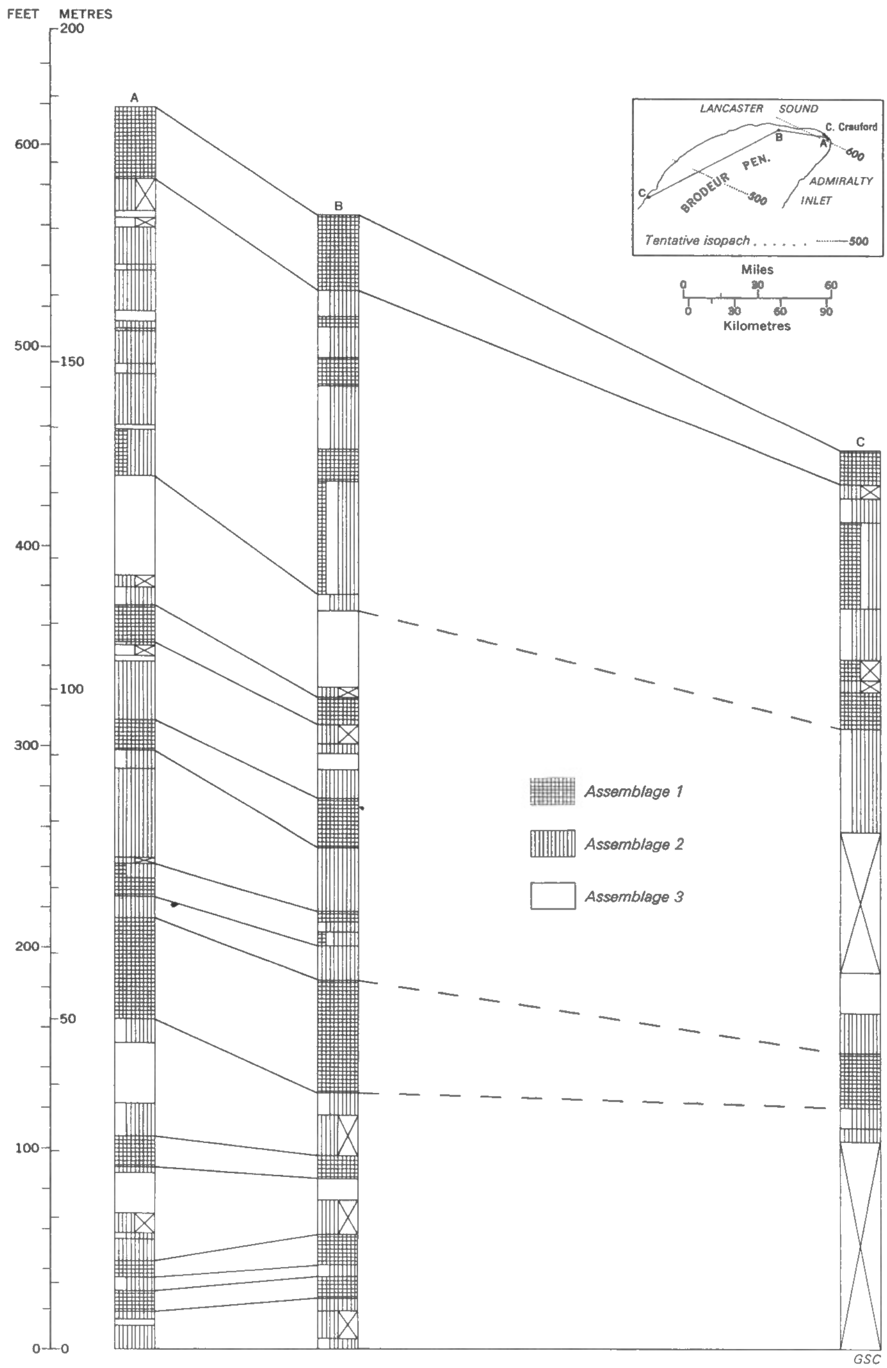


Figure 9. Columnar sections, member A, Cape Crawford Formation

Three stratigraphic sections of member A, which at the type section is about 616 feet thick, are represented on Figure 9. These sections, and a fourth incompletely exposed section at Port Bowen, about 15 miles south of locality C (Fig. 9), indicate that the proportion of assemblage 3, and to lesser extent of assemblage 1, increase southwestward, at the expense of assemblage 2. Member B, at Cape Crauford about 360 feet thick, is lighter in colour, and more recessive than members A and C. The limestone of this unit—except for the lower 140 feet—has been replaced by medium to microcrystalline, vaguely stratified dolomite. Some strata contain microcrystalline, authigenic pyrite, and others a few per cent of argillaceous matter and silt of quartz with minor K-feldspar and albite. Relicts of fossils, mainly echinoderm columnals, and of an originally brecciated texture are visible in the dolomite. The base and the top of member B are marked by relatively dark and resistant limestone ledges assigned to members A and C respectively. Member C is at Cape Crauford about 365 feet thick, and preserved only on northern Brodeur Peninsula. The limestone of this unit is more extensively dolomitized than the limestone of member A, but less so than the limestone of member B. Beds in the upper part of the member contain as much as 10 per cent of silt.

The Cape Crauford Formation overlies the Baillarge Formation, with conformable contact placed at the base of the lowest beds of assemblage 2. The upper boundary of the formation is a Pleistocene to Recent erosion surface.

Assemblage 1 probably originated in waters of not excessively high salinity protected by barriers from vigorous waves and currents. On the basis of various petrographic criteria the dolomite of assemblage 2 is believed to have formed by penecontemporaneous replacement of calcium carbonate (see Pettijohn, 1957, pp. 421-424; Leighton and Pendexter, 1962, p. 57), and the associated microcrystalline limestone by fairly advanced recrystallization (see Shoji and Folk, 1964, pp. 147-152) of an originally cryptocrystalline, probably aragonitic, chemically precipitated lime mud (see Cloud, 1962). The assemblage as a whole is typical of carbonates in evaporitic sequences (Leighton and Pendexter, 1962, p. 57). Norris (1963) concluded that the breccias formed by solution of evaporites and collapse of overlying beds. Present petrographic studies strongly support this explanation, and indicate that the inferred evaporites were thinly interstratified with assemblage 2. It is estimated that at the type section, evaporites made up less than 10 per cent of member A. Associated small-scale soft-sediment deformations indicate that solution began before the immediately overlying beds were lithified. It is difficult to determine to what extent the undulations in the overlying strata were produced by differential settling of the ground beneath them, and to what extent by algal stromatolites; both modes of origin are indicated. Large-scale structural adjustments continued until perhaps a few hundred feet of overlying beds were deposited. In these processes the breccias of assemblage 3 seem to have had a high mobility—probably due to a high content of water held in their pore spaces. In summary, the Cape Crauford Formation seems to have formed in a lagoon protected by barriers which exerted a fluctuating control on the regimen of inflow, outflow, and evaporation, and hence on the chemical composition of the lagoonal waters. The three assemblages represent different states of the composition, and probably also, the depth of the water. The height and continuity of these barriers may have been controlled by shifting currents or, possibly, slight tectonic oscillations. The composition of the groundwaters beneath the lagoon also must have changed frequently because it seems to have brought about such different types of alteration as secondary dolomitization (see Deffeyes, Lucia and Weyl, 1964), solution of evaporites, and formation of epigenetic gypsum (see Kerr and Thomson, 1963).

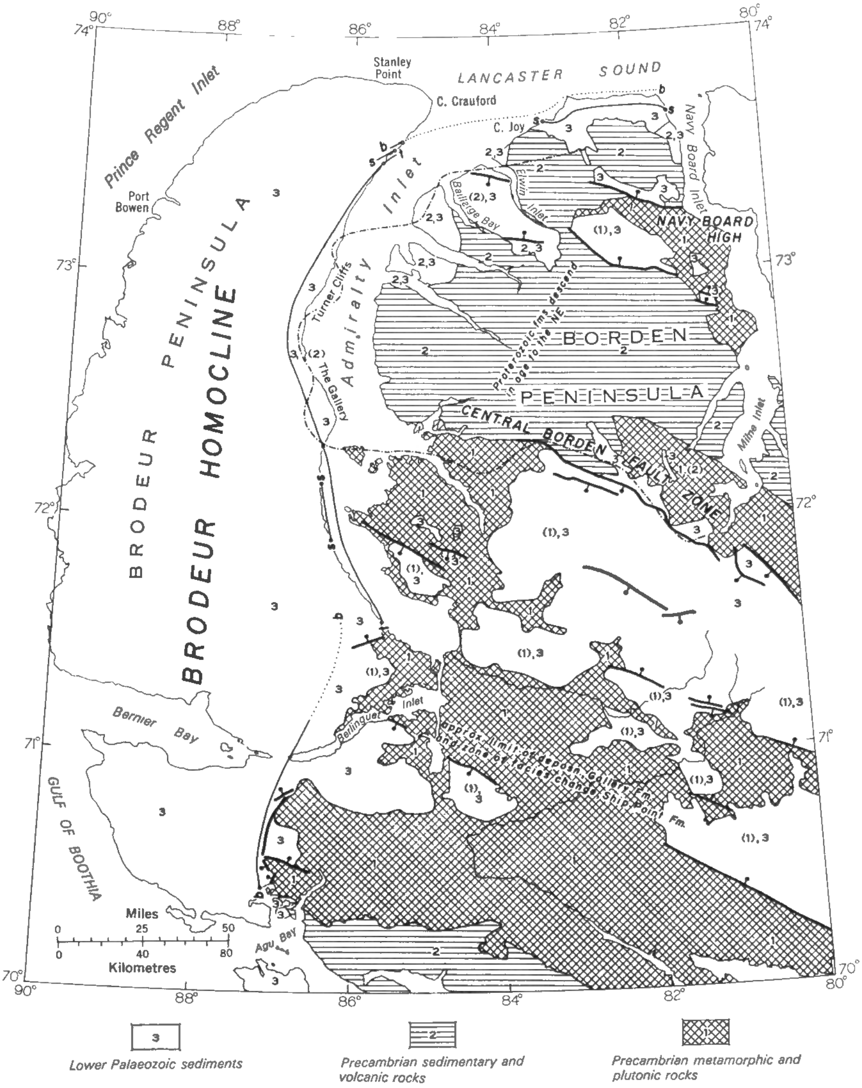
T.E. Bolton concludes that the fossils collected from the lower 975 feet of the formation can be correlated best with the Niagaran. As stated before, specimens of Atrypella, the index fossil of the late Wenlockian and younger Read Bay Formation, are not represented in the collections. The lower 1,000 feet or so of the formation, then, appear to be Middle Silurian and correlative with upper parts of the Allen Bay Formation (Thorsteinsson, 1958). The upper 340 feet, from which no fossils have been collected, could conceivably extend into the late Wenlockian or early Ludlowian.

STRUCTURAL HISTORY

The Lower Palaeozoic succession was laid down on an erosion surface which transected various structures formed during Cambrian and/or Proterozoic time (see Fig. 10). Some of these, notably the Central Borden Fault Zone, and the Navy Board High, were intermittently active in Lower Palaeozoic and later times as well, but with changing directions of (vertical) movement. The Central Borden Fault Zone lies at or near the contact between the crystalline Precambrian rocks occupying most of the southern parts of the map-area, and the Proterozoic sedimentary and volcanic formations underlying large parts of northern Borden Peninsula. This contact zone seems to have been an important hinge during Proterozoic sedimentation. It was faulted before the deposition of the Gallery Formation, and probably mildly active during Gallery and Turner Cliffs time (see isopachs of Figs. 3, 4). The predominant type of movement in Lower Palaeozoic and earlier times seems to have been relative elevation of the southern block. The fault zone was active again in post-Silurian time, but then with a reverse direction of movement. A horst of Precambrian crystalline rocks surrounded by Proterozoic sediments and unconformably overlain by the Gallery Formation, located near the head of Navy Board Inlet, is here termed the "Navy Board High". This fault block, elevated in pre-Gallery time, was mildly positive in Gallery time, mildly negative in Turner Cliffs time (see Figs. 3, 4), and emergent in the Middle Ordovician (see Fig. 6). In the post-Silurian it experienced negative fault movements.

During the time interval represented by the Lower Palaeozoic succession, the area formed part of a cratonic shelf subjected to slight vertical oscillations superimposed upon a gradual sinking of its base to a minimum depth of about 5,300 feet. The surface of the Lower Palaeozoic sequence was never at great depth, as the environments represented range from fluviatile through predominantly littoral to shallow marine.

During the time interval represented by the Admiralty Group, Borden Peninsula was occupied by a slowly sinking basin, here named the "Admiralty Basin". The axis of this structure plunged in an easterly direction, perhaps to the southeast. Figure 10, showing the 400-foot isopach of the Turner Cliffs Formation together with structural elements of various ages, suggests that the basin may have been controlled by an arch ancestral



Note: Units shown in brackets are subordinate. The patterns emphasize the maximum extent of the Palaeozoic sediments, and where Precambrian rocks only are represented, the predominant type of Precambrian rock.

Structure contour (sea-level) approximate, assumed

of base, Baillarge Formation . . . . b

of base, Ship Point Formation . . . . s

of base, Turner Cliffs Formation . . . . t

Isopach (400 ft) Turner Cliffs Formation

Major fault in Palaeozoic rocks, solid circle indicates downthrow side

GSC

Figure 10. Tectonic elements of northwestern Baffin Island map-area

to the Brodeur Homocline, and by the Central Borden Fault Zone. During Gallery time, the basin seems to have been mostly above sea-level, and during Turner Cliffs time, at shallow depth below it. The clastic sediments came both from northwesterly and southerly directions (see Fig. 3) but the north or northwest was the major source area (see Fig. 5).

Regional lithological relationships suggest that the Admiralty Basin may be late Lower and Middle Cambrian but diagnostic fossils, and evidence of a major disconformity at the top of the Admiralty Group, are unfortunately lacking. It appears to be a post-tectonic feature related to a major uplift.

The Lower and early Middle Ordovician Ship Point Formation, overlapping the Admiralty Basin, covered the whole area. In the earlier part of Ship Point time, the shore seems to have been not far south of the present map-area; in the later part it transgressed farther to the south.

Anomalously thin sections and a solution zone at the top of the formation indicate that at least in northeastern Borden Peninsula, at the Navy Board High, the Ship Point Formation was eroded in Mid-Ordovician time. Conditions in the rest of the area are not well known; a brief emergence with only shallow erosion is possible.

The Ship Point Formation is overlain by a carbonate sequence that represents three successive environments: (1) a lagoonal and shore environment—member A of the Baillarge; (2) a protected shelf—member B of the Baillarge; and (3) a predominantly lagoonal and shore environment—Cape Crauford Formation. This sequence indicates a trangressive—regressive cycle with the deepest submergence mainly in the late Ordovician and early Silurian (see Fig. 8). The late Ordovician submergence corresponds to the widest known advance of the Arctic seas (see Trettin, 1965).

Post-Silurian deformation produced two major structural elements: a gentle, arcuate, northwesterly to southwesterly dipping homocline known as the "Brodeur Homocline" (Thorsteinsson and Tozer, 1960, Fig. 2) which extends from northern Borden Peninsula through Brodeur Peninsula to Agu Bay; and, in the remaining parts of the area, a group of steeply dipping, northwesterly trending faults with vertical displacements of from a few to a few hundred feet. These faults, striking about 300 degrees, conform to a predominant regional trend expressed in the preferred orientation of Precambrian dyke swarms as well as in prominent lineaments forming the northeastern and southwestern coasts of Baffin Island. North of Agu Bay, where the two structural trends meet at nearly right angles, they are separated by a major fault; and on northern Borden Peninsula, where the difference in trend is less pronounced, by numerous, complicated, minor faults.

The age of these deformations is uncertain. The Boothia Arch to the west, formed in the early Devonian (Thorsteinsson and Tozer, 1960; Christie, 1963), parallels to some extent the Brodeur Homocline. On the other hand Bylot Island adjacent to the map-area in the northeast seems to have been deformed by Tertiary and (?) younger movements. Both periods of diastrophism as well as the Mid-Palaeozoic movements felt in many parts of the Archipelago (Thorsteinsson and Tozer, 1960) could have affected the present area.

The Lower Palaeozoic rocks together with the Precambrian basement, and to some extent the unconsolidated Pleistocene and Recent deposits, are cut by a complicated system of steeply dipping fractures which exert a strong control on the drainage. The azimuth and length of about 500 lineaments in the southeastern parts of the area (NTS 47H, mainly N 1/2) have been measured. The most important maxima, in the order of their abundance, occur in the following sectors: 334-336, 328-330, 346-348, 318-320, 58-60, 292-294, 324-326, 22-24, 286-288, and 6-8 degrees azimuth. These fractures have no obvious relation to the older structural elements, and their origin is unknown.

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- Appendix -

NOMENCLATURE

Terms Used to Indicate the Size Ranges of Carbonate Crystals

The grades distinguished correspond to the Wentworth scale, and the nomenclature used has been adapted from Leighton and Pendexter (1962) and Drummond (1963). In this nomenclature, carbonate grains of sand size are described in terms of "sand grades", those of silt size are termed "microcrystalline", and those of clay size are termed "cryptocrystalline":

2-1 mm .... very coarse crystalline
1-0.5 mm........................... coarse crystalline
0.5-0.25 mm........................ medium crystalline
0.25-0.12 mm....................... fine crystalline
0.12-0.06 mm....................... very fine crystalline

0.06-0.004 mm...................... microcrystalline
0.06-0.03 mm....................... coarsely microcrystalline
0.03-0.004 mm...................... finely microcrystalline

0.004 mm or less................... cryptocrystalline

Terms Used to Describe the Thickness of Strata
(after McKee and Weir, 1953)

Thickness greater than 120 cm........ very thick bedded
120-60 cm .... thick bedded
60 cm-5 cm........................... thin bedded
5 cm-1 cm............................ very thin bedded
1 cm-2 mm .... laminated
2 mm or less .... thinly laminated