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DEPARTMENT OF MINES AND TECHNICAL SURVEYS

MEMOIR 332

WESTERN QUEEN ELIZABETH ISLANDS, ARCTIC ARCHIPELAGO

E. T. Tozer and R. Thorsteinsson

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By

E. T. Tozer and R. Thorsteinsson

DEPARTMENT OF
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PREFACE

Until 1954 investigation of the western Queen Elizabeth Islands, in the northwest part of the Arctic Archipelago, had virtually been confined to coastal exploration by British Expeditions of the last century, by Canadian Arctic Expeditions between 1909 and 1918 under Captain Bernier and Vilhjalmur Stefansson, and in later years by members of the Royal Canadian Mounted Police. Although they worked under difficult conditions, valuable geological observations and collections were made by some of these parties. However, when air photographs of these islands were taken in 1950 and later years it was apparent that the geology was probably more complicated than was formerly supposed. Reconnaissance field work was accordingly started by the Geological Survey in 1954 and continued in 1955, 1958, and 1959.

This work revealed that the area is underlain by a substantial thickness of sedimentary rock of Palaeozoic, Mesozoic, and Tertiary age, and that a complex sequence of structural events had taken place. Preliminary results of this work, published in 1956 and 1959, made available data of considerable scientific and economic interest. The first petroleum exploration well in the Arctic Archipelago has already been drilled at Winter Harbour, Melville Island, within the area described in this report.

J. M. HARRISON,
Director, Geological Survey of Canada

OTTAWA, December 7, 1961

Memoir 332—Die westlichen Königin-Elisabeth-Inseln im Franklin-Distrikt

Von E. T. Tozer und R. Thorsteinsson

Die Stratigraphie, Struktur, Pleistozängeologie und die physikalischen Verhältnisse der Melville, Prince Patrick, Eglinton, Mackenzie King, Borden, Brock und Emerald Inseln werden beschrieben.

Paläozoische Gesteine des Ordoviziums, Silurs, Devons, Pennsylvaniums und Perms sind vorhanden. Alle mesozoischen Formationen sind vertreten, und Ablagerungen des Alttertiärs (?) und Jungtertiärs (?) sind gleichfalls vorhanden. Meeres- und nicht marine Tiere und Pflanzen des Paläozoikums und des Mesozoikums sind aufgezählt. Die Tertiärschichten sind nicht marin, und Leitfossilien sind nicht bekannt. Die paläozoische und spätere geologische Geschichte ist zusammenfassend dargestellt. Es besteht die Möglichkeit, daß die vorliegenden Bedingungen Ansammlungen von Kohlenwasserstoff begünstigen könnten.

Мемуар 332 — Западные острова Королевы Елизаветы, район Франклина.

Авторы: Е. Т. Тозер и Р. Торстейнссон.

Описание стратиграфии, структуры, четвертичной геологии и физических особенностей островов Мелвилль, Принц Патрик, Эглинтон, Макензи Кинг, Борден, Брок и Смарагдовых.

В районе исследований развиты палеозойские породы ордовикского, силурского, девонского, пенсильванского и перьмского возраста. Все мезозойские системы представлены. Также представлены отложения раннего (?) и позднего (?) третичного возраста. Даются списки морской и неморской фауны и таковые флоры палеозойского и мезозойского возраста. Все третичные отложения неморского происхождения и лишены руководящих ископаемых. Дается резюме палеозойской и последующей геологической истории. Указывается возможность существования условий благоприятных для накопления углеводородов.

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WESTERN QUEEN ELIZABETH ISLANDS, ARCTIC ARCHIPELAGO

Abstract

The geology of Melville, Prince Patrick, Eglinton, Brock, Borden, Mackenzie King, and Emerald Islands of the Canadian Arctic Archipelago is described.

Ordovician, Silurian, and Devonian rocks form a concordant sequence on Melville Island. These rocks were deposited in the Franklinian geosyncline and were folded between mid-Upper Devonian and Middle Pennsylvanian times. Ordovician and Silurian rocks include more than 3,000 feet of carbonate and graptolitic strata. Devonian strata reach 15,000 feet in thickness and include Middle Devonian limestone overlain by thick marine and non-marine terrigenous clastic rock, probably derived from tectonic lands to the north.

On Melville Island about 2,000 feet of marine Middle Pennsylvanian conglomerate, sandstone and minor limestone overlies the folded older rocks. On eastern Melville Island the Permian is represented by 2,000 feet of marine sandstone and limestone that lies disconformably on the Pennsylvanian strata. On western Melville Island an angular unconformity underlies the Permian rocks. Pennsylvanian or Permian limestone and evaporites underlie Sabine Peninsula where these rocks are brought to the surface in two piercement domes.

The Mesozoic and early Tertiary strata are mainly sand, sandstone, and shale. Marine beds of Upper Triassic, Jurassic, and Cretaceous age occur. Non-marine beds of Lower Triassic, Jurassic, Lower Cretaceous, and early Tertiary age are also present. Source of the Mesozoic and early Tertiary sediment probably lay to the south or southeast. Several Mesozoic formations are transgressive and Lower Cretaceous beds transgress beyond the Sverdrup Basin and form outliers resting upon the folded Devonian rocks of southeastern Melville Island.

Gabbro dykes of Cretaceous (?) age occur on Melville Island.

Following deposition of the early Tertiary beds gentle folding affected the Sverdrup Basin and normal faults developed throughout much of southern Prince Patrick Island, and parts of Melville Island. After the folding, at least 250 feet of late Tertiary or Pleistocene sand and gravel (Beaufort Formation) was deposited upon the site of the Arctic Coastal Plain of Prince Patrick, Brock, and Borden Islands. On Prince Patrick Island movement of some pre-existing faults seems to have followed the deposition of the Beaufort Formation.

Southeastern Melville Island and perhaps also the remainder of the area were probably glaciated by Laurentide ice in early Pleistocene time and later, local glaciation probably affected Melville and Prince Patrick Islands. Emerged strand lines are highest and best developed in southeastern Melville Island and probably this part of the island experienced greater post-Wisconsin uplift than the remainder of the area.

The great thickness of sedimentary rock, including possible source and reservoir types, and also the occurrence of large closed structures suggest that the area has petroleum possibilities. Melville Island appears to present the most favourable features.

Résumé

Le présent mémoire décrit la géologie des îles Melville, Prince-Patrick, Eglinton, Brock, Borden, Mackenzie King et Emerald, dans l'archipel Arctique.

Les roches ordoviciennes, siluriennes et dévoniennes constituent une succession concordante sur l'île Melville. Les roches en question ont été déposées dans le géosynclinal franklinien; elles ont été plissées entre le milieu du Dévonien supérieur et le Pennsylvanien moyen. Les roches ordoviciennes et siluriennes comprennent plus de 3,000 pieds de couches carbonatées et graptolitiques. Les couches dévoniennes atteignent une épaisseur de 15,000 pieds et comprennent du calcaire mésodévonien recouvert d'une épaisse succession de roches clastiques terrigènes tant marines que non marines, qui proviennent vraisemblablement des régions tectoniques du Nord.

Sur l'île Melville, environ 2,000 pieds de conglomérat, de grès et, en moindre quantité, de calcaire tous d'origine marine et du Pennsylvanien moyen recouvrent les roches plissées plus anciennes. Dans l'Est de l'île, le Permien est représenté par 2,000 pieds de grès et de calcaire marins qui reposent en discordance sur les couches pennsylvaniennes. Dans l'Ouest de l'île, la discordance est angulaire. Du calcaire et des évaporites qui remontent au Pennsylvanien ou au Permien recouvrent la presqu'île Sabine. Les évaporites forment deux dômes diapirs.

Les couches du Mésozoïque et du début du Tertiaire se composent surtout de sable, de grès et de schiste argileux. Il y a des couches marines qui remontent au Trias supérieur, au Jurassique et au Crétacé. Il existe également des couches non marines qui remontent au Trias inférieur, au Jurassique, au Crétacé inférieur et au début du Tertiaire. La source des sédiments du Mésozoïque et du début du Tertiaire se situe probablement plus au Sud ou au Sud-Est. Plusieurs formations mésozoïques sont transgressives, et des couches du Crétacé inférieur se prolongent au-delà du bassin Sverdrup et constituent des lambeaux qui reposent sur les roches dévoniennes plissées du Sud-Est de l'île Melville.

L'île Melville présente des dykes de gabbro d'âge crétacique.

Après la mise en place des couches du début du Tertiaire, des plissements peu accentués se sont produits dans le bassin Sverdrup et des failles normales se sont formées dans la majeure partie du Sud de l'île Prince-Patrick et dans certaines régions de l'île Melville. Après ces plissements, une couche d'au moins 250 pieds de sable et de gravier de la fin du Tertiaire ou du Pléistocène (formation Beaufort) s'est déposée sur la plaine côtière arctique des îles Prince-Patrick, Brock et Borden. Sur l'île Prince-Patrick, il semble qu'il y ait eu mouvement le long de certaines failles préexistantes après la déposition de la formation Beaufort.

Au début du Pléistocène, les glaces laurentides ont probablement recouvert le Sud-Est de l'île Melville et peut-être aussi le reste de la région. Plus tard, une glaciation locale a probablement recouvert les îles Melville et Prince-Patrick. Les lignes de rivage émergées sont plus élevées et mieux développées dans le Sud-Est de l'île Melville, et il est probable que cette partie de l'île a été soumise à un soulèvement postérieur au Wisconsin de plus grande envergure que le reste de la région.

La grande épaisseur des roches sédimentaires, dont certaines pourraient contenir du pétrole et d'autres être des roches-magasins, et la présence de grandes structures fermées portent à croire à l'existence de pétrole. A cet égard, c'est l'île Melville qui semble la plus prometteuse.

Chapter I

INTRODUCTION

The group of islands described in this report has an aggregate land area of 26,686 square miles, made up as follows: Melville, 16,141; Prince Patrick, 6,081; Mackenzie King, 1,922; Borden, 1,344; Eglinton, 551; Brock, 396; and Emerald Isle, 251 square miles. These islands lie in the northwest part of the Canadian Arctic Archipelago; the west and north parts of the area face the Arctic Ocean. Melville Island, the southern member of the group, is 1,400 miles due north of Edmonton; Borden Island, in the northern part of the area, is about 830 miles from the North Pole.

Until 12 years ago the islands had been visited by only a few explorers; even now all except Prince Patrick are completely uninhabited. The geology described is based on field work done by the Geological Survey of Canada in 1954, 1955, 1958, and 1959. Many different rock formations are exposed, ranging in age from Ordovician to Pleistocene. Within this time span only the Mississippian system is unrepresented. The area has experienced a complex tectonic history; two periods of orogeny are distinguished in the Palaeozoic, and tectonic activity also occurred in Tertiary time. The area is of considerable scientific interest, and recent activity by companies searching for petroleum indicates that it may eventually be of economic importance.

Settlement and Accessibility

The only establishment within the area is the Mould Bay weather station on eastern Prince Patrick Island, at latitude 76°14′N, longitude 119°20′W. This station was established by air-lift from Resolute Bay in the spring of 1948, and is jointly operated by the Canadian Department of Transport and the United States Weather Bureau. The normal complement is eight men. An air strip at Mould Bay is normally serviceable in the spring and the autumn. Construction to improve this strip continues each year and during favourable years it can be used the year round. Aircraft are solely responsible for re-supply at the station.

Aircraft equipped with skis, or ski-wheels, can operate throughout much of the area for parts of the year. The best months for flying with skis are late March, April, and May, when the weather is generally good and landings can be made on sea ice, lake ice, and snow-covered land. Douglas DC-3 aircraft equipped with ski-wheels have landed on unprepared snow surfaces at Landing Lake, Tingmisut Lake, and Bridport Inlet, and other landing areas could doubtless be found. By mid-June soft snow may make operation with large ski-wheel aircraft difficult.

In summer the most satisfactory method of air travel is by light aircraft equipped with oversized tires. This method was pioneered by W. W. Phipps, of Bradley Air Services, Ottawa, who in 1958 equipped a Piper Super-Cub PA 18 A aircraft with tires designed for the larger Stinson SR 5. These tires are 25 by 11 by 4 inches inflated to a pressure of 5 pounds. The aircraft was engaged under contract by the Geological Survey, and in one summer season made 400 landings on unprepared land surfaces in various parts of the map-area. Landings were made in 246 different places, one on the ice-cap south of Purchase Bay. On several occasions in 1958 the aircraft became mired in mud on landing; it was released by one man lifting on the wing strut while the other built a support of rocks under the tires. In 1959 Phipps equipped the Super-Cubs with larger tires (35 inches in diameter) and difficulty with soft terrain was no longer encountered. The Super-Cub is licensed to carry a pay load of 300 pounds. This capacity enables the aircraft to transport a geologist on traverses, and it also permits the moving of light camps and the caching of fuel. In 1960 Phipps used a de Havilland Beaver aircraft for landing on unprepared terrain. This aircraft, fitted with tires 45 inches in diameter, carries a pay load of 1,000 pounds over a range of about 300 miles.

Seaplanes and float planes are not particularly useful in this area owing to persistent ice on both the sea and lakes. Canso aircraft have landed at Walker Inlet, near Cape Russell, and at Bridport Inlet. In 1954 Landing Lake, Prince Patrick Island, was ice-covered on July 17; in 1958 Tingmisut Lake was free of ice by the middle of August.

The only part of the area that has been reached by ship is the south coast of Melville Island, between Cape Providence and Nelson Griffiths Point. In recent years the only vessels to do so have been the RCMP Schooner *St. Roch* and icebreakers of the Royal Canadian Navy, the Department of Transport, the United States Navy, and the United States Coast Guard Service. Details of the ice conditions within the area are provided by the *Pilot of Arctic Canada* (1959), and Swithinbank (1960).

Tracked vehicles ("Weasels" and "Bombardiers") have been used for travel in the vicinity of Mould Bay weather station. Such vehicles could probably be used on the ice between the individual islands during the winter and spring. After the end of June the open shore leads would make travel by this means unpredictable and probably impossible.

Sledges have been used throughout the area during the winter and in summer as late as July.

History of Exploration

Exploration of the islands of the map-area started in 1819 when Lieutenant (later Sir Edward) Parry discovered Melville Island in the course of the first expedition by civilized man that involved wintering in the arctic islands. Parry undertook this expedition as a direct consequence of having been commander,

during the preceding year, of HMS *Alexander,* under the direction of Captain (later Sir John) Ross. Ross was dispatched from England in 1818 with orders from the Admiralty to "ascertain the existence or non-existence of a north-west passage" (*see* Ross, 1819a, p. iv). In this endeavour he was unsuccessful although he did confirm some of the discoveries of William Baffin, made two centuries before. Baffin had named three sounds: for Sir Thomas Smith, Alderman Jones, and Sir James Lancaster. Ross confirmed that these bodies of water existed but he made a grievous error by concluding that Lancaster Sound was a bay, with the "Croker Mountains" blocking the route to the west (op. cit., p. 174). Ross' account of the Croker Mountains satisfied neither his own officers, particularly Parry and Edward Sabine, nor the Commissioners of the Admiralty, and his account of these mountains led to considerable argument and ill-feeling (Sabine, 1819; Ross, 1819b). Shortly after Ross returned, in May 1819, Parry was instructed to undertake a new expedition "... to explore the bottom of (Lancaster) Sound; or, in the event of it proving a strait opening to the westward ... to use all possible means, consistently with the safety of the two ships, to pass through it and ascertain its direction and communications" (*see* Parry, 1821, p. xx). These instructions led to the discovery of Melville Island.

Parry left England, with his two ships, the *Hecla* and *Griper*, in May 1819. He passed through Lancaster Sound in August and in September he reached Melville Island, which was named for Viscount Melville, the First Lord of the Admiralty. He established winter quarters at Winter Harbour, having charted the south coast of the island between Nelson Griffiths Point and Cape Dundas. In the spring of 1820, Parry, travelling with a cart drawn by his sailors, crossed from Winter Harbour to Nias Point, on the south side of the bay that he named for their ships. There he built a massive cairn and left a record (Pl. II). From Nias Point the party sighted Sabine Peninsula, which was mistaken for an island. Leaving Nias Point the party travelled southwest to discover Liddon Gulf, named for the master of the *Griper*. When they descended to the gulf at Bushnan Cove, their cart was damaged beyond repair and was abandoned at the head of the cove. The party then crossed the gulf via Hooper Island and walked overland to the ships at Winter Harbour. Near their destination they stopped at the Table Hills where another massive cairn was built on the summit of these morainal hills (Pl. XIII). In August 1820 the ships were released from the ice, and a second attempt was made to force their way westward but again, as in the previous year, they were frustrated by the heavy ice of M'Clure Strait. Reluctantly Parry returned to England. He had gained the prize for passing the 110th meridian (commemorated by the naming of Cape Bounty) but he had failed to discover a northwest passage. Before leaving Winter Harbour a brief account of their notable achievement was carved upon a large ice-rafted mass of Devonian sandstone (Pl. I). This rock—Parry's rock—was to become an important Arctic 'post office' and was destined to house the letter that saved the crew of HMS *Investigator* under M'Clure, who was the first to discover a northwest passage some 35 years later.

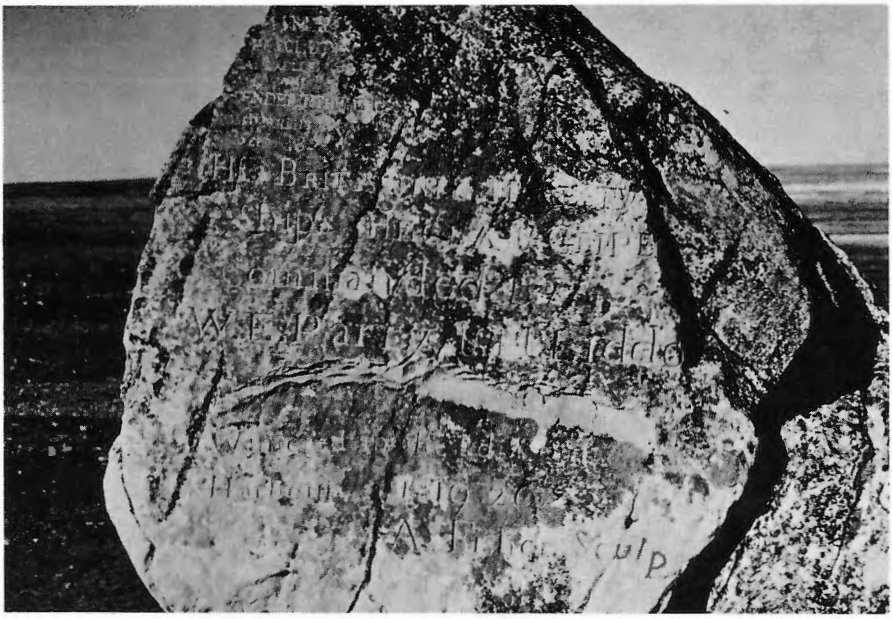

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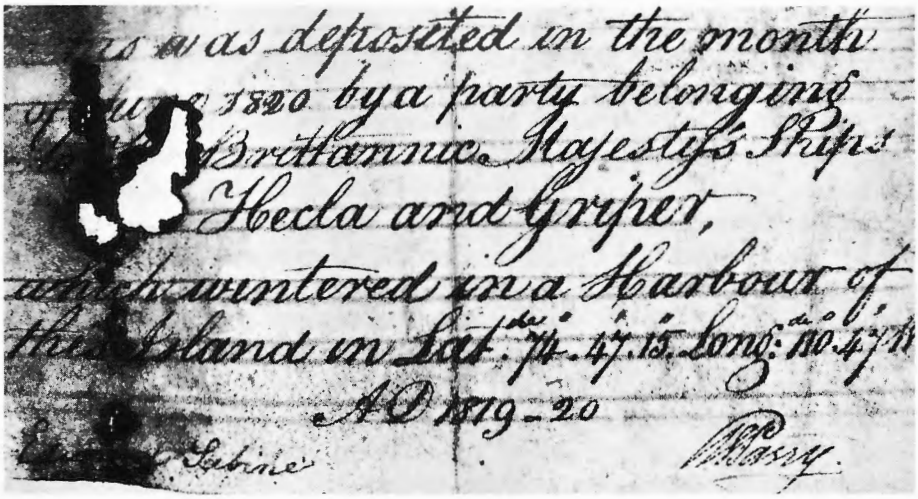
PLATE I. Parry's Rock, Winter Harbour, Melville Island—an ice-rafted boulder of Devonian sandstone. The inscription describes Parry's visit, 1819–1820. A later inscription, recording the arrival of HMS *Resolute* and *Intrepid* at Melville Island in 1852, is on the upper part of the rock.



was deposited in the month
1820 by a party belonging
Britannic Majesty's Ships
Hecla and Griper,
wintered in a Harbour of
Island in Lat. 74. 47. 15. Long. 110. 47.
AD 1819-20
Sabine
Parry

110427

PLATE II. Facsimile of parchment record buried by Sir Edward Parry in 1820 at Nias Point, on Hecla and Griper Bay, Melville Island. This record was excavated by Lieutenant Pim in 1853 and left at the cairn. On the back of the parchment is written "Opened and copied in the month of July 1853 by a party from HMS *Intrep* (id) . . . at Dealy Island (signed) F. L. M'Clintock, Commander".

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PLATE III. Cairn in Bushnan Cove, Melville Island, built by Sir Leopold M'Clintock in 1851. At the cairn are the hubs and wheel shoeing of Parry's cart, abandoned nearby in 1820.

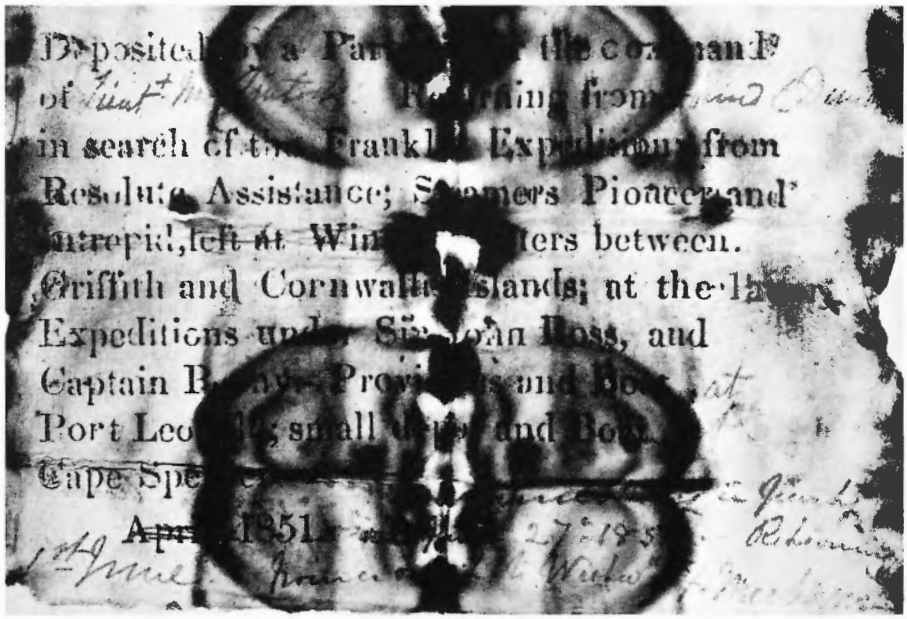

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PLATE IV. Record deposited in the cairn at Bushnan Cove by M'Clintock in 1851. In 1853 G. F. Mecham visited this cairn and added the note "Examined by a party on June 27th 1853, returning from a search to the westw'd".

The next explorers to visit Melville Island were engaged in the search for the missing expedition of Sir John Franklin, which left England in 1845 never to return. In 1850, Captain H. T. Austin entered Lancaster Sound to prosecute the search. He wintered his ships, the *Resolute* and *Assistance,* with steam tenders *Pioneer* and *Intrepid,* in the ice between Griffith and Cornwallis Islands. In the following spring Leopold M'Clintock sledged west to Melville Island. He followed the south coast, rounded Dundas Peninsula to Liddon Gulf and proceeded up the gulf to Bushnan Cove. There M'Clintock recovered the remains of Parry's cart, most of which was used for firewood. The steel shoeing of the wheels and the hubs were removed to a cairn that he built (Pl. III), where he also left a record (Pl. IV).

At the time of this expedition, another sledge party, under A. R. Bradford, surgeon of the *Resolute,* explored the east coast of Melville Island, between Nelson Griffiths and Bradford Points.

The next expedition to visit Melville Island was also engaged in the search for Franklin. This expedition left England in 1852 under the command of Sir Edward Belcher (Belcher, 1885; M'Clintock, 1857; M'Dougall, 1857, and British Parliamentary Papers, 1855). Belcher's Arctic Squadron included the four ships that had been under Austin's command with the addition of another vessel, the *North Star.* Belcher divided his squadron into three parts. He himself sailed up Wellington and Queens Channels with the *Assistance* and *Pioneer,* to winter at Northumberland Sound, on Grinnell Peninsula. *Resolute* under Captain Henry Kellett and *Intrepid* under Commander M'Clintock sailed west hoping to reach Winter Harbour, but they eventually wintered in a distinctly unsheltered situation on the south side of Dealy Island, near Bridport Inlet, Melville Island. The *North Star* remained at Beechey Island as a retreat vessel. This expedition completed the exploration of the coasts of Melville Island and it also led to the discovery of Prince Patrick, Eglinton, and Emerald Islands. This was achieved by Leopold M'Clintock, G. F. Mecham, R. Vesey Hamilton, G. H. Richards, and Sherard Osborn. The journeys of the Commander, Sir Edward, did not take him to these islands. Prince Patrick Island was named for the seventh child of Queen Victoria, who later became the Duke of Connaught and Governor General of Canada, 1911-16.

Resolute and *Intrepid* reached Dealy Island in September 1852. M'Clintock and Mecham immediately established depots for use on the journeys they planned to undertake in the following spring. M'Clintock placed a depot near Reid Point, on the shore of Hecla and Griper Bay; Mecham placed his at Cape Hoppner, in Liddon Gulf.

In the spring of 1853 their great journeys started. M'Clintock again crossed to Hecla and Griper Bay and travelled west to explore the whole of the north coast of Melville Island, west of Reid Point; the west coast as far south as Purchase Bay; parts of northern Eglinton Island and the coasts of Prince Patrick Island from Intrepid Inlet, which was penetrated to its head, around to Satellite Bay on the north coast. On his return from northern Prince Patrick Island he

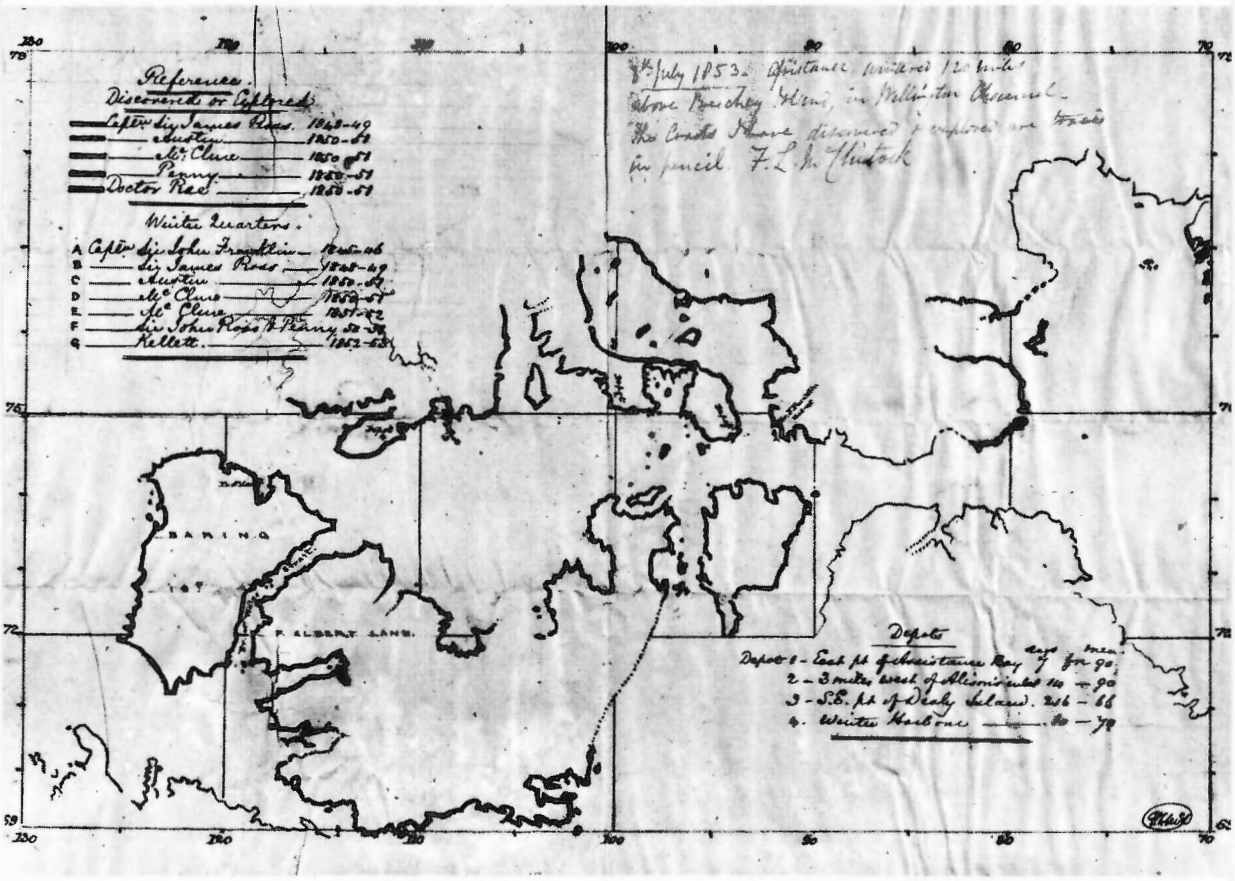
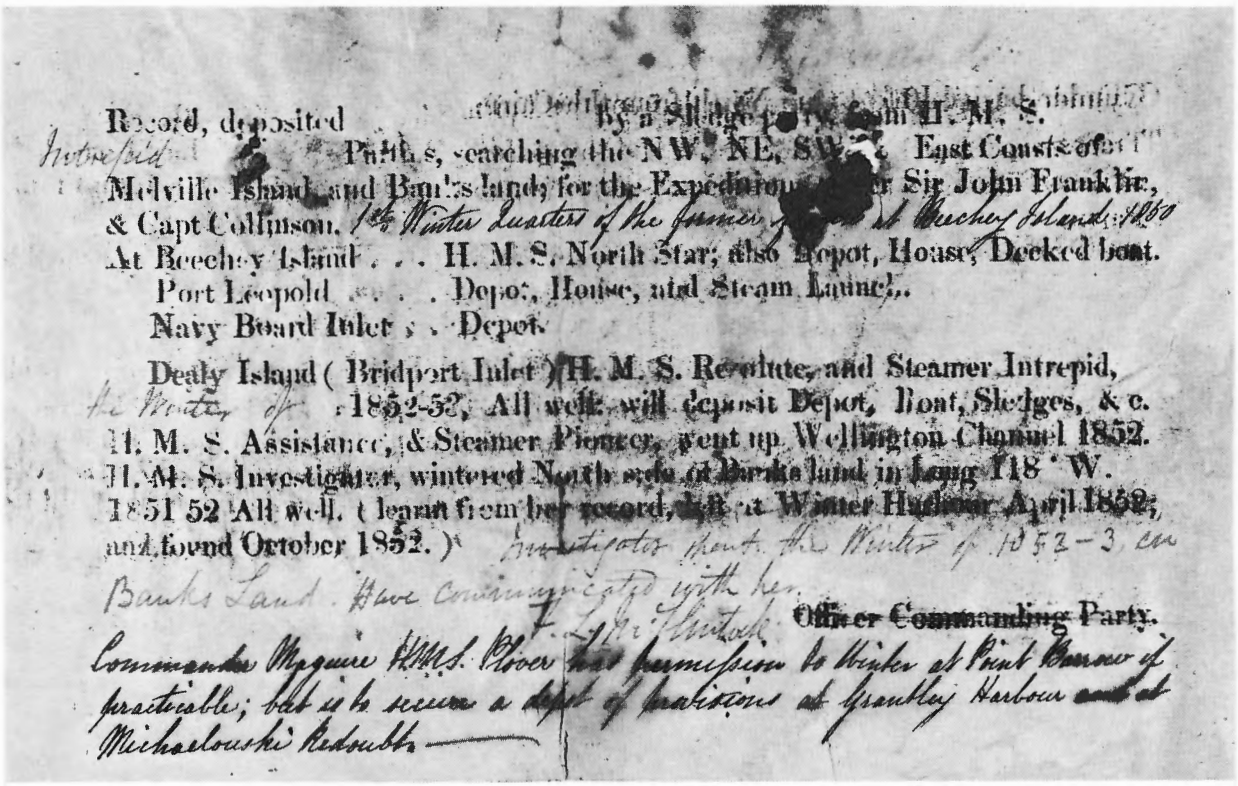


PLATE V. Facsimile of chart drawn by G. F. M'Dougall, Master of HMS *Resolute*, showing the Arctic coasts discovered to 1851. This copy was left at Nias Point by Sir Leopold M'Clintock in July 1853 and it shows, in M'Clintock's pencilled hand, the newly discovered coasts of Melville, Prince Patrick, Eglinton, and Emerald Islands.

discovered Emerald Isle. When he returned to Nias Point he wrote a note on the back of Parry's parchment record "which Lieutenant Pim's party had dug up from beneath the monument, after several hours labour" (M'Clintock, 1855, p. 581). Parry's parchment was left at the cairn, together with a record of his own, and a beautiful chart, drawn by G. F. M'Dougall, Master of the *Resolute* (*see* Pls. V and VI). This chart shows the earlier discoveries, with the coasts coloured and an explanatory legend attributing the various coasts to the discoverers. Superimposed on the chart M'Clintock has shown, in pencil, the coasts that he had discovered and explored on this great journey. On July 14, about 10 miles east of Reid Point, M'Clintock started his return journey over the land between Hecla and Griper Bay and Dealy Island. Sledging was soon found



Record, deposited By a Sledge Party from H. M. S.
Intrepid Parties, searching the NW. NE. SW. East Coasts of
Melville Island and Banks land for the Expedition under Sir John Franklin,
& Capt Collinson. 1st Winter Quarters of the former at Beechey Island 1850
At Beechey Island . . . H. M. S. North Star; also Depot, House, Decked boat.
Port Leopold . . . . Depot, House, and Steam Launch.
Navy Board Inlet . . Depot.
Dealy Island (Bridport Inlet) H. M. S. Resolute, and Steamer Intrepid,
the Winter of 1852-53. All well. will deposit Depot, Boat, Sledges, & c.
H. M. S. Assistance, & Steamer Pioneer, went up Wellington Channel 1852.
H. M. S. Investigator, wintered North side of Banks land in Long 118° W.
1851 52 All well. (learnt from her record, left at Winter Harbour April 1852,
and found October 1852.) Investigator shout the Winter of 1853-3 on
Banks Land. Have communicated with her.
F. M'Clintock Officer Commanding Party.
Commander Maguire H.M.S. Plover has permission to winter at Point Barrow if
practicable; but is to secure a depot of provisions at Grantley Harbour and at
Michaelowski Redoubt.

PLATE VI. Facsimile of record deposited at Nias Point, Melville Island, by M'Clintock in July 1853.

impractical and the sledge was abandoned about a mile from the shore (Pls. VII-IX). The party then packed their equipment on a cart that had been left nearby the previous autumn. Again they set out for the ships, but "the earth was too soft for the ladened cart" (M'Clintock, 1855, p. 583) and this, too, was abandoned, with most of their equipment "to be sent for at a future period if circumstances permit" (op. cit., p. 584). Circumstances did not permit M'Clintock's return and in 1958 the Geological Survey recovered his shotgun, sextant, and cooking equipment, together with geological and other specimens (Pls. VII-IX). M'Clintock was a keen and able naturalist and one can imagine his feelings on abandoning the geological specimens that he had carried on his sledges for hundreds of miles. He did not abandon all his fossils for some were later described by Haughton (1857) (*see* p. 16).

Mecham's journey was no less notable. From Dealy Island he travelled west to Winter Harbour, crossed overland to Liddon Gulf and then followed the coast of Melville Island as far west as Cape Russell. He continued west, along the north side of what is now called M'Clure Strait, and was the first to reach Eglinton and Prince Patrick Islands. Mecham then charted most of the south coast of Prince Patrick Island, west of Cape Frederick, and the west coast to a latitude of about

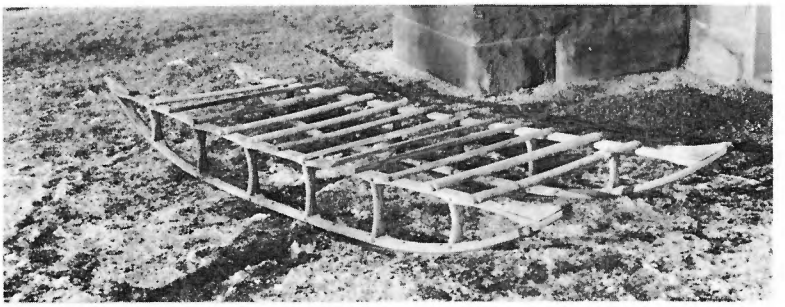


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PLATE VII

HM Sledge *The Star of the North,* used by Sir Leopold M'Clintock in 1853, recovered by the Geological Survey in 1958 and assembled in Ottawa.

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PLATE VIII

The Star of the North as found southeast of Reid Point, Melville Island.

110439

PLATE IX

M'Clintock's cart, as abandoned in 1853, southeast of Reid Point, with most of his field equipment and scientific specimens. The runners of HM Sledge *Satellite* may be seen in the cart.

77°10′. By the time that he reached this latitude on the west coast shortage of supplies forced him to return. Travelling south and east he crossed overland to the head of Walker Inlet and eagerly started to explore the parts of southeastern Prince Patrick Island, that lay east of his original landfall, at Cape Frederick. He started by charting Carter and Mould Bays and then, on June 6, having rounded Manson Point, he discovered a cairn containing a record which had been left by M'Clintock, 13 days before. He was understandably disappointed, and "greatly vexed" (Mecham, 1855, p. 526) to find from this record that M'Clintock had forestalled him in the discovery and exploration of the remainder of eastern Prince Patrick Island. Mecham then returned to Dealy Island *via* northern Eglinton Island and the west coast of Melville Island. As he sledged back along Liddon Gulf he devoted two days to an examination of Murray Inlet and at Bushnan Cove he visited M'Clintock's cairn of 1851, where he left a record of his visit.

Sabine Peninsula, by chance, was explored by two parties—one from Northumberland Sound, the other from Dealy Island. G. H. Richards with Sherard Osborn travelled west from the winter quarters of *Assistance* and *Pioneer* at Northumberland Sound, and they were the first to see the coast east of Weatherall Bay and the east side of Sabine Peninsula. Vesey Hamilton crossed from Dealy Island to Hecla and Griper Bay and explored the west coast of the Peninsula. Hamilton met Richards a few miles north of Cape Colquhoun. Osborn had left Richards by this time and was returning to the east. He was overtaken by Hamilton and awakened with the message ". . . I'm Hamilton from the *Resolute*. We are at Melville Island and have relieved the *Investigator,* and the *Northwest Passage is discovered*" (Osborn, 1855, p. 214). Following the meeting with Hamilton, from whom he learned that M'Clintock was exploring the country to the west, Richards abandoned his plans for exploring in that direction and instead travelled to Dealy Island to make contact with Captain Kellett.

The expedition of 1852 thus led to the completion of the coastal exploration of Melville Island and of most of Eglinton and Prince Patrick Islands. The success of this expedition was somewhat marred, however, by the abandonment, on Belcher's orders, of the *Resolute, Intrepid, Assistance,* and *Pioneer*. This expedition will be remembered for the achievements of M'Clintock and Mecham rather than for the actions of Sir Edward. M'Clintock's main sledge journey covered 1,408 statute miles; Mecham's was 1,163 miles. These journeys, it must be remembered, were made with sledges drawn by men, and, as Markham (1909, p. 173) has written: "The great sledge travelling achievements of M'Clintock and Mecham stand alone and unapproached".

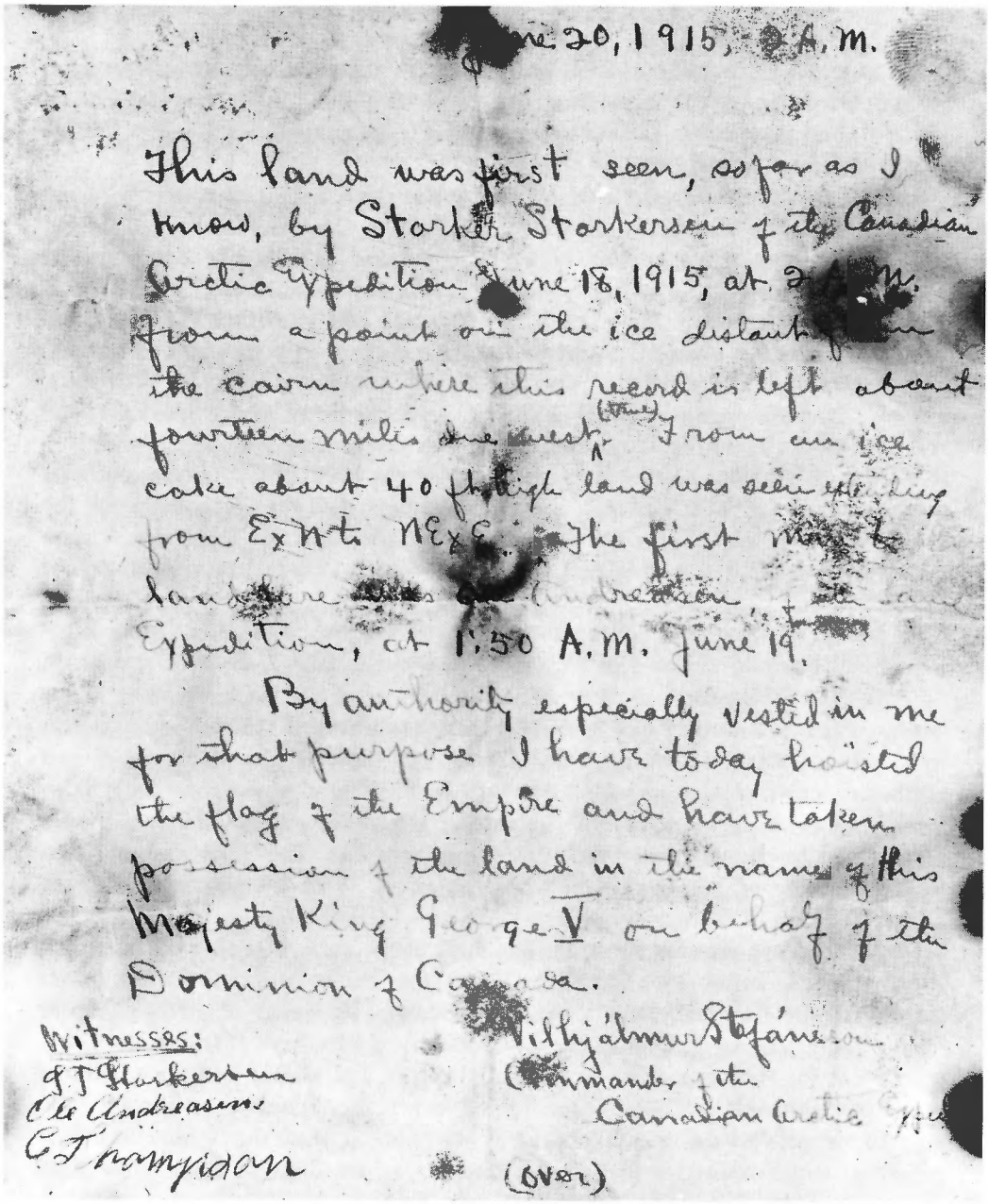
Melville Island had been unvisited for 54 years when, in 1906 Captain J. E. Bernier (1909) in charge of the Dominion Government expedition in DGS *Arctic* visited the south coast of the island. On a second expedition Bernier spent the winter of 1908-09 at Winter Harbour (Bernier, 1910); in 1910 he again visited Melville Island (Bernier, 1911). This time he left a cache, and built a house at Winter Harbour. This building still stands.

Geographic exploration in the western Queen Elizabeth Islands was resumed by the Canadian Arctic Expedition of 1913-18 under Vilhjalmur Stefansson (1921). He, personally, virtually completed the geographic exploration of the islands described in this memoir.

In 1915 Stefansson left his winter quarters at Cape Kellett, Banks Island, and after following the west coast of Banks Island to the Gore Islands he sledged out to the Arctic Ocean. Stefansson, unlike Mecham and M'Clintock, was travelling with dog teams. He travelled northwest over the ice to 76°40′ north, 130°30′ east and then turned east to make a landfall near Lands End on Prince Patrick Island. From Lands End he travelled northeast along the coast of Prince Patrick Island and he was the first to bridge the gap between the farthest points reached by M'Clintock and Mecham. He continued northeast from the north tip of Prince Patrick Island and on June 19, 1915, discovered what was later named Brock Island (for R. W. Brock, Director of the Geological Survey from 1908-14); 10 miles southeast of Cape Murray a cairn was built and a record deposited therein announcing the new discovery (Pls. X-XII). The season was well advanced and Stefansson had no opportunity to map his new island. However, he did travel east to visit and name the Leffingwell Crags (Pls. XXXI, XXXII), on what is now called Mackenzie King Island. He then travelled back to Banks Island *via* Fitzwilliam Owen, Eight Bears, and Emerald Islands, the west coast of Melville Island, and M'Clure Strait.

In 1916 Stefansson was back again, and he spent the whole summer in the islands north and northeast of Melville Island. He travelled the southwest, northwest, and northeast coasts of Brock Island and most of the south, west, and northwest coasts of what he called Borden Island. What is now known as Wilkins Strait was mistaken for a bay by Stefansson, who believed that the two islands now named for Borden and Mackenzie King were one. This error was not corrected until the islands were seen from the air in 1947. Stefansson's summer's work also led to the discovery of Lougheed and Meighen Islands and in September, with the days growing short, he was back at the cairn he had built on Brock Island the year before (*see* Pl. XII). It was too late to return to Banks Island and Stefansson travelled south to Melville Island. The winter of 1916-17, spent on the south side of Liddon Gulf, was evidently a hard one (Stefansson, 1921, pp. 594-595). Bernier's cache at Winter Harbour was visited and apparently of some use although Stefansson, fearing an outbreak of scurvy, cautioned "the men to be sure to eat plenty of ovibos meat along with the Winter Harbour groceries, and if necessary to feed the groceries to the dogs so as to leave fresh meat for the men" (op. cit., p. 593).

Stefansson made his last journey to the north in 1917. He left his winter quarters in March and travelled more or less directly north, up the west side of Hecla and Griper Bay, and along the east coasts of Mackenzie King and Borden Islands. Once again bad weather prevented him from recognizing that the islands were separated by a strait. On his return journey he travelled *via* Lougheed Island and the east and south coasts of Melville Island. In passing



[illegible]e 20, 1915, [illegible] A. M.

This land was first seen, so far as I know, by Storker Storkersen of the Canadian Arctic Expedition June 18, 1915, at 2 A. M. from a point on the ice distant [illegible] the cairn where this record is left about fourteen miles due west (true). From an ice cake about 40 ft. high land was seen extending from E x N to NE x E. The first man to land here was [illegible] Andreasen of the Expedition, at 1:50 A. M. June 19.

By authority especially vested in me for that purpose I have today hoisted the flag of the Empire and have taken possession of the land in the name of His Majesty King George V on behalf of the Dominion of Canada.

Witnesses:
G. T. Storkersen
Ole Andreasen
C. T. Ramsydon

Vilhjálmur Stefánsson
Commander of the Canadian Arctic Expe[illegible]

(over)

PLATE X. Facsimile of record deposited by Stefansson on the coast of Brock Island, 7 miles southeast of Cape Murray, on June 20, 1915, recording the discovery of new land. (See *also* Pls. XI and XII.)

Party, dogs (13) and equipment all well.
Shall proceed eastward along this coast some
distance, should it prove extensive, and the scant
time is, or around Melville Island to the Expedition
headquarters near Cape Kellett, Banks Island.

V. Stefansson

May 2, 1916.

Two parties of the Canadian Arctic Expedition left this
place May 1st and May 2d going in a NWesterly direction
for the further exploration of this land. The first party
on May 1st Storker Storkersen had 1 sled, 9 dogs and 3 men,
~~Charles~~ Karsten Andersen and Harold Noice; the second party under
my charge has 4 sleds, 34 dogs and 7 men — Alexander
Cantel, ~~Maddy~~ Charles Thomsen, Martin Kelly,
Natkusiak and Emile. All well.

V. Stefansson

PLATE XI. Facsimile of Stefansson's record from Brock Island (page 2), recording his second visit in May 1916. (See also Pls. X and XII.)

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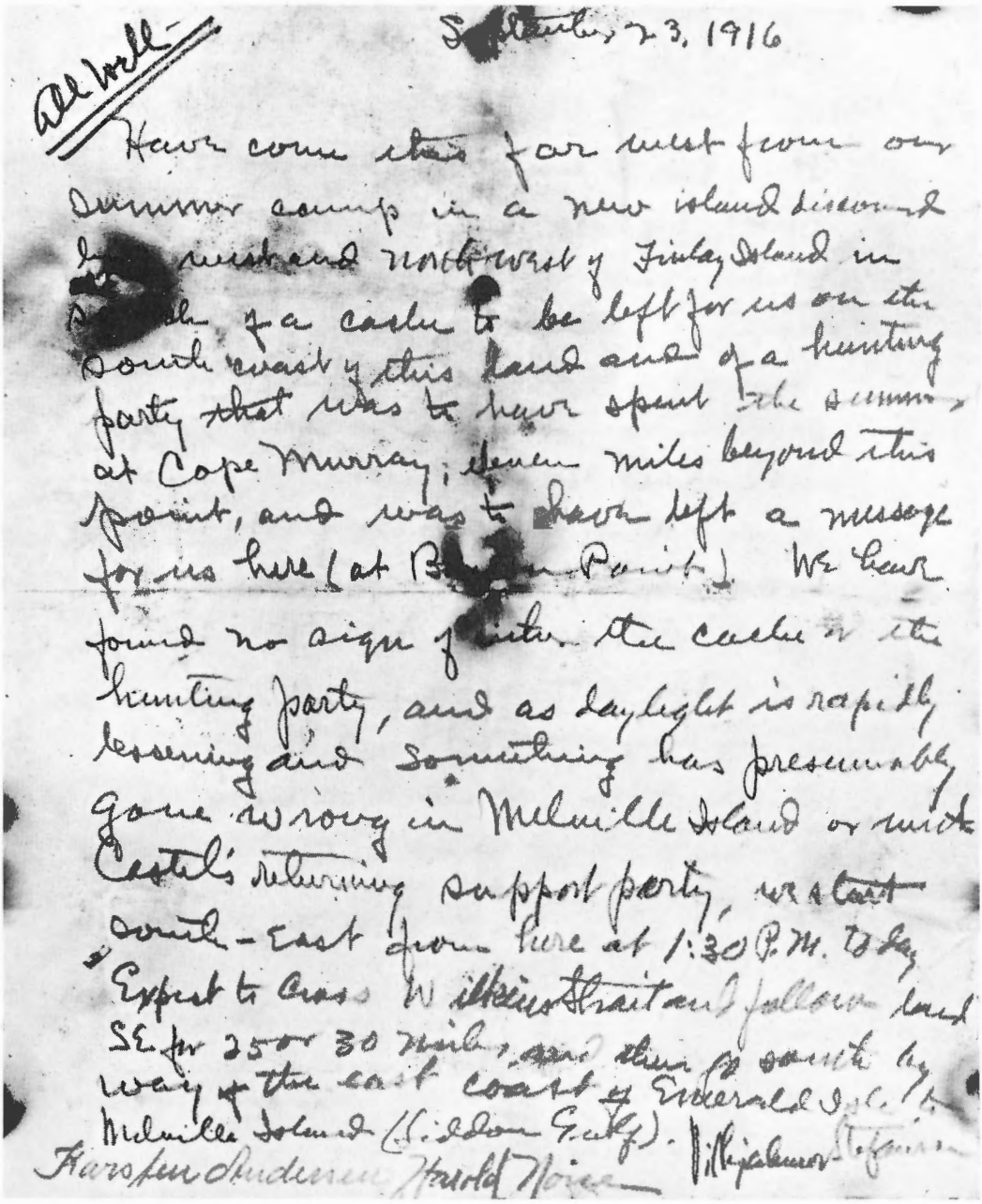

All Well

Sept. 23, 1916

Have come this far west from our summer camp in a new island discovered by us northwest of Finlay Island in search of a cache to be left for us on the south coast of this land and of a hunting party that was to have spent the summer at Cape Murray, eleven miles beyond this point, and was to have left a message for us here (at Brock Point). We have found no sign of either the cache or the hunting party, and as daylight is rapidly lessening and something has presumably gone wrong in Melville Island or with Castel's returning support party, we start south-east from here at 1:30 P.M. today. Expect to cross Wilkins Strait and follow land SE for 25 or 30 miles, and then go south by way of the east coast of Emerald Island to Melville Island (Liddon Gulf).

Harsfen Andersen Harold Noice

Vilhjalmur Stefansson

PLATE XII. Facsimile of Stefansson's record from Brock Island (page 3), recording his third visit, in September 1916, after the long summer journey that led to the discovery of Meighen and Lougheed Islands. (See *also* Pls. X and XI).

Dealy Island he made some use of Kellett's cache and then he continued back to Banks Island.

With Stefansson's work the geographic exploration of the area was virtually complete. It only remained for Wilkins Strait to be recognized as such. This was achieved in 1947 in the course of a long-range navigation flight performed by the U.S. Army Air Force, with RCAF participation (*see* Greenaway and Colthorpe, 1948, p. 257; Dunbar and Greenaway, 1956, p. 501). Stefansson's Borden Island was shown to be two islands and eventually the larger, southern one was named for Mackenzie King.

Between 1917 and 1948, when the establishment of the weather station at Mould Bay made the area relatively accessible, few people visited the area. In 1929, Inspector Joy of the RCMP, with the Greenlander *Nookapingwa,* made a notable patrol to Melville Island, starting from Dundas Harbour on Devon Island and eventually returning to Bache Peninsula, Ellesmere Island, having travelled 1,700 miles. In 1937 Hubert Wilkins landed in a Canso aircraft on Walker Inlet (Prince Patrick Island) and near Cape Russell (Melville Island). He was engaged in the unsuccessful search for the Russian aviators, under Levanevskiy, who attempted to fly from Moscow to Fairbanks (*see* Dunbar and Greenaway, 1956, p. 492). In 1944, Henry Larsen, of the RCMP, called at Nelson Griffiths Point, Palmer Point, Dealy Island, and Winter Harbour, before completing the Northwest Passage for the second time in the *St. Roch.* Larsen's voyage was a 'double first': it was the first navigation of the passage by Prince of Wales Strait, and it was the first passage achieved in a single season.

Previous Geological Exploration

The rock specimens collected by Parry were described by Konig (1824), but their description is not particularly illuminating because, as noted by Konig (op. cit., p. ccliii), "little can be said respecting the relative situation of most of them (they being chiefly rolled pieces, or casual fragments) . . ." Many of the rocks he described are igneous and were clearly either ice-rafted or derived from glacial drift. It was however recognized, by both Parry and Konig (op. cit., p. ccliv) that "the principal formation of the island [Melville] appears to be the fletz sandstone, with the subordinate one of coal and ironstone." Konig (op. cit., p. cclvi) mentioned that "some specimens from Table Hill and its neighbourhood, as also from Liddon's gulf, are marked with the impressions of bivalves, particularly of a small, flat, ovate cuneiform species of *Avicula,* of which a figure will be given elsewhere under the name *A. melvilleana*". As far as the writers are aware this fossil was never figured. No bedrock is exposed at the Table Hills so the fossil may have been collected from drift. Konig also recorded trilobite and crinoid remains and these, too, were probably not collected in situ. The fossiliferous limestone recorded from the Table Hills (Konig, op. cit., p. cclvi) must also be dismissed as drift.

The Franklin Search Expeditions gathered important geological collections

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and information. This was particularly a reflection of the interest shown by individual officers, notably M'Clintock. Sir Edward Belcher also encouraged his officers to collect specimens, as shown by his instructions to Richards: "I do not expect from you sledge loads of fossils, or whole carcasses of mastodon or megatherium; but sketches, records, etc., will not much encumber your head, and some waistcoat-pocket specimens may serve to determine important desiderata in the field of science. I will not say more: perhaps I have said too much. 'A word to the wise is sufficient' " (Belcher, 1855, vol. 11, p. 43).

The geological results of the Franklin Search Expeditions have been summarized in an able fashion by Haughton (1857, 1859), who based his account mainly on notes and specimens provided by M'Clintock. Sir Roderick Murchison (1857) also commented upon the collections made by these expeditions. Haughton produced the first geological map of the Archipelago and he distinguished five main map-units, in ascending order: the granite and gneissic rocks; the Silurian strata; the Carboniferous limestone; the coal-bearing sandstones, Lower Carboniferous; and the Liassic rocks. Haughton's map is reasonably accurate in some respects but it incorporated one major error. The "Lower Carboniferous sandstones" were believed, by analogy with the section in Great Britain, to overlie the "Carboniferous limestones". The sandstones are now known to be Devonian and the fossils that led Haughton to suspect the presence of the Carboniferous limestone are of Permian age. Haughton thus mistakenly reversed the sequence of the "sandstone" and "limestone". The only "Carboniferous" fossils recorded by Haughton from this map-area were assigned to *Spirifer arcticus* and *"Productus sulcatus* var. *borealis"*, and had been collected by M'Clintock from Hillock Point. According to Dunbar (1955, pp. 94, 139), *Spirifer arcticus* is probably a synonym of *Spiriferella keilhavii* (von Buch) and Haughton's illustrated specimens of the productids may include more than one species, of which the figures are too poor to permit their discrimination or recognition. Among the fossils that M'Clintock abandoned with his sledge there is a good collection of Permian brachiopods, presumably from Hillock Point. This collection, according to P. Harker, includes *Spiriferella keilhavii* (von Buch), *Spirifer striatoparadoxus* Toula and others. Fossil plants from the "Carboniferous" sandstone were described by Heer (1868).

One of Haughton's principal contributions was the recognition of Jurassic rocks. This was based on a few fossils that M'Clintock brought back from Wilkie Point. As with the Permian fossils, M'Clintock was forced to abandon most of his collection, but representatives of four species (*Ammonites m'clintocki, Monotis septentrionalis, Pleurotomaria* sp., and another, undetermined, gastropod) were described and figured by Haughton (1857, pp. 62-63, Pl. IX) and correctly attributed to the Jurassic. M'Clintock's abandoned collection includes specimens of *Leioceras opalinum* (identified by H. Frebold). M'Clintock should therefore be credited with the discovery of this species in Arctic Canada. Ironically the collection of Permian and Jurassic fossils that he abandoned in 1853 is now extant and safely housed with the Geological Survey of Canada, whereas the few specimens that he saved were taken to Dublin and cannot now be located.

Sir Edward Belcher must be credited with the correct identification of gypsum from the structures that are now known to be piercement bodies. The specimens identified by Belcher were from Cape Colquhoun (Cape North West). They had been collected by Richards, who described the occurrence as follows (1855, p. 321) "The hill is about 600 feet high, and is cut up in an extraordinary manner by watercourses, a hundred feet or more in perpendicular depth, running in every direction. The lower land is sandstone; on the summit are large masses of lime, and I think, some granite. Mica (at least so I take it to be) is very abundant in the cliffs which are bared by the melting of the snows. The surface soil is covered with a red and green coloured earth, resembling the dust of copper ore." Belcher (1855, vol. 2, p. 47) was not convinced by Richard's description for he wrote "(Pray number the intervening series between the shell-bearing limestones and granite). It is not for me to dispute these records; all have been told of their mistakes but determine to adhere to their adopted theories. The specimens are *selenite*." The full significance of Belcher's mineral identification was to pass unnoticed for almost 100 years, until 1952, when W. W. Heywood, of the Geological Survey, discovered that the circular structures of the Arctic Islands are piercement bodies exposing gypsum (Heywood, 1955; 1957).

Mecham (1855, pp. 518, 522-523) also made a notable contribution to the geology of the map-area. He was the first to see and describe the fossil wood that characterizes what is now known as the Beaufort Formation. This wood was studied by Heer (1868).

J. G. McMillan, who was attached to Bernier's expedition of 1908-1909 as geologist, made numerous observations on the geology of southern Melville Island. He recognized that the strata between Cape Bounty and Bridport Inlet were steeply inclined (McMillan, 1910, p. 448). He mistakenly attributed the steep dips to faulting, but it must be remembered that he was handicapped by the lack of accurate maps. McMillan collected fossils from Liddon Gulf and Dundas Peninsula that were described by Lambe (1910) as *Lingula melvillensis, Estheria canadensis,* and *Carbonicola arctica.* These were attributed to the Carboniferous but it is now known that they are of Devonian age.

After the establishment of the Mould Bay weather station, biological investigations were conducted on Prince Patrick Island by S. D. Macdonald, in 1949 and 1952, for the National Museum of Canada, and by P. F. Bruggeman, in 1952, for the Department of Agriculture. In the course of this work collections of Upper Jurassic fossils were made and they have been reported on by Jeletzky (1954). Another collection of fossils made by weather station personnel has been described by Imlay (1955).

In 1950 the Royal Canadian Air Force took trimetrogon air photographs of the islands and these photographs, together with flights over the area, enabled Y. O. Fortier and Thorsteinsson to detect a belt of folded rocks in the western part of the Archipelago. This structural feature, named the Parry Islands Fold Belt, was shown to extend to the west coast of Melville Island (Fortier and Thorsteinsson, 1953).

Climate

The climate of the Arctic Archipelago has been described by Rae (1951), whose account incorporates observations made at Mould Bay between 1948 and 1950. The tables given below summarize the temperature and precipitation data given by Rae. A detailed climatological summary for Mould Bay, giving the data from May 1948 to December 1952, has been published by the Meteorological Division, Department of Transport (1957).

At Mould Bay the sun is continuously below the horizon from the beginning of November until early February, and continuously above, between late April and mid-August. Snow has disappeared from most of the land by early July and returns to stay in September. Some snow banks last throughout the summer, and in southwest Melville Island there are three small ice-caps. Until the beginning of June the snow cover is a serious handicap to geological studies. Low stratus is common throughout the area in the summer and although this does not interfere with the work of a geologist on the ground it often makes flying with ground contact impossible.

The mean annual extremes of temperature, for the years 1948-50, are maximum 57°; minimum —56°. The absolute extremes, taken from the later climatological summary, 1948-53, are maximum 59° (recorded in July); minimum —63° (recorded in December).

Temperature Data for Mould Bay 1948-50

Mean	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
Daily max.	−20	−22	−13	−1	18	34	43	39	24	4	− 8	−23	6
Daily min.	−41	−39	−29	−20	5	24	33	29	14	−8	−22	−33	−7
Mean	−32	−31	−21	−11	12	30	38	34	19	−2	−16	−26	−1

Mean Monthly and Mean Annual Precipitation for Mould Bay

Rainfall (inches)	0	0	0	0	0	0.06	0.81	0.20	0.07	0	0	0	1.14
Snowfall (inches)	0.4	0.5	1.2	0.2	1.5	2.2	1.5	1.4	4.2	0.8	0.8	0.3	15.0
Totals (inches of water)	0.04	0.05	0.12	0.02	0.15	0.28	0.96	0.34	0.49	0.08	0.08	0.003	2.64

Wildlife

The wildlife of Prince Patrick Island has recently been studied by Macdonald (1954) who records polar bear, musk-ox, caribou, fox, wolf, hare, weasel, and lemming, also ringed and bearded seal and twenty-three species of birds. The birds and mammals of Banks Island have recently been studied in some detail (Manning, Höhn, and Macpherson, 1956; Manning and Macpherson, 1958). These reports provide some data on the fauna of Prince Patrick and Melville Islands.

Vegetation

The flora of these islands has been described and discussed by Porsild (1955, 1957).

The extent of the vegetation is evidently largely controlled by the type of bedrock. Formations that commonly support a good cover of vegetation include the Ibbett Bay, grey and green siltstones and sandstones of the Devonian formations, the Assistance, Borden Island, lower part of the Wilkie Point, Mould Bay, and Christopher. As well as the attractive wild flowers of the Arctic-Alpine flora, these formations support mosses, grass, and in favourable situations, stunted willow. Notable meadows occur where the Ibbett Bay beds are exposed on south slopes of the Canrobert Hills and also upon the Cretaceous shales of Eglinton Island. The Ordovician, Silurian, and Devonian limestones and dolomites are commonly bare of vegetation and these formations form barren grey hills in the Canrobert Hills, at the west of Raglan Range, and around Weatherall Bay. The white sandstones of the Hecla Bay and Griper Bay Formations, particularly at high elevations, support very little plant life. Soft varieties of this sandstone commonly form white desert country. The harder varieties are commonly encrusted with black lichens. Fields of sandstone felsenmeer, with the individual blocks blackened by lichen are a common feature on Prince Patrick Island, between Mould Bay and Walker Inlet, and in southwestern Melville Island. The Canyon Fiord and Bjorne Formations support little vegetation and where these formations are exposed red, pink, and orange desert country prevails. The upper beds of the Wilkie Point Formation also appear to be inimical to plant life and these beds form an extensive desert around Intrepid Inlet, Prince Patrick Island. The same is true of the Isachsen Formation, which forms spectacular deserts on Eglinton Island, eastern Prince Patrick Island, and Mackenzie King Island. The Beaufort beds of the Arctic Coastal Plain support relatively little vegetation, although the individual boulders that litter the plain are commonly encrusted with dark lichens.

Field Work

The field work on which this report is based was started in 1954, when Tozer spent the months of April to September on Prince Patrick, western Melville, and Eglinton Islands. During this period he investigated the west coast of Melville

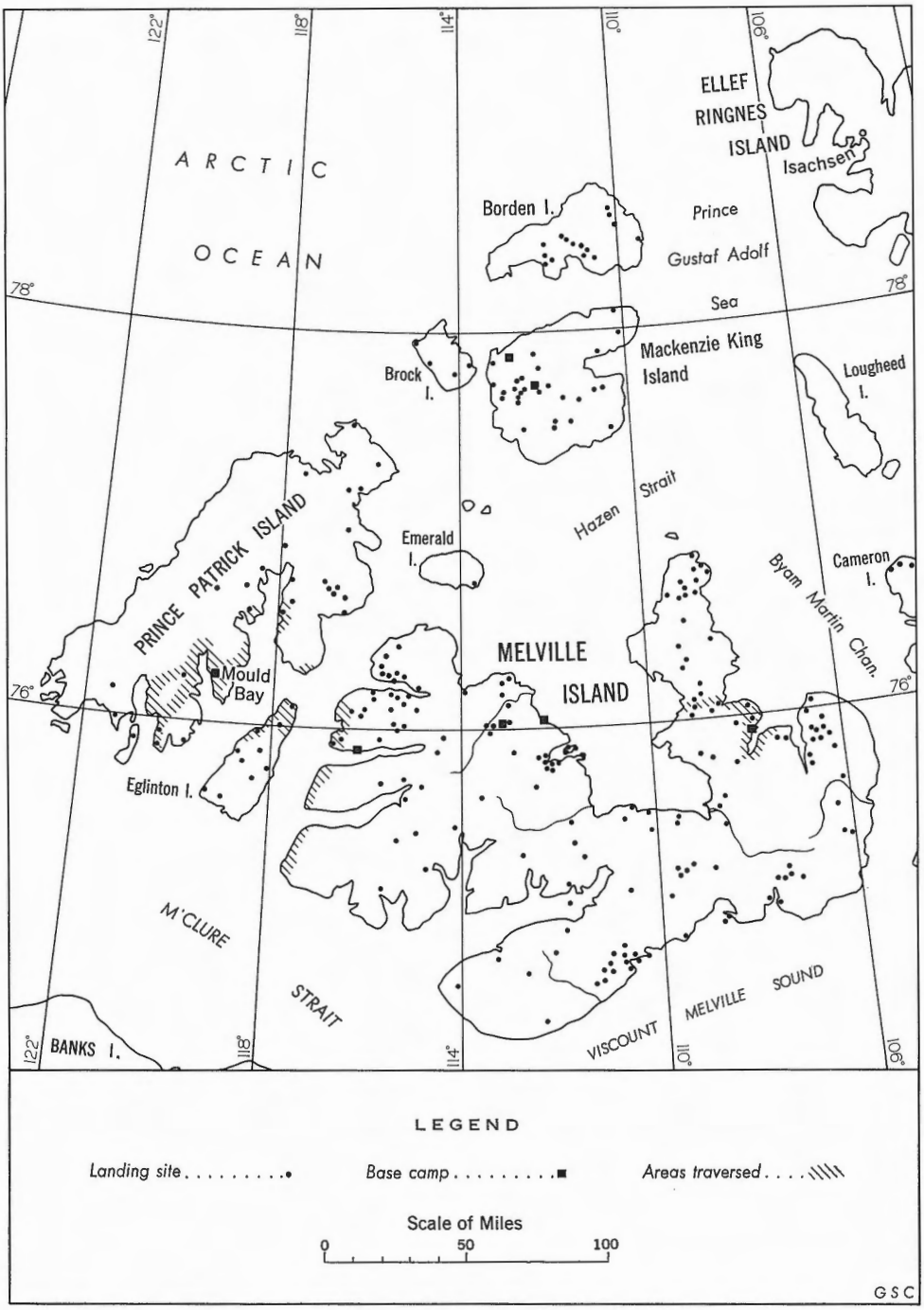

FIGURE 1. Western Queen Elizabeth Islands showing landing sites, 1958 and 1959; and areas traversed, 1954 and 1956 (shaded).

Island between Capes De Bray and Russell, travelling by dog sledge. Most of southern Prince Patrick Island between Wilkie Point and Walker Inlet was also studied, partly while travelling with the dog team and partly on foot, and a brief visit was paid to northern Eglinton Island. A preliminary report on this work was published in 1956 (Tozer, 1956).

In May 1955 Tozer spent three weeks working around Tingmisut Lake, eastern Melville Island. Snow cover and bad weather hindered this work considerably (Tozer, 1963a).

The remaining parts of Melville, Prince Patrick, and Eglinton Islands, and the whole of Brock, Borden, Mackenzie King and Emerald Islands were mapped in 1958 by Thorsteinsson and Tozer (1959a, b) using a Piper Super-Cub aircraft for transportation (*see* p. 2). A brief visit to the Weatherall Bay area was made by Tozer in 1959. The landing sites of 1958 and 1959 are shown on Figure 1.

Acknowledgments

The writers wish to acknowledge the courtesy and cooperation of officers of the Meteorological Division, Department of Transport, thanks to whom facilities at Resolute Bay and Mould Bay were used in 1954 and 1958. In 1954 Tozer was assisted by A. H. Macpherson and Amagualik, a Pond Inlet Eskimo now living at Resolute Bay, who capably performed his duties as dog driver. Transportation to Resolute Bay in 1954 and 1958, and to Mould Bay in 1954, was provided by the Royal Canadian Air Force. In 1954 the Air Force not only transported Tozer, Macpherson, and their equipment, but they also air-lifted Amagualik, his family, and his dog team. R. Gibson, who in 1954 formed the Resolute Bay Detachment of the Royal Canadian Mounted Police, assisted in many ways. In 1954 W. R. Morris of the United States Weather Bureau kindly donated a collection of fossils made near Mould Bay. T. E. Bolton, M. J. Copeland, H. Frebold, W. L. Fry, P. Harker, J. A. Jeletzky, D. C. McGregor, D. J. McLaren, J. Terasmae, and Miss F. J. E. Wagner, all of the Geological Survey, identified most of the invertebrate and plant fossils collected. Some Silurian fossils were examined by A. J. Boucot of the California Institute of Technology. Graptolites and fusulinids recorded in this report have been identified by Thorsteinsson. The Triassic faunas have been studied by Tozer. Some published reports on the fossils collected in this area are now available: Devonian spores have been described by McGregor (1960); Jurassic ammonoids and pelecypods have been described by Frebold (1958a, 1960, 1961); a Jurassic crustacean has been described by Copeland (1960); and the Triassic faunas have been treated by Tozer (1961). The vertebrate fossils collected in the course of this work have been identified by Wann Langston Jr., of the National Museum of Canada. J. D. Hale, of the Forestry Department, determined some specimens of wood. Radiocarbon ages of wood specimens have been determined by the Yale Geochronometric Laboratory and the Lamont Geological Observatory.

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Chapter II

PHYSICAL FEATURES

Physiography

The western Queen Elizabeth Islands show a considerable variety of physiographic form. The physiography is intimately related to the composition and structure of the bedrock, and subaerial erosion is largely responsible for the surface features. Local glaciers have produced U-shaped valleys and fiords on Melville and Prince Patrick Islands. Parts, and perhaps all, of the area have experienced continental glaciation. This probably took place relatively early in the Pleistocene, and any depositional glacial landforms that may have been produced have been mainly or entirely obliterated by later erosion. The glaciation of these islands is discussed on pages 32-40; only the physiographic features unrelated to glaciation are considered here.

The physically distinct regions of these islands may be classified under the following headings (*see* Fig. 2).

A. *Arctic Coastal Plain*

Western Prince Patrick Island, northwest Brock Island, and northern Borden Island

B. *Lowlands and plateaux developed on gently folded or horizontal upper Palaeozoic to early Tertiary rocks*

1. Eastern Prince Patrick Island
2. Eglinton Island
3. Northwestern Melville Island
4. Sabine Peninsula, Melville Island
5. Emerald Isle
6. Southeastern Brock Island
7. Southeastern Borden Island
8. Mackenzie King Island

C. *Ridges and plateaux developed on terrain that has experienced Tertiary faulting*

1. Southern Prince Patrick Island
2. Southwestern Melville Island
3. Weatherall Bay, Melville Island

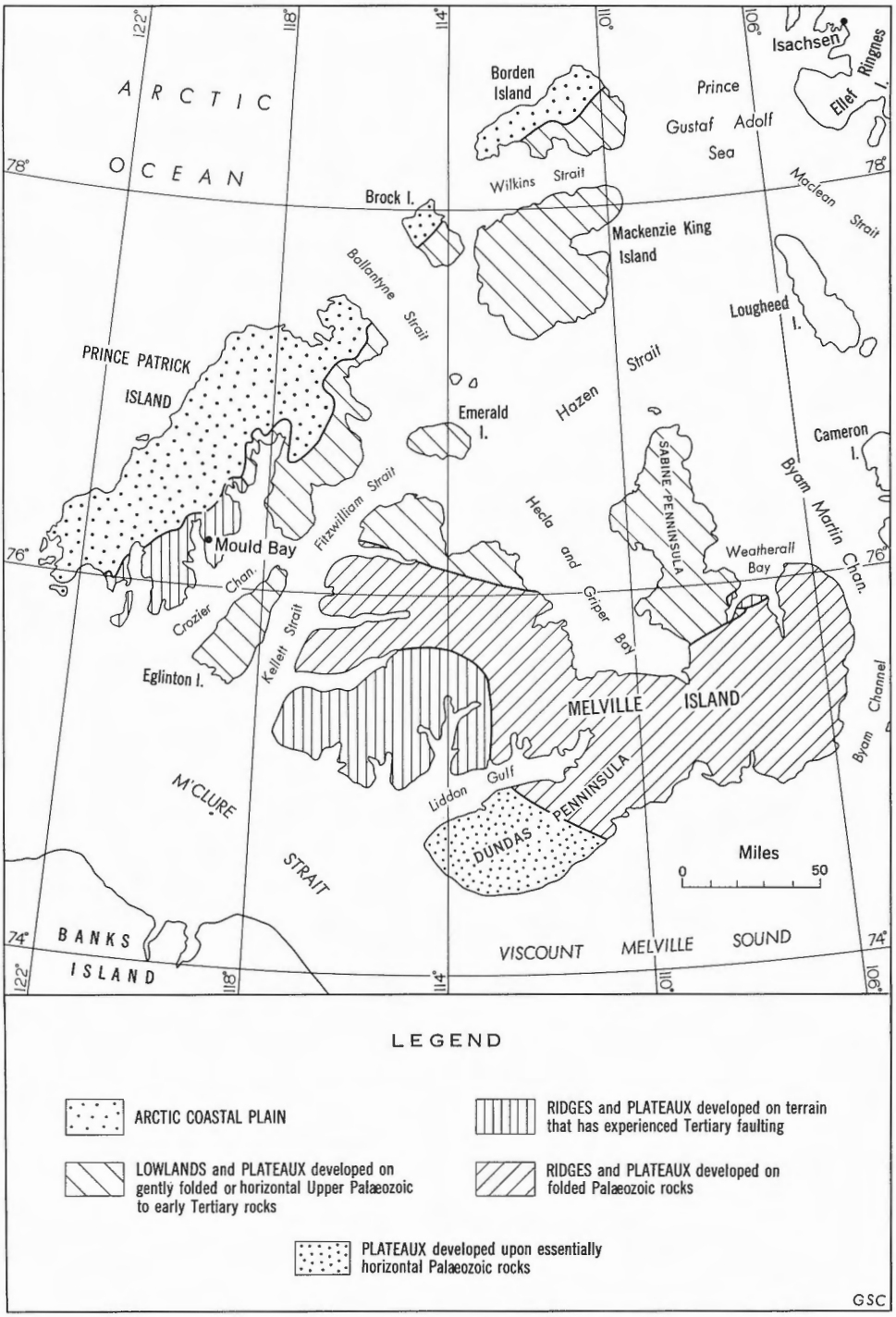

FIGURE 2. Physiographic regions, western Queen Elizabeth Islands.

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D. *Ridges and plateaux developed on folded Palaeozoic rocks*
Central Melville Island

E. *Plateau developed on essentially horizontal Palaeozoic rocks*
Southwestern Dundas Peninsula

Arctic Coastal Plain

Western Prince Patrick Island, Northwestern Brock Island and Northern Borden Island

The Arctic Coastal Plain occupies the northwest parts of Prince Patrick and Brock Islands and the northern part of Borden Island. This plain is developed on, and is coextensive with, the Beaufort Formation, which consists of unconsolidated sand and gravel of late Tertiary or Pleistocene age (*see* p. 167). It is a remarkably distinctive and homogeneous physiographic province, most of which is drained by streams that lead to the Arctic Ocean but on the eastern part some of the drainage is to the east. Although a drainage divide occurs within the plain on Prince Patrick Island the upland surface of the whole plain slopes gently to the northwest and north, towards the Arctic Ocean. Where the plain meets the Arctic Ocean the coast is exceedingly low but the southeastern limit of the plain, especially on Prince Patrick and Borden Islands, is locally a moderately well-defined escarpment. On Prince Patrick Island, many outliers of the Beaufort beds are present inland from the plain. These outliers reveal the distinctive characters of the plain.

The master streams that flow over the plain and discharge into the Arctic Ocean are generally long and straight and display parallel drainage patterns. Tributaries to the master streams are characteristically dendritic and medium textured, with moderately numerous and medium-spaced drainage lines. The lower reaches of most master streams and many of the larger tributaries are braided. Farther inland these streams are actively downcutting and extending headwards. Interstream areas are, for the most part, remarkably flat. Numerous islets and shoals on the Arctic Coast attest to shallow water and active erosion of the plain. The general parallelism of the master streams and the smoothness of the slope that guides them suggest that they are consequent streams.

The streams that drain the southeast and south side of the plain have steeper profiles and are more deeply entrenched than those that drain towards the Arctic Ocean. On Borden Island some southerly flowing streams have captured the upper reaches of rivers that originally drained to the north.

Ice-wedge polygons, of the kind that commonly characterize loosely consolidated to unconsolidated sandy and gravelly terrain in Arctic regions, are ubiquitous features of the Arctic Coastal Plain (*see* Pl. XLII). Those examined on the ground are generally from 75 to 125 feet in diameter, but air photographs reveal some that are considerably larger. Their borders are marked by V-shaped fissures that vary from a few inches to over a foot deep, and from about 6 inches

to 4 feet wide. Commonly the fissures are flanked by raised ridges that lend a false impression of depth. On nearly level terrain these polygons are commonly hexagonal; on slopes they commonly assume a tetragonal form. Thorsteinsson (1961) has excavated ice-wedge polygons on the surface of the Beaufort Formation of Meighen Island. There the fissures are underlain by vertical wedges of pure ice in the permafrost layer. The ice-wedges investigated were about 2 inches wide and extend from the surface of the frost table to an undetermined depth. It would appear that they are tensional features, produced by contraction, in areas of permafrost.

Lowlands and Plateaux Developed on Gently Folded or Horizontal Upper Palaeozoic to Early Tertiary Rocks

1. Eastern Prince Patrick Island

This region is a dissected plateau, whose remnants reach elevations of about 600 feet between Intrepid Inlet and Fitzwilliam Strait. Towards the north, summit elevations are lower. Several prominent cuestas occur. Beds near the middle of the Wilkie Point Formation (Jurassic) support a cuesta that extends from Wilkie Point to Hiccles Cove, in Intrepid Inlet. A series of sea-cliffs occurs where the cuesta intersects Intrepid Inlet (Pl. XXVI). The sandstones of the upper Mould Bay beds (Upper Jurassic and Lower Cretaceous) form another cuesta, extending from Jameson Bay to Intrepid Inlet. These beds also form prominent bluffs at the head of the inlet. North of the cuesta formed by the Mould Bay beds conspicuous topographic features are few. Two small but prominent hills—Brown Bluff, near Jameson Bay, and The Redoubt, a conical flat-topped hill a few miles to the north—are formed by the hard sandstones of the Isachsen Formation.

2. Eglinton Island

Eglinton Island is a particularly good example of a dissected plateau. Flat-topped hills characterize its interior; its highest part, near the small lake southeast of Callaghan Point, is about 800 feet above sea-level. The table-like plateau remnants are particularly conspicuous in the southern part of the island. There the locally indurated Cretaceous sandstone (map-unit 27), capping soft shales of map-unit 26, is an effective scarp-forming stratum. The Isachsen exposures in the northern part of the island form spectacular badlands (Pl. XXXIII).

3. Northwestern Melville Island

In this region the bedrock dips northeast and several prominent south-facing cuestas are formed by the successively exposed beds. The Bjorne sandstones and conglomerates (Triassic) form a prominent cuesta that extends from the north side of Marie Bay, east to the north side of Raglan Range, and forms the high bluffs immediately adjacent to the upper reaches of Marie Bay. East of Marie Bay several conspicuous canyons are entrenched in the north slope of the cuesta. A hard sandstone in the Wilkie Point Formation (Jurassic) underlies the flat-topped hills

known as Marie Heights but the remaining part of the Jurassic sequence does not form prominent topographic features. The sands and sandstones of the Mould Bay Formation (Upper Jurassic and Lower Cretaceous) form a fairly prominent escarpment north of Marie Heights. The northern part of this region, underlain by the Isachsen and Christopher Formations (Lower Cretaceous), is generally low lying. Examination of air photographs suggests that the Christopher beds southeast of Cape Scott form fairly prominent bluffs; a moderately conspicuous bluff is formed by the upper Isachsen and Christopher strata near Cape Grassy. Marie Heights attains an elevation of about 600 feet; the cuesta formed by the Bjorne Formation may be somewhat higher. It is unlikely that elevations exceed 800 feet in this area.

4. Sabine Peninsula, Melville Island

On Sabine Peninsula the bedrock dips north, and numerous south-facing cuestas and escarpments occur. In the central part of the peninsula, northeast of Eldridge Bay, the strata are horizontal and an inland plateau is present, flanked by an escarpment exposing the basal Kanguk beds (Upper Cretaceous). Elevations reach about 700 feet north of Tingmisut Lake and 500 feet in the middle of the peninsula.

Between Sabine and Weatherall Bays the Canyon Fiord beds (Pennsylvanian) form a series of cuestas facing southeast. North of Tingmisut Lake two prominent cuestas occur: the southern one is formed by the hard calcareous beds in the lower part of the Sabine Bay Formation (Permian); the second, about a mile to the north, is supported by the basal beds of the Assistance Formation (Permian). Towards the west the cuesta formed by the Sabine Bay beds becomes indistinct; the Assistance cuesta too diminishes in prominence to the west but is nevertheless fairly distinct for several miles. About half-way between Sabine and Weatherall Bays are several isolated buttes composed of Assistance beds. South and southwest of Sherard Bay several cuestas are formed by successive units of the Bjorne Formation (Triassic). The next younger beds, the Wilkie Point (Jurassic), Mould Bay (Upper Jurassic and Lower Cretaceous), and Isachsen (Lower Cretaceous) Formations, are not physiographically prominent in this region. These beds underlie the low isthmus between Eldridge and Sherard Bays. On the north side of the isthmus another prominent cuesta appears; it is underlain by the lower beds of the Christopher Formation (Lower Cretaceous). The higher Christopher beds are essentially recessive and produce low terrain, intricately dissected by small streams. The overlying Hassel and Kanguk Formations (Cretaceous) produce moderately prominent topographic features. Scarps and cuestas are formed where these beds intersect the surface, both around the central outlier (northeast of Eldridge Bay) and to the north, where these formations disappear beneath the Eureka Sound Formation (Tertiary).

At the north end of Sabine Peninsula two circular piercement domes relieve the monotony of the landscape. These domes rise about 700 feet above the surrounding undulating plain and their prominent topographic expression probably reflects recent and perhaps contemporary tectonic uplift.

5. Emerald Isle

Emerald Isle is apparently underlain entirely by soft Cretaceous shales (Christopher Formation), which are more or less horizontal. The geological homogeneity of this island is reflected in uniform topography, and as the shales do not support prominent topographic features the landscape is a gently undulating, featureless plain. The maximum elevation is probably between 250 and 300 feet.

6. Southeastern Brock Island

Southeastern Brock Island has not been thoroughly investigated, but the available data suggest that this region is underlain by the Heiberg Formation (Triassic). Low north-trending escarpments, some of which are apparently offset by faults, traverse this part of the island. The most prominent escarpments are in the eastern part of the Island. The maximum elevation of Brock Island is not known but it probably does not exceed 300 feet.

7. Mackenzie King Island

The rock formations exposed on Mackenzie King Island range in age from Jurassic to Lower Cretaceous. The greater part is loosely consolidated sediment, and the general absence of resistant strata is clearly responsible for the salient topographic features of the island, namely, low subdued plains, low shelving coasts, and streams that are generally characterized by medium drainage textures. In the few places where the rocks are indurated prominent landforms are found. The Leffingwell Crags and Castel Butte are the most prominent landmarks; both are composed of hard Isachsen sandstone. Castel Butte is about 500 feet high and flat-topped; its surface is presumably either an old erosion surface or an exhumed bedding plane. The Leffingwell Crags reach an elevation of about 525 feet. Their summit may also be at the height of an old surface, but as the crags are now reduced to jagged peaks this cannot be established.

In southeastern Mackenzie King Island hard sandstone in the lower part of the Christopher Formation (Lower Cretaceous) forms small, but prominent topographic features in the form of isolated rectangular blocks about 15 feet high (Pl. XXXIX).

The relatively unconsolidated beds vary in their resistance to erosion and form several cuestas parallel with geological boundaries. Sands in the middle of the Wilkie Point Formation (Jurassic) form a series of relatively prominent cuestas in the eastern part of the island. Both the upper and lower shale members of the Mould Bay Formation locally form cuestas. These cuestas seem to have formed from excavation of the soft shales by nivation.

8. Southeastern Borden Island

Southeastern Borden Island is an undulating plain composed of Triassic and Jurassic rocks. The elevation of this part of the island probably does not exceed 300 feet. The most notable topographic feature is the exhumed plain that lies between the Borden Island and Wilkie Point Formations, both of Jurassic age (*see* p. 30).

Ridges and Plateaux Developed on Terrain that has Experienced Tertiary Faulting

1. Southern Prince Patrick Island

The southern part of this island between Cape Mecham and Salmon Point is dominated by northerly trending topographic features that clearly reflect the Tertiary faulting that has affected this region. Faulting is probably also responsible for the loci of Walker Inlet and Mould Bay.

Between Walker Inlet and Mould Bay there are at least four grabens: near Cape Cam, at the head of Butter Bay, in the middle of the peninsula, and immediately east of Mould Bay. The graben in the middle of the peninsula has a relatively subdued topographic expression but the other three are pronounced valleys with straight walls. North of Cape Cam (facing Walker Inlet), and along most of the east side of Mould Bay, precipitous sea-cliffs rise to about 700 feet above sea-level. Most of the inland area (except for the grabens already described) is plateau country, rising to about 800 feet above sea-level.

Several north-trending escarpments between Mould Bay and Crozier Channel are also related to Tertiary faulting. Fault-line scarps are commonly developed where the hard Devonian sandstones (Griper Bay Formation) are in fault contact with the Mesozoic beds. The series of ridges that extend north, *en échelon*, from Manson Point are the best example; similar escarpments occur east of the head of Mould Bay. Escarpments are also common where the Mould Bay beds (Upper Jurassic and Lower Cretaceous) overlie the relatively incompetent Wilkie Point strata (Jurassic). The most prominent escarpment formed in this way is northeast of the Mould Bay weather station; the high hill east of Crozier Channel is a similar feature. Maximum elevations are about 600 feet.

2. Southwestern Melville Island

The part of Melville Island that lies between Purchase Bay and Murray Inlet has certain distinctive topographical features. High sea-cliffs border virtually the whole of the coast and elevations in excess of 1,000 feet are commonly attained within a mile or so of the shore. In general this is a region of high plateau country, relatively undissected, with many deep narrow ravines. The ice-caps east of Purchase Bay attain an elevation of about 2,500 feet. Between the heads of Purchase Bay and Murray Inlet elevations reach about 2,000 feet. Some charts give an elevation of 3,500 feet for parts of this region but aneroid readings taken in the interior suggest that this figure is too high.

Fault-line scarps are the dominant topographic features, and are commonly capped by the hard sandstones of the Hecla Bay Formation (Devonian). The most prominent are formed by the Blue Hills, Murray Inlet, and Mount Joy faults. It is possible that some of these may be fault scarps rather than simply fault-line features.

3. Weatherall Bay Area, Melville Island

Post-Permian (probably Tertiary) faults in this area have made the south and west sides of Weatherall Bay quite distinct from the surrounding terrains. The most notable feature is the wall-like bluff that rises abruptly on the south side of the bay. Its elevation has not been determined but it is probably about 1,000 feet. The south side of this prominent bluff is a fault-line (or fault) scarp, and it is possible that the steep sea-cliffs on the north side are also the locus of a fault. The small bluffs on the west side of the bay, where the Silurian dolomite is exposed, are also related to faults.

Ridges and Plateaux Developed on Folded Palaeozoic Rocks

Central and Southeastern Melville Island

Folded Palaeozoic rocks outcrop on this part of Melville Island. Fold axes trend east-west and this strike had determined the grain of the country. It is a large area, with many local variations in topography. West of the isthmus between Liddon Gulf and Hecla and Griper Bay the country is relatively rugged with summit elevations in excess of 1,000 feet; east of the isthmus maximum elevation is about 800 feet, and much of the country is considerably lower. High sea-cliffs border the coast of Liddon Gulf between Bushnan Cove and Murray Inlet, and also the coast that faces Kellett Strait. East of the 112th meridian the coasts are generally relatively low and sea-cliffs are absent except in the fiord that forms the east arm of Weatherall Bay.

The most picturesque part of this region, and indeed of the whole map-area, is the Canrobert Hills. There prominent, east-trending anticlinal ridges underlain by the Canrobert and Ibbett Bay Formations (Ordovician) are separated by synclinal valleys, in which the Weatherall (Devonian) and Canyon Fiord (Pennsylvanian) Formations are exposed. Flat concordant summits characterize the ridges and maximum elevations are about 2,000 feet. The coasts facing Marie Bay, Kellett Strait, and Ibbett Bay are relatively low compared with the high sea-cliffs to the south, although moderately abrupt bluffs lie adjacent to the coast of Marie Bay.

Between Ibbett and Purchase Bays the geological structure is homoclinal with southerly dips. In this area a dramatic cuesta extends from Cape Terrace to the glacier near the head of Ibbett Bay. This cuesta, like the fault-line scarps of southwestern Melville Island, is supported by the hard sandstones of the Hecla Bay Formation (Devonian). High sea-cliffs face Kellett Strait and prominent cliffs also occur on the north side of Purchase Bay.

Raglan Range is a conspicuous feature. The greater part of the range is a flat-topped plateau underlain by gently dipping hard Hecla Bay sandstone (Devonian). At the northwest end of the range resistant Ordovician and Silurian carbonates form the summit, again in the form of a flat-topped plateau.

The folded terrain east of the 112th meridian is essentially an undulating plain. In some places east-trending ridges are developed, revealing the geological strike.

The Hecla Bay sandstone locally assumes the role of a ridge former, for example on the ridge southeast of Sabine Bay and on the ridge that extends into Bridport Inlet. This formation does not always produce ridges for in some areas the Hecla Bay sandstones are weakly consolidated, and indeed form badlands. The Griper Bay Formation (Devonian) is commonly a valley former, but again the topographic expression of this formation varies, because the upper Griper Bay sandstones, southeast of the east arm of Weatherall Bay, underlie relatively high plateau country. The Blue Fiord limestone (Devonian), exposed in the Towson Point anticline, forms a prominent ridge.

Outliers of horizontal Cretaceous beds (Isachsen and Christopher Formations) rest upon the bevelled surface of folded Devonian rocks in southeastern Melville Island. It is possible that the concordant summits that characterize much of southeastern Melville Island represent the exhumed remains of a sub-Cretaceous erosion surface (*see* below).

Plateau Developed on Essentially Horizontal Palaeozoic Rocks

Southwestern Dundas Peninsula

The southwestern part of Dundas Peninsula is a youthfully dissected plateau developed upon the Devonian Griper Bay Formation. The greater part of the plateau surface is inclined to the east or northeast. High sea-cliffs characterize the part of the peninsula adjacent to M'Clure Strait; lower sea-cliffs face Liddon Gulf. An altitude of 1,100 feet above sea-level was measured by aneroid, about 15 miles west of Cape Dundas, which is probably the highest part of the area.

Erosion Surfaces

Flat upland surfaces and locally concordant summits characterize virtually all the islands within the map-area. With the available data, and without accurate topographic maps, it is not possible to offer a thorough analysis of these surfaces. Some observations nevertheless seem justified.

Mesozoic and Sub-Mesozoic Erosion Surfaces

On Borden Island a Lower Jurassic erosion surface that developed upon the Borden Island Formation, beneath the Wilkie Point Formation, has been exhumed. The Borden Island Formation is apparently of Sinemurian (mid-Lower Jurassic) age and the basal beds of the Wilkie Point Formation are Toarcian (late Lower Jurassic). This surface is, therefore, of Lower Jurassic age and is probably a mid-Lower Jurassic plain of marine erosion.

In southeastern Melville Island the Isachsen and Christopher Formations (Lower Cretaceous) rest as outliers upon a bevelled plain of folded Devonian rocks. It is possible that this sub-Cretaceous plain may be preserved throughout much of southeastern Melville Island, but in areas remote from the Cretaceous outliers it is not easy, and perhaps impossible, to distinguish remnants of the sub-

Cretaceous surface from the younger surfaces that occur throughout much of the Archipelago.

Tertiary or Younger Surfaces

The elevated peneplain remnants that occur in so many parts of the area are clearly much younger than the features described above, and are probably Tertiary or even younger. In the section on physiography frequent mention was made of flat-topped concordant summits, plateau remnants, and the like, and the dominant impression gained from an examination of the topography of these islands is the existence of these surfaces. For present purposes it will be assumed that these upland surfaces represent the remains of one peneplain, although it is admitted that full history of these detached surfaces may be more complicated. In the discussion that follows this upland surface will be called the 'main peneplain'.

It is not known whether the main peneplain is older or younger than the Beaufort Formation (late Tertiary or early Pleistocene). On southern Prince Patrick Island there is a general concordance between summits composed of Palaeozoic and Mesozoic rocks and summits capped by the Beaufort Formation. This suggests that on southern Prince Patrick Island the main peneplain may be younger than the Beaufort Formation. On the other hand, all outliers of the Beaufort Formation are fairly close to the main outcrop. Those that are farthest removed are near Hiccles Cove, on the east side of Intrepid Inlet. The apparent absence of Beaufort outliers on Eglinton and Melville Islands suggests that the Beaufort may have been deposited not more than about 20 miles southeast of the main outcrop. It is therefore possible that the original upper surface of the Beaufort Formation may have been a plain of aggradation that intersected the level of the main peneplain.

The main peneplain has experienced substantial uplift. There is some evidence that this uplift did not take the form of broad warping but was related to normal faulting. The most elevated parts of Prince Patrick Island have clearly experienced Tertiary faulting. Some movement of these faults clearly took place prior to the deposition of the Beaufort Formation but there is good evidence (*see* p. 201) that some faults also experienced movement after the deposition of the Beaufort Formation. It therefore seems reasonable to use these faults in part, at any rate, to explain the Tertiary uplift, the topographic discontinuities between islands, and the presence of the numerous straits and channels.

As a result of faulting and uplift the following features seem to have been imposed upon the main peneplain within this area.

On the Arctic Coastal Plain the upland surface is inclined northwest and north. On the coasts that face the Arctic Ocean this surface intersects sea-level. On southern Prince Patrick Island, between Cape Mecham and Wilkie Point, the main peneplain has been uplifted and it is probable that movement on north-trending faults accompanied this uplift.

On Mackenzie King Island the main peneplain seems to have been obliterated, although Castel Butte may represent a remnant of this surface.

Southwestern Melville Island, with its high sea-cliffs and lofty interior, has clearly been elevated compared with the remaining parts of the island. There, as on southern Prince Patrick Island, we have evidence of relatively recent faults and it is possible (*see* p. 185) that a substantial fault lies on the north side of M'Clure Strait.

Geological evidence suggests that Eglinton Island is depressed compared with Melville and Prince Patrick Islands. The level of the main peneplain nevertheless attains a height of 800 feet on Eglinton Island. This seems high in relation to Prince Patrick Island, but when we consider the high elevations of southwestern Melville Island immediately to the east, Eglinton Island falls into perspective. It is possible that the level of the main peneplain of Eglinton Island is depressed in relation to that of Prince Patrick Island, and the rough concordance shown today between these islands is due to elimination of the probable original west-sloping gradient of the main peneplain.

Glaciation

Several glacial events can be distinguished in the western Queen Elizabeth Islands. The first recorded is a period of partly, and perhaps entirely, Laurentide glaciation. Ice-sheets covered much of Melville Island and may have reached all the western Queen Elizabeth Islands. More than one ice-advance may have taken place, but of this there is no evidence available. Whether multiple or not, this period of glaciation evidently predates the late Wisconsin glaciation of the southern islands of the Arctic Archipelago (*see* Craig and Fyles, 1960). For convenience, this early period glaciation will be termed the 'Pre-Wisconsin glaciation', but it should be noted that the glacial deposits formed during this period have not been accurately dated.

A later event appears to have been of Wisconsin age. Although the western Queen Elizabeth Islands show no obvious sign of Wisconsin Laurentide glaciation, eastern Melville Island and also Lougheed Island have experienced considerable uplift in the last 9,000 years, i.e., since Wisconsin time. According to J. G. Fyles (pers. com.) this uplift suggests that Wisconsin Laurentide ice may have crossed Viscount Melville Sound and penetrated the straits between Melville and Bathurst Islands.

Melville and Prince Patrick Islands have clearly experienced glaciation by local ice-caps, which evidently took place after the Pre-Wisconsin glaciation. This local glaciation produced striated pavements at Liddon Gulf and Mould Bay and probably also excavated the fiords of Melville and Prince Patrick Islands. Possibly this event took place in Wisconsin time.

The most recent glacial event was the growth of the small ice-caps that cover parts of western Melville Island. These ice-caps seem to be superimposed upon small watercourses cut subsequent to the development of the fiords. It thus seems reasonable to suggest that they are a relatively recent growth rather than remnants of the ice-caps that excavated the fiords.

PLATE XIII

Aerial view, westward, from an altitude of about 1,000 feet, of the Table Hills, 7 miles west of Winter Harbour, Melville Island. The hills rise about 200 feet above the surrounding terrain and are composed of glacial till, of Laurentide source, probably of pre-Wisconsin age. Parry's cairn is visible in the foreground.

'Pre-Wisconsin Glaciation'

Melville Island

Hills and tracts of hilly terrain composed of glacial till occur throughout Dundas Peninsula and east of the isthmus between Liddon Gulf and Hecla and Griper Bay. Hills composed of till are particularly common south of latitude 75°15′, the Table Hills, west of Winter Harbour, being a notable example (Pl. XIII). There the thickness of the till is probably at least 150 feet. In other areas it is commonly less and the landforms are in consequence less spectacular. These hills seem to represent erosional remnants of a once more extensive cover of glacial deposits. At the Table Hills the till is sandy and contains boulders up to 4 feet in diameter. Fresh cuts of the till are rare; commonly it has flowed downhill by solifluction. The boulders are rounded to subrounded; a few facetted and striated ones were also seen. About half are composed of sandstone, like the sandstone of the Devonian formations of Melville Island; the remainder represent a wide variety of lithological types most of which are foreign to Melville Island. The most common foreign erratics are red, white, and brown quartzite, red granite, gneiss, chert, and gabbro. Limestone and dolomite boulders also occur. The nearest source for the quartzite and gabbro is the Precambrian terrain of Victoria Island (Thorsteinsson and Tozer, 1961). An even more distant source, namely the continental mainland, seems probable for the gneiss and granite. The limestone and dolomite could have been derived from northern Melville (e.g., from Raglan Range and Weatherall Bay) but it seems more likely that these carbonate boulders, like the Precambrian rocks, are derived from Victoria Island or the mainland.

A small patch of bouldery rubble, evidently glacial till, caps a hill on Sabine Peninsula, 13 miles northeast of Chads Point. This material is slumped but apparently at least 60 feet of till is present, also boulders up to a foot in diameter. Most of the boulders are composed of Devonian sandstone, but fossiliferous Permian and Jurassic rocks also occur; no igneous or metamorphic rocks were seen. This material, like the till of southern Melville Island, is clearly derived from the south. Study of air photographs suggests that there are several other small patches of this material capping the uplands of central Sabine Peninsula.

No thick deposits of till were observed in other parts of Melville Island, however erratics foreign to Melville Island are virtually ubiquitous although not abundant. In the Canrobert Hills they were found at summit elevations, i.e., at about 2,000 feet.

The evidence from southern Melville Island leaves no doubt that Laurentide ice reached the area in Pleistocene time. As already mentioned, fresh constructional glacial landforms are absent on Melville Island. Fresh glacial landforms do, however, cover virtually the whole of Victoria and Stefansson Islands and, according to Craig and Fyles (1960), these landforms were produced by the Wisconsin Laurentide ice-sheet. The fresh glacial landforms of the southern islands are quite unlike the old dissected moraines of Melville Island. It is concluded that the Laurentide tills of Melville Island are older than the Wisconsin drift of Victoria and Stefansson Islands. The outlier of till on Sabine Peninsula and the erratics elsewhere suggest that this old Laurentide ice-sheet may have covered the whole of Melville Island.

Arctic Coastal Plain of Prince Patrick, Brock, and Borden Islands

A veneer of pebbles, cobbles, and boulders covers the Beaufort beds that underlie the Arctic Coastal Plain of Prince Patrick, Borden, and Brock Islands. As in the glacial till of southern Melville Island, a wide variety of rock types is represented. West of the head of Mould Bay an examination of boulders at two localities revealed that about half were composed of Devonian sandstone; the remainder included pink and brown quartzite, conglomerate, Palaeozoic limetone, graptolitic shale, purple rhyolite, gabbro, red granite, and gneiss, pink and brown quartzite being most abundant. Five miles southwest of the head of Mould Bay some boulders attain 5-foot dimensions and occur at elevations above 500 feet. The veneer of boulders above the Beaufort beds of Brock and Borden Islands also includes a considerable variety of rock types. Precambrian rocks are rare. Cherts, probably Permian, are more common than in the samples examined on Prince Patrick Island. Possibly the Permian cherts of Brock and Borden Islands came from Axel Heiberg and Ellesmere Islands, but a Melville Island source is also possible.

The origin of this veneer of boulders presents many problems. Some pebbles may represent a coarse fraction of the Beaufort Formation but it is hard to

PLATE XIV. Aerial view, westward, of the head of the west arm of Barry Bay, Melville Island. The bedrock formations are the Weatherall, Hecla Bay, and Griper Bay. At the head of the bay, which is probably a fiord, may be seen a well-developed U-shaped, glaciated valley. This valley, and the similar valleys that occur at the head of many of the inlets of Melville Island,were probably developed from the action of a local ice-cap, perhaps in Wisconsin time. Small ravines, within V-shaped valleys, have been cut subsequent to the glaciation. (RCAF T416L-34)

believe that the streams that deposited the Beaufort beds were capable of transporting Precambrian and other foreign boulders, up to 5 feet in diameter, from distant sources. Some of the boulders may have been ice-rafted, but this explanation is not entirely satisfactory because the boulders are found in an area where there is no unequivocal evidence of recent or Pleistocene marine submergence. The writers believe that the most probable explanation is that these boulders are the remains of till and that this till, like that of southern Melville Island, was formed during pre-Wisconsin glaciation. The nature of the boulders on Prince Patrick Island suggests that this ice had a Laurentide source, but it is also possible that ice from the Ellesmere-Baffin Complex (Craig and Fyles, 1960, p. 13) may have transported Permian erratics to Brock and Borden Islands.

Other Areas

Erratic rocks, similar in composition to those of the southern Melville tills and to the veneer of boulders on the Beaufort Formation, are sparsely distributed at all elevations on Eglinton and Mackenzie King Islands and also on the parts of Prince Patrick and Borden Islands that lie outside the area of the Beaufort beds. Some of these boulders occur on raised beaches and were probably ice-rafted. This mode of transportation does not explain, satisfactorily, the situation of boulders at higher elevations. It seems probable that many of these inland, upland boulders—like the southern Melville till, the Sabine Peninsula till, and the boulder veneer above the Beaufort beds—are remains of moraines of pre-Wisconsin age. It would appear that much of the till may have had a Laurentide source, but some may have been deposited by ice that came from the east, from Axel Heiberg and Ellesmere Islands.

There is one anomaly that must be mentioned. The boulders are far more common on the Beaufort Formation than on the Palaeozoic and Mesozoic terrains adjacent to the belt of Beaufort outcrops. This anomaly to some extent conflicts with the interpretation offered above, because if the boulders are the remains of old moraines it is surprising that the distribution of this morainal material should be related to the distribution of the fluvial Beaufort Formation. Despite this anomaly a glacial source for the boulders on the Arctic Coastal Plain seems the most satisfactory hypothesis at present.

Possible Wisconsin Glaciation of the Straits

The western Queen Elizabeth Islands show no evidence of Wisconsin Laurentide glaciation. According to J. G. Fyles (pers. com.) there is nevertheless some evidence to suggest that Wisconsin Laurentide ice may have occupied Viscount Melville Sound and have penetrated some of the straits and channels north of the sound. This hypothesis is based on the marked post-Wisconsin uplift shown by eastern Melville Island and Lougheed Island. On Melville Island elevated shells, 8,275 years old, occur at an elevation of 175 feet. On Lougheed Island shells 8,200±180 years old occur 75 or 100 feet above sea-level (Craig and Fyles,

1960, pp. 11, 12, 18). The age of these shells indicates that substantial uplift has taken place within the last 9,000 years, i.e., since Wisconsin time. This uplift is presumably "glacial rebound". However, eastern Melville and Lougheed Islands show no sign of Wisconsin Laurentide glaciation. It might be supposed that this uplift has taken place following deglaciation of local ice-caps, for as mentioned below, Melville Island may have been covered by an ice-cap in Wisconsin time. However Lougheed Island is small and it is unlikely that it could have supported an ice-cap large enough to have depressed the island by 100 feet, compared with its present level. The figure of 100 feet is a minimum for the post-Wisconsin uplift of Lougheed Island. Shells were found at elevations of 400 feet by Thorsteinsson in 1955, but these shells have not yet been dated. Local ice-caps thus seem inadequate to the task of depressing Lougheed Island. Fyles suggests that the sequence of events may have been as follows. In Wisconsin time a tongue, or tongues, of Laurentide ice may have crossed Viscount Melville Sound and extended north, between Melville and Bathurst Islands, towards Lougheed Island. This ice apparently did not override the islands. Lougheed Island, and perhaps also eastern Melville Island, were depressed by this mass of ice and following Wisconsin deglaciation the islands experienced the uplift that is evident today.

Local Glaciation of Wisconsin (?) Age

Evidence of local glaciation has been found on Melville and Prince Patrick Islands. Some of the other islands may have experienced local glaciation, but for this there is no evidence available.

Melville Island

McMillan (1910, p. 461) described glacial striae on the shores of Liddon Gulf and suggested that these striae may have been produced by local glaciation. The fiord-like inlets that indent the coasts of Melville Island (e.g., Marie, Ibbett, Purchase and Barry Bays, Murray Inlet, Liddon Gulf, and the arms of Weatherall Bay) are probably valleys, originally stream-cut, that have been scoured and deepened by ice radiating from a local cap, or caps, of ice. U-shaped valleys occur at the head of many of these fiords. These modifications of the landscape of Melville Island probably post-date the pre-Wisconsin Laurentide glaciation described above. Tentatively the formation of these fiords is attributed to action by local glaciers, perhaps in Wisconsin time.

Prince Patrick Island

At north end of Mould Bay there are glacial striae, aligned parallel with the axes of the valleys at the head of the bay. Striae occur at elevations of up to 300 feet and they reveal that movement of ice towards the south has taken place. Several lakes occur in this area, including Landing Lake, the largest lake on the island. A small lake east of Landing Lake is in a basin excavated in bedrock. These

PLATE XV

Head of the east arm of Mould Bay, Prince Patrick Island, showing glaciated outcrops of Griper Bay sandstone.

features are attributed to the action of a small local ice-cap that developed subsequent to the establishment of the main drainage system of Prince Patrick Island and presumably also subsequent to the older, Laurentide glaciation, of the map-area. Mould Bay, like the narrow inlets of Melville Island, has probably been deepened and scoured by glacier ice, and the same may be true of Walker and Intrepid Inlets.

Present Day Glaciers

Several small glaciers cap the highlands of western Melville Island, south of the latitude of Ibbett Bay. The glaciers occur in three areas: south of the head of Ibbett Bay; south of the head of Purchase Bay; and west of the head of Murray Inlet, on the summit of the Blue Hills fault scarp (*see* Fig. 3, Pl. L). The summits of these glaciers lie at elevations between 2,500 and 2,700 feet, determined by aneroid barometer and aircraft altimeter. The aggregate area of these glaciers is about 150 square miles.

On August 22, 1958, a landing was made on the glacier situated on the Blue Hills fault scarp. The surface of the glacier was free of snow, and was composed of a layer of loose, granular ice about 4 inches thick; this layer was underlain by solid ice. The surface of the ice was covered with cryoconite holes. The main body of the glacier is confined to the upland plateau but some tongues of ice extend down the narrow, V-shaped ravines that intersect the scarp. Some of these ravines are filled with detached bodies of ice and these small isolated glaciers are evidently nourished by wind-drifted snow rather than by the main ice-cap.

The thickness of these ice-caps is not known but judging from their low relief, in relation to the surrounding plateau, there seems to be little doubt that they are very thin, probably less than 200 feet. They rest upon a surface that includes immature ravines, V-shaped in section, which were probably formed by stream action. The glaciers apparently have not influenced the form of these ravines to any extent. It thus seems probable that these glaciers are a relatively recent growth rather than the remains of the ice-caps that excavated the fiords of Melville

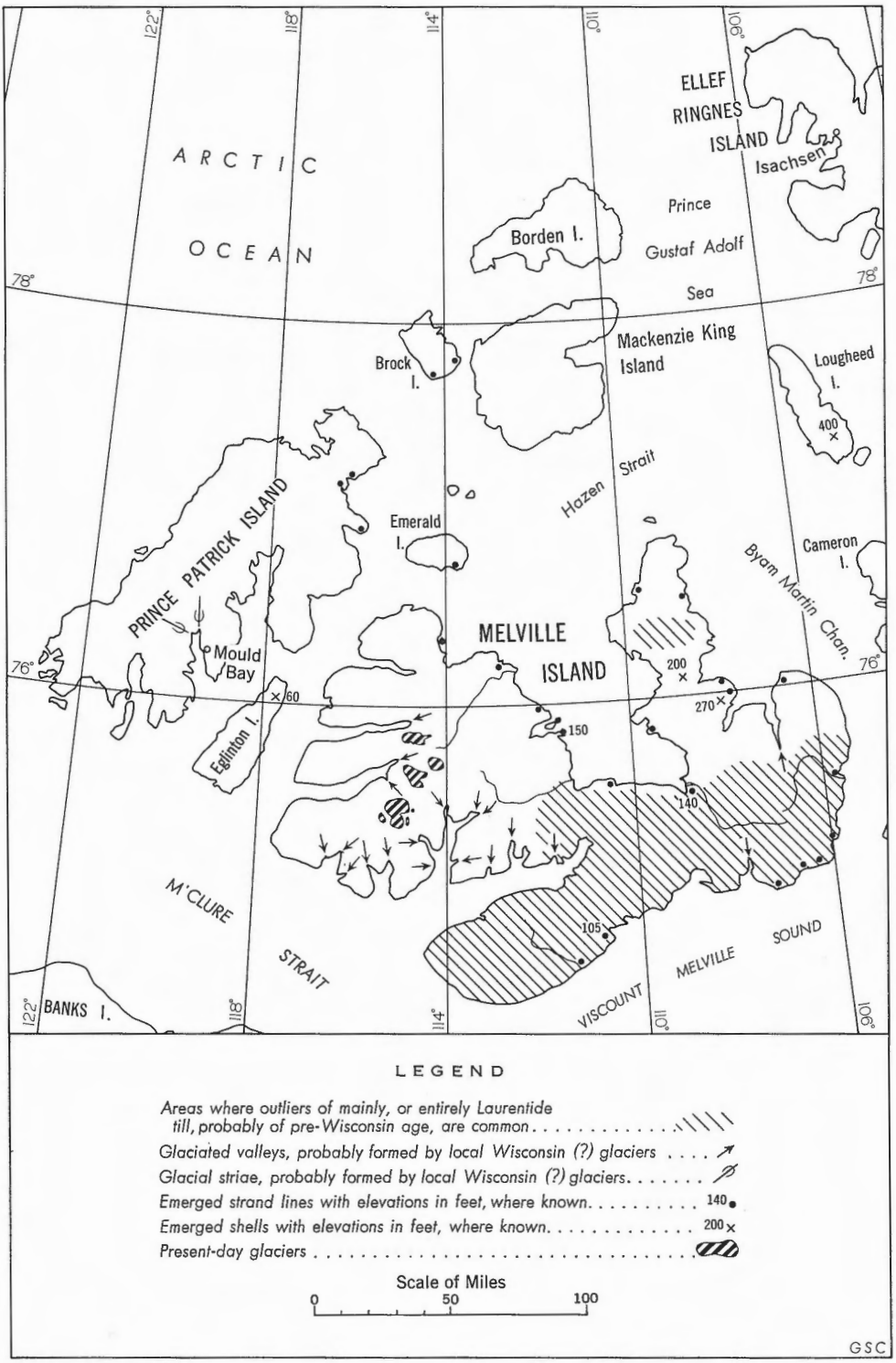

FIGURE 3. Glacial and emergence features, western Queen Elizabeth Islands

Island. Judging from the surface features observed in 1958, the glacier west of Murray Inlet is wasting at present.

Permanent snow banks occur in many parts of the area. In some areas these snow banks, from the standpoint of composition, should be described as small glaciers for they consist of glacier ice, not snow. A notable example occurs in a ravine on the south side of the anticlinal ridge, exposing Devonian limestone, east of Weatherall Bay. Similar small glaciers occur in ravines in the Canrobert Hills. These small glaciers were clearly formed from wind-drifted snow.

Emergence Features

Melville Island

Emerged strand lines occur on the southeast, east, and north coasts of Melville Island but none is known in the southwest part (*see* Fig. 3). On the south coast they have been noted 5 miles west of Cape Phipps, around Winter Harbour, and near Ross Point. According to McMillan (1910, p. 460), the raised beaches at Winter Harbour occur at elevations up to 105 feet. On the east coast of Melville Island strand lines are clearly visible on the air photographs of the coast south of Robertson Point, and also near Consett Head. To the north they are well developed around Weatherall Bay: on the east side near Domett Point and on the west side near Cape Selwyn and around Tingmisut Lake. A collection of sea shells was obtained from an elevation of 175 feet, on the south side of Tingmisut Lake. These shells have a radiocarbon age of 8,275 years (Craig and Fyles, 1960, p. 18). The highest shells observed at Tingmisut Lake were at an elevation of about 270 feet. Shells are common throughout the isthmus between Sherard and Eldridge Bays, where they occur at elevations of at least 200 feet. This isthmus was presumably flooded by the sea until relatively recently and at that time the northern part of Sabine Peninsula was evidently an island. Raised beaches occur on the shores of Hecla and Griper Bay, for example at Cape Mudge, on the east side; at Nias Point, on the south; and at Cape Fisher and Depot Island on the west. At Cape Fisher the strand lines rise to at least 150 feet above sea-level. East of the head of Sabine Bay the highest raised beach is at an elevation of 140 feet above sea-level. Raised beaches are visible on air photographs of Sabine Peninsula, near Cape Collingwood and at Hoyle Bay.

No strand lines or elevated sea shells were found on the west and southwest coasts of Melville Island. Much of the southwest coastal area has high cliffs where emerged strand lines would not be well preserved. However, if this area has experienced uplift, emerged beaches would be expected in small bays such as Blackley Haven and Comfort Cove. No raised beaches or shells were found in these areas and this suggests that the apparent absence of emergence features in southwestern Melville Island truly reflects lack of recent emergence.

Prince Patrick Island

Low raised beaches are visible on the air photographs of Cape Hemphill and the west shore of Moore Bay. No emergence features are known from southern Prince Patrick Island.

Eglinton Island

No emerged strand lines have been seen on Eglinton Island. Six miles south of Gardiner Point numerous shells of *Hiatella arctica* (Linnaeus) (identified by Miss F. J. E. Wagner) were found at an elevation of about 60 feet above sea-level, indicating that some emergence has taken place.

Brock Island

Aerial photographs show emerged strand lines on the southeast coast of Brock Island. Their elevation has not been determined.

Borden and Mackenzie King Islands

No emergence features are known on these islands. Stefansson (1921, p. 511) stated that recent marine shells are common on "Borden" Island. Unusually well-preserved Jurassic shells lie loose on the surface of parts of what is now known as Mackenzie King Island (i.e., on the southern part of Stefansson's Borden Island). The writers believe that Stefansson may have mistaken these Mesozoic shells for shells of living species.

Emerald Isle

Low raised beaches are visible on air photographs of the southeastern part of Emerald Isle.

Conclusions

The available evidence suggests that eastern Melville Island has experienced uplift of about 175 feet in the last 9,000 years and a total recent uplift of at least 270 feet. Possibly this uplift is a reaction that followed the wasting of Wisconsin Laurentide ice-sheets that may have occupied Viscount Melville Sound and the straits between Melville and Bathurst Islands (*see* p. 36). To the west and north there is less evidence of uplift and no evidence of recent uplift of more than 60 feet. Perhaps the west and northern parts of the map-area were remote from Wisconsin ice-sheets and in consequence escaped the substantial depression imposed on eastern Melville Island.

Chapter III

STRATIGRAPHY

GENERAL STATEMENT

Rocks of Ordovician, Silurian, Devonian, Pennsylvanian, Permian, Triassic, Jurassic, Cretaceous, early Tertiary (?), and late Tertiary (?) age are exposed in the western Queen Elizabeth Islands. The record of Melville Island spans Ordovician to early Tertiary (?); that of Prince Patrick, from the Devonian to the late Tertiary (?). The exposed rocks of Brock, Borden, and Mackenzie King Islands are entirely Mesozoic and late Tertiary (?). A major unconformity occurs between the Devonian and the Pennsylvanian, another beneath the late Tertiary (?) Beaufort Formation, and several other breaks occur in the rock succession.

The Ordovician, Silurian, and Devonian rocks of Melville Island form a conformable sequence that was deposited in the miogeosynclinal part of the Franklinian geosyncline. Melville Island exposes the southwestern part of this geosyncline, which extends south through Ellesmere Island and then west through the Parry Islands.

The Canrobert Formation, which includes more than 1,000 feet of limestone, dolomite, edgewise conglomerate, calcarenite, and shale, is the oldest in the area, and the oldest exposed anywhere in the Parry Islands Fold Belt. Lower Ordovician (Arenig) graptolites occur in the top beds but the underlying beds are unfossiliferous and of uncertain age. Marked facies differences characterize much of the Ordovician-Silurian sequence, with three different developments exposed, as follows (*see* Fig. 4): 1, In the Canrobert Hills, the Ibbett Bay Formation is composed of about 3,000 feet of graptolitic shale, argillite, chert and minor dolomite, ranging in age from Arenig (Lower Ordovician) to upper Ludlow (highest Silurian). 2, At the west end of Raglan Range, a thick carbonate sequence of Ordovician (?) and Silurian age underlies 300 feet of graptolitic shale—the Kitson Formation—of Upper Ludlow age. Most of the Silurian, and probably also the Ordovician is represented by carbonate in this section. Silurian carbonates also occur at Weatherall Bay, eastern Melville Island. 3, In the McCormick Inlet area, on the west side of Hecla and Griper Bay, the sequence resembles that of northern Cornwallis Island, with the Cape Phillips Formation lying upon the Cornwallis Formation. The Cape Phillips Formation of McCormick Inlet apparently ranges in age from the Ashgillian (Upper Ordovician)

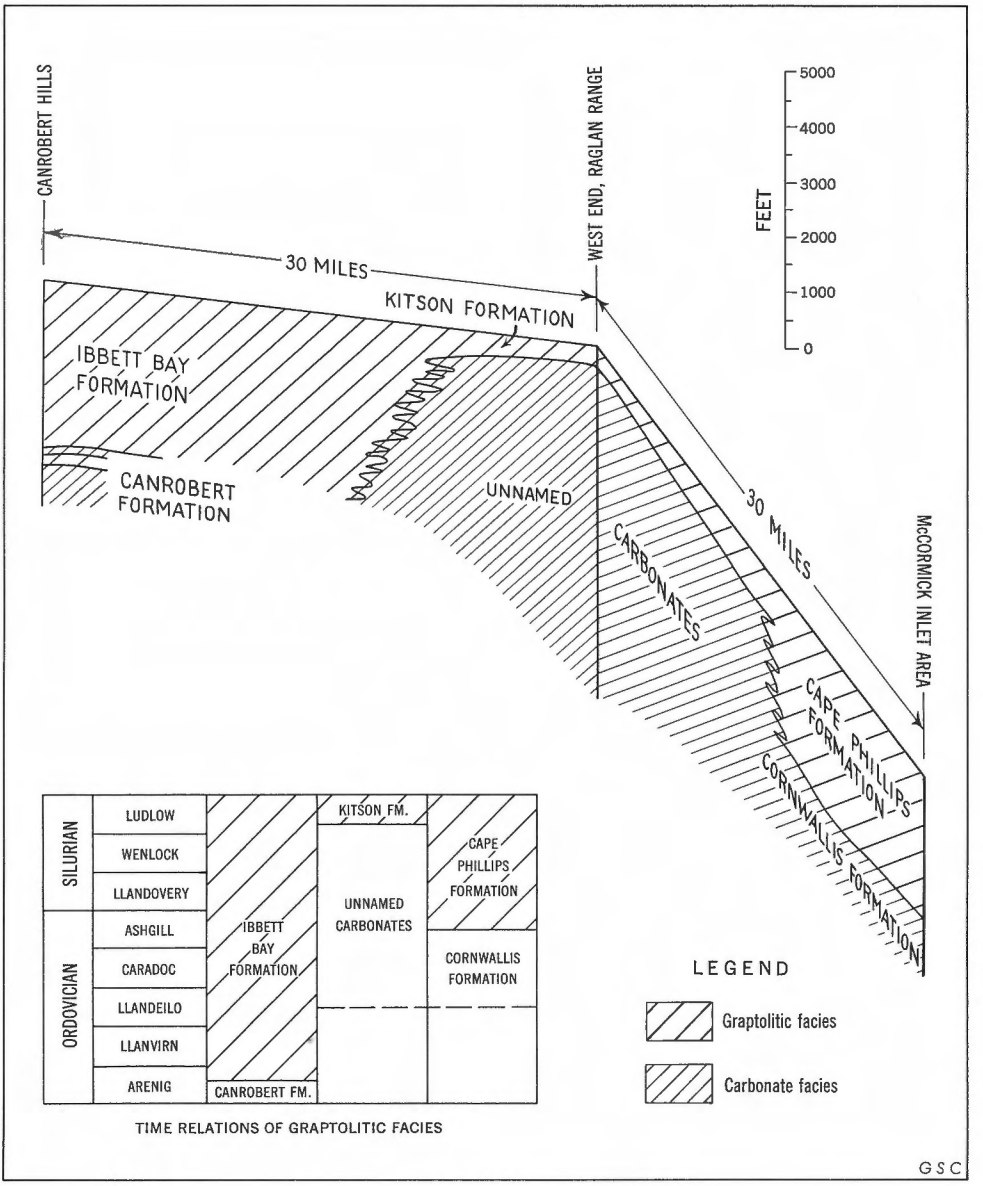

FIGURE 4. Fence diagram showing relationship between Ordovician and Silurian formations, western Melville Island.

to the Upper Ludlovian; although it is only about 2,500 feet thick, it includes beds younger than occur in the type section on Cornwallis Island. The exposed lower Palaeozoic carbonate rocks of Melville Island are mainly fine-grained to aphanitic limestone and dolomite, with minor bioclastic rock.

The evidence from Cornwallis, Bathurst, Devon, and Ellesmere Islands suggests that in Ordovician and Silurian time graptolitic rocks characterize the inner parts of the Franklinian miogeosyncline, and carbonate formations, with shelly faunas, occur on the outer part, adjacent to the Arctic Lowlands and the Canadian Shield. The formations on Melville Island reveal that the picture may, in fact, be more complex, for carbonates of Ordovician (?) and Silurian age dominate the sequence at Raglan Range. These carbonate rocks lie *north* of the Cape Phillips graptolitic beds of McCormick Inlet, which is not in accord with the generalization suggested in the preceding paragraph. Perhaps the Raglan Range was a bank area of carbonate deposition, north of the main area of graptolitic rocks. The isolated Silurian carbonates of Weatherall Bay were perhaps deposited under a similar regime. The graptolitic rocks exposed in west-central Melville Island probably pass, to the south, into carbonate rocks, as do the graptolitic rocks on Cornwallis Island, but such carbonates are not exposed on Melville Island. The closest exposures, to the south, are about 150 miles away, on Victoria and Stefansson Islands. These rocks are of carbonate facies.

Four Devonian formations are recognized: the Blue Fiord, Weatherall, Hecla Bay, and Griper Bay. The three last-mentioned constitute the Melville Island Group. The base of the Devonian sequence is exposed only in western Melville Island, where the beds are assigned to (in ascending order) the Weatherall, Hecla Bay, and Griper Bay Formations. This sequence is entirely clastic and attains a thickness of about 15,000 feet. Much of the rock is probably of non-marine origin, but late Middle Devonian (Givetian) fossils occur in the middle of the Weatherall sequence and there is at least one marine band with Upper Devonian (Frasnian) fossils in the Griper Bay. On eastern Melville Island the base of the Devonian is apparently not exposed. The lowest beds are 2,000 feet of limestone, with early Middle Devonian (Eifelian) fossils, assigned to the Blue Fiord Formation. The Blue Fiord Formation is overlain by clastic beds, which are placed in the Weatherall, Hecla Bay, and Griper Bay Formations. These clastic formations are more or less the same as the Devonian clastic beds of western Melville Island but the thickness of Weatherall strata is about half that on the western part of the island. The Blue Fiord limestone disappears between east and west Melville Island. Possibly the limestone passes into the Weatherall clastic beds, with change in facies. Alternatively, it may be cut out by an unconformity. The Devonian section on Prince Patrick Island exposes only the Griper Bay Formation, which, as on Melville Island, includes both marine and non-marine rocks. Marine bands are relatively abundant in the lower part of the Griper Bay of Prince Patrick Island. In addition to the Frasnian fauna known from Melville Island, there are also some older, early Upper Devonian faunas which are known from no other locality in the Archipelago. The Devonian clastic rocks of Melville and Prince Patrick Islands probably represent a 'clastic wedge' similar to the Chemung-Catskill delta of New York State. The clastic sediments were probably derived from tectonic lands that may have been situated close to what is now the northwest edge of the Archipelago.

A major unconformity and change in sedimentary regime took place between the Devonian and the Middle Pennsylvanian. The Pennsylvanian rocks rest with marked angular unconformity on the older formations, and Pennsylvanian time marks the beginning of sedimentation within the Sverdrup Basin, a basin that apparently developed on the site of part of the folded and eroded Franklinian geosyncline.[1] In the axial part of the Sverdrup Basin, which apparently extends northeasterly from Sabine Peninsula towards Axel Heiberg Island, sedimentation was probably more or less continuous from the Pennsylvanian to the early Tertiary. The evidence for this conclusion is derived mainly from Axel Heiberg and Ellesmere Island (Thorsteinsson and Tozer, 1960), not from this map-area. The Pennsylvanian and Mesozoic rocks are commonly sand and sandstone on the south and east margins of the Sverdrup Basin, but Pennsylvanian and Permian rocks in the axial part of the basin are shale and siltstone, and also include carbonates and evaporites. The available evidence suggests that most of the sediment within the Sverdrup Basin was derived from the south and east. Remnants of the old tectonic lands to the northwest may also have contributed sediment, but for this there is little or no evidence available. The main direction of sedimentary transport for Pennsylvanian and Mesozoic time was probably the reverse of the Devonian direction.

The Canyon Fiord Formation includes red sandstone, conglomerate, and minor limestone beds. Middle Pennsylvanian fusulinids and brachiopods occur in the lower beds. This formation is apparently confined to the margins of the Sverdrup Basin, indeed some parts of it may have been deposited in relatively small intermontane basins fringing the edge of the Sverdrup Basin proper.

Permian rocks of Sabine Peninsula include two formations, the Sabine Bay and the Assistance. The Sabine Bay Formation about 580 feet thick, includes calcareous beds with Lower Permian fusulinids overlain by unfossiliferous sands and conglomerate. It is exposed only on Sabine Peninsula, where it overlies the Canyon Fiord beds and is followed by the Assistance Formation. Both contacts are apparently conformable but they are probably disconformable. The Assistance Formation is transgressive and rests on Silurian, Devonian, and Pennsylvanian rocks, as well as on the Sabine Bay Formation. The contact with the Pennsylvanian and older rocks is unconformable. The Assistance beds consist mainly of glauconitic sandstone, chert, and minor limestone beds with abundant brachiopods of the 'Arctic Permian fauna'. This formation is about 1,600 feet thick on Sabine Peninsula but is less than 200 feet in northwestern Melville.

Both the Permian and Pennsylvanian rocks probably change in facies beneath northern Sabine Peninsula, where evaporites of Pennsylvanian or Permian age are brought to the surface in two piercement domes. Porous Permian or Pennsylvanian limestone occurs as upthrust masses in the central dome of Sabine Peninsula and this rock probably forms a subsurface layer in this area.

The Bjorne and Schei Point Formations represent the sandstone and calcareous siltstone Triassic facies that characterizes the margin of the Sverdrup

[1] *See* Addendum, p. 227.

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Basin (Tozer, 1961). The contemporary shales and siltstones that were deposited in the axial part of the Sverdrup Basin are not exposed in the map-area but it is possible that they would be encountered in the subsurface of Sabine Peninsula. The Bjorne Formation is unfossiliferous, but is probably of Lower Triassic age. The Schei Point beds contain early Upper Triassic (Karnian) fossils. The Heiberg Formation outcrops only on Brock Island. The Heiberg beds are mainly sandstone, partly marine and partly non-marine. A marine band on Brock Island contains Norian (mid-Upper Triassic) fossils. On Melville and Prince Patrick Islands the Heiberg beds either were not deposited or were removed prior to Jurassic deposition. The Heiberg might be expected in the subsurface of Sabine Peninsula.

The oldest Jurassic Formation is named for Borden Island. The Borden Island Formation in its type area comprises about 200 feet of glauconitic sand and sandstone, and is probably of early Lower Jurassic (Sinemurian) age. A thin equivalent of the Borden Island Formation occurs north of Marie Bay, Melville Island, but it has not been possible to map these beds separately. On Prince Patrick Island, and apparently also on Sabine Peninsula, the Borden Island beds are absent and the oldest Jurassic rocks exposed are referable to the Wilkie Point Formation. The Wilkie Point Formation of Prince Patrick and Melville Islands includes from 500 to about 600 feet of sand and sandstone. The lower beds are marine, with faunas of late Lower Jurassic (Toarcian) and Middle Jurassic (Bajocian and Bathonian) age. The upper beds are non-marine. The section of the Wilkie Point Formation on Borden and Mackenzie King Islands is somewhat different, for the basal Wilkie Point beds are shale, with Toarcian fossils, overlain by sand and sandstone with a Bajocian fauna. The Bathonian beds and the upper non-marine strata that occur on Prince Patrick and Melville Islands seem to be absent on Mackenzie King Island.

The Mould Bay Formation is now restricted to include only the lower (marine) member of the type section. The upper, non-marine beds are now mapped as the Isachsen Formation. On the south margin of the Sverdrup Basin (i.e., on southern Prince Patrick and Melville Islands) the Mould Bay beds reach a thickness of about 300 feet and consist mainly of sand and sandstone, with some shale at the base. Uppermost Jurassic (Tithonian), and Lower Cretaceous (Berriasian and Valanginian) fossils occur. On Mackenzie King Island the section differs. There, three members are present: a lower shale, a middle sand and sandstone member, and an upper shale, about 500 feet in aggregate thickness. Oxfordian or Kimmeridgian (Upper Jurassic) and also Tithonian fossils occur in the lower shale; Tithonian and Berriasian fossils in the middle member; and Valanginian fossils in the upper member. The section on Mackenzie King Island illustrates, both faunally and lithologically, the correlation with the Deer Bay shale of the axial part of the Sverdrup Basin. The upper shale member is also present in sections on eastern Prince Patrick Island.

The Isachsen Formation, of mid-Lower Cretaceous age, is a non-marine deposit composed mainly of sand and conglomerate, and is fairly uniform throughout the map-area. It ranges in thickness from 60 to 500 feet, and is therefore much thinner than on the Ringnes Islands and western Axel Heiberg Island. The formation is irregularly indurated. The hard facies forms buttes and crags, such as the Leffingwell Crags; the soft facies forms badlands.

The Christopher Formation reaches a thickness of about 600 feet and consists mainly of shale, siltstone, and sandstone. This formation contains proportionately more sand and silt than in the type section. Poorly preserved fossils, possibly of Aptian (mid-Lower Cretaceous) age occur on Mackenzie King Island, and Albian fossils (late-Lower Cretaceous) are known on Sabine Peninsula, Melville Island.

The Hassel (mid-Cretaceous), Kanguk (Upper Cretaceous), and Eureka Sound (Early Tertiary?) Formations are preserved only on Sabine Peninsula. These formations have been identified by their stratigraphic position and their similarity to beds on Ellef Ringnes and Axel Heiberg Islands. No diagnostic fossils have been obtained in this area and their correlation and assignment are tentative. The Hassel includes about 200 feet of non-marine sand and sandstone; the Kanguk about 500 feet of apparently marine shale; and the Eureka Sound beds include about 200 feet of non-marine sand.

On Eglinton Island the Isachsen Formation is overlain by about 750 feet of Cretaceous beds of uncertain age and correlation. These beds, which are not assigned to any formation, probably include equivalents of the Christopher Formation and perhaps also of the Kanguk.

On the margins of the Sverdrup Basin the following Mesozoic formations are transgressive and overstep the older beds: the Schei Point Formation, near Salmon Point, Prince Patrick Island; the Borden Island Formation, on Borden Island, having overstepped the Heiberg Formation; the Wilkie Point Formation on Prince Patrick Island; and the Mould Bay Formation on southern Prince Patrick Island, where it rests directly on Devonian rocks. In southeastern Melville Island the Isachsen and Christopher Formations occur as outliers, resting on the folded Devonian rocks of the Parry Islands Fold Belt.

The Beaufort Formation consists of sand and gravel, at least 250 feet thick, with abundant logs and sticks of well-preserved fossil wood. This formation rests unconformably upon the gently folded rocks of the Sverdrup Basin and at the Prince Patrick Uplift, the Beaufort rests on Devonian rocks. The unconformable blanket of Beaufort beds covers the whole of the west and northwest edge of the map-area, from Prince Patrick Island, through Brock Island, to Borden Island. The age and correlation of this formation is uncertain. It is probably late Tertiary or early Pleistocene and perhaps represents the edge of a wedge of late Tertiary sediments on the continental shelf to the northwest. The existence of such a wedge of sediment may be postulated to accommodate the erosional products derived from the bevelling of the Tertiary mountains that were formed in the Queen Elizabeth Islands after the deposition of the Eureka Sound Formation.

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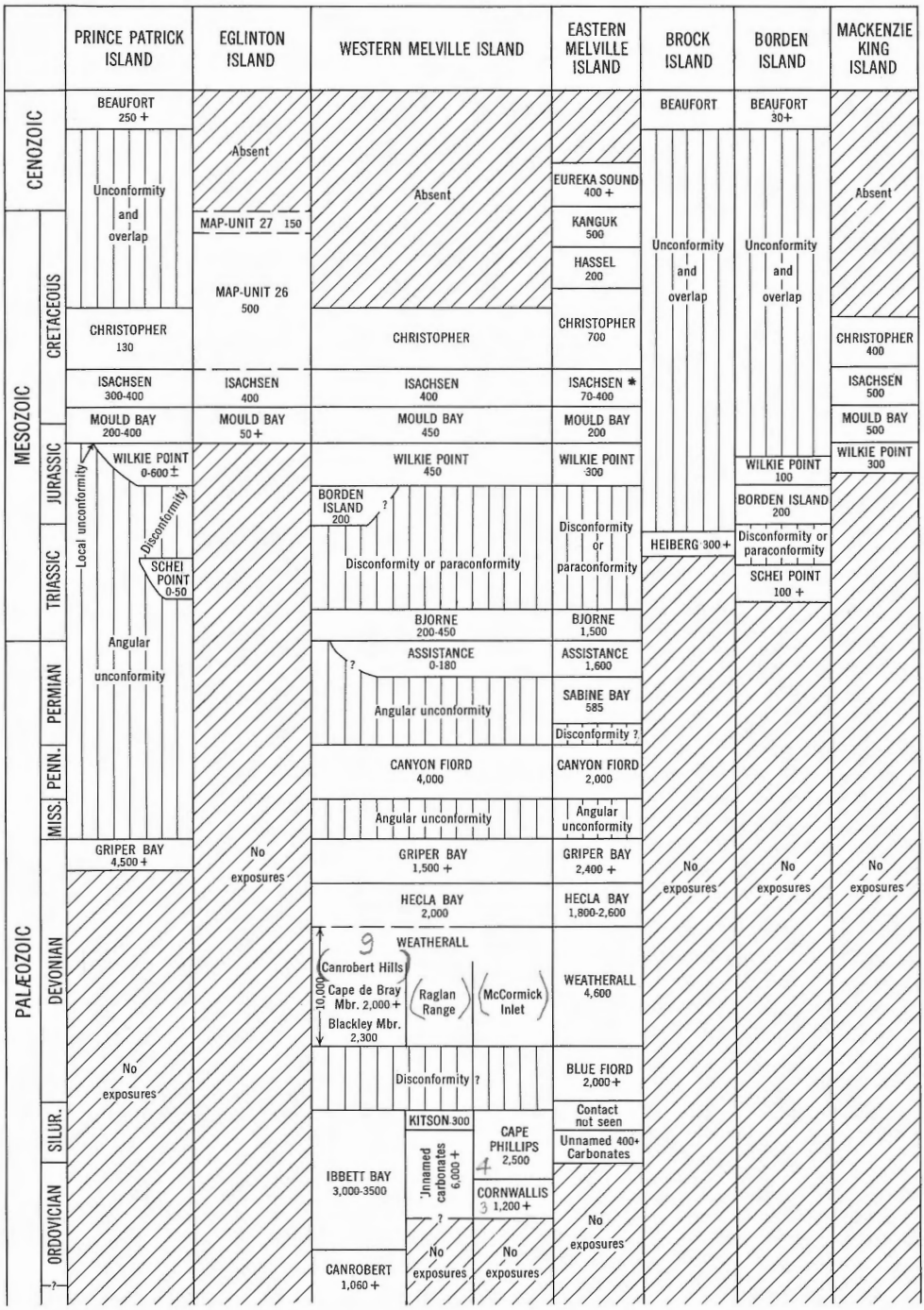

* In southeastern Melville Island, the Isachsen Formation rests directly upon Devonian rocks

Numbers indicate approximate thicknesses in feet

Table of Formations

GSC

DESCRIPTION OF FORMATIONS

Ordovician and (?) Earlier

Canrobert Formation

Tozer (1956, p. 12) has given the name "Canrobert" to the oldest formation exposed within the map-area, in the Canrobert Hills, Melville Island. The type locality is near the western extremity of the Nisbet Point anticline, between Blackley Haven and Ibbett Bay. This formation comprises a sequence of alternating limestone, silty dolomite, edgewise conglomerate, calcarenite, and calcareous sandstone beds. The maximum known thickness is at least 1,060 feet, but the base is nowhere exposed. The contact with the overlying Ibbett Bay Formation is conformable and gradational (*see* Pl. XVI). The upper beds of the Canrobert have yielded graptolites that indicate a correlation with the Arenig (Lower Ordovician) series; the lower beds have not provided determinable fossils. Exposures occur along the axes of five major anticlines between Ibbett and Marie Bays. Of all the formations exposed in the Canrobert Hills, this is the most resistant to erosion, and consequently it underlies the areas of greatest relief.

Northeast of Nisbet Point

About 600 feet of dark grey, yellowish weathering, thin-bedded, silty dolomite and impure limestone, interbedded with clastic carbonate rocks that include calcarenite and edgewise conglomerate, is exposed in the type area of the Canrobert Formation. Most of the fragments in the calcarenites are composed of carbonate

PLATE XVI. South side of anticline in the Canrobert Hills, viewed from the north side of Ibbett Bay, 16 miles east of Nisbet Point. The light coloured beds forming the flat summit are the Canrobert Formation. The overlying dark strata are the Ibbett Bay Formation.

material but small grains of quartz are also present as a minor constituent. Carbonate slabs up to 6 inches long occur in the edgewise conglomerates. At locality 1, about 4 miles northeast of Nisbet Point, the uppermost beds yielded *Didymograptus* n. sp. aff. *D. nicholsoni* Lapworth (GSC loc. 24772). A talus collection made at the same locality provided the following (GSC loc. 24774):

Goniograptus cf. *G. macer* T. S. Hall
Tetragraptus cf. *T. quadribrachiatus* (Hall)
Didymograptus sp. indet.
indeterminate dichograptids
fragment of a phyllocarid telson

In the preliminary report on western Melville Island, Tozer (1956, p. 13) included the bed yielding the above-mentioned graptolites in the basal part of the Ibbett Bay Formation. This procedure was adopted in order to place all beds of graptolitic facies in one formation. Later work in the Canrobert Hills has shown that it is more practical to place the top of the Canrobert Formation at the highest stratigraphic occurrence of edgewise conglomerate and quartzose rocks. Accordingly these beds, which include quartzose carbonates, are now placed in the Canrobert Formation.

Giddy River

At locality 2, some 16 miles upstream on the west headwater branch of Giddy River, the following generalized section was measured in the Canrobert Formation.

Unit		Approximate thickness (feet) Unit	Total from base
	Overlying beds: shale and argillite member of the Ibbett Bay Formation		
	Canrobert Formation (part)		
3	Interbedded shale, dark grey; dolomite, medium dark grey, fine-grained, thin-bedded, weathering yellowish grey; limestone edgewise conglomerate and breccia, with clasts up to several inches long embedded in a matrix of quartzose limestone that is grey and weathers greyish yellow (three beds, each under 3 feet thick). *Tetragraptus approximatus* (Nicholson) was collected from upper part of unit (GSC loc. 37332)	30	1,060
2	Interbedded dolomite, medium dark grey, aphanitic to fine-grained, thin-bedded, weathering yellowish grey; limestone edgewise conglomerate and breccia in beds up to 30 feet thick (lithology as in unit 3); minor shale, dark grey; minor calcarenite, quartzose, medium dark grey, medium-grained, in beds up to 3 feet thick, weathering medium dark grey and greyish yellow	330	1,030
1	Interbedded limestone, medium dark grey, fine-grained to aphanitic, weathering to yellowish grey flagstones; minor edgewise conglomerate as described in unit 3; unidentifiable graptolite fragments near base	700	700
	Underlying beds: poorly exposed beds of Canrobert Formation.		

Tetragraptus approximatus (Nicholson) was first described from the Lower Ordovician Levis shale of Quebec. Its distribution is now known to be world-wide, and it has been reported from Arkansas, Norway, and Australia. In the Levis shale *T. approximatus* occurs in association with *T. quadribrachiatus* (Hall). Fragmentary specimens compared with *T. quadribrachiatus* are recorded from talus derived from the Canrobert Formation at locality 1. In the Womble shale of Arkansas *T. approximatus* is associated with *Didymograptus extensus* (Hall), the index fossil of the middle of the three Arenig (Lower Ordovician) graptolite zones. The graptolites collected in situ from the Canrobert Formation, and also those derived from talus, suggest a correlation with the Arenig Series of the Lower Ordovician, in particular with the zone of *Didymograptus extensus*.

Ordovician

Cornwallis Formation

The name "Cornwallis" was applied by Thorsteinsson and Fortier (1954; *see also* Thorsteinsson, 1958, p. 33) to a distinctive assemblage of marine rocks, about 5,000 feet thick, that outcrop on Cornwallis and Little Cornwallis Islands. The type section is near the northern extremity of Cornwallis Island. Later investigations have shown that the Cornwallis Formation also occurs on Ellesmere, Devon, Bathurst, and Melville Islands. In all the complete sections the Cornwallis Formation comprises three members. In ascending order these are: 1, a lower gypsiferous member; 2, a middle carbonate member, and 3, an upper member, which is relatively thin, composed of shale and limestone. The upper member characteristically contains abundant fossils of the well-known, but as yet imperfectly understood, 'Arctic Ordovician fauna'.

McCormick Inlet

Within the map-area, outcrops of the Cornwallis Formation are limited to the McCormick Inlet area, on the west side of Hecla and Griper Bay. The structures that involve this formation are largely obscured by the waters of McCormick Inlet and Hecla and Griper Bay, and also by the unconformable cover of Pennsylvanian rocks. It nevertheless appears that this formation and also the overlying Cape Phillips Formation are exposed along the axis of an east-west striking, westerly plunging anticline. The anticlinal axis probably parallels the narrow channel that separates Middle Island from the south shore of McCormick Inlet. The lower gypsiferous member, which characterizes the Cornwallis Formation on the islands to the east of the map-area, is not exposed on Melville Island. Without subsurface information the presence or absence of this member cannot be determined. The oldest Cornwallis beds exposed on Melville Island evidently represent the middle carbonate member. The beds are dolomite, generally

medium light grey to medium dark grey, medium bedded to massive, and intricately traversed by thin veins of white crystalline calcite. These beds weather to various shades of grey and brown. Graphic measurements indicate a thickness of about 1,200 feet for this member on the south side of McCormick Inlet.

The upper member of the Cornwallis Formation, represented by about 60 feet of limestone and shale, is well exposed in the cliffs along the west side of Middle Island. The limestone is light to medium grey, aphanitic, mainly thin bedded, in part nodular, and weathers light grey. Interbedded with the limestone is greyish green, soft shale.

No fossils are known from the Cornwallis exposures of Melville Island. The beds are assigned to the Cornwallis on the grounds of their relationship to the overlying, fossiliferous, Cape Phillips beds and on their lithological resemblance to typical Cornwallis beds. The lithological resemblance of the distinctive upper member is particularly impressive and the apparent absence of fossils is surprising.

Ordovician and Silurian[1]

Ibbett Bay Formation

Tozer (1956, p. 13) has given the name "Ibbett Bay" to a formation composed of mainly dark coloured graptolitic rocks that overlie the Canrobert Formation of northwestern Melville Island. The type section is on the small stream that flows into the delta at the head of Blackley Haven. Graphic measurement of a section near the east end of the Canrobert Hills indicates that the Ibbett Bay Formation is about 3,000 feet thick, which is probably the most reliable estimate of thickness. This formation overlies the Canrobert transitionally, without a sharp break. The upper boundary, with the Blackley Member of the Weatherall Formation, is very abrupt, but apparently perfectly concordant. Commonly the Ibbett Bay-Weatherall boundary is followed by stream valleys.

The Ibbett Bay Formation is exposed only in the Canrobert Hills. Outcrops occur on the limbs of the anticlinal folds between Ibbett and Marie Bays. The formation consists mainly of dark grey to black shale, calcareous shale, argillite, dolomite, chert, and minor limestone beds. Graptolites are common in many sections; with the exception of one inarticulate brachiopod, *Tentaculites, Styliolina,* and some radiolarians, they are the only fossils known. The graptolite faunas reveal that the formation spans early Ordovician to latest Silurian time. The Arenig, Caradoc, Ashgill, Llandovery, and Ludlow Series are represented. No fossils of Llanvirn, Llandeilo, or Wenlock age have been found, but it is likely that these series are also represented.

Between Blackley Haven and Ibbett Bay

Good exposures of much of the Ibbett Bay Formation occur in several small streams draining the southwestern part of the Canrobert Hills, and flowing into Blackley Haven, Kellett Strait, and Ibbett Bay. It was in this area that the formation was first discovered and named (Tozer, 1956).

[1] *See* Addendum, p. 230.

There are many good exposures but most of them reveal only a small part of the formation and consequently it is not possible, at present, to provide a complete lithological section. It is also impossible to offer an accurate estimate of thickness. On the small creek flowing into Blackley Haven, upstream from localities 8 and 9, the thickness was estimated to be about 3,500 feet (Tozer, 1956, p. 13).

Beds near the base are well exposed northeast of Nisbet Point, at localities 3 and 4. At locality 3, from black shales within 100 feet of the base of the formation, the following graptolites were collected (GSC loc. 37231):

Tetragraptus quadribrachiatus (Hall)
Didymograptus extensus (Hall)
Didymograptus uniformis Elles and Wood
Didymograptus sp. indet.
Isograptus gibberulus (Nicholson)
Trigonograptus cf. *T. ensiformis* (Hall)

Tetragraptus quadribrachiatus was collected in talus. The other forms were obtained in association, in place. All the graptolites from locality 3 indicate a correlation with the zone of *Didymograptus extensus,* the middle of the three zones in the Arenig Series (Lower Ordovician). It appears that the basal Ibbett Bay strata represent the same graptolite zone as the upper beds of the Canrobert Formation (p. 51).

At locality 4, from black, well-bedded shales, approximately on strike with those of locality 3, the following graptolites were collected from talus (GSC loc. 24779):

Tetragraptus cf. *T. serra* (Brongniart)
Didymograptus cf. *D. extensus* (Hall)
Glyptograptus cf. *G. dentatus* (Brongniart)

The species with which these forms are compared range through the two upper Arenig zones, namely the zones of *Didymograptus extensus* and *Didymograptus hirundo*. A middle or upper Arenig age is therefore indicated.

Specimens of *Isograptus* were observed in talus at locality 5, south of the head of Blackley Haven, indicating the presence of Arenig rocks on the north limb of the Nisbet Point anticline.

At locality 6, at the foot of the prominent cliff on the south side of Blackley Haven, the following graptolite was collected from talus (GSC loc. 24769):

Climacograptus bicornis (Hall) cf. var. *C. tridentatus* Lapworth

This is a unique occurrence for the Canadian Arctic Archipelago and it indicates a correlation with the lower part of the Caradoc Series (Middle Ordovician).

Upper Caradocian and Ashgillian graptolites have not been found in this area, but they are known north of Blackley Haven (p. 55).

The next younger graptolites are of Silurian age. Near the shore of Ibbett Bay, in the bank of a small stream, at locality 7, the following were collected in talus of black shale derived from beds representing a stratigraphic interval of about 100 feet (GSC loc. 24777):

Petalograptus palmeus (Barrande)

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Glyptograptus tamariscus (Nicholson)
Climacograptus sp.
Monograptus regularis (Tornquist)
Monograptus turriculatus (Barrande)

These species range between the zones of *Monograptus cyphus* and *Monograptus turriculatus* of Germany and Czechoslovakia (Münch, 1952, pp. 45-47). They indicate a Llandoverian (Lower Silurian) age.

A younger Llandoverian faunule has been obtained from talus derived from beds about 800 feet below the top of the Ibbett Bay Formation, at locality 8, southeast of Blackley Haven. From this talus collection the following have been identified (GSC loc. 24770):

Cyrtograptus n. sp. A
Stomatograptus grandis (Suess)
Monograptus priodon (Bronn)
Monograptus cf. *M. vomerinus* (Nicholson)
Monograptus convolutus coppingeri (Etheridge)

With the exception of *M. convolutus coppingeri,* these forms indicate correlation with the zone of *Stomatograptus grandis,* youngest of the Llandoverian (Lower Silurian) graptolite zones of Europe. *M. convolutus coppingeri* is probably somewhat older, as deduced from its occurrence on Cornwallis Island (Thorsteinsson, 1958, p. 99), which is apparently below *Stomatograptus grandis* but above the zone of *M. turriculatus.*

Upper Silurian (Ludlovian) graptolites occur at localities 9 and 10. At locality 9, east of Blackley Haven, *M. bohemicus* (Barrande) was collected in situ in black shale about 200 feet below the top of the formation (GSC loc. 24765). This species ranges from the zone of *M. nilssoni* to that of *M. tumescens,* in the Lower Ludlow Subseries of Europe. Talus at locality 9 yielded one slab with the following (GSC loc. 24767):

M. bohemicus (Barrande)
Monograptus cf. *M. ultimus* (Perner)

Another slab at locality 9 has *M. tumescens* Wood n. subsp.

The new subspecies of *M. tumescens* occurs on Cornwallis Island, in association with early Lower Ludlovian graptolites, representing the zone of *M. nilssoni* (Thorsteinsson, 1958, p. 101). The slab with *M. bohemicus* and *Monograptus* cf. *M. ultimus* is evidently younger. It is possible that the form here identified as *Monograptus* cf. *M. ultimus* is, in fact, *M. ultimus. M. ultimus* occurs in the *M. leintwardinensis* zone of Shropshire, the highest zone of Great Britain. Münch (1952) places *M. leintwardinensis* and *M. ultimus* at the base of the Middle Ludlow. *M. bohemicus* occurs in the subjacent zones in the Lower Ludlow. It is interesting to note that *M. bohemicus* and *M. ultimus* may be associated on Melville Island, as the two species are not associated either on Cornwallis Island or in Europe. Decker (1935) listed these two species from the Henryhouse Shale of Oklahoma but he does not state if they are associated.

At locality 10, northeast of Nisbet Point, the following graptolites were collected from the dark grey shale (GSC loc. 37221):

Monograptus bohemicus (Barrande)
Monograptus dubius (Suess)
Monograptus n. sp. B

This assemblage, like that obtained in situ at locality 9, represents the Lower Ludlow.

North of Blackley Haven

The upper part of the Ibbett Bay Formation was examined near the small lake a mile north of Blackley Haven. Exposures are few, but rubble and talus show the lithology. The beds are exposed in an anticlinal structure. The upper beds comprise black platy shales and the middle part of the section consists of black shale with thin interbeds of chert. The oldest beds, in the core of the anticline, are poorly exposed but rubble derived from this interval consists mainly of hard, light grey weathering, relatively thick-bedded shale, traversed by veins of carbonate. Two fossil collections were obtained. Talus derived from beds near the base of the cherty sequence, three quarters of a mile north of the lake, at locality 11 (GSC loc. 24774), yielded the following:

Orthograptus quadrimucronatus (Hall)
Climacograptus sp. indet.

This collection, on the basis of *Orthograptus quadrimucronatus,* is assigned to the *Pleurograptus linearis* zone, at the top of the Caradoc Series (Upper Ordovician).

Graptolites obtained from the cherty beds on the south limb of the anticline immediately north of the small lake, at locality 12 (GSC loc. 24778), are as follows:

Climacograptus cf. *C. latus* (Elles and Wood)
Orthograptus sp. indet.
Dicellograptus? sp. indet.

Climacograptus latus occurs in the *Dicellograptus anceps* zone, at the top of the Ashgill Series (uppermost Ordovician) in Scotland. This collection is assigned to this zone. *C. latus* occurs in the lower part of the Cape Phillips Formation of Cornwallis Island (Thorsteinsson, 1958, p. 95).

Hawk Creek

Intermittent exposures, representing about the lower half of the Ibbett Bay Formation, were studied on Hawk Creek, which flows from the Canrobert Hills to Ibbett Bay. From outcrops on this creek at locality 13 the following graptolites were collected about 100 feet above the base of the Ibbett Bay Formation (GSC loc. 37230):

Tetragraptus pendens (Elles)
Phyllograptus cf. *P. iliciformis* Hall
Climacograptus sp. indet.

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Glyptograptus dentatus (Brongniart)
lasiograptid, gen. and sp. indet.

Tetragraptus pendens, as well as the presence of *Climacograptus* and a lasiograptid, suggests correlation with the zone of *Didymograptus hirundo,* in the upper part of the Arenig Series.

One quarter of a mile from the mouth of Hawk Creek, at locality 14, outcrops of dark grey shale yielded the following (GSC loc. 37223):

Retiolites geinitzianus densereticulatus Bouček and Münch
Monograptus priodon (Bronn)
Monograptus cf. *M. vomerinus* (Nicholson)
Cyrtograptus n. sp. A

On Cornwallis Island (Thorsteinsson, 1958, p. 98) these four species of graptolites occur in the zone of *Stomatograptus grandis,* which in Germany and Czechoslovakia constitutes the uppermost zone of the Llandovery Series (Münch, 1952, p. 43).

Headwaters of Giddy River

A nearly perfect section of the Ibbett Bay Formation is exposed in the deep gorge cut by Giddy River between localities 15 and 16. A generalized description of this section follows:

Unit		Approximate thickness (feet) Unit	Total from base
	Overlying beds: Blackley Member of Weatherall Formation		
	Ibbett Bay Formation		
5	Shale and calcareous shale, dark grey to black, weathering to the same colours. *Monograptus* n. sp. A (GSC loc. 37229) collected about 700 feet below upper contact of formation at locality 15	1,600	3,025
4	Argillite, dark grey, aphanitic, thin-bedded with interbeds of dark grey shale, weathers dark grey and dusky red	300	1,425
3	Dolomite, dark grey, fine-grained, thin- to thick-bedded calcite veined; upland surfaces weather light grey	275	1,125
2	Shale, calcareous, dark grey, interbedded with limestone, argillaceous, dark grey; the rocks are veined with calcite and possess incipient cleavage; entire member weathers medium dark grey and brownish grey; upland surface developed on this unit weathers light grey	600	850
1	Chert, dark grey to black, thin-bedded, interbedded with dark grey, fine-grained dolomite, argillaceous limestone, black argillite and shale; all rocks weather dark grey. *Tetragraptus* cf. *T. approximatus* Nicholson was observed at locality 16 in a bed about 30 feet above the base of the formation	250	250
	Underlying beds: Canrobert Formation		

Monograptus n. sp. A from the upper beds of this section suggests a correlation with the Upper Ludlow Subseries of Germany and Czechoslovakia (*see* p. 58).

It also indicates a correlation with the upper beds of the Cape Phillips Formation as developed at McCormick Inlet (p. 58), the Kitson Formation of Raglan Range (p. 64), and with the Bathurst Island Formation (McLaren, 1963*b*).[1] *Tetragraptus* cf. *T. approximatus* indicates an Arenig age for the basal beds.

The occurrence of dolomite in this section (unit 3) is of considerable interest. Dolomite is not known in the Ibbett Bay beds of the western Canrobert Hills and is almost certainly absent. At McCormick Inlet much of the Ordovician sequence is represented by dolomite (Cornwallis Formation), and Ordovician carbonates are probably present in the Raglan Range (p. 61). The dolomite in unit 3 probably represents a tongue of Cornwallis-type rocks that extends east from McCormick Inlet to the Canrobert Hills. The Giddy River section evidently shows interfingering of Cornwallis dolomite beds with the middle part of the Ibbett Bay Formation.

Cape Phillips Formation[1]

The Cape Phillips Formation was originally described by Thorsteinsson (1958, p. 78) for graptolitic rocks on Cornwallis and Little Cornwallis Islands, where it comprises mainly impure shale and limestone, at least 8,500 feet thick, ranging in age from Ashgill (late Ordovician) to Middle Ludlow (late Silurian). The upper contact of the formation probably does not occur on the Cornwallis Islands. The type locality is on the northeast coast of Cornwallis Island. The Cape Phillips Formation overlies the Cornwallis Formation with abrupt, yet conformable contact. On the Cornwallis Islands, the Cape Phillips Formation is confined to the smaller island and the north half of Cornwallis Island proper. On the south half of Cornwallis Island the chronological equivalent of the Cape Phillips Formation is found in two formations, the Allen Bay and the Read Bay, which are mainly carbonates, with shelly faunas. The transition zone between the graptolitic and shelly facies is well exposed on the central-east coast of Cornwallis Island where it is sharply defined and remarkably narrow. This narrow boundary between contrasting depositional environments was maintained in one position throughout a long period of geological time (late Ordovician to late Silurian) (*see* p. 203).

Later studies in the Arctic islands have demonstrated the presence of the Cape Phillips Formation at two localities on Bathurst Island (McLaren, 1963b; Thorsteinsson and Glenister, 1963b) and at three localities on Ellesmere Island (Norris, 1963; Tozer, 1963b; and Thorsteinsson and Tozer, 1957, p. 17). The Cornwallis Formation underlies the Cape Phillips at all localities where the base of the formation is exposed. On the other hand, the nature of the beds that overlie the Cape Phillips varies considerably from place to place; several formation names have been introduced for these beds, which are commonly hard to correlate. The beds that overlie the Cape Phillips Formation on Bathurst Island are particularly relevant to the discussion of this map-area.

At Stuart Bay, Bathurst Island, McLaren (op. cit.) has given the name "Bathurst Island Formation" to a sequence of graptolitic rocks, 3,410 feet thick,

[1] *See* Addendum, p. 230.

that overlies some 1,500 feet of Cape Phillips beds. The base of the Cape Phillips is not exposed at Stuart Bay. The Bathurst Island Formation is described by McLaren as "largely fine-grained quartzose sandstone, variably argillaceous and calcareous, and calcareous mudstone". The contact between the Bathurst Island and Cape Phillips Formations is transitional; the upper contact, with the Devonian Stuart Bay Formation, is also apparently conformable. The Bathurst Island Formation has yielded two new species of *Monograptus* and also *Styliolina* and *Tentaculites*. One of the new graptolites appears to be closely related to *Monograptus hercynicus* Perner, index fossil of the Upper Ludlow Subseries of Germany and Czechoslovakia. The other news species is referred to as "*Monograptus* n. sp. A". *Monograptus* n. sp. A is not closely related to any other described monograptid; it ranges above and below the stratigraphic occurrence of *Monograptus* n. sp. aff. *M. hercynicus*. On the basis of: 1, the presumed affinities of *Monograptus* n. sp. aff. *M. hercynicus,* and 2, the presence of Middle Ludlow graptolites in the Cape Phillips beds of Stuart Bay, it is provisionally concluded that the graptolites from the Bathurst Island Formation are Upper Ludlovian.[1]

Monograptus n. sp. A has now been found on Melville Island. It represents the youngest graptolite zone in: 1, the upper part of the Cape Phillips Formation of McCormick Inlet; 2, the upper beds of the Ibbett Bay Formation (p. 56). It also constitutes the solitary graptolite zone of the Kitson Formation, a thin graptolitic formation that occurs at the west end of Raglan Range (p. 63). In the Cape Phillips and Ibbett Bay Formations there is no marked change in lithology at the appearance of this graptolitic zone. Consequently, it is neither practical nor appropriate to separate the beds containing this fossil. The sections on Melville Island thus differ from that of Stuart Bay, where an influx of quartzose sediment occurred at the time of the *Monograptus* n. sp. A zone. It follows that the Cape Phillips Formation of Melville Island includes younger beds than the Cape Phillips of Bathurst, Cornwallis, and Ellesmere Islands.

Within the map-area, outcrops of the Cape Phillips Formation are confined to the environs of McCormick Inlet, on the west side of Hecla and Griper Bay. The total thickness in this area is about 2,500 feet and the beds consist of shale, argillaceous and nodular limestone, and calcareous shale. The beds rest with a sharp, conformable contact upon the Cornwallis Formation and are overlain, again with a sharp, apparently conformable contact, by the Weatherall Formation (Devonian).

Graptolite faunules of Llandoverian, Wenlockian, and Ludlovian age are known from the Cape Phillips beds of McCormick Inlet. The Upper Ordovician (Ashgillian) graptolites, which occur in the Cape Phillips Formation of other areas and in the Ibbett Bay Formation of Canrobert Hills, are not known at McCormick Inlet. However, the basal Cape Phillips strata at McCormick Inlet, although unfossiliferous, are strikingly similar, lithologically, to the basal, Ashgillian Cape Phillips beds of Cornwallis Island. This suggests that the Ashgill Series is represented by unfossiliferous beds at the base of the section.

[1] *See* Addendum, p. 230.

Middle Island, McCormick Inlet

Excellent exposures of about 1,300 feet of the lower Cape Phillips beds occur on the west coast of Middle Island (locality 17), where the beds rest upon the Cornwallis Formation. The highest beds are not preserved, although they do occur a few miles to the south (p. 60). Three major stratigraphic subdivisions may be recognized in this section, which resemble those of the type section of the Cape Phillips Formation (Thorsteinsson, 1958, p. 81). Although this section has not been studied in detail or measured accurately, in general terms it can be described as follows:

Unit		Approximate thickness (feet) Unit	Total from base
	Overlying beds: Cape Phillips strata concealed by the water of McCormick Inlet		
	Cape Phillips Formation (part)		
3	Shale, in part calcareous, greyish black to black, weathering to various shades of grey and in part varicoloured from staining by ferruginous minerals, probably derived from the Canyon Fiord Formation (Pennsylvanian); interbeds of shaly limestone are common near the base, where this unit is transitional with the underlying unit. Graptolites abundant; the following were collected (in descending order):		
	(d) GSC loc. 37209: *Monograptus ultimus* (Perner) (Middle Ludlow)		
	(c) GSC loc. 37204: *M. bohemicus* (Barrande) (Lower Ludlow)		
	(b) GSC loc. 37228: *M. nilssoni* (Barrande) (Lower Ludlow)		
	(a) GSC loc. 37227: *M. testis* (Barrande) (Wenlock)	700	1,200
2	Shale, calcareous, greyish black, contains numerous round, dark grey to greyish brown calcite concretions, about 6 inches in diameter; alternating with shaly limestone, dark grey to greyish black, fine-grained to aphanitic, laminated and thin-bedded, weathering to flagstones; unit weathers to various shades of grey, contact with underlying unit is sharp. Graptolites collected as follows (in descending order):		
	(b) GSC loc. 37225: *Monograptus* cf. *M. priodon* (Bronn); *Monograptus* cf. *M. vomerinus* (Nicholson); *Cyrtograptus* n. sp. A (uppermost Llandovery)		
	(a) GSC loc. 37206: *Monograptus spiralis spiralis* Geinitz (Llandovery)	200	500
1	Limestone and shaly limestone, medium light grey to medium dark grey, fine-grained to aphanitic, thin and unevenly bedded, upper part of unit remarkably nodular; some partings of grey shale. Graptolites collected as follows (GSC loc. 37260):		
	Climacograptus cf. *C. scalaris* (Hisinger)		
	Monograptus turriculatus (Barrande) (Llandovery)	300	300
	Underlying beds: Cornwallis Formation		

Climacograptus scalaris and *Monograptus turriculatus* occur together in the zone of *Monograptus turriculatus* (Upper Llandovery Series) of Germany and Czechoslovakia (*see* Münch, 1952, for the Silurian graptolitic sequence with which these faunas are compared). *M. spiralis* constitutes the index fossil of a higher zone in the same Series. *Cyrtograptus* n. sp. A is known, from its associates on Cornwallis Island (Thorsteinsson, 1958, p. 98), to represent the zone of *Stomatograptus grandis,* the uppermost zone of the Llandovery. *Monograptus testis* represents the highest Wenlockian zone. This is the only record of the presence of Wenlockian fossils on Melville Island. *Monograptus nilssoni* indicates a correlation with the lowest zone of the Lower Ludlow Subseries, namely the zone of *M. scanicus* and *M. nilssoni.* In Europe, *M. bohemicus* occurs throughout the Lower Ludlow Subseries, but in the Canadian Arctic Thorsteinsson (1958, p. 101) has shown that this species forms a distinct zone immediately above the zone of *M. nilssoni. M. ultimus* is considered to form the lowest zone of the Middle Ludlow.[1]

South of McCormick Inlet

A monoclinal sequence of the Cape Phillips Formation is partly exposed south of McCormick Inlet. The beds lie between the Cornwallis and Weatherall Formations, with an unconformable cover of Pennsylvanian rocks concealing the westward extension of the belt of Cape Phillips strata. The lower beds of the Cape Phillips and the basal contact with the Cornwallis Formation are not exposed. The width of the belt mapped as Cape Phillips Formation suggests that the total thickness is about 2,500 feet.

Good exposures of the upper beds occur on the banks of two small streams, one cutting the eastern part of the belt, and the other at the west end. On the eastern stream, around locality 18, the lower Cape Phillips beds are concealed by alluvium, regolith, and soil. In the western section, near locality 19, unconformably overlying beds of the Canyon Fiord Formation (Pennsylvanian) conceal the lower part of the Cape Phillips section.

Approximately 1,100 feet of Cape Phillips beds outcrops near locality 19. These beds comprise greyish black to black, graptolitic shale, and calcareous shale. At locality 19, 700 feet below the top of the formation, *Monograptus* n. sp. A, *Styliolina* sp., and *Tentaculites* sp. (GSC loc. 37207) were collected. *Monograptus* n. sp. A, as already noted (p. 58), appears to be of Upper Ludlovian (highest Silurian) age. No other graptolites were found in this section, which seems to indicate that the beds exposed near locality 19 are younger than the beds exposed on Middle Island, where the youngest preserved Cape Phillips beds contain the Middle Ludlovian *Monograptus ultimus.* The upper contact of the Cape Phillips Formation, with the Weatherall Formation, is very sharp but is apparently conformable.

Near locality 18 about 1,200 feet of beds is exposed. These beds comprise black and grey graptolitic shales with some relatively thick-bedded, yellow weather-

[1] *See* Addendum, p. 230.

ing shales in the upper part. Talus derived from these beds provided the Upper Ludlovian[1] graptolite *Monograptus* n. sp. A, *Styliolina* sp., and *Tentaculites* sp. (identified by Thorsteinsson) and some well-preserved fragments of *Elrodoceras* sp. (identified by T. E. Bolton) (GSC locs. 37203, 37208, 37174).

Ordovician (?) and Silurian

Carbonate Rocks of Raglan Range and Weatherall Bay

Silurian carbonate rocks are exposed at two localities on Melville Island, at the west end of Raglan Range and on the shore of Weatherall Bay, southeast of Tingmisut Lake. As already mentioned (p. 43), in all other exposed sections the Silurian rocks are of graptolitic facies, and mainly composed of shale. The only known fossils from the carbonates of these two areas are of Silurian age. However, in Raglan Range there is a substantial thickness of rock beneath the beds with Silurian fossils, and this introduces the possibility that the Ordovician is also represented. For this there is no proof, and accordingly the beds are classed as Ordovician (?) and Silurian.

Raglan Range

A roughly rectangular tract of highlands at the west end of Raglan Range exposes a considerable thickness of carbonate rocks (*see* Pl. XVII). The base of this sequence is not exposed. The carbonates are overlain by a thin graptolitic shale of uppermost Silurian age—the Kitson Formation. The carbonate rocks are extremely resistant to erosion compared with the soft, overlying beds, and in consequence they stand out with prominent topographic expression and form a rugged, barren plateau. The total thickness of carbonate beneath the Kitson Formation is estimated to be about 6,000 feet. The rocks comprise aphanitic to fine-grained, medium-bedded limestone and dolomite. Predominant colours are grey and greyish yellow. At locality 20, from beds 30 feet below the upper contact, the following fossils were collected (GSC loc. 37240). Identifications are by T. E. Bolton.

Coenites sp.
Conchidium sp.

Bolton states that the presence of *Conchidium* suggests a Silurian age for this collection.

Weatherall Bay

The Silurian carbonates are confined to a small area southeast of Tingmisut Lake. In the preliminary account of the map-area (Thorsteinsson and Tozer, 1959a) some of the other limestones were tentatively assigned to the Silurian. All these other limestones are now believed to be of Devonian age (p. 68).

In the Tingmisut Lake area the base of the carbonate sequence is not exposed and the rocks are overlain, paraconformably, by the Canyon Fiord

[1] *See* Addendum, p. 230.

PLATE XVII. Aerial view of Raglan Range, Melville Island, looking east to Hecla and Griper Bay. In the foreground are Ordovician (?) and Silurian carbonates (OS u) overlain by the Kitson (S k) and Weatherall (D w) Formations. A prominent fault separates the carbonates from the main part of the range which has extensive exposures of the Hecla Bay Formation (D h) and, to the north, a low, felsenmeer-covered area, probably underlain by the Griper Bay Formation (D g). North of the range is the southeast part of the Marie homocline with exposures of the Assistance (Pm a), Bjorne (Tr b), and Wilkie Point (J wp) Formations. In the distance, on the south side of the range, is a large isolated syncline of Canyon Fiord beds (Cp cf). (RCAF T416L–75)

Formation (Pennsylvanian). The Silurian rocks form a precipitous sea-cliff facing Weatherall Bay. From the summit of the cliff the carbonate terrain extends to the north for about a mile, where it disappears beneath the Canyon Fiord beds. The beds on the face of the sea-cliff are almost or quite inaccessible and were not reached by the writers. Talus includes considerable limestone and dolomite breccia. The cliff face is probably a fault-line feature and this rock may be fault breccia. Immediately north of the cliffs, at locality 21, disintegrated outcrops of light grey, vuggy dolomite yielded abundant specimens of *Conchidium* sp. cf. *C. alaskense* Kirk and Amsden (GSC loc. 25895, identified by T. E. Bolton). According to Bolton, these fossils indicate a Silurian age.

The thickness of this Silurian sequence is not known but it is probably in excess of 400 feet.

Silurian[1]

Kitson Formation

At the west end of Raglan Range about 300 feet of mainly black, marine shale rests with abrupt, yet conformable contact on the Silurian carbonates described above (*see* p. 61 and Pl. XVII). This thin distinctive rock-unit is named the Kitson Formation. An almost completely exposed section occurs on a small tributary of Kitson River, near the western extremity of Raglan Range, at locality 22. This section may be considered typical of the Kitson Formation. The rock is mainly black fissile shale. Interbeds of thin-bedded, dark grey, argillaceous limestone and calcareous siltstone also occur. The base of the Kitson Formation is not exposed at this locality. The upper contact is exposed and it reveals light grey Weatherall (Devonian) shale, with hackly fracture, overlying, abruptly, the platy shale of the Kitson Formation. At locality 22 thin beds of dark grey argillaceous limestone about 60 feet above the base of the formation have yielded the following brachiopods (GSC loc. 37233):

orthotetacid brachiopods
Atrypa reticularis (Linnaeus)
a single valve of a *Gypidula*-like brachiopod

These fossils were identified by A. J. Boucot who states that the material is not sufficiently well preserved to permit an accurate age determination.

Two miles northeast of the type locality, at locality 23, about 100 feet of beds representing the basal part of the Kitson Formation is exposed. There the basal contact is exposed and black, fossiliferous Kitson shale rests abruptly and conformably upon the underlying Silurian limestone. The following fossils were collected from calcareous shale about 60 feet above the basal contact (GSC loc. 37224):

pentamerid brachiopods, indet.
Styliolina sp.
Tentaculites sp.
Monograptus n. sp. A

[1] *See* Addendum, p. 230.

Monograptus n. sp. A dates the Kitson Formation as Upper Ludlow (late Silurian)[1] and indicates a correlation with the Bathurst Island Formation of Bathurst Island (McLaren, 1963b); with the upper beds of the Cape Phillips Formation, as developed at McCormick Inlet, a few miles to the southeast; and the uppermost beds of the Ibbett Bay Formation (*see* p. 56). *Styliolina* and *Tentaculites* are common associates of *Monograptus* n. sp. A. This association occurs in the Cape Phillips beds of McCormick Inlet, the Bathurst Island Formation, and the Ibbett Bay Formation.

The section at the west end of Raglan Range, in which only the Upper Ludlovian is of graptolitic facies, illustrates the minimum development of this facies on Melville Island (*see* Fig. 4). This section presents a marked contrast to that of McCormick Inlet, where the whole of the Silurian, and perhaps also the Upper Ordovician, are of graptolitic facies. An even greater contrast is found in the Canrobert Hills, where graptolitic rocks were deposited between Arenig (Lower Ordovician) and Upper Ludlow (Upper Silurian) times.

Devonian

General Character of the Devonian Formations

Devonian rocks form the surface of much of Melville Island and are also exposed on southern Prince Patrick Island, between Intrepid Inlet and Cape Mecham. The exposures cover about 11,000 square miles on Melville Island and about 600 square miles on Prince Patrick Island. Within the map-area Devonian rocks occur in a belt 260 miles long in an east-west direction. This belt is broken only by Eglinton Island and the adjacent straits. The maximum breadth of the Devonian terrain, at the 113th meridian, is about 100 miles.

These rocks are the youngest in the structurally conformable early Palaeozoic sequence of the Parry Islands, so the top of the Devonian in this area, as it is throughout the Archipelago, is an erosion surface. The base of the sequence is exposed only in the central part of the belt, namely, in the Canrobert Hills and the Raglan Range. To the west, on Prince Patrick Island, only the higher beds of the sequence, of Upper Devonian age, are at the surface. To the east, around Weatherall Bay, the exposed section goes down to the early Middle Devonian, but sub-Devonian rocks are known only on one isolated fault block and the succession of basal Devonian rocks has not been seen.

In the western Queen Elizabeth Islands, the Devonian rocks have been placed in four formations: the Blue Fiord, Weatherall, Hecla Bay, and Griper Bay Formations. The Blue Fiord Formation is typically developed on southern Ellesmere Island (McLaren, 1959; 1963a); the three overlying formations are new units with type sections on Melville Island. Tozer (1956) used the name "Melville Island Formation" for the Devonian rocks of western Melville and southern Prince Patrick Islands. The Melville Island Formation now becomes a group, composed of three formations, the Weatherall, Hecla Bay, and Griper Bay.

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[1] *See* Addendum, p. 230.

In order to explain the correlation and nomenclature of these formations it is necessary to describe in general terms the Devonian rocks that extend from Prince Patrick Island, eastwards through Melville and Bathurst Islands to Grinnell Peninsula and southwestern Ellesmere Island, a distance of 480 miles. The dominant characters of the sequence in this area are shown diagrammatically by Figure 5. The main features of the succession for the eastern part of this belt have been determined by McLaren (1959; 1963a, b) as follows. Following the Upper Silurian (Upper Ludlow), marine conditions prevailed in Lower (?) and early Middle Devonian times with deposition of a basal sandy unit on central Bathurst Island (Stuart Bay Formation), followed by shale (Eids Formation), and limestone (Blue Fiord Formation). During the Middle Devonian, quartzose sediment appears in the section (Bird Fiord Formation), followed by mainly non-marine rocks, mainly or entirely of Upper Devonian age (Okse Bay Formation). On Cameron Island, Upper Devonian (Frasnian) fossils occur at one level in the Okse Bay Formation (Greiner, 1963). On eastern Bathurst Island an unconformity, unrepresented in central Bathurst Island, separates the Silurian and Devonian rocks (Thorsteinsson and Glenister, 1963) and on southern Ellesmere Island the position of the Siluro-Devonian boundary is uncertain, but these matters do not concern us here.

On eastern Melville Island the exposed part of the section bears some resemblance to the section of central Bathurst Island. At least 2,000 feet of Blue Fiord limestone (with early Middle Devonian fossils) is present. The base is not exposed. The limestone is overlain by about 4,600 feet of thin-bedded sandstone, siltstone, and shale, which constitutes the typical Weatherall Formation. The lower beds of the Weatherall Formation contain late Middle Devonian fossils that indicate a correlation with the Bird Fiord Formation. The upper beds lack marine fossils. To some extent the Weatherall beds resemble the Bird Fiord Formation of central Bathurst Island. A case might be made for placing the Weatherall beds of eastern Melville Island in the Bird Fiord Formation. However the typical Bird Fiord rocks of Ellesmere Island include much sandy limestone, a rock not present in the Weatherall Formation. The Bird Fiord rocks of Bathurst Island seem to be intermediate in character between those of the type section, to the east, and the Weatherall Formation on Melville Island, to the west. It is suggested that Byam Channel, between Bathurst and Melville Islands, be an arbitrary line of division between the partly (and perhaps entirely) contemporary Bird Fiord and Weatherall Formations. The change in name emphasizes the gradual replacement of sandy limestone by terrigenous clastic rocks as the late Middle Devonian rocks are traced from east to west.

The Weatherall beds of eastern Melville Island are followed, with a sharp contact, by from 1,800 to 2,600 feet of sandstone, white or light grey, and probably non-marine. In some sections exposures are excellent and reveal that this unit is composed entirely of sandstone, without shale interbeds. This unit is ideal for mapping purposes and is named the Hecla Bay Formation. It is overlain by

the Griper Bay Formation, a less homogeneous sequence comprising at least 3,000 feet of sandstone, shale, siltstone, and thin coal seams. Greenish sandstone is particularly characteristic of the lower Griper Bay beds; lighter coloured sandstones (like those of the Hecla Bay) occur throughout as thin units and in the upper Griper Bay they are a prominent constituent. Most of the Griper Bay is clearly non-marine, but in several sections marine Upper Devonian (Frasnian) brachiopods occur about 2,300 feet above the base. The contact between the Hecla Bay and Griper Bay Formations is sharp and is easily mapped throughout eastern Melville Island.

On western Melville Island the highest Silurian beds, which are graptolitic shales of Upper Ludlovian age[1] (upper Ibbett Bay Formation, upper Cape Phillips Formation, Kitson Formation), are followed by a Devonian sequence composed entirely of clastic rocks: the Melville Island Group. Marine shale and limestone formations, like the Eids and Blue Fiord, are completely unrepresented. The lowest beds, which are placed in the Weatherall Formation, are composed mainly of thin-bedded sandstone and shale, about 10,000 feet thick. In the Canrobert Hills two distinct lithological units are distinguished as members of the lower part of the Weatherall Formation. They are the Blackley Member, about 2,300 feet thick, at the base; followed by the Cape De Bray Member, about 2,000 feet thick. The Blackley Member is apparently unfossiliferous; fossils of Middle Devonian age appear in the Cape De Bray Member. Good late Middle Devonian (Givetian) faunas occur in beds above the Cape De Bray Member. The upper Weatherall beds, as on eastern Melville Island, lack marine fossils and may be non-marine. The Weatherall beds of western Melville Island are followed, transitionally, by beds correlated with the Hecla Bay Formation. The Hecla Bay equivalent includes about 2,400 feet of strata comprising beds of massive, light coloured sandstone, divided by units of thin-bedded, grey sandstone and shale. These grey interbeds are like the upper Weatherall strata. The top of the Hecla Bay is generally a massive, light coloured sandstone and it is overlain abruptly by beds comprising thin-bedded, greenish sandstone and shale, with thin coal seams. These beds clearly represent the Griper Bay Formation. Thus on western Melville Island the upper contact of the Hecla Bay Formation is distinct, but the lower boundary, with the Weatherall Formation, is transitional. Where possible an attempt has been made to map the Hecla Bay Formation as a distinct unit but in some areas this has not been possible and the Hecla Bay and Weatherall Formations have been mapped together. The Devonian succession of western Melville Island is thick, monotonous, and repetitious and is not easily subdivided for mapping purposes.

It should be noted that the Blue Fiord limestone disappears between Weatherall Bay (eastern Melville) and McCormick Inlet (western Melville). The fact of the disappearance is certain, the explanation is unknown. There are two alternative explanations: first, that the Blue Fiord Formation passes laterally, with change in facies, into the Weatherall Formation of western Melville Island;

[1] *See* Addendum, p. 230.

second, that time correlatives of the Blue Fiord limestone are absent on western Melville Island. If the first is correct, the Weatherall beds of western Melville Island include Blue Fiord equivalents and represent a longer interval of time than the Weatherall strata of the eastern part of the island. If the second is correct there is a substantial stratigraphic hiatus beneath the Weatherall beds of western Melville Island. In this connection it should be mentioned that the basal Weatherall beds (Blackley Member) of the Canrobert Hills are apparently without counterpart in the basal Weatherall of eastern Melville Island. The Blackley Member, 2,300 feet thick, is unfossiliferous. In the Canrobert Hills the first Middle Devonian fossils occur about 3,000 feet above the base of the Weatherall Formation in the Cape De Bray Member. On eastern Melville late Middle Devonian fossils occur about 300 feet above the base. It is therefore possible that the Blackley Member is Lower Devonian, or early Middle Devonian, perhaps equivalent to the Stuart Bay Formation of Bathurst Island. According to this hypothesis, higher beds of the Weatherall Formation in the Canrobert Hills would probably contain equivalents of the Eids and Blue Fiord Formations. The great thickness of Weatherall beds in western Melville Island is compatible with this suggestion, but the lack of fossils makes it impossible to settle this problem at present.

The Devonian rocks of Prince Patrick Island are placed in the Griper Bay Formation. The lower part of this sequence comprises at least 1,800 feet of thin-bedded, mainly greenish and grey sandstone and shale with several fossiliferous Upper Devonian horizons. The faunas include the Frasnian fauna known on Melville and Cameron Islands and also some older, early Upper Devonian faunules that are not known elsewhere in the Queen Elizabeth Islands. The upper beds are at least 2,700 feet thick and include thick-bedded, light coloured sandstone, like the upper Griper Bay beds of Melville Island.

The Hecla Bay and Griper Bay Formations evidently correlate (certainly in the sense of lithology, and partly, at least, in the sense of time) with the Okse Bay Formation of Ellesmere and Bathurst Islands. The best known Okse Bay section is the type, which was studied in southwestern Ellesmere Island by McLaren (1959, 1963a). McLaren distinguished four members in this section. The Hecla Bay Formation appears to be equivalent to the greater part of the "Lower Sandstone Member" and the Griper Bay Formation resembles the upper members.

The Devonian fossils from Prince Patrick and Melville Islands have been studied by D. J. McLaren. The faunal succession he has recognized may be summarized as follows.

1. The fauna of the Blue Fiord Formation of eastern Melville Island includes *Digonophyllum, Dendrostella,* and *Amphipora.* It permits a correlation with the Blue Fiord Formation of Bathurst and Ellesmere Islands and is of early Middle Devonian (probably Eifelian) age.

2. The Weatherall Formation contains digonophyllids, *Schizophoria* sp. A; *Atrypa* cf. *A. independensis* Webster, *Emanuella* cf. *E. meristoides* Meek, and *Dechenella.* Similar forms occur in the Bird Fiord Formation of Bathurst and Ellesmere Islands. This fauna is of late Middle Devonian (probably Givetian) age.

3. The Griper Bay Formation contains several faunules, all Upper Devonian. The oldest faunule (known only on Prince Patrick Island) includes *Schizophoria* cf. *S. athabaskensis* Warren, *Eostrophalosia* sp., *Devonoproductus,* and *Allanaria* cf. *A. allani* (Warren). McLaren dates this assemblage as earliest Upper Devonian. A younger faunule (also known only from Prince Patrick Island) includes *Douvillinella, Nervostrophia,* and *Warrenella* sp. B. A third fauna (known from Prince Patrick, Melville, and Cameron Islands) includes *Cyrtospirifer,* two species of *Chonetes* and *Camarotoechia* cf. *C. letiensis* Gosselet.[1] This fauna is Frasnian. The fauna with *Douvillinella,* etc., may be about the same age as the assemblage with *Cyrtospirifer,* or it may be slightly older.

Fossil plants and fragmentary vertebrates occur in the Griper Bay Formation but they have not been studied in detail and at present do not contribute additional data on age and correlation. The fossil spores have been described by McGregor (1960). Faunules with estherians occur (Lambe, 1910; Copeland, 1962) in areas remote from well-dated marine faunas and their exact age is uncertain. They probably occur in the interval between the horizons with late Middle Devonian and Upper Devonian (Frasnian) fossils.

Blue Fiord Formation

Within the map-area, the Blue Fiord Formation is exposed only in two belts around Weatherall Bay. One belt forms a conspicuous range of hills, 10 miles long, east of the bay, the other forms the very prominent ridge and sea-cliffs on the south side of the bay.

This formation probably occurs in the subsurface of eastern and southern Melville Island, but no structures bring it to the surface; it is absent in northwestern Melville Island (pp. 66, 82).

East of Weatherall Bay

The Blue Fiord Formation east of Weatherall Bay is the oldest unit exposed in the core of an anticline (*see* Pl. XVIII). The basal beds are not exposed. No exposures of the upper contact have been seen but in a small ravine on the south limb of the anticline, 4 miles from the east end of the limestone belt, a covered interval of 20 feet separates the Blue Fiord limestone from the overlying Weatherall Formation. An abrupt and pronounced topographic depression marks the boundary between these formations, and this sharp physiographic boundary probably reflects a sharp contact between the two formations. Although the contact appears to be sharp the two formations seem to be structurally conformable.

About 2,000 feet of beds is exposed intermittently near the southeast margin of the limestone belt. The dominant rock is fine-grained, brownish grey, light grey weathering, well-bedded limestone. Greyish black, thin-bedded, shaly limestone also occurs. In the deep ravine at the west end of the limestone belt the beds near the base of the section include light brownish grey, fine-grained limestone with small blebs of clear, crystalline calcite. In the ravine 4 miles from

[1] *See* page 84.

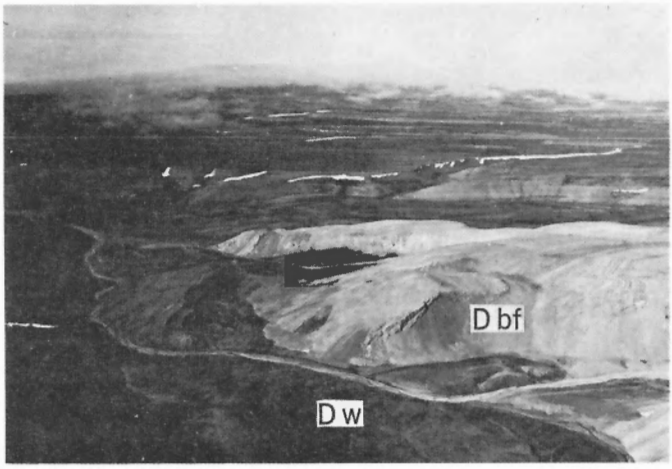

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PLATE XVIII

Aerial view, from an altitude of about 1,000 feet, of the west end of the anticline on the east side of Weatherall Bay, Melville Island, exposing the contact between the light coloured limestones of the Blue Fiord Formation (D bf) and the overlying dark, Weatherall sandstones, etc. (D w).

the east end of the limestone belt the rock includes mottled dolomitic limestone. The limestone in this mottled rock is brownish grey, the dolomite is greenish yellow. Crinoidal and coralline limestone are minor constituents throughout the section.

The following fossils have been collected from this area. Fossil and age determinations are by D. J. McLaren.

1. From the intermittently exposed section on the southeast edge of the limestone belt.
   (a) Locality 24. Within 200 feet of the top of the section (GSC loc. 37235)
   Digonophyllum sp. C
   Digonophyllum sp. D
   (b) Locality 25. About 1,000 feet below the top of the section (GSC loc. 40801)
   Cystiphylloides sp.
   Grypophyllum? sp.
   Alveolites sp. B
   (c) Locality 25. About 1,050 feet below the top of the section (GSC loc. 40806)
   Dendrostella sp. cf. *D. rhenana* (Frech)
   (d) Locality 26, talus derived from beds. About 2,000 feet below the top of the section (GSC loc. 40802)
   Zonodigonophyllum sp. B
   Bactrites sp.
   Warrenella sp. A
   Atrypa sp.
   Spinatrypa sp.

(e) Talus collection (GSC loc. 40805)
Spongophyllum sp. K
Favosites sp. K, *Favosites* sp. L

2. Locality 27, from the small ravine 4 miles from the east end of the limestone belt, from beds about 1,000 feet below the top of the section (GSC loc. 37176)
Hexagonaria sp. G
Atrypa? sp.
Spinatrypa? sp.

3. Locality 28. West end of the limestone belt, from beds near the top of the section (GSC loc. 37175)
Dendrostella sp. C

According to McLaren, these faunules are Middle Devonian, and probably Eifelian (early Middle Devonian).

South Side of Weatherall Bay

The main outcrop of the Blue Fiord Formation forms a remarkably conspicuous ridge of limestone. The north side of the ridge is the steep sea-cliff facing the bay; a prominent fault-line scarp, facing south, forms the south side. Bounded to the north and south by steep slopes, this ridge is a veritable wall (*see* Pl. XLVII). The Blue Fiord rocks of this ridge are isolated by the fault and neither the upper nor the lower contact is exposed. Good exposures occur in the ravine, cut by a superimposed stream flowing north, in the middle of the ridge. About 2,000 feet of limestone is intermittently exposed. This section has not been studied in detail but the most common variety of limestone is a well-bedded, fine-grained rock with small blebs of crystalline calcite, similar to the limestone at the base of the exposed section east of Weatherall Bay. Dark grey, thin-bedded limestone is a minor constituent. The highest beds of this section, exposed at the north end of the ravine, include bioclastic limestone. Fossils obtained from the mouth of the ravine at locality 29 (GSC locs. 25896, 25897) include *Amphipora* sp. and *Bellerophon* sp. (identified by D. J. McLaren). No coral beds were seen. As already mentioned, corals are fairly common in the Blue Fiord exposures east of Weatherall Bay, where the upper 2,000 feet of the formation is exposed. Much of the rock on the south side of Weatherall Bay resembles beds at the base of the exposed section to the east. Possibly the beds south of Weatherall Bay lie below the horizon of those to the east. If this is so, the total thickness of the formation in the Weatherall Bay area is probably at least 3,000 feet.

The uppermost beds of the Blue Fiord Formation are exposed in a narrow belt on the west shore of the east arm of the bay. These beds appear to be in fault contact with the ridge-forming outcrops described in the preceding paragraph. Intermittent exposures of brownish grey limestone occur. About 500 feet of beds is probably present but the exposures are mainly masked by talus. Fossils from

the uppermost Blue Fiord beds at this locality (locality 30) have been determined by D. J. McLaren as follows:

1. In place (GSC loc. 40803)
   Warrenella sp.

2. Talus collection (GSC loc. 40804)
   auloporid tabulate corals
   Disphyllum sp. A
   proetid trilobite fragments
   Gypidula sp. B
   "*Reticularia* ex gr. *R. curvata* (Schlotheim)", form D of GSC Mem. 320. Probably *Warrenella* sp.
   Schizophoria sp.
   Spinatrypa sp.
   Atrypa sp.

These fossils, like those from the section east of Weatherall Bay, are dated as Middle Devonian, probably Eifelian, by McLaren.

Weatherall Formation of Eastern Melville Island

This formation consists of sandstone, siltstone, and shale. Marine Middle Devonian (probably Givetian) fossils occur in the lower beds; the upper beds are unfossiliferous and are probably non-marine. In the type section east of Weatherall Bay the formation lies between the Blue Fiord limestone and the overlying white sandstone of the Hecla Bay Formation. In eastern Melville Island the lower boundary is exposed only in the Weatherall Bay area. The formation appears in most of the anticlines of the Parry Islands Fold Belt of southeastern Melville Island but none of these structures brings the basal beds to the surface.

Scattered observations have been made throughout Melville Island and relatively detailed studies have been made around Weatherall Bay and north of Beverley Inlet. These observations indicate that the exposed part of the Weatherall Formation preserves a fairly uniform character throughout eastern and southeastern Melville Island. There are two distinct members in the Weatherall Formation of eastern Melville Island: the lower consists of thin-bedded, drab-coloured sandstone, siltstone and shale with marine fossils in some beds; in the upper member relatively thick units of light coloured sandstone appear. No marine fossils occur in the upper member. The Weatherall Formation of western Melville Island is somewhat different (*see* p. 76).

East of Weatherall Bay

The type section of the Weatherall Formation is on the south side of the prominent anticlinal limestone ridge, where the Blue Fiord limestone is exposed. A homoclinal sequence of the Weatherall Formation is present, with intermittent exposures. The total thickness is about 4,600 feet.

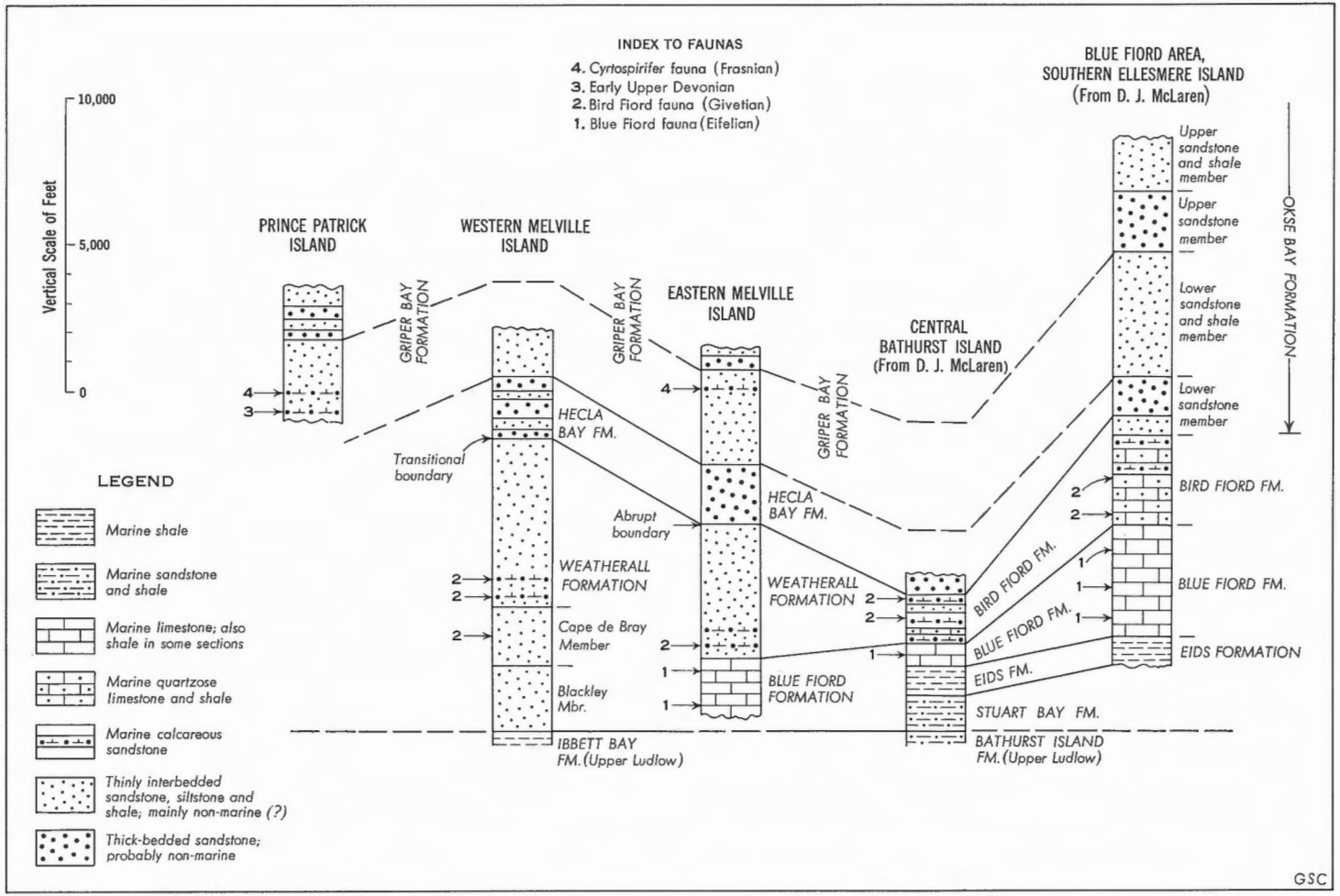

FIGURE 5. Columnar sections of Devonian formations.

Beds near the base are exposed at locality 31, in the small stream that leaves the limestone ridge 4 miles from the east end. There the following section was measured. These are the only exposures known within the basal 300 feet.

Unit		Thickness (feet) Unit	Total from base
4	Sandstone, fine-grained, grey, weathers greenish grey, weathers to flagstones less than an inch thick	15	90
3	Covered interval	50	75
2	Shale, brownish grey, with plant fragments and one calcareous band with *Tentaculites* sp. (GSC loc. 37172)	5	25
1	Covered interval	20	
	Underlying beds: Blue Fiord limestone		

No detailed section has been compiled for the remaining 4,300 feet, which comprises interbedded sandstone, siltstone, and shale. The sandstone is quartzose, mainly fine grained, grey or light grey; weathers to drab colours in the lower part of the section and commonly to a yellowish brown in the upper part. In the lower 700 feet, the sandstones are commonly brown weathering and calcareous. Bedding planes on all rocks are commonly flecked with white mica and carbonaceous material, the latter being particularly abundant in the upper part of the section. Friable, grey micaceous shale is interbedded throughout but the shale exposures are generally poor.

From a bed of grey calcareous sandstone at locality 32 about 300 feet above the base of the formation (GSC loc. 37235) D. J. McLaren has identified:

Zonodigonophyllum sp. A
Schizophoria sp. D
Atrypa sp. D
Emanuella cf. *E. meristoides* (Meek)

These fossils are Middle Devonian, probably Givetian, according to McLaren.

Northeast of the Head of Beverley Inlet

About 2,900 feet of beds, representing part of the Weatherall Formation, was examined in the core of the Robertson Point anticline, about 8 miles northeast of the head of Beverley Inlet. These beds are well exposed in the stream that flows south to the inlet. The section illustrates particularly well the difference between the lower and upper members.

The lower 1,400 feet of this section represents the lower member and comprises thin- to medium-bedded, grey, fine-grained sandstone, weathering greenish grey, dusky red, or brown, interbedded with grey shale, silty shale, and siltstone. Sandstone is the dominant rock. Individual beds are thin, commonly less than a foot thick. Bedding planes commonly have 'worm trails', carbonaceous material, and white mica. Fossil brachiopods, pelecypods, and trilobites occur in

the lower 800 feet but are mainly poorly preserved. At locality 33, from a bed near the base (GSC loc. 37171), D. J. McLaren has identified *Emanuella* cf. *E. meristoides* (Meek), of Middle Devonian (probably Givetian) age. The upper 600 feet of this unit is unfossiliferous.

The succeeding 1,500 feet of the Weatherall Formation in this section represents the upper member. This member, like the underlying beds, is also composed of interbedded sandstone, siltstone, and shale. However, this member is characterized by the appearance of units of light grey, yellowish brown weathering sandstone, from 35 to 150 feet thick. The individual sandstone units become thicker towards the top of the formation, and they seem to express the gradual change in sedimentary regime which culminates with the appearance of the overlying white sandstone of the Hecla Bay Formation. Interbedded with these thick, light coloured sandstones are drab coloured, thin-bedded, sandstone, siltstone, and shale. All beds in this member are commonly carbonaceous.

Other Areas

Scattered observations made throughout eastern Melville Island confirm that the two-fold division of the Weatherall Formation, described above, applies throughout the area.

The lower marine beds have been located 11 miles east of Rae Point. Fossils collected from this locality (locality 34) have been identified by D. J. McLaren as follows (GSC loc. 37358):

Conularia sp.
Schizophoria sp. A
Productella sp. Q
Atrypa cf. *A. independensis* Webster

They have also been found at locality 35 near the core of the anticline that intersects the east side of Liddon Gulf, north of Chevalier Bay. From this locality (GSC loc. 37237) McLaren has identified:

Productella sp. Q
bellerophontid gastropods
small orthoconic cephalopods

These faunules are Middle Devonian, probably Givetian, according to McLaren.

Hecla Bay Formation of Eastern Melville Island

The Hecla Bay Formation of eastern Melville Island consists of light grey to white sandstone. It lies between the Weatherall Formation, below, and the Griper Bay Formation, above. Both contacts are conformable. The Hecla Bay Formation is homogeneous in lithology. Throughout eastern Melville Island it constitutes a very useful unit for structural mapping; in western Melville Island it is not well differentiated from the underlying Weatherall Formation (p. 76).

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PLATE XIX. Aerial view, from an altitude of about 1,000 feet, of southeastern Melville Island, looking east to Byam Channel. Exposed are the Weatherall (D w), Hecla Bay (D h), and Griper Bay (D g) Formations.

The type section on the south limb of the Robertson Point anticline, 7 miles northeast of the head of Beverley Inlet, is almost completely exposed. It is about 2,600 feet thick and is composed of light grey to white, fine- to medium-grained sandstone and sand. The sandstone is essentially quartzose but also contains carbonaceous material and white chalky grains of kaolinized feldspar. The beds in this section vary greatly in degree of consolidation: some are white unconsolidated sand, but some hard beds are also present. The hard beds are commonly cemented by ferruginous or siliceous material, and weather orange, yellowish brown and, less commonly, red. In this section, and probably also in other sections east of the 111th meridian, grey, thin-bedded sandstones and shales are absent. Thin beds, up to a foot thick, of black, carbonaceous sandstone were noted in the type section. Individual beds of sandstone are commonly thick and show cross-bedding. Thin-bedded, light grey or white sandstone is a minor constituent.

Southeast of Weatherall Bay, where the Hecla Bay beds succeed the type section of the Weatherall Formation, graphic measurements indicate a thickness of about 1,800 feet for the Hecla Bay Formation. Eighteen hundred and twenty-six hundred feet probably establish the approximate limits for the thickness of the Hecla Bay Formation.

The Hecla Bay Formation commonly forms a white terrain, which is easily followed from the air or on air photographs. However, in some areas these rocks

are encrusted with black lichens and their distinctive light colours are concealed. The beds usually do not form positive topographic features. The soft facies commonly forms spectacular badlands and 'hoodoos'. In some areas the Hecla Bay Formation is a hard, ridge-forming sandstone. The hard facies normally has a black lichen cover. Ridges formed by this hard facies occur at Cape Bounty, southeast of Sabine Bay and elsewhere.

No fossils, other than carbonized plant fragments, are known from the Hecla Bay Formation, which is almost certainly a non-marine, deltaic, deposit. The underlying Weatherall beds contain Middle Devonian fossils; the Griper Bay Formation, above, has Frasnian fossils. The Hecla Bay Formation is therefore late Middle Devonian, or early Upper Devonian.

Weatherall and Hecla Bay Formations of Western Melville Island

The boundary between the Weatherall and Hecla Bay Formations is ill defined on western Melville Island. Accordingly the rocks assigned to these formations are treated under a single heading.

Canrobert Hills

The Devonian rocks of the Canrobert Hills have been assigned to two rock-units, which are treated as members of the Weatherall Formation. They are the Blackley Member at the base of the section, and the overlying Cape De Bray Member. The Blackley Member, unlike the basal beds of the typical Weatherall Formation, rests directly upon Upper Silurian rocks.[1] As already mentioned (p. 67), it is possible that both members are older than any other beds in the type section of the Weatherall Formation. However, this is by no means established, and these members appear to be genetically related to the overlying beds, which both faunally and lithologically resemble the type section of the Weatherall Formation. The sections within the Canrobert Hills do not go as high as these typical Weatherall beds. The relationship between the Cape De Bray Member and the overlying rocks is exposed near the head of Ibbett Bay (p. 80).

The type section of the Blackley Member is 7 miles northeast of the northeast corner of Blackley Haven. It comprises about 2,300 feet of grey micaceous shale with siltstone interbeds. The siltstone bands are commonly from an inch to a foot thick, and they weather yellowish brown or orange. Bedding planes are commonly covered with flecks of white mica. The contact between the Blackley Member and the underlying Ibbett Bay Formation is exposed on the south side of Marie Bay, 9 miles from the head of the bay. The contact is very sharp but is perfectly concordant. The sharp lithological boundary is reflected prominently by the topography. The Blackley rocks are less resistant to erosion than the underlying hard Ibbett Bay shales. In consequence, the Blackley Member generally forms hills of rounded contour adjacent to the prominent ridges of Ibbett Bay rocks. The Blackley rocks weather to a rather distinctive greenish grey.

[1] *See* Addendum, p. 230.

No fossils are known from the Blackley Member but the beds are clearly related to the overlying strata (Cape De Bray Member) in which Middle Devonian fossils have been found. The graptolitic shales beneath the Blackley Member are of Upper Ludlovian (highest Silurian) age.[1] Undoubtedly, therefore, the Blackley Member is Devonian, but the exact age is unknown.

The Blackley Member is followed by at least 1,000 feet of grey to black, mainly micaceous shale, with siltstone interbeds. The shales commonly contain dusky red clay ironstone nodules. These beds are named the Cape De Bray Member. The exposures 2 miles south of Cape De Bray may be considered typical. There is no profound lithological difference between the Blackley and Cape De Bray Members, but the Cape De Bray beds contain proportionally more shale and lack the greenish weathering siltstone bands that impart the distinctive colour to outcrops of the Blackley Member. The Cape De Bray beds form a distinctive dark terrain. The total thickness of this member is not known, but it probably does not exceed 2,000 feet. A few rather poorly preserved fossils have been obtained. The following identifications are by D. J. McLaren:

1. Locality 36, 1½ miles S33°E of Cape De Bray (GSC loc. 24879)
   "Nuculana" sp.
   Dechenella sp.
   crinoid stems

2. Talus at locality 37, east shore of Blackley Haven, immediately north of the large river that enters the bay (GSC locs. 24876, 24877, 24878)
   Atrypa sp.
   Martinia sp. (finely spinose)
   Nuculana sp.
   Dechenella sp.
   crinoid stems

McLaren states that these faunules are probably about the same age as assemblages from the Bird Fiord Formation, and the typical Weatherall Formation, i.e., Middle Devonian (probably Givetian).

Sea-Cliffs Facing Kellett Strait, Between Ibbett and Purchase Bays

About 7,500 feet of Devonian beds are exposed in the essentially homoclinal southerly dipping section exposed in the sea-cliffs between Ibbett and Purchase Bays. The lower 6,000 feet includes equivalents of part of the Weatherall Formation and the whole of the Hecla Bay. The upper 1,500 feet represents the Griper Bay Formation (*see* p. 88). All the beds in this section are younger than the Devonian rocks of the Canrobert Hills.

The lower beds exposed along the northern 7 miles of this stretch of coast, comprise about 3,000 feet of thin-bedded grey and green sandstone, with interbeds of grey siltstone and shale. Fossils collected, from talus, at locality 38, about

[1] *See* Addendum, p. 230.

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three quarters of a mile southwest of Humphries Head (GSC loc. 24861) have been identified by D. J. McLaren as:

Emanuella cf. *E. meristoides* (Meek)
"Nuculana" sp.
Paracyclas sp.
Dechenella sp.

These fossils are late Middle Devonian (probably Givetian), according to McLaren.

Seven miles south of Ibbett Bay yellowish brown, thick-bedded sandstone first appears in the section, above the 3,000 feet of beds described in the preceding paragraph. The cliffs at this point are capped by about 250 feet of light grey, yellowish brown weathering sandstone. This sandstone is overlain by about 1,000 feet of mainly drab-coloured, thin-bedded rocks that form the steep cliffs between 7 and 11 miles north of Stevens Head. Minor yellowish brown, thick-bedded sandstone occurs in this part of the section but beds of such rock are impersistent and are replaced laterally by grey, thin-bedded sandstone and shale.

The succeeding 2,000 feet is exposed in the high cliffs between 4 and 7 miles north of Stevens Head. These beds comprise yellowish brown, thick-bedded sandstone, in units up to about 200 feet thick interbedded with substantial amounts of grey, thin-bedded sandstone and shale. This unit is followed by greenish beds assigned to the Griper Bay Formation. This upper 2,000 feet appears to be the western equivalent of the Hecla Bay Formation and it has been mapped as such. The section described above reveals that the Hecla Bay Formation (a homogeneous unit of light coloured sandstone on eastern Melville) is replaced to the west by alternating units of thick-bedded, light coloured sandstone (Hecla Bay lithology) and thinly interbedded grey sandstone and shale (Weatherall lithology).

South Side of Ibbett Bay

Good exposures of the lower 3,300 feet of the homoclinal sequence south of Ibbett Bay were examined in a ravine 4 miles east of Humphries Head. The beds in this section represent the middle part of the Weatherall Formation. They, like the beds on the coast to the west, are younger than the Cape De Bray Member.

The lower 800 feet comprise thin-bedded, grey sandstones with micaceous and carbonaceous debris, with interbeds of calcareous, fossiliferous, in part dusky red weathering sandstone and grey shale. Fossils collected from this interval at locality 39 have been identified by D. J. McLaren as follows (GSC locs. 24872, 24873, 24874):

Alveolites ex gr. *A. suborbicularis* Lamarck
Uralophyllum sp.
Zonodigonophyllum sp.
Productella sp.

Anatrypa sp.
Atrypa cf. *A. independensis* Webster
Plectospirifer cf. *P. fongi* Grabau
Emanuella cf. *E. meristoides* (Meek)
Cyrtina sp.
trepostome bryozoan
Goniophora sp.
Dechenella (*Dechenella*) cf. *D. verneuili* (Barrande)

According to McLaren, this faunule is of late Middle Devonian (probably Givetian) age and is essentially the same age as the faunas from the Bird Fiord Formation and the type section of the Weatherall Formation.

The succeeding 2,500 feet in this section includes thin-bedded, grey sandstone and shale with the addition of thick beds (from 5 to 30 feet) of grey, yellowish brown weathering, carbonaceous, crossbedded sandstone. The dip of foreset beds is commonly to the south. Fossils are rare. At locality 40 a coquinoid band in the lower part of this unit contains *Myalina* sp. (GSC loc. 24875 identified by D. J. McLaren).

Near Head of Ibbett Bay

A very thick sequence of Devonian rocks is intermittently exposed 7 miles east of the head of Ibbett Bay. This section reveals a substantial part of the homocline south of Canrobert Hills, the western parts of which have been described above. In this section the beds dip steeply in the northern part of the homocline (adjacent to the unconformably overlying Pennsylvanian rocks). To the south, towards the plateau capped by the Leopold Glacier, the dip decreases and at the summit of the plateau the beds are horizontal, or very nearly so. This section includes equivalents of the Hecla Bay and Weatherall Formations, and it serves to relate the main part of the Weatherall Formation to the Cape De Bray Member, which is best displayed in the Canrobert Hills (p. 76).

Unit		Approximate thickness (feet) Unit	Total from base
	Hecla Bay Formation (part)		
5	Sandstone, light grey to white, essentially quartzose, weathers light brown to orange, forms thick beds (more than 20 feet), which weather to talus of large blocks; sandstone is partly carbonaceous and has impressions of plant fragments. Some grey, medium- to thin-bedded sandstone and silty carbonaceous shale is interbedded but exposures of this facies are poor owing to widespread talus from the thick-bedded sandstone. This unit is exposed on the plateau at the east end of Leopold Glacier and in the upper part of the ravine that takes the drainage of the northeastern part of the glacier	1,100	7,475

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Weatherall Formation (part)

4	Sandstone and shale interbedded. Sandstone is medium- to fine-grained, quartzose, grey and green. Unlike the overlying unit, these sandstones weather to thin (1- or 2-inch) flagstones. Sandstones are carbonaceous; shale is grey, silty, and carbonaceous. Dusky red clay ironstone nodules occur in talus in lower part of the section	650	6,375
3	Sandstone, grey and green, carbonaceous and micaceous, weathers yellowish brown. This sandstone is the lowest prominent, light coloured sandstone in this Devonian section, and it forms a prominent ledge in the lower part of the ravine leading north from the Leopold Glacier	25	5,725
2	Sandstone, siltstone, and shale interbedded. Sandstone is fine grained, partly calcareous and commonly micaceous, grey, weathers greenish grey and locally dusky red; forms obscurely or irregularly bedded units about 2 to 6 feet thick. Siltstone and shale units alternate but are not well exposed. Shale is grey, in part silty and micaceous, in part argillaceous. Dusky red clay ironstone nodules occur in the shale. *Atrypa* sp. observed in situ at locality 41 near base of unit. *Myalina* sp. and *Nuculana* sp. B (GSC loc. 37167, identified by D. J. McLaren) collected in talus at locality 42 from upper beds of unit. This unit is exposed in the lower part of the ravine that extends north from the Leopold Glacier; the base of the unit is exposed where the ravine leaves the continuation of the prominent escarpment south of Ibbett Bay	700	5,700
1	Intermittent exposures of beds beneath unit 2 continue north of the escarpment; these exposures lie immediately east of the head of Ibbett Bay and appear to represent a continuous (although not completely exposed) section down to the Cape De Bray Member. The beds between the Cape De Bray Member and the base of unit 2 are as follows: the lithology is essentially the same as unit 2, namely interbedded thin-bedded greenish grey micaceous sandstone, siltstone, and shale. Dusky red clay ironstone nodules are common. Hard resistant beds are lacking and these beds are less resistant to erosion than those of unit 2. The thickness of this unit is uncertain but provided that there are no repetitions from faulting it is at least 5,000 feet thick	5,000	

Although the Devonian section at the head of Ibbett Bay is rather imperfectly known it nevertheless illustrates the remarkably great thickness of the Weatherall Formation in this area. The thickness between the Cape De Bray Member and the beds assigned to the Hecla Bay Formation appears to be at least 6,400 feet. If we add to this the thickness of the Blackley and Cape De Bray Members, as exposed in the Canrobert Hills (2,300 feet and 2,000 ± feet), a figure of at least 10,000 feet for the Weatherall Formation of northwestern Melville Island seems inescapable.

Raglan Range

The Devonian rocks of Raglan Range include equivalents of the Weatherall and Hecla Bay Formations, and possibly also the Griper Bay (p. 86). The structure is rather complicated and much of the sequence is obscured by felsenmeer and talus. Consequently, it is not possible, at present, to provide a stratigraphic sequence for this area or to calculate the total thickness of Devonian rocks.

The basal Devonian rocks are exposed west and south of the lower Palaeozoic inlier that forms the west end of Raglan Range. The Siluro-Devonian[1] contact is exposed on the south side of this inlier and there the basal Devonian rocks comprise grey, friable, somewhat micaceous shale. They rest with an abrupt, but structurally conformable contact upon the underlying Kitson graptolitic shale.

A substantial part of the Devonian sequence is present on the north limb of the Raglan anticline, where East Kitson River cuts through Raglan Range. Graphic measurements show that about 7,000 feet of beds are present in this section. The lowest beds examined are near the core of the anticline. They are exposed on the north side of East Kitson River, where this stream flows westward, near the axis of the anticline. They comprise thin-bedded, greyish green, carbonaceous sandstone, siltstone and shale with dusky red clay-limestone nodules. Fossils from locality 43 (GSC loc. 37168) have been identified by D. J. McLaren as

Atrypa cf. *A. independensis* Webster
Emanuella cf. *E. meristoides* (Meek)
trepostome bryozoan
"Aviculopecten" sp.

These Middle Devonian fossils clearly indicate the presence of the Weatherall Formation.

These relatively thin-bedded, dark coloured rocks are overlain by strata in which light coloured, thick-bedded, yellowish brown and orange weathering sandstone is dominant. Talus and felsenmeer from these sandstones commonly obscure the outcrops, and consequently it is not possible to give a detailed description of this part of the section. Felsenmeer composed of these light coloured sandstones caps most of the Raglan Range plateau. The lithology of these sandstones and their position with respect to the fossiliferous Weatherall beds leave no doubt that the Hecla Bay Formation is represented in Raglan Range. The exposures seen are too poor to establish whether the Hecla Bay is composed entirely of light coloured, thick-bedded sandstone (as on eastern Melville) or whether it comprises intercalations of thickly and thinly bedded rocks (as on the west coast).

The felsenmeer-covered lowland north of Raglan Range probably represents an area underlain by the Griper Bay Formation (p. 86).

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[1] *See* Addendum p. 230.

South of McCormick Inlet

A complete section of the Weatherall Formation is more or less continuously exposed south of the head of McCormick Inlet. This section has not been studied in detail and the total thickness is not known.

The contact with the underlying Cape Phillips Formation is exposed 3 miles southwest of the head of McCormick Inlet, and is sharp. The basal Weatherall beds include much grey, friable, micaceous shale and siltstone, less resistant to erosion than the underlying graptolitic shales. Higher beds of the Weatherall Formation are well exposed in canyons 8 miles south of McCormick Inlet and include drab-coloured, interbedded sandstone and shale, like the upper Weatherall beds south of Ibbett Bay. Exposures of the overlying Hecla Bay Formation are relatively poor, for, as in most parts of Melville Island, the exposures are masked by talus and felsenmeer of the dominant rock type: thick-bedded, white, yellowish brown or orange weathering sandstone. Such sandstones form the surface of the plateau west of Hecla and Griper Bay, on the axis of the Blue Hills syncline.

Although the details of this section are not known, this well-exposed, structurally simple sequence reveals that the Devonian sequence in this area consists entirely of clastic rocks, without any representative of the Blue Fiord limestone. As already mentioned, it is impossible to determine, without subsurface data, the extent of this limestone in southern Melville Island. The section south of McCormick Inlet reveals that the limestone is definitely not present in this area. It should also be mentioned that the lower Weatherall beds in the McCormick Inlet area seem to be essentially homogeneous and are not readily differentiated from the higher beds. This section therefore seems to differ from the sequence in the Canrobert Hills, where the Blackley and Cape De Bray Members form distinct units at the base of the Weatherall Formation.

Between Purchase Bay and Liddon Gulf

The Weatherall and Hecla Bay Formations outcrop extensively at the head of Purchase and Barry Bays; on the face of the Blue Hills fault-line scarp; in the upper reaches of Murray Inlet; and on the face of the Mount Joy fault-line scarp, which crosses the lower part of Murray Inlet. Small outcrops, probably mainly or entirely Hecla Bay Formation, are exposed on a fault block north of Warrington Bay and adjacent to the Hardy Bay and Comfort Cove faults. These rocks have not been studied in detail. The available data suggest that they resemble the upper Weatherall and Hecla Bay beds that are exposed on the west coast of Melville Island, between Ibbett and Purchase Bays (p. 77). At the head of Purchase Bay, adjacent to the Blue Hills fault, and at Mount Joy, the lowest part of the exposed section includes thinly interbedded grey sandstones and shales; the upper beds in these areas are mainly yellowish brown and orange

weathering thick-bedded sandstone. Throughout much of this area these hard thick-bedded sandstones are more or less horizontal and they form high felsenmeer covered plateaux. At the head of Purchase Bay and north of Barry Bay it has been possible to map a boundary corresponding to the appearance of abundant thick-bedded sandstone. This boundary, as on the west coast, is presumed to be at approximately the same level as the base of the Hecla Bay Formation. In other sections, namely in upper Murray Inlet and along the Mount Joy and Blue Hills faults, the presumed equivalents of the upper part of the Weatherall Formation have not been separately mapped. Such equivalents are nevertheless probably present. Throughout this area, as on the west coast, the boundary between the Weatherall and Hecla Bay Formations is transitional, and drab coloured, thinly bedded rocks occur within the Hecla Bay equivalent. No fossils have been collected from the Weatherall beds in these areas, and it is improbable that any sections expose the relatively low, fossiliferous parts of the Weatherall Formation.

Griper Bay Formation

The Griper Bay Formation rests conformably upon the Hecla Bay and includes the youngest Devonian rocks in the western Queen Elizabeth Islands. The Griper Bay, like the Weatherall Formation, consists mainly of sandstone, siltstone and shale, but thin coal seams and conglomerate beds also are present. Much of the Griper Bay was probably deposited under non-marine conditions but marine Upper Devonian fossils also occur in thin beds. The most distinctive lithological feature of the Griper Bay Formation is the colour, for it includes green, dusky red, and pink rocks in addition to drab grey beds (like most of the Weatherall Formation) and white sandstone (like the Hecla Bay).

In the account that follows the occurrences of the Griper Bay Formation are described from east to west, starting with eastern Melville Island, then the exposures of western Melville Island, and finally the outcrops on Prince Patrick Island.

Eastern Melville Island, South and East of Weatherall Bay

A substantial thickness of Griper Bay beds is preserved in the section east of the east arm of Weatherall Bay. These rocks may be regarded as the type section of the Griper Bay Formation. The exposures were examined inland where they are intermittent. Better exposures of the lower part of the formation could probably be studied in the sea-cliffs that face the east arm of Weatherall Bay. The lower contact, with he Hecla Bay Formation, is sharp and easily mapped. The lower part of this section, about 2,300 feet thick, includes green sandstone, in part micaceous and carbonaceous, greenish grey shale and siltstone, and, as minor constituents, purple shale and thin coal seams. Talus of brown weathering sandstone derived from beds near the top of this 2,300-foot sequence has yielded

the following Upper Devonian (Frasnian)[1] brachiopods, identified by D. J. McLaren (fossil locality 44, GSC loc. 37236):

Chonetes sp. H

Camarotoechia cf. *C. letiensis* Gosselet

These species also occur about 2,400 feet above the base of the Griper Bay Formation in the section north of Beverley Inlet. Marine bands are rare in the Griper Bay of Melville Island and it is probable that this bed with *Chonetes* and *Camarotoechia* represents a marine marker bed. Exposures above the *Camarotoechia* bed are poor. The rock in this part of the section is mainly disintegrated by frost action. The frost-shattered debris consists of pink, white, light grey and yellowish brown, fine- to medium-grained quartz sandstone. These light coloured Griper Bay beds are the youngest Devonian rocks in eastern Melville Island and are of relatively restricted extent. In addition to the occurrence described above, similar light coloured upper Griper Bay beds occur in the syncline between King and Robertson Points and they form a long belt following the axis of the syncline between Robertson Point and Consett Head. These upper Griper Bay beds are probably about 700 feet thick. Adding this figure to the thickness of the predominantly green lower Griper Bay beds it would appear that the total thickness of the Griper Bay Formation in eastern Melville Island is about 3,000 feet.

Northeast of Beverley Inlet

Good exposures of about 2,400 feet of Griper Bay beds occur on the south limb of the Robertson Point anticline, 6 miles northeast of the head of Beverley Inlet. This section is as follows.

Unit		Thickness (feet) Unit	Total from base
8	Intermittently exposed unit; mainly sandstone, green, thin-bedded, and carbonaceous; units of light grey, yellowish brown, and almost white sandstone, from 20 to 60 feet thick, are interbedded. Also interbedded are grey and green, silty and carbonaceous shales, which are not well exposed. At the top of this unit a thin, brown weathering calcareous sandstone contains (loc. 45, GSC loc. 37173): *Chonetes* sp. G; *Chonetes* sp. H; *Camarotoechia* cf. *C. letiensis* Gosselet; *Cyrtospirifer* sp. (identifications by D. J. McLaren)[1]	1,800	2,393
7	Sandstone, light grey to white, thin- to medium-bedded, locally carbonaceous and with dusky red specks and streaks	35	593
6	Thinly laminated coal	1	558
5	Shale, grey, poorly exposed	4	557
4	Poorly exposed interval; apparently mainly green sandstone	65	553

[1]These collections are now dated as Famennian by McLaren.

3	Sandstone, green, thin-bedded, with abundant carbonaceous material on bedding planes	63	488
2	Sandstone, white, medium- to thin-bedded, weathers to slope covered with thin flagstones	215	425
1	Sandstone, green, thin- to medium-bedded; contains some carbonaceous material. Sandstone has bands and irregular patches of dusky red weathering sandstone; dusky red bone bed conglomerate occurs near base; minor grey shale interbedded	210	
	Underlying beds: Hecla Bay Formation. At the contact, which is sharp, there is a foot of grey shale with bands of white sandstone up to 2 inches thick.		

This section illustrates the character of a substantial part of the Griper Bay Formation as developed in southern Melville Island. The white sandstone (unit 2) that lies just above the base has a wide distribution. Despite the occurrence of white sandstone within the section, the lower 2,300 feet of Griper Bay beds forms a very distinctive green terrain throughout southern Melville Island. This greenish colour characterizes most of the area underlain by the Griper Bay Formation, except for the areas where, as already noted, there are higher beds, mainly light in colour.

Southwestern Dundas Peninsula

The Griper Bay Formation forms the bedrock for the whole of southwestern Dundas Peninsula. Throughout most of this area the beds are horizontal, or nearly so. These horizontal beds form a fine range of sea-cliffs on the south and west ends of the peninsula. The dominant rocks are greyish green and grey, thin-bedded sandstone and shale. Dusky red, brown, and purple colours also prevail locally. The sandstones are commonly carbonaceous and micaceous. The total thickness of Griper Bay beds exposed in this area probably does not exceed 1,500 feet. There is no evidence that the section goes as high as the level of the light coloured sandstones preserved in some of the synclines to the east (p. 84).

Detailed observations on parts of the south coast of the peninsula 3 miles east of Cape Providence have been made by McMillan (1910, pp. 387-388), and at Cape Clarendon (idem., pp. 401, 402). McMillan collected fossils from these beds and they were described, but not figured, by Lambe (1910). They include *Lingula melvillensis* Lambe "from beds of shale in the second ravine northeast of Cape Providence and elsewhere in clay ironstone" (McMillan, 1910, p. 455); and *Estheria canadensis* Lambe, "found abundantly in clay ironstone at an elevation of 450 feet in the first ravine—4 miles—northeast of Cape Providence" (McMillan, idem.). The estherians described by Lambe have been figured by Copeland (1962). The relationship of this estherian horizon to the beds with marine Frasnian fossils, that occur in the Griper Bay elsewhere, is not known, possibly the estherian bed is lower. Estherian-bearing beds are also known from two localities on the west coast of Melville Island (p. 88), but they are unknown elsewhere.

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At locality 45A, about 10 miles west of Cape Clarendon, some vertebrate fossils were collected from the Griper Bay beds. They have been examined by Wann Langston Jr., of the National Museum of Canada, who reports:

> The specimens include part of a postventrolateral plate of *Bothriolepis,* a fragment of Arthrodiran bone and an incomplete scale of a porolepiform crossopterygian fish. The identification of these specimens is open to question owing to the incompleteness of the material. *Bothriolepis* and its allies were confined to the Devonian period and were essentially cosmopolitan. The arthrodires were practically limited to the Devonian and are best represented in the northern hemisphere whereas holoptychiid crossopterygians are known to occur only in Middle and Late Devonian deposits, mainly in the northern hemisphere, but possibly also in Antarctica. The holoptychiid scale submitted resembles somewhat a scale of *Laccognathus* from the Oredesch beds of Latvia (upper Middle Devonian).

North of Raglan Range

On the north side of the central part of Raglan Range, between the Range and the cuesta formed by the overlying Assistance and Bjorne Formations, there is a belt of felsenmeer 1 mile to 2 miles wide, composed mainly of grey sandstone covered with black lichen. The felsenmeer belt forms a topographic depression north of the Range, and this depression is parallel with the strike of exposed Hecla Bay beds. It is probable that this depression represents an area where the hard, resistant, Hecla Bay sandstones are overlain by the softer beds of the Griper Bay Formation. Structurally this suggestion seems reasonable, for, as already mentioned (p. 81), a very substantial thickness of northerly dipping Hecla Bay rocks occurs south of this topographic depression, near the west end of Raglan Range. Owing to the heavy felsenmeer cover, no exposures were found to confirm that Griper Bay beds are present in this area, but they are nevertheless shown on the map.

West of Murray Inlet

Good exposures of the basal Griper Bay beds were examined in the prominent valley at the head of the west arm of Murray Inlet. This arm joins the inlet proper immediately south of Mount Joy. On the north side of this valley the Hecla Bay beds dip beneath the Griper Bay; on the south side, the Hecla Bay is brought into contact with the Griper Bay along the Murray Inlet fault. Approximately 1,000 feet of Griper Bay beds is preserved on this down-faulted block. The basal beds, on the north side of the valley, are medium- to thin-bedded, greenish and grey sandstone and shale. The higher beds, on the south side of the valley, adjacent to the fault, include thin-bedded green and grey sandstone with dusky red clay ironstone nodules; grey micaceous shale; grey argillaceous shale and at least one bed (poorly exposed) of coal. A single brachiopod (GSC loc. 37165), identified by D. J. McLaren as *Cyrtospirifer* sp., preserved in brown sandstone, was collected in talus on the south side of the valley at locality 46. Thin pieces of dusky red intraformational conglomerate with impressions of placoderm plates were also found in talus.

North of Murray Inlet

The Griper Bay Formation forms a substantial patch of horizontal and gently dipping strata north of the head of Murray Inlet, on the axis of the Blue Hills syncline. Near the northernmost part of Murray Inlet these beds form steep cliffs, showing the characteristically well-bedded Griper Bay strata. Scattered small exposures occur on the plateau to the north. The thickness of Griper Bay beds preserved in this syncline is probably between 1,500 and 2,000 feet. The basal beds, immediately above the Hecla Bay Formation, were examined in the valley at the head of Murray Inlet. They comprise thin-bedded, green and grey sandstone, forming rubbly, recessive outcrops above the hard, cliff-forming, uppermost Hecla Bay sandstone. The fine cliff exposures to the north were not examined. Pieces of coal, up to 4 inches thick, are common in the streams that drain these cliffs.

Small outcrops of the Griper Bay Formation were examined on the plateau north of Murray Inlet (at locality 47), about latitude 75°38′N, longitude 113°45′W. The beds there comprise greenish grey sandstone and grey shale with plant fragments.

Plants from this locality have been described by D. C. McGregor as follows (GSC palaeobotanical cat. No. 5234):

> The fragmentary megafossil remains on the sample are similar to axes and scattered pinnules described by Nathorst (1904) from the Upper Devonian of Ellesmere Island, which he identified as *Archaeopteris fissilis* Schmalh., a species originally described from the Donetz Basin. Assignment of the present specimens to this species is tentative; they are too fragmentary to allow positive identification.
>
> Numerous spores were extracted from the sample by bulk maceration. They definitely confirm an Upper Devonian age. Spores with bifurcate spines, of the *Archaeotriletes-Hystrichosporites* group are abundant. Comparison of several types with drawings of spores from the Russian Platform suggest that the age is Frasnian, but too little is known of spore distribution in the Upper Devonian of North America to confirm this. The Canadian material I have seen that is most similar to 5234 is from the Upper Devonian *Archaeopteris* beds at Escuminac Bay, Quebec, but detailed comparisons between these two assemblages have not been made yet.

South of Purchase Bay

The Griper Bay Formation is exposed over an extensive area between Purchase Bay and M'Clure Strait. Throughout much of this area the Griper Bay beds dip at low angles or are horizontal and sections within a confined area reveal only a small part of the formation. No detailed studies have been made in this area. The basal beds have been examined south of the head of Purchase Bay, where, as throughout Melville Island, they consist mainly of thin-bedded, green and greyish green sandstone. Nearly all the beds in this area apparently represent green and grey, medium- to thin-bedded rocks, mainly sandstone with minor shale. The beds on the west coast, between Kelly Point and Comfort Cove are different (*see* p. 88) for they include thick-bedded, yellow weathering sand-

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stones. There are two small areas where light coloured sandstones occur high in the Griper Bay Formation. One is 13 miles north of the head of Warrington Bay, where reddish weathering sandstones were observed from the air. These sandstones overlie typical, green, lower Griper Bay beds. Light coloured sandstones were also seen 11 miles northwest of the head of Warrington Bay, on the north (downthrown) side of the Comfort Cove fault. Both these occurrences of thick-bedded, light coloured sandstone probably represent strata equivalent to the upper Griper Bay beds of eastern Melville Island (p. 84).

Sea-Cliffs Facing Kellett Strait, North of Purchase Bay

The Griper Bay Formation forms sea-cliffs for 3 miles north of Stevens Head, the cape at the northwest corner of Purchase Bay. The Griper Bay beds rest with an abrupt contact upon the hard, yellowish brown to orange weathering sandstone which has been mapped as the top of the Hecla Bay Formation. The Griper Bay beds in this section comprise about 1,500 feet of medium- to thin-bedded, grey and greenish grey hard sandstone with poorly exposed softer beds intercalated. These softer beds include platy, micaceous, fine-grained, grey carbonaceous sandstone and minor grey shale. Thin coal beds occur but are poorly exposed. Pieces of coal are common in talus. No pieces more than 4 inches thick were seen. It is unlikely that the thickness of any seam greatly exceeds this figure. Some of the green sandstones show ripple-mark. Dusky red patches occur in the sandstone, and chip-conglomerate composed of dusky red shale in green sandstone matrix is also present. Twenty-four species of spores have been identified from talus fragments of coal collected at this locality (McGregor, 1960).

Sea-Cliffs Facing Kellett Strait, Between Purchase Bay and M'Clure Strait

Good exposures are found along this stretch of coast, where the sea-cliffs reach a height of about 900 feet. The structure along the coast is essentially anticlinal, with a fault interrupting the section south of Comfort Cove. The higher beds of the anticlinal section, exposed near the entrance to Purchase Bay, at Kelly Point, consist mainly of greenish grey and grey, thin-bedded carbonaceous sandstone. Fragments of dusky red sandstone and clay ironstone occur as talus and at locality 48 they contain *Lingula* sp., *Asmussia* sp. cf. *A. membranacea* (Pacht) and *Asmussia* sp. cf. *A. pogrebovi*? (Lutkevich) (GSC loc. 21863). These fossils have been identified by M. J. Copeland (1962).

Lower beds are exposed between Kelly Point and Comfort Cove. These rocks include thick beds of hard, yellowish weathering sandstone, similar to the sandstones in the Hecla Bay equivalent exposed between Ibbett and Purchase Bays (p. 77). On the preliminary map for Melville Island published in 1959 (Thorsteinsson and Tozer, 1959) these beds were tentatively assigned the unit now named the Hecla Bay Formation. However they contain thin coal seams,

unlike the Weatherall and Hecla Bay Formations, and it is now suggested that they represent an unusual facies in the lower part of the Griper Bay. It is impossible to assign these beds to the upper, light coloured part of the Griper Bay Formation because they are clearly overlain by typical, green, Griper Bay beds. In placing these beds in the Griper Bay Formation it is not suggested that this is a final, satisfactory solution. Considerable uncertainty exists regarding their exact correlation.

In the cliffs 2½ miles south of Kelly Point, at locality 49, the beds comprise yellowish brown sandstone, with abundant talus, presumably derived from a thin bed of dusky red, slightly calcareous and pyritic, red, phosphatic sandstone with indeterminate fragments of placoderm fish (identified by Wann Langston) and *Schizophoria* sp. indet. (identified by D. J. McLaren) (GSC loc. 24864). Unfortunately these fossils, although certainly Devonian, do not permit an accurate age determination, but the placoderm fragments are probably Upper Devonian according to Langston.

The lithology of these Devonian rocks may be further illustrated by a section measured in the cliffs at locality 50, 5 miles north of Comfort Cove. There the beds underlie the strata with *Schizophoria* and placoderms, described in the preceding paragraph.

Unit		Thickness (feet) Unit	Total from base
6	Sandstone, grey, fine-grained, weathers yellowish brown, forms talus of flagstones	210	662
5	Coal and carbonaceous shale, occupying a poorly exposed interval of 5 feet	5	452
4	Sandstone, grey, micaceous and carbonaceous, with dusky red ironstone nodules alternating with yellowish brown weathering, relatively thick-bedded sandstone. *Pteroleaia canadensis* Copeland in dusky red clay ironstone about 200 feet above base of unit (fossil locality 50, GSC catalogue No. 24866) (identified by M. J. Copeland)	420	447
3	Shale, grey, with dusky red clay ironstone nodules	7	27
2	Sandstone, grey, very thinly bedded, bedding planes micaceous and carbonaceous, with nodules of dusky red clay ironstone	20	
1	Talus covered interval to sea-level	260	

The beds exposed at Cape Russell, facing M'Clure Strait, are mainly covered by talus. The exposures and talus consist of greenish grey and yellowish brown, mainly thin-bedded sandstone with minor dusky red sandstone and clay ironstone. Plant fragments are common in the sandstone. These beds are typical representatives of the lower part of the Griper Bay Formation.

Prince Patrick Island

Devonian rocks are exposed on the southern part of the island, where they represent the oldest exposed formation, and lithologically resemble the Griper Bay Formation of Melville Island. Several marine faunules also occur, and all appear to be Upper Devonian, according to D. J. McLaren. In addition to the Frasnian fauna, which is known in the Griper Bay of Melville Island, there are some older, early Upper Devonian faunules which are not known at any other locality within the Queen Elizabeth Islands. From the available data it would appear that Middle Devonian rocks are not exposed on Prince Patrick Island. Light coloured sandstones, similar to those of the Hecla Bay Formation, do occur, and in some areas demonstrably overlie the marine Frasnian rocks. They are therefore probably correlative with the upper, light coloured Griper Bay beds of Melville Island. Some of the light coloured sandstones on Prince Patrick Island occur in isolated fault blocks and inliers where they cannot be related to fossiliferous rocks of known age. It is conceivable that some of these inliers may represent the Hecla Bay Formation, but there is no evidence to support this and accordingly all the Devonian rocks of Prince Patrick Island are placed in the Griper Bay Formation.

The best section of the Griper Bay Formation is exposed on the west side of Mould Bay. The beds form a southerly dipping homocline, with the oldest strata exposed near the head of the bay, on the face of the escarpment a mile south of Landing Lake. This section was examined in 1954 and a brief account has already been published (Tozer, 1956, p. 16). It was originally suggested that this section included about 7,300 feet of beds. In the account that follows only 4,500 are considered to be represented. The difference in thickness is accounted for by the omission of the beds exposed on the prominent cliff southwest of Mould Bay weather station. These beds were formerly believed to be the highest in the section, but it is now considered possible that they may represent a repetition, through faulting, of beds exposed farther north. The following section therefore is restricted to the beds exposed south of Landing Lake and those forming cliffs on the west side of Mould Bay as far south as the latitude of the weather station:

Unit		Approximate thickness (feet)	
		Unit	Total from base
3	Mainly light grey to white, thick-bedded, yellowish brown weathering sandstone; sandstone is mainly quartzose but also contains white grains of kaolinized feldspar; sandstone is commonly cemented by pods of dusky red hematite. Minor constituents of unit are light grey, ripple-marked sandstone and conglomerate composed of chert pebbles up to about ½ inch in diameter; shale is probably present but is not exposed. Units, up to 3 feet thick, composed partly		

	or entirely of thinly bedded coal and carbonaceous shale are easily recognized by talus and rubble but are poorly exposed. These beds are exposed south of the small cove 5 miles northwest of the weather station	1,200	4,500
2	Mainly thin-bedded, green, fine-grained sandstone, weathering green and locally dusky red. Sandstone is essentially quartzose but also contains grains of feldspar, white mica, and carbonaceous material; minor light coloured sandstone (as in unit 3) is interbedded but is poorly exposed. This unit is exposed north and east of the small cove 5 miles northwest of the weather station	1,500	3,300
1	Sandstone and shale interbedded. Sandstone is grey and green, commonly micaceous and in part carbonaceous; shale is grey, friable, silty, in part carbonaceous, with dusky red clay ironstone nodules. Shale is well exposed at the top of this unit, on the scarp 2 miles south of Landing Lake; there is also considerable shale at the base, ½ mile south of the lake; the intervening exposures are relatively poor and consist mainly of sandstone rubble and talus	1,800	

Fossils collected from unit 1 have been identified by D. J. McLaren as follows. The age of these fossils is discussed on page 68.

1. From bed about 1,000 feet above base of section, at locality 51 (GSC loc. 24882)
   Atrypa sp.
   Cyrtospirifer sp.

2. Talus from bed exposed at locality 51 (GSC loc. 24883)
   Atrypa ex gr. *A. devoniana* Webster
   Cyrtospirifer ex gr. C. *verneuili* (Murchison)

3. Locality 52, from bed about 1,000 feet above the base of section. This fossil bed is approximately on strike with the beds exposed at locality 51. The beds at both localities represent approximately the same horizon but the exact relationship has not been established (GSC loc. 24880)
   Warrenella sp. B

4. Also from locality 52, from beds 20 feet lower in the section (GSC loc. 24881)
   Douvillinella sp.
   Nervostrophia sp.
   large rhynchonellid, cf. *Camarotoechia*
   Leiorhynchus sp. A
   Eoreticularia sp.
   Cyrtina sp.
   pelecypods indet.

5. Talus, locality 53 (GSC loc. 24885)
   Schizophoria sp.
   Eleutherokomma? sp.

6. About 100 feet above base of unit 1, locality 54 (GSC loc. 24884)

Schizophoria sp.
Allanaria sp.
Emanuella? sp.

Fragmentary plant fossils (GSC palaeobotanical cat. No. 4428) were collected about 500 feet above the base of unit 3 at locality 61. They have been identified by W. L. Fry as follows:

Bothrodendron sp. L and H

An axis similar to those associated with *Archaeopteris*

Fry states that although the plants in this collection lack the diagnostic elemental features that are necessary for an accurate age determination, they nevertheless resemble Devonian form genera.

Thin-bedded rocks, with fossiliferous bands, similar to those in the lower part of the section described above (unit 1) outcrop extensively at the north end of Mould Bay and between the bay and Landing Lake.

Immediately east of Landing Lake (locality 60, GSC loc. 24889) *Cyrtospirifer* ex gr. *C. verneuili* (Murchison) and *Atrypa* ex gr. *A. devoniana* Webster of Frasnian (Upper Devonian) age, determined by McLaren, were collected. Lower beds in this area have provided several faunules that are probably not widely separated stratigraphically. The following have been identified by McLaren:

Locality 55 (GSC loc. 24886)

rhynchonellids indet.
spiriferids indet.
Cyrtina sp.

Locality 56 (GSC loc. 24887)

Schizophoria cf. *S. athabaskensis* Warren
Eostrophalosia sp.
Allanaria cf. *A. allani* (Warren)

Locality 57 (GSC loc. 24888)

Eleutherokomma cf. *E. leducensis* Crickmay

Locality 58 (GSC loc. 24890)

Schizophoria sp.
Devonoproductus sp.
Allanaria cf. *A. allani* (Warren)
Cyrtina sp.

Locality 58 (GSC loc. 24891). From 6-inch coral bed about 20 feet below GSC loc. 24890.

Alveolites sp.
Thamnopora sp.
Phacellophyllum sp.

Locality 59 (GSC loc. 24894), in association with *Callixylon* sp. (identified by W. L. Fry)

Eleutherokomma sp.

McLaren considers that the faunules from localities 55, 56, 57, 58 and 59 inclusive are of early Upper Devonian age (p. 68). At present they are known from no other localities within the Queen Elizabeth Islands.

The Devonian rocks exposed in other parts of Prince Patrick Island resemble parts of the section described above.

On the west side of Intrepid Inlet the Devonian rocks are mainly green sandstone and grey micaceous shale with dusky red clay ironstone nodules. Poorly preserved brachiopods were seen 8 miles north of Disappointment Point. The beds in this area probably correlate with beds in the lower part of the section at the head of Mould Bay.

Devonian rocks reach the surface as isolated inliers on several fault blocks between Crozier Channel and Mould Bay. Light coloured, thick-bedded, orange weathering sandstone, forming heavy talus and felsenmeer, forms the cliffs on the east side of Mould Bay, south of the weather station. A similar rock forms the prominent ridge 3 miles to the east of the station. In the sea-cliffs immediately north of the station green carbonaceous sandstone is the prevalent rock. The green beds are underlain by poorly exposed thick-bedded, light coloured sandstone, forming a belt of felsenmeer about a mile north of the station.

An extensive Devonian terrain occurs between Mould Bay and Walker Inlet. The best exposures in this area occur at the head of Mould Bay and have already been described. The prominent cliffs on the west side of the bay, 4 miles southwest of the weather station, expose light grey to white, thick-bedded quartzose, locally hematitic sandstone interbedded with green sandstone. Two thin, poorly exposed coal seams also occur in this cliff. The exposures inland are mainly thick-bedded, yellowish weathering sandstone. Good exposures occur on the east side of Walker Inlet, 9 miles north of Cape Cam. These beds are mainly well-bedded to medium-bedded, green and grey, in part dusky red weathering sandstone. They resemble the beds in unit 2 in the section at the head of Mould Bay.

The Devonian rocks west of Walker Inlet have been examined 11 miles north of Cape Mecham and 6 miles north of Domville Point. At these localities they comprise greenish grey, thin-bedded, fine-grained sandstone and siltstone. They, like the beds north of Cape Cam, are probably equivalent to strata in the middle of the section at the head of Mould Bay.

Pennsylvanian

Canyon Fiord Formation

J. C. Troelsen, geologist of the Danish Thule and Ellesmere Lands Expedition, 1939-41, was the first to describe Pennsylvanian rocks in the Canadian Arctic Archipelago. His discovery locality was in Canyon Fiord, one of the largest fiords penetrating the west side of Ellesmere Island. For these rocks, which yielded Middle Pennsylvanian fossils, Troelsen (1950, p. 65) proposed the name "Canyon Fiord formation". On his first visit he studied only the upper

part of the formation, which he described as "chiefly composed of grey, impure, highly fossiliferous limestone overlain by grey sandstone" and totalling some 420 feet of beds. The grey sandstone did not yield fossils and consequently he excluded it from the Canyon Fiord formation.

In 1952 Troelsen returned to the type section of the Canyon Fiord formation. On this occasion he made a major contribution to the geology of Ellesmere Island by demonstrating that an angular unconformity separated the Canyon Fiord beds from the underlying Silurian rocks. He also examined much, and perhaps all, of the formation. Troelsen has published a brief account of this work (1952), and in an unpublished manuscript (1954) he has provided further details. In the manuscript report (p. 14) he described the Canyon Fiord Formation as "composed mainly of conglomerate, quartzose sandstone and impure limestone. The colors vary from grey and yellow to violet and upon weathering the rocks in some cases assume brilliant red colours.....". This is an excellent brief lithological description of the Canyon Fiord beds and it applies not only to the type section, but to occurrences elsewhere.

In 1955, Thorsteinsson (1963) examined the lower part (about 500 feet) of the Canyon Fiord Formation in the region of the type locality. He found that these lower beds comprise a basal stratum of conglomerate, about 100 feet thick, composed of rounded to subrounded pebbles and cobbles of chert and limestone embedded in a matrix of sandstone and calcareous material. The conglomerate is succeeded by beds of thin- to medium-bedded, fine- to medium-grained sandstone. Interbeds of quartzose limestone form a minor constituent. The predominant colours of the rocks are pale yellowish orange, dark yellowish orange, moderate red, and dusky red. The total thickness of the Canyon Fiord Formation in the region of the type section was estimated to be about 1,000 feet.

Before leaving the discussion of the type section of the Canyon Fiord Formation it should be mentioned that in 1957 Thorsteinsson (*unpublished*) obtained Lower Permian fusulinids in the "grey sandstone" that Troelsen observed above the typical Canyon Fiord beds with Middle Pennsylvanian fossils. The close proximity of Lower Permian and Middle Pennsylvanian rocks in this section suggests that a substantial disconformity occurs at the base of the "grey sandstone".

In addition to the type area, the Canyon Fiord Formation is also known at Trold Fiord (Tozer, 1963b) and near Eids Fiord (McLaren, 1963a) on Ellesmere Island, and on Melville Island. It is possible that the "Guide Hill group" of Feilden Peninsula, northern Ellesmere Island (Blackadar, 1953), which is composed of reddish beds with corals, may also represent the Canyon Fiord Formation.

Certain lithological, faunal, and structural characters are common to all known occurrences of the Canyon Fiord Formation. They are as follows: 1, the formation is composed mainly of quartzose sandstone and less abundant conglomerate, quartzose limestone, argillaceous limestone, and shale; 2, outcrops of the formation, as well as soil developed on these rocks, are commonly stained various distinctive hues of red; 3, the lower beds of the formation are commonly fossiliferous

and they yield fusulinids, corals, brachiopods, and occasional trilobite fragments of Middle Pennsylvanian age; 4, the formation rests with angular unconformity on the eroded and bevelled surface of formations that range in age from Ordovician to Upper Devonian.

In the course of field work in northwestern Ellesmere Island and northern Axel Heiberg Island, Thorsteinsson has demonstrated the widespread occurrence of another facies of Pennsylvanian rocks. In these regions a relatively thick formation, composed mainly of light coloured limestone, rests with structural unconformity on rocks of lower Palaeozoic age. Minor constituent beds in the lower part of this formation include quartzose sandstone, quartzose limestone, and gypsum. The light coloured limestone has yielded both Middle and Upper Pennsylvanian fossils. It thus appears that the Middle Pennsylvanian part of this sequence represents an off-shore, basinal facies correlative with the Canyon Fiord Formation, which was probably deposited in near-shore, shoreline, and perhaps non-marine environments. The pattern of facies belts that apparently became established in Pennsylvanian time, namely, with near-shore deposits on the east and south margins on the Sverdrup Basin and off-shore deposits to the north and west will be seen to occur again in the Permian, and yet again throughout most of Mesozoic time. The relationship is particularly well established for the Permian and Mesozoic rocks. For the Pennsylvanian it is perhaps wise to interject a word of caution regarding the palaeogeography.

The Canyon Fiord Formation is remarkably discontinuous in distribution, and locally there is a substantial unconformity between Permian and Pennsylvanian beds. This is particularly well shown by the Canyon Fiord beds south of Raglan Range, northwestern Melville Island (p. 98). At least 2,000 feet of Canyon Fiord beds are present south of the Range. About 15 miles to the north, on the north side of the Range, Pennsylvanian rocks are entirely absent, and Permian rocks lie directly on the Devonian. The Canyon Fiord rocks south of the Range include much conglomerate, apparently of local derivation. The basal beds of the sequence contain marine Pennsylvanian fossils, suggesting communication with the Sverdrup Basin, to the north. The upper beds are unfossiliferous and consequently there is no evidence to suggest such a connection. This introduces the possibility that the Canyon Fiord rocks south of Raglan Range were deposited within an intermontane basin, with only intermittent and perhaps indirect marine connection with the open sea of the Sverdrup Basin. In attempting to picture the palaeogeography of the Queen Elizabeth Islands for Pennsylvanian time, the possibility of the existence of such basins should be borne in mind (*see* p. 209).

Within the map-area the Canyon Fiord Formation is exposed only on Melville Island, and occurs as discontinuous belts and isolated outcrops extending from Weatherall Bay to Marie Bay. Throughout this region the formation rests with angular unconformity upon most of the Devonian and older formations exposed in the Parry Islands Fold Belt. The structural relationship of the Pennsylvanian rocks in eastern Melville Island, between Weatherall and Sabine Bays, is comparatively simple. There the principal exposures constitute a con-

tinuous belt that strikes northeasterly and follows the narrow neck of land that joins Sabine Peninsula with Melville Island proper. In this part of Melville Island the regional dip of the Canyon Fiord Formation is northwesterly, towards the axis of the Sverdrup Basin. Normal faulting, probably of Tertiary age, has resurrected a relatively small inlier of Pennsylvanian rocks around Tingmisut Lake. This inlier is not far from the main outcrop. In northwestern Melville Island the relationship is more complex. Not only was the Canyon Fiord Formation deposited on the folded and eroded lower Palaeozoic formations, but the Canyon Fiord beds were themselves folded and eroded prior to deposition of the Permian Assistance Formation. As a consequence of erosion and the complex sequence of structural events the Pennsylvanian rocks of northwestern Melville Island are preserved as isolated outliers in the depressions of twice-folded structures. As already mentioned, it is possible that some of the Pennsylvanian outliers, e.g., the beds south of Raglan Range, may have been detached areas of sedimentation during part of Pennsylvanian time.

The macrofossils from the Canyon Fiord Formation have been identified by P. Harker. These fossils include the distinctive and widely distributed *Choristites* cf. *C. fritschi* (Schellwien). Harker states that the *Choristites* cf. *C. fritschi* fauna is Pennsylvanian and that this fauna is characteristic of the Canyon Fiord beds throughout the Queen Elizabeth Islands. The Canyon Fiord fusulinids have been identified by Thorsteinsson. The most abundant genus of Melville Island is *Profusulinella* which is regarded as the index genus of the early Middle Pennsylvanian (lower Atokan) in North America. *Profusulinella* and *Choristites* occur in association. Younger Middle Pennsylvanian faunas, with *Fusulina* and *Fusulinella* occur on Ellesmere Island. All the fossils from the Canyon Fiord Formation are from the lower beds. The upper beds on Melville Island appear to be unfossiliferous. These upper Canyon Fiord beds are overlain, in places unconformably, by Permian rocks. This circumstance, and the lithological homogeneity of the Canyon Fiord beds, suggest that the whole formation is of Pennsylvanian age. Possibly the upper beds are correlative with the *Fusulina*-bearing rocks (i.e. Desmoinesian) in the Canyon Fiord Formation of Ellesmere Island.

Between Sabine and Weatherall Bays

The Canyon Fiord Formation forms an extensive terrain extending from Sabine Bay, northeast to Weatherall Bay. Throughout most of this belt the beds are essentially homoclinal to the northwest and they overlie, with angular unconformity, the folded rocks of the Parry Islands Fold Belt. At the east end of the belt the structure of the Pennsylvanian rocks is synclinal. The extent of the unconformity is shown, not only by the angular discordance and the difference in strike but also by the fact that the Canyon Fiord beds rest on four Devonian Formations (Blue Fiord, Weatherall, Hecla Bay, and Griper Bay) in different parts of the belt. The Canyon Fiord beds are abruptly overlain by Permian beds.

Fairly good exposures occur where the west arm of Weatherall Bay traverses this belt of Canyon Fiord strata. No detailed section has been measured, but the total thickness is about 2,000 feet. Brilliant colours, mainly red and orange, characterize most of the exposures, but shades of green, brown, and white also occur. The beds are mainly conglomerate and sandstone with minor red shale containing grey nodules of limestone. Pebbles in the conglomerates are mainly well rounded. They attain a diameter of at least 6 inches but are commonly much smaller, and are composed of sandstone, like the local Devonian sandstones, together with grey, black, and red chert. Fossils appear to be rare. At locality 62, on the west shore of Weatherall Bay a few brachiopods (GSC locs. 25911, 25912) identified by P. Harker as *Chonetes* sp. were collected.

Tingmisut Lake

The Canyon Fiord Formation is brought to the surface around Tingmisut Lake, where it flanks, on three sides, the inlier of Silurian dolomite. The beds rest disconformably upon the Silurian dolomite and are overlain by the Sabine Bay Formation of Permian age; their total thickness is about 1,800 feet. The beds are commonly soft and slumped, consequently it was not possible to measure the dip with the precision necessary to determine the thickness accurately. The lowest beds, immediately above the Silurian dolomite, comprise about 300 feet of light grey to white, quartzose, medium-grained sandstone, with some grains of black chert and much carbonate cement. At locality 63, east of Tingmisut Lake, a well-preserved Middle Pennsylvanian brachiopod fauna was obtained from this basal unit of the formation. The following species have been identified by P. Harker (GSC loc. 25910).

Linoproductus cora, auctt.
Echinoconchus punctatus Martin
Productus cf. *P. longispinus* Sowerby
Productus ex gr. *P. irginae* Stuckenberg
Spirifer sp.
Choristites sp.
Choristites cf. *C. fritschi* (Schellwien)
Phillipsia sp.

The succeeding beds consist of interbedded sandstone and conglomerate, with, at the top of the section, red shale containing grey limestone concretions up to about 3 inches in diameter. The conglomerates consist mainly of well-rounded, grey, black, and red chert pebbles. The pebbles reach a diameter of about 3 inches but most are smaller. One pebble of black chert was found to contain an indeterminable diplograptid and hence to be of Ordovician or Silurian age. Pebbles of light grey and reddish quartzite also occur but are less common. The sandstone interbedded with the conglomerate is light grey to light brown and of fine to coarse grain. It is essentially quartzose, but, like the conglomerate, also

contains considerable chert. Locally the sandstone is crossbedded. Most of the rock weathers, or is stained, a reddish colour.

South of Raglan Range

Here the formation outcrops throughout a large area that is essentially synclinal, and the beds rest unconformably upon the Cornwallis, Cape Phillips, Weatherall, and Hecla Bay Formations. The relatively soft Canyon Fiord beds are flanked, to the north and south, by harder, older formations. Where the belt of these rocks intersects the coast we find the indentation of McCormick Inlet. The soft Pennsylvanian strata are probably responsible for the locus of this inlet.

The total thickness of Canyon Fiord rocks preserved in this area has not been accurately determined, but is probably about 4,000 feet. These beds are the youngest in the syncline and no succeeding formations are preserved.

The lower 1,500 feet of the Canyon Fiord Formation was examined on the south flank of the Raglan Range, 8 miles west of the head of McCormick Inlet. This area is on the north flank of the syncline and the Canyon Fiord beds rest upon the Hecla Bay Formation. The actual Hecla Bay-Canyon Fiord contact was not seen but the bedding of the two formations is essentially parallel, suggesting that they could be conformable. However, the structural relations in other parts of this synclinal area, throughout Melville Island, and indeed throughout the Archipelago, indicate that this structural conformity is purely fortuitous. This local situation does not alter the conclusion that a profound regional unconformity separates the Devonian and Pennsylvanian rocks.

The lower 500 feet of the section on the south flank of the range comprises an alternating series of red and green sandstone. The alternating layers are from 1 foot to 20 feet thick and impart a distinctive banded appearance to the landscape. The sandstone is loosely consolidated to unconsolidated and mainly fine grained. At locality 64 a thin limestone bed occurs about 200 feet above the base. This limestone has yielded the following fossils (GSC loc. 37215):

Profusulinella sp.
Chaetetes cf. *C. radians* Fischer

Sandstones as described above continue throughout the 1,500-foot section. About 500 feet above the base of the section, beds of conglomerate become an important constituent. These are composed of rounded to subangular pebbles and cobbles of grey and brown sandstone, and are clearly identifiable with rock types in the Devonian of Melville Island. The clasts, which increase in size in stratigraphically higher beds, are embedded in a matrix of red, medium- to coarse-grained sandstone. Individual beds range in thickness from a few inches to over 20 feet.

The basal contact of the Canyon Fiord Formation is actually exposed on the south limb of the syncline, near locality 19, 3 miles southwest of the head of McCormick Inlet (Pl. XX), where the Cape Phillips Formation underlies the Canyon Fiord beds with marked angular discordance. The basal 20 feet of the

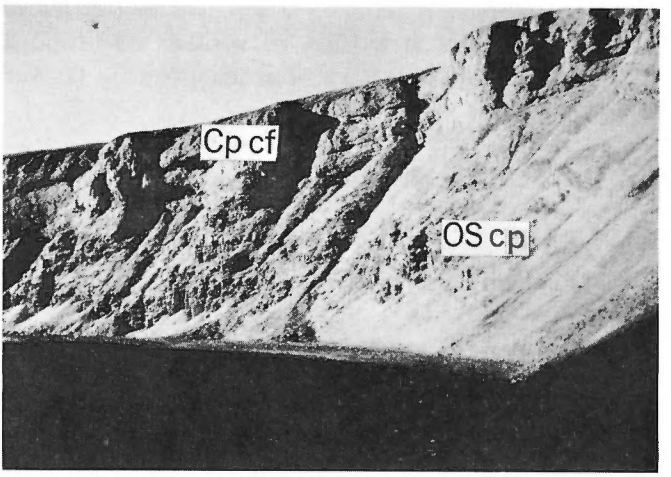

PLATE XX

Unconformable contact between the basal conglomerate of the Canyon Fiord Formation (Cp cf) and the Cape Phillips Formation (OS cp) 3 miles west of McCormick Inlet, Melville Island. The Canyon Fiord beds dip north (left); the Cape Phillips beds to the south (right).

Canyon Fiord Formation consists of massive conglomerate, grey in overall colour, composed of pebbles (up to 4 inches in diameter) of grey dolomite, black chert, white and black shale. These pebbles are evidently derived from the local Ordovician and Silurian formations.

Near the Head of Ibbett Bay

The lower part of the Canyon Fiord Formation is well exposed along the north side of the valley formed by the main stream that enters the head of Ibbett Bay. Some 8 miles northeast of the head of the bay and, at the southern limit of extensive Canyon Fiord outcrops, the basal beds (about 50 feet thick) were examined. At this locality the basal unit of the formation is a 5-foot bed of pebble conglomerate composed of varicoloured, rounded to subrounded sandstone pebbles embedded in a matrix of red, coarse-grained, quartzose sandstone. Fusulinids and crinoid columnals are scattered sparsely throughout this rock. The conglomerate is overlain by beds, variable in colour but mainly light grey and dusky red, of calcareous quartzose sandstone, quartzose sandstone, and quartzose limestone. At locality 65, from a thin dusky red limestone about 35 feet above the basal contact, the following fossils were collected (GSC loc. 37214):

Ozawainella sp.
Pseudostaffella sp.
Profusulinella sp.
Dictyoclostus sp.
Choristites cf. *C. fritschi* (Schellwien)

Giddy River, Canrobert Hills

A collection of well-preserved brachiopods was obtained at locality 66, on Giddy River some 15 miles upstream from the mouth of the river at Marie Bay. At this locality the Canyon Fiord formation is downfaulted against the Weatherall Formation. The fault is evidently one of minor stratigraphic displacement and

the stratigraphic position of the brachiopods is probably a few tens of feet above the base of the formation. The brachiopods at locality 66 weather free from a loosely consolidated bed of red sandstone. They have been identified by Harker as follows (GSC loc. 37213):

Chonetes sp.
Dictyoclostus cf. *D. gruenewaldti* (Krotova)
Waagenoconcha sp.
Marginifera cf. *M. typica* Waagen
Echinoconchus cf. *E. punctatus* (Martin)
Choristites cf. *C. fritschi* (Schellwien)
Composita sp.

South of Marie Bay

The Canyon Fiord Formation forms several linear outliers south of Marie Bay, in the relatively low-lying tract that lies north of the Canrobert Hills. In this area the Canyon Fiord beds rest unconformably upon the Ibbett Bay Formation and on the Blackley and Cape De Bray Members of the Weatherall Formation. The rock includes sandstone and conglomerate and, near the base, at least one thin bed of limestone. Most of the outcrops include much poorly consolidated rock and consequently they are commonly covered by wash and sheets of material that have been moved by solifluction. Outcrops, wash, and solifluction products in this area, as elsewhere, are commonly a brilliant red. The total thickness of Canyon Fiord rocks preserved in these outliers is relatively small, probably less than 1,000 feet. No detailed studies of these rocks have been made.

At locality 67, 11 miles west-southwest of the head of Marie Bay, a 4-foot bed of limestone with *Profusulinella* sp. (GSC loc. 37153) is exposed. The limestone is horizontal and lies about 100 feet above folded Silurian and Devonian rocks, i.e., this limestone appears to be within 100 feet of the base of the Canyon Fiord Formation. Disintegrated outcrops above the limestone yielded abundant isolated brachiopods and corals, the former including *Choristites* cf. *C. fritschi* (Schellwien) (GSC loc. 37155, identified by P. Harker).

North of Marie Bay

The Canyon Fiord Formation is not well exposed north of Marie Bay, but a reddish terrain occurs beneath the Assistance and Bjorne Formations there. The mapping of the Canyon Fiord Formation is based mainly on the occurrence of this distinctive terrain, rather than on outcrops. No Pennsylvanian fossils were found in this area.

Permian

Permian rocks are exposed only on Melville Island. Two formations are recognized: the Sabine Bay and the Assistance. The Sabine Bay Formation is

present around Weatherall and Sabine Bays, where it rests, apparently disconformably, upon the Canyon Fiord Formation (Pennsylvanian). The Assistance beds on Melville Island, as in many other parts of the Archipelago, are transgressive and rest on various older formations. The Sabine Bay Formation, which is named for the first time in this report, is of Lower Permian age; the Assistance is younger, but the exact age is uncertain.

Sabine Bay Formation[1]

The only good exposures of this formation are in the vicinity of Tingmisut Lake (Pl. XXI). The formation lies between the Middle Pennsylvanian Canyon Fiord beds and the Permian Assistance Formation. The upper and lower contacts are sharp; they appear to be conformable but are probably disconformable. The boundary between the Sabine Bay and Assistance Formations has been mapped only in the Tingmisut Lake area; in other areas data are insufficient to delimit the boundary.

Two distinct members may be recognized within the formation. The upper member consists mainly of quartzose sandstone, generally pale orange, medium grained, and commonly crossbedded. Carbonaceous material, coal seams up to 2 inches thick, beds of varicoloured chert pebbles, and coarse, quartzose sandstone also occur in the upper part of the Sabine Bay Formation. These beds are unfossiliferous and are probably of non-marine origin. The lower member includes quartzose limestone, sandy limestone, and clay, with abundant brachiopods, fusulinids, and bryozoans. The maximum known thickness of the formation is about 600 feet, but in parts of the area it appears to be considerably less.

The best exposures of the Sabine Bay Formation are north of Tingmisut Lake, between localities 68 and 73, where the following section was measured. These exposures constitute the type section of the Sabine Bay Formation. In this section the lower member of the Sabine Bay (units 1-3) forms the first conspicuous escarpment north of Tingmisut Lake. The upper member (unit 4) is exposed on the face of the second escarpment north of the lake. This second escarpment is capped by the lower beds of the overlying Assistance Formation.

Unit		Approximate thickness (feet)	
		Unit	Total from base
	Overlying beds: Assistance Formation		
	Sabine Bay Formation		
4	Sandstone, quartzose, mainly very pale orange, medium-grained, thin- to thick-bedded; interbedded with minor moderate reddish brown sandstone which on weathering imparts a pale reddish brown colour to the outcrops;		

[1] *See* Addendum, p. 229.

	numerous beds of varicoloured chert pebbles, particularly in lower part of unit; unit is intermittently exposed	400	585
3	Limestone, quartzose and bioclastic; pale yellowish brown and light grey, medium- to coarse-grained, mainly medium-bedded, weathering to pale yellowish orange, yellowish grey and dusky red; limonite specks throughout; mainly poorly preserved brachiopods and bryozoans. From locality 68 (GSC loc. 35313) the following have been identified by P. Harker: *Linoproductus* cf. *L. simensis* (Tschernyschew) *Dictyoclostus* cf. *D. neoinflatus* Licharew *Spiriferella saranae* (de Verneuil) *Fenestella* cf. *F. foraminosa* Eichwald	30	185
2	Sand, quartzose, and interbedded calcareous quartzose sandstone, pale yellowish brown, mainly medium-grained and medium-bedded; varicoloured chert grains are common; numerous round calcareous sandstone concretions	80	155
1	Limestone, variably quartzose and in part coquinoid, medium light grey, fine- to coarse-grained; thin- to thick-bedded, thin interbeds of dark grey clay and bands of varicoloured chert pebbles and quartz granules in basal 8 feet of unit; upper 30 feet of unit is composed mainly of calcareous sandstone, in part coquinoid, and soft sandstone. The following fossils were obtained from locality 68: (a) From basal 8 feet of unit (GSC loc. 37212) *Linoproductus* cf. *L. simensis* (Tschernyschew) *Waagenoconcha* cf. *W. irginaeformis* (Stepanow) *Marginifera* cf. *M. septentrionalis* Tschernyschew *Dictyoclostus* cf. *D. neoinflatus* Licharew *Kochiproductus* sp. *Spiriferella saranae* (de Verneuil) *Dielasma* sp. *Dielasma* cf. *D. truncatum* Waagen (b) 30 feet above base of unit (GSC loc. 35319) *Schwagerina* n. sp. A *Chonetina*? sp. *Paeckelmannia* cf. *P. toulai* Dunbar *Rhynchopora* cf. *R. nikitina* Tschernyschew	75	
	Underlying beds: Canyon Fiord Formation		

Several other fossil collections have been obtained from the beds assigned to unit 1 in the above section. They are as follows:

Locality 72, 1½ miles north of Tingmisut Lake (GSC locs. 25899, 25900, 25901)

Derbyia cf. *D. grandis* Waagen
Spiriferella saranae (de Verneuil)

Locality 70, 2 miles south of Tingmisut Lake (GSC locs. 25906, 37160)

Linoproductus cf. *L. simensis* (Tschernyschew)
Dictyoclostus cf. *D. neoinflatus* Licharew
Muirwoodia cf. *M. mammatus* (Keyserling)
Spiriferella saranae (de Verneuil)
Spiriferella cf. *S. keilhavii* (von Buch)
Spirifer sp.

PLATE XXI. Aerial view of Tingmisut Lake and Weatherall Bay, looking east. The Silurian dolomites (S u) are overlain by the Canyon Fiord Formation (Cp cf). Gabbro dykes, trending north, cut the Canyon Fiord beds immediately east of Tingmisut Lake. The base of the type section of the Sabine Bay Formation (Pm sb) is the cuesta north of Tingmisut Lake; this cuesta is marked by snow-filled nivation hollows. The red, basal Assistance bed (Pm a) shows as dark-toned material above the light-toned upper Sabine Bay beds (Pm sb). To the north (left) are the basal beds of the Bjorne Formation (Tr b). (RCAF T417R–40)

A small patch of the Sabine Bay Formation is preserved at locality 71, south of the ridge of Blue Fiord limestone, on the south side of Weatherall Bay. The rocks at this locality consist of brown calcareous sandstone, disintegrated by frost action. Fossils collected at this locality have been identified by P. Harker as follows (GSC loc. 25909):

Spirifer cf. *S. striatoparadoxus* Toula
Fenestrellina sp.

Seven miles southwest of Tingmisut Lake, at locality 69, beds that appear to be the equivalent of unit 4 contain thin seams (about 2 inches thick) of coal. The sandstone in this area is carbonaceous. Rocks like these were not seen at the type section, but could be present in one of the covered intervals. The total thickness of the Sabine Bay Formation in this region is probably considerably less than in the type section. The formation seems to become thinner west, south, and southwest from the type section. On the west side of Hecla and Griper Bay it is absent completely.

The fossils in the foregoing lists were identified by P. Harker (brachiopods and bryozoans) and Thorsteinsson (fusulinids). The stratigraphic position of the Sabine Bay Formation is comparable to that of the Belcher Channel Formation of Grinnell Peninsula (*see* Harker and Thorsteinsson, 1960), in that both formations are overlain by the Assistance Formation. The fusulinids from the Belcher Channel and lower member of the Sabine Bay Formations indicate that both are Lower Permian, i.e., not younger than Leonard.

It might therefore be suggested that the Sabine Bay and Belcher Channel Formations are correlative. However, there are some indications that the Sabine Bay formation is younger. If so, it was presumably deposited during the time interval that is believed to separate the Belcher Channel and Assistance Formations. The arguments that favour this interpretation are as follows:

1. Several brachiopod species (*Derbyia* cf. *D. grandis, Waagenoconcha irginaeformis, Dictyoclostus* cf. *D. neoinflatus, Muirwoodia* cf. *M. mammatus* and *Spirifer* cf. *S. striatoparadoxus*) are common to the Assistance and Sabine Bay, but are unknown in the Belcher Channel. 2. *Schwagerina* n. sp. A is a large species, apparently biologically advanced, related to, and perhaps derived from, *Schwagerina jenkinsi* Thorsteinsson. *S. jenkinsi* occurs at the top of the Belcher Channel Formation. 3. None of the fusulinid zones of the Belcher Channel Formation is known in the Sabine Bay beds. *Schwagerina* n. sp. A, which, as already noted, may be younger than the highest fusulinids in the Belcher Channel Formation, occurs near the base of the Sabine Bay Formation. This suggests that the basal Sabine Bay beds are younger than the Belcher Channel formation. 4. According to Harker, the absence of corals in the Sabine Bay Formation may be of stratigraphic significance. No corals are known in the type Assistance Formation, nor do they occur in the Assistance and Sabine Bay Formations on Melville Island. They are, however, abundant below the *Schwagerina jenkinsi* horizon, in the type Belcher Channel Formation. There is thus the suggestion

that the Sabine Bay and Assistance Formations, unlike the Belcher Channel, were deposited after the Permian corals had left the Sverdrup Basin area.

Not one of these suggestions is, by itself, conclusive. However, the weight of evidence seems to suggest that the Sabine Bay Formation is younger than the Belcher Channel.

Assistance Formation[1]

The Assistance Formation was named by Thorsteinsson to include about 200 feet of glauconitic, sandy clay of Permian age exposed on northern Grinnell Peninsula, Devon Island (*see* Harker and Thorsteinsson, 1960). In the type area the formation rests, apparently disconformably, upon the Belcher Channel Formation of early Permian age. The upper contact of the Assistance Formation on Grinnell Peninsula is the present erosion surface.

The Assistance Formation has now been recognized at widely scattered localities within the Queen Elizabeth Islands. On Ellesmere Island, the occurrences form a northeast-trending belt extending from Canyon Fiord, south to Trold Fiord. There is also an east-west belt that extends from Grinnell Peninsula to Cameron and Melville Islands. The total length of this discontinuous belt of occurrences, which is the shape of a reversed 'L', is about 700 miles. The Assistance Formation probably also occurs to the north of Canyon Fiord, namely, in Greely Fiord (Troelsen, 1950, pp. 69, 70) and near Lake Hazen (R. L. Christie, pers. com.). This formation appears to have been deposited in the eastern and southern shoreline regions of the Sverdrup Basin. Towards the basin the character of the Permian sequence changes, with the appearance of limestone, shales, and evaporites.

Throughout this extensive area the Assistance Formation rests upon a number of different formations and the basal contact marks an unconformity, which, in places, is represented by a disconformity, elsewhere by an angular unconformity. The formation is generally overlain by rocks of Triassic age.

The main localities for the Assistance Formation are as follows: (1) Between Canyon and Bay Fiords, Ellesmere Island, where Assistance beds rest upon older Permian rocks (Thorsteinsson and Tozer, *unpublished*); (2) Trold Fiord, Ellesmere Island, where the Assistance rests on Silurian, Devonian (?), and Pennsylvanian rocks (Tozer, 1963b); (3) The type area, Grinnell Peninsula, where the Belcher Channel Formation underlies the Assistance (Harker and Thorsteinsson, 1960); (4) Cameron Island, where the Assistance rests on the Upper Devonian (Greiner, 1963); and (5) Melville Island, the westernmost area, with which we are particularly concerned. There the Assistance Formation rests on Silurian, Devonian, Pennsylvanian, and early Permian strata.

Thus the Assistance Formation appears to represent the deposit of a Permian transgression directed east and south from the axial part of the Sverdrup Basin.

[1] *See* Addendum, p. 229.

The formation maintains relatively uniform character throughout its area of outcrop. It is composed mainly of green, glauconitic, quartzose sand and sandstone with lesser amounts of chert-pebble conglomerate, bedded limestone, and impure limestone. The type section, which comprises mainly glauconitic sandy clay, is not typical. Almost every outcrop of the Assistance Formation yields abundant, and commonly well-preserved, brachiopods with rare pelecypods, gastropods, and cephalopods. Corals are conspicuously absent. Harker and Thorsteinsson (1960) have correlated the Assistance Formation at its type locality with the 'Spiriferenkalk' and 'Productus kieselgestein' of Spitsbergen. The Spitsbergen beds have been assigned to a new stage, the Svalbardian by Stepanow (1957). Stepanow considered that the Svalbardian is the marine equivalent of the Kungurian, which is a non-marine formation that overlies the Artinskian in the standard Permian section of Russia. In the past the Arctic Permian faunas have generally been correlated with the Artinskian, but the present tendency is to place them higher in the section. This problem is discussed in some detail by Harker and Thorsteinsson (1960).

Outcrops of the Assistance Formation on Melville Island form two linear belts of sediments. One belt strikes northeasterly across the southern part of Sabine Peninsula; the other strikes northwesterly from near Hillock Point, in Hecla and Griper Bay, to Marie Bay, on the northwest coast of the island. These belts dip homoclinally, to the northwest on Sabine Peninsula and to the northeast in the northwestern part of the island. In northwestern Melville Island the formation rests, with angular unconformity, upon three and possibly four different formations. They are the Silurian limestone and dolomite of Raglan Range; the Hecla Bay and possibly also the Griper Bay Formations; and finally the Canyon Fiord Formation. On Sabine Peninsula the Assistance rests with structural conformity upon the Lower Permian Sabine Bay Formation. This contact is very abrupt and is probably disconformable. Throughout Melville Island the Assistance Formation is followed by the Bjorne Formation, which is apparently of Lower Triassic age. The Assistance-Bjorne contact is structurally conformable but is apparently also a disconformity.

The thickest known section of Assistance beds in the Queen Elizabeth Islands occurs on Sabine Peninsula, where the formation is about 1,600 feet thick. On Melville Island the formation thins progressively from the west to the east: on the north side of Raglan Range it is 180 feet thick, and near the head of Marie Bay it is about 50 feet. Towards the mouth of the bay the formation seems to disappear completely.

North of Tingmisut Lake, Sabine Peninsula

Good exposures of much of the Assistance Formation occur on Hiccles Creek (Pl. XXI), where the following generalized section was measured. This section appears to be representative for the Assistance Formation of Sabine Peninsula.

Unit		Approximate thickness (feet) Unit	Total from base
	Overlying beds: Bjorne Formation		
	Assistance Formation		
3	Sandstone, quartzose, glauconitic, dark greenish grey to light grey, mainly medium-grained, loosely consolidated to unconsolidated; interbedded with grey to black beds of chert up to at least a foot thick; fossils common throughout. Fossils collected from the upper 25 feet, at locality 76 (GSC loc. 37157) productids indet. *Spirifer* cf. *S. striatoparadoxus* Toula Fossils from lower beds of unit, from locality 75 (GSC loc. 37179) *Paeckelmannia toulai* Dunbar? *Marginifera*? sp. *Dictyoclostus* cf. *D. neoinflatus* Licharew *Spiriferella* sp. *Spirifer* sp. *Spirifer* cf. *S. striatoparadoxus* Toula	1,300	1,600
2	Sandstone, quartzose, calcareous, light grey, mainly medium-grained, loosely consolidated; minor beds of bioclastic limestone, unit poorly exposed. Fossils from locality 74 have been identified as follows (GSC loc. 37161) *Streptorhynchus kempei* Anderson *Marginifera* sp. *Muirwoodia* sp. *Dictyoclostus* cf. *D. neoinflatus* Licharew *Spiriferella* cf. *S. keilhavii* (von Buch) *Spirifer* cf. *S. striatoparadoxus* Toula	250	300
1	Sandstone, quartzose, dusky red, medium- to coarse-grained, interbedded with conglomerate composed of rounded to subrounded, varicoloured chert pebbles. Fossils from locality 73 (GSC loc. 37158) as follows: *Orbiculoidea* sp. productid fragments *Rhynchopora* cf. *R. nikitini* Tschernyschew	50	50
	Underlying beds: Sabine Bay Formation		

As already mentioned, Assistance outcrops are commonly covered with fossils, and many collections from widely scattered localities on Sabine Peninsula have been made. The following collections add to our knowledge of the Assistance fauna in this area.

At locality 77, about 3 miles north of Tingmisut Lake (GSC loc. 25902) the following brachiopods were collected from the dusky red sandstone that forms the base of the Assistance in this area:

Cancrinella cf. *C. germanicus* (Frebold)

Waagenoconcha cf. *W. payeri* (Toula)
Waagenoconcha cf. *W. irginaeformis* (Stepanow)
Reticularia sp.
Rhynchopora sp.
Orbiculoidea cf. *O. capuliformis* McChesney
Aviculopecten aff. *A. mutabilis* Licharew

At locality 78, 3½ miles north of Tingmisut Lake, the following were obtained from rubble derived from beds that are equivalent to unit 2 in the section described above (GSC loc. 25903).

Spiriferella keilhavii (von Buch)
Dictyoclostus cf. *D. neoinflatus* Licharew
Waagenoconcha cf. *W. irginaeformis* (Stepanow)
Spirifer osborni Harker
Streptorhynchus cf. *S. macrocardinalis* Toula
Athyris cf. *A. royssiana* Keyserling
Fenstrellina cf. *F. retiformis* Geinitz
Stenopora sp.

North of Raglan Range

Excellent exposures of the Assistance Formation outcrop in a cutbank of Green Creek, some 4 miles northwest of Hillock Point, on the west side of Hecla and Griper Bay. This locality is of some historical interest in that Sir Leopold M'Clintock collected Permian brachiopods at Hillock Point in 1853. This section is the best in the belt of Assistance rocks that crosses northwestern Melville Island.

The Assistance rests with angular unconformity on the Hecla Bay Formation (Devonian). A small, isolated patch of the Bjorne Formation, which overlies the Assistance, is a few hundred feet southeast of the Green Creek section described here. The Assistance Formation is about 180 feet thick. The lower and upper 10 feet are covered by talus. Three types of rock are represented in the exposed part of the section. More than ninety per cent comprises dark greenish grey, to greenish black, medium-grained, glauconitic, quartzose sand and loosely consolidated sandstone, partly calcareous and partly conglomeratic. Irregular and discontinuous beds of moderate red, medium- to coarse-grained, calcareous, conglomeratic sandstone make up the second rock type. These reddish beds are commonly replete with brachiopods. The third rock type is light to medium light grey, medium-grained, thin-bedded, flaggy, quartzose sandstone, commonly conglomeratic. The pebbles in the conglomerate consist of rounded to subrounded varicoloured pebbles of chert. Fossil brachiopods are abundant throughout. The following have been identified by P. Harker from locality 79 (GSC loc. 35320):

Streptorhynchus kempei Anderson
Strophalosia cf. *S. pulchella* Dunbar
Waagenoconcha cf. *W. payeri* Toula

Sowerbina rudis Dunbar
Sowerbina cf. *S. maynci* Dunbar
Spirifer sp.
Spiriferella cf. *S. keilhavii* (von Buch)
Cleiothyridina sp.

North Side of Marie Bay

Poor exposures of the Assistance Formation have been recognized on the north side of Marie Bay, 6 miles west of the head of the bay (loc. 80, Pl. XXII). At this locality the Assistance beds form a structural terrace characterized by a distinctive green colour. Slopes below the terrace are composed of bright red soil and frost-riven debris, which material is believed to be derived from the Canyon Fiord Formation (Pennsylvanian). Above the terrace are slopes covered with talus of sandstone and conglomerate derived from the Bjorne Formation (Triassic). The structural terrace represents a stratigraphic interval of about 50 feet and this figure probably represents, approximately, the total thickness of the Assistance Formation at this locality. Outcrops are rare and small. They comprise grey and greenish grey, slightly calcareous, glauconitic sandstone, weathering to a pale greenish grey. The sandstone is further characterized by scattered pebbles of chert that average about a quarter of an inch in diameter. These beds represent the westernmost known occurrence of the Assistance Formation. Fossils collected from talus at locality 80 have been identified by P. Harker as follows (GSC loc. 37162):

Waagenoconcha cf. *W. irginaeformis* (Stepanow)
Spirifer cf. *S. striatoparadoxus* Toula

Pennsylvanian or Permian

Rocks in Piercement Domes of Sabine Peninsula[1]

At the north end of Sabine Peninsula are two gypsum piercement domes: one is at the coast, at Cape Colquhoun; the other, the Barrow dome, is inland, about 9 miles to the southwest (*see* Pl. XXII). Cape Colquhoun and the Barrow dome are conspicuous landmarks that relieve the topographical monotony of northern Sabine Peninsula. Cape Colquhoun is not without historical interest geologically for it was there, in 1853, that Commander G. H. Richards, of the Franklin Search vessel HMS *Pioneer,* thought that he had discovered an abundance of mica only to be corrected by his superior officer, Captain Sir Edward Belcher, who identified the specimens as selenite (*see* Belcher, 1855, vol. 2, p. 47; *also* this report, p. 17).

No detailed examination of these domes has been made. They are principally composed of gypsum (including, as indicated by Sir Edward, the selenite variety).

[1] *See* Addendum, p. 228.

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PLATE XXII. Aerial view across western Sabine Peninsula towards the east. Prevailing dip of bedrock is to the north (left), with the Christopher (Kl c), Hassel (K h), Kanguk (K k), and Eureka Sound (T e) Formations exposed. The Cape Colquhoun piercement dome is visible in the distance and in the middle of the peninsula is the perfectly circular Barrow dome. (RCAF T417L–59)

Lesser amounts of limestone and shale are also present, as well as masses of gabbroic rock which are discussed on page 173. The internal structure of the rocks forming the domes is complex and it is impossible to present any stratigraphic data. Good exposures were examined in a ravine on the west side of Barrow dome, at locality 81. Most of the exposures in this ravine are gypsum, but there are also chaotically distributed masses of black, well-bedded limestone, black shale, and grey vuggy limestone. Fossils collected from a mass of vuggy limestone at locality 81 (GSC loc. 37154) have been identified by P. Harker as *Dictyoclostus* sp. of

Pennsylvanian or Permian age. The gypsum and the enclosed masses of limestone and shale resemble those within the piercement structures of the Ringnes Islands, Axel Heiberg Island, and Ellesmere Island. The available evidence suggests that the material in these piercement domes is derived from a subsurface formation of Pennsylvanian or Permian evaporites (Thorsteinsson and Tozer, 1957, p. 22). The black limestone, shale, and vuggy limestone presumably also occur beneath the surface of Sabine Peninsula. Rocks of these types are common in the Permian, and near the Pennsylvanian-Permian boundary, in the sequence exposed on the northwest coast of Ellesmere Island.

Triassic

Three Triassic formations are exposed in the western Queen Elizabeth Islands. From oldest to youngest they are the Bjorne, Schei Point, and Heiberg. In this region no complete section exposes all three formations.

The Bjorne Formation, composed of unfossiliferous sandstone and conglomerate, probably of Lower Triassic age, is exposed on Melville Island. In most sections it rests on Permian rocks but near the mouth of Marie Bay it apparently lies on pre-Permian formations. It is overlain, paraconformably, by Jurassic strata.

The Schei Point Formation, composed of limestone and calcareous sandstone, occurs on Prince Patrick and Borden Islands. On these islands it is mainly, or entirely, of Karnian (early Upper Triassic) age. On Prince Patrick Island it is transgressive and rests directly upon Devonian rocks, without any intervening representative of the Bjorne Formation. The Schei Point beds are the oldest exposed on Borden Island. On both Prince Patrick and Borden Islands they are paraconformably overlain by Jurassic rocks.

In the western Queen Elizabeth Islands the Heiberg Formation, with Norian (mid-Upper Triassic) fossils is exposed only on Brock Island. It is the only Mesozoic formation recognized on this island and its relationship to the other Mesozoic formations is therefore not known.

Bjorne Formation

The Bjorne Formation was named by Tozer (1961; and *in* Fortier, *et al.*, 1963) for a unit, mainly composed of sandstone, that overlies Permian strata and is succeeded by the Schei Point Formation of Middle and Upper Triassic age. The type section is at Bjorne Peninsula, southern Ellesmere Island. The Bjorne Formation can be recognized as a distinct lithological unit on the east and south margins of the Sverdrup Basin; in central Ellesmere Island it occurs along a belt extending from East Cape to the mouth of Bay Fiord. From the type section, on Bjorne Peninsula, the formation extends to the west for it appears, north of Grinnell Peninsula, on Table and Exmouth Islands. Traced westward from these small islands it reappears on Cameron Island and finally its westernmost occurrence is on Melville Island.

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The Bjorne Formation evidently represents a shallow-water, possibly non-marine, deposit, laid down on the east and south margins of the Sverdrup Basin. These beds are commonly unfossiliferous, and diagnostic fossils are not known from any section.[1] However, the Bjorne strata rest abrutly upon Permian beds and, in many sections, are overlain by fossiliferous Anisian (early Middle Triassic) rocks. A Lower Triassic age may be suggested because of the age of the beds above and below. Within the Sverdrup Basin fossiliferous Lower Triassic siltstones (Blind Fiord Formation) occupy the same stratigraphic position as the Bjorne beds, which supports the dating suggested above.

Sabine Peninsula

The Bjorne Formation outcrops throughout a belt crossing the southern part of Sabine Peninsula, where the lower Bjorne beds are commonly a distinctive red, as in Canyon and Bay Fiords, Ellesmere Island. These lower, red Bjorne beds are very conspicuous, for they are sandwiched between drab, green Permian strata and the upper Bjorne beds that lack the red colour and support a fair cover of vegetation, of a sombre hue. The total exposed thickness of the Bjorne Formation of Sabine Peninsula is probably about 1,500 feet.

Good exposures of much of the basal 500 feet occur about 5 miles north of Tingmisut Lake. These beds consist of sandstone and conglomerate with minor amounts of dusky red shale. The sandstones are quartzose, commonly with soft, white grains of kaolinized feldspar. They are grey, dusky red, green, and brown, locally crossbedded, and mainly soft, but locally indurated with carbonate cement to form subspherical concretions ranging from an inch to about 3 inches in diameter. In parts of the section the sandstone has hard, dusky red bands, cemented by hematite. This facies is well developed on the south side of Sherard Bay. The red hematitic bands, and, to a lesser extent, the beds of red shale, are responsible for the distinctive colour of the lower part of the formation. The dusky red shale has been seen only in the outcrops 6 miles north of Tingmisut Lake. Exposures of this facies are poor; two or three beds are present, in aggregate about 15 feet thick. Thin seams of conglomerate occur throughout the lower 500 feet. Most pebbles are less than an inch in diameter and are composed of red, grey, and black chert.

The remaining part of the formation, about 1,000 feet thick, apparently consists essentially of medium-grained, quartzose sandstone. In the hills south of the isthmus between Eldridge and Sherard Bays this sandstone is massive to thick-bedded, and greyish green. The highest Bjorne beds of Sabine Peninsula are exposed 16 miles northwest of Cape Mudge, where they are overlain by the Wilkie Point Formation (Jurassic). These beds comprise about 20 feet of massive, in part crossbedded, light grey to almost white, medium-grained quartz sandstone.

[1] Lower Triassic fossils are now known on Ellesmere Island (*Geol. Surv., Canada,* Paper 63-30, p. 2).

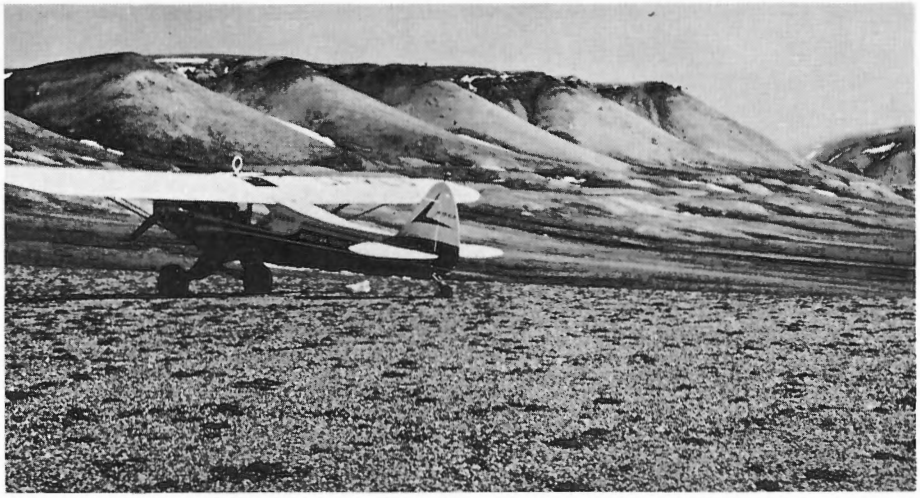

PLATE XXIII. Bluffs of Bjorne conglomerate and sandstone, capped by Borden Island Formation, on the north side of Marie Bay, Melville Island, 7 miles from the head of the bay. The lower slopes have small exposures of the Assistance and Canyon Fiord Formations.

Northwestern Melville Island

In northwestern Melville Island the Bjorne Formation outcrops along an east-west belt extending from Hecla and Griper Bay to the north side of Marie Bay. Within this area the formation has been examined north of the Raglan Range and at several points north of Marie Bay.

Fair exposures occur north of Raglan Range and on the banks of East Kitson River. In this area the Bjorne formation overlies the Assistance formation (Permian). No exposures of the contact have been seen but the two formations are apparently conformable. The lower part of this Bjorne section forms a prominent cuesta north of Raglan Range. About 200 feet of beds are exposed on this cuesta, mainly yellowish brown sandstone, commonly crossbedded, with seams of conglomerate. The conglomerate is composed mainly of pebbles less than an inch in diameter. The pebbles are well rounded and are mainly orange, red, black, and white chert. The lowermost beds on the face of this cuesta weather bright red; the upper beds, which are commonly covered by talus from the seams of conglomerate, are yellowish brown.

On East Kitson River, south of locality 102, white, crossbedded sandstone with some conglomerate, overlies the beds exposed immediately north of Raglan Range. This white sandstone is overlain, paraconformably, by Jurassic rocks. The total thickness of the Bjorne Formation in this area is about 450 feet.

At the head of Marie Bay the Bjorne Formation forms prominent yellowish brown bluffs, like the cuesta north of Raglan Range. At locality 88, six miles west of the head of Marie Bay, the following section was measured (*see* Pl. XXIII). In this section, Jurassic rocks rest directly upon the brown weathering, conglomerate facies of the Bjorne Formation without any intervening white sandstone, as on East Kitson River.

	Approximate thickness (feet)	
	Unit	Total
Overlying beds: Borden Island Formation (Jurassic)		
Covered interval	10	280
Bjorne Formation		
Conglomerate and sandstone, grey and yellowish brown; massive and crossbedded; sandstone is quartzose with black chert grains; conglomerate has well-rounded pebbles, up to 4 inches in diameter, composed of quartzite, black, grey and white chert. This unit weathers brown and includes beds of conglomerate up to 20 feet thick	100	270
Covered interval; covered with talus of pebbles from the overlying conglomerate	170	
Underlying beds: Assistance Formation (Permian)		

Parts of the Bjorne Formation have been studied in the country west of this section, where the uppermost exposures include white and red sandstone with thin seams of conglomerate. The white sandstone in these sections resembles the upper beds of the Bjorne Formation exposed on East Kitson River (p. 113). These upper Bjorne beds have been examined immediately south of the flat-topped hills known as Marie Heights. They also occur on a small, but prominent, white bluff 2 miles north of the shore of Marie Bay, at a point 11 miles west of the head

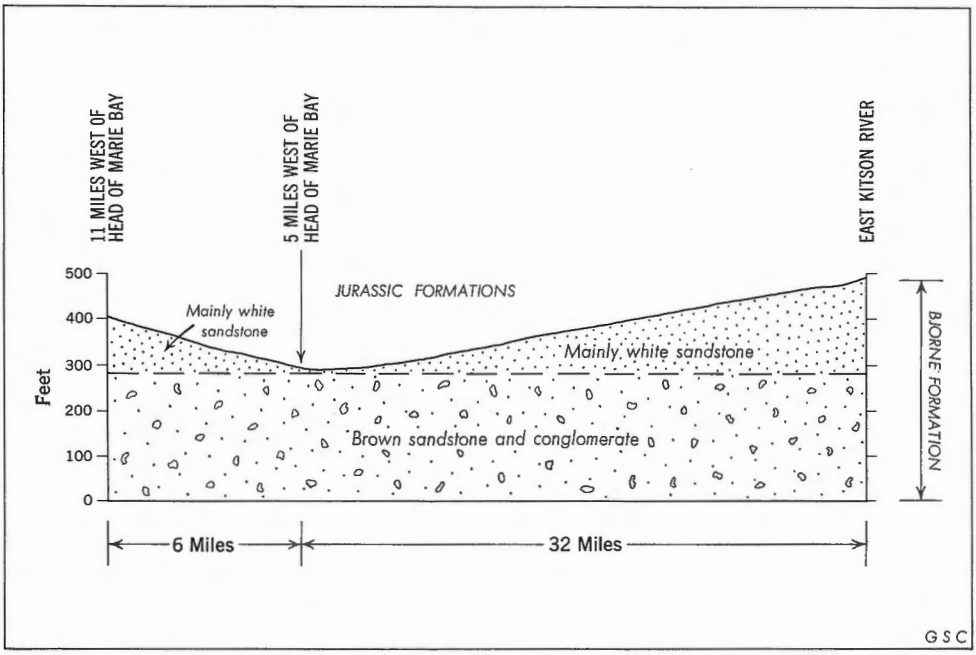

FIGURE 6. Diagram showing relationship between Bjorne and Jurassic formations, northwest Melville Island.

of the bay (locality 89). At each of the above localities, the Bjorne Formation is overlain by Jurassic strata. No exposures of the Assistance Formation were seen west of locality 88. Near the entrance to Marie Bay the Bjorne probably rests directly upon the Canyon Fiord Formation (Pennsylvanian), without any intervening Assistance beds.

The foregoing account of the Bjorne beds of northwestern Melville Island reveals that two lithological members are present: (1) a lower member dominated by brown weathering conglomerate, and (2) an upper member in which white sandstone predominates. In the sections north of Marie Bay and on East Kitson River the Jurassic beds rest upon the upper member of white and red sandstone. In the section at locality 88 the Jurassic beds lie directly upon a thin Bjorne section (not more than 280 feet thick) which lacks the upper member. It is suggested that these variations in the highest beds of the Bjorne Formation are a local reflection of the regional unconformity that separated the Bjorne from the Jurassic formations. This interpretation is illustrated diagrammatically by Figure 6.

With reference to this figure, it should be noted that section 1 (in which the upper member has escaped pre-Jurassic erosion) is regionally downdip from section 2 (in which the upper member has been removed). The regional dip in this area is northerly and reflects the dip of the Mesozoic formations towards the axis of the Sverdrup Basin. In sections (e.g., on Axel Heiberg Island) that reveal the sequence characteristic of the axis of the basin the unconformity between the Bjorne Formation and Jurassic beds is not present. In such sections Middle and Upper Triassic rocks, several thousand feet thick, occupy the interval represented by the unconformity north of Marie Bay. It thus seems reasonable to suppose that progressively younger Triassic beds appear beneath the Jurassic in the subsurface north of Marie Bay. The relationship between sections 1 and 2 probably illustrates, to a minor extent, the regional, northward, decrease in amplitude of the sub-Jurassic unconformity.

Schei Point Formation

The Schei Point Formation was named by Tozer (1961; and *in* Fortier *et al.*, 1963) for a sequence of calcareous siltstones, limestones, and shales, with marine Middle and Upper Triassic fossils, typically exposed on Bjorne Peninsula, Ellesmere Island. In the type section the Schei Point beds are about 800 feet thick. They rest on the Bjorne Formation and are overlain by the Heiberg.

The Schei Point Formation represents a relatively thin, calcareous and arenaceous deposit, laid down on the east, south, and apparently also the west margins of the Sverdrup Basin. Within the basin the contemporary deposits are thicker and mainly argillaceous (Blaa Mountain Formation).

This formation can be traced throughout central and western Ellesmere Island along a belt extending from East Cape in Canyon Fiord, to Hat Island at the mouth of Bay Fiord. From the type area in southern Ellesmere Island it extends westwards to Table and Exmouth Islands and on to Cameron Island. Traced farther west, it might be expected to appear on Melville Island. However there the Schei Point beds have apparently been overstepped by the Jurassic

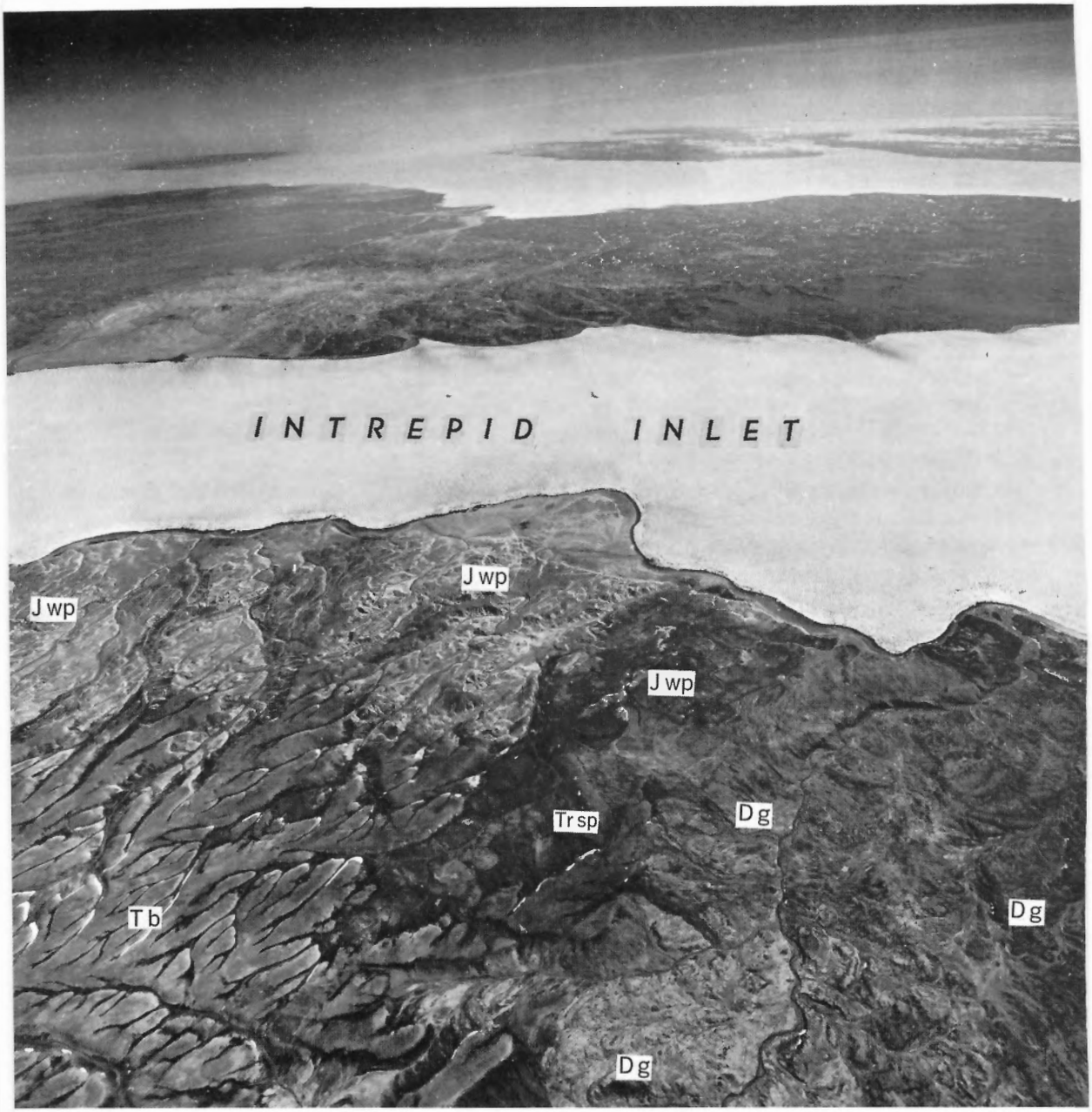

PLATE XXIV. Aerial view of Intrepid Inlet, Prince Patrick Island, looking east. The Griper Bay Formation (D g) is overlain by the Schei Point Formation (Tr sp) in the foreground. Adjacent to the inlet the Griper Bay beds are overlain by Wilkie Point (J wp) strata, without any intervening Schei Point beds. To the left is the unconformable blanket of Beaufort beds (T b). (RCAF T430R–39)

strata, which rest directly upon the Bjorne Formation. The Schei Point Formation reappears, in the role of a transgressive deposit, near Salmon Point, Prince Patrick Island. This transgressive character cannot be established from surface exposures at any other locality.[1] This information is also known on Borden Island.

On Ellesmere, Table, and Exmouth Islands the Schei Point beds contain faunas of Anisian (early Middle), Ladinian (late Middle), and Karnian (early Upper Triassic) age (Tozer, 1961). The faunas from Prince Patrick Island comprise only pelecypods and brachiopods. As now known they cannot be used for precise age determination but they are probably Karnian and certainly not older than Ladinian. The fossils from Borden Island include *Sirenites senticosus* (Dittmar), *Proclydonautilus spirolobus* (Dittmar) and *Halobia* cf. *H. zitteli* Lindstrom, together with pelecypods that occur on Prince Patrick Island. The Borden Island faunas are unquestionably of Karnian age.

The beds (on Prince Patrick Island) with Karnian (or possibly Ladinian) fossils lie about 20 feet above Devonian rocks, with a covered interval between. It therefore seems probable that these beds represent a Karnian (or possibly Ladinian) transgressive deposit, without any intervening deposits of Anisian age. There is no doubt that on Prince Patrick Island the Schei Point beds have completely overstepped the Lower Triassic Bjorne Formation.

Prince Patrick Island

On Prince Patrick Island, exposures of the Schei Point Formation are known only on the west side of Intrepid Inlet, 4 miles north of Salmon Point, which is the only place on the island where Triassic exposures are known. Southwest of Salmon Point Jurassic rocks rest directly upon the Devonian. This small patch probably represents the only exposure of the Schei Point Formation on Prince Patrick Island.

The Schei Point beds at this locality comprise about 15 feet of grey, yellowish brown weathering, slightly quartzose, fragmental limestone. The limestone contains abundant fossils and the rock itself is composed mainly of broken shell fragments. The Schei Point beds lie between the Griper Bay Formation (Devonian) and the Wilkie Point Formation (Jurassic). Neither the upper nor the lower contact is exposed, but these beds evidently rest on the Devonian unconformably and are overlain, again unconformably, by the Wilkie Point Formation. There is no marked angular discordance between the Wilkie Point and Schei Point beds; the bedding of the two formations is roughly parallel. The interval between the base of the Wilkie Point and the Devonian would accommodate about 50 feet of beds. The exposed thickness of the Schei Point beds is therefore no more than 50 feet.

The following fossils have been identified by Tozer from the Schei Point beds exposed at locality 82, north of Salmon Point (GSC loc. 37200):

Oxytoma sp. (as on Borden Island)
Plicatula cf. *P. hekiensis* Nakazawa

[1] It is now also known in Tanquary Fiord, Ellesmere Island (*Geol. Surv., Canada,* Paper 63-30, p. 6).

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Lima (Plagiostoma) sp.
Gryphaea cf. *G. arcuatiformis* Kiparisova
"Myophoria" sp.
terebratuloid and spiriferid brachiopods indet.

The species of *Oxytoma, Plicatula, Lima,* and *Gryphaea* also occur in the Schei Point beds at other localities. These fossils are, therefore, certainly of Triassic age and they are probably Karnian (see above).

Borden Island

Schei Point beds form a nearly continuous belt extending northeasterly through Borden Island. The formation is the oldest on the island, consequently the base has not been seen. These beds are overlain, paraconformably, by the Jurassic Borden Island Formation. The Schei Point beds in this area consist of calcareous sandstone, sand, and coquina beds.

Good exposures occur on Oyster River where about 100 feet of beds is present. These beds comprise greenish grey, yellowish brown weathering, medium-grained, calcareous, quartzose sandstone, with beds of coquina up to 10 feet thick. On this river the Schei Point beds are overlain by the Borden Island Formation. The actual contact was not seen but it is probably very abrupt for it has a prominent topographic expression. The highest Schei Point exposures consist of grey sandstone and sand, with a leached, somewhat ashy appearance. This may indicate that the Schei Point beds were subjected to leaching or weathering prior to the deposition of the Borden Island Formation. Alternatively it might be due to percolation of ground water along the Schei Point-Borden Island contact. The evidence suggests that this contact is sharp and paraconformable.

Fossils, particularly pelecypods, are abundant in the coquina beds of Oyster River at localities 83 and 84 (GSC locs. 37220, 37156). The following have been identified:

Oxytoma sp.
Plicatula cf. *P. hekiensis* Nakazawa
Lima (*Plagiostoma*) sp.
Lima cf. *L. naumanni* Kobayashi and Ichikawa
Gryphaea cf. G. *arcuatiformis* Kiparisova
Myophoria aff. *M. nathorsti* Dames

From a moderately fresh block of sandstone in the bed of Oyster River *Halobia* sp. cf. *H. zitteli* Lindstrom was collected.

The Schei Point beds were also examined in the banks of a small southern tributary to Andersen River, about 14 miles south of Cape Malloch. There about 14 feet of horizontal beds is exposed. These beds comprise thin- to medium-bedded, light grey, yellowish orange weathering calcareous siltstone and sandstone interbedded with light grey sand. Fossils occur at two levels in this section. From a bed near the top of the section at locality 85 (GSC loc. 37216) the following have been identified:

Proclydonautilus spirolobus (Dittmar)
Sirenites sp., group of *S. betulinus* (Dittmar)

Eleven feet lower in the section the following were collected (GSC loc. 37218):

Lima (*Plagiostoma*) sp.
Sirenites senticosus (Dittmar)

Both these faunules are of Karnian (early Upper Triassic) age.

The beds exposed near Andersen River probably underlie the beds exposed on Oyster River.

Heiberg Formation

The Heiberg Formation was recognized as a distinct lithological unit following field work performed by members of Operation Franklin. The type section is at Buchanan Lake, Axel Heiberg Island (Souther, 1963; *see also* Tozer, 1961). The formation is widely distributed around Eureka Sound, on western Ellesmere Island, and Axel Heiberg Island, and it is also known on Cornwall and Cameron Islands.

In the Eureka Sound area the Heiberg is up to 4,660 feet thick and consists mainly of grey, yellow, and red sandstone, with some shale, coal, and ironstone. There it rests, with a transitional boundary, upon the Blaa Mountain Formation and is overlain quite abruptly, by marine deposits of Lower Jurassic age. Much of the formation is of non-marine deposition, as testified by the coal seams in the upper part. Thin beds with marine fossils occur in the lower part.

Two distinct marine faunas are present. The lower fauna contains *Meleagrinella antiqua* Tozer and is of Karnian or Norian age. The upper fauna contains the Norian *Monotis ochotica* (Keyserling) and its varieties. The upper beds contain fossil plants which according to Wayne Fry (*in* Fortier, *et al.,* 1963) are of "Rhaeto-Liassic" age, i.e., of latest Triassic or earliest Jurassic age.

In western Queen Elizabeth Islands the Heiberg Formation outcrops only on Brock Island. It is the only Mesozoic formation known on this island and consequently the upper and lower contacts are not known.

Brock Island

The Heiberg Formation occurs on southeastern Brock Island where it probably underlies the whole of the southeast half of the island. True outcrops are few in number, or non-existent; in the course of a low flight over this part of the island none was found. Disintegrated outcrops and felsenmeer make it possible to determine lithology, but structural attitudes and thicknesses were not obtained. The monotonous nature of the topography, and apparently also the lithology, suggest that the strata are gently inclined. The relief is about 300 feet, and the thickness of Heiberg beds is probably not less than this figure.

Near the southeast corner of the island, at locality 86, 22 miles S65°E of Cape Murray, frost-shattered outcrops consist of light grey, fine- to medium-grained, glauconitic, quartz sandstone. *Monotis ochotica* (Keyserling), of Norian (mid-Upper Triassic) age, is abundant at this locality (GSC loc. 37201).

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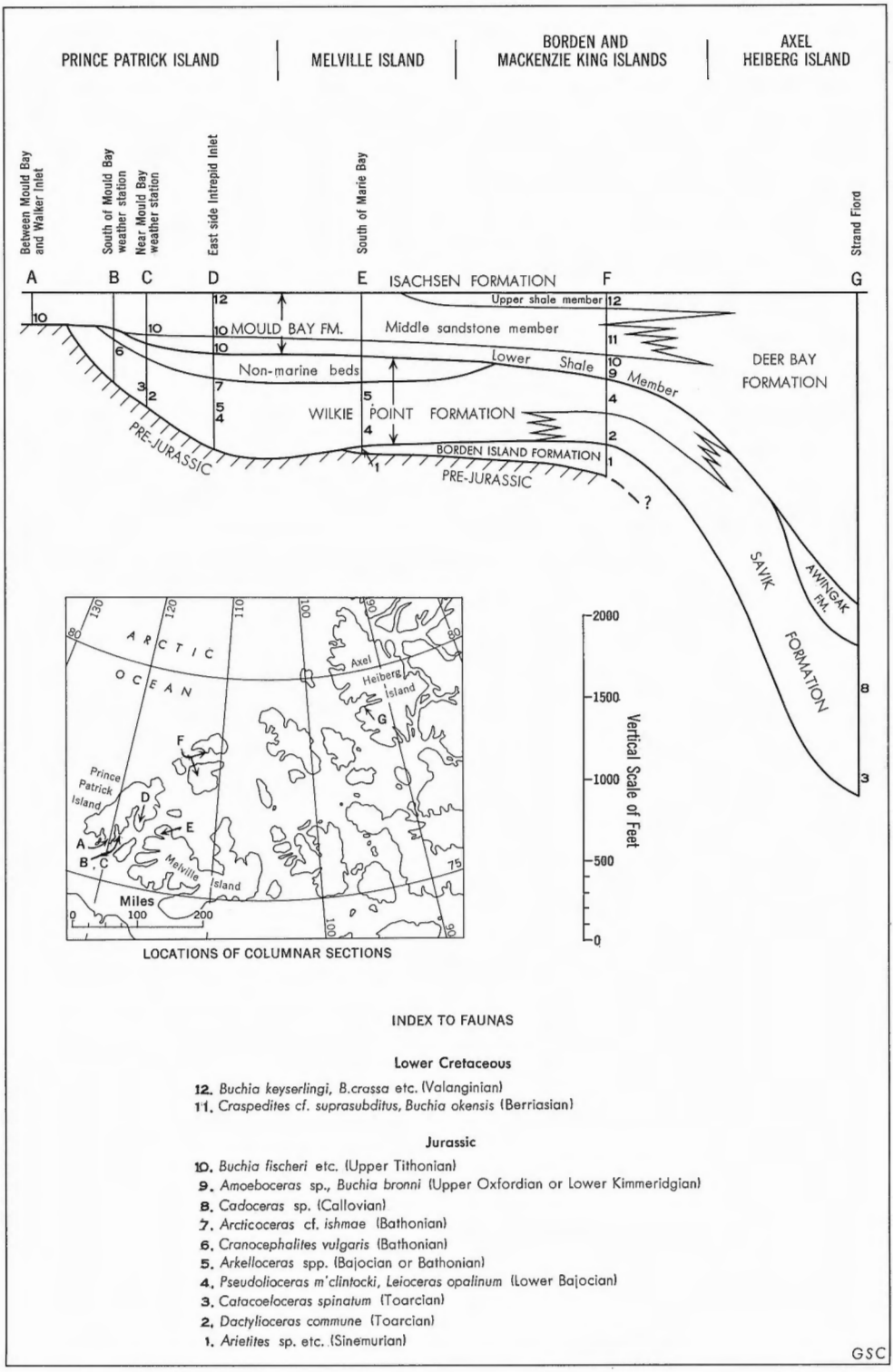

FIGURE 7. Section showing relationships of Jurassic and lowermost Cretaceous formations.

A landing was made near the centre of the part of Brock Island underlain by Mesozoic rocks, at a point 18 miles S50°E of Cape Murray. No outcrops were found but the felsenmeer at this locality consists of grey and reddish brown, fine-grained, quartz sandstone. Rocks of this lithology are common in the lower part of the Heiberg Formation on Cornwall, Axel Heiberg, and Ellesmere Islands.

Jurassic

Jurassic rocks are exposed on Prince Patrick, Melville, Borden, and Mackenzie King Islands. They are placed in three formations, in ascending order, the Borden Island, Wilkie Point, and Mould Bay. The Borden Island and Wilkie Point Formations are wholly of Jurassic age, but the Mould Bay Formation includes both Upper Jurassic and lowermost Cretaceous beds. All three formations are locally transgressive. Major transgressions evidently took place in the Sinemurian (Borden Island), Toarcian (basal Wilkie Point), and in the Upper Jurassic (basal Mould Bay). The Jurassic-Cretaceous boundary apparently lies within the Mould Bay Formation, but does not correspond with any change in the sedimentary regime in the Queen Elizabeth Islands.

The relationship between these formations and the relative position of the various faunas are shown diagrammatically by Figure 7.

Borden Island Formation

The Borden Island Formation is composed of marine, glauconitic sand, and red, ferruginous sandstone. The available evidence, although not quite conclusive, suggests that this formation is of Sinemurian (early Lower Jurassic) age. It has been mapped as a distinct unit only on Borden Island, but a thin representative is also present in northwestern Melville Island. The Borden Island beds are restricted in extent compared with the succeeding Jurassic formations. Near Mould Bay weather station, Prince Patrick Island, the Wilkie Point Formation, with Toarcian (late Lower Jurassic) fossils at the base, has certainly overstepped the Borden Island beds. The same is probably true on Sabine Peninsula, Melville Island.

Borden Island

In the type area, for which the beds are named, the Borden Island Formation comprises about 200 feet of glauconitic sand with hard red ferruginous bands and grey phosphatic nodules. These beds rest, paraconformably, upon the Schei Point Formation (Triassic), and are overlain, apparently very abruptly, by grey clay shales referred to the Wilkie Point Formation.

Fairly good exposures of about 140 feet of beds occur on the west side of Oyster Creek, near the contact with the Schei Point Formation. They comprise wash-covered exposures of greyish green sand with projecting ledges of hard,

dusky red weathering, ferruginous sandstone. In the bed of a small tributary on the east side of Oyster Creek, near locality 84, an ammonite fragment, determined by Frebold (1960, p. 13) as *Arietites* s.l. sp. indet., was collected (GSC loc. 35322). As noted below, this ammonite is probably derived from the Borden Island beds.

About 40 feet of beds, near the top of the formation, was examined in eastern Borden Island (locality 87) 19 miles south of Cape Malloch. These beds resemble those exposed near Oyster Creek. Fossil wood was noted in the hard sandstone bands at this locality. The phosphatic nodules there contain small fragments of ammonites and the decapod crustacean *Erymastacus bordenensis* Copeland (1960).

The fossils collected in situ do not permit determination of a precise age for the Borden Island Formation. The ammonites collected south of Cape Malloch are too poorly preserved for identification. The *Arietites* collected loose near Oyster Creek is almost certainly of Lower Sinemurian age according to Frebold (1960, p. 26). Fossils of this age are very rare in the Canadian Arctic Archipelago, consequently the problem of the source of this ammonite fragment is of considerable interest and importance. The arguments seem to favour, overwhelmingly, the conclusion that it is from the Borden Island Formation. The small stream, in which the fossil was found, rises on exposures of this formation and then flows down to join Oyster Creek, crossing the contact between the Borden Island and Schei Point Formations on the way. Clearly this fossil did not come from the Schei Point beds, which are of Karnian (Upper Triassic) age. The arietitid would be from either Wilkie Point or Borden Island strata. The nearest Wilkie Point outcrops are 5 miles from the small stream in which the fossil was found. The Wilkie Point beds have provided Toarcian ammonites, in situ, about 30 feet above the base. The arietitid is considerably older than these Toarcian fossils, consequently it is probable that it came from beds beneath the Wilkie Point Formation, i.e., from the Borden Island Formation. The evidence given above suggests that the arietitid came from the Borden Island Formation; if so, the formation is of Sinemurian age.

This Sinemurian dating is supported by all other evidence. On stratigraphic evidence, the Borden Island Formation is younger than the Heiberg Formation (Norian and (?) younger), yet it is older than the basal Wilkie Point beds (Toarcian). This leads to a dating less precise but entirely compatible with the one suggested here.

Northwestern Melville Island

The Borden Island Formation has been recognized at two localities near Marie Bay, northwestern Melville Island. In this area the formation rests para-

PLATE XXV. Aerial view, westward, of Borden Island, showing the Borden Island Formation (J bi) overlain by the lower shale member of the Wilkie Point Formation (J wp). In the distance is the Arctic Coastal Plain underlain by the Beaufort Formation (T b). (RCAF T411L–147)

conformably upon the Bjorne Formation (Lower Triassic). The contact with the overlying Wilkie Point Formation has not been seen, and consequently it has been necessary to map the two formations together.

Borden Island beds cap the cliffs on the north side of Marie Bay (locality 88) 6 miles west of the head of the bay. At this locality mainly disintegrated outcrops, representing about 40 feet of beds, overlie the conglomerates of the Bjorne Formation. A covered interval of about 10 feet separates the Bjorne and Borden Island beds. The Borden Island rocks comprise green sand, red and greenish ferruginous sandstone, and grey phosphatic nodules. The red sandstone contains poorly preserved ammonoids, pelecypods, crustaceans, and plant fragments (GSC loc. 35345).

Six miles west of the section described above, at fossil locality 89, the Bjorne Formation is overlain by rubble or red sandstone. Fossils collected there (GSC loc. 35323) have been identified by Frebold (1960, p. 13) as *Arietites* s.l., sp. indet., of Lower Sinemurian (early Lower Jurassic) age.

The total exposed thickness of the Borden Island Formation in this area is not known. At Marie Heights typical Wilkie Point rocks and fossils of Bajocian age occur about 100 feet above the Bjorne sandstone. The exposed Borden Island thickness in northwestern Melville Island is presumably less (*see* Fig. 9).

The Borden Island and Wilkie Point Formations are very similar lithologically, and to separate them on lithology alone would be difficult, perhaps impossible. However, as these beds represent deposits of different ages, probably separated by a hiatus (Pliensbachian time), it seems desirable to treat them as distinct formations.

Wilkie Point Formation

The name "Wilkie Point" was given by Tozer (1956, p. 18) to the main Jurassic formation exposed on Prince Patrick Island. The beds exposed in the cliffs on the east side of Intrepid Inlet, 11 miles north of Cape Canning, were regarded as the type section. This section is well exposed but does not show the base of the formation. Immediately northeast of Mould Bay weather station the Wilkie Point beds overlie, unconformably, the Griper Bay Formation of Devonian age. Frebold (1958, p. 21) has identified *Dactylioceras commune* (Sowerby), of Toarcian age, from the basal Wilkie Point beds near Mould Bay. The Toarcian transgression appears to have been an important event in the geological history of the Queen Elizabeth Islands and the basal Wilkie Point beds of the type area were laid down during this transgression.

The Wilkie Point Formation has been recognized on Prince Patrick, Melville, Borden, and Mackenzie King Islands. On Prince Patrick and Melville Islands the formation comprises up to about 600 feet of sand and sandstone with some glauconite, dusky red ferruginous bands, and grey phosphatic nodules. The lower

PLATE XXVI. Type section of the Wilkie Point Formation on the east side of Intrepid Inlet, 11 miles north of Cape Canning, Prince Patrick Island.

part of the formation is of marine and the upper part of non-marine deposition. The Wilkie Point beds of Borden and Mackenzie King Islands are somewhat different. Grey shale occurs at the base followed by sand and sandstone similar to the Prince Patrick Island facies. The non-marine upper beds apparently do not occur on these islands. The shale at the base of the Wilkie Point section on Borden and Mackenzie King Islands evidently represents a tongue of the shale facies that characterizes the Toarcian, Bajocian and Callovian of western Axel Heiberg Island, i.e., a tongue of the Savik Formation.

The Wilkie Point Formation and its eastern equivalents (namely the Jaeger and Awingak Formations of Cameron and Cornwall Islands) evidently represent an arenaceous Jurassic lithofacies deposited upon the margin of the Sverdrup Basin (Tozer, 1960). Within the Sverdrup Basin, equivalents of the marine member are mainly shale (Savik Formation). Sandstone equivalents of the upper member (Awingak Formation) extend a considerable distance into the basin, judging from the sequence exposed on the west side of Axel Heiberg Island where the Awingak Formation is present. If we compare the Jurassic lithofacies belts with those of the Triassic, the lower Wilkie Point (and Jaeger) beds are analogous to the Schei Point Formation. The Savik Formation finds its analogue in the Blaa Mountain Formation.

The marine faunas that occur in the Wilkie Point Formation are summarized in the following table. All identifications and age determinations are by H. Frebold. The age of the faunas with *Arcticoceras* and *Cranocephalites* has also been discussed by Callomon (1959).

Faunas of the Wilkie Point Formation

Fauna	Age	Distribution
Arcticoceras ishmae (Keyserling)	Upper Bathonian	Intrepid Inlet, Prince Patrick Island
Cranocephalites vulgaris Spath	Lower Bathonian	South of Mould Bay weather station, Prince Patrick Island
Arkelloceras spp. *Zetoceras thorsteinssoni* Frebold *Inoceramus lucifer* Eichwald	Probably Upper Bajocian or Lower Bathonian	Intrepid Inlet, Prince Patrick Island; Marie Heights, Melville Island
Leioceras opalinum (Reinecke) *Pseudolioceras m'clintocki* (Haughton) *Oxytoma jacksoni* (Pompeckj)	Lower Bajocian	Near Mould Bay, Wilkie Point and Intrepid Inlet, Prince Patrick Island; northwestern Melville Island; Sabine Peninsula (?); Mackenzie King Island
Catacoeloceras spinatum (Frebold)	Toarcian	Near Mould Bay weather station, Prince Patrick Island
Dactylioceras commune (Sowerby)	Toarcian	Near Mould Bay, Prince Patrick Island; Borden Island

Prince Patrick Island

Mould Bay Area

The Wilkie Point Formation is widely distributed on the peninsula between Mould Bay and Crozier Channel and also outcrops near Landing Lake. The complete sequence is preserved on several fault blocks north and east of the weather station. Small patches, consisting only of the lower (marine) member, form conspicuous flat-lying outliers west of Disappointment Point.

The lower member is not usually well exposed, but rubble and talus serve to illustrate the lithology of this part of the section. The upper (non-marine) beds are commonly well exposed, particularly at the foot of the cuestas formed by the Mould Bay Formation (*see* Pl. XXVII).

A complete but discontinuously exposed section occurs in the outcrop belt immediately east of the weather station (Section 3, Fig. 8). Beds close to the base occur about a mile north of the weather station; these beds form small outliers, detached by erosion from the main belt. They comprise about 10 feet of dusky red sandstone and conglomerate. A covered interval, representing at the most 20 feet of strata, separates these beds from the underlying Griper Bay Formation (Devonian). From this locality (loc. 90, Fig. 3) H. Frebold (1958a, p. 18) has identified *Dactylioceras commune* (Sowerby), of Toarcian age (GSC loc. 24652). The beds above the basal conglomeratic strata are poorly exposed in this section. Good exposures of the uppermost Wilkie Point beds occur at the foot of the cuesta 5 miles northeast of the weather station. The top beds

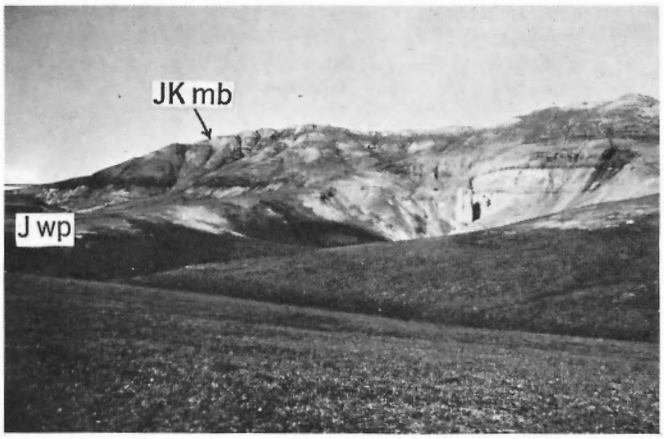

PLATE XXVII

Contact of the Wilkie Point (J wp) and Mould Bay (JK mb) Formations, 3 miles northeast of Mould Bay weather station. The basal Mould Bay stratum is dark shale, overlying the light coloured, castellated sand of the Wilkie Point Formation.

comprise about 150 feet of light grey to white, very fine grained sand and sandstone, weathering to castellated forms. Beneath this distinctive unit is some 150 feet of medium-grained, yellow, quartz sand with hard dusky red, ferruginous sandstone bands.

The lower Wilkie Point beds are widely distributed on this peninsula but, as in the section described above, they are generally disintegrated by frost action. They appear to comprise soft, grey sand and sandstone, with reddish brown and dusky red hard bands, and light grey phosphatic nodules. These nodules are commonly fossiliferous. The following notes will amplify the description of the lithology and fauna of this part of the Wilkie Point Formation.

Marine fossils of Toarcian age are abundant in these beds. The faunas have been studied by H. Frebold (1958), who has made the following identifications:

Dactylioceras commune, already mentioned as occurring in the basal conglomeratic beds, was also collected within 20 feet of the contact with the Griper Bay Formation on the ridge 3 miles southeast of the weather station, at locality 91 (GSC loc. 24650).

Phosphatic nodules collected on the surface of disintegrated outcrops representing beds not more than 100 feet above the base of the formation, 3¾ miles northeast of the weather station, at locality 92 have yielded the following (GSC loc. 24641):

Catacoeloceras spinatum (Frebold)
Pseudolioceras aff. *P. compactile* (Simpson)
Cucullaea sp.
Protocardia striatula (Phillips)
Pleuromya aff. *P. simplex* Warren

Nodules from the small downfaulted outcrops immediately east of Landing Lake at locality 93 (GSC loc. 24642) contain:

Catacoeloceras spinatum (Frebold)
Pseudolioceras aff. *P. compactile* (Simpson)
Pleuromya aff. *P. simplex* Warren

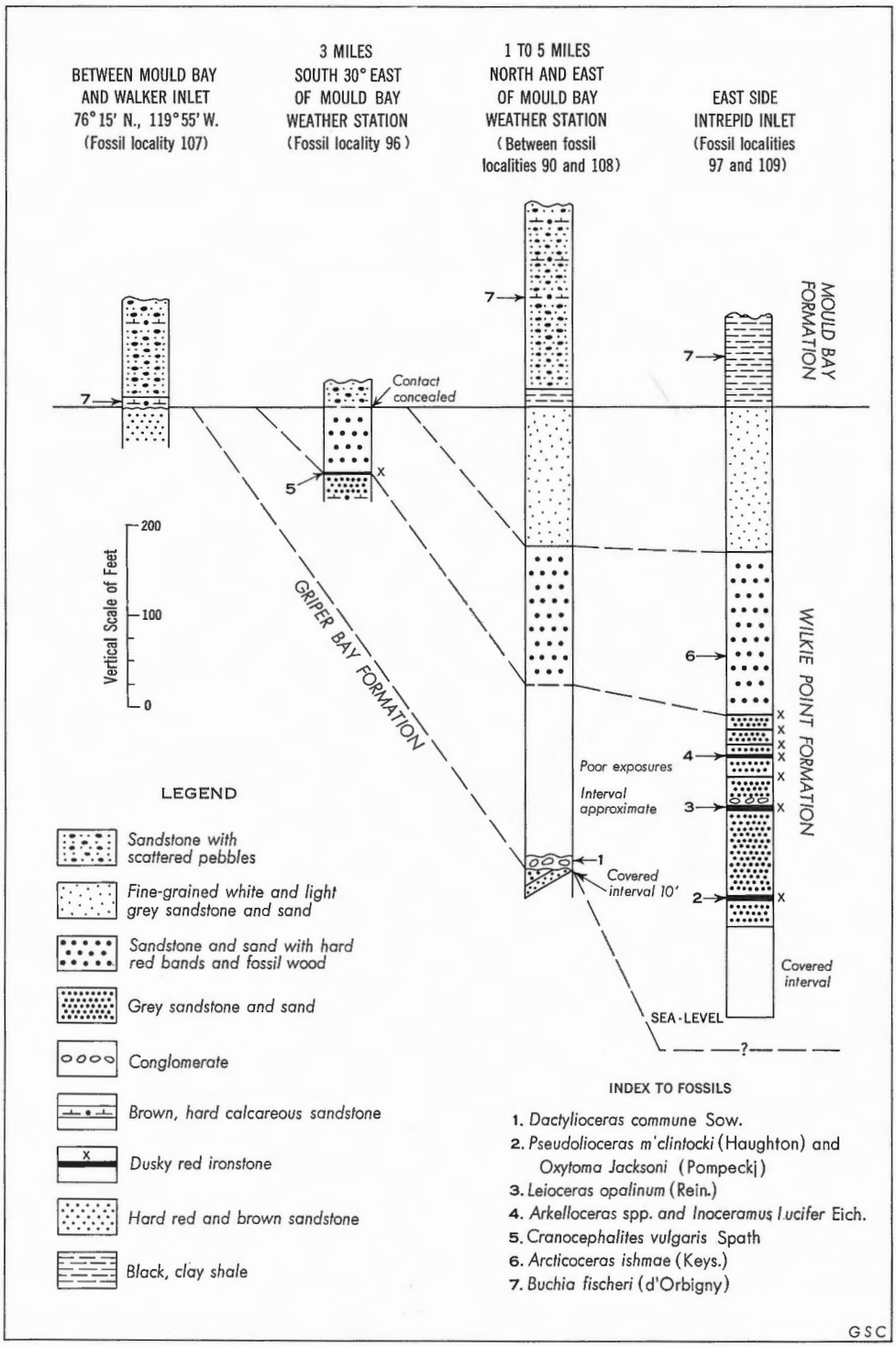

FIGURE 8. Columnar sections of Wilkie Point Formation, Prince Patrick Island.

Lower Bajocian (early Middle Jurassic) fossils have been identified from at least two localities, namely:

1. Locality 94, from red sandstone on disintegrated outcrop, 7 miles east of the weather station (GSC loc. 24656)
   Pseudolioceras m'clintocki (Haughton)
2. Locality 95, from the northernmost of the outliers, 3 miles north of Disappointment Point (GSC loc. 24657)
   Leioceras opalinum (Reinecke)

An unusual partial section of the Wilkie Point Formation is exposed at locality 96 in a small creek, 3 miles south of the weather station. This section (Section 2, Fig. 8) exposes the youngest marine beds known on this peninsula, beds younger than those described in preceding paragraphs. The section is as follows:

Unit		Thickness (feet)
	Overlying beds: rubbly exposures of the Mould Bay Formation	
	Wilkie Point Formation	
4	Covered interval ..... about	50
3	Sand, yellow, fine- to medium-grained, with irregular beds, up to a foot thick, of dusky red weathering ferruginous sandstone and red fossil wood ..... about	70
2	Sandstone, grey, mottled with patches of dusky red sandstone; *Arctocephalites* sp. 1, indet., (GSC loc. 24665)	0.5
1	Sand and sandstone, fine-grained, grey	28

Talus collections, probably derived from bed 2 in this section, contain the following fossils, which have been identified by Frebold (1958a):

Cranocephalites vulgaris Spath
Arctocephalites sp. 2, indet.
Cylindroteuthis sp.
Inoceramus sp. indet.

Frebold considers that these fossils, and also the specimen from bed 2, are of Lower Bathonian age.

The uppermost white sand of the Wilkie Point Formation (p. 127) is missing in this section. Although the Mould Bay-Wilkie Point contact is concealed, the stratigraphic thickness of the concealed interval is insufficient to accommodate the white sand. This white sand is present about 2 miles to the north. Consequently it is unlikely that its absence in the section described above is the result of non-deposition. The most satisfactory explanation is that the white sands were removed by erosion before the deposition of the Mould Bay Formation, and that the Wilkie Point-Mould Bay boundary is unconformable (*see* Fig. 8).

West Side of Intrepid Inlet

A continuous belt of Jurassic rocks occurs on the west side of Intrepid Inlet, northwards from Salmon Point for about 15 miles. The exposures near Salmon Point have been examined in some detail, but the northern part of this belt has been seen only from the air. Exposures of the Mould Bay Formation are known to occur in the northwest corner of the inlet. Although the precise position of the Mould Bay-Wilkie Point boundary is not known, it certainly crosses the northern part of the inlet. It follows that a complete Wilkie Point section is represented on the western shore of Intrepid Inlet.

No exposures of the basal beds of this section have been seen and it is unlikely that they exist. Near Salmon Point, the Wilkie Point Formation evidently rests directly upon the Griper Bay Formation (Devonian). Four miles to the northwest a thin sliver of Schei Point beds (Triassic) intervenes between the Griper Bay and Wilkie Point Formations (*see* p. 117). The lower Wilkie Point beds in this area resemble those near Mould Bay weather station and comprise rubbly, mainly disintegrated, exposures of grey sand, with dusky red ferruginous bands and grey phosphatic nodules. Poorly preserved ammonites and *Inocerami* have been collected from these beds. The upper Wilkie Point beds near Salmon Point resemble those in the type section, near Mould Bay, with a unit of yellow sand with red hard bands and fossil wood, overlain by remarkably castellated, soft, white, fine-grained sand (Pl. XXVIII). A coal seam, about 3 feet thick, occurs on the face of a prominent bluff 4 miles north of Salmon Point. This coal seam probably lies near the top of the yellow sand unit.

Between Intrepid Inlet and Fitzwilliam Strait

On this peninsula the Wilkie Point beds dip gently to the northeast, towards the axis of the Sverdrup Basin. The basal beds have not been seen and are probably not exposed but at least 560 feet of beds is present. The greater part of the formation is moderately resistant to erosion, and the beds form a fairly prominent escarpment facing the southwest, which extends from Wilkie Point, northwest, to Intrepid Inlet. The escarpment meets the coast of the inlet south of Hiccles Cove resulting in the appearance of spectacular sea-cliffs, 500 feet high, with excellent rock exposures (Pl. XXVI).

The following section, exposing much of the Wilkie Point Formation, has been pieced together from several incomplete sections in the Hiccles Cove area. The greater part of the section (units 1—lower part of 7) is exposed on the face of the cliffs south of Hiccles Cove at locality 97. Unit 7 is well exposed about a mile east of the cliffs. Unit 7 and much of unit 8 are well exposed around the two rather prominent, flat-topped hills, a mile northeast of Hiccles Cove. The upper part of unit 8, and the contact with the overlying Mould Bay Formation, were examined around the rather prominent, dark coloured butte at locality 109, 5 miles northeast of Hiccles Cove.

Much of this section was originally studied in 1954 (Tozer, 1956, p. 19; Frebold, 1958a, p. 17). Later field work has resulted in some additions and revision. Fossil and age determinations are the work of H. Frebold.

PLATE XXVIII

Uppermost castellated sands of the Wilkie Point Formation, 6 miles north of Salmon Point, Prince Patrick Island. The individual pinnacles are about 20 feet high.

PLATE XXIX

Upper, non-marine beds of the Wilkie Point Formation, 6 miles north of Salmon Point, Prince Patrick Island.

Unit		Approximate thickness (feet) Unit	Total from base
	Overlying beds: lower shale member of Mould Bay Formation		
	Wilkie Point Formation		
8	Sandstone and sand, light grey to white, mainly massive but partly crossbedded; weathers to castellated forms	150	560
7	Sandstone and sand, yellowish orange, medium-grained, with reddish brown, hard ferruginous bands; *Arcticoceras ishmae* (Keyserling) 60 feet above base (GSC loc. 35345) (Upper Bathonian)	180	410
6	Sandstone and sand, light grey, fine-grained, with dusky red, fossiliferous, ironstone bands and grey phosphatic nodules;		

	Arkelloceras tozeri, A. mclearni Frebold, *Zetoceras thorsteinssoni* Frebold, *Inoceramus lucifer* Eichwald (GSC locs. 24661, 35324, etc.) (Upper Bajocian or Lower Bathonian)	70	230
5	Sandstone and sand, light grey, fine-grained; lenticular 6-inch conglomerate, composed of fragments of underlying sandstone, at base	30	160
4	Sandstone, pale reddish brown, fine-grained, calcareous; upper contact sharp, lower contact indefinite; *Leioceras opalinum* (Reinecke), *Pleuromya* sp. (GSC loc. 24658) (Lower Bajocian)	5	130
3	Sandstone and sand, soft, light grey, fine-grained; partly covered	98	125
2	Sandstone, pale reddish brown, fine-grained; *Pseudolioceras m'clintocki* (Haughton), *Oxytoma jacksoni* (Pompeckj) (Lower Bajocian)	2	27
1	Sand, soft, light grey, fine-grained, partly covered	25	
	Covered interval to sea-level, probably concealing lower beds of Wilkie Point Formation	100	

The Wilkie Point Formation has also been examined near the Point for which the beds are named. This area is of considerable historical interest for it was there that Leopold M'Clintock collected Jurassic fossils in 1853. For almost exactly 100 years (until 1954) the Reverend Samuel Haughton's descriptions of M'Clintock's fossils provided the only unequivocal evidence that Jurassic rocks occur in the Canadian Arctic Archipelago. When Tozer visited Wilkie Point in 1954 no good outcrops were found but fossils were collected from rubble and talus of dusky red ironstone a mile east of Wilkie Point at locality 98. They have been identified by Frebold (1958a, p. 19; 1960) as follows:

Leioceras opalinum (Reinecke)
Pseudolioceras m'clintocki (Haughton)
Goniomya cf. *G. v-scripta* (Sowerby)
Oxytoma septentrionalis (Haughton)
Gresslya cf. *G. abducta* (Phillips)

Frebold dates these fossils as Lower Bajocian.

Melville Island

Northwestern Melville Island

Jurassic beds form a belt extending from Marie Heights to Long Point. As already mentioned (p. 122), the beds represent both the Borden Island and Wilkie Point Formations. The Borden Island Formation has been recognized only in the country north of Marie Bay, where it forms the basal part of the Jurassic sequence. Farther east, north of Raglan Range, the Wilkie Point Formation probably rests directly upon the Bjorne beds (Triassic), without any intervening Borden Island strata. No exposures of the contact between the Borden Island and Wilkie Point Formations have been seen. Lithologically these formations are very similar and consequently it has not been possible to map them separately.

The Wilkie Point beds of northwestern Melville Island are known from several incomplete sections—there are no complete, continuously exposed sections of the formation. The lithology, thickness, and supposed relationship of these partial sections is shown by Figure 9. The following remarks will serve to amplify the information presented in the columnar sections and to indicate the overall characters of the formation in this area.

The total thickness is about 450 feet. The rocks are almost entirely sand and sandstone. As in the type section, the formation may be divided into two parts, a lower, marine part, and an upper sequence, of non-marine deposition.

The lower member is about 300 feet thick, and consists of grey and green, in part glauconitic, sand, with grey phosphatic nodules and thin bands of dusky red ironstone. In the Marie Heights area a hard, calcareous, grey, brown weathering sandstone, containing very large specimens of *Inoceramus*, is a conspicuous bed in the formation. This bed is about 3 feet thick and lies near, or at, the top of the marine part of the Wilkie Point Formation. This *Inoceramus* bed caps the two conspicuous flat-topped hills known as Marie Heights at localities 99 and 100. A similar sandstone, perhaps representing the same bed, occurs north of Raglan Range, on East Kitson River, at locality 101.

In the section on East Kitson River *Leioceras opalinum*, of Bajocian age, occurs about 100 feet above the Bjorne sandstone (Triassic) at locality 102. There is no evidence to suggest that the Borden Island Formation is present in this section. Probably the Wilkie Point beds rest directly upon the Bjorne Formation. No Toarcian faunas are known in this section or elsewhere on Melville Island, and it is therefore possible that the basal Wilkie Point beds on this island are of Lower Bajocian age. *Pseudolioceras* cf. *P. m'clintocki*, also of Bajocian age, was collected south of Depot Island, at locality 103 (GSC loc. 35344).

The *Arkelloceras* fauna (Upper Bajocian or Lower Bathonian) has been collected from talus at localities 99 and 100.

The upper, non-marine, Wilkie Point beds are probably about 150 feet thick. Good exposures of the uppermost beds have been examined in a ravine south of Cape Grassy, at locality 115. The uppermost unit comprises about 60 feet of white, fine-grained, massive, in part crossbedded sand and sandstone. It is overlain, abruptly, but apparently conformably, by the lower shale member of the Mould Bay Formation.

Sabine Peninsula

Exposures of the Wilkie Point Formation on Sabine Peninsula are poor, but they are sufficient to show that the beds form a narrow strip extending from Eldridge Bay to Sherard Bay.

The lower, marine beds have been studied 16 miles northeast of Cape Mudge at locality 104, where the contact between the Wilkie Point and Bjorne Formations is exposed. The basal bed of the Wilkie Point Formation consists of 10 inches of conglomerate resting upon light grey Bjorne sandstone. The contact is sharp with a slightly undulating bedding plane.

The conglomerate is overlain by about 100 feet of rubble consisting of dusky red ironstone; grey phosphatic nodules containing grains of glauconite; grey, light brown weathering, thin-bedded, slightly calcareous, fine-grained sandstone; grey and green sand. Poorly preserved belemnites, pentagonal crinoid columnals, and *Pseudolioceras* sp. indet. (GSC loc. 37021) were collected from this rubble (Frebold, 1960, p. 8).

The non-marine beds have been examined at two localities. Nineteen miles northeast of Cape Mudge the uppermost Wilkie Point beds comprise 65 feet of grey to white, medium- to fine-grained, quartz sand and sandstone with carbonaceous laminae. About 35 feet of similar beds are exposed in a small stream 5½ miles west of Sherard Bay.

The total exposed thickness of the Wilkie Point Formation on Sabine Peninsula is probably between 250 and 300 feet.

Borden and Mackenzie King Islands

The Wilkie Point Formation occurs on southern Borden Island and on western Mackenzie King Island, but the exposed section on each island is incomplete. The basal beds occur on Borden Island and the upper beds are exposed on Mackenzie King Island. These sections complement each other and so they are dealt with together.

Exposures of the Wilkie Point Formation are generally poor and reveal only a small part of the whole sequence. Much of the lithological data have been derived from a study of disintegrated outcrops and rubble. The strata dip at low angles which cannot be determined accurately from surface data. Consequently it is impossible to measure accurately the thickness of the Wilkie Point Formation on these islands. The total thickness is probably about 500 feet.

Fair exposures of beds near the base were examined on southern Borden Island, west of Piper Bay. There the basal Wilkie Point beds rest on the Borden Island Formation, but no exposures of the contact were seen. The boundary is reflected in a marked and abrupt change in physiography, and the two formations are quite different in lithology. The abrupt physiographic change probably indicates that the contact between the Borden Island and Wilkie Point Formations is also abrupt. At fossil locality 105, west of Piper Bay, about 100 feet of beds is exposed. These beds lie within 20 feet of the base of the formation. They consist of greyish green, plastic clay with yellow and dusky red weathering clay ironstone bands and nodules. Fossils collected from clay ironstone concretions near the base of this section have been identified by H. Frebold as follows (GSC loc. 35342):

Harpoceras cf. *H. exaratum* (Young and Bird)
Dactylioceras commune (Sowerby)

This fossil bed lies about 30 feet above the base of the Wilkie Point Formation. The fossils are dated as Toarcian by Frebold.

The Wilkie Point exposures of western Mackenzie King Island are generally poor. Two lithological units are present, a lower shale and an upper unit of

sand and sandstone. The lower shale presumably represents the same unit as is exposed on Borden Island.

Twelve miles north of McConnell Island the hills immediately adjacent to the coast rise to about 200 feet above sea-level. The slopes of these hills are covered with grey muddy wash and are strewn with pieces of clay ironstone and belemnite fragments.

About 9 miles inland (i.e., east) from the locality described in the preceding paragraph, at locality 106, the sand and sandstone unit appears in the section, stratigraphically above the shale. Its appearance is expressed topographically by the occurrence of a prominent cuesta. Rock exposures are poor on the face of this cuesta, but judging from wash and talus, at least 80 feet of beds is present. These beds apparently comprise soft grey and green sand with hard bands composed of yellowish brown weathering, grey calcareous sandstone, and dusky red, ferruginous sandstone. Fossils are abundant. The following section illustrates the sequence of fossiliferous horizons at locality 106.

Unit	Top of Section	Thickness (feet)
5	Sandstone, grey, yellowish brown weathering, calcareous; with *Pseudolioceras m'clintocki* (Haughton) and *Inoceramus* sp. (GSC loc. 35315)	3.0
4	Covered interval	8.0
3	Disintegrated beds of grey and red sandstone; this bed forms a bench upon which fossils, presumably more or less in situ, are very abundant. *Pseudolioceras m'clintocki* (Haughton), *Pseudolioceras*? sp. indet., *"Terebratula"* sp., *"Rhynchonella"* sp. etc. (GSC locs. 35312, 35313)	1.0
2	Covered interval	70.0
1	Bench of sandy wash with numerous shells of *Oxytoma jacksoni* (Pompeckj) and *Ostrea* sp.	?

Frebold identified the fossils from this section, and states that all are of Lower Bajocian age (*see* Frebold, 1960, p. 8).

Higher beds of the Wilkie Point Formation occur east of the cuesta described above. Exposures are poor. These beds consist of grey and green sand with some dusky red ironstone and clay ironstone concretions. Poorly preserved harpoceratids and belemnites were noted. The succeeding exposures contain Oxfordian or Kimmeridgian fossils and are placed in the lower shale member of the Mould Bay Formation. It follows that the Upper Bajocian and Bathonian beds and the overlying non-marine strata that form the upper part of the Wilkie Point Formation on Prince Patrick and Melville Islands appear to be absent on Mackenzie King Island. It is possible that time-equivalents of the non-marine Wilkie Point beds are present in the lower Mould Bay shale (*see* p. 144), but of Upper Bajocian, Bathonian, and Callovian beds there is no apparent trace.

Upper Jurassic and Lower Cretaceous

Mould Bay Formation

This formation was named by Tozer (1956, p. 23) to accommodate the beds, mainly sand and sandstone, that lie between the Wilkie Point and "Landing Lake" [1] Formations. It was recognized that the Mould Bay Formation included two units of distinct lithology, a lower marine member and an upper non-marine member. As field work progressed in the Queen Elizabeth Islands it became apparent that the upper member resembles closely the Isachsen Formation, which was originally defined on Ellef Ringnes Island (Heywood, 1957). It has now been established that the upper member is in fact an attenuated equivalent of the Isachsen Formation. The lower and upper members, as originally defined, can be mapped separately throughout the area described in this report and it therefore seems desirable to treat these 'members' as 'formations'. The Mould Bay Formation is, therefore, now restricted to include only the beds of the original lower, marine, member; the upper, non-marine beds are mapped as the Isachsen Formation.

In most areas the Mould Bay Formation rests, with an abrupt but apparently conformable contact, upon the Wilkie Point Formation. However, south of the weather station there is an unconformity between these formations. Between Walker Inlet and Mould Bay the beds are transgressive, and rest directly upon Devonian rocks.

The Mould Bay Formation occurs on Prince Patrick, Eglinton, Melville, and Mackenzie King Islands. The lithology varies considerably in different parts of this area. In the type area, near Mould Bay, the formation is predominantly sand and sandstone with a thin unit of shale at the base; west of the bay it is apparently entirely sand and sandstone; northeast, from Prince Patrick Island to Mackenzie King Island, increasing amounts of shale appear.

The faunas of the Mould Bay Formation permit a correlation with the Deer Bay shale, of the Ringnes Islands, Axel Heiberg Island, and western Ellesmere Island. The appearance of shale to the northeast reflects the interfingering relationship between the Mould Bay and Deer Bay Formations (*see* Fig. 7).

The sandstone facies of the formation is very distinctive and easily recognized throughout the northwestern islands. As noted above, in the sections on southern Prince Patrick Island, this facies makes up the greater part, or in some sections the whole, of the formation. On Mackenzie King Island the sandstone facies constitutes the middle of three members, the upper and lower members being grey marine shale, similar to that of the Deer Bay Formation. The Mould Bay sand and sandstone is grey and greenish grey, quartzose and fine grained. Hard bands of slightly calcareous, yellowish brown weathering sandstone are interbedded. Fossils are common. Most common are pelecypods (*Buchia,* better

[1] Now the Christopher Formation, of Lower Cretaceous age (*see* p. 154).

known as *Aucella,* being the most widely distributed genus) and worm tubes (possibly *Ditrupa*). The latter occur in vast numbers in nearly every area where the formation has been recognized. Echinoderms (ophiuroids and crinoid columnals) are also common, and bones of marine reptiles (ichthyosaurs and plesiosaurs) are known from several localities. Ammonoids are very rare.

The sandstone facies of the Mould Bay Formation was evidently deposited upon the southeast margin of the Sverdrup Basin. It is analogous to the Schei Point and Wilkie Point Formations.

The faunas have been studied by H. Frebold and J. A. Jeletzky. The oldest (known only on Mackenzie King Island) is of Upper Oxfordian or Lower Kimmeridgian (Upper Jurassic) age according to Frebold; the youngest is dated as Upper Valanginian (Lower Cretaceous) by Jeletzky. Several faunas of intermediate age also occur (*see* Fig. 7, and below). There seems to be no doubt that the Jurassic-Cretaceous boundary lies within the Mould Bay Formation. Faunas with *Buchia piochii* and *B. fischeri* are the most widespread. Both are dated as Upper Tithonian by Jeletzky. They may, however, also be partly equivalent to the Uppermost Portlandian of England and East Greenland.

Prince Patrick Island

Between Mould Bay and Walker Inlet

In this area, where Devonian outcrops predominate, the Mould Bay Formation has been preserved in outliers, most of which are downfaulted. The lithology in this area may be illustrated by a partial section measured at locality 107 on the banks of a small river that flows into Mould Bay, 13 miles north of Dames Point. This section was measured on the southwest side of the river, 4 miles from its mouth (*see also* Fig. 8).

Unit		Approximate thickness (feet) Unit	Total from base
	Mould Bay Formation (in part)		
4	Sandstone, soft, grey, poorly exposed and covered with wash	10	133
3	Sandstone, hard, yellowish brown weathering, with pebbles of black quartzite up to 3 inches in diameter	3	123
2	Sandstone and sand, grey, with irregular yellowish brown weathering hard bands containing abundant fossils, *Buchia* cf. *B. fischeri* (d'Orbigny) (GSC loc. 24820) 30 feet above base of unit (det. J. A. Jeletzky)	100	120
1	Sandstone, hard, brown weathering, pebbles of black quartzite in upper part; *Buchia* cf. *B. fischeri* (d'Orbigny) (GSC loc. 28423) in lower part (det. J. A. Jeletzky)	20	20
	Underlying beds: locally in structural conformity, hard green and brown sandstone of Griper Bay Formation (Devonian)		

The *Buchia* species from this section are dated as Upper Tithonian (uppermost Jurassic) by Jeletzky.

In this section the Mould Bay Formation rests directly upon Devonian rocks. The same situation occurs in the graben on the west side of Mould Bay, immediately opposite the weather station. This contact relationship apparently applies on the entire peninsula between Mould Bay and Walker Inlet. The Wilkie Point Formation disappears completely between the east and west sides of Mould Bay.

The total thickness of the formation in this area is not certainly known; it is probably about 200 feet.

Between Mould Bay and Intrepid Inlet

The formation is well exposed on several fault blocks on the peninsula between these inlets, where it rests upon the Wilkie Point Formation. In the sections north and east of the weather station the contact is sharp and appears to be conformable. Three miles south of the station the Mould Bay strata rest upon beds below the top of the Wilkie Point Formation. Viewed regionally, the Mould Bay-Wilkie Point boundary is therefore unconformable (Fig. 8).

The Mould Bay beds are moderately resistant to erosion and commonly form conspicuous scarps and cuestas. The scarp faces are nearly free of vegetation, and the beds, grey and greenish grey, with bands of brown, red, and, at the base, black, form distinctively coloured exposures. This is particularly true where they overlie the sands at the top of the Wilkie Point Formation, which are of a contrasting white colour (*see* Pl. XXVII).

The following section (type section of the formation) was measured at locality 108 on the cuesta that faces west and lies about 2 miles east of Mould Bay. This section illustrates the lithology of the beds in this area. The shale unit at the base is probably correlative with the lower shale member of Mackenzie King Island. The uppermost beds of the Mould Bay Formation and the contact with the overlying Isachsen Formation are not exposed in this section, and probably not exposed on this peninsula. However, the highest beds of the section probably lie within about 25 to 50 feet of the base of the Isachsen. The total thickness of the Mould Bay Formation in this area is probably between 250 and 300 feet.

Unit		Approximate thickness (feet)	
		Unit	Total from base
	Mould Bay Formation (part)		
7	Sandstone, grey, quartzose, fine-grained, slightly calcareous, weathers yellowish brown, in part with ripple-mark; *Ditrupa*? and pelecypods	2	225
6	Sand and sandstone, soft, grey, fine-grained; *Aucellina* n. sp. aff. *A. schmidti* Sokolow and *Arctotis*? sp. nov., 5 feet from top (GSC loc. 24828) (det. J. A. Jeletzky)	60	223

			Stratigraphy
5	Ironstone, dusky red, with abundant *Ditrupa*?	1	163
4	Sand and soft sandstone; outcrop is covered with wash and pebbles of black and green quartzite	40	162
3	Sandstone, grey, quartzose, fine-grained, weathers yellowish brown; poorly preserved *Buchia* seen with bands and nodules of red ironstone	2	122
2	Sand and soft sandstone; covered with pebbles and boulders, like unit 4	100	120
1	Shale, dark grey, deeply weathered and covered with wash	20	
	Underlying beds: uppermost white sand of Wilkie Point Formation		

The black and green boulders and pebbles that litter these outcrops are probably derived from thin beds of conglomeratic sand and sandstone within this section.

Vertebrate bones were collected from unit 6. Wann Langston Jr., of the National Museum of Canada, reports on these bones as follows:

> The collection includes four anterior caudal vertebrae, three distal phalanges, and a fragmentary limb bone of plesiosaur, possibly of the polycotylid type.

Bones were also collected from the hill 6 miles northeast of the weather station, at locality 134. According to Langston, this collection "includes the right humerus of an ichthyosaur of the *Opthalmosaurus* (=*Baptanodon*) type".

Buchia and other pelecypods are common in the Mould Bay beds throughout this area. From locality 135, on the east side of Mould Bay, J. A. Jeletzky has identified the following (GSC loc. 24818):

Buchia piochii Gabb s. lato
Buchia fischeri (d'Orbigny) (early forms)
Aucellina n. sp. aff. *A. schmidti* Sokolow
Pteria sp.
Ostrea sp.
pectinid indet.
belemnites indet.

According to Jeletzky this assemblage is of Upper Tithonian (uppermost Jurassic) age.

Eastern Prince Patrick Island

The Mould Bay Formation forms an extensive terrain extending from the upper reaches of Intrepid Inlet to Jameson Bay. The beds are almost flat lying and relief is insufficient to provide a complete section within any one place. However, several partial sections have been examined and they probably illustrate the lithology of most of the formation in this area. Three members have been distinguished; a lower shale, a middle sandy member, and an upper shale.

The basal beds were examined on the small, prominent, dark coloured butte 3 miles east of Intrepid Inlet, and 5 miles northeast of Hiccles Cove (locality 109). They represent the lower shale member and comprise about 150 feet of

deeply weathered grey friable shale with large, yellow weathering concretions of calcareous mudstone. These beds rest, with an abrupt contact, upon the uppermost white sand of the Wilkie Point Formation. The following fossils, dated as Upper Tithonian (uppermost Jurassic) by J. A. Jeletzky, were collected 100 feet above the base of the formation (GSC loc. 37181).

Buchia fischeri (d'Orbigny)
Buchia piochii cf. var. *B. russiensis* (Pavlow)
Buchia cf. *B. blandfordiana* (Stoliczka)
Buchia cf. *B. subpallasi* (Krumbeck)

A section of higher beds (middle sand member) was examined in the hills on the east side of Intrepid Inlet, 6 miles south of the head of the inlet (locality 110). These beds comprise 160 feet of soft greyish green sand, with hard, yellowish brown weathering, calcareous bands. Layers with abundant pelecypod shells are common in this section, both in the soft sands and the hard sandstone. *Buchia* sp. indet. (GSC loc. 37197) was collected at the top of this section. The base of this section probably lies close to the boundary with the lower shale member.

Exposures of the middle sand member were also examined north of the head of Intrepid Inlet, at locality 112. At this locality specimens of *Buchia fischeri* (d'Orbigny), of Upper Tithonian age, identified by J. A. Jeletzky, were collected (GSC loc. 37245).

The uppermost beds of the Mould Bay Formation were examined 6 miles northwest of the cylindrical hill christened 'The Redoubt' by M'Clintock. The following section was measured at this locality (111).

Unit		Approximate thickness (feet) Unit	Total from base
	Mould Bay Formation		
	Overlying beds: basal sands and pebble beds of the Isachsen Formation		
4	Shale, grey, friable	8.0	36
3	Ironstone, dusky red, with *Buchia keyserlingi* (d'Orbigny), *B.* aff. *B. crassa* (Pavlow), *B.* cf. *B. bulloides* (Lahusen), *Inoceramus* sp. indet. (GSC loc. 37199, det. by J. A. Jeletzky)	1.0	28
2	Sand, quartzose, medium- to coarse-grained	7.0	27
1	Slumped and weathered beds; probably fine-grained sand	20.0	
	Underlying beds: not exposed		

The fossils in this section are dated as Upper Valanginian by Jeletzky. The shale at the top of this section probably represents the attenuated remnant of the upper shale member of Mackenzie King Island (*see* p. 144).

The partial sections studied in this area show that the Mould Bay Formation includes a lower shale, about 150 feet thick, followed by a sand and sandstone

member, at least 160 feet thick. At the top there is a thin shale member. The total thickness of the Mould Bay Formation in eastern Prince Patrick Island is probably about 400 feet.

Northeastern Prince Patrick Island

In northeastern Prince Patrick Island the Mould Bay Formation is brought to the surface on the axis of the Moore Bay anticline. The beds in this area have not been studied in detail. Grey, yellowish brown weathering, slightly calcareous, fine-grained sandstone with numerous pelecypods outcrops 15 miles southeast of Cape Ludlow Rich (locality 113). These beds evidently represent the middle sandstone member. Observations from the air suggest that the upper shale member is also present. This section probably resembles that of Mackenzie King Island.

Fossils collected 15 miles southeast of Cape Ludlow Rich have been identified by J. A. Jeletzky as follows (GSC loc. 37182):

Buchia sp. indet.
Pholadomya sp. indet.
Pecten (*Entolium*) sp. indet.
Tellina? sp. indet.

Eglinton Island

Rubble of typical Mould Bay sand and sandstone litters the surface of northeastern Eglinton Island. No exposures have been seen and it is unlikely that good outcrops occur.

Melville Island

Northwestern Melville Island

The Mould Bay Formation forms a belt crossing the peninsula north of Marie Bay; it also outcrops south of Cape Grassy. South of Marie Bay these beds dip north and form a distinct cuesta, facing south (Pl. XXX).

Moderately good exposures occur north of Marie Heights. Two members can be recognized. The lower member consists of black friable shale with large concretionary masses of yellow weathering calcareous mudstone. The overlying beds comprise soft, grey and greenish grey sand and sandstone with yellowish brown weathering, hard calcareous bands and concretions. The sandstone also contains aggregates of calcite crystals radially arranged. At locality 114 fossils are moderately common. They include *Buchia* sp. indet. and other pelecypods, an ophiuroid, and tubular shells (GSC loc. 37193). The thicknesses of these members have not been accurately measured: the lower shale member is probably about 100 feet; the overlying sand member is probably about 350 feet.

A partial section of the formation is well exposed in a small ravine 8 miles south of Cape Grassy (locality 115), where about 100 feet of typical Mould Bay sand and sandstone overlies about 60 feet of grey shale with concretions. Poorly preserved specimens of *Buchia* were collected from this shale (GSC loc. 37198). This shale rests upon the Wilkie Point Formation with an abrupt contact.

68975-2—11

PLATE XXX. Aerial view of northwestern Melville Island looking west to Fitzwilliam Strait. The exposures are on the Marie homocline, dipping gently to the north (right). Exposed are the Wilkie Point Formation (J wp), Mould Bay Formation (JK mb), and the Isachsen Formation (Kl i). The cuesta formed by the Mould Bay beds, and the desert country developed upon Isachsen strata, are common throughout the western Queen Elizabeth Islands. (RCAF 419L–48)

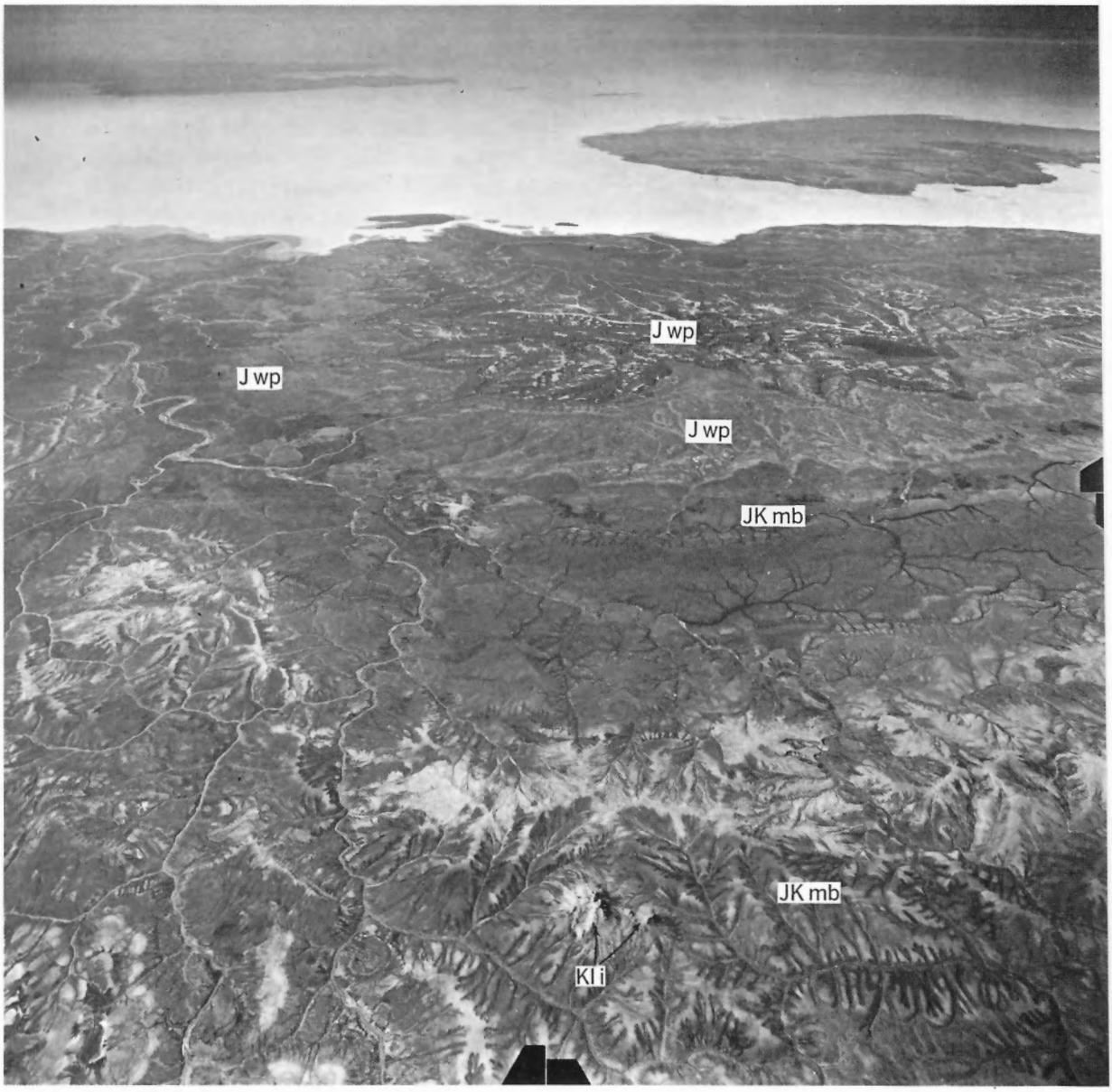

PLATE XXXI. Aerial view of western Mackenzie King Island, looking west towards Brock Island. The bedrock dips east exposing the Wilkie Point (J wp) and Mould Bay (JK mb) Formations and an outlier of the hard facies of the Isachsen Formation forms the Leffingwell Crags, in the foreground. The dark-toned Mould Bay beds are the lower shale member; the lighter beds, with dendritic drainage, represent the middle sand member. (RCAF T423L–191)

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The upper shale member, which occurs on Mackenzie King and Prince Patrick Islands, is apparently absent in northwest Melville Island.

Sabine Peninsula

Exposures on Sabine Peninsula are very poor. At the west end of the isthmus between Eldridge and Sherard Bays a low ridge lies between exposures of the upper Wilkie Point and those of the basal Isachsen beds. This ridge is capped by rubble of greyish green sand, brown weathering calcareous sandstone, and dusky red ironstone. The rubble evidently represents a stratigraphic interval of about 35 feet overlying exposures of the Wilkie Point Formation. This interval of poor (or probably non-existent) outcrops clearly indicate the occurrence of the Mould Bay Formation. It is impossible to measure the thickness from the surface data; however, the formation is thin, probably less than 200 feet. There is no evidence that shale occurs in the Mould Bay Formation on Sabine Peninsula and it appears that the shale members developed elsewhere are not present. The shale probably appears in the subsurface of northern Sabine Peninsula (*see* p. 198).

Mackenzie King Island

Here the Mould Bay Formation includes three distinct members, a lower member of shale, a middle member composed mainly of sand and sandstone, and an upper shale member. This section has as much in common with the Deer Bay Formation as with the Mould Bay unit and it illustrates the interfingering relationship between these two formations (Fig. 7).

The Mould Bay beds have been studied in most detail in a belt that extends across the formation at the latitude of the Leffingwell Crags (*see* Pl. XXXI). In this belt the beds dip regionally to the east, but a number of small folds, e.g., the Leffingwell Crags syncline, cause some repetition of strata at the surface, particularly in the middle of the belt.

No exposure of the Wilkie Point-Mould Bay contact was seen. A sharp physiographic boundary marks the contact and the lithology of the two formations is quite different. As already mentioned (p. 135), the youngest Wilkie Point beds on this island are of Bajocian (early Middle Jurassic) age. The oldest Mould Bay faunas are late Oxfordian or early Kimmeridgian (mid-Upper Jurassic). The apparently abrupt change in lithology, and the absence of Upper Bajocian, Bathonian, and Callovian faunas may mean that the Mould Bay-Wilkie Point boundary marks a substantial hiatus.

Good exposures of beds near the base of the lower shale member occur on the east side of the river 4 miles west of Leffingwell Crags, at locality 116. These shale exposures form a rather prominent cuesta, facing west. They comprise about 45 feet of black and dark grey shale with very conspicuous ovoid masses of yellow weathering calcareous mudstone up to 10 feet in diameter. *Amoeboceras* sp. indet. of late Oxfordian or early Kimmeridgian age, occurs in a bed of hard shale at the base of this section (GSC loc. 35346, determined by Frebold). Thirty feet higher in the section *Buchia bronni* Rouillier (GSC

loc. 37184, determined by J. A. Jeletzky), also of late Oxfordian or early Kimmeridgian age, occurs.

Ichthyosaur bones were also obtained at locality 116. Wann Langston Jr., of the National Museum of Canada, reports on these bones as follows:

> *Identification*—Occipital condyle and three vertebrae of *Opthalmosaurus* (= *Baptanodon*).
>
> The occipital condyle and especially two of the three vertebrae closely resemble bones of the North American *Opthalmosaurus* called *Baptanodon* in the older literature. They differ accordingly from the common Oxfordian *Opthalmosaurus* of Europe. The systematic relation between the two 'genera' is not clear, but it has often been suggested that they are congeneric. The North American record of the genus extends from the middle Jurassic (Sundance Formation, *Baptanodon* beds) probably into the Upper Cretaceous, but the principal material pertains to Jurassic species.
>
> The large vertebra that accompanies the above specimens belonged to a second individual. In size and proportions it resembles Jurassic vertebrae called *Baptanodon robustus* by Gilmore (1906).

At locality 117, about 2 miles west of Leffingwell Crags, about 20 feet of dark grey, hard to soft shale is exposed. A collection from these beds has been identified as follows by Jeletzky (GSC loc. 37187).

Buchia cf. *B. fischeri* (d'Orbigny)
Buchia cf. *B. subpallasi* (Krumbeck)

Jeletzky dates this collection somewhat tentatively, as Upper Tithonian (uppermost Jurassic). These beds evidently lie near the top of the lower shale member. The total thickness of this shale is probably about 100 feet.

The middle member of the Mould Bay Formation consists mainly of grey and greenish grey sand, of red and yellowish brown weathering sandstone with hard, calcareous bands. Exposures of this member are poor, discontinuous, and, within the belt studied, gently folded. The uppermost bed of the middle member is a 4-foot, orange weathering, greyish green, fine-grained, calcareous sandstone.

Twelve miles north of Leffingwell Crags, 20 feet of poorly exposed grey shale occurs about 130 feet below this distinctive orange sandstone. This indicates that at least one thin shale is interbedded within this dominantly arenaceous member.

The following fossils have been identified from the middle member by J. A. Jeletzky:

Locality 118, east of Leffingwell Crags (GSC loc. 37191):

Craspedites (Subcraspedites) cf. *C. suprasubditus* Bogoslowsky
Phylloceras (Partschiceras) sp.
Buchia okensis (Pavlow)

These fossils are of lowermost Cretaceous (earliest Berriasian or Riasanian) age, according to Jeletzky.

Locality 119, west of Leffingwell Crags (GSC loc. 37243):

Buchia piochii cf. var. *B. russiensis* (Pavlow)
Buchia cf. *B. piochii* (Gabb) s. lato
Aucellina n. sp. aff. *A. schmidti* Sokolow
Pecten (Camptonectes) cf. *P. praecinctus* Spath

Thracia? sp. indet.

Pentacrinus sp. indet.

This collection is dated Upper Tithonian (uppermost Jurassic) by Jeletzky.

The upper member forms an easily traced belt of dark, vegetated terrain bordering the desert formed by the overlying Isachsen Formation. This member is composed of dark grey shale with dusky red and yellow clay ironstone concentrations. West of Leffingwell Crags, beds near the base of this member form a moderately conspicuous cuesta. Fossils obtained from this member include:

Locality 120, east of cuesta formed by base of upper shale member, 6 miles east of Leffingwell Crags (GSC loc. 37196):

Buchia cf. *B. keyserlingi* (d'Orbigny)

Buchia cf. *B. inflata* (Toula)

This collection is dated as either Lower or Upper Valanginian by Jeletzky.

Locality 121, lowest concretionary band of upper shale member (GSC loc. 37190):

Buchia cf. *B. keyserlingi* (d'Orbigny)

Oxytoma cf. *O. cornueliana* (d'Orbigny)

This collection is dated as Lower Valanginian by J. A. Jeletzky.

Owing to the discontinuous nature of the outcrops and the low and irregular dip, it is impossible to give an accurate thickness for the Mould Bay Formation in this area, but the lower member is about 100 feet, the middle member probably about 300, and the upper member about 100 feet thick.

Cretaceous

Isachsen Formation

This formation was named by Heywood (1955; 1957, p. 11) for the essentially non-marine, arenaceous strata that lie between the Deer Bay and Christopher marine shales. The type section is on Ellef Ringnes Island.

The Isachsen beds are mainly light coloured, quartzose, sandstone and conglomerate with some shale, coal, and ironstone. This formation is now known to occur throughout the Sverdrup Basin for it occurs on western Ellesmere, Axel Heiberg, Amund Ringnes, Ellef Ringnes, Melville, Mackenzie King, Prince Patrick, and Eglinton Islands. A distinctive characteristic of the Isachsen Formation is variable lithification. The beds vary from hard, cemented rock to unconsolidated sediment. Apart from differences in the degree of cementation, lithologically the Isachsen beds are moderately uniform throughout the Archipelago. However, the thickness varies greatly: on the edge of the Sverdrup Basin it is commonly about 500 feet; within the basin it increases, to about 4,500 feet at Strand Fiord, western Axel Heiberg Island (*see* Thorsteinsson and Tozer, 1960, p. 25).

The beds formerly classed as the "upper member of the Mould Bay Formation" (Tozer, 1955, p. 24) are now known to represent the Isachsen Formation (*see* p. 136).

Marine fossils of Upper Valanginian age occur near the base in some areas, but not within the area described in this report. Lower Cretaceous plants are known from the higher beds. Although the Isachsen beds mostly lack fossils diagnostic of age, they can be dated approximately from the age of the beds above and below. The Mould Bay Formation, which underlies the Isachsen in western islands, and the Deer Bay shale, which lies in the same position to the east, both contain Upper Valanginian fossils (J. A. Jeletzky, pers. com.). As already noted, the basal Isachsen beds contain Upper Valanginian fossils at some localities. The Christopher Formation, which succeeds the Isachsen, is of Albian and possibly also Aptian age. The Isachsen Formation is therefore entirely Lower Cretaceous and includes beds of Upper Valanginian, probably Hauterivian and Barremian, and possibly also Aptian age.

On Prince Patrick, Eglinton, and northern Melville Islands the Isachsen Formation consists of two members: The lower consists of coarse-grained sand and conglomerate, the upper of fine-grained arenaceous rocks. The Isachsen beds of Mackenzie King Island are apparently entirely of the coarse-grained facies.

Outliers of flat-lying, mainly non-marine sediments overlie the Devonian rocks of southeastern Melville Island. In the preliminary account of this area (Thorsteinsson and Tozer, 1959, p. 4) these beds were tentatively assigned to the Eureka Sound Formation (Tertiary), with the reservation that they might, in fact, be older. Study of the microflora (by D. C. McGregor) and the vertebrate fossils (by Wann Langston) collected from these beds has confirmed that they are not Tertiary, but Jurassic or Cretaceous, and probably not younger than Lower Cretaceous. These beds are now assigned to the Isachsen and Christopher Formations for the following reasons: 1, the lower, non-marine part of the sequence resembles the Isachsen Formation in lithology; 2, there is no resemblance to the Jurassic beds of northern Melville Island, and consequently no evidence to support a Jurassic assignment; 3, the palaeontological dating of the beds in southern Melville Island, although not precise, is entirely compatible with the suggestion that the non-marine beds are the same age as the Isachsen Formation, and that the overlying strata are the same age as the Christopher, i.e., that all these beds are Lower Cretaceous; 4, the Isachsen Formation, overlain by fossiliferous Christopher, is now known to rest directly upon Devonian and older rocks on Banks Island (Thorsteinsson and Tozer, 1961). This sequence on Banks Island thus resembles the sequence suggested for southern Melville Island.

The evidence from lithology, fossils, and comparison with an adjacent area supports the assignment of the outliers of southern Melville Island to the Isachsen and Christopher Formations. The occurrence is of considerable palaeogeographic interest in that it suggests that this region was subjected to transgression in Lower Cretaceous time.

Prince Patrick Island

Between Mould Bay and Walker Inlet

On this peninsula the Isachsen Formation is known only from poor exposures and it is unlikely that good outcrops occur. The total thickness is probably less than 300 feet.

Small outcrops of grey sand with much reddish brown ironstone debris and fragments of coal occur on the east side of the Mesozoic outlier (at locality 122) 2½ miles south of Landing Lake. Fossil plants in the ironstone debris include *Nilssonia* cf. *N. nigracollensis* Wieland, determined by W. L. Fry. Rubble of dusky red ironstone with plant fragments also occurs in the west side of this outlier.

Between Mould Bay and Intrepid Inlet

Exposures are poor and discontinuous, and are limited to a triangular area near the middle of the peninsula. The most common lithology is soft, grey and white sand and sandstone, with dusky red bands of ironstone. Outcrops of the lithified facies of the Isachsen occur 5½ miles northeast of Mould Bay weather station, in a branch of Station Creek. About 25 feet of bed outcrops, mainly hard, slightly calcareous, brown weathering, quartz-pebble conglomerate, granule sand, and coarse-grained sandstone. Thin laminae of red ironstone with plant fragments occur in the sandstone. A coal seam, at least 5 feet thick (the base is not exposed), occurs 6 miles north-northeast of the weather station.

Eastern Prince Patrick Island

The Isachsen Formation forms an extensive terrain on eastern Prince Patrick Island. There, as elsewhere, the beds support practically no vegetation, and this terrain of nearly horizontal beds is a sandy desert (*see* Pl. XXXIV).

The beds reveal their characteristic variable induration in this area. The cementing material was apparently deposited in an irregular manner, not concentrated in particular beds but forming irregular hardened masses that cannot be traced as stratigraphic units. For example, northwest of Jameson Bay the basal Isachsen conglomerate is unconsolidated but near Brown Bluff, about 8 miles to the southeast, these beds have a brown ferruginous cement and consist of hard, consolidated rock. These hard basal Isachsen beds form a small but conspicuous butte at Brown Bluff. Five miles north of Brown Bluff there is a remarkable, almost perfectly conical, flat-topped hill, appropriately named 'The Redoubt' by Leopold M'Clintock. The Redoubt itself was not visited but it is apparently formed of Isachsen beds of the cemented facies.

Partial sections of the formation have been examined in several parts of eastern Prince Patrick Island. The basal beds near Brown Bluff comprise about 75 feet of coarse-grained sandstone and small pebble conglomerate, cemented by hematite. The pebbles in the conglomerate are mainly quartz, with some white chert and weathered carbonate. Four miles northwest of The Redoubt at least

150 feet of beds occurs in the lower part of the formation. These beds are unconsolidated and poorly exposed but apparently comprise quartz sand and pebble beds. The upper Isachsen beds have been examined 6 miles northwest of John Point and 11 miles northwest of Cape Hemphill (= Giddie Point of M'Clintock's map). At the former locality about 50 feet of fine- to medium-grained, grey and white, slightly micaceous quartz sand lies directly beneath the shales of the Christopher Formation. These beds have carbonaceous laminae and, near the base of the section, a 6-inch seam of friable coal. At the locality northwest of Cape Hemphill about 80 feet of similar sand is exposed.

These partial sections show that the Isachsen Formation of eastern Prince Patrick Island has a basal unit of coarse quartz sand and conglomerate, overlain by fine-grained quartzose sediments. A similar two-fold division occurs on Eglinton and Melville Islands. The total thickness is probably between 300 and 400 feet.

Eglinton Island

The Isachsen Formation forms a spectacular belt of badlands and desert on northern Eglinton Island (Pl. XXXIII). The beds that form the badlands consist mainly of soft, light grey to white, medium- to coarse-grained quartz sand and sandstone, with some conglomerate. The formation also contains light brown, hard, ferruginous bands and dark dusky red ironstone nodules, both of which contain abundant plant fragments. Coal seams and beds of carbonaceous shale also occur in the Isachsen of this area.

Seven miles south of Gardiner Point, a 3-foot seam was noted in 1954. This seam lies above light coloured sands, grits, and small-pebble conglomerate. In 1958 a landing was made at plateau level 11 miles south of Gardiner Point. There the following partial section was measured:

	Top of Section	Thickness (feet)
4	Sand, light grey, quartzose, fine-grained	10
3	Carbonaceous shale	1
2	Sand, as 4	10
1	Coal	3.5

The coal seam at the base of this section overlies an undetermined thickness of light grey, medium- to coarse-grained quartz sand and soft sandstone.

The uppermost beds of the Isachsen Formation are exposed in creek banks 8 miles northwest of Catherine Point. These beds comprise about 50 feet of fine-grained, very soft, slightly micaceous sandstone with thin, brown, hard bands. They are followed, abruptly, by grey shales of map unit 26.

The total thickness of the Isachsen Formation on Eglinton Island is probably about 400 feet.

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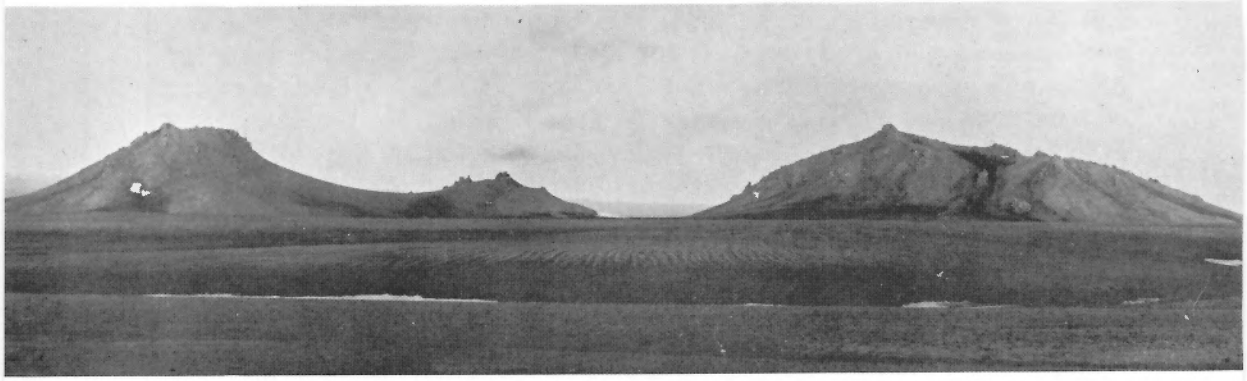

PLATE XXXII. Leffingwell Crags, Mackenzie King Island. The Crags are an outlier of the Isachsen Formation overlying the Mould Bay beds that form the plain in the foreground.

Melville Island

Northwestern Melville Island

Fourteen miles southwest of Cape Scott the uppermost Mould Bay beds are overlain by about 50 feet of soft, light grey, coarse-grained quartz sand and gravel that represent the basal Isachsen beds (Pl. XXX). The boundary between the Mould Bay and Isachsen Formations is apparently abrupt. Exposures of the Isachsen Formation are also known in the vicinity of Cape Grassy, the best being in a bluff 2 miles south of the cape. Low exposures also occur near the coast, 2 miles west of the cape. The outcrops south of the cape expose about 200 feet of beds, mainly light grey sand and silt with carbonaceous shale and dusky red ironstone bands. The highest beds in this section are darker and contain more shale than the underlying strata. They probably represent the basal part of the Christopher Formation. The low exposures west of the cape include about 60 feet of soft, grey sand, dusky red ironstone and minor grey shale. Abundant pieces of thin-bedded coal also occur. It was presumably in this neighbourhood that Stefansson and his party discovered coal and a "kind of pitch" in 1916 (Stefansson, 1921, p. 564). Stefansson described his coal seam as inclined. The best outcrops in this area reveal that the beds are nearly horizontal and Stefansson's inclined seam may have slumped.

On northwestern Melville Island, the Isachsen exposures reveal that two members are present, a lower coarse-grained member and an upper member of fine-grained rocks. The total thickness is probably about 400 feet.

Sabine Peninsula

The Isachsen Formation forms a narrow strip in the isthmus between Eldridge and Sherard Bays. Fair exposures occur 4 miles from the west end of the isthmus. The lower part of the Isachsen includes at least 25 feet of unconsolidated white sand and gravel, with pebbles of quartz up to half an inch in diameter. The upper beds are fine-grained, soft, badland-forming sand and silt, with thin bands

PLATE XXXIII

Typical exposures of the soft facies of the Isachsen Formation, northern Eglinton Island. The black streak is a 3½-foot coal seam. Kellett Strait is in the background and the Canrobert Hills on the horizon.

PLATE XXXIV

Contact of dark coloured recessive Christopher beds (above), and the Isachsen Formation, 2 miles north of 'The Redoubt', eastern Prince Patrick Island.

PLATE XXXV

Exposures of the Isachsen Formation, northwest of Bridport Inlet, southern Melville Island.

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of dusky red ironstone and carbonaceous shale. The total thickness is probably about 400 feet.

Southeastern Melville Island

Several outliers of nearly, or completely, horizontal beds of the Isachsen Formation are present in this area. These beds rest directly upon the folded Devonian rocks of the Parry Islands Fold Belt. The largest outliers are northwest of Bridport Inlet and northeast of Skene Bay. The geological map of Melville Island may not show all these outliers because these beds are generally poorly exposed and commonly not easily distinguished from regolith developed upon the Devonian formations.

The best known exposures are about 16 miles northwest of the head of Bridport Inlet, on the banks of Mecham River (*see* Pls. XXXV, XXXVI). The total thickness of the Isachsen Formation is about 70 feet. Two lithological members may be distinguished. The lower member, about 30 feet thick, consists of alternating thin beds of dark grey, fine-grained, carbonaceous quartzose sand and silt. Thin coal seams, up to a foot thick, carbonaceous shale, and light grey sand form minor constituents. At locality 123, this member rests unconformably upon the Griper Bay Formation. From samples of carbonaceous shale at locality 123 the following plant microfossils have been identified by D. C. McGregor (GSC palaeobotanical loc. 5226).

Alisporites Daugherty
Abietaepollenites R. Pot.
Podocarpacae (*Podocarpites* Bolch. and cf. *Podocarpus*)
cf. *Pinus*
Gleicheniidites Ross
cf. *Perotrilites* Couper
Rugulatisporites Pflug.
Stenozonotriletites Naum.
several other trilete spores, possibly related to ferns

The upper member is about 40 feet thick. It consists of light grey, thin- to medium-bedded, fine- to coarse-grained quartzose sand that is commonly poorly sorted and crossbedded. Quartzite and quartz pebbles and coal seams up to an inch thick form a minor, yet characteristic, part of this member.

The upper member is overlain by dark coloured silt, sand, and clay, assigned to the Christopher Formation (*see* Pl. XXXVI, and p. 158).

McGregor states that the spores and pollen in the above collection include forms that range from the Jurassic to the early Cretaceous. Some are known only from the Lower Cretaceous of Europe. An early Cretaceous age is most probable, but the possibility of a Jurassic age cannot be excluded.

Mackenzie King Island

The Isachsen beds of Mackenzie King Island consist mainly of coarse-grained, quartzose sediments. In grain size they vary from coarse sand, to granule sand and

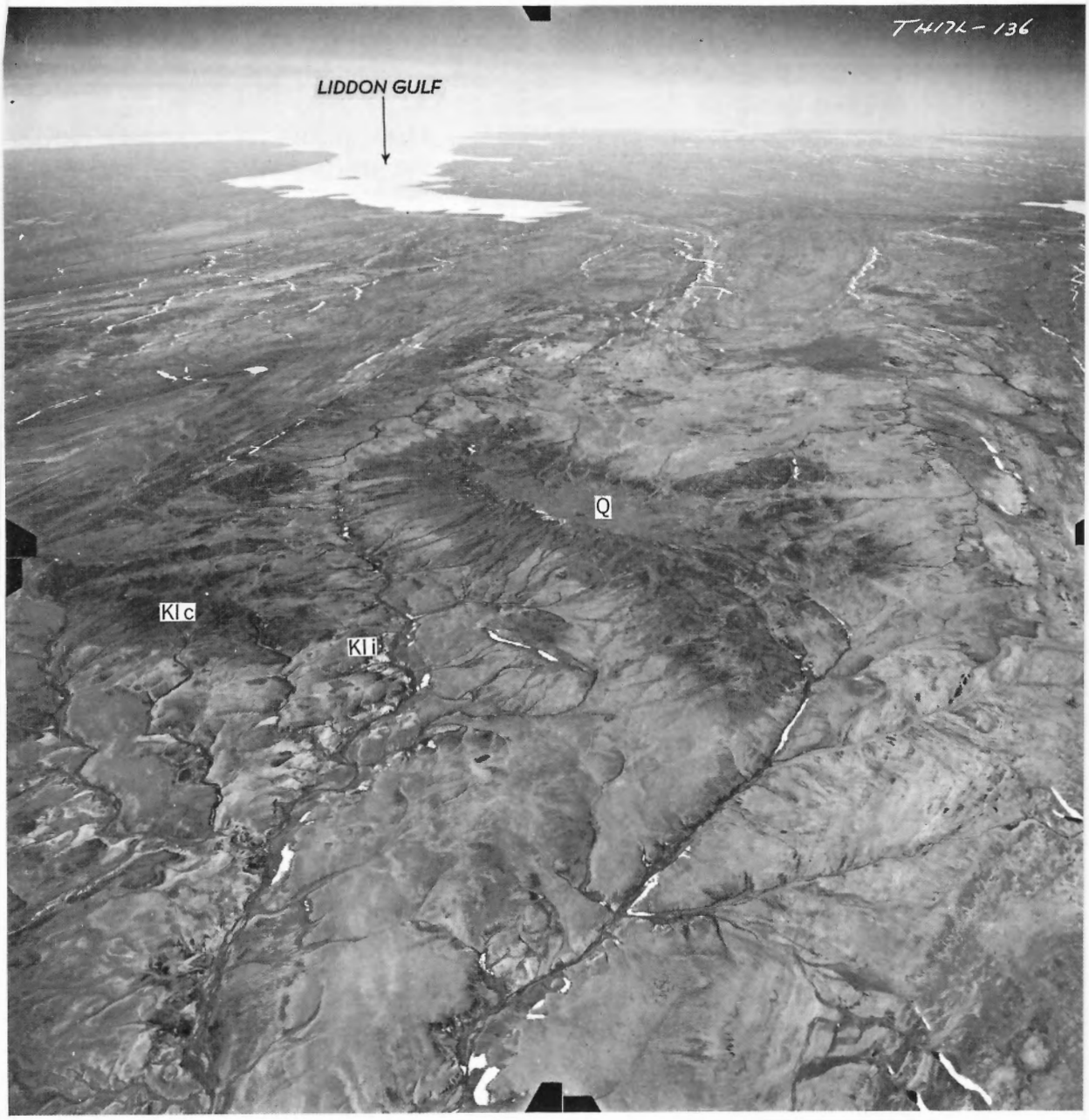

PLATE XXXVI. Aerial view of southern Melville Island, looking west of Liddon Gulf. Outliers of the Isachsen (Kl i), and Christopher (Kl c) Formations overlie the folded Devonian formations. Glacial till (Q) caps the highest ground. (RCAF T417L–136) (see Addendum, p. 230)

conglomerate. As on eastern Prince Patrick Island, they are variably lithified. Twelve miles east of Cape Beuchat, beds near the base of the Isachsen comprise about 50 feet of unconsolidated, coarse-grained sand and grit with thin, dusky red, ironstone bands and shale laminae. The hard facies of the Isachsen Formation is responsible for the most prominent topographic features of the island. Leffingwell Crags and Castel Butte, 11 miles to the east, are both capped by exceptionally hard, brown weathering, slightly calcareous sandstone, grit, and conglomerate (*see* Pls. XXXI, XXXII). The Crags represent an outlier of the Isachen Formation and the hard beds at this locality are probably close to the base of the formation. This same hard, coarse-grained facies forms a group of small buttes, 23 miles east of Cape Beuchat. The beds at this latter locality lie at, or near the top of the formation. These buttes are a local feature and the hard beds exposed there cannot be traced along the strike. This suggests, as does the evidence on Prince Patrick Island, that the hard facies of the Isachsen Formation represents irregularly distributed patches within a formation composed mainly of unconsolidated rock.

The fine-grained rocks that occur in the upper part of the Isachsen Formation of Prince Patrick, Eglinton, and Melville Islands have not been recognized on Mackenzie King Island. If present, this facies is poorly exposed and does not form a distinct member as on the other islands.

At Castel Butte talus and outcrops of Isachsen beds occur throughout a stratigraphic interval of 260 feet. This figure provides a minimum thickness for the formation. The total thickness probably does not exceed 500 feet.

Christopher Formation

The Christopher Formation was named by Heywood (1955; 1957, p. 12) for the marine shale that lies between the non-marine Isachsen and Hassel Formations. The type section is on Ellef Ringnes Island. Recent work has shown that the formation is widely distributed within the Sverdrup Basin, for, in addition to Ellef Ringnes Island, it is known on Amund Ringnes, Axel Heiberg, western Ellesmere, Prince Patrick, Melville, Mackenzie King, and Emerald Islands. Equivalents of the Christopher are probably also present on Eglinton Island (p. 163). The beds placed in the "Landing Lake Formation" on Prince Patrick Island (Tozer, 1956, p. 25) are now known to represent the Christopher Formation, and the formation name "Landing Lake" is abandoned.

Unlike the older marine formations within the Sverdrup Basin, the Christopher was deposited beyond the limits of the Basin proper. Occurrences in southeastern Melville Island illustrate the transgressive nature of the Christopher sea, as do occurrences on Banks Island (Thorsteinsson and Tozer, 1961). The Christopher transgression was probably approximately, and perhaps exactly, contemporary with the Lower Cretaceous inundation that affected much of the western interior of Canada and which left the deposits on Anderson River, the Fort St. John Group and contemporary formations.

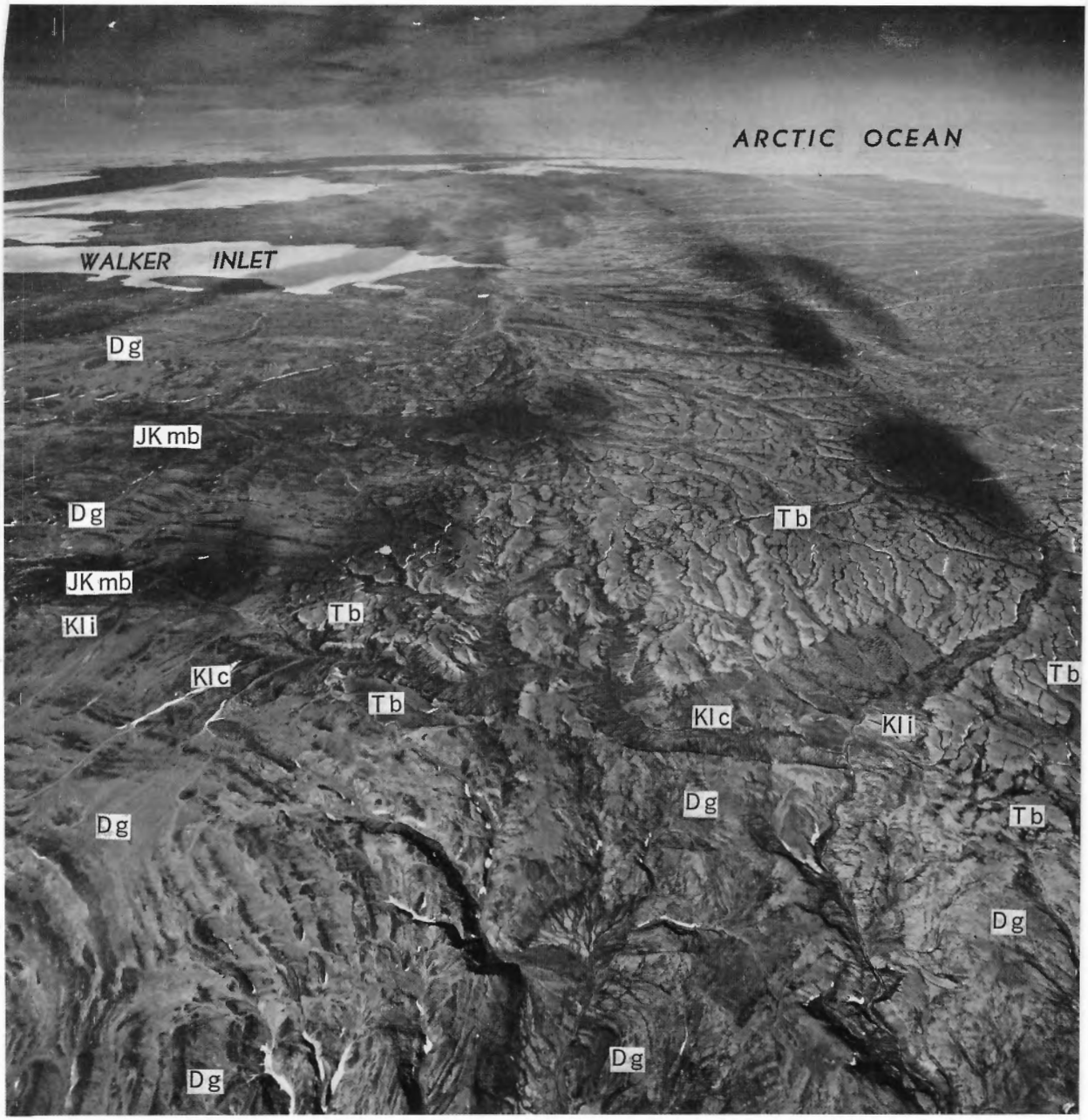

PLATE XXXVII. Aerial view of southern Prince Patrick Island, between Mould Bay and Walker Inlet. Two down-faulted Mesozoic outliers are visible with exposures of the Mould Bay (JK mb), Isachsen (Kl i) and Christopher (Kl c) Formations. To the north is the Arctic Coastal Plain composed of Beaufort beds (T b). Right of centre, in the foreground, is the fault line scarp separating the Griper Bay (D g) and Christopher (Kl c) Formations. (RCAF T429R–84)

Shale constitutes the characteristic Christopher lithology. A sandstone member occurs in the middle of the section on Axel Heiberg and Ellesmere Islands. Sandstone and siltstone also occur on Melville and Mackenzie King Islands. It appears that the Christopher is essentially shale within the axial part of the Sverdrup Basin, with lenses and tongues of sandstone and siltstone appearing towards the margins. The thickness of complete sections of the Christopher Formation varies between about 600 and 4,600 feet.

Diagnostic fossils are rare. Lower Albian (late Lower Cretaceous) faunules with *Sonneratia, Beudanticeras,* and *Lemuroceras* have been identified from several localities by J. A. Jeletzky. Some fossils from Mackenzie King Island are possibly of Aptian (mid-Lower Cretaceous) age, according to Jeletzky.

Prince Patrick Island

Southern Prince Patrick Island

In this area the Christopher Formation has been preserved on two downfaulted outliers, one is north of Landing Lake and the other is west of Mould Bay.

The exposures north of Landing Lake are deeply weathered and consist of yellow concretions of calcareous mudstone projecting from grey, muddy, cutbanks.

Good exposures occur west of Mould Bay, in the valley 4 miles southwest of Landing Lake (Pls. XXXVII, XXXVIII). They comprise about 130 feet of grey, friable, clay shale with large concretionary masses of yellow weathering limestone and calcareous mudstone. Also present are pieces of fossil wood and aggregates of calcite crystals, radially arranged ('hedgehog' concretions).

Pelecypods occur in the Christopher Formation in this area but no good specimens were found.

Eastern Prince Patrick Island

The Christopher Formation forms several patches of nearly horizontal beds on eastern Prince Patrick Island. These beds have been examined 6 miles northwest of John Point and 5 miles west of Cape Ludlow Rich. The remaining areas of the formation shown on the map (*in pocket*) were identified solely from the air.

Northwest of John Point the Christopher beds comprise 40 feet of poorly exposed grey shale with large yellow concretions and cone-in-cone. These beds rest, apparently with an abrupt contact, upon the Isachsen Formation (Pl. XXXIV). The beds examined west of Cape Ludlow Rich resemble those northwest of John Point.

This is the youngest Mesozoic formation exposed on Prince Patrick Island, consequently its total thickness cannot be determined. The thickest remaining section is probably on the Cape Hemphill peninsula, but this sequence has not yet been examined.

PLATE XXXVIII

Valley 5 miles west of Mould Bay, south of locality 122, Prince Patrick Island. The dark outcrops in the foreground are of the Christopher Formation. The escarpment beyond is composed of Beaufort beds and marks the inland edge of the Arctic Coastal Plain.

Melville Island

Northwestern Melville Island

The Christopher Formation may occur near Cape Grassy (*see* p. 150). Examination of air photographs suggests that the formation forms an extensive terrain southeast of Cape Scott, but these beds have not been studied on the ground.

Sabine Peninsula

The Christopher forms an extensive terrain on Sabine Peninsula, where the whole formation is present. Exposures are discontinuous, and in the middle of the formation they are rather poor.

The basal beds are well exposed in small gullies on the face of the cuesta that lies on the north side of the isthmus between Eldridge and Sherard Bays. This section comprises about 400 feet of grey shale, silty shale, and fine-grained, soft sandstone, thinly interbedded. Most of these rocks are poorly lithified but beds and large concretionary masses of hard, yellow weathering calcareous mudstone, siltstone, and sandstone are also present. Poorly preserved specimens of *Astarte*? sp. (GSC locs. 25878, 25879) occur in this section (locality 124).

Higher beds of the Christoper Formation were examined north of the cuesta, at locality 125, east of Eldridge Bay. Poor outcrops of grey, friable shale weathering to mud, with yellow weathering concretions of calcareous mudstone occur. Also noted was a deeply weathered bed, about a foot thick, of soft, sticky, yellow clay, probably bentonite. Ammonites collected from concretions at this locality (GSC loc. 37183) have been identified as follows by J. A. Jeletzky:

Beudanticeras affine (Whiteaves)
Lemuroceras (s. l.) *belli* McLearn

According to Jeletzky these fossils indicate either late lower or early middle Albian (late Lower Cretaceous) age.

The uppermost Christopher beds were examined 13 miles northwest of Invincible Point. They comprise about 120 feet of grey shale, with light grey sand

and siltstone laminae up to about an inch thick. The shale contains dark dusky red ironstone concretions.

From the foregoing it would appear that at least three members occur within the Christopher Formation of Sabine Peninsula. The basal member is composed of shale, siltstone, and sandstone with yellow calcareous concretions; the middle member (known only from very poor exposures) is apparently composed of shale with yellow concretions; and the upper member consists of shale with some interbedded sandstone and dusky red ironstone concretions. The total Christopher thickness is probably about 700 feet.

Southeastern Melville Island

A thin veneer of dark coloured beds caps some of the outliers of the Isachsen Formation that occur in southeastern Melville Island (Pl. XXXVI). These beds are assigned to the Christopher Formation (*see* p. 152). Where exposures are good, the contact between the Isachsen and Christopher Formations is seen to be sharp. However, as good exposures are rare it has not been possible to map the Isachsen-Christopher boundary in southeastern Melville Island.

The best known Christopher exposures are northwest of Bridport Inlet, on Mecham River (locality 126), where about 25 feet of beds are present. These beds comprise an alternating series of light to dark grey quartzose silt, fine-grained sand, and dark grey clay. Light grey quartzose sand is a minor constituent. Dusky red weathering clay ironstone concretions are common in the lower part of the sequence. A microflora from 3 feet of dark grey clay at the base of the formation has been identified by D. C. McGregor as follows (GSC palaeobotanical loc. 5223):

Abieteaepollenites sp.
Pinus haploxylon-typ Rud.
Podocarpites Bolch.
Appendicisporites tricornitatus Weyl. and Greif.
Cicatricosporites dorogensis Pot. and Gel.
Cicatrisporites sp.
Cyathidites sp.
Gleicheniidites senonicus Ross
Trilobosporites apiverrucatus Couper
cf. *Lycopodium*
cf. *Tsugaepollenites*
?Cycadales

Microfloral analysis of a channel sample of the upper 22 feet of the upper member has yielded the following forms (GSC palaeobotanical loc. 5224):

Abieteaepollenites
Pinus haploxylon-typ Rud.
Appendicisporites tricornitatus Weyl. and Greif.
Caytonipollenites pallidus (Reis.) Couper

Cicatricosporites dorogensis Pot. and Gel.
Chasmatosporites Nilsson

Some fragmentary vertebrate remains were collected from the uppermost exposures of the Christopher Formation at locality 126. These bones have been presented to the National Museum of Canada (Nat. Mus. Canada, No. 9897). Wann Langston Jr., of that institution, comments on the bones as follows:

> The collection includes 3 vertebrae, and the symphysial fragment of a coracoid of an elasmosaurid plesiosaur. The long-necked elasmosaurs were widely distributed in oceans and epicontinental seas of the Upper Cretaceous, and comprise the bulk of the North American late Cretaceous plesiosaurian fauna. However the family appears to have originated in the late Jurassic, and genera are reported from Kimmeridgian deposits of England. The elasmosaurs evidently evolved from the Plesiosauridae, the common European Liassic plesiosaurs. The specimens submitted are too incomplete to permit refined identification, but clearly they represent a long-necked plesiosaur of either the *Elasmosauridae* or *Plesiosauridae* and the length of the cervical vertebrae suggests the former. It is fairly certain from the state of preservation that the bones were not found *in situ*, but the vertebral fragments evidently pertained to a single individual, suggesting that little transportation has occurred from the original place of deposition.

D. C. McGregor, who identified the microflora, states that the spores and pollen are probably about the same age as those from the underlying Isachsen beds (p. 152), i.e., Jurassic or Lower Cretaceous, more probably the latter. It would appear that the palaeontological evidence, from both the microflora and the vertebrate bones, does not permit a precise age determination but that this evidence is compatible with the assignment of these beds to the Lower Cretaceous.

Emerald Isle

One landing was made near the southeast corner of Emerald Isle. The exposures observed consist of dark grey shale, of marine aspect, containing large yellow weathering concretions of calcareous mudstone. No fossils were seen. The whole island is apparently capped by similar beds, which appear to be horizontal. The thickness is probably about 250 feet. The beds are assigned to the Christopher Formation because of their lithological similarity with Christopher beds of the adjacent islands.

Mackenzie King Island

The Christopher beds of Mackenzie King Island dip at low angles in an area of relatively little relief. Consequently individual stratigraphic sections expose only a small part of the formation.

In this area the formation includes dark grey shale and grey to brownish grey, fine-grained, commonly calcareous sandstone. Most of the shales contain concretions, commonly of large size, composed of yellow weathering calcareous mudstone, large masses of fossil wood, and aggregates of radiating calcite crystals. These aggregates are common in the Christopher Formation throughout the

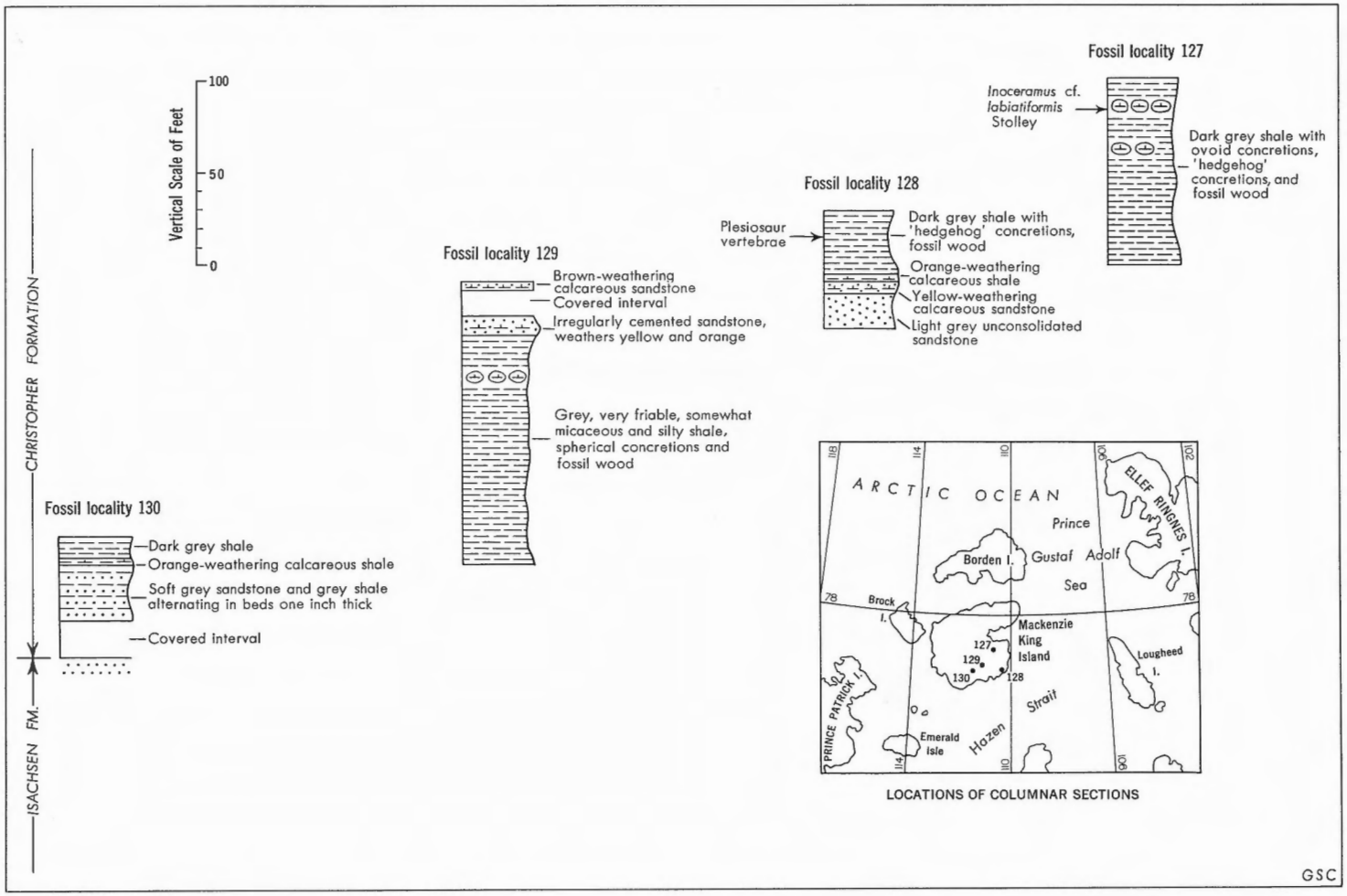

FIGURE 10. Columnar sections of Christopher Formation, Mackenzie King Island.

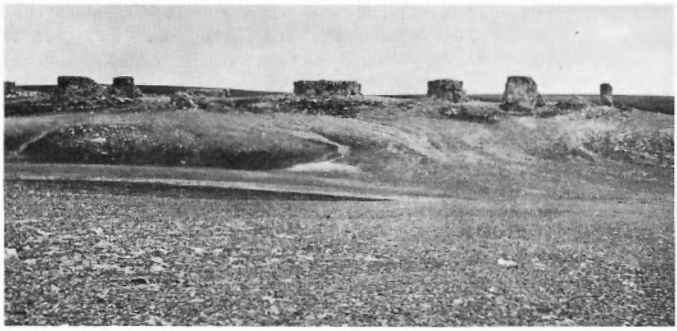

PLATE XXXIX

Hard sandstone bed in the Christopher Formation southeastern Mackenzie King Island. The individual isolated blocks are about 15 feet high.

Archipelago and for brevity are referred to as 'hedgehog concretions' in the columnar sections (Fig. 10). The Christopher sandstones are very irregularly indurated. The hard varieties are cemented by calcite and weather yellowish brown and orange. The irregular induration is well displayed by a 15-foot sandstone unit that lies about 150 feet above the base of the formation. Exposures of the soft facies are generally poor but masses of the hard facies form resistant rectangular blocks (Pl. XXXIX). This bed is nearly horizontal, and where it is exposed the terrain is reminiscent of a field strewn with large bales of hay. The irregular distribution of cement is presumably due to differential deposition of carbonate, or differential leaching. Whatever the cause, the rectangular nature of the blocks suggests that vertical joints and two permeable bedding planes have controlled the movement of the cementing, or leaching, solutions.

The details of four partial sections of the Christopher Formation are shown by Figure 10.

The total preserved thickness of the Christopher Formation on Mackenzie King Island probably does not exceed 400 feet.

Well preserved fossils, other than fossil wood, are rare. Invertebrate fossils from two localities have been identified by J. A. Jeletzky as follows:

Locality 127, southeastern Mackenzie King Island (GSC loc. 37189):

Inoceramus cf. *I. labiatiformis* Stolley

Locality 131, northeastern Mackenzie King Island (GSC loc. 37244):

Fragment of the living chamber of an uncoiled ammonite strongly resembling the living chamber of *Tropaeum*. Positive generic identification is impossible.

Jeletzky states that the fossils in these collections are suggestive of an Aptian (mid-Lower Cretaceous) age.

At locality 128, near the southeastern corner of Mackenzie King Island some plesiosaur vertebrae were collected from the Christopher Formation. They have

been presented to the National Museum of Canada (Nat. Mus. Canada, No. 9898). Wann Langston Jr., comments as follows:

> The collection includes 4 cervical and 8 caudal vertebrae, fragments of limb bones and ribs of a polycotylid plesiosaur. The specimens have the necessary diagnostic features of the family *Polycotylidae* and possibly they pertain to the genus *Polycotylus* itself, but it is impossible to be sure without direct comparisons. This identification, like the record of *Polycotylidae* from the Mould Bay Formation [*see* p. 139], would demand a downward revision of the range of the genus *Polycotylus*, provided that the age assigned to the Christopher Formation is correct. *Polycotylus* is typically known from the Niobrara Formation (Upper Cretaceous) of Kansas.

Hassel Formation

This formation was named by Heywood (1955; 1957, p. 13) for the non-marine sandstone and shale that overlies the Christopher Formation on Ellef Ringnes Island. The top of the Hassel is not exposed in the area studied by Heywood. In 1955, members of the Geological Survey discovered a marine shale of Upper Cretaceous age above the Hassel non-marine beds (Fortier, 1957, p. 436), which has been named the Kanguk Formation (*see below*). The Hassel Formation therefore refers to the non-marine, essentially arenaceous beds, between the Christopher and Kanguk shales.

This formation is now known on Ellef Ringnes, Axel Heiberg, and western Ellesmere Islands, and possibly also on Graham Island. On Sabine Peninsula, the Christopher shale is overlain by unfossiliferous sands and sandstones, evidently of non-marine deposition. On the basis of their stratigraphic position these beds are provisionally placed in the Hassel Formation.

Sabine Peninsula

The Hassel Formation forms a belt extending from McDougall Point to Cape Caledonia, as well as a somewhat circular ring bordering the upland between Chads Point and Invincible Point. Sand and sandstone make up much, or all of the formation, the total thickness being about 200 feet.

The Hassel sand is characteristically yellow, quartzose, and of medium to coarse grain. Interbedded with the soft sand are hard ferruginous, yellowish brown and reddish brown, bands. Hassel outcrops are commonly covered with fragments of the hard red and brown sandstone. The Christopher-Hassel contact was studied 13 miles northeast of Invincible Point, where 25 feet of interbedded sand and shale lies between typically Hassel sands and the grey, dominantly shaly, Christopher Formation. The boundary between the two formations thus appears to be transitional. Fourteen miles east of Chads Point the upper Hassel beds include about 20 feet of grey quartz sand with carbonaceous laminae.

Kanguk Formation

This formation is a marine Upper Cretaceous shale that occurs on Ellesmere, Axel Heiberg, and Ellef Ringnes Islands and possibly also on Graham Island. Throughout most of this area the Kanguk Formation rests upon the Hassel Forma-

tion, but around Strand Fiord, Axel Heiberg Island, volcanic rocks are interposed between the two. The Kanguk is followed by the Eureka Sound Formation, a non-marine deposit of Upper Cretaceous (?) and early Tertiary age.

On Sabine Peninsula, a marine shale overlies the beds placed in the Hassel Formation. This shale, like the typical Kanguk, is overlain by non-marine beds. It lacks diagnostic fossils but apparently occupies a similar stratigraphic position to the Kanguk Formation, with which it is provisionally correlated.

Sabine Peninsula

On Sabine Peninsula the Kanguk Formation occurs in two areas. It forms an outlier in the central part of the peninsula and it also forms an arcuate belt extending south and west from Cape Colquhoun. Fair exposures of the lower Kanguk beds were examined on the south side of the central outlier, 12 miles N70°E of Chads Point. These beds comprise about 200 feet of thinly fissile, light and dark grey shale. The upper beds include some dark, dusky red ironstone; in the lower part of the section the shale weathers light grey to almost white, and commonly contains fragmentary fish remains.

A complete section of the Kanguk Formation is believed to occur on northern Sabine Peninsula. However, exposures are poor and individual outcrops reveal only a small part of the formation. Beds near the base were examined 9 miles south of Barrow dome. These comprise light grey weathering, grey, thinly laminated shale with fish remains, like the lower beds of the central outlier described above. Deeply weathered exposures of about 40 feet of grey shale were examined between Barrow dome and Eden Bay. With the available surface data, the discontinuity of exposures makes it impossible to produce a reliable estimate of the total thickness of the Kanguk Formation; it probably amounts to about 500 feet.

Map-Units 26 and 27 of Eglinton Island

The Isachsen beds of Eglinton Island are overlain by a sequence of beds that comprises, first, a formation composed mainly of shale, with lesser sandstone and siltstone, map-unit 26. Map-unit 26 is overlain by medium- to coarse-grained quartz sands and grits, with hard beds of black sandstone and conglomerate, map-unit 27. In the course of field work it was supposed that map-unit 26 represents the Christopher Formation and that the overlying map-unit 27 is the Hassel. Fossils are rare in this section, but those that have been obtained render this interpretation suspect. Some poorly preserved fossils from the upper part of map-unit 26 are probably Upper Cretaceous according to J. A. Jeletzky; the typical Christopher Formation does not include beds younger than Albian (late Lower Cretaceous). If Jeletzky's tentative age determination is correct, map-unit 26 includes beds much younger than the Christopher Formation. The Upper Cretaceous fossils with which he compares the poorly preserved specimens from Eglinton Island are characteristic of the Kanguk Formation, which overlies the Hassel and

Christopher beds. Possibly the Christopher and Kanguk shales have coalesced on Eglinton Island. Alternatively there may be an unrecognized disconformity within the section on Eglinton Island. At present this problem cannot be resolved and the beds are not assigned to named formations.

Map-unit 26 can be divided into three lithologically distinct members: a lower shale, a middle sandstone, and an upper member of shale and sandstone.

The lower member consists of dark grey clay shale with large, yellow weathering concretions and abundant fossil wood. The concretions are composed of grey calcareous mudstone. This member has been recognized on the west coast, 14 miles southwest of Gardiner Point; inland, 8 miles north of Catherine Point; and also on the east coast, near Catherine Point. At the inland locality these shales rest, apparently with an abrupt contact, upon the uppermost beds of the Isachsen Formation. It would appear that this member forms a belt, trending slightly west of north, paralleling the boundary with the upper part of the Isachsen Formation. The exact thickness of the member is not known, but it is probably about 100 feet.

The best known exposures of the middle member occur in the cliffs immediately north of Cape Nares, at the southwest extremity of Eglinton Island. At this locality about 85 feet of irregularly indurated, fine-grained, finely cross-laminated sandstone is exposed. The hard varieties of the sandstone are cemented by carbonate and form yellowish brown beds about 10 feet thick. The hard sandstone contains poorly preserved pelecypods. This member has also been seen on northern Eglinton Island, at a place 16 miles southwest of Gardiner Point, and about a mile inland. There, irregular, yellow weathering sandstone masses form small, discontinuous outcrops, which form scattered projections from the rolling hills. The situation of these outcrops establishes that the sandstone member lies above the lower shale member. The total thickness, like that of the lower shale, is probably about 100 feet.

The upper member of map-unit 26 consists principally of light grey and greyish green shale with thin bands of sand and sandstone. It is well exposed on faces of the bluffs that surround the plateau of southwestern Eglinton Island. Exposures also occur in the cliffs north of Cape Nares, where the upper shale member is seen to overlie the middle sandstone member. Good exposures have been examined on the bluffs 8 miles south of Callaghan Point. There the upper member comprises about 300 feet of grey shale, with thin bands of grey and green sandstone, and thin bands of white and yellow bentonitic shale. Thin bands and concretionary masses of dark, dusky red clay ironstone also occur. Sandstone becomes increasingly abundant towards the top of the section. The appearance of the sandstone evidently expresses a gradational transition between map-units 26 and 27. A similar section is exposed 7 miles southwest of Catherine Point, where a 6-inch seam of yellow bentonitic shale occurs about 200 feet from the top of map-unit 26. Prisms of large *Inoceramus* shells occur about 10 feet lower in this section. Some poorly preserved fossils were collected from the upper shale member at locality

132, 6 miles northeast of Cape Nares. These fossils have been identified by J. A. Jeletzky as follows (GSC loc. 37188):

Inoceramus cf. *I. cardissoides* Goldfuss s.l.

Oxytoma sp. cf. *O. camselli* McLearn

Regarding this collection Jeletzky states that the *Inoceramus* fragments are "closely comparable with the specialized mid-Upper Cretaceous (Santonian to Lower Campanian) species group of *Inoceramus lobatus-cardissoides-steenstrupi.* These fragments are, at the same time, unlike any hitherto described Lower Cretaceous and early Upper Cretaceous (Cenomanian) *Inocerami* known to the writer. The mid-Upper Cretaceous age of this collection is almost assured, in the writer's opinion, despite the poor preservation of the fossils concerned".

The total thickness of map-unit 26 probably approximates 500 feet, made up as follows: lower member, about 100 feet; middle member, about 100 feet; upper member, about 300 feet.

Map-unit 27 overlies unit 26 and is the youngest formation preserved on Eglinton Island. It consists of sand, sandstone, grit, and conglomerate. The beds are variably indurated. The hard beds are very resistant and they form the bluffs that surround the high plateau remnants in the interior of southern Eglinton Island.

Map-unit 27 consists mainly of greyish green, grey, and almost white sand, grit, and gravel. Most of the formation seems to be soft but some beds are indurated by a cement that is partly siliceous and partly composed of black, ferruginous, and manganiferous material. The black cement locally imparts a metallic lustre to the rock, reminiscent of gunmetal. Outcrops are commonly obscured by talus of the black indurated rock. It would be necessary to remove this talus in order to assess, accurately, the proportion of hard, manganiferous sandstone, in the sequence. The rock, apart from the cement, is composed essentially of quartz grains, mainly of medium to coarse size but locally with granules and pebbles up to about 10 mm size. A small amount of chert is also present as grains and granules. The lower boundary of map-unit 27 appears to be transitional with unit 26. Eight miles south of Callaghan Point the thickness of map-unit 27 is about 150 feet. This figure probably indicates, approximately, the maximum thickness preserved. At locality 133, a few poorly preserved pelecypod steinkerns were collected (GSC loc. 41619). According to J. A. Jeletzky they probably represent marine genera but they are too poorly preserved for identification.

The age and correlation of map-unit 27 is unknown. If the underlying strata represent the Christopher Formation, map-unit 27 might represent the Hassel. The beds on Sabine Peninsula placed in the Hassel are similar in lithology, although they lack the manganiferous cement. If the underlying shale is the same age as the Kanguk, as suggested by the poorly preserved *Inocerami,* map-unit 27 is without parallel in the Archipelago because this unit bears no resemblance to the Eureka Sound, which normally overlies the Kanguk.

Tertiary

Eureka Sound Formation

The non-marine Tertiary succession now known as the Eureka Sound Formation was first discovered by members of the expeditions that explored northern Ellesmere Island towards the end of the last century. These pioneers described the strata as Tertiary continental beds with coal seams. Heer (1878), who described the fossil collections, considered the beds to be Miocene. Per Schei, the geologist of the *Fram* Expedition (1898-1902) discovered additional occurrences of the Tertiary beds, and he suggested that the non-marine Tertiary formation was deposited after the folding of the Mesozoic rocks of Ellesmere and Axel Heiberg Islands. Nathorst (1915), who studied the fossil plants collected by members of the *Fram* Expedition, was more conservative than Heer and simply dated the beds as Tertiary. Troelsen (1950; 1952), who applied the name "Eureka Sound" to these beds, like Schei, believed that the beds were laid down after the folding of the Mesozoic rocks. Relatively recent work by members of the Geological Survey has shown that the Eureka Sound beds are themselves folded and faulted and that the formation is essentially pre-orogenic (Thorsteinsson and Tozer, 1957). On Ellesmere and Axel Heiberg Islands the Eureka Sound Formation attains a thickness of about 10,000 feet. Palaeobotanical studies by Wayne Fry and D. C. McGregor suggest that it is mainly or entirely of early Tertiary (Paleocene or Eocene) age.

Sabine Peninsula

Within the map-area, some poorly exposed, non-marine beds at the tip of Sabine Peninsula are tentatively assigned to the Eureka Sound Formation on the admittedly unsatisfactory grounds that they overlie a presumed equivalent of the Upper Cretaceous Kanguk Formation. The Eureka Sound beds of Ellef Ringnes, Axel Heiberg, and western Ellesmere Islands lie above the Kanguk, hence the suggested correlation for the beds on Sabine Peninsula.

About 2 miles north of Barrow dome exposures near the upper boundary of the Kanguk Formation comprise about 95 feet of very soft, thinly interbedded sand and shale with some dusky red clay ironstone near the top of the section. Carbonaceous shale and carbonized wood fragments occur in talus at this locality. These beds presumably lie near the base of the Eureka Sound Formation.

The remaining exposures seen comprise soft, yellow, and almost white, medium- to coarse-grained quartz sand with large fragments and logs of carbonized wood. About 50 feet of such beds are exposed at three places: 1½ miles west of the south side of Barrow dome; a quarter of a mile west of the dome; and near the northwest edge of the Cape Colquhoun dome. These soft sands probably overlie the interbedded shale and sand described above. The total thickness of Eureka Sound beds on Sabine Peninsula is not known, the figure is probably relatively small, about 300 to 400 feet.

Tertiary and (or) Pleistocene

Beaufort Formation

The Beaufort Formation was named by Tozer (1956) to include the deposits of crossbedded sand and gravel that cover much of Prince Patrick Island. It is now known to be widespread on the islands facing the Beaufort Sea and Arctic Ocean, from Cape Kellett, southern Banks Island, to Meighen Island (Craig and Fyles, 1960; Thorsteinsson, 1961). Within the map-area this formation overlies, unconformably, formations ranging in age from Devonian (Griper Bay Formation) to Lower Cretaceous (Christopher Formation). On Banks Island the Beaufort beds overlie, apparently disconformably, beds that are probably of early Tertiary age (Thorsteinsson and Tozer, 1961). The dominant sediment is coarse-grained, quartzose sand; seams of gravel with pebbles of sandstone, quartzite, and chert are also common. The most distinctive feature is the occurrence of uncompressed logs and sticks of remarkably unaltered fossil wood.

The age and mode of origin of this formation are uncertain. There seems to be little doubt that it is younger than the Eureka Sound Formation, which includes beds of early Tertiary (Paleocene-Eocene) age. The reasons for this conclusion are: First, on Banks Island a probable correlative of the Eureka Sound Formation underlies the Beaufort beds. Second, within the Queen Elizabeth Islands the Eureka Sound Formation was folded during a period of Tertiary tectonic compression. The Beaufort beds rest unconformably upon the northwest limb of the Sverdrup Basin synclinorium which was produced by these Tertiary earth movements. There is, therefore, no doubt that the Beaufort Formation post-dates the Tertiary compressive movements. However, as shown in the chapter on structural geology (p. 202) some normal faults apparently dislocate the Beaufort beds of Prince Patrick Island. The spores, pollen, and wood specimens that have been obtained from the Beaufort do not assist materially in determining its age. According to J. Terasmae, who has studied the microfossils, some of the pollen and spore specimens may be derived from older formations and consequently the whole suite does not give a clear indication of the age.

Some data are available concerning the upper age limit. According to Craig and Fyles (1960), it is older than the glaciation of Banks Island and the evidence within the map-area suggests that the Beaufort is older than the glaciation of these islands also. The early glaciation of Banks Island and the glaciation of Prince Patrick Island probably took place prior to Wisconsin time, and the wood from the Beaufort Formation is too old for age determination by the Carbon-14 method. It follows that if the Beaufort is Pleistocene it is probably very early Pleistocene. The sum of evidence suggests that the Beaufort Formation of the map-area is late Tertiary or very early Pleistocene. According to Terasmae, the palynological evidence is compatible with this suggestion but does not positively confirm it.

The source of the Beaufort beds undoubtedly lay to the east and southeast. The formation probably represents alluvial and deltaic material derived from

denudation of the parts of the Archipelago that were uplifted after the Tertiary compressive movements. The mass of sediment produced during this period of erosion must have been considerable. Presumably the Beaufort beds represent part of this sediment, and the remainder may be present on the submarine continental shelf.

Prince Patrick Island

The Beaufort Formation apparently underlies the whole of Prince Patrick Island northwest of a line joining Dyer Bay and Cape Krabbé. Many small outliers occur southeast of the main belt. The beds are unconsolidated and are commonly slumped or covered with material that has moved by solifluction. However, isolated fresh outcrops, revealing beds of uniform lithology, have been seen throughout much of the area and the character of these isolated outcrops suggests that the Beaufort beds are essentially uniform throughout Prince Patrick Island.

Data on the thickness of the Beaufort and the elevation of its base are as follows. The figures were determined by aneroid barometer and are, therefore, approximate.

Locality	Elevation of base (feet)	Thickness of beds (feet)
North of Moore Bay, 18 miles south of Cape Krabbé	100	20
East side Intrepid Inlet, 10 miles north of Cape Canning	400	100
West side of Intrepid Inlet, 4 miles north of Salmon Point	330	60
Hill 6 miles northeast of Mould Bay weather station	500	70
Bluff immediately east of Landing Lake	330	20
West of Landing Lake	from below 240 to 360	ca 250

At each locality the beds consist of coarse quartzose sand with seams of gravel containing pebbles up to at least 2 inches in diameter, and numerous fragments of wood. Some logs attain a diameter of a foot. North of Salmon Point the pebbles from the Beaufort Formation consist mainly of brown quartzite and grey and black chert. Some specimens of wood from Intrepid Inlet have been studied by J. D. Hale, of the Forests Products Laboratory, Ottawa, who identified *Picea* sp. (spruce) and *Pinus* sp. (a 5-needle pine) from this area.

The variation in the elevation of the base of the Beaufort Formation is presumably a function of (1) the relief and regional slope upon which the beds

PLATE XL

Outcrops of crossbedded Beaufort sand and gravel, with fossil wood, 9 miles north of Wolley Bay, southern Prince Patrick Island.

PLATE XLI

Slumped outcrops of Beaufort Formation, with a large log, about 12 inches in diameter, 2 miles east of the head of Mould Bay, Prince Patrick Island. The large boulders that characteristically cover the Beaufort exposures are clearly seen.

PLATE XLII

Aerial view of the Beaufort terrain, south of Satellite Bay, northern Prince Patrick Island, from an altitude of about 500 feet. This view shows ice-wedged polygons that characteristically are found on the Beaufort terrain.

were deposited, and (2) post-depositional tectonic uplift. Both these factors have probably played a part in determining the present contours of the base of the formation. West of the line joining Dyer Bay and Cape Krabbé the base is apparently below sea-level.

Fossil wood was found by Mecham (1855, pp. 518, 522-523) near Cape Manning and northeast of the head of Walker Inlet. At the latter locality Mecham records that one piece was at least 8 feet long, another had a diameter of 2 feet, 10 inches, and two others had a circumference of 4 feet. The wood collected by Mecham was said by Heer (1868, p. 23) to have a microscopic structure similar to that of *Pinus strobus,* a living species; however he referred the beds from which it came to the Miocene. W. L. Fry states that fossil wood is rarely useful in stratigraphic correlation and Heer's Miocene dating is probably not justified, furthermore, the new identifications made by Hale do not assist in determining the age of these beds. Radiocarbon ages determined on two samples of wood, by the Yale Geochronometric laboratory (Preston, Person and Deevey, 1955, p. 957), were more than 25,300 years and more than 31,840 years. Another determination, by the Lamont Laboratory (Broecker, Kulp and Tucek, 1956) gave a figure of more than 33,000 years for a sample from the beds north of Salmon Point.

The Beaufort beds of Prince Patrick Island are commonly overlain by a veneer of boulders, some of which reach 3-foot dimensions. Despite the fact that this veneer seems, at first sight, to be intimately related to the Beaufort beds, it is now considered more likely that the boulders are the remains of a later glacial deposit (*see* p. 36).

Brock Island

The northwest half of Brock Island appears to be underlain by the Beaufort Formation. This conclusion is drawn from the sandy and pebbly nature of the terrain and the presence of the distinctive physiographic features associated with the Beaufort beds in other areas. No true outcrops have been seen. A sample of the material forming the surface at Cape Murray consists of coarse quartzose sand, with pebbles of chert and sandstone. Some of the pebbles may have ice-rafted or derived from glacial material.

Borden Island

The northern part of Borden Island is underlain by the Beaufort Formation. Good exposures of 30 feet of beds were seen north of DuVernet River, at locality 136 about 12 miles south of Cape Malloch. A covered interval of about 20 feet separates the Beaufort and Schei Point beds. The Beaufort beds comprise thin-bedded, dark grey to medium dark grey, fine- to medium-grained, unconsolidated, carbonaceous quartzose sand and light grey non-carbonaceous sand. Discontinuous seams of gravel and fragments of wood occur throughout the sand.

PLATE XLIII. Aerial view of northern Borden Island, westward. Most of the view is of the Arctic Coastal Plain. The dark terrain to the south (left) is underlain by Mesozoic formations. (RCAF T411R–164)

The carbonaceous sand was submitted to J. Terasmae for palynological study. His analysis is as follows:

	No. of pollen grains counted	Per cent of total AP
TREE POLLEN (AP)		
Pinaceae	15	9
Pinus (pine)	48	31
Picea (spruce)	31	19
Tsuga (hemlock)	2	1
Betula (birch)	33	20
Alnus (alder)	13	8
Corylus (hazel)	8	5
Carpinus (blud-beech)	10	6
Populus (poplar)	2	1
	162	100
NON-TREE POLLEN (NAP)		
Ericaceae	85	52
cf. *Calluna*	2	1
cf. *Rubus Chamaemorus*	1	0.6
Myrica	1	0.6
cf. Saxifragaceae	2	1
unidentified	4	2.5
SPORES		
Polypodiaceae	7	4
monolete fern spores	5	3
trilete fern spores	7	4
Selaginella	1	0.6
Lycopodium cf. *annotinum*	13	8
Lycopodium sp.	5	3
Sphagnum	3	2
unidentified	6	4

Terasmae's views on the age of this flora have been published by Craig and Fyles (1960, p. 3). The general conclusion is that this pollen flora "represents a warmer climate than would be expected in this region even during the warm (interglacial) parts of the Pleistocene and is tentatively considered to be late Tertiary".

Chapter IV

IGNEOUS ROCKS

Igneous rocks are exposed in two parts of the map-area: (1) Tingmisut Lake, eastern Melville Island, where some basic dykes occur; (2) Sabine Peninsula, where igneous rocks occur in the piercement domes.

The dykes east of Tingmisut Lake intrude the Canyon Fiord (Pennsylvanian) and Sabine Bay (Permian) Formations. The largest, which lies immediately east of the lake, is 2 miles long and about 200 feet wide. To the north of the large dyke are three smaller ones. All these dykes trend north. R. G. Blackadar studied a thin section from the main dyke, and reports as follows:

Percentages given are from estimations made by eye. No attempt was made to determine the clinopyroxene but it is probably augite.

Mineral	*Per cent*
Labradorite An_{60}	40
Labradorite (zoned)	10
Carbonate, chlorite etc.	25
Clinopyroxene	15
Titaniferous magnetite / Leucoxene	10
Amorphous biotite	trace
Quartz	trace

The rock has a sub-ophitic texture and on the basis of the plagioclase composition is a gabbro. Use of the term diabase is open to misunderstanding and consequently is undesirable although texturally the term would be correct.

The clinopyroxene is extensively altered to a fine-grained agglomeration of carbonate, chlorite, feldspar, and possibly quartz. The plagioclase is unaltered. Large zoned plagioclase crystals, probably labradorite, are present. This zoning appears to be due to crystal growth and not a reflection of sub-microscopic twinning. It suggests that the rock cooled slowly and that some differentiation took place. The rock is rich in ore minerals and the abundance of leucoxene suggests that the ore mineral is titaniferous magnetite.

The igneous rocks in the Barrow and Cape Colquhoun domes of the Sabine Peninsula have not been studied in detail, but the most spectacular mass is in the Barrow dome. In the northwest quadrant of this dome the igneous body is a nearly vertical, arcuate mass, about 500 feet thick (Pl. LIII), and bordered, on both sides, by evaporites, etc., of the piercement body. Observations from the air show that somewhat similar, although less well defined, masses occur near the north, east, and south edges of the dome. The southwest part apparently lacks

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large masses of gabbro. A specimen from the northwest part has been sectioned and studied by R. G. Blackadar, who reports as follows:

The following minerals were noted

Mineral	*Per cent*
Plagioclase	35
Micropegmatite	20
Hornblende	15
Biotite	15
Quartz	10
Magnetite	5
Carbonate	trace
Apatite	trace

The texture is slightly diabasic, but due to the large amount of micropegmatite, which has a rather irregular form, this texture is not well developed. Plagioclase is poorly twinned and its composition was not determined. The development of micropegmatite was late in the crystallization sequence as it corrodes the plagioclase laths, giving rise to irregular grain boundaries. The biotite is derived from alteration of amphibole. The rock is unusually rich in potash feldspar (in micropegmatite) and it has apparently been subjected to extensive K - metasomatism. In this respect the rock differs from the usual basic intrusions of the Queen Elizabeth Islands petrographic province. Only in the largest sills in this province have similar rocks been found. The K - metasomatism is probably a differentiation effect and suggests that the specimen is part of a body of considerable size. The volume percentages given are only approximate as a Rosiwal analysis was not made.

The igneous body of Barrow dome has the appearance of a ring dyke. Possibly its arcuate nature and nearly vertical attitude is due to upthrusting within the dome: in other words, it might represent an upthrust sill. However, it seems more probable that the body is a true ring dyke. This suggestion is based on the following reason. Basic dykes and sills are common in parts of the Sverdrup Basin, and were probably emplaced in Cretaceous time. In parts of the world where piercement domes have been studied in detail it is commonly found that they show a long history of movement. It is not possible to prove that the Barrow dome existed, at depth, in Cretaceous time, but by analogy with similar structures elsewhere it seems likely that the doming may have started in the Cretaceous or even earlier. If the dome existed in the Cretaceous, i.e., at the probable time of emplacement of the basic magma, it may have presented a cylindrical conduit, which was followed by the magma. According to this hypothesis, the dyke may have been emplaced in Cretaceous time and subsequently moved upwards with the surrounding evaporites of the piercement structure.

The age of these igneous intrusions cannot be dated precisely from the evidence within the map-area. The dykes of Tingmisut Lake are certainly younger than Permian and the igneous rocks of Sabine Peninsula are younger than Pennsylvanian. The gabbroic intrusions in the eastern part of the Sverdrup Basin, on the Ringnes Islands, Axel Heiberg Island, and Ellesmere Island, intrude rocks as young as mid-Cretaceous (Hassel Formation). Above the Hassel, on western Axel Heiberg Island, is the Strand Fiord Volcanic Formation, composed of basalt.

No intrusions are known that are younger than these basalt flows; i.e., none is known in the Kanguk and Eureka Sound Formations. The gabbroic intrusions of these eastern islands therefore appear to be of Cretaceous age. Possibly they were emplaced at the time of extrusion of the Strand Fiord basalts. By analogy with Axel Heiberg Island it seems unlikely that the gabbroic rocks of Melville Island are younger than Cretaceous.

According to Gregory, *et al.* (1960), aeromagnetic data suggest that igneous rocks may occur near the surface of Prince Patrick Island, west of Mould Bay, but no exposures are known.

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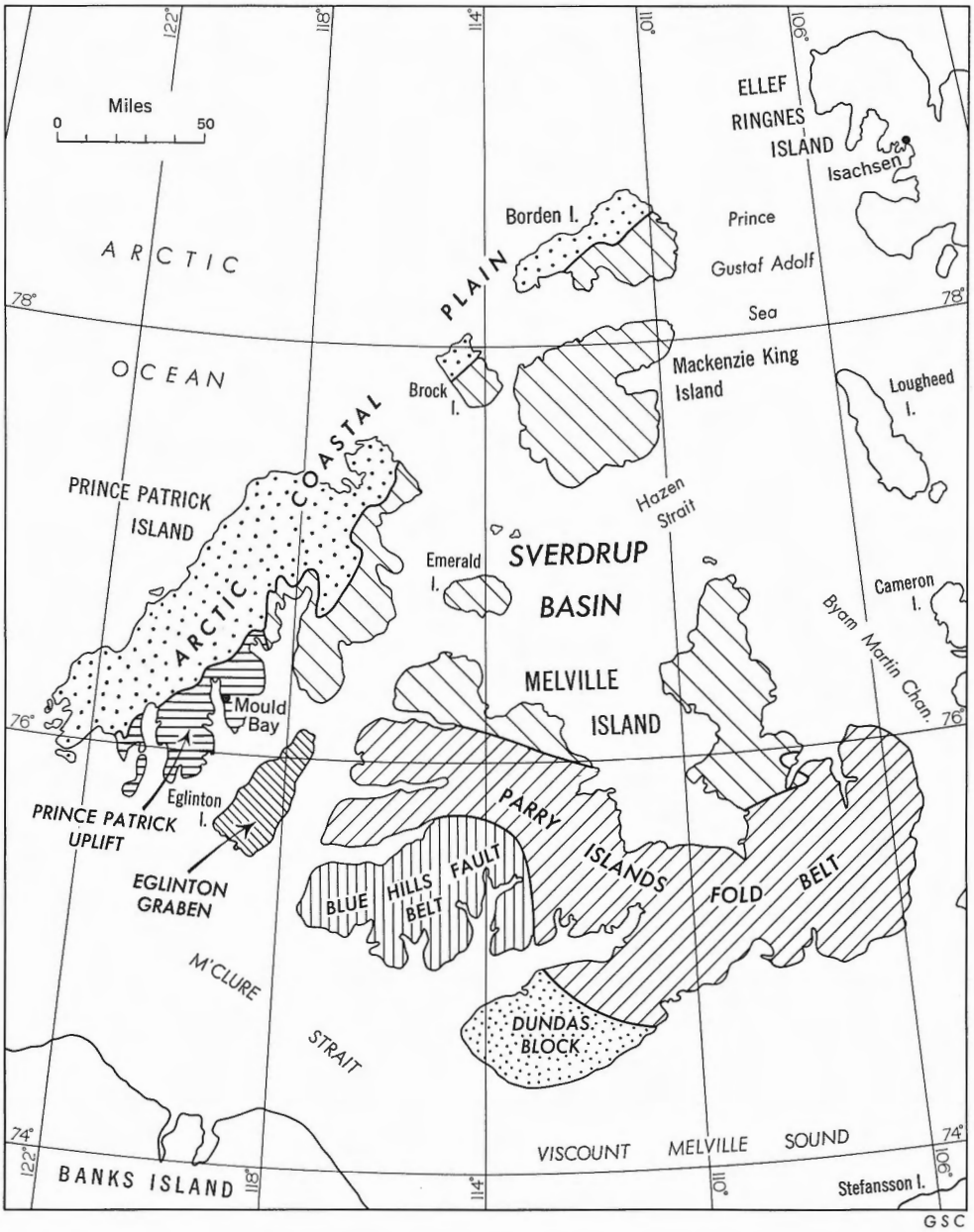

FIGURE 11. Structural provinces, western Queen Elizabeth Islands.

Chapter V

STRUCTURAL GEOLOGY

Introduction

Considered structurally the map-area may be divided into six provinces: 1, the Parry Islands Fold Belt; 2, the Blue Hills Fault Belt; 3, the Dundas Block; 4, the Eglinton Graben; 5, the Prince Patrick Uplift; 6, the Sverdrup Basin; and 7, the Arctic Coastal Plain (Fig. 11).

The principal structures within the area are shown on the tectonic map (Fig. 12). No subsurface geological information is available, and most of the discussion regarding the subsurface character of the structures must, of necessity, be speculative.

Parry Islands Fold Belt

This structural province occupies most of west, central, and southeast Melville Island, and represents the folded part of the Franklinian miogeosyncline. Rocks of Ordovician, Silurian, Devonian, Pennsylvanian, and Lower Cretaceous age are exposed. The Palaeozoic formations are folded and the Lower Cretaceous beds occur as outliers, with essentially horizontal bedding, overlying folded Devonian rocks. Three unconformities concern us in this structural province—those beneath the Pennsylvanian, Permian, and Lower Cretaceous rocks.

Folds

The principal fold axes of the Parry Islands Fold Belt are shown on the tectonic map (Fig. 12). It will be seen that most trend east-west, and that the most intense folding is in the Canrobert Hills, northwest Melville Island. There the Canrobert, Ibbett Bay, Weatherall, and Canyon Fiord Formations are involved in the folding. The Canrobert and Ibbett Bay Formations are the most competent members of the sequence. These rocks show few minor structures and little or no cleavage. The Blackley and Cape De Bray Members of the Weatherall Formation (Devonian) rest upon this competent sequence and are more highly deformed than the underlying beds. Micaceous siltstones in these members commonly show slaty cleavage. Many of the structures shown on the geological map as synclines preserving these members are, in fact, synclinoria lying between the relatively simple anticlines that expose the older, more competent rocks. Many of the anticlines are essentially symmetrical but some overturning of beds has been observed. On the north side of Ibbett Bay, northeast of Hawk Creek, Canrobert, Ibbett Bay, and Weatherall beds are overturned on the south limb of an anticline

PLATE XLIV

Canrobert beds, overturned to the south, in the core of an anticline on the south side of the Canrobert Hills, north of Ibbett Bay, Melville Island. The exposures are in the stream 16½ miles east of Nisbet Point.

(*see* Pl. XLIV). Another anticline in this area, on strike with Blackley Haven, shows overturning on the north limb. Thus the overturning does not provide unambiguous evidence regarding the direction of release of stress.

In parts of northwest Melville Island, Pennsylvanian rocks (Canyon Fiord Formation) occur within the Parry Islands Fold Belt. This is true south of Marie Bay, between the Canrobert Hills and Raglan Range, and south of Raglan Range. These Pennsylvanian rocks are folded and the strike of the folds in the Pennsylvanian rocks parallels the strike of the older beds. An angular unconformity underlies the Pennsylvanian sequence and several structures show gently warped Pennsylvanian strata overlying relatively highly deformed older Palaeozoic rocks (Pl. XLV). This relationship reveals that two periods of movement can be distinguished for some of the folds of northwest Melville Island. These two periods are the "mid-Palaeozoic" and "late Palaeozoic" movements of Thorsteinsson and Tozer (1960). The mid-Palaeozoic folding took place between the mid-Upper Devonian (Frasnian) and the Middle Pennsylvanian. The late Palaeozoic structures were imposed between Middle Pennsylvanian and Permian times. Within the map-area, the late Palaeozoic movements are recorded only in northwest Melville Island. The Canyon Fiord beds of eastern Melville Island occur in a different structural situation. They conform to the essentially homoclinal, upper-Palaeozoic-Mesozoic sequence of Sabine Peninsula and show no obvious sign of late Palaeozoic folding.

PLATE XLV. Aerial view of the Canrobert Hills, Melville Island, looking east. The Ibbett Bay (OS ib), Weatherall (D w), and Canyon Fiord (Cp cf) Formations are exposed. The Canyon Fiord beds overlie the older formations unconformably. The synclines have been folded twice; first between the Devonian and the Middle Pennsylvanian, and again between Pennsylvanian and Permian time. (RCAF T419R–36)

PLATE XLVI. Aerial view of the Parry Islands Fold Belt, Melville Island, looking west to Hecla and Griper Bay. Most of the exposures in the foreground are of the Hecla Bay (D h) and Griper Bay (D g) Formations. In the distance, to the north, may be seen two anticlines that bring dark coloured Weatherall beds to the surface. (RCAF T419R–132)

To the north, the folds of Canrobert Hills are lost beneath the Permian and younger beds of the Sverdrup Basin. To the south lies the Purchase Bay homocline, presumably a mid-Palaeozoic flexure. Beyond this homocline no pronounced Palaeozoic folds have been recognized. The dominant structures in this area are younger faults (p. 185) that obscure any older structures. One of the interesting problems of the map-area is that of the westward fate of the Parry Islands folds. These folds can be traced from west to east for about 350 miles, through Melville, Byam Martin, and Bathurst Islands and on to Grinnell Peninsula. From Grinnell Peninsula they apparently swing northeasterly, through Ellesmere Island. However they apparently end, abruptly, at the west coast of Melville Island. The next Palaeozoic rocks that appear to the west are those of the Prince Patrick Uplift. These rocks are Devonian and although they show evidence of pre-Jurassic tectonism they reveal no clear sign of the east-west trending Parry Islands folds.

The folds of south and southeast Melville Island vary considerably. The width of the fold belt in this area, across strike from Domett Point to Cape Phipps, is about 100 miles. Folds in the southern part of the belt between Cape Phipps and Cape Bounty are relatively gentle, with dips of 7 degrees or less. In the greater part of this belt, which lies between Cape Bounty and Towson Point, the folding is more intense and the structures have a distinctive pattern. The anticlines are narrow, with steeply dipping, symmetrical limbs and long axes. The intervening synclines are relatively wide shallow structures. It should also be noted that the strata on the north limb of the Towson Point anticline, the northeastern fold of the belt, are only gently inclined. Southwest from Hecla and Griper Bay, towards the Blue Hills Fault zone, the fold structures lose amplitude and finally, beyond the longitude of Murray Inlet they seem to lose their identity entirely.

Possibly the variations in intensity of folding noted in south and east Melville Island are related to subsurface changes in the lithology of the folded sequence. No such changes are apparent at the surface, for the Hecla Bay and Griper Bay Formations are essentially uniform, lithologically, throughout Melville Island east of the 111th meridian. However, it should be borne in mind that the evidence indicates that the concealed Ordovician and Silurian rocks must vary considerably. This evidence may be summarized by comparing the Silurian rocks of three areas: McCormick Inlet, Weatherall Bay on Melville Island, and Stefansson Island south of the map-area (*see* Thorsteinsson and Tozer, 1962). At McCormick Inlet the Silurian rocks are graptolitic shale (Cape Phillips Formation). At Tingmisut Lake, on the west side of Weatherall Bay, the Silurian is partly, at any rate, represented by a dolomite facies. On Stefansson Island the Silurian rocks are mainly limestone and dolomite, with a thin intercalation of graptolitic shale. Somewhere between McCormick Inlet and Stefansson Island the graptolitic shale facies is largely replaced by carbonates. This change probably also takes place somewhere between McCormick Inlet and Weatherall Bay. Unfortunately there are no Silurian exposures within the triangular area outlined by these points. On

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Cornwallis Island both the carbonate and graptolitic facies occur and the boundary is exposed (Thorsteinsson, 1958). This boundary trends east-west, and if extended west comes close to the Cape Bounty area, i.e., close to the point where the relatively intense Parry Islands folds die out. The gently inclined beds on the north limb of the Towson Point anticline lie on strike with the Silurian dolomites of Tingmisut Lake. Both these relationships may be no more than coincidence, but the possibility exists that the relatively intense folds, between Towson Point and Cape Bounty, reflect, in part at least, the subsurface presence of incompetent, Cape Phillips graptolitic strata. The gently folded country east of Weatherall Bay and south of Cape Bounty may be underlain by more competent carbonates.[1]

Another possibility that should be mentioned in connection with the folds of eastern and southern Melville Island is that their tight, narrow anticlines and broad, shallow synclines may indicate a very incompetent, perhaps even diapiric, layer in the subsurface. On Cornwallis Island gypsum measures occur in the Ordovician sequence (Cornwallis Formation). No exposures of this gypsum unit are known on Melville Island, indeed in the Canrobert Hills strata correlative with the entire Cornwallis Formation are exposed, but there is no gypsum. In this area, then, the gypsum is definitely absent. At McCormick Inlet too gypsum is not evident, but it could possibly be present at depth. Nonetheless, it is possible that Ordovician gypsum occurs beneath the surface of eastern and southern Melville Island. If evaporites do occur in this stratigraphic position their presence may have contributed to the style of the Parry Islands folds.

It is also possible to present arguments opposing the theory that evaporites underlie the folds of eastern Melville Island. Comparison with areas that are known to have mobile evaporites at depth does not seem to reveal many similarities. On the west coast of Axel Heiberg Island, Tertiary folds have warped a thick Mesozoic-Tertiary section with upper Palaeozoic evaporites at, or near, the base. The fold axes in this area are short and plunging, unlike the long anticlinal axes of southern Melville Island, some of which can be traced for nearly 100 miles. Evaporites pierce the axes of the Axel Heiberg structures; no such piercements are known on Melville Island.

Faults

Various kinds of faults occur within the Parry Islands Fold Belt. Several, probably thrust faults of mid-Palaeozoic age, dislocate the folded Devonian rocks of southeast Melville Island. The coincidence of the strike of these faults with that of the fold axes, and the omission of strata produced by these faults, suggest that they are thrusts. Good examples occur west of Rea and King Points, on the east coast of the island. The situation of these faults suggests that they are thrusts inclined to the north. The faults on the north limb of the Robertson Point anticline, on the other hand, appear to be inclined to the south. The stratigraphic displacement on these faults is relatively small and their generally straight surface trace suggests that they are steeply inclined. Apparently there are no low-angle thrusts in the Parry Islands Fold Belt.

[1] *See* Addendum, p. 227.

PLATE XLVII. Aerial view of Weatherall Bay, eastern Melville Island, looking west. To the south (left) the Hecla Bay Formation (D h) is unconformably overlain by the Canyon Fiord Formation (Cp cf). Near the centre is the fault-bounded mass of Blue Fiord limestone (D bf). South of the fault the Weatherall (D w) and Blue Fiord (D bf) Formations are in normal contact and overlain unconformably by the Canyon Fiord (Cp cf) beds. A small patch of Sabine Bay beds (Pm sb) overlies the Canyon Fiord Formation. On the west side of the bay are bluffs of Silurian dolomite (Su). (RCAF T419R–200)

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Small transcurrent faults, probably wrench faults related to the mid-Palaeozoic earth movements, occur throughout the Parry Islands Fold Belt.

A large fault, trending northeast, occurs near the west end of the Raglan Range (*see* Pl. XVII). At its north end the fault shows a substantial stratigraphic displacement, for it brings Ordovician (?) and Silurian carbonates into contact with the Hecla Bay Formation (Devonian). Towards the south the displacement of this fault apparently decreases abruptly. The fault plane disappears beneath the cover of Assistance (Permian) and younger beds, which beds show no sign of displacement. This structure is presumably either a normal fault or a wrench fault of Palaeozoic age.

Younger faults, which are probably normal faults, occur around Weatherall Bay. Most of these trend east. The most prominent fault is on the south side of the mass of Blue Fiord limestone (Devonian), immediately south of Weatherall Bay (*see* Pl. XLVII). The steep cliffs on the north side of this massif, facing Weatherall Bay, may also reflect the presence of a fault. Displacement on the south side is to the south. Possibly this massif is a small horst. East-trending faults with displacement to the south, bound the south side of the Silurian inlier east of Tingmisut Lake. Small faults, with similar displacement and strike, dislocate the Pennsylvanian and Permian beds to the west. East-trending faults, with both north and south displacement, dislocate the Devonian rocks of the Cape Towson anticline, east of Weatherall Bay. Some of these faults dislocate Permian strata and are clearly younger than the Parry Islands folds and thrusts. It seems probable that all the east-trending faults around Weatherall Bay are related structures, and all of post-Permian age. The prominent topographic expression of some of these faults suggests that they are of Tertiary age, as are the faults of the Prince Patrick Uplift. The Weatherall Bay area thus represents a structurally elevated area, where tectonic movement has occurred in post-Permian, possibly Tertiary, time. The fault south of Weatherall Bay, where a small outlier of Canyon Fiord beds has been preserved on the downfaulted (south) side, may also be a related feature.

Unconformities

Two important unconformities—one beneath Pennsylvanian rocks, the other beneath Lower Cretaceous strata—occur within the Parry Islands Fold Belt. In northwest Melville Island a third unconformity, beneath Permian rocks, defines the boundary between the Parry Islands Fold Belt and the Sverdrup Basin. In the eastern part of the island this sub-Permian unconformity is not indicated by obvious discordance of strata; there the Pennsylvanian rocks evidently conform, structurally, with the overlying Permian and younger formations of the Sverdrup Basin.

In the northwest the Ordovician, Silurian, and Devonian rocks are structurally concordant. This relationship is exposed in the Canrobert Hills, at the west end of Raglan Range, and in the McCormick Inlet area. The only pre-Devonian rocks recognized in eastern Melville Island are the Silurian dolomites east of Tingmisut

Lake. This outcrop is bounded by faults and the relationship to the Devonian rocks is not seen. It seems reasonable to suggest that the Devonian rocks of south and east Melville Island are underlain by a concordant sequence of Silurian and Ordovician strata. This concordant relationship holds true throughout all the parts of the Parry Islands Fold Belt where Ordovician and Silurian rocks are exposed, i.e., in northwestern Melville Island, and in central Bathurst Island (McLaren, 1963b).

The sub-Pennsylvanian unconformity is dramatically exposed in northwest Melville Island (*see* Pls. XLV, XLVIII, XLIX). South of Marie Bay the angular discordance reaches about 50 degrees and the Canyon Fiord (Pennsylvanian) beds rest on the Ibbett Bay and Weatherall Formations. Southwest of the head of McCormick Inlet the angular discordance reaches 30 degrees and the sub-Pennsylvanian rocks include the Cornwallis, Cape Phillips, Weatherall, and Hecla Bay Formations. As already noted, the Pennsylvanian rocks of northwest Melville Island were folded prior to Permian deposition, and structurally they pose some interesting questions. As shown in the chapter on stratigraphy (p. 98), it is possible that these rocks were deposited in "intermontane basins", adjacent to the Sverdrup Basin proper.

In east Melville Island the Canyon Fiord beds rest, in different places, upon Silurian dolomite and the Blue Fiord, Weatherall, Hecla Bay, and Griper Bay Formations. Near the head of the west arm of Weatherall Bay the angular discordance, between the Hecla Bay and Canyon Fiord beds, is 30 degrees. East of Tingmisut Lake the Canyon Fiord and Silurian rocks appear to be structurally conformable (*see* Pl. XXI). This relationship is probably fortuitous and is not considered to conflict with the view that the sub-Pennsylvanian unconformity probably underlies the whole of the Sverdrup Basin. The Pennsylvanian rocks of this area unlike those to the northwest were not deformed prior to Permian deposition.

Blue Hills Fault Belt

The part of southwestern Melville Island between Murray Inlet and Purchase Bay is occupied entirely by Devonian formations that are disrupted by several faults, and is known as the Blue Hills Fault Belt.

Throughout most of this area the strata dip at low angles or are horizontal, although steep dips occur adjacent to some faults. The inclination of the strata is probably largely due to faulting as no certain evidence of Palaeozoic folding has been found, with the possible exception of a gentle anticlinal flexure, striking east-west, south of Purchase Bay.

The structures of the Blue Hills Fault Belt appear to be normal, or gravity faults. Most of these faults trend east-west, but some minor faults trend north. The position of the principal faults is shown on the tectonic map (Fig. 12). As a rule, on the major faults the downthrown block is on the north side. This is true for the Blue Hills, Murray Inlet, Mount Joy, Comfort Cove, Warrington Bay,

PLATE XLVIII. Aerial view of the head of Marie Bay, Melville Island, looking east. On the south side of the bay are the Ibbett Bay (OS ib), Weatherall (D w), and Canyon Fiord (Cp cf) Formations of the Parry Islands Fold Belt. On the north side are the northerly dipping beds on the south side of the Sverdrup Basin; the Assistance (Pm a), Bjorne (Tr b), Borden Island (J bi), and Wilkie Point (J wp) Formations. A thin representative of the Canyon Fiord Formation may also occur on the north side of the bay. (RCAF T419R–41)

PLATE XLIX. Aerial view of the head of Ibbett Bay, Melville Island, looking east. View shows the southeas part of the Canrobert Hills with folded Ibbett Bay (OS ib) and Weatherall (D w) rocks. On the north side of the bay the Weatherall rocks belong to the Blackley (D wb) and Cape De Bray Members (D wc). Younger Weatherall beds and the Hecla Bay Formation (D h) are exposed on the south side of the bay. To the north is the unconformable cover of Canyon Fiord (Cp cf) rocks (RCAF T419R–32)

and Hardy Bay faults. An exception is the fault north of Warrington Bay, which apparently shows downthrown beds on the south side.

The Blue Hills Fault is at least 50 miles long. The maximum stratigraphic throw on this fault is probably near longitude 115°31′, where it is about 2,000 feet. To the east and west the throw gradually decreases. The Mount Joy fault is a relatively short structure for its effects have been noted for a mere 5 miles. This fault nevertheless achieves a stratigraphic throw of at least 2,000 feet at the west side of the Mount Joy peninsula, in Murray Inlet. The maximum stratigraphic throw on the Murray Inlet fault occurs a short distance west of the inlet. For the remaining faults there is insufficient data to determine the displacement, but it is unlikely that any have a throw greater than 2,000 feet.

As the only rocks exposed within the Blue Hills Fault Belt are of Devonian age, it is not possible to date the fault movement from stratigraphic relationships, but all these faults have a remarkably youthful physiographic expression (*see* Pl. L). The uplifted blocks are bordered by dramatic fault scarps, for example the Blue Hills, Mount Joy, and Murray Inlet scarps. This topographic expression is comparable with that shown, in other parts of the Archipelago, by faults that are known to have moved in Tertiary time, for example the fault adjacent to Nelson Head, southern Banks Island (*see* Thorsteinsson and Tozer, 1962). The writers therefore suggest that the faults of the Blue Hills Fault Belt are relatively recent structures, probably of late Tertiary age.

As the major faults have uplifted south sides, the aggregate movement within the belt is a substantial uplift of the south side with depression to the north.

In order to place the Blue Hills Fault Belt in perspective, it may be noted that the lands of the northeast side of M'Clure Strait comprise straight, southeast-facing coasts. These coasts extend from Cape Mecham (Prince Patrick Island), to Capes Russell and Smyth (on the south side of the Blue Hills Fault Belt) and on, to the southeast, to Capes James Ross and Hay on Dundas Peninsula. All these capes facing M'Clure Strait are more or less on line, on a bearing N60°W. This linear stretch of coast is broken by Liddon Gulf, Kellett Strait, and Crozier Channel. The linear and aligned character of these coasts is almost certainly a reflection of faulting, probably with downthrow to the southwest. Beyond the map-area, in the northeast part of Banks Island, a straight, northeasterly facing stretch of coast is found. The rocks of northeast Banks Island are about the same age as those of southwest Melville Island. Thus we have geologically similar coasts facing each side of the eastern part of M'Clure Strait, which is known to be at least 600 feet deep (Collin, 1960). M'Clure Strait is almost certainly a graben, depressed between Banks Island and the islands to the north. As already shown, the aggregate uplift of the Blue Hills Fault Belt is adjacent to M'Clure Strait, and it appears that the strait itself is depressed. Thus the Blue Hills Fault Belt may be regarded as a horst adjacent to the M'Clure Strait graben.

In conclusion, the Blue Hills Fault Belt seems to show—preserved above sea-level—faults of the type that were probably instrumental in late Tertiary time in dividing the Archipelago into its constituent islands and channels.

PLATE L. Aerial view, eastward, across the Blue Hills, southwestern Melville Island. The Hecla Bay (D h) and Griper Bay (D g) Formations are widely exposed, and equivalents of the Weatherall Formation are probably also present in the deeper ravines that cut the escarpment near the middle of the photograph. This escarpment is the fault line scarp of the Blue Hills Fault Belt. (RCAF T419R–18)

Dundas Block

On southern Melville Island the part of Dundas Peninsula that lies southwest of a line joining Shellabear Point and Cape Phipps is underlain by essentially horizontal strata of the Griper Bay Formation (Devonian). This area may be termed the "Dundas Block". In earlier papers (e.g., Fortier, *et al.,* 1954; Thorsteinsson and Tozer, 1959a) it has been classed as part of the Melville Basin. Application of the term 'basin' to southern Melville Island and the adjacent parts of Victoria and Banks Islands no longer seems appropriate as there is no evidence that this area is a discrete depositional sedimentary basin. The available evidence suggests that the Palaeozoic formations of the lands bordering M'Clure Strait and Viscount Melville Sound simply thicken to the north, towards the Franklinian geosyncline, the exposed part of which is now represented by the Parry Islands Fold Belt.

The horizontal strata of the Dundas Block are bordered to the north by the Parry Islands Fold Belt. To the south lie the waters of M'Clure Strait, and as already mentioned (p. 188), it is probable that a Tertiary fault defines the southwest edge of Dundas Peninsula. South of M'Clure Strait and Viscount Melville Sound the next Palaeozoic rocks that come to sight are the gently inclined strata of the Prince Albert and Stefansson homoclines, with northwest and northerly dips. These homoclines abut the Precambrian rocks of the Minto Arch (Thorsteinsson and Tozer, 1962).

Regionally the Dundas Block constitutes a structural terrace, bordered to the north by the Parry Islands folds and to the south by the Palaeozoic homoclines that slope away from the Minto Arch. The M'Clure Strait graben, which is probably a Tertiary structure, is superimposed upon these Palaeozoic rocks and structures.

Eglinton Graben

Eglinton Island exposes a southwest-dipping, homoclinal sequence of Mesozoic strata. Dips are low—probably less than 5 degrees, throughout the island. The nearest exposures to the east and west, Melville and Prince Patrick Islands, are of older formations. The strike of the Mesozoic rocks on Eglinton Island is unrelated to that of Mesozoic beds on the surrounding islands and it seems probable that the island is an isolated fault block, regionally depressed by faulting in Crozier Channel and Kellett Strait. Eglinton Island thus seems to constitute a small graben.

Prince Patrick Uplift

The part of southern Prince Patrick Island that lies between Intrepid Inlet and Dyer Bay exposes Devonian rocks overlain by outliers of Mesozoic strata. This area has been extensively broken by north-trending normal faults, probably of Tertiary age. There is also evidence of pre-Jurassic, probably Palaeozoic, tectonism. This area has clearly experienced uplift compared with neighbouring

regions and the name "Prince Patrick Uplift" seems appropriate. Unconformities, both beneath and within the Mesozoic sequence, suggest that the history of uplift is a long one. Considered regionally (*see* Thorsteinsson and Tozer, 1960, p. 18) the Prince Patrick Uplift seems to be related to the Cape Crozier anticline, of northern Banks Island and perhaps also to Nelson Head structural uplift, at the south end of Banks Island. It has been suggested that all three structural uplifts are related, and perhaps represent culminations on the site of a largely buried cratonic arch. Structures on Banks Island apparently experienced uplift in Tertiary time, and it is probable that much of the movement of the Prince Patrick Uplift also took place in the Tertiary.

Folds

An angular discordance, locally attaining about 30 degrees, separates the Devonian and Mesozoic rocks of the Prince Patrick Uplift. Undoubtedly, therefore, the Devonian rocks experienced some sort of tectonic deformation prior to the Jurassic. Triassic rocks are locally present adjacent to the uplift and it is probable that this deformation took place before Triassic time. Structures that reflect this deformation include an apparently anticlinal feature, trending northwest, at the head of Mould Bay. Dips observed on the east side of Walker Inlet are also suggestive of an anticlinal structure, trending north. Some reservations are expressed regarding the interpretation of these structures as folds. Post-Lower Cretaceous faulting has affected much of the uplift (*see below*) and in many places the dip of the Devonian rocks is partly related to this faulting. It is probable that there are more faults than shown on the tectonic map (Fig. 12) so it should be admitted that the opposing dips on the east side of Walker Inlet, for example, may be related to an unrecognized post-Lower Cretaceous fault rather than to pre-Mesozoic folding. Although the Palaeozoic rocks of the uplift clearly experienced tectonic activity between the mid-Upper Devonian and the Mesozoic, these Palaeozoic rocks show no sign of the easterly trending folds that characterize the Parry Islands Fold Belt.

Faults

Normal faults, trending north, dislocate the Devonian and Mesozoic rocks of the Prince Patrick Uplift. Many of these faults are responsible for the occurrence of down-faulted outliers of Mesozoic strata. East of Mould Bay weather station an extensive Mesozoic terrain is preserved and the status of the Devonian exposures is reduced to that of inliers.

Between Mould Bay and Crozier Channel most of the faults show the down-faulted block to the west. The structures between Mould Bay and Walker Inlet are mainly small grabens and horsts. The maximum stratigraphic throw determined on any fault of the Prince Patrick Uplift is about 1,500 feet. This displacement is achieved 3 miles east of Mould Bay weather station, where the Griper Bay Formation is faulted against the Isachsen. The stratigraphic throw on other faults probably does not exceed this figure.

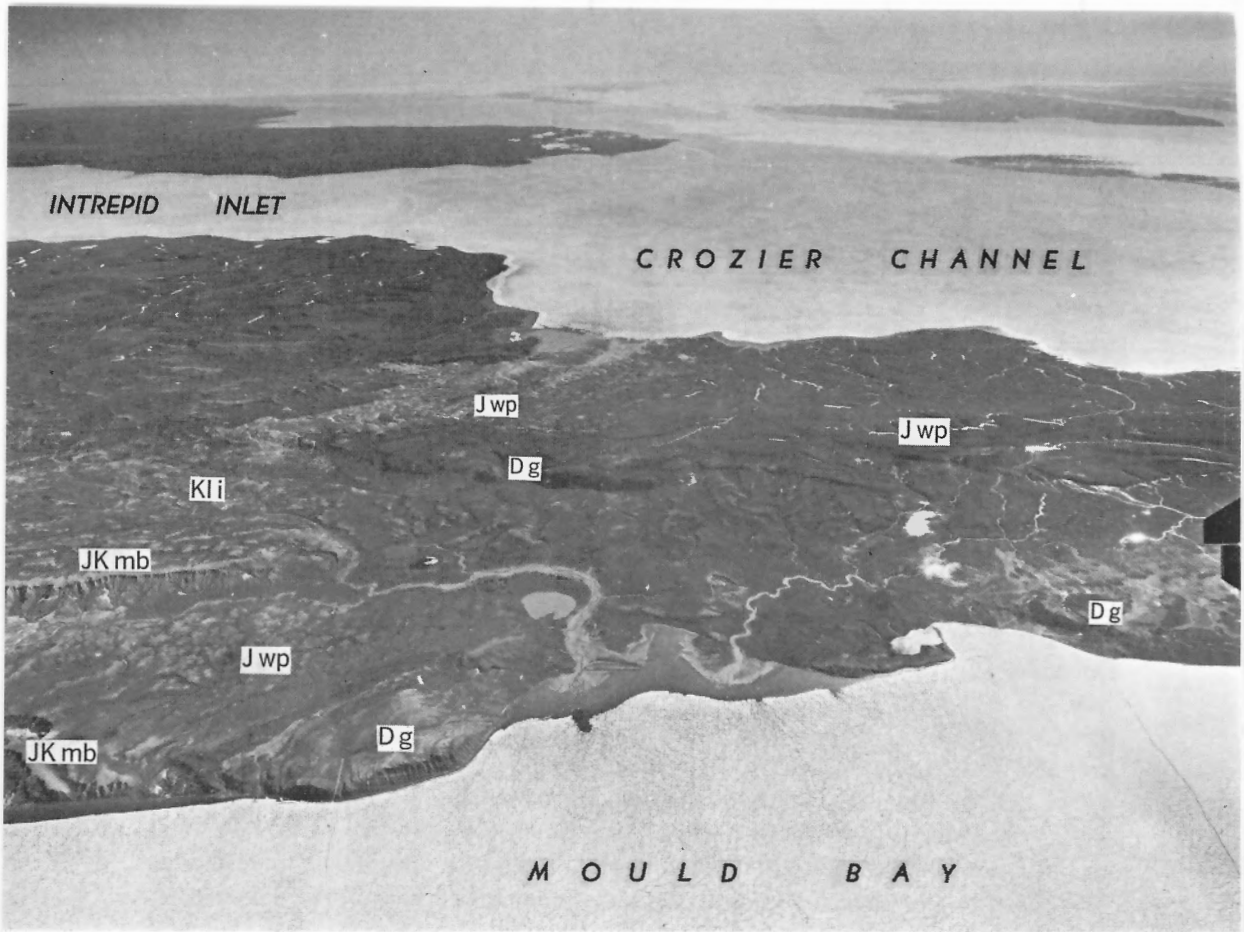

PLATE LI. Aerial view of southern Prince Patrick Island from Mould Bay to Crozier Channel. Ridges are formed by the hard Griper Bay sandstones (D g) and the Mould Bay Formation (JK mb). The low country is underlain by the Wilkie Point (J wp) and Isachsen (Kl i) Formations. The north-trending ridges reflect the Tertiary faults that dislocate the beds in this area. (RCAF T429L–86)

The faults of the Prince Patrick Uplift do not show a measurable displacement of the Beaufort Formation. Between Mould Bay and Walker Inlet the Beaufort beds rest on both Devonian and Mesozoic rocks and the formation of this sub-Beaufort surface clearly post-dates most of the fault movement. Most of the movement therefore took place between the Lower Cretaceous and the late Tertiary. However, on the surface of the Beaufort beds to the north there are prominent lineaments on strike with these faults (p. 201). It is, therefore, probable that some movement on the faults of the Prince Patrick Uplift (or their northern extensions) has taken place since the deposition of the Beaufort Formation.

Unconformities

Several unconformities occur in the sequence preserved on the Prince Patrick Uplift, which may have a bearing on the structural history.

The major unconformity is between the Palaeozoic and Mesozoic beds. Two miles north of the Mould Bay weather station the angular unconformity between the Griper Bay and Wilkie Point Formations attains about 30 degrees. Four miles east of the station the angle is about 10 degrees (*see* Pl. LII). West of Mould

Bay, the unconformity beneath the Mould Bay beds seems less profound, and locally the Griper Bay and Mould Bay Formations are concordant in this area. We have not sufficient data to state whether these variations in the intensity of the sub-Mesozoic discordance are of regional significance.

Triassic rocks (Schei Point Formation) abut the Devonian rocks on the east side of the uplift, near Salmon Point in Intrepid Inlet. To the southwest these Triassic rocks disappear and the oldest Mesozoic rocks are of Jurassic age. Throughout the country between Mould Bay and Green Bay, and also near Landing Lake, Jurassic rocks (Wilkie Point Formation) overlie the Devonian beds. Between the east and west sides of Mould Bay this Jurassic formation, like the Schei Point beds, disappears. The Wilkie Point Formation is fully developed, and followed by concordant Mould Bay beds, northeast of the Mould Bay weather station. Three miles southeast of the station the Mould Bay strata rest unconformably upon the Wilkie Point beds (p. 129). Four miles west of the station, on the far side of the bay, the Mould Bay beds rest directly upon Devonian rocks, without any intervening Wilkie Point strata. This last relationship is also found in the downfaulted outliers between Mould Bay and Walker Inlet. The presence of these unconformities seems to suggest that the Prince Patrick Uplift was intermittently tectonically active in Mesozoic time. The Wilkie Point beds southeast of the weather station were apparently uplifted, with removal of the top beds, prior to deposition of the Mould Bay Formation. Possibly the Schei Point Formation (Triassic) was originally more extensive, but was removed prior to Wilkie Point deposition.

Sverdrup Basin

The whole of the western part of the Sverdrup Basin lies within the map-area. The general characters and history of this basin have been discussed in a recent paper (Thorsteinsson and Tozer, 1960). The salient features of the rock succession are as follows. In the axial part of the basin, extending southwesterly from northwest Ellesmere Island, a thick concordant sequence of formations

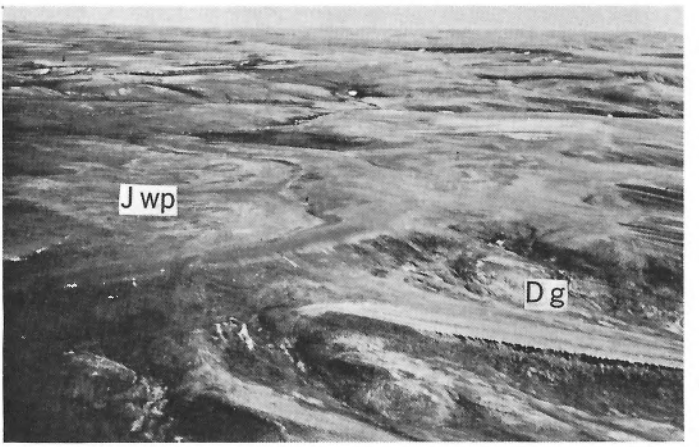

PLATE LII

Aerial view, from an elevation of about 1,000 feet, of country 3½ miles northeast of Mould Bay weather station, Prince Patrick Island. The Wilkie Point Formation (J wp) rests unconformably upon the Griper Bay Formation (D g). (110338)

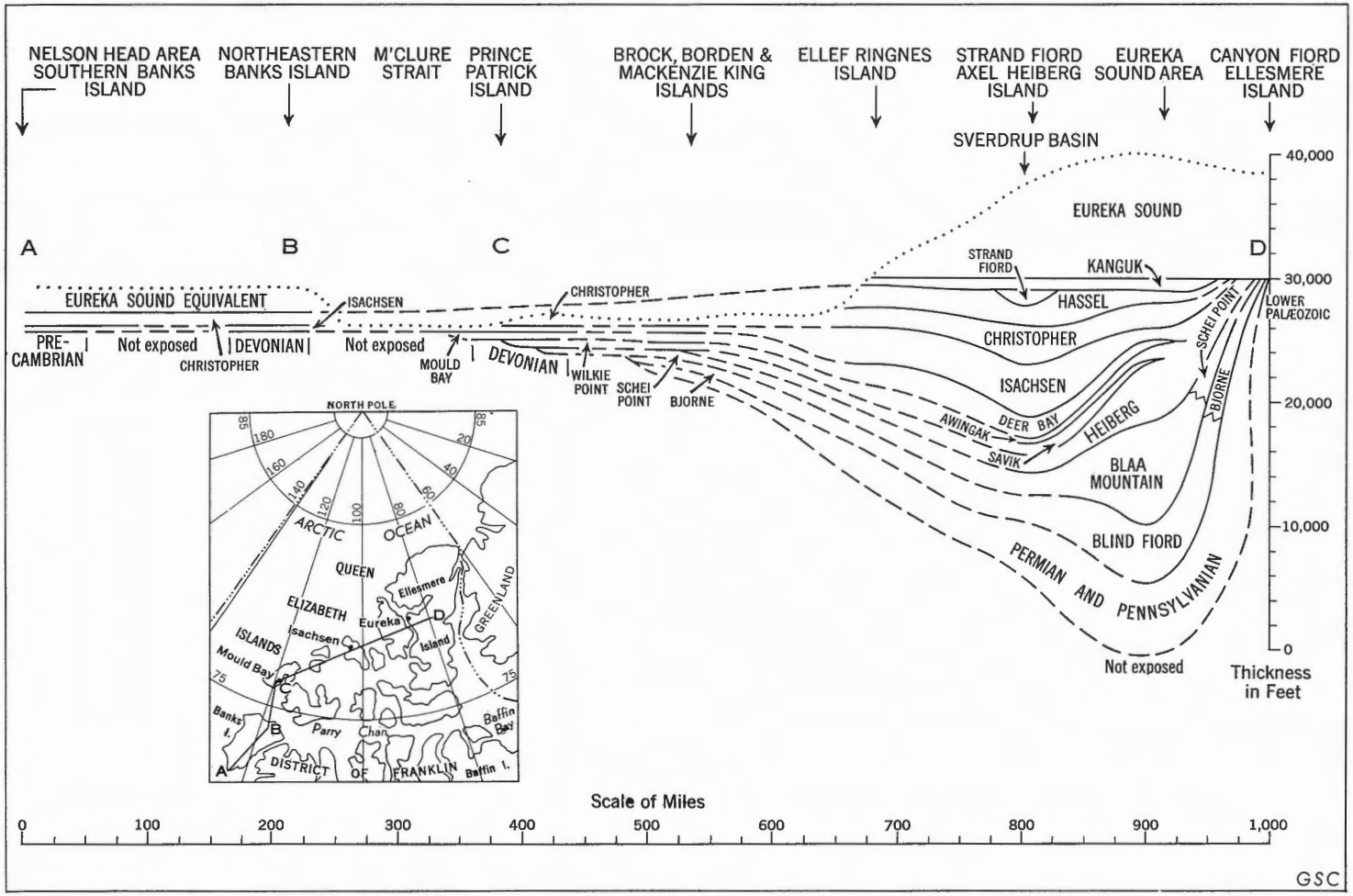

FIGURE 13. Section across Sverdrup Basin (*from* Thorsteinsson and Tozer, 1960).

occurs, ranging in age from Middle Pennsylvanian to early Tertiary. Locally the sediments in the basin probably attain a thickness of about 40,000 feet (*see* Fig. 13).

Towards the southwest part of the basin the formations become much thinner and several disappear completely. Most of the exposed sections within the map-area are near the edge of the basin and are relatively thin. However, it is probable that the northern part of Sabine Peninsula is underlain by a thick section, perhaps comparable with the sections exposed on the Ringnes Islands and Axel Heiberg Island.

Folding has affected the Sverdrup Basin. This folding is dated as Tertiary on Ellef Ringnes, Axel Heiberg, and Ellesmere Islands, and the folds that affect the western part of the basin are probably also of Tertiary age. As a result of this folding the western part of the basin (i.e., the part in the map-area) may be described as a northeasterly plunging synclinorium, the axis of which probably extends from northern Sabine Peninsula towards Ellef Ringnes Island. This is the Sverdrup Basin synclinorium (Fig. 12). Minor folds are superimposed upon the synclinorium. Within the map-area, dips are low, generally less than 5 degrees. The pattern of the synclinorium may be envisaged by examining the outcrop pattern of the Wilkie Point Formation (Jurassic). This pattern is roughly parabolic. Starting from Sabine Peninsula the outcrop belt extends west to Hecla and Griper Bay; it reappears in northwest Melville Island, and again north of Wilkie Point, Prince Patrick Island. Farther to the northwest the exposures are lost beneath the Beaufort Formation but the belt appears again, trending northeast on Borden and Mackenzie King Islands. All the exposures enclosed by this parabolic belt (except the piercement bodies of Sabine Peninsula) are of younger formations. The exposed evidence suggests that the position of the depositional axis of the Sverdrup Basin corresponds with the axis of the synclinorium.

An interesting problem regarding the Sverdrup Basin is that of the character of the underlying, concealed rocks. Some suggestions regarding the nature of the basement beneath the basin may be advanced, although the only evidence is derived from study of the exposed rocks that flank the border of the basin. The characteristics of the exposed rocks may be summarized as follows: the south and east sides of the basin are flanked by Palaeozoic fold belts, with miogeosynclinal sequences (Parry Islands and Ellesmere Folds Belts); at the southwest corner the Prince Patrick Uplift exposes Devonian rocks that were mildly disturbed prior to sedimentation within the basin; the northwest margin, unfortunately, is concealed beneath the Beaufort Formation and the Arctic Ocean; the northeast corner is of especial interest. On northern Ellesmere Island and northernmost Axel Heiberg Island exposed metamorphic, sedimentary, and volcanic rocks have been studied by Blackadar, Christie, and Thorsteinsson (*see* Thorsteinsson and Tozer, 1960, p. 11, for summary description and references). This area is considered to represent the Franklinian eugeosyncline, in which the youngest dated rocks are Silurian.[1] Near the north tip of Axel Heiberg Island this metamorphic terrane

[1] *See* p. 206.

is seen to pass beneath the Pennsylvanian and younger rocks of the Sverdrup Basin. The extension of this eugeosynclinal belt, to the south and west, is concealed by the Sverdrup Basin deposits. It has been suggested that this eugeosynclinal belt continues southwest and intersects the northern part of the western Cordillera in northern Yukon. The main grounds for this suggestion is the apparent relationship between the Devonian clastic wedge deposits that extend from Ellesmere Island, through the Parry Islands to Banks Island and northern Yukon (*see* Martin, 1959, p. 2443). All these Devonian clastic rocks are believed to be derived from a northerly source (*see* p. 206). The eugeosynclinal terrane of northern Ellesmere and Axel Heiberg Islands may represent the exposed remains of part of this source area. If this is so, presumably this eugeosynclinal belt continues to the southwest, adjacent to the Devonian clastic belt. Thus it is possible that the remains of the mountains that shed the Devonian clastics constitute the basement of the Sverdrup Basin.

As an alternative hypothesis it might be assumed that the sub-Pennsylvanian unconformity, exposed on the southeast and northeast sides of the basin, loses its identity towards the axis. If this hypothesis is correct it might be expected that Devonian, Mississippian, and Pennsylvanian rocks form a concordant sequence within the axial part of the Sverdrup Basin. The writers believe that this hypothesis has little support, for the following reasons. First, Mississippian rocks are unknown, and probably absent, throughout the Archipelago.[1] Second, the sub-Pennsylvanian unconformity is found on the south, east, and northeast margins of the basin. Thirdly, the axis of the Sverdrup Basin is aligned with the axis of the Franklinian eugeosyncline and it thus seems probable that this eugeosynclinal belt may extend beneath the basin.

In conclusion, it is the writers' opinion that a marked sub-Pennsylvanian unconformity probably underlies the Sverdrup Basin. Beneath this unconformity the rocks are probably Devonian and older and of geosynclinal character. In the southern part of the basin these geosynclinal rocks may represent part of the Franklinian miogeosyncline. In the northern and northwestern parts of the basin, the basement is probably composed of the foundered remains of the Franklinian eugeosyncline.

Within the map-area much of the Sverdrup Basin is covered by the waters of Hecla and Griper Bay, and Hazen, Fitzwilliam, and Ballantyne Straits. These bays and straits divide the exposures of the basin into several isolated areas: Sabine Peninsula, northwest Melville Island, eastern Prince Patrick Island, Brock Island, Borden Island, and Mackenzie King Island.

Sabine Peninsula

On Sabine Peninsula an essentially homoclinal, structurally concordant sequence of rocks is exposed, ranging in age from Middle Pennsylvanian to early Tertiary (Canyon Fiord, Sabine Bay, Assistance, Bjorne, Wilkie Point, Mould Bay, Isachsen, Christopher, Hassel, Kanguk, and Eureka Sound Formations).

[1] *See* Addendum, p. 227.

The cumulative thickness of these beds, where they outcrop, is about 10,000 feet. The Canyon Fiord beds definitely seem to constitute the basal unit of the Sverdrup Basin sequence in this area, unlike northwestern Melville Island where the contemporary strata occur in detached synclines that were perhaps detached basins at the time of sedimentation. At the south edge of the homocline dips up to 20 degrees have been recorded. To the north the dips decrease and north of the isthmus between Sherard and Eldridge Bays prevailing dips are 5 degrees or less. Over extensive areas in central Sabine Peninsula the beds are virtually horizontal. The prevailing northerly dip is interrupted near Tingmisut Lake by a structurally elevated area which appears to be a faulted anticline. In the central part of the peninsula, between Chads Point and Invincible Point, the strata are essentially horizontal but the northerly homocline is resumed at the latitude of Macdougall Point. It is possible that a gentle anticlinal flexure occurs in this area, between Macdougall and Marryatt Points, and that the apparently flat beds to the south are folded into a shallow syncline. However, sufficient data are not available to establish whether or not dip reversals occur in this area. If such a reversal is present, it is very gentle.

Near the north end of Sabine Peninsula are two almost perfectly circular piercement domes composed of Pennsylvanian or Permian gypsum, with lesser limestone and gabbroic intrusive rock (*see* Pls. XXIII, LIII). These are the Barrow and Cape Colquhoun domes. Exposures adjacent to these domes are poor. Essentially horizontal Eureka Sound beds occur within half a mile of the Cape Colquhoun dome. If a belt of steeply inclined strata occurs adjacent to these domes it must be very narrow and clearly these domes are not surrounded by a relatively wide zone of warped strata, as are the piercement structures of the Ringnes Islands (Heywood, 1957, etc.). In the Barrow dome the gabbroic rock forms an impressive, arcuate wall and has the appearance of a ring dyke (*see* p. 174). No exposures of halite have been found at the domes, which seems to be characteristic of the Sverdrup Basin piercement structures.

As already noted, the exposed thickness of sedimentary rock on Sabine Peninsula is about 10,000 feet. These rocks have been described previously (*see* Chapter III). In this structural discussion it seems appropriate to discuss the probable changes in thickness, and lithology that may be anticipated in the subsurface of Sabine Peninsula.

The northern part of Sabine Peninsula evidently lies near the axis of the Sverdrup Basin, whereas the southern part lies near the margin. Some formations that are widely distributed in the axial parts of the Sverdrup Basin but are not exposed on southern Sabine Peninsula, probably appear downdip and add to the total thickness of rock that underlies the Peninsula. Notable absentees at the outcrop are the Schei Point Formation (Middle and Upper Triassic) and the Heiberg Formation (Upper Triassic). The Schei Point Formation (or the contemporary Blaa Mountain shales) may be expected in the subsurface of this area and the same is true of the Heiberg Formation.

The Mesozoic formations of the Sverdrup Basin change radically in facies,

PLATE LIII

Northwest side of Barrow piercement dome, Sabine Peninsula. The dark, flat-topped hill is gabbro, possibly a ring dyke. Most of the light coloured material is gypsum.

between the margins and the axis of the structure. In general, sands characterize the margins, to be replaced by shales and siltstones in the axial part (*see* Tozer, 1960). Thus it is probable that marine formations, such as the Wilkie Point and Mould Bay, exposed as sand and sandstone on southern Sabine Peninsula, may change to shale (Savik and Deer Bay Formations, respectively) towards the north, in the subsurface of the Peninsula. Unpublished data obtained by the writers on Ellesmere and Axel Heiberg Islands indicate that the Pennsylvanian and Permian rocks change in a fashion somewhat analogous to that of the Mesozoic rocks. It is therefore considered unlikely that the Canyon Fiord, Sabine Bay, and Assistance Formations retain their exposed characters when traced into the subsurface of Sabine Peninsula. By analogy with Ellesmere and Axel Heiberg Islands, these formations might be expected to change laterally into limestone, dark shales, and argillaceous limestone, gypsum, etc. Confirmation that dramatic changes do occur in the upper Palaeozoic part of the section is provided by the piercement domes, which have brought to the surface beds that are unrepresented in the outcrop belt to the south.

Many of the formations on Sabine Peninsula probably thicken in the subsurface. The Isachsen Formation, for example, is about 400 feet thick, where exposed on southern Sabine Peninsula. In the axial part of the Sverdrup Basin this formation reaches a thickness of 4,500 feet. The thickness of this formation almost certainly increases between the south and north end of Sabine Peninsula. A summary of the available data on the thickness of this formation, and a partly conjectural isopachous map, have been provided by the writers (Thorsteinsson and Tozer, 1960).

Thus on Sabine Peninsula we are probably dealing with an area where the sedimentary thickness is increasing downdip. This increase is achieved by (1) thickening of individual formations, and (2) by the appearance in the subsurface, of formations that do not reach the surface. The writers conclude that the total thickness of Pennsylvanian and younger formations on northern Sabine Peninsula is probably a great deal more than the exposed thickness of 10,000 feet.

Northwest Melville Island

In northwest Melville Island, north of Marie Bay and Raglan Range, an essentially homoclinal terrane of upper Palaeozoic and Mesozoic beds, the Marie homocline, is exposed. The direction of dip is about N20°E, and the beds are inclined at low angles. A dip of 4 degrees was observed north of Marie Heights, but throughout most of the area dips are probably less than this figure. The exposed sedimentary column includes the Assistance, Bjorne, Borden Island, Wilkie Point, Mould Bay, Isachsen, and Christopher Formations, in aggregate about 2,000 feet thick. On the north side of Marie Bay, red beds, apparently of Pennsylvanian age (Canyon Fiord Formation) underlie, concordantly, the Assistance Formation (Permian). Farther to the east, between the head of Marie Bay and Raglan Range, a marked angular unconformity separates the Assistance and Canyon Fiord beds. There the Assistance Formation is the basal unit of the exposed Sverdrup Basin sequence. The unconformity between the Pennsylvanian and Permian rocks thus seems to be a local feature. At the entrance to Marie Bay the Assistance Formation is apparently absent and the basal beds of the basin sequence seem to be red Canyon Fiord beds, followed by the Bjorne Formation (Triassic).

Eastern Prince Patrick Island

The whole of Prince Patrick Island, northeast from a line joining Salmon and Wilkie Points, lies within the Sverdrup Basin structural province. The southwest part of this terrain, in the Intrepid Inlet area, exhibits a homoclinal section dipping northeast, the Jameson Bay homocline. Farther north there are at least two gentle folds, the Cape Hemphill syncline and the Moore Bay anticline. A second shallow syncline probably occurs near Cape Ludlow Rich. These structures trend about northwest. The occurrence of Christopher beds on Emerald Isle indicates a moderate structural low. Thus it is possible that the Cape Hemphill syncline extends east to Emerald Isle and then, farther east, towards the main axis of the Sverdrup Basin synclinorium (*see* Fig. 12). The northwest strike of the folds on Prince Patrick Island is a mild expression of the northwest strike imposed

PLATE LIV

Cape Colquhoun piercement dome, Sabine Peninsula.

on much of the western part of the Sverdrup Basin, for example on the Ringnes Islands (*see* Geol. Surv. Can., Prel. Map 14-1959). These folds seem to trend more or less at right angles to the axis of the basin and the synclinorium.

The sedimentary column in this area includes the Schei Point, Wilkie Point, Mould Bay, Isachsen, and Christopher Formations, in aggregate thickness about 1,700 feet. The Heiberg Formation (known on Brock Island) and the Assistance, Bjorne, and Borden Island Formations, all of which occur on the neighbouring part of Melville Island, are not exposed on eastern Prince Patrick Island. However, it is possible that these formations may be present in the more depressed parts of this area, adjacent to the axis of the Sverdrup Basin.

Brock Island

Much or all of the southeast part of Brock Island exposes the Heiberg Formation (Upper Triassic). Relief is low and most of the rock has been disintegrated by frost action and as a consequence the attitude of bedding was nowhere determined. The apparently widespread occurrence of the Heiberg beds suggests that the beds are relatively undisturbed, tectonically. Obscure cuestas visible on the air photographs suggest that the beds dip to the east. The stratigraphic relationship between the Upper Triassic beds on Brock Island and the Jurassic beds on the neighbouring Mackenzie King Island suggests that an easterly dip component is present. Lineaments and scarps visible on the air photographs suggest that several small faults, trending east-west, occur in the southeast part of the island.

Borden Island

The regional dip of Borden Island is southeast, with the successive appearance of the Schei Point, Borden Island, and Wilkie Point Formations, about 500 feet in aggregate, exposed, thickness. On this island we are confronted with the northwest edge of the Sverdrup Basin. The Schei Point beds, the oldest exposed on Borden Island, are the oldest exposed at the west and southwest ends of the Sverdrup Basin. There the base of the Schei Point is exposed only on Prince Patrick Island, where the underlying rocks, of Devonian age, represent the basement beneath the Sverdrup Basin. Possibly the same may be the situation on Borden Island but unfortunately the unconformable cover of Beaufort beds conceals the base of the Schei Point there and perhaps conceals the evidence that might reveal the character of the rocks beneath the northwest part of Sverdrup Basin.

Several normal faults (Fig. 12) cut the Mesozoic strata of Borden Island. Stratigraphic throw on these faults is small, probably less than 200 feet.

Mackenzie King Island

Broadly speaking the regional dip on Mackenzie King Island is east and southeast, with the older rocks exposed on the west and northwest sides of the island and younger beds to the east and southeast. Thus Mackenzie King Island

lies on the northwest limb of the Sverdrup Basin synclinorium. Superimposed upon this southeast-dipping terrain are several small folds and faults. Near the Leffingwell Crags the folds trend northerly, whereas on the northeast part of the island the folds strike northwest. These folds conform to the prevalent strike within the western part of the Sverdrup Basin.

The exposed sedimentary column of Mackenzie King Island includes the Wilkie Point, Mould Bay, Isachsen, and Christopher Formations, about 1,700 feet in aggregate thickness. Southeastern Mackenzie King Island is approaching the axial part of the Sverdrup Basin and it may be that a substantially thick section is present. The reasons for this suggestion are essentially those given in the discussion of the probable sub-surface features of Sabine Peninsula (p. 198).

Arctic Coastal Plain

The Arctic Coastal Plain structural province fringes the west and northwest margin of the Archipelago from Banks Island to Meighen Island, a distance of about 750 miles. Within the map-area this province includes much of Prince Patrick, Brock, and Borden Islands. This monotonous plain is underlain by the Beaufort Formation, which is composed of non-marine sand and gravel, attains a thickness of at least 250 feet and is apparently of late Tertiary and Pleistocene age. The distinctive physiographic characters of the plain are described above (p. 24). As mentioned in the physiographic discussion, the surface of the plain slopes seaward. This slope is probably in part an expression of the gradient upon which the beds were deposited, but the physiographic evidence also suggests that some seaward tilting has taken place subsequent to the deposition of the Beaufort beds.

The base of the Beaufort Formation, which represents the boundary of the Coastal Plain, is an unconformity. In different parts of the map-area the Beaufort rests on the Griper Bay Formation (Devonian) and on nearly all the Mesozoic formations.

The only prominent tectonic features of the plain are several prominent lineaments in central Prince Patrick Island (*see* Fig. 12 and Pl. LV).

The lineaments northwest of Intrepid Inlet are about 40 miles long, and intersect west of the head of the inlet. The western lineament is arcuate, the eastern one is almost perfectly straight. On the ground these lineaments have no appreciable topographic expression, but merely define the boundary between two areas with slightly different vegetation. The length and linear character of these features leave little doubt that they represent the surface trace of faults. The strike of the western, arcuate, lineament is north to northeast. The south end of this lineament, where it strikes north, seems to reflect the strike of faults on the Prince Patrick Uplift, to the south. An extension of this lineament would meet, almost perfectly, the east shore of Mould Bay, the locus of which may be due to fault control.

Two prominent, and several lesser lineaments, trending north, occur directly north of the peninsula between Mould Bay and Walker Inlet. Some of

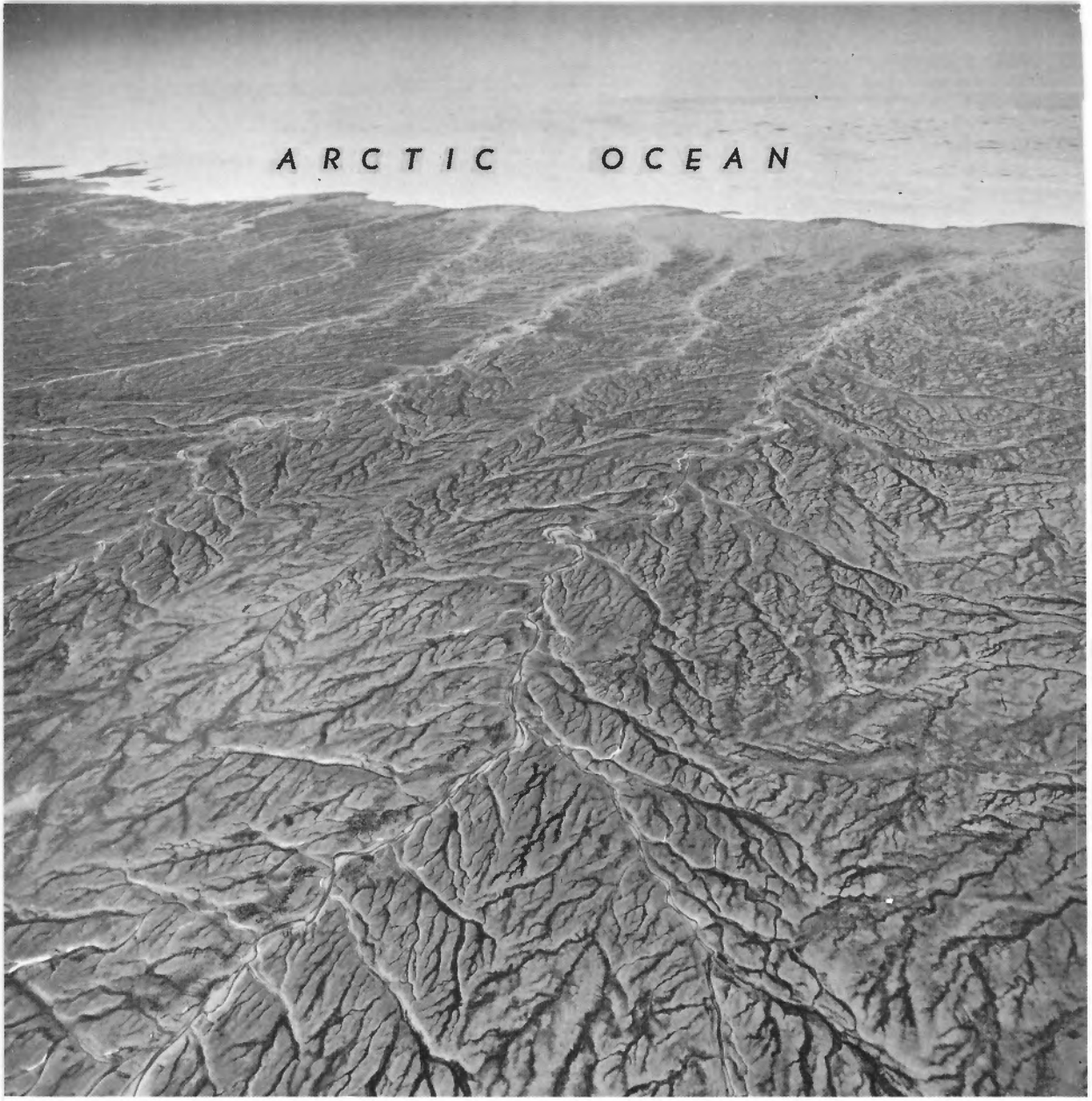

PLATE LV. Aerial view of central Prince Patrick Island, west of the head of Intrepid Inlet, westward towards the Arctic Ocean. This area is part of the Arctic Coastal Plain, underlain by the Beaufort Formation. In the middle distance is the prominent arcuate lineament that intersects the surface of the plain. (RCAF T430L–49)

these lineaments are perfectly aligned with faults that dislocate the Devonian and Mesozoic rocks of the peninsula. These lineaments have not been examined on the ground.

As already mentioned (p. 192), most of the movement on the faults of the Prince Patrick Uplift clearly predates the deposition of the Beaufort Formation. However, the presence of these lineaments suggests that some movement also took place after the Beaufort beds were laid down. This later period of movement was presumably a late Tertiary or Pleistocene event.

Chapter VI

HISTORICAL GEOLOGY

In this chapter conclusions regarding the geological history of the map-area are summarized under the following headings:

1. Ordovician and Silurian sedimentation
2. Devonian sedimentation
3. Mid-Palaeozoic earth movements
4. Pennsylvanian sedimentation in northwestern Melville Island
5. Late Palaeozoic earth movements
6. Pennsylvanian to early Tertiary history of the Sverdrup Basin and adjacent areas
7. Tertiary earth movements
8. Late Tertiary, Pleistocene, and Recent history.

Ordovician and Silurian Sedimentation

Within the map-area Ordovician and Silurian history is recorded only on Melville Island, in four areas: Canrobert Hills, Raglan Range, McCormick Inlet, and Tingmisut Lake. Rocks of these ages were deposited in the Franklinian geosyncline, and are entirely carbonate and graptolitic shale, which testify to marine conditions remote from a source of terrigenous clastic material.

The record on Melville Island reveals that more or less continuous sedimentation occurred through Ordovician and Silurian times, for the dated rocks range in age from Arenig (Lower Ordovician) to Upper Ludlow (latest Silurian). In the Canrobert Hills the rocks are mainly graptolitic shale (Ibbett Bay) overlying mainly unfossiliferous carbonates (Canrobert) which may be as old as Cambrian. The Canrobert Hills graptolitic shale sequence represents the longest continuous record of this facies known in North America, and probably the longest known in the world. At the Raglan Range, some 28 miles to the east, a very different sedimentary regime is recorded. There the only graptolitic rocks are of Upper Ludlow age (Kitson Formation), and they overlie a thick sequence of Silurian and (?) Ordovician carbonates. Around McCormick Inlet, 25 miles southeast of Raglan Range, yet another regime is evident with late Ordovician (?) to Upper Ludlow graptolitic rocks (Cape Phillips Formation) overlying dolomite assigned to the Cornwallis Formation.

The McCormick Inlet development has much in common with the contemporary sequence on eastern Bathurst Island (Thorsteinsson and Glenister, 1963), northern Cornwallis Island (Thorsteinsson, 1958), and central Ellesmere Islands (Trold and Bay Fiord areas) (Thorsteinsson and Tozer, 1957). In all these areas the change from carbonate deposition (Cornwallis Formation) to graptolitic sedimentation (Cape Phillips) apparently took place at the same time.

Thus, this change seems to have been a very widespread, contemporary event throughout much of the Franklinian miogeosyncline. The graptolitic formations of the miogeosyncline clearly represent sediments that accumulated over long periods in a stable environment. Benthonic faunas apparently could not colonize this environment. Furthermore the position of the boundary between graptolitic and carbonate facies was extraordinarily stable in position for long periods of time. It appears that a profound ecological barrier, more or less fixed in position throughout Upper Ordovician and Silurian time, separated areas of carbonate and graptolitic facies. It therefore seems reasonable to suggest that the graptolitic beds were deposited in a deep trough, or troughs, flanked by shelf and bank areas with shallow water and carbonate deposition. This trough system seems to have extended throughout the Franklinian miogeosyncline. In the Canrobert Hills the trough evidently existed throughout most Ordovician time and for the whole of the Silurian. Elsewhere, where the Cape Phillips Formation was laid down, the trough seems to have experienced a shorter life, from Upper Ordovician to Upper Silurian. In the areas where trough deposition started in Upper Ordovician time, for example McCormick Inlet and northern Cornwallis Island, the graptolitic beds succeed, abruptly, shallow-water carbonates of the Cornwallis Formation. This abrupt geological boundary, which can be recognized in widely separated areas (McCormick Inlet, eastern Bathurst Island, northern Cornwallis Island, Trold Fiord, Bay Fiord, etc.) presumably indicates a sudden change in bottom environment. Perhaps this change reflects abrupt crustal downwarping, and formation of the trough that then existed until the end of Silurian time.

On northern Ellesmere and Axel Heiberg Islands eugeosynclinal sedimentary, and probably also volcanic, rocks were being formed at the time of deposition of the carbonate and graptolitic rocks of Melville Island. The Melville Island record provides no evidence of such events, but it is possible that eugeosynclinal Ordovician and Silurian rocks are hidden beneath the sediments of the Sverdrup Basin, in the northern part of the map-area.

The available facts, and our interpretation of Ordovician and Silurian palaeogeography, are shown diagrammatically by Figure 14.

Devonian Sedimentation

The Devonian rocks of the map-area follow the Silurian strata concordantly. This area escaped the early Palaeozoic tectonism that affected Cornwallis and adjacent islands (Thorsteinsson, 1958; Thorsteinsson and Tozer, 1960).

On Ellesmere Island and central Bathurst Island, as shown by McLaren (1959; 1963a, b), marine shales and carbonates, with some fine-grained sandstone, were deposited in Lower (?), and early Middle Devonian (Eifelian) time (Stuart Bay, Eids, and Blue Fiord Formations). Quartzose sediment in the Stuart Bay Formation is interpreted by McLaren as a reflection of uplift of the nearby early Palaeozoic tectonic belt. The succeeding Eids and Blue Fiord Formations (Middle Devonian) indicate a return to carbonate and shale deposition. The

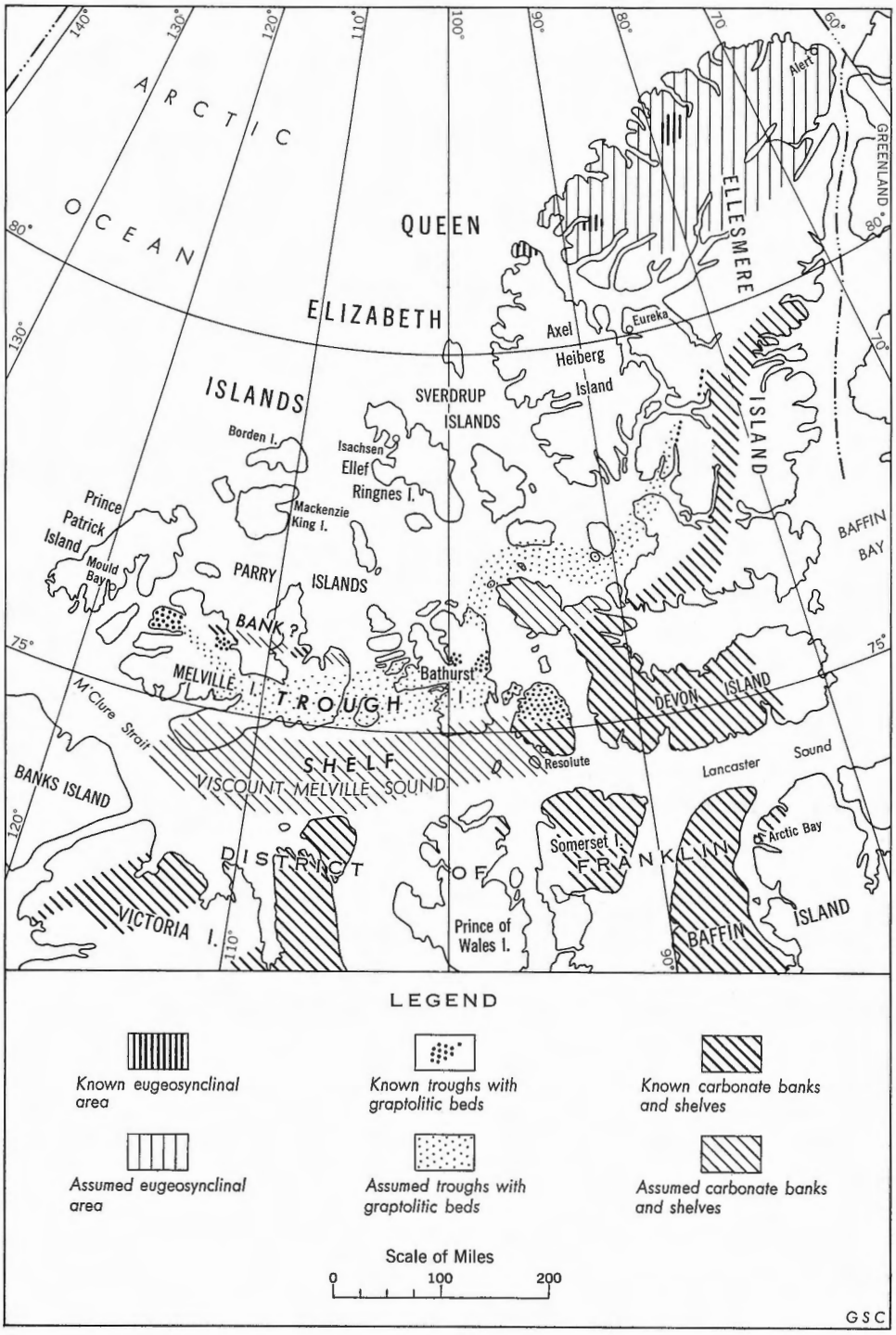

FIGURE 14. Ordovician and Silurian facies belts, Arctic Archipelago.

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Blue Fiord limestone is exposed around Weatherall Bay, Melville Island, and reveals that the regime typified by Bathurst and Ellesmere Islands extended as far west as eastern Melville Island. In western Melville Island the Blue Fiord and Eids Formations are absent but whether this is through non-deposition or removal is not known.

Throughout the Archipelago, from Banks Island, through the Parry Islands to southern Ellesmere Island the late Middle and Upper Devonian rocks indicate a sedimentary regime completely unlike that shown by the underlying carbonate rocks. These younger Devonian rocks (Bird Fiord and Okse Bay Formations of Bathurst and Ellesmere Islands; Weatherall, Hecla Bay, and Griper Bay Formations of Melville Island) testify to the arrival, within the Franklinian geosyncline, of a vast flood of terrigenous clastic sediment, mainly quartzose sand and silt. Most of the Bird Fiord Formation, and much of the Weatherall, were deposited under marine conditions and contain faunas dated as late Middle Devonian (probably Givetian) by D. J. McLaren. The younger beds (Okse Bay, Hecla Bay, and Griper Bay) are mainly non-marine, with coal seams in the Okse Bay and Griper Bay Formations. Some marine bands with Upper Devonian (mainly Frasnian) faunas occur in the Griper Bay. The facies of these late Middle, and early Upper Devonian Formations is very reminiscent of the classic "clastic wedge" deposits of the Appalachians, for example, the Chemung Group and the Pocono Sandstone. The clastic wedges of the Appalachians were clearly derived from the east, from the 'tectonic lands' of Marshall Kay and P. B. King. It seems reasonable to suggest that the great belt of Devonian clastic rocks that extends throughout the Franklinian miogeosyncline and the adjacent Lowlands was derived from an analogous belt of 'tectonic lands' to the northwest (Fig. 15). A great thickness of mainly clastic rocks occurs in Canyon Fiord, Ellesmere Island, above graptolitic shale of Ludlow age (Thorsteinsson, *unpublished*). These clastic rocks may represent the northeastern extension of this clastic belt and have been interpreted as such on Figure 15.

The exact site of these tectonic lands is not known but it is possible that the folded eugeosynclinal rocks of northern Ellesmere and Axel Heiberg Islands, where the youngest dated rocks are of Silurian age[1], represent the remains of a part of the tectonic area that shed the Devonian clastic sediments. If this interpretation is correct, the folding and uplift of the Franklinian eugeosyncline must have taken place prior to Givetian time and the views expressed by Lauge Koch on the age of the folding of northern Ellesmere Island would be vindicated. Clastic Devonian rocks occur in northern Yukon (*see* Martin, 1959) and it has been suggested that the Devonian clastic rocks of that area were also derived from a northern source. If we assume that a belt of tectonic lands lay adjacent to the Devonian clastic terrane it is apparent that the tectonic belt may have extended from northern Ellesmere Island, southwest to northern Yukon. This interpretation

[1] Fossiliferous Lower (?) Devonian rocks and an unconformity between the Silurian and Devonian have been discovered recently in northern Axel Heiberg Island by H. P. Trettin. (*See Geol. Surv., Canada,* Paper 62-18; *Can. Bull. Petrol. Geol.*, vol. 11, No. 2, pp. 102-117, 1963.)

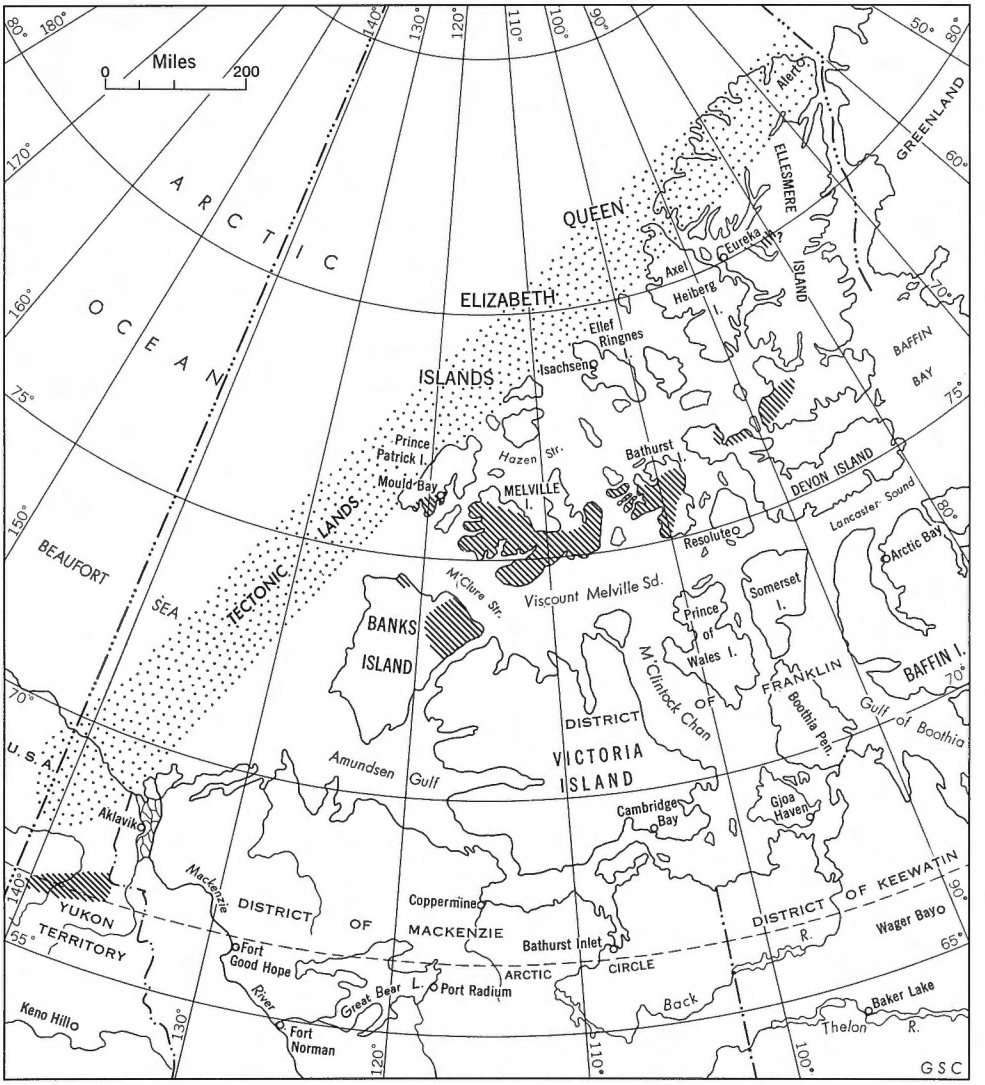

FIGURE 15. Extent of Devonian clastic formations, Arctic Archipelago (line pattern) and the probable site of their source (dot pattern). (Northern Yukon Territory *after* Martin, 1959.)

seems to be essentially the same as Martin's (1959). The only alternative explanation for this situation would be to assume derivation of the material from the Canadian Shield, to the south, and this seems an unsatisfactory potential source area. All the available evidence suggests that the Shield area (except for the Boothia Arch) was low-lying in Devonian time, fringed, and partly covered by epicontinental seas with carbonate sedimentation in progress.

The Shield thus seems ill qualified to be the source of clastic wedge sediments that locally attain a thickness of at least 15,000 feet.

Mid-Palaeozoic Earth Movements

Within the Franklinian miogeosyncline the end of Devonian sedimentation marks the end of a major cycle of deposition. The youngest dated Devonian rocks are of Frasnian age[2]. Throughout the map-area, and throughout the miogeosyncline, these Devonian rocks were folded prior to deposition of the next younger formations, which are of Middle Pennsylvanian age. Most of the folding of the Parry Islands Fold Belt took place within this time interval, i.e., between the Frasnian and the Middle Pennsylvanian. Only in northwestern Melville Island is there evidence of later folding within the Parry Islands Fold Belt and these younger folds are superimposed upon the older, mid-Palaeozoic structures (p. 178).

Mississippian[1], and early Pennsylvanian rocks are unknown in the Archipelago and are probably not exposed. Consequently it is not possible to date the mid-Palaeozoic movements with precision. Broadly speaking they are of Variscan age.

Pennsylvanian Sedimentation in Northwestern Melville Island

As already shown there is no record of sedimentation in the Archipelago between Frasnian (Upper Devonian) and Middle Pennsylvanian time[1]. Middle Pennsylvanian rocks are widespread and wherever the base of the Pennsylvanian sequence is exposed a profound unconformity lies beneath the sequence. The Pennsylvanian rocks of Melville Island occur in two different structural situations. One is in northwest Melville Island where these rocks occur as detached outliers, mainly of a synclinal nature. In this area the Pennsylvanian rocks are bounded, both above and below, by angular unconformities. Beneath the Pennsylvanian are folded Ordovician, Silurian, and Devonian formations; above, unconformably, are Permian strata. The other situation is displayed on Sabine Peninsula, where the Pennsylvanian rocks rest unconformably upon the older formations but are followed concordantly by Permian strata. The Pennsylvanian rocks of Sabine Peninsula were evidently deposited within the Sverdrup Basin and are discussed later (p. 209).

Most of the Pennsylvanian rock of Melville Island (Canyon Fiord Formation) is unfossiliferous sandstone and conglomerate, but thin limestone beds with

[1] Mississippian rocks are now known. (*See* Addendum, p. 227.)
[2] *See* page 84.

marine fossils occur near the base of the formation. Pebbles in the conglomerates include Devonian sandstones and lower Palaeozoic chert and limestone, so that much of the sediment was evidently derived from the denudation of the folded rocks of the Franklinian miogeosyncline. Some, or all, of the detached synclines of northwestern Melville Island may have been detached areas of sedimentation. The tectonic situation of the Pennsylvanian beds in that area seems to resemble that of the Devonian intermontane basins within the Caledonides of Greenland, Spitsbergen, and Scotland and the grabens filled with Triassic red beds that occur in the Appalachians. All these occurrences have several features in common: they post-date a strong orogenic phase; they are partly (or wholly) derived from the denudation of the adjacent mountains; and the beds are predominantly red.

Although the Pennsylvanian beds of northwestern Melville Island may have been deposited in relatively small, partly or intermittently isolated basins there is nevertheless a marked lithological similarity with the Pennsylvanian beds that appear to have been laid down on the edge of the Sverdrup Basin, for example those of Sabine Peninsula. All these Pennsylvanian clastic rocks are assigned to the same formation—the Canyon Fiord Formation. A tentative picture for Pennsylvanian time would include a major sedimentary area—the Sverdrup Basin—with sands and conglomerates being deposited on the margins. To the north, on northern Axel Heiberg and Ellesmere Islands the contemporary rocks are mainly limestone (Christie, 1957; Thorsteinsson, *unpublished*). On the southern margin of the Sverdrup Basin there may have been isolated uplifts, such as the Raglan Range, shedding sediment into nearby troughs detached from the basin proper. The clastic beds on the margins of the basin, and those of the isolated areas, probably had a similar source, namely uplifted ranges of rocks folded by the mid-Palaeozoic movements.

Late Palaeozoic Earth Movements

In northwestern Melville Island a period of folding took place between the Middle Pennsylvanian and the Permian. This folding may be described as a renewal of movement on the axes established by the mid-Palaeozoic tectonism. In this area these movements have resulted in spectacular examples of twice folded structures. Although this period of folding did not affect Sabine Peninsula, it was probably not an entirely local phenomenon, because essentially contemporary movements are recorded at Trold Fiord, on Ellesmere Island, and probably also elsewhere (Thorsteinsson and Tozer, 1960, p. 13).

Pennsylvanian to Early Tertiary History of the Sverdrup Basin and Adjacent Areas

Within the Sverdrup Basin, Middle Pennsylvanian time marks the beginning of a long period of essentially uninterrupted sedimentation which continued through the Mesozoic to early Tertiary time. On the exposed margins of the basin the

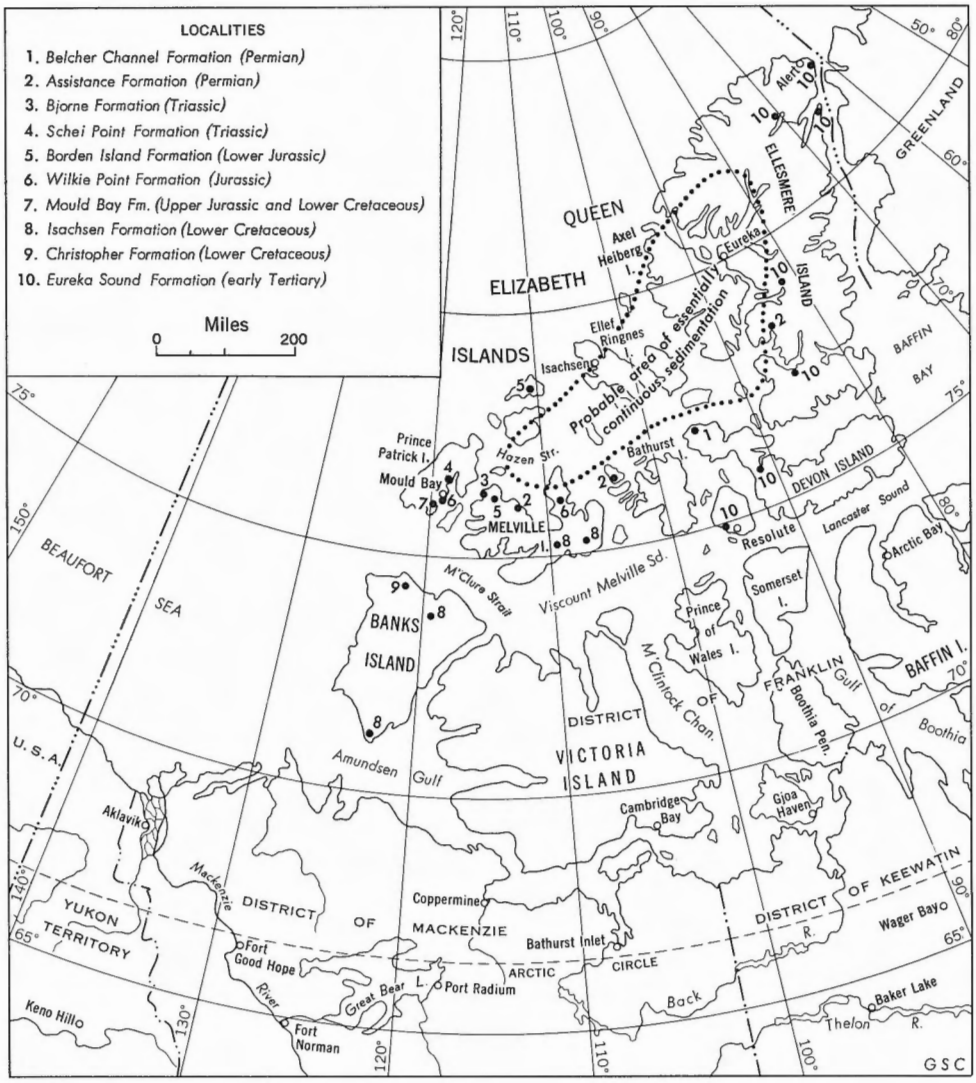

FIGURE 16. Localities where formations of Sverdrup Basin show overstep or overlap.

Pennsylvanian beds rest with profound angular unconformity upon the folded rocks of the Franklinian geosyncline, and it seems probable that this unconformity underlies the whole of the basin. In other words, it is suggested that the Sverdrup Basin is superimposed on the deformed rocks of the Franklinian geosyncline. From the available evidence it would appear that the axis of the basin, characterized by a thick, concordant section, extends from northern Sabine Peninsula, northeast through the Ringnes Islands and Axel Heiberg Island to northern Ellesmere Island. The evidence that the axial part of the basin records essentially continuous sedimentation is not provided within the map-area but the critical sections are well exposed in the northeast part of the basin, on Axel Heiberg and Ellesmere Islands (Thorsteinsson and Tozer, 1960, p. 12). The exposed section on Sabine Peninsula reveals most of the formations in concordant sequence but there are significant gaps in the Triassic, with the two formations unrepresented at the surface. However, it is probable that these formations appear in the subsurface and that the buried section at the tip of Sabine Peninsula is complete. The map-area includes much of the south and southwest parts of the basin and within the area is shown, *par excellence,* overstep and overlap between the axis and the margins of the basin. No less than ten formations overstep or overlap older beds on the margins of the Sverdrup Basin and eight of these relationships affect the succession in the map-area (Fig. 16).

Overlapping or overstepping formations that occur in the map-area are: the Assistance (Permian), Bjorne (Lower Triassic), Schei Point (Upper Triassic), Borden Island (Sinemurian, Lower Jurassic), Wilkie Point (Jurassic), Mould Bay (Upper Jurassic and Lower Cretaceous), and Isachsen (Lower Cretaceous). The transgressive nature of all these formations, except one, is well exposed and described in Chapter III. The one exception is the Bjorne Formation. This formation apparently oversteps the Assistance beds near the entrance to Marie Bay but exposures are not ideal there and a thin representative of the Assistance may occur but not be exposed. Formations that are transgressive beyond the map-area are the Belcher Channel (Permian) (Harker and Thorsteinsson, 1960), Christopher (Lower Cretaceous) (Thorsteinsson and Tozer, 1962), and Eureka Sound (early Tertiary) (Thorsteinsson and Tozer, 1957).

Most of the sediment within the Sverdrup Basin is sand and shale. Near the base of the sequence, in the Pennsylvanian and Permian, carbonates and evaporites are also present on Ellesmere and Axel Heiberg Islands. The sedimentary record for many of the marine Mesozoic formations shows that well-defined facies belts occur (*see* Figs. 17, 18, 19). Sand and sandstones characterize the margins of the basin and pass laterally into shales and siltstones towards the axis (Tozer, 1960). Analogous facies belts evidently characterize the Pennsylvanian and Permian strata. Sandy formations such as the Canyon Fiord (Pennsylvanian), Sabine Bay (Permian), and Assistance (Permian) occur on the margins, whereas the contemporary deposits of northern Axel Heiberg Island and adjacent parts of Ellesmere Island are limestone, chert, shale, siltstone, and gypsum (Fortier, *et al.,* 1963; Thorsteinsson and Tozer, *unpublished*). Most of the rock exposed in the

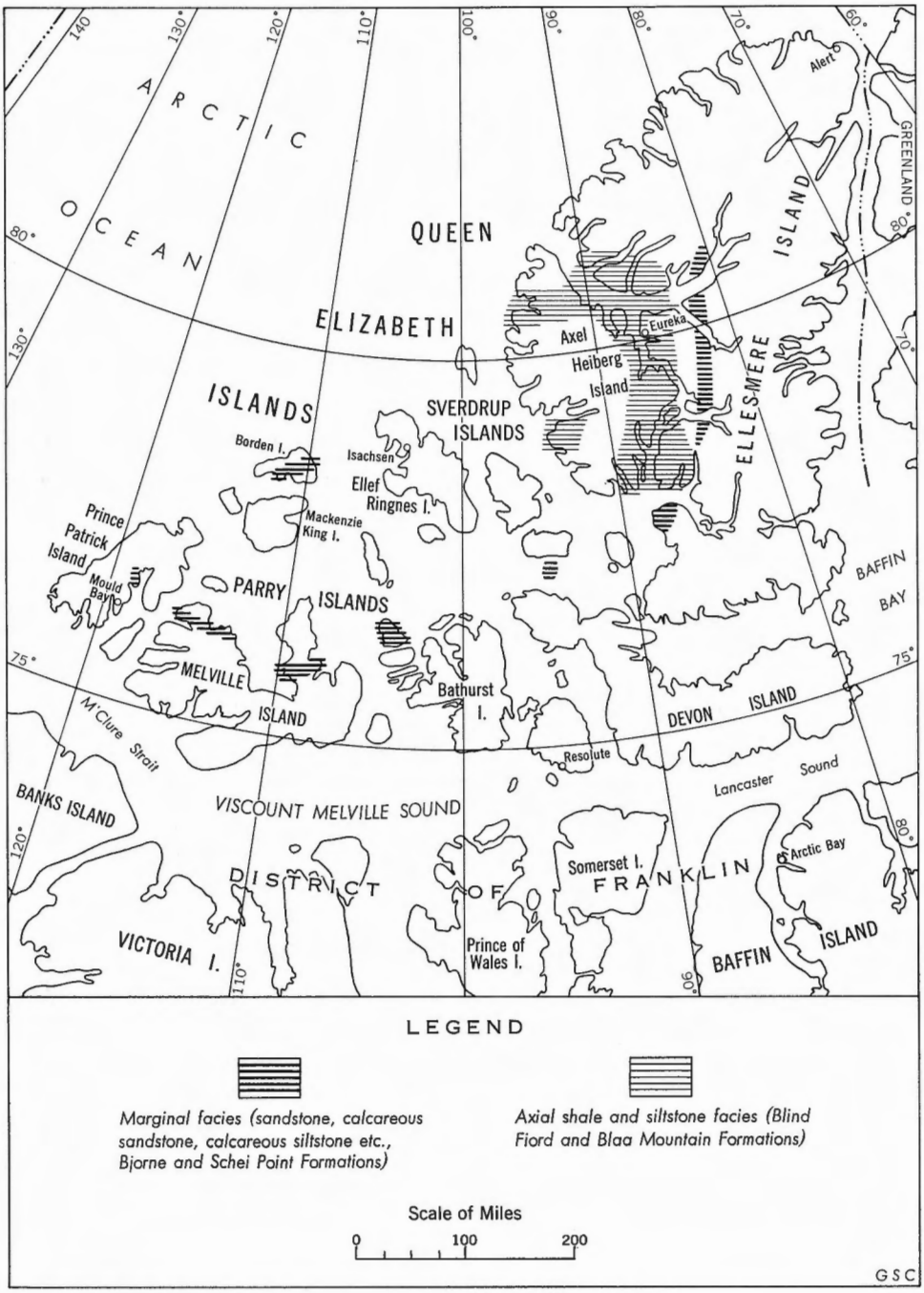

FIGURE 17. Triassic facies belts, Queen Elizabeth Islands (*from* Tozer, 1960).

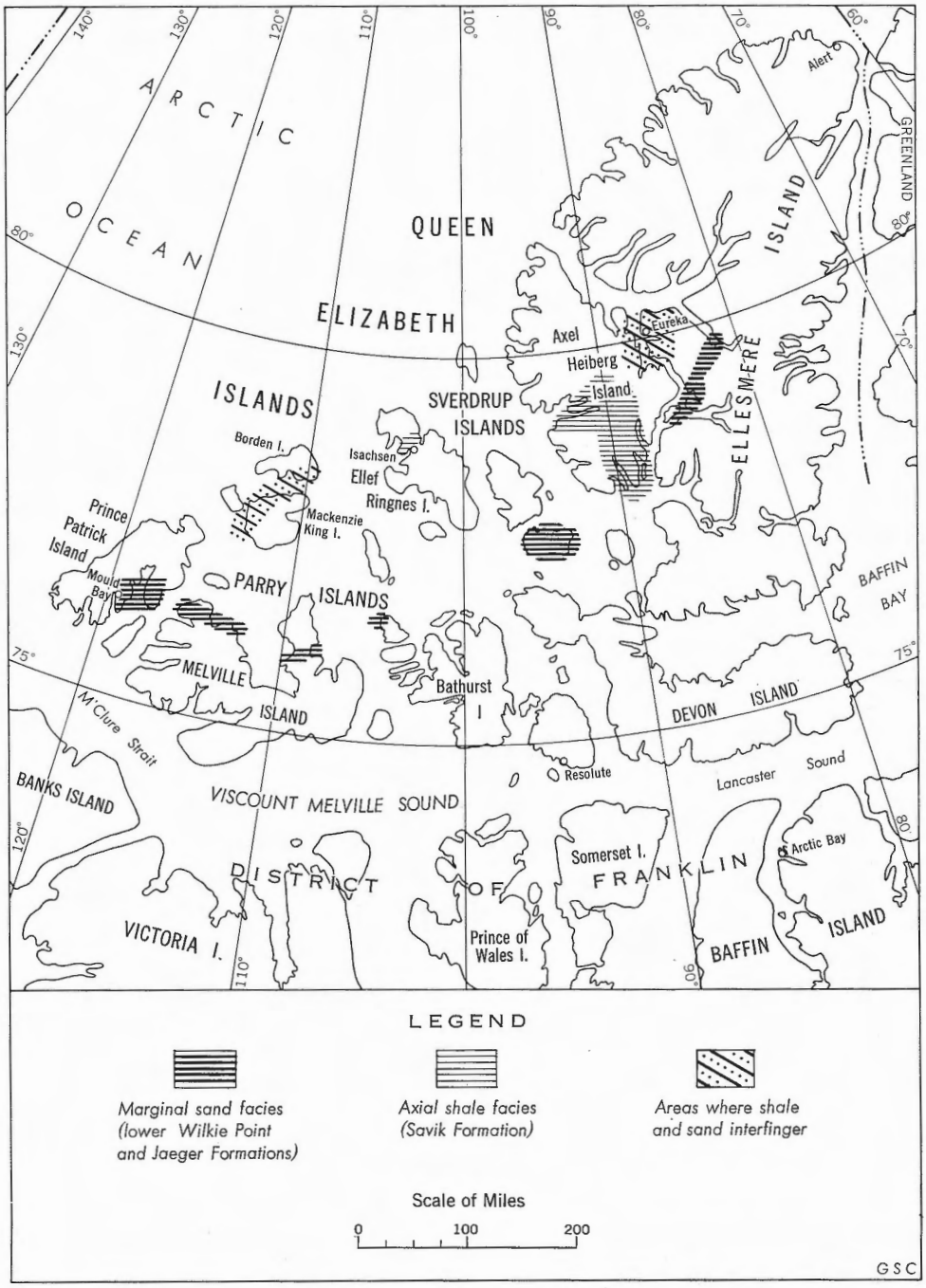

FIGURE 18. Jurassic facies belts, Queen Elizabeth Islands (*from* Tozer, 1960).

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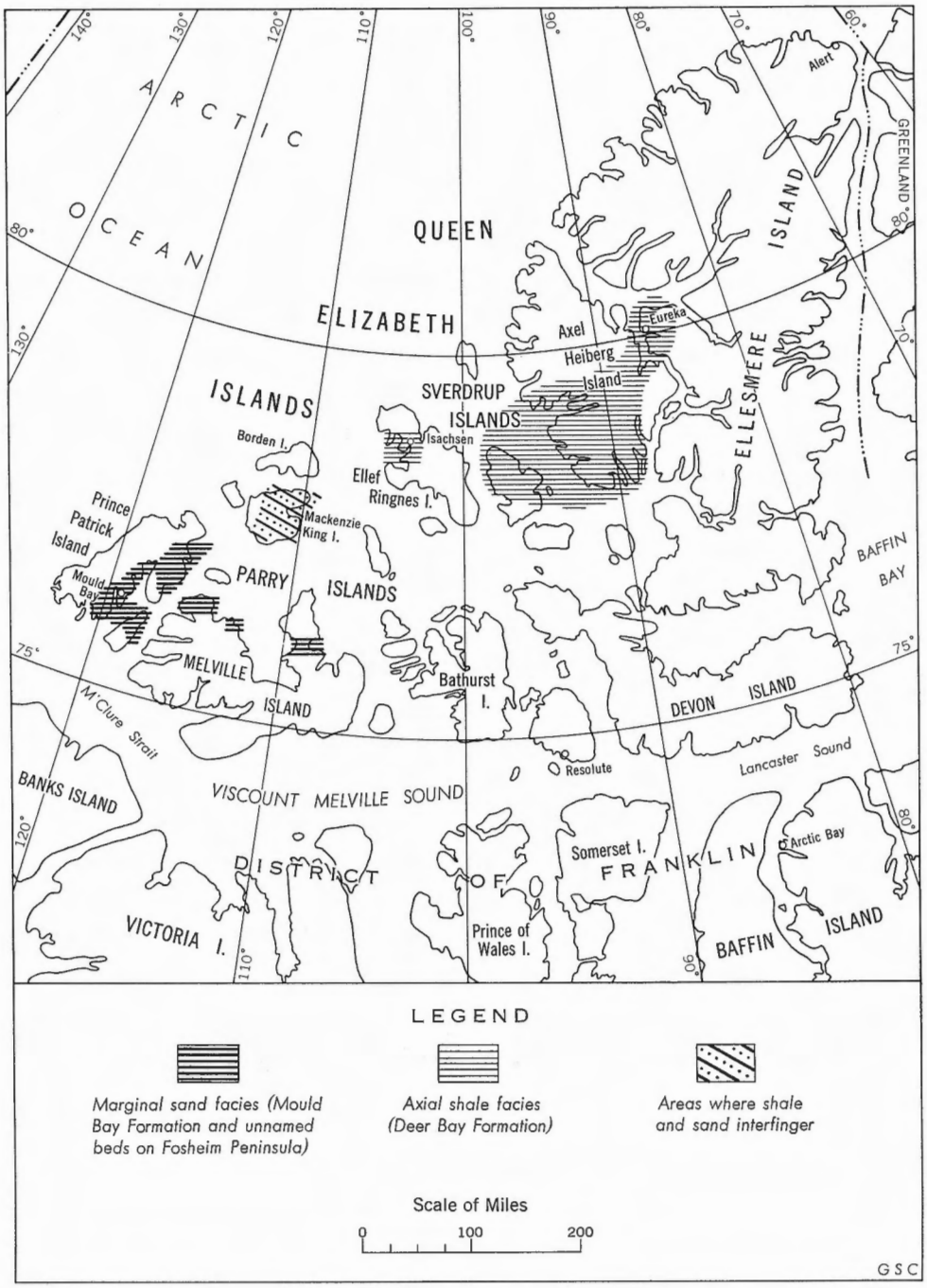

FIGURE 19. Upper Jurassic and lowermost Cretaceous facies belts, Queen Elizabeth Islands (*modified from* Tozer, 1960).

map-area, both of upper Palaeozoic and Mesozoic age, is of the marginal sand facies, but it is probable that the axial facies is developed in the subsurface of the central part of the basin, for example beneath Sabine Peninsula, where Pennsylvanian or Permian[1] evaporites reach the surface in piercement domes. The Wilkie Point and Mould Bay Formations of Borden and Mackenzie King Islands are of some interest in this connection. These formations reveal interfingering of the shale and sand facies.

The distribution of the upper Palaeozoic and Mesozoic facies belts suggests that much or all of the sediment in the Sverdrup Basin was derived from the south and the east. Unfortunately the northwest margin of the basin is not well exposed, but the available evidence provides no indication for a northwestern source[2]. It thus seems probable that the hypothetical 'tectonic lands', invoked (p. 206) to provide the Devonian clastic material of the Franklinian miogeosyncline, had foundered by the time that sedimentation in the Sverdrup Basin was under way. During the times of marine sedimentation within the basin it seems probable that the shorelines lay close to the present south and east limits of outcrops. To the northwest the area of sedimentation was probably bordered by an oceanic basin, whence came the transgressive seas that repeatedly flooded the northwest part of the Archipelago. This is the palaeogeographic picture envisaged by Haug (1910, p. 1113), Diener (1916), Frebold (1929, Pls. IV-VII), Stille (1948), and Arkell (1956, p. 604), and with it the writers are in complete agreement. Major marine transgressions are recorded in Pennsylvanian time (basal Canyon Fiord and contemporary formations of Axel Heiberg and Ellesmere Islands); Permian (Belcher Channel, lower Sabine Bay, and Assistance Formations); Triassic (Blind Fiord, Schei Point, and Blaa Mountain Formations); Jurassic (Borden Island, Savik, Jaeger, and Wilkie Point Formations); uppermost Jurassic and lowermost Cretaceous (Mould Bay and Deer Bay Formations); late Cretaceous (Christopher Formation); and Upper Cretaceous (Kanguk Formation). These periods of marine sedimentation were interrupted, at least five times, by periods when the level of sedimentation rose above sea-level. During these periods the basin area was presumably the site of a low delta, at times with conditions permitting the development of coal seams. The evidence for these successive deltas is provided as follows: in the Permian by the upper Sabine Bay Formation[1]; in the Triassic by the Heiberg Formation; in the Jurassic by the upper Wilkie Point and Awingak Formations; and in the Cretaceous by the Isachsen and Hassel Formations. In some areas relatively minor transgressions occurred during periods of essentially non-marine conditions. Such transgressions are recorded in the Heiberg, Awingak, and Isachsen Formations by the occurrence of thin beds with marine fossils (Tozer, 1960). The last marine transgression, in the Upper Cretaceous, was followed by an episode of deltaic sedimentation, with the deposition of the early Tertiary Eureka Sound Formation.

[1] *See* Addendum, p. 228.

[2] There is now evidence that minor amounts of Upper Triassic sediment were derived from the northwest (*Geol. Surv., Canada;* Papers 63-30, p. 14; 63-31, p. 15).

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The problem of the source of sediment within the Sverdrup Basin is an interesting one. It has been suggested (Tozer, 1960, p. 15) that much of the sediment may be redeposited Devonian sandstone derived from the folded rocks of the Franklinian miogeosyncline and the adjacent lowlands. Some formations, for example the coarse quartz sands and grits of the Isachsen Formation, may represent first-cycle orthoquartzites derived from the Canadian Shield. As already mentioned (p. 97), the Devonian sandstones and older Palaeozoic formations may have been an important source in Pennsylvanian time. The writers now believe that although the sources mentioned above may have been important, they are barely sufficient to account for the whole of the great thicknesses of Mesozoic and early Tertiary sediment in the Sverdrup Basin. The occurrence of outliers of Isachsen beds overlying bevelled Devonian rocks on southern Melville Island reveals that the Parry Islands folds had been reduced to a peneplain, not unlike its present surface, by Lower Cretaceous time. Thus the Parry Islands Devonian area was probably not an important source in later Mesozoic and early Tertiary time. Much of the Mesozoic Sverdrup Basin sediment was silt and mud and this introduces the possibility that the sediment was derived from a distant source. This is no evidence that an uplifted area immediately to the south or east provided this fine-grained sediment. It is therefore probable that it was produced by the denudation of distant uplifts. In this connection it seems profitable to compare the Sverdrup Basin with the Gulf Coastal Plain of the southern United States. This area is a paraliogeosyncline in the terminology of Marshall Kay; others call it a "coastal geosyncline". The thick Tertiary sediments of the Gulf Coastal area reflect uplift in an area remote from the site of sedimentation. There seems to be little doubt that the sudden flood of sediment that arrived on the site of the Gulf in early Tertiary time was derived largely from the newly uplifted mountains of the Western Cordillera. If we attempt to envisage the geography of eastern North America (including Greenland) in late Palaeozoic and Mesozoic time, the picture must have been dominated by mountainous areas on the site of the East Greenland Caledonides and the Appalachians. These eastern ranges were probably physiographically similar to the Western Cordillera of the present. Such mountains must have been drained by westward-flowing streams. These streams must have carried a substantial load of sediment, whose fate has long been uncertain. The writers suggest that it may have been transported west and then north from the mountains, across the site of the Canadian Shield, to the deltas of the Sverdrup Basin (Fig. 20). This interpretation involves the presence, in the Mesozoic and early Tertiary time, and perhaps also in the late Palaeozoic, of river systems flowing to the north having drained the west slopes of the eastern mountains. These rivers probably had dimensions, gradients, and capacity comparable to that of today's Missouri-Mississippi system. There is no evidence that the area between the Sverdrup Basin and these eastern mountains was covered by seas in Mesozoic or early Tertiary time. This intervening area was probably continental and could have supported the suggested drainage system.

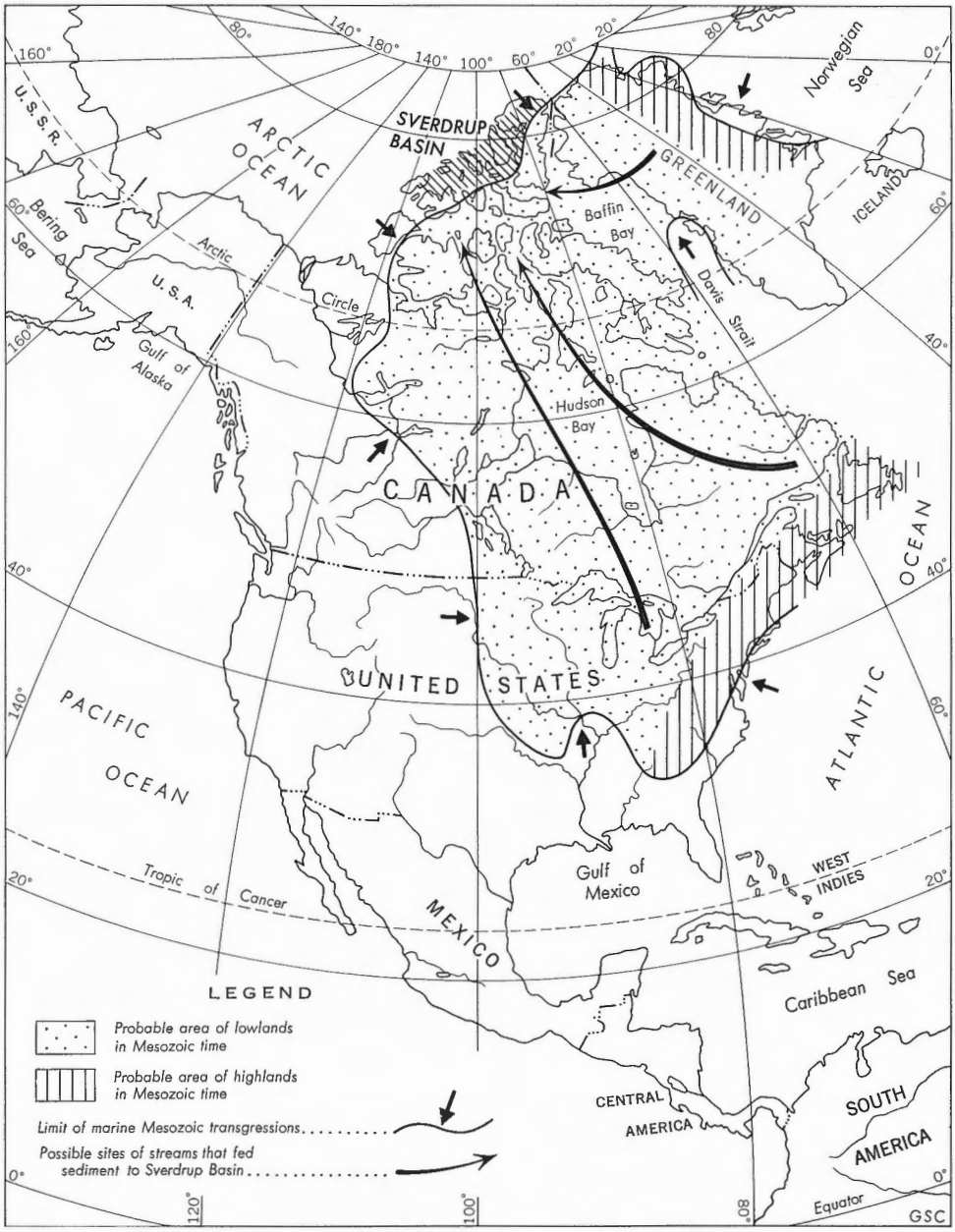

FIGURE 20. Palaeogeographic interpretation of the Sverdrup Basin.

Even the great Cretaceous transgressions made only a small impression upon the Mesozoic continental forerunner of North America.

According to this interpretation the Sverdrup Basin may have played a major role in connection with the drainage of North America. It may have played the role that the Gulf Coastal area adopted in Tertiary time and is fulfilling today. Furthermore, it may not be coincidence that heavy sedimentation in the Gulf area was initiated at about the time (early in the Tertiary) that sedimentation ceased in the Sverdrup Basin. The palaeogeography of North America was completely reorganized between late Cretaceous and early Tertiary times: the mid-Continent Cretaceous seaway disappeared and the continent began to assume its present appearance. Perhaps there was also a major reorganization in drainage during this time and much of the drainage that formerly carried sediment to the north (to the Sverdrup Basin) was replaced by systems that carried it to the south, to the Gulf.

Basalt was extruded on western Axel Heiberg Island in Cretaceous time (Fortier, *et al.,* 1963), and gabbroic sills and dykes cut the upper Palaeozoic and Mesozoic rocks of the Sverdrup Basin. The intrusions are not known to cut the Tertiary beds and it is probable that this igneous activity took place in Cretaceous time.

Tertiary Earth Movements

With the deposition of the Eureka Sound Formation, of early Tertiary age, sedimentation ceased in the Sverdrup Basin. The next recorded event is a period of folding. This folding affected most of the Sverdrup Basin and also parts of eastern Ellesmere Island, adjacent to the basin (Thorsteinsson and Tozer, 1957; 1960). The folding is relatively gentle in the map-area but to the east, particularly on Axel Heiberg and Ellesmere Islands fairly intensive folding, with some thrust faulting, took place[1]. Most of the folds between Prince Patrick Island and Axel Heiberg Island strike northwesterly; on Ellesmere Island north and northeast striking structures are predominant. The strike of most folds is therefore transverse to the sedimentary axis of the basin. In the western part of the basin the position of the sedimentary axis is expressed, structurally, as the axis of a synclinorium—the Sverdrup Basin synclinorium. The axis of this synclinorium, like that of the sedimentary axis, is transverse to the folds. This synclinorium seems to express crustal 'sag' on the site of the axis of the basin, whereas the transverse folds are clearly compressional features.

In the axial part of the Sverdrup Basin occur numerous piercement structures, exposing gypsum, limestone, and igneous rock. The mobile evaporites that form these intrusive bodies are apparently of Pennsylvanian or Permian age, and derived from beds near the base of the Sverdrup Basin sequence (Thorsteinsson and Tozer, 1957)[2]. The stratigraphic position of the evaporites in the Sverdrup Basin is thus analogous to that of the salt that forms piercement domes on the

[1] It is now known that some deformation occurred between the deposition of Lower Cretaceous and early Tertiary beds on Eastern Axel Heiberg Island (*Geol. Surv., Canada,* Paper 63-30, p. 34).

[2] *See* Addendum, p. 228.

Gulf Coastal Plain and in northwest Germany (*see* Murray, 1956; Trusheim, 1960). No salt is exposed in the Sverdrup Basin structures but it may be present at depth. It is possible that the movement of these structures was initiated in Mesozoic time and the pronounced local relief of the domes of Sabine Peninsula, and elsewhere, suggests that they may still be in motion.

Normal faulting has affected parts of the map-area, particularly the Blue Hills Fault Belt and the Prince Patrick Uplift. The age of these faults cannot be precisely dated from stratigraphic evidence, but the physiographic and regional relationships suggest that they are of Tertiary age. As mentioned below, it is probable that some of these faults have moved relatively recently and that they may have contributed to the present relief and coastal outlines of the Archipelago.

Late Tertiary, Pleistocene and Recent History

After the folding of the rocks of the Sverdrup Basin, which probably took place in, or shortly after, Eocene time, we have no record of deposition until the Beaufort Formation of the Arctic Coastal Plain. We therefore have very little data from which to reconstruct the late Tertiary history of the Archipelago. Some tentative suggestions nevertheless seem warranted, mostly based on physiographic evidence rather than on stratigraphy. These suggestions are set forth below. Their tentative and suggestive nature is stressed. The style may appear dogmatic but this mode of presentation is adopted because any alternative method would involve almost endless qualification and reservation. The facts are presented in the preceding chapters; our interpretation follows.

Following the Tertiary folding, mountains were produced by the uplift of the folded areas. This conclusion is inescapable from the present state of erosion of the folded area. Elevated erosion surfaces characterize practically the whole of the Archipelago, and this elevated surface indicates that Tertiary erosion reduced the terrain in the map-area, and most or all of the Queen Elizabeth Islands, to a peneplain.

After the initial peneplanation, uplift was again widespread. This second period of uplift was probably a complex event or series of events, and may have taken place at different times in different parts of the Queen Elizabeth Islands. On Prince Patrick, Brock, and Borden Islands, facing the Arctic Ocean, this uplift probably took the form of northwesterly tilting. On these islands the period of uplift post-dates the Beaufort Formation. On Melville Island the high plateau of the southwest part of the island has evidently been elevated to a greater extent than the southeastern and northern parts of the island. Southwest Melville Island experienced faulting, probably in late Tertiary time. It is probable that the supposedly Tertiary faults of southwest Melville Island illustrate the character, on land, of the faults that are probably responsible for the linear coast lines that characterize so much of the Archipelago. The writers believe that the main period of uplift following the earlier Tertiary planation involved vertical movement of individual islands. This was probably achieved by movement on gravity faults

between the islands rather than by epeirogenic adjustment affecting the Archipelago as a whole. In other words, it appears that gravity faults probably define the boundaries of individual areas of uplift. Examples of faults of this type are believed to define the north side of M'Clure Strait and the west coast of Melville Island. The writers believe that uplift of this type would account for the very different physiographic characters of adjacent islands that are stratigraphically and structurally similar. The best example of this physiographic contrast is beyond the map-area and is seen by comparing the Ringnes Islands with western Axel Heiberg Island. Both the Ringnes Islands and western Axel Heiberg Island are composed of Mesozoic and Tertiary rocks that were folded in early Tertiary time. After the folding both areas experienced uplift and planation. Physiographically these areas are very different today and Axel Heiberg Island has clearly been elevated compared with the Ringnes Islands. This physiographic contrast is best explained by invoking north-trending faults. The linear connection between the headlands of the west coast of Axel Heiberg Island indicates the probable position of the master fault. This hypothesis may resolve the major physiographic paradox of the Archipelago. The existence of numerous straits and sounds suggests a drowned topography, whereas the character of many individual islands suggests uplift. This paradox may be resolved by invoking faulting to account for the elevation of some islands (e.g., southwestern Melville Island and Axel Heiberg Island), tilting of others (Prince Patrick Island) and depression of the adjacent sounds (e.g., M'Clure Strait). These ideas are not entirely original, for McMillan (1910, p. 448) has also stressed the role that faulting has played in the development of the Archipelago.

The position of the Beaufort Formation with respect to this hypothetical sequence of Tertiary events presents many problems. This formation, which is probably late Tertiary or Pleistocene, probably represents a part of the sediment produced during a late stage of the Tertiary denudation of the mountains that rose on the site of the eastern part of the Sverdrup Basin and adjacent areas. The Beaufort beds may represent a thin inland edge of a thicker body of sediment, derived from this same source, and lying today upon the submarine continental shelf. Some faulting on the Prince Patrick Uplift definitely predates the Beaufort Formation but later faults apparently dislocate the Beaufort beds of central Prince Patrick Island. The presence of these young faults reveals that the Beaufort Formation may predate the principal period of uplift and fragmentation that has affected the Queen Elizabeth Islands.

The outliers of drift on southern Melville Island, the erratics found elsewhere, and the numerous erratics on the Arctic Coastal Plain suggest that the islands within the map-area were partly or entirely glaciated. The character of the erratics suggests that the ice responsible for this glaciation may have come from lands south of Viscount Melville Sound. Fresh glacial landforms, such as occur on the islands south of Parry Channel, are conspicuously absent in the map-area and consequently it seems reasonable to conclude that this Laurentide glaciation was a relatively early Pleistocene event.

A relatively recent period of uplift can be recognized in northern Canada from the presence of emerged strand lines. This period of uplift must not be confused with the older period, described in the preceding paragraphs (*see also* Thorsteinsson, 1958, p. 18). Southeastern Prince Patrick Island and southwestern Melville Island show clear signs of uplift but no sign of strand lines. For this reason distinction between older and younger periods of uplift seems justified. Within the map-area recent uplift of at least 60 feet is shown on Eglinton Island and 270 feet of uplift has been established at Tingmisut Lake, eastern Melville Island.

It has been suggested by J. G. Fyles that this uplift may be 'glacial rebound' following retreat of Wisconsin Laurentide ice-sheets that may have filled Viscount Melville Sound and the adjacent straits. There is, however, no evidence that Wisconsin Laurentide ice covered the islands of the map-area.

Local glaciers covered parts of Prince Patrick and Melville Islands relatively late in Pleistocene time, possibly in Wisconsin time. This is shown by striated pavements at Mould Bay and Liddon Gulf and by the U-shaped valleys and fiords of Melville Island. Some ravines have been cut since the retreat of these glaciers and the glaciers that today cap the highlands of western Melville Island are probably a recent growth.

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Chapter VII

ECONOMIC GEOLOGY

Oil and Gas

No oil seepages are known in the map-area and no wells have been drilled.[1] The islands nevertheless present certain features that have already engaged the attention of companies seeking accumulations of hydrocarbons. In presenting the data assembled in the preceding chapters we have attempted to provide the facts that will enable petroleum geologists to form an opinion regarding the possibilities of the area. In this chapter we propose to summarize the data that seem relevant in connection with petroleum exploration.

Reservoir and Source Rocks

Ordovician and Silurian

The exposed Ordovician and Silurian rocks are mainly carbonates and graptolitic shale. The carbonates of Raglan Range and McCormick Inlet (pp. 51, 61) appear to be mainly dense limestone and dolomite with poor potential reservoir qualities. The Silurian formation near Tingmisut Lake (p. 61), on the other hand, includes dolomite with well-developed vuggy porosity. The graptolitic beds of Canrobert Hills and McCormick Inlet may also be regarded as potential source rocks for hydrocarbons. In many parts of the Archipelago occur Ordovician and Silurian porous dolomites that emit a strong smell of petroleum. The Allen Bay Formation (Thorsteinsson, 1958) is the best example. This formation is not exposed on Melville Island but it may be present beneath the surface of southern Melville Island.

Devonian

The Blue Fiord limestone, which is exposed only in the Weatherall Bay area (p. 68), does not appear, from its outcrops, to offer promise as a reservoir. In other parts of the Archipelago, for example on the Princess Royal Islands (Thorsteinsson and Tozer, 1962), this formation is very porous. The possibility that porous Blue Fiord limestone occurs in the subsurface of Melville Island may therefore be entertained. The remaining Devonian rocks of the map-area (Weatherall, Hecla Bay, and Griper Bay Formations) are mainly sandstone, siltstone, and shale. These beds include much non-marine sediment, which probably diminishes their importance as potential source rocks. The white sandstones of the Hecla Bay Formation have excellent porosity and permeability, and similar rocks occur in the Griper Bay Formation. However, these rocks do not appear to be favourably placed in relation to a potential source of hydrocarbons.

[1] *See* Addendum, p. 227.

Pennsylvanian and Permian

The Canyon Fiord, Sabine Bay, and Assistance Formations include sands and conglomerates with good potential reservoir properties. Upper Palaeozoic rocks brought to the surface in the Barrow dome of Sabine Peninsula include dark limestones and vuggy limestones. Both source and reservoir beds of upper Palaeozoic age may be present in this area.

Mesozoic Rocks of the Sverdrup Basin

The Mesozoic rocks of the Sverdrup Basin comprise alternating quartzose sands, sandstones, shales, and siltstones. Marine sands and sandstones that constitute potential reservoirs occur in the Schei Point, Borden Island, Wilkie Point, and Mould Bay Formations. The non-marine Isachsen and Hassel Formations have excellent reservoir properties. Marine shales are exposed in the Wilkie Point and Mould Bay Formations, and this shale facies may be more extensive in the subsurface in Sabine Peninsula (p. 198). These shales may be regarded as a potential source of hydrocarbons. The same applies to the Christopher and Kanguk shales, of Cretaceous age, but these formations are probably too widely exposed to have contributed to trapped accumulations of petroleum.

Petroleum Possibilities of Individual Structural Provinces

Parry Islands Fold Belt[1]

Several anticlines in the Parry Islands Fold Belt reveal closure, for example the structures south and southeast of Hecla and Griper Bay. In that area the Weatherall Formation probably constitutes a good 'seal' above any potential reservoirs. Silurian or Devonian carbonates beneath the Weatherall Formation probably constitute the most important potential petroleum target in this area. In this connection the lateral changes between carbonate and grapolitic rocks in the Ordovician and Silurian succession of northwest Melville Island may be of interest (*see* Fig. 4, p. 43). It has been suggested above (p. 182), that the southern part of the fold belt is the most likely place to reveal Ordovician and Silurian carbonates at depth, because a boundary between the carbonate and graptolitic facies is probably present beneath the surface of the fold belt. The probable existence of this facies boundary beneath the surface of southern Melville Island introduces the possibility that stratigraphic traps may occur in the fold belt. It should be borne in mind that the Blue Fiord limestone (Devonian) definitely disappears between Weatherall Bay and McCormick Inlet and thus is not everywhere present beneath the Weatherall Formation.

Blue Hills Fault Belt

From the stratigraphic point of view the petroleum possibilities of this province are probably akin to those of the Parry Islands Fold Belt. Structurally they are perhaps less favourable owing to the absence of well-defined anticlinal structures.

[1] *See* Addendum, p. 227.

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Dundas Block

This area reveals only the Griper Bay Formation at the surface. The stratigraphic column of Banks and Victoria Islands, to the south, suggests that Ordovician, Silurian, and Devonian carbonates may occur at depth (*see* Thorsteinsson and Tozer, 1962), but no favourable structures have been recognized in this area.

Eglinton Graben

The exposed Mesozoic rocks of Eglinton Island are probably unconformably underlain, at no great depth, by Palaeozoic formations. The Mesozoic rocks themselves do not appear to present attractive petroleum possibilities and the nature of the underlying Palaeozoic formations cannot be assessed.

Prince Patrick Uplift

The Mesozoic rocks of this area are probably too thin and widely exposed to be of interest from the petroleum standpoint. The underlying Devonian rocks belong to the Griper Bay Formation. At present there seems to be no rational basis on which to assess the petroleum possibilities of beds beneath the Griper Bay.

Sverdrup Basin

Sabine Peninsula seems the most interesting area within the part of the Sverdrup Basin that lies in the map-area. Stratigraphic traps may occur as a result of northward facies change in the Canyon Fiord, Sabine Bay, Assistance, Wilkie Point, and Mould Bay Formations. A good case can be made for assuming that all these formations change their character in the subsurface of Sabine Peninsula (*see* p. 197). It is also possible that unexposed Triassic formations appear towards the north, in the subsurface, and this introduces the possibility of further stratigraphic traps. The possibility of an anticline south of Barrow dome may also enhance the petroleum possibilities of the area. It is also possible that traps may occur adjacent to the Barrow and Cape Colquhoun domes.

The folds on Mackenzie King Island involve the Mould Bay Formation at the surface and it is possible that the Jurassic and older formations may contain hydrocarbons in this area.

In the remaining parts of the Sverdrup Basin the petroleum possibilities seem less attractive. In these areas, namely northwest Melville Island, eastern Prince Patrick Island, Brock Island, and Borden Island, there is no evidence of favourable structures and the sedimentary column, within the basin sequence, is probably relatively thin.

It is impossible to assess the petroleum possibilities of the rocks, presumably of pre-Pennsylvanian age, that underlie the Sverdrup Basin. In our discussion of the probable nature of these rocks (p. 196) we have shown that the pre-Pennsylvanian rocks probably do not constitute a promising field for petroleum exploration.

Arctic Coastal Plain

The geology of the surface beneath the Beaufort Formation of the Arctic Coastal Plain is unknown, but because of the regional southeast dip displayed on Borden and Ellef Ringnes Islands it seems unlikely that a substantial thickness of Mesozoic rocks would be encountered beneath the Beaufort Formation. It is not known whether or not upper Palaeozoic (Pennsylvanian and Permian) rocks occur at the base of the Sverdrup Basin sequence in this area. On southern Prince Patrick Island these late Palaeozoic rocks are definitely absent. The pre-Pennsylvanian rocks in this area, as in the Sverdrup Basin, are completely unknown. The possibility exists (p. 196) that the older Palaeozoic rocks beneath the northern part of the plain may be metamorphic rocks, like the eugeosynclinal formations of northern Axel Heiberg Island, rather than potentially petroliferous formations, as in the Franklinian miogeosyncline.

Metalliferous Deposits

A small show of galena was observed in the Blue Fiord limestone (Devonian) on the southwest side of the anticline east of Weatherall Bay. Several faults in this area are apparently filled with vein calcite and it is possible that other mineral deposits may occur.

Coal

Coal is present in the Griper Bay, Sabine Bay, upper Wilkie Point, and Isachsen Formations. A seam at least 5 feet thick occurs in the Isachsen Formation on Prince Patrick Island. The Griper Bay coal seams are very thin, none exceeding 6 inches has been found. The coal in the Sabine Bay Formation occurs as very thin laminae.

W. J. Montgomery of the Division of Fuels, Mines Branch, has made the following analyses of five samples, the stratigraphic position and localities of which are:

1. Griper Bay Formation, coal from disintegrated outcrop 3 miles south of Mould Bay weather station, Prince Patrick Island.

2. Griper Bay Formation, coal from disintegrated outcrop in creek flowing into Kellett Strait at Stevens Head, Melville Island.

3. Wilkie Point Formation, from 3-foot seam 4 miles north of Salmon Point, Prince Patrick Island.

4. Isachsen Formation, from 3-foot seam 7 miles south of Gardiner Point, Eglinton Island.

5. Isachsen Formation, from seam 5 feet thick without base exposed, 6 miles north-northeast of Mould Bay weather station, Prince Patrick Island.

Analyses of Coal

Sample	1			2			3			4			5		
	As received	Dry	At capacity moisture	As received	Dry	At capacity moisture	As received	Dry	At capacity moisture	As received	Dry	At capacity moisture	As received	Dry	At capacity moisture
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Proximate analysis															
Moisture	2.94	0.00	4.20	2.36	0.00	4.70	10.50	0.00	9.40	9.80	0.00	19.50	4.49	0.00	12.00
Ash	35.81	36.89	35.40	8.29	8.49	8.10	11.38	12.72	11.50	16.10	17.85	14.40	24.63	25.79	22.70
Volatile matter	39.10	40.28	38.60	42.78	43.81	41.80	46.80	52.29	47.40	51.91	57.55	46.3	41.55	43.50	38.30
Fixed carbon (by difference)	22.15	22.83	21.80	46.57	47.70	45.40	31.32	34.99	31.70	22.19	24.60	19.80	29.33	30.71	27.00
Ultimate analysis															
Sulphur	.....	.....	0.60	.....	.....	1.30	.....	.....	0.70	.....	.....	0.40	.....	.....	0.40
Calorific value															
BTU/lb gross	7985			12690			9375			7815			8145		
BTU/lb dry	8330			13315			10350			9710			9255		
Moist mineral matter free BTU/lb	13078			13951			10746			9282			10857		
Rank (ASTMD 388-38 designation)	High volatile B bituminous			High volatile B bituminous			Subbituminous B			Subbituminous C			Subbituminous B		

ADDENDUM

September 1963

The preparation of this memoir was completed in June 1961. Since that time, further field work by J. W. Kerr, H. P. Trettin, and the writers on Ellesmere and Axel Heiberg Islands permits some revision of the account written in 1961. New geological information has also become available from the first oil well drilled in the Canadian Arctic Islands, the Dome, *et al.,* well, which was spudded in near Winter Harbour on September 10, 1961 and abandoned as a dry hole on April 7, 1962 (*see* "The story behind the world's most northerly drilling project"; *World Petroleum,* vol. 34, No. 3, March 1963, pp. 40-53). In addition, oil saturated sand has recently been discovered in the Bjorne Formation of northwestern Melville Island. The following notes relate the new data and conclusions to the account given in the memoir. Footnote references to this addendum are given in the appropriate parts of the text.

Geological Section in Winter Harbour Well

The well was drilled about 6 miles west of Wakeham Point (lat. 74°48′06″, long. 110°30′37″), to a depth of 12,543 feet. A provisional columnar section has been published by the staff of Dome Petroleum Limited, Calgary, Alberta (op. cit., p. 49). Following the stratigraphic terminology proposed in this report, the drilling thicknesses (in feet) encountered were: Hecla Bay Formation, 1,774; Weatherall Formation, 6,041. Beneath the Weatherall, 1,815 feet of calcareous shale and argillaceous limestone, with *Tentaculites* and *Styliolina,* occurs; these rocks probably include a shale equivalent of the Blue Fiord limestone, exposed in northeastern Melville Island. The next underlying beds comprise about 2,000 feet of mudstone, with graptolites assigned to species of Lower Silurian (Llandoverian) age. The lowest unit comprises about 800 feet of dolomite and anhydrite, with ostracods of uncertain age.

The section in this well raises many geological problems but two interesting features are clearly indicated. The Devonian Blue Fiord Formation is absent as a discrete, carbonate unit and the Silurian sequence is largely, or entirely of graptolitic facies. This well provides a new control point for the facies map for the Silurian (Fig. 14, p. 205), and necessitates slight modification of the suggested boundary between the Silurian carbonate and graptolitic facies belts.

A showing of gas was obtained between 1,048 and 2,385 feet.

Age of the Oldest Known Sediments in the Sverdrup Basin

Formerly (p. 208) no rocks older than Pennsylvanian were known in the Sverdrup Basin but it is now known that non-marine Upper Mississippian (Visean) rocks occur at the base of the sequence on northern Ellesmere and Axel Heiberg

Islands (*see* J. W. Kerr and H. P. Trettin "Mississippian Rocks and the Mid-Palaeozoic Earth Movements in the Canadian Arctic Archipelago"; *J. Alta. Soc. Petrol. Geol.*, vol. 10, No. 5, pp. 247-256).

Evaporites and Piercement Structures of the Sverdrup Basin

Field work by Thorsteinsson in 1961-63, on Ellesmere and Axel Heiberg Islands, has clarified the relations of evaporite formations in the Upper Palaeozoic sequence of the Sverdrup Basin. This leads to improved understanding of the piercement domes of Sabine Peninsula, Melville Island (p. 109).

In northwest Ellesmere Island two units of gypsum and anhydrite occur in the Upper Palaeozoic sequence. The upper evaporite is of Lower Permian age and is restricted to the parts of Ellesmere Island that lie between Canyon and Tanquary Fiords. This unit, like the Ordovician evaporites of the Cornwallis Formation, is interposed between two competent carbonate units. Both the Ordovician and Permian evaporites apparently do not form piercement structures. This circumstance is evidently related to the presence of an overlying competent carbonate unit.

The lower evaporite is extensively exposed, in normal stratigraphic sequence, on northern Ellesmere and Axel Heiberg Islands (Map-unit 8, *Geol. Surv., Canada,* Map 21-1963). It is locally underlain by Upper Mississippian non-marine beds and is succeeded by marine rocks with a distinctive brachiopod and ammonoid fauna of Lower, or early Middle, Pennsylvanian age.

In some areas, for example at Svartevaeg, and south of Bunde Fiord on Axel Heiberg Island, the rocks above the lower evaporite are massive carbonates. Elsewhere, particularly between Borup Fiord and Hare Fiord (Ellesmere Island), and on eastern Axel Heiberg Island between White Mountain and Whitsunday Bay, the lower evaporite is overlain by Pennsylvanian and Permian rocks composed mainly of incompetent black shale and siltstone. Locally there are carbonate reefoid masses immediately above the lower evaporite, and these reefs pass laterally into black shale and siltstone. Blocks of this distinctive reef rock occur in piercement structures on Axel Heiberg Island and the limestone with *Dictyoclostus* recorded from the Barrow Dome (p. 110) represents a similar material.

On Ellesmere Island and eastern Axel Heiberg Island, large diapirs and domes occur throughout the area where the lower evaporite is overlain by black shale and siltstone. In contrast, where massive carbonates overlie the lower evaporite, piercement structures are rare and small. There is thus a relationship between the distribution of piercement structures and the nature of the beds that overlie the lower evaporite.

Between central Axel Heiberg Island and Sabine Peninsula late Palaeozoic rocks are exposed only in piercement structures and the nature of the immediately overlying rocks cannot be observed. On eastern Axel Heiberg Island and Ellesmere Island the lower evaporite in normal stratigraphic position can be traced laterally into piercement structures. This relationship seems to justify the suggestion that a similar control, namely the absence of a competent layer above the

evaporite, governs the locus of the piercement structures in the western part of the Sverdrup Basin. It is therefore suggested that the locus of the belt of piercement structures extending across the Sverdrup Basin from Ellesmere Island to Sabine Peninsula is coincident with the occurrence of incompetent Pennsylvanian and Permian black shale and siltstone above the lower evaporite. Reefs are evidently locally present, as on Ellesmere Island.

Revision of Nomenclature of Permian Formations

It seems desirable to record that recent work by Thorsteinsson on the Permian stratigraphy of Ellesmere and Axel Heiberg Islands will necessitate revision of the nomenclature proposed in this memoir. It now appears that the two members defined herein (p. 101) as comprising the Sabine Bay Formation are better regarded as two distinct formations. The lower member is, in all probability, correlative with the Belcher Channel Formation, and this name may be applied to these beds. The upper, non-marine, member (p. 101) is a discrete rock unit, to which it is proposed to restrict the name "Sabine Bay". There are now reasons to suppose that the Belcher Channel and Sabine Bay (restricted) Formations are separated by a disconformity.

Studies on Axel Heiberg and Ellesmere Islands indicate that most, if not all, of the Permian rocks of Melville Island classified (p. 105) as the Assistance Formation represent a new formation, younger than the type Assistance Formation of Grinnell Peninsula (Harker and Thorsteinsson, 1960). The stratigraphic relations of the Belcher Channel, Sabine Bay, and Assistance Formations, and the overlying new, and as yet unnamed, formation identified in this report as "Assistance" are most clearly displayed near East Cape, in Canyon Fiord, Ellesmere Island. There all four formations occur in sequence. The true Assistance Formation is apparently absent in western Melville Island, and perhaps also in eastern Melville Island.

The age of the Belcher Channel Formation is Lower Permian (i.e., not younger than Leonardian). The Assistance Formation of the type area, and the so-called Assistance beds of this memoir, are Upper Permian.

Oil Saturated Sands in the Bjorne Formation

On June 30, 1962, Mr. Alan Spector, a seasonal employee of the Gravity Division of the Dominion Observatories Branch of the Department of Mines and Technical Surveys, while attached to the Polar Continental Shelf Project, observed bituminous sands, or similar material, near the north shore of Marie Bay (*Geol. Surv., Canada,* Paper 63-1, p. 7). Later the same year geologists engaged in petroleum exploration visited the area and found approximately 80 feet of oil-saturated sand in the upper part of the Bjorne Formation at localities north of Marie Bay and west of Kitson River (*see* Dinsdale, Hon. W. G., "Announcement of Discovery of Oil Saturated Sand Deposit"; *Canada, House of Commons Debates,* Official Reports, October 10, 1962, vol. 107, p. 343; "Arctic Islands Yield Big Oil Sand Deposit", *Oilweek,* Calgary, vol. 13, No. 5, pp. 17-19, October 15, 1962).

Probable Unconformity Beneath the Isachsen Formation at Leffingwell Crags, Mackenzie King Island

In the eastern part of Mackenzie King Island the Isachsen Formation overlies the upper member of the Mould Bay Formation. At Leffingwell Crags there are no exposures of this member and the Isachsen beds apparently rest directly upon the middle member of the Mould Bay Formation. The actual contact has not been seen and is probably concealed, but the covered interval appears to be insufficient to accommodate the upper member. A possible explanation, of some regional significance, is now proposed to account for this anomaly. Recent work has shown that the Isachsen beds are transgressive on the east side of the Sverdrup Basin, on Ellesmere Island (*Geol. Surv., Canada,* Paper 63-1, p. 7; Paper 63-30), as on the southern margins, namely southern Melville Island (this memoir, p. 152) and Banks Island (Thorsteinsson and Tozer, 1962). If, as is probable, the Isachsen Formation rests on the middle member of the Mould Bay Formation at the Leffingwell Crags, it seems reasonable to suggest that a sub-Isachsen unconformity appears on the northwest edge of the Sverdrup Basin, as on the east and south edges.

Probable Occurrence of the Beaufort Formation on Melville Island

In 1958 Thorsteinsson noted logs of unaltered wood on the slopes of the high, gravel-capped hill northeast of Liddon Gulf (*see* Pl. XXXVI). It was originally supposed that these gravels were Pleistocene, but J. G. Fyles suggests that the occurrence of wood renders it probable that the Beaufort Formation is represented in this area.

Position of the Siluro-Devonian Boundary

In recent years considerable research has been devoted to the Siluro-Devonian boundary problem, especially in Europe. As a result many new concepts in the correlation of the classic Silurian and Devonian sections of Europe have emerged, and research continues. Graptolite-bearing beds that have been assigned to the upper Ludlovian subseries of the Silurian are now generally accepted as Lower Devonian. Furthermore the middle Ludlovian graptolite sequence is regarded by many European geologists as correlative with the newly erected Skala Series. The Skala Series is considered intermediate in age between the Ludlovian Series (of the British type section) and the Gedinnian Series in the Devonian of continental Europe. The authors of the Skala Series favour its inclusion in the Devonian rather than in the Silurian. Based on the above considerations, beds bearing *Monograptus* n. sp. A, dated as upper Ludlovian in this memoir, and possibly also the beds with *Monograptus ultimus* Perner, dated as middle Ludlovian, are now assigned to the Lower Devonian. Thus the Siluro-Devonian boundary lies below the top of the Ibbett Bay, Kitson, and Cape Phillips Formations of Melville Island.

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