STRATIGRAPHY AND PALEONTOLOGY OF THE LOWER DEVONIAN SEQUENCE, SOUTHWEST ELLESMERE ISLAND, CANADIAN ARCTIC ARCHIPELAGO

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January, 1984

VOLUME I: TEXT

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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"The Arctic has a meaning of inspiration, fed by examples of courage, comradship, decency, and giving ... it offers the ultimate challenge to the human spirit and the human capacity"

Thomas Symons

ABSTRACT

The Lower Devonian carbonate-clastic sequence of southwest Ellesmere Island accumulated in the Franklinian Basin at approximately 15° N latitude. A variety of depositional settings are represented, ranging from tidal flat to basinal environments. These environments can be recognized in Lower Devonian rocks across the Arctic Islands.

Progradation of the carbonate sequence of southwest Ellesmere Island occurred in the Early Devonian, but was periodically interrupted in the Zlichovian/Dalejan by transgressive events. Upward movement in the newly named Inglefield Uplift occurred throughout the Devonian, and shed clastic sediments westward that, in Middle to Late Devonian time, finally overwhelmed the marine carbonates and resulted in fluvial deposition on southern Ellesmere Island.

Certain formations in the Lower Devonian sequence are profusely fossiliferous, in particular the Blue Fiord Formation, which contains an abundant fauna including numerous species of corals and brachiopods. Both of these groups belong to the Old World Biogeographic Realm, and indicate a Zlichovian age for the lower Blue Fiord Formation of southern Ellesmere Island.

RESUME

La série calcaire-détritique d'âge dévonien inférieur du sud-ouest de l'Ile d'Ellesmere s'est accumulée dans le bassin franklinien sous une latitude d'environ 15° N. Plusieurs d'environnements de sédimentation y est représentée; des dépôts peu profonds à profonds. Ces environnements peuvent être identifiés dans les strates du Dévonien inférieur de l'ensemble des îles arctiques.

La progradation de la série calcaire du sud-ouest de l'Ile d'Ellesmere a eu lieu au début du Dévonien, mais a été périodiquement interrompue au cours du Zlichovien/Daléjan par des épisodes transgressifs. Le mouvement ascendant du soulèvement d'Inglefield, nouvellement nommé, s'est poursuivi au cours du Dévonien. Celui-ci fournissait à l'ouest un apport de sédiments détritiques qui, du Dévonien moyen au supérieur, dominèrent finalement les calcaires marins, pour former les dépôts fluviaux du sud de l'Ile d'Ellesmere.

Certaines formations de la série du Dévonien inférieur sont abondamment fossilifères, en particulier la formation de Blue Fiord, qui renferme une faune abondante, dont de nombreuses espèces de coraux et de brachiopodes. Les représentants de ces deux groupes s'apparentent à ceux de la province biogéographique de l'Ancien Monde, et indiquent un âge zlichovien pour la partie inférieur de la formation de Blue Fiord du sud de l'Ile d'Ellesmere.

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CHAPTER 1

INTRODUCTION

GENERAL STATEMENT

Southwest Ellesmere Island is crossed by the Devonian outcrop belt that stretches from Ellesmere Island in the east to Banks Island in the west. This region is important to the Devonian stratigraphy and economics of the Arctic Islands for a number of reasons. Firstly, it contains the type sections of four of the most widespread Devonian formations in the archipelago - the Eids, Blue Fiord, Bird Fiord, and Okse Bay formations (elevated to group status by Embry and Klovan, 1976). The Goose Fiord Formation type section also occurs in this area. Secondly, the Devonian outcrop belts in this area are well exposed and little deformed, so that a clear picture of the stratigraphic relationships can be deduced. Thirdly, it contains a number of standard sections in which the distribution of conodonts and spores have been determined and from which refined biostratigraphic correlation across the Islands is possible. And fourthly, the area is one of the three most important "oil exploration regions" in the Arctic Islands, as outlined by Rayer (1981).

The main aim of the project was to accomplish detailed facies and faunal analyses of the Lower Devonian carbonate-clastic sequence on southwest Ellesmere Island. The measurement and sampling of nearly 100 stratigraphic sections and outcrops exposed in 2 parallel, northeast-trending strike belts, each over 175 km in length, has delineated a wide variety of lithofacies. These were deposited on a gently sloping accretionary rimmed shelf. In general, 4 facies domains can be recognized. From southeast to northwest, they are: (1) a tidal flat, represented by the Goose Fiord, Vendom Fiord and Disappointment Bay

formations, (ii) a shallow lagoon and shelf margin (Blue Fiord Formation), (iii) a slope and basin (Cape Phillips, Eids, and Blue Fiord formations), and (iv) a narrow tract of carbonate buildups developed on the slope (Eids and Blue Fiord formations). This facies distribution can also be recognized in the Devonian of Bathurst, Victoria, and Banks Islands.

Integration of the Lower Devonian lithofacies information with published data on the Middle to Upper Devonian sequence allows an overall model of the Devonian tectono-sedimentary history of southern Ellesmere Island to be constructed. In general terms, this model illustrates an Early Devonian phase of carbonate platform progradation, periodically interrupted by transgressive events. This progradation was halted in Middle and Late Devonian time by the encroachment of fluvial clastics of the Okse Bay Group into southern Ellesmere Island. Paleocurrent and mineralogical information, and facies relationships indicate that these sediments were derived from the newly named Inglefield Uplift, that was situated on the east coast of Ellesmere Island and northwest coast of Greenland.

A worldwide study of Lower Devonian carbonate buildups shows that the number of buildups increases rapidly through the Lower Devonian. This increase can be related to the augmentation in the number of possible growth sites that accompanied the gradual transgression at the Gedinnian/Siegenian boundary. Detailed work on a large, well preserved buildup in the Blue Fiord Formation shows a marked community succession, controlled by physical and possibly biological influences.

The coral and brachiopod faunas of the upper Eids Formation and Disappointment Bay and Blue Fiord formations were studied in detail, and

both show a great diversity. A total of 30 genera and 39 species of corals are documented from the Lower Devonian of southern Ellesmere Island and the Middle Devonian of Bathurst Island. The rugosans (19 genera, 25 species) are numerically dominated by *Spongonaria*. *Alveolites, Favosites,* and *Thamnopora* are the main components of the tabulate fauna (11 genera, 14 species). New species of *Planetophyllum, Spongonaria* (2), and *Taimyrophyllum* are reported. Three genera are recognized for the first time in North America, 22 species for the first time in the Arctic Islands, 4 genera and 1 species for the first time in Lower Devonian strata, and 2 genera for the first time in Middle Devonian strata. The brachiopod fauna shows a great diversity (40 species).

The trilobite and cricoconarid faunas were also studied, and the first biostratigraphic zonation for cricoconarids in the Arctic Islands has been devised.

The determination of a depositional model, and faunal studies of the Lower Devonian sequence of southwestern Ellesmere Island is of practical as well as academic interest because the Lower Devonian Blue Fiord Formation is the only unit in the Arctic Paleozoic succession that contains substantial oil accumulations (Cameron Island).

LOCATION, ACCESSIBILITY, AND PHYSIOGRAPHY OF THE STUDY AREAS

The Canadian Arctic Islands comprise one of the world's largest archipelagos, extending 2400 km from west to east and over 1900 km from north to south. Ellesmere Island is the northernmost island in the archipelago, and is the largest of the Queen Elizabeth Islands.

The main study area is located in southwestern Ellesmere Island, approximately bounded by 76° 35' and 78° 05' N latitude, and 82° 00' and 88° 30' W longitude (see Fig. 1-1). The nearest airline terminal is Resolute Bay on Cornwallis Island, which receives regular passenger flights from Montreal and Edmonton. From Resolute Bay, de Havilland Twin Otters operated by Bradley Air Services were used to reach the field area, a distance of about 350 km. These small, short take-off and landing airplanes are equipped with balloon tires capable of landing on the rough, unprepared surfaces of the study area. Once, skis were used instead of tires due to deep snow conditions. Most snow melts in the study area by early July.

Physiographically, the central and northern parts of the region are characterized by valleys and ridges cut mainly by stream action. Roots (1963) included this area in the Central Mountain Belt physiographic province. The ridges are formed of the resistant carbonates of the Blue Fiord Formation, and the valleys of the recessive weathering Cape Phillips and Eids formations. The average relief is approximately 250 m, but relief can range up to 500 m. Roots (1963) placed the southern part of the study area in the plateau province, in which fiords form the dominant valleys. The carbonates of the Disappointment Bay Formation form the plateaux. Relief here is in the order of 300 m.

No settlements are located within the main study area, and the nearest permanent inhabitants live in Grise Fiord, approximately 125 km southeast of the study area.

The secondary study area, situated on Bathurst Island (see Fig. 1-1), was visited briefly, for three days. It was reached by a Bell 206 helicopter, operated by Okanagan Helicopters, directly from Resolute Bay. The gently rolling region is within 75° 05' and 76° 30' N latitude, and 97° 37' and 99° 30' W longitude. No permanent settlements are present on Bathurst Island.

PREVIOUS GEOLOGICAL INVESTIGATIONS

Northeast Asiatic nomads were the first people to visit the Canadian Arctic Islands more than 4,000 years ago (Schledermann, 1981). Later, around 1000 A.D., Vikings arrived in the New World and established colonies on the west coast of Greenland. From there they probably sailed northward and landed on the shores of Ellesmere Island (Christie *et al.*, 1972).

The first reliable records of a voyage in the region of Ellesmere Island came from William Baffin, who, in 1616, sailed into Smith Sound and Jones Sound, which, respectively, mark the eastern and southern boundaries of the island. In the middle and late 19th century, Jones Sound was explored to some extent, but it was not until the famous Norwegian "Fram" expedition of 1898-1902, lead by Otto Sverdrup, that the waters surrounding Ellesmere Island and the landmass itself were explored and mapped. Christie (1982) shows the route travelled by the Sverdrup expedition. This party spent four winters in three different harbours - just south of Bache Peninsula (1898), Harbour Fiord (1899), and Goose Fiord (1900-1902). The geologist attached to the expedition, Per Schei, carried out widespread reconnaissance studies, mostly in the Paleozoic sedimentary sequence (Christie and Kerr, 1982). Southwest Ellesmere Island was thus one of the first geologically mapped areas in Arctic Canada. Schei assigned the various strata to alphabetically lettered units in his publications (Schei, 1903, 1904) - the Goose Fiord Formation was described as "series C", the overlying Disappointment Bay and Bird Fiord formations as "series D", and the Okse Bay Group was termed "series E". Unfortunately, Schei died shortly after his return to

Europe, but the material he collected while on Ellesmere Island was described later by specialists: plants by Nathorst (1904), corals by Loewe (1913), brachiopods by Meyer (1913), fish by Kiaer (1915), trilobites, ostracods, phyllocarids, molluscs, and bryozoans by Tolmachoff (1926), and cephalopods by Foerste (1926).

Subsequent to the "Fram" expedition and prior to the mid-fifties, few geological studies were carried out in central and southern Ellesmere Island. Bentham (1936, 1941) visited southeastern Ellesmere Island several times in that period, and Wordie (1938) explored the Bache Peninsula area in search of fossiliferous beds. Troelsen (1950) reported Lower Paleozoic limestones and shales on the east coast of Ellesmere Island, and Prest (1952) documented Lower Paleozoic limestones, dolomites, and sandstones in the same area.

With the advent of aircraft to the Arctic in the early fifties, the modern era of geological field work began. In 1955, during Operation Franklin, the Geological Survey of Canada accomplished a major reconnaissance mapping of the north-central part of the Arctic Archipelago. D.J. McLaren was the geologist assigned to study the Devonian stratigraphy of southwest Ellesmere Island during the operation. He concentrated on the area between Goose Fiord and Bjorne Peninsula, describing four new formations: the Eids, Blue Fiord, Bird Fiord, and Okse Bay formations (McLaren, 1963a). This study laid the groundwork for subsequent work in the area by J. Wm. Kerr, who published a reconnaissance geological map of the Baumann Fiord to Goose Fiord area (Kerr, 1968), and later a 1:250,000 map of the entire Baumann Fiord region (Kerr & Thorsteinsson, 1972). The latter was the first map to show the type localities of the formations noted above.

A regional study of the Paleozoic succession of southwest Ellesmere Island was recently initiated (1980) by the Geological Survey of Canada (Okulitch and Mayr, 1982). The aim of this project is to provide more detailed stratigraphic and structural information from the area, and to systematically examine the previously unmapped regions of the Craig Harbour (49A), Baad Fiord (49B), and Vendom Fiord (49D) map sheets.

A number of recent detailed studies dealing with parts of the Devonian sequence have been carried out in the study area. General Devonian stratigraphy has been discussed by Kerr (1967a, 1976) on central and eastern Ellesmere Island, Kerr (1970) on southern Ellesmere Island, Kerr (1972a) on the Schei Summit area, just north of the field area, McGill (1974) and Roblesky (1979) in the Vendom Fiord region, Trettin (1978) on west-central Ellesmere Island, and Thorsteinsson (1980) and Mayr (1982) in the southern Ellesmere Island area. Okulitch (1982) concentrated on structures associated with the Ellesmerian and Eurekan orogenies of southern Ellesmere Island. Sedimentologic studies on specific Devonian formations include Kerr (1967b) on the Vendom Fiord Formation, Stearn and Smith (1979) on the Blue Fiord Formation, and Embry and Klovan (1976) and Rice (1982) on the Okse Bay Group.

Most of the common Devonian fossil groups have been studies to some extent in the field area. Brachiopods have been documented by Jones and Smith, G. (1980, in press a,b) from the Eids Formation, by Smith, D. (1980), Smith, D. and Stearn (1981) and Smith, D. *et al.* (1981) from the Blue Fiord Formation, and Jones (1982 a, b) from the Bird Fiord Formation. Johnson and Talent (1967), and Harper *et al.* (1967), respectively, documented *Cortezorthis* and *Phragmostrophia merriami* from the Blue Fiord Formation. Brice (1982) published a detailed account of brachiopods from

the Blue and Bird Fiord formations, and Jones and Boucot (1983) discussed Lower Devonian spiriferid brachiopods from the study area. Collins (1969) briefly reviewed the cephalopods from the Eids Formation. Conodont taxonomy and biostratigraphy have been outlined by Weyant (1971, 1975a) from the Blue Fiord Formation of the Eids Fiord region, by Mayr *et al.* (1978) from two wells drilled in the Lower Paleozoic succession on Bjorne Peninsula, and by Uyeno and Klapper (1980) from the Blue and Bird Fiord formations in the Blue-Sör Fiord region. Study of the coral fauna is still in its infancy. Pedder and Smith (1983) documented and described the first rugose coral collected from the Eids Formation of southwestern Ellesmere Island. Corals from the Blue Fiord Formation are better understood due to recent publications by Pedder (1978, 1982a, 1983), Pedder and McLean (1982), and Pedder and Smith (in prep.). Corals from the Bird Fiord Formation of southern Ellesmere Island were recently reviewed by Pedder (1982b) and Pedder and Goodbody (1983). Weyant (1975b) has described a rich ostracod fauna from the Blue Ford Formation of the field area. The only sponge that has been described in the region is a new heteractinid from the Blue Fiord Formation (Rigby, 1976). Spores have been documented by McGregor (1974) from the Vendom Fiord Formation near Cañon Fiord, just north of the study area, and by Chi (*in* Embry and Klovan, 1976) from the Bird Fiord Formation and the Okse Bay Group at Okse Bay, southwest Ellesmere Island. Stearn (1983) has recently reviewed part of the extensive stromatoporoid fauna from the Blue Fiord Formation. Trilobites from the Blue Fiord Formation of southwest Ellesmere Island were briefly described by Ormiston (1967) as part of a larger study on Lower and Middle Devonian trilobites from the Canadian Arctic Islands.

Senior-authored publications related to this study are Smith and

Stearn (1980, 1981a, b, 1982a, b, 1983) and Smith *et al.* (submitted).

Oil companies have also been active in the project area. Numerous seismic lines have been shot, and two wells, Panarctic Tenneco *et al.* CSP Eids M-66 and Panarctic Arco *et al.* Blue Fiord E-46, were drilled in 1974 (see Fig. 1-3 for location). These wells were spudded in the Eids Formation and tested Silurian carbonates.

A discussion of previous geological work on Bathurst Island can be found in Polan (1982).

PRESENT INVESTIGATIONS

Field work:

This study is based on a total of 120 days in the field, over three field seasons: June 19 - August 13, 1978; June 16 - July 31, 1979; and July 2 - July 26, 1980. Of the total number of field days, 77½ (65%) were spent examining rock exposures, 19½ (16%) were lost to inclement weather, 16 (13%) were spent moving (or waiting to move) camp, and 7 (6%) were lost for other reasons. Three full days were spent working on Bathurst Island, the remainder on Ellesmere Island.

On Ellesmere Island, 11 "base" camps, lettered A through K, were established by de Havilland Twin Otter or Bell 206 helicopter (see Figs. 1-2, 1-3, 1-4, 1-5 for camp and section locations). Camps C and E were used twice. A base camp generally comprised two men and two tents. Field studies within the camp area were by foot. Rarely, more wide ranging reconnaissance work was possible using helicopters. Field work consisted of the measurement of detailed sections (39 in total) and reconnaissance observations at 59 localities. Helicopter work provided information to help correlate stratigraphic sections measured from adjacent base camps, and to extend the field area. Appendix I notes the exact locations of all data points.

Topographic maps (1:250,000) and airphotos were used to locate the outcrops accurately and to check and revise previous geological maps. Stratigraphic sections were identified by a lettering system e.g. AC, EB etc.. The first letter refers to the camp letter (A through K), and the second to the order in which the sections were measured, i.e. A is the

first section, C is the third, etc.. Each unit in a section was identified by a number starting with 1 at the base. A 1.5 m staff was used to measure the detailed stratigraphic sections, and some of the reconnaissance sections. The thickness of units was measured to the nearest decimeter. Occasionally, where outcrop was sparse or where a thick section was measured in a short period of time, airphotos were used to estimate thickness. Data for each field unit were recorded on a standardized field card which noted unit thickness, lithology, contacts, presence of fossils or sedimentary structures, weathered and fresh colour, bedding thickness and style (terminology of Reineck and Singh, 1975, Fig. 136), and number and type of samples taken. Lithologic samples were taken at most changes of lithology. Fossil collections were made where possible, but the size of most samples was restricted by the remoteness of the area and by the time available. Strikes and dips were taken on selected bedding planes. However, due to the proximity of the North magnetic pole, a magnetic compass does not give reliable readings. Therefore, strike directions were visually estimated.

The geologic maps of Kerr (1968) and Kerr and Thorsteinsson (1972) were used to interpret the distribution of the formations south of Baumann Fiord. In the unmapped Vendom Fiord region, the sketch maps of McGill (1974) and Roblesky (1979) were used.

On Bathurst Island, field work was conducted from a base camp at Polar Bear Pass. Eleven localities were visited briefly during three days of field work (Fig. 1-6). Their exact locations are listed in Appendix I.

Laboratory work:

Once the samples were received via sea from Resolute Bay, usually in

November, they were carefully unpacked, sorted and labelled. They were then divided into lithologic and biologic specimens.

The lithology samples were cut and polished. Some were stained with Alizarin Red S to determine the dolomite content, using the method described by Friedman (1959). A total of 276 thin sections were made for lithology analysis. These were stained with Alizarin Red S and potassium ferrocyanide (Dickson, 1965). They were then examined microscopically for microfacies determination. The comparison chart for visual percentage estimation of rock components was used (Terry and Chilingar, 1955). Some of the rocks were also broken down and dissolved using HCl to determine their argillaceous content, using the method of Ireland (1971).

The biologic specimens were divided into faunal groups. The corals (rugose and tabulate), brachiopods, trilobites, and cricoconarids were retained, and the rest of the fauna sent to specialists. The coral fauna was identified with both thin sections (160) and peels (164), the latter prepared using the technique of Sternberg and Belding (1942). The brachiopods, trilobites, and cricoconarids were classified by quantitative comparisons with previously published faunas.

CONTRIBUTIONS TO KNOWLEDGE

1) First detailed lithofacies description and environmental interpretation of the upper Eids and Goose Fiord formations on southern Ellesmere Island, and the entire Disappointment Bay and Blue Fiord formations on southern Ellesmere Island and Bathurst Island.

2) Revision of Lower Devonian stratigraphy of southern Ellesmere Island - (a) reassignment of the Devon Island Formation west of Vendom Fiord to the Cape Phillips Formation; (b) assignment of the Emsian tidal flat facies on southern Ellesmere Island, previously referred to the Blue Fiord Formation, to the Disappointment Bay Formation, and designation of a reference section for the Disappointment Bay Formation of the eastern Arctic Islands.

3) Revision of the Emsian-Eifelian stratigraphy on certain islands in the archipelago by the new division of the Disappointment Bay Formation into a dolostone member (previously entire Disappointment Bay Formation), and a limestone member (previously part of Blue Fiord Formation). Division recognized on Cornwallis, Bathurst, Melville, Cameron, Victoria, and Banks Islands. Designation of type section for limestone member on eastern Bathurst Island.

4) Delineation of facies belts in the Lower Devonian sequence of southern Ellesmere Island, from tidal flat to basinal deposits, and development of a Lower Devonian depositional model.

5) Construction of paleogeographic maps for selected stages of the Lower Devonian sequence, and formulation of the Lower Devonian depositional history of southern Ellesmere Island.

6) Determination of Early Devonian paleowind direction on southern Ellesmere Island using sediment type and distribution.

7) Application of the Lower Devonian depositional model of southern Ellesmere Island to other Emsian/Eifelian carbonate rock sequences across the Arctic Islands and construction of a generalized map showing the Late Emsian/Early Eifelian carbonate margin across the Canadian Arctic Islands.

8) History of Devonian sedimentation and tectonism of southern Ellesmere Island.

9) Recognition of the newly named Inglefield Uplift and its influence on the depositional history of southern Ellesmere Island.

10) Documentation of 36 Lower Devonian carbonate buildups, previously considered to be rare, and explanation of the numerical increase in buildups through Early Devonian time by an increase in the number of available growth sites during the basal Siegenian transgression.

11) Assessment of Lower Devonian paleomagnetically-derived global paleolatitudinal maps, using the distribution of Lower Devonian buildups. The following shifts are recommended: (a) North America should be positioned completely within the tropical belt; (b)Siberia/Asia should be shifted approximately 10° to 15° southwards; (c) Gondwanaland should be shifted approximately 10° northwards.

12) Microfacies description and evolutionary history of probably the best exposed example of a Lower Devonian reefal sequence in the world. Comparison of this reef in the Blue Fiord Formation to other Lower Devonian buildups.

13) Description, age assessment, and faunal affinities of the coral fauna from the upper Eids (first documented coral fauna), Blue Fiord, and Disappointment Bay formations of southern Ellesmere Island, and from the Blue Fiord Formation and limestone member of the Disappointment Bay Formation on Bathurst Island. Thirty genera and 39 species are

described, including 4 new species. The geographic and stratigraphic ranges of numerous species have been extended in this study.

14) First description of the brachiopod fauna from the Eids Formation (22 genera, 28 species) of southern Ellesmere Island, and description of a brachiopod fauna mostly from the lower Blue Fiord Formation (26 genera and 40 species) of southern Ellesmere Island.

15) Description of a Lower Devonian trilobite fauna from southern Ellesmere Island, and abandonment of the previously proposed North American trilobite subprovinces of the Old World Realm.

16) First detailed description of a cricoconarid fauna from the Arctic Islands, including one new species.

17) Proposed biostratigraphic zonation of cricoconarids.

18) Assessment of hydrocarbon potential of southern Ellesmere Island, and outline of possible exploration prospects.

CHAPTER 2

TECTONIC HISTORY OF THE CANADIAN ARCTIC ISLANDS

INTRODUCTION

Because of the size, inhospitable climate, and, until quite recently, relative inaccessibility of the Canadian Arctic Islands, a clear picture of the geologic history of the region is only now coming to light, in spite of the fact that geological investigations began in the nineteenth century.

The Arctic Archipelago is a geologically complex region, which has been occupied since Late Precambrian time by a continental margin-type mobile belt. The area is characterized by an almost continuous geosynclinal sequence which was interrupted periodically by orogenic activity.

The Arctic Islands have been divided into a number of tectonostratigraphic provinces by various workers, on the basis of the current knowledge and concepts of that time. Different terms have been coined for essentially the same features, and this had lead to confusion as to the correct usage of the terminology.

The following is a summary of how the present geological concept has evolved, and attempts to unravel the sequence of terms used. Emphasis is placed on the Lower to Middle Paleozoic sequence, especially of Ellesmere Island, as this is the only region in the Arctic Islands where plate-tectonic considerations can be made.

HISTORY OF GEOLOGICAL CONCEPTS

The first published geological map and synthesis of the Canadian Arctic Archipelago was by Haughton (1859) (Figure 2-1), who based his map on all the available rock and fossil specimens from the Arctic Islands, most of which were collected by officers of the Franklin search expeditions. He divided the Arctic Archipelago into 4 map units: (i) granitoid rocks, now included in the Canadian Shield, (ii) Silurian Limestone, now regarded as part of the Arctic Platform, (iii) Lower Carboniferous sandstones and coal, now known to be of Devonian age, and (iv) Carboniferous Limestone, now regarded as Upper Paleozoic limestones of the Sverdrup Basin. The influence of British geology can be seen in this geological scheme as, in England, Carboniferous limestone is underlain by sandstone, and therefore the sandy and silty formations outcropping on Bathurst and Melville Islands were assumed to be Early Carboniferous in age, as in England (Christie *et al.*, 1972, p. 5). Haughton's compilation, which noted the presence of only the southeast coast of Ellesmere Island (called "North Lincoln") and showed the total lack of knowledge of the geology of Ellesmere Island at that time, was a milestone in the geological interpretation of the islands, and acted as a standard reference for nearly a century.

In 1906, Suess outlined a simple structural style for the Arctic Islands, in which successively younger, essentially flat-lying strata onlapped onto the Canadian Shield. Suess' idea remained unchallenged until 1953, when Fortier and Thorsteinsson delineated and named several fold belts in the Arctic Islands.

Schuchert (1923), on the basis of characteristics of the North

American sedimentary basins, developed his new geosynclinal scheme, in which the northern marginal sedimentary belt, which trended northeast-southwest across the archipelago, was named the Franklinian Geosyncline, and Pearya, a hypothetical, former landmass consisting of crystalline rocks situated in northern Ellesmere Island, was proposed (Figure 2-2). The concept of Pearya was based on specimens of crystalline rocks returned by the Nares (1875-76) and Peary (1898-1909) expeditions. As reconstructed by Schuchert, the Franklinian Geosyncline came into existence in Late Cambrian time, and was "blotted out" by a Permian orogeny. This statement was remarkably accurate given the state of knowledge at that time.

In 1952, Troelsen noted downwarping in a "Permian basin of deposition", and recognized an important sub-Pennsylvanian unconformity. His work laid the foundation for the concept of the Sverdrup Basin. He also reintroduced the name Franklinian Geosyncline, which had been unused for 29 years.

Fortier *et al.* (1954) were the first to recognize the geological complexity of the Arctic Islands. In a northerly direction, they documented (Figure 2-3) (i) the Canadian Shield, with its 3 extensions: the Boothia, Wellington, and Minto arches, (ii) 3 intracratonic basins (Wollaston, Victoria Strait, and Foxe), (iii) 2 non-folded miogeosynclinal basins (Melville and Jones-Lancaster), (iv) the Innuitian orogenic system, and (v) the Arctic Coastal Plain. The term "Innuitian orogenic system" was introduced for the "complex assemblage of mountain structures extending from the Beaufort Sea across the Princess (now Queen) Elizabeth Islands and which continues through northern Greenland" (p. 2087). The orogenic system was divided into (a) miogeosynclinal (Parry Islands and

Ellesmere-Greenland) and eugeosynclinal (northern Ellesmere) fold belts of an early orogenic system, and (b) the Eureka Sound Fold Belt, a later, superimposed geosyncline. Schuchert's term Pearya was abandoned, and its area was included as part of the eugeosynclinal fold belt. The name Franklinian Geosyncline was not used. The geology of southwest Ellesmere Island (Figure 2-3) was not sufficiently known to place the area in a structural province.

In the monumental account of Operation Franklin, Fortier *et al.* (1963) divided the Arctic Islands into 3 major tectonic regions: (i) the Canadian Shield, (ii) the Arctic Lowlands and Plateaux, which included the intracratonic and non-folded miogeosynclinal basins of Fortier *et al.* (1954), and (iii) the Innuitian Region, which was equivalent to the Innuitian orogenic system of Fortier *et al.* (1954). The Arctic Coastal Plain, located on the northwest edge of the archipelago, was retained from Fortier *et al.* (1954). The Innuitian Region was subdivided into: (a) a Lower Paleozoic miogeosyncline, which included the Central Ellesmere (Ellesmere-Greenland fold belt of Fortier *et al.* (1954)), Parry Islands, and Cornwallis fold belts, the latter having the Boothia Arch at its core, (b) a northern Ellesmere fold belt, which was not classified as eugeosynclinal, as in Fortier *et al.* (1954), and (c) an Upper Paleozoic to Tertiary Sverdrup Basin, equivalent to the Eureka Sound Fold Belt and "Sverdrup Area" of Fortier *et al.* (1954). Three orogenies were recognized: (i) Caledonian (Upper Silurian to Lower Devonian), which affected the Cornwallis Fold Belt, (ii) Variscan (Upper Devonian and Pennsylvanian), which folded the Central Ellesmere and Parry Islands fold belts, and (iii) Alpine (post-Paleocene/Eocene), which affected the Sverdrup Basin.

Douglas *et al.* (1963) resurrected the name Franklinian Geosyncline

and divided it into a southern miogeosyncline, used in the same sense as Fortier *et al.* (1963), and a northern eugeosyncline, which included the northern Ellesmere Fold Belt and the northeast portion of the Ellesmere-Greenland Fold Belt of Fortier *et al.* (1954). The Precambrian Shield, Arctic Lowlands, Sverdrup Basin, and Arctic Coastal Plain were also recognized.

Trettin (1967) distinguished 2 subprovinces of the eugeosyncline (Figure 2-4): a northern magmatic belt, characterized by Precambrian to Devonian volcanic and metamorphic rocks with granitic and ultrabasic intrusions, and a southern Lower Paleozoic axial trough, with turbidity currents flowing along the trough axis to the southwest. This axial trough separated the magmatic belt from the miogeosyncline to the south. Trettin (1967) also named the Rens Fiord Uplift, which was active in Late Silurian to Early Devonian time, and dated granitic intrusions on northern Axel Heiberg and northwest Ellesmere Islands at 360 ± 25 million years (Middle to Upper Devonian).

Kerr (1967a) named the Lower to Middle Paleozoic miogeosyncline the Franklinian miogeosyncline, and introduced another term, the Central Stable Region, first used by King (1959), for the Arctic Lowlands. Kerr (1967b) noted widespread emergence of east-central Ellesmere Island in latest Early to early Middle Devonian time resulting in the deposition of the red beds of the Vendom Fiord Formation, and named the Bache Peninsula Arch, an east-west trending tectonic element in the northern part of this emergent region (Kerr, 1967c).

Trettin (1969) inferred an Early Devonian phase of rifting in the area of the northeast coast of Axel Heiberg Island (Nansen Sound) from the abundant turbidites and volcanic rocks of the Svartvaeg Formation which

are underlain by shallow water sediments of the Stallworthy Formation.

Ziegler (1969) resurrected the concept of Schuchert's northern borderland in his paleogeographic maps of the Silurian-Devonian transition, Early Devonian, and Middle Devonian times. He called this elongate borderland the Innuitian Geanticline. It trended northeast-southwest, and occupied the present area of the Arctic continental shelf and slope.

The work of Thorsteinsson and Tozer (1970), which updated their 1960 paper, concisely summarized the geology of the Arctic Islands. They employed essentially the same terminology as Douglas *et al.* (1963), but introduced yet another term, the Arctic Platform, instead of Arctic Lowlands or Central Stable Region. The Variscan and Alpine orogenies of Fortier *et al.* (1963) were renamed, respectively, Ellesmerian and Eurekan. They also erected the term Franklinian Orogen for the sequence of rocks folded during the Ellesmerian Orogeny. This was a slightly confusing term because the name Franklinian had already been linked with a geosyncline. They did not refer to a northern borderland (Pearya or Innuitian Geanticline).

Trettin (1971) agreed with Ziegler's (1969) concept of a northern geanticline, but preferred to retain the term Pearya Geanticline, as Schuchert (1923) used this name when he recognized and named it. Trettin did not restrict the geanticline to the subaerial parts, but also included in the tectonic unit a shore and shelf region on its southeastern flank. The metamorphic core of the geanticline was interpreted as being Late Proterozoic sediments of the Franklinian Geosyncline which had been metamorphosed in Late Proterozoic or Early Cambrian time. Trettin (1971) elected to abandon the name Franklinian eugeosyncline for 3 reasons. Firstly, it was not meaningful to include the persistently positive metamorphic core of the geanticline within a unit that was defined as a

depositional basin. Secondly, the Franklinian Geosyncline was no longer considered to be divided into 2 depositional belts (eu- and miogeosyncline), but comprised 3 belts - the newly named Hazen (axial) Trough, and its 2 bordering shelves (the southeast miogeosyncline and the shelf bordering the Pearya Geanticline). Thirdly, the term eugeosyncline implies development on oceanic crust, and Trettin showed that the Hazen Trough developed on the shallow-marine Grant Land Formation, which must have been deposited on continental crust which subsequently foundered and formed the trough. Therefore, Trettin restricted the use of the name Franklinian Geosyncline to the Hazen Trough and the southeastern miogeosyncline.

The comprehensive summary of Trettin *et al.* (1972) was a landmark paper for the understanding of the geologic history of the Arctic Archipelago, as it was the first paper to interpret the structure and stratigraphy of the region using the concept of the "new global tectonics" which had recently been outlined by Dewey and Bird (1970 a,b). Trettin *et al.* (1972) described the Queen Elizabeth Islands as having been occupied by a continental margin-type mobile belt since Late Proterozoic time. The archipelago was divided into (i) the Innuitian orogenic system of Fortier *et al.* (1954), which comprised the Franklinian Geosyncline, Pearya Geanticline, and Sverdrup Basin, (ii) the Arctic Platform, distinguished from the Innuitian orogenic system by its unfolded nature and thinner sedimentary sequence, and (iii) a Cenozoic geosyncline, which paralleled the earlier depositional basins, and whose age overlapped that of the Sverdrup Basin. The Late Proterozoic to Late Devonian history of the Innuitian mobile belt (equivalent to Innuitian orogenic system of Fortier *et al.*, 1954) was explained as being similar to

the Cordilleran-type mountain belts of Dewey and Bird (1970b). In this scheme (Figure 2-5), the Pearya Geanticline was regarded as an orogenic welt or "arc" which rose out of the Franklinian Geosyncline, and provided the main source of clastic sediments for the geosyncline. The granitic and ultrabasic intrusions outcropping in the geanticline were interpreted, respectively, as being formed as melts rising from a southeasterly-dipping subduction zone, which developed in the Cambrian, and remnants of oceanic mantle caught between colliding masses. The Ellesmerian Orogeny was tentatively explained as being due to a Middle to Late Devonian collision with Siberia, which ended the life of the Franklinian Geosyncline. A successor basin, the Sverdrup Basin, developed on top of the rocks of the Ellesmerian orogen (similar to Franklinian orogen of Thorsteinsson and Tozer (1970)), in Carboniferous time. The history of the Sverdrup Basin was postulated as being terminated in the Late Cretaceous to Middle Tertiary by the Eurekan Orogeny, which was possibly associated with seafloor spreading in the Labrador Sea and Baffin Bay. The unnamed Cenozoic geosyncline was regarded as probably originating in the Early Tertiary, and was formed by sediment loading on the outer continental margin.

Frisch (1974) shed more light on the enigmatic Pearya Geanticline by documenting the details of the metamorphic rocks exposed in the core. They consist of gneisses and lower grade metamorphics, which were previously considered to be Late Proterozoic eugeosynclinal deposits metamorphosed in Late Proterozoic or Early Cambrian time (Trettin, 1971). However, later work by Sinha and Frisch (1975, 1976) isotopically dated these rocks between 0.8 and 1.0 billion years old, and these authors considered them to be mainly Helikian sedimentary deposits involved in a Grenvillian age orogeny.

Kerr (1977), in a paper dealing with the Cornwallis Fold Belt, reverted to the older geologic subdivisions of Douglas *et al.* (1963) and Thorsteinsson and Tozer (1970). He employed the term Franklinian eugeosyncline which included the area comprising the Pearya Geanticline, in spite of the earlier recommendations of Trettin (1971), which divorced the Pearya Geanticline from the Franklinian Geosyncline.

Stuart Smith and Wennekers (1977) decided to dispense with the term Franklinian Geosyncline, and use the term Franklinian basin instead. They divided this basin into a stable platform, miogeosyncline, and eugeosyncline because these terms were "established in the literature of the geology of the Canadian Arctic Islands" (p. 3). However, they would have preferred to use the terms shelf and basin. Their Figure 2, which shows the sedimentary basins and tectonic features of the Arctic Islands, is confusing as they employ previously used terms but not in the same sense they were originally defined. Their stable platform and miogeosynclinal area is equivalent to the Arctic Platform of Thorsteinsson and Tozer (1970), their Franklinian Foldbelt is equivalent to the Franklinian miogeosyncline, their eugeosyncline area is equivalent to the Hazen Trough, and their tectonically active area of northern Ellesmere and Axel Heiberg Islands is equivalent to the Pearya Geanticline.

In an updated summary of Trettin *et al.* (1972), Trettin and Balkwill (1979) divided the tectonic history of the Innuitian Province into 2 phases, separated by the Devonian-Carboniferous Ellesmerian Orogeny. In the first (Early to Middle Paleozoic) phase, Trettin (*in* Trettin and Balkwill, 1979) divided the mobile belt into a southeastern Franklinian Basin, comprised of the central Hazen Trough and 2 bordering shelves, and a northwestern Pearya orogenic welt. Early Devonian K-Ar

ages were reported from a group of alpine ultramafics (remanent oceanic mantle?) and gabbro-noritic (indicator of incipient rifting?) rocks on northern Ellesmere Island. He interpreted the tectonic history of the region in much the same way as Trettin *et al.* (1972), but postulated that the Lomonosov Ridge (Figure 2-6) which is presently attached to the northern Ellesmere shelf, is underlain by continental crust, and was possibly attached to the present Barents shelf sometime in the past, collided with northern Ellesmere Island when a Proto-Arctic Ocean closed. This event was probably correlative with the Ellesmerian Orogeny. The final closure possibly occurred in the Middle Devonian, and the orogeny progressed gradually southwards with time. The Lomonosov Ridge was later separated from the Barents shelf by spreading along the Gakkel Ridge, an extension of the Mid-Atlantic Ridge, which commenced about 63 million years ago. In the second phase, Balkwill (*in* Trettin and Balkwill, 1979) noted that the Sverdrup Basin developed on the eroded rocks of the Franklinian Basin due to basin subsidence resulting from lithospheric cooling. In latest Cretaceous time, part of the northwest rim of the Sverdrup Basin sagged, and became the Arctic Continental Terrace, equivalent to the unnamed Cenozoic geosyncline of Trettin *et al.* (1972).

Christie (1979), in a paper describing the Franklinian Geosyncline and its relationship to Svalbard, reverted to the old geosynclinal subdivisions to describe the Lower to Middle Paleozoic basinal history of the archipelago. He attempted to explain the geology of Svalbard and the Innuitian region by a simple model in which the Svalbard Hecla Hoek Geosyncline was separated from the Franklinian Geosyncline by the Pearya Geanticline. In terms of the Dewey and Bird plate tectonic models

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(1970a), Christie envisaged 2 "small ocean basins" lying between 2 continents, separated by an island arc ("Pearya") (Figure 2-7a). In the Early Paleozoic, the Barents Plate, which included Svalbard (Figure 2-6), collided with the island arc and formed the Pearya Geanticline (Figure 2-7b). Later, the collision of the North American and Eurasian plates possibly caused the Caledonian Orogeny, which Christie has postulated as resulting in the Late Silurian to Early Devonian tectonic activity in the Boothia, Rens Fiord, and east-central Ellesmere uplifts (see Figure 2-4 for uplift locations), which all have east-west compressional features. In Figure 2-7c, Christie envisaged a northwest-dipping subduction zone at this time, presumably with a spreading centre further to the southeast (west Greenland?) moving the North American Platform and Barents Plate closer together. In the Middle to Late Devonian, the North American Platform collided with the Barents Plate resulting in the Ellesmerian Orogeny (Figure 2-7d). Christie's model, which links the Ellesmerian Orogeny to the collision of the American Plate with the Barents Shelf, as did Trettin (*in* Trettin and Balkwill, 1979), explains most of the available data. However, the model has a major flaw in that it infers oceanic crust under the Franklinian Geosyncline and a northwest-dipping subduction zone south of Pearya. Trettin (1971) showed that the Franklinian Geosyncline was developed on continental crust, and was formed by subsidence: A subduction zone dipping to the southeast, as in Figure 2-5 (Trettin *et al.*, 1972) fits the stratigraphic evidence better.

Kerr (1981) provided yet another summary of the evolution of the Canadian Arctic Islands. He used the more modern terminology of Trettin *et al.* (1972) rather than of Kerr (1977). Kerr introduced 3 new concepts:

(i) he considered the Pearya Geanticline to be connected to the Canadian Shield due to the Precambrian age (0.8 to 1.0 billion years) of its core. However, studies by Christie (1962) and Frisch (1983) on the nearest part of the Canadian Shield in southern Ellesmere and Devon Islands show K-Ar ages of approximately 1.75 billion years, much older than the rocks of Pearya; (ii) Kerr (1981) considered the Ellesmerian Orogeny to have begun in Early Devonian time, with the intrusion of igneous rocks. By Middle to Late Devonian time, the Pearya Geanticline was a broad uplift, with slopes steep enough to cause sediments deposited in the geosyncline to be moved away from the geanticline by gravity transport. Folds and thrust faults developed, with overriding in structures in a southeasterly direction. He noted that Ellesmerian deformation began later in the southeast (Late Devonian to Early Mississippian) than in the geanticline; (iii) Kerr (1981), extending the idea of Trettin *et al.* (1972), postulated that the Eurekan Orogeny was due to compressional deformation caused by extension in the Baffin Bay Basin.

Mayr (1981) noted that the ?Lower Devonian Sail Harbour "Group" of northernmost Ellesmere Island was undeformed, and was therefore probably of post-Ellesmerian origin. He concluded that the deformation front of the Ellesmerian Orogeny proceeded southwards with time, starting in the Early Devonian in northernmost Ellesmere Island, and reaching southern Ellesmere Island by Late Devonian time.

Trettin (1981), updating his 1971 concept, concluded that the Hazen Trough was underlain by thin continental crust rather than oceanic crust due to the absence of basal ophiolites or volcanics anywhere in the sequence. The trough probably originated as a rift basin in the North American Plate, rather than by foundering of the crust, and certainly

not by seafloor spreading. Surlyk and Hurst (1983), in a discussion of the Early Paleozoic deep-water basin of north Greenland, which is an extension of the Hazen Trough (Trettin *et al.*, 1972), were undecided as to whether the basin represented a narrow ocean basin or a rift-related aulacogen.

Trettin *et al.* (1982) reported that the alpine ultramafic rocks (ophiolites) that had yielded K-Ar dates of 398 ± 20 million years (Early Devonian) (Trettin and Balkwill, 1979), are better dated (zircon) as 481 million years old suggesting seafloor spreading in the late Early Ordovician. The K-Ar clock in these rocks was apparently reset by Early Devonian folding. The newly named Ordovician M'Clintock Orogeny affected pre-late Middle Ordovician rocks and was interpreted as being due to a collision following seafloor spreading earlier in the Ordovician.

The most up to date summary of the tectonic history of the Arctic Islands is by Trettin (1982). He divided the region into (Figure 2-8); (i) the Canadian Shield, (ii) the Arctic Platform, (iii) the Innuitian Orogen (equivalent to the Innuitian orogenic system of Fortier *et al.*, 1954), and (iv) Arctic Continental Terrace. The Innuitian orogen was separated into the Sverdrup Basin (Carboniferous to Eocene) and the Franklinian Mobile Belt (Proterozoic to Devonian), the latter consisting of a magmatic belt, Hazen Trough, and Southern Shelf. Trettin (1982) indicated a link between the Franklinian and Caledonian mobile belts, with the timing of their orogenies the most obvious characteristic in common (Middle to Late Ordovician and Upper Silurian), and between the Franklinian and Cordilleran belts, which have larger, ensialic, deep water basins (Hazen Trough, Richardson Trough, Selwyn Basin), and Late Devonian to Early Carboniferous deformation in common (Figure 2-8).

Trettin (1983) also discussed the Early Paleozoic link between the Franklinian and the Caledonian and Cordilleran mobile belts.

The Inglefield Uplift (new name) of east-central Ellesmere Island, was active in Early Devonian, and Middle to Late Devonian times, and produced the sediment of the Vendom Fiord Formation and the Okse Bay Group of Ellesmere Island. However, no obvious deformation resulted from the uplift (Smith *et al.*, submitted). (The Inglefield Uplift is further discussed in Chapter 4).

In this study, the terminology of Trettin and Balkwill (1979) and Trettin (1982) will be employed.

SUMMARY OF TECTONO-SEDIMENTARY HISTORY OF THE INNUITIAN OROGEN

Helikian	First sediments deposited in Franklinian Mobile Belt on northern Ellesmere Island, later involved in a Grenvillian age orogeny.
Late Proterozoic	Deposition of shelf carbonate rocks on east-central Ellesmere Island.
Early Cambrian	Deposition of Grant Land Formation on northern Ellesmere Island, derived from a northern upland area; shelf carbonate rocks on east-central Ellesmere Island.
Mid-Late Cambrian	Hazen Trough produced by rifting, deposition of deep water sediments in trough; shelf carbonates to southeast.
Early Ordovician	Seafloor spreading off north coast of Ellesmere Island.
Early - Mid-Ordovician	Subduction of oceanic crust along southeast-dipping subduction zone; collision resulting in M'Clintock Orogeny in northern Ellesmere Island; deposition of deep water sediments in Hazen Trough, shelf carbonates to southeast.
Silurian	Shallow water carbonates and clastics deposited on shelf of magmatic belt; deep water sediments in Hazen Trough, shelf carbonates to southeast.
Late Silurian - Early Devonian	Uplift in Boothia and Rens Fiord uplifts.
Early Devonian	Rifting phase in northeast coast of Axel Heiberg Island (Svartvaeg Formation); a layered gabbro-norite pluton on northern Ellesmere Island suggests incipient rifting in this region; undeformed Sail Harbour "Group" of northernmost Ellesmere Island suggests that collision of the Barents shelf with North America had already occurred in this area. Uplift in Inglefield Uplift.
Mid- Late Devonian	Ellesmerian Orogeny affected northern Ellesmere Island; deformation front progresses southwards with time, affecting the southeastern shelf by Famennian (Late Devonian) time; thick molasse deposits (Okse Bay Group) spread over shelf and trough, probably derived from easterly sources (Inglefield Uplift).

Early Carboniferous	Erosion of exposed beds of Franklinian orogen, producing major unconformity.
Early Carboniferous - Cretaceous	Subsidence and filling of Sverdrup Basin.
Late Cretaceous	Foundering of northwest margin of Sverdrup Basin to form Arctic Continental Terrace.
Middle Tertiary	Eurekan Orogeny deformed sediments of Sverdrup Basin by compressional deformation caused by extension in the Baffin Bay Basin.
Late Tertiary - Recent	Sedimentation in Arctic Continental Terrace.

CHAPTER 3

DEVONIAN STRATIGRAPHY OF SOUTHERN ELLESMERE ISLAND

"Facies is a term used when the same rocks are deposited in different places at different times, or when different rocks are deposited in the same place at different times or when different rocks are deposited at different places at the same time."

T.D.F., Geological Howlers

INTRODUCTION

The field work for this study was concentrated on the upper parts of the Eids and Goose Fiord formations, and the lower Blue Fiord and Disappointment Bay formations of southwest Ellesmere Island. The first 3 formations have their type sections in the study area. The following section presents discussions, descriptions, and environmental interpretations of these 4 formations. Figure 3-1 (pocket) shows the lithologic sections measured in these formations, and the vertical and lateral distribution of the lithofacies. Environmental interpretations of the lithofacies are based on lithology, paleontology, and sedimentary structures, viewed in a stratigraphic context. For a better comprehension of the complete Devonian sedimentary history of the region, descriptions taken from published information of the Cape Phillips, Vendom Fiord, and Bird Fiord formations, and the Okse Bay Group are included. Devonian depositional models, paleogeography, and tectonic history will be discussed in Chapter 4.

Figure 3-2 shows the Devonian stratigraphy of southern Ellesmere Island at 4 representative localities, and their correlation with the standard Nevada conodont and Arctic megaspore zones. A small part of the Lower/Middle Devonian stratigraphy of Bathurst Island is also included. The sequence will be discussed from the base upwards.

FORMATIONAL DESCRIPTIONS

GOOSE FIORD FORMATION (Plate 4)

INTRODUCTION

In this study, investigation of the Goose Fiord Formation was limited to a brief examination of the uppermost beds of the formation immediately south of Borgen (Loc. 59), and northwest of the head of Muskox Fiord (unit KA1).

The Goose Fiord Formation was proposed by Greiner (1963) for a 308 m (1010 ft.) thick unit of dolomiticsiltstone and silty dolostone, whose type section is 3 km southeast of Section FA (Borgen) (see Fig. 1-5). According to Thorsteinsson (1980, p. 18), the Goose Fiord Formation is of limited extent, and is not known outside the extreme southwestern part of Ellesmere Island. However, Mayr (1982) has extended the formation into the Grise Fiord area and Okulitch (1982) into the eastern Vendom Fiord region. Previously, east of Vendom Fiord, this unit has been referred to as the undivided Allen Bay-Read Bay formations (McGill, 1974; Trettin, 1978; Roblesky, 1979). In the Goose Fiord to Grise Fiord region, the Goose Fiord Formation lies conformably between the Devon Island and Disappointment Bay formations. East of the Vendom Fiord region, the formation is conformably underlain by the Douro Formation, and both conformably and unconformably overlain by the Vendom Fiord Formation. The unconformity disappears to the west. The maximum measured thickness of the Goose Fiord Formation is 710 m (Mayr, 1982).

DESCRIPTION AND DEPOSITIONAL ENVIRONMENT

The formation consists of light to medium grey-brown, fine to

medium grained, thin to medium bedded dense dolostone. Megafossils are very rare, but one gastropod was noted in unit KA1. Pinpoint and vuggy porosity is present in some units. Outcrops examined at Locality 59 contain numerous sedimentary structures, including desiccation cracks, irregular algal/sedimentary laminations, intraclasts (up to 5 cm in diameter), and small channel structures. The laminae consist of silt-sized detrital dolomite and quartz grains. Roblesky (1979) noted solution features and brecciation in the formation east of Vendom Fiord.

The lithology, scarcity of megafossils, and sedimentary structures strongly indicate that the Goose Fiord Formation was deposited in a tidal flat, possibly supratidal to upper intertidal, environment (Lucia, 1972; Shinn, 1983).

AGE IN THE STUDY AREA

The age of the Goose Fiord Formation is still poorly known, due mainly to the scarcity of megafossils. However, Thorsteinsson (1980) noted conodonts from the base of the formation east of Muskox Fiord that can be assigned to the *Pelekysgnathus index* fauna of Early Pridolian (Late Silurian) age, and ?*Pandorinellina* sp. from the top of the formation near the head of Muskox Fiord, which indicates a possible Early Devonian age. Just north of Vendom Fiord, Trettin (1978) assigned a Middle Lochkovian to Zlichovian, probably Early Pragian age to the formation.

CAPE PHILLIPS FORMATION

INTRODUCTION

Thorsteinsson (1958) named a thick sequence of calcareous shale and argillaceous limestone exposed on northeast Cornwallis Island, the Cape Phillips Formation. In the study area, the formation outcrops in a small area south of Baumann Fiord (Kerr and Thorsteinsson, 1972), and extensively west of Vendom Fiord (McGill, 1974; Kerr, 1976; Roblesky, 1979). The formation has been noted in the subsurface at 2 localities east of Blue and Eids Fiords (Mayr *et al.*, 1978). In all areas, the Cape Phillips Formation is conformably underlain by the Allen Bay Formation, and overlain by the Eids Formation.

DESCRIPTION AND DEPOSITIONAL ENVIRONMENT

The Cape Phillips Formation consists of "varve-like", laminated, organic-rich, dark grey weathering calcareous shales and siltstones, and interbedded yellow weathering silty limestones and dolostones. The fauna is sparse consisting mainly of graptolites, fish fragments, and tentaculitids.

The presence of laminated, organic-rich, fine-grained sediments and a restricted pelagic fauna suggest deposition in a relatively deep water, basinal environment (Wilson, 1969).

AGE IN THE STUDY AREA

The age of the Cape Phillips Formation varies within the study area. Roblesky (1979) noted the presence of graptolites of the *Monograptus uniformis* Zone, the basal graptolite zone of the Lochkovian,

midway in the formation west of Vendom Fiord (Roblesky section 3), and conodonts assignable to the *Eognathodus sulcatus* n. subsp. Zone of Late Pragian age at the top of the formation. Earlier, Raasch (*in* McGill, 1974) had reported tentaculitids from the uppermost beds of the formation west of Vendom Fiord as indicating a possible Emsian age. South of Baumann Fiord, Mayr *et al.* (1978) noted that the Cape Phillips Formation ranged into the Lower Emsian stage.

DISCUSSION

At present, some confusion exists as to the formational assignment of the Silurian-Lower Devonian shale and siltstone sequence west of Vendom Fiord. Kerr and Thorsteinsson (1972), Mayr (1973), McGill (1974), and Kerr (1976) assigned this unit to the Cape Phillips Formation. Trettin (1978, 1979) also placed correlative beds just north of the study area within this formation. These shales and siltstones west of Vendom Fiord were recently reassigned to the Devon Island Formation by Roblesky (1979), and this terminology was followed by Okulitch (1982) and Poey (1982). The reason for this revision, according to Roblesky (1979, p. 29-31) is that the name Cape Phillips Formation should only be applied, "according to the style of stratigraphic nomenclature in common use in Canadian Arctic stratigraphy", to the shales and siltstones that rest conformably on the Ordovician Cornwallis Group, and are laterally equivalent to the Allen Bay-Read Bay formations. Where the shales and siltstones overlie the Allen Bay-Read Bay formations, a different name should be applied, for example, the Kitson Formation of Melville Island. Therefore, according to Roblesky's reasoning, the shales and siltstones on Ellesmere Island should be reassigned to the Devon

Island Formation, which also consists of a sequence of graptolitic shales and rests on the Allen Bay-Read Bay formations equivalents at its type section on northwest Devon Island (Thorsteinsson, 1963). This reassignment is unnecessary and complicates the stratigraphy of the study area. Formations are defined by the physical characteristics of their rock units, e.g. composition, texture, primary structures, biologic remains, etc. (North American Commission on Stratigraphic Nomenclature, 1983, p. 853), and not solely by their relationship to adjacent formations. Therefore, the reassignment of the shales and siltstones to the Devon Island Formation should be abandoned, and the original name Cape Phillips Formation reapplied. Following this reasoning, the rocks named the Kitson Formation on Melville Island (Tozer and Thorsteinsson, 1964), a black, graptolitic shale resting on the Allen Bay-Read Bay formations equivalents and laterally equivalent to the Cape Phillips Formation, should be reassigned to the Cape Phillips Formation.

EIDS FORMATION (Plate 5)

INTRODUCTION

The Eids Formation underlies a large part of the study area, but is poorly exposed due to its lack of resistance to weathering. The formation is widespread in the Arctic Islands, occurring from Victoria Island (Mayr *et al.*, 1980) to Ellesmere Island.

The uppermost beds of the Eids Formation were briefly examined in the study area, mainly between Blue and Sör Fiords. Extensive brachiopod collections comprising 28 species have been made from these

uppermost units (see Fig. 7-1, 2), and have been or will be described (Jones and Smith, 1980, in press a, b). A new species of the rugose coral *Zelolasma* has also been documented (Pedder and Smith, 1983).

McLaren (1963a) proposed the name Eids Formation for a succession of thin-bedded, grey weathering, black calcareous mudstone and less common orange weathering dolomitic mudstone, black argillaceous siltstone, shale, and bioclastic limestone that is exposed in the type area southeast of Eids Fiord. A sparse fauna of cricoconarids, cephalopods, and pelecypods was noted. McLaren estimated the formation thickness to be 350 m (1000 ft.) or greater. Later, Roblesky (1979) showed the formation to be much thicker (766 m at Loc. 53 of this study). McLaren (*in* Kerr and Thorsteinsson, 1972) placed the type section 1.5 km east of the head of Eids Fiord (Fig. 1-3), but no description of a measured section has been published. The formation lies conformably between the Cape Phillips and Blue Fiord formations. The upper boundary of the Eids Formation will be discussed in the section on the Blue Fiord Formation.

DESCRIPTION AND DEPOSITIONAL ENVIRONMENT

Four lithofacies have been identified in the upper beds of the Eids Formation and are listed below in order of abundance. These lithologies are also present in the overlying Blue Fiord Formation (see below).

Lithofacies 1: Interbedded calcareous shale and silty lime and dolomudstone

This lithofacies dominates the upper Eids Formation in the study area. The shales are dark grey-brown, weathering light grey to tan, calcareous, consist of thin, planar laminae, and contain very rare

fossils - cephalopods (including *Spiroceras thoas*), trilobites (*Dechenella* (*Dechenella*) *spaekkassensis*), and horizontal trace fossils. Interbedded with and subordinate to these shales are lime and dolomitic mudstones. The former are dark grey, weathering light grey and the latter are medium greenish-grey, weathering yellow-orange. Both are thin-bedded and contain very rare fossils - mostly brachiopods and crinoids. Quartz silt comprises up to 10% of the rock. This lithofacies is typical of deeper water, slope to basinal environments as outlined by Wilson (1969).

Lithofacies 2: Argillaceous, fossiliferous wackestone

The argillaceous fossiliferous wackestone lithofacies occurs relatively commonly in the uppermost beds of the Eids Formation in the study area. It is composed of dark grey-brown, weathering medium greenish-grey to grey-brown, thin to very thin bedded fossiliferous wackestone. Fossils are common to abundant and comprise brachiopods (see Jones and Smith, 1980, in press a, b), crinoids, fenestellid and ramose bryozoans, *in situ* corals (mostly hemispherical *Alveolites* and *Favosites* colonies), and ostracods. In some beds, brachiopods (e.g. unit DA 13) or corals (e.g. unit DA 27) totally dominate the fauna. This lithofacies is always closely associated and interbedded with deep water shales and lime mudstones (Lithofacies 1). This, along with the dark colour, thin bedded, fossiliferous nature of the lithology, suggests deposition in a quiet water environment below wave base. Jones and Smith (in press, b), in their analysis of the environmental setting of the brachiopod fauna from the topmost beds of the Eids Formation, using paleogeographic and sedimentologic information along with previously documented brachiopod biofacies studies, also deduced a sub-wave base setting for the brachiopods

collected between Blue and Sör Fiords from argillaceous fossiliferous wackestones, but inferred a shallower water habitat for the brachiopods from west of Vendom Fiord, collected below sections GA, GB, and HA (see Fig. 7-1 for location of brachiopod collections from the Eids Formation).

Lithofacies 3: Crinoidal packstone/grainstone

This lithofacies consists of medium to light grey, weathering light grey-brown, thin to thick bedded, abundantly fossiliferous packstones/grainstones. The fossils are dominated by crinoid fragments, but brachiopods are also present. The units range from a few centimeters up to 2 meters thick. The lithofacies is closely associated with either lime mudstones and calcareous shales or coral-rich boundstones. This association provides an important clue to the depositional environment of this lithofacies. Crinoid packstones/grainstones associated with deep water shales and lime mudstones (e.g. unit EA 20, Loc. 39) have been considered the result of mass transport of platform-derived debris into deeper water slope environments (Davies, 1977; Yurewicz, 1977). The association of crinoidal packstone/grainstone with shallow water coral-rich boundstones (e.g. units AC2, EA8) probably indicates deposition in a shallow water, high energy environment, probably as crinoid banks. Thus, this lithofacies was deposited in both deep water slope and shallow water environments.

Lithofacies 4: Coral boundstone

This lithofacies is uncommon in the upper beds of the Eids Formation, and is not found below this level. It consists of light grey, weathering light grey-brown, indistinctly bedded fossiliferous

wackestone/packstone, with *in situ* corals (*Alveolites, Spongonaria parca, Roemeria* sp.cf. *R. infundibulifera*) and stromatoporoids dominating the fauna. Also present are crinoid fragments (some up to 5 cm long and 1 cm in diameter), bryozoans, and brachiopods. Beds of crinoid packstone/grainstone are closely associated. One of the buildups (AC1 and Loc. 3) is noted by McLaren (1963a, p. 319, 320) as occurring in the lower Blue Fiord Formation, but is placed within the Eids Formation in this study. It is large (over 1 km long and approximately 20 m thick), and thins and grades into crinoidal wackestone (Locs. 4, 5) along strike.

This lithofacies is closely associated with the deeper water facies outlined above, and is not laterally continuous with a shallow water platform sequence. This lithofacies developed as downslope buildups similar to those in the overlying Blue Fiord Formation (Smith and Stearn, 1982b).

The lower and middle parts of the Eids Formation were studied by Roblesky (1979) near Sör Fiord (Loc. 53 of this study). The lower part consists of unfossiliferous, laminated mudstone and lesser amounts of siltstone , and the middle part consists of glauconitic siltstone with lesser amounts of variably calcareous and dolomitic glauconitic sandstone and limestone. Structures include cross-bedding, ripple marks, and flute casts. Roblesky (1979) interpreted these sediments as representative of sub-wavebase outer to inner shelf environments, where sedimentation was dominated by sediment gravity flows.

AGE IN THE STUDY AREA

The Eids Formation is relatively well dated south of Baumann Fiord. Klapper and Johnson (1975) have identified *Polygnathus dehiscens* from the upper part of the formation near Sör Fiord (section K of this study) and Mayr *et al.* (1978) reported conodonts assignable to the *dehiscens* Zone from the Eids Formation in the Blue Fiord E-46 well (see Fig. 1-3). Both indicate an Early Zlichovian age for the formation. Chatterton (*in* Jones, 1982b) reported conodonts from the upper Eids Formation at brachiopod locality C78 (see Fig. 7-1) that could belong to the *dehiscens* to *serotinus* Zones, but which he considered probably part of the *gronbergi* Zone. A sample collected as part of this study from the upper Eids Formation (unit DA1) did not yield age diagnostic conodonts (see p.271). Spore analysis of samples from this same unit suggest "an approximate mid-Emsian age" (p.276). Brachiopod collections from the upper Eids Formation south of Baumann Fiord (Jones and Smith, 1980, in press a, b) were correlated with the *E. pinyonensis* Zone of Nevada, which ranges from the *dehiscens* to *inversus* Zones (Johnson and Niebuhr, 1976). However, the fauna could not be correlated with a specific subzone within the *pinyonensis* Zone. At Sör Fiord (Loc. 53 of this study), Roblesky (1979) reported conodonts probably assignable to the *dehiscens* Zone from near the top of the formation. West of Vendom Fiord, no conodonts have been collected from the Eids Formation. However, the age of the formation can be bracketed by the ages of the overlying and underlying formations as Late Pragian to Early Zlichovian (Roblesky, 1979), or possibly Late Zlichovian.

VENDOM FIORD FORMATION

INTRODUCTION

The Vendom Fiord Formation was introduced by Kerr (1967b) for a red-bed unit that is overlain by the carbonates of the Blue Fiord Formation (the latter is herein considered to be the Disappointment Bay Formation). The type section of the Vendom Fiord Formation is located north of the study area in the vicinity of Irene Bay (section 25 of Kerr, 1967b). The only exposure of the formation in the study area is east of Vendom Fiord. There, it both conformably (western part) and unconformably (eastern part) overlies the Goose Fiord Formation and is conformably overlain by the Disappointment Bay Formation (Fig. 3-2). Thicknesses range from 57 m to 396 m (Roblesky, 1979).

DESCRIPTION AND DEPOSITIONAL ENVIRONMENT

Roblesky (1979), who conducted a thorough study of the Vendom Fiord Formation east of Vendom Fiord, reported that the formation is lithologically complex, with a great deal of lateral and vertical variation. In the easternmost exposure, adjacent to the north arm of Makinson Inlet, the formation comprises red weathering unfossiliferous dolostones, sandstones, and siltstones, with subordinate gypsum. The base of these exposures is marked by a dolomite cobble conglomerate, up to 66 m thick (section 1 of Roblesky, 1979). Sedimentary structures in the units include planar and trough cross-stratification, and current ripple marks. Paleocurrent measurements indicate a current direction of 276° . Roblesky (1979) interpreted the dolostones and sandstones as a

fluvial, possibly braided stream deposit, the conglomerates as of alluvial fan origin, and the gypsum as a precipitate in playa lakes.

In the westernmost exposures, the formation consists of greyish-green weathering, silty dolostone, with lesser amounts of flat pebble conglomerate, limestone, and gypsum. Cryptalgal lamination, fenestral texture, and desiccation cracks were noted. This suggested a tidal flat environment to Roblesky (1979). The provenance and significance of the Vendom Fiord Formation will be discussed in Chapter 4.

AGE IN THE STUDY AREA

The age of the Vendom Fiord Formation is relatively poorly known. Uyeno (*in* Roblesky, 1979) reported *Pandorinellina exigua philipi* from one sample collected 5 m below the top of the formation near Locality 41 of this study. Uyeno assigned this to the *P. dehiscens* Zone (Early Zlichovian) probably because Klapper (1977) had reported that *P. e. philipi* ranged into the *P. dehiscens* Zone in North America. However, Klapper and Johnson (1980, Table 5) later reported that *P. e. philipi* also occurs in the overlying *P. gronbergi* Zone (Late Zlichovian) in Alaska and New South Wales. Indeed, Uyeno (*in* Roblesky, 1979) also reported the occurrence of *P. e. philipi* with *P. e. exigua* (GSC Loc. C-76810, 76811), which he assigned tentatively to the *P. gronbergi* Zone. Therefore, the upper boundary of the Vendom Fiord Formation is either Early or Late Zlichovian in age. It is herein regarded as Late Zlichovian in age because of facies relationships with the Blue Fiord Formation west of Vendom Fiord (see p.100), and the possible existence of the lower *P. inversus* Zone transgressive event at the base of the overlying Disappointment Bay Formation (Fig. 4-12).

No data is available from the study area on the age of the lower contact, but Trettin (1978), in describing a section just north of the head of Vendom Fiord, placed the formational base in the Early Zlichovian.

DISAPPOINTMENT BAY FORMATION (Plates 6-9)

INTRODUCTION

Prior to this study, the distribution of the Disappointment Bay Formation was limited to Cornwallis Island and adjacent smaller islands (Map 1054A of Thorsteinsson, 1958, and Map 25-1967 of Thorsteinsson and Kerr, 1968), Bathurst Island (Map 1350A of Kerr, 1974), northwest Devon Island (Thorsteinsson, 1980), and the subsurface of Cameron and Prince Patrick Islands (Mayr, 1980; Indian and Northern Affairs, 1978). Examination of outcrops on southern Ellesmere Island and southern and eastern Bathurst Island has shown that the distribution of the Disappointment Bay Formation should be extended into southern and central Ellesmere Island (Smith and Stearn, 1983), and that the formation can be divided into a dolostone and limestone member (Fig. 3-3) in certain areas of the Arctic Islands. This revision will be discussed below in more detail.

The type section of the Disappointment Bay Formation was first designated by Thorsteinsson (1958) on northern Cornwallis Island (see Fig. 3-3). The formation was later restudied on Cornwallis Island by Thorsteinsson and Kerr (1968) who distinguished 3 principal lithofacies: (1) a basal carbonate conglomerate unit ranging from 0 to 122 m (0 to 400 ft.) in thickness, (2) a middle unit of dolostone and minor quartz sandstone 3 to 15 m (10 to 50 ft.) thick, and (3) an upper unit of resistant,

medium to thick bedded dolostone that is commonly porous and from 122 to 152 m (400 to 500 ft.) thick.

In the study area on Ellesmere Island, the Disappointment Bay Formation lies conformably above the Goose Fiord and Vendom Fiord formations and below the Bird Fiord and Strathcona Fiord formations (Fig. 3-2). It is up to 726 m thick (Mayr, 1982). In the study area on Bathurst Island (Fig. 1-1), the formation lies unconformably above the Stuart Bay Formation and conformably below the Bird Fiord Formation, and is up to 884 m thick (section B42A).

DESCRIPTION AND DEPOSITIONAL ENVIRONMENTS

Four main lithofacies can be recognized in the Disappointment Bay Formation of southwest Ellesmere Island and Bathurst Island, and are described below in order of abundance.

Lithofacies 1: Fenestral dolostone (Plate 7)

The fenestral dolostone lithofacies comprises a large proportion of the Disappointment Bay Formation on Ellesmere Island, and almost the entire dolostone member of the Disappointment Bay Formation on Bathurst Island.

This facies consists primarily of light grey-brown, weathering light to medium grey-brown, medium bedded, silty, poorly fossiliferous, fenestral dolomicrosparite and dolopseudosparite. The silt is composed mostly of quartz grains, with minor muscovite, and comprises up to 5% of the rock. Fossils are exceeding rare, but *Calcisphaera*, *Parathurammina*, ostracods, and crinoids (commonly algally bored) have been noted. The dolomicrosparite and dolopseudosparite is Fe^{2+} free and is composed of equidimensional crystals of dolomite up to 100 μ in diameter. Fenestrae

are generally irregular in shape, less than 1 mm in maximum diameter, and are commonly unoccluded. Locally (e.g. Loc. 41) many of the fenestrae are vertically elongate and probably were formed by burrowing organisms (Grover and Read, 1978). Vugs up to 5 cm are also present. In unit HC19, this dolostone contains abundant quartz silt of eolian or fluvial origin. Large vertical (escape?) burrows, current ripples, and graded storm washup layers were noted. Roblesky (1979) has reported gypsum associated with this lithofacies east of Vendom Fiord at Localities 7, 8, 9, 11 and 12 of Fig. 3-4.

Light grey-buff, weathering cream-buff or orange-yellow, thin bedded, wavy laminated, silty dolostone is distinguished here as a subfacies of the fenestral dolostone lithofacies. It consists of alternating laminae of silt-poor and silt-rich dolomudstone. The silt comprises mainly subrounded quartz, but muscovite and dolomite are also present. The laminae are flat to gently undulating, and are in places moderately steeply sloping, especially when the laminae form domes over large irregular fenestrae. The laminae are commonly disturbed or destroyed by bioturbation. This texture was formed by alternating deposition of algal mats (dolomudstone) and eolian silt. The silt was trapped by the sticky upper surface of the algal mat during dust storms. Fenestrae are common in this subfacies, and comprise both laminoid and irregular types. Crystal silt floors some of the larger fenestrae.

The light colour, paucity of fossils, presence of fenestrae, algal mats, vertical burrows, current ripples, and storm washups all indicate a tidal flat environment of deposition.

Lithofacies 2: Fenestral lime mudstone (Plate 8)

The fenestral lime mudstone lithofacies is common in the Disappointment

Bay Formation. On Ellesmere Island, it is commonly interbedded with fenestral dolomudstone (Lithofacies 1) e.g. Loc. 41. On Bathurst and adjacent islands, the lime mudstone lithofacies comprises the entire limestone member of the Disappointment Bay Formation.

The facies consists of light grey-brown, weathering grey-buff, medium bedded lime mudstone. Allochems, which form 20 to 40% of the rock volume, are dominated by rounded peloids, averaging 80 μ in diameter. These peloids possibly resulted from micritization of algal and other material. Other allochems include algae?(*Bevocastria, Bisphaera, Calcisphaera,* and *Parathurammina*), ostracods, gastropods, crinoids and brachiopods, rounded lime mudstone intraclasts up to 3 mm in diameter, and subrounded quartz grains (insoluble residue values up to 7%). The matrix consists mostly of very fine grained lime microspar, although some beds contain calcite cement. Structures include irregular, laminoid, and tubular fenestrae, some floored with crystal silt. However, fenestrae do not occur in all units. Two generations of calcite cement are present in most fenestrae - an early acicular crystal cement, and a later, large, blocky cement. Micrite envelopes are commonly present, and calcitic shells are commonly dissolved. Pockets of oligomictic cemented rubble packbreccia (terminology of Morrow, 1982) within this facies at Loc. 47 suggest the prior existence of evaporites, which later were dissolved, producing a solution - collapse breccia.

The above features indicate deposition of this lithofacies in a tidal flat, and possibly very shallow subtidal (lacking fenestrae) environment. Units HC40 and KA48 which consist of abundant intraclasts and micritized skeletal material in a calcite cement were deposited in a higher energy, possibly tidal channel or nearshore shoal environment,

similar to that described by Read (1982) for the nearshore zone of homoclinal ramps.

On Bathurst Island, the limestone member of the Disappointment Bay Formation consists of the above rock type, with minor interbeds containing the shallow water corals *Dendrostella* and *Hillaepora* and stromatoporoids, in a peloidal lime mudstone matrix, probably deposited in a quiet, very shallow subtidal environment. It outcrops at localities B22, B30, B42A and B42B.

This lithofacies forms a tongue of the Disappointment Bay Formation in the Blue Fiord Formation west of Vendom Fiord (Fig. 3-1). It also comprises the lower unit and upper part of the upper unit of the Disappointment Bay Formation at Grise Fiord described by Mayr (1982).

Lithofacies 3: Dark coloured fossiliferous lime and dolowackestone (Plate 9)

This lithofacies is dark brown-black in colour on both fresh and weathered surfaces, and therefore stands out from the light coloured carbonates which comprise the bulk of the Disappointment Bay Formation. The dark coloured wackestone generally occurs in thin bedded units, which sometimes are discontinuous laterally, and pinch out into adjacent dolostone. This lithofacies contains common allochems (15 to 40%) consisting of crinoids, peloids, ostracods, brachiopods (*Atrypa* sp. A), rare charophytes, *Girvanella*, and *Parathurammina*, with scattered *in situ* colonies of corals (mainly *Alveolites* and *Thamnopora randsi*) and stromatoporoids. The matrix is composed of either lime or dolomicrospar and rarely dolopseudospar. Organic matter and iron-rich clays are also present in the matrix (insoluble residue values of 1 to 1.5%), and in microstylolitic swarms (terminology of Wanless, 1979). This gives the rock its dark colour. Micrite envelopes on and algal borings in the

allochems are common, as is dissolution and recrystallization of the allochems.

The presence of a normal salinity, subtidal fauna, abundant evidence of algal activity, and interbedding with a tidal flat facies indicates that the dark coloured fossiliferous lime and dolowackestone lithofacies was deposited in a very shallow subtidal, nearshore environment.

The middle unit of the Disappointment Bay Formation described by Mayr (1982) from the Grise Fiord area can also be assigned to this facies and environment.

Lithofacies 4: Siltstone/sandstone (Plate 9)

This lithofacies occurs only at the base and top of section FA. It consists of light to medium brown, weathering buff, cross-laminated siltstone/sandstone. The grains are well sorted and rounded coarse silt to fine sand, and comprise orthoclase (45%) and quartz (40%), with minor muscovite, plagioclase (albite), and detrital dolomite. The matrix is generally composed of dolomite cement.

This lithofacies appears to be similar to the eolian sediments described by Kukal & Saadallah (1973) and Shinn (1973) from the Persian Gulf.

AGE IN THE STUDY AREA

Ellesmere Island

Four samples have been processed by B.D.E. Chatterton for conodonts from the Disappointment Bay Formation as part of this study - KA21 (67.1 m above formation base), KA49 (176.5 m), KA53 (210.0 m), and Loc. 14 (435.2 m). The first 3 samples all yielded conodonts assignable to the upper

inversus Zone of Early Dalejan age (see p.272). The sample from Loc. 14 was barren. Uyeno (pers. comm., 1983) noted that the Disappointment Bay Formation in the Grise Fiord section measured by Mayr (1982) (Locality 5 of Fig. 3-4) yielded conodonts from the *inversus* Zone (GSC Loc. C-91865, 311.5 m above formation base) and *serotinus* Zone (GSC Loc. C-91869, approximately 385 m above formation base), indicating an Early to Middle Dalejan age for that part of the formation. From approximately 520 m above the formation base, Uyeno also reported *Pandorinellina expansa*, which only occurs in the upper *inversus* to *serotinus* Zones in the study area (Uyeno and Klapper, 1980). East of Vendom Fiord, Roblesky (1979) suggested that the age of the Disappointment Bay Formation ranged from Early Zlichovian to Latest Dalejan based on the ages of the underlying and overlying formations. Trettin (1978) reported *Pandorinellina expansa* from 9 m below the top of the formation near Strathcona Fiord at his section 11-3 (Locality 18 of Fig. 3-4), indicating a Late Zlichovian to Dalejan age for the formation in that area.

The tongue of the Disappointment Bay Formation west of Vendom Fiord can be dated as mid-*inversus* Zone (Early Dalejan) at the base and upper *inversus*/lower *serotinus* Zone (early Late Dalejan) at the top, based on conodonts reported by Uyeno (*in* Roblesky, 1979). Due to differences in measured thicknesses between sections reported here and those of Roblesky (1979), the stratigraphic height of the conodont samples have been "scaled down" to coincide with the thicknesses measured in this study.

The Disappointment Bay Formation on Ellesmere Island therefore ranges from Late Zlichovian to Late Dalejan in age.

Bathurst Island

Kerr (1974) noted that the dolostone member of the Disappointment Bay Formation on Bathurst Island could be tentatively dated as Emsian and possibly Eifelian in age on the basis of fossils in enclosing and equivalent formations. The limestone member on Bathurst Island is poorly dated, but Kerr (1974) reported fossils of Late Emsian age from northeast Bathurst Island (GSC Loc. 67146), probably assignable to this member. In the subsurface of Cameron Island (Panarctic *et al.* West Bent Horn C-44), Uyeno and Mayr (1979) have noted the conodont *Polygnathus costatus costatus* (Eifelian) in beds immediately overlying the limestone member of the Disappointment Bay Formation. This conodont suggests an Eifelian upper age limit for the member. In this study, *Dendrostella trigemme*, a coral typical of Eifelian age rocks in northern Canada, has been noted at section B30, and therefore indicates an Eifelian age for the limestone member of the Disappointment Bay Formation.

DISCUSSION

As mentioned in the introduction to this section, the distribution of the Disappointment Bay Formation has been extended into Ellesmere Island in this study (Fig. 3-4). Much of what has previously been referred to as the Blue Fiord Formation is now included in the Disappointment Bay Formation. The formation also occurs as tongues within the Blue Fiord Formation west of Vendom Fiord and at the top of section BC (unit BC9).

McLaren (1963a) assigned the generally unfossiliferous dolostones and limestones outcropping on southern and central Ellesmere Island

to the Blue Fiord Formation. He (1963b) noted a 61 m (200 ft.) thick unit of pale brown, fine grained, medium bedded, unfossiliferous dolostone southeast of Arthur Fiord, northwest Devon Island, that is underlain by brown limestones containing abundant specimens of *Gypidula pseudogaleata* Meyer *non* Hall. At the type area of the Blue Fiord Formation, McLaren reported these brachiopods as common in the lower member of the Blue Fiord Formation, and consequently he assigned the dolostones to the Blue Fiord Formation. He also assigned the dolostones and limestones in the region of Goose Fiord, southern Ellesmere Island to the Blue Fiord Formation, as these units contain beds of fossiliferous limestone similar to that found in the type area of the Blue Fiord Formation. Thorsteinsson (1963, p. 231), influenced by McLaren's (1963b) earlier work, mapped a section of similar light coloured, massive dolostone in the Sutherland River area, northwest Devon Island as the Blue Fiord Formation.

Later, Kerr (1967b, p. 4) assigned the bluff-forming dolostone overlying the Vendom Fiord Formation on central Ellesmere Island (Locality 20 of Fig. 3-4) to the Blue Fiord Formation "on stratigraphic grounds". He did not mention the marked lithologic difference between these beds and those in the type area of the Blue Fiord Formation. Later workers on Ellesmere Island, e.g. Kerr (1968), McGill (1974), Kerr (1976), Trettin (1978), Roblesky (1979), Mayr (1982), Okulitch (1982) and Smith and Stearn (1982b) continued to assign the unfossiliferous dolostone and limestone facies to the Blue Fiord Formation. Thorsteinsson (1980, p. 18-19) suggested that the rocks overlying the Goose Fiord Formation in the Goose Fiord and Muskox Fiord regions could not be assigned to the Blue Fiord Formation on lithologic

grounds, but made no further comments.

Recently, Smith and Stearn (1983), in their revision of the Emsian stratigraphy of southern Ellesmere Island, assigned the dolostone and limestone unit that had previously been referred to the Blue Fiord Formation to the Disappointment Bay Formation. The major reason for this revision was the marked lithologic dissimilarity between the Blue Fiord Formation in the type area, which consists of thin bedded, dark coloured, fossiliferous limestone and calcareous shale, and the medium bedded, light coloured, unfossiliferous dolostone and limestone outcropping on the south coast of Ellesmere Island (Localities 1, 2, and 3 of Fig. 3-4). These rocks closely resemble the Disappointment Bay Formation at its type area of Cornwallis Island. As mentioned earlier, the Disappointment Bay Formation on Cornwallis Island consists of a locally developed basal carbonate conglomerate, overlain by a middle unit of thin bedded dolostone and quartz sandstone, overlain by an upper unit consisting mainly of dolostone, with rare limestone beds. This upper dolostone comprises both thin bedded, pale greyish-yellow, fine grained dolostone with irregular laminations, similar to the wavy laminated fenestral dolostone subfacies (Lithofacies 1) recognized on Ellesmere Island, and thick bedded, yellowish-grey, fine to coarse grained, porous and vuggy dolostone similar to the bulk of the fenestral dolostone facies of Ellesmere Island. Thorsteinsson (1980, p. 20) noted that, in the Cornwallis Island area, the lower and middle units are sometimes absent, and the Disappointment Bay Formation consists solely of the upper dolostone unit. Clearly, the upper unit of dolostone, which comprises most of the Disappointment Bay Formation in the type area, is very similar to the fenestral

dolostone facies (Lithofacies 1) present at the sections examined on southern Ellesmere Island. Thin units of sandstone (Lithofacies 4), similar to those in the middle unit of the type Disappointment Bay Formation, occur near the base of the thick fenestral dolostone unit at section FA, further reinforcing the lithologic similarity between southern Ellesmere Island and the type area on Cornwallis Island. The age of the dolostones on southern Ellesmere Island (*inversus* Zone, Late Zlichovian to Early Dalejan) is also similar to that of the formation on northwest Devon, Cornwallis, and Lowther Islands (Thorsteinsson, 1980, p. 30).

There are 3 differences between the Disappointment Bay Formation in its type area and the formation on southern Ellesmere Island: (1) The basal carbonate conglomerate, which Thorsteinsson (1980) considered characteristic of the formation in the Cornwallis Island area, is absent on Ellesmere Island. However, the distribution of this conglomerate was controlled by the Boothia Uplift which did not affect the sediments in the environs of Ellesmere Island. (2) The dark coloured fossiliferous lime and dolowackestone facies (Lithofacies 3) present in the sections on southern Ellesmere Island has not been reported from the type area. However, beds rich in brachiopods and algae occur on Lowther Island in a section composed mainly of dolostone, limestone, and sandstone, that has been assigned to the Disappointment Bay Formation (Johnson, 1975; Thorsteinsson, 1980). (3) The fenestral lime mudstone facies (Lithofacies 2) is common on Ellesmere Island, but rare in the type area. This facies commonly comprises almost the entire formation on Ellesmere Island, e.g. the Grise Fiord section of Mayr (1982) (Locality 5 of Fig. 3-4).

The above discussion demonstrates conclusively that the sections examined as part of this study which comprise mainly fenestral dolostone and lime mudstone (sections FA, KA, KB, Loc. 41, Loc. 47, Loc. 57, and parts i.e. tongues, of sections GA, GB, GC, HA, HB, HC, and ED) should be reassigned to the Disappointment Bay Formation, and no longer included in the Blue Fiord Formation. A study of Ellesmere Island literature has shown that the Disappointment Bay Formation should be extended outside the study area as far north as Cañon Fiord (Fig. 3-4). The outcrop belt of the Blue Fiord Formation on Ellesmere Island has been drastically reduced by this major reassignment of the formation to the Disappointment Bay Formation.

Due to the confusion that has surrounded the formational assignment of this dolostone and limestone facies on Ellesmere Island, section KA is herein designated as a reference section of the Disappointment Bay Formation (North American Commission on Stratigraphic Nomenclature, 1982, p. 853) and should be used as a standard for the formation in the eastern Arctic Islands. This section is described in detail in Appendix II.

Brief visits to outcrops on southern and eastern Bathurst Island have suggested further stratigraphic revisions on the other islands in the archipelago. These changes also involve the reassignment of beds previously mapped as the Blue Fiord Formation to the Disappointment Bay Formation.

On Bathurst Island, Kerr (1974) described the Disappointment Bay Formation as light coloured, medium to thick bedded, finely crystalline, unfossiliferous, porous and vuggy dolostone, similar to the fenestral dolostone facies (Lithofacies 1) of Ellesmere Island.

On southern and eastern Bathurst Island, Kerr (1974) reported that the Disappointment Bay Formation is overlain by light coloured, medium to thick bedded, cryptocrystalline, generally unfossiliferous limestone, with "calcite blebs" (= fenestrae), which he assigned to the Blue Fiord Formation. This lithofacies has been examined at Loc. B22, B30, B42A, and B42B (Fig. 1-6), and can be classified as a fenestral lime mudstone, similar to that occurring in the Disappointment Bay Formation of Ellesmere Island (Lithofacies 2). Clearly, this fenestral lime mudstone facies is lithologically unlike the type Blue Fiord Formation, and therefore cannot be mapped as this formation. The facies could be named a new formation, or better still, included in a previously established formation, so as not to increase the plethora of formational names already in existence in Arctic stratigraphy. The Disappointment Bay Formation of Ellesmere Island contains numerous beds of fenestral lime mudstone, and therefore, this facies can be considered part of the Disappointment Bay Formation on Bathurst Island. However, on Bathurst Island, the fenestral lime mudstone facies is underlain by dolostones already assigned to the Disappointment Bay Formation. To circumvent these nomenclatural difficulties, it is herein proposed that, on Bathurst Island, the dolostones of the Disappointment Bay Formation be assigned to the dolostone member of the Disappointment Bay Formation, and the fenestral lime mudstone facies, previously mapped as the Blue Fiord Formation, be assigned to the newly named limestone member of the Disappointment Bay Formation. On Ellesmere Island, these members are intimately interbedded, and the formation cannot be subdivided.

The fenestral lime mudstone facies occurring at the following localites, previously referred to the Blue Fiord Formation, can also

be assigned to the limestone member of the Disappointment Bay Formation: (i) Cornwallis Island area (Thorsteinsson and Kerr, 1968), (2) bank interior facies, subsurface of Cameron Island (M-21, C-44, and N-72 wells (Mayr, 1980)), (3) south and east of Weatherall Bay, Melville Island (Tozer and Thorsteinsson, 1964), (4) 16 miles northeast of Armstrong Point, northwest Victoria Island (Thorsteinsson and Tozer, 1962), and (5) 1948 to 2036 m, Storkerson Bay A-15 well, southwest Banks Island (Miall, 1976).

As the new limestone member of the Disappointment Bay Formation is being defined herein, a type section of this member must be selected (North American Commission on Stratigraphic Nomenclature, 1983, p. 853). Section B30, near Moses Robinson River, eastern Bathurst Island, is chosen as the stratotype. Its exact location is noted in Appendix I. A detailed description of this section is included in Appendix II. The boundary of the limestone member with the underlying dolostone member is marked at the base of the first bed of fine grained, fenestral lime mudstone. The base of the first bed of sandstone marks the upper boundary of the limestone member with the overlying Bird Fiord Formation. Due to these stratigraphic revisions, the previously named type section of the Disappointment Bay Formation on Cornwallis Island (Thorsteinsson, 1958) now becomes the stratotype for the dolostone member of the Disappointment Bay Formation.

BLUE FIORD FORMATION (Plates 10-16)

INTRODUCTION

The major portion of the field work in this study was spent examining the rocks of the Blue Fiord Formation, and the majority of megafossils were collected from this formation. Numerous sections were measured and collected in the outcrop belts between Blue and Sör Fiords, and west of Vendom Fiord (Figs. 1-3, 1-4). The Blue Fiord Formation was also briefly examined on Bathurst Island at Localities B19, B20, B22, B25, B37, B39, B43, and B44 (Fig. 1-6).

The Blue Fiord Formation was first mentioned and briefly described by McLaren (1959) on Ellesmere Island, and later by Thorsteinsson and Tozer (1962) from Victoria Island and the Princess Royal Islands. The "original description" was delayed in publication and appeared later in the memoir on Operation Franklin (McLaren, 1963a). There, McLaren described the formation as consisting of bedded limestone, dolostone, and calcareous shale "variable in detail along and across strike" (p. 318), and divided the formation into 2 members - a lower limestone and shale member, and an upper limestone member - with a total thickness of 1158 m (3800 ft.). McLaren (1963a) did not designate a type section for the formation but chose a type area in the vicinity of Blue Fiord. McLaren (*in* Kerr and Thorsteinsson, 1972) later selected a type section 13 km east-southeast of the head of Blue Fiord. This type section as indicated on Kerr and Thorsteinsson's (1972) map lies in an area of poor exposure between 2 creeks, and it is assumed here that the section should have been placed in the creek 1 km east of that position. Uyeno (pers. comm., 1983) corroborated this placement. A detailed description

of this stratotype has never been published. As part of this study, a reconnaissance section (section BC) was measured up this creek using air photos, and a description of the units is included in Appendix II.

Figure 3-5 shows the distribution of the Blue Fiord Formation across the Arctic Islands. The distribution of the Blue Fiord Formation on Ellesmere Island is shown in Fig. 3-6. This figure demonstrates that the majority of the exposures of the Blue Fiord Formation on Ellesmere Island occur within the study area.

In the study area, the Blue Fiord Formation lies conformably between the underlying Eids Formation and the overlying Bird Fiord and Strathcona Fiord formations (Fig. 3-2), and thins from over 1300 m 2.5 km east of the type section to approximately 800 m west of Vendom Fiord. The boundary with the Eids Formation is gradational, and has been drawn at the base of the first well-developed limestone bed (McLaren, 1963a, p. 317). This is generally either coral-rich limestone or unfossiliferous lime mudstone. However, in the field the boundary is commonly covered by a talus interval, and therefore the contact is difficult to place. Lenses of limestone (e.g. coral buildups at section AC and EA) occur in the upper Eids Formation, and can be confused with the base of the Blue Fiord Formation if their discontinuous nature is not recognized. In the course of this study, the base of the Blue Fiord Formation has been drawn at the base of the continuous cliff-line exhibiting Blue Fiord Formation lithologies as this is the only level that can be consistently and objectively located. The upper boundary of the Blue Fiord Formation is also gradational, and is generally drawn at the horizon where shale and sandstone units become common (Embry and Klovan, 1976; Roblesky, 1979).

DESCRIPTION AND DEPOSITIONAL ENVIRONMENT

Ten lithofacies have been recognized in the Blue Fiord Formation of Ellesmere Island. Figure 3-1 shows their stratigraphic and geographic distribution. The first 4 lithofacies occur mainly west of Vendom Fiord, and the remainder have been recognized in the Blue to Sör Fiord region.

Lithofacies 1: Faunally-restricted argillaceous limestone (Plate 11)

This lithofacies consists of dark grey-brown, laminated, argillaceous (insoluble residue average 30%) limestone, with a low diversity and low abundance fauna. However, in some beds, the fauna is very abundant. The fauna is generally dominated by one of three species - the ostracod *Paraparchites*, or the brachiopods *Costellirostra* or *Chonetes* sp. A. The brachiopod species are mutually exclusive, but *Paraparchites* is commonly associated with either brachiopod fauna. Other faunal elements present in the lithofacies are "New genus" Churkin and Carter sp. nov. (cricoconarid), fish, trochiliscid algae (charophytes), *Calcisphaera*, *Paratharammina*, pelecypods, gastropods, and bryozoans. Peloids, quartz silt, muscovite, pyrite, and iron-rich clays also occur. Allochems usually form 5-10% of the rock, but where one of the above faunal elements is abundant, it can form over 50% of the rock volume. The rock matrix is largely lime microspar. Sedimentary features present in this lithofacies include algal boring and micrite envelopes.

In situ, monotypic shell beds indicate colonization by opportunistic species (Levinton, 1970), which are able to exploit restricted environments. The presence of opportunists, in this case ostracods and brachiopods, generally indicates unstable environments. Braun (1978) noted that ostracods in environmentally restricted lagoonal carbonates are generally of low diversity and locally occur

in great abundance. Articulate brachiopods, generally considered to be fully marine, have been shown to have inhabited both high and low salinity environments in the past (Fürsich and Hurst, 1980). The close stratigraphic association of this lithofacies with the tidal flat facies (tongue of Disappointment Bay Formation) and the presence of charophytes, which grow in fresh or brackish water at present, suggest a shallow, low salinity environment. This is supported by Copeland (written comm., 1983), who reported that *Paraparchites* is considered to be a very shallow marine to estuarine form.

The above information suggests deposition of this lithofacies in a shallow, low salinity, nearshore environment such as an estuary, which is a marginal marine body of water in which salinity is markedly diluted by fluvial discharge (Fairbridge, 1968). Clifton (1982) considered the presence of a brackish water fauna as the best evidence for recognizing ancient estuarine deposits. A recent analogue of this facies is the modern Belize Shelf, where an ostracod-rich lime mud is forming where 2 rivers discharge into the Caribbean Sea (Purdy *et al.*, 1975). A close ancient analogue is member C of the Strathcona Fiord Formation south of Cañon Fiord (Trettin, 1978) and west of Vendom Fiord (Roblesky, 1979). It consists of a lime wackestone containing ostracods, charophytes, fish, and peloids in a microcrystalline calcite matrix. Both of the above authors considered this facies to have formed in brackish water lakes or lagoons.

Lithofacies 2: Fossiliferous lime wackestone (Plate 11)

Medium to dark grey-brown, very thin bedded to laminated, fossiliferous limestone composes this lithofacies. Fossils are abundant, and include crinoids, some with long, articulated stems, brachiopods

(e.g. *Atrypa* sp. A, *Perryspirifer scheii*, *Carinagypa*), *in situ* colonies of hemispherical and laminar corals (*Alveolites*, *Favosites*, *Utaratuia*, *Spongonaria*, and *Hexagonaria*), and *in situ* coral bafflestone thickets (*Thamnopora*, *Alveolitella*), stromatoporoids, and pelecypods (mostly *Paracyclas*), along with scattered algae including *Rhabdoporella bascillum* (sometimes in abundance, e.g. unit HB34), *R. stolleyi*, *Issinella*, and "*Uva*", *Calcisphaera*, *Parathurammina*, bryozoans, and ostracods. Peloids and quartz silt (average 5%) are also present. The allochems are generally poorly sorted and unrounded. The rock matrix is lime microspar. Iron-rich clay microstylolitic swarms are relatively common, and are responsible for the thin bedded nature of the rock. Micrite envelopes, algal boring, and horizontal feeding traces are present.

The presence of an abundant, *in situ* stenohaline fauna, including algae, the unrounded, unsorted nature of the allochems, micrite envelopes and algal boring, and the close stratigraphic association of this lithofacies with the tidal flat lime mudstone facies of the Disappointment Bay Formation tongue indicates a nearshore, shallow subtidal environment.

This facies is present at sections B22, B37, and B39 on Bathurst Island, and there consists of abundantly fossiliferous limestone with the corals *Yacutiopora hillae*, *Lekanophyllum* sp. cf. *L. retiforme*, *Taimyrophyllum nolani baumannense*, *T.* sp. nov., *Tauruphyllum atypica*, *Acanthophyllum*, *Alveolites* and *Favosites*.

Lithofacies 3: Coral/stromatoporoid boundstone (Plate 12)

This lithofacies only occurs at points 34, 35, 36, and 38 of Figure 5-8. It is medium to dark grey-brown and medium bedded, and

is dominated by a coral/stromatoporoid fauna. The corals consist of several species of *Spongonaria*, mostly *S. parca* and *S. loewei*, *Alveolites*, *Favosites*, and rare *Thamnopora*. Crinoid debris is abundant, and individuals with a stem diameter of 10 mm are common, especially at the base of the units.

The presence of abundant *in situ* corals and stromatoporoids, and the close stratigraphic association with the nearshore fossiliferous facies, indicates that this facies probably formed as buildups in a relatively shallow, turbulent environment.

Lithofacies 4: Crinoid grainstone (Plate 12)

This lithofacies occurs mainly west of Vendom Fiord (Fig. 5-8). It consists of light grey-brown, medium bedded crinoidal grainstone. Crinoids form the main allochems, comprising 50% of the rock. The crinoid grains are commonly algally-bored. Other allochems are scattered fenestrate bryozoans, brachiopods, and trilobites. The allochems are moderately to well sorted, and moderately rounded. Syntaxial calcite cement forms the rock matrix. This lithofacies is locally dolomitized, e.g. units HA 6, 8, and the crinoid grains become recrystallized and difficult to recognize. This dolostone has up to 5% secondary porosity.

The moderately well sorted and rounded nature of the allochems, presence of calcite cement, and the close stratigraphic association with the coral/stromatoporoid and fossiliferous wackestone lithofacies indicate a shallow, moderate to high energy environment. This facies probably formed as shallow water crinoid banks. The lithofacies is also sometimes associated with downslope buildups e.g. unit JA14.

Lithofacies 5: Argillaceous fossiliferous wackestone (Plate 13)

This lithofacies is very similar to that developed in the upper Eids Formation (Lithofacies 2). It consists of medium to dark grey-brown, very thin bedded to laminated fossiliferous limestone that is commonly interbedded with shale. The fossils are abundant and diverse, and include crinoids, brachiopods including *Schizophoria, Carinagypa, Atrypa* sp. A and B, *Chonetes* sp. D, *P.* sp. *P. merriami,* and *Athyrhynchus loriei*, fenestellid and ramose bryozoans, corals (*Alveolites, Alveolitella, Favosites, Thamnopora*) which form small mounds up to 2 m high in unit ACA 3, cricoconarids ("New genus" Churkin and Carter sp. nov.), pelecypods e.g. *Palaeoneilo*(?), and ostracods. The allochems are poorly sorted, generally unfragmented, and unoriented. The matrix is composed of argillaceous lime mud. Iron-rich clay microstylolitic swarms are common. Features indicative of storm reworking (Kreisa, 1981) are present in unit AAA9. These include (1) sharp (erosional) bases of individual beds, (2) interbedded fine beds and coarse (shell) beds between 1 and 2 cm thick, (3) a reworked, but autochthonous fauna (the majority of shells are convex up and are closely packed together), (4) oblique (near vertical) "escape" burrows, and (5) horizontal feeding traces in lime mud above the shell lag. The thickness of each storm layer, and the absence of amalgamation surfaces indicates that unit AAA9 is a deep storm deposit, probably formed near storm wave base (23 m (75 ft.) according to Logan, 1969).

The presence of an abundant, generally unfragmented, *in situ* fauna, an argillaceous lime mud matrix, and storm generated features indicate probable development of this lithofacies in quiet water below wave base, but at least partly above storm wave base. This

lithofacies is identical to Facies 2 of the Blue Fiord Formation mentioned in Chapter 5 on coral buildups.

Lithofacies 6: Downslope coral/stromatoporoid boundstone (Plate 13)

This lithofacies is described in detail in Chapter 5. It is relatively similar to coral/stromatoporoid boundstone, but is stratigraphically associated with deeper water lithofacies that developed below wave base, and was deposited in a similar environment to that in the Eids Formation (Lithofacies 4).

Lithofacies 7: Bryozoan lime mudstone (Plate 32 j)

The bryozoan lime mudstone lithofacies has been noted only at a few localities in the study area (Fig. 5-8). It forms in mounds of limited lateral extent up to 2 m high. Cryptostomate bryozoans generally comprise the main skeletal element, although laminar *Alveolites*, hemispherical *Favosites*, solitary rugosans (including *Pseudamplexus*), crinoids and fenestellid bryozoans are also locally abundant. The matrix is composed of medium to light grey-brown, very fine lime mud. Pockets of calcite cement are present, usually developed in shelter cavities floored with fine sediment. The texture somewhat resembles that of phylloid algal lime mudstones (see Wray *in* Ginsburg *et al.*, 1971, p. 7.3), which formed mud banks in the Permo-Pennsylvanian. The bryozoan lime mudstone lithofacies overlies lime mudstone and shale (Lithofacies 8), and in unit CH4, is laterally equivalent to that lithofacies.

The cryptostomate bryozoans may have acted as sediment baffles and possibly trapped and stabilized the fine lime mud. The mud could have been produced by the *in situ* disintegration of calcareous algae, as in mud accumulations in Florida Bay (Stockman *et al.*, 1967). A source of the lime mud from contemporaneous surrounding sediments is

less likely, as these contained more terrigenous impurities. Mountjoy and Jull (1978) and Mountjoy and Riding (1981) considered the lime mud present in Devonian mud mounds of Alberta to be a micrite cement. However, no evidence was found in this study to support this hypothesis.

The presence of fine lime mud, delicate bryozoan skeletons, and the close association with the deeper water lime mudstone and shale lithofacies indicate a relatively deep water environment. This lithofacies was probably developed in bryozoan mud mounds, which are commonly developed in relatively deep water, on the flanks of buildups (Wilson, 1975; Mountjoy and Riding, 1981).

Lithofacies 8: Lime mudstone and shale (Plate 14)

This lithofacies is represented by regularly interbedded units of medium to dark grey-brown, massive to laminated lime mudstone in beds averaging 20 cm thick, and calcareous shale in beds averaging 1 cm thick. The limestone beds consist of (in order of abundance) peloids, quartz silt, *Styliolina*, ostracods, sponge spicules, *Calcisphaera*, and *Parathurammina*, with rare fine crinoidal debris, trilobites (dominated by *Schizoproetoides richteri*), brachiopods including *Warrenella franklini praefranklini* forme transversale and *Chonetes* sp. D, gastropods, cephalopods (*Spirocerас thoas*), and *Girvanella*. Allochems average 25% of the rock volume. The matrix consists generally of either lime or dolomicrospar, although some beds contain lime cement. Scattered pyrite and microstylolitic swarms are common. An average of 13% insoluble residue is present in the lime mudstone. Wilson (1969) termed this microfacies a homogeneous lime mudstone. Features present in this lithofacies are sedimentary boudinage and rare horizontal

feeding traces. This facies is present at B19, B20, B25, B43, and B44 on Bathurst Island.

The dominance of lime mud, the dark colour, intercalated calcareous shales, and restricted benthic and pelagic fauna suggest deposition of this facies below wave base in a relatively deep, low energy environment. Wilson (1969) noted a similar lithofacies, and assigned it to a slope environment. The interbedded limestone and shale he termed rhythmites, and mentioned that the lime mud, predominant in this lithofacies, was probably manufactured in a shallow water environment, was stirred up and washed seaward, and later settled. Transport of shallow water lime muds into deeper water has been demonstrated to occur at present in the Persian Gulf (Houbolt, 1957), and the Bahamas (Schlager and James, 1978). Schlager and James (1978) termed these fine grained, shallow water-derived slope sediments "peri-platform ooze". This origin for the lime mud is supported by the presence of peloids, *Calciosphaera*, *Parathurammina*, and *Girvanella*, all of which are abundant in the shallow water facies of the coeval Disappointment Bay Formation. In this model, as the distance from the shallow water environment increases, the thickness of the lime mudstone beds would decrease as less shallow water material would be transported further offshore. Also, the percentage of calcareous shale, which was probably the ambient pelagic sediment, would increase offshore. This model can be used to demonstrate an upwards shallowing sequence in section BA, where the basal beds of the section (units BA1, BA2) contain limestone beds averaging 1 to 3 cm thick in a predominantly shale-rich (70%) unit. These basal beds grade upwards into unit BA4, which contains limestone beds 3 to 10 cm thick, with subordinate (25%)

shale, and further upwards into unit BA6, which contains limestone beds 10 to 30 cm thick, with even less (15%) shale. Therefore, this sequence documents an upwards shallowing sequence.

Wilson (1969) suggested that the uniform, rhythmic bedding of the limestone/shale couplets resulted from "regular climatic fluctuations" (p. 7). These fluctuations were probably storms or hurricanes. The regularity of the couplet bedding implies that such storm events capable of washing shallow water sediment seaward were regular in the past.

Lithofacies 9: Skeletal grainstone/packstone (Plate 15)

This lithofacies occurs closely associated with the lime mudstone and shale facies (Lithofacies 8). It consists of medium to dark grey-brown, thin bedded skeletal grainstones and packstones, which are resistant to weathering compared to the adjacent lime mudstone and shale beds. Allochems are abundant (up to 60%), and are overwhelmingly composed of disarticulated crinoid columnals, with subordinate bryozoans, brachiopods (*Schizophoria, Carinagypa, Atrypa* sp. A, and *Warrenella transversa* are common), trilobites, ostracods, peloids, and quartz silt, and rare coral fragments. Locally, the green algae *Rhabdoporella bascillum* (e.g. units AA7, AA22) and *Litanaia* (Loc. 29) form the major bioclastic components. The average range in size of the predominately crinoidal debris is from 1 to 2 mm, but larger, multisegment crinoids up to 5 cm long were also noted. The matrix consists of either lime cement, which commonly forms syntaxial overgrowths on the crinoid grains, or lime microspar with admixed argillaceous material. Partial to complete dolomitization of the matrix is very common. The coarsest grained sediments tend to be cemented, whereas the finer grained sediments have fine grained, argillaceous matrices. Features observed include

graded bedding, sharp planar unit bases, algal boring, micrite envelopes, poor sorting, and grain compaction (particularly *R. bascillum*). The graded beds occur in units between 3 and 10 cm thick. They commonly occur stacked on top of each other, in thicknesses up to 11 m (unit BA5). Some of these units can be traced on airphotos for great distances (e.g. unit BB12 can be traced along strike (east-west) for over 10 km).

The above features, especially the presence of graded beds and the close stratigraphic association with Lithofacies 8 (slope deposits), suggests that these units were transported in and deposited from turbidity currents, with sediment derived from the shallower water crinoid grainstone (Lithofacies 4), argillaceous fossiliferous wackestone (Lithofacies 5), and fossiliferous lime wackestone (Lithofacies 2) facies. The units consisting of coarse grains and sparry cement, and exhibiting dense spacing of turbidite beds and high bed thickness probably represent the proximal portions of turbidity currents (e.g. unit BB4), as compared to those that contain finer grains and microspar and argillaceous matrix, and exhibit low density of turbidity beds (higher percentage of background sedimentation) and low bed thickness (e.g. unit BB12), which are the deposits of more distal portions of turbidity currents (Thomson and Thomasson, 1969; Crevello and Schlager, 1980; Flügel, 1982). The low content of fine grained matrix in the coarse grained turbidites probably results from winnowing by strong bottom currents, and later submarine cementation, as occurs today in the Bahamas (Mullins and Neumann, 1979).

Similar graded units to these from the Blue Fiord Formation have been reported by McKenzie (1970), Davies (1977), and Hurst and Surlyk (1983), all of whom concluded a turbiditic origin for the sediments.

This facies is identical to the deeper water crinoidal packstone/ grainstone facies (Lithofacies 3) of the Eids Formation.

Lithofacies 10: Laminated limestone and shale (Plate 16)

This lithofacies represents the deepest water facies recognized in the Blue Fiord Formation. It consists of alternating millimeter thick, light and dark coloured laminae. The light coloured laminae comprise micropeloids (40 μ diameter), ostracods and sponge spicules, and small fragments of crinoids, trilobites, *Girvanella*, and bryozoans. The matrix consists of lime microspar although lime cement was also observed in some laminae. This facies is comparable to the micropelletoid lime grainstone microfacies of Wilson (1969). The dark coloured laminae are composed of quartz silt, sponge spicules, *Styliolina* and brachiopods (*Lingula* and *Warrenella franklini praefranklini* are common), in an iron-rich clay matrix. Organic matter is also abundant. Features observed include groove casts (with an estimated north-south elongation), micrograding (in grainstone laminae), parallel lineation of sponge spicules and vertical (escape) and horizontal (feeding) burrows.

The presence of fine grained, dark coloured sediment, the even millimeter lamination, groove casts produced by scour, micrograding, the alignment of sponge spicules, and the restricted biota suggest deposition in a deep water, basinal environment. The dark coloured laminae represent the normal pelagic settleout in this environment. The light coloured laminae represent influxes of material derived from shallow water environments, similar to that in the lime mudstone and shale lithofacies (Lithofacies 8). However, the presence of scour features, and the alignment of sponge spicules suggest that

this material did not settle out of suspension but was deposited from a moving current, probably a turbidity current. Stow and Bowen (1978) also attributed the lamination seen in deep sea, fine grained sediments to deposition from turbid flows. These thin, light coloured laminae may represent the distal portions of the crinoid turbidites (Lithofacies 9) that originated in shallower water environments.

AGE IN THE STUDY AREA

Ellesmere Island

This section summarizes the biostratigraphy from this study (Chapters 6, 7, and 8), and previous works.

A number of conodont studies completed in the study area on Ellesmere Island have delineated the age of the Blue Fiord Formation. Weyant (1971, 1975a) collected samples from near the head of Eids Fiord (section AA(A) of this study) and identified *Polygnathus foveolatus* from 156 m above the base of the Blue Fiord Formation. Later, Uyeno and Klapper (1980) reidentified these specimens as *P.* aff. *P. perbonus*, which is found in the *P. gronbergi* Zone (Late Zlichovian) of Nevada. Klapper and Johnson (1975) discovered a sequence of *Polygnathus* in a section near Sör Fiord (section K of this study) from the *P. dehiscens* Zone (Early Zlichovian) at the base of the formation to the *P. serotinus* Zone (Late Dalejan) at the top of the formation. Later, this sequence was discussed in greater detail by Uyeno and Klapper (1980, Fig. 8.3), along with a conodont sequence from 2.5 km east of the type section (Uyeno and Klapper, 1980, Fig. 8.2), which showed the same zonation from the *P. dehiscens* Zone at the base to the *P. serotinus* Zone at the top of the formation. Conodont samples collected from the

lower Blue Fiord Formation between Blue and Sör Fiords as part of this study (see p. 271) did not yield any species of *Polygnathus*. However, Uyeno (written comm., 1980) estimated that the samples belonged to the *P. dehiscens* to *P. inversus* Zones (Early Zlichovian to Early Dalejan). In summary, conodont data between Blue and Sör Fiords indicates an Early Zlichovian to Dalejan age for the formation.

West of Vendom Fiord, the age of the formation is still uncertain due to the lack of *Polygnathus* in the lower half of the formation. Uyeno (*in* Roblesky, 1979) reported conodonts tentatively assignable to the *P. gronbergi* Zone (Late Zlichovian) approximately 100 m above the base of the formation. Fossils in this zone occur approximately 200 to 250 m above the base of the formation between Blue and Sör Fiords. Uyeno also noted the base of the *P. serotinus* Zone (Dalejan) about mid-way up the formation, continuing to the top. The base of this zone occurs near the top of the formation in the Blue to Sör Fiords region. Uyeno (written comm., 1980) identified *Pandorinellina expansa* 116 m above the base of the Blue Fiord Formation west of Vendom Fiord (unit GB40), which he considered as belonging to the *P. inversus* to *P. costatus costatus* Zones (Late Zlichovian to Eifelian in age). As conodonts assignable to the *P. serotinus* Zone overlie this locality, this unit can probably be considered part of the *P. inversus* Zone. Therefore, these conodont data indicate that the lower Blue Fiord Formation west of Vendom Fiord is possibly slightly younger (Late Zlichovian) than between Blue and Sör Fiords (Early Zlichovian). Similar spore assemblages from 1 m above the base of the formation between Blue and Sör Fiords and 134 above the base of the formation west of Vendom Fiord (McGregor, written comm., 1980) do not support this diachroneity of the formational base. Both spore assemblages indicate "an approximate mid-Emsian age".

Brachiopods collected from the lower 200 m of the formation as part of this study suggest a correlation with the middle to upper subzone of the *Eurekaspirifer pinyonensis* Zone of Nevada (Johnson and Niebuhr, 1976), indicating a Late Zlichovian (*P. gronbergi* Zone) age. Trilobites, generally collected in the lower 100 m of the formation, indicate an Early Zlichovian (*P. dehiscens* Zone) age. These ages are in accordance with those derived using conodont data. Neither of these groups suggest an age for the base of the formation west of Vendom Fiord younger than that in the Blue Fiord area.

Cricoconarids from approximately 130 m above the base of the formation west of Vendom Fiord (units GB43 and GE8) indicate an Early to Late Zlichovian (*P. dehiscens/P. gronbergi* Zones) age for this part of the formation. Approximately 100 m above this (unit ED27), the cricoconarids suggest a Late Zlichovian (lower *P. inversus* Zone) age. The cricoconarids suggest that the basal Blue Fiord Formation west of Vendom Fiord is coeval with the basal Blue Fiord Formation between Blue and Sör Fiords. Therefore, they directly conflict with the age derived using conodonts. However, the cricoconarid zonation from this study is tentative due to the lack of knowledge of species ranges (see Chapter 8) and therefore is not as reliable as the conodont zonation.

The corals identified are dominated by the genus *Spongonaria*, which ranges from Early Zlichovian to Dalejan in age. In particular, *S. parca*, abundant in the lower portion of the Blue Fiord Formation, is typical of Zlichovian age rocks (Pedder; 1977b). *Utaratuia*, typical of Middle to Upper Devonian rocks, occurs approximately 100 m above the base of the formation west of Vendom Fiord, and possibly indicates a younger age for the base of the formation in that region

than between Blue and Sör Fiords. This occurrence substantially extends the range of the genus downwards into the Lower Devonian.

In summary, the Blue Fiord Formation ranges in age from Early Zlichovian to Dalejan. A slightly younger age for the base of the formation west of Vendom Fiord, possibly Late Zlichovian is suggested by conodonts and corals. However, not all the data support this.

Bathurst Island

Little recent work has been done on the age of the Blue Fiord Formation on Bathurst Island.

Uyeno (*in* McGregor and Uyeno, 1972) described conodonts from section B20 of this study, and tentatively regarded them as of Eifelian age. Ormiston (*in* Kerr, 1974, p. 44) dated conodonts from section B39 also as Eifelian. *Tauraphyllum atypica* noted here from that section also indicates a Middle Devonian age. A similar age for the formation was derived by Ormiston (*in* Klapper and Johnson, 1980, Table 7) using conodonts from section B25 of this study.

Thus, the Blue Fiord Formation of Bathurst Island is considerably younger than the formation on Ellesmere Island (Zlichovian/Dalejan), and is coeval with the limestone member of the Disappointment Bay Formation on Bathurst Island.

BIRD FIORD FORMATION

INTRODUCTION

McLaren (1963a) first defined the Bird Fiord Formation in the vicinity of Bird Fiord. Later, he selected a type section for the formation (*in* Kerr and Thorsteinsson, 1972) 9 km east of the head of

Bird Fiord.

The formation is exposed in the study area (1) between Blue and Sör Fiords, where it is bounded conformably by the Blue Fiord Formation below and the Strathcona Fiord Formation above, and (2) in the vicinity of Goose Fiord, where it is conformably underlain and overlain by the Disappointment Bay Formation and Strathcona Fiord Fromation, respectively (Fig. 3-2). Previous geological investigations (Kerr, 1976; Trettin, 1978; Roblesky, 1979) have shown that the Bird Fiord Formation thins and eventually disappears in the Vendom Fiord region and northwards. A detailed sedimentologic/paleontologic study of the formation is in progess by Q.H. Goodbody (University of Alberta).

Near Bird Fiord (type area), the formation has been described by McLaren (1963a) and Embry and Klovan (1976), and is 900 m thick. The contact with the underlying Blue Fiord Formation is placed at the horizon above which shale and sandstone units become common (Embry and Klovan, 1976; Roblesky, 1979). The boundary with the suprajacent Strathcona Fiord Formation is drawn at the first occurrence of red shale beds.

In the vicinity of Goose Fiord, the Bird Fiord Formation has been described by McLaren (1963a), who noted that is was 533 m thick. Later, Jones (1982a) estimated the formation to be much thinner, in the order of 300 m. Recent work by Goodbody (*in* Pedder and Goodbody, 1983) shows the formation to be in the order of 500 m thick.

DESCRIPTION AND DEPOSITIONAL ENVIRONMENT

Bird Fiord area

Here, the formation consists mainly of fossiliferous limestone and shale, with common corals, stromatoporoids, brachiopods and crinoids.

Thin siltstone and fine grained sandstone beds occur scattered at the base, and gradually become more abundant upwards in the section at the expense of limestone. Cross-bedding occurs in some sandstone units. The uppermost beds of the formation consist of fining-upward cycles of white, fine grained sandstone, and dark grey shale and siltstone. Pelecypods occur in the shales.

Embry and Klovan (1976) interpreted the major fossiliferous portion of the formation to have been deposited in a deltaic-marine setting, and the uppermost white sandstone to have been the product of sedimentation in a meandering stream. B. Jones (pers. comm., 1981) noted very shallow water (tidal flat?) sediments at the top of the Bird Fiord Formation near Sör Fiord.

Goose Fiord area

Goodbody (*in* Pedder and Goodbody, 1983) described 4 units in the Bird Fiord Formation near Goose Fiord. In ascending order, (1) a basal unfossiliferous unit of dolostone and gypsum, forming nearly half the thickness of the formation, (2) bioturbated, calcareous sandstone and sandy limestone, (3) shale-calcareous sandstone couplets, with biostromal beds, and (4) cross-bedded micaceous sandstone. Unit 1 was described by Jones (1982a) as being deposited in a high intertidal/supratidal environment, and Pedder and Goodbody (1983) attributed unit 3 to a nearshore, open marine environment. Unit 2 was possibly deposited in a deltaic-marine setting similar to the bulk of the formation in the type area. Unit 4 is possibly similar to the sandstone beds at the top of the formation in the type area, and might also have been deposited in a meandering stream environment.

AGE IN THE STUDY AREA

The age of the formation is poorly known. In the type area, Uyeno and Klapper (1980, p. 87) considered that the Emsian/Eifelian boundary may be placed near the base of the formation, and that the top of the formation might possibly be within the *Warrenella kirki* Zone, equivalent to the *kockelianus* conodont Zone of Nevada, which is considered to be Upper Eifelian in age (Fig. 3-2). Chatterton (*in* Jones, 1982b) considered the base of the formation in the Sör Fiord region to be in the *P. serotinus* Zone (Dalejan). Chi (*in* Embry and Klovan, 1976) reported spores (*macromanifestus* Zone) from the top of the Bird Fiord Formation in the type area as indicating a Lower to Middle Givetian age. The top of the formation may be placed at the Eifelian/Givetian boundary. In the Goose Fiord area, Chatterton (*in* Jones, 1982a) reported conodonts of the upper *P. inversus* Zone or lower *P. serotinus* Zone (Early Dalejan) approximately midway up the formation at section J. Pedder and Goodbody (1983) using brachiopod and coral evidence, reported an age of Late *P. serotinus* Zone or *P. costatus patulus* Zone (Late Dalejan) for beds approximately 375 m above the base of the formation in the Goose to Muskox Fiord region. It is likely, therefore, that the upper boundary of the Bird Fiord Formation in this area is approximately the Emsian/Eifelian boundary or Early Eifelian in age.

OKSE BAY GROUP

McLaren (1963a) proposed the Okse Bay Formation for a 3078 m (10,100 ft.) thick sequence of largely nonmarine quartzose sandstones

and shales, and divided the formation into 4 members. The type area was designated in the vicinity of Okse Bay and Bird Fiord and a Late Devonian age was assigned. McGill (1974) and Kerr (1976) did further studies on the formation in the study area. In their study of the Middle to Upper Devonian succession, Embry and Klovan (1976) decided to raise the formation to group status. They recognized 5 formations within the group - the Strathcona Fiord, HeclaBay, Fram, Hell Gate, and Nordstrand Point formations. The Okse Bay Group is currently under study on southern Ellesmere Island by R.J. Rice (McMaster University).

STRATHCONA FIORD FORMATION

INTRODUCTION

Trettin (1978) named a sequence of red and green-weathering sandstones and siltstones the Strathcona Fiord Formation, and designated its type section 15 km south of Cañon Fiord (section 7-4 of Trettin, 1978). The distribution of the formation was previously documented by Embry and Klovan (1976, Fig. 25).

The Strathcona Fiord Formation outcrops widely in the study area, from Vendom Fiord in the north to Goose Fiord in the south. In the Vendom Fiord region, the formation lies conformably above the Blue Fiord and Disappointment Bay formations, and below the Hecla Bay Formation (Fig. 3-2). Southwards, in the Baumann Fiord and Goose Fiord regions, the Bird Fiord Formation is present conformably beneath the Strathcona Fiord Formation. The formation ranges in thickness from 200 m in the Okse Bay region (Embry and Klovan, 1976) to 1168 m in the Stenkul Fiord region (Rice, 1982).

DESCRIPTION AND DEPOSITIONAL ENVIRONMENT

McGill (1974), Kerr (1976), Embry and Klovan (1976), Roblesky (1979) and Rice (1982) have studied the Strathcona Fiord Formation in the study area. It is composed of fine grained, greyish-red weathering sandstones and siltstones that are generally recessive weathering, and sometimes arranged in fining-upward cycles. Fossils are scarce, and consist mainly of the brachiopod *Lingula* and plant fragments. Sedimentary structures in these units include parallel and ripple cross-lamination, planar and trough cross-bedding, which indicate a paleocurrent direction of west southwest in the Vendom Fiord region (Roblesky, 1979), oscillation and current ripple marks, scours filled with intraformational conglomerate, desiccation cracks, and root casts. Thin interbeds of lime wackestone and lime mudstone occur in the formation, and contain ostracods, charophyte oogonia, and fish fragments. Stromatolite beds are also present. Gypsum beds, shale-pebble conglomerate, and beds with skeletal debris of brachiopods, crinoids and corals also occur in isolated horizons.

The Strathcona Fiord Formation has been interpreted as being deposited in very shallow subtidal, meandering fluvial, alluvial plain, and fresh/brackish water lacustrine environments.

AGE IN THE STUDY AREA

The age of the Strathcona Fiord Formation is only relatively well known in the Vendom Fiord region. Roblesky (1979) noted conodonts of the *P. serotinus/patulus* Zones at the base of the formation, and considered this to indicate a Late Dalejan or Early Eifelian age. Spores from higher in the formation belong to the *macromanifestus* Zone, not

younger than Middle Givetian in age. Embry and Klovan (1976) dated the Strathcona Fiord Formation south of Baumann Fiord as being in the *macromanifestus* Zone. No ages are available from the Goose Fiord area.

HECLA BAY FORMATION

INTRODUCTION

Tozer and Thorsteinsson (1964) proposed the name Hecla Bay Formation for beds of light grey to white sandstone outcropping on eastern Melville Island. Figure 26 of Embry and Klovan (1976) shows the distribution of the formation across the Arctic Islands. In the study area, the Hecla Bay Formation occurs from Vendom Fiord to Goose Fiord. The formation is conformably underlain by the Strathcona Fiord Formation, and conformably overlain by the Fram Formation. Thicknesses in the region range from 180+ m east of Vendom Fiord to 641± m west of Vendom Fiord (Roblesky, 1979).

DESCRIPTION AND DEPOSITIONAL ENVIRONMENT

In the study area, the formation is dominated by white to orange weathering, medium grained, well sorted, compositionally mature sandstone occurring in thick, well-bedded units, commonly with basal scoured contacts. Lesser amounts of siltstone and conglomerate are also present. Clasts of igneous, metamorphic, and sedimentary origin occur in the conglomerate. Sedimentary structures are uncommon, but large scale trough cross-beds with shale chips, and planar cross-beds are present. Paleocurrent data from the Okse Bay area (Embry and Klovan, 1976) indicate a direction of 260°. Fining upwards cycles have also been

noted (Roblesky, 1979).

A braided stream depositional origin for the Hecla Bay Formation was suggested by Embry and Klovan (1976), who drew an analogy with the modern, braided river deposits of the Brahmaputra River.

AGE IN THE STUDY AREA

Roblesky (1979) reported spores representative of the upper *macromanifestus* Zone and lower *delicatus* Zone from near the base of the Hecla Bay Formation in the Vendom Fiord region. They suggest a late Middle Givetian age for the formation base. He suggested a probable Frasnian age for the upper part of the formation. Chi (*in* Embry and Klovan, 1976) indicated that the formation ranged from Middle Givetian (*macromanifestus* Zone) to Early Frasnian (*médius* Zone) south of Baumann Fiord. Fish collected from the Hecla Bay Formation ("lower sandstone member of the Okse Bay Formation") near Goose Fiord indicate an early Late Devonian age (Kiaer, 1915).

FRAM FORMATION

INTRODUCTION

Proposed by Embry and Klovan (1976), the Fram Formation is composed of alternating beds of sandstone and red and green shales and siltstones, and lies conformably between the Hecla Bay and Hell Gate formations. Its type section is located just south of Okse Bay. In the study area, the formation occurs from Vendom Fiord to Goose Fiord, and varies in

thickness from 1125 m to 1480 m (McGill, 1974; Embry and Klovan, 1976).

DESCRIPTION AND DEPOSITIONAL ENVIRONMENT

The Fram Formation consists of an alternation of resistant, fine grained, quartzose sandstone and recessive shale and siltstone units arranged in fining upward cycles, in which the shales and siltstones predominate. The base of the sandstone units are marked by scour surfaces, above which shale and limestone pebbles form thin conglomerates. Fossils are rare, and comprise plant and fish fragments. Sedimentary structures include trough cross-stratification, current ripple cross-lamination, groove and prod marks, and desiccation cracks. Paleocurrent data from the Bird Fiord region (Embry and Klovan, 1976) indicates a direction of 237°.

Both Embry and Klovan (1976) and Rice (1982) suggest deposition of the Fram Formation in a meandering stream environment. The sandstones represent point bar and channel fill deposits, and the shales and siltstones overbank deposits.

AGE IN THE STUDY AREA

Chi (*in* Embry and Klovan, 1976) indicated an age of Early to Middle Frasnian for the formation south of Baumann Fiord, on the basis of spores of the *media* and *maclarenii* Zones. Nathorst (1904) and Kiaer (1915), based a Late Devonian age for the formation in the Goose Fiord region on plant and fish collections made by the Fram expedition.

HELL GATE FORMATION

INTRODUCTION

The Hell Gate Formation was named for a unit of white sandstone outcropping along the east side of Okse Bay conformably underlain and overlain by the Fram and Nordstrand Point formations (Embry and Klovan, 1976). In the study area, the formation outcrops in the region south of Baumann Fiord and north of Goose Fiord. Its thickness is 637 m (Embry and Klovan, 1976).

DESCRIPTION AND DEPOSITIONAL ENVIRONMENT

The Hell Gate Formation is composed of white, fine grained sandstone, with subordinate, interbedded siltstone and shale, very similar to the Hecla Bay Formation. Fossils include plant debris and rare fish remains. Trough and planar cross-beds are the predominant sedimentary structures.

Embry and Klovan (1976) interpreted the sediments as deposits of a braided fluvial environment.

AGE IN THE STUDY AREA

Embry and Klovan (1976), on the basis of ages derived for the supra- and subjacent formations, dated the Hell Gate Formation as Middle Frasnian (*maclarenii* Zone).

NORDSTRAND POINT FORMATION

INTRODUCTION

Embry and Klovan (1976) proposed the Nordstrand Point Formation for an alternating sequence of predominantly red weathering shale and siltstone and subordinate sandstone arranged in fining upward cycles. Thin coal seams are common. Its type section is located 1 to 6 km south of Okse Bay, and is over 674 m thick. The formation is restricted to a small area between Goose Fiord and Okse Bay, due mainly to post-Devonian erosion.

DESCRIPTION AND DEPOSITIONAL ENVIRONMENT

Lithologically, the Nordstrand Point Formation closely resembles the Fram Formation, and has likewise been interpreted as being of meandering fluvial origin. Embry and Klovan (1976) report paleocurrent directions averaging 239°.

AGE IN THE STUDY AREA

Palynological analysis by Chi (*in* Embry and Klovan, 1976) has shown that of the formation is Middle Frasnian (*maclarenii* Zone) and that the upper part of the formation is Late Frasnian (*devonica* Zone).

CHAPTER 4

DEPOSITIONAL MODELS, PALEOGEOGRAPHY, AND DEVONIAN TECTONIC HISTORY OF SOUTHERN ELLESMERE ISLAND

INTRODUCTION

In Chapter 3, the lithofacies in the Devonian formations of southern Ellesmere Island are described, and the depositional environment of each is interpreted. This information is integrated in this chapter to develop a carbonate platform model, and to draw paleogeographic maps. This chapter also discusses the newly named Inglefield Uplift, which is incorporated in an overall model for the Devonian tectono-sedimentary history of southern Ellesmere Island.

DEPOSITIONAL MODEL

In the Early Devonian, southern Ellesmere Island was occupied by a carbonate platform, which was later overwhelmed in the Middle and Late Devonian by fluvial clastic sediments. On this platform, a number of facies, outlined in Chapter 3, were deposited. In a seaward direction, these facies belts include: (a) tidal flat deposits of light coloured, fine grained fenestral dolostone and lime mudstone, and eolian siltstone/sandstone (Goose Fiord Formation; Lithofacies 1, 2, and 4 of Disappointment Bay Formation), (b) nearshore estuarine deposits of dark coloured, faunally-restricted, argillaceous limestone (Lithofacies 1 of Blue Fiord Formation), (c) shallow subtidal deposits of thin bedded, fossiliferous lime wackestone (Lithofacies 3 of Disappointment Bay Formation; Lithofacies 2 of Blue Fiord Formation), (d) shallow buildups/banks, which did not form a continuous barrier, of coral-and/or crinoid-rich limestone(Lithofacies 3 and 4 of Blue Fiord Formation), (e) sub-wave base deposits of diversely and abundantly fossiliferous argillaceous wackestone (Lithofacies 2 of Eids Formation; Lithofacies 5 of Blue Fiord Formation), (f) coral boundstone and bryozoan lime mudstone, developed in a "downslope" position (Lithofacies 4 of Eids Formation; Lithofacies 6 and 7 of Blue Fiord Formation), (g) slope periplatform lime mudstone and pelagic shale (Cape Phillips Formation; Lithofacies 1 of Eids Formation; Lithofacies 8 of Blue Fiord Formation), and interbedded skeletal turbidites (Lithofacies 3 of Eids Formation; Lithofacies 9 of Blue Fiord Formation), and (h) basinal deposits of laminated limestone and shale (distal turbidites)(Cape Phillips Formation; Lithofacies 1 of Eids Formation; Lithofacies 10 of Blue

Fiord Formation).

There are 2 major types of carbonate platforms developed on continental margins: (1) carbonate ramps (Ahr, 1973) are gently sloping (less than 1°) platforms, in which the nearshore zone generally consists of a wave-agitated facies that passes downslope into deeper water, low energy deposits. They differ from (2) rimmed shelves (Ginsburg and James, 1974) in lacking continuous reef trends, and sediment gravity-flow deposits containing shallow water clasts. Read (1982) subdivided carbonate ramps into 2 types (homoclinal and distally steepened), and rimmed shelves have been classified into 3 types by McIlreath and James (1979) (depositional or accretionary, bypass, and erosional). Read (1982) summarized the characteristics and facies belts of each type of carbonate platform. The turbidite facies of distally steepened ramps contain material derived from the deep ramp and slope, and lack the platform-derived material that is present in the skeletal turbidites of the Eids and Blue Fiord formations. Exotic blocks derived from the shelf edge, not present in the Lower Devonian platform sequence of southern Ellesmere Island, are common in the bypass and erosional margin types of rimmed shelves. Therefore, the homoclinal ramp and accretionary rimmed shelf models best fit the Lower Devonian rocks of southern Ellesmere Island.

The Lower Devonian carbonate platform of southern Ellesmere Island has attributes of both of the above platform models. The following outlines the general facies belts in the above 2 models as outlined by Read (1982), and notes where and if they occur:

(1) homoclinal ramp - tidal flat carbonates (facies belt a of above) and associated lime sand flats (rare

intraclast/peloidal sand microfacies of Lithofacies 2, Disappointment Bay Formation) pass seaward into lagoonal skeletal wackestone (facies belts b and c), into shallow ramp buildups and skeletal sands (facies belt d) or ooid/peloid sands (absent), into deep ramp argillaceous lime wackestone with a diverse biota, whole fossils, local storm generated sequences, and downslope buildups (facies belts e and f), into slope and basinal pelagic and periplatform lime muds and shale (facies belts g and h). They generally lack significant sediment gravity flow deposits containing clasts of shallow platform material, and continuous reef trends are absent.

(2) accretionary rimmed shelf - tidal flat carbonates (facies belt a) pass seaward into lagoonal muds and wackestone (facies belts b and c), into shelf edge skeletal sands and reefal carbonates (facies belt d), into periplatform foreslope sands (Lithofacies 9 of Blue Fiord Formation?) and breccias (absent), into lower slope/basin turbidites and lime mud (facies belt g) and breccias containing cemented clasts of reefal and skeletal limestone (absent), into deep water pelagic and periplatform lime muds, distal turbidites, and shale (facies belt g and h).

There are 2 differences between a typical homoclinal ramp and the Lower Devonian platform of southern Ellesmere Island. Firstly, homoclinal ramps generally lack significant sediment gravity flow deposits

containing platform-derived material. However, Read (1980, p. 1600) has noted allochthonous ramp-derived skeletal sands in the slope facies of the Middle Ordovician ramp to basin transition of the Virginia Appalachians. Secondly, the lime sand flat facies which is generally interbedded with the tidal flat facies in homoclinal ramps is very rare (only units HC40 and KA48). This rarity of grainstone was also noted by Read (1980, p. 1593) in the northwestern part of the Middle Ordovician ramp of the Virginia Appalachians. There, lime wackestone/mudstone with a restricted biota, similar to Lithofacies 1 of the Blue Fiord Formation, was deposited in a nearshore depositional environment. Read (1980) explained this lack of grainstone by invoking lower energy conditions in that part of the ramp.

There are 2 differences between the accretionary rimmed shelf platform model and the Lower Devonian platform of southern Ellesmere Island. Firstly, the absence of the abundantly fossiliferous argillaceous wackestone facies (facies belt e) in typical accretionary rimmed shelves, and secondly, the presence of a foreslope lime sand and breccia facies in typical accretionary rimmed shelves. The absence of cemented clasts of platform derived material suggests relatively gentle slopes into the basin (Read, 1980, p. 1600). However, Bebout and Loucks (1974), in their study of the Cretaceous Stuart City shelf of south Texas, which was classified by Read (1982, p. 202) as an accretionary rimmed shelf with a gentle slope, reported very little forereef talus. They also noted a facies in an upper slope position with a very diverse and abundant fauna which contains isolated coral patch reefs and banks, similar to facies belts e and f above.

The carbonate platform of southern Ellesmere Island could be classified as either a homoclinal ramp or an accretionary rimmed shelf with a gentle slope, based on the above discussion. However, because platform derived gravity flow deposits are generally not associated with homoclinal ramps, the Lower Devonian carbonate platform of southern Ellesmere Island is classified here as a gently sloping accretionary rimmed shelf. Figure 4-1 shows the depositional model for the Lower Devonian carbonate sequence of southern Ellesmere Island. It consists of a tidal flat (facies belt a), a lagoon with associated estuarine deposits (facies belts b and c), a shelf margin (facies belt d), an upper slope (facies belt e) with associated downslope buildups (facies belt f), a lower slope (facies belt g) and a basin (facies belt h). This model (Fig. 4-1) resembles the Type II carbonate shelf margin (sand shoals and knoll reefs) of Wilson (1974), which has a gentle slope, and develops in quiet seas. Also, James and Mountjoy (1983) noted that, when carbonate sand shoals form the shelf margin, skeletal sand turbidites (Lithofacies 3 of Eids Formation; Lithofacies 9 of Blue Fiord Formation) commonly occur on the slope.

EARLY DEVONIAN PALEOGEOGRAPHY

The depositional model outlined above (Fig. 4-1), in conjunction with the geographic and stratigraphic distribution of the facies (Fig. 3-1) enables paleogeographic maps to be drawn for selected time periods in the Lower Devonian sequence.

The general temporal and geographic distribution of the facies is as follows: (a) fluvial - only east of Vendom Fiord in Early to Late Zlichovian time (Vendom Fiord Formation); (b) tidal flat - mainly in a belt extending from Goose Fiord to the region east of Vendom Fiord throughout the Early Devonian (Goose Fiord, Vendom Fiord and Disappointment Bay formations), but also west of Vendom in the Early Dalejan (Disappointment Bay tongue); (c) estuarine - only west of Vendom Fiord in the Late Zlichovian (lower Blue Fiord Formation); (d) shelf - mainly west of Vendom Fiord in the Late Zlichovian - Dalejan (Blue Fiord Formation), but also in Goose Fiord to Grise Fiord region in Late Dalejan (Disappointment Bay Formation) and south of Baumann Fiord in Late Dalejan (Blue Fiord Formation); (e) shelf margin - west of Vendom Fiord in the Late Zlichovian (lower Blue Fiord Formation), and south of Baumann Fiord in the Early to Late Dalejan (upper Blue Fiord Formation); (f) upper slope - mostly south of Baumann Fiord in Early to Late Zlichovian (upper Eids and lower Blue Fiord formations); (g) downslope buildups - only south of Baumann Fiord in the Early to Late Zlichovian (upper Eids, lower and middle Blue Fiord formations); and (h) lower slope and basin - south of Baumann Fiord throughout the Early Devonian (Cape Phillips, Eids, and Blue Fiord formations) and west of Vendom Fiord in the Lochkovian and

Pragian (Cape Phillips Formation).

Paleocurrent indicators are useful in the reconstruction of paleogeographic maps. Cross-stratification in the fluvial deposits of the Vendom Fiord Formation east of Vendom Fiord indicates a land area to the east of Vendom Fiord. Scour-produced groove casts in the distal turbidite (basinal) facies of the Blue Fiord Formation south of Baumann Fiord indicate a flow direction (source) from either the north or the south. Due to the distribution of the other facies, and the presence of the Canadian Shield (land area) to the south and the Hazen Trough to the north of the area in Early to Middle Paleozoic time (see Chapter 2), it is probable that the turbidites originated from a shelf area located to the south of Baumann Fiord.

With the above information, paleogeographic maps of selected time periods in the Lower Devonian can be constructed (Figs. 4-2, 3, 4, 5). For the Lochkovian interval (Fig. 4-2a), only a partial reconstruction can be made because only the tidal flat facies (Goose Fiord Formation) and the slope and basin facies (Cape Phillips Formation) are at present exposed. A carbonate shelf is presumed to have separated these 2 facies in Lochkovian time. The facies belts trend generally east-west south of Baumann Fiord, and swing markedly to trend north-south in the Vendom Fiord region. Figure 4-2b (Pragian) shows a similar paleogeography to that of the Lochkovian, but the unconformity in the Makinson Inlet region indicates emergence of a land area (Inglefield Uplift). In the Early Zlichovian (Fig. 4-3a), the Makinson Inlet region was still emergent, and alluvial and fluvial sediments of the Vendom Fiord Formation were fed from this source. Tidal flat deposits (Goose Fiord and Vendom Fiord formations) were

deposited seaward of these terrestrial facies. Rivers emptying into the shelf region west of Vendom Fiord created a clastic shelf (Eids Formation) that contrasted with the carbonate shelf south of Baumann Fiord. The existence of this carbonate shelf beneath the Schei Syncline is postulated to give a source area for the crinoidal turbidites and periplatform ooze (upper Eids and lower Blue Fiord formations) deposited on the slope between Blue and Sör Fiords. Downslope buildups (Eids and Blue Fiord formations) established themselves, and one grew upwards towards sea level ("Camp C" buildup, see Chapter 5). In the Late Zlichovian (lower *P. inversus* Zone) (Fig. 4-3b), a transgression drowned the downslope buildup south of Baumann Fiord, and created basinal environments east of Blue and Eids fiords. An estuarine facies (lower Blue Fiord Formation) developed west of Vendom Fiord due to the freshwater discharge onto the shelf by rivers depositing the Vendom Fiord Formation east of Vendom Fiord. The Early Dalejan (middle to upper *P. inversus* Zone) (Fig. 4-4a) was a period of progradation, marked by the encroachment of the tidal flat facies west of Vendom Fiord (tongue of Disappointment Bay Formation), and the presence of shelf margin crinoid banks south of Baumann Fiord (upper Blue Fiord Formation, unit BC7), which had prograded over slope lime mudstones deposited in the Late Zlichovian. A transgressive event in the early Late Dalejan (uppermost *P. inversus* Zone) (Fig. 4-4b) resulted in the landward displacement of the tidal flat facies by the subtidal shelf facies. This event is recorded from the Goose/Muskox Fiords region (e.g. units FA36, KA49), Grise Fiord (middle member Disappointment Bay Formation) and Vendom Fiord regions (e.g. unit

GC 26-28). However, this transgressive event was not recorded south of Baumann Fiord, where the shelf margin appears to have remained stationary since the Early Dalejan (Fig. 4-4a). If the transgression was caused by a relatively minor relative sea level rise, it could have encroached a great distance on the low sloping shelf, but would not greatly affect the facies developed at the more steeply sloping shelf margin. In the Late Dalejan (middle to upper *P. serotinus* Zone) (Fig. 4-5a), the rate of carbonate production exceeded the rate of relative sea level rise, and the tidal flat facies prograded northwards and westwards, as in the Early Dalejan (Fig. 4-4a). The shelf reached its greatest seaward extent during the Early Devonian at this time, and the shelf margin probably reached as far north as Eids Fiord and as far west as Svarte Fiord.

Smith and Stearn (1980) noted that the paleogeography of southern Ellesmere Island in the Early Devonian, especially in the Zlichovian stage, closely resembles that in the Early Silurian (Late Llandoverian) (Fig. 4-5b) as illustrated by Mayr (1973). The shelf margin was in essentially the same position in the Llandoverian and Zlichovian stages. Also noteworthy is the presence of downslope buildups in both stages in similar geographic locations. Mayr (1973) called these shelf carbonates, but recent work by Mayr *et al.* (1978) and Poey (1980) has shown their reefoid nature. The size of the Llandoverian downslope buildup shown in Figure 4-5b is hypothetical, as data is only available from east of Blue Fiord and on Hoved Island, and there is no evidence of a connection between these 2 areas. This roughly parallel distribution of facies belts in the Llandoverian and Zlichovian stages has an economic application, as the outcropping

Zlichovian carbonates can then be used to predict the distribution of the subsurface Llandoverian reservoirs (see Chapter 9 on Economic Geology).

Recent studies in the northern Bahamas have outlined features of windward and leeward shelf margins. These studies have shown the strong influence of wind direction on the distribution of carbonate sediments. In general terms, windward margins are dominated by on-bank transport of shallow water sediment, and leeward margins by off-bank transport (Hine and Neumann, 1977; Mullins and Neumann, 1979; Hine *et al.*, 1981a). Hine and Mullins (1983) noted that most modern sand shoal-dominated rimmed shelf margins are located along the leeward sides of carbonate platforms. Reefs dominate the windward margin of modern carbonate platforms. James and Mountjoy (1983) have also noted this correlation in fossil carbonate platforms. Another feature characterizing leeward carbonate bank margins is a stratigraphic sequence of reefs overlain by carbonate sand bodies (Hine and Mullins, 1983). The above criteria suggest that the Lower Devonian carbonate shelf of southern Ellesmere Island was developed on a leeward-open margin (classification of Hine *et al.*, 1981b, p. 288) - the shelf margin is dominated by sand (crinoid) banks, off-bank transport of shelf material is common (skeletal turbidites, periplatform ooze), and, west of Vendom Fiord, "reefs" (units ED48, HA2, 4, HC2) are overlain by carbonate sand bodies (units ED41, 44, HA6, 8). This implies an offshore paleowind direction, probably from the east or southeast.

The eolianite developed near the base of the Disappointment Bay Formation at section FA comprises mostly quartz and feldspar that probably was derived from the Precambrian Shield to the east, and

therefore also implies a paleowind blowing from the east or southeast. Shinn (1973, p. 209) considered coastal eolianites to have developed on leeward coasts, which corroborates the above paleowind direction. Stanton (1967) noted that talus tends to develop on the windward margins of reefs. The talus deposit developed on the southern margin of the "Camp C" reef (see Chapter 5 on carbonate buildups) suggests an offshore paleowind direction from the south.

The above information on the type and distribution of sediment suggest that the Lower Devonian carbonate platform sequence of southern Ellesmere Island developed on a leeward margin, with the wind-direction from the east or southeast.

Early Devonian global paleogeographic studies (see Chapter 5 for references) indicate a paleolatitudinal position for southern Ellesmere Island ranging from 13° S to 30° N. In Chapter 5, it is concluded, on the basis of the global distribution of Lower Devonian buildups, that the North American continent is best positioned completely within the tropical belt. This reconstruction places southern Ellesmere Island at approximately 15° N latitude in the Early Devonian. At present, land masses positioned in this latitude are affected by easterly trade winds (Perry and Walker, 1977). Drewry *et al.* (1974) suggested that the present general pattern of atmospheric circulation has not changed substantially throughout much of Phanerozoic time. Therefore, it can be concluded that southern Ellesmere Island was affected by easterly trade winds in Early Devonian time. This paleowind direction based on paleolatitudinal position corroborates the easterly/southerly paleowind direction derived using the type and distribution of sediment from the Lower Devonian sequence of southern Ellesmere Island.

APPLICATION OF DEPOSITIONAL MODEL OUTSIDE OF SOUTHERN ELLESMERE ISLAND

INTRODUCTION

The depositional model for the Lower Devonian carbonate succession of southern Ellesmere Island is based on field data gathered during this study. The following section attempts to apply this model, using published lithologic data, to other Emsian-Eifelian carbonate platform sequences outcropping north and west of the study area. Most of these platform sequences presumably were part of the same platform that extended in the Lower to Middle Paleozoic from Ellesmere Island in the east to Banks Island in the west, and thence onto the mainland.

CENTRAL ELLESMERE ISLAND (Figure 4-6)

Figures 3-4 and 3-6 show the distribution of the Late Emsian Disappointment Bay and Blue Fiord formations, and the data points available for paleogeographic reconstruction. Kerr (1976) and Trettin (1978) have described the Disappointment Bay Formation of this area. It consists of light coloured fenestral dolostones and lime mudstones (Lithofacies 1 and 2 of Disappointment Bay Formation), with minor siltstone (Lithofacies 4), deposited in a tidal flat environment. The Blue Fiord Formation has been briefly described by Kerr (1976) as medium grey-brown, thin to medium bedded shaly limestone (Localities 2 and 3 of Fig. 3-6), possibly similar to Lithofacies 8 of the Blue Fiord Formation (lower slope). No description is available for Locality 4 of Figure 3-6. Figure 4-6 shows the inferred Late Emsian paleogeography of central Ellesmere Island.

NORTHWEST DEVON ISLAND

Uyeno (*in* Thorsteinsson, 1980) dated the Disappointment Bay Formation of northwest Devon Island as in the *P. inversus* Zone of Late Zlichovian to Early Dalejan age. There, the formation consists of 2 lithofacies. First, a light to medium brown, fine grained, unfossiliferous, vuggy dolostone, which appears to be similar to the Disappointment Bay Formation (Lithofacies 1) on Ellesmere Island that was deposited in a tidal flat environment. This lithofacies has been reported by McLaren (1963b) from just north of the mouth of Arthur Fiord (Tucker River), by McLaren (1963c) from the Colin Archer Peninsula, by Thorsteinsson (1963) from the head of Prince Alfred Bay (Sutherland River), and by Morrow and Kerr (1977) from west of Arthur Fiord. Second, a brownish-grey, medium bedded, fossiliferous limestone with abundant crinoids and brachiopods, similar to the Disappointment Bay Formation (Lithofacies 3) on Ellesmere Island that was deposited in a nearshore shelf environment. This lithofacies usually underlies the vuggy dolostone lithofacies, and has been reported by all the above authors.

Thus, a tidal flat and nearshore shelf environment occupied northwest Devon Island in the Late Emsian.

CORNWALLIS ISLAND

The dolostone member of the Disappointment Bay Formation on Cornwallis Island has been dated as Late Emsian (*P. inversus* Zone) by Uyeno (*in* Thorsteinsson, 1980). It consists of light grey-brown, medium bedded porous dolostone (Thorsteinsson and Kerr, 1968), similar to the Disappointment Bay Formation (Lithofacies 1, tidal flat)

on Ellesmere Island. The overlying limestone member of the Disappointment Bay Formation consists of lithographic, medium bedded limestone (Thorsteinsson and Kerr, 1968), similar to the Disappointment Bay Formation (Lithofacies 2, tidal flat) on Ellesmere Island, and has been dated as Eifelian in age (Uyeno and Klapper, 1980). The distribution of these 2 facies on Cornwallis Island is shown in Figure 3-3.

Thus, in Late Emsian through Eifelian time, Cornwallis Island was occupied by a tidal flat.

BATHURST ISLAND (Figures 4-7a, b)

The Late Emsian to Eifelian carbonate platform sequence of Bathurst Island was examined during 3 days of helicopter-supported field work. The data gathered in this survey were augmented by those previously published by Ormiston (1967) and Kerr (1974). Smith and Stearn (1981a) briefly compared the facies present in the Disappointment Bay and Blue Fiord formations on Bathurst Island and Ellesmere Island.

The Eids and Disappointment Bay (dolostone member) formations comprise the Late Emsian sequence, and have been studied by Kerr (1974), and dated by McGregor and Uyeno (1972) and Kerr (1974). The Eids Formation is composed of 2 lithofacies: (1) dark grey-black calcareous shale, similar to the Eids (Lithofacies 1) and Blue Fiord formations (Lithofacies 10, basinal) on Ellesmere Island (Localities 1 to 4 on Figure 4-7a), (2) dark grey, thin bedded, argillaceous limestone and calcareous mudstone and interbedded calcareous shale, similar to the Eids (Lithofacies 1) and Blue Fiord formations (Lithofacies 8, lower

slope) on Ellesmere Island (Localities 5 to 13 on Figure 4-7a). The Disappointment Bay Formation consists entirely of light brown, vuggy, sucrosic dolostone, similar to the Disappointment Bay Formation (Lithofacies 1, tidal flat) on Ellesmere Island (Localities 14 to 19 on Figure 4-7a, and B30 and B42A on Figure 1-6). No fossiliferous shelf facies is exposed, but it is possible that extensive dolomitization has destroyed its texture. Figure 4-7a illustrates the Late Emsian paleogeography of Bathurst Island.

The Eifelian sequence on Bathurst Island is represented by the limestone member of the Disappointment Bay Formation, and the Blue Fiord Formation. A tidal flat facies (Disappointment Bay Formation, limestone member) is represented by light grey-brown, poorly fossiliferous lime mudstones, similar to the Disappointment Bay Formation (Lithofacies 2) on Ellesmere Island (Localities B22, B30, B42A, B42B of Fig. 1-6, and Locality 3 of Fig. 4-7b). Dark grey-brown, thin bedded, fossiliferous lime wackestone with an abundant and diverse Eifelian coral fauna (Localities B22, B37, B39 of Fig. 1-6 and Locality 5 of Fig. 4-7b), and scattered bioherms (Locality 6 of Fig. 4-7b) of the Blue Fiord Formation represent the shelf and shelf margin facies, similar to the Blue Fiord Formation (Lithofacies 2 and 3) on Ellesmere Island. A deeper water slope and basin facies (Blue Fiord Formation) consists of medium to dark grey-brown, medium bedded, poorly fossiliferous lime mudstone and interbedded calcareous shale (Localities B19, B20, B25, B43, B44 of Fig. 1-6, and Localities 1, 2, and 4 of Fig. 4-7b) is similar to the Blue Fiord Formation (Lithofacies 8 and 10) on Ellesmere Island. Biostromal beds at Locality 4 (Fig. 4-7b) possibly represent downslope buildups (Lithofacies 6 of Blue Fiord Formation on

Ellesmere Island). The skeletal turbidite facies of Ellesmere Island has not been recognized on Bathurst Island. This suggests lower slopes on the Emsian-Eifelian carbonate platform of Bathurst Island than on the Lower Devonian platform of southern Ellesmere Island, and implies the presence of a ramp in the Emsian-Eifelian of Bathurst Island.

The Eifelian paleogeography of Bathurst Island is illustrated in Figure 4-7b.

CAMERON, VANIER, AND MELVILLE ISLANDS (Figure 4-8)

The Late Emsian to Eifelian carbonate sequence in the subsurface of Cameron and Vanier Islands has been studied and dated by Uyeno and Mayr (1979) and Mayr (1980). Tozer and Thorsteinsson (1964) studied a coeval carbonate succession outcropping in the Weatherall Bay area of Melville Island, and Uyeno and Mason (1975) dated the sequence as ranging from Late Emsian to Eifelian in age. Three major lithofacies are present. First, light brownish-grey, poorly fossiliferous lime mudstone with "calcite blebs" (fenestrae) and scattered *Dendrostella trigemme* and *Amphipora* occurs in the subsurface of Cameron Island (mainly Locality 7 of Fig. 4-8) and south and east of Weatherall Bay (Localities 1, 2, and 3 of Fig. 4-8). This lithofacies is analogous to the Disappointment Bay Formation (Lithofacies 2, tidal flat) on Ellesmere Island. Second, fossiliferous limestone, with abundant corals, stromatoporoids and crinoids commonly occurs on Cameron Island (Localities 6 and 8 of Fig. 4-8) and possibly occurs at Locality 4 (Fig. 4-8) on Melville Island, although the descriptions of those rocks are poor. This lithofacies is analogous to the Blue Fiord Formation (Lithofacies 2

and 3, shallow water shelf) on Ellesmere Island. And third, dark grey-brown lime mudstone and calcareous shale, with tentaculitids, and crinoidal packstone/grainstone exhibiting graded bedding occurs predominantly at Locality 5 (Fig. 4-8) on Vanier Island. This lithofacies is analogous to the Blue Fiord Formation (Lithofacies 8, 9, and 10) on Ellesmere Island, and represents deposition in a slope and basin environment.

The shallow water facies present on Cameron and Melville Islands are not continuous with the main carbonate platform to the south, and were isolated carbonate buildups in the basin. The fenestral lime mudstone lithofacies probably formed as a "lagoonal" deposit in the centre of an atoll, whose margin was formed of fossiliferous coral/stromatoporoid-rich limestone. The lime mudstone, shale, and graded skeletal packstones/grainstones formed in deeper water surrounding the atoll, and crinoid packstones/grainstones represent turbidites derived from the shallow water atoll facies. The shallow water facies on Cameron Island and northeast Melville Island may have been connected, forming one large atoll (Fig. 4-8 and Daae and Rutgers, 1975) or may have been discrete atolls (Embry and Klovan, 1976; Meneley, 1976; Stuart Smith and Wennekers, 1977; Mayr, 1980).

A similar atoll formed in Late Emsian or Eifelian time on Prince Patrick Island.

BANKS AND VICTORIA ISLANDS (Figure 4-9)

The carbonate platform sequence outcropping on northwest Victoria Island and in the subsurface of Banks Island has been described by Thorsteinsson and Tozer (1962), Ormiston (1967), and Miall (1976).

A Late Emsian age is indicated by conodonts and cricoconarids (Norris, and Uyeno, *in* Miall, 1976; Mayr *et al.*, 1980).

Three formations comprise the sequence - the Disappointment Bay (both limestone and dolostone members), Blue Fiord, and Orksut formations. The Disappointment Bay Formation consists of 3 lithofacies: (1) light grey, peloidal lime mudstone with fenestrae, similar to the Disappointment Bay Formation (Lithofacies 2, tidal flat) on Ellesmere Island (Localities 1 and 11 of Fig. 4-9); (2) dark grey lime wackestone with corals, stromatoporoids and crinoids, similar to the Disappointment Bay Formation (Lithofacies 3, shallow shelf) on Ellesmere Island (Locality 1 of Fig. 4-9); and (3) grey dolostone with *Amphipora* and "mound-like structures", probably deposited in a nearshore environment (Locality 4 of Fig. 4-9). The Blue Fiord Fromation also comprises 3 lithofacies: (1) dark grey, thin to medium bedded, fossiliferous limestone, with abundant brachiopods (*Atrypa, Carinagypa, Schizophoria*), corals (*Alveolites* and *Favosites*), and some pelecypods (*Paracyclas*), which could either belong to Lithofacies 2 (shallow shelf) or Lithofacies 5 (upper slope) of the Blue Fiord Formation on Ellesmere Island (Localities 5, 10, and 12 of Fig. 4-9); (2) interbedded black calcareous shale and argillaceous limestone, with *Styliolina*, sponge spicules, the brachiopod *Chonetes*, and the trilobites *Leonaspis* and *Harpes*, almost identical to the Blue Fiord Formation (Lithofacies 8, lower slope) on Ellesmere Island (Localities 3, 6, 7, and 9 of Fig. 4-9); and (3) very coarse grained, massive, fossiliferous limestone, with abundant large crinoid columnals, corals, and brachiopods, possibly representing part of a large downslope buildup (Lithofacies 6 of the Blue Fiord Formation on Ellesmere Island), which occurs on the larger of the Princess Royal Islands

(Locality 8 of Fig. 4-9). The Orksut Formation is composed of dark grey calcareous shale and dolomitic mudstone with cricoconarids, similar to Eids Formation (Lithofacies 1, lower slope and basin) on Ellesmere Island (Locality 2 of Fig. 4-9).

The Late Emsian paleogeography of Banks and Victoria Islands is shown in Figure 4-9. The facies appear to be similar to those of Late Emsian age on Ellesmere Island. However, further field work would be required for a definite comparison to be made.

Figure 4-10 integrates all the information presented above into a generalized Late Emsian/Early Eifelian paleogeographic map of the Canadian Arctic Islands. The facies belts cannot be traced into northern Greenland due to a lack of Lower Devonian strata in that region (Dawes, 1976; J.M. Hurst, written comm., 1981). However, beds of this age are common flanking the craton in the northern Yukon Territory and District of MacKenzie. There, the Bear Rock, Gossage, Sombre, Arnica and Landry formations represent tidal flat and lagoonal deposits, the Manetoe Formation represents shelf margin deposits, and the Funeral and Prongs Creek formations comprise the slope and basin facies (Lenz, 1972; Chatterton, 1978; Perry and Lenz, 1978). The fossiliferous limestone lithofacies does not appear to be present, but may have been dolomitized. Lenz (1972, Fig. 11) and Perry and Lenz (1978, Fig. 4) show the distribution of these facies in northwestern Canada. Further discussion is beyond the scope of this thesis.

DEVONIAN TECTONO-SEDIMENTARY HISTORY OF SOUTHERN ELLESMERE ISLAND

From the above information on lithofacies, depositional models, and paleogeography, the Devonian tectono-sedimentary history of southern Ellesmere Island can be reconstructed. This has also been discussed by Smith and Stearn (1982b).

Figure 4-11 shows the Devonian lithostratigraphy at 5 localities on southern Ellesmere Island: (1) south of Eids Fiord, (2) east and south of Blue Fiord, (3) west of Vendom Fiord, (4) Goose and Muskox Fiords, and (5) east of Vendom Fiord. The line of section A-A' (see inset of Fig. 4-11) was chosen (i) to illustrate the variety of marine facies occurring in the Lower Devonian sequence, and (ii) to incorporate published information describing the Middle and Upper Devonian succession. In general, sections 1, 2, and 3 show a progressive upward change from dark grey shales and thin bedded lime mudstones of the Cape Phillips, Eids, and Blue Fiord formations, though lime mudstones and subordinate shales of the Eids and Blue Fiord formations, through the fossiliferous limestones of the Blue Fiord Formation and the fenestral lime mudstones of the Disappointment Bay Formation, through the fossiliferous sandy limestones, siltstones, and sandstones of the Blue Fiord and Bird Fiord formations, through the red-weathering siltstones, sandstones, and rare limestones of the Strathcona Fiord Formation, and into the alternating sequence of resistant sandstones (Hecla Bay and Hell Gate formations) and more recessive siltstones, shales, and sandstones (Fram and Nordstrand

Point formations). In Figure 4-12, the succession is interpreted as an upward environmental change from basin to slope, through shelf and tidal flat, into deltaic and meandering fluvial/marginal marine, and finally into an alternation of braided and meandering fluvial environments. This shallowing upwards sequence at these 3 localities records the infilling of the Franklinian Basin, accomplished by progradation of the Lower Devonian carbonate facies present on the shelf over the deeper water sediments of the slope and basin. Later, in the Middle and Upper Devonian, the carbonate realm was overwhelmed by clastics deposited in fluvial environments. Sections 4 and 5 were occupied throughout most of Early Devonian time by dolostones of the Goose Fiord, Vendom Fiord, and Disappointment Bay formations. Conglomerates and sandstones were also deposited east of Vendom Fiord (Vendom Fiord Formation). Fossiliferous limestones and sandstones of the Disappointment Bay (Lithofacies 3) and Bird Fiord formations were deposited at three intervals at section 4 (Goose and Muskox Fiords). This sequence is overlain, as at sections 1 to 3, by an alternation of recessive siltstones, shales and sandstones (Strathcona Fiord, Fram and Nordstrand Point formations) and resistant sandstones (Hecla Bay and Hell Gate formations) of the Okse Bay Group. Figure 4-12 shows that this sequence records an Early Devonian tidal flat invaded periodically by shelf environments (3 transgressions), with alluvial fan and braided fluvial environments in the Zlichovian east of Vendom Fiord. This sequence was later covered by fluvial clastics of the Okse Bay Group as the Franklinian Basin infilled. The 3 late Early Devonian transgressions correlate well with those recognized by Johnson (1982) in the *P. inversus* Zone of Euramerica, and by Lenz (1982) in the Zlichovian and

Dalejan of western and northern Canada.

In any progradational succession, the time lines cross facies boundaries. This tenet is well illustrated in the Lower Devonian sequence of southern Ellesmere Island (Fig. 4-12), where time lines marking the Early/Late Zlichovian boundary and the 2 (lower and uppermost) *P. inversus* Zone transgressions cross from deeper water slope and basin environments into the tidal flat environment, showing that these facies coexisted and prograded with time over one another. This progradation was interrupted three times in the Early Devonian by transgressive events. Figure 4-12 also shows that the fluvial clastics of the Middle to Upper Devonian Okse Bay Group spread rapidly across southern Ellesmere Island, so that time lines do not transect facies boundaries (Middle/Late Devonian boundary, and Middle Frasnian time lines of Fig. 4-12).

Progradation occurs when the rate of sedimentation is greater than that of subsidence. Progradation may take place in spite of rising sea level if there is sufficient sediment supply to continue building the land seaward. At certain times in the Early Devonian of southern Ellesmere Island, rising sea level halted progradation, and caused a landward retreat of the facies belts. However, the uppermost *P. inversus* Zone transgression at section 2 (Fig. 4-12) did not cause the shelf margin to retreat, probably due to the higher rate of sediment accumulation in the shelf margin environment and to the slopes at the margin steeper than the gentle slopes of the shelf and tidal flat. Schlager (1981) noted that carbonate platform margins commonly prograde in the geologic record due to the high rates of sediment accumulation there. He listed accumulation rates of prograding

platforms from the geologic record (Schlager, 1981, Table 2). These range from 30 to 500 µm/yr. (average 105 µm/yr.), uncorrected for compaction. Subsidence in sedimentary basins was estimated as between a few tens and hundreds of µm/yr., slightly less than the rates of sediment accumulation quoted above. This is what would be expected in prograding platforms.

A rough estimate of sediment accumulation rate in the Lower Devonian platform of southern Ellesmere Island was calculated by dividing the stratigraphic thickness measured by the absolute time span averaged from values in Boucot (1975), Ziegler (1978), and McKerrow *et al.* (1980). The localities chosen were section 2 (Fig. 4-11) where platform rocks are represented by the upper Blue Fiord and lower Bird Fiord formations, and section 3, where the Blue Fiord Formation comprises the entire platformal sequence. The computed accumulation rates are 177 µm/yr. and 137 µm/yr., respectively. These values appear to be in rough agreement with those of similar prograding rock sequences elsewhere.

Therefore, the Lower Devonian sequence of southern Ellesmere Island can be understood in terms of progradation of carbonate lithofacies over deeper water clastic lithofacies, interrupted by periods of transgression. This progradation probably was directed westwards in the Vendom Fiord region, and approximately northwards in the Goose and Muskox Fiords region, perpendicular to the inferred paleoshoreline.

In latest Early Devonian and early Middle Devonian time (see Fig. 4-12), clastic material was introduced onto the shelf, and deltaic conditions predominated. This introduction of clastics records the initial phase of uplift of a land area, which supplied the sandy and silty material to the shelf. As the land area continued to rise in

the Middle Devonian, marine conditions disappeared as terrestrial environments of the Strathcona Fiord Formation gradually encroached. The Goose/Muskox Fiords and eastern Vendom Fiord regions were the first to receive fluvial sediments, in the latest Early Devonian (Fig. 4-12). This is to be expected, as these 2 regions are closest to the presumed Devonian land area. Fluvial environments reached the region west of Vendom Fiord at the end of the Early Devonian, and continued to prograde in a seaward direction, until they encroached into the area east and south of Blue Fiord in Latest Eifelian time (Fig. 4-12). Throughout the remainder of the Devonian, southern Ellesmere Island was characterized by an alternating sequence of braided and meandering fluvial environments, derived from the same land mass that supplied the sediments of the initial clastic pulse in latest Early Devonian to early Middle Devonian.

Three types of evidence can be used to locate this land area that was the source of these clastic sediments: (1) paleocurrent directions in sediments of fluvial origin, (2) composition of clastic sediments, and (3) facies relationships:-

(1) Paleocurrent directions are available from most of the fluvially deposited clastic sediments of southern Ellesmere Island. Roblesky (1979) reported an average direction of 276° for the Vendom Fiord Formation, and a general westsouthwest direction for the Strathcona Fiord Formation. Embry and Klovan (1976) recorded average paleocurrent directions of 260°, 237°, and 239° for the Hecla Bay, Fram and Nordstrand Point formations, respectively. Therefore, paleocurrent measurements from these Devonian formations record a general westsouthwest direction of sediment transport, from a land mass (source)

located to the east.

(2) Clastic sediments derived from petrographically distinct source areas will have different mineralogies. Precambrian Shield areas, such as those on eastern Ellesmere Island and northwest Greenland, consist of gneisses, granulites, and granitic intrusives (Dawes, 1976; Frisch, 1983) and, when eroded, produce sediments in which quartz and feldspar dominate. An area such as Pearya, which contains low grade metasediments, would be expected to have supplied a wide range of clastic fragments such as quartz, feldspar, mica, rock fragments, and chert (Embry and Klovan, 1976). The mineralogy of the Devonian clastic sediments of southern Ellesmere Island is indicative of a Shield provenance.

(3) Facies relationships in the Early Devonian (Figs. 4-2a to 4-5a) suggest a land area situated to the east of Vendom Fiord, in the region of the present Canadian Shield, which supplied the sediments of the Vendom Fiord Formation. The above paleocurrent directions and sediment composition suggest that this land mass also supplied the clastics of the Okse Bay Group.

The above information indicates that a land area composed of Shield rocks was located to the east of the study area in Devonian time. This is in agreement with Embry and Klovan (1976) and Roblesky (1979), who postulated an easterly source for the Devonian clastics of Ellesmere Island. However, radiolarian chert pebbles in a Givetian conglomerate in west central Ellesmere Island indicate derivation from uplifted beds of the Hazen Trough to the north of the study area (Trettin and Balkwill, 1979). Pearya has also been postulated as the source of the Devonian clastics of Ellesmere Island (Thorsteinsson and Tozer, 1970; Christie,

1979, Kerr, 1981). This northern source may have provided some of the clastic material of the Okse Bay Group, but only north and west of the study area.

This eastern land mass that supplied Devonian clastics to the study area is herein named the Inglefield Uplift. The name is derived from the Inglefield Mountains on the eastern coast of Ellesmere Island, and Inglefield Land on the northwest coast of Greenland (Figs. 1-1, and 1-2), both of which were part of this tectonically active land mass. This land area was composed of the Precambrian crystalline rocks of the Canadian and Greenland Shields, that outcrop along the east coast of Ellesmere Island from the southern coastline as far north as Bache Peninsula (Fig. 1-2), and eastwards into the northern part of Inglefield Land on the northwest coast of Greenland (see Dawes and Kerr, (1982, Fig. 2) for distribution of the Precambrian crystalline rocks of eastern Ellesmere Island and northwestern Greenland). These 2 Shield areas are at present separated by the Nares Strait, but, prior to Cretaceous rifting and continental breakup, they were part of a single land mass (Kerr, 1967c).

An uplifted landmass in this region has been previously recognized. Kerr (1967b) was the first to report the "widespread emergence of central Ellesmere Island in latest Early to early Middle Devonian time" (p. 7). Trettin *et al.* (1972, p. 126) and Kerr (1976, p. 15) also referred to an uplifted area on central eastern Ellesmere Island in the Lower Devonian. They ascribed the clastic deposits of the Vendom Fiord Formation to this emergent area, but did not consider the area to be a source for the Okse Bay Group. Trettin (1978, *in* Trettin and Balkwill, 1979, 1982) referred to this uplifted region as the southeasterly

or cratonic Bache Peninsula arch. Roblesky (1979) followed this nomenclature. However, as originally defined (Kerr, 1967c, p. 485), the Bache Peninsula arch "is a narrow positive basement feature... extending from Greenland to Ellesmere Island". Kerr (1967a, Fig. 1) illustrated the Bache Peninsula arch as being a narrow, east-west trending tectonic feature confined to the Bache Peninsula region of Ellesmere Island, and did not include in it the Precambrian Shield of the east coast of Ellesmere Island. Clearly, Kerr (1967c) did not intend the emergent area of central eastern Ellesmere Island to be referred to the Bache Peninsula arch. Besides, the emergent area of eastern Ellesmere Island and northwestern Greenland is not 2-sided in nature, as are arches, but is merely an uplifted region at the margin of the Precambrian craton. Therefore, to avoid further nomenclatural confusion, the eastern landmass that was the source of the clastics of the Vendom Fiord Formation and Okse Bay Group on southern Ellesmere Island is herein referred to as the Inglefield Uplift. Figure 4-13 shows the interpreted location of the Inflefield Uplift. The south-eastern sector of the Inglefield Uplift probably supplied the clastics to the Goose and Muskox Fiords region, but further study of the clastic sediments and paleocurrent indicators is needed to prove this.

Devonian tectonic history of the Inglefield Uplift

Lochkovian to Late Pragian - The Goose Fiord Formation was deposited on the western margin of the Inglefield Uplift. A generally quiescent period.

Late Pragian to Late Zlichovian - Uplift occurred and subaerial erosion of the Goose Fiord Formation began east of Vendom Fiord, producing

the unconformity between the Goose Fiord and Vendom Fiord formations. Continued uplift in the Zlichovian resulted in the deposition of alluvial fan and braided stream sediments of the Vendom Fiord Formation east of Vendom Fiord. The Inglefield Uplift probably consisted, at least initially, of Lower Paleozoic carbonate rocks, as alluvial fan sediments at the base of the Vendom Fiord Formation consist of dolostone cobble conglomerates. As uplift and erosion continued, Precambrian crystalline rocks became exposed.

Late Zlichovian to Late Dalejan - Upward movement of the Inglefield Uplift decreased or halted, and marine conditions encroached over the western boundary of the uplift, depositing the dolostones of the Disappointment Bay Formation.

Late Dalejan to Middle Givetian - A gradual rise of the Inglefield Uplift caused an influx of clastic material into the marine carbonate realm, causing deltaic conditions on the shelf (Bird Fiord Formation). Continued uplift caused progradation of the meandering fluvial sediments of the Strathcona Fiord Formation into the marine environment. Areas closest to the Uplift area (sections 4 and 5 of Fig. 4-12) received fluvial sediments first.

Middle Givetian to Late Frasnian - Continued uplift of the land area created higher slopes and more rapid fluvial discharge, causing a change from meandering (Strathcona Fiord Formation) to braided fluvial (Hecla Bay Formation) conditions. Walker and Cant (1979) outlined the controls on braided and meandering rivers. Embry and Klovan (1976) attributed this change from meandering to braided fluvial conditions to climatic change. They postulated that braided stream deposits occurred in very humid (wet) conditions, and meandering streams in savanna (drier)

conditions. In the Middle to Late Frasnian, a cycle of meandering (Fram Formation) to braided (Hell Gate Formation) back to meandering (Nordstrand Point Formation) fluvial conditions occurred, which probably reflects decreasing (meandering) and increasing (braided) rates of upward movement in the Inglefield Uplift. This would cause changes in the depositional slope of the rivers and therefore affect the type of fluvial development. Embry and Klovan (1976) explained this change by shifts in climatic conditions, but were unable to explain the cause of the shifts. The proposed model of differential rates of uplift (pulses) in the source area better explains these cyclic changes in fluvial style.

Famennian/Early Mississippian - The Ellesmerian Orogeny uplifted the fluvial basin, and ended the Devonian tectonic activity in the Inglefield Uplift.

CHAPTER 5

LOWER DEVONIAN CARBONATE BUILDUPS ON ELLESMERE ISLAND AND WORLDWIDE: THEIR DISTRIBUTION AND EVOLUTION

Deep in the wave is a coral grove,
Where the purple mullet and gold-fish rove;
Where the seaflower spreads its leaves of blue,
That never are wet with the falling dew,
But in bright and changeful beauty shine,
Far down in the green and glassy brine.

- The Coral Grove; J.G. Percival

LOWER DEVONIAN BUILDUPS WORLDWIDE

According to Wilson (1975, p. 119), Upper Silurian and Lower Devonian carbonate buildups are rare, in spite of widespread exposure of Middle Paleozoic rocks in the northern hemisphere. In contrast, Middle and Upper Devonian buildups are very common, and are well documented, for example Western Canada, Belgium, Germany, Western Australia. A literature survey has shown that Lower Devonian buildups are relatively common, and therefore Wilson's statement needs to be modified, at least for the Lower Devonian.

In this study, the term carbonate buildup is used in the sense of Heckel (1974), that is, a carbonate mass which differs from adjacent rocks, and at some time in its development stood topographically higher than the surrounding sediment.

Thirty-six Lower Devonian carbonate buildups have been discovered, including those discovered from Ellesmere Island: 9 in the Gedinnian (Lochkovian) (Figure 5-1), 8 in the Siegenian (Pragian) (Figure 5-2), and 20 in the Emsian (Zlichovian and Dalejan) (Figure 5-3).

Carbonate buildups are more common in the Emsian than in the Gedinnian or Siegenian. In fact, there are more buildups documented in the Emsian (20) than in the Gedinnian and Siegenian combined (16). Is this difference a function of (i) a substantially longer time interval for the Emsian as compared to the Gedinnian or Siegenian, and therefore more time for buildups to grow, (ii) a larger outcrop area of Emsian rocks, and therefore a statistically higher possibility of discovering buildups, or (iii) an increase in the possible number of growth sites of buildups in the Emsian?

Question (i) can be answered by referring to recent published values for the length of the 3 Lower Devonian stages. Boucot (1975) estimated the Gedinnian to have lasted 6 Ma, the Siegenian 6 Ma, and the Emsian 7.4 Ma. Ziegler (1978) estimated the length of the Gedinnian as 5.2 Ma, the Siegenian 4.5 Ma, and the Emsian 9.7 Ma. McKerrow *et al.* (1980) considered the duration of the Gedinnian to be 8 Ma, the Siegenian 5 Ma, and the Emsian 8 Ma. When these time values are averaged, the duration derived for the Gedinnian is 6.4 Ma, the Siegenian 5.2 Ma, Gedinnian and Siegenian combined 11.6 Ma, and the Emsian 8.4 Ma. Evidently, the Emsian stage lasted longer than either the Gedinnian or Siegenian alone, but combined, these 2 stages lasted more than 3 Ma longer than the Emsian. Therefore, the rapid increase in the number of buildups in the Emsian compared to the number in the Gedinnian and Siegenian cannot be explained by a substantially longer time interval for the Emsian stage.

Question (ii) is difficult to evaluate, as little data are available on the outcrop area of the 3 Lower Devonian stages. The histogram of Raup (1976, Fig. 2a), which used worldwide data modified from Blatt and Jones (1975), shows the geologic map area covered by each of the Phanerozoic systems. However, the histogram is not refined enough to illustrate data to the stage level. Sloss (1976) analyzed areas and volumes of Paleozoic and Mesozoic sediments from western North America and the Russian Platform. His graphs show a lack of earliest Devonian sediment in both western North America and the Russian Platform, with a sharp increase in sediment area and volume in approximately Middle Devonian time. Therefore, it appears that no marked increase in the area or volume of sediment occurred in Emsian

time in western North America and eastern Europe to account for the more numerous buildups of this stage.

Question (iii) asks whether the increase in the number of carbonate buildups from the Gedinnian and Siegenian to the Emsian can be explained by an increase in the number of possible growth sites (Smith and Stearn, 1982a). A marine transgression at a continental margin would increase the potential sites available for buildups to become established and grow (Figure 5-4). Sloss (1963), in his work outlining sequences in the North American craton, documented a major transgression in the late Early Devonian (base of Kaskaskia sequence). Johnson (1979, p. 298) considered that the beginning of the major Devonian transgression was coincident with the base of the Pragian (roughly equivalent to the Siegenian) stage. Lenz (1982) also noted this transgression in western and arctic North America. The generalized worldwide sea level curve of Vail *et al.* (1977) showed a major transgression at the base of the Devonian, but the curve has been shown to be inexact in some time periods (Shanmugan and Moiola, 1982). This transgression in late Early Devonian time would account for the sudden increase in the number of carbonate buildups worldwide.

Paleozoic reefs associated with carbonate sediments are generally assumed to have grown in the tropical belt between 30° N and 30° S (Wells, 1957; Heckel and Witzke, 1979; Hill, 1981). This assumption is based on the occurrence of the vast majority of modern reefs in warm, shallow, normal salinity water of the tropical regions. Modern buildups have also been documented in deep, cold water e.g. in the North Atlantic

(Teichert, 1958), and north of Little Bahama Bank (Mullins *et al.*, 1981). The Lower Devonian carbonate buildups documented herein all appear to be associated with typical shallow water, fossiliferous carbonates, and probably grew in the tropical regions. None of the criteria for recognizing ancient deep water buildups have been recognized (Mullins, *et al.*, 1981). Therefore, these climatically indicative rocks can be used to consider the paleogeographic reconstruction of the Lower Devonian continents, usually produced with paleomagnetic data. The 36 Lower Devonian buildups identified worldwide occur in 27 regions. These are plotted on 5 global and 3 North American paleogeographic maps, and are used to evaluate the validity of the continental positionings (Figures 5-5, 6, 7). All the maps were constructed using paleomagnetic data except that of Heckel and Witzke (1979), which used paleoclimatic data.

One of the earliest continental reconstructions was by Smith *et al.* 1973, identical to a later version by Briden *et al.* (1974) (Figure 5-5a). Most of the Lower Devonian buildups occur in the tropical zone between 30° N and 30° S, however 5 buildups (9, 10, 11, 19, and 24), on the present North American and Asian continents, lie outside this tropical zone. To bring these buildups within the Early Devonian tropical zone, the North American continent must be shifted approximately 20° northwards, and the Asian continent approximately 10° southwards. In the later reconstruction of Zonenshayn and Gorodnitskiy (1977) (Figure 5-5b), the Lower Devonian buildups closely follow the tropical belt, except for 2 buildups (12; 19), which suggest that Africa should be shifted 5° northward (and the whole supercontinent of Gondwanaland of which Africa was a part), and that the Siberian continent be shifted similarly southward. Five buildups lie outside the tropical belt when plotted on the paleo-

geographic map of Kanasewich *et al.* (1978) (12, 19, 22, 23, and 24) (Figure 5-6a), indicating that Asia should be shifted southward by 10 to 15°, and Africa (and Gondwanaland) 10° northward. Also in 1978, Morel and Irving produced a map which linked all the continents together to form "Pangea C". On this very different reconstruction, 5 buildups lie outside the tropical belt (12, 19, 22, 23, and 24) (Figure 5-6b), 3 on the Siberian continent, 1 in Africa, and 1 in India. This suggests that the Siberian continent should be shifted southward by approximately 20°, and Africa 10° northward. The west Pakistani buildup (23), located at about 70° S, raises major questions about this reconstruction. The reconstruction of Scotese *et al.* (1979) (Figure 5-7a), identical to that of Ziegler *et al.* (1979), shows 9 buildups outside the tropical belt, 7 of them on the North American continent (1 to 7). The other 2 are on Africa (12) and India (23). These data suggest that North America should be shifted about 10° southward, and the southern supercontinent Gondwanaland about 10° northwards. Figure 5-7b shows 3 different interpretations of the Lower Devonian paleolatitude of North America (Irving, 1979; Heckel and Witzke, 1979; Lapointe and Dankers, 1982). The interpretation of Irving (1979) is in total agreement with the Lower Devonian buildup data. Heckel and Witzke's (1979) reconstruction shows 3 buildups outside the tropical belt (9, 10, 11), indicating that North America should be shifted northwards approximately 15°. The paleogeographic map of Lapointe and Dankers (1982) has 2 buildups (10, 11) plotted outside the tropical region, thus indicating that North America should be shifted northwards approximately 10°.

In summary, the Lower Devonian buildup data demonstrate that the North American continent is best positioned completely within the tropical belt (as in Irving, 1979). Four out of the 5 global reconstructions show

that Siberia/Asia should be shifted approximately 10 to 15° southwards, and Gondwanaland approximately 10° northwards from the continental position indicated using paleomagnetic data. The paleolatitudinal map of Zonenshayn and Gorodnitskiy (1977) best incorporates the Lower Devonian buildup data.

LOWER DEVONIAN BUILDUPS OF SOUTHWEST ELLESMERE ISLAND

Carbonate buildups are common in the Lower Devonian sequence of Ellesmere Island. Most occur in the Blue Fiord Formation, but scattered examples occur in the underlying Eids Formation. The buildups are primarily in the outcrop belt between Blue and Sör Fiords (Figure 5-8). Others crop out west of Vendom Fiord. The buildups are of 3 types: (a) coral/stromatoporoid-rich buildups, (b) crinoid-rich buildups, and (c) bryozoan lime mud mounds. Types (b) and (c) are uncommon, and will not be discussed further here (see Chapter 3 for description and discussion.)

Many of the coral/stromatoporoid-rich buildups on southwest Ellesmere Island are of limited vertical and lateral extent, and show no evidence of water turbulence (e.g. points 1, 2 and 3 of Figure 5-8) and will be briefly discussed later in the chapter. The major buildup exposed in the region is in the "Camp C" area (see Figure 1-3). It shows evidence of growth in turbulent water, is organically bound, and includes talus deposits. Therefore, it can be classed as an organic-framework reef in the sense of Heckel (1974). The reef comprises points 13 to 22 on Figure 5-8, and possibly continues farther west although poor exposure and faulting makes this difficult to determine. The reef measures over 10 km long, 2 km wide, and 100 m thick. Detailed study of this well-preserved reef, which involved measurement of 12 stratigraphic sections around its margins (Plate 17), has revealed that it is comprised of a complex series of superposed and laterally equivalent facies (Figure 5-9). Locality 26 was a reconnaissance section and therefore detailed facies analysis of this section is not possible. Using the characteristics of reef facies documented by James (1978), Longman (1981), and Burchette

(1981), Devonian reef facies examples, e.g. Krebs (1972) and McGillivray and Mountjoy (1975), and the concept of Walther's Law, a reef facies model has been developed which can be used to interpret the community succession and decipher the reef history. Stearn (1982) has recently shed doubt on facies interpretations based solely on growth forms of colonial organisms. Care has been taken in this study not to rely only on coral and stromatoporoid morphology to interpret feef facies.

Eight facies can be recognized in the reef complex. From the base upwards, these include:

1) The lower slope/basin facies (Plate 5a), which consists of dark grey-brown, very thin-bedded to laminated argillaceous lime mudstone and shale, with rare fossils - ostracods, crinoids, and *Styliolina*.

2) The upper slope facies (Plate 18b), which is usually closely associated with the lower slope/basin facies, and is composed of dark grey-brown, very thin-bedded argillaceous wackestone with shale interbeds. Fossils are relatively common and diverse, and consist of crinoids, ostracods, brachiopods (including *Schizophoria, Carinagypa* and *Atrypa*), fenestellid bryozoans, and rare (less than 5% rock volume) *in situ* corals (*Favosites, Alveolitella,* and *Thamnopora*). In unit IA12, a "shell bank" composed of *Carinagypa maclareni* was encountered in this facies. This bank could be analogous to the *Stringocephalus* clusters developed on the flanks of Middle Devonian reefs.

3) The lower reef facies (Plate 18c-e) (reef slope facies of Longman, 1981) always develops above facies (2), and is of limited vertical extent. *In situ* corals are common in this facies, and are dominated by platy and branching growth forms typical of deeper portions of a reef complex (James, 1978). These include "potato-chip" *Alveolites*, along

with *Alveolitella* and *Thamnopora*. Rare hemispherical colonies of *Favosites*, *Spongonaria parca* and *S. ogilviensis* and stromatoporoids are also present. Medium to dark grey-brown crinoid and brachiopod wackestone forms the matrix. Rare units containing "potato-chip" *Alveolites* and *Alveolitella* debris are present, indicating that this facies was periodically affected by storm activity. A small bryozoan mud mound developed in this facies in unit CH4. According to Wilson (1975, p. 145), mud mounds are common on the lower flanks of Silurian and Devonian reefs. The lower reef facies can be classified as a coral bindstone/bafflestone in the terminology of Embry and Klovan (1971).

4) The upper reef facies (Plate 19 a) (reef framework facies of Longman, 1981), like the lower reef facies, is also dominated by corals, but the coral fauna is much more diverse than that of the lower reef facies. Upper reef corals are larger (up to 50 cm diameter) and have a hemispherical morphology. They are therefore more able to withstand the higher energy conditions of the upper reef. The commonest corals are *Spongonaria parca*, *Spongonaria* sp.nov. 1, *Favosites*, and laminar *Alveolites*, along with less common hemispherical stromatoporoids. The branching corals *Thamnopora* and *Alveolitella* occur in thin, shaly interbeds. The matrix is formed of medium to dark grey-brown argillaceous wackestones, with abundant and diverse crinoid fragments. This facies can be classified as a coral framestone.

5) The reef crest facies (Plate 19 b) is the shallowest facies of the reef complex and is dominated (up to 96% rock volume) by laminar stromatoporoids (commonly *Salairella prima*, see Stearn, 1983), accompanied by laminar *Alveolites* and hemispherical *Spongonaria parca* in some places. The laminar growth form is an adaption to the highly turbulent conditions

of this facies (James, 1978; Longman, 1981). Crinoids are common components of the light grey grainstone matrix. The reef crest facies can be classified as a stromatoporoid bindstone/framestone.

6) The reef flat facies (Plate 19 c), deposited in the lee of the reef crest facies in very shallow, moderate to high energy conditions, consists of well-sorted and rounded crinoid-peloid grainstone. Algae flourished in the well-lit, moderately turbulent water, and their presence is attested to by the many grains having thick micrite envelopes, and rounded peloids which result from algal micritization of grains (Bathurst, 1976, p. 389). *Girvanella staminea* and *Issinella* are present but not in great abundance, along with calcispheres.

7) The back reef facies (Plate 19 d) developed in the lee of the reef crest and reef flat facies. It is readily distinguished from the reef flat facies by the presence of common to abundant green algae (*Rhabdoporella bascillum* and *Dimorphosiphonoides*), typical of backreef facies (Flügel, 1982, p. 332), and by a lime mud matrix. Rounded peloids, calcispheres, crinoids, and ostracods are also common, and algal borings in crinoid grains (Swinchatt, 1969), micrite envelopes and branching corals (*Alveolitella*) are present. This suggests deposition in a quiet, shallow water environment. A small mound of *Rhabdoporella bascillum* 0.8 m high and approximately 2 m at the base developed in unit ID7. This could be analogous to the small *Amphipora* mounds developed in the back reef environment of the Alexandra Reef Complex near Great Slave Lake, Northwest Territories (Jamieson, 1971). Corals and stromatoporoids, which form a minor component of this facies, are both *in situ* and transported, and include hemispherical *Favosites*, laminar *Alveolites*, and hemispherical stromatoporoids. *Amphipora*, typical of backreef facies in the Middle

and Upper Devonian (Wilson, 1975, p. 121), was noted only at one locality, where it was closely associated with the reef crest facies (unit CA16, locality 22 of Stearn, 1983).

8) The reef talus facies (Plate 19 e) is only developed at section CH, and is laterally equivalent to the main reef facies. It consists of thin- to thick-bedded packstone to grainstone beds dominated by large crinoid fragments and *Alveolitella*, and rare lenses of large (up to 30 cm diameter) overturned heads of *Spongonaria parca* and *Alveolites* (unit CH 24).

Figure 5-9 shows that most of the measured sections record an upward change from shales and argillaceous wackestones at the base (facies 1 and 2), through coral bindstone/bafflestone (facies 3) and coral framestone (facies 4), into stromatoporoid bindstone/framestone (facies 5) and concomitant crinoid-peloid grainstone and algal wackestone (facies 6 and 7). This vertical community zonation is interpreted as being due to a progressive replacement of deep water communities by shallow water ones as the reef grew upwards to sea level (allogenic succession) (Figure 5-10). The writer therefore proposes that the community succession was controlled by physical (extrinsic) changes, but notes that biologic (intrinsic) controls may also have operated simultaneously. Lecompte (1970) invoked water turbulence to explain the distribution patterns of Devonian frame-building organic assemblages, and recognized 5 "bathymetric zones" in reefs. Embry and Klovan (1972) assigned absolute water depths to these zones, but assumed a static sea level position.

The growth of the reef started in relatively deep, quiet water conditions evidenced by the deposition of shales and thin-bedded

argillaceous wackestones of the lower slope/basin and upper slope facies at the base of the sections (stages 1 and 2 of Figure 5-10). Corals adapted to the limited light and low energy levels in this environment colonized the substrate (stage 3). The platy morphology of "potato-chip" *Alveolites* would have increased the surface area available to attract light if these corals did possess light-dependent zooxanthellae, and the delicately branched colonies of *Alveolitella* and *Thamnopora* could only have thrived in areas of minimal wave agitation. The sharp contact between the upper slope and the lower reef facies indicates that rapid colonization took place as soon as a suitable, stabilized substrate was available. Crowley (1973), in his study of Middle Silurian reefs of New York, also noted a sharp contact between these 2 facies. The lower slope/basin, upper slope, and lower reef facies developed in a quiet water zone (deep water, still water and calm water zones of Lecompte, 1970), probably below average wave base (9 m, according to Logan, 1969). As the reef grew above average wave base, wave agitation increased, and the substrate was affected by constant wave activity (stage 4). In these favourable conditions, coral diversity increased. In response to the higher energy conditions, larger, more robust corals and stromatoporoids of the coral framestone (upper reef) community replaced the coral bindstone/ bafflestone community of the lower reef facies. The coral framestone community probably developed in the subturbulent zone of Lecompte (1970) above average wave base. The final reefal community - the stromatoporoid bindstone/framestone (reef crest) community, developed in the highly agitated waters of the surf zone (stage 5). As stated earlier, the laminar growth form was an adaptation to the high energy conditions. Stromatoporoids are the most common colonial organisms in this environment in the Devonian

(Wilson, 1975). This community developed in the turbulent zone of Lecompte (1970) (equivalent to rough water zone of Embry and Klovan, 1971). With the growth of the reef crest community towards sea level, a shallow, more protected area of moderate wave energy, the reef flat, developed. This is characterized by crinoid-peloid grainstone. Relatively low circulation, lack of hard substrates, and frequent shifting of the sediments in the reef flat environment explain the paucity of colonial organisms. However, well-rooted organisms such as crinoids flourished. Abundant light encouraged the growth of algae, which micritized skeletal grains and created the peloids common in this facies. Mud was winnowed out by the currents, which also sorted and rounded the sediment particles. The back reef facies developed in the lee of the reef flat facies. In these tranquil, well-lit conditions, large green algae were able to thrive, and lime mud was deposited. The delicate branching organisms *Alveolitella* and *Amphipora* also grew in this protected environment. Large coral and stromatoporoid coralla were transported from the upper reef and reef crest environments into the back reef facies. There is no evidence in the reef flat or back reef facies of subaerial exposure, e.g. fenestrae, desiccation cracks, solution features.

The reef talus facies is only developed at section CH, between units CH11 and CH30. Talus consists of crinoid fragments and coral heads derived from the upper reef front. Stanton (1967) noted that talus deposits tend to be concentrated along the windward margins of modern reefs. If this was true in the past, then it can be postulated that the wind was directed from the south. The vertical succession at section CH terminates in the very shallow water reef crest and reef flat facies, indicating that

the talus pile accumulated into shallow water, at which point the reef crest facies was able to develop.

An alternative interpretation of the control of the community succession observed in the Blue Fiord Formation reef is the model of Walker and Alberstadt (1975), who assumed stable environmental conditions. They envisaged biologic (intrinsic) controls on the ecologic succession observed in ancient reefs, "in particular the gradual alteration of the substratum by organisms and elaboration of energy-flow pathways as the community develops" (p. 240-241), but conceded that "it is difficult even in modern examples to distinguish between changes induced by community activity and those wrought by physical environmental changes" (p. 238). Walker and Alberstadt (1975) divided the vertical zonation of reefs into 4 developmental stages (Figure 5-11), 3 of which represent autogenic succession ((i) through (iii)): (i) stabilization stage, commonly represented by accumulations of pelmatozoan material which stabilize the substrate, (ii) colonization stage, characterized by branching and encrusting reef building metazoans, generally of short duration, (iii) diversification stage, in which the number of reef building taxa increases dramatically, along with the variety of growth habits, and (iv) domination stage, commonly represented by one or a few taxa with one growth habit (generally encrusted to laminated). This stage often shows evidence of the effect of surf action, and may represent extrinsic controls on the community. Figure 5-11 shows an example of a typical section (CA) from the Blue Fiord Formation reef, and the 2 possible controls on its community succession: (a) as mentioned above, the community succession can be interpreted as upward reef growth from a quiet, through a subturbulent, into a turbulent water zone (physical control), or (b) according to the biologic

control model, the stabilization stage would be represented by the upper slope facies, the colonization stage by the lower reef facies, the diversification stage by the upper reef facies, and the domination stage by the reef crest, reef flat and back reef facies (Smith and Stearn, 1982a).

The major evidence for a predominantly physical control of the community succession is that at 45 m in the section (Figure 5-11), the community changes from an upper reef community to a lower reef community. This event is most easily explained as being a replacement controlled by a physical change in the environment - a relative sea level rise - and is difficult to explain using the biologic control model of Walker and Alberstadt (1975). Hoffman and Narkiewicz (1977) noted that, in a changing environment, adjacent communities in a reef are likely to replace each other, and used this to argue for physically controlled community succession and against biological control.

The writer believes that community changes in the Blue Fiord Formation reef were generally physically controlled, and occurred at 2 major thresholds of wave action: average wave base and surf zone conditions. However, this hypothesis does not account for the replacement of the upper slope community by the lower reef community, which occurred in relatively quiet water only periodically affected by storms. This community change is best viewed as an autogenic succession whereby the crinoids, brachiopods, and bryozoans of the upper slope facies stabilized the substrate and permitted colonization by platy and branching corals of the lower reef community.

Therefore, the community succession in the Blue Fiord Formation reef developed in 4 main stages: (i) stabilization of the substrate by the

upper slope community, allowing (ii) colonization of the substrate by the lower reef community (biologic control), which was replaced at average wave base by the (iii) upper reef community which grew upwards into the surf zone and was replaced by the (iv) reef crest community, and its concomitant reef flat and back reef communities.

The distribution of facies and the presence of back reef sediments indicate that this reef was an atoll (see Burchette 1981, p. 109 for features of atolls). As mentioned in Chapter 4, this reef developed as a downslope buildup surrounded by shales and argillaceous wackestones. With the present data, a series of "time-slice" maps representing the depositional history of the atoll at time intervals T1 to T7 of Figure 5-9 can be drawn, similar to those of Walls (1983, p. 451). In order to prepare these "time-slices", it is assumed that the base of the Blue Fiord Formation in this area is synchronous, and that any horizontal line connecting the stratigraphic sections is also a time line. Because of the size of the atoll, the relatively low density of control points, and the number of reefal facies, these maps are necessarily speculative and over-simplified. However, a general picture of atoll development can be derived. The southern face of the buildup, between CC and Locality 26 (see Plate 17), appears to be a continuous series of reefal beds judging from field and airphoto data, and the maps are therefore drawn to account for this.

T1. The reef is in the stabilization stage of development (Figure 5-12).

T2. The reef organisms were able to colonize the stabilized substrate (Figure 5-12).

T3. The reef quickly grew into average wave base and a series of facies belts began to form (Figure 5-12).

T4. The northeastern part of the reef attained surf zone conditions, and the reef crest facies was formed. The reef flat and back reef facies are assumed to have developed in the lee of this facies (Figure 5-12).

T5. The backreef facies spread west across the atoll and a well developed series of facies belts formed (Figure 5-13). A talus pile also formed at this time.

T6. Deeper water conditions encroached on the southwest flank of the atoll, but the eastern and northern parts of the atoll continued to flourish (Figure 5-13).

T7. Atoll growth was terminated when it was enveloped by deep water shales of the basin (Figure 5-13). This implies a relative sea level rise causing the atoll to be drowned (Smith and Stearn, 1982b, p. 152). Schlager (1981) has noted that long-term subsidence or sea level rise is far too slow to drown a healthy reef, and therefore invoked short-term pulses of relative sea level rise to account for reef drowning, including pulses of tectonic subsidence. Trettin (1979) postulated that the location of the Silurian Allen Bay-Read Bay buildups at Cañon Fiord were controlled by faults. Smith and Stearn (1982b) used this idea to suggest that downward movements along such faults would have caused this Blue Fiord Formation reef to be drowned. However, there is no physical evidence for the existence of such faults in the area.

Of all the Lower Devonian buildups recognized in this study, only 3 documented examples of vertical community successions in buildups could be found. How do these successions compare to that exhibited by the Blue Fiord Formation reef?

1) Stauffer (1968), in his study of the Gedinnian Nowshera Formation buildup of west Pakistan, which is almost 200 m thick, recognized the following vertical succession: (a) a basal layer of sparsely fossiliferous fine grained limestone with some brachiopods and crinoids, (b) beds containing abundant *Thamnopora*, solitary rugose corals, dendroid favositids, and stromatoporoids, (c) a layer consisting largely of tabular stromatoporoids and abundant rugose corals, with some *Favosites*, and (d) a top layer dominated by tabular stromatoporoids. Clearly, this succession closely resembles that of the Blue Fiord Formation reef, with Stauffer's layer (a) corresponding to facies 1 and 2, layer (b) to facies 3, layer (c) to facies 4, and layer (d) to facies 5. The major difference between these successions is that layer (c) in the Nowshera buildup contains more abundant stromatoporoids than the Blue Fiord Formation reef. Stauffer (1968) also explained this community succession by upward growth of the reef from quiet to rough water conditions.

2) Isaacson and Curran (1981) examined a small (9.5 m thick) Gedinnian buildup in central New York. They divided the buildup into 4 successive layers: (a) crinoidal calcarenite at the base, (b) large heads of *Favosites* in a mud matrix, (c) *in situ* dendritic rugosans and favositids, in a mud matrix, and (d) crinoidal debris with dendritic and solitary rugosans. This buildup, which is an order of magnitude smaller than that in the Blue Fiord Formation, appears to have a substantially different vertical community succession. In particular, the base of the succession consists of hemispherical *Favosites* instead of platy and branching corals as in the Blue Fiord Formation, and the major portion of the buildup consists of branching corals and lacks stromatoporoids and large heads of colonial rugosans. These dissimilarities can possibly

be explained by differences in water turbulence. The New York buildup probably grew in a protected shallow epeiric sea, never exposed to high water agitation.

3) Mendez-Bedia (1976) studied a thick (over 110 m) buildup succession in the Emsian Moniello-St. Lucia Formation of northern Spain. This buildup exhibits 4 communities. Upwards, these include (a) argillaceous limestone with brachiopods, crinoids, bryozoans, solitary rugosans and *Thamnopora*, (b) beds with solitary rugosans, laminar stromatoporoids and tabulate corals, (c) beds rich in massive stromatoporoids and *Alveolites*, and (d) a zone of high diversity, containing massive stromatoporoids and *Alveolites*, *Thamnopora*, massive and branching rugose corals, and *Favosites*. Mendez-Bedia (1976) interpreted this succession in terms of the Walker and Alberstadt (1975) model, with community (b) representing the stabilization phase, community (c) the colonization stage, community (d) the diversification stage, and the top beds (here interpreted as a reoccurrence of community (c)) as the domination stage. The writer disagrees with this interpretation, and prefers to interpret the succession as a basal stabilization stage (community (a)) colonized by community (b), which grew above wave base, and was then replaced by community (c). A minor relative rise of sea level caused community (d) (similar position to upper reef facies of the Blue Fiord Formation reef) to form briefly, but this community soon grew into the surf zone and was replaced by the massive stromatoporoids and *Alveolites* of community (c), which formed the reef crest facies of this buildup. The Spanish buildup resembles the Blue Fiord Formation buildup to some extent. Community (a) resembles the upper slope community, and community (c) resembles the reef crest community. However, the lower and upper reef communities of the

Blue Fiord Formation buildup are quite different from that in the Spanish buildup (communities (b) and (d)).

The above evidence shows that the Blue Fiord Formation buildup does resemble coeval buildups in other parts of the world, especially the Pakistani buildup. Differences can be ascribed to varying depositional settings and to the wide geographic separation between the localities at the time of growth.

As mentioned above, many of the carbonate buildups in the study area are small. Typical examples of these buildups are well exposed at points 1 (AD37) and 2 (AAA17) of Figure 5-8, at the top of their respective stratigraphic sections. Both buildups are 12 m in stratigraphic thickness and approximately 20 m in diameter, and have been exhumed from surrounding shales. AD37 is particularly well preserved (Plate 13b,c), and probably closely resembles the morphology of the original buildup.

Statistical studies were done on both of these buildups to determine accurately their faunal composition. This was accomplished by detailed vertical line traverses on well exposed faces in the buildups, where the exact thickness of each component was gauged. Figure 5-14 shows the results of the 4 traverses measured on AAA17, and the 6 on AD37. In AAA17, the framework organisms are largely *Alveolites*, mostly of laminar morphology. All the colonies are *in situ*. The matrix consists of crinoid wackestone. The survey of AD37 again shows a dominance by *Alveolites*, but *Spongonaria* also forms a significant percentage of the framework organisms, which are also all *in situ*. The matrix consists of lime mud or crinoidal wackestone/packstone. No vertical community zonation was seen in either buildup.

Both the buildups consist of a relatively high percentage of framework organisms (42% and 56% respectively). However, no talus facies developed around the buildups, and few of the framework organisms have been overturned. Therefore, there is no evidence of growth in turbulent water, and thus these buildups do not conform to Heckel's (1974) definition of a reef. Instead, Heckel (1974) classed these types of buildups as potential reefs, which he considered to have grown in deep or calm water. The fact that both buildups were drowned and covered by deep water shales very rapidly, judging from the proximity of the overlying shale, also indicates that these buildups probably did not grow in very shallow water. Relatively deep storm deposits (Unit AAA9, see Chapter 3) have been recognized just below the AAA17 buildup, pointing to its development at or near storm wave base. These buildups are regarded as having developed on the upper slope.

In conclusion, this chapter has demonstrated the hitherto unrevealed abundance of Lower Devonian buildups worldwide. It has also shown their use in analyzing relative sea level and paleogeographic maps. Similar analyses from other time periods might also prove enlightening. A large, well-exposed reef studied in the Blue Fiord Formation exhibits a complex series of reefal facies, which document the growth of the reef towards sea level, and its development into an atoll. This is probably the best exposed example yet documented of a fully developed Lower Devonian reefal sequence in the world.

CHAPTER 6

CORAL TAXONOMY AND DISCUSSION

INTRODUCTION

Loewe (1913) was the first to formally describe Devonian corals from the Canadian Arctic Islands. The specimens he described were collected between 1898 and 1902 by Per Schei, the geologist attached to the Second Norwegian Arctic Expedition.

Until recently, this was the only detailed taxonomic work that had been done on Devonian corals of the area. In 1963, McLaren (*in* Fortier *et al.*, 1963) listed Devonian corals from the Blue Fiord and Disappointment Bay formations of Ellesmere and Bathurst Islands. The first Devonian corals to be illustrated since Loewe's publications were those figured by Embry and Klovan (1971, 1972) from the Upper Devonian of Banks Island. In 1971, A.E.H. Pedder collected corals from the entire Blue Fiord Formation at a section 16 km west of the head of Sör Fiord. Some material from this work was illustrated by Pedder in 1978 (Plates 41, 42), but the first formal descriptions of these corals was not published until 1982 by Pedder (1982a, 1983) and by Pedder and McLean (1982). Pedder (1982b) described cystiphyllid corals from the Bird Fiord Formation of southwest Ellesmere Island from material loaned to him by B. Jones and Q. Goodbody (U. of Alberta). One of the corals collected from the Eids Formation as part of this study has been recently described (Pedder and Smith, 1983). This is the first formal description of a coral from the Eids Formation.

As noted above, 39 species of corals have been recognized in this study, 22 of which have not been reported previously from the Arctic Islands. Most of the corals derive from the lower Blue Fiord Formation of Ellesmere Island, as this is the main fossil-bearing unit in the Lower Devonian sequence of the area. However, a number of corals are described

from the upper Eids Formation, the upper Blue Fiord Formation, and the Disappointment Bay Formation of Ellesmere Island. The first formal description of Devonian corals from Bathurst Island is also included. Figure 6-1 shows a faunal list of the corals studied, and their stratigraphic distribution.

Bibliographic references are included only for taxonomic units of generic level and lower in the systematic section that follows in order to limit the bibliography to a reasonable length. All references to taxonomic units above the generic level can be found in Hill (1981).

The classification scheme used herein generally follows the Treatise on Invertebrate Paleontology (Hill, 1981).

SYSTEMATIC PALEONTOLOGY

Phylum COELENTERATA Frey and Leuckart, 1847

Class ANTHOZOA Ehrenberg, 1834

Subclass RUGOSA Milne Edwards and Haime, 1850

Order CYSTIPHYLLIDA Nicholson, 1889

Family CYSTIPHYLLIDAE Milne Edwards and Haime, 1850

Subfamily CYSTIPHYLLINAE Milne Edwards and Haime, 1850

Genus ZONOPHYLLUM Wedekind, 1924

Zonophyllum Wedekind, 1924, p. 12

Atelophyllum (Cystiphylloides) Yoh, 1937, p. 53

Zonophyllum (Neozonophyllum) Ulitina, 1968, p. 52

Type species - *Zonophyllum duplicatum* Wedekind, 1924, p. 14, 15, 20, figs. 6-8; Lower Nohn Formation, Lower Eifelian, Hillesheimer Mulde, Germany.

Zonophyllum sp. cf. *Z. sorense* Pedder and McLean, 1982

Plate 20 a,b

(*Zonophyllum sorense* Pedder and McLean, 1982, p. 66, 67, Pl. 4, figs. 1-12; Pl. 5, figs. 1-3, 6; text-fig. 4).

Type specimen - Lower Blue Fiord Formation (Zlichovian), Sör Fiord section, Ellesmere Island.

Material - One well-preserved corallum.

Description - Corallum solitary. Adult corallite diameter 20 mm. Septa distinct at periphery, short; have distinct, relatively long spines; thin septal crusts rarely developed in central part of corallum. Dissepiments small, globose, and steeply inclined. Tabularium comprises large, globose

tabellae.

Remarks - Z. sp. cf. Z. *sorense* differs slightly from Z. *sorense* in having less well-developed septal spines, being slightly smaller in diameter (22 to 28 mm for Z. *sorense*), and in lacking a few distinct carinae. Pedder and McLean (1982, p. 67) discussed the similarity between Z. *sorense* and other closely related forms.

The holotype of Z. *sorense* was first figured by Pedder (1978, Pl. 41, figs. 5, 7) as *Zonophyllum* sp. nov. This sample was from GSC loc. C-12426 in the lower Blue Fiord Formation (*P.* sp. aff. P. *perbonus* Zone, Upper Zlichovian), Sör Fiord section, Ellesmere Island. Paratypes are from the same geographic location and the same conodont zone (see locality register and faunas, Pedder and McLean, 1982, p. 78-81).

The specimen from IC7 is in the same stratigraphic range as the type material of Z. *sorense*, and is also from between Blue and Sör Fiords.

Occurrence - The single specimen is from IC7, in the lower Blue Fiord Formation, Ellesmere Island.

Subfamily DIGONOPHYLLINAE Wedekind, 1923

Genus LEKANOPHYLLUM Wedekind, 1924

Lekanophyllum Wedekind, 1924, p. 29-34

Type species - *Lekanophyllum punctatum* Wedekind, 1924, p. 30, 34, figs. 36-38; Junkerberg Formation, Eifelian, Auberg, Gerolsteiner Mulde, Germany.

Lekanophyllum sp. cf. *L. retiforme* Pedder, 1982b

Plate 20 c,d

(*Lekanophyllum retiforme* Pedder, 1982b, p. 84, 88, Pl. 10.1a, figs. 1-9, Pl. 10.1b, figs. 10-14; Pl. 10.1c, figs. 15-21).

Type specimen - Lower Bird Fiord Formation (Dalejan), Blubber Point, southwest Ellesmere Island.

Material - 6 well-preserved specimens.

Description - Corallum solitary. Corallite wall thin (average 0.4 mm); mean adult diameter 40 mm, range 34 to 47 mm. Septa numerous, mean 100, range 82 to 114; septal apparatus well developed into two orders, commonly discontinuous peripherally; major septa commonly 0.8 radius, minors 0.6 radius; at periphery, septal apparatus generally consists of carinate fragments of septal crests and isolated spines; become continuous inwards, and thicken in inner dissepimentarium; thickened area of septa incorporate dissepiments resulting in retiform septal apparatus in places; adaxial ends of minor septa commonly deflect towards an adjacent major septum; adaxial end of major septa attenuate towards axis, or merge into axial schlerenchyme, or expand. Presepiments and dissepiments similar in size, numerous, comprise approximately 20 rows; at periphery, dissepiments flat to gently sloping axially, bulbous; closer to axis, dissepiments steeper sloping. Tabellae abundant, bulbous in tabularium, merge laterally with dissepiments.

Remarks - *L.* sp. cf. *L. retiforme* differs from *L. retiforme* in having a larger diameter (maximum of 35 mm in *L. retiforme*), higher septal counts (maximum of 88 in *L. retiforme*), and in generally lacking tabulae rejuvenation (only seen in CH23). A comparison of *L. retiforme* with similar species can be found in Pedder (1982b, p. 88).

The type species of *L. retiforme* is from the Bird Fiord Formation

(*P. serotinus* Zone or younger, probably Dalejan), Blubber Point, southwest Ellesmere Island (Pedder, 1982b, p. 89). The majority of samples of *L.* sp. cf. *L. retiforme* come from B22 in the Blue Fiord Formation on northeastern Bathurst Island (Kerr, 1974, section 22). Ormiston (1967, p. 20) noted a species of *Lekanophyllum* from the Blue Fiord Formation of northwestern Bathurst Island. McGregor and Uyeno (1972, p. 13-16) described conodonts from the Blue Fiord Formation (Kerr, 1974, section 20), 13 km west of B22, and regarded the entire Blue Fiord Formation tentatively as Eifelian. The one sample from CH23 in the lower Blue Fiord Formation on Ellesmere Island is probably late Early to early Late Zlichovian in age. Thus, it appears that *L. retiforme* is in the range of *L.* sp. cf. *L. retiforme*.

Occurrence - 5 samples from B22, in the Blue Fiord Formation of Bathurst Island, and one sample from CH23, in the lower Blue Fiord Formation of Ellesmere Island.

Genus MOCHLOPHYLLUM Wedekind, 1923

Digonophyllum Wedekind, 1923, p. 27

Mochlophyllum Wedekind, 1923, p. 31

Type species - *Cyathophyllum maximum* Wedekind, 1923, p. 35; Eifelian, Gerolsteiner, Germany.

Mochlophyllum sp.

Plate 20 e,f

Material - 7 well-preserved specimens.

Description - Corallum solitary. Mean adult corallite diameter 18.3 mm, range 15 to 21 mm. Septa represented by discontinuous thin to medium

laminar segments, mainly developed in the axial region but also present at periphery; replaced peripherally by arched crossbar plates and naotic dissepiments. Sclerocones present in axis.

Remarks - *Mochlophyllum* has not been described from northern or Arctic Canada previously. All the samples are from AC4 in the upper Eids Formation of Ellesmere Island, which is usually regarded as being Early Zlichovian in age (Smith and Stearn, 1982b, Figure 2). The genus has been documented by Hill (1981, p. 75) as being Middle Devonian in age. Thus, the occurrence of *Mochlophyllum* in the Eids Formation considerably extends the range of this genus downwards.

Occurrence - All 7 samples are from AC4, in the upper Eids Formation of Ellesmere Island.

Order STAURIIDA Verrill, 1865

Suborder COLUMNARIINA Soshkina, 1941

Family COLUMNARIIDAE Nicholson, 1879

Subfamily HEXAGONARIINAE Bulvanker, 1958

Genus HEXAGONARIA Gürich, 1896

Hexagonaria Gürich, 1896, p. 171

Hexagoniella Gürich, 1896, p. 500

Hexagoniophyllum Gürich, 1908-9, p. 102

Type species - *Cyathophyllum hexagonum* Goldfuss, 1826, p. 61; by subsequent designation Lang, Smith, and Thomas, 1940, p. 69; Middle Devonian, Eifel district, Germany.

Hexagonaria sp.

Plate 20 g,h

Material - 23 well-preserved samples.

Description - Corallum cerioid. Corallites prismatic, thin-walled; mean adult diameter 7.4 mm, ranging from 6.2 to 9.0 mm. Septa radially arranged, commonly 38 in number, range 32 to 44; in two orders, major septa 0.51 radius, range 0.45 to 0.71 radius, minors rarely developed, slightly shorter; unevenly thickened in dissepimentarium, rarely fusiform, very rarely reach far into tabularium, where quickly attenuate; yard-arm and zig-zag carinae common; septal spines commonly present in tabularium. Dissepiments in 3 to 4 rows, slightly larger at periphery, floors nearly horizontal, gently sloping axially. Dissepimentarium commonly 0.45 radius. Tabulae generally complete, flat.

Remarks - *Hexagonaria* sp. is distinguished from *Spongonaria* by its unevenly thickened, rarely fusiform septa, that commonly bear carinae. It differs from typical species of *Hexagonaria* in that the septa are not well differentiated and do not reach the axis, and in that septal spines are present.

The genus *Hexagonaria* is cosmopolitan, and has been reported from rocks of Middle and Upper Devonian age (Hill, 1981, p. 85, 275). Pedder, A.E.H. (pers. comm., 1983) has recognized *Hexagonaria* from Frasnian beds of the Mercy Bay Member of the Weatherall Formation on northeast Banks Island. Oliver *et al.* (1975) illustrate *Hexagonaria* sp. A from the Upper Devonian limestone of Arctic Village, eastern Brooks Range (Pl. 14, figs. 5, 6) which is similar to *Hexagonaria* sp. reported herein. Merriam (1973) reports a number of species of *Hexagonaria* from the Middle Devonian of the central Great Basin.

Therefore, the occurrence of *Hexagonaria* sp. in the lower Blue Fiord Formation (late Early to early Late Zlichovian) in the Sör Fiord - Vendom Fiord region is not only the first published report of *Hexagonaria*

from the Arctic Islands, but also the first record of *Hexagonaria* from true Lower Devonian strata anywhere.

The presence of septal spines in *Hexagonaria* sp. suggests a close relationship with *Spongonaria* from which it differs only in septal character. *Hexagonaria* sp. may be an evolutionary link between *Spongonaria*, common in upper Lower Devonian strata of western and Arctic Canada, and true *Hexagonaria*, present in Middle and Upper Devonian rocks worldwide.

Occurrence - All 23 specimens are from the lower Blue Fiord Formation - CCA8, CD3B, CD3C, CF11, GB33, GB35, HA2, HB30 (3 specimens) HC30 (2 specimens), IA15, IB3, IB10 (4 specimens), IB11, IB12, ID14 (2 specimens), Loc. 21 (2 specimens).

Subfamily SPONGONARIINAE Crickmay, 1962

Genus PARASPONGONARIA Pedder, 1983

Paraspongonaria Pedder, 1983, p. 231

Type species - *Paraspongonaria delicata* Pedder, 1983, p. 231, 233, Pl. 26.1, figs. 23-30; *P. serotinus* and possibly topmost *P. inversus* Zones (Dalejan), Blue Fiord Formation, Sör Fiord and Vendom Fiord regions of southern Ellesmere Island; 77° 15' 48" N. lat., 85° 03' 30" W. long.

Paraspongonaria delicata Pedder, 1983

Plate 21 h,i

Phaceloid species of *Spongonaria*; Pedder and McLean, 1982, p. 59

Spongonaria (?) sp. nov. (phaceloid form); Pedder and McLean, 1982, p. 80

Paraspongonaria delicata Pedder, 1983, p. 231, 233, Pl. 26.1, figs. 23-30

Type specimen - Upper Blue Fiord Formation (Dalejan), Sör Fiord section, Ellesmere Island.

Material - One moderately well-preserved specimen.

Description - Corallum phaceloid. Corallites cylindrical, thin-walled, adult diameter 9.5 mm. Septa radially arranged, 40 in number; in two orders, majors 0.6 radius, minors 0.5 radius; minor septa barely penetrate tabularium; thin, straight, noncarinate; septal fragments present in tabularium. Dissepiments in 3 rows, outer flatter and larger than inner, which can be steeper inclined axially. Tabularium clearly differentiated from dissepimentarium. Tabulae complete to incomplete, elevated centre.

Remarks - *P. delicata* has been documented recently by Pedder (1983) from the Blue Fiord Formation (*P. serotinus* Zone, Dalejan) of the Sör Fiord (GSC loc. C-12473) and Vendom Fiord (GSC loc. C-76823 = C-76831) regions. The single sample from ED29 is from the lower Blue Fiord Formation (208 m above base) of the Vendom Fiord region. The basal part of the Blue Fiord Formation in this area is poorly dated (see discussion in biostratigraphy); however, a Late Zlichovian age is likely. Thus, this occurrence of *P. delicata* slightly extends the range of the species downwards.

Occurrence - The single sample is from ED29, in the lower part of the Blue Fiord Formation, Ellesmere Island.

Genus PLANETOPHYLLUM Crickmay, 1960

Planetophyllum Crickmay, 1960, p. 4

Type species - *Planetophyllum planetum* Crickmay, 1960, p. 4, Pl. 1, figs. 1-5; basal bed of Devonian system (Zlichovian/Dalejan Fitzgerald Formation of Pedder, 1983), Stony Island, Slave River, Alberta; 59° 39' N. lat., 111° 26' W. long.

Planetophyllum sp. nov.

Plate 21 c,d

Type specimen - Lower Blue Fiord Formation (*P. deliscens* Zone (?), Lower Zlichovian), section CF, southwest Ellesmere Island. Type specimen (CF17-1), will be stored at the Geological Survey of Canada, Ottawa, and will be given a G.S.C. number.

Material - 3 well-preserved coralla.

Diagnosis - A species of *Planetophyllum* with large corallite diameter (mean 10 mm), short septa, rare septal spines, one row of dissepiments, and complete, generally flat, tabulae.

Description - Corallum fasciculate with some cateniform tendency. Corallites cylindrical, with a very thin outer wall; marked tendency for outer wall to form strong, rounded interseptal ridges; mean adult diameter 10 mm, range 9 to 11 mm. Septa radially arranged, 36 to 42 in number; short, in two weakly-differentiated orders, majors 0.2 radius, minor septa slightly shorter; thin, straight to gently undulating, noncarinate; short septal spines present in tabularium, not penetrating tabulae. Dissepiments in 1, rarely 2, rows, large, dipping moderately axially. Dissepimentarium slightly shorter than minor septa; sharp boundary with tabularium. Tabulae generally complete, flat to very gently arched.

Remarks - The type and only previously named species of *Planetophyllum* is *P. planetum*, first documented by Crickmay (1960) and later by Rice (1967, Pl. 2, figs. 7, 8) from the Zlichovian/Dalejan Fitzgerald Formation of northeast Alberta. Pedder and Klapper (1977, figs. 43.2, 4) noted the presence of an unnamed species of *Planetophyllum* from the type area of the Cranswick Formation (*P. inversus* Zone, Upper Zlichovian to Lower

Dalejan), GSC loc. C-63102; however, they mentioned that it "may be identical with forms identified as *P. planetum* by Rice (1967)". The corallites of *Planetophyllum* sp. nov. are much larger than those of *P. planetum* (average diameter *P. planetum* is 5 to 6 mm), and possess septal spines.

All three samples of *Planetophyllum* sp. nov. are from the lower part of the Blue Fiord Formation, between Blue and Sör Fiords, probably late Early to early Late Zlichovian in age. Thus, *P.* sp. nov. appears to be slightly older than *P. planetum*.

Occurrence - 2 samples are from CF17, the other from ID11, both in the lower Blue Fiord Formation of Ellesmere Island.

Genus SPONGONARIA Crickmay, 1962

Spongonaria Crickmay, 1962, p. 2

Spongaria Bolton, 1974, p. 54

Type species - *Spongonaria filicata* Crickmay, 1962, p. 2, Pl. 1, figs. 1, 2; Pl. 3, figs. 6, 7. "Supposed equivalent of the Bear Rock Formation... on Houston River, Yukon Territory; 65° 30' N. lat., 131° 15' W. long." Type horizon now known to be in Zlichovian/Dalejan Landry Formation of the Mackenzie Mountains, northwestern District of Mackenzie (see discussion in Pedder (1977a, p. 177, 1978) and Pedder (1983, p. 15)).

Spongonaria filicata Crickmay, 1962

Plate 21 e,f

Spongonaria filicata Crickmay, 1962, p. 2, Pl. 1, figs. 1, 2; Pl. 3, figs. 6, 7.

Type specimen - see type species above.

Material - 4 well-preserved coralla.

Description - Corallum cerioid. Corallites prismatic, thin-walled, faintly zig-zag; mean adult diameter 12.0 mm, range 10.7 to 14.0 mm. Septa radially arranged, average 38 in number, ranging from 36 to 42; in two, poorly differentiated orders, major septa 0.46 radius, range 0.4 to 0.51 radius, minor septa a little shorter; thin, straight, commonly bearing small bulbs at axial ends. Dissepiments in 3 to 4 rows, larger at periphery, very gently sloping, flat-topped. Dissepimentarium commonly 0.4 radius, with a sharp tabularial border. Tabulae mostly complete, very variable in form.

Remarks - *Spongonaria filicata* has not been previously noted in the Arctic Islands. It resembles *S. parca* in relative septal length and size of dissepimentarium, but differs from it by having a much larger corallite diameter (7 mm for *S. parca*).

The holotype is from the Zlichovian/Dalejan Landry Formation, Mackenzie Mountains, and it has also been documented from the Ogilvie Formation (*P. serotinus* Zone), Ogilvie Mountains (Pedder, 1978, GSC loc. C-9046).

S. filicata has been discovered in the lower Blue Fiord Formation of the Sör Fiord and Vendom Fiord regions (Upper Zlichovian part), and the upper Blue Fiord Formation between Blue and Sör Fiords (Zlichovian/Dalejan). It is therefore in the same stratigraphic range as the holotype.

Occurrence - 3 samples from the lower Blue Fiord Formation, Ellesmere Island, EC16, ED35, HA23; 1 sample from the upper Blue Fiord Formation, Ellesmere Island - JA15.

Spongonaria loewei (Stumm, 1953)

Plate 21 a,b

Cyathophyllum quadrigeminum mut. nov. *arctica* Loewe, 1913, p. 9, Pl. 2, figs. 3a-c.

Hexagonaria loewei Stumm, 1953, p. 759.

Type specimen - Series Db (Disappointment Bay Formation, Zlichovian/Dalejan), Goose Fiord, southwest Ellesmere Island.

Material - 17 well-preserved coralla.

Description - Corallum cerioid. Corallites prismatic, thin-walled, faintly zig-zag; mean adult diameter 5.2 mm, range 4.0 to 7.5 mm. Septa radially arranged, commonly numbering 30, ranging from 28 to 36; in one order, 0.24 radius generally, range 0.11 to 0.33 radius; thin, smooth, straight. Dissepiments in 1 row; small, steeply sloping axially. Dissepimentarium averages 0.2 radius, sharp tabularial border. Tabulae generally complete, flat to gently sagging.

Remarks - *Spongonaria loewei* resembles *S.* sp. nov. 1 in having very reduced septa, but has a much smaller corallite diameter (average 10.2 mm in *S.* sp. nov. 1). *S. parca* has a similar corallite diameter range to *S. loewei*, but has longer and more numerous septa.

S. loewei has been found previously between Blue and Sör Fiords in the Blue Fiord Formation (*P. dehiscens* Zone) at GSC loc. C-12498 (Pedder, 1982a), and GSC loc. C-27776 (Pedder and McLean, 1982). It was found earlier by Schei from series Db (now Disappointment Bay Formation) of southern Ellesmere Island (Loewe, 1913) (*P. inversus* Zone, Zlichovian/Dalejan).

It is herein documented from the upper Eids Formation between Blue

and Sör Fiords (*P. dehiscens* Zone, Early Zlichovian), and in the lower Blue Fiord Formation of the Sör Fiord and Vendom Fiord regions (late Early Zlichovian to early Late Zlichovian).

Occurrence - 9 samples from the upper Eids Formation, Ellesmere Island - AC1 (7 specimens); EA5, EA7; 8 samples from the lower Blue Fiord Formation, Ellesmere Island - EC15, HA2, HB28, HB32, HC2, JC8, Loc. 40 (2 specimens).

Spongonaria ogilviensis (Crickmay, 1968)

Plate 21 g

Exilifrons ogilviensis Crickmay, 1968, p. 4, 5, Pl. 1, figs. 5, 6

Spongonaria ogilviensis Pedder, 1977a, p. 1979

Type specimen - about "middle thickness" of Bear Rock equivalent (Ogilvie Formation of Pedder, 1977a, p. 173), north side of Ogilvie Mountains, between Ogilvie and Blackstone rivers: 65° 37' N. Lat., 137° 45' W. Long.

Material - 25 well-preserved samples.

Description - Corallum cerioid. Corallites prismatic, thin-walled; mean adult diameter 8.4 mm, ranging from 5.8 to 12.0 mm. Septa radially arranged, averaging 36 in number, range 30 to 40; in two, well differentiated orders, major septa 0.7 radius, range 0.48 to 0.9 radius, minors 0.43 radius, range 0.25 to 0.55 radius; moderately thin, straight, noncarinate. Dissepiments common, arranged in 3 to 4 rows; bulbous, gently sloping axially. Dissepimentarium average 0.4 radius, with a sharp boundary with the tabularium. Tabulae generally complete, flat to gently arching.

Remarks - *Spongonaria ogilviensis* does not closely resemble any other species of the genus.

The holotype is from the middle Ogilvie Formation of the Ogilvie Mountains (Zlichovian/Dalejan). The species has also been previously noted from the lower Blue Fiord Formation in the Sör Fiord area (*P.* sp. aff. *P. perbonus*, Upper Zlichovian) by Pedder and McLean (1982) (GSC loc. C-12429, 12432).

S. ogilviensis has been found in the study area from the lower Blue Fiord Formation in the Sör Fiord and Vendom Fiord regions (Zlichovian) and from the Disappointment Bay Formation of southern Ellesmere Island (*P. inversus* Zone).

Occurrence - 24 specimens from the lower Blue Fiord Formation, Ellesmere Island - AA29, AB2 (2 specimens), AB4 (5 specimens), AB9, ABA6/8, AD9, AD31, CCA4, CD3A, CF8B (2 specimens), CF15, EC22, GE22, K6 (2 specimens), Loc. 11, Loc. 40 (2 specimens); one specimen from the Disappointment Bay Formation, Ellesmere Island - KA49.

Spongonaria parca Crickmay, 1968

Plate 22 e,f

Spongonaria parca Crickmay, 1968, p. 1, 2, Pl. 1, figs. 1, 2; Pl. 2, figs. 7, 8.

Spongonaria richardsonensis Crickmay, 1968, p. 2, 3, Pl. 1, figs. 3, 4; Pl. 3, figs. 3, 4.

Hexagonaria sp. Oliver, Merriam, and Churkin, 1975, Pl. 18, figs. 10, 11.

Type specimen - base of Bear Rock equivalent (Ogilvie Formation of Pedder, 1977a, p. 173), Ogilvie River area, Yukon Territory; 65° 23' N. lat., 138° 24' W. long.

Material - 73 coralla, mostly well-preserved.

Description - Corallum ceroid. Corallites prismatic, thin-walled; mean adult diameter 7.0 mm, range 3.5 to 9.5 mm. Septa radially arranged, commonly numbering 34, ranging from 26 to 40; in two orders, poorly differentiated, major septa 0.5 radius, range 0.33 to 0.7, minor septa slightly shorter; thin, straight, rarely undulating, noncarinate. Dissepiments common, forming 2 to 4 rows, commonly 3; generally small, larger at periphery; bulbous. Dissepimentarium generally 0.4 radius, sharp boundary with tabularium. Tabulae generally complete, flat to gently sagging; rare tabulae.

Remarks - Crickmay (1968) erected 2 new species of *Spongonaria*, *S. parca* and *S. richardsonensis*, which differed only in that *S. richardsonensis* had a larger corallite diameter (7 to 9 mm compared to 4.4 mm for *S. parca*), and had more septa (32 compared to 28 in *S. parca*). More material is available in this study, and it has been possible to show by biometrical studies (see Fig. 6-2) that these two species are intergradational. Therefore, *S. richardsonensis* is herein placed in synonymy with *S. parca*. *S. parca* has been retained as it was the first described (Crickmay, 1968, p. 1 versus p. 2 for *S. richardsonensis*). Also, the type locality of *S. richardsonensis* is poorly described, and the location and age of the formation are not clear ("Bear Rock equivalent, in middle thickness, vicinity of White Dome, Yukon Territory"). However, the type locality, formation, and range of *S. parca* are well known (Ogilvie Formation, *P.* sp. aff. *P. perbonus* Zone, Ogilvie Mountains - see Pedder, 1978, GSC loc. C-6435]).

See remarks sections of *S. filicata* and *S. lowei* for discussion of related species.

S. parca has been previously noted (as *S. richardsonensis*) in the

lower Blue Fiord Formation between Blue and Sör Fiords (*P. dehiscens* Zone, GSC loc. C-12498, 27776; *P.* sp. aff. *P. perbonus*, GSC loc. C-12405) (Pedder, 1978; Pedder 1982a; Pedder and McLean, 1982). It has also been documented from the Cranswick Formation of the McKenzie Mountain region (*P. inversus* Zone, GSC loc. C-63102) (Pedder and Klapper, 1977), from the limestone and shale member of the McCann Hill Chert, east-central Alaska (*P. inversus* Zone) (Blodgett, 1978), and from the Porcupine River area, Alaska, where it was called *Hexagonaria* sp. by Oliver *et al.* (1975, Pl. 18, figs. 10, 11).

In this study, it is present in the upper Eids Formation (*P. dehiscens* Zone, Early Zlichovian), abundant in the lower Blue Fiord Formation of the Sör Fiord and Vendom Fiord regions (Zlichovian), and rare in the upper Blue Fiord Formation (Zlichovian/Dalejan).

Occurrence - 6 specimens from the upper Eids Formation, Ellesmere Island - DA29 (2 specimens), DA30 (2 specimens), Loc. 7-U9 (2 specimens); 61 specimens from the lower Blue Fiord Formation, Ellesmere Island - AA28, AAA13/15, ABA6/8, AD34, AD37 (3 specimens), CA5 (2 specimens), CA5A, CA16 (3 specimens), CD7, CF25 (3 specimens), CH15 (3 specimens), CH23 (2 specimens), CH24, CH25, EC20, EC38, ED36, ED48 (5 specimens), GC28, GD1, IA14 (2 specimens), IA15, IB4, IC5, IC7, ID5 (s specimens), ID11, JA4, JC8 (2 specimens) K6, Loc. 21, Loc. 26 (2 specimens); 6 specimens from the upper Blue Fiord Formation - JA15 (6 specimens).

Spongonaria sp. nov. 1

Plate 22 c,d

Type specimen - Top of Blue Fiord Formation (*P. serotinus* Zone, Dalejan), section BC, southwest Ellesmere Island. Type specimen (BC8-1) will be

stored at the Geological Survey of Canada, Ottawa, and will be given a G.S.C. number.

Material - 5 well-preserved specimens.

Diagnosis - A species of *Spongonaria* with large corallite diameter (mean 10.2 mm), common septal spines, greatly reduced, thin septa which penetrate the tabularium, 2 rows of steeply sloping dissepiments, and generally complete flat to gently arching tabulae.

Description - Corallum cerioid. Corallites prismatic, moderately thin-walled, zig-zag; mean adult diameter 10.2 mm, range 8.5 to 12.0 mm. Septa radially arranged, commonly 36 in number, ranging from 32 to 40; in one order, 0.20 radius, ranging from 0.15 to 0.25 radius; moderately thin, straight, no peripheral thickening; septal spines common in tabularium. Dissepiments in 2 rows, steeply sloping axially. Dissepimentarium average 0.2 radius, sharp tabularial boundary. Tabulae generally complete, flat to gently arching.

Remarks - *Spongonaria* sp. nov. 1 differs from *S. loewei* in having much larger corallites (mean corallite diameter 5.2 mm in *S. loewei*). *Utaratuia* closely resembles *S.* sp. nov. 1 but can be distinguished from it by its absence of septal spines, the presence of short, triangular septa that do not penetrate the tabularium, and a relatively wider dissepimentarium with more rows of dissepiments.

S. sp. nov. 1 occurs between Blue and Sör Fiords in the upper Eids Formation (*P. dehiscens* Zone, Early Zlichovian), in the lower Blue Fiord Formation (late Early to early Late Zlichovian), and in the upper Blue Fiord Formation (*P. serotinus* Zone, Dalejan). It also occurs in the Disappointment Bay Formation, southern Ellesmere Island (*P. inversus*

Zone, Zlichovian/Dalejan).

Pedder, A.E.H. (pers. comm., 1983) has noted *S.* sp. nov. 1 in the Blue Fiord Formation at Sör Fiord (*P. serotinus* Zone, GSC loc. C-12491).

Occurrence - 1 sample from the Eids Formation, Ellesmere Island - CD2; 2 samples from the lower Blue Fiord Formation, Ellesmere Island - ID5 (2 specimens); 1 sample from the upper Blue Fiord Formation, Ellesmere Island - BC8; 1 sample from the Disappointment Bay Formation, Ellesmere Island - FA6.

Spongonaria sp. nov. 2

Plate 22 a,b

Type specimen - Lower Blue Fiord Formation (*P. dehiscens* Zone, Lower Zlichovian), section EC, southwest Ellesmere Island. Type specimen (EC11-2) will be stored at the Geological Survey of Canada, Ottawa, and will be given a G.S.C. number.

Material - 5 well-preserved specimens.

Diagnosis - A species of *Spongonaria* with relatively small corallite diameter, septa well differentiated into two orders, major septa almost reaching axis, minor septa about half length, 4 rows of moderately sloping dissepiments, and incomplete, generally flat tabulae.

Description - Corallum cerioid. Corallites prismatic, thin-walled, faintly zig-zag; mean adult corallite diameter 5.2 mm, ranging from 4.0 to 6.2 mm. Septa radially arranged, averaging 32 in number, range 28 to 36; well differentiated into two orders, major septa long, 0.9 radius, range 0.81 to 0.92 radius, minor septa 0.5 radius, range 0.45 to 0.6 radius; generally thin, straight. Dissepiments arranged in 4 rows, larger at periphery, flat at periphery, sloping axially. Dissepimentarium

commonly averaging 0.5 radius. Tabulae incomplete, flat to axially sloping.

Remarks - *Spongonaria* sp. nov. 2 differs from *S. ogilviensis* in having a smaller corallite diameter and longer major septa. *S. parca* and *S. loewei* are distinguished from *S.* sp. nov. 2 by having shorter septa and less dissepiments. *S. filicata* and *S.* sp. nov. 1 are larger and have shorter major septa compared to *S.* sp. nov. 2. *Exilifrons* Crickmay is similar to *S.* sp. nov. 2 in having long, generally thin major septa, but differs from it by having zig-zag carinae and markedly folded septa.

S. sp. nov. 2 occurs in the lower Blue Fiord Formation (late Early to early Late Zlichovian) near Sör Fiord, and in the upper Blue Fiord Formation (Dalejan) near Blue Fiord.

Pedder, A.E.H. (pers. comm., 1983) has also noted a species similar to *S.* sp. nov. 2 from the Blue Fiord Formation (*P. inversus* Zone, Zlichovian/Dalejan) in the Sör Fiord region. However, the average corallite diameter of this species is 10 mm.

Occurrence - 4 coralla from the lower Blue Fiord Formation, Ellesmere Island - EC11 (2 specimens), Loc. 40 (2 specimens); 1 coralla from the upper Blue Fiord Formation, Ellesmere Island - JA15.

Subfamily TROPIDOPHYLLINAE Pedder, 1983

Genus ZELOLASMA Pedder, 1964a

Zelolasma Pedder, 1964a, p. 364, 365.

Type species - *Diphyphyllum gemmiforme* Etheridge, 1902, p. 253-255, Pl. 37, fig. 1; Pl. 39, figs. 1, 2; Pl. 40, fig. 1. "Cave Limestone - Middle Devonian". Type stratum now assigned to Cavan Limestone, and is either Late Pragian or Early Zlichovian.

Zelolasma apsidiferum Pedder and Smith, 1983

Plate 22 g,h,i

Zelolasma apsidiferum Pedder and Smith, 1983, p. 197, 199, Pl. 22.1, figs. 1-7.

Type specimen - Top of Eids Formation (*dehiscens* Zone, Early Zlichovian), 20.5 km west of Sör Fiord, southwestern Ellesmere Island.

Material - 3 well-preserved coralla.

Description - Corallum fasciculate, with tendency for groups of 3 to 4 corallites to be attached to each other and aligned like links in a chain. Corallites thin-walled; mean adult diameter 5.0 to 6.5 mm. Septa radially arranged, commonly 34 to 36 in number; in two weakly differentiated orders, majors 0.5 radius, minors slightly shorter, barely penetrating tabularium; thin, mostly straight or slightly undulant, rarely carinate; short septal spines present in parts of the tabularium. Dissepiments in one, rarely 2 rows, almost symmetrically arched. Tabulae generally complete, broad, flat or slightly concave.

Remarks - See Pedder and Smith (1983, p. 197, 199) for comparison between *Zelolasma apsidiferum*, *Z. planivesiculosa*, and *Z. gemmiforme*. *Z. apsidiferum* is from the Early Zlichovian upper Eids Formation (*P. dehiscens* Zone), near Sör Fiord.

The genus *Zelolasma* has been discovered in Pragian, Lower Zlichovian and Dalejan strata (Pedder and Smith, 1983, p. 196), and shows considerable homeomorphy with the genus *Spongonaria*. They differ mainly in the fact that *Zelolasma* is fasciculate, and its septa are commonly carinate. As *Zelolasma* is a close relative of and predates *Spongonaria*, it is likely that a close phylogenetic relationship exists between the two, and that

Spongonaria evolved from *Zelolasma*. Pedder *et al.* (1970, p. 232) and Pedder (1978, p. 47) reached the same conclusion.

Occurrence - All samples are from DA27, in the upper Eids Formation (*dehiscens* Zone), Ellesmere Island.

Subfamily UTARATUIINAE Spasskiy, Kravtsov, and Tsyganko, 1975

Genus UTARATUIA Crickmay, 1960

Utaratuia Crickmay, 1960, p. 5.

Type species - *Utaratuia laevigata* Crickmay, 1960, p. 5, Pl. 1, figs. 6-9, Pl. 8, fig. 1. Low Middle Devonian limestone, *verrilli* Zone, Rainbow Arch, Carcajou River, Northwest Territories; 65° 27' N. lat., 128° 13' W. long. Type horizon is in the Late Eifelian Hume Formation.

Utaratuia sp.

Plate 23 a,b,c

Material - 13 well-preserved coralla.

Description - Corallum cerioid. Corallites prismatic, thick-walled; mean adult diameter 9.4 mm, range 6.5 to 13.5 mm. Septa radially arranged, average 38 in number, range 34 to 42; in one order, commonly 0.15 radius, but 0.30 radius in some corallites, range 0.09 to 0.65 radius; short, thick, triangular in shape, sometimes attenuate into thin threads that barely penetrate tabularium but generally do not reach into tabularium; septal spines rare, generally not seen. Dissepiments arranged in 4 to 5 rows, strongly sloping axially, grade imperceptably into tabellae which are sloped axially and flatter in axis. Dissepimentarium 0.3 to 0.4 radius commonly. Tabulae flat to gently sagging.

Remarks - The similarities between *Utaratuia* sp. and *S.* sp. nov. 1

have been discussed previously (see remarks, *S.* sp. nov. 1). *Utaratuia* sp. resembles the type species *U. laevigata* Crickmay, but has smaller diameter corallites (15 to 17 mm in *U. laevigata*) and has fewer septa (44 to 66 in *U. laevigata*). It differs from *U. acupicta* Crickmay in having thick septa.

Utaratuia sp. differs from typical species of *Utaratuia*, as, in some coralla, the septa of some corallites just attain the tabularium (as thin threads), whereas septa in other corallites do not. Rarely, this difference in septal length can be seen within one corallite. Therefore, it appears that the atypical septal length can be explained by intraspecific variation. Also, septal spines are very rarely seen in some corallites of some coralla. Their presence could be regarded as diagnostic of the genus *Spongonaria* (Pedder and McLean, 1982, p. 77), although septal spines have been recognized in 3 Eifelian species of *Utaratuia* from the Longdongshui Member of the Houershan Formation of southern Kweichow, China (Yü and Liao, 1974, 1978; Kong and Huang, 1978). This study chooses to place coralla that conform to the diagnosis of *Utaratuia*, apart from the presence of rare septal spines and some septal lengthening, into *Utaratuia* rather than *Spongonaria*, and to explain these atypical features as intraspecific variation.

Undoubtedly, *Utaratuia* and *Spongonaria* are closely related. Indeed, Pedder and McLean (1982, p. 77), using examples from the Blue Fiord Formation of Ellesmere Island, suggest that *Utaratuia* was derived from *Spongonaria*. The specimens examined support this concept and show that *Spongonaria* and *Utaratuia* coexisted for part of the Lower Devonian.

All of the specimens of *Utaratuia* sp. examined come from the lower Blue Fiord Formation (Zlichovian) of the Vendom Fiord area. *Utaratuia*

has previously been recognized only from the Middle and Upper Devonian. Therefore, this is the first report of *Utaratuia* from the Arctic Islands, and also from Lower Devonian strata worldwide.

Occurrence - 13 samples from the lower Blue Fiord Formation, Ellesmere Island - ED36 (2 specimens), GB18, GB19 (2 specimens), GB28 (2 specimens), GB31 (4 specimens), GE2, HB28.

Suborder CYATHOPHYLLINA Nicholson, 1889

Family CYATHOPHYLLIDAE Dana, 1846

Subfamily STERICTOPHYLLINAE Pedder, 1965

Genus CAVANOPHYLLUM Pedder, 1965

Cavanophyllum Pedder, 1965, p. 215, 216.

Type species - *Miotophyllum trochoides* Hill, 1940, p. 265, 266, Pl. 11, figs. 7-10; Lower Middle Devonian, Cavan Bluff Limestone, Murrumbidgee River, New South Wales, Australia.

Cavanophyllum sp.

Plate 23 d,e

Material - 6 well-preserved specimens.

Description - Corallum solitary. Mean adult corallite diameter 29 mm, range 30-34 mm. Septa numerous, average 84 in number, ranging from 76 to 88; in two orders, majors reaching axis, minors half majors; straight to gently undulating, thickened in outer and middle dissepimentarium; axially, majors attenuate when minors end. Dissepiments small, numerous, averaging 15 rows, well-inflated, becoming steeper inclined axially; innermost dissepiments locally grade to tabellae. Tabulae floor complete to incomplete, flat to slightly arched.

Remarks - *Cavanophyllum* sp. is the first member of the genus to be recognized in the Arctic Islands. Pedder (1982a) has documented *C. uyenoi* from the lower Blue Fiord Formation near Sör Fiord; however, it is now regarded as belonging to *Mansuyphyllum uyenoi uyenoi* (Pedder and Goodbody, 1983).

All the specimens are from ED29 in the lower Blue Fiord Formation of the Vendom Fiord region. A Late Zlichovian age is likely. This age is in agreement with Hill (1981, p. 304, 305) who regarded *Cavanophyllum* as a synonym of *Steriatophyllum*, which is restricted to the Lower Devonian (Hill, 1981, p. 84).

Occurrence - All samples are from ED29, in the lower Blue Fiord Formation, Ellesmere Island.

Genus MANSUYPHYLLUM Fontaine, 1961

Mansuyphyllum Fontaine, 1961, p. 100, 101.

Type species - *Cyathophyllum annamiticum* Mansuy, 1913, p. 9.

Mansuyphyllum uyenoi (Pedder, 1982a)

Mansuyphyllum uyenoi uyenoi (Pedder, 1982a)

Plate 23 f,g

Cavanophyllum sp. Pedder, 1978, p. 152, Pl. 41, figs. 2, 4.

Cavanophyllum uyenoi Pedder, 1982a, p. 76, Pl. 9,16, figs. 5-10.

Type specimen - Lower Blue Fiord Formation (Zlichovian), Sör Fiord Section, Ellesmere Island.

Material - One well-preserved specimen.

Description - Corallum solitary. Corallite thick-walled (0.4 mm); mean adult diameter 30 mm. Septa numerous, 66 in number; well-differentiated

into two orders; majors reach or almost reach axis, minors just penetrate tabularium, approximately 0.6 radius; thicken peripherally, generally straight. Dissepiments variable in size, inflated, in 15 rows; surfaces gently inclined at periphery, becoming steeper axially. Dissepimentarium 0.55 radius. Tabulae mostly incomplete, flat to depressed in axial region.

Remarks - *Mansuyphyllum uyenoi uyenoi* noted herein is very similar to forms noted by Pedder (1982a) which he named *Cavanophyllum uyenoi*. He later transferred these specimens to *Mansuyphyllum uyenoi uyenoi* because true species of *Cavanophyllum* have flatter and less divergent trabeculae (Pedder and Goodbody, 1983).

The other subspecies of *Mansuyphyllum uyenoi*, *M. uyenoi avernale*, differs from *M. uyenoi uyenoi* by being smaller (maximum diameter 26 mm), and by having a lower septal count (62).

M. uyenoi uyenoi has previously only been reported from the Lower and Upper Zlichovian parts of the Blue Fiord Formation near Sör Fiord (GSC loc-12424, 12498) (Pedder, 1982a).

Occurrence - The corallum is from Loc. 26 in the lower Blue Fiord Formation, Ellesmere Island.

Suborder LYCOPHYLLINA Zhavoronkova, 1972

Family HALLIIDAE Chapman, 1893

Subfamily HALLIINAE Chapman, 1893

Genus THOULELASMA Pedder, 1983

Thoulelasma Pedder, 1983, p. 226-7

Type species - *Thoulelasma loewei* Pedder, 1983, p. 227-8, Pl. 26.1, figs. 6-20; near top Blue Fiord Formation (Dalejan, *P. serotinus* Zone), Sör Fiord section, southwestern Ellesmere Island.

Thoulelasma loewei Pedder, 1983

Glossophyllum sp. Oliver and Pedder, 1979a, p. 240

Glossophyllum sp. Pedder, 1982c, p. 564

Glossophyllum sp. nov; Pedder and McLean, 1982, p. 80

Thoulelasma loewei Pedder, 1983, p. 227-8, Pl. 26.1, figs. 6-20

Type specimen - see type species

Material - One well-preserved corallum.

Description - Corallum solitary. Corallite thin-walled; mean adult diameter 27 mm. Septa abundant, 74 in number; majors attaining axis and forming axial whorl, minors approximately 0.6 radius; continuous, thin, gently undulating, slightly dilating in tabularium. Dissepiments in 14 rows, larger and shallower at periphery, much steeper and smaller axially. Dissepimentarium 0.52 radius, poorly defined border with tabularium. Tabulae incomplete, flat to sinuous.

Remarks - *T. loewei* noted herein is slightly smaller and has a lower septal count than adult *T. loewei* noted by Pedder (1983). However, it closely resembles a corallum at a middle ontogenetic stage, and is therefore probably not a mature corallum.

See Pedder (1983, p. 227-8) for a thorough comparison of *T. loewei* with related forms.

T. loewei has previously only been noted from GSC loc. C-12472 and GSC C-12473 in the upper Blue Fiord Formation near Sör Fiord (*P. serotinus* Zone, Dalejan) by Pedder (1983). The single sample from ED29 in the lower Blue Fiord Formation of the Vendom Fiord region is probably Late Zlichovian in age, and thus extends the species range somewhat downwards.

Occurrence - The single sample is from ED29, in the lower Blue Fiord Formation, Ellesmere Island.

Suborder PTENOPHYLLINA Wedekind, 1927

Family SPONGOPHYLLIDAE Dybowski, 1873

Subfamily PTENOPHYLLINAE Wedekind, 1923

Genus ACANTHOPHYLLUM Dybowski, 1873

Acanthophyllum Dybowski, 1873, p. 339

Neostringophyllum Wedekind, 1922, p. 16

Ptenophyllum Wedekind, 1923, p. 28

Astrophyllum Wedekind, 1924, p. 46

Rhopalophyllum Wedekind, 1924, p. 52

Stenophyllum Wedekind, 1925, p. 9

Leptoinophyllum Wedekind, 1925, p. 4

Type species - *Cyathophyllum heterophyllum* Milne Edwards and Haime, 1851, p. 367; Junkerberg Formation, Eifelian, Eifel district, Germany.

Acanthophyllum sp.

Plate 23 h

Material - One well-preserved and one poorly-preserved specimen.

Description - Corallum solitary. Adult corallite diameter commonly 20-22 mm. Septa 78 in number, long; in two orders, majorsextending to axis, forming axial whorl, minor septa commonly 0.6 radius; major septa moderately thin, minors thinner; straight to gently undulating, smooth. Dissepiments common, larger at periphery, bulbous, not steeply sloping. Dissepimentarium moderately wide, 0.6 - 0.7 radius. Tabulae incomplete.

Remarks - This is the first occurrence of a species of *Acanthophyllum* in

the Arctic Islands. Both samples are from the Blue Fiord Formation of northeastern Bathurst Island (B22), which is regarded as Eifelian in age (McGregor and Uyeno, 1972, p. 13-16). *Acanthophyllum* has also been found widely scattered in Alaska (Oliver *et al.*, 1975) - upper Lower Devonian (*P. inversus* Zone) Ogilvie Formation, east-central Alaska (Blodgett, 1978); upper Lower Devonian McCann Hill Chert, Yukon-Nation Rivers area; Lower-Middle Devonian Skajit Limestone of west Brooks Range; and the Middle Devonian Wadleigh Limestone of San Alberto Bay area, the limestone associated with the Woodchopper volcanics, Woodchopper area, and the Middle Devonian of Heceta and Tuxekan Islands, and the eastern Alaska Range.

Occurrence - Both coralla are from B22, in the Blue Fiord Formation of Bathurst Island.

Genus DOHMOPHYLLUM Wedekind, 1923

Dohmophyllum Wedekind, 1923, p. 28

Sparganophyllum Wedekind, 1925, p. 13

Pseudoptenophyllum Wedekind, 1925, p. 60, 78

Type species - *Dohmophyllum involutum* Wedekind, 1923; Eifelian, Junckerberg Schichten, Rhenish Mountains, Germany.

Dohmophyllum sp.
Plate 23 i,j

Material - 7 well-preserved coralla, one poorly-preserved.

Description - Corallum solitary. Mean adult corallite diameter 30 mm, range 23 to 34 mm; moderate to thin peripheral stereozone. Septa numerous, average 60, ranging from 52 to 64; in two orders, majors reach axis and form an axial whorl, minor septa approximately 0.75 radius;

have expanded bases, thinning axially with some stereoplasmic thickening, generally straight, rare zig-zag carinae. Dissepiments numerous, larger at periphery where they are slightly expanded upwards; axially very small, steeply inclined. Dissepimentarium 0.7 radius. Tabellae numerous, close together, inwardly sloping.

Remarks - *Dohmophyllum* sp. can be distinguished from *Acanthophyllum* sp. only by its relatively wider dissepimentarium.

Pedder (1978, Pl. 42, figs. 1, 2) was the first to document *Dohmophyllum* in the Arctic Islands, from the Blue Fiord Formation (*P.* sp. aff. *P. perbonus* Zone, Upper Zlichovian) from the Sör Fiord area (GSC loc. C-12498). It has also been documented from the northern Yukon Territory in the Royal Mountain area from an unnamed carbonate (*P. dehiscens* Zone, Lower Zlichovian) (Pedder, 1978, Pl. 36, figs. 1, 5), and in the northwest MacKenzie Mountains from the Cranswick Formation (*P.* sp. aff. *P. perbonus* Zone) (Pedder, 1978, Pl. 38, figs. 8, 9).

Most of the coralla noted herein occur in the lower Blue Fiord Formation, Sör Fiord and Vendom Fiord regions (upper Lower to lower Upper Zlichovian). One coralla was from the Disappointment Bay Formation (*P. inversus* Zone, Upper Zlichovian/Lower Dalejan).

Occurrence - The well-preserved coralla are from CA16, CC2A (2 specimens), ED48 (2 specimens), ID 14, Loc. 40, all in the lower Blue Fiord Formation, Ellesmere Island; KA49 provided the poorly preserved sample from the Disappointment Bay Formation of Ellesmere Island.

Genus EMBOLOPHYLLUM Pedder, 1967

Embolophyllum Pedder, 1967, p. 10

Type species - *Acanthophyllum asper* Hill, 1940; Emsian, Cave Flat road

from Wee Jasper, New South Wales, Australia.

Embolophyllum sp.

Plate 23 k,l

Material - 6 well-preserved specimens.

Description - Corallum solitary, subcylindrical. Mean adult corallite diameter 17 mm, range 12 to 22 mm; stereozone thin to medium in thickness. Septa average 52 in number, range 48 to 58; well-differentiated into two orders, majors extending to axis forming axial whorl, minor septa average 0.6 radius; expanded at base, generally of medium thickness, some stereoplasmic thickening in middle dissepimentarium; gently undulating. Dissepiments numerous, average 10 rows, larger, more globose at periphery, becoming smaller and steeper sloping axially. Dissepimentarium commonly 0.7 radius. Tabulae incomplete, sloping gently axially.

Remarks - *Embolophyllum* is closely related to both *Acanthophyllum* and *Dohmophyllum*. It can be distinguished from them by its relatively thicker stereozone.

Pedder (*in* Pedder and McLean, 1982, p. 79) has identified *Embolophyllum* from the Blue Fiord Formation (*P.* sp. aff. *P. perbonus* Zone, U. Zlichovian) from the Sör Fiord area (GSC loc. C-12415). It has also been documented by Blodgett (1978, p. 47) from the Ogilvie Formation (*P. invareus* Zone, U. Zlichovian) from east-central Alaska, and by Pedder (1978, Pl. 44, figs. 1, 2) from the Ogilvie Formation (*P. serotinus* Zone, Dalejan) of the Ogilvie Mountains.

In the study area, *Embolophyllum* occurs in the upper Eids Formation, and the lower Blue Fiord Formation (upper Lower Zlichovian to lower Upper Zlichovian), and in the upper Blue Fiord Formation (Upper Zlichovian to

Dalejan).

Occurrence - The 6 coralla are from AC1 in the upper Eids Formation, Ellesmere Island; CH24, ID16, Loc. 40 (2 specimens), in the lower Blue Fiord Formation, Ellesmere Island; and JA15, in the middle-upper Blue Fiord Formation, Ellesmere Island.

Genus TAIMYROPHYLLUM Chernyshev, 1941

Taimyrophyllum Chernyshev, 1941, p. 12, 53

Eddastraea Hill, 1942, p. 147, 148

Type species - *Taimyrophyllum speciosum* Chernyshev, 1941, p. 12, 13, 53, 54, text-fig. 1, Pl. 1, figs. 1-3; Pl. 2, figs. 1-3; Pl. 5, fig. 5; holotype from 40 km above the mouth of Tareya River, southwest Taimyr, U.S.S.R., Lower Devonian.

Taimyrophyllum nolani Merriam, 1974

Phillipsastraea vermeuili Milne Edwards and Haime; Loewe, 1913, p. 12-14 (in part), Pl. 3, figs. 1a, b; Pl. 4, figs. 1a, b.

Phillipsastraea schaii Loewe, 1913, p. 12-14 (in part), Pl. 4, figs. 3a, b.

Phillipsastraea gigas Billings, Loewe, 1913, p. 14, Pl. 4, fig. 2

Taimyrophyllum nolani Merriam, 1974, p. 44, 45 (in part?), Pl. 9, figs. 1, 2?, 3-5, 6?; Pl. 10, figs. 10S?, 6, 7?

Taimyrophyllum nolani baumannense Pedder, 1982a

Plate 24 a

Taimyrophyllum nolani baumannense (non *beaumannense*) Pedder, 1982a, p. 74, 75

Type specimen - Lower Blue Fiord Formation (herein considered upper Eids

Formation) (Early Zlichovian), just northeast of Sör Fiord Section, Ellesmere Island.

Material - 2 well-preserved specimens.

Description - Corallum thamnasterioid. Diameter of adult corallites ranging from 10 to 12 mm. Septa number 36 in adult corallites; well-differentiated into two orders, majors attain axis, and form axial whorls in some corallites, minor septa commonly 0.85 radius; thicken in inner dissepimentarium; slightly crenulate; at periphery, most are confluent with septa of adjacent corallite, but in places are deflected and form a discontinuous wall between the corallites. Dissepiments abundant, in 24 rows; at periphery, larger and less inflated than in inner dissepimentarium, where dissepiments are strongly inflated and steeply inclined. Dissepimentarium commonly 0.8 radius; minor septa always penetrate tabularium. Tabulae incomplete, depressed axially.

Remarks - The holotype of *T. nolani baumannense* was recently described by Pedder (1982a, p. 74, 75) from the basal Blue Fiord Formation (*P. dehiscens* Zone), first gorge northeast of Sör Fiord section, southwest Ellesmere Island (equivalent to section EA of this study). The present work has shown that these beds are part of the upper Eids Formation. Further, Pedder (1982a, p. 75) derived the subspecies name *baumannense* from Baumann Fiord. However, he misspelled the name of the fiord (Beaumann), and therefore the subspecies name *beaumannense* was used. To ensure stability and universality of nomenclature, the subspecies name is herein altered to *baumannense* (see Article 19, Rules of Zoological Nomenclature).

Pedder (1982a, p. 73, 75) thoroughly compared *T. nolani baumannense* with related forms.

The 2 samples in this study come from the Blue Fiord Formation on northeast Bathurst Island (B22) tentatively dated as Eifelian (McGregor and Uyeno, 1972, p. 13-16). Therefore this occurrence would significantly extend the range of the subspecies upwards.

Occurrence - Both samples are from B22, in the Blue Fiord Formation of Bathurst Island.

Taimyrophyllum sp. nov.

Plate 24 b,c

Type specimen - Blue Fiord Formation (Eifelian), Section B37, southwest Bathurst Island. Type specimen (B37-3) will be stored at the Geological Survey of Canada, Ottawa, and will be given a G.S.C. number.

Material - 2 well-preserved coralla.

Diagnosis - A pseudocerioid species of *Taimyrophyllum*, with a mean adult corallite diameter of 12 mm, commonly 34 crenulate septa, bearing zig-zag carinae, abundant commonly chevron-shaped dissepiments, in 30 rows on average, and incomplete, generally flat tabulae forming a low angle with the dissepimentarium.

Description - Corallum pseudocerioid. Mean adult corallite diameter 12 mm, range 10 to 14 mm. Septa radially arranged; number 34, ranging from 32 to 36; well-differentiated into 2 orders, majors reach centre and form axial whorl, minors approximately 0.85 radius; crenulate, bear prominent zig-zag carinae; "line-up" with septa from adjacent corallites, but are separated by a "pseudowall" formed by bifurcating septa and isolated septal fragments. Dissepiments abundant, commonly in 30 rows; close together, steeply dipping, commonly chevron-shaped. Dissepimentarium commonly 0.8 radius. Tabulae incomplete, flat to gently dipping,

forming low angle with dissepimentarium.

Remarks - *Taimyrophyllum* sp. nov. differs from all other species assigned to the genus by having a relatively well developed pseudowall. *T. vesicibalteatum* Pedder also has intercorallite walls developed, but they are much weaker than in *T.* sp. nov., and are absent in places. It also is smaller (corallite diameter range 6 to 11 mm), and has fewer septa (22 to 30) than *T.* sp. nov.. *T. nolani baumannense* is biometrically similar to *T.* sp. nov. but is thamnasterioid, has a different dissepiment number and character, has more depressed tabulae, and less pronounced septal crenulae.

The holotype and paratype of *T.* sp. nov. are from the Blue Fiord Formation of southwest Bathurst Island (B37). Conodonts collected from the Blue Fiord Formation 15 km south of B37 (section 39 of Kerr, 1974) were dated as Eifelian (Kerr, 1974, p. 44). Thus they are younger than the type specimens of *T. nolani baumannense*, but are similar in age to *T. nolani baumannense* at B22.

Occurrence - Both specimens are from B37, in the Blue Fiord Formation of Bathurst Island.

Genus TAWUPHYLLUM Pedder, 1980

Tawuphyllum Pedder, 1980, p. 602, 604

Type species - *Australophyllum praeclarum* Crickmay, 1962, p. 6, Pl. 2, figs. 4, 5, Late Eifelian "Norman Wells Formation" (Hume Formation), "Houston River", MacKenzie Mountains, District of MacKenzie; 65° 21' N Lat., 131° 24' W. Long.

Tawuphyllum atypica (Crickmay, 1960)

Plate 25 a,b

Hexagonaria atypica Crickmay, 1960, p. 9, 10, Pl. 6, figs. 4, 5.

Exilifrons atypica Crickmay, 1968, p. 6

Type specimen - Middle Devonian, *arctica* Zone, Little Doctor Lake, south shore 2 miles east of "efflux", Northwest Territories; 61° 52' N. Lat., 123° 21' W. Long.

Material - 3 well-preserved coralla.

Description - Corallum cerioid with deep calical pit. Corallites large, elongated with thick, continuous walls; mean adult diameter 11 mm, range 8 to 14 mm. Septa abundant, averaging 50 in number, ranging from 38 to 60; predominantly continuous, rarely discontinuous peripherally; strongly differentiated into two orders, major 0.85 radius, minors 0.25 radius; thickened at base, otherwise very thin, gently undulating. Dissepiments in 5 or more rows, bulbous, moderately sloping at periphery, becoming steeper axially, and smaller. Dissepimentarium approximately 0.7 radius; very diffuse border with tabularium, dissepiments grading through tabellae into tabulae. Tabulae complete, flat to gently arched.

Remarks - *Tauraphyllum atypica* differs substantially from the type species *T. praeclarum* by having less peripherally withdrawn septa. *T. impedita* (Crickmay, 1960) has much fewer septa (38), more numerous dissepiments (6 to 7 rows), and a much sharper tabularial border than *T. atypica*. *T. furtiva* (Crickmay, 1960) is distinguished from *T. atypica* by having fewer septa (38 to 44), dissepiments which increase in size axially, arranged in more rows (7 to 9), and incomplete tabulae.

The holotype of *T. atypica* is from the Middle Devonian of the Northwest Territories. The samples in this study come from the Blue Fiord Formation of southwest Bathurst Island (B37), which can be dated as Eifelian (Kerr, 1974, p. 44).

Occurrence - All specimens are from B37, in the Blue Fiord Formation of Bathurst Island.

Suborder STAURIINA Verrill, 1865

Family CYATHOPHYLLOIDIDAE Dybowski, 1873

Genus DENDROSTELLA Glinski, 1957

Favistella (Dendrostella) Glinski, 1957, p. 87, 88

Soshkinella Ivaniya, 1960, p. 41, 42

Iteophyllum Crickmay, 1962, p. 1

Type species - *Cyathophylloides rhenanum* Frech, 1886, p. 207, Pl. 15, figs. 19, 19a; Givetian, Bücheler beds, Schladetal near Bergisch-Gladbach, Germany.

Dendrostella trigemme (Quenstedt, 1879)
Plate 25 c,d

Cyathophyllum caespitosum trigemme Quenstedt, 1879, p. 518; 1881, Pl. 162, figs. 5-8.

See Pedder (1980, p. 596) for further synonymy.

Type specimen - Givetian, Schwelmer Kalk, near Paffrath, Germany.

Material - 3 moderately well-preserved coralla.

Description - Corallum loosely fasciculate. Corallites cylindrical with very thick stereozone (0.8 mm thick); mean adult diameter 6.5 mm. Septa 36 in number, well-differentiated into two orders, majors up to 0.9 radius, minors approximately 0.4 radius; septal bases expanded, afterwards thin, smooth. Dissepiments absent. Complete tabulae not seen in views, interrupted by septa; depressed axially.

Remarks - In the Arctic Islands, *Dendrostella trigemme* has been previously

documented in the Blue Fiord Formation east of Weatherall Bay, Melville Island (considered here as limestone member of the Disappointment Bay Formation) by McLaren (*in* Tozer and Thorsteinsson, 1964). It has also been found in Late Eifelian rocks of the Ogilvie, Hume, Nahanni, and Headless formations of northwest Canada, generally from shallow water facies (Pedder, 1964b, 1980).

D. trigemme comes from the limestone member of the Disappointment Bay Formation of east-central Bathurst Island (B30-11) and indicates a probable Eifelian age. The corals occurred in a very shallow water environment, and it is probable that this genus is indicative of a very shallow water biofacies.

Occurrence - All samples are from B30-11 in the limestone member of the Disappointment Bay Formation of Bathurst Island.

Suborder STREPTELASMATINA Wedekind, 1927

Family MUCOPHYLLIDAE Soshkina, 1947

Subfamily PSEUDAMPLEXINAE Stumm, 1949

Genus PSEUDAMPLEXUS Weissermel, 1897

Pseudamplexus Weissermel, 1897, p. 878

?Pseudomphyma Wedekind, 1927, p. 34

Pseliophyllum Lang, Smith, and Thomas, 1940, p. 107

?Pseudotryplasma Ivaniya, 1958

?Gyalophylloides Cao *in* Li *et al.*, 1975, p. 193

Type species - *Zaphrentis ligeriensis* Barrois, 1889, p. 52; Emsian, Calcaire d'Erbray, France.

Pseudamplexus sp.

Plate 24 d,e

Material - 2 well-preserved coralla.

Remarks - The 2 samples of *Pseudamplexus* are currently on loan to A.E.H. Pedder (Calgary), and no description is available at present. An article concerning *Pseudamplexus* from the Blue Fiord Formation is in preparation (Pedder and Smith, in prep.).

Occurrence - Both samples are from the lower part of the Blue Fiord Formation, Ellesmere Island, CC2C and CH4.

Subclass TABULATA Milne Edwards and Haime, 1850

Order AULOPORIDA Sokolov, 1947

Superfamily SYRINGOPORICAE de Fromentel, 1861

Family ROEMERIIDAE Počta, 1904

Genus ROEMERIA Milne Edwards and Haime, 1851

Roemeria Milne Edwards and Haime, 1851, p. 152, 253.

Type species - *Calamopora infundibulifera* Goldfuss, 1829, p. 78, Pl. 27, figs. 1a, b; Middle Devonian, Eifel district and Bernsberg, Germany.

Roemeria sp. cf. *R. infundibulifera* (Goldfuss, 1829)

Plate 26 a,b

(*Calamopora infundibulifera* Goldfuss, 1829, p. 78, Pl. 27, figs. 1a, b)

(*Roemeria infundibulifera* Milne Edwards and Haime, 1851, p. 152, 253)

(*Roemeria infundibuliformis* Lecompte, 1936, p. 68, Pl. 12, figs. 1a-1)

Type specimen - see *Roemeria* type species.

Material - 11 well-preserved coralla.

Description - Corallum cerioid, massively branching. Corallites polygonal, usually 6-sided; adult mean diameter commonly 1.1 to 1.4 mm; thick-walled (0.25 to 0.3 mm), straight, slightly corrugated longitudinally, composed of medium dark zone bordered on either side by fibrous lighter sclerenchyme, fibres oriented perpendicular to the dark zone. Short, slender spines project into lumen, very rare; mural pores very rare. Tabulae thin, concave to infundibuliform, widely spaced.

Remarks - This is the first report of the genus *Roemeria* from North America. According to Hill (1981, p. 499), *Roemeria* is known only from the Middle Devonian. *R. infundibulifera* has been found in the Middle

Devonian of the Eifel District, and in the Eifelian of the River Salairika, Kuznetsk Basin, U.S.S.R. Pedder (1983, pers. comm.) has noted *R.* sp. cf. *R. infundibulifera* from the Dalejan of Ellesmere Island.

R. sp. cf. *R. infundibulifera* is similar to *R. infundibulifera* but differs only in having a much smaller adult corallite diameter (mean 2.35 mm, range to 3 mm for *R. infundibulifera*). Jell and Hill (1970a, p. 160-162) have redescribed the lectotype of *R. infundibulifera* in detail.

The corallum form and external characters of *Roemeria* sp. cf. *R. infundibulifera* resemble *Thamnopora*. The two can be differentiated by the convave to infundibuliform tabulae and rare mural pores of *R.* sp. cf. *R. infundibulifera* compared to horizontal tabulae and common mural pores in *Thamnopora*.

The specimens of *R.* sp. cf. *R. infundibulifera* come from the upper Eids Formation near Sör Fiord (*P. dehiscens* Zone, Early Zlichovian), and from the lower Blue Fiord Formation in the Sör Fiord and Vendom Fiord regions (late Early to early Late Zlichovian). Thus, the documentation of *R.* sp. cf. *R. infundibulifera* considerably extends the range of *Roemeria*, both geographically, and stratigraphically.

Occurrence - 9 specimens from the upper Eids Formation, Ellesmere Island - EA3, EA7 (7 specimens), EA9; 2 specimens from the lower Blue Fiord Formation, Ellesmere Island - CH32, HA2.

Genus ROEMERIPORA Kraicz, 1934

Roemeripora Kraicz, 1934, p. 45

Vaughanites Paul, 1937, p. 110

Roemeriolites Dubatolov, 1963, p. 58

Armalites Tchudinova *in* Dubatolov, 1963a, p. 62

Pseudoroemeripora Koksharskaya 1965, p. 88

Bajhaium Langenheim and McCutcheon, 1959, p. 99

Type species - *Roemeria bohemica* Barrande *in* Počta, 1902, p. 262, Pl. 102, figs. 9, 10; Pl. 111, figs. 21-25; Pl. 116, figs. 11, 12; Lower Devonian (Pragian) Koneprus Limestone, Koneprus, Czechoslovakia.

Roemeripora progenitor (Chapman, 1921)

Plate 26 c,d

Michelinia progenitor Chapman, 1921, p. 220, Pl. 9, figs. 7,8

?Syringopora thomii Chapman, 1921, p. 222, Pl. 10, fig. 14

Syringopora cf. *spelaeanus* Etheridge; Jones, 1945, p. 57, Pl. 3, fig. 6

Roemeria ocellata Hill, 1950, p. 159, Pl. 9, figs. 35a, b.

?Roemeria sp. Hill, 1950, p. 159, 160, Pl. 19, figs. 36a, b

?Roemeria thomii (Chapman); Phillip, 1962, p. 169, text-fig. 3. Pl. 20, figs. 3, 4

Roemeripora sp. cf. *ocellata* (Hill); Hill, Playford, and Woods, 1967, p. d8, Pl. D4, figs. 5a, b

Roemeripora sp. Polan, 1982, p. 64, Pl. 5, fig. 5

Type specimen - Cave Hill, Lilydale, Victoria, Australia (Lower Devonian).

Material - 19 well-preserved coralla.

Description - Corallum generally dendroid, although some corallites are contiguous in part; calyx very deep. Corallites have a rounded cross-section, and are wrinkled externally; a peripheral stereozone is well-developed, commonly 0.5 to 0.75 mm thick, divided into 3 zones: a dark thin epitheca, a thin zone of fibres perpendicular to surface, and an inner thick lamellar zone, with lamellae sometimes paralleling epitheca wrinkles; mean adult diameter 4.5 mm, range 3.75 to 5.5 mm. Septal spines

developed in stereozone, project into lumen; also present on tabulae; arranged in longitudinal and horizontal series. Mural pores and connecting tubules present. Tabulae complete to incomplete, mainly infundibuliform, thin; syrinx sometimes developed, crossed by small, thin tabellae, not always axial, curves and opens through connecting tubules to neighbouring corallites.

Remarks - The holotype of *Roemeripora progenitor*, redescribed by Hill and Jell (1970, p. 180), is slightly smaller in corallite diameter (average adult corallite diameter 4 mm) and its corallites are generally more contiguous than the samples described herein, but the latter are within the range of variability shown by the paratypes. *R. progenitor* from Ellesmere Island also bears some resemblance to the genus *Roemerolites* Dubatolov from the lower Middle Devonian (Salairka beds) of the Kuznetsk Basin, Siberia, which has been merged with *Roemeripora* by Hill and Jell (1970, p. 182, 183).

R. progenitor is known from the Lower - ?Middle Devonian of eastern Australia and New Zealand (Hill and Jell, 1970, p. 182). A species of *Roemeripora* (probably *R. progenitor*) has been recognized from the Early Pragian part of the Stuart Bay Formation east-central Bathurst Island by Polan (1982). *Roemeripora* sp. has been noted by Pedder (1983) from the Blue Fiord Formation (*P. serotinus* Zone, Dalejan) of the Vendom Fiord region (GSC loc. C-76823 = 76831).

Specimens of *R. progenitor* have been found in the upper Eids Formation of the Sör Fiord region (*P. dehiscens* Zone, Early Zlichovian), the lower Blue Fiord Formation of the Sör Fiord and Vendom Fiord region (late Early to early Late Zlichovian), and from the upper Blue Fiord Formation (*P. serotinus* Zone, Dalejan). Thus, these samples are within

the range of those from Australia.

Occurrence - 1 sample from the upper Eids Formation, Ellesmere Island - EA9; 14 samples from the lower Blue Fiord Formation, Ellesmere Island - AA5, AA35 (2 specimens), ABA5, ABA6, AD23, EC20, EC22, GB10, GE2, HA2, IB12, K9, Loc. 40; 4 samples from the upper Blue Fiord Formation - BC8 (4 specimens).

Family SYRINGOPORIDAE de Fromentel, 1861

Genus SYRINGOPORA Goldfuss, 1826

Syringopora Goldfuss, 1826, p. 75

Caunopora Phillips, 1841, p. 18

?Praesyringopora Ivanov *in* Ivanov and Myagkova, 1950, p. 16

Type species - *Syringopora ramulosa* Milne Edwards and Haime, 1850, p. lxii, 251; Lower Carboniferous, Olne, Germany.

Syringopora formosa Tchudinova, Churkin, and Eberlein, 1974

Plate 26 e

Syringopora formosa Tchudinova, Churkin, and Eberlein, 1974, p. 131, 132, Pl. 2, figs. 1a, b, text-fig.3.

Type specimen - Wadleigh limestone, Middle-Upper Devonian, southeastern Alaska.

Material - 1 well-preserved corallum.

Description - Corallum fasciculate. Corallites close together, from contact to 0.5 mm commonly up to 1 mm apart; mean adult diameter 1.4 mm; thick-walled (0.35 mm), walls formed of thin epitheca, a middle layer of fibres perpendicular to wall, and an inner lamellar sclerenchyne which is concentrically laminated. Septal spines common, in vertical

rows on walls; subtriangular in shape, some longer, sharp, reaching up to 0.2 mm in length; spine base grades into sclerenchyme of wall. Tabulae infundibuliform, deep, very thin. Connecting tubules widely spaced, 0.5 mm diameter.

Remarks - *Syringopora formosa* is similar to *S. caespitosa* Goldfuss from the Middle Devonian of Paffrath, but differs by having smaller diameter corallites, connecting tubules, and having a well developed septal apparatus. *S. formosa* can be distinguished from *S. schulzei* Hörnes by its larger corallite diameter and presence of spines, and from *S. meyeri* Loewe by its smaller size. Both *S. schulzei* and *S. meyeri* are present in the Lower Devonian of Ellesmere Island.

The holotype and only previous report of *S. formosa* is from the Middle Devonian of the Wadleigh limestone, southeast Alaska. It is herein reported from the lower Blue Fiord Formation (late Early to early Late Zlichovian) of the Vendom Fiord region, and thus extends the species range downwards.

Occurrence - The single specimen is from GB19, in the lower Blue Fiord Formation, Ellesmere Island.

Syringopora schulzei Hörnes sensu Penecke, 1894

Plate 26 f

Syringopora schulzei Hörnes sensu Penecke, 1894, p. 590, Table 7, figs. 3, 4

Type specimen - Kul'triyugatovye beds lower part of the Middle Devonian, Gratza, U.S.S.R.

Material - 14 coralla, generally well-preserved.

Description - Corallum fasciculate. Corallites closely spaced, from

contact to 0.5 mm, rarely 1 mm; mean adult diameter 1.0 to 1.3 mm; thick-walled (0.3 mm). Septal spines not seen. Tabulae few, thin, infundibuliform. Connecting tubules scarce, commonly 0.3 mm diameter.

Remarks - For a discussion of forms similar to *Syringopora schulzei*, see Remarks section, *S. formosa*.

S. schulzei has been found in the Siegenian stage of the Kuznetsk Basin, Siberia, in the lower Middle Devonian of Gratza, U.S.S.R., and in the Middle Devonian Wadleigh limestone (middle part) of southeast Alaska.

On Ellesmere Island, *S. schulzei* occurs in the upper Eids Formation (*P. dehiscens* Zone, Early Zlichovian), near Sör Fiord, and in the lower Blue Fiord Formation (late Early to early Late Zlichovian) between Blue and Sör Fiords.

Occurrence - One specimen from the upper Eids Formation, Ellesmere Island - EA9; 13 samples from the lower Blue Fiord Formation, Ellesmere Island - AA15, CC2A (8 specimens), CC6 (4 specimens).

Genus SYRINGOPORELLA, Kettner, 1934

Syringoporella Kettner, 1934, p. 2

Type species - *Syringopora moravica* Roemer, 1883, p. 495; Upper Givetian, central Moravia.

Syringoporella moraviceformis Dubatolov, 1963b

Plate 26 g,h,i

Syringoporella moraviceformis Dubatolov, 1963b.

Syringoporella sp. Polan, 1982, Pl. 7, fig. 4.

Type specimen - Middle Devonian of Altai, U.S.S.R.

Material - 10 specimens, generally well-preserved, all living commensurally with stromatoporoids.

Description - Corallum fasciculate. Corallites very slender, cylindrical, regularly arranged in stromatoporoid coenosteum, generally spaced 0.8 to 1 mm apart; mean adult diameter commonly 0.45 to 0.5 mm; relatively thick-walled (0.1 mm), of 2 layers of which the inner is much thicker and lighter coloured. Tubules connecting corallites commonly 0.3 mm in diameter; intertubule distance 1 to 2 mm. Tabulae not visible.

Remarks - *Syringoporella moravicoformis* is distinguished from *S. rara* Tchudinova *et al.* by the lack of septal spines and smaller corallite diameter (0.6 to 0.7 mm in *S. rara*) and from *S. moravica* (Roemer) by the wider spacing of the corallites.

S. moravicoformis has been documented in the Middle Devonian deposits of Altai and in the Tas-Khayakhtakh, northeast U.S.S.R. and in the middle Lower Devonian part of the Stuart Bay Formation of east-central Bathurst Island (Polan, 1982). Stearn (1983, figs. 3a, b, e, 4a, b) illustrates but does not name *S. moravicoformis* from the lower Blue Fiord Formation (late Early to early Late Zlichovian) between Blue and Sör Fiords (called commensural syringoporid coral).

In this study, *S. moravicoformis* is always commensural with stromatoporoids. It occurs in the upper Eids Formation (*P. dehiscens* Zone, Early Zlichovian) near Sör Fiord, in the lower Blue Fiord Formation (late Early to early Late Zlichovian) between Blue and Sör Fiords, in the upper Blue Fiord Formation (Dalejan) near Blue Fiord, and in the limestone member of the Disappointment Bay Formation (Eifelian) of southern Bathurst Island.

Occurrence - One corallum from the upper Eids Formation, Ellesmere Island - EA17; 7 coralla from the lower Blue Fiord Formation, Ellesmere Island - ABA3, CA5B, CCA8, CD3C, CF8A, IB4, K6; one corallum from the upper Blue Fiord Formation, Ellesmere Island - JA15; one corallum from the limestone member of the Disappointment Bay Formation of Bathurst Island - B42A.

Order FAVOSITIDA Wedekind, 1937

Suborder ALVEOLITINA Sokolov, 1950

Family ALVEOLITIDAE Duncan, 1872

Subfamily ALVEOLITINAE Duncan, 1872

Genus ALVEOLITES Lamarck, 1801

Alveolites Lamarck, 1801, p. 375

Type species - *Alveolites suborbicularis* Nicholson and Etheridge, 1877, p. 356; upper Middle or Upper Devonian, Bernsberg, Germany.

Alveolites sp.

Plate 27 a,b,c,

Material - 260 coralla, mostly well-preserved. 35 "potato-chip" coralla, generally well-preserved.

Description - Corallum formed of layers, 0.5 to 2 cm thick; termed "potato-chip" *Alveolites* if corallum very thin, commonly 4 mm thick. Corallites initially recumbent on the substrate, then turn upwards sharply to grow perpendicular to initial growth direction; mean adult diameter commonly 0.5 mm; rounded-polygonal to compressed polygonal in cross-section; walls thinner basally, then even thickness. Triangular septal spines present. Mural pores numerous, large. Tabulae well developed, thin, flat.

Remarks - *Alveolites* is a cosmopolitan genus that ranges from Upper Silurian to Upper Devonian.

It is ubiquitous in the study area, occurring in the upper Eids Formation (*P. dehiscens* Zone, Early Zlichovian) between Blue and Sör Fiords, in the lower Blue Formation (late Early to early late Zlichovian) in the Sör Fiord-Vendom Fiord region, in the upper Blue Fiord Formation (Dalejan) near Blue Fiord, in the Disappointment Bay Formation (*P. inversus* Zone, Zlichovian/Dalejan), southern Ellesmere Island, and in the Blue Fiord Formation (Eifelian) of northern and southwestern Bathurst Island. It has also been noted in the study area by Pedder (1982b) from the lower Bird Fiord Formation (*P. serotinus* Zone or younger, Dalejan), southern Ellesmere Island (UA loc. PCC 92070), by Pedder and McLean (1982) from the lower Blue Fiord Formation (*P.* sp. aff. *P. perbonus* Zone, Late Zlichovian) near Sör Fiord (GSC loc. C-12401, 12429, and 12432), and by Pedder (1983) from the upper Blue Fiord Formation (*P. serotinus* Zone, Dalejan) near Vendom Fiord (GSC loc. C-76823 = 76831).

Occurrence - 14 coralla from the upper Eids Formation, Ellesmere Island - AC1 (3 specimens), AD1, AD3, CC1, DA15, DA27, EA9 (3 specimens), EA13 (2 specimens), loc. 7 - U9; 200 coralla from the lower Blue Fiord Formation, Ellesmere Island - AA3 (2 specimens), AA22 (2 specimens), AA28, AA35 (4 specimens), AAA17 (4 specimens), AAAA (2 specimens), AB2 (4 specimens), AB4, AB9 (4 specimens), ABA1, ABA12, Upper ABA, AD6 (2 specimens), AD21 (4 specimens), CA5 (3 specimens), CA6, CA10 (2 specimens), CA11, CA12, CA14 (4 specimens), CA16 (2 specimens), CB17 (4 specimens), CC2A (3 specimens), CC2B (2 specimens), CC2C, CC4 (5 specimens), CC6, CCA4, CCA8, CCA10, CD3A, CD3D, CD5 (2 specimens), CD7 (3 specimens), CE19 (4 specimens), CF8A, CF11, CF18, CH4 (6 specimens), CH11 (3

specimens), CH12 (5 specimens), CH23 (4 specimens), CH24, CH25, CH30 (6 specimens), CH32, CH33, EC8, EC10, EC11 (3 specimens), EC15, EC20 (2 specimens), EC25, ED29 (2 specimens), ED33, ED34, ED35 (4 specimens), ED36, ED48, GA10 (2 specimens), GA16, GB12, GB18, GB19, GB35 (3 specimens), GC28 (2 specimens), GC30 (3 specimens), GE2, GE22(2 specimens), HA2, HB28, HC2, HC30, IA13B, IA15 (2 specimens), IB1, IB4, IB10, IB12 (5 specimens), IC5 (2 specimens), IC7 (3 specimens), ID3, ID11, ID12, ID14 (2 specimens), JB2, JC3, JC4, JC6 (2 specimens), JC8, K6 (3 specimens), Loc. 40 (2 specimens), Loc. 43, Loc. 54 (4 specimens); 14 coralla from the upper Blue Fiord Formation, Ellesmere Island - BC8, BC10 (2 specimens), JA15 (11 specimens); 13 coralla from the Disappointment Bay Formation, Ellesmere Island - FA26, FA36, KA21 (2 specimens), KA49 (8 specimens), KB25; 20 coralla from the Blue Fiord Formation of Bathurst Island - B22 (16 specimens), B37 (4 specimens).

Occurrence "Potato-Chip" *Alveolites* - 35 coralla from the lower Blue Fiord Formation, Ellesmere Island - AD23, base CA5 (3 specimens), CC2A (5 specimens), CC6, CH4, CH11, CH23, CH25, CH30 (3 specimens), ED29, ED 48 (3 specimens), GA16, GB33, GB35 (2 specimens), HB32, IA13, IA13C, IB2 (5 specimens), ID3, JB2.

Genus ALVEOLITELLA Sokolov, 1952

Alveolitella Sokolov, 1952, p. 77

Type species - *Alveolites fecundus* Lecompte, 1939, p. 57; lectotype by Sokolov, 1955, Pl. 32, fig. 3, Middle Devonian (Givetian), Belgium.

Alveolitella sp.

Plate 27 d,e

Material - 527 coralla, generally well-preserved.

Description - Corallum ramose, moderately slender, cylindrical, average diameter 3 to 4 mm. Corallites rounded-polygonal in cross-section, commonly 0.25 mm in diameter; long, straight, thin-walled in axial part of corallum, curving to open at acute angle to surface, with distally thickening walls. No spines or mural pores observed. Tabulae rare to common, thin, flat.

Remarks - Sokolov (1952) considered *Alveolitella* as a subgenus of *Alveolites* mainly because of its ramose growth form.

The lectotype of *Alveolitella* is from the Middle Devonian of Belgium.

In the study area, *Alveolitella* is commonly closely associated with "potato-chip" *Alveolites*, especially in the basal parts of buildups. It occurs in the upper Eids Formation (*P. dehiscens* Zone, Early Zlichovian) near Eids Fiord, and in the lower Blue Fiord Formation (late Early to early Late Zlichovian), mainly between Blue and Sör Fiords.

Occurrence - 86 coralla from the upper Eids Formation, Ellesmere Island - AC1 (86 specimens); 441 coralla from the lower Blue Fiord Formation, Ellesmere Island - AA13 (8 specimens), AA27 (3 specimens), AAAA (2 specimens), ABA 6/8 (4 specimens), AD23 (3 specimens), CB17 (10 specimens), CC4 (5 specimens), CCA8 (6 specimens), CD3A (20 specimens), CF8A (30 specimens), CH4 (15 specimens), CH9 (10 specimens), CH11 (24 specimens), CH12, CH15 (3 specimens), CH19 (8 specimens), EC10 (4 specimens), GB10 (3 specimens), IA14 (52 specimens), IB2 (28 specimens), IC5 (50 specimens), IC7 (28 specimens), ID3 (41 specimens), JB2 (40 specimens), JC4 (18 specimens), Loc. 26 (25 specimens).

Suborder FAVOSITINA Wedekind, 1937

Superfamily FAVOSITICAE Dana, 1846

Family FAVOSITIDAE Dana, 1846

Subfamily FAVOSITINAE Dana, 1846

Genus FAVOSITES Lamarck, 1816

Favosites Lamarck, 1816, p. 204

Type species - *Favosites gothlandicus* Milne Edwards and Haime, 1850, p. lx; Upper Silurian, Mulde Märgelsten, Gotland.

Favosites sphaericus Počta, 1902

Plate 27 f,g

Favosites barrandei laticella Počta, 1902, p. 244, Pl. 93, figs. 3-5

Favosites barrandei sphaerica Počta, 1902, p. 245, Pl. 86, figs. 11, 12; Pl. 117, figs. 6, 7

Favosites sp. corallites bimodal; Churkin and Brabb, 1967, Table III, p. 240

Favosites sp. B; Oliver *et al.*, 1975, p. 30, Pl. 16, figs. 12, 13

Type specimen - Upper Koneprusy Limestone (Pragian), Zlaty Kun Hill, Koneprusy area, central Bohemia.

Material - 4 well-preserved coralla.

Description - Corallum cerioid. Corallites polygonal, thin-walled, distinctly differentiated into two sizes, large commonly 2.0 mm, small 1.1mm in adult diameter. Septal spines short, blunt, relatively rare. Mural pores commonly 0.3 mm diameter, circular in centre of wall. Tabulae complete, flat, average 2 per mm.

Remarks - *Favosites sphaericus* can be easily distinguished from all other Devonian favositids by its bimodal corallites.

F. sphaericus has been documented from the Lower Devonian (Pragian) of central Bohemia (Počta, 1902; Galle, 1978) and from the Salmontrout Limestone (Lower to Middle Devonian) of the Porcupine River area, east-central Alaska (Churkin and Brabb, 1967; Oliver *et al.*, 1975).

It is herein reported from the lower Blue Fiord Formation (late Early to early Late Zlichovian) of the Sör Fiord-Vendom Fiord region.

Occurrence - 4 specimens from the lower Blue Fiord Formation, Ellesmere Island - CCA3, GD1 (2 specimens), HB28.

Favosites sp.

Favosites "gothlandicus" species group Polan, 1982, p. 65, Pl. 6, figs. 5, 6.

Material - 141 well-preserved coralla.

Description - Corallum cerioid, generally hemispherical. Corallites polygonal, thin-walled, mean adult diameter 1.47 mm, range 0.6 to 2.45 mm. Septal spines present in some samples. Mural pores commonly 0.3 mm diameter, uniserial or biserial, generally in wall centre. Tabulae complete, flat, average 2 per mm, ranging from 1 to 4 per mm.

Remarks - Since Sokolov first published his studies on tabulates in the early fifties, the quantitative approach to species differentiation has become generally applied. However, Stel (1978, p. 21), based on his detailed studies on Silurian favositids from Gotland, convincingly demonstrated that "the range of quantitative and qualitative features, currently applied to identify favositids, often is too narrow to allow for ecophenotypic responses of the colony". Polan (1982, p. 65-81) has conducted biometrical studies of *Favosites* from the middle Lower

Devonian Stuart Bay Formation of Bathurst Island. He agreed with the conclusion of Stel (1978) and stated (p. 80) that "current species definitions within the genus *Favosites* are too narrow and that, if the taxonomy is based on corallite diameter, tabular density, wall thickness and pore size, then it is based on inadequate criteria", and that "It is ... possible that the genus *Favosites* consists of forms that cannot be divided into species except arbitrarily" (p. 80). Brakel (1977, Fig 1) has shown that the variation of 20 corallite characters in the modern scleractinian coral *Porites* is nearly continuous, and he concludes that there is a continuum of genetic variation within the genus. Clusters of more similar specimens have been given the rank of species by some authors, but these species are links in a continuous chain.

Biometric data from this study using 141 samples from the Eids, Blue Fiord, and Disappointment Bay Formations support the above statements. Figure 6-3 plots corallite diameter against tabular density and closes the "morphologic gaps" in Figure 12 of Polan (1982), showing that the samples all belong to the same species population.

Occurrence - 21 specimens from the upper Eids Formation, Ellesmere Island - AC1 (2 specimens), CC1, CD2 (2 specimens), CH1, DA15 (3 specimens), DA27 (3 specimens), EA5, EA7 (3 specimens), EA8, EA9 (2 specimens), EA13, IA5; 107 specimens from the lower Blue Fiord Formation, Ellesmere Island - AA28, AA35 (2 specimens), AAA17, AB4, AB8, AB10, ABA 10, AD19, AD21 (2 specimens), AD34, CA5 (2 specimens), CA7, CC2A (2 specimens), CC2B, CC4, CC6, CCA8 (3 specimens), CD3A, CD3C, CD5, CD7 (3 specimens), CF5, CF18 (3 specimens), CF25, CH4 (3 specimens), CH6,

EC11 (2 specimens), EC13, EC20, EC22 (2 specimens), EC38, ED29 (2 specimens), ED30, ED34, ED35, ED36, ED48 (3 specimens), GA11, GA16 (2 specimens), GA45, GB28, GB31, GB33 (2 specimens), GB35, GC30 (2 specimens), GE22 (2 specimens), HA2, HC2 (2 specimens), HC30, IA14 (2 specimens), IA15, IB2 (3 specimens), IB4, IB12, IB18, IC2, IC5, IC7 (3 specimens), IC8, ID3, ID5, ID11, JB2, JC4 (2 specimens), K3, K6, Loc. 21, Loc. 26 (3 specimens), Loc. 40 (5 specimens), Loc. 43 (2 specimens), Loc. 54; 10 specimens from the upper Blue Fiord Formation, Ellesmere Island - BC8 (3 specimens), BC10 (2 specimens), JA15 (5 specimens); 1 specimen from the Disappointment Bay Formation, Ellesmere Island - KA49; 2 specimens from the Blue Fiord Formation, Bathurst Island - B22 (2 specimens).

Superfamily PACHYPORICAE Gerth, 1921

Family PACHYPORIDAE Gerth, 1921

Genus HILLAEPORA Mironova, 1960

Hillaepora Mironova, 1960, p. 97

Type species - *Hillaepora spica* Mironova, 1960, Tom-Chumysh beds, "Sukhaya suite", East Salair, Bachaty, U.S.S.R.

Hillaepora sp.

Plate 25 c,d, 27 h

Material - 3 moderately preserved coralla.

Description - Corallum branching. Corallites slender, diameter commonly 1.5 mm; directed upwards and opening at acute angle at surface; calical end projects out from surface of branch; bound together in branch axis, but separating at surface and becoming rounded in cross-section; very thin-walled. Septal spines absent. Tabulae not seen.

Remarks - *Hillaepora* is only presently known from the Lower Devonian of east Salair. Therefore, the occurrence of *Hillaepora* sp. from the Middle Devonian of east-central Bathurst Island (B30-11) significantly extends its range stratigraphically and geographically.

It occurs in the very shallow water limestone member of the Disappointment Bay Formation, closely associated with *Dendrostella trigemme*.

Occurrence - 3 specimens from the limestone member of the Disappointment Bay Formation, Bathurst Island - B30-11 (3 specimens).

Genus THAMNOPORA Steininger, 1831

Thamnopora Steininger, 1831, p. 10

?Dendrofavosites Rukhin, 1937

?Gertholites Sokolov, 1955

Type species - *Alveolites cervicornis* de Blainville, 1830, p. 370; Givetian, Bensberg, Germany.

Thamnopora randai Jell and Hill, 1970b

Plate 27 i,j

Thamnopora sp. ex. gr. *reticulata* (de Blainville); Hill, Playford, and Woods, 1967, Pl. D3, fig. 7

Thamnopora randai Jell and Hill, 1970b, p. 107, 108, Pl. 8, Fig. 5

Type specimen - Douglas Creek limestone, Loc. 1 (Late Emsian or Early Eifelian), Douglas Creek, county Clermont, central Queensland, Australia.

Material - 550 well-preserved coralla.

Description - Corallum branching, branches commonly 7.5 to 10 mm in

diameter, ranging from 6 to 12 mm; up to 60 mm in length. Corallites slender, 0.6 mm average diameter in axis, 0.9 mm diameter at periphery; longitudinally directed in axis, distally curved sharply to open nearly perpendicular or slightly oblique to the surface; peripheral zone of corallite 2 mm long; wall thickness increases gradually from 0.1 mm in axis to 0.4 mm at periphery, formed of fibres directed perpendicularly to median plane of wall. Septal spines not seen. Mural pores circular, uniserial; average diameter 0.2 mm in peripheral region. Tabulae complete, thin, widely spaced, horizontal.

Remarks - *Thamnopora* is distinguished from its close relative *Yacutiopora* by the sharp change in wall thickness in *Yacutiopora* versus the gradual change in wall thickness in *Thamnopora*.

Thamnopora is a cosmopolitan genus, found in Lower to Upper Devonian rocks.

Jell and Hill (1970b, p. 108) discuss the similarities between *T. randsi* and other species of the genus.

T. randsi has been previously reported from the late Early to early Middle Devonian Douglas Creek limestone of central Queensland. It is herein reported from the upper Eids Formation (*P. dehiscens* Zone, Early Zlichovian) between Blue and Sör Fiords, from the lower Blue Fiord Formation (late Early to early Late Zlichovian) in the Sör Fiord-Vendom Fiord region, in the upper Blue Fiord Formation (Dalejan) near Blue Fiord, and in the Disappointment Bay Formation (*P. inversus* Zone; Zlichovian/Dalejan), southern Ellesmere Island.

Occurrence - 111 coralla from the upper Eids Formation, Ellesmere Island - AD3 (8 specimens), CH1, DA30 (28 specimens), EA3 (25 specimens), EA5 (7 specimens), EA7 (30 specimens), EA8 (3 specimens), EA9 (9 specimens); 388

coralla from the lower Blue Fiord Formation, Ellesmere Island - AA27 (2 specimens), AAAA (40 specimens), AB7 (11 specimens), AB9, ABA1 (2 specimens), ABA6/8, AD6 (6 specimens), AD23 (3 specimens), AD24 (36 specimens), CA5 base (6 specimens), CF11 (13 specimens), CF15 (3 specimens), CF25 (28 specimens), CH11 (2 specimens), CH15, CH30 (2 specimens), CH32, EC38 (5 specimens), ED36 (16 specimens), GB28 (4 specimens), GC28 (5 specimens), HA23 (37 specimens), HC2 (24 specimens), IB9 (18 specimens), IC5 (7 specimens), ID16 (3 specimens), JA4, JC8, K6 (21 specimens), oc. 21 (36 specimens), Loc. 40 (11 specimens), Loc. 43 (41 specimens); 31 coralla from the upper Blue Fiord Formation, Ellesmere Island - BC8, JA15 (30 specimens); 20 coralla from the Disappointment Bay Formation, Ellesmere Island - FA12 (12 specimens), KA49 (8 specimens).

Thamnopora sp. cf. *T. randsi* Jell and Hill, 1970b

Material - 10 well-preserved coralla.

Description - Corallum and corallite description same as *T. randsi*, but the corallum branches are much larger, averaging 15 to 20 mm in diameter.

Occurrence - All 10 samples are from the lower part of the Blue Fiord Formation, Ellesmere Island - AA5 (3 specimens), AB2 (7 specimens).

Family PARASTRIATOPORIDAE Tchudinova, 1959

Genus YACUTIOPORA Dubatolov *in* Dubatolov & Spasskiy, 1964

Yacutiopora Dubatolov *in* Dubatolov and Spasskiy, 1964, p. 123

Type species - *Yacutiopora dogdensis* Dubatolov *in* Dubatolov and Spasskiy, 1964, p. 124, Pl. 6, fig. 2; Pl. 7, fig. 1; Lower Devonian, Khobochalo River, left tributary of the Dogdo River, Tas-Khayakhtakh.

Yacutiopora hillae (Jones, 1940)

Plate 28 a,b

Striatopora ? hillae Jones, 1940, p. 50, Pl. 2, fig. 4

Yacutiopora hillae Jell and Hill, 1970b, p. 111, 112, Pl. 7, figs. 7, 8

Type specimen - Douglas Creek limestone, Loc. 1 (Late Emsian or Early Eifelian), Douglas Creek, County Clermont, central Queensland, Australia.

Material - 76 very well-preserved coralla.

Description - Corallum of thick branches, average branch diameter 20 to 25 mm, length 40 mm. Corallites polygonal in axis, 0.75 to 1.5 mm diameter, longitudinally directed, have thin common wall, fibres oriented perpendicularly to wall; rounded polygonal distally, 1.5 to 2 mm diameter, thick-walled, open perpendicular to surface; walls thicken midway as branches curve to surface; in long section, thickening appears as thick, rounded projections from median plane of wall. Mural pores very common at periphery, scarce axially; circular, uniserial, 0.25 mm diameter. Tabulae numerous, 6 per 5 mm in axis, 15 per 5 mm distally, flat or gently curved, complete.

Remarks - This is the first report of *Yacutiopora* in North America. *Yacutiopora* has been reported from the Lower Devonian, with one possible exception being the (?) Eifelian of North Africa (Hill, 1981, p. 589).

Y. hillae has previously been recorded in the upper Lower or (?) lower Middle Devonian Douglas Creek limestone of central Queensland (Jell and Hill, 1970b). *Y. hillae* documented herein is from the Eifelian Blue Fiord Formation of northern and southwest Bathurst Island, and, as such, is the first reliably dated occurrence of *Yacutiopora* from the Middle Devonian.

Occurrence - All 76 coralla are from the Blue Fiord Formation of Bathurst Island - B22 (4 samples), B37 (72 samples).

Order HELIOLITIDA Frech, 1897

Suborder HELIOLITINA Frech, 1897

Superfamily HELIOLITICAE Lindström, 1876

Family HELIOLITIDAE Lindström, 1876

Genus HELIOLITES Dana, 1846

Heliolites Dana, 1846, p. 541

?Lonsdalia D'Orbigny, 1849, p. 12

Heliolithes Lindström, 1873, p. 15

?Pachycanalicula Wentzell, 1895

Type species - *Astraea porosa* Goldfuss, 1826, p. 64; Eifelian, Eifel district, Germany.

Heliolites sp.

Plate 28 c

Material - One very small, moderately preserved piece of a corallum (tangential view only).

Description - Corallites commonly 0.35 mm in diameter, rounded, closely spaced, separated by only 1 or 2 tubules; each surrounded by 10 to 11 tubuli, polyhedral, commonly 0.1 mm diameter; spines not seen. No longitudinal view available.

Remarks - The one-very small sample available is only the second Devonian heliolitid reported in the Arctic. The other, from the Early Pragian part of the Stuart Bay Formation, east-central Bathurst Island (Polan, 1982, p. 64, Pl. 6, figs, 1, 2), was also named *Heliolites* sp., but differs from this sample by having larger diameter corallites (average 1 mm), spines (12), and more coenenchymal tubules surrounding each corallite (12 to 13).

Dixon (1979) was the first to record heliolitids from the Arctic Island, in the Late Silurian rocks of Somerset Island.

The Ellesmere Island sample comes from the lowest Blue Fiord Formation (late Early to early Late Zlichovian) between Blue and Sör Fiords.

Occurrence - The sample comes from the lower Blue Fiord Formation, Ellesmere Island - base CA5.

CORAL BIOSTRATIGRAPHY

Figure 6-4 shows the generic and, if applicable, specific range of all the genera documented in this study from Ellesmere Island. In general, the corals indicate an upper Lower Devonian (Zlichovian-Dalejan) age for this sequence, which agrees with the age determined from conodonts (Uyeno and Klapper, 1980). In particular, the rugosan fauna is dominated by *Spongonaria*, a genus which makes its first appearance in Canada in the Michelle Formation of the Yukon Territory (*P. dehiscens* Zone, Early Zlichovian), continues into the overlying *P. inversus* and *P. serotinus*-bearing beds, but is not found in Eifelian strata (Pedder, 1978, p. 41, 43). Therefore, the genus is an excellent indicator of late Early Devonian age. However, according to Besprozvannykh *et al.* (1975), *Spongonaria* does not range into the Eifelian in the Taimyr-Kolyma Province of northeast Asia.

The age of the lower part of the Blue Fiord Formation in the Vendom Fiord region has been difficult to determine precisely, due to the lack of the conodont *Polygnathus*. However, 2 rugosan species, *Paraspongonaria delicata* and *Thoulelasma loewei*, from unit ED29 (208 m above the base of the Blue Fiord Formation in the Vendom Fiord region) shed light on this problem. Both have only been recognized on Ellesmere Island in rocks bearing *P. serotinus* (Dalejan). Therefore, this could indicate a substantially younger age for the lower part of the Blue Fiord Formation in the Vendom Fiord area than had been previously suspected (Roblesky, 1979). Supporting evidence for this younger age is that *Utaratuia*, a typical Middle to Upper Devonian rugosan genus of northwestern Canada, is found only in the Vendom Fiord region at a stratigraphic height roughly

correlative with ED29. However, an alternative explanation for these occurrences is that all 3 of the above rugosans were restricted to a shallow platform environment, such as was present in the lower Blue Fiord Formation at Vendom Fiord. This environment was not present in the Sör Fiord region, where *P. delicata* and *T. loewei* were dated as Dalejan (Pedder, 1983), until the latest Zlichovian to Dalejan. This alternative suggests that these corals are facies controlled, and therefore cannot be used reliably biostratigraphically. This problem is difficult to solve at present, until data from other faunal elements are available.

Figure 6-5 illustrates the generic and, if applicable, specific ranges of all genera reported here from Bathurst Island. A Dalejan to Eifelian age can be deduced from the corals present. This concurs with the Eifelian age for the Blue Fiord Formation and limestone member of the Disappointment Bay Formation from Bathurst Island determined using trilobites (Ormiston, 1967) and conodonts (McGregor and Uyeno, 1972, p. 13-16; Kerr, 1974, p. 44). The genus *Spongonaria*, typical of the upper Lower Devonian sequence of Ellesmere Island is absent. Also, *Dendrostella trigemme*, present in the limestone member of the Disappointment Bay Formation, is a species which is widespread in Upper Eifelian and Givetian rocks (Oliver and Pedder, 1979a, p. 247). Therefore, the Blue Fiord Formation is younger on Bathurst Island than on Ellesmere Island.

FAUNAL AFFINITIES

The coral fauna of Ellesmere Island bears a striking resemblance to the fauna of the upper Lower Devonian Cranswick Formation, MacKenzie Mountains, Yukon Territory (Pedder and Klapper, 1977). They have the following genera in common (data from Pedder, 1982a, is included) - *Cavanophyllum*, *Dohmophyllum*, *Planetophyllum*, *Spongonaria (parca)*, *Taimyrophyllum*, *Alveolites*, and *Favosites*. The coral fauna of the Ogilvie Formation of the northern Yukon Territory and adjacent east-central Alaska (Perry *et al.* 1974; Blodgett, 1978) is also very similar to that of the Lower Devonian of Ellesmere Island, having *Acanthophyllum*, *Embolophyllum*, *Spongonaria filicata* and *S. ogilviensis* in common. Another very similar coral fauna is found in the Douglas Creek limestone of Central Queensland (Jell and Hill, 1970b), although it lacks *Spongonaria*. Genera in common are all tabulates - *Favosites*, *Heliolites*, *Roemeripora (progenitor)*, *Syringopora*, *Thamnopora (randsi)*, and *Yacutiopora (hillae)*.

The Eifelian coral fauna of the Hume Formation of northwest Canada (Pedder, 1964b; Table 23, Oliver and Pedder, 1979b; Pedder, 1980) includes 4 rugosan genera in common with the coral fauna of Bathurst Island - *Dendrostella (trigemme)*, *Lekanophyllum*, *Taimyrophyllum* and *Tawuphyllum*. The Late Eifelian Ogilvie Formation of Mount Burgess, Yukon Territory (Pedder, 1980) contains the following genera in common with the Bathurst Island fauna - *Dendrostella (trigemme)*, *Tawuphyllum*, *Alveolites*, *Favosites*, and *Thamnopora*.

If the coral fauna from Ellesmere Island is compared to other faunas on a worldwide scale, using Table 1 of Oliver and Pedder (1979a),

it most closely resembles the corals from the Zlichovian of the Great Basin, western Europe, Novaya Zemlya and the Urals, Altai-Sayan, Taimyr, and Indigiro-Kolyma, U.S.S.R., and eastern Australia and New Zealand.

The Bathurst Island coral fauna has affinities with the Eifelian faunas of western Europe, Altai-Sayan, U.S.S.R., and eastern Australia and New Zealand.

Both coral faunas from Ellesmere and Bathurst Islands belong to the Old World Biogeographic Realm (Oliver, 1976). The distribution of corals in this realm was controlled by the warm equatorial currents, which flowed freely around the world, linking eastern Australia and western North America by the Paleotethys Sea and Uralian Seaway (Heckel and Witzke, 1979). This explains the similarity between the faunas of Australia, Europe, the Urals, the Arctic Islands, Yukon Territory, and Nevada.

CHAPTER 7

BRACHIOPOD TAXONOMY AND DISCUSSION

INTRODUCTION

Per Schei collected the first brachiopods from the area in the early part of this century, during the Norwegian ""Fram" expedition. They were later described by Meyer (1913). The brachiopod fauna of the region was not described further until McLaren (1963a) listed the fauna that he had collected during Operation Franklin in 1955. Harper *et al.* (1967) and Johnson and Talent (1967) reported single species from the lower Blue Fiord Formation south of Eids Fiord that were part of McLaren's collections. Knowledge of the Lower-Middle Devonian brachiopod fauna of southwest Ellesmere Island has increased recently due to studies by Jones and Smith, G. (1980, in press a, b) on the Eids Formation, Smith, D. (1980), Smith, D. and Stearn (1981), Smith, D. *et al.* (1981), and Brice (1982) on the Blue Fiord Formation, and Brice (1982) and Jones (1982 a, b) on the Bird Fiord Formation.

In the course of this study, brachiopods have been discovered in the Eids and Blue Fiord formations. The brachiopod fauna of the Eids Formation was collected in cooperation with Dr. B. Jones (University of Alberta), and 3 articles have been, or will be, published which are the first to describe the nature, distribution, and causes of variability of the fauna (see references above). In these papers, Jones prepared the taxonomic sections, while all other sections were prepared by both authors. A total of 8297 brachiopods were collected from 24 localities (Figure 7-1) comprising 22 genera and 28 species (Figure 7-2).

In the following section, the brachiopod fauna of the Blue Fiord Formation of southwest Ellesmere Island is described. A total of 1746 brachiopods were collected, the majority (1700 specimens) from the lower

Blue Fiord Formation of southwest Ellesmere Island. Other specimens derived from the uppermost strata of the Eids Formation (15), and the Disappointment Bay Formation (8) of southwest Ellesmere Island, and the Blue Fiord Formation of Bathurst Island (23). Twenty-six genera and 40 species have been identified (Figure 7-3). This study incorporates the data of Smith, D. (1980) who collected 539 specimens from 2 locations just south of Eids Fiord (AAA 3-11, AD36) while working as an assistant with the writer in the summer of 1979. A number of his identifications are revised herein.

In the occurrence section of each species, each location is listed, followed by a set of numbers and letters in brackets. The first number is the total collected at that locality, the other numbers subdivide the total into the number of specimens articulated (a), disarticulated (d), or fragmented (f).

SYSTEMATIC PALEONTOLOGY

Phylum BRACHIOPODA Dumeril, 1806

Class ARTICULATA Huxley, 1869

Order ORTHIDA Schuchert and Cooper, 1936

Suborder DALMANELLOIDEA Moore, 1952

Superfamily DALMANELLACEA Schuchert, 1913

Family DALMANELLIDAE Schuchert, 1913

Subfamily CORTEZORTHINAE Johnson and Talent, 1967

Genus CORTEZORTHIS Johnson and Talent, 1967

Type species - *Cortezorthis maclareni* Johnson and Talent, 1967, p. 146, Pl. 19, figs. 1-20; Pl. 20, figs. 28, 29.

Cortezorthis maclareni Johnson and Talent, 1967

Plate 28 d,e,f

Cortezorthis maclareni Johnson and Talent, 1967, see type species.

Material - 25 articulated and 13 disarticulated specimens, total of 38 specimens.

Remarks - Jones and Smith (1980, p. 677) outlined the differences between *Cortezorthis maclareni* and other closely related species of the genus.

C. maclareni was first recognized by Johnson and Talent (1967) from the lower Blue Fiord Formation in the Eids Fiord area. It has been documented in the Arctic Islands by Jones and Smith (1980, in press a) from the upper Eids Formation (Early Zlichovian) of southwest Ellesmere Island, by Pedder (1982a) in the lower Blue Fiord Formation near Sör Fiord (GSC loc. C-12498) and by Jones (1982b) in the Bird Fiord Formation (referred to as upper Blue Fiord Formation herein) in the Vendom Fiord

area. The species occurs abundantly in the Emsian beds of the Delorme Formation of the MacKenzie Mountains and in the Lower Zlichovian of the Mount Lloyd George area, northern British Columbia (Perry *et al.*, 1981). *Cortezorthis* sp. has been reported from the Upper Emsian Ogilvie Formation of Yukon Territory (Perry *et al.*, 1974).

The genus is not known to range into the Eifelian, and therefore is a good indicator of upper Lower Devonian age.

Occurrence - AAA 3-11 (2; 1a, 1d), AD36 (33; 24a, 9d), BC1 (1; 1d), Loc. 19 (2; 2d).

Superfamily ENTELETACEA Waagen, 1884

Family SCHIZOPHORIIDAE Schuchert and LeVene, 1929

Subfamily SCHIZOPHORIINAE Schuchert and LeVene, 1929

Genus SCHIZOPHORIA King, 1850

Type species - *Conchyliothus (Anomites) resupinatus* Martin, 1809, Pl. 49, figs. 13, 14.

Schizophoria nevadaensis Merriam, 1940

Plate 28 g,h,i

Schizophoria nevadaensis Merriam, 1940, p. 79, Pl. 7, figs. 1, 2.

Material - 53 articulated, 21 disarticulated, and 71 fragments, total of 145 specimens.

Remarks - The differences between *Schizophoria nevadaensis* and *S. eidsensis*, a closely related species of the genus, are mentioned in Jones and Smith (1980, p. 680).

S. nevadaensis has been found in the upper Eids Formation in the Sör Fiord region (Jones and Smith, 1980), in the lower Blue Fiord Formation

(GSC loc. C-12498) by Pedder (1982a), and by Johnson (1975) from the Upper Zlichovian Disappointment Bay Formation of Lowther Island. Blodgett (1978) has documented the species from the Upper Zlichovian Ogilvie Formation of east-central Alaska, and Ludvigsen (1970) noted it in the Lower Zlichovian Michelle Formation of the Yukon Territory. *Schizophoria* sp. has been noted by Perry (1979) from the Zlichovian Prongs Creek Formation, northern Yukon Territory, and from the Mount Lloyd George area, northern British Columbia by Perry *et al.*, (1981).

The first appearance of *S. nevadaensis* marks the lower boundary of the upper subzone of the *Eurekaspirifer pinyonensis* Zone of central Nevada (Johnson and Niebuhr, 1976).

Occurrence - AAA3-11(120; 45a, 15d, 60f), AD36 (14; 5a, 2d, 7f), BB12 (4; 1d, 3f), BC1 (2; 1d, 1f), CF19 (2; 2a), GA6 (1; 1a), GA16 (2; 2d).

Schizophoria sp.

Material - 2 disarticulated and 3 fragments; total of 5 specimens.

Remarks - The fragmentary nature of the specimens precludes a definite assignment to a particular species of *Schizophoria*.

Occurrence - CF17 (1; 1f), GA26 (4; 2d, 2f).

Order PENTAMERIDA Schuchert and Cooper, 1931

Suborder PENTAMEROIDEA Schuchert and Cooper, 1931

Superfamily PENTAMERACEA M'Coy, 1844

Family GYPIDULIDAE Schuchert and LeVene, 1929

Subfamily GYPIDULIDINAE Schuchert and LeVene, 1929

Genus CARINAGYPA Johnson and Ludvigsen, 1972

Type species - *Carinagypa loweryi* Merriam, 1940, p. 81, Pl. 7, fig. 9

Carinagypa aseptata Johnson, 1975

Plate 28 m,n,o

Carinagypa aseptata Johnson, 1975, p. 952, Pl. 3, figs. 1-16

Material - 45 articulated, 38 disarticulated, and 41 fragments, total of 124 specimens.

Remarks - *Carinagypa aseptata* differs from *C.(A) maclareni* by virtue of its more globose shell, less elongate outline, and lack of a well defined sulcus.

C. aseptata has been documented by Jones and Smith (1980, in press a) from the Lower Zlichovian upper Eids Formation between Blue and Sör Fiords, and by Johnson (1975) from the Upper Zlichovian Disappointment Bay Formation of Lowther Island. Pedder (1982a) noted *C.* sp. from the Lower Blue Fiord Formation at GSC loc. C-12498 near Sör Fiord. Blodgett (1978) recognized the species in the Ogilvie Formation of east-central Alaska.

C. aseptata occurs in the upper subzone of the *E. pinyonensis* Zone of central Nevada (Johnson and Niebuhr, 1976).

Occurrence - AAA3-11 (70; 35a, 30d, 5f), AD36 (18; 9a, 5d, 4f), CC1 (Eids Formation; 3; 3f), CC2A (3; 1a, 2f), CF5 (1; 1d), CF17 (1; 1f), CF19 (6; 6f), CH1 (Eids Formation; 1; 1d), ED34 (2; 2f), GA 6 (1; 1f), GA16 (8; 8f), GB32 (3; 3f), GE6 (6; 6f), Loc. 17 (1; 1d).

Subgenus ASEPTAGYPA Brice, 1982

Carinagypa (Aseptagypa) maclareni Brice, 1982

Plate 28 j,k,l

Carinagypa (Aseptagypa) maclareni Brice, 1982, p. 26, 28-30, Pl. 1, figs. 1-10, Pl. 4, figs. 1-9, Pl. 5, figs. 1-11.

Material - 51 articulated, 41 disarticulated, 8 fragments, total of 100 specimens.

Remarks - A comparison of *Carinagypa (Aseptagypa) maclareni* and *C. aseptata* can be found in the previous remarks section.

C. (A). maclareni was first recognized by Brice (1982) from the upper Blue Fiord Formation on southwest Ellesmere Island. Jones (1982b) also documented the species from the Bird Fiord Formation (now upper Blue Fiord Formation) in the Vendom Fiord region.

Occurrence - AAA3-11 (7; 2a, 5f), AD36 (18; 9a, 4d, 5f), CF19 (9; 4a, 5d), CF25 (1; 1a), CH30 (4; 4a), ED34 (3; 3a), GA6 (1; 1a), GA16 (33; 14a, 19d), GE6 (4; 1a, 3d), IA12 (17; 10a, 7d), Loc. 19 (3; 3a).

Order RHYNCHONELLIDA Kuhn, 1949

Superfamily CAMAROTOECHIACEA Schuchert and LeVene, 1929

Family EATONIIDAE Schmidt, 1965

Genus COSTELLIROSTRA Cooper, 1942

Type species - *Atrypa peculiaris* Conrad, 1841, p. 56

Costellirostra sp.

Plate 28 p,q,r

Material - 54 articulated, 51 disarticulated, and 36 fragments, total of 141 specimens.

Remarks - *Costellirostra* has been recognized in the Arctic Islands by Brice (1982) in the Blue Fiord Formation of Victoria Island. All other previous reports of the genus in North America are from Gedinnian to

Lower Emsian strata of the Appalachian Province (Brice, 1982, p. 60; Boucot *et al.*, 1969, p. 10). Boucot *et al.* (1969, p. 24) explained the absence of *Costellirostra* and other genera from coeval central Nevada faunas by the fact that they belonged to shallow, near-shore communities which are not represented in the deeper-water narrow limestone belt of Nevada.

In this study, *Costellirostra* sp. is found only in the Vendom Fiord region.

Occurrence - GA27 (5; 5d), GA33 (127; 50a, 45d, 32f), GB12 (8; 4a, 4f), GB27 (1; 1d).

Family LEIORHYNCHIDAE Stainbrook, 1945

Genus ATHYRHYNCHUS Johnson, 1973

Type species - *Athyrhychus susanae* Johnson, 1973, p. 469.

Athyrhynchus loriei Jones, 1980

Plate 28 s,t,u

Athyrhynchus loriei Jones, Jones and Smith, 1980, p. 687-8, Pl. 2, figs. 26-27, Pl. 3, figs. 16-23, Pl. 4, figs. 1-6.

Material - 4 articulated, 1 disarticulated, and 3 fragments, total of 8 specimens.

Remarks - *Athyrhynchus loriei* differs from *A. susanae* by virtue of its more lenticular outline, less elongate shell, more distinct ventral sulcus, and well developed ribbing.

A. loriei has been documented by Jones and Smith (1980, in press a) from the upper Eids Formation near Sör Fiord, and by Pedder (1982a, GSC loc. C-12498) in the lower Blue Fiord Formation near Sör Fiord.

Johnson (1975) has recognized *A. susannae*, a species known from the *E. pinyonensis* Zone of central Nevada, from the Disappointment Bay Formation of Lowther Island. Perry *et al.* (1981) noted *Athyrhynchus* sp. from the Mount Lloyd George area of northern British Columbia. The genus has also been recognized in the Zlichovian Michelle and Ogilvie formations of the northern Yukon Territory (Johnson, 1973; Perry *et al.*, 1974).

Occurrence - BB12 (1; 1d), Loc. 21 (7; 4a, 3f).

Family TRIGONIRHYNCHIIDAE Schmidt, 1965

Genus ANCILLOTOECHIA Havlíček, 1959

Type species - *Rhynchonella ancillans* Barrande, 1879.

Ancillotoechia (?) sp.
Plate 29 a,b

Material - 1 articulated specimen.

Remarks - *Ancillotoechia* (?) sp. differs from *A. ventricosa variabilis* noted by Brice (1982) from the lower Blue Fiord Formation of Ellesmere and Devon Islands by being less globose, and from *A. rex* from the Disappointment Bay Formation of Lowther Island (Johnson, 1975) by having finer ribbing.

Another species of the genus (*A. aptata*) has been documented in the *Trematospira* Zone (Upper Siegenian) of central Nevada (Johnson, 1970, p. 63).

Occurrence - GA16 (1; 1a).

Genus TRIGONIRHYNCHIA Cooper, 1942

Type species - *Uncinulina fallaciosa* Bayle, 1878, Pl. 13, figs. 13-16

Trigonirhynchia occidens (Walcott, 1884)

Plate 29 c,d,e

Rhynchonella? occidens Walcott, 1884, p. 152, Pl. 15, figs. 3, 3a, 3b

Material - 3 articulated, 1 disarticulated, and 2 fragments, total of 6 specimens.

Remarks - *Trigonirhynchia occidens* differ from *T.* sp. aff. *T. occidens* by having more costae in the sulcus (only 2 to 3 in *T.* sp. aff. *T. occidens*).

T. occidens has been noted by Jones and Smith (in press a) in the upper Eids Formation of Southwest Ellesmere Island, and by Johnson (1970) in the *E. pinyonensis* Zone of central Nevada.

Occurrence - BB8 (1; 1d), GB32 (1; 1a), GB33 (4; 2a, 2f).

Trigonirhynchia sp. aff. *T. occidens* (Walcott, 1884)

Plate 29 f,g

Material - 24 articulated, and 2 fragments, total of 26 specimens.

Remarks - *Trigonirhynchia* sp. aff. *T. occidens* differs from *T.* sp. aff. *T. occidens* noted by Jones and Smith (1980) from the upper Eids Formation near Sör Fiord by having less costae in the sulcus and on the shell flanks. It is very similar to *T.* aff. *occidens* illustrated by Perry *et al.* (1974, Pl. 2, figs. 12-19) from the Upper Emsian Ogilvie Formation of the northern Yukon Territory. *T.* aff. *T. occidens* has been noted by Blodgett (1978) from the Zlichovian/Dalejan Ogilvie Formation of northern Yukon Territory, but cannot be compared to this species due to lack of a description.

Occurrence - AD36 (11; 11a), CF19 (12; 10a, 2f), Loc. 21 (3; 3a).

Order SPIRIFERIDA Waagen, 1883

Suborder ATHYRIDOIDEA Boucot, Johnson, and Staton, 1964

Superfamily ATHYRIDACEA M'Coy, 1844

Family NUCLEOSPIRIDAE Davidson, 1881

Genus NUCLEOSPIRA Hall, 1859

Type species - *Spirifer ventricosa* Hall, 1857, p. 57

Nucleospira subsphaerica Johnson, 1970

Plate 29 h,i

Nucleospira subsphaerica Johnson, 1970, p. 178-9, Pl. 51, figs. 17-24

Material - 4 articulated, 1 disarticulated, and 1 fragment, total of 6 specimens.

Remarks - *Nucleospira subsphaerica* is identical to forms illustrated by Jones and Smith (1980, in press a) from the upper Eids Formation in the Sör to Vendom Fiords region. Other occurrences of this genus in Arctic and northwestern North America are (i) Jones (1982 a, b) noted *Nucleospira* sp. from the Bird Fiord Formation of the Goose Fiord and Vendom Fiord regions (upper Blue Fiord Formation at the latter), (ii) *N.* sp. was documented by Perry (1979) from the Upper Zlichovian Prongs Creek Formation of the northern Yukon Territory, (iii) by Perry *et al.* (1981) from the Mount Lloyd George area of northern British Columbia and (iv) *N. hecetensis* was noted by Savage (1981) from the Pragian strata of Heceta Island, southeast Alaska.

N. subsphaerica occurs in the lower and middle subzones of the *E. pinyonensis* Zone of central Nevada (Johnson and Niebuhr, 1976).

Occurrence - GB32 (2; 1a, 1f), GB33 (1; 1a), Loc. 21 (3; 3a, 1d).

Suborder ATRYPOIDEA Moore, 1952

Superfamily ATRYPACEA Gill, 1871

Family ATRYPIDAE Gill, 1871

Subfamily ATRYPINAE Gill, 1871

Genus ATRYPA Dalman, 1828

Type species - *Anomia reticularis* Linnaeus, 1758, p. 702

Atrypa sp. A

Plate 29 j,k,l

Atrypa sp. A, Jones, 1982b, p. 1393-4, Pl. 2, figs. 21-23, 28-37

Material - 237 articulated, 40 disarticulated, and 29 fragments, total of 306 specimens.

Remarks - Jones (1982a, b) noted that there is some confusion as to the classification of *Atrypa*. This problem is compounded by the abundance of species names associated with the genus, many of which are synonyms. For this reason, Jones followed Johnson (1975) who did not attempt any specific designation. This procedure is continued herein.

Atrypa sp. A is identical to *A.* sp. A of Jones (1982 b) from the Bird Fiord Formation (upper Blue Fiord Formation) of the Vendom Fiord area. It differs from *A.* sp. B by being more transverse and having finer ribbing, and from *A.* sp. C by having much finer ribbing.

Atrypa is a long-ranging genus, Lower Silurian to Upper Devonian, of little biostratigraphic use (Boucot *et al.*, 1965, p. H639).

Occurrence - AAA3-11 (23; 21a, 2f), AD36 (87; 85a, 2f), CC2A (2; 1a, 1d), CC6 (1; 1f), CF17 (5; 2a, 3d), CF18 (1; 1f), CF19 (30, 28a, 2d), CF25 (2; 2f), CH1 (Eids Formation; 1; 1a), CH23 (2; 2a), CH24 (1; 1a), ED34 (5; 5a), FA36 (Disappointment Bay Formation; 8; 6a, 2f), GA6 (6; 4a, 2d),

GA9 (2; 2a), GA16 (17; 10a, 7d), GB32 (52; 40a, 6d, 6f), GB33 (33; 12a, 12d, 9f), GB35 (2; 1a, 1f), GE6 (1; 1f), HC16 (9; 9a), Loc. 19 (10; 6a, 4d), B37 (Blue Fiord Formation, Bathurst Island; 6; 1a, 3d, 2f).

Atrypa sp. B

Plate 29 m,n,o

Atrypa sp. B Jones, 1982a, p. 1403, Pl. 2, figs. 1-15

Material - 140 articulated, 14 disarticulated, and 52 fragments, total of 206 specimens.

Remarks - This species is identical to *Atrypa* sp. B of Jones (1982a) from the Bird Fiord Formation of the Goose Fiord area, and to *A.* sp. B of Jones and Smith (in press, a) from the Eids Formation of the Sör and Vendom Fiord regions.

A. sp. B differs from *A.* sp. C by being commonly equibiconvex, and by having finer ribbing and less prominent growth lines.

Occurrence - BB8 (1; 1d), CC2A (3; 1a, 2d), ED34 (1; 1a), GB33 (2; 1a, 1d), HC16 (39; 29a, 10d), Loc. 21 (160; 108a, 52f).

Atrypa sp. C

Plate 29 p,q,r

Atrypa sp. C Jones, 1982a, p. 1403, Pl. 2, figs. 16-25

Material - 11 articulated, 5 disarticulated, and 4 fragments, total of 20 specimens.

Remarks - *Atrypa* sp. C is identical to *A.* sp. C of Jones (1982a) from the Bird Fiord Formation of the Goose Fiord area.

Occurrence - CA11 (1; 1f), CA16 (1; 1f), CC2B (1; 1d), CF17 (2; 2a), CH23 (5; 3a, 1d, 1f), CH25 (3; 1a, 1d, 1f), CH30 (6; 5a, 1d), GA9 (1; 1d).

Genus SPINATRYPA Stainbrook, 1951

Type species - *Atrypa occidentalis* Stainbrook, 1938, p. 241

Spinatrypa sp.

Plate 29 s,t,u

Material - 46 articulated, 6 disarticulated, and 10 fragments, total of 62 specimens.

Remarks - Prominent radial ribs and concentric growth lamellae distinguish this genus from *Atrypa*.

Spinatrypa sp. has been documented in the Arctic Islands from the Eids Formation of the Sör to Vendom Fiord areas (Jones and Smith, in press a), from the Bird Fiord Formation (now upper Blue Fiord Formation) of the Vendom Fiord region (Jones, 1982b), and from the Bird Fiord Formation of the Goose Fiord area (Jones *in* Pedder, 1982b). Other species of *Spinatrypa* from the Arctic Islands are from the Disappointment Bay Formation of Lowther Island (Johnson, 1975) and from the Bird Fiord Formation of Bathurst Island (Johnson and Perry, 1976). Other occurrences include the Ogilvie Formation of east-central Alaska (Blodgett, 1978), the Prongs Creek Formation of northern Yukon Territory (Perry, 1979), and the Mount Lloyd George area (Perry *et al.*, 1981). It is known from the *Quadrithyris* Zone (Lower Siegenian) of central Nevada (Johnson, 1970).

Occurrence - BB4 (1; 1d), CE7 (3; 3d) ED34 (40; 40a), Loc. 21 (1; 1a), B37 (Blue Fiord Formation, Bathurst Island; 17; 5a, 2d, 10f).

Suborder SPIRIFERIDINA Waagen, 1883

Superfamily CYRTINACEA Fredericks, 1912

Family CYRTINIDAE Fredericks, 1912

Genus CYRTINA Davidson, 1858

Type species - *Calceola heteroclita* Defrance, 1824, p. 306

Cyrtina sp.

Plate 29 v,w,x

Material - 9 articulated and 4 disarticulated, total of 13 specimens.

Remarks - These specimens are very similar to *Cyrtina* sp. from the upper Eids Formation described by Jones and Smith (1980, in press a), and the lower Blue Fiord Formation of southwest Ellesmere Island (Brice, 1982; Pedder, 1982a, GSC loc. C-12498). Other species of the genus are known from the Prongs Creek Formation (Perry, 1979), and from the "Delorme" Formation of the Yukon Territory (Norris and Uyeno, 1981), and from the Mount Lloyd George area of northern British Columbia (Perry *et al.*, 1981). A species of *Cyrtina* (*C.* sp. D) occurs in the *E. pinyonensis* Zone of central Nevada (Johnson, 1970).

Occurrence - AD36 (7; 7a), BB12 (1; 1d), GA16 (1; 1a), GB32 (1; 1d), GB33 (2; 2d), Loc. 21 (1; 1a).

Superfamily SPIRIFERACEA King, 1846

Family DELTHYRIDIDAE Waagen, 1883

Subfamily FIMBRISPIRIFERINAE Pitrat, 1965

Genus HOWELLELLA Kozlowski, 1946

Type species - *Delthyris elegans* Muir-Wood, 1925, p. 89

Howellella smithi Jones and Boucot, 1983

Plate 29 y

Howellella smithi Jones and Boucot, 1983, p. 343-5, figs. 3A-Q, 7

Material - 1 fragment.

Remarks - *Howellella smithi* differs from *H.* sp. A in having finer, more rounded, less pronounced plica, and well developed concentric growth lines, and from *H.* sp. B by having better developed growth lamellae. The species has been recognized from the Eids Formation in the Vendom Fiord area (Jones and Boucot, 1983; Jones and Smith, in press a).

The genus *Howellella* has been previously recorded from the Blue Fiord Formation near Sör Fiord (Pedder, 1982a), and from the Bird Fiord Formation (now upper Blue Fiord Formation) of the Vendom Fiord region (Jones, 1982b). In the Yukon Territory, it has been documented by Perry (1979) from the Prongs Creek Formation, and by Norris and Uyeno (1981) from the "Delorme" Formation.

Occurrence - GB32; (1; 1f).

Howellella sp. A

Plate 29 z

Material - 1 articulated, 6 disarticulated, and 2 fragments, total of 9 specimens.

Remarks - *Howellella* sp. A differs from *H.* sp. B by its more pronounced, sharper-crested plicae. *H.* sp. A superficially resembles *H.* cf. *textilis* from the *E. pinyonensis* Zone of central Nevada, but the material available is not good enough for a definite assignment to this species.

Occurrence - AB18 (1; 1d), AD36 (1; 1a), CC28 (1; 1d), CH23 (2; 2f), CH25 (1; 1d), GB32 (1; 1d), GB33 (1; 1d), JA4 (1; 1d).

Howellella sp. B

Plate 29 aa,bb,cc

Material - 3 articulated specimens.

Remarks - see preceeding species.

Occurrence - AD36 (3a 3a).

Genus PERRYSPIRIFER Jones and Boucot, 1983

Type species - *Spirifer scheii* Meyer, 1913, p. 25-26, Pl. 5, fig. 7; Pl. 6, fig. 1a-c.

Perryspirifer scheii (Meyer, 1913)
Plate 29 dd, ee, ff

Spirifer scheii Meyer, 1913, see type species.

Material - 51 articulated, 30 disarticulated, and 37 fragments, total of 118 specimens.

Remarks - This species was first described by Meyer (1913) as *Spirifer scheii* from collections made by the crew of the Fram between 1898 and 1902. McLaren (1963a) assigned similar spiriferids in the Blue Fiord Formation of southwest Ellesmere Island to *Fimbrispirifer*. This generic assignment was followed by Jones and Smith (1980) for specimens from the Eids Formation of the Sör Fiord area, by Brice (1982) for specimens from the Blue Fiord and Bird Fiord formations of Ellesmere and Devon Islands, and by Jones (1982a, b) for specimens from the Bird Fiord Formation in the Goose Fiord and Vendom Fiord areas. Pedder (1982a) noted *F.* sp. cf. *F. pseudoscheii* Brice, 1982 from the Blue Fiord Formation near Sör Fiord. This species was later placed in synonymy with *P. scheii* by Jones and Boucot (1983). The species has also been recognized (as *F. scheii*) in the Yukon Territory by Perry *et al.* (1974) in the Ogilvie Formation, and by Perry (1979) in the Prongs Creek Formation.

Occurrence - AAA3-11 (6; 4a, 2f), AD36 (21; 18a, 3f), BB8 (1; 1f), BB12 (4; 4f), BC1 (1; 1d), CA16 (2; 2f), CC2A (1; 1a), CC6 (2; 2f), CF17

(2; 1a, 1d), CF19 (3; 3a), ED34 (1; 1f), GA6 (2; 1d, 1f), GA9 (6; 1a, 5d), GA11 (1; 1a), GA16 (19; 10a, 3d, 6f), GB32 (23; 5a, 9d, 9f), GB33 (13; 2a, 7d, 4f), GB35 (2; 1a, 1d), GE6 (1; 1f), HC16 (5; 4a, 1d), Loc. 40 (1; 1d).

Superfamily RETICULARIACEA Waagen, 1883

Family RETICULARIIDAE Waagen, 1883

Genus NAJADOSPIRIFER Havlíček, 1957

Type species - *Spirifer najadum* Barrande, 1848, p. 171.

Najadospirifer sp.

Plate 30 a,b,c

Najadospirifer sp. Jones, 1982b, p. 1392-3, Pl. 1, figs. 16-25

Material - 2 articulated specimens.

Remarks - *Najadospirifer* sp. is identical to forms illustrated by Jones (1982b) from the Bird Fiord Formation (now upper Blue Fiord Formation) of the Vendom Fiord region, and by Perry *et al.* (1974) from the Emsian Ogilvie Formation of the Yukon Territory. It differs from *N. najadum* by lacking strong plications on the fold and sulcus (Boucot, 1962).

Occurrence - CH23 (2; 2a).

Genus WARRENELLA Crickmay, 1953

Type species - *Warrenella eclectea* Crickmay, 1953, p. 596

Warrenella disjuncta Brice, 1982

Warrenella disjuncta Brice, 1982, p. 90, 92, Pl. 21, figs. 8-17

Material - 2 disarticulated specimens and 5 fragments, total of 7 specimens.

Remarks - *Warrenella disjuncta* is distinguished from *W. extensa* by being

less transverse and in lacking low ribs on the shell flanks, and from *W. franklini praefranklini* (f.t.) and *W. transversa* by being less transverse, lacking a dorsal fold, and by having a less deflected anterior commissure.

W. disjuncta has only been recognized in the upper part of the lower Blue Fiord Formation near Blue Fiord (*P. inversus* Zone, Zlichovian/Dalejan) (Brice, 1982).

Occurrence - CE2 (1; 1d), JA2 (6; 1d, 5f).

Warrenella extensa Brice, 1982

Plate 30 d

Warrenella (W.) extensa Brice, 1982, p. 104, 106, Pl. 24, figs. 1-8, 10

Material - 1 disarticulated specimen.

Remarks - Brice (1982, p. 103) erected a new subgenus *Warrenella (Warrenellina)* based on *Warrenella (W.) extensa* in which she placed species of *Warrenella* with low ribs on the flanks. *W. transversa* was also included in this subgenus due to the occasional presence of low rounded plicae on the shell flanks of large specimens (see Ludvigsen and Perry, 1975, p. 73). I believe, at least for *W. transversa*, that this feature is an expression of intraspecific variation, and therefore should not be considered a character of subgeneric value. Therefore, these two species are retained in *Warrenella*.

W. extensa differs from *W. franklini praefranklini* (f.t.), mainly in the presence of ribs on the shell flanks, and from *W. transversa* by being less transverse, by possessing ribs on the shell flanks, and by having a much less deflected anterior commissure.

W. extensa has only been reported from the upper part of the lower and the lower part of the upper Blue Fiord Formation in the region of Blue Fiord (Brice, 1982).

Occurrence - CB1 (1; 1d).

Warrenella franklini praefranklini (forme transversale) Brice, 1982

Plate 30 e

Warrenella franklini praefranklini (forme transversale) Brice, 1982, p. 92, 94, 96, Pl. 23, figs. 6-14

Material - 1 articulated, 27 disarticulated, 8 fragments, total of 36 specimens.

Remarks - *Warrenella franklini praefranklini* (f.t.) differs from *W. transversa* by being generally smaller, and by having a much less deflected anterior commissure. It has been documented by Brice (1982) from the upper part of the lower Blue Fiord Formation near Blue Fiord, in the Blue Fiord Formation of northeast Bathurst Island, and from the Disappointment Bay Formation of the Goose Fiord area and Grinell Peninsula.

Occurrence - CB1 (2; 1d, 1f), CE7 (11; 1a, 8d, 2f), EA35 (5; 4d, 1f), EA46 (9; 7d, 2f), JA2 (4; 2d, 2f), Loc. 19 (5; 5d).

Warrenella transversa Ludvigsen and Perry, 1975

Plate 30 f

Warrenella transversa Ludvigsen and Perry, 1975, p. 72-75, Pl. 13, figs. 1-26

Material - 1 articulated, 6 disarticulated, and 17 fragments, total of 24 specimens.

Remarks - *W. transversa* has been recognized in the upper Eids Formation of the Sör Fiord region (Jones and Smith, 1980, in press, a) and in the Lower Zlichovian Michelle Formation of west-central Yukon Territory (Ludvigsen and Perry, 1975).

Occurrence - CB1 (23; 6d, 17f), GB33 (1; 1a).

Order STROPHOMENIDA Öpik, 1934

Suborder CHONETOIDEA Muir-Wood, 1955

Superfamily CHONETACEA Bronn, 1862

Family CHONETIDAE Bronn, 1862

Subfamily CHONETINAE Bronn, 1862

Genus CHONETES Fischer de Waldheim, 1830

Type species - *Terebratulites sarcinulatus* von Schlotheim, 1820, p. 256

Chonetes sp. A

Plate 30 g,h,i,j

Material - 4 articulated, 39 disarticulated, 35 fragments, total of 78 specimens.

Remarks - *Chonetes* sp. A is a moderate to small, semicircular, moderately concavo-convex, very finely capillate species, with growth lines and oblique spinules up to 2 mm long, developed at its hinge line. It differs from *C.* sp. B by having growth lines and much finer capillae, and by having oblique spinules, from *C.* sp. C by being larger, having growth lines, and in not possessing a ventral sulcus, and from *C.* sp. D in being larger, having growth lines and much finer capillae, and by being gently concavo-convex.

Johnson (1975) recognized 3 species (A, B, C) of "*Chonetes*" from

the Disappointment Bay Formation of Lowther Island; *C.* sp. A is distinguished from "*C.*" sp. A by having no ventral sulcus, from "*C.*" sp. B by having much finer ornament, and from "*C.*" sp. C by being more transverse.

Other species of *Chonetes* have been recognized by Blodgett (1978) from the Ogilvie Formation and limestone and shale member of the McCann Hill Chert of east-central Alaska, and by Johnson (1970) from the *E. pinyonensis* Zone of central Nevada.

Occurrence - EA35 (1; 1d), GB43 (75; 4a, 36d, 35f), GD5 (no samples), GE8 (1; 1d), Loc. 19 (1; 1d).

Chonetes sp. B

Plate 30 k

Material - 6 disarticulated specimens and 5 fragments, total of 11 specimens.

Remarks - This is a moderate to small, semicircular, slightly concavo-convex, coarsely capillate species with short, vertical spines. It differs from *C.* sp. C by being larger, and by having much coarser capillae and no ventral sulcus, and from *C.* sp. D by being larger, gently concavo-convex, and by having finer capillae.

C. sp. B differs from "*C.*" sp. A of Johnson (1975) by having no sulcus, from "*C.*", sp. B by being gently concavo-convex, and from "*C.*" sp. C by being more transverse.

Occurrence - AD3 (1; 1d), BB2 (4; 3d, 1f), CB1 (1; 1d), CE2 (1; 1f), CH4-6 (2; 2f), GE8 (2; 1d, 1f).

Chonetes sp. C

Plate 30 j

Material - 4 disarticulated specimens.

Remarks - This species differs from all other species of *Chonetes* recognized herein mainly by having a ventral sulcus. It differs from "*C.*" sp. A of Johnson (1975) in that its sulcus attains the beak region, whereas in "*C.*" sp. A, the sulcus is only developed in the anterior portion of the shell.

Occurrence - EA35 (2; 2d), EA46 (1; 1d), Loc. 19 (1; 1d).

Chonetes sp. D

Plate 30 m,n,o

Material - 20 articulated, 6 disarticulated, and 1 fragment, total of 27 specimens.

Remarks - *Chonetes* sp. D resembles "*C.*" sp. B of Johnson (1975) but differs by being much smaller and less transverse.

Occurrence - EA35 (6; 5d, 1f), EA46 (1; 1d), Loc. 21 (20, 20a).

Subfamily PARACHONETINAE Johnson, 1970

Genus PARACHONETES Johnson, 1966

Type species - *Chonetes macrostriata* Walcott, 1884, p. 126.

Parachonetes macrostriatus (Walcott, 1884)

Plate 30 p

Chonetes macrostriata Walcott, 1884, p. 126, Pl. 2, fig. 13, Pl. 13, figs. 14, 14a-c

Material - 17 disarticulated specimens and 5 fragments, total of 22 specimens.

Remarks - *Parachonetes macrostriatus* is identical to forms from the upper Eids Formation of Ellesmere Island (Jones and Smith, 1980, in press

a) and from the *E. pinyonensis* Zone of central Nevada (Johnson, 1970). A similar form was illustrated but not fully described by Johnson (1975) from the Disappointment Bay Formation of Lowther Island.

P. macrostriatus is well known in Emsian beds of northwestern Canada in the Michelle (Ludvigsen, 1970), Road River (Lenz and Pedder, 1972), and Delorme formations (Perry, 1974), and from northern British Columbia (Perry *et al.*, 1981).

The genus is unknown in beds older than Emsian in western North America.

Occurrence - CA6 (1; 1d), CF17 (3; 3d), CH1 (Eids Formation; 1; 1f), GA9 (9; 7d; 2f), GA16 (2; 2d), GA26 (1; 1f), GB32 (4; 4d), Loc. 40 (1; 1f).

Suborder STROPHOMENOIDEA Öpik, 1934

Superfamily DAVIDSONIACEA King, 1850

Family CHILIDIOPSIDIDAE Boucot, 1959

Genus EOSCHUCHERTELLA Gratsianova, 1974

Type species - *Eoschuchertella popovi* Gratsianova, 1974, p. 83, Pl. 13, figs. 1-9.

Eoschuchertella tuktui Jones *in* Jones and Smith, in press a

Plate 30 q

Eoschuchertella tuktui Jones, Jones and Smith, in press a.

Material - 8 articulated, 3 disarticulated and 1 fragment, total of 12 specimens.

Remarks - The holotype of *Eoschuchertella tuktui* is from the upper Eids

Formation of the Sör Vendom Fiord regions. It differs from *E.* cf. *E. murphyi* (Chatterton, 1973) illustrated by Perry (1979) from the Prongs Creek Formation of northern Yukon Territory by being much larger, and by having a smaller width/length ratio. *E. tuktui* is distinguished from *E.* sp. noted by Smith, R. (1980) from the Lower Lochkovian of Prince of Wales Island in having much coarser, less bifurcating ribs.

Species of *Eoschuchertella* have been documented in the lower Blue Fiord Formation of the Sör Fiord area (Pedder, 1982a), by Perry *et al.* (1981) from the Mount Lloyd George area of northern British Columbia, and by Savage (1981) from the Pragian strata of Heceta Island, southeast Alaska.

Occurrence - AAA3-11 (8; 8a), BB12 (1; 1d), CF17 (1; 1d), CH32 (1; 1d), GA16 (1; 1f).

Superfamily STROPHEODONTACEA Caster, 1939

Family PHOLIDOSTROPHIIDAE Stainbrook, 1943

Genus PARAPHOLIDOSTROPHIA Johnson, 1971a

Type species - *Parapholidostrophia harperi* Johnson, 1971a, p. 310, Pl. 39, figs. 1-18.

Parapholidostrophia harperi Johnson, 1971a

Plate 30 r,s

Parapholidostrophia harperi Johnson 1971a, see type species.

Material - 31 articulated, 12 disarticulated, and 3 fragments, total of 46 specimens.

Remarks - *Parapholidostrophia harperi* differs from *P. sorensis* in length/width and length/height ratios, and also in its higher apical angle (see Jones and Smith, 1980, text-fig. 6; in press a, text-fig. 8).

Occurrence - AAA3-11 (15; 15a), AD36 (16; 16a), CF25 (1; 1d), CH23 (1; 1d), GA11 (1; 1d), GA16 (2; 2d), GA26 (9; 6d, 3f), GB25 (1; 1d).

Parapholidostophia sorensis Jones *in* Jones and Smith, 1980

Plate 30 t,u

Parapholidostrophia sorensis Jones, Jones and Smith, 1980, p. 681, 683, 685, Pl. 2, figs. 10, 16-25.

Material - 21 articulated, 8 disarticulated, and 3 fragments, total of 32 specimens.

Remarks - *Parapholidostrophia sorensis* has been documented from the upper Eids Formation of southwest Ellesmere Island in great abundance (Jones and Smith, 1980, in press a).

Occurrence - AAA3-11 (5, 4a, 1f), AD36 (15; 13a, 2f), BB12 (3; 3d), CH24 (1; 1a), EA1 (Eids Formation; 1a; 1a), ED34 (1; 1a), Loc. 19 (5; 5d), Loc. 21 (1; 1a).

Genus PHRAGMOSTROPHIA Harper, Johnson, and Boucot, 1967

Type species - *Phragmostrophia merriami* Harper, Johnson, and Boucot, 1967, p. 430, Pl. 7, figs. 5-8, Pl. 8, figs. 4-5.

Phragmostrophia sp. aff. *P. merriami* Harper, Johnson, and Boucot, 1967

Plate 30 v,w

Phragmostrophia merriami Harper, Johnson, and Boucot, 1967, see type species.

Material - 11 articulated specimens and 2 fragments, total of 13 specimens.

Remarks - *Phragmostrophia* sp. aff. *P. merriami* differs from the type

P. merriami of the *E. pinyonensis* Zone of central Nevada (Harper *et al.*, 1967) by having a strong sulcus and parvicostellate ornamentation. A species similar to *P. merriami* was documented by Harper *et al.* (1967, Pl. 8, fig. 1) from the lower Blue Fiord Formation near Eids Fiord (GSC loc. 26513). *P.* sp. from the Emsian of Devon Island (Harper *et al.*, 1967, Pl. 8, figs. 6-9) has a stronger sulcus than *P.* sp. aff. *P. merriami*. *P.* cf. *P. merriami* reported by Johnson (1975) from the Disappointment Bay Formation of Lowther Island differs from *P.* sp. aff. *P. merriami* in having a weaker sulcus. Occurrences of *P. merriami* (or cf. *merriami*) have been noted from northwestern North America by Perry *et al.* (1974) and Blodgett (1978) from the Ogilvie Formation, and by Perry (1979) from the Prongs Creek Formation. *P.* sp. was listed by Perry *et al.* (1981) from the Mount Lloyd George area of northern British Columbia.

Occurrence - AD36 (2; 2a), HC16 (1; 1a), Loc. 21 (10. 8a, 2f).

Family STROPHEODONTIDAE Caster, 1939

Genus CYMOSTROPHIA Caster, 1939

Type species - *Strophomena stephani* Barrande, 1848, p. 230, Pl. 20, fig. 7.

Cymostrophia (?) sp.

Plate 30 x,y

Material - 30 articulated, 6 disarticulated, and 16 fragments, total of 52 specimens.

Remarks - *Cymostrophia* sp. is identical to forms noted by Jones and Smith (in press a) from the upper Eids Formation of southwest Ellesmere Island. *C.* sp. has also been documented in the Arctic Islands by Jones (1982b) from

the Bird Fiord (now upper Blue Fiord) Formation of the Vendom Fiord area and by Johnson (1975) from the Upper Emsian Disappointment Bay Formation of Lowther Island. *C.* sp. has been reported by Blodgett, (1978) from the Ogilvie Formation of east-central Alaska, and by Johnson (1970) from the *E. pinyonensis* Zone of central Nevada.

Occurrence - AAA3-11 (9; 9a), AD36 (20; 20a), CA3 (Eids Formation; 5; 5f), CC1 (Eids Formation; 4; 4f), CC2A (5; 1d, 4f), CF17 (1; 1d), CH30 (1; 1a), GA6 (1; 1d), GA16 (2; 2d), HC16 (3; 3f), K4 (1; 1d).

Large Strophedontid

Plate 31 a

Material - 5 fragments.

Remarks - This species resembles *Cymostrophia* sp. externally, but is plano-convex as opposed to concavo-convex as in *Cymostrophia* sp.

Occurrence - AAA3-11 (5; 5f).

Subfamily BRACHYPRIONINAE Harper and Boucot, 1978

Genus MEGASTROPHIA Caster, 1939

Subgenus MEGASTROPHIA (MEGASTROPHIELLA) Harper and Boucot, 1978

Type species - *Strophomena* (*Strophodonta*) *concava*, Hall, 1857, p. 140

Megastrophia (*Megastrophiella*) sp.

Plate 31 b

Material - 1 articulated and 2 disarticulated specimens, total of 3 specimens.

Remarks - This species is included in *Megastrophia* (*Megastrophiella*) rather than *Megastrophia* (*Megastrophia*) Caster, 1939, due to the small

size of the shell (see Jones, 1982a, p. 1400-1402 for discussion). *M.* (*Megastrophiella*) *frami*, from the Bird Fiord Formation of Goose Fiord (Jones, 1982a), differs from *M.* (*Megastrophiella*) sp. by being plano-convex rather than concavo-convex. The best known species of the subgenus, *M.* (*Megastrophiella*) *iddingsi* (Merriam), from the *E. pinyonensis* Zone of central Nevada (Johnson, 1970), is distinguished from *M.* (*M.*) sp. by having a less transverse shell. *Megastrophia* sp. has also been reported from the Ogilvie Formation of the northern Yukon Territory (Perry *et al.*, 1974).

Occurrence - ED34 (2; 1a, 1d), JA14 (1; 1d).

Order TEREBRATULIDA Waagen, 1883

Family CRANAENIDAE Cloud, 1942

Subfamily CRANAENINAE Cloud, 1942

Genus COSTACRANAENA Johnson and Perry, 1976

Type species - *Costacranaena marlenae* Johnson and Perry, 1976, p. 633, 634, Pl. 4, figs. 1-14.

Costacranaena sp.

Plate 31 d,e,f

Material - 3 articulated specimens.

Remarks - The specimens included herein were described by Smith, D. (1980) from the lower Blue Fiord Formation of the Eids Fiord area as a terebratulid, genus unknown. Later, Smith, D. and Stearn (1981) identified the specimens as *C. marlenae*, which has also been recognized from the Bird Fiord Formation of Bathurst Island (Johnson and Perry, 1976). However, the specimens from the Blue Fiord Formation are much smaller than *C. marlenae*, averaging 15 mm long, 12 mm wide, and 5 mm high,

compared to 22 mm long, 17 mm wide, and 9 mm high in *C. marlenae*. The specimens could, however, be younger individuals than those from the Bird Fiord Formation, but more samples would be needed to demonstrate this.

Occurrence - AD36 (3; 3a).

Class INARTICULATA Huxley, 1869

Order ACROTRETIDA Kuhn, 1949

Suborder ACROTRETIDINA Kuhn, 1949

Superfamily DISCINACEA Gray, 1840

Family DISCINIDAE Gray, 1840

Subfamily ORBICULOIDEINAE Schuchert and LeVene, 1929

Genus ORBICULOIDEA D'Orbigny, 1847

Type species - *Orbicula forbesi* Davidson, 1848, p. 334.

Orbiculoidea (?) sp.

Material - 1 disarticulated specimen.

Remarks - The single specimen available is tentatively assigned to *Orbiculoidea* by its external ornament. It occurs closely associated with another inarticulate brachiopod, *Lingula*.

Orbiculoidea sp. has been noted by Smith, R. (1980) from the Early Lochkovian of Prince of Wales and Baillie Hamilton Islands, and by Blodgett (1978) from the Upper Emsian Ogilvie Formation of east-central Alaska.

Occurrence - CB1 (1; 1d).

Order LINGULIDA Waagen, 1885

Superfamily LINGULACEA Menke, 1828

Family LINGULIDAE Menke, 1828

Genus LINGULA Bruguière, 1797

Type species - *Lingula anatina* Lamarck, 1801, p. 141.

Lingula sp.

Plate 31 c

Material - 29 disarticulated specimens.

Remarks - *Lingula* ranges from the Ordovician to the Recent (Rowell, 1965, p. H263), and therefore is of little biostratigraphic value. Many species are known, especially in the Silurian and Devonian.

Lingula sp. has been recorded in the Lower Lochkovian strata of Prince of Wales and Baillie Hamilton Islands by Smith, R. (1980), and in the Lochkovian "Delorme" Formation of the Yukon Territory by Norris and Uyeno (1981).

Another species of the genus, *L. lonensis* Walcott, is known from the *E. pinyonensis* Zone of Nevada (Johnson, 1970).

Occurrence - CB1 (29; 29d).

FAUNAL AGE AND AFFINITY

The Lower Devonian (Siegenian to Emsian) section of central Nevada has been widely used for correlation due to its well preserved, abundant fauna, and relatively close biostratigraphic control. The section has been divided into 5 major faunal assemblage zones that are based primarily on brachiopods:- *Quadrithyris*, *Spinoplasia*, *Trematospira*, *Acrospirifer kobehana*, and *Eurekaspirfer pinyonensis* zones (Johnson, 1970). Merriam (1940) placed the Lower-Middle Devonian boundary between the *A. kobehana* and *E. pinyonensis* zones, but later work on the brachiopods (Johnson, 1962), goniatites (House, 1962), and conodonts (Klapper and Johnson, 1975) indicated an upper Lower Devonian (Emsian) age for the *E. pinyonensis* zone, in the *Polygnathus dehiscens* to *P. inversus* zones.

The brachiopod fauna of the *E. pinyonensis* zone of Nevada has been divided into lower, middle, and upper subzones by Johnson and Niebuhr (1976, fig. 5) and Johnson (1977, table 3). Seventeen of the 26 genera and 7 of the 41 species recognized in this study have been documented in the *E. pinyonensis* zone (Figure 7-3). The presence in the Blue Fiord Formation of *S. nevadaensis*, the first occurrence of which marks the base of the upper subzone, and *C. aseptata*, *Chonetes* sp. *Athyrhynchus*, and *Cortezorthis*, which occur solely in the upper subzone, suggest correlation with the upper subzone of the *E. pinyonensis* zone. *P. macrostriatus*, *P. merriami*, and *T. occidens* range into the upper subzone from the zones below. However, *N. subsphaerica* is documented only in the lower to lower middle subzones and *W. transversa* (listed as *Elythyna transversa* by Johnson and Niebuhr, (1976), as Johnson (1975, p. 973-974) believes them to be conspecific) only in the lower subzone. These ranges indicate

an age slightly older than that of the upper subzone, possibly the lowest part of the upper subzone or the highest part of the middle subzone. This part of the *E. pinyonensis* zone occurs in the *P. gronbergi* conodont Zone (Johnson and Niebuhr, 1976, fig. 2), and therefore a Late Zlichovian age for the brachiopod assemblage of the lower Blue Fiord Formation is indicated. The age of the lower Blue Fiord Formation deduced by brachiopod correlations is in agreement with the age determined by conodonts (Uyeno and Klapper, 1980).

The brachiopod fauna of the lower Blue Fiord Formation of southwest Ellesmere Island has many genera and species in common with the following faunas from Arctic and northwest Canada:- Lower Zlichovian Eids Formation of southwest Ellesmere Island (16 genera, 14 species in common), Upper Zlichovian Disappointment Bay Formation of Lowther Island (12 genera, 4 species), Lower Zlichovian Michelle Formation (7 genera, 3 species) and Upper Zlichovian Prongs Creek Formation (11 genera, 2 species) of the Yukon Territory, the Zlichovian/Dalejan Ogilvie Formation of Yukon (15 genera, 3 species) and Alaska (10 genera, 4 species), and the Lower Zlichovian of the Mount Lloyd George area of northern British Columbia (12 genera, 2 species). This similarity to Lower to Upper Zlichovian faunas of Arctic and northwest Canada corroborates the age of the faunas determined by comparison with the *E. pinyonensis* zone of central Nevada.

Only 2 genera have been found in the Blue Fiord Formation of Bathurst Island - *Spinatrypa* sp. and *Atrypa* sp. A. Both are long-ranging, cosmopolitan forms, and are therefore unsuitable as biostratigraphic tools.

Boucot *et al.* (1969) defined 3 brachiopod faunal provinces from the Lower Devonian:- the Appalachian, Malvinokaffric, and Old World. The Old World Province includes Eurasia, North Africa, southeastern Australia, and western and Arctic North America, and is divided into the Cordilleran, Mongolo-Okhotsk, New Zealand, Rhenish-Bohemian, Tasman, and Uralian subprovinces (Boucot, 1975, fig. 2). The Cordilleran subprovince extends from Nevada to the Arctic Islands, via the west coast of North America, and the Yukon Territory. Johnson (1973, Table 1) listed 9 genera characteristic of the Cordilleran subprovince of the Old World Province, 6 of which occur in the lower Blue Fiord Formation of southwest Ellesmere Island - *Athyrhynchus*, *Carinagypa*, *Cortezorthis*, *Parachonetes*, *Phragmostrophia*, and *Warrenella* (*Elythyna*). Therefore, it is evident that the fauna of the lower Blue Fiord Formation is part of the Cordilleran subprovince of the Old World Province. *Cortezorthis* and *Phragmostrophia* are both also found in northern and northeastern U.S.S.R. (Johnson, 1973) and indicate a connection between the Canadian Arctic Islands and the U.S.S.R. via the Uralian Seaway.

CHAPTER 8

TAXONOMY AND DISCUSSION OF THE TRILOBITE AND CRICOCONARID FAUNA, AND FAUNAL/FLORAL LISTS OF OTHER GROUPS

INTRODUCTION

This chapter deals with the taxonomy of the trilobites and cricoconarid fauna, along with a discussion of the faunal age and affinities of both groups. Other groups of fossils (algae, bryozoans, chitinozoans, conodonts, fish, gastropods, ostracods, pelecypods, receptaculitids, spores, and "worms"), mostly identified by specialists, are listed and commented on at the end of the chapter.

TRILOBITES

The first descriptions of Devonian trilobites from the Canadian Arctic Islands were by Tolmachoff (1926). He used material collected by Per Schei from series D near Goose Fiord during the "Fram" expedition.

The first major study of the Devonian trilobite fauna of the Arctic Islands was by Ormiston (1967), who supplemented his own Arctic collections with the original material of Schei, and collections made by D.J. McLaren and J. Wm. Kerr in the 1950's and 1960's. The only other publication dealing with the taxonomy of Devonian trilobites from the Arctic Islands was by Ormiston (1971a). The Lower Devonian trilobite fauna of northwestern Canada and Alaska has been described by Ormiston (1969, 1971b), Perry and Chatterton (1976) and Chatterton and Perry (1977).

The trilobite fauna described herein (Figure 8-1) was collected mainly from the lower Blue Fiord Formation in the Sör Fiord and Vendom Fiord regions. Other specimens derive from the upper Eids Formation (Loc. 37) and the upper Blue Fiord Formation (JAI4).

SYSTEMATIC PALEONTOLOGY

Phylum ARTHROPODA Siebold and Stannius, 1845

Subphylum TRILOBITOMORPHA Størmer, 1944

Class TRILOBITA Walch, 1771

Order ODONTOPLEURIDA Whittington, 1959

Family ODONTOPLEURIDAE Burmeister, 1843

Subfamily ODONTOPLEURINAE Burmeister, 1843

Genus LEONASPIS R. and E. Richter, 1917

Subgenus LEONASPIS (KETTNERASPIS) Prantl and Přibyl, 1949

Type species - *Acidaspis pigra* Barrande, 1872

Leonaspis (Kettneraspis) elliptica (Burmeister, 1843)

Plate 31 g

Odontopleura elliptica Burmeister, 1843, p. 73, Pl. 1, fig. 4

Material and occurrence - BB2 (1 articulated pygidium and thorax)

Remarks - The features that distinguish *Leonaspis (Kettneraspis) elliptica* from the type species *L. (K.) pigra* from the Lower Devonian of central Bohemia are generally cranidial, as outlined by Ormiston (1967, p. 56).

L. (K.) elliptica occurs in the Lower Devonian of central Bohemia (Burmeister, 1843) and in the Middle Devonian Blue Fiord Formation of northeastern Bathurst Island (section B25 of this study) and Princess Royal Islands (Ormiston, 1967, p. 53). *Leonaspis* sp. 2 from the Emsian Delorme Formation, Northwest Territories (Perry and Chatterton, 1976) is very similar to *L. (K.) elliptica*.

Order PTYCHOPARIIDA Swinnerton, 1915

Suborder HARPINA Whittington, 1959

Family HARPIDAE Hawle and Corda, 1847

Genus HARPES Goldfuss, 1839

Type species - *Harpes macrocephalus* Goldfuss, 1839

Harpes macrocephalus Goldfuss, 1839

Plate 31 h

Harpes macrocephalus Goldfuss, 1839, p. 358, Pl. 33, figs. 2a - d

Material and occurrence - 2 complete cephalons - CB16(1), CF4(1).

Remarks - The morphologic relationships between *Harpes macrocephalus* and other forms is documented by Ormiston (1967, p. 50-52).

H. macrocephalus has been reported in the Eifel district of Germany (Richter, 1920), and in the Middle Devonian Blue Fiord Formation of northeastern Bathurst Island (section B25 of this study) (Ormiston, 1967).

Suborder ILLAENINA Jaanusson, 1959

Superfamily ILLAENACEA Hawle and Corda, 1847

Family SCUTELLUIDAE R. and E. Richter, 1955

Genus SCUTELLUM Pusch, 1833

Type species - *Scutellum costatum* Pusch, 1833

Scutellum (?) sp.

Material and occurrence - CB1 (1 partial pygidium)

Remarks - The specimen found in the lower Blue Fiord Formation is poorly preserved and is placed in *Scutellum* (?) because of its similarity to the *Scutellum* figured by Ormiston (1967, Pl. 1, figs. 1-6) from the Blue

Fiord Formation of northeastern Bathurst Island (Loc. 4 of Ormiston, 1967). The genus has been listed in the Emsian-Eifelian of Alaska, western Canada, and central Nevada (Ormiston, 1972, p. 603), and ranges from Silurian to Upper Devonian.

Superfamily PROETACEA Salter, 1864

Family PROETIDAE Hawle and Corda, 1847

Subfamily DECHENELLINAE Přibyl, 1946

Genus DECHENELLA Kayser, 1880

Subgenus DECHENELLA (DECHENELLA) Kayser, 1880

Type species - *Phillipsia verneuili* Barrande, 1852

Dechenella (Dechenella) spaekkassensis (Tolmachoff, 1926)

Plate 31 i, j

Basidechenella spaekkassensis Tolmachoff, 1926, p. 23, Pl. 1, figs. 6-8

Material and occurrence - 1 complete specimen, 2 articulated pygidia and thoraxes, 1 cephalon, 3 free cheeks, and 4 pygidia - CB16 (1 f.c., 1 py.), EA35 (1 articulated py. + th., 1 py.), EC38 (1 complete, rolled specimen), GB25 (1 partial py.), JA14 (1 ceph.), Loc. 37 (2 f.c., 1 articulated py. + th., 1 py.).

Remarks - Ormiston (1967, p. 94-96) compared *Dechenella (Dechenella) spaekkassensis* to closely related specimens of the genus, and noted that it was especially similar to *D. (D.) arschensis* Maximova from the Upper Givetian of the central Urals. Ormiston (1971, p. 32) noted the many similarities between *D. (D.) spaekkassensis* and *Lacunoporaspis norrisi* Ormiston from the Michelle Formation of the Yukon Territory, and stated that *D. (D.) spaekkassensis* possibly should be transferred to *Lacunoporaspis*. He also noted (1971, p. 33) that a specimen identified as *Dechenella* sp.

indet. from Emsian beds of the Princess Royal Islands (Ormiston, 1967, p. 108, Pl. 17, fig. 10) may also be a *Lacunoporaspis*.

Tolmachoff (1926) reported *Basidechenella* (=*Dechenella*) *spaekkassensis* from series Db and Dh (now Disappointment Bay and Bird Fiord (?) formations) in the extreme southwestern part of Ellesmere Island. It has also been documented from the lower Blue Fiord Formation near Blue Fiord (Ormiston, 1967) and near Sör Fiord (GSC. Loc. C-12437) (Ormiston, A., written comm. to Klapper, G., 1974).

Genus SCHIZOPROETOIDES Ormiston, 1967

Type species - *Cyrotosymbole richteri* Tolmachoff, 1926

Schizoproetoides richteri (Tolmachoff, 1926)

Plate 31 l,m

Cyrtosymbole richteri Tolmachoff, 1926, p. 26, Pl. 1, fig. 14

Material and occurrence - 1 articulated pygidium and thorax, 10 cephalons, and 33 pygidia - ABA3 (1 py.), BB12 (2 py.), CB6 (1 py.), CB10 (1 py.), CB16 (7 ceph., 10 py.), CE8 (4 py.), CE18 (4 py.), CF4 (1 py.), CF17 (1 py.), CF24 (1 py.), CH23 (1 ceph., 1 py.), DA37 (1 articulated py. + th., 2 ceph., 6 py.).

Remarks - The differences between *Schizoproetoides richteri* and its close relative *S. ellesmerensis* Ormiston are outlined in Ormiston (1967, p. 117).

S. richteri was originally named *Crytosymbole richteri* by Tolmachoff (1926) who examined specimens from the east side of Goose Fiord (series Db = Disappointment Bay Formation). *S. richteri* has also been documented in the lower and upper Blue Fiord Formation of the Blue Fiord and Vendom Fiord areas, respectively (Ormiston, 1967). The genus

has been reported in the Yukon Territory from the Lower Zlichovian Michelle Formation (Ludvigsen, 1970), the Upper Zlichovian Prongs Creek Formation (Ormiston, 1975), and in the Zlichovian/Dalejan Ogilvie Formation (Ormiston *in* Perry *et al.*, 1974).

Subfamily PROETINAE Salter, 1864

Genus PROETUS Steininger, 1831; emend. R. Richter, 1913

Type species - *Calymene concinna* Dalman, 1827

Proetus sp. cf. *P. bohemicus* Hawle and Corda, 1847

Plate 31 k

Material and occurrence - BB2 (1 articulated pygidium and thorax).

Remarks - This specimen closely resembles *Proetus* cf. *bohemicus* illustrated by Ormiston (1967, Pl. 6, figs. 10-11) from the Disappointment Bay Formation of Devon Island. However, it is approximately half the size of *Proetus* cf. *bohemicus*, but it may be merely a young individual.

The holotype of *P. bohemicus* comes from the Lower Devonian (Pragian) Koneprusy Limestone of Bohemia. Other species of *Proetus* have been found in the Lower Zlichovian Michelle Formation (*Proetus* sp. cf. *P. nerudai*, and *P.* sp.) (Ormiston *in* Ludvigsen, 1970, p. 425) and in the *E. pinyonensis* Zone of central Nevada (*P.* cf. *nevadae*) (Johnson, 1970, Table 8).

FAUNAL AGE AND AFFINITY

Ormiston (1967, p. 10) suggested that older (Emsian ?) beds were present in the Blue Fiord Formation of Ellesmere Island than on Bathurst Island for 2 reasons: (i) the first appearance of 3 trilobite species - *D. maclareni*, *D. paragranulata*, and *L. elliptica*, which occur well above the base of the Blue Fiord Formation on Devon and Ellesmere Islands, are present near the base of the Blue Fiord Formation on Bathurst Island (regarded as Eifelian in age) and (ii) trilobite species that occur near the base of the Blue Fiord Formation on Ellesmere Island are absent on Bathurst Island. New data from this study shows that *L. elliptica* does occur near the base of the Blue Fiord Formation on Ellesmere Island (unit BB2, approx. 50 m. above the base), and that *L. elliptica*, *H. macrocephalus*, and *Scutellum* (?) sp., now known from the base of the Blue Fiord Formation on Ellesmere Island, are also present on Bathurst Island. Therefore, it appears that, although the base of the Blue Fiord Formation on Ellesmere Island can be shown to be older than on Bathurst Island by conodonts, this conclusion cannot be reached on the basis of trilobite ranges.

A number of species of trilobites from the Blue Fiord Formation of Ellesmere Island are present in well-dated trilobite bearing sections in northwestern Canada. *L. elliptica* is similar to *L.* sp. 2 from the Delorme Formation (Lower Zlichovian, *P. dehiscens* Zone) of the Northwest Territories (Perry and Chatterton, 1976, p. 1476-1477); *D. spaekkassensis* bears a strong resemblance to *Lacunoporaspis norrisi* from the Lower Zlichovian Michelle Formation of the Yukon Territory (Ormiston, 1971b, p. 32); *S. richteri* is very close to *S.* sp. in the Zlichovian/Dalejan Ogilvie Formation of the Yukon Territory (Ormiston,

1971b, p. 33); *S. ellesmerensis*, which occurs in the Blue Fiord Formation of the Vendom Fiord region (Ormiston, 1967, p. 115) is very similar to *S.* sp. A from the Michelle Formation of the Yukon Territory (Ormiston, 1971b, p. 33); *Leonaspis eremia*, found in the lower Blue Fiord Formation near Blue Fiord (Ormiston, 1967, p. 56) resembles *L.* aff. *L. eremia* from the Michelle Formation of the Yukon Territory (Ormiston, 1971b, p. 35); and *Ceratarges* sp., from the Blue Fiord Formation of the Vendom Fiord region (Ormiston, 1967, p. 125) is similar to *C.* sp. from the Michelle and Delorme formations (Ormiston, 1971b, p. 37; Perry and Chatterton, 1976, p. 1473-1474). These occurrences demonstrate a close relationship between the trilobite faunas of the lower Blue Fiord Formation of southwest Ellesmere Island, and those of the Lower Zlichovian (*P. dehiscens* Zone) Michelle and Delorme formations. The Early Zlichovian age suggested by the trilobite fauna confirms that deduced using conodonts (Uyeno and Klapper, 1980).

In his discussion of Lower Devonian trilobite paleobiogeography, Ormiston (1972, 1975) divided North America into 2 major faunal realms in the Gedinnian - an Old World Province, occupying the western and Arctic regions of the continent, and an Appalachian Province, occupying the east coast and southeastern region. This provincial pattern was disrupted only slightly in the Siegenian by the incursion of members of the Appalachian Province into Nevada, causing a mixing of the Appalachian and Old World faunas. This closely matches the provincial pattern of brachiopods for these 2 Lower Devonian stages (Boucot *et al.*, 1969, figs. 1, 2). In Emsian through Eifelian time, Ormiston (1972, 1975) envisaged a marked increase in provinciality (Figure 8-2), with an Appalachian Province occupying the east coast, as before, but the Old

World Province being divided into the Cordilleran (Great Basin region), the Canadian-Siberian (northwestern Canada and eastern Alaska), and the Uralian (Arctic Islands) subprovinces. This pattern is markedly different from that determined for brachiopods (Boucot *et al.*, 1969, Figure 4), which shows a decrease in provinciality at this time. To demonstrate this increase in trilobite provinciality in the Emsian-Eifelian, Ormiston (1972, p. 603) listed all genera reported from the Appalachian Province, and the Cordilleran, Canadian-Siberian, and Uralian subprovinces, and compared each province/subprovince using the Provinciality Index (P.I.) as defined by Johnson (1971 b, p. 259). He noted (Ormiston, 1972, Table 1) high levels of provinciality (dissimilarity) between the Appalachian Province and the Canadian-Siberian (P.I. = 0.35) and Uralian (P.I. = 0.25) subprovinces, and between the Cordilleran and Uralian subprovinces (P.I. = 0.30). Lower levels of provinciality (P.I. = 0.62) were reported both between the Cordilleran and Canadian-Siberian subprovinces and the Canadian-Siberian and Uralian subprovinces.

Is the presence of these trilobite subprovinces of the Old World Province real, or is it merely due to a lack of available data? Perry and Chatterton (1976, p. 1467) noted that, although Emsian trilobites are probably the best known of the Lower Devonian trilobite faunas of western North America, the localities are relatively few and widely scattered, and the lack of correspondance in faunal affinities shown by coexisting Emsian brachiopods and trilobites from northern Yukon Territory and central Nevada is "at least partially the product of inadequate sampling" (p. 1469). In their study of the Emsian trilobites of the Delorme Formation of the Northwest Territories, Perry and Chatterton (1976) recorded the first occurrence of *Phacops* in Lower and Middle Devonian strata of northwestern and Arctic Canada. They also proposed

(p. 1469) that Ormiston's (1972) assignment of *Proetus*, from Emsian beds of Nevada, to *Ganinella* was incorrect. Therefore the genus *Proetus* should be included in the faunal list of Ormiston (1972, p. 603). The addition of *Phacops* from northwestern Canada and *Proetus* from Nevada creates 2 more common genera between these 2 areas (6 in total), and substantially alters the P.I. value assigned to these regions from 0.62 to 1.0. Therefore, this demonstrates a relatively close relationship between the trilobite faunas of Nevada and northwestern Canada. The differentiation of these 2 regions into 2 subprovinces, as suggested by Ormiston (1972, 1975) appears questionable.

Ormiston (1972, 1975) separated northwestern Canada and the Arctic Islands into 2 subprovinces, the Canadian-Siberian and the Uralian. Is this separation also due to a paucity of data? Ormiston (1971b) noted that 2 Emsian species of *Dechenella* (*D. spaekkassensis* and *D.* sp. indet.) from the Arctic Islands could probably be placed in the genus *Lacunoporaspis*, due to their similarity with *L. norrisi* from the Michelle Formation of the Yukon Territory. *Ceratarges*, a genus present in the Blue Fiord Formation of the Vendom Fiord region, has also been reported from the Delorme Formation of the Northwest Territories (Perry and Chatterton, 1976, p. 1473-1474). The addition of *Lacunoporaspis* in the Arctic Islands and *Ceratarges* in northwest Canada to the generic list of Ormiston (1972, p. 603) creates 2 more common genera (12 in total). *Acanthopyge* and *Phacops*, noted by Perry and Chatterton (1976) from northwestern Canada, should be added to the list of endemic genera of northwestern Canada and Alaska. This slightly alters the P.I. value from 0.62 to 0.66. Even though this P.I. value is still relatively low, there is no doubt that northwestern Canada and the Arctic Islands had similar trilobite faunas in the Emsian, with 12 genera and a number of species in

common. Their division into the Canadian-Siberian and Uralian sub-provinces is likely a result of poor knowledge of trilobite faunas in the 2 areas, especially the Arctic Islands.

A comparison of the Arctic Island trilobites with those of Siberia is difficult currently, due to meagre information on the Soviet faunas. The presence of genera in common between the Arctic Islands and western Europe demonstrates that both areas belonged to the Old World Province in the Emsian (Ormiston, 1967, p. 27).

In conclusion, trilobite faunas of the Arctic Islands fill the gap between similar known European and western North American trilobite faunas, which were all part of the Old World Province.

CRICOCONARIDS

Cricoconarids have received little systematic or biostratigraphic study in the Devonian of northwestern and Arctic Canada even though they are relatively common. When referred to in the literature, they are generally quoted as either *Tentaculites* sp. or *Styliolina* sp. Both are overextended genera of little use for biostratigraphic purposes.

Reports of cricoconarids from the Canadian Arctic Islands are rare. Miall (1976) recorded *Tentaculites* (later identified by A.W. Norris, 1973, as *Nowakia* sp. cf. *N. barrandei* in GSC report D1-1973 - AWN) and *Styliolina* from the Orksut Formation, and *Tentaculites* from the Blue Fiord Formation of the Banks Island subsurface. Norris, A.W., (*in* Mayr *et al.*, 1980, p. 214) documented *Nowakia* cf. *N. cancellata* and *Styliolina* from the Eids Formation (Dalejan) of the Murphy Alminex *et al.* Victoria Island F-36 well on northwest Victoria Island (see Figure 4-9).

The fine details of the external ornament on the cricoconarids collected as part of this study are generally very well preserved. Commonly, these fossils occur in large numbers on bedding planes, e.g. unit AAA9. The specimens can be divided into 6 species, most of which were collected from the lower Blue Fiord Formation in the Sör-Vendom Fiord region (Figure 8-3). The samples from HB6 are from the upper Eids Formation, those from JA9 are from the middle Blue Fiord Formation, and those from GSC Loc. C-12471 and C-12472, which were kindly loaned by A.E.H. Pedder, Geological Survey of Canada (Calgary), were collected from the upper Blue Fiord Formation (uppermost *P. inversus* Zone, Dalejan) of the Sör Fiord section (section K of this work).

The classification used herein is that of the Treatise on Invertebrate Paleontology (Fisher, 1962).

SYSTEMATIC PALEONTOLOGY

Phylum MOLLUSCA

Class CRICOCONARIDAE Fisher, 1962

Order DACRYOCONARIDA Fisher, 1962

Family STYLIOLINIDAE Grabau, 1912

Genus STYLIOLINA Karpinsky, 1884

Type species - *Styliola nucleata* Karpinsky, 1884.

Styliolina sp. cf. *S. fissurella* (Hall, 1843)

Plate 32 a

Material and occurrence - 8 fragments - CF20(1), EA35(2), JA9(5); numerous specimens in thin sections of units AD19, GA4, BB5, BB11, BC5, CB2, CB16, CE18, CF2, EA46, EC39, JB5, and JC2.

Remarks - *Styliolina* sp. cf. *S. fissurella* differs from *S. fissurella* described by Bouček (1964) only in being smaller (average length 3 mm). *Styliolina* is a long-ranging (Middle Silurian to Upper Devonian), cosmopolitan genus (Fisher, 1962, p. W116).

S. sp. cf. *S. fissurella* has been recognized in the Early Zlichovian Michelle (Ludvigsen, 1970) and Road River (Ludvigsen, 1972) formations of the northern Yukon Territory, and the Late Zlichovian McCann Hill Chert, east-central Alaska (Churkin and Carter, 1970) and Stuart Bay Formation of northeast Bathurst Island (Polan, 1982).

Order TENTACULITIDA Lyashenko, 1955

Family HOMOCTENIDAE Lyashenko, 1955

Genus HOMOCTENUS Lyashenko, 1955

Type species - *Homoctenus kreatovnikovi* Lyashenko, 1955

Homoctenus sp.

Plate 32 b

Material and occurrence - 7 complete and 94 fragments - HB6 (6 complete, 46 fragments), C-12471 (1 complete, 48 fragments).

Remarks - *Homoctenus* sp. has regularly-spaced rings of one size, with an average of 14 rings/mm at the apex, and many fewer at the aperture. It differs from *Dicricoconus* and all the other members of the Uniconida by having a ridged interior wall which repeats the external "ripple-like" ornamentation.

According to Fisher (1962, p. W110), *Homoctenus* occurs only in the Upper Devonian. However, Chatterton and Perry (1978) noted *H. caldwelli* from the Early Eifelian of northwest Canada, and Sokolov and Garkovetts (1978) documented *H. acutatus* from the Lower Zlichovian (*P. dehiscens* Zone) of the Khodzha-Kurgan and Zinzilban regions of Russia.

This is the first report of the genus in the Arctic Islands.

Family UNICONIDAE Lyashenko, 1955

Genus DICRICOCONUS Fisher, 1962

Type species - *Tentaculites mesodevonicus* Lyashenko, 1955

Dicricoconus dutroi Churkin and Carter, 1970

Dicricoconus dutroi Churkin and Carter, 1970, p. 58, Pl. 15, figs. 4-8.

Material and occurrence - 2 fragments - ED27.

Remarks - The specimens from the Blue Fiord Formation are similar in length (7 mm), apertural width (0.6 mm), number of rings/mm (5), and

number of rings/cycle (10) to *D. dutroi* from the Upper Zlichovian McCann Hill Chert (Churkin and Carter, 1970, p. 58-59). *Dicricoconus* sp. has been recognized by Blodgett (1978, p. 85-86) also from the McCann Hill Chert.

This is the first report of *Dicricoconus* from the Arctic Islands.

Dicricoconus sp. cf. *D. dutroi* Churkin and Carter, 1970

Plate 32 c,d

Material and occurrence - 4 complete, 14 fragments - Loc. 19.

Remarks - This species is very similar to *D. dutroi*, except that the larger rings are not as flat-sided.

Dicricoconus sp.

Plate 32 e

Material and occurrence - 1 complete, 127 fragments - C-12472.

Remarks - *Dicricoconus* sp. has an average length of 13 mm, a minimum width of 0.15 mm and a maximum of 0.85 mm. It has rings in 2 orders, the larger being flat-sided, and the smaller sharp-crested, 9 to 16/mm, and 17 to 28 rings/cycle. *D.* sp. differs from *D. dutroi* in its length and number of rings/cycle, and from *D.* cf. *D. mesodevonicus* of Churkin and Carter (1970, p. 58) by being much longer (*D.* cf. *D. mesodevonicus* is 2.6 mm long on average).

Genus "NEW GENUS" Churkin and Carter, 1970

Type species - "New genus and species" Churkin and Carter, 1970

"New genus" Churkin and Carter sp. nov.

Plate 32 f

Material and occurrence - 29 complete, 137 fragments - AAA9 (29 complete, 123 fragments), GB43 (1 fragment), GE8 (13 fragments).

Description - Shell thick, with smooth interior and blunt base. Length of shell 6.5 to 12.5 mm (mean 9.4 mm), initial width 0.2 mm, maximum width

0.6 to 1.0 mm (mean 0.8 mm). Apical angle 5°. Rings very sharp-crested, pronounced, evenly spaced, symmetrical, 12/mm at base, 4/mm at aperture.

Remarks - This new species differs from the only other species of the genus, "New genus and species" Churkin and Carter, 1970 from the Upper Zlichovian McCann Hill Chert of east-central Alaska in being much longer (mean 3.5 mm for "New genus and species" Churkin and Carter, 1970) and having less rings/mm at the aperture (minimum number of rings/mm in "New genus and species" Churkin and Carter, 1970 is 9). *Uniconus* is distinguished from "New genus" Churkin and Carter sp. nov. by its asymmetrical rings. "New genus" Churkin and Carter sp. nov. is similar to species of *Homoctenus*, except for its smooth interior.

FAUNAL AGE AND AFFINITY

The study of cricoconarid biostratigraphy began about 20 years ago with the work of Bouček (1964) who computed a detailed dacryoconarid zonation for the Devonian of Bohemia, based mainly on the distinctive genus *Nowakia* Gürich (Lütke, 1979). This zonation was recently revised slightly by Lütke (1979, Text - Figure 1). Unfortunately, the only dacryoconarid in the collections at hand is *Styliolina* sp. cf. *S. fissurella*, of little use for biostatigraphic purposes due to its long time range. The dacryoconarids that have been identified from the Arctic Islands - *Nowakia* sp. cf. *N. barrandei* from the Orksut Formation of Banks Island, and *N.* cf. *N. cancellata* from the Eids Formation of Victoria Island, can be used to date these formations accurately as Late Zlichovian and Early Dalejan, respectively.

Tentaculitid (thick-walled) cricoconarids, although relatively common in northwestern Canada, have been totally ignored for biostratigraphic purposes (Chatterton and Perry, 1978, p. 37). Tentaculitids from the Russian Platform have shown to be of some biostratigraphic value (Lyashenko, 1953). Churkin and Carter (1970) made the only systematic and biostratigraphic study of this order from northwestern North America. They examined specimens from the basal limestone and shale member of the McCann Hill Chert of east-central Alaska. Churkin and Carter noted *Dicricoconus dutroi* and "New genus and species" Churkin and Carter in strata bearing *Nowakia barrandei* and *Polygnathus inversus* (Blodgett, 1978) from east-central Alaska. *N. barrandei* was unknown in the *P. inversus* Zone (Lütke, 1979, Text - Figure 1); therefore this represents a slight upward range extension of *N. barrandei*. A Late Zlichovian

(low *P. inversus* Zone) age is indicated for the strata. The occurrence of *D. dutroi* in unit ED27 in the poorly dated lower part of the Blue Fiord Formation west of Vendom Fiord could indicate a Late Zlichovian age for these strata. *Dicricoconus* sp. occurs in the upper Blue Fiord Formation near Sör Fiord (uppermost *P. inversus* Zone, Dalejan) and could represent a species of *Dicricoconus* in a higher zone (equivalent to *N. richteri* Zone) than *D. dutroi*, although the total range of *Dicricoconus* sp. is unknown (Figure 8-4). "New genus" Churkin and Carter. sp. nov. occurs abundantly in unit AAA9 which is reliably dated as late Early to early Late Zlichovian (*P. dehiscens/P.* aff. *perbonus* boundary) by Uyeno and Klapper (1980), using conodonts collected and misidentified by Weyant (1975a) from section AAA, and is therefore older than "New genus and species" Churkin and Carter from the Upper Zlichovian of Alaska. "New genus" Churkin and Carter sp. nov. is also present at 2 localities west of Vendom Fiord (units GB43 and GE8), both approximately 100 m below the occurrence of *D. dutroi* (unit ED27). This occurrence of "New genus" Churkin and Carter sp. nov. indicates that the species belongs in a zone below *D. dutroi*, (Figure 8-4) and therefore suggests a similar age to those in unit AAA9 (*P. dehiscens/P.* aff. *perbonus* zones).

The tentaculitid zonation (Figure 8-4) derived from this study is tentative due to the paucity of information and the lack of knowledge of species ranges. It is, however, the first zonation of its kind in the Devonian of western and arctic North America, and will serve as a starting point for future studies.

FAUNAL/FLORAL LISTS OF OTHER GROUPS

ALGAE (Plates 33, 34)

An abundant and diverse flora of algae and incertae sedis is present in the Lower Devonian sequence of southwest Ellesmere Island, and in the limestone member of the Disappointment Bay Formation and the Blue Fiord Formation of Bathurst Island. The collection was submitted to B.L. Mamet (University of Montreal) for identification. Dr. Mamet also kindly provided photographs of part of the fauna.

CHLOROPHYTA

Charophyceae

Quasiumbella	Loc. 29
Uva? Maslov sensu Johnson	HB48
trochiliscid	GB50
umbellinid	CH19, GC24, HA56, HB42, Loc. 56 (9)

Chlorophyceae

Codiaceae

Bevocastria	FA22, GA8, GB1, GB66, GC1, GC13, GC24, HA31, HA40, HA50, HA56, HB24, HB40, HB42, HB58, HB59, HB67, HB71, HC44, KA25, KA41, Loc. 57(6), Loc. 57(8), B22, B32-11.
"*Dimorphosiphonoides*"	CB12, CH19, EA9, GA45, ID10, Loc. 29.
Litanaia mira	Loc. 29
Ortonella	B32-11

Codiaceae?

Halysis	AA7, AA22, ABA8, BA4, CA5, CD4, DA7, EC39, GA10, GC13, JC3, Loc.29.
Flabellia	JA15

Dasycladaceae

Issinella	CA10, EA9, FA26, GA10, GA27, GA45, GC10, GC29, HA28, HA35, HA50, HB48, HB69, JB6, JC3, B22.

Rhabdoporella bascillum AA7, AA22, AB1, ABA2, ABA8, CB12, CA6, CD4, HB34, ID7, ID10, ID12, JA15, Loc. 11, Loc. 29.

R. stolleyi AA22, AB10, ABA2, ABA8, AC4, EA9, GA45, GC10, JB7, JB14, B22, B30-4.

Vermiporella EA9, HC40.

CHLOROPHYTA? OR SCHIZOPHYTA?

Girvanella problematica AC2, BA4, CH19, EA8, FA26, HA28.

G. staminea AA22, AA28, ABA8, AC4, BA4, CA10, CB12, CD4, CH19, DA7, EA8, EA9, EC17, EC34, FA26, GA10, HA28, HB35, HB40, HB58, JA15, JB6, JB7, Loc. 2, Loc. 29.

G. wetheredii JB7

Sphaerocodium gotlandicum EA9, HB48, JA15, B22, Loc. 11, Loc. 29, Loc. 52.

CYANOPHYTA

"*Nostocites*" CH19, HC44, Loc. 29

RHODOPHYTA

Tharama B30-4, B42A.

INCERTAE SEDIS

"*Archaesphaera*" HA50

Bisphaera AB10, EC17, FA22, GA45, GB50, GC24, HA28, HA35, HA50, HA56, HB24, HB35, HB40, HB42, HB52, HB58, HB59, HB67, HB71, HC44, JA15, KA25, KA41, B22, B32-11, Loc. 2, Loc. 56(9), Loc. 57 (6, 8).

Calcisphaera FA22, FA26, GA8, GA45, GB1, GB66, GC1, GC10, GC13, GC24, GC29, HA31, HA35, HA40, HA50, HA56, HB24, HB40, HB42, HB48, HB52, HB58, HB59, HB67, HB71, HC44, JB6, JB14, JC3, KA25, KA41, B22, B30-4, Loc. 2, Loc. 11, Loc. 29, Loc. 56(9), Loc. 57 (6, 8).

Cateniphycus friatus DA29, JA15

Irregularina HB52

Parathurammina AA10, AA11, AA16, AB10, ABA2,

AC4, BA4, BB11, CA10, CD4, EC17, EC34, EC39, FA22, FA26, GA27, GA35, GA45, GB27, GB50, GB66, GC1, GC13, GC24, GC29, HA31, HA35, HA40, HA50, HA56, HB24, HB40, HB42, HB48, HB52, HB58, HB59, HB67, HB71, HC44, JA9, JA15, JB6, JB14, JC3, KA25, KA41, B22, B30-4, Loc. 2, Loc. 11, Loc. 29, Loc. 56(9), Loc. 57(6, 8).

Prominella HC44
Radiosphaera AA11, GC29, Loc. 2
Rauserina HB58, KA41
Uslonia GA10, GC24, HA50, HA56, B22, Loc. 11
Wetheredella silurica AC2, CB12, DA7, DA21, DA29, EA8, EA9, HC40, JA15, JC3, B22, B42A, Loc. 29.

Dr. Mamet (oral comm., 1983) believes this collection to be a typical Upper Silurian to Lower Devonian flora. The only group which has not been previously found in this interval is the umbellinids, which have previously been regarded as starting in the Middle Devonian (Eifelian), and becoming abundant in the Upper Devonian. This flora bears many resemblances to those described from the Upper Silurian of Gaspé (Héroux *et al.*, 1977, Bourque *et al.*, 1981).

BRYOZOA (Plate 32 g-j)

Bryozoans are relatively common in the upper Eids and lower Blue Fiord formations, southwest Ellesmere Island. A collection was submitted to T.E. Bolton (Geological Survey of Canada Ottawa) for identification. These are the first Devonian bryozoans to be identified from Arctic Canada.

Fistuliramus sp. CH30, HB3
Isotrypa sp. CH25, GA16
Leptotrypella (*Leptotrypella*) sp. EA10
Stereotoechus sp. cf. *S. typicus* Duncan CH1, CH4A, GB32

S.(?)sp. GB35
Trachytoechus(?)sp. CH23
Cryptostomate bryozoans indet. CE19 (CC6, CH4, ID3, ID11, JB3 identified by writer)
Trepostome bryozoan branches indet. BC1

"Lower Devonian Bryozoa are rare, and so precise correlation is difficult based on genera recognized in this study....The *Stereotoechus-Leptotrypella* assemblage is well known in the Middle Devonian of New York and Michigan and rare in Gaspé (as *Trachytoechus*) and western Canada (as *Leptotrypa-Eostenopora*)" (Bolton, 1983, GSC Fossil Report D1-1983-TEB).

CHITINOZOA (Plate 32 k,l)

Samples prepared for spore analysis by D.C. McGregor (Geological Survey of Canada, Ottawa) that contained Chitinozoa were sent to A. Achab (Institut national de la recherche scientifique, Québec City) for identification. She identified (written comm., 1983):

GSC 97202 (BB2)	*Eisenackitina*
GSC 97208 (GB40)	*Eisenackitina*
GSC 97209 (Loc. 14)	*Angochitina*

No further systematic or biostratigraphic details were available at the time of writing. Dr. Achab provided photographs of the fauna.

CONODONTS

Fifteen bulk samples for conodont analysis were collected from the upper Eids, lower Blue Fiord, and Disappointment Bay formations of southwest Ellesmere Island. They were submitted to T.T. Uyeno (Geological Survey of Canada, Calgary) and B.D.E. Chatterton (University

of Alberta) for identification. The conodont colour alteration index (CAI) is included for each locality. Thirteen samples produced conodont assemblages.

T.T. Uyeno documented the following fauna (GSC Report No. 17-TTU-80).

AAA7 (GSC Loc. C-86751) *Pandorinellina* cf. *P. exigua* (Philip)
Panderodus sp.
age: Early to Middle Devonian, probably Early Devonian
CAI: 1

CB5 (GSC Loc. C-60999) *Pandorinellina exigua exigua* (Philip)
Belodella sp.
Panderodus sp.
age: Early Devonian, *P. dehiscens* to *P. inversus* Zones.
CAI: 1

CB16 (GSC Loc. C-61000) *Belodella* sp.
Panderodus sp.
age: Silurian to Middle Devonian.
CAI: 1

CE3 (GSC Loc. C-86752) *Pandorinellina exigua exigua* (Philip)
Panderodus sp.
Coelocerodontus sp.
age: *P. dehiscens* to *P. inversus* Zones.
CAI: 1.5

DA1 (GSC Loc. C-86753) *Pandorinellina* sp.
Panderodus sp.
Belodella sp.
age: Early to Middle Devonian
CAI: 1

GA26 (GSC Loc. C-86755) *Pandorinellina* sp.
Panderodus sp.
age: Early to Middle Devonian.
CAI: 1.5

GB40 (GSC Loc. C-86756) *Pandorinellina expansa* Uyeno and Mason
Panderodus sp.
Belodella sp.
age: late Early to early Middle Devonian, *P. inversus* Zone to at least *P. costatus costatus* Zone
CAI: 1

Base JA2 (GSC Loc. C-86754) *Ozarkodina excavata excavata* (Branson & Mehl)
Panderodus sp.
Belodella sp.

age: Late Silurian to Early Devonian
CAI: 1.5

Locality 14 (GSC Loc. C-86757) No conodonts recovered.

B.D.E. Chatterton (written comm., 1981):

KA21
Polygnathus inversus-serotinus
Pandorinellina expansa Uyeno and Mason
Steptotaxis glenisteri (Klapper)
Panderodus sp.
age: Emsian - upper *P. inversus* Zone
CAI: 3

KA49
Pandorinellina expansa Uyeno and Mason
Panderodus sp.
age: Emsian - upper *P. inversus* Zone

KA53
Polygnathus inversus Klapper and Johnson
Pelekysgnathus n. sp.
Steptotaxis sp.
Panderodus sp.
age: Emsian - upper *P. inversus* Zone
CAI: 3

KI
Pandorinellina optima (Moskalenko)
Panderodus sp.
age: Emsian - *P. gronbergi* to lowest *P. serotinus* Zone
CAI: 3-4

KII
Polygnathus inversus Klapper and Johnson
Polygnathus serotinus Telford
Pandorinellina exigua exigua (Philip)
Panderodus sp.
Pandorinellina sp. A Uyeno and Mason, 1975
Steptotaxis sp.
Belodella sp.
age: Emsian - lowest *P. serotinus* Zone
CAI: 1.5

FISH (Plate 32 m,n)

Specimens of fish were rarely observed. A small collection was submitted to D.L. Dineley (University of Bristol) for identification.

Indet. large armour-bearing placoderm Loc. 36, Loc. 51.

The ornamentation on the plates "is found in a great many Middle

and Upper Devonian arthrodires" (Dineley, written comm., 1980).

GASTROPODS (Plate 32 o-s)

Gastropods are rare in the Lower Devonian sequence of southwest Ellesmere Island. A few specimens were collected from the lower Blue Fiord Formation and were identified by D.M. Rohr (Sul Ross State University) who also kindly provided photographs of the material. *Platyceras* was identified by J. Pojeta, Jr., and T. Dutro (U.S.G.S., Washington).

Gyronema sp.	Loc. 21
Murchisonia fragments	CC6, Loc. 21
Platyceras (Orthonychia)	ACA1 (1 specimen), CC6 (1 specimen)
Stenoloron n. sp.	Loc. 21

"They are mostly long-ranging forms" (Rohr, written comm., 1981).

OSTRACODS

Ostracods are common components of the Lower Devonian sequence of southwest Ellesmere Island. Weyant (1975b) noted 93 species and subspecies of ostracods from the upper Eids and lower Blue Fiord formations southwest of Eids Fiord (section AA of this study).

2 samples from the lower Blue Fiord Formation, rich in ostracods, were sent to M.J. Copeland (Geological Survey of Canada, Ottawa) for identification.

GA28	*Paraparchites* sp.
	Microcheilinella sp.
	cf. *Bairdiocypris* sp.
	cf. *Bairdia* sp.
	beyrichiacean? indet.
GA35	*Paraparchites* sp.
	cf. *Bairdiocypris*? sp.

"With the exception of the indeterminate beyrichiacean? this is a completely smooth shelled fauna. All of the genera are marine but in particular *Paraparchites* (which is the most common form in these collections) is considered to be a very shallow water to estuarine form" (Copeland, 1983, GSC Report No. MP-2-1983-MJC).

Weyant (1975b) documented 3 of the above genera - *Bairdiocypris*, *Microcheilinella*, and *Paraparchites*, from the lower Blue Fiord Formation southwest of Eids Fiord.

Braun (1978) noted "*Aparchites*" (similar to *Paraparchites*), *Bairdia*, *Bairdiocypris*, and *Microcheilinella* in his DLM2 assemblage, to which he assigned a Late Emsian age. This suggests a similar age for lower Blue Fiord Formation west of Vendom Fiord.

PELECYPODS

A generically diverse but small pelecypod fauna occurs in the lower Blue Fiord Formation of southwest Ellesmere Island. One specimen was also collected from the Disappointment Bay Formation of the Muskox Fiord area. A collection was submitted to J. Pojeta, Jr. (U.S.G.S., Washington) for identification.

Cimitaria sp.	Loc. 19 (1 spec.)
Goniophora cf. *G. nucella* LaRocque	Loc. 21 (1 spec.)
Grammysia (?) sp.	CC2A (1 spec.)
Modiomorpha (?) sp.	IA10 (1 spec.)
Mytilarca sp.	GB27 (2 specs.)
Nuculites sp.	Loc. 21 (1 spec.)
Palaeoneilo (?) sp.	Loc. 21 (7 specs.)
Palaeosolen (?) sp.	GB35 (1 spec.)
Paracyclas sp.	small - CH15 (3 specs.), GC28 (1 spec.), ID2 (1 spec.) Loc. 19 (1 spec.)
	large - GA9 (1 spec.), GA11 (2 specs.), GB31 (17 specs.)

Parallelodon (?) sp.	Loc. 21 (1 spec.)
grammysiid (?)	GA43 (1 spec.)
modiomorphid	EA35 (1 spec.), EC39 (1 spec.), Loc. 19 (1 spec.),
orthonotid	GB25 (1 spec.), KB25 (1 spec.)
indet.	CC2A (2 specs.), GB25 (1 spec.), GB45 (1 spec.), GD3 (1 spec.), Loc. 23 (1 spec.)

"If these collections had been sent to me without independent dating such as you have I would have called them Middle Devonian. Large *Paracyclas*, only slightly smaller than what you have are known from the Middle Devonian of Moravia and from the Lower Givetian of the Eifel District of West Germany. *Cimitaria* is a reasonably common fossil in the Hamilton of New York and Maryland, and has not previously been found in rocks older than this; your specimen is not quite typical, but the difference may be preservational. *Paracyclas elliptica* and *P. lirata* are reasonably common in the Jeffersonville, Onondaga, and Hamilton. *Goniophora nucella* is known from the Rogers City and possibly the Dundee. *Orthonychia* is common at some localities in the Onondaga, but ranges both above and below that level." (Pojeta, written comm., 1982).

RECEPTACULITIDS (Plate 34 h)

A small collection of Receptaculitids was sent to M.H. Nitecki (Field Museum of Natural History, Chicago) for identification. Dr. Nitecki also kindly provided a photograph of *R. neptuni*.

Receptaculites neptuni Defrance CC1 (1 spec.), Loc. 17 (10 specs.)

"I don't think that *R. neptuni* has ever been convincingly

demonstrated from North America" (Nitecki, written comm., 1983).

R. neptuni has been found in the Eifelian of the Eifel district, the Frasnian of Belgium, and the Upper Devonian of Pakistan (Reitschel , 1970). Therefore, this is possibly the first Lower Devonian occurrence of the species.

SPORES

Bulk samples for spore analysis were collected from the upper Eids and lower Blue Fiord formations. 8 samples were sent to D.C. McGregor (Geological Survey of Canada, Ottawa) for identification, of which 4 produced spore assemblages.

BB2 (GSC Loc. 97202) *Retusotriletes* sp.

"The age is Devonian but no more precise date is possible" (McGregor, written comm., 1980, G.S.C. Report FI-11-1980-DCM).

CE3 (GSC Loc. 97205)
DA1 (GSC Loc. 97206)
GA26 (GSC Loc. 97207)

Aneurospora sp.
Apiculiretusispora brandtii Streel
A. ?densiconata Tiwari & Schaarschmidt
cf. *Archaeozonotriletes varius* Nadler
Calamospora sp.
?Convolutispora sp.
Cymbosporites sp.
Dibolisporites echinaceus (Eisenack) Richardson
Dictyotriletes sp.
Emphanisporites rotatus McGregor
Punctatisporites sp.
Retusotriletes dubiosus McGregor
R. rotundus (Streel) Streel
Tholisporites ancylius Allen
Verruciretusispora dubia (Eisenack) Richardson & Rasul

"I do not know of any assemblage that closely resembles this one. In overall general aspect the spores bear some similarity to those of the Vendom Fiord Formation south of Cañon Fiord (McGregor, 1974), the lower

Daleje Shale of Czechoslovakia (McGregor, 1979), and to some extent the Krasnogorsk Formation of the Kuznetsk Basin (Nadler, 1969). However, the resemblance is not sufficiently proven to justify positive correlation with these beds. I can only say that an approximately mid-Emsian age is suggested" (McGregor, written comm., 1980).

"WORMS"

A species of *Chaetosalpinx* Sokolov infests some samples of *Spongonaria* from the lower Blue Fiord Formation, southwest Ellesmere Island. *Chaetosalpinx* has also been documented infesting *Spongonaria* in the Blue Fiord Formation of the study area by Pedder (1978, Pl. 42, Fig. 4).

Chaetosalpinx sp.	AA28, ED48, GC28, GD1, HB30, IB3, IB11, K6, Loc. 21, Loc. 26.

CHAPTER 9

ECONOMIC GEOLOGY

HYDROCARBONS

Introduction

Hydrocarbons were first noted in the Arctic Islands by early explorers such as Parry (1821), Belcher (1855) and Armstrong (1857). Later, McMillan (1910) and Stefansson (1921) further mentioned their presence. The first realistic assessment of the hydrocarbon potential of the region was made by Fortier *et al.* (1954), who wrote (p. 2103) that "several large areas appear to have many similarities to other regions that produce, or have in reserve, large quantities of petroleum". Douglas *et al.* (1963) also noted the potential of the Arctic Islands for hydrocarbons and stated that the region was one of the largest remaining, relatively little explored petroleum provinces of the world.

The modern era of hydrocarbon exploration in the Arctic Islands began with the drilling of the first exploratory well in 1961 at Winter Harbour, south Melville Island (see Figure 9-1). Since then, more than 140 wells have been drilled for hydrocarbons, and these have resulted in the discovery of eight major gasfields and one oilfield (Waylett, 1979; Rayer, 1981).

Of the three major structural basins in the Arctic Archipelago, the Sverdrup basin contains the greatest number of hydrocarbon fields, including the Drake Point and Hecla gasfields, which are amongst the largest in Canada (Waylett, 1979). The only major hydrocarbon find in the Franklinian basin is the Devonian Bent Horn oilfield on Cameron Island, which was discovered in 1974 (Meneley, 1976). However, numerous small shows of bitumen, gas, and oil-staining exist in the basin (Figure 9-1).

The hydrocarbon potential of this large basin is virtually unknown, because only twenty exploratory wells (including Cameron Island) have been drilled to date (Waylett, 1979). Some of the large number of possible prospects in the area are outlined by Rayer (1981, pp. 369-370). The basin must be considered as having a very large resource potential.

Little is known at present regarding the hydrocarbon resources of the third major structural basin, the Arctic Coastal Plain.

Hydrocarbon potential of southwest Ellesmere Island

Southwest Ellesmere Island, particularly between Blue and Sör Fiords, has been one of the main regions in the Franklinian basin for hydrocarbon exploration. Rayer (1981, Figure 7) included the area as one of the three favourable carbonate plays in the Franklinian basin.

In the early 1970's, numerous seismic lines were shot, both north and south of the Schei syncline. Two wells were drilled in 1974, the Panarctic Tenneco *et al.* CSP Eids M-66 and Panarctic ARCO *et al.* Blue Fiord E-46, both spudded in the Eids Formation (see Figure 1-3). Blue Fiord E-46 is located in the centre of a breached anticline, an excellent well placement for a hydrocarbon prospect in a structural trap. No structural or stratigraphic trap is obvious at the surface of the Eids M-66 well. It was presumably drilled on seismic evidence.

Potential reservoir rocks, source rocks, and both structural and stratigraphic traps are present in the region.

1) Potential reservoir rocks:

(a) Allen Bay Formation (Silurian)

This formation generally consists of dolostone. At certain locations, mostly in the ranges west of Vendom Fiord, the dolostone is unbedded, medium to coarsely crystalline, poorly fossiliferous, and has good intergranular and vuggy porosity (5-15%), with good permeability

(McGill, 1974; Poey, 1982). This lithology has been interpreted as representing a dolomitized reef complex (McGill, 1974). Some of these reefs are large. One, nicknamed "Big Reef" by Rayer (1981), measures 13 by 3 km, with 600 m of stratigraphic thickness. McGill (1974) also recognized this reef, and another that was 4 km long and over 300 m thick, with abundant signs of oil-staining. He noted that if this reef were located in the subsurface, it would be an excellent prospect. The Blue Fiord E-46 well encountered Allen Bay reefal carbonates (Mayr *et al.*, 1978). Rayer (1981) reported these to be oil-stained; however, no significant quantities of oil were encountered.

The Allen Bay Formation is overlain in the study area by the shales and limestones of the Cape Phillips Formation, which would act as a suitable seal for oil accumulated in Allen Bay reservoirs.

(b) Cape Storm Formation (U. Silurian)

Kerr (1975) described a 14 m thick unit of the lower member of the Cape Storm Formation on the east side of Goose Fiord that consists of vuggy, grey dolostone, with minor reefal limestone. Rayer (1981, p. 369) briefly mentioned that this formation (which he included as a member in the Allen Bay Formation) contains 120 m of vuggy carbonates on southern Ellesmere Island in the vicinity of Baad Fiord.

(c) Blue Fiord Formation (L. Devonian)

Little evidence of porosity or oil-staining has been found in the Blue Fiord Formation in the study area. Most of the porosity and bitumen is present in isolated corals (intertabulae, interdissepiment) in the area of the "Camp C" buildup. Other porosity occurs to the west of Vendom Fiord in small (up to 2 mm wide) calcite-filled tectonic fractures, and in some large (up to 1 cm) occluded fenestral porosity in lime mudstones.

Sucrosic dolostones, probably dolomitized crinoid buildups, with pinpoint and larger (up to 5 mm diameter) porosity, occur rarely in Section HA and locally form up to 5% of the rock volume. Isolated, larger vugs up to 4 cm in diameter occur in bioherms at Sections CH and JA, at the latter with small quantities of bitumen. The origin of these vugs is uncertain. These buildups differ in porosity from the Blue Fiord Formation buildups in the subsurface of Cameron Island, which contains abundant cavernous and fracture porosity (Meneley, 1976; Waylett, 1981).

(d) Disappointment Bay Formation (L. Devonian)

The Disappointment Bay Formation (formerly known as the Blue Fiord Formation) on southern Ellesmere Island (Smith and Stearn, 1983), which consists mainly of tidal flat dolostones and limestones, commonly contains fenestral, vuggy, and some moldic porosity, ranging from 2-5%. The size of the pores ranges from pinpoint to 5 cm in diameter, with an average of 1 mm. They are commonly occluded, but unoccluded porosity does occur. No bitumen was observed. The overlying dolostones, sandstones, and limestones of the Bird Fiord Formation would not form an effective cap rock.

(e) Hecla Bay Formation (M. - U. Devonian)

McGill (1974) noted that the fine to medium grained, quartzose, well-sorted, cross-bedded sandstones of the sandstone member of the Okse Bay Formation (now Hecla Bay Formation) can have up to 25% porosity west of Vendom Fiord, and are therefore a good potential reservoir. This formation is oil-stained in the subsurface of Cameron and Vanier Islands (Embry and Klovan, 1976).

(f) Fram Formation (U. Devonian)

East of Stenkul Fiord, the upper member of the Okse Bay Formation (now Fram Formation) consists of red and green shales with interbeds of sandstone, which have porosity up to 5% (McGill, 1974).

2) Potential source rocks:

(a) Cape Phillips Formation (Silurian-L. Devonian)

The Cape Phillips Formation is widespread in the study area. It overlies and is laterally equivalent to the Silurian carbonates of the Allen Bay and Read Bay formations(Mayr *et al.*, 1978) and consists of bituminous, dark grey, calcareous shale. At Vendom Fiord, McGill (1974, p. 375) noted that the physical and geochemical properties of the shale all indicated that the formation had an excellent source potential, was thermally mature, and would probably produce oil rather than gas. Powell (1978, p. 64) and Rayer (1981, p. 370) also mentioned that the Cape Phillips shales would form good to excellent source beds. In a study relating conodont colour alteration index (CAI) to source rock potential in the Eids M-66 and Blue Fiord E-46 wells, Mayr *et al.*(1978) concluded that the formation had a CAI of 2, and occurred in the mature hydrocarbon zone. This value is unusual as Epstein *et al.* (1977) have found that commercial oil production is unknown from source rocks with CAIs above a value of 1.5.

(b) Eids Formation (L. Devonian)

This formation consists of medium grey, calcareous siltstone and shale, and minor limestone. Conodonts from the Eids Formation in the Blue Fiord E-46 well have a CAI value of 1 and have been assessed as in the mature zone (Mayr *et al.*, 1978).

(c) Blue Fiord Formation (L. Devonian)

A fetid odour is emitted by the dark-coloured, thin-bedded lime

mudstones and calcareous shales deposited in a slope environment. CAI values of 1 - 1.5 (T.T. Uyeno, written comm., 1983) indicate that the formation is probably in the mature hydrocarbon zone. Similar CAI values (1.5 - 2) have been recorded from the oil-producing Blue Fiord Formation in the subsurface of Cameron Island (Uyeno and Mayr, 1979). The laterally equivalent Disappointment Bay Formation at Muskox Fiord appears to be overmature, with CAI values of 3 (B.D.E. Chatterton, written comm., 1981).

3) Possible traps:

(a) Structural

The Devonian-Mississippian Ellesmerian Orogeny and the Tertiary Eurekan Orogeny generated the folding and faulting on southwest Ellesmere Island (Okulitch, 1982). Anticlinal traps have been recognized in the study area. The Blue Fiord E-46 well was drilled into one such trap. Rayer (1981) has recognized an anticlinal structure in the vicinity of Sör Fiord, using seismic evidence. He states (p. 370) that this project outlines an 11,000 acre closure, with 80 m of net pay, and could contain 500 MM barrels of oil. McGill (1974) proposed a number of possible structures that could act as potential traps. He theorized the presence of an anticlinal structure under Vendom Fiord, which developed at the hinge point of a scissors fault believed to cut the Vendom syncline. Due to a decline in dip in a southeasterly direction towards "Sör Peninsula" he believed that a dome whose crest would lie in Baumann Fiord was indicated. The radial arrangement of faults in an area to the southeast of Vendom Fiord suggested to him the possible presence of salt diapirs probably originating from the Ordovician Baumann Fiord Formation. However, he mentioned that diapirism would probably be limited by the thick

overlying sequence of competent carbonates.

(b) Stratigraphic

Three types of stratigraphic traps could occur on southwest Ellesmere Island:

(i) Reefs - These occur in the Silurian Allen Bay Formation, and Devonian Eids and Blue Fiord formations. All the reefs are enclosed by dark coloured shales and lime mudstones (Cape Phillips Formation, Eids Formation, and the middle and upper parts of the Blue Fiord Formation respectively).

(ii) Carbonate sediment gravity flows - Mayr (1973) noted the presence of debris beds in the Allen Bay Formation and Poey (1982) mentioned a series of debris flows in his unit D of the Allen Bay Formation. The Blue Fiord Formation also commonly contains carbonate sediment gravity flows, encased in dark coloured lime mudstones and shales, particularly in the vicinity of "Camp B", where beds up to 11 m thick and up to 10 km in lateral extent are present.

(iii) Channel sandstones - Sandstone units in the Strathcona Fiord, Fram, and Nordstrand Point formations were deposited in channels in a meandering river system, and pinch out into shales of the overbank facies. However, these channels are generally of very small size (Embry and Klovan, 1976).

4) Exploration prospects:

Few good reservoir rocks are present on southwest Ellesmere Island. Amongst these, the Allen Bay Formation is the best prospect. It has good porosity and permeability, is near an excellent source of hydrocarbons, and includes numerous structural and stratigraphic traps. The best drilling prospects would be (a) between Blue and Sör Fiords in the

anticlines just south of "Camp C"; (b) in the anticlines west of Vendom Fiord; (c) under Vendom Fiord, into McGill's (1974) theoretical anticline; (d) Rayer's (1981) prospect just south of Sör Fiord on an anticline. The most promising prospects in stratigraphic traps in the Allen Bay Formation are west of Vendom Fiord.

The Cape Storm and Disappointment Bay formations have moderate porosity, but source rocks and traps are lacking.

Poor porosity, and proximity to the present erosion surface make the Blue Fiord Formation an unsuitable target for hydrocarbon exploration on southwest Ellesmere Island. However, some of the downslope buildups (e.g. JA 15) have minor porosity and some bitumen staining. These buildups can probably be traced to the west into the subsurface, and might be good prospects in the area south of Graham Island. Also, the formation can be used as a predictor of the underlying reservoirs in the Allen Bay Formation, as the carbonate development of the Blue Fiord Formation roughly parallels the distribution of the Allen Bay Formation (see discussion in Chapter 4 and Smith and Stearn, 1980).

The sandstone reservoirs of the Hecla Bay and Fram formations have moderate to poor porosity, have no apparent source rocks except the intraformational overbank shale deposits, and are preserved only in synclinal structures that offer no possibility of structural traps. The Fram Formation could accumulate oil in stratigraphic traps, but this would probably escape or oxidize due to the proximity of the present erosion surface.

COAL

Another potential energy source, coal was not observed in the study area during field work. However, McLaren (1963a, p. 331) noted the presence of thin (2-3 inches) coal seams in the upper sandstone and shale member of the Okse Bay Formation (now called the Nordstrand Point Formation) inland from Okse Bay and Blue Fiord. Obviously, this coal is presently uneconomic.

METALLIC MINERALS

No significant occurrences of metallic minerals were found in the study area. Only microscopic traces of pyrite were seen scattered in the rocks.

Trettin (1978) in his study of the Devonian stratigraphy of west-central Ellesmere Island, noted (p. 87) that he did not encounter any large quantities of metallic minerals. He also mentioned that an exploration company that worked in that area in 1973 found little evidence of minerals.

GYPSUM AND ANHYDRITE

Neither gypsum nor anhydrite were observed by the writer in the study area. However, Roblesky (1979, p. 95-96) noted beds of gypsum just west of Makinson Inlet (his locality F) in the Disappointment Bay Formation. Gypsum in the Devonian sequence on southern Ellesmere Island was also recorded by McLaren (1963a, p. 326), and later confirmed

by Jones (1982a) from the Bird Fiord Formation outcropping on the east side of Goose Fiord, in beds up to 2 m thick. Gypsum was also noted by Rice (1982) in the Strathcona Fiord Formation at Stenkul Fiord.

The most significant quantities of anhydrite in the study area occur in the Lower Ordovician Baumann Fiord Formation (Mossop, 1979) between Harbour Fiord (Okulitch, 1982; Packard and Mayr, 1982) and Svendsen Peninsula (Kerr and Thorsteinsson, 1972; McGill 1974).

Due to the great distance of these deposits from the southern markets, they have no economic value at present.

CHAPTER 10

CONCLUSIONS

1. The Lower Devonian sequence of southwest Ellesmere Island consists of a wide range of carbonate-clastic lithofacies.
2. The Emsian tidal flat facies of southern Ellesmere Island, previously assigned to the Blue Fiord Formation, is now referred to the Disappointment Bay Formation.
3. The Disappointment Bay Formation can be divided across the Arctic Islands into a dolostone and limestone member.
4. The Lower Devonian sequence of southwest Ellesmere Island was deposited in a variety of depositional settings: fluvial (Vendom Fiord Formation), tidal flat (Goose Fiord, Vendom Fiord, and Disappointment Bay formations), eolian (Disappointment Bay Formation), estuarine, shelf, and shelf margin (Blue Fiord Formation), upper slope and downslope buildups (Eids and Blue Fiord formations), lower slope and basin (Cape Phillips, Eids, and Blue Fiord formations).
5. The northwestward progradation of the carbonate platform sequence in Early Devonian time was interrupted by 3 Zlichovian/Dalejan transgressive events.
6. Sediment type and distribution, and paleolatitudinal position indicate that the paleowind was directed from the east in the Early Devonian on southern Ellesmere Island.
7. In the Middle Devonian, upward movement in the newly named Inglefield Uplift caused fluvial clastics of the Strathcona Fiord Formation to encroach westwards and overwhelm the carbonate realm.
8. Continued uplift of the Inglefield Uplift in the Late Devonian caused fluvial conditions to dominate on southwestern Ellesmere

Island.

9. The cyclic pattern of these meandering and braided fluvial deposits (Okse Bay Group) was caused by differential rates of upward movement of the Inglefield Uplift.

10. Lower Devonian buildups are not rare. Thirty-six have been documented worldwide.

11. The number of Lower Devonian carbonate buildups worldwide increased rapidly through the Early Devonian. This increase can be related to a transgression at the Gedinnian/Siegenian boundary that increased the growth sites available for buildups.

12. Lower Devonian paleomagnetically-derived paleolatitudinal maps depict Siberia/Asia 10 to 15° north and Gondwanaland 10° south of their position indicated by the distribution of Lower Devonian buildups worldwide. North America should be positioned completely within the tropical belt.

13. Carbonate buildups are common in the Lower Devonian sequence of southwestern Ellesmere Island, and are of 3 types: (1) coral/stromatoporoid-rich, (2) crinoid-rich, (3) bryozoan lime mud mounds.

14. A large buildup in the lower Blue Fiord Formation south of Baumann Fiord can be shown, using microfacies analysis, to have developed in relatively deep water and to have grown upwards into the surf zone. A physical control of the community changes is postulated.

15. Corals are common in the Blue Fiord Formation, and parts of the upper Eids Formation and Disappointment Bay Formation of southwestern Ellesmere Island. They are also common in the Blue Fiord

Formation and parts of the limestone member of the Disappointment Bay Formation on Bathurst Island.

16. Of the 30 genera and 39 species of corals described herein, 4 are new species, and the geographic and stratigraphic ranges of numerous species have been extended.

17. The coral fauna from the Blue Fiord Formation of Ellesmere Island indicates a Zlichovian-Dalejan age for the formation. The fauna of the Blue Fiord Formation and limestone member of the Disappointment Bay Formation of Bathurst Island indicates a Dalejan to Eifelian age.

18. The Lower and Middle Devonian coral fauna of Ellesmere and Bathurst Islands closely resembles coeval faunas of Nevada, west Europe, U.S.S.R., and Australia and New Zealand, which also belong to the Old World Biogeographic Realm.

19. Brachiopods are common in the upper Eids Formation (22 genera, 28 species) and Blue Fiord Formation (26 genera, 40 species) of southern Ellesmere Island. Both indicate a Zlichovian age, and belong to the Cordilleran subprovince of the Old World Biogeographic Realm.

20. Six species of trilobites have been identified from the lower Blue Fiord Formation of southern Ellesmere Island. An Early Zlichovian age is indicated.

21. The division of the North American Old World trilobite province into 3 subprovinces (Ormiston 1972, 1975) is unwarranted, and is probably a result of poor knowledge of trilobite faunas in northwestern and Arctic Canada.

22. Six species of cricoconarids, including 1 new species, have been identified from the Blue Fiord Formation of southwestern Ellesmere Island.

23. A biostratigraphic zonation of cricoconarids from this study demonstrates a Zlichovian-Dalejan age for the Blue Fiord Formation.

24. The Lower Devonian sequence of southwestern Ellesmere Island does not show promise for hydrocarbon exploration.

25. The facies distribution of the Blue Fiord Formation parallels that of the Allen Bay Formation, and thus the Lower Devonian carbonates can be used to predict the distribution of possible subsurface Silurian reservoirs.

ACKNOWLEDGEMENTS

I would like to thank the Polar Continental Shelf Project, in particular Mr. Fred Alt, for their support without which this study would not have been possible, and for providing efficient logistical aid in the Arctic. Thanks also to the pilots of Bradley Air Services and Okanagan Helicopters for their skill and courage in putting us down and picking us up in some very unfavourable conditions.

Field work and research were supported by grants from the Natural Sciences and Engineering Research Council (#A2135 to Stearn), the McGill University Centre for Northern Studies and Research, and the Department of Energy, Mines and Resources. Research was also aided by scholarships from the Natural Sciences and Engineering Research Council (1979-1982), F.C.A.C. (1982-1983) and the Max Bell Foundation (1982-1983). The Government of the Northwest Territories and the Grise Fiord Settlement Council permitted access to the field areas.

I am indebted to J. Irwin, D.A. Smith, and G. Hill for their excellent field assistance, sometimes under very trying conditions, and M. Boctor, G. Hill, K. Rodd and J. Ruggles for assistance in other aspects of the study. T. Shahzada provided considerable aid in the final stages of this study.

A number of specialists have provided me with helpful fossil identifications: A. Achab (chitinozoans), T.E. Bolton (bryozoans), M.J. Copeland (ostracods), D.L. Dineley (fish), B.L. Mamet (algae), D.C. McGregor (spores), M.H. Nitecki (receptaculitids), J. Pojeta, jr. (bivalves), D.M. Rohr (gastropods), and T.T. Uyeno and B.D.E. Chatterton (conodonts). To the above individuals, I offer my

sincere thanks. I would particularly like to thank A.E.H. Pedder for his invaluable help with the coral fauna.

Discussions with O.A. Dixon, P. Enos, Q.H. Goodbody, R.H. Hesse, N.P. James, B. Jones, J. Wm. Kerr, U. Mayr, E.W. Mountjoy, G.M. Narbonne, A.V. Okulitch, J.F. Read, R.F. Roblesky, R. Thorsteinsson, and H.P. Trettin proved to be of great assistance. The comments of innumerable fellow students at McGill University were also of great benefit.

Special thanks are due to C.W. Stearn for his excellent guidance and advice, helpful discussion and support throughout the project; O.A. Dixon, B. Jones and the "Arctic Group" at the University of Ottawa for initially stimulating my interest in research in the Arctic; R. Yates for drafting and photographic help throughout the study; L. Barash for typing parts of the first draft; L. Choquette for typing the final draft; K.P. Polan for help, encouragement, and useful advice throughout my research; my parents for always encouraging me in my studies; and, lastly, my wife, Louise, who provided the impetus I needed to "get going", for putting up with my endless monologues on trilobites, cricoconarids and other unintelligible subjects, for typing parts of a first draft, and for just being there.
Gratitude is extended to Chevron Canada Resources Ltd. for help in the final stages of preparation of this thesis.

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STRATIGRAPHY AND PALEONTOLOGY OF THE LOWER DEVONIAN SEQUENCE, SOUTHWEST ELLESMERE ISLAND, CANADIAN ARCTIC ARCHIPELAGO

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January, 1984

VOLUME II: FIGURES, PLATES, AND APPENDICES

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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FIGURE 1-1. Map of the Canadian Arctic Archipelago, locating study areas and localities mentioned in text: (1) Weatherall Bay, (2) Resolute Bay, (3) Prince Alfred Bay, (4) Arthur Fiord, (5) Colin Archer Peninsula, (6) Nansen Sound, (7) Nares Strait, (8) Inglefield Land.

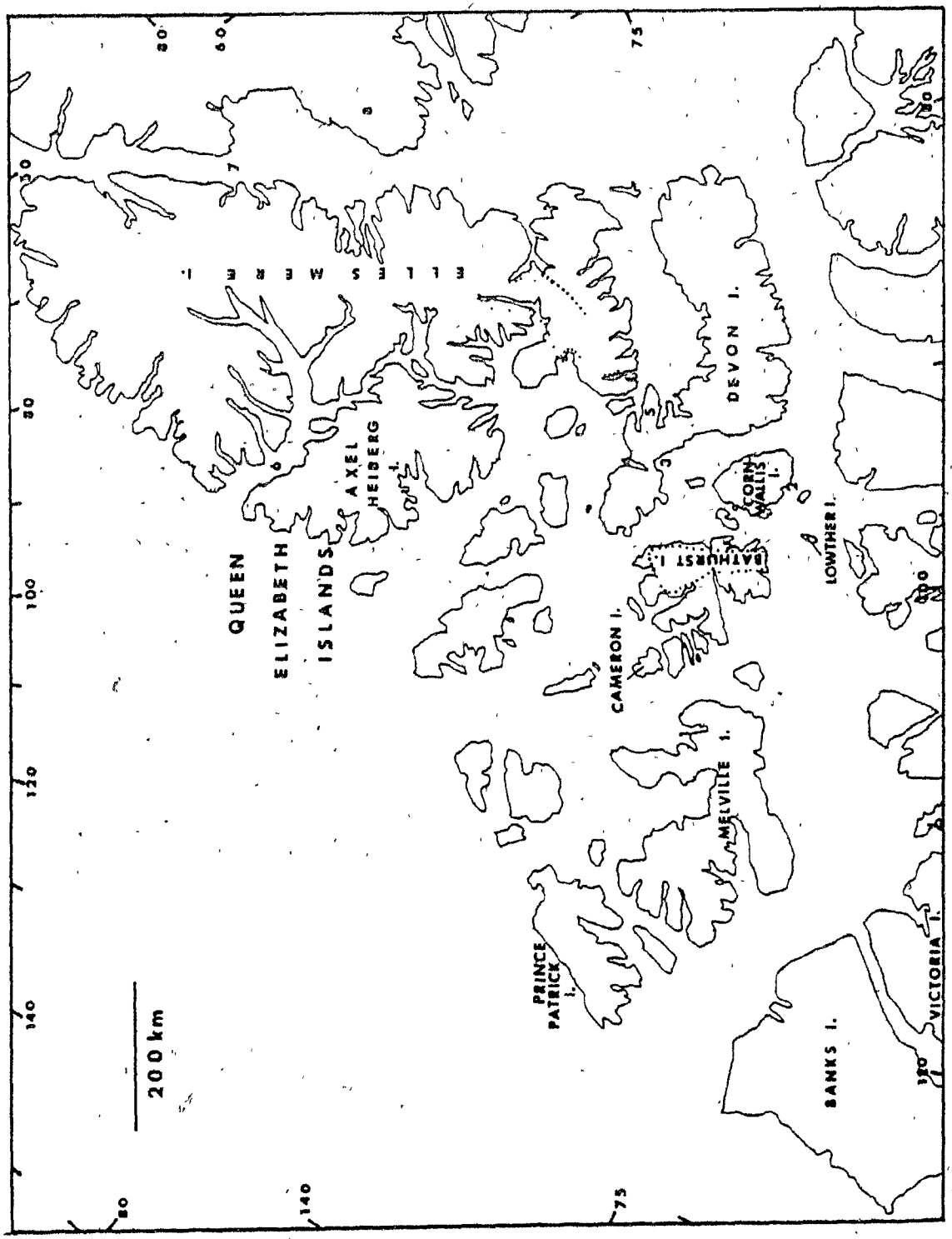

ELLESMERE I.
QUEEN
ELIZABETH
ISLANDS
AXEL
HEIBERG I.
DEVON I.
CORNWALLIS I.
BATHURST I.
LOWTHER I.
CAMERON I.
MELVILLE I.
PRINCE
PATRICK
I.
BANKS I.
VICTORIA I.
200 km
80
60
75
90
100
120
140

FIGURE 1-1

FIGURE 1-2. Map of Ellesmere Island, locating positions of Figures 1-3, 1-4, and 1-5, and localities mentioned in text: (1) Baad Fiord, (2) Harbour Fiord, (3) Grise Fiord, (4) Craig Harbour (abandoned), (5) Makinson Inlet, (6) Inglefield Mountains, (7) Graham Island, (8) Bjorne Peninsula, (9) Svarte Fiord, (10) Strathcona Fiord, (11) Irene Bay, (12) Bache Peninsula, (13) Cañon Fiord.

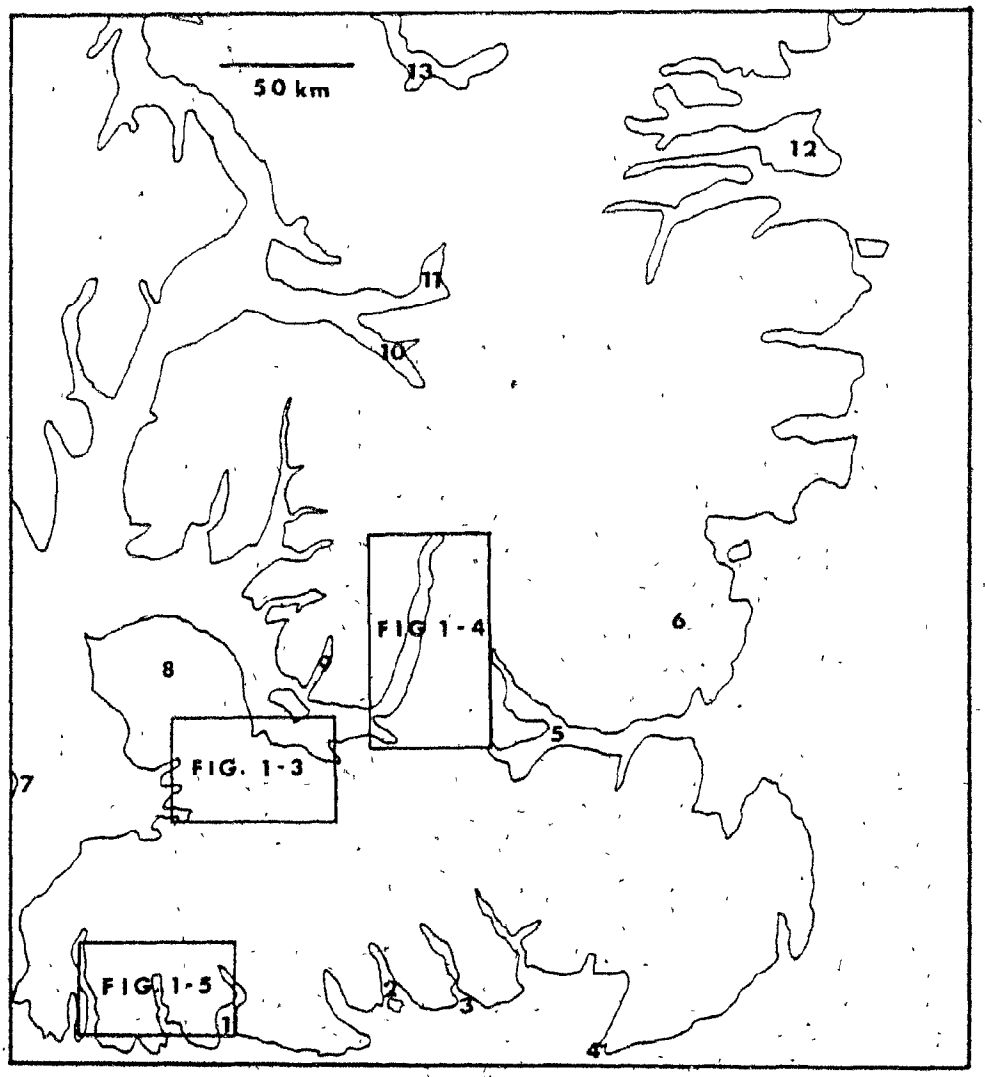


FIGURE 1-2

FIGURE 1-3. Map of the Baumann Fiord region, showing locations of measured sections, other data points, camps, type sections, and the 2 wells drilled in the area; (1) AD, (2) AA(A), (3) Loc. 1, (4) Loc. 2, (5) AB(A), (6) Loc. 3, (7) AC(A), (8) Loc. 4, (9) Loc. 5, (10) Loc. 6, (11) Loc. 7, (12) Loc. 8, (13) Loc. 9, (14) Loc. 10, (15) Loc. 11, (16) JC, (17) Loc. 12, (18) Loc. 13, (19) JA, (20) BB, (21) Loc. 46, (22) BA, (23) BC, (24) JB, (25) Loc. 15, (26) Loc. 16, (27) Loc. 17, (28) IC, (29) Loc. 19, (30) Loc. 18, (31) IA, (32) Loc. 20, (33) Loc. 21, (34) Loc. 22, (35) Loc. 23, (36) Loc. 24, (37) Loc. 25, (38) Loc. 26, (39) Loc. 27, (40) Loc. 28, (41) Loc. 29, (42) Loc. 30, (43) Loc. 31, (44) CB(A), (45) CF, (46) CE, (47) Loc. 45, (48) Loc. 51, (49) CH, (50) ID, (51) IB, (52) CD, (53) CA, (54) CG, (55) CC(A), (56) Loc. 44, (57) Loc. 32, (58) Loc. 33, (59) Loc. 34, (60) Loc. 35, (61) Loc. 36, (62) DA, (63) EB, (64) EC, (65) K, (66) EA, (67) Loc. 37, (68) Loc. 38, (69) Loc. 39, (70) Loc. 40, (71) Loc. 58, (72) Loc. 53.

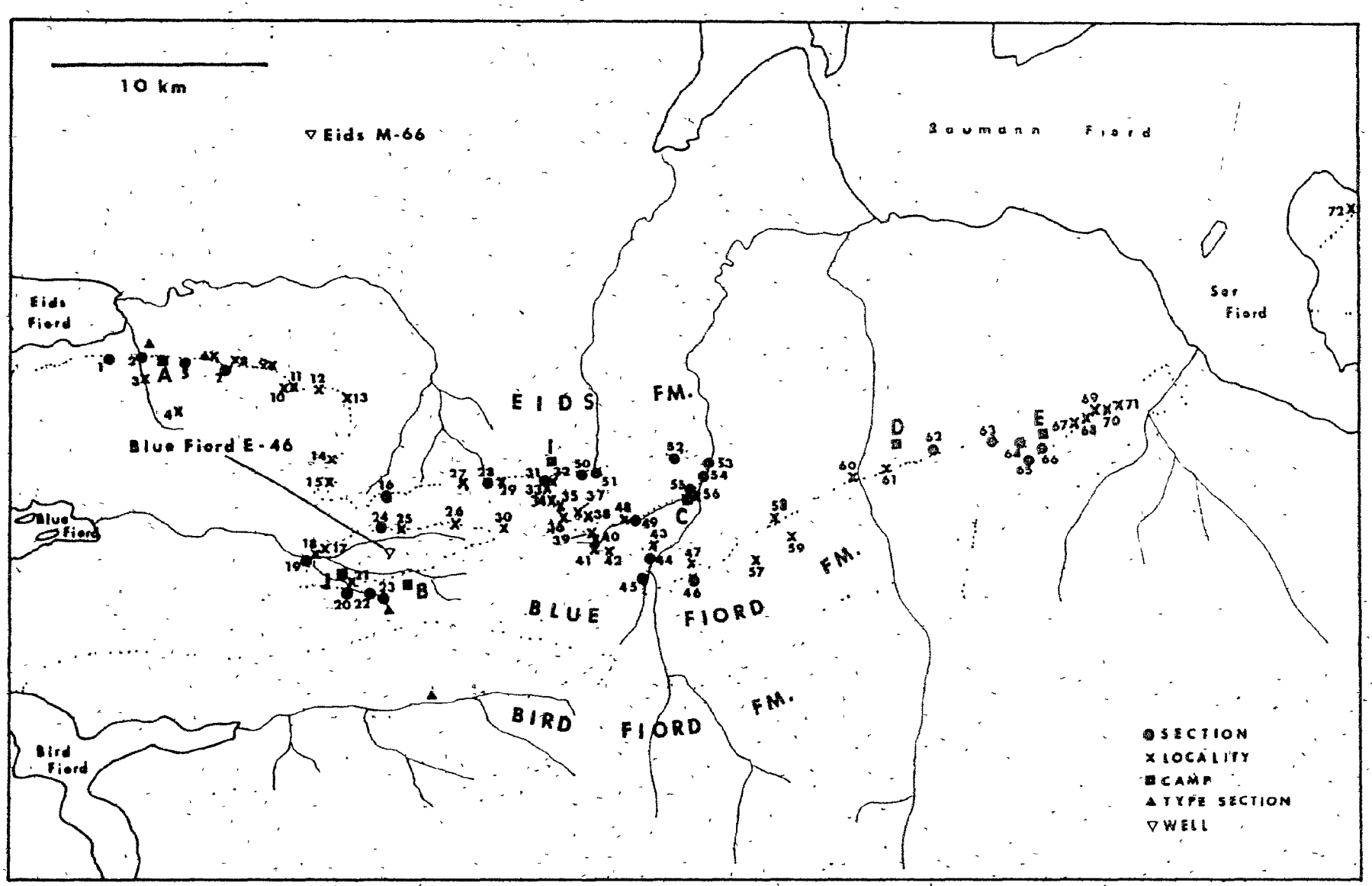

10 km
Eids M-66
Baumann Fiord
Eids Fiord
Ser Fiord
Blue Fiord E-46
Blue Fiord
Bird Fiord
EIDS FM.
BLUE FIORD FM.
BIRD FIORD FM.
A
B
C
D
E
SECTION
LOCALITY
CAMP
TYPE SECTION
WELL

FIGURE 1-3

FIGURE 1-4. Map of the Vendom Fiord region, showing locations of measured sections, other data points, and camps: (1) ED, (2) HB, (3) HA, (4) HC, (5) Loc. 52, (6) GB, (7) GA, (8) GD, (9) GE, (10) GC, (11) Loc. 54, (12) Loc. 55, (13) Loc. 56, (14) Loc. 57, (15) Loc. 47, (16) Loc. 48, (17) Loc. 49, (18) Loc. 42, (19) Loc. 41, (20) Loc. 43.

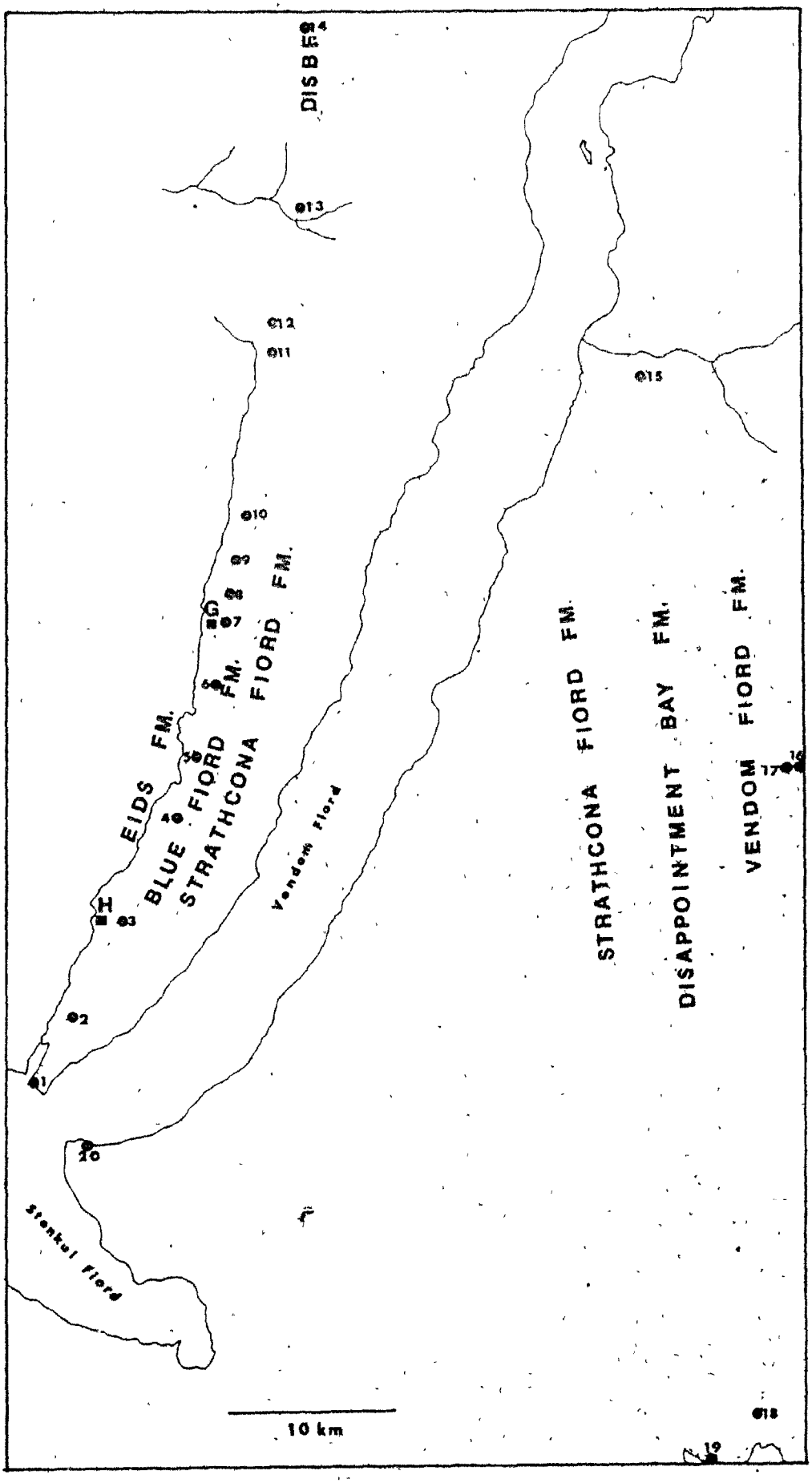

DISB
EIDS FM.
BLUE FIORD FM.
STRATHCONA FIORD FM.
Vendom Fiord
STRATHCONA FIORD FM.
DISAPPOINTMENT BAY FM.
VENDOM FIORD FM.
Stenkul Fiord
10 km

FIGURE 1-4

FIGURE 1-5. Map of the Goose Fiord region, showing locations of measured sections, other data points, camps, and type section; (1) Loc. 14, (2) FA, (3) Loc. 59, (4) KA, (5) KB, (6) Loc. 50. Formational distributions based on Kerr (1968).

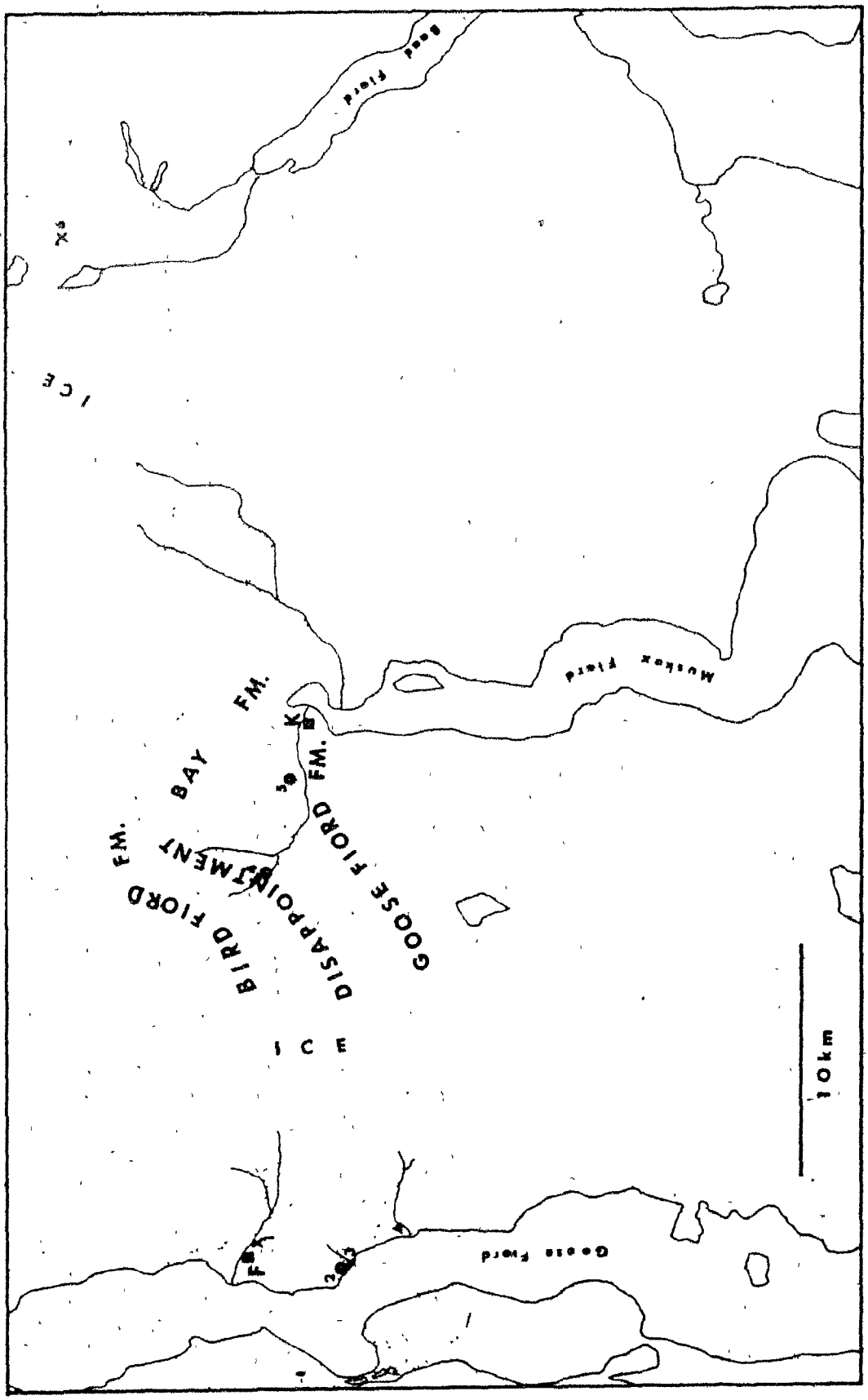

Bird Fiord
Ice
Muskox Fiord
K
BAY FM.
DISAPPOINTMENT FM.
GOOSE FIORD
BIRD FIORD FM.
ICE
10 km
Goose Fiord

FIGURE 1-5

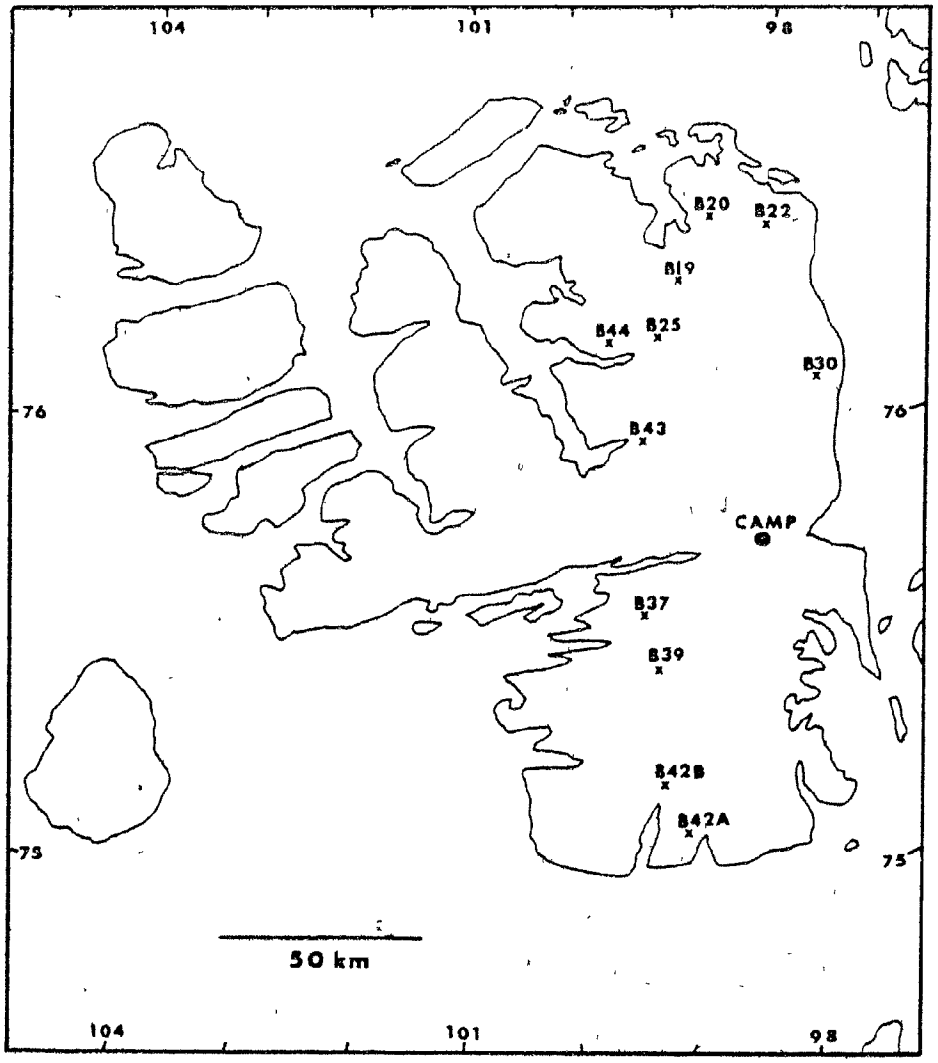


FIGURE 1-6. Map of Bathurst Island, showing locations of localities visited

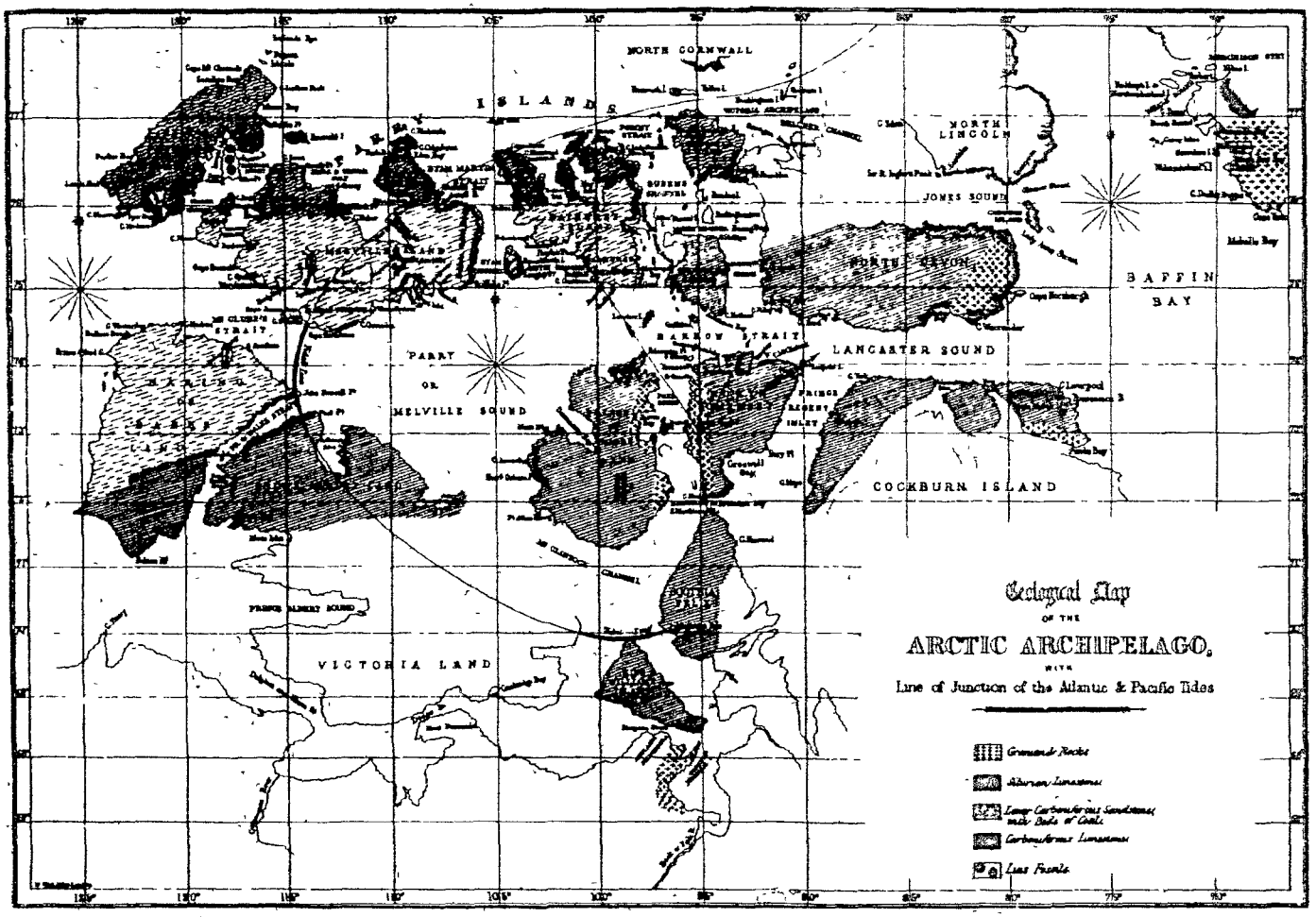


FIGURE 2-1. First geological map of the Arctic Archipelago (from Haughton, 1859)

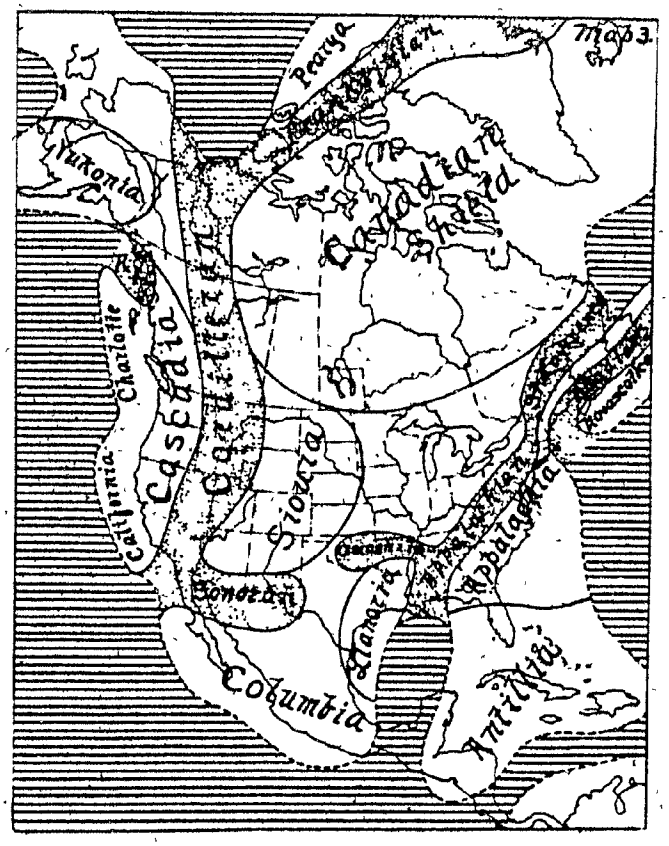


FIGURE 2-2. Map illustrating location of North American geosynclines, in particular the Franklinian Geosyncline, and Pearya (from Schuchert, 1923)

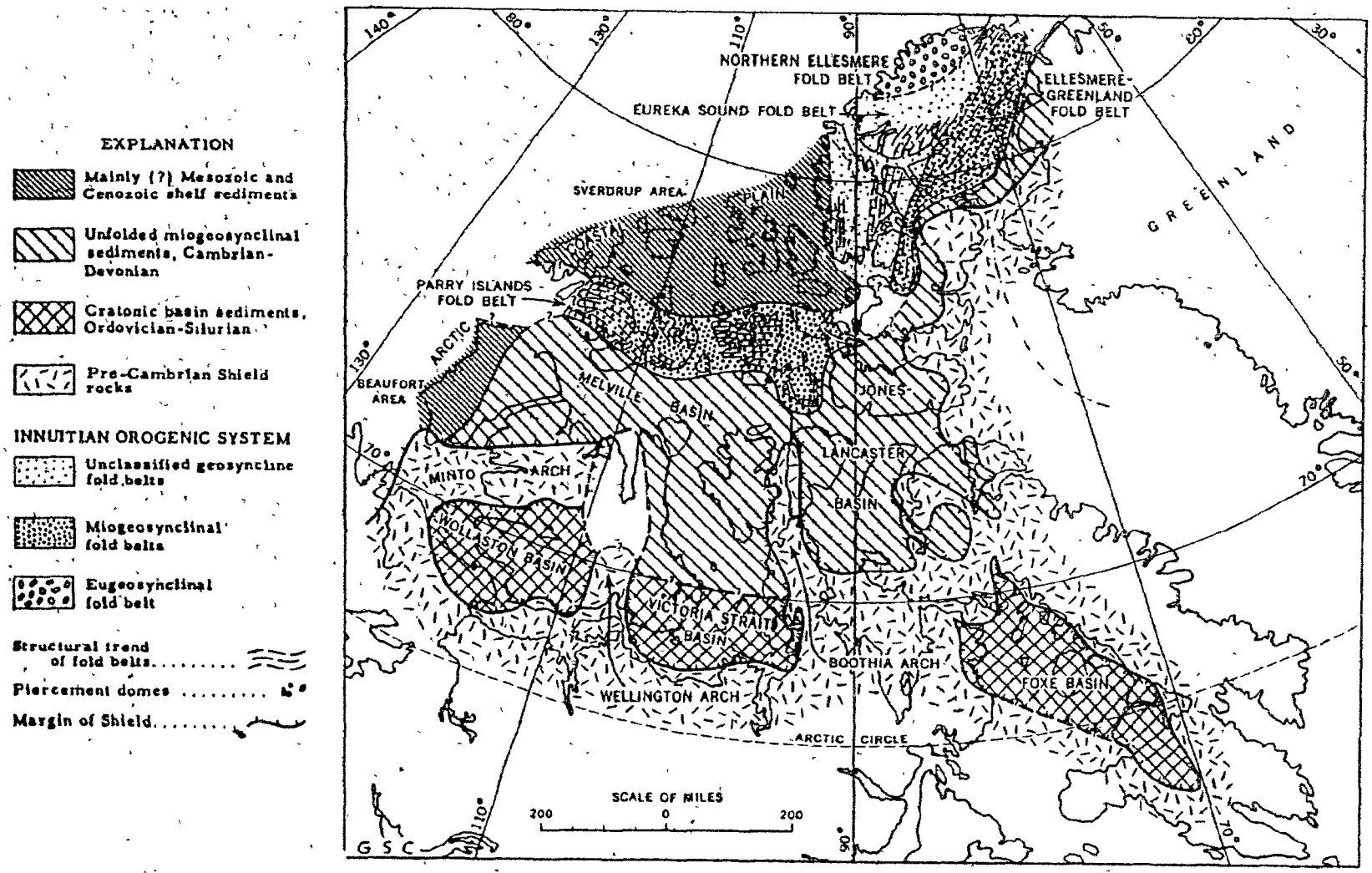


FIGURE 2-3. Stratigraphic-structural provinces of northern Canada (from Fortier *et al.*, 1954)

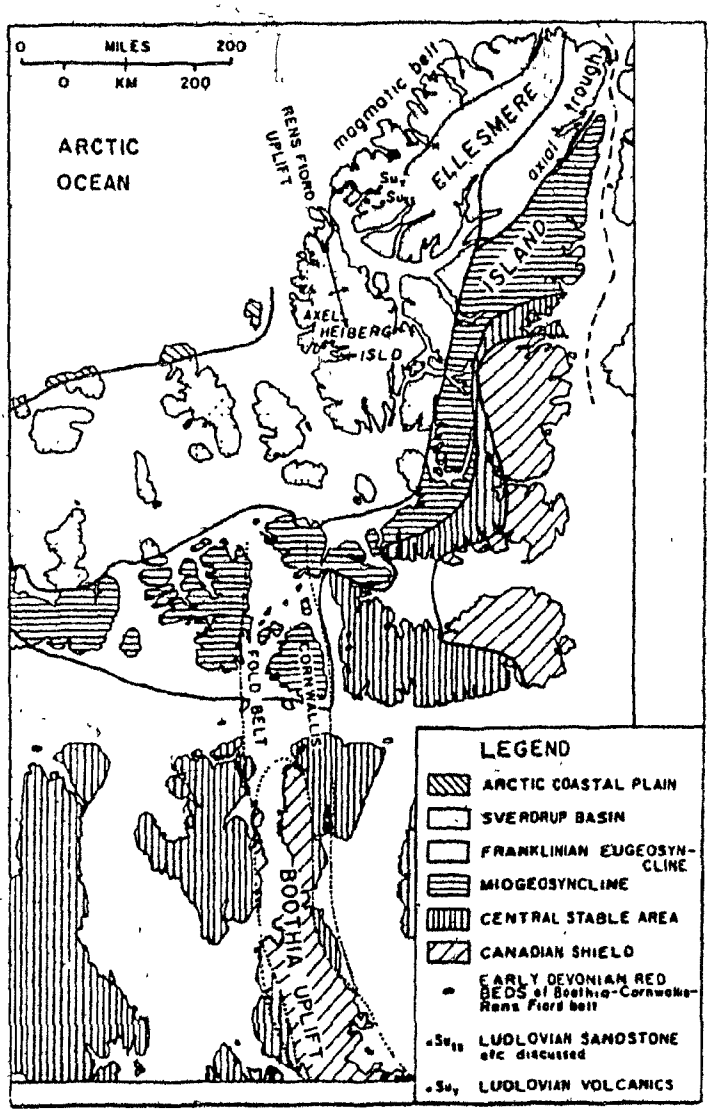


FIGURE 2-4. Stratigraphic-structural provinces of the eastern and central Arctic Islands (from Trettin, 1967)

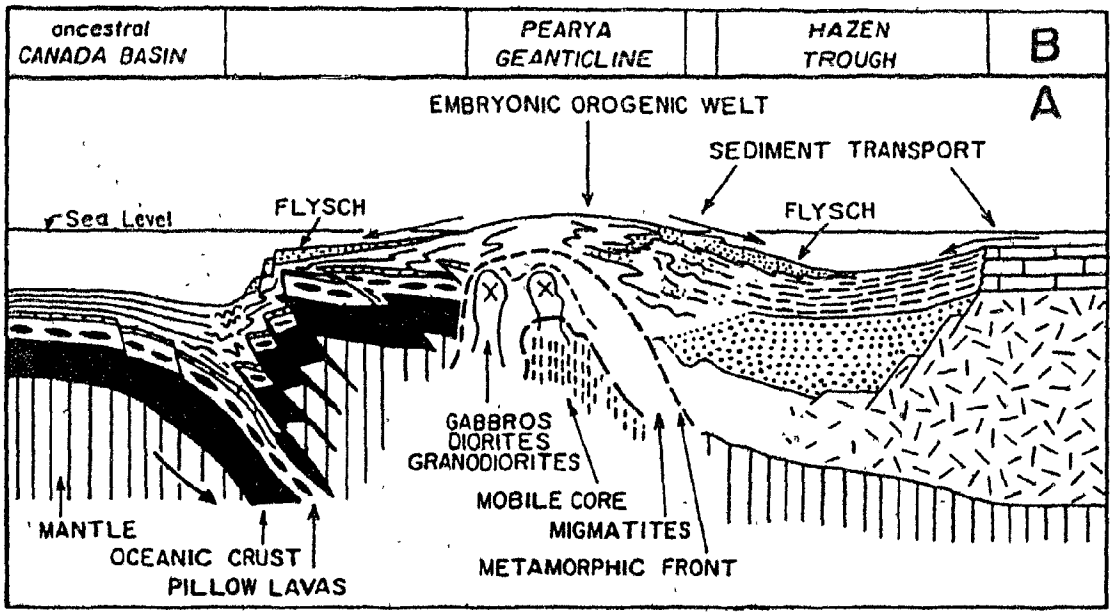


FIGURE 2-5. Plate tectonic model for northern Ellesmere Island in the Lower to Middle Paleozoic (from Trettin *et al.*, 1972)

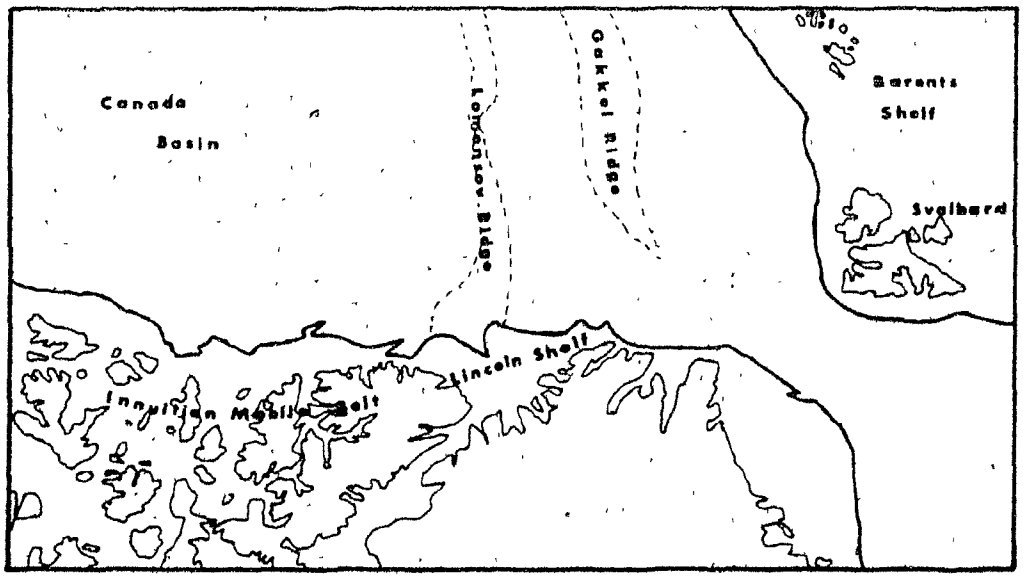


FIGURE 2-6. Map illustrating the relationship between the Innuitian Mobile Belt, and the Lomonsov Ridge and Barents Shelf (after Trettin and Balkwill, 1979)

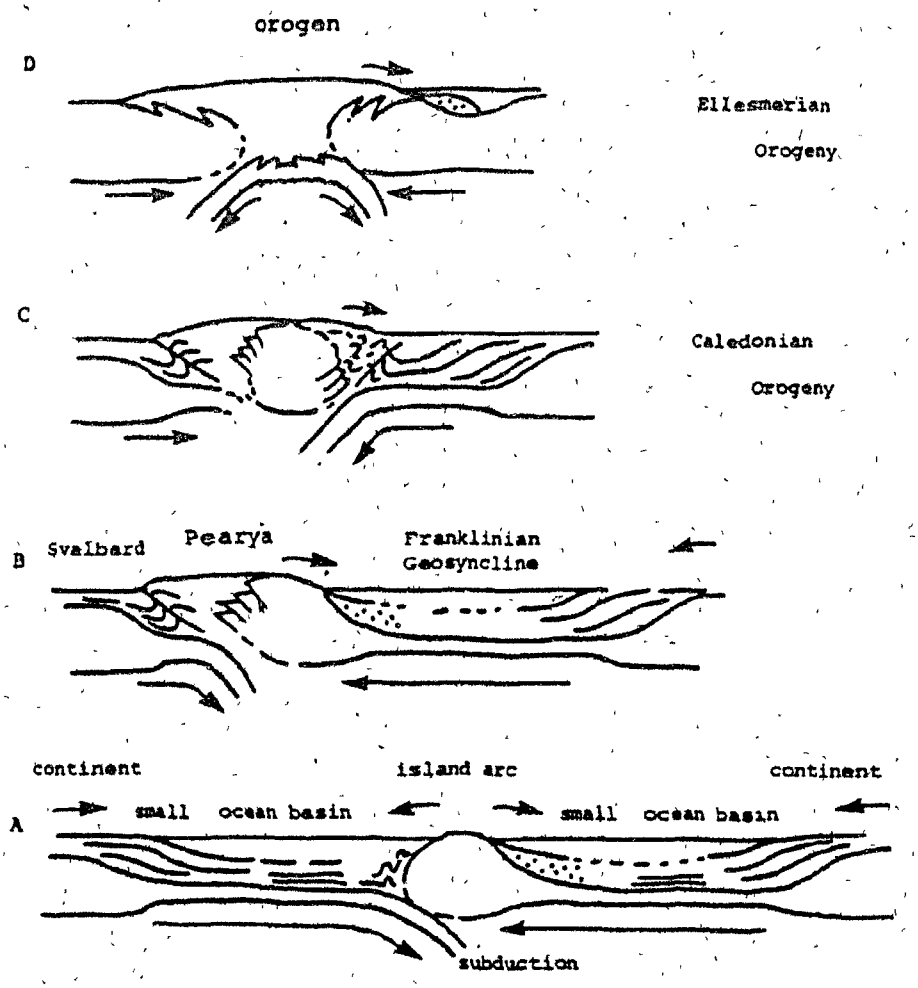


FIGURE 2-7. Lower to Middle Paleozoic tectonic history of the Franklinian and Hecla Hoek geosynclines (from Christie, 1979)

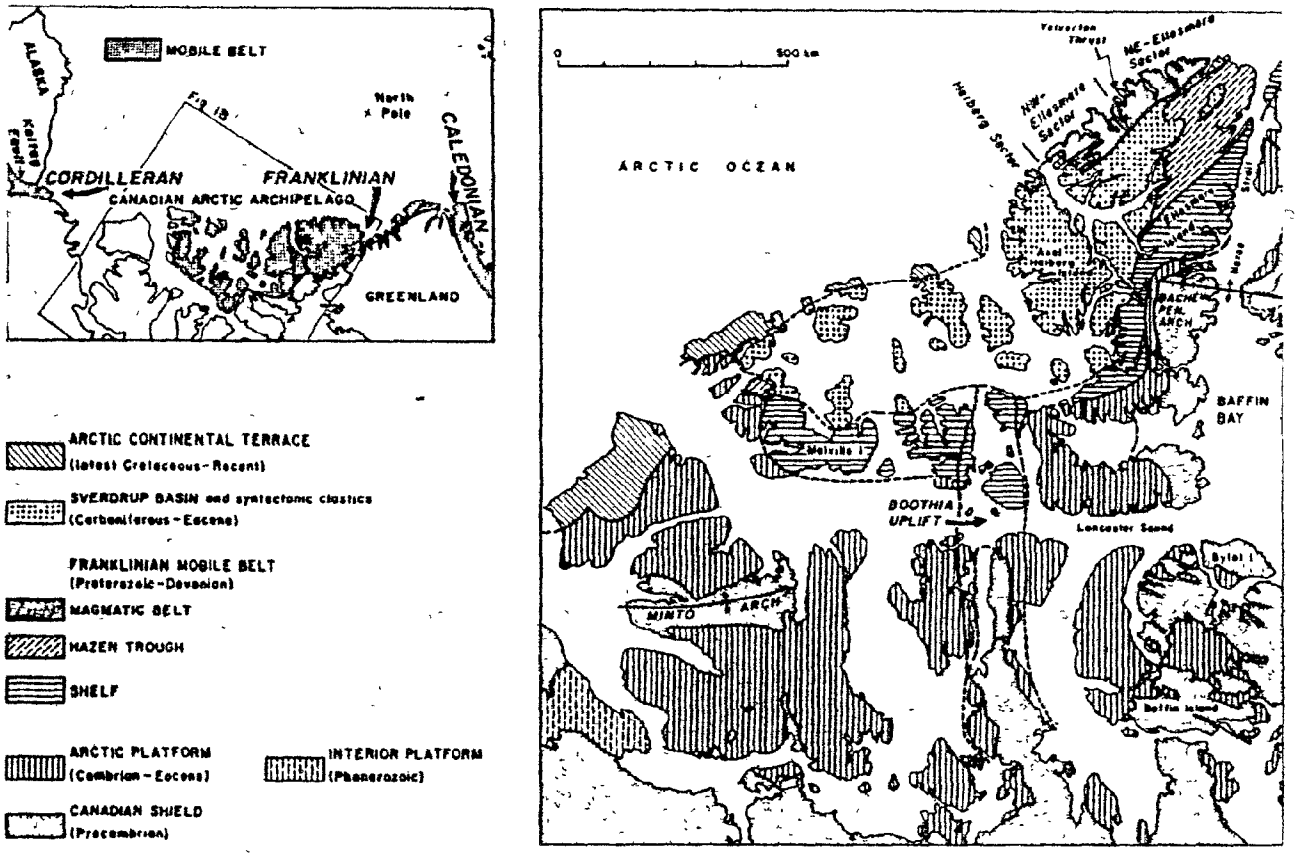


FIGURE 2-8. Stratigraphic-structural provinces of the Arctic Islands, with a diagram showing the link between the Franklinian, Cordilleran, and Caledonian mobile belts (from Trettin, 1982)

FIGURE 3-2. Devonian stratigraphy, southern Ellesmere Island and Bathurst Island, and applicable biostratigraphic zonations; Note (1) correlation of European with Bohemian stages after Trettin (1978), (2) from Chlupac (1976), (3) from Klapper and Johnson (1980), (4) from Chi and Hills (1976).

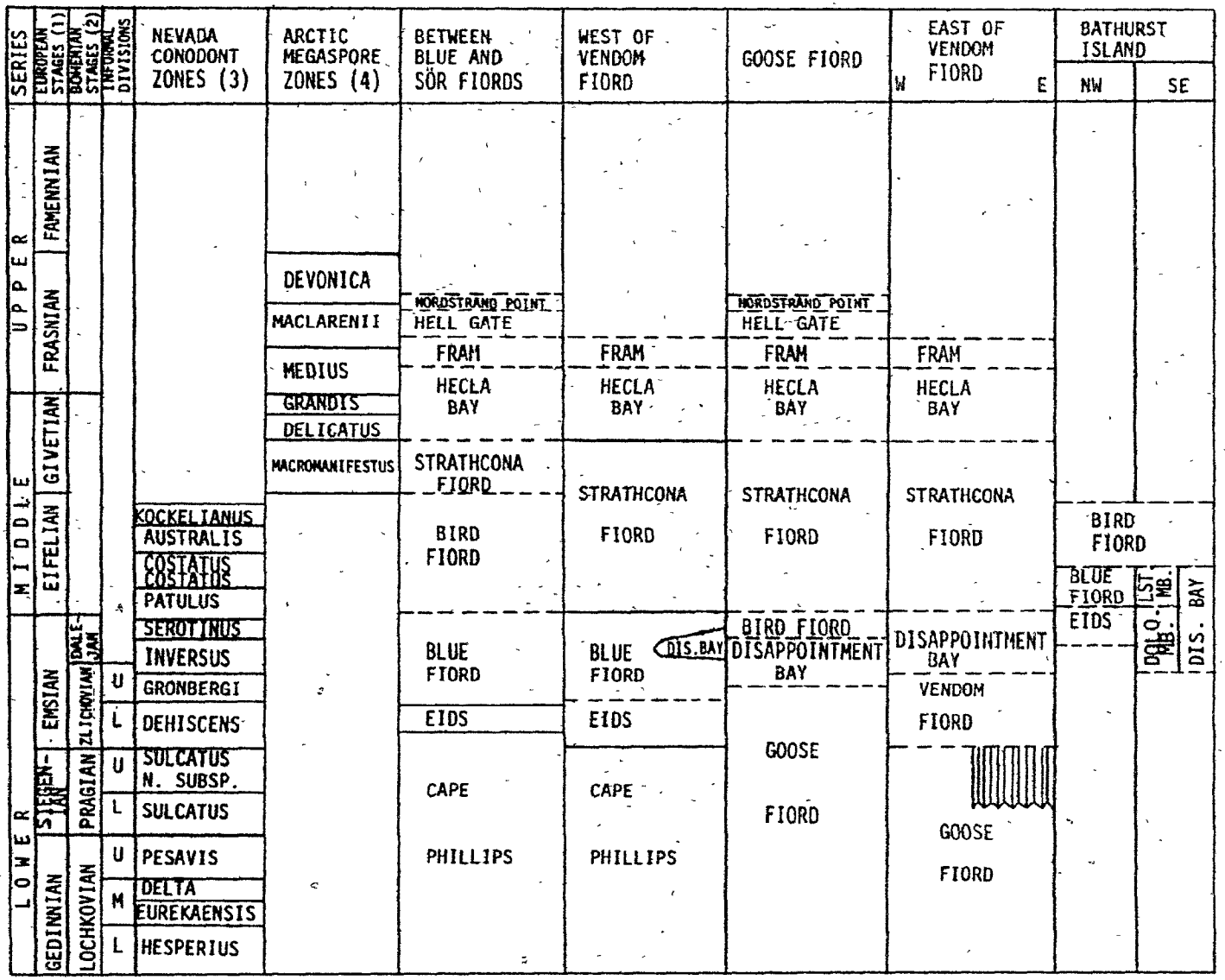

SERIES
EUROPEAN STAGES (1)
BOREHOLE STAGES (2)
INFORMAL DIVISIONS
NEVADA CONODONT ZONES (3)
ARCTIC MEGASPORE ZONES (4)
BETWEEN BLUE AND SÖR FIORDS
WEST OF VENDOM FIORD
GOOSE FIORD
EAST OF VENDOM FIORD
W
E
BATHURST ISLAND
NW
SE
UPPER
MIDDLE
LOWER
FAMENNIAN
FRASNIAN
GIVETIAN
EIFELIAN
EMSIAN
SIEGEN-IAN
GEDINNIAN
DALEJAN
ZLICHOVIAN
PRAGIAN
LOCHKOVIAN
DEVONICA
MACLARENII
MEDIUS
GRANDIS
DELICATUS
MACROMANIFESTUS
KOCKELIANUS
AUSTRALIS
COSTATUS COSTATUS
PATULUS
SEROTINUS
INVERSUS
U
GRONBERGI
L
DEHISCENS
U
SULCATUS N. SUBSP.
L
SULCATUS
U
PESAVIS
M
DELTA
EUREKAENSIS
L
HESPERIUS
NORDSTRAND POINT
HELL GATE
FRAM
HECLA BAY
STRATHCONA FIORD
BIRD FIORD
BLUE FIORD
EIDS
CAPE PHILLIPS
DIS. BAY
BIRD FIORD
DISAPPOINTMENT BAY
VENDOM FIORD
GOOSE FIORD
BLUE FIORD
EIDS
DOLO. MB.
LST. MB.
DIS. BAY

FIGURE 3-2.

FIGURE 3-3. Outcrop distribution of the dolostone and limestone members of the Disappointment Bay Formation, Arctic Archipelago. Distribution outside Ellesmere Island based on McLaren (1963b, c), Thorsteinsson (1963), and Morrow and Kerr (1977) for Devon Island, Thorsteinsson and Kerr (1968) for Cornwallis Island, Kerr (1974) and Kerr and Ruffman (1979) for Bathurst Island, Mayr (1980) for the subsurface of Cameron Island, Tozer and Thorsteinsson (1964) for Melville Island, Thorsteinsson and Tozer (1962) for Victoria Island, Miall (1976) for the subsurface of Banks Island, and Indian and Northern Affiars (1978) for the subsurface of Prince Patrick Island.

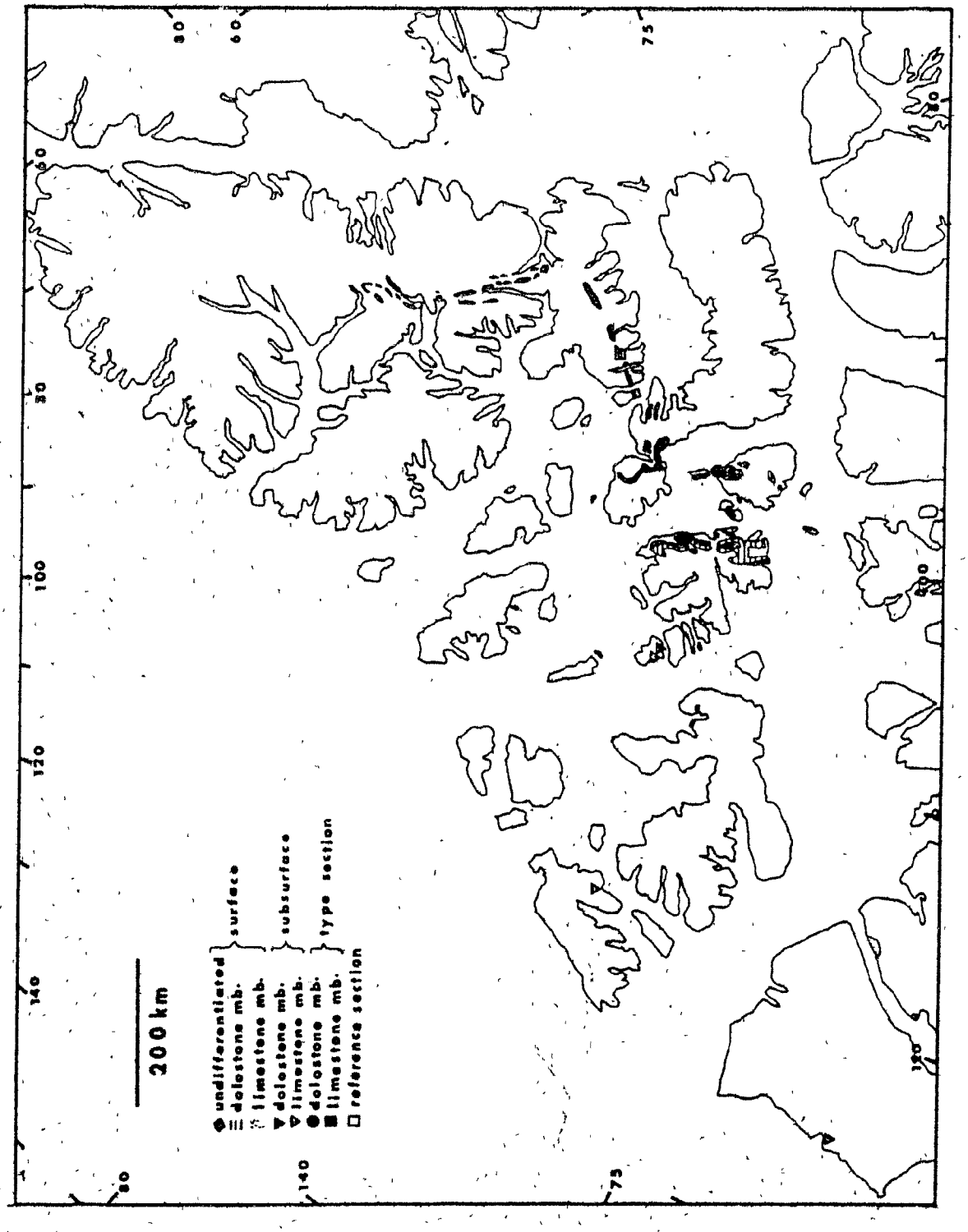

200 km
undifferentiated
dolostone mb.
limestone mb.
dolostone mb.
limestone mb.
dolostone mb.
limestone mb.
reference section
surface
subsurface
type section
80
60
75
90
100
120
140
160
180
140
75

FIGURE 3-3

FIGURE 3-4. Outcrop distribution of the Disappointment Bay Formation on Ellesmere Island, and location of data points: (1) section FA, (2) section KA, (3) section KB, (4) Okulitch (1982), (5) Mayr (1982), (6) Station 322 (McGill, 1974), section 20 (Roblesky, 1979), Locality 41 (this study), (7) Locality F (Roblesky, 1979), (8) section 19 (Roblesky, 1979), (9) section 14 (Roblesky, 1979), (10) section 18 (Roblesky, 1979), (11) section 42 (Kerr, 1976), Locality E (Roblesky, 1979), (12) section 6 (Roblesky, 1979), Locality 47, (this study), (13) Locality D (Roblesky, 1979), (14) section 41 (Kerr, 1976), (15) Locality 51 (this study), (16) section 40 (Kerr, 1976), (17) section 38 (Kerr, 1976), (18) section 32 (Kerr, 1976), section 11-3 (Trettin, 1978), (19) section 33 (Kerr, 1976), (20) section 25 (Kerr, 1976), (21) section 22 (Kerr, 1976), (22) section 18 (Kerr, 1976), (23) section 14 (Kerr, 1976), section 7-3 (Trettin, 1978). Outcrop distribution from Map 10-1968 (Kerr, 1968), Map 1307A (Thorsteinsson, 1971), Map 1308A (Thorsteinsson, 1972), and Figures 18 and 19 of Roblesky (1979).

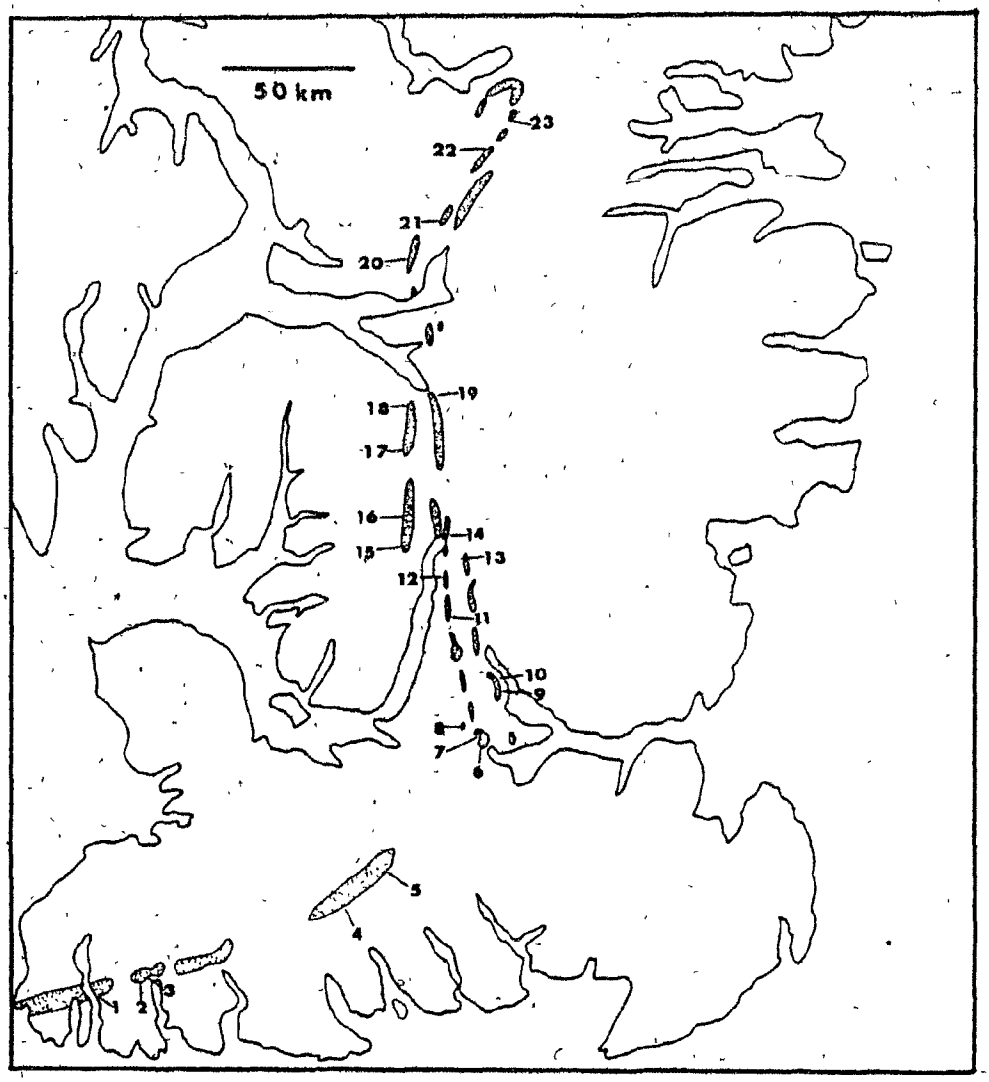


FIGURE 3-4

FIGURE 3-5. Outcrop distribution of the Blue Fiord Formation, Arctic Archipelago. Distribution outside Ellesmere Island based on Kerr (1974) for Bathurst Island, Mayr (1980) for the subsurface of Cameron and Vanier Islands, Tozer and Thorsteinsson (1964) for Melville Island, Thorsteinsson and Tozer (1962) for Victoria and Princess Royal Islands, Miall (1976) for the subsurface of Banks Island, and Indian and Northern Affairs (1978) for the subsurface of Prince Patrick Island.

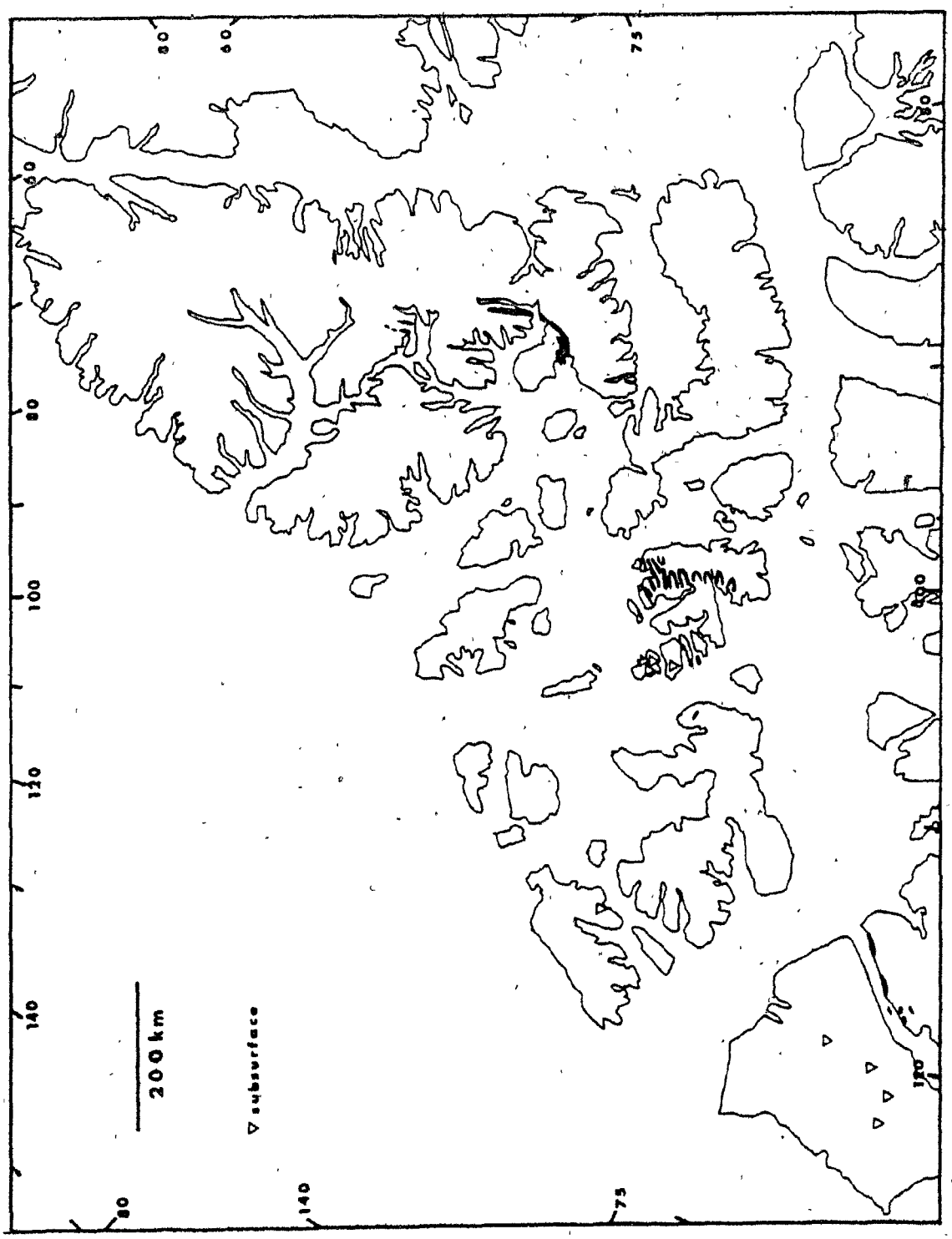


FIGURE 3-5

FIGURE 3-6. Outcrop distribution of the Blue Fiord Formation on Ellesmere Island, and location of data points outside of field area: (1) section 23 (Kerr, 1976), (2) section 16 (Kerr, 1976), (3) section 24 (Kerr, 1976), (4) section 13 (Kerr, 1976). Outcrop distribution from Map 1308A (Thorsteinsson, 1972), Map 1357A (Kerr, 1972b), and Map 1312A (Kerr and Thorsteinsson, 1972).

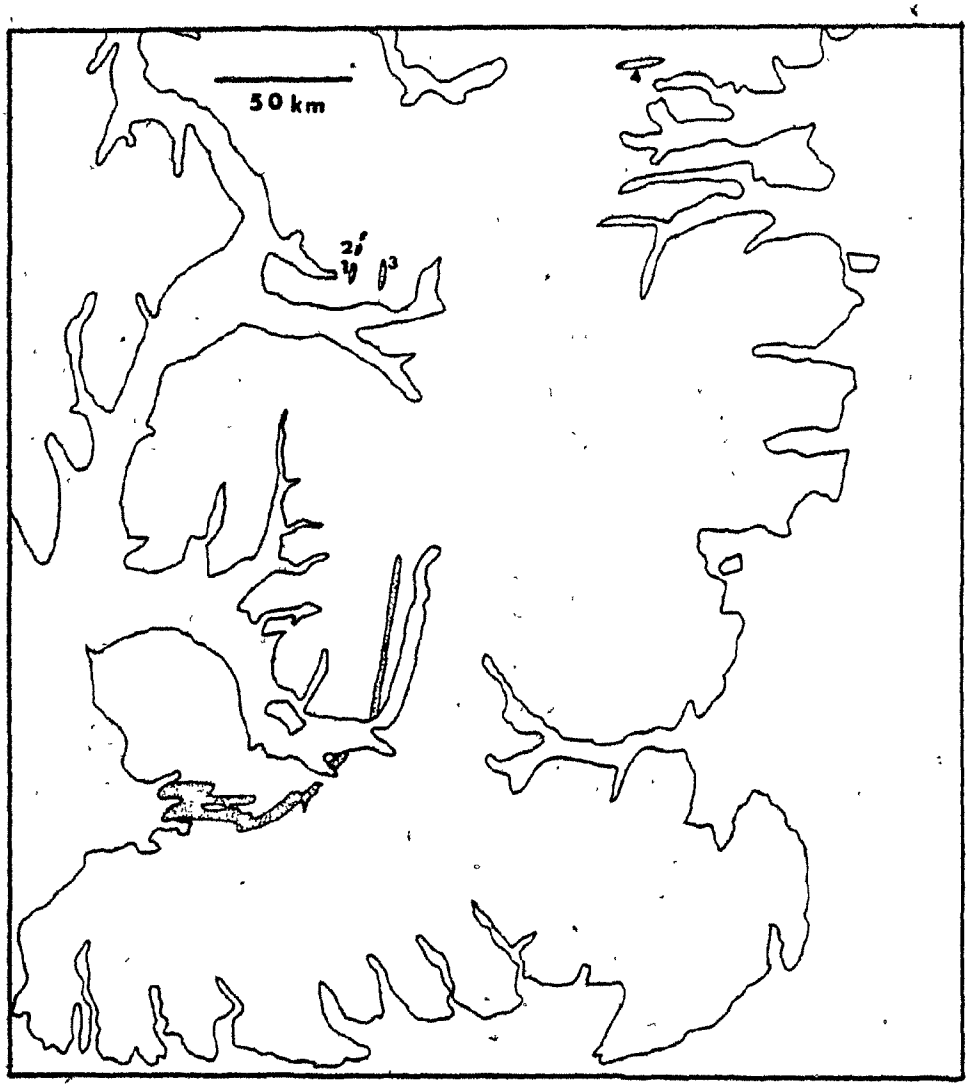


FIGURE 3-6

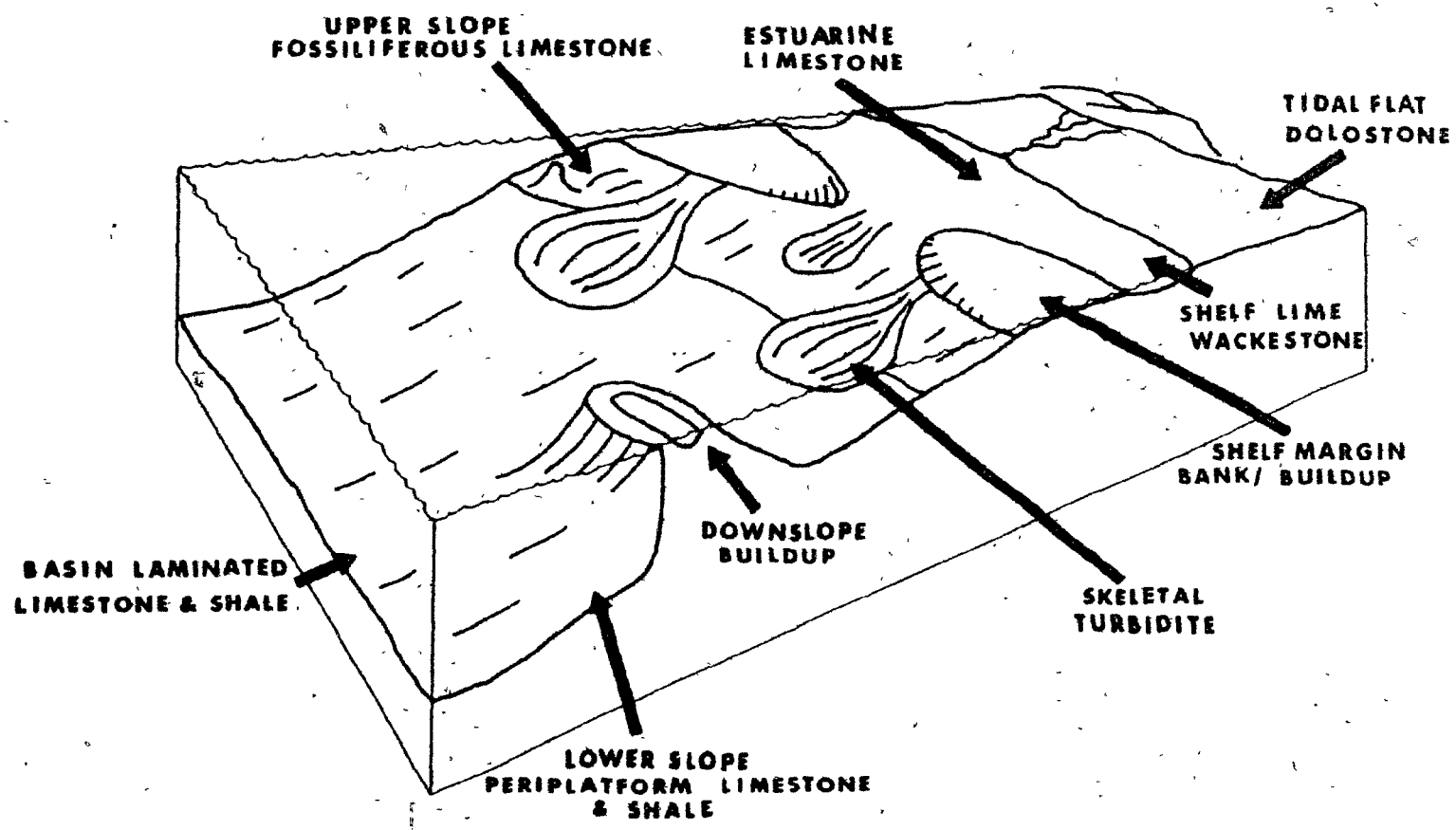


FIGURE 4-1. Depositional model for the Lower Devonian shelf, southern Ellesmere Island

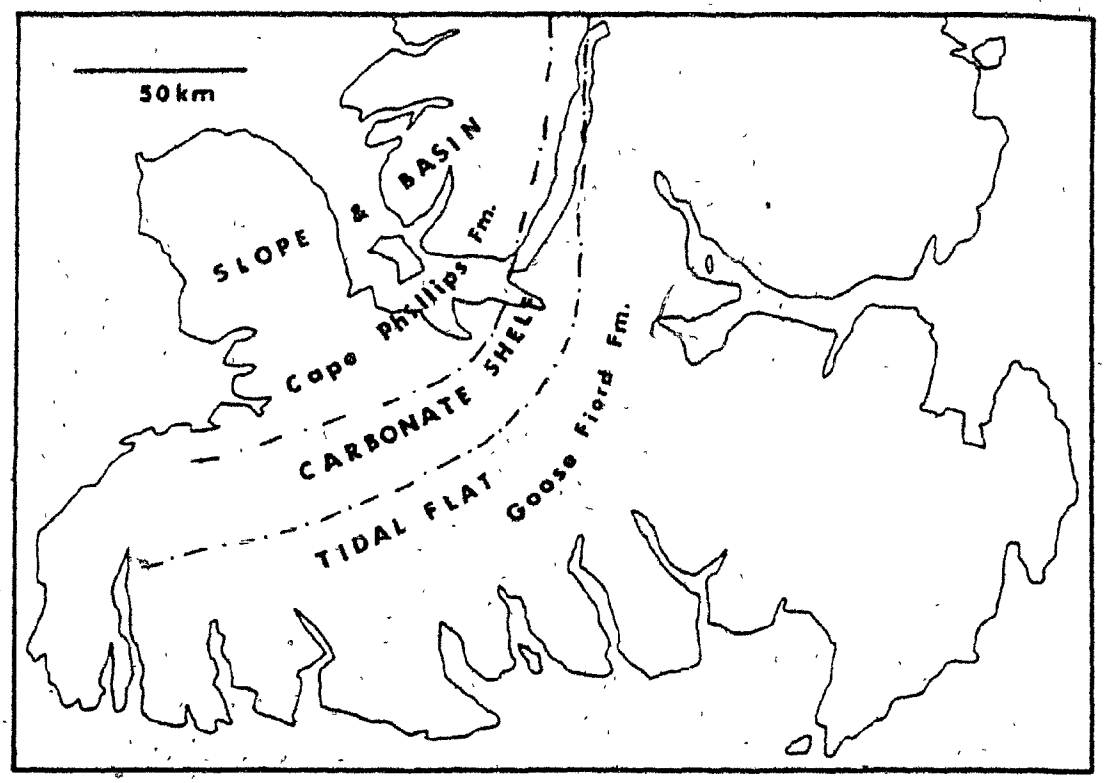
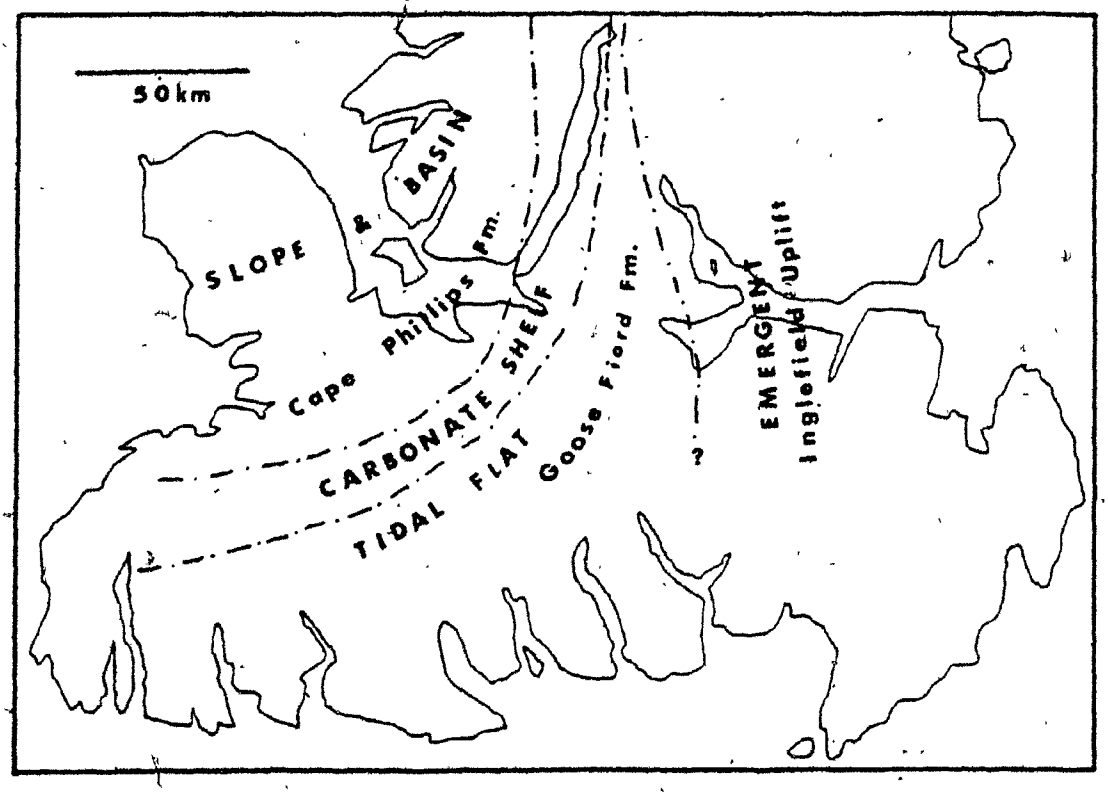


FIGURE 4-2. Paleogeography of southern Ellesmere Island in the
(a) Lochkovian



(b) Pragian

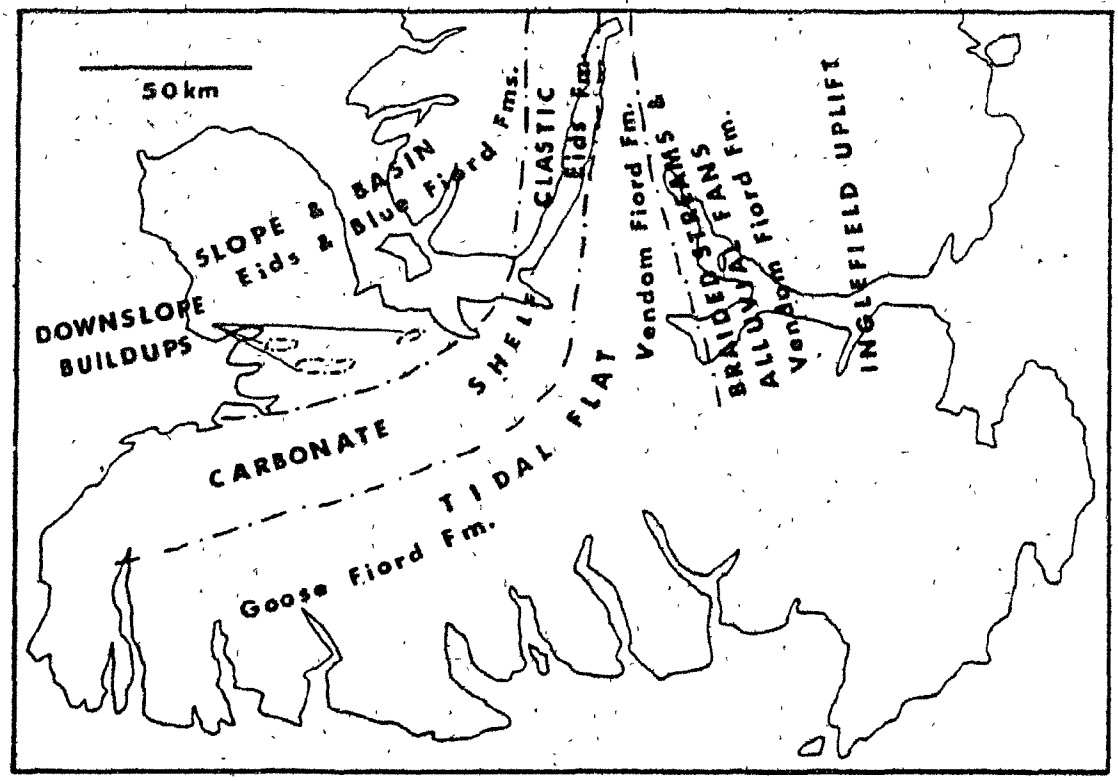
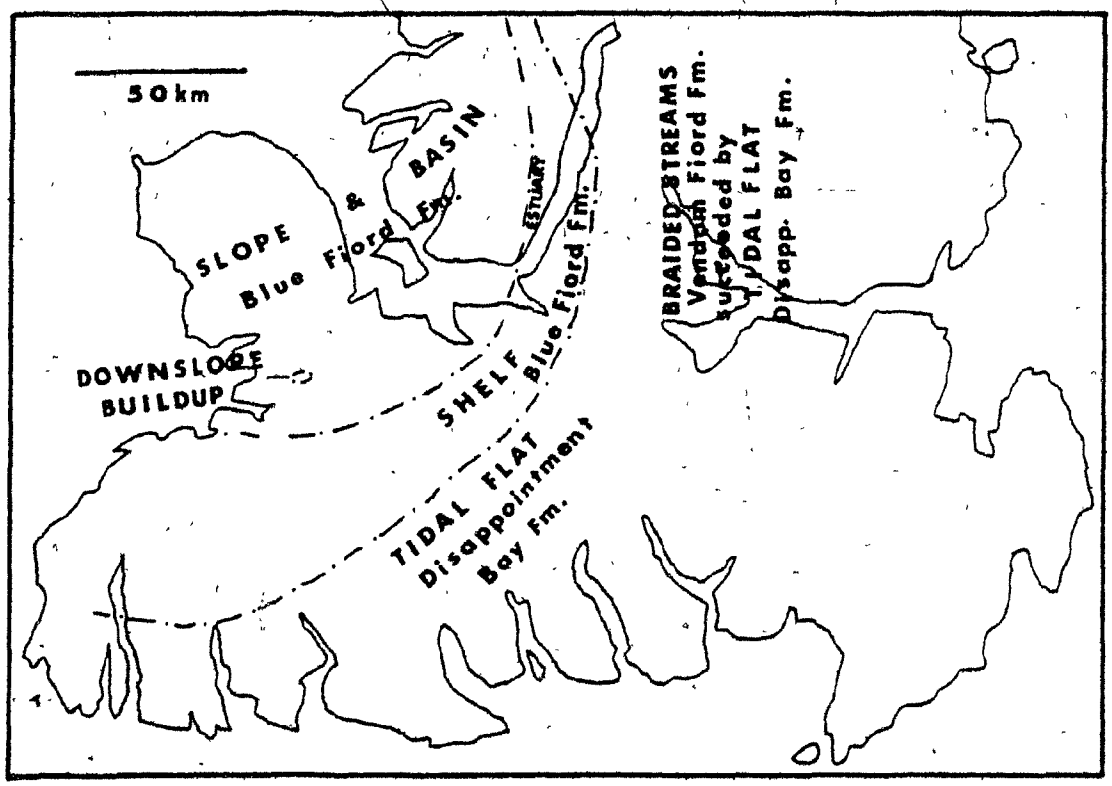


FIGURE 4-3. Paleogeography of southern Ellesmere Island in the (a) Early Zlichovian



(b) Late Zlichovian

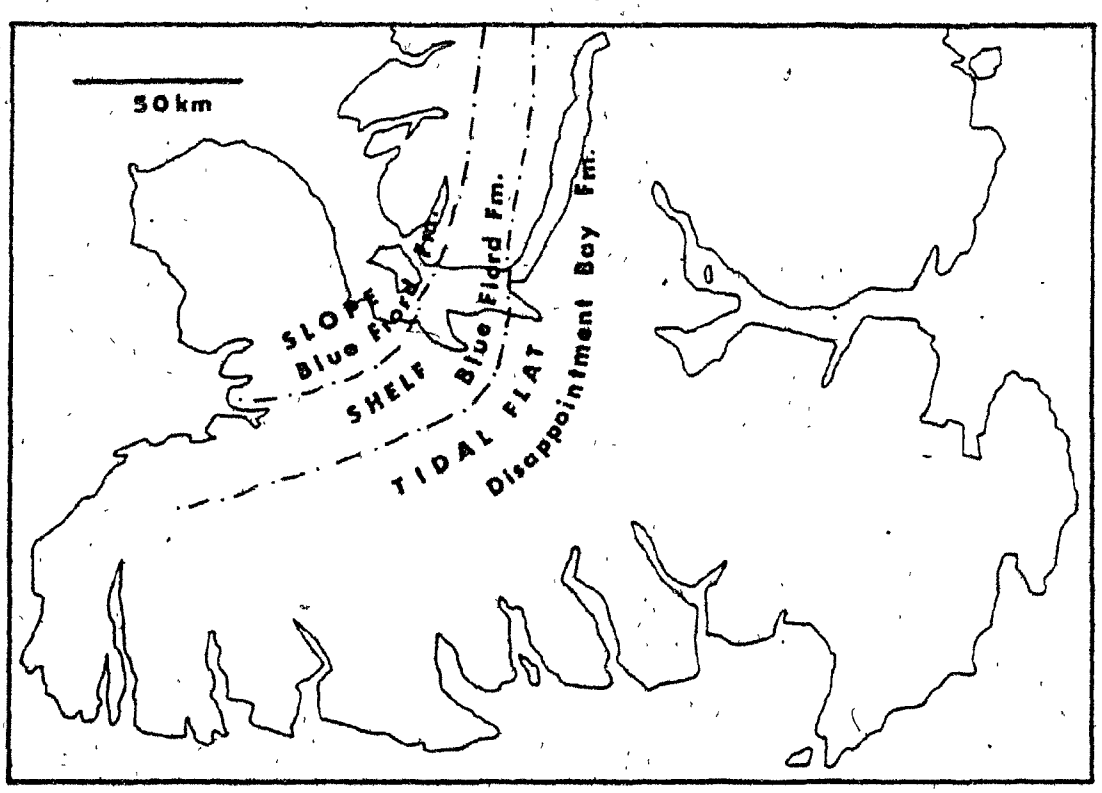
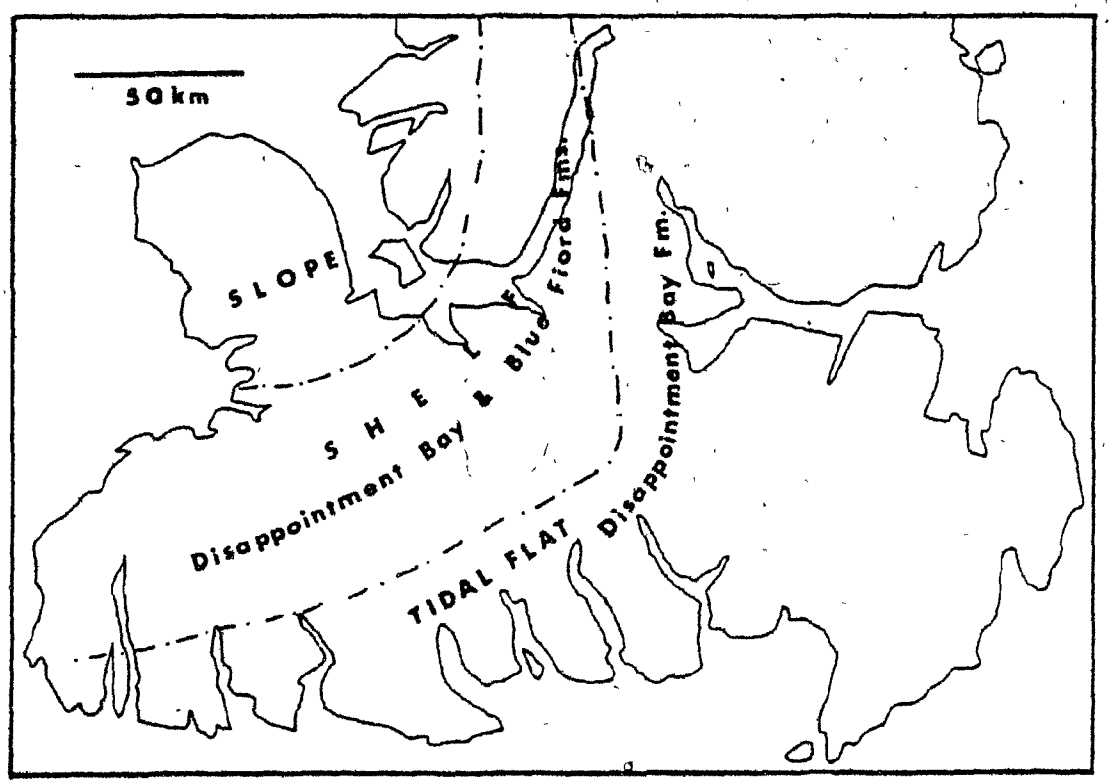


FIGURE 4-4. Paleogeography of southern Ellesmere Island in the
(a) Early Dalejan



(b) early Late Dalejan

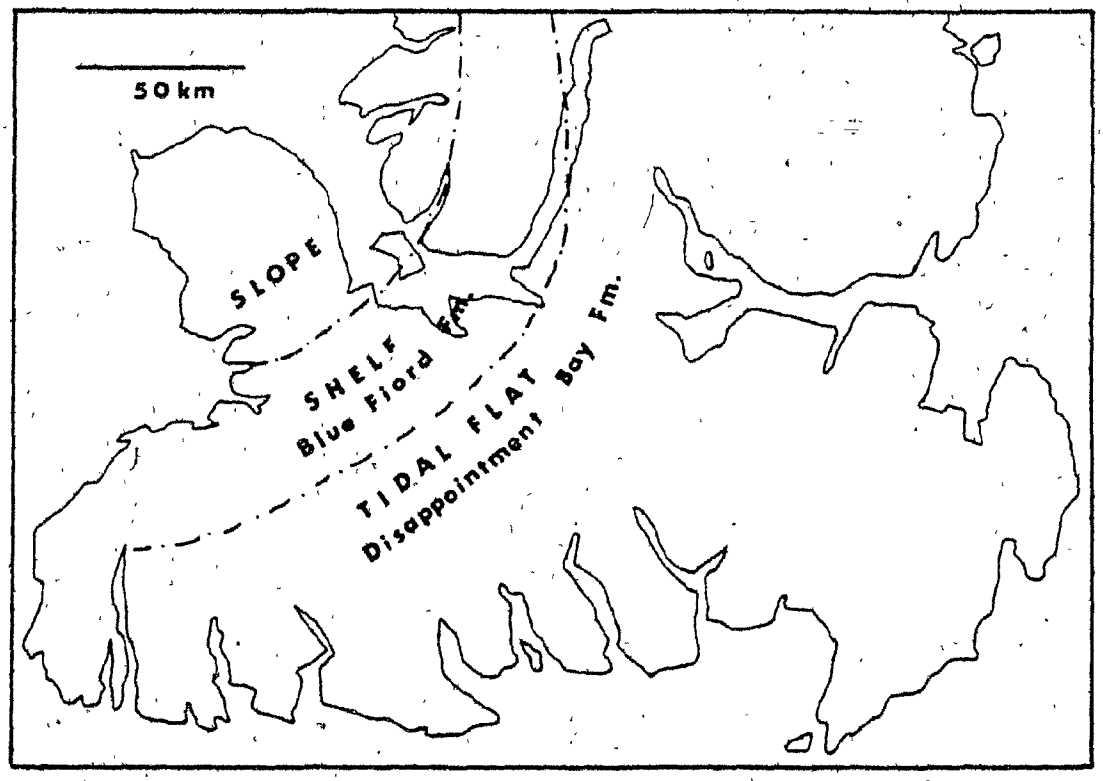
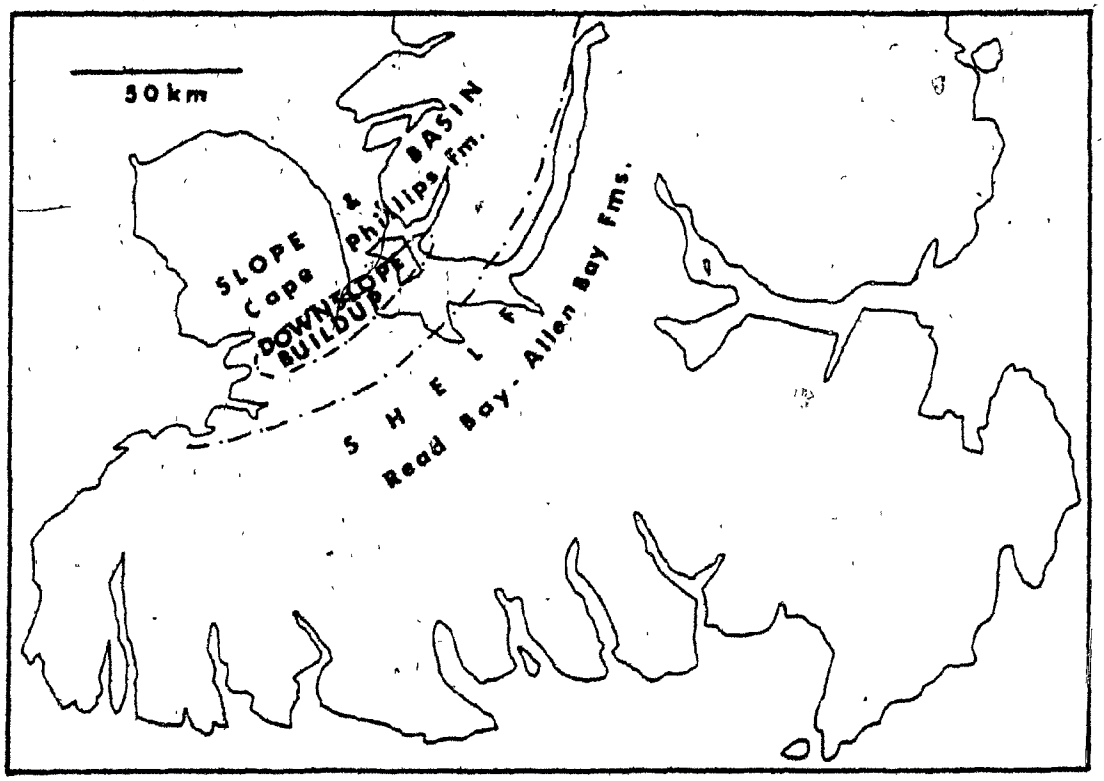


FIGURE 4-5. Paleogeography of southern Ellesmere Island in the

(a) Late Dalejan



(b) Late Llandoverian

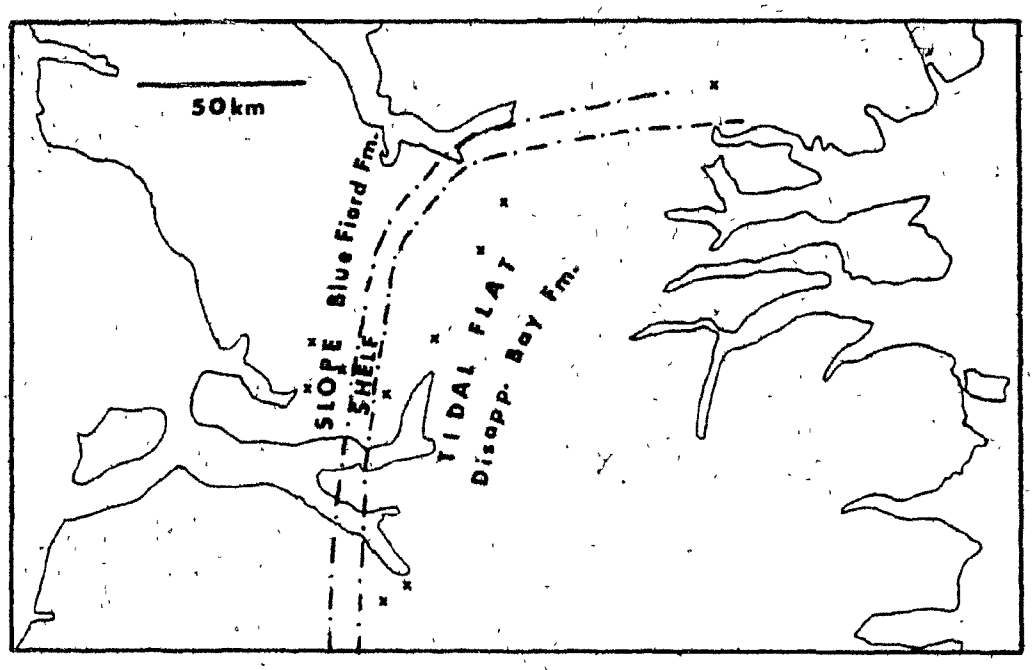


FIGURE 4-6. Paleogeography of central Ellesmere Island in the Late Emsian

FIGURE 4-7a. Paleogeography of Bathurst Island in the Late Emsian based on data points from Kerr (1974): (1) section 11, (2) section 15, (3) section 16, (4) section 6, (5) section 20, (6) section 21, (7) section 19, (8) section 25, (9) section 27, (10) section 28, (11) section 32, (12) section 36, (13) section 39, (14) section 22, (15) section 31, (16) section 35, (17) section 33, (18) section 34, (19) section 41.

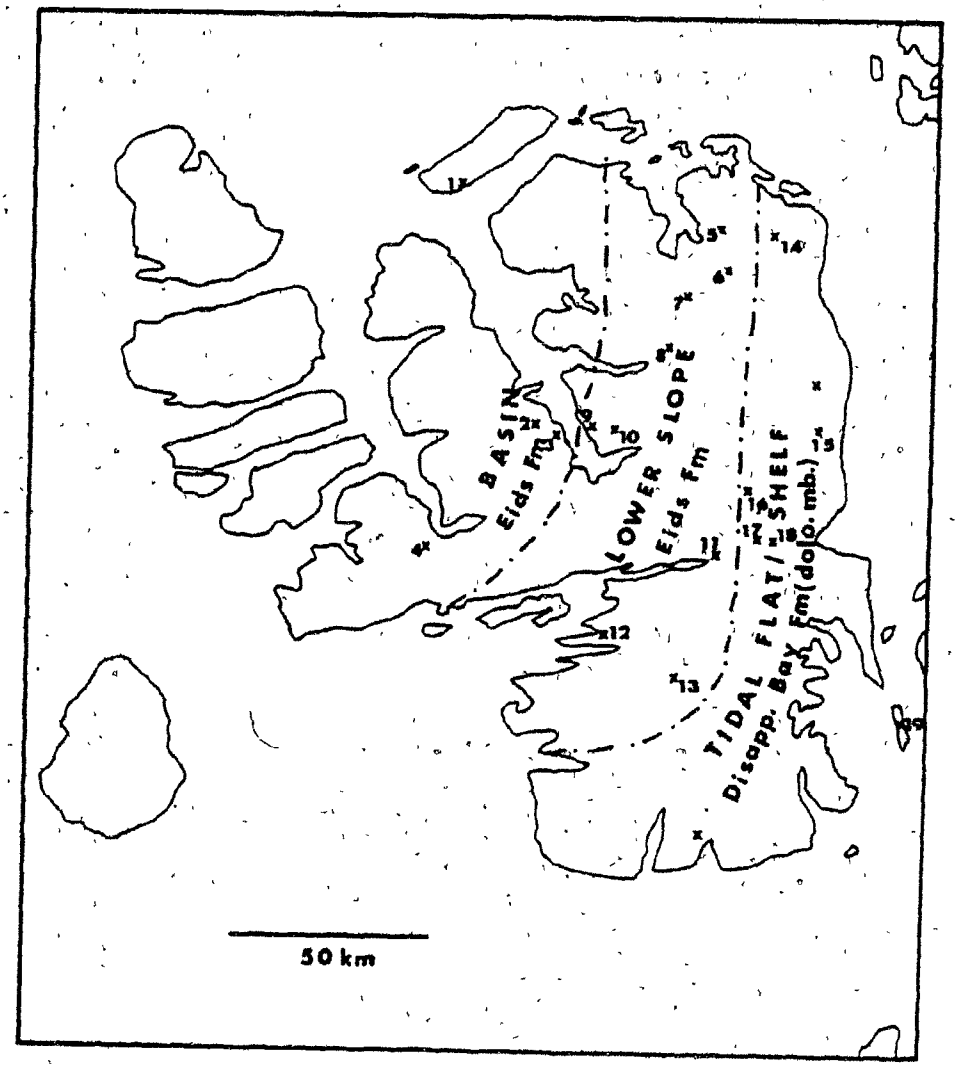

BASIN
Eids Fm
LOWER SLOPE
Eids Fm
TIDAL FLAT/SHELF
Disapp. Bay Fm(dolo. mb.)
50 km

FIGURE 4-7a

FIGURE 4-7b. Paleogeography of Bathurst Island in the Eifelian based on data from this study augmented by Kerr (1974): (1) section 11, (2) section 21, (3) section 31, (4) section 27, (5) section 32; and by Ormiston (1967): (6) section 11.

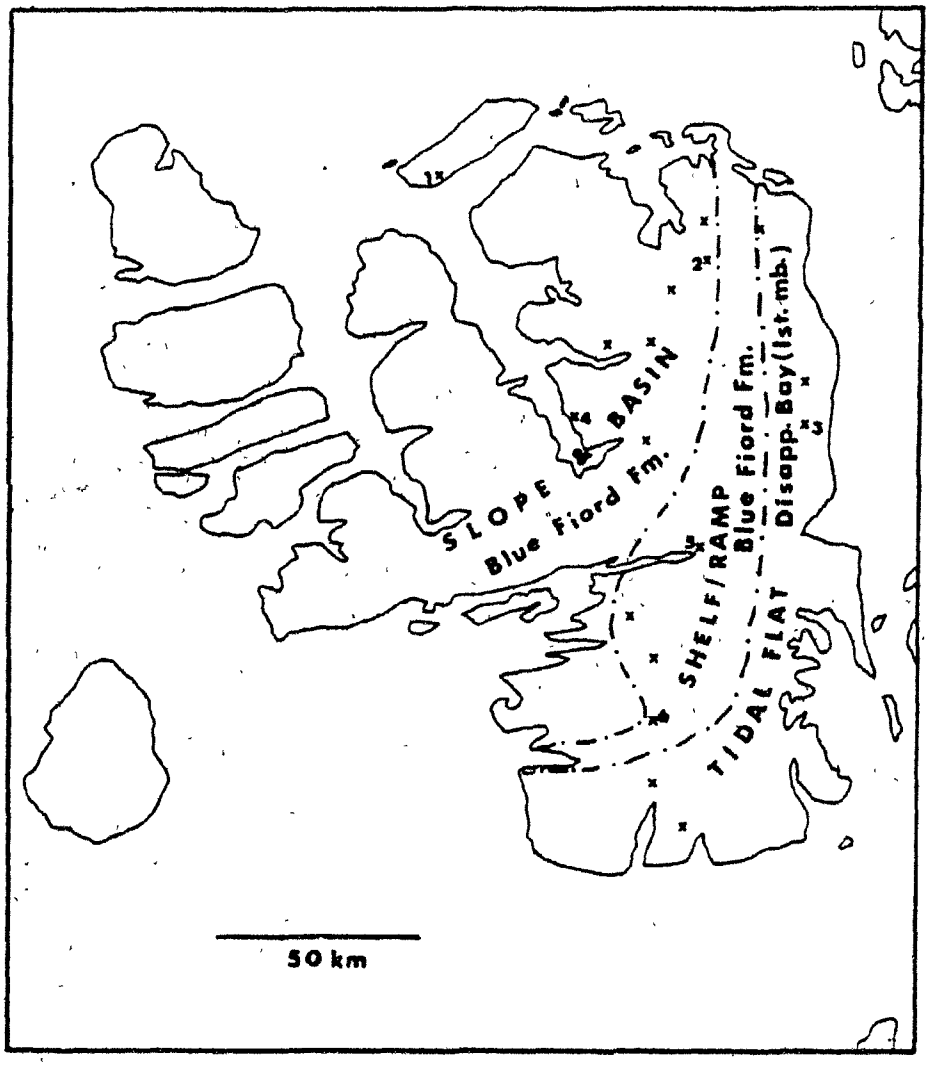

SLOPE BASIN
Blue Fiord Fm.
SHELF/RAMP
Blue Fiord Fm.
Disapp. Bay(lst. mb.)
TIDAL FLAT
50 km

FIGURE 4-7b

FIGURE 4-8. Paleogeography of eastern Melville, Cameron and Vanier Islands in the Late Emsian to Eifelian based on data points from Tozer and Thorsteinsson (1964): (1) Locality 29, (2) Locality 28, (3) Locality 25, (4) Locality 27; and Mayr (1980): (5) BP *et al.* Panarctic Hotspur J-20, (6) Panarctic Tenn. *et al.* Bent Horn N-72, (7) Panarctic *et al.* West Bent Horn C-44, (8) Panarctic Cape Fleetwood M-21.

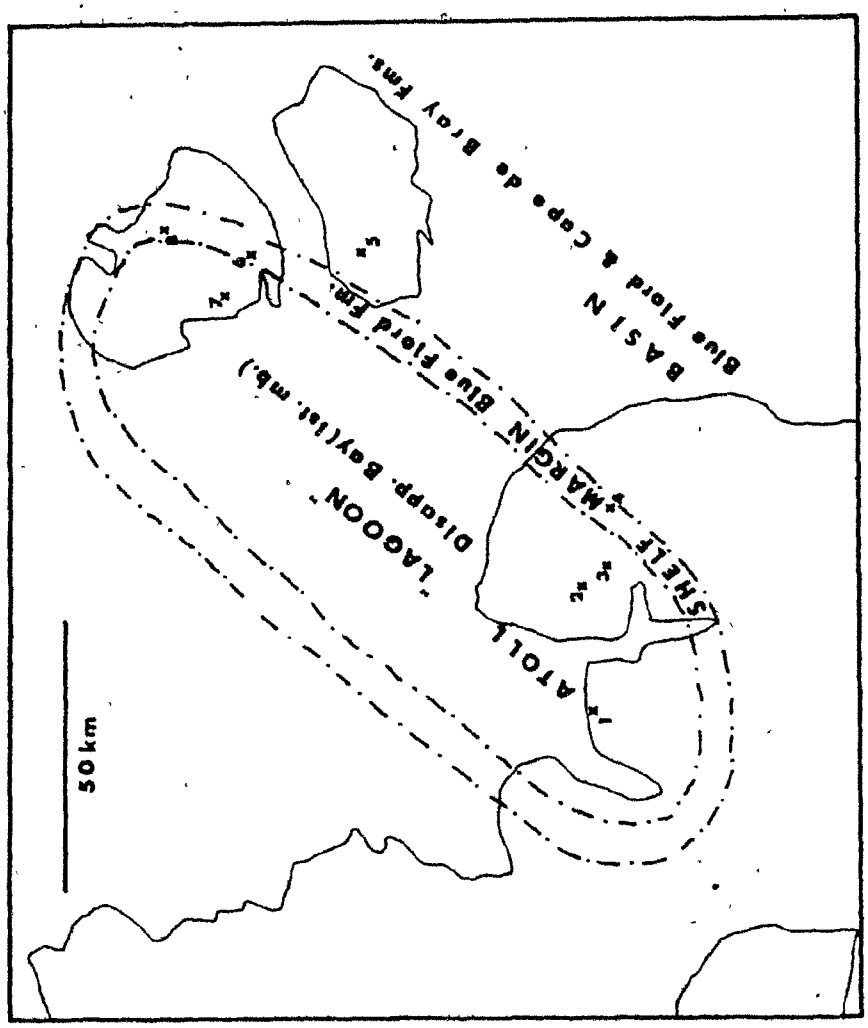

Blue Fjord & Cape de Broy Fms.
BASIN
MARGIN Blue Fjord Fm.
SHELF
ATOLL
"LAGOON"
Disapp. Bay(Ist. mb.)
50 km

FIGURE 4-8

FIGURE 4-9. Paleogeography of northwestern Victoria, Princess Royal, and Banks Islands in the Late Emsian based on data points from Miall (1976): (1) Elf *et al.* Storkerson Bay A-15, (2) Elf Nanuk D-76, (3) Deminex *et al.* Orksut I-44; Thorsteinsson and Tozer (1962): (4) Locality 18, (5) Locality 19, (7) Locality 20, (8) Locality 21, (9) Locality 22, (10) Locality 23, (11) 16 miles northeast of Armstrong Point, (12) Locality 24; and Mayr *et al.* (1980): (6) Murphy Alminex Victoria Island F-36.

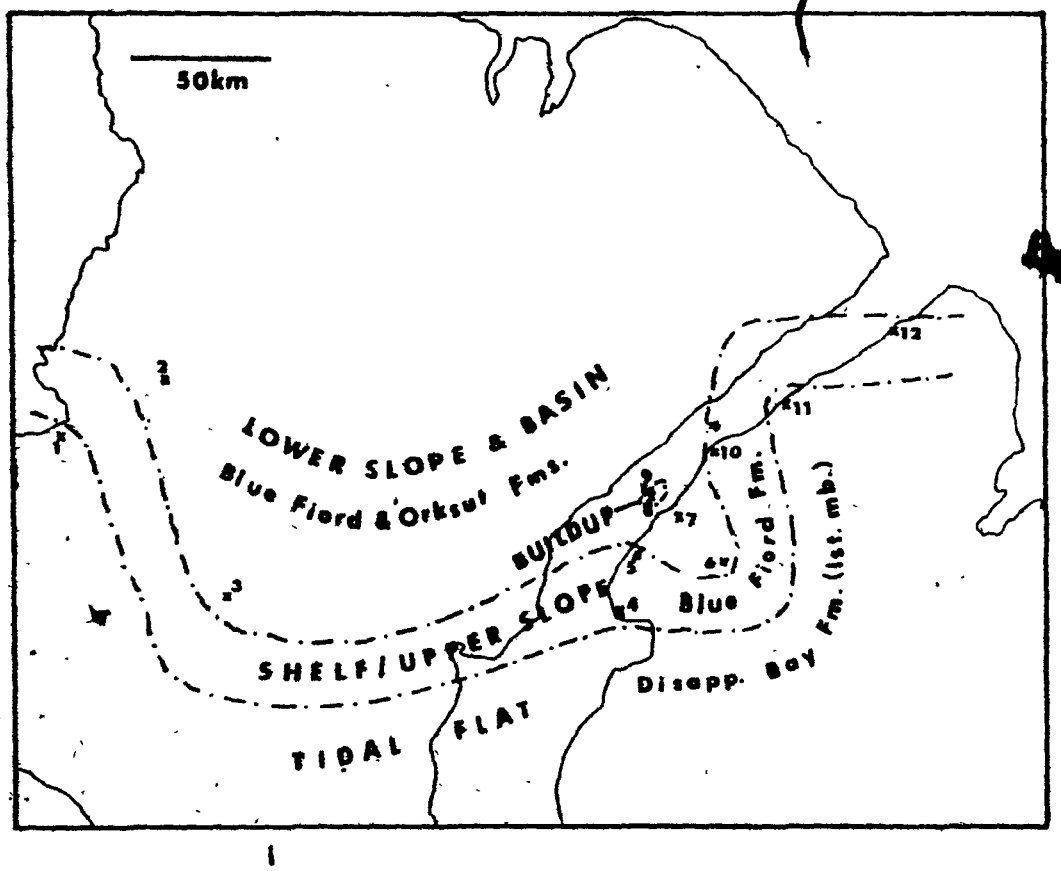

50km
LOWER SLOPE & BASIN
Blue Fiord & Orksut Fms.
BUILDUP
SHELF/UPPER SLOPE
TIDAL FLAT
Blue Fiord Fm.
Disapp. Bay Fm. (1st. Emb.)
1
2
3
4
5
6
7
8
9
10
11
12

FIGURE 4-9

FIGURE 4-10. Location of the late Early to early Middle Devonian carbonate shelf and associated facies, Canadian Arctic Archipelago.

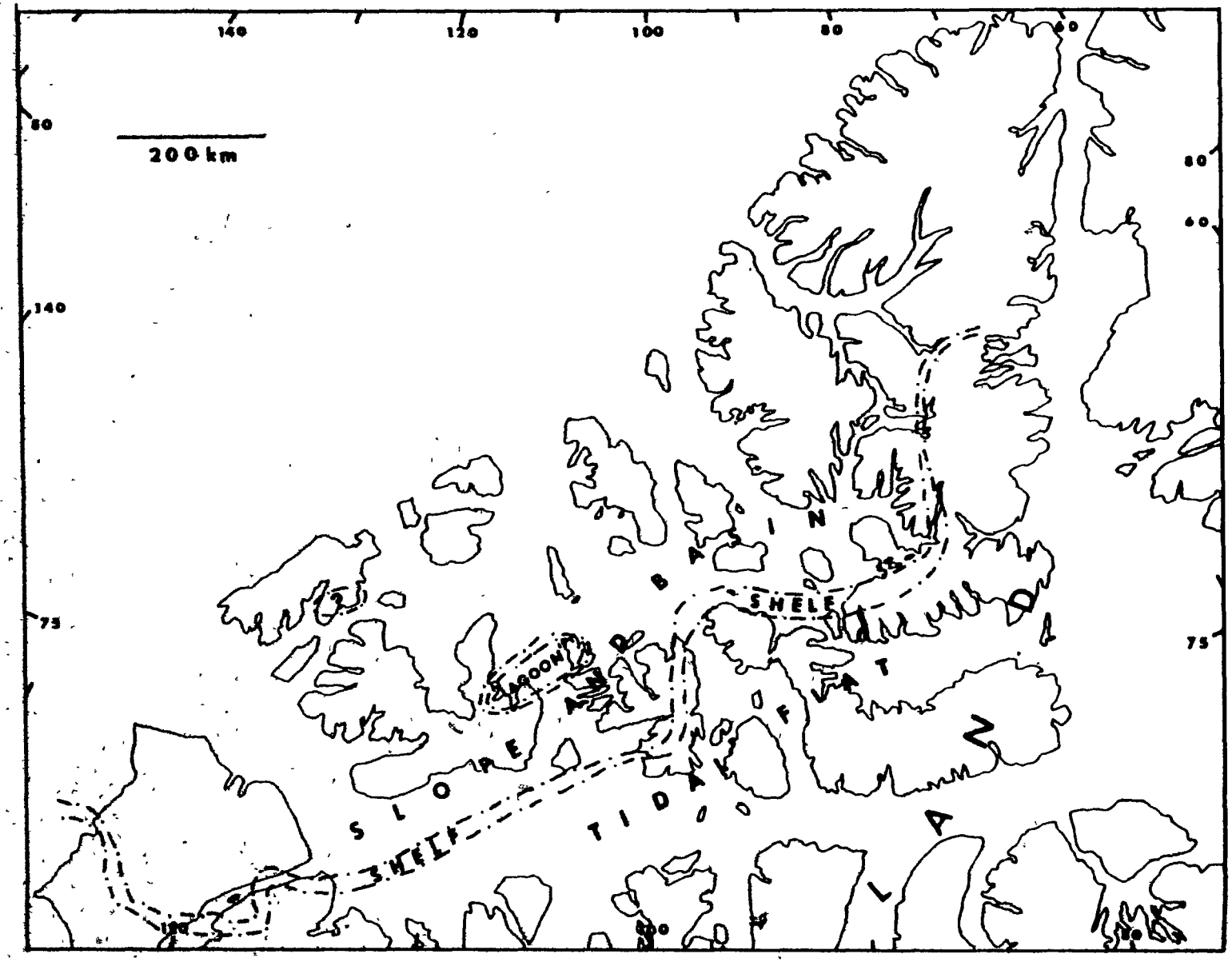

140
120
100
80
60
200 km
80
140
75
80
60
75
BEAUFORT SEA SHELF
LAGOONAL
SHORE
TIDAL
FLATS
SLOPE
SHELF
ALASKA

FIGURE 4-10

FIGURE 4-11. Detailed Devonian lithostratigraphy at 5 localities, southern Ellesmere Island. Conventional lithologic symbols used. Inset shows line of section A-A'. Stratigraphic thicknesses and lithologies derived from this study, and from data in McGill (1974), Embry and Klovan (1976), Kerr (1976), Uyeno and Klapper (1980), Rice (1982), and Pedder and Goodbody (1983).

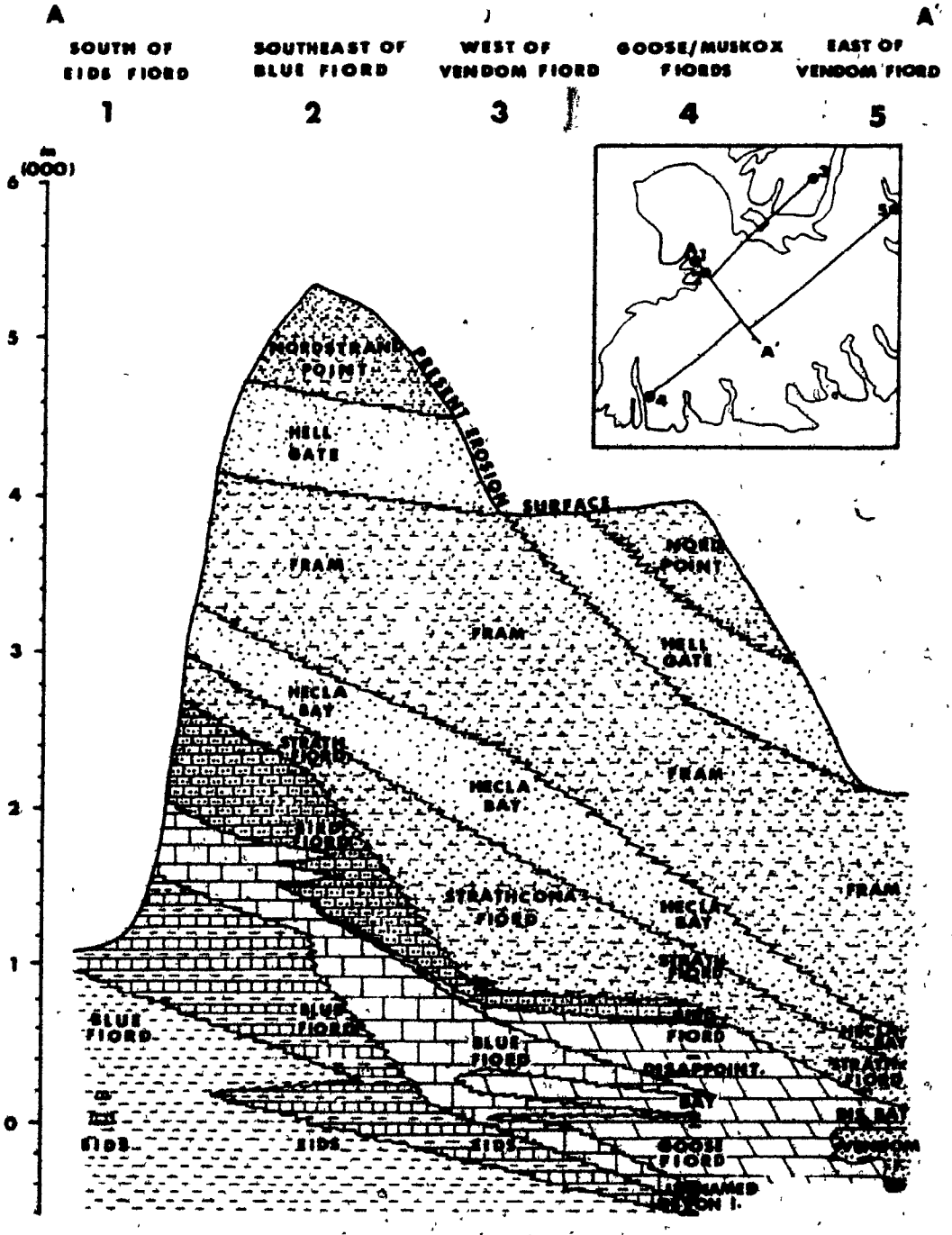

A
A'
SOUTH OF EIDS FIORD
SOUTHEAST OF BLUE FIORD
WEST OF VENDOM FIORD
GOOSE/MUSKOX FIORDS
EAST OF VENDOM FIORD
1
2
3
4
5
m (000)
6
5
4
3
2
1
0
NORDSTRAND POINT
PARTIAL EROSION SURFACE
HELL GATE
FRAM
NORD POINT
HECLA BAY
STRATHCONA FIORD
BLUE FIORD
EIDS
DISAPPOINT. BAY
GOOSE FIORD
A
A'

FIGURE 4-11

FIGURE 4-12. Facies interpretation of stratigraphy shown in Figure 4-11. Time lines marking epoch and stage boundaries based on data in Kiaer (1915), Weyant (1975a), Embry and Klovan (1976), Roblesky (1979), Uyeno and Klapper (1980), Chatterton (written comm., 1981), Uyeno (1981), and Pedder and Goodbody (1983). The time lines recording the lower and uppermost *P. inversus* Zone transgressions are based on deepening events recorded by lithologic changes combined with actual dates in Uyeno and Klapper (1980) for section 2, Roblesky (1979) for section 3, Chatterton (written comm., 1981) and inferred dates for section 4, and inferred dates for section 5 based on (a) possible *P. gronbergi* Zone conodonts near the top of the Vendom Fiord Formation east of Vendom Fiord (Roblesky, 1979), (b) probable co-existence of the fluvial facies of the Vendom Fiord Formation at section 5 with the estuarine facies of the Blue Fiord Formation (Late Zlichovian) west of Vendom Fiord, and (c) the transgressive event marking the base of the Disappointment Bay Formation east of Vendom Fiord (tidal flat facies overlying braided fluvial facies) could be time correlative with the lower *P. inversus* Zone transgression (Latest Zlichovian) recognized at sections 2, 3, and 4.

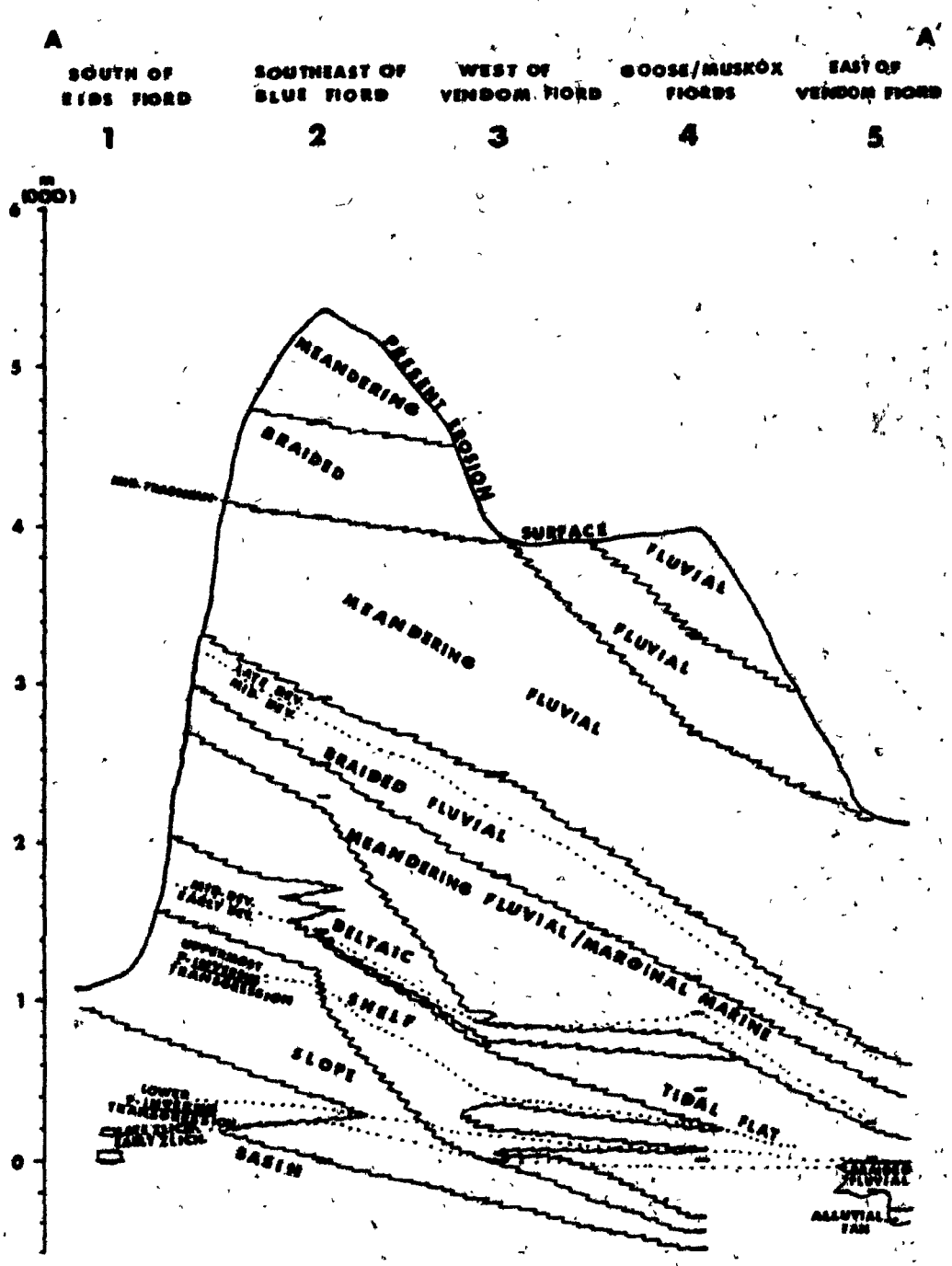

A
A'
SOUTH OF EIDS FIORD
1
SOUTHEAST OF BLUE FIORD
2
WEST OF VENDOM FIORD
3
GOOSE/MUSKOX FIORDS
4
EAST OF VENDOM FIORD
5
m (000)
6
5
4
3
2
1
0
MEANDERING
BRAIDED
PRESENT EROSION
SURFACE
FLUVIAL
FLUVIAL
MEANDERING
FLUVIAL
BRAIDED FLUVIAL
MEANDERING FLUVIAL/MARGINAL MARINE
DELTAIC
SHELF
SLOPE
TIDAL FLAT
BASIN
ALLUVIAL FAN

FIGURE 4-12

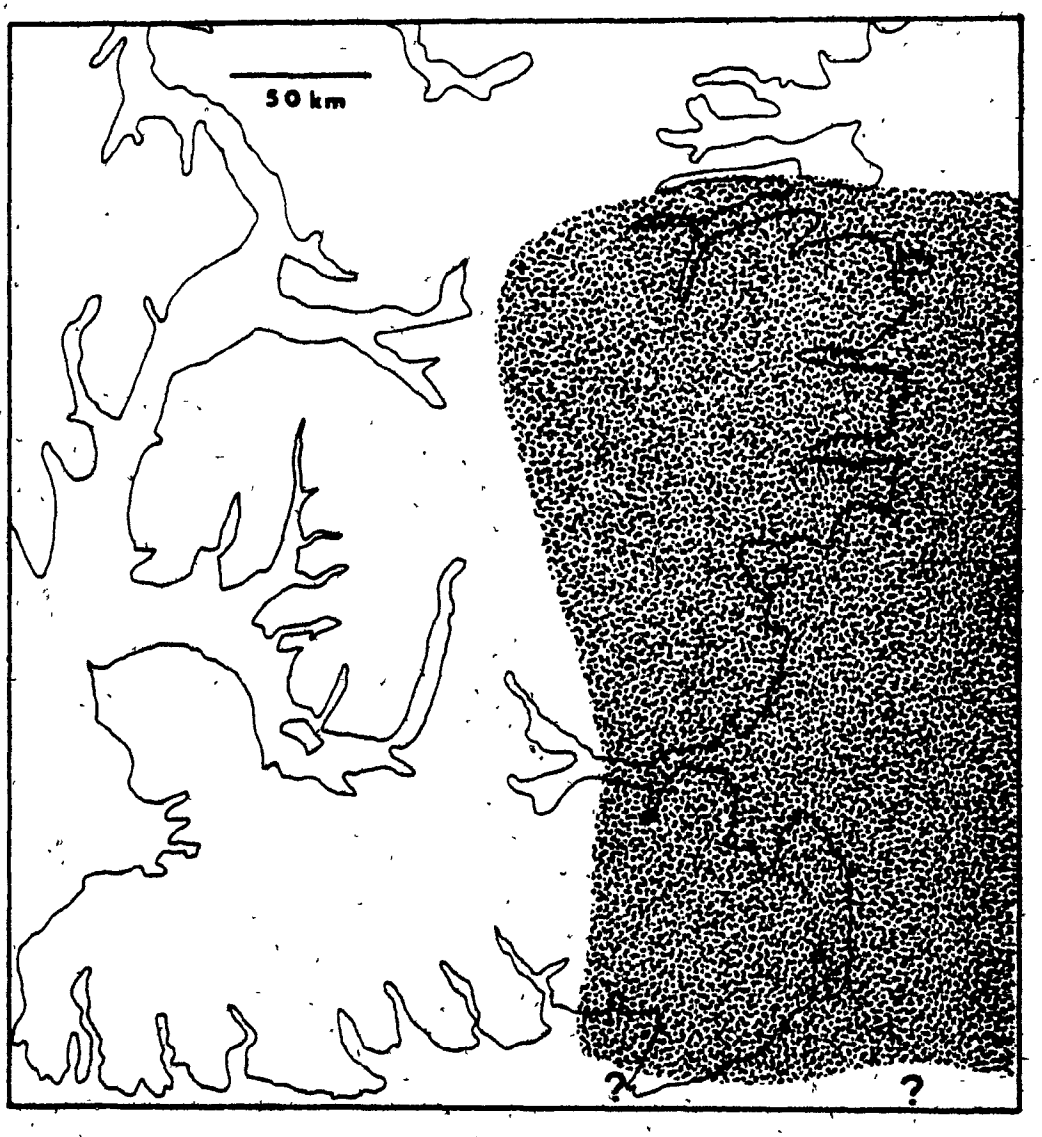


FIGURE 4-13. Location of interpreted Inglefield Uplift, (patterned area)

FIGURE 5-1. Gedinnian buildups worldwide

(1) Drake Bay Formation, northwest Prince of Wales Island (Smith, R., 1980), (2) West Point Formation, northeast Gaspe Peninsula (Bourque and Lesperance, 1977), (3) Coeymans Formation, central New York State (Isaacson and Curran, 1981), (4) northwest New Jersey (Precht, 1982), (5) Keyser Formation, west Virginia (Smosna and Warshauer, 1979), (6) Vaygach Island and Pay-Khoy (Markov *et al.*, 1967; (7) eastern sector, southern Tien Shan (Brezhnev *et al.*, 1967; Biske *et al.*, 1977), (8) Nowshera Formation, west Pakistan (Stauffer, 1968).

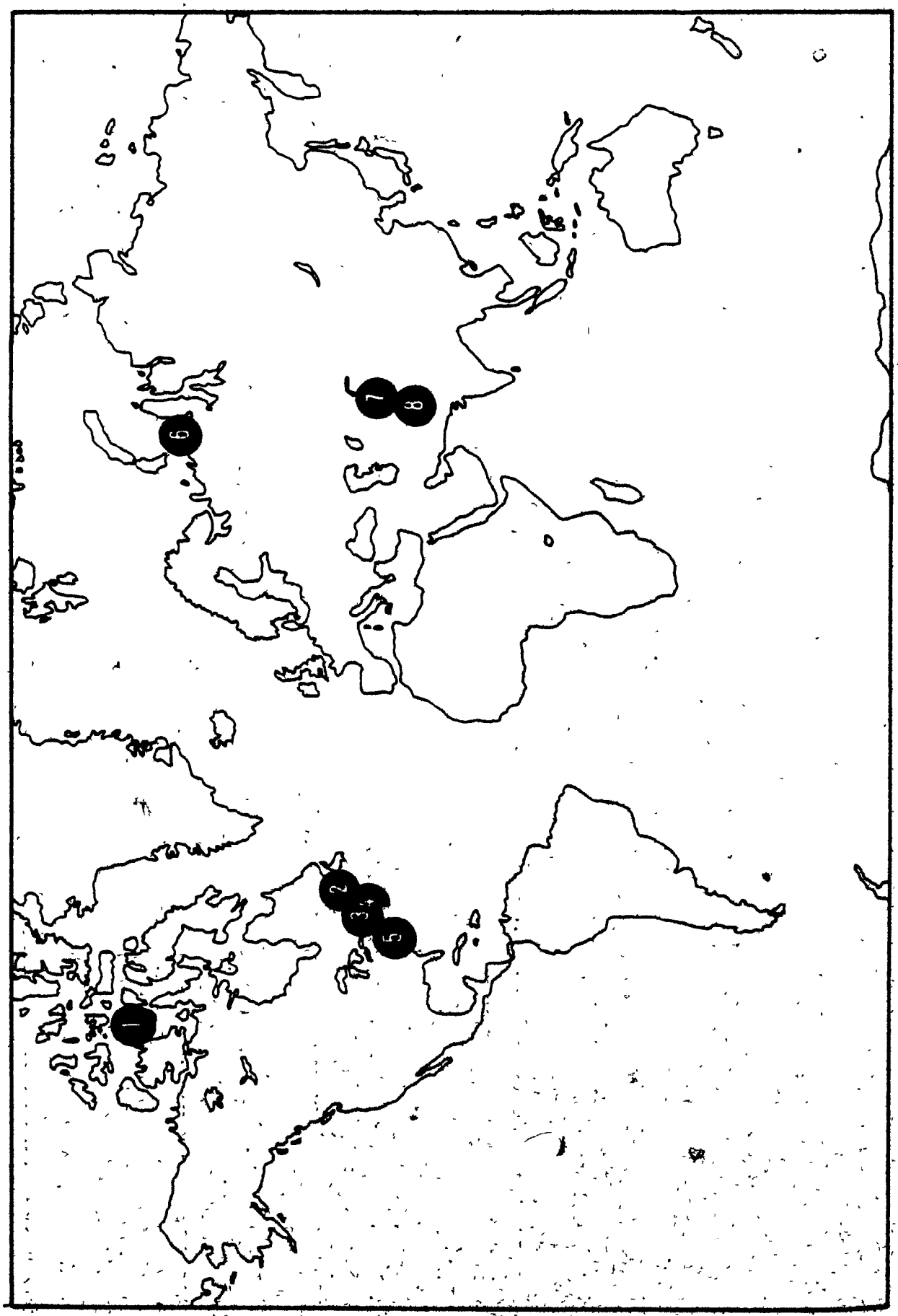


FIGURE 5-1

FIGURE 5-2. Siegenian buildups worldwide

(1) Stuart Bay Formation (allochtonous blocks), eastern Bathurst Island (Polan, 1982), (2) Baubigny Limestone, Armorican Massif (Poncet, 1972), (3) Koneprusy Limestone, Bohemia (Chlupáč, 1968), (4) Rauchkofel facies, Carnic Alps (Schönlaub, 1971), (5) Vaygach Island and Pay-Khoy (Markov *et al.*, 1967), (6) western slope of the Urals (Kondfain *et al.*, 1967), (7) western and eastern sector, southern Tien Shan (Brezhnev *et al.*, 1967), (8) Lilydale limestone, central Victoria (Talent and Banks, 1967; Philip and Pedder, 1967).

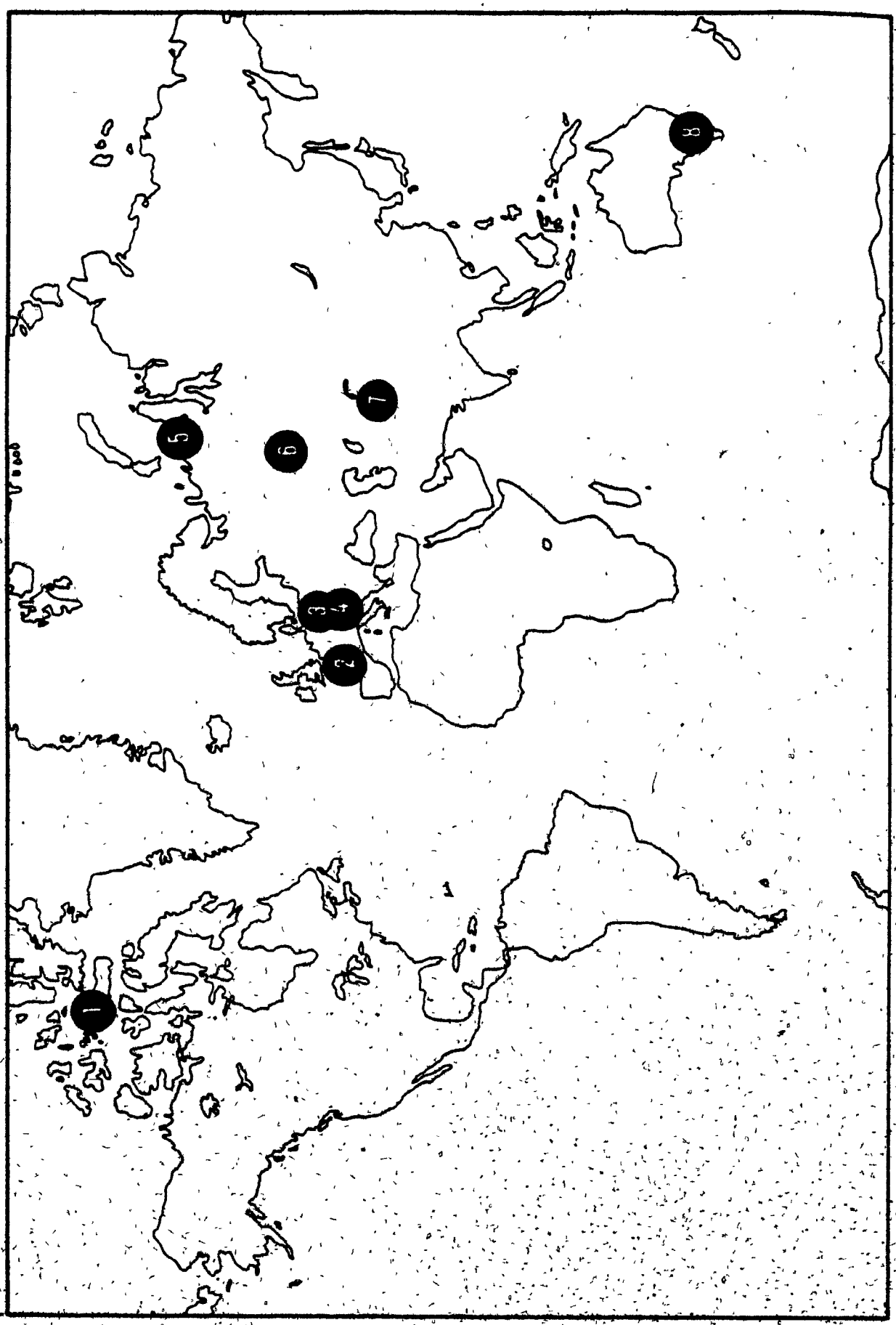


FIGURE 5-2

FIGURE 5-3. Emsian buildups worldwide

(1) Blue Fiord Formation, southwest Ellesmere Island (Smith and Stearn, 1980), (2) Disappointment Bay Formation, Lowther Island (Johnson, 1975), (3) Blue Fiord Formation, Cameron Island (Mayr, 1980), (4) Blue Fiord Formation, larger of the Princess Royal Islands (Miall, 1976), (5) Ogilvie Formation, northern Yukon Yerritory (Perry *et al.*, 1974), (6) Salmontrout limestone, east-central Alaska (Churkin and Brabb, 1967), (7) Ogilvie Formation, east-central Alaska (Blodgett, 1978), (8) Moniello-St. Lucia Formation, northern Spain (Mendez-Bedia, 1976), (9) west-central Morocco (Hollard, 1967), (10) Rauchkofel facies, Carnic Alps (Schönlaub, 1971), (11) *Favosites regularissimus* zone, southern Novaya Zemlya (Markovet *al.*, 1967), (12) Vaygach Island and Pay-Khoy (Patrunov and Samoilovich, 1973), (13) Taymyr Peninsula (Patrunov and Samoilovich, 1973), (14) Maloshezhim Formation, western slope of the Urals (Kondiain *et al.*, 1967), (15) eastern slope of the Urals (Breivel *et al.*, 1967), (16) western and eastern sector, southern Tien Shan (Brezhnev *et al.*, 1967), (17) west China (Batang) (Yang *et al.*, 1981), (18) Martin's Well Limestone Member of Broken River Formation, east-central Queensland (Wyatt and Jell, 1967), (19) Garra Formation, New South Wales (Strusz, 1967), (20) Taemas Formation, New South Wales (Pedder, 1967b)

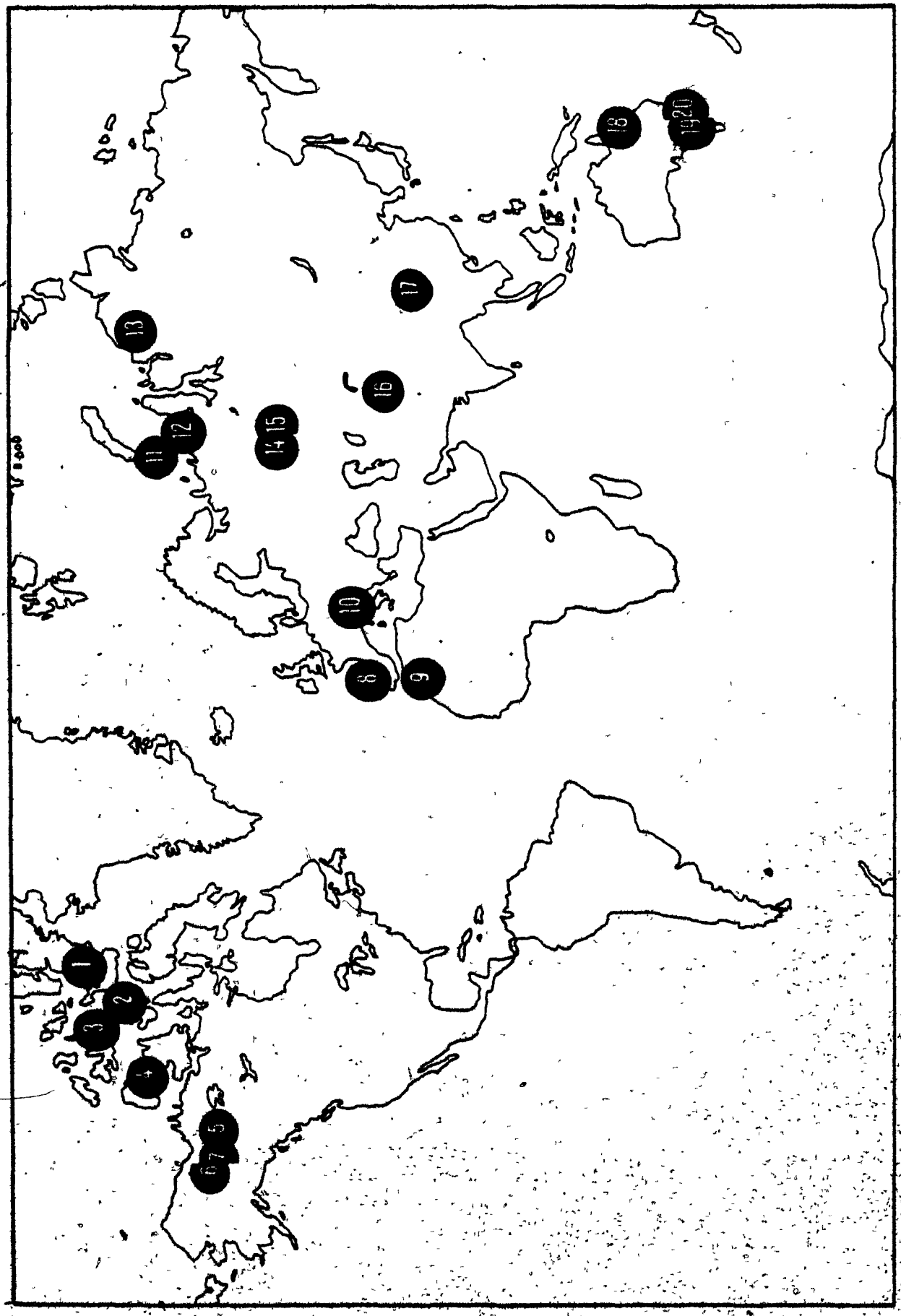


FIGURE 5-3

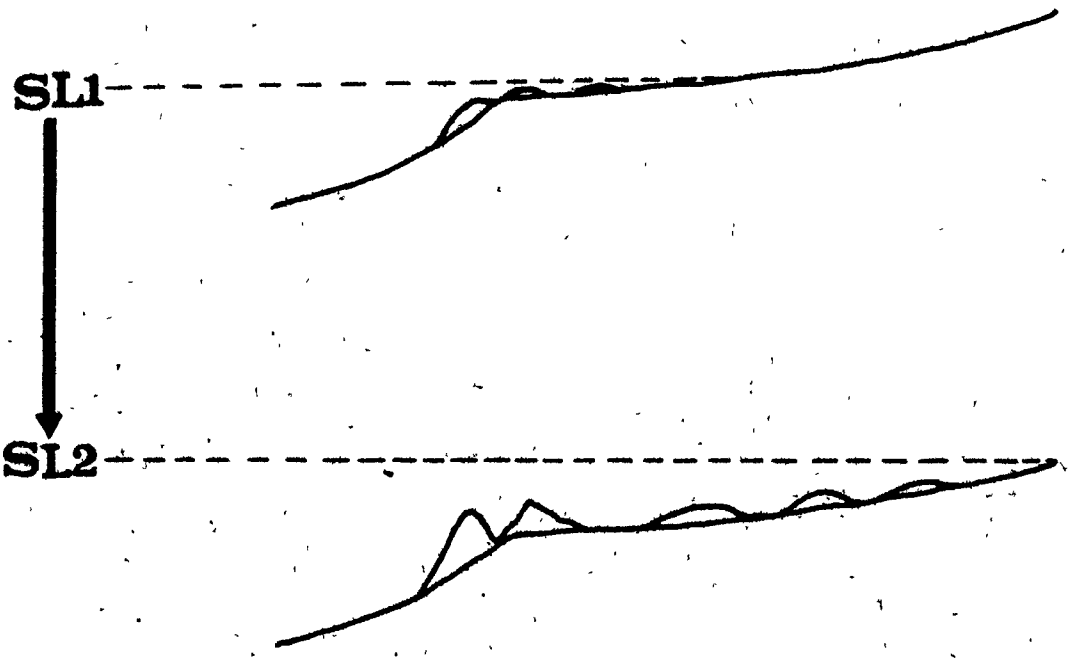


FIGURE 5-4. Illustration of how a marine transgression increases the potential growth sites for buildups.

LEGEND FOR POINTS ON FIGURES 5-5, 6, 7

1. East-central Alaska
2. North Yukon Territory
3. Princess Royal Islands
4. Prince of Wales Island
5. Cameron Island
6. East Bathurst Island
7. Lowther Island
8. Southwest Ellesmere Island
9. Northeast Gaspé Peninsula
10. New York/New Jersey
11. West Virginia
12. West-central Morocco
13. North Spain
14. Armorican Massif
15. Carnic Alps
16. Bohemia
17. South Novaya Zemlya
18. Vaygach Island and Pay-Khoy
19. Taymyr Peninsula
20. West slope of the Urals
21. East slope of the Urals
22. South Tien Shan
23. West Pakistan
24. West China
25. East-central Queensland
26. New South Wales
27. Central Victoria

FIGURE 5-5. Lower Devonian paleogeographic reconstructions of (a) Smith *et al.* (1973) and Zonenshayn and Gorodnitskiy (1977) with Lower Devonian buildups plotted.

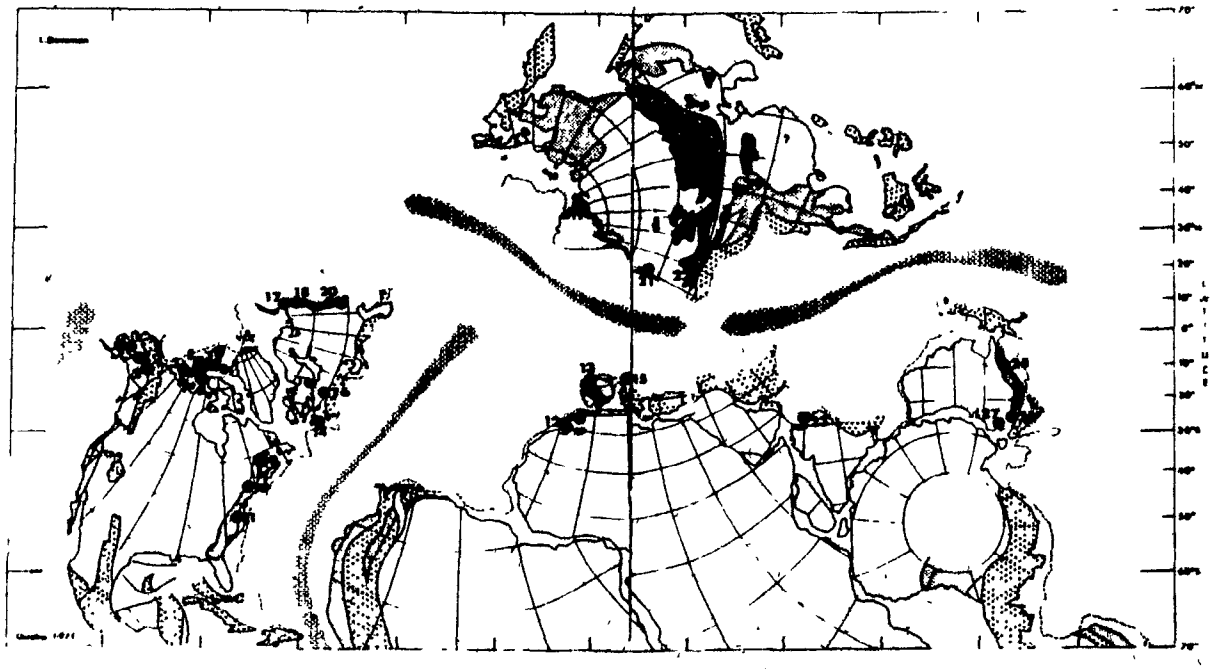


FIGURE 5-5a

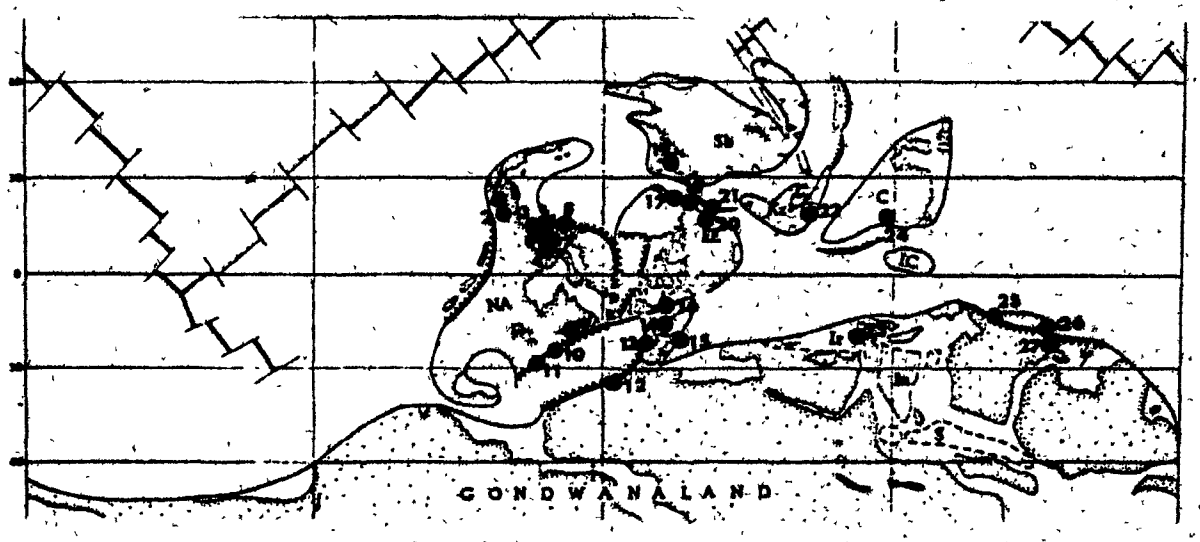


FIGURE 5-5b



FIGURE 5-6. Lower Devonian paleogeographic reconstructions of (a) Kanasewich *et al.* (1978) and Morel and Irving (1978) with Lower Devonian buildups plotted.

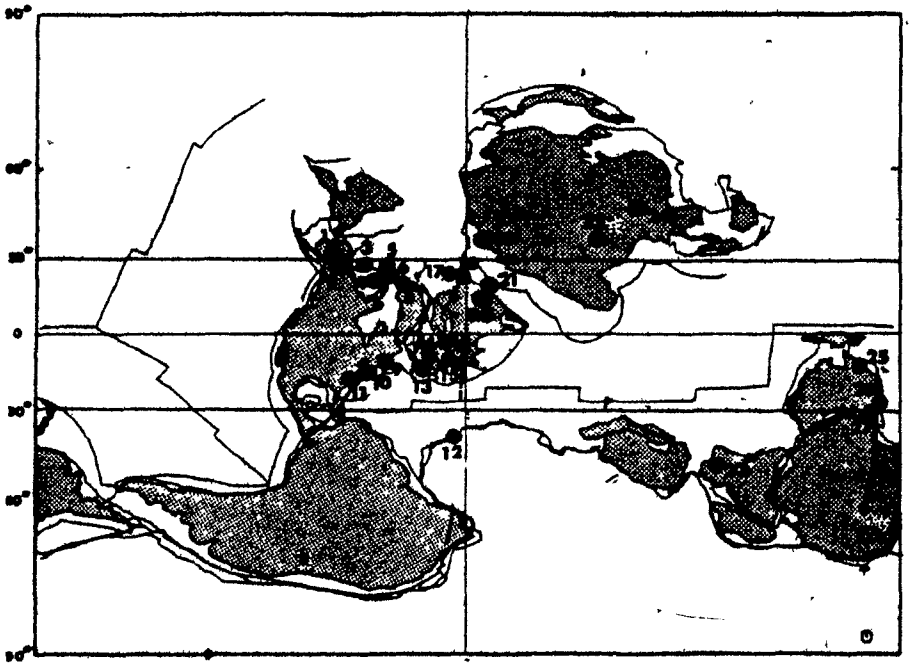


FIGURE 5-6a

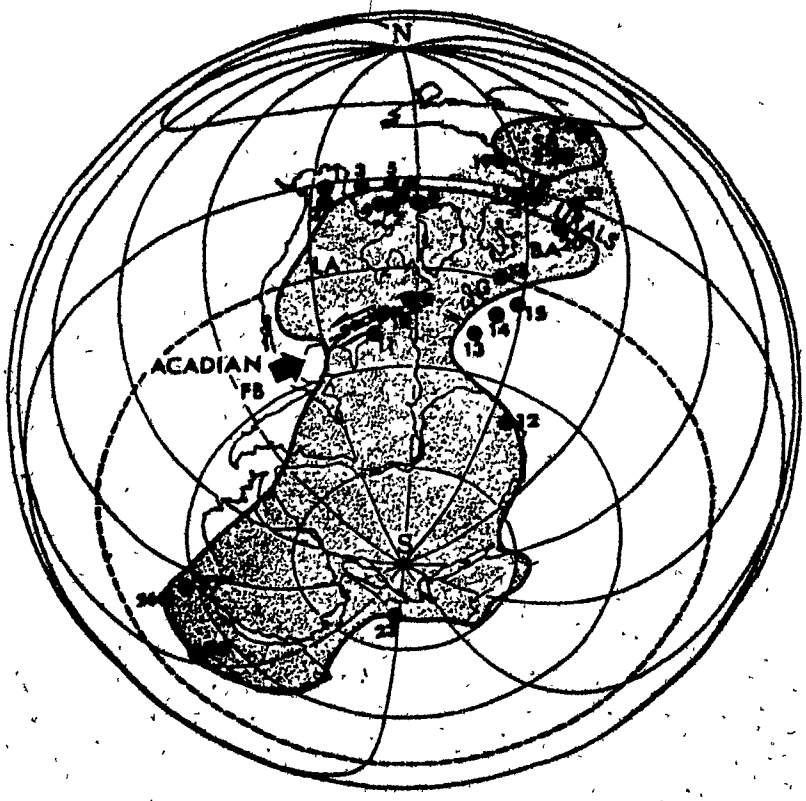


FIGURE 5-6b

FIGURE 5-7. Lower Devonian paleogeographic reconstruction of (a) Scotese *et al.* (1979) and (b) Irving (1979) (solid lines), Heckel and Witzke (1979) (dashed lines), and Lapointe and Dankers (1982) (dotted lines) with buildups plotted.

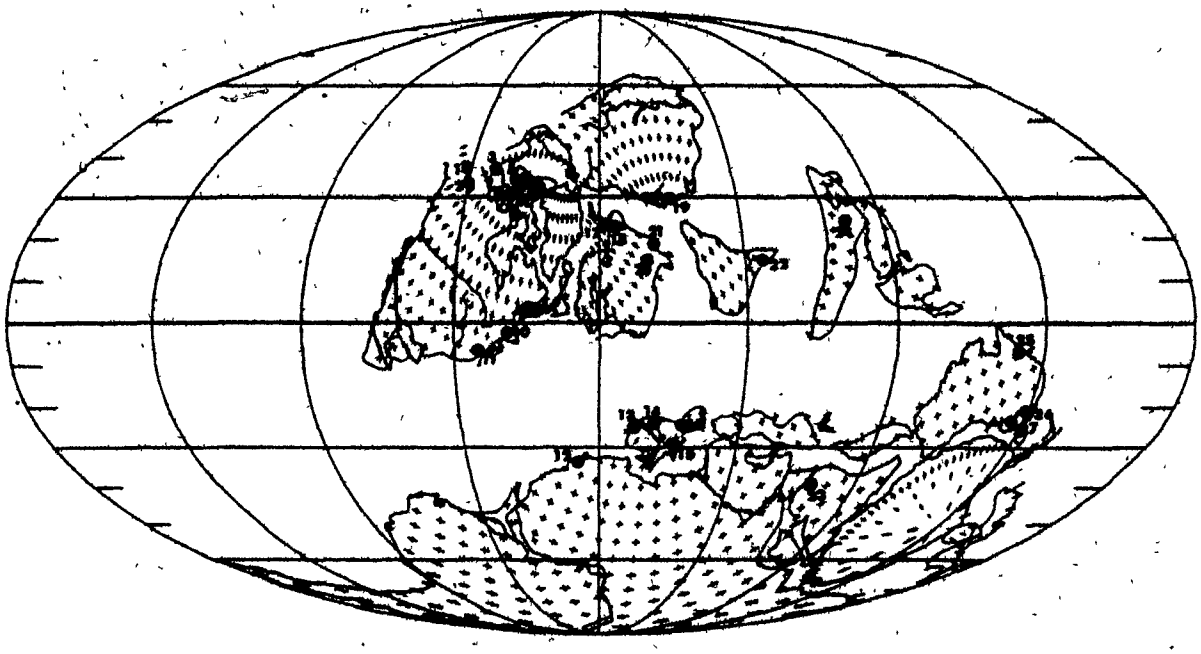


FIGURE 5-7a

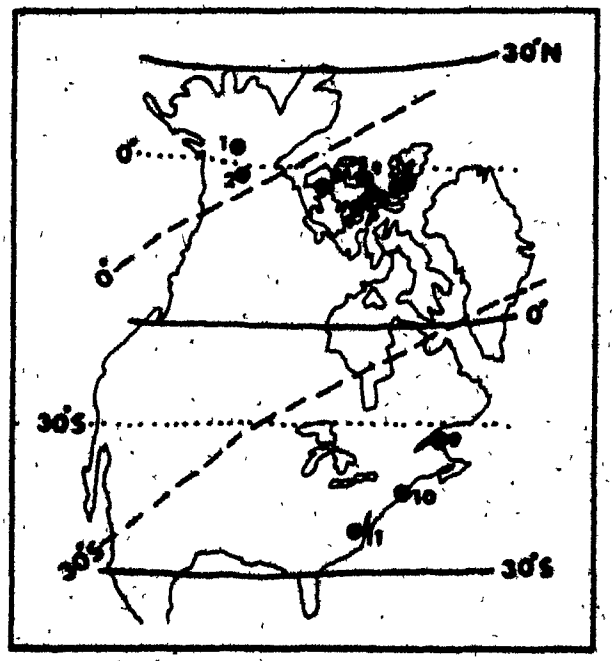


FIGURE 5-7b

FIGURE 5-8. Location of Lower Devonian carbonate buildups, southern Ellesmere Island. There are 3 buildup types: (a) = coral/stromatoporoid buildup, (b) = crinoid-rich buildup, (c) = bryozoan lime mud mound; all buildups are in the Blue Fiord Formation unless otherwise stated.

(1) AD19 (a), AD37 (a), (2) AA3-5, AA35-AAA1, AAA13, AAA15, AAA17 (a), (3) AB2-4, AB14-15 (a), (4) AC1-2 (Eids) (a), (5) ACA2-3 (a), (6) Loc. 6 (a)(b), (7) Loc. 7 (Eids) (a), (8) Loc. 10 (a), (9) JA15 (a), (10) JB10 (b), (11) JC8 (a), (12) Loc. 17 (a), (13) IC5-7 (a), (14) Loc. 18 (a), (15) IA14 (a), (16) Loc. 26 (a), (17) ID3-14 (a), (18) IB10-12 (a), (19) CH4 (c), CH33 (a), (20) CD3A-11 (a), (21) CC2A-CCA10 (a), (22) CA5-16 (a), (23) BC7 (b), (24) CB17 (c), (25) CF8-11, 15, 25 (a), (26) CE19 (c), (27) DA7-9 (Eids) (b), (28) EC22-25 (a), (29) K6, K9 (a), (30) EA1-13 (Eids) (a), (31) EA51 (b), (32) Loc. 40 (a), (33) Loc. 53 (a), (34) ED48 (a), ED41 (b), (35) HA2-4 (a), (36) HC2 (a), (37) Loc. 52 (b), (38) Loc. 54 (a).

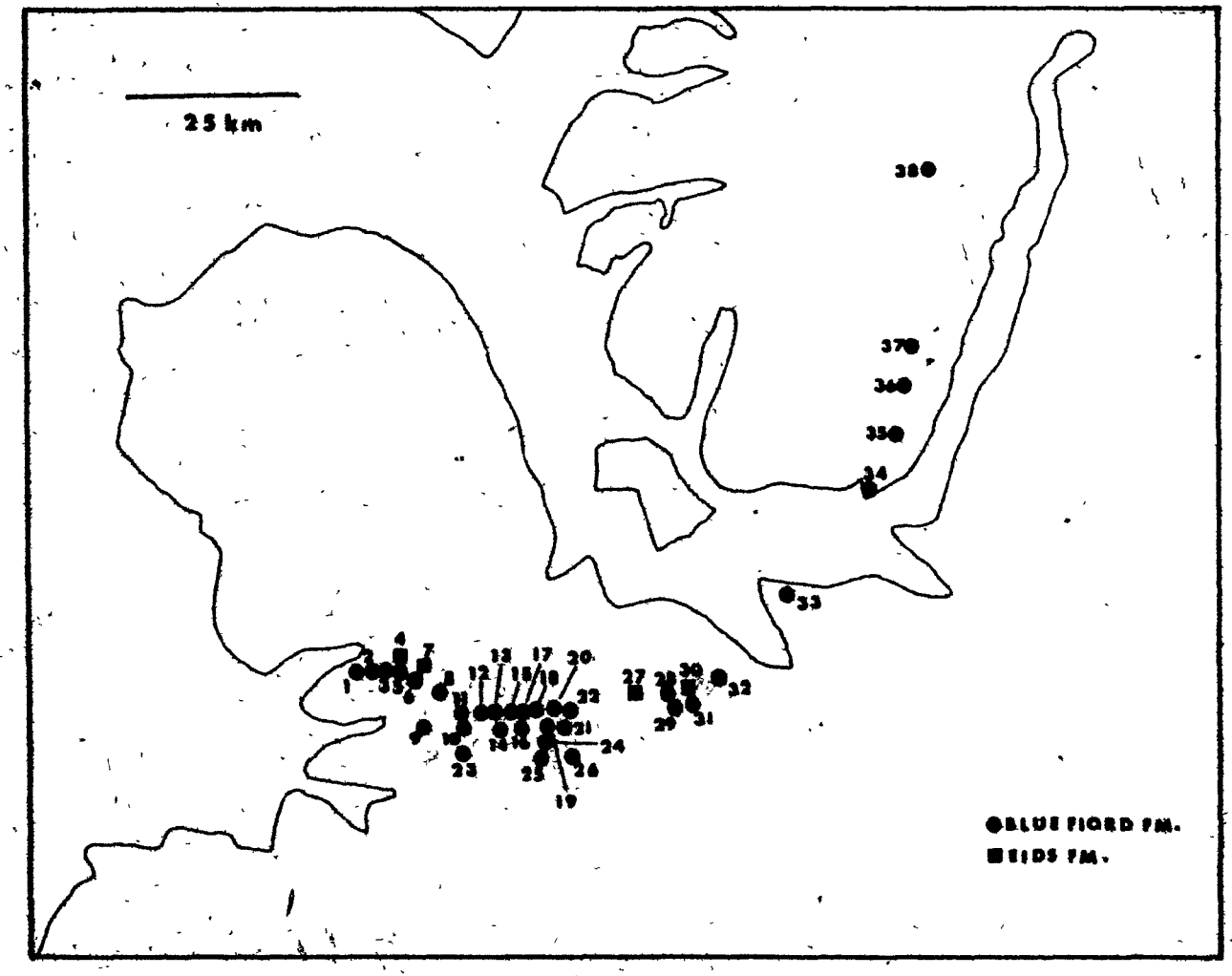


FIGURE 5-8. Location of Lower Devonian carbonate buildups, southern Ellesmere Island and their types.

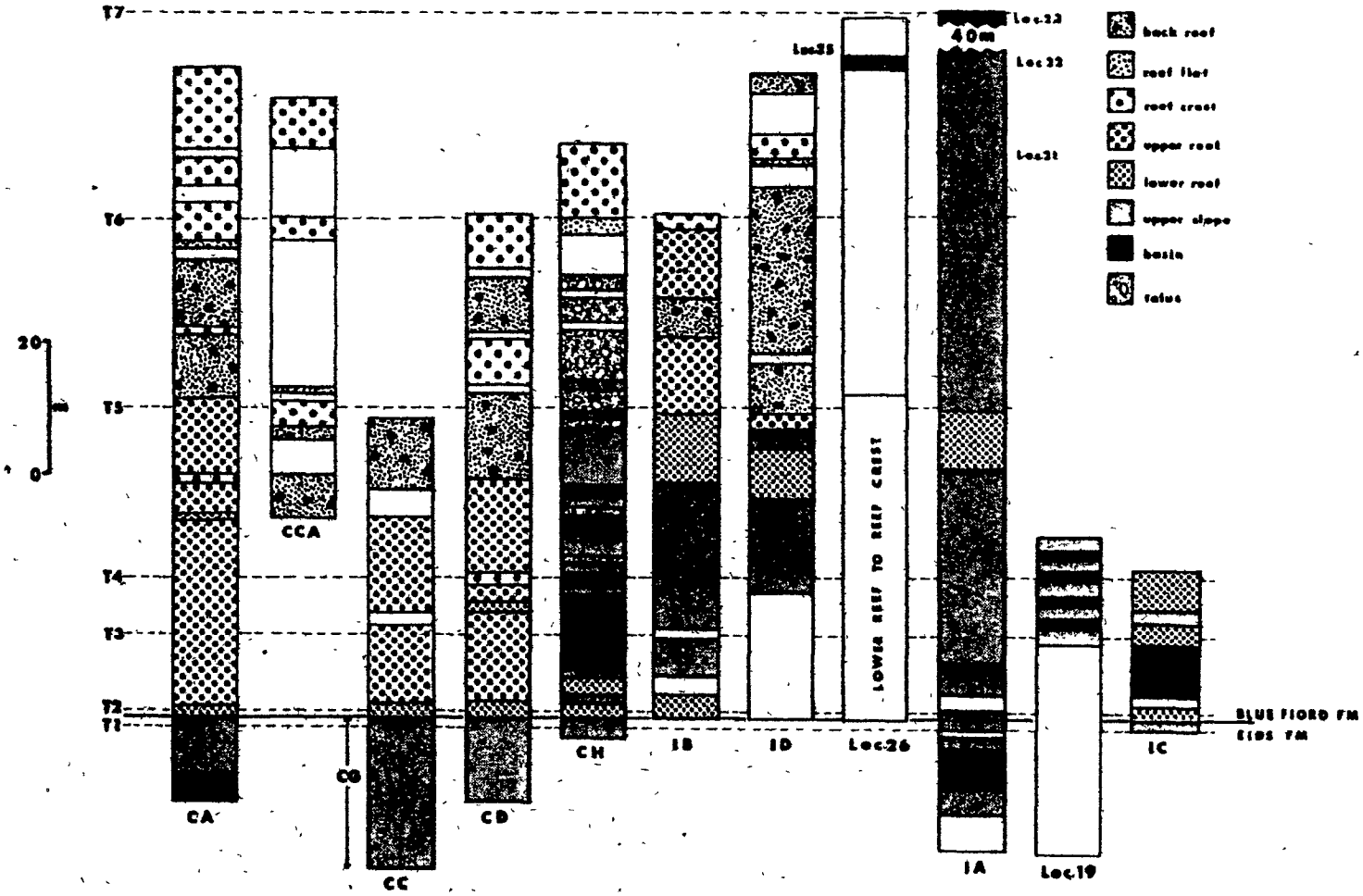


FIGURE 5-9. Lateral and vertical distribution of reef facies in the "Camp C" area

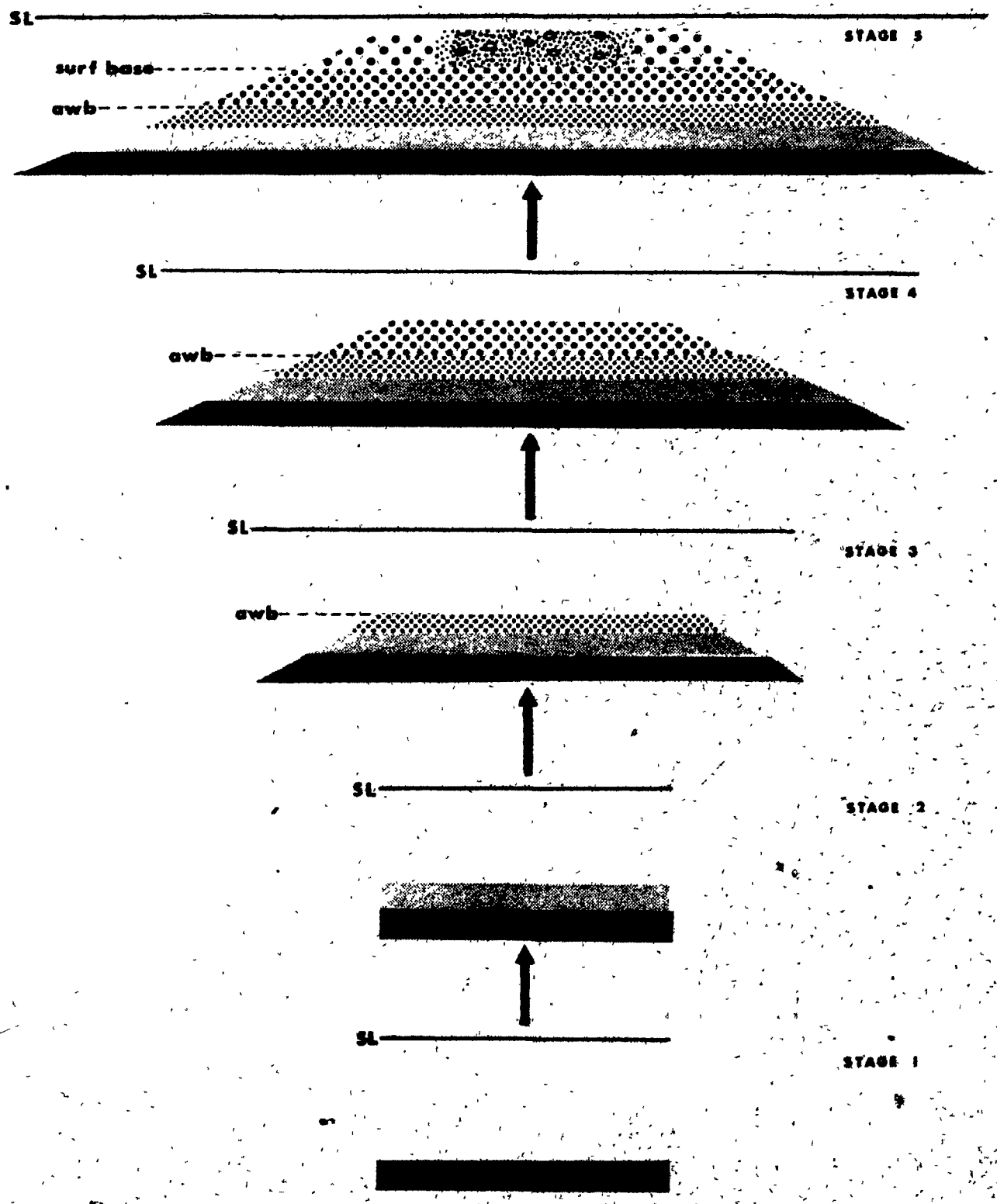
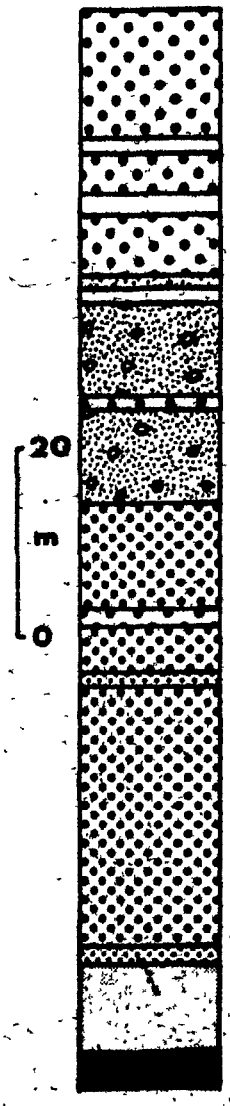


FIGURE 5-10. Vertical community succession in the Blue Fiord Formation reef. Rock symbols as in Fig. 5-9.



PHYSICAL CONTROL	BIOLOGIC CONTROL
TURBULENT	DOMINATION
SUBTURBULENT	DIVERSIFICATION
TURBULENT	DOMINATION
SUBTURBULENT	DIVERSIFICATION
QUIET WATER	COLONIZATION
SUBTURBULENT	DIVERSIFICATION
	COLONIZATION
QUIET WATER	STABILIZATION

FIGURE 5-11. Two differing interpretations of the control on the community succession observed in the Blue Fiord Formation reef

FIGURE 5-12. "Time-slice" diagrams showing the depositional history of the Blue Fiord Formation atoll from T1 to T4 of Figure 5-9.

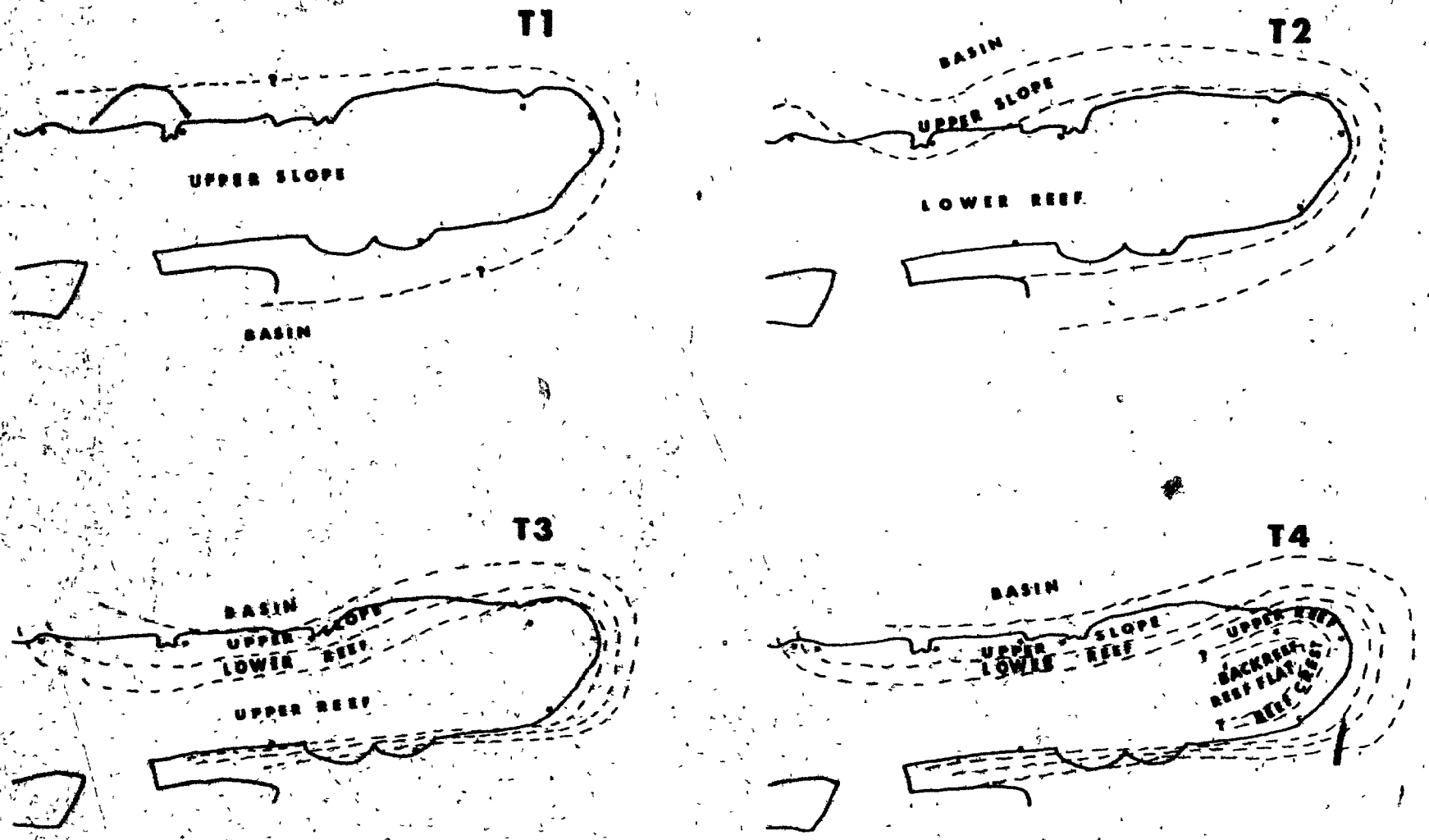

T1
UPPER SLOPE
BASIN
T2
BASIN
UPPER SLOPE
LOWER REEF
T3
BASIN
UPPER SLOPE
LOWER REEF
UPPER REEF
T4
BASIN
UPPER SLOPE
LOWER REEF
UPPER REEF
BACKREEF
REEF FLAT
REEF CREST

FIGURE 5-12

FIGURE 5-13. "Time-slice" diagrams showing the depositional history of the Blue Fiord Formation atoll from T5 to T7 of Figure 5-9.

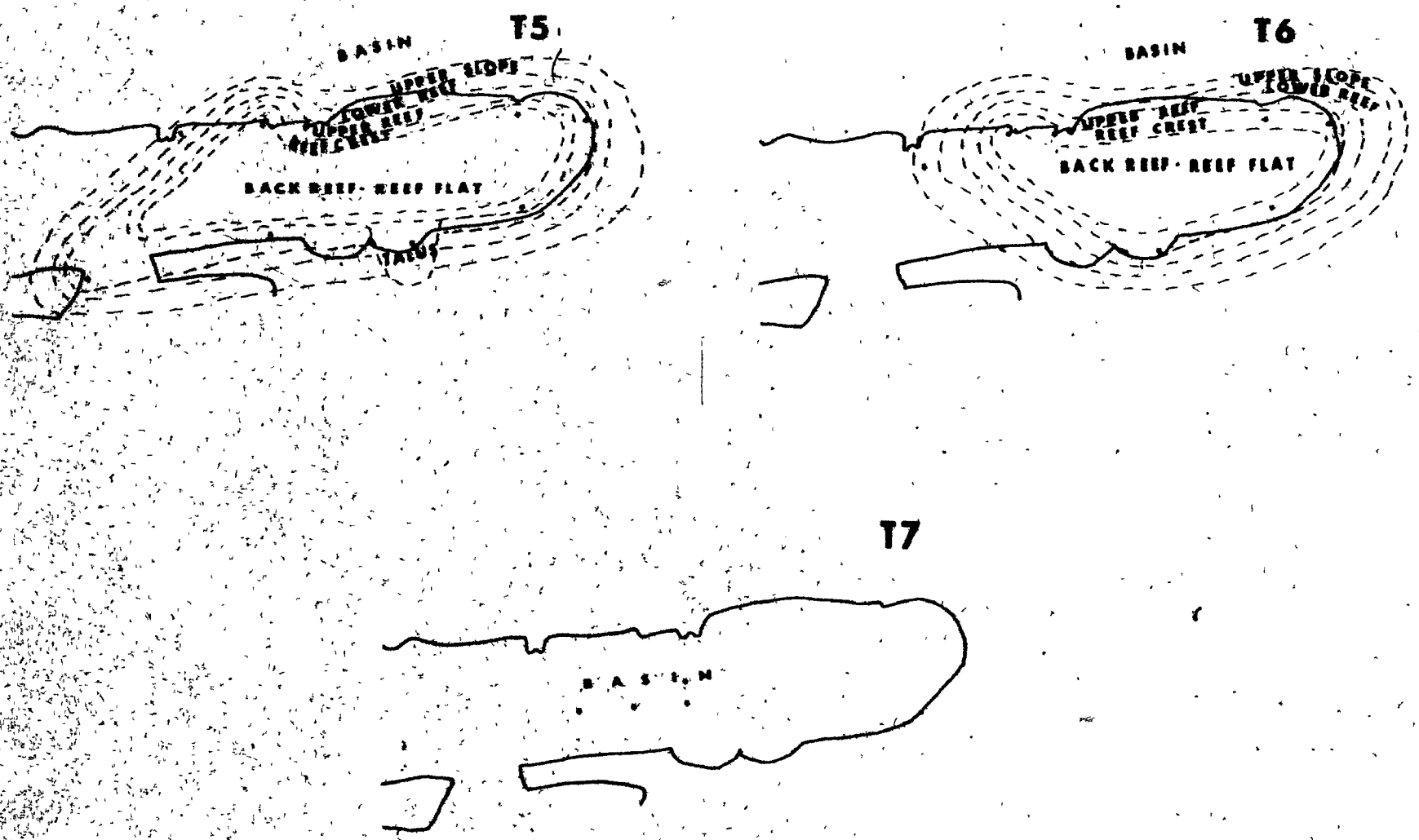

T5
BASIN
UPPER SLOPE
LOWER REEF
UPPER REEF
REEF CREST
BACK REEF - REEF FLAT
TALUS
T6
BASIN
UPPER SLOPE
LOWER REEF
UPPER REEF
REEF CREST
BACK REEF - REEF FLAT
T7
BASIN

FIGURE 5-13

	Traverse	Total Thickness (m)	FRAMEWORK (%)			MATRIX (%)		
			Alveolites	*Spongonaria*	Stromatoporoids	Lime mud	Wackestone	Packstone
AAA17	TA	1.3	45	-	2	-	53	-
	TB	1.3	31	-	-	-	69	-
	TC	1.4	34	-	-	-	66	-
	TD	1.3	55	-	2	-	42	-
	Ave	1.3	41	-	1	-	58	-
AD37	TE	1.9	20	64	-	15	-	2
	TF	2.2	17	39	11	-	16	19
	TG	2.1	-	-	-	14	40	46
	TH	1.5	35	23	-	5	21	16
	TJ	1.2	52	-	-	4	30	14
	TK	1.8	71	-	-	-	22	7
	Ave	1.8	33	21	2	6	17	17

FIGURE 5-14. Percentage of components in AAA17 and AD37 buildups.

CORAL NAME	FIRST REPORT IN ARCTIC ISLANDS?	MATERIAL	ELLESMERE ISLAND				BATHURST ISLAND	
			UPPER EIDS	LOWER BLUE FIORD	UPPER BLUE FIORD	DISAPPOINTMENT BAY	BLUE FIORD	LIMESTONE MEMBER DISAPPOINTMENT BAY
Acanthophyllum sp.	X	2					2	
Cavanophyllum sp.	X	6		6				
Dendrostella trigemma		3						3
Dohmophyllum sp.		8		7		1		
Embolophyllum sp.		6	1	4	1			
Hexagonaria sp.	X	23		23				
Lekanophyllum sp. cf. *L. retiforme*		6		1			5	
Manayphyllum ugenoi ugenoi		1		1				
Mochlophyllum sp.	X	7	7					
Paraspongonaria delicata		1		1				
Planetophyllum sp. nov.	X	3		3				
Pseudamplexus sp.	X	2		2				
Spongonaria filicata	X	4		3	1			
S. lowei		17	9	8				
S. ogilviensis		25		24		1		
S. paroa		73	6	61	6			
S. sp. nov. 1	X	5	1	2	1	1		
S. sp. nov. 2	X	5		4	1			
Talmyrophyllum nolani baumannense		2					2	
Talmyrophyllum sp. nov.	X	2					2	
Tanaphyllum atypica	X	3					3	
Thaulelasma lowei		1		1				
Utaratuia sp.	X	13		13				
Zaolasma apatiferum	X	3	3					
Zonophyllum sp. cf. *Z. soranse*		1		1				
Alveolitella sp.	X	527	86	441				
Alveolites sp.		261	14	200	14	13	20	
"potato-chip" *Alveolites*		35		35				
Favosites sphaericus	X	4		4				
Favosites sp.		141	21	107	10	1	2	
Heliolites sp.		1		1				
Hillaspora sp.	X	3						3
Roemeria sp. cf. *R. infundibulifera*	X	11	9	2				
Roemeripora progenitor		19	1	14	4			
Syringopora formosa	X	1		1				
S. schulzei	X	14	1	13				
Syringoporella moraviooformis		10	1	7	1		1	
Thamnopora randei	X	550	111	388	31	20		
T. sp. cf. *T. randei*	X	10		10				
Yaoutiopora hillae	X	76					76	
TOTAL		1885	271	1388	70	37	113	6

FIGURE 6-1. Composition of coral fauna

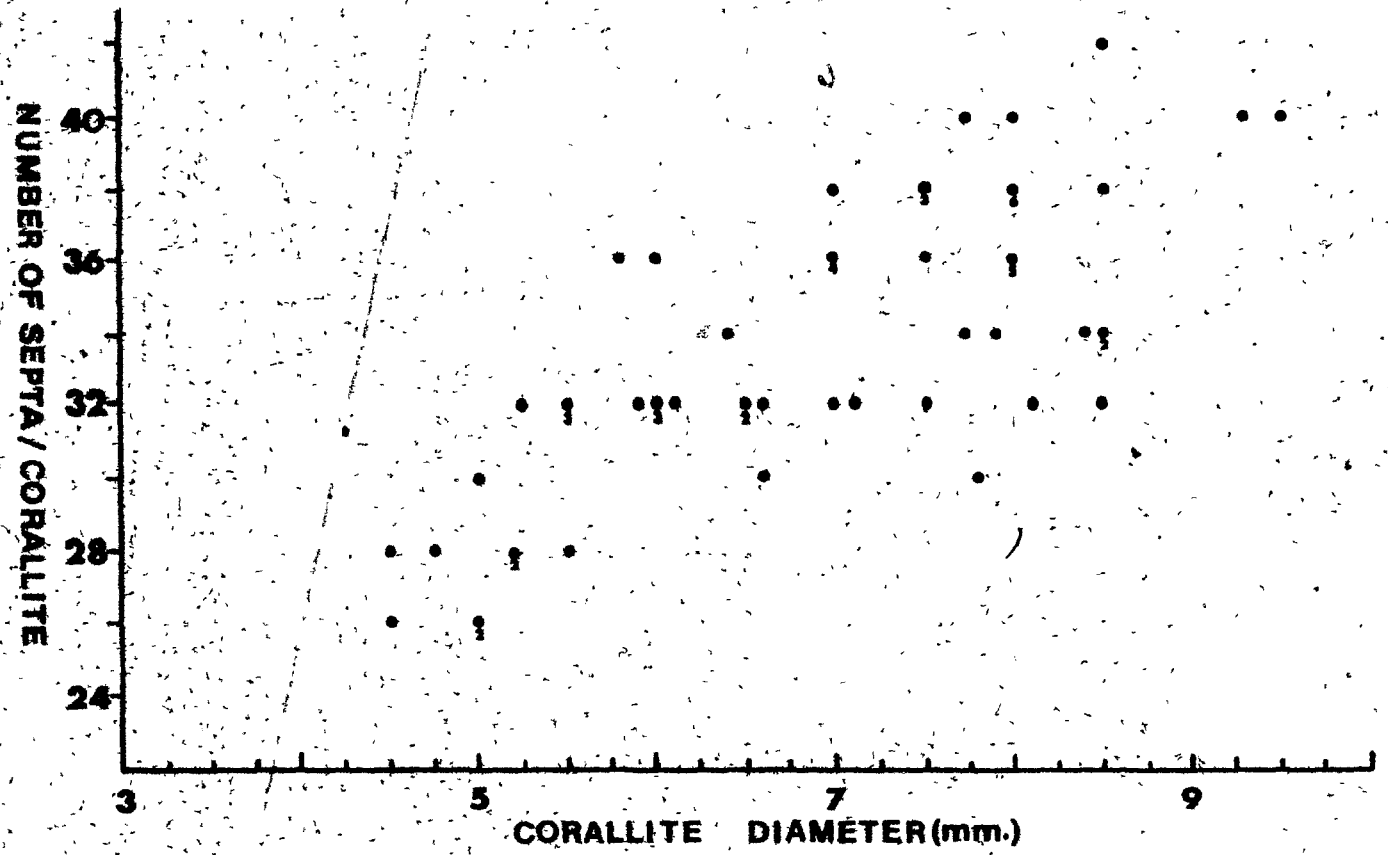


FIGURE 6-2. Graph plotting corallite diameter (mm) versus number of septa/corallite in *Spongonaria parca*. Numbers underneath points represent multiple data available.

FIGURE 6-3. Graph plotting corallite diameter (mm) versus tabular density (tabulae/mm) in *Favoattes* sp.

GENUS	GENERIC RANGE	SPECIES	SPECIES RANGE
Cavanophyllum	Lower Devonian		-
Dohmophyllum	Lower to Middle Devonian		-
Embolophyllum	Lower to ?Middle Devonian		-
Hexagonaria	Middle to Upper Devonian		-
Lekanophyllum	Lower to Middle Devonian	*retiforme*	- Dalejan (or younger)
Mansuyphyllum	upper Lower to Middle Devonian	*uyenoi uyenoi*	- Lower to Upper Zlichovian
Moohlophyllum	Middle Devonian		-
Paraspongonaria	upper Lower Devonian	*delicata*	- Dalejan
Planetophyllum	upper Lower Devonian		-
Pseudamplexus	Lower Devonian		-
Spongonaria	upper Lower Devonian	*filicata*	- Zlichovian to Dalejan
		loewei	- Lower to Upper Zlichovian
		ogilviensis	- Upper Zlichovian to Dalejan
		parca	- Lower Zlichovian to Dalejan
Thoulelasma	upper Lower Devonian	*loewei*	- Dalejan
Utaratuia	Middle to Upper Devonian		-
Zelolasma	middle to upper Lower Devonian	*apsidiferum*	- Lower Zlichovian
Zonophyllum	Lower to Middle Devonian	*sorense*	- Upper Zlichovian
Alveolitella	Middle Devonian		-
Alveolites	Upper Silurian to Upper Devonian		-
Favosites	Upper Ordovician to Middle Devonian	*sphaericus*	- Pragian
Heliolites	Middle Ordovician to Middle Devonian		-
Roemeria	Middle Devonian	*infundibulifera*	- Eifelian
Roemeripora	Lower to Middle Devonian	*progenitor*	- Lower to ?Middle Devonian
Syringopora	Upper Ordovician to ?Lower Permian	*formosa*	- Middle Devonian
		schulzei	- Lower to Middle Devonian
Syringoporella	?Lower to Middle Devonian	*moravicoformis*	- Lower to Middle Devonian
Thamnopora	Lower to Upper Devonian	*randsi*	- Lower to ?Middle Devonian

FIGURE 6-4. Generic and specific ranges of corals, Ellesmere Island

GENUS	GENERIC RANGE	SPECIES RANGE
Acanthophyllum	?Lower to Middle Devonian	-
Dendrostella	Lower to Middle Devonian	*trigemme* - Upper Eifelian
Lekanophyllum	Lower to Middle Devonian	*retiforme* - Dalejan (or younger)
Taimyrophyllum	Lower to Middle Devonian	*nolani baumannense* - Lower Zlichovian
Taunphyllum	Middle Devonian	*atypica* - Middle Devonian
Alveolites	Upper Silurian to Upper Devonian	-
Favosites	Upper Ordovician to Middle Devonian	-
Hillaspora	Lower Devonian	-
Syringoporella	?Lower to Middle Devonian	*moravicoformis* - Lower to Middle Devonian
Yacutiopora	Lower to ?Middle Devonian	*hillae* - Lower to ?Middle Devonian

FIGURE 6-5. Generic and specific ranges of corals, Bathurst Island

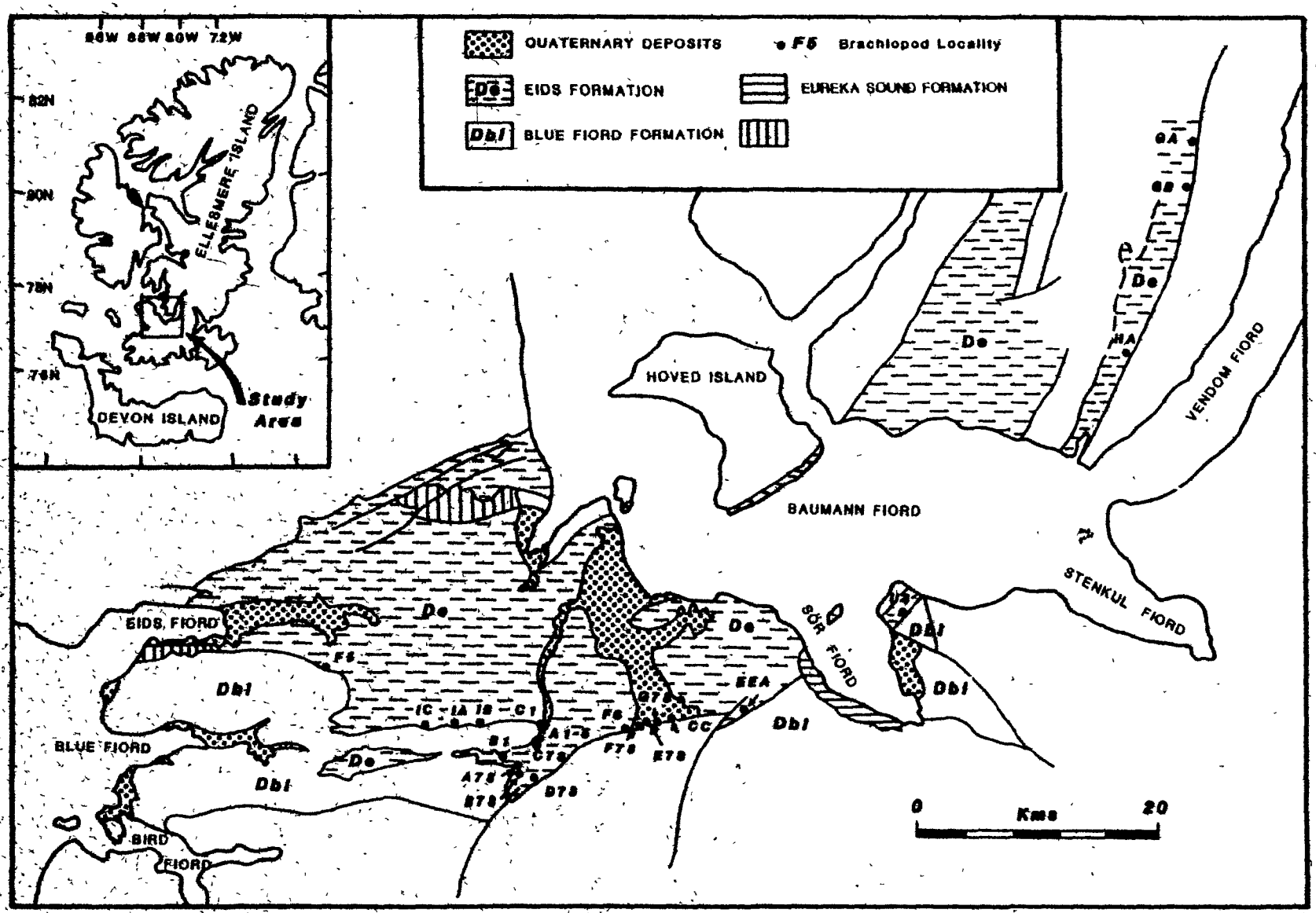


FIGURE 7-1, Localities where brachiopods were collected from the Eids Formation, southern Ellesmere Island

SPECIES	LOCALITY																								
	GA	GB	HA	U4	EEA	CC	G78	E78	F78	F6	A78	B78	D78	B1	C78	A1	A3	A4	A5	C1	IB	IA	IC	F5	Total
Atrypa sp. B		6	16	8	38	112				18				6		6	10	8	8	3			7	9	255
Atrypa sp. D	38																		8						46
Atrypa aff. A. aspiformis							142	18	12		32	1	17		6										228
Atrypa spp.			1																						1
Athyrhynchus loriei				31			7	22	38	15	2		2												117
Carinagyna asppiata						6	19	7	2	1						5		5	11				1	4	60
Carinagyna lowaryi				17																					17
Cortesorthis maclareni	3		32	10		19	25	151	256	107	365	79	102	116	19	2		11	3		8	9	48		1366
Cyrtina sp.				1		1		1						3										1	7
Cymostrophia sp.	2	1	3												1			2	1	3				1	14
Boschuchertella tuktui	420	11	3					1		1											2			1	439
Howellella smithi	9	2	18																						29
Minutostrophedonta? sp.	2		3	1																					6
Nucleospira subsphaerica	14		9	5	2					14	318	11		2										1	376
Parachonetes macrostriatus	5	4	2			10	8	3	2																34
Parapholidostrophia harperi			36	1	4	5	18	272	139	855	85	9	35	106	14				1		17		2	13	1612
Parapholidostrophia sorensis	28			35		180	100	226	227	165	37	8	54		2							12			1074
Parryspirifer schei	99	17	284		3		1	2	2	2	4	1	1	3	29	2		6	17	16	11	4		19	523
Schizophoria sidensis										160	153	5	2	10	16	3		22	41		3		186	1	602
Schizophoria nevadaensis								33	176																209
Sieberella? sp.																								2	2
Spinatrypa sp.			1														1								2
Strophodonta irwini		2	1							1	30	3		7							1	1			46
Trigonirhynchia occidens	11	62	488	4			2	6	2	4														2	581
Warrenella transversa				97		159			49	3	4										4	3			319
indet. strophomenid (transv.)				3																					3
indet. strophomenid				1																					1
Vagrania amaroki																								332	332
Total	631	105	897	214	47	492	322	742	905	1346	030	117	213	253	87	18	11	54	91	22	46	29	244	385	8301

FIGURE 7-2. Composition of the brachiopod fauna from the Eids Formation, southern Ellesmere Island

GENUS	SPECIES	#	% FAUNA	E. pinyonensis Zone?
Anastrophia(?)	sp.	1	0.1	
Athyrhynchus	*A. loriei*	8	0.5	X
Atrypa	*A.* sp. A	306	17.5	X
	A. sp. B	206	11.8	
	A. sp. C	20	1.2	
Carinagypa	*C. aseptata*	124	7.1	X
	C. maclarenі	100	5.7	X
Chonetes	*C.* sp. A	78	4.5	X
	C. sp. B	11	0.6	
	C. sp. C	4	0.2	
	C. sp. D	27	1.6	
Cortesorthis	*C. maclarenі*	38	2.2	X
Costacrania	sp.	3	0.2	
Costellirostra	sp.	141	8.1	
Cymostrophia(?)	sp.	52	3.1	X
Cyrtina	sp.	13	0.8	X
Eoschuchertella	*E. tuktui*	12	0.7	X
Howellella	*H. smithi*	1	0.1	
	H. sp. A	9	0.5	
	H. sp. B	3	0.2	
Lingula	sp.	29	1.7	X
Megastrophia (Megastrophiella)	sp.	3	0.2	X
Nalajadospirifer	sp.	2	0.1	X
Nucleospira	*N. subsphaerica*	6	0.3	X
Orbiculoidea(?)	sp.	1	0.1	X
Parachonetes	*P. macrostriatus*	22	1.3	X
Paraphalloidostrophia	*P. harperi*	46	2.6	
	P. sorensis	32	1.8	
Perryspirifer	*P. schuli*	118	6.8	
Phaganostrophia	*P.* sp. aff. *P. marriami*	13	0.8	X
Schizophoria	*S. nevadaensis*	145	8.3	X
	S. sp.	5	0.3	
Spinatrypa	sp.	62	3.6	
Indet. stropheodontid		5	0.3	X
Trigonirhynchia	*T. occidens*	6	0.3	X
	T. sp. aff. *T. occidens*	26	1.5	X
Warrenella	*W. diffusata*	7	0.4	X
	W. eatonea	1	0.1	
	W. franklini prosfranklini (f.t.)	36	2.1	
	W. transversa	24	1.4	X
Total		1746		

FIGURE 7-3. Composition of the brachiopod fauna from the Blue Fiord Formation, southern Ellesmere Island

NAME	# OF SPECIMENS
Dechenella (Dechenella) spaekkassensis	11
Harpes macrocephalus	2
Leonaspis (Kettneraspis) elliptica	1
Proetus sp. cf. *P. bohemicus*	1
Scutellum (?) sp.	1
Schizoproetoides richteri	44
Total	60

FIGURE 8-1. Composition of trilobite fauna

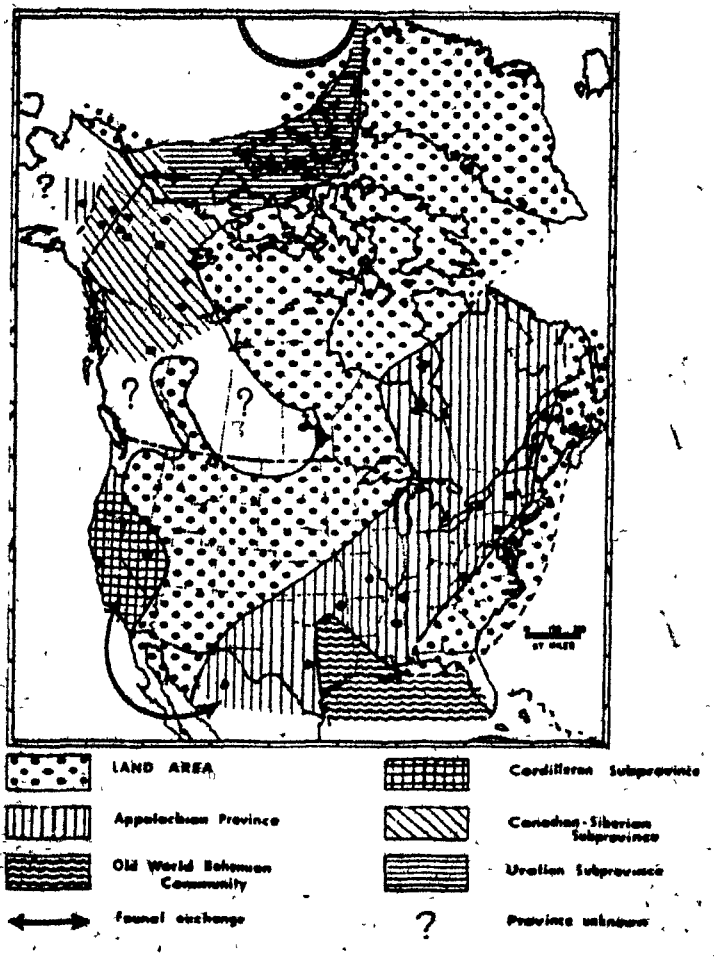


FIGURE 8-2. Emsian-Eifelian trilobite paleogeography of North America (from Ormiston, 1975)

NAME	# OF SPECIMENS
Dioricoconus dutroi	2
Dioricoconus sp. cf. *D. dutroi*	18
Dioricoconus sp.	128
Homoctenus sp.	101
Styliolina sp. cf. *S. fissurella*	8
"New genus" Churkin and Carter sp. nov.	166
Total	423

FIGURE 8-3. Composition of cricoconarid fauna

STAGE	CONODONT ZONE (UYENO & KLAPPER, 1980)	DACRYOCONARID ZONATION (LÜTKE, 1979)	TENTACULITID ZONATION (THIS STUDY)
DALEJAN	*P. serotinus*	*N. richteri*	?
			Dicricoconus sp.
	P. inversus	*N. cancellata*	?
		N. elegans	*D. dutroi* & "New genus & species" Churkin and Carter
UPPER ZLICHOVIAN	*P.* aff. *perbonus*	*N. barrandei*	?
			"New genus" Churkin and Carter sp. nov.
LOWER ZLICHOVIAN	*P. dehiscens*	*N. zlichovensis*	?

FIGURE 8-4. Comparison of conodont, dacryoconarid, and tentaculite zonation of the upper Lower Devonian, Ellesmere Island

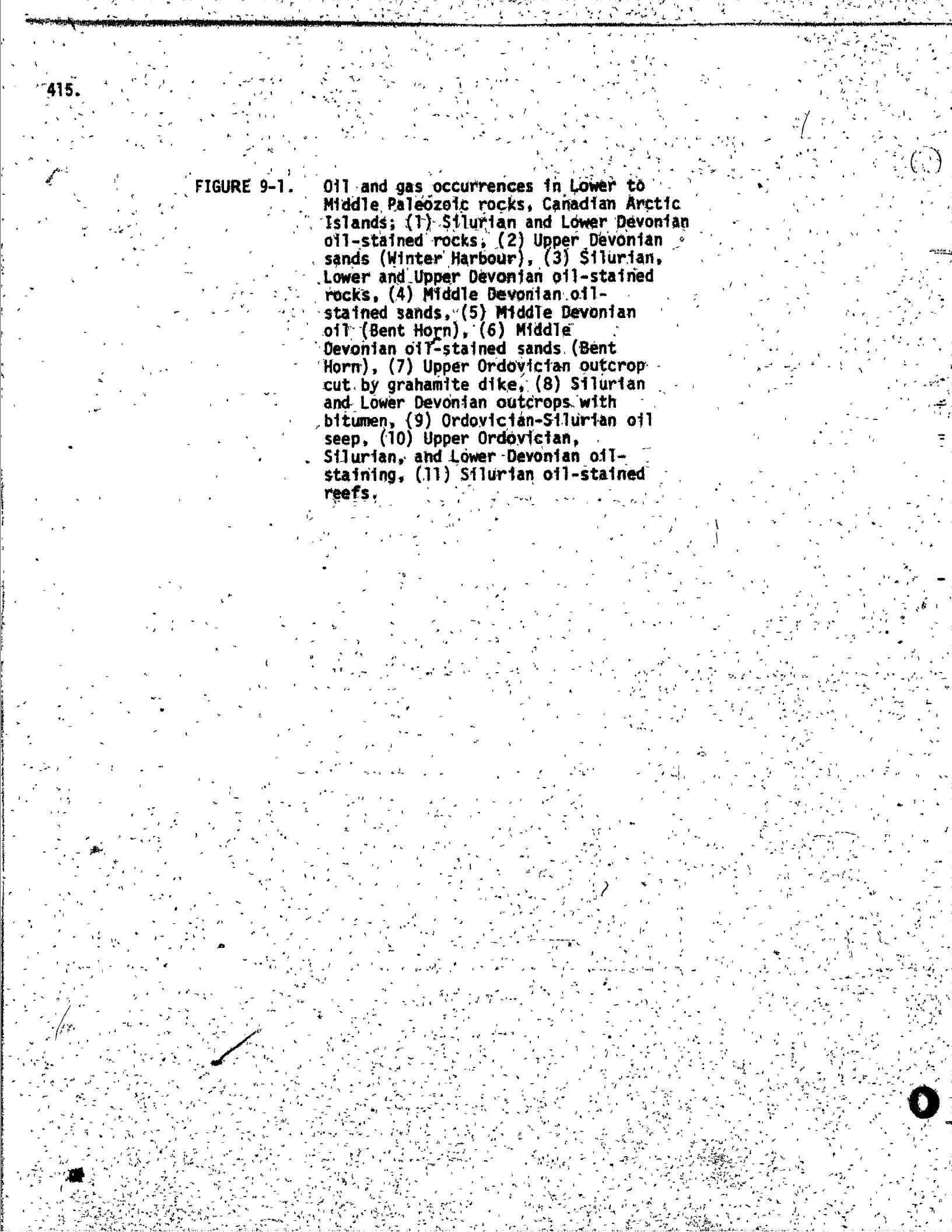


FIGURE 9-1. Oil and gas occurrences in Lower to Middle Paleozoic rocks, Canadian Arctic Islands; (1) Silurian and Lower Devonian oil-stained rocks, (2) Upper Devonian sands (Winter Harbour), (3) Silurian, Lower and Upper Devonian oil-stained rocks, (4) Middle Devonian oil-stained sands, (5) Middle Devonian oil (Bent Horn), (6) Middle Devonian oil-stained sands (Bent Horn), (7) Upper Ordovician outcrop cut by grahamite dike, (8) Silurian and Lower Devonian outcrops with bitumen, (9) Ordovician-Silurian oil seep, (10) Upper Ordovician, Silurian, and Lower Devonian oil-staining, (11) Silurian oil-stained reefs.

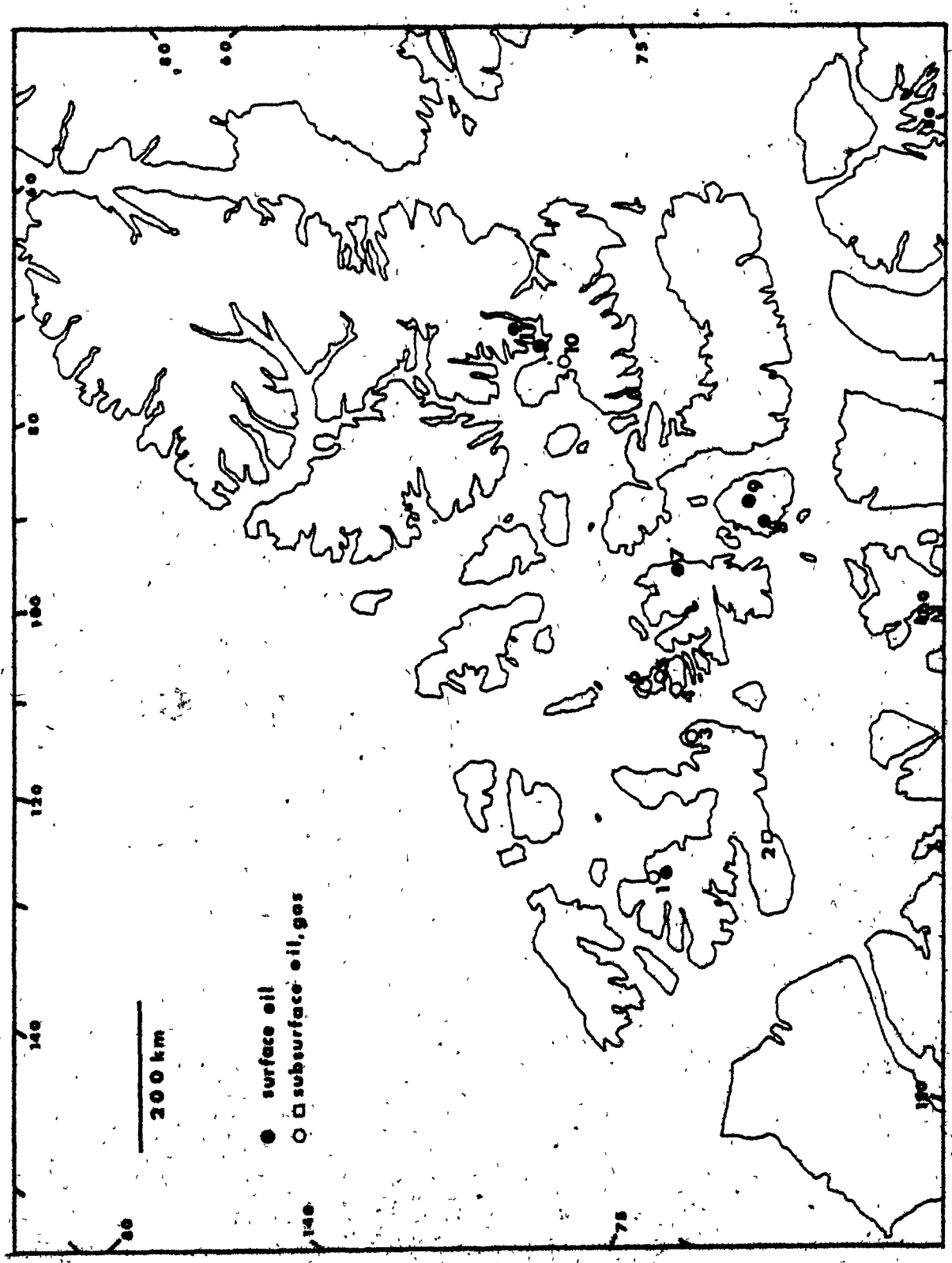

80
80
75
80
120
140
140
120
20
75
200 km
surface oil
subsurface oil, gas

FIGURE 9-1

PLATE 1. Selected aerial views of field area, southwest Ellesmere Island

a) east of Blue Fiord (facing west)
b) west of Vendom Fiord (facing northeast)
c) Goose Fiord (facing south)







PLATE I

PLATE 2. Typical measured sections, southwest Ellesmere Island

a) section CF
b) section IA
c) section AA(A)







PLATE 2

PLATE 3. Selected localities, Bathurst Island

a) B30 (type section of limestone member, Disappointment Bay Formation)
b) B42A (Disappointment Bay Formation)
c) B43 (Blue Fiord Formation)

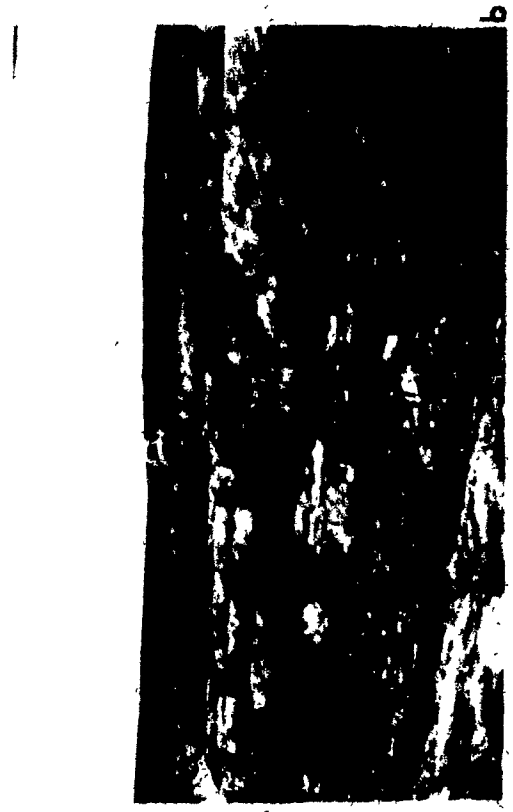






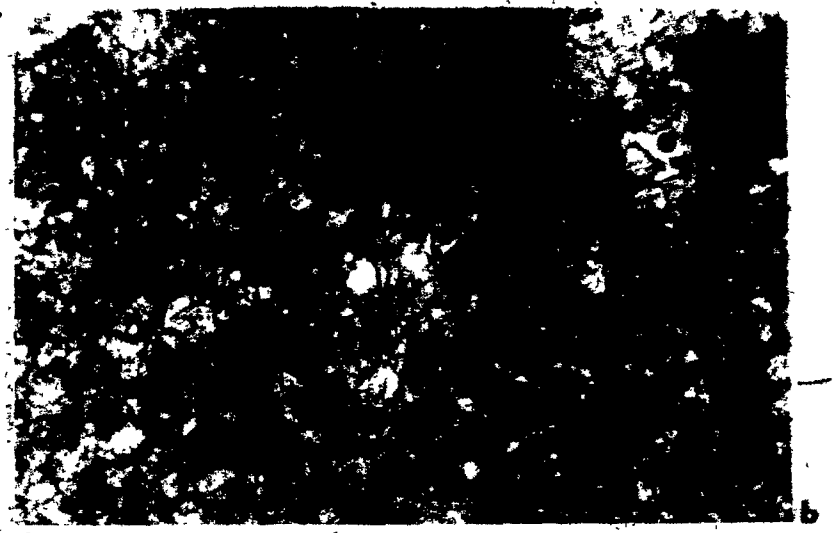
PLATE 3

PLATE 4. Goose Fiord Formation

a) desiccation cracks in dolostone facies, Locality 59
b) photomicrograph of dolostone facies, unit KA1 (x34)
c) laminated dolostone, illustrating desiccation crack and large intraclast, Locality 59 (x1)



a



b

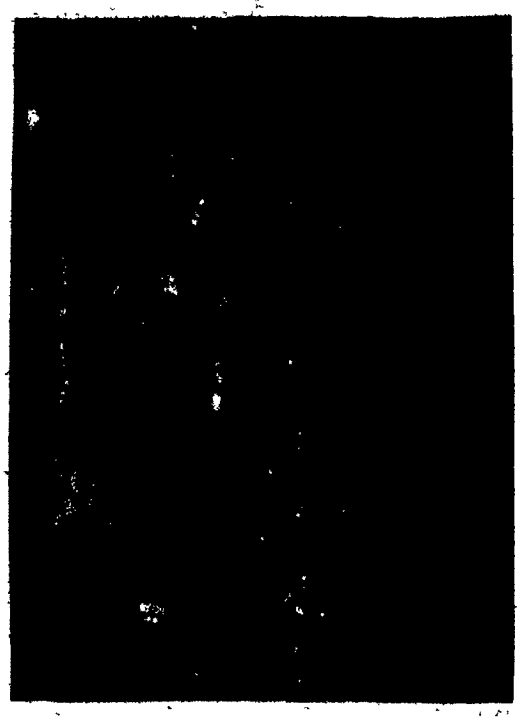


c

PLATE 4

PLATE 5. Eids Formation

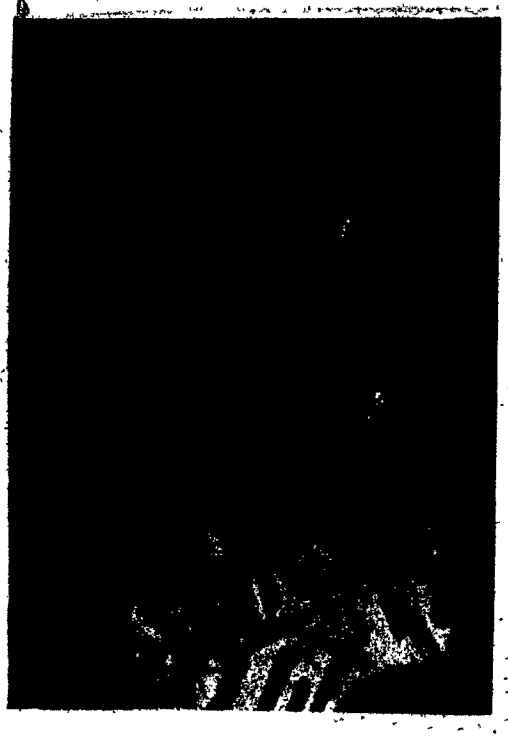
a) horizontal trace fossils on bedding plane of Lithofacies 1, Locality 37 (x0.5)
b) thin skeletal turbidite (Lithofacies 3), section EB
c) coral boundstone lithofacies, showing hemispherical *Alveolites* colonies, unit DA15



b



c



a

PLATE 5

PLATE 6. Disappointment Bay Formation: typical exposures

a) section FA (Borgen), facing west
b) south face of Borgen, showing fenestral dolostone and lime mudstone facies (light coloured), and fossiliferous limestone facies (dark coloured)
c) section KB from south
d) interbedded fenestral dolostone facies (light) and lime mudstone facies (dark), Locality 41



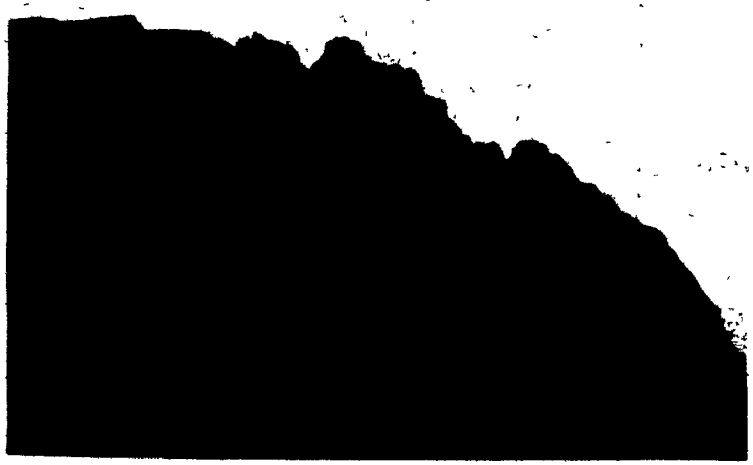
a



b



c



d

PLATE 6

PLATE 7. Disappointment Bay Formation: fenestral dolostone lithofacies

a) photomicrograph of fenestral dolostone facies, showing fenestrae (x34)
b) burrowed hardground surface, unit FA25 (x0.5)
c) wavy (algal) laminated dolostone, unit FA27 (x1.5)
d) interlaminated dolostone and silt layers penetrated by a large vertical burrow, unit HC19
e) current ripples, unit HC19 (x0.5)
f) graded, skeletal storm washup layer, unit HC19 (x1)

PLATE 7

PLATE 8. Disappointment Bay Formation: fenestral lime mudstone lithofacies

a) fenestral lime mudstone facies, showing tubular and irregular fenestrae, and dissolved gastropod shell (arrow), unit HC44 (x1)
b) oligomictic cemented rubble packbreccia, Locality 47 (x1)
c) photomicrograph of fenestral lime mudstone lithofacies, showing calcispheres, peloids, fenestrae, and microspar matrix, unit HA56 (x55)
d) photomicrograph of peloidal grainstone subfacies, showing peloids, abundant micritization, and cement, unit KA48 (x34)





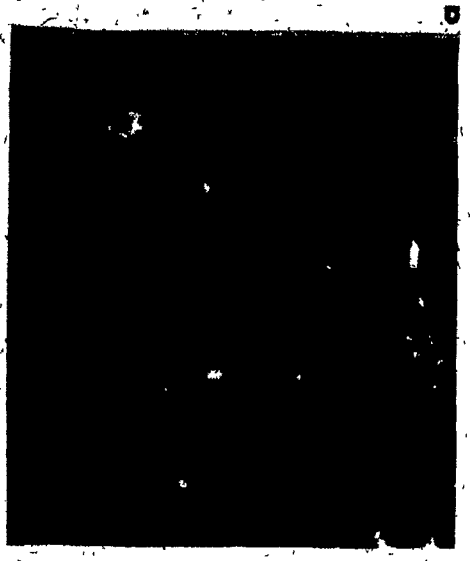




PLATE 8

PLATE 9. Disappointment Bay Formation: fossiliferous limestone (3) and siltstone (4) lithofacies

a) fossiliferous limestone lithofacies (dark coloured) wedging out into fenestral dolostone lithofacies, section FA (cliff face approximately 10 m high)
b) siltstone lithofacies, showing the well sorted, subrounded nature of the grains, unit FA5 (x55)

b

a

PLATE 9

PLATE 10. Blue Fiord Formation: boundary with Eids Formation

a) Blue Fiord Formation (cliff) separated from Eids Formation (lowland where tents are pitched) by talus interval. Boundary placed at first unit in cliff line, camp C.
b) interfingering nature of the boundary at Locality 53. Boundary placed at first well developed fossiliferous limestone unit (arrow).
c) discontinuous lens of limestone (coral boundstone) in upper Eids Formation, camp D area (facing east).
d) discontinuous lens of limestone in upper Eids Formation, separated from continuous cliff line (Blue Fiord Formation) by recessive shale interval, camp A area (facing east).

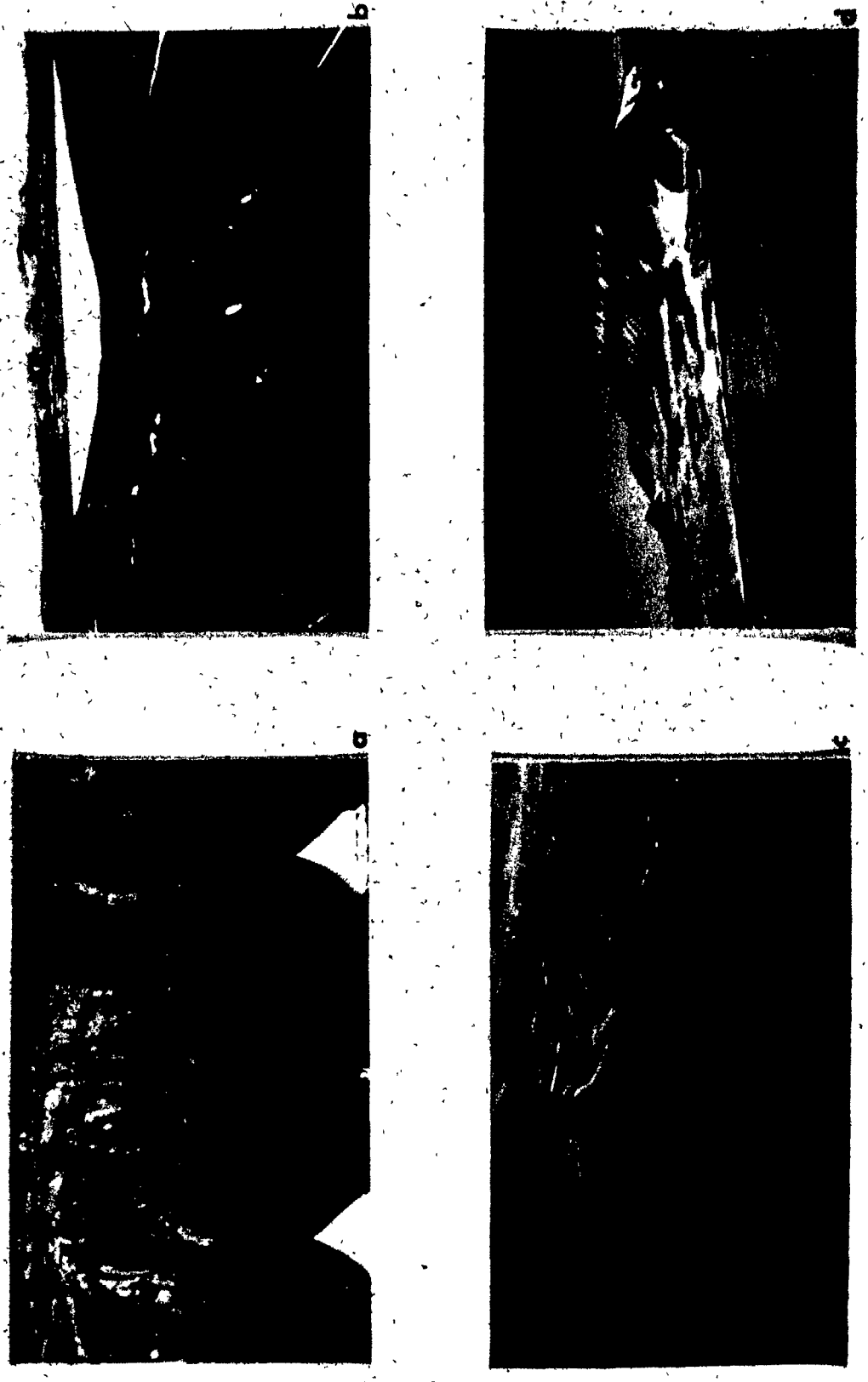


PLATE 10.

PLATE II. Blue Fiord Formation: Lithofacies 1 and 2

a) photomicrograph of ostracod-rich argillaceous limestone, unit GA35 (x34).
b) fossiliferous lime wackestone with *Thamnopora* and *Rhabdoporella stolleyi* (arrow), unit HA28 (x1.5)
c) photomicrograph of dasyclad-rich fossiliferous lime wackestone with *Alveolitella* (A) and *Rhabdoporella bascillum* (R), unit HB34 (x34).
d) coral-rich lime wackestone, with *Tauraphyllum atypica* (T), *Yacutiopora hillae* (Y), and *Alveolites* (A), Locality B37.

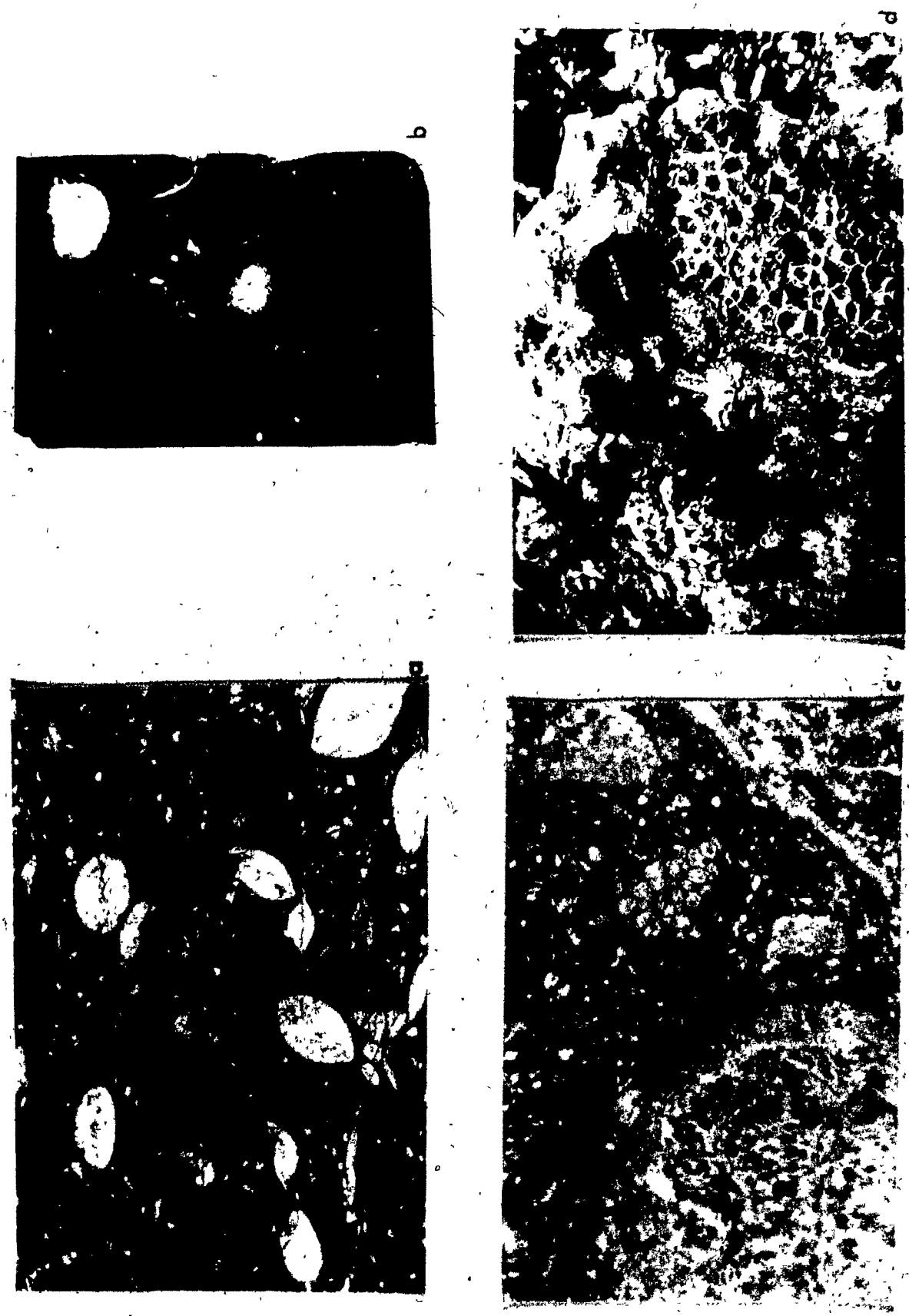


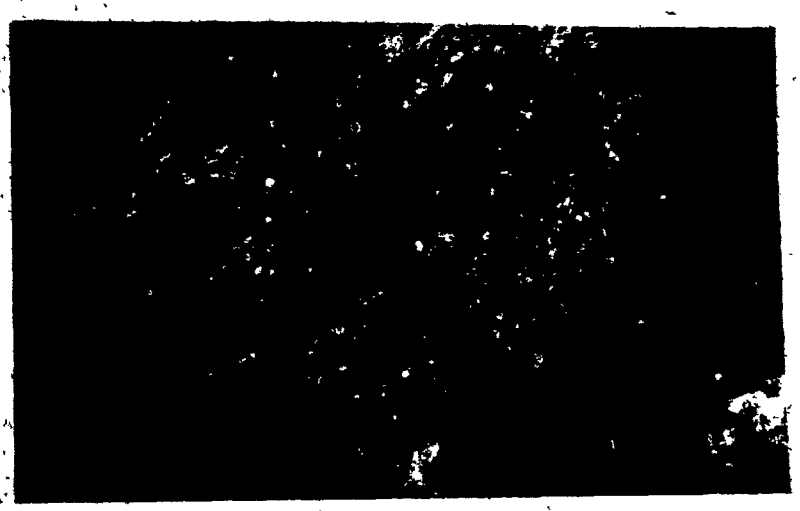
PLATE II

PLATE 12. Blue Fiord Formation: Lithofacies 3 and 4

a) abundant *in situ* coral colonies, unit ED48 (staff divided into decimeters).
b) coral-rich boundstone, with abundant debris of large crinoid columnals, and a colony of *Spongonaria paroa*, unit ED48
c) crinoid grainstone facies (light coloured cliff), Locality 52 (unit approximately 20 m thick).
d) photomicrograph of crinoid grainstone facies, showing abundant crinoid ossicles and syntaxial cement (x34).



a



b



c



d

PLATE 12

PLATE 13. Blue Fiord Formation: Lithofacies 5 and 6

a) brachiopod-rich argillaceous wackestone, unit AAA 3-11 (note hammer head on right).
b) coral-rich downslope buildup, unit AD37 (note man in foreground).
c) close up of unit AD37, showing great abundance of *in situ* coral colonies.
d) statistical studies on a downslope buildup, unit AAA17.



a



b



c

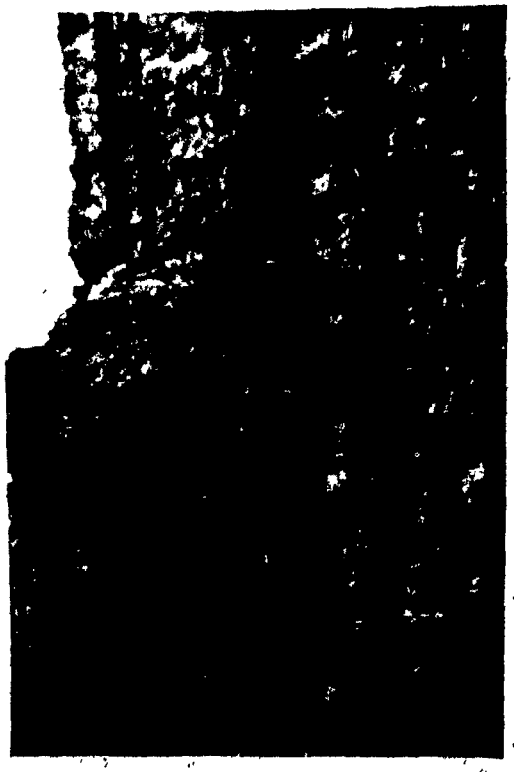


d

PLATE 13

PLATE 14. Blue Fiord Formation: - Lithofacies 8

a) thinly bedded lime mudstone and shale, section BB (section thickness approximately 80 m).
b) rhythmically interbedded lime mudstone and shale, section B25 (cliff height 10 m).
c) sedimentary boudinage, unit BA4.
c) photomicrograph of lime mudstone lithofacies, showing peloids, quartz silt, and *Styliolina*, unit BB5 (x55).



b



d



a

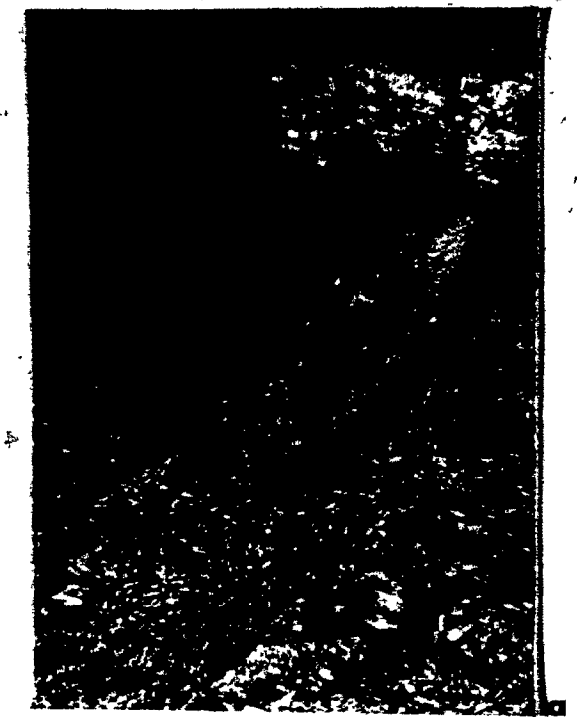


c

PLATE 14

PLATE 15. Blue Fiord Formation: Lithofacies 9

a) crinoidal turbidite (light coloured unit) resting sharply on interbedded lime mudstone and shale, section BB (turbidite unit 11 m thick).
b) crinoidal turbidite exhibiting graded bedding, unit CB3 (x1)
c) dasyclad-rich (*Rhabdoporella bascillum*) turbidite, unit AA22 (x1).
d) photomicrograph of crinoidal turbidite (x34).



a



b



c

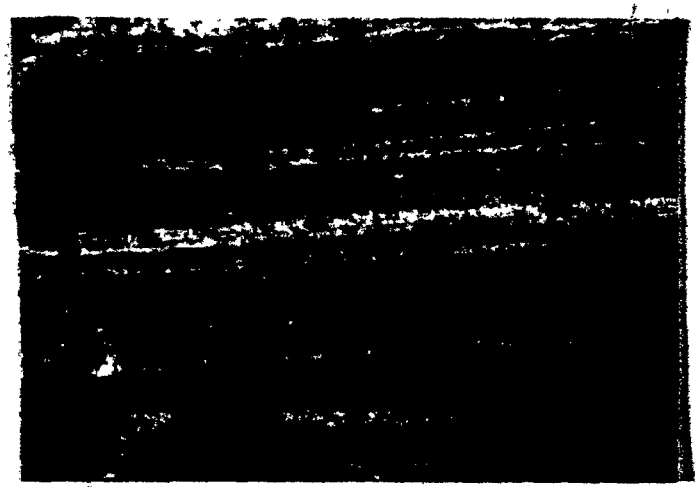


d

PLATE 15

PLATE 16. Blue Fiord Formation: Lithofacies 10

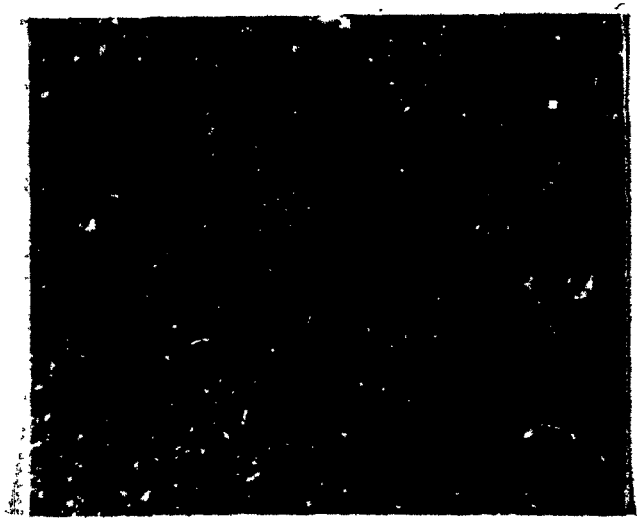
a) laminated limestone (light layers) and shale, unit JA2 (x1.5).
b) groove cast, Locality 23 (x1).
c) parallel lineation of sponge spicules, Locality 23 (x3).
d) micrograding in limestone laminae, Locality 23 (x40).



a



b



c



d

PLATE 16

PLATE 17. "Camp C" reef, with location of measured sections and localities.



PLATE 17

PLATE 18. Blue Fiord Formation reef complex.

a) view of "camp C" buildup from south (cliff height approximately 100 m).
b) shell bank composed of *Carinagypa maclareni*, upper slope facies, unit IA12 (note pen top for scale).
c) thin, platy colonies of *Alveolites*, lower reef facies, unit IB2.
d) branching colony of *Alveolitella*, lower reef facies, unit ID3.
e) debris bed containing *Alveolitella* and *Alveolites*, lower reef facies, unit IB2.

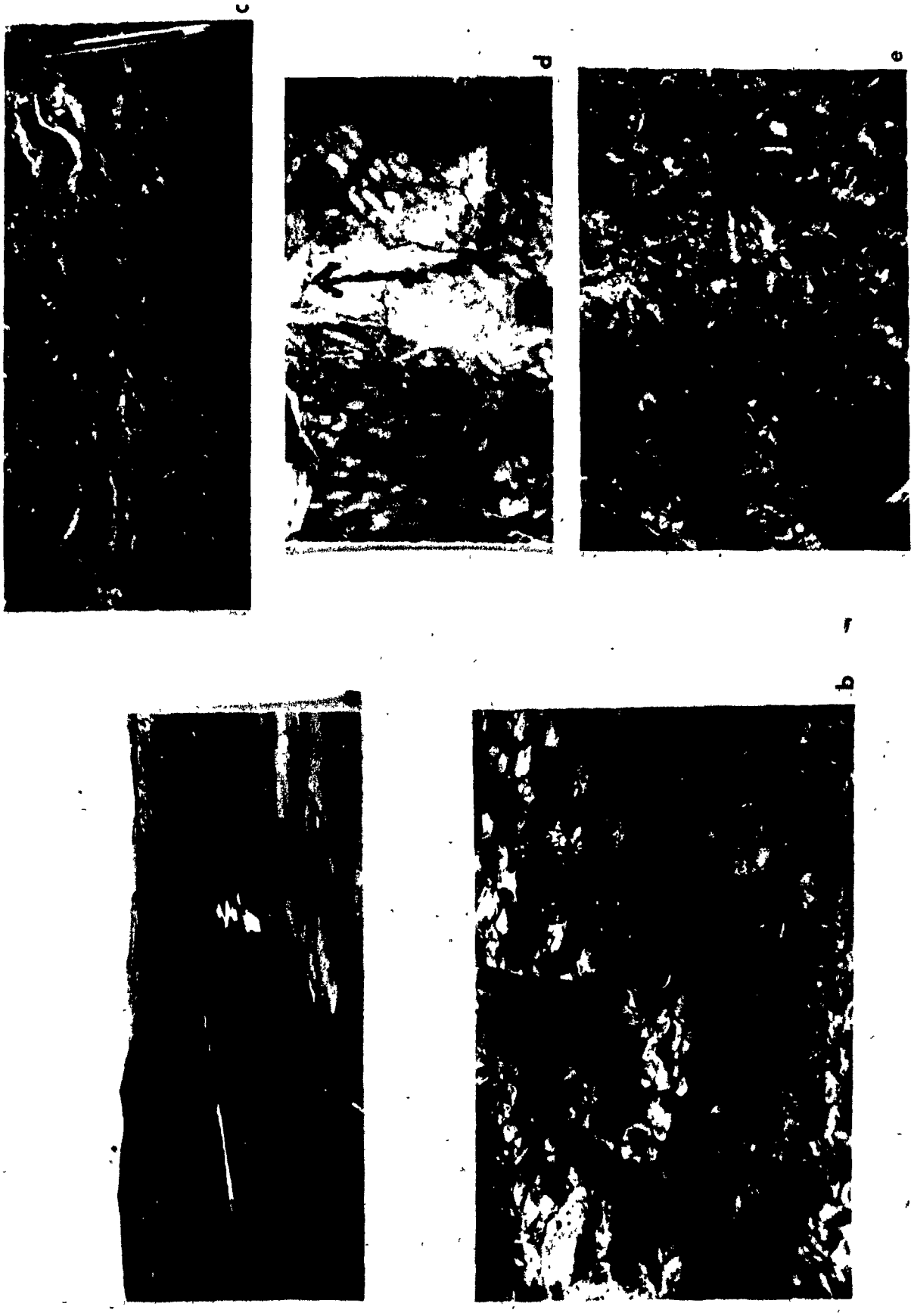


PLATE 18

PLATE 19. Blue Fiord Formation reef complex (cont.)

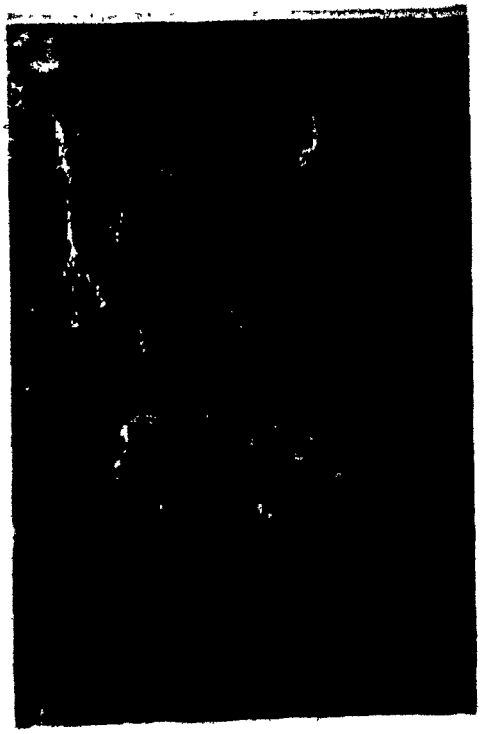
a) diverse coral assemblage, including *Spongonaria*(S), *Favosites*(F), and *Alveolites*(A), upper reef facies, unit CA5 .
b) laminar stromatoporoid colonies, reef crest facies, unit CA16.
c) photomicrograph of peloidal grainstone, showing evidence of micritization, reef flat facies, unit CCA6 (x34).
d) dasyclad wackestone composed of *Rhabdoporella bascillum*, backreef facies, unit ID7 (x1).
e) overturned heads of *Spongonaria parca* and *Alveolites*, reef talus facies, unit CH24.



d



c



b



a



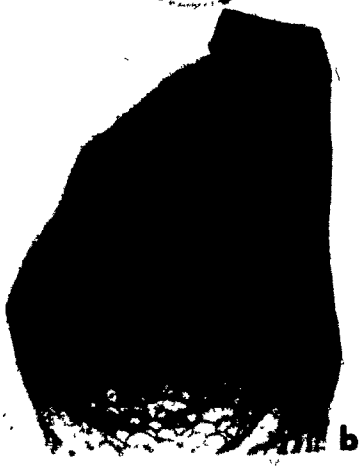
e

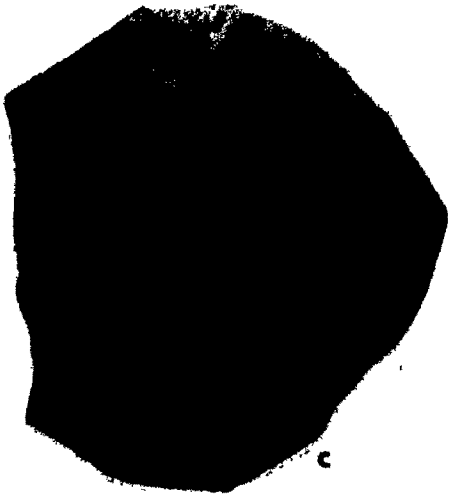
PLATE 19

PLATE 20. Rugose corals

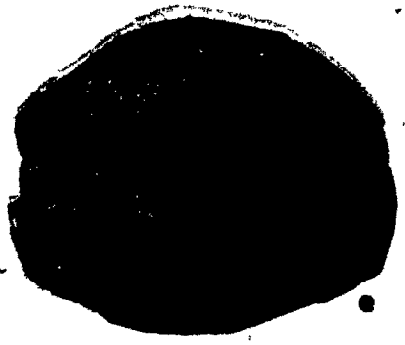
a,b) *Zonophyllum* sp. cf. *Z. sorense*, tangential and longitudinal views, IC7, x2.
c,d) *Lekanophyllum* sp. cf. *L. retiforme*, tangential and longitudinal views, B22, x1.
e,f) *Mochlophyllum* sp., tangential (x2.5) and longitudinal (x1.5) views, AC4.
g,h) *Hexagonaria* sp., tangential (x3.5), photomicrograph tangential showing carinae (x34), IB10.


a


b


c


d


e


f


g


h

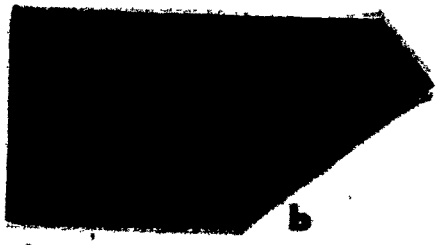
PLATE 20

PLATE 21. Rugose corals.

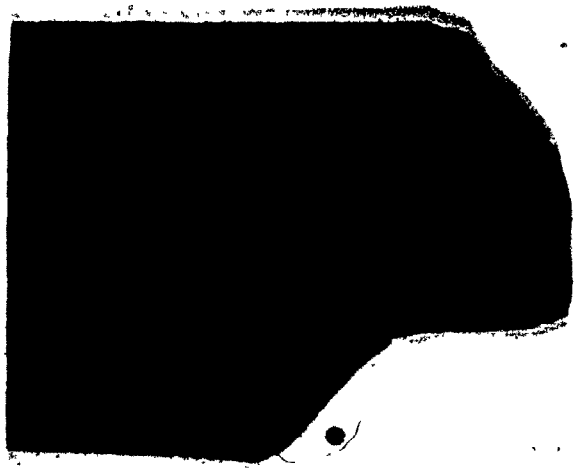
a,b) *Spongonaria loewei*, tangential and longitudinal views, AC1, x1.5.
c,d) *Planetophyllum* sp. nov. tangential and longitudinal views, ID11, x4.
e,f) *Spongonaria filicata*, tangential and longitudinal views, EC16, x1.5.
g) *Spongonaria ogilviensis*, tangential view, AB4, x1.5.
h,i) *Paraspongonaria delicata*, tangential and longitudinal views, ED29, x1.5.

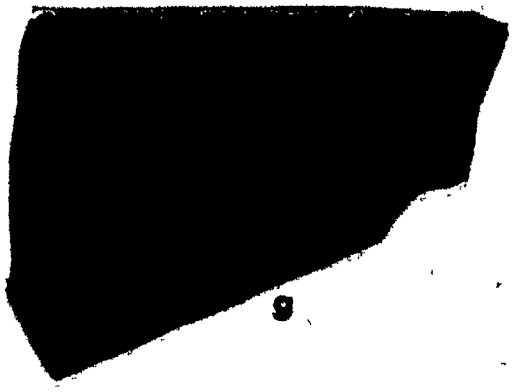

a


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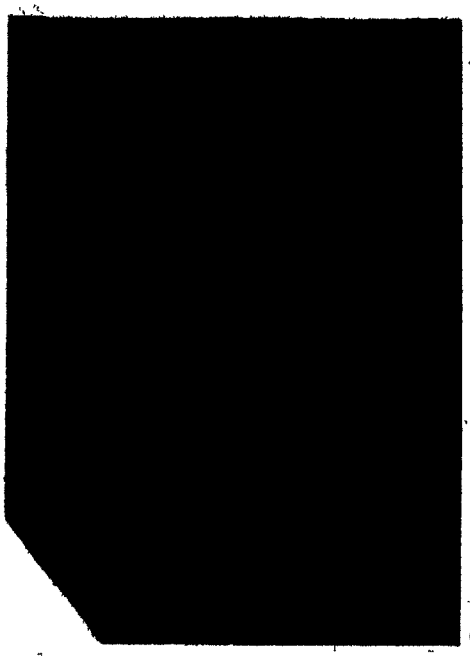

h


i

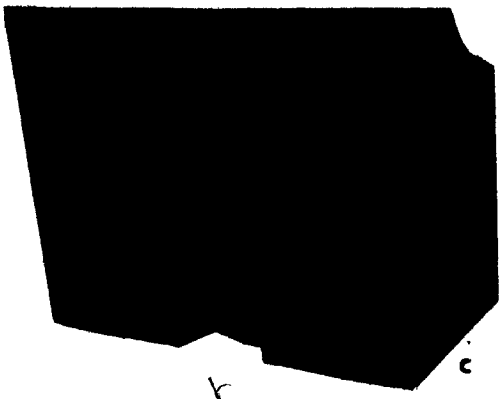
PLATE 21

PLATE 22. Rugose corals

a,b) *Spongonaria* sp. nov. 2, tangential and longitudinal views, EC11, x 2.5.
c,d) *Spongonaria* sp. nov. 1, tangential and longitudinal views, BC8, x 1.5.
e,f) *Spongonaria parca*, tangential and longitudinal views, DA29, x 1.5
g,h,i) *Zelolasma apeidiferum*, tangential and 2 longitudinal views, DA27, x 4.



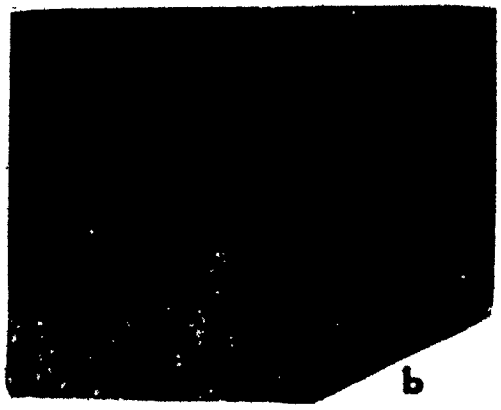
a



c

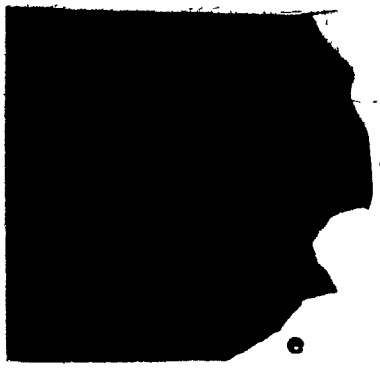


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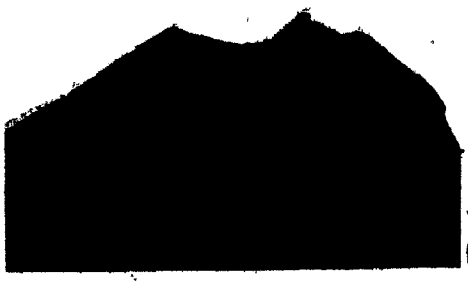


b





e



f





PLATE 22

PLATE 23. Rugose corals..

a,b,c) *Utaratuia* sp., tangential and longitudinal views (x1.5), and photomicrograph (x34) showing short septa not penetrating tabularium, and example of septal thread (left), GB31

d,e) *Cavanophyllum* sp., tangential (x1.) and longitudinal (x1.5) views, ED29.

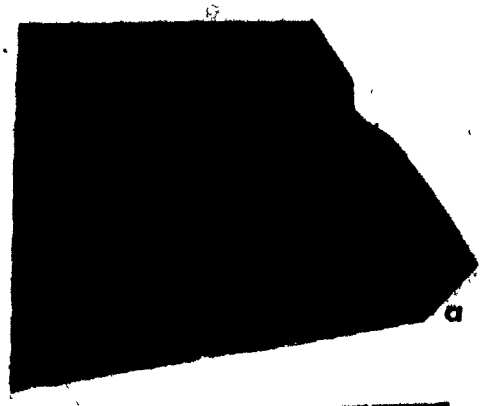
f,g) *Mansuyphyllum uyenoi uyenoi*, tangential and longitudinal views, Loc. 26, x 1.

h) *Acanthophyllum* sp., tangential view, B22, x1.5.

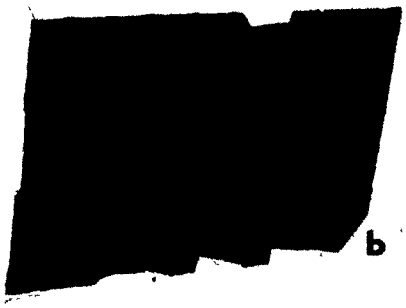
i,j) *Dohmophyllum* sp., tangential and longitudinal views, CA16, x 1.5.

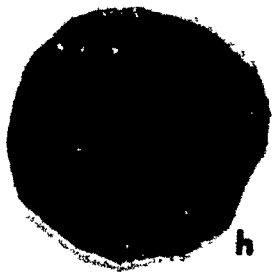
k,l) *Embolophyllum* sp., tangential and longitudinal views, Loc. 40, x 1.5.

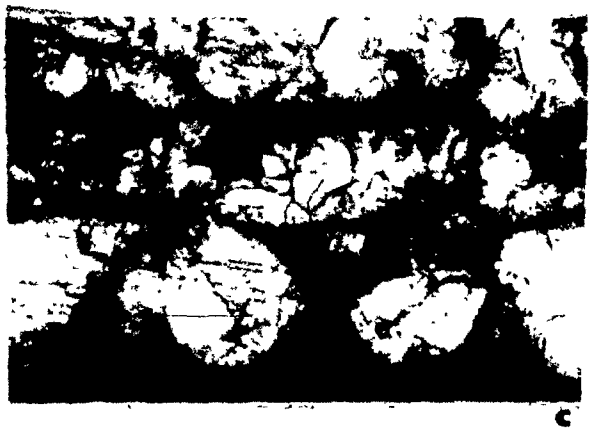


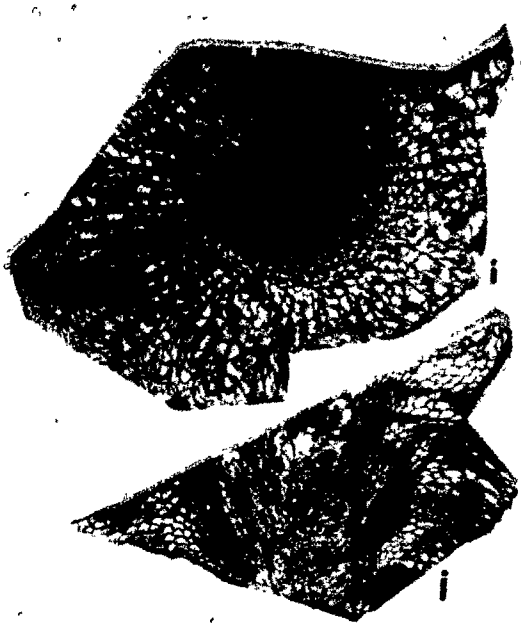


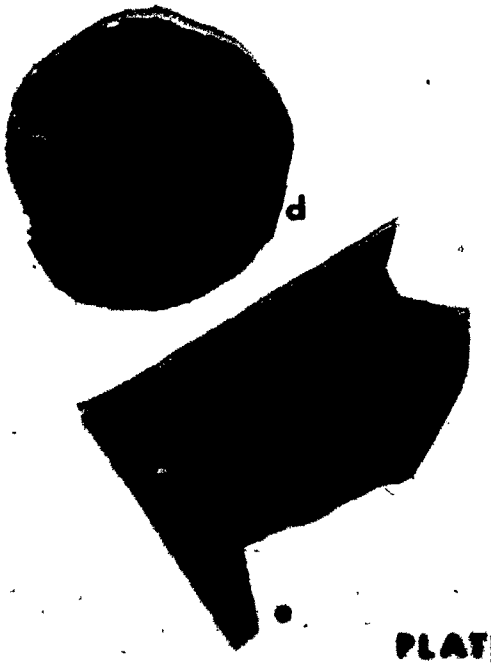












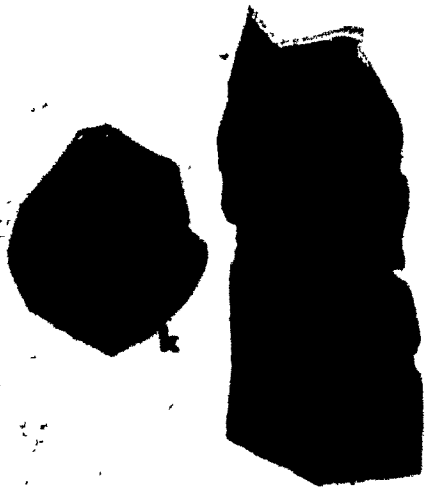
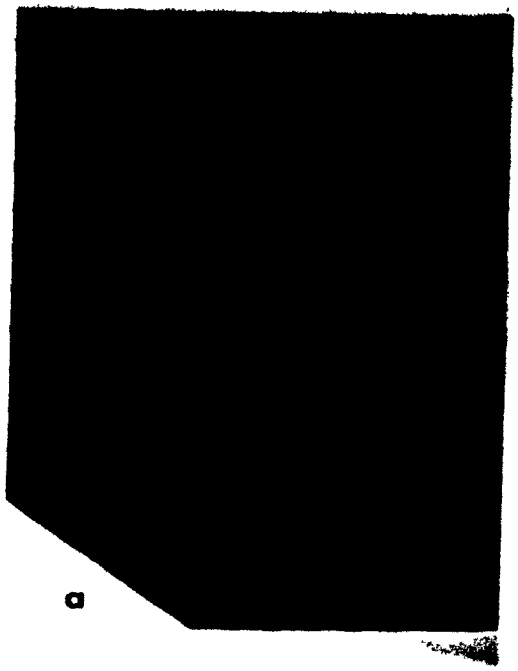


PLATE 23

PLATE 24. Rugose corals.

a) *Taimyrophyllum nolani baumannense*, tangential view, B22, x 3.
b,c) *Taimyrophyllum* sp. nov. tangential and longitudinal views, B37, x3.
d,e) *Pseudamplexus* sp., tangential and longitudinal views, CH4, x2.



a



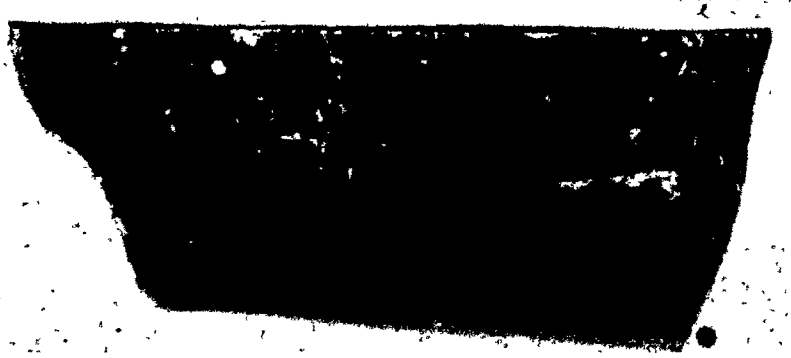
b



c



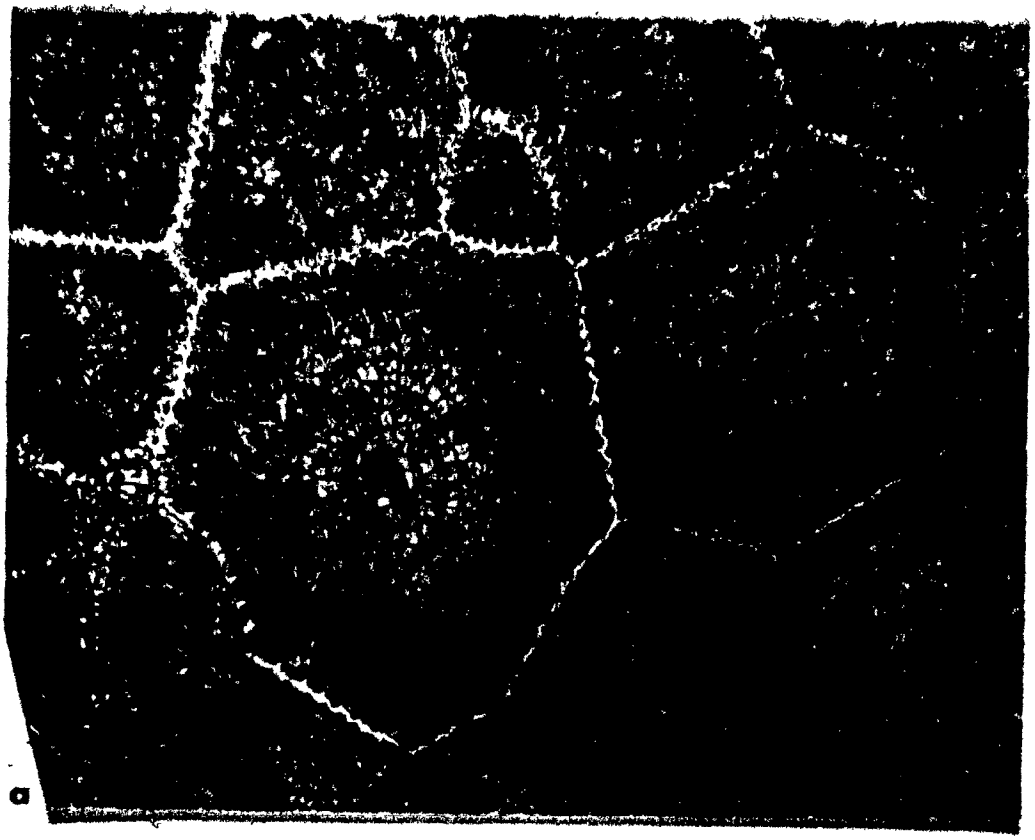
d



e

PLATE 25. Rugose corals.

a,b) *Tauraphyllum atypica*, tangential and longitudinal views, B37, x 3.
c,d) *Dendrostella trigemme*, tangential and longitudinal views, and *Hillaepora*, B30-11, x 3.



a



b



c



d

PLATE 26. Tabulate corals.

a,b) *Roemeria* sp. cf. *R. infundibulifera*, tangential and longitudinal views, EA7, x 1.5.

c,d) *Roemeripora progenitor*, tangential and longitudinal views, EA9, x 1.5.

e) *Syringopora formosa*, tangential view, GB19, x 1.5.

f) *Syringopora schulzei*, tangential view, AA15, x1.5.

g,h,i) *Syringoporella moravicoformis*, tangential and longitudinal views (x2.5), and photomicrograph tangential (x34), K6.

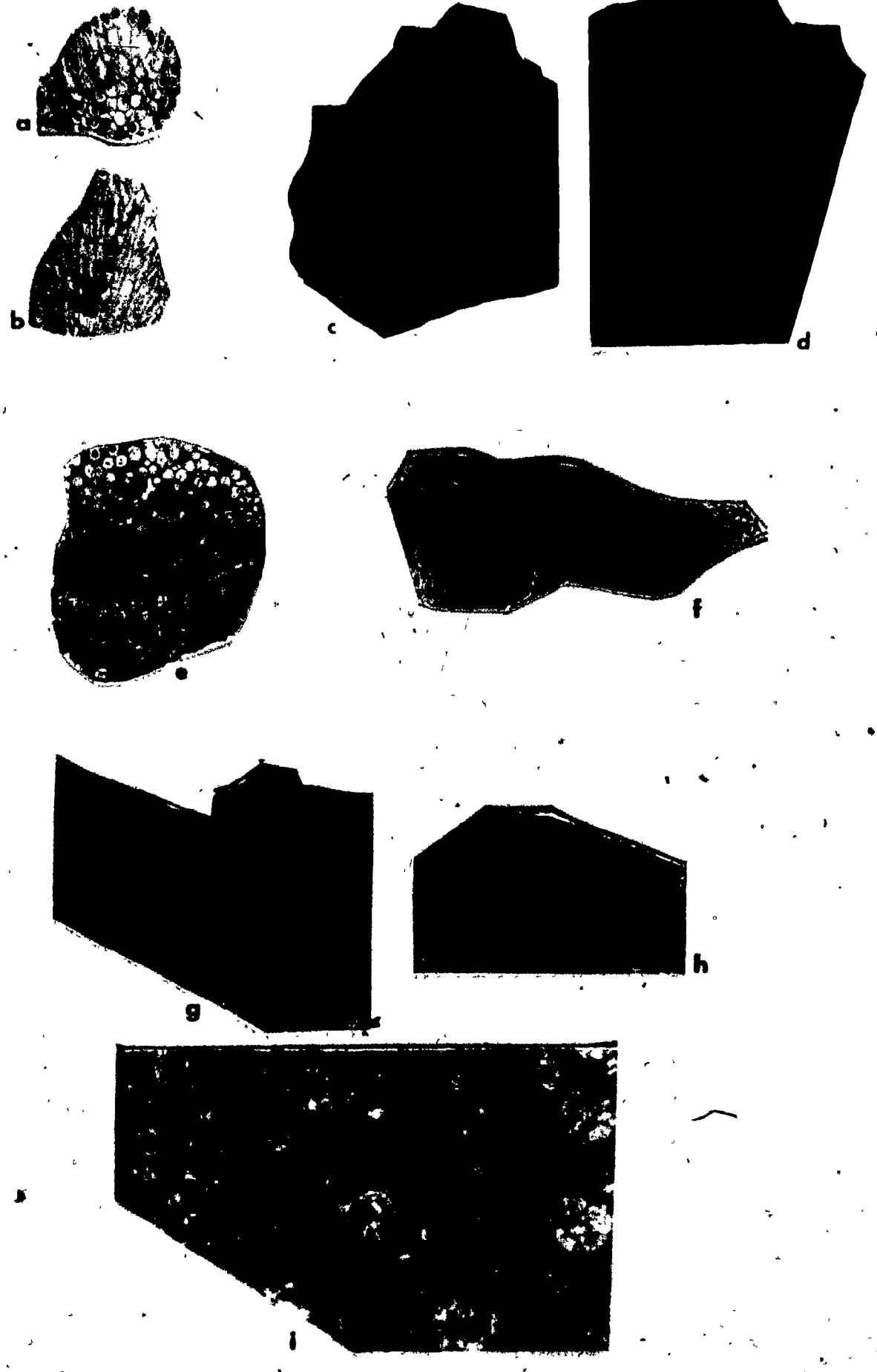


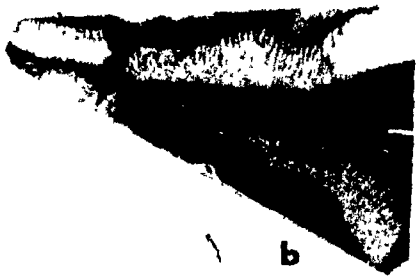
PLATE 26

PLATE 27. Tabulate corals.

a) *Alveolites*, longitudinal view, Loc. 40, x 1.5.
b,c) "Potato-chip" *Alveolites*, longitudinal (x1.5) view, and photomicrograph longitudinal (x34) showing recumbent corallites (base) and longitudinally-oriented corallites, CA5.
d,e) *Alveolitella*, tangential and longitudinal views, CD3A, x 1.5.
f,g) *Favosites sphaericus*, tangential and longitudinal views, GD1, x 1.5.
h) *Hillaepora*, longitudinal view, B30-11, x 1.5.
i,j) *Thamnopora randsii*, tangential and longitudinal views, CA5, x 1.5.









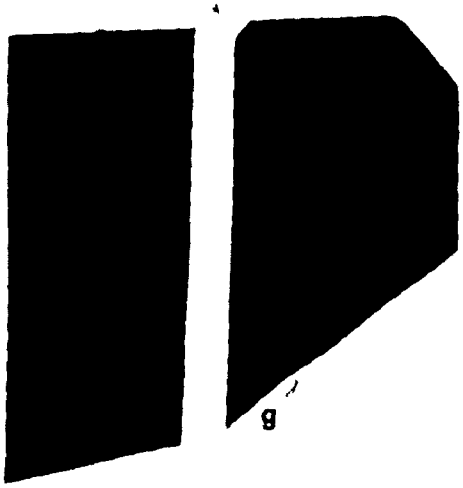






PLATE 97

PLATE 28. Tabulate corals and brachiopods.

a,b) *Yacutiopora hillae*, tangential and longitudinal views, B37, x 1.5.
c) *Heliolites* sp., photomicrograph tangential view, CA5, x34.
d,e,f) *Cortezorthis maclareni*, pedicle, brachial, and anterior views, AD36, x 1.5.
g,h,i) *Schizophoria nevadaensis*, pedicle, brachial, and anterior views, CF19, x 1.
j,k,l) *Carinagypa (Aseptagypa) maclareni*, pedicle, brachial, and anterior views, IA12, x1.
m,n,o) *Carinagypa aseptata*, pedicle, brachial, and anterior views, AD36, x1.
p,q,r) *Costellirostra* sp., pedicle, brachial, and anterior views, G A33, x1.5.
s,t,u) *Athyrhynchus loriei*, pedicle, brachial, and anterior views, Loc. 21, x1.

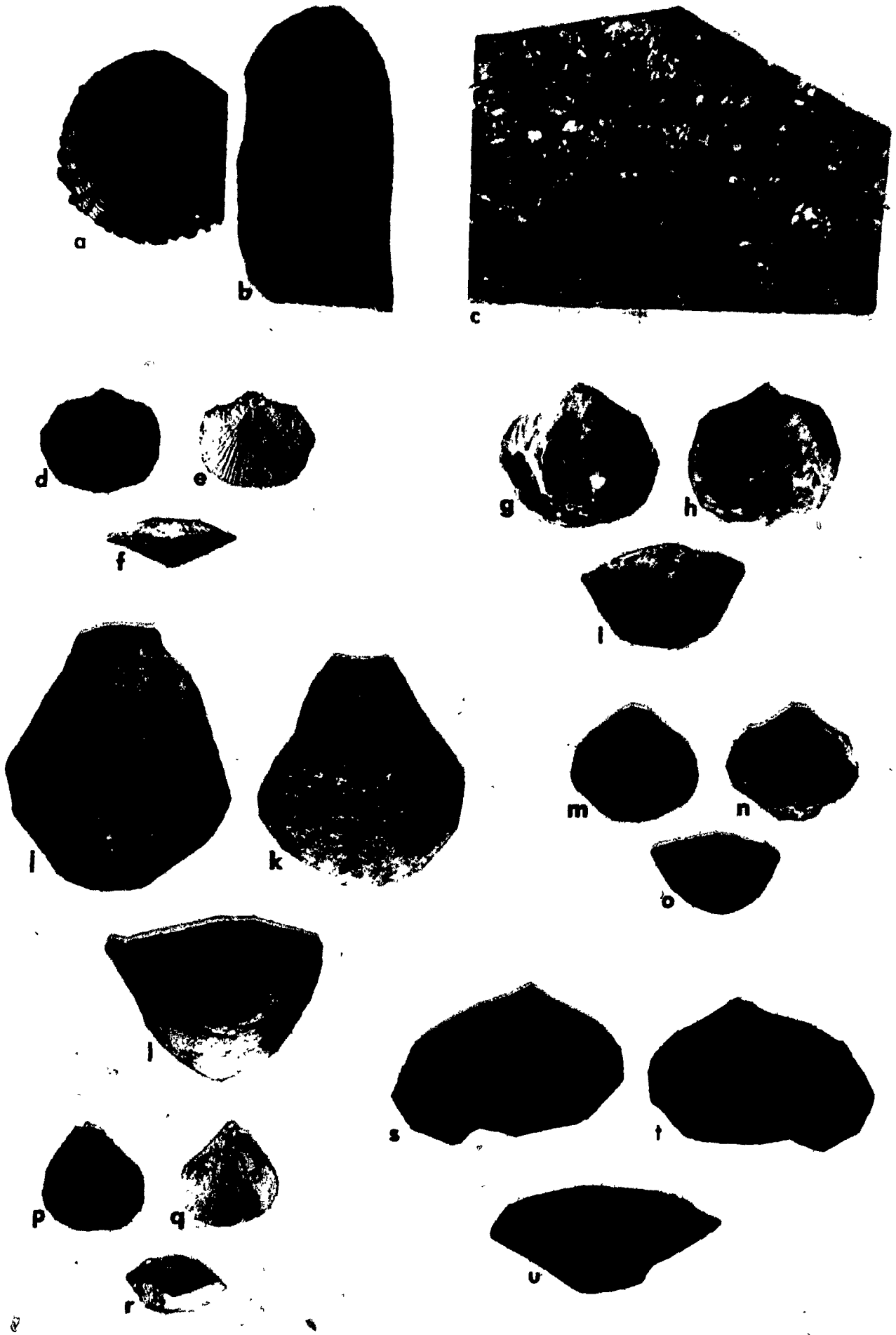


PLATE 28

PLATE 29. Brachiopods.

a,b) *Ancillotoechia*(?) sp., pedicle and brachial views, GA16, x2.
c,d,e) *Trigonirhynchia occidens*, pedicle, brachial, and anterior views, GB33, x1.
f,g) *Trigonirhynchia* sp. aff. *T. occidens*, pedicle and brachial views, CF19, x1.5.
h,i) *Nucleospira subsphaerica*, pedicle and brachial views, GB32, x1.
j,k,l) *Atrypa* sp. A, pedicle, brachial, and anterior views, CF19, x1.
m,n,o) *Atrypa* sp. B, pedicle, brachial, and anterior views, Loc. 21, x1.
p,q,r) *Atrypa* sp. C, pedicle, brachial, and anterior views, CH30, x1.
s,t,u) *Spinatrypa* sp., pedicle, brachial, and anterior views, ED34, x1.
v,w,x) *Cyrtina* sp., pedicle, brachial, and anterior views, AD36, x2.
y) *Howellella smithi*, brachial view, GB32, x1.5.
z) *Howellella* sp. A, brachial view, JA14, x1.5.
aa,bb,cc) *Howellella* sp. B, pedicle, brachial, and anterior views, AD36, x1.
dd,ee,ff) *Perrypspirifer scheii*, pedicle, brachial, and posterior views, GA16, x1.

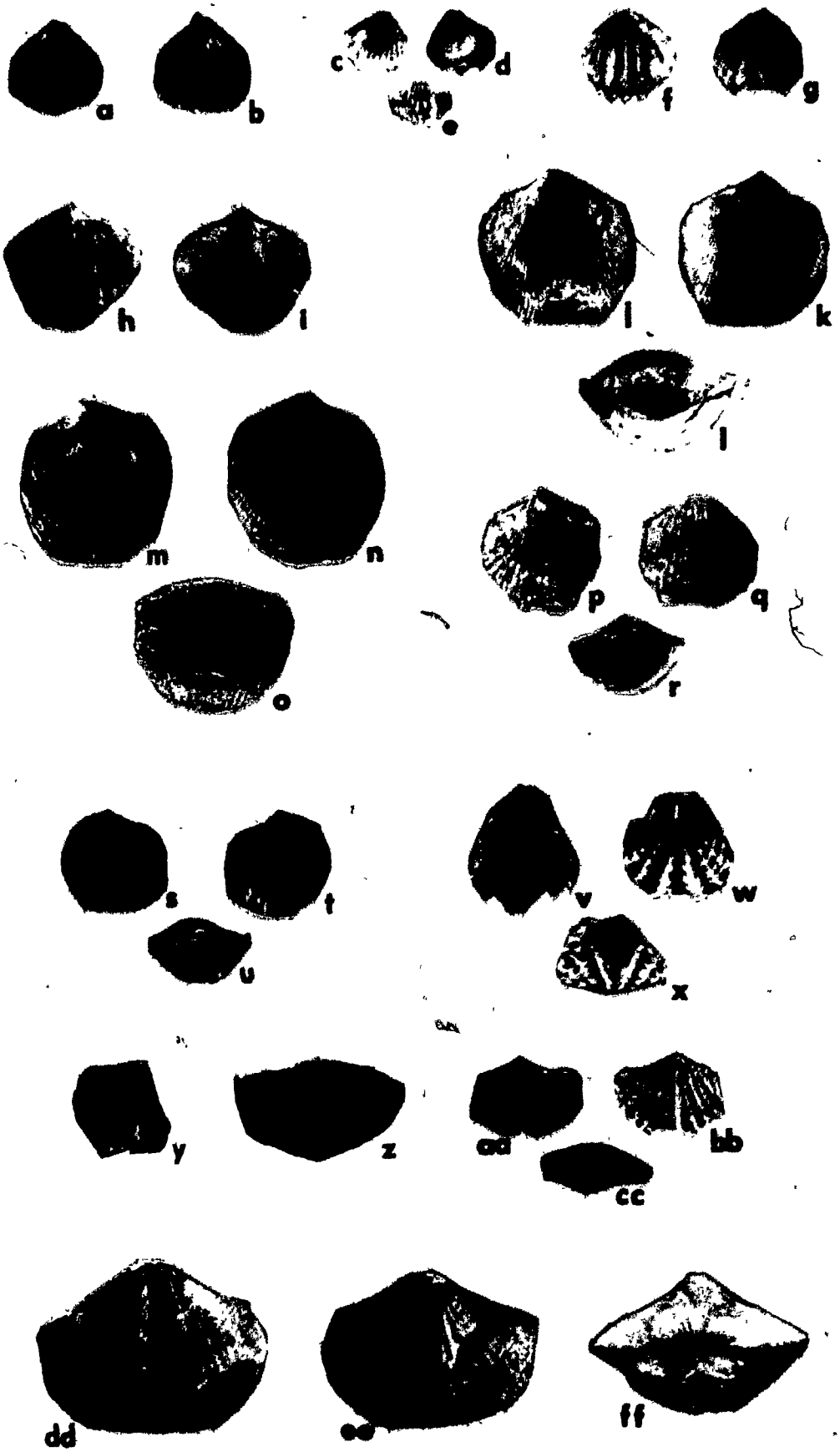


PLATE 29

PLATE 30. Brachiopods.

a,b,c) *Najadospirifer* sp., pedicle, brachial, and anterior views, CH23, x1.

d) *Warrenella extensa*, brachial view, CB1, x2.

e) *Warrenella franklini praefranklini* (forme transversale), brachial view, JA2, x2.

f) *Warrenella transversa*, pedicle view, CB1, x1.

g,h,i,j) *Chonetes* sp. A, pedicle, brachial and anterior views (x1.5) and pedicle hinge line view (note spines) (x6), GB43.

k) *Chonetes* sp. B, pedicle view, BB2, x1.5.

l) *Chonetes* sp. C, pedicle view, EA35, x2.

m,n,o) *Chonetes* sp. D, pedicle, brachial, and anterior views, Loc. 21, x2.

p) *Parachonetes macrostriatus*, pedicle view, GA16, x1.

q) *Eoschuchertella tuktui*, pedicle view, GA16, x1.

r,s) *Parapholidostrophia harperi*, pedicle and brachial views, AD36, x1.

t,u) *Parapholidostrophia sorensis*, pedicle and brachial views, CH24, x1.

v,w) *Phragmostrophia* sp. aff. *P. merriami*, pedicle and brachial views, Loc. 21, x1.

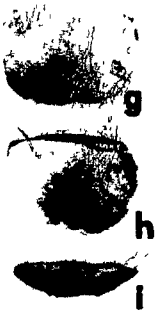
x,y) *Cymostrophia*(?) sp., pedicle and brachial views, CH30, x1.



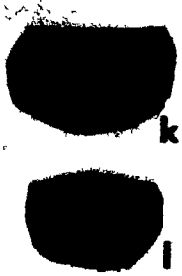




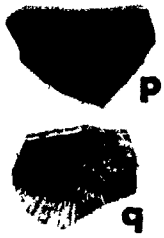














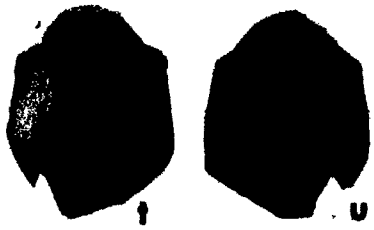




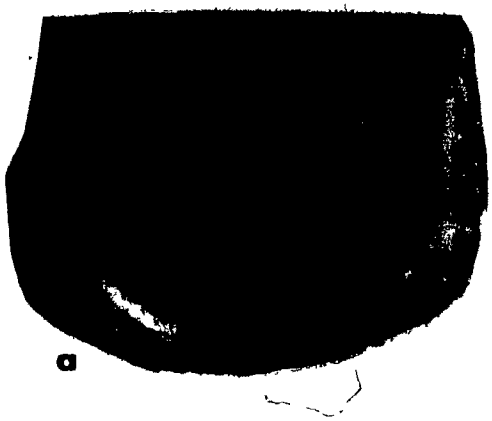




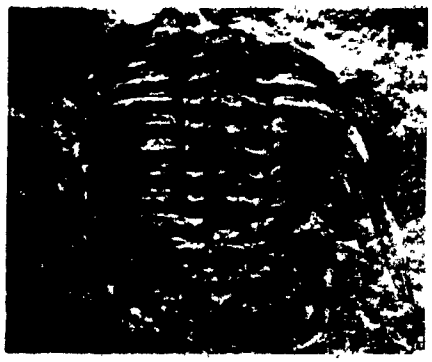
PLATE 30

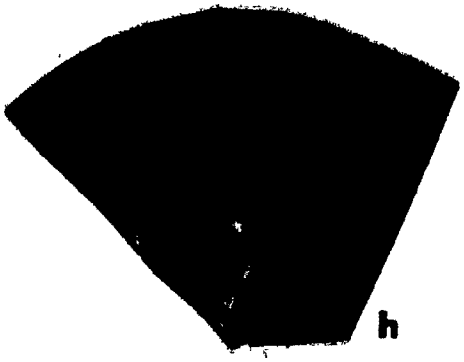
PLATE 31. Brachiopods and trilobites

a) Large strophedontid, brachial view, AA43-11, x1.
b) *Megastrophia (Megastrophella)* sp., pedicle view, JA14, x1.5.
c) *Lingula* sp., interior view, CB1, x2.
d,e,f) *Costacranaena* sp., pedicle, brachial and anterior views, AD36, x1.5.
g) *Leonaspis (Kettneraspis) elliptica*, thorax and pygidium, BB2, x2.
h) *Harpes macrocephalus*, cephalon, CF4, x 1.2
i,j) *Dechenella (Dechenella) spaskkassensis*, cephalon (JA14, x2), and pygidium (EC38, x1.5).
k) *Proetus* sp. cf. *P. bohemicus*, thorax and pygidium, BB2, x2.
l,m) *Schizoproetoides richteri*, pygidium (x1) and cephalon (x2), CB16.

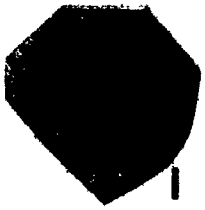

a


b c d e f


g


h


i


j


k


l


m

PLATE 31

PLATE 32. Cricoconarids, bryozoans, chitinozoans, fish, and gastropods

a) *Styliolina* sp. cf. *S. fissurella*, CF20, x5.
b) *Homoctenus* sp., G.S.C. Loc. C-12471, x3.
c,d) *Dicricoconus* sp. cf. *D. dutroi*, Loc.19, x3.75.
e) *Dicricoconus* sp., G.S.C. Loc. C-12472, x2.
f) "New genus" Churkin and Carter sp. nov., AAA9, x1.7.
g) *Stereotoechus*(?) sp., GB35, x 1.5.
h,i) *Trachytoechus*(?) sp., tangential and longitudinal views, CH23, x 1.5.
j) Cryptostomate bryozoans, CE19, x 1.5.
k) *Angochitina*, Loc. 14 (G.S.C. 97209), scale bar 100 μ.
l) *Eisenackitina*, BB2 (G.S.C. 97202), scale bar 100 μ.
m) Placoderm plate, Loc. 51, x1.
n) Placoderm plate, HC41, x 1.5.
o) *Gyronema*, Loc. 21, x2.
p) *Murchisonia*, Loc. 21, x1.
q,r,s) *Stenoloron* n. sp., Loc. 21, x2.

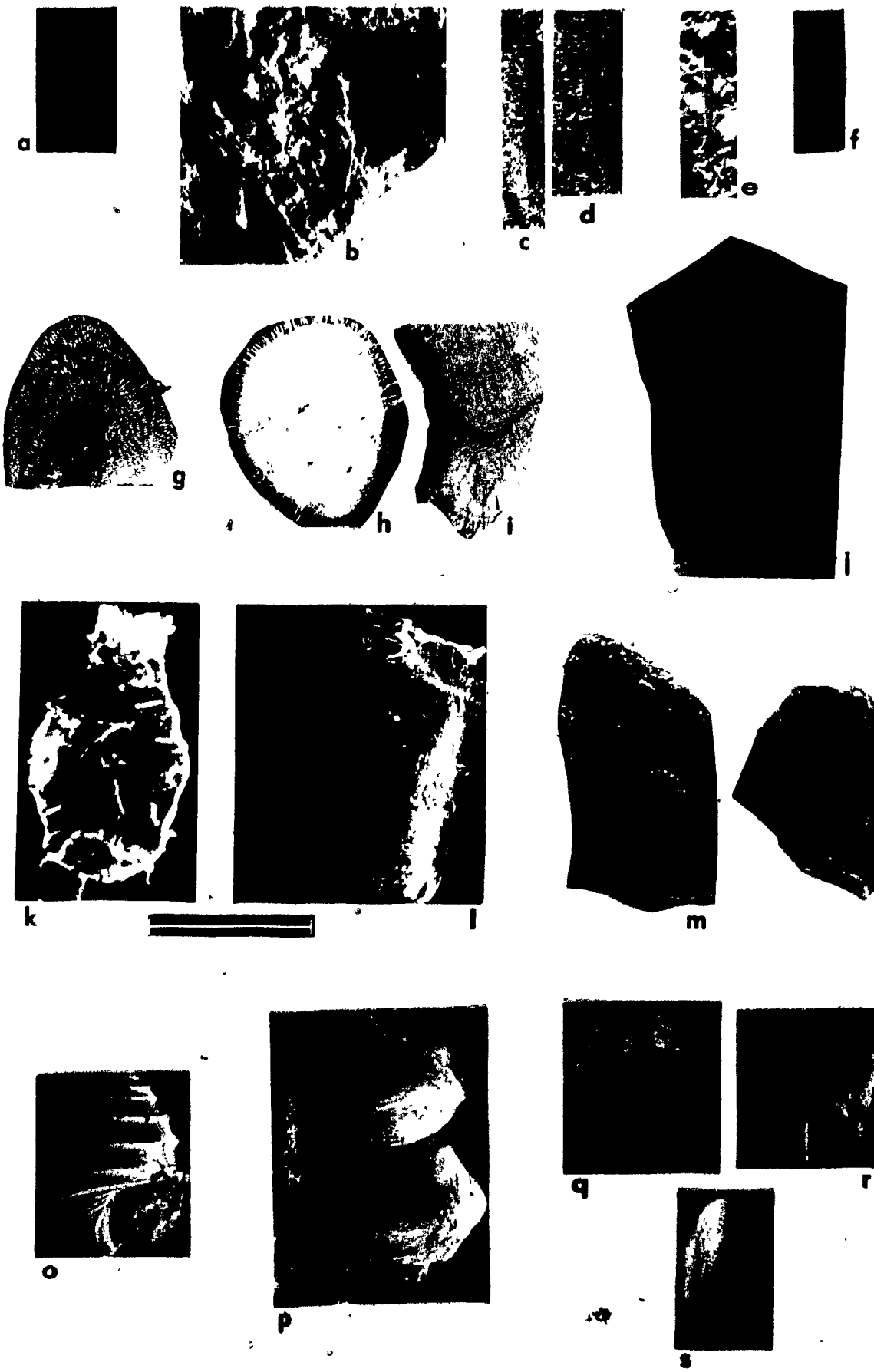


PLATE 32

PLATE 33. Algae and incertae sedis

a) *Cateniphycus friatus*, DA29, x78.
b) *Girvanella problematica*, CH19, x78.
c) *Girvanella staminea*, CH19, x78.
d) *Sphaerocodium gothlandicum*, Loc. 52, x31.
e) *Issinella* sp., ABA2, x 98.
f) *Halysis* sp. AA22, x98.
g) *Litanaia mira*, Loc. 29, x98.
h) *Quasiumbella* sp., HB48, x78.
i) *Nostocites* sp., CH19, x 98.



PLATE 33

PLATE 34. Algae, incertae sedis, and receptaculitids

a) *Parathurammina* sp., Loc. 56(9), x121.
b) *Rhabdoporella stolleyi*, AA22, x98.
c) *Rhabdoporella bascillum*, AA7, x98.
d) *Uelonia* sp., HB52, x121.
e) *Uva*? sp., HB48, x98.
f) *Wetheredella* sp., DA7, x38.
g) Charophyte(?), KA49, x34.
h) *Receptaculites neptuni*, CC1, x1.

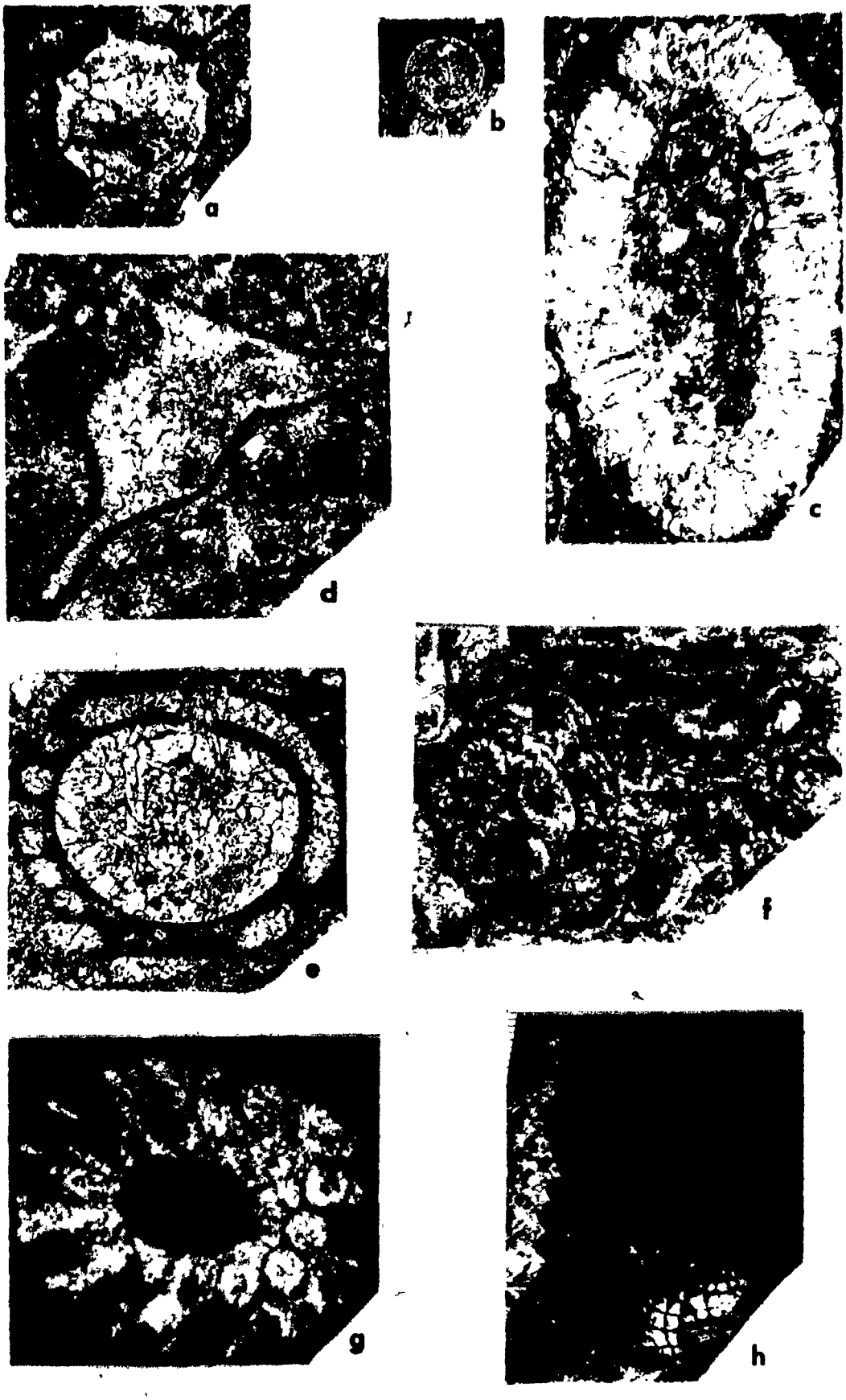


PLATE 34

APPENDIX I

COORDINATES OF DATA POINTS, ELLESMERE AND BATHURST ISLANDS

ELLESMERE ISLAND

NAME	LATITUDE	LONGITUDE
AA(A)	77° 20' 02"	86° 46' 26"
AB(A)	77° 20' 02"	86° 41' 11"
AC(A)	77° 19' 56"	86° 36' 26"
AD	77° 20' 02"	86° 49' 31"
BA	77° 14' 25"	86° 20' 43"
BB	77° 14' 21"	86° 23' 25"
BC	77° 14' 21"	86° 19' 03"
CA	77° 17' 15"	85° 45' 28"
CB(A)	77° 15' 00"	85° 51' 12"
CC(A)	77° 16' 27"	85° 47' 09"
CD	77° 17' 18"	85° 47' 37"
CE	77° 14' 25"	85° 45' 14"
CF	77° 14' 28"	85° 51' 26"
CG	77° 16' 56"	85° 45' 00"
CH	77° 16' 07"	85° 51' 26"
DA	77° 17' 37"	85° 18' 34"
EA	77° 17' 28"	85° 07' 08"
EB	77° 17' 41"	85° 12' 09"
EC	77° 17' 34"	85° 09' 31"
ED	77° 29' 41"	83° 54' 17"
FA	77° 36' 19"	88° 29' 03"
GA	77° 44' 28"	83° 29' 03"
GB	77° 42' 42"	83° 30' 00"
GC	77° 48' 00"	83° 26' 26"

NAME	LATITUDE	LONGITUDE
GD	77° 45' 32"	83° 28' 06"
GE	77° 46' 33"	83° 27' 09"
HA	76° 35' 02"	83° 42' 23"
HB	77° 31' 59"	83° 48' 06"
HC	77° 38' 18"	83° 34' 17"
IA	77° 16' 59"	86° 01' 26"
IB	77° 17' 09"	85° 55' 57"
IC	77° 16' 59"	86° 07' 08"
ID	77° 17' 05"	85° 57' 09"
JA	77° 15' 10"	86° 27' 51"
JB	77° 15' 55"	86° 19' 46"
JC	77° 16' 40"	86° 19' 31"
KA	76° 38' 21"	87° 48' 06"
KB	76° 37' 36"	87° 38' 48"
K	77° 17' 12"	85° 08' 34"
Loc. 1	77° 19' 46"	86° 45' 28"
Loc. 2	77° 18' 48"	86° 42' 09"
Loc. 3	77° 20' 12"	86° 38' 20"
Loc. 4	77° 20' 02"	86° 35' 43"
Loc. 5	77° 19' 56"	86° 31' 40"
Loc. 6	77° 19' 24"	86° 30' 43"
Loc. 7	77° 19' 20"	86° 29' 03"
Loc. 8	77° 19' 17"	86° 26' 40"
Loc. 9	77° 19' 07"	86° 23' 20"
Loc. 10	77° 17' 34"	86° 25' 14"
Loc. 11	77° 17' 02"	86° 25' 43"

NAME	LATITUDE	LONGITUDE
Loc. 12	77° 15' 29"	86° 25' 29"
Loc. 13	77° 15' 16"	86° 26' 40"
Loc. 14	76° 38' 19"	88° 26' 57"
Loc. 15	77° 15' 55"	86° 17' 37"
Loc. 16	77° 16' 07"	86° 12' 23"
Loc. 17	77° 16' 56"	86° 10' 43"
Loc. 18	77° 15' 51"	86° 05' 57"
Loc. 19	77° 17' 02"	86° 05' 43"
Loc. 20	77° 16' 59"	86° 01' 26"
Loc. 21	77° 16' 49"	86° 01' 11"
Loc. 22	77° 16' 40"	86° 00' 43"
Loc. 23	77° 16' 20"	86° 00' 14"
Loc. 24	77° 16' 11"	85° 59' 32"
Loc. 25	77° 16' 17"	85° 58' 34"
Loc. 26	77° 16' 11"	85° 57' 37"
Loc. 27	77° 15' 55"	85° 57' 23"
Loc. 28	77° 15' 32"	85° 56' 26"
Loc. 29	77° 15' 16"	85° 57' 09"
Loc. 30	77° 15' 22"	85° 55' 14"
Loc. 31	77° 15' 26"	85° 50' 14"
Loc. 32	77° 15' 00"	85° 39' 03"
Loc. 33	77° 16' 04"	85° 37' 08"
Loc. 34	77° 15' 32"	85° 34' 46"
Loc. 35	77° 16' 59"	85° 28' 06"
Loc. 36	77° 17' 09"	85° 24' 17"
Loc. 37	77° 18' 10"	85° 03' 20"

NAME	LATITUDE	LONGITUDE
Loc. 38	77° 18' 16"	85° 01' 40"
Loc. 39	77° 18' 26"	85° 00' 57"
Loc. 40	77° 18' 32"	84° 59' 46"
Loc. 41	77° 18' 29"	82° 11' 40"
Loc. 42	77° 19' 59"	82° 09' 46"
Loc. 43	77° 27' 35"	83° 45' 43"
Loc. 44	77° 15' 57"	85° 45' 29"
Loc. 45	77° 15' 10"	85° 45' 27"
Loc. 46	77° 14' 38"	86° 23' 24"
Loc. 47	77° 52' 40"	82° 30' 00"
Loc. 48	77° 40' 27"	82° 07' 23"
Loc. 49	77° 40' 33"	82° 01' 06"
Loc. 50	76° 42' 58"	86° 43' 20"
Loc. 51	77° 16' 07"	85° 52' 48"
Loc. 52	77° 40' 23"	83° 35' 03"
Loc. 53	77° 23' 16"	84° 28' 58"
Loc. 54	77° 53' 12"	83° 23' 20"
Loc. 55	77° 54' 13"	83° 23' 48"
Loc. 56	77° 57' 48"	83° 19' 03"
Loc. 57	78° 03' 55"	83° 19' 31"
Loc. 58	77° 18' 36"	84° 59' 03"
Loc. 59	76° 36' 13"	88° 27' 47"

BATHURST ISLAND

NAME	LATITUDE	LONGITUDE
B19	76° 20' 40"	99° 03' 43"
B20	76° 29' 34"	98° 40' 04"
B22	76° 29' 14"	98° 14' 42"
B25	76° 13' 12"	99° 11' 48"
B30	76° 05' 18"	97° 46' 48"
B37	75° 34' 14"	99° 15' 33"
B39	75° 26' 56"	99° 16' 40"
B42A	75° 03' 51"	99° 08' 37"
B42B	75° 10' 25"	99° 16' 07"
B43	75° 59' 52"	99° 11' 06"
B44	76° 12' 01"	99° 29' 33"

APPENDIX II

DESCRIPTIONS OF TYPE AND REFERENCE SECTIONS, DISAPPOINTMENT BAY AND BLUE FIORD FORMATIONS

SECTION BB AND BC

TYPE SECTION OF BLUE FIORD FORMATION

Section BB starts at base of steeply sloping covered interval formed below first cliff exposure (Blue Fiord Formation). Measured upstream (southwards) a distance of approximately 0.65 km, then section transferred eastwards approximately 1.5 km along main ridge into major river. Section continued southwards (section BC)a distance of 1.9 km to the top of the Blue Fiord Formation. Section coordinates in Appendix I. Section BB measured with Jacob's Staff, section BC measured using thicknesses derived from air photos.

UNIT NO.	THICKNESS(m.)	CUMULATIVE THICKNESS(m.)	DESCRIPTION
		Base of Bird Fiord Formation	
BC10	20.0	1423.3	Medium brown, thin bedded fossiliferous wackestone, with corals (*Alveolites, Favosites*), stromatoporoids, crinoids.
BC9	3.0	1403.3	Light grey-brown, thick bedded fenestral lime mudstone.
BC8	200.0	1400.3	Medium grey-brown, medium bedded fossiliferous wackestone, with crinoids, corals (*Alveolites, Favosites, Roemeripora progenitor, Thamnopora randsii, Spongonaria* sp. nov. 1).
BC7	223.0	1200.3	Light grey-brown, thin to medium, wavy bedded, fossiliferous grainstone, crinoids abundant, some allochthonous corals; forms resistant unit at falls!

UNIT NO.	THICKNESS(m.)	CUMULATIVE THICKNESS(m.)	DESCRIPTION
BC6	198.0	977.3	Interbedded medium to dark grey-brown, thin bedded lime mudstone (90%) and dark grey-brown shale (10%, crinoids abundant in isolated "pods", some articulated up to 2 cm long.
BC5	380.0	779.3	Interbedded medium grey-brown, thin bedded lime mudstone (85%) and medium to dark grey-brown shale (15%) with cricoconarids.
BC4	100.00	399.3	Covered interval (talus of dark blue-grey shale and orange weathering dolomitic mudstone).
BC3	20.0	299.3	Interbedded medium grey-brown calcareous shale (60%) and argillaceous, very thin bedded lime mudstone (40%), both lithologies with abundant horizontal feeding traces.
BC2	80.0	279.3	Covered interval.
BC1(=BB12)	6.0	199.3	Interbedded medium grey-brown, thin to very thin bedded, fossiliferous packstone (60%) with abundant and diverse fauna - crinoids (dominant), fenestellid and ramose bryozoans, trilobites (*Schizoproetoides richteri*), brachiopods (*Perryspirifer, Schizophoria*), horizontal feeding traces (1.5 cm width), and calareous shale (40%).
BB11	57.0	193.3	Covered interval.

UNIT NO.	THICKNESS(m.)	CUMULATIVE THICKNESS(m.)	DESCRIPTION
BB10	1.3	136.3	Interbedded dark grey-brown, thin bedded lime mudstone (95%) and calcareous shale (5%).
BB9	1.0	135.0	Covered interval.
BB8	0.8	134.0	Medium grey-brown, thin bedded fossiliferous packstone, abundant crinoids, rare brachiopods; abrupt basal contact.
BB7	5.3	133.2	Same as BB6, recessive.
BB6	8.5	127.9	Interbedded dark grey-brown, thin bedded lime mudstone (70%) and calcareous shale (30%).
BB5	2.8	119.4	Dark grey-brown, thin bedded lime mudstone, very rare brachiopods.
BB4	8.6	116.6	Medium to light grey-brown, medium bedded fossiliferous packstone, abundant crinoids, some brachiopods, fenestellid bryozoans; abrupt wavy basal contact.
BB3	13.4	108.0	Regularly interbedded, dark grey-brown medium bedded lime mudstone (85%), scattered brachiopods and crinoids at base, and calcareous shale (15%).
BB2	94.6	94.6	Regularly interbedded dark grey-brown, very thin bedded lime mudstone (50%), with rare trilobites (*Leonaspis*

UNIT NO.	THICKNESS(m.)	CUMULATIVE THICKNESS(m.)	DESCRIPTION
BB2 (cont'd)			*(Kettneraspis) elliptica*, and *Proetus* sp. cf. *P. bohemicus*) and calcareous shale (50%) with rare cephalopods (*Spiroceras thoas*), upwards, lime mudstone units become thicker (medium bedded) and more common (70% at 60 m, 85% at 90 m.)
		Base of Blue Fiord Formation	
BB1	30.0	30.0	Covered interval
		Eids Formation	

SECTION B30

TYPE SECTION OF LIMESTONE MEMBER, DISAPPOINTMENT BAY FORMATION

Section located 7 km northwest of the mouth of Moses Robinson River, east-central Bathurst Island, along the northern of 2 tributaries that cut the Disappointment Bay Formation outcrop belt. Section starts at base of exposure in cliff, which rises above the underlying covered interval of the dolostone member of the Disappointment Bay Formation. Section coordinates in Appendix I. Measured using Jacob's Staff.

UNIT NO.	THICKNESS(m.)	CUMULATIVE THICKNESS(m.)	DESCRIPTION
		Base of Bird Fiord Formation	
15	3.0	102.4	Light grey-brown, medium bedded fenestral lime mudstone.
14	0.7	99.4	Medium to dark grey-brown, fossiliferous wackestone, abundant crinoids, corals, brachiopods.
13	0.8	98.7	Light grey-brown, medium bedded, fenestral lime mudstone, rare ostracods, corals *(Dendrostella trigemme)*
12	7.5	97.9	Covered interval.
11	10.5	90.4	Light grey-brown, medium bedded, fenestral lime mudstone, rare gastropods, ostracods, corals (*Dendrostella trigemme*, *Hillaepora*), possible oncolites.
10	7.5	79.9	Light grey-brown, thin bedded, fenestral lime

UNIT NO.	THICKNESS(m.)	CUMULATIVE THICKNESS(m.)	DESCRIPTION
10 (cont'd)			mudstone, rare ostracods, gastropods.
9	4.5	72.4	Covered interval.
8	0.4	67.9	Light grey-brown, thin bedded, fenestral lime mudstone, rare ostracods.
7	18.0	67.5	Covered interval (talus of fenestral lime mudstone).
6	10.5	49.5	Light grey-brown, thin to medium bedded, fenestral lime mudstone, rare gastropods.
5	3.0	39.0	Light grey-brown, thin bedded, fenestral lime mudstone, rare ostracods.
4	27.0	36.0	Light grey-brown, thin to medium bedded fenestral lime mudstone.
3	4.5	9.0	Covered interval.
2	4.5	4.5	Light grey-brown, weathering cream, thin to medium bedded, fenestral lime mudstone.
			Base of limestone member, Disappointment Bay Formation
1	-		Covered interval (talus of light grey-brown, sucrosic dolostone with pinpoint porosity).
			Dolostone member, Disappointment Bay Formation

SECTION KA

REFERENCE SECTION OF DISAPPOINTMENT BAY FORMATION

Section starts at base of first good exposure in the most westward of the 3 adjacent river valleys that converge into the main east-west flowing river, which flows into the head of Muskox Fiord. Section coordinates in Appendix I. Jacob's Staff used to measure section.

UNIT NO.	THICKNESS(m.)	CUMULATIVE THICKNESS(m.)	DESCRIPTION
		Base of Bird Fiord Formation	
KA72	15.0	347.5	Covered interval.
KA71	2.0	332.5	Light grey-brown fenestral lime mudstone.
KA70	30.0	330.5	Covered interval (talus of fenestral dolostone).
KA69	4.5	300.5	Light grey-brown, thin bedded fenestral dolostone, rare ostracods.
KA68	6.0	296.0	Covered interval.
KA67	6.0	290.0	Light grey-brown, thin bedded fenestral dolostone, some pinpoint porosity.
KA66	1.0	284.0	Covered interval.
KA65	2.5	283.0	Light grey-brown fenestral lime mudstone.
KA64	9.0	280.5	Covered interval (talus of fenestral dolostone with pinpoint porosity).

UNIT NO.	THICKNESS(m.)	CUMULATIVE THICKNESS(m.)	DESCRIPTION
KA63	3.0	271.5	Light grey-brown fenestral lime mudstone, rare ostracods.
KA62	1.5	268.5	Covered interval.
KA61	3.0	267.0	Light grey-brown, medium bedded fenestral dolostone, 5-10% pinpoint porosity.
KA60	6.0	264.0	Covered interval.
KA59	4.5	258.0	Light grey brown, medium bedded fenestral dolostone.
KA58	3.0	253.5	Covered interval.
KA57	19.5	250.5	Light grey-brown, medium bedded fenestral dolostone, abundant pinpoint porosity, some large occluded vugs up to 7.5 mm diameter.
KA56	4.5	231.0	Covered interval.
KA55	7.5	226.5	Same as KA53.
KA54	7.5	219.0	Covered interval.
KA53	1.5	211.5	Medium grey-brown, laminated fossiliferous lime wackestone, with crinoids and rare brachiopods.
KA52	2.0	210.0	Covered interval.
KA51	3.0	208.0	Same as KA49.
KA50	3.0	205.0	Covered interval.
KA49	25.5	202.0	Dark brown-black, thin bedded fossiliferous lime wackestone, abundant fossils - crinoids, *in situ Alveolites, Favosites, Thamnopora randelli, Spongonaria ogilviensis*, charophyte algae(?), stromatoporoids, gastropods, brachiopods.

UNIT NO.	THICKNESS(m.)	CUMULATIVE THICKNESS(m.)	DESCRIPTION
KA48	3.0	176.5	Light to medium grey-brown, laminated fossiliferous lime wackestone, crinoids, ostracods, brachiopods.
KA47	4.5	173.5	Light grey-brown, medium bedded fenestral lime mudstone, rare ostracods.
KA46	7.5	169.0	Covered interval.
KA45	4.5	161.5	Light grey-brown fenestral lime mudstone.
KA44	3.0	157.0	Covered interval.
KA43	9.0	154.0	Light grey-brown fenestral lime mudstone.
KA42	4.5	145.0	Covered interval.
KA41	6.0	140.5	Light grey-brown, medium bedded fenestral lime mudstone.
KA40	1.5	134.5	Covered interval.
KA39	7.0	133.0	Same as KA37.
KA38	3.0	126.0	Covered interval.
KA37	3.0	123.0	Light grey-brown, thick bedded, sucrosic dolostone.
KA36	1.5	120.0	Light grey-brown, medium bedded fenestral lime mudstone.
KA35	6.0	118.5	Light grey-brown, thin bedded sucrosic dolostone, 10% pinpoint porosity.
KA34	5.7	112.5	Light grey-brown, medium bedded fenestral lime

UNIT NO.	THICKNESS(m.)	CUMULATIVE THICKNESS(m.)	DESCRIPTION
KA34 (cont'd)			mudstone.
KA33	1.5	106.8	Light grey-brown, thick bedded, silty sucrosic dolostone.
KA32	1.0	105.3	Light grey-brown, thin bedded, fine grained dolostone.
KA31	1.5	104.3	Light grey-brown, silty sucrosic dolostone.
KA30	3.0	102.8	Covered interval.
KA29	3.0	99.8	Light grey-brown, medium to thin bedded, fine grained fenestral dolostone.
KA28	3.0	96.8	Light grey-brown, thick bedded sucrosic dolostone.
KA27	2.0	93.8	Covered interval.
KA26	1.5	91.8	Light to medium grey-brown, thick bedded sucrosic dolostone.
KA25	3.0	90.3	Light grey-brown, very thin bedded fenestral lime mudstone.
KA24	4.5	87.3	Light to medium grey-brown, medium bedded, silty sucrosic dolostone.
KA23	3.0	82.8	Light grey-brown, very thin bedded sucrosic dolostone.
KA22	9.0	79.8	Covered interval.
KA21	3.7	70.8	Dark brown-black, very thin bedded fossiliferous lime wackestone, abundant fossils - crinoids

UNIT NO.	THICKNESS(m.)	CUMULATIVE THICKNESS(m.)	DESCRIPTION
KA21 (cont'd)			(some *Gasterocoma bicaula*), *Alveolites*, stromatoporoids, brachiopods; emits fetid odour when struck.
KA20	9.0	67.1	Covered interval.
KA19	3.0	58.1	Light grey-brown, thick bedded sucrosic dolostone, abundant pinpoint porosity, vugs up to 2 cm diameter.
KA18	1.5	55.1	Covered interval.
KA17	3.0	53.6	Light grey-brown, thin bedded sucrosic dolostone, pinpoint porosity 10-15%.
KA16	0.5	50.6	Same as KA14.
KA15	3.0	50.1	Dark brown-black, very thin bedded fossiliferous dolowackestone, crinoids (some *Gasterocoma bicaula*).
KA14	0.5	47.1	Light to medium brown, medium bedded fossiliferous dolowackestone, crinoids.
KA13	3.0	46.6	Light grey-brown, thick bedded sucrosic dolostone.
KA12	9.0	43.6	Dark brown-black, thin bedded fossiliferous dolowackestone, crinoids, rare brachiopods.
KA11	4.5	34.6	Light to medium brown, thick bedded sucrosic dolostone, minor pinpoint porosity.

UNIT NO.	THICKNESS(m.)	CUMULATIVE THICKNESS(m.)	DESCRIPTION
KA10	1.5	30.1	Light grey-brown, thick bedded sucrosic dolostone, abundant pinpoint porosity (25%), some large vugs (5 mm diameter), only partially occluded.
KA9	6.0	28.6	Light grey-brown, thick bedded sucrosic fenestral dolostone, some pinpoint porosity.
KA8	3.0	22.6	Light to medium brown, thick bedded sucrosic dolostone, abundant unoccluded vugs (5 mm diameter), pinpoint porosity.
KA7	0.5	19.6	Light grey-brown, very thin bedded sucrosic dolostone, minor pinpoint porosity.
KA6	10.3	19.1	Light grey-brown, medium bedded sucrosic dolostone, pinpoint porosity.
KA5	3.0	8.8	Same as KA3.
KA4	1.0	5.8	Dark brown-black, thin bedded fossiliferous dolowackestone, crinoids.
KA3	2.8	4.8	Light grey-brown, medium bedded sucrosic fenestral dolostone, abundant pinpoint porosity.
KA2	2.0	2.0	Very light grey-brown, medium bedded, silty sucrosic dolostone.
		Base of Disappointment Bay Formation	
KA1	7.5	7.5	Light to medium grey-

UNIT NO.	THICKNESS(m.)	CUMULATIVE THICKNESS(m.)	DESCRIPTION
KA1 (cont'd)			brown, medium bedded, sucrosic fenestral dolostone, rare gastropods, abundant pinpoint porosity and vugs (some unoccluded, up to 3 cm diameter)

Goose Fiord Formation

APPENDIX III

STRATIGRAPHIC POSITION OF UNITS YIELDING PALEONTOLOGIC SPECIMENS

Each unit that has provided paleontological specimens for this study is listed below, along with its formational assignment and stratigraphic position. This position is the distance of the unit base above the base of the formation. Those units in the Eids Formation list the distance of the unit base below the Blue Fiord Formation base.

UNIT NO.	EIDS	BLUE FIORD	DISAPPOINTMENT BAY		STRATIGRAPHIC POSITION(m)
			UNDIFFERENTIATED	LIMESTONE MBR.	
AA3		X			0.0
AA5		X			8.9
AA7		X			15.4
AA10		X			26.6
AA11		X			29.4
AA13		X			35.4
AA15		X			46.6
AA16		X			47.7
AA22		X			67.7
AA27		X			82.7
AA28		X			84.0
AA29		X			90.0
AA35		X			102.0
AAA3		X			112.1
AAA7		X			117.0
AAA9		X			118.8
AAA13		X			140.8
AAA17		X			154.4
AB1	X				2.0↓
AB2		X			0.0
AB4		X			11.4
AB7		X			32.4
AB8		X			33.9
AB9		X			46.6
AB10		X			50.1
ABA1		X			56.1
ABA2		X			58.0
ABA3		X			58.7
ABA5		X			63.2
ABA6		X			72.2
ABA8		X			76.7
ABA10		X			86.7
ABA12		X			91.2
AC1	X				98.4↓
AC2	X				93.9↓
AC4	X				81.4↓
AD1	X				18.7↓
AD3	X				8.2↓
AD6		X			0.0
AD9		X			10.3

UNIT NO.	EIDS	BLUE FIORD	DISAPPOINTMENT BAY UNDIFFERENTIATED	DISAPPOINTMENT BAY LIMESTONE MBR.	STRATIGRAPHIC POSITION(m)
AD19		X			59.4
AD21		X			69.6
AD23		X			74.5
AD24		X			76.0
AD31		X			88.6
AD34		X			97.1
AD36		X			103.1
AD37		X			154.1
BA4		X			72.0
BB2		X			0.0
BB4		X			108.0
BB8		X			133.2
BB11		X			136.3
BB12		X			193.3
BC1		X			193.3
BC8		X			1200.3
BC10		X			1403.3
CA3	X				7.1+
CA5		X			0.0
CA5A		X			17.0
CA5B		X			35.0
CA6		X			47.5
CA7		X			59.5
CA10		X			70.0
CA11		X			71.8
CA12		X			75.8
CA14		X			80.8
CA16		X			86.8
CB1		X			10.9
CB6		X			32.3
CB10		X			38.1
CB12		X			44.8
CB16		X			76.1
CB17		X			77.1
CC1	X				23.4+
CC2A		X			0.0
CC2B		X			9.0
CC2C		X			9.0
CC4		X			15.9
CC6		X			35.4
CCA3		X			42.6
CCA4		X			44.0
CCA8		X			72.5
CCA10		X			86.7
CD2	X				7.5+
CD3A		X			2.0
CD3B		X			6.0
CD3C		X			13.0
CD3D		X			21.0

UNIT NO.	EIDS	BLUE FIORD	DISAPPOINTMENT BAY		STRATIGRAPHIC POSITION(m)
			UNDIFFERENTIATED	LIMESTONE MBR.	
CD4		X			36.0
CD5		X			43.5
CD7		X			50.5
CE2	X				0.5+
CE3		X			0.0
CE7		X			10.0
CE8		X			10.6
CE18		X			60.5
CE19,		X			77.0
CF4		X			22.4
CF5		X			32.9
CF8A		X			77.1
CF8B		X			79.1
CF11		X			85.6
CF15		X			104.7
CF17		X			110.4
CF18		X			113.4
CF19		X			116.4
CF20		X			124.9
CF24		X			139.1
CF25		X			146.6
CH1	X				2.7+
CH4		X			2.7
CH6		X			7.7
CH9		X			23.1
CH11		X			24.5
CH12		X			24.9
CH15		X			33.2
CH19		X			44.7
CH23		X			51.8
CH24		X			53.8
CH25		X			56.3
CH30		X			66.3
CH32		X			74.3
CH33		X			77.1
DA1	X				126.6+
DA7	X				101.6+
DA15	X				61.9+
DA21	X				49.2+
DA27	X				34.9+
DA29	X				12.4+
DA30	X				11.2+
DA37		X			48.0
EA1	X				94.3+
EA3	X				89.8+
EA5	X				85.4+
EA7	X				78.8+
EA8	X				74.7+
EA9	X				71.7+
EA10	X				67.2+

UNIT NO.	EIDS	BLUE FIORD	DISAPPOINTMENT BAY		STRATIGRAPHIC POSITION(m)
			UNDIFFERENTIATED	LIMESTONE MBR.	
EA13	X				60.6↓
EA17	X				28.9↓
EA35		X			22.4
EA39		X			27.4
EA46		X			41.2
EC8		X			172.4
EC10		X			158.9
EC11		X			157.4
EC13		X			156.8
EC15		X			154.3
EC16		X			152.8
EC17		X			148.3
EC20		X			130.8
EC22		X			124.3
EC25		X			117.0
EC29		X			97.5
EC34		X			82.5
EC38		X			61.5
EC39		X			30.0
ED29		X			208.5
ED30		X			217.5
ED33		X			168.0
ED34		X			144.0
ED35		X			133.5
ED36		X			73.5
ED48		X			0.0
FA6			X		63.0
FA12			X		118.8
FA22			X		158.5
FA26			X		163.4
FA36			X		173.5
GA6		X			24.9
GA8			X		56.9
GA9		X			59.9
GA10		X			64.9
GA11		X			65.4
GA16		X			103.4
GA26		X			148.0
GA27		X			149.5
GA33		X			164.5
GA35		X			166.8
GA43		X			199.6
GA45		X			211.1
GB1			X		34.3
GB3		X			43.0
GB10		X			66.1
GB12		X			70.3
GB13		X			71.7
GB18		X			75.9
GB19		X			77.9

UNIT NO.	EIDS	BLUE FIORD	DISAPPOINTMENT BAY UNDIFFERENTIATED	DISAPPOINTMENT BAY LIMESTONE MBR.	STRATIGRAPHIC POSITION(m)
GB25		X			85.5
GB27		X			90.0
GB28		X			91.2
GB31		X			95.2
GB32		X			96.7
GB33		X			100.9
GB35		X			106.9
GB40		X			115.9
GB43		X			130.9
GB45		X			152.9
GB50		X			187.1
GB66			X (tongue)		223.7
GC1			X (tongue)		191.7
GC10		X			232.3
GC13			X (tongue)		240.3
GC24			X (tongue)		295.1
GC28		X			306.0
GC29			X (tongue)		334.5
GC30		X			341.2
GD1		X			198.8
GD3		X			170.8
GD5		X			151.8
GE2		X			119.6
GE6		X			133.3
GE8		X			145.8
GE22		X			223.1
HA2		X			0.0
HA23		X			146.0
HA28		X			173.8
HA31		X			176.2
HA35			X (tongue)		191.7
HA40			X (tongue)		198.7
HA50			X (tongue)		217.2
HA56			X (tongue)		227.4
HB3		X			33.0
HB6		X			19.5
HB24			X (tongue)		61.5
HB28		X			66.2
HB30		X			96.7
HB32		X			133.7
HB34		X			148.2
HB35			X (tongue)		167.7
HB40			X (tongue)		183.4
HB42			X (tongue)		190.9
HB48			X (tongue)		213.6
HB52			X (tongue)		225.4
HB58			X (tongue)		233.5
HB59			X (tongue)		235.0
HB67			X (tongue)		257.9
HB69		X			280.4

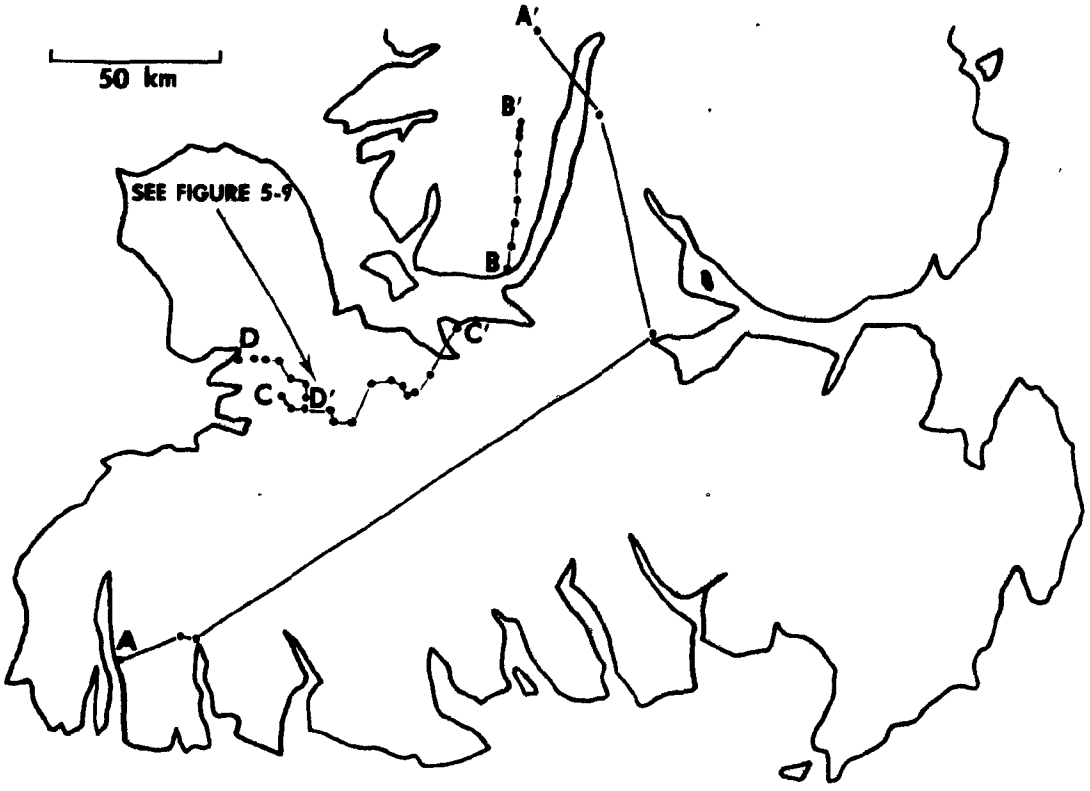
UNIT NO.	EIDS	BLUE FIORD	DISAPPOINTMENT BAY		STRATIGRAPHIC POSITION(m)
			UNDIFFERENTIATED	LIMESTONE MBR.	
HB71			X (tongue)		285.9
HC2		X			0.0
HC16		X			51.9
HC30		X			103.7
HC40		X			169.6
HC44			X (tongue)		193.1
IA5	X				3.3+
IA10		X			8.6
IA12		X			14.1
IA13		X			15.6
IA13B		X			30.6
IA13C		X			38.1
IA14		X			39.6
IA15		X			41.1
IB1		X			0.0
IB2		X			1.0
IB3		X			4.4
IB4		X			5.9
IB9		X			36.1
IB10		X			46.6
IB11		X			58.4
IB12		X			64.4
IC2		X			0.0
IC5		X			12.0
IC7		X			16.3
ID2		X			19.5
ID3		X			34.5
ID5		X			44.5
ID7		X			49.0
ID10		X			56.8
ID11		X			67.3
ID12		X			68.8
ID14		X			86.0
ID16		X			96.5
JA2		X			21.0
JA4		X			357.0
JA9		X			431.0
JA14		X			510.5
JA15		X			515.0
JB2		X			0.0
JB3		X			6.0
JB6		X			22.5
JB7		X			27.0
JB14		X			53.0
JC3		X			56.0
JC4		X			65.5
JC6		X			70.0
JC8		X			85.0
KA21			X		67.1

UNIT NO.	EIDS	BLUE FIORD	DISAPPOINTMENT BAY UNDIFFERENTIATED	DISAPPOINTMENT BAY LIMESTONE MBR.	STRATIGRAPHIC POSITION(m)
KA25			X		87.3
KA41			X		134.5
KA49			X		176.5
KA53			X		210.0
KB25			X		173.8
K1	X				35.0+
K3		X			59.3
K4		X			85.5
K6		X			137.9
K9		X			194.8
K11		X			272.8
Loc. 2		X			900.0
Loc. 7-U9	X				uppermost
Loc. 11		X			lower 100
Loc. 17		X			lower
Loc. 19		X			lower
Loc. 21		X			90.0
Loc. 23		X			156.0
Loc. 26		X			lower 60
Loc. 29		X			lower
Loc. 37	X				120.0+
Loc. 40		X			120.0
Loc. 43		X			35.0
Loc. 52		X			lower
Loc. 54		X			0.0
Loc. 56(9)		X			35.9
Loc. 57(8)			X		48.1
GSC Loc. C-12471		X			896.1
GSC Loc. C-12472		X			903.7
B22		X			lower 100
B30-4				X	9.0
B30-11				X	79.9
B37		X			lower 100
B42				X	lower 100

There's a land where the mountains are nameless,
And the rivers all run God knows where;
There are lives that are erring and aimless,
And deaths that just hang by a hair;
There are hardships that nobody reckons;
There are valleys unpeopled and still.
There's a land - oh, it beckons and beckons,
And I want to go back - and I will.

- Spell of the Yukon; R. Service

LEGEND TO FIGURE 3-1



FENESTRAL DOLOSTONE

FENESTRAL LIME MUDSTONE

FOSSILIFEROUS LIME WACKESTONE

SILTSTONE

FAUNALLY-RESTRICTED ARGILLACEOUS LIMESTONE

CORAL/STROMATOPOROID BOUNDSTONE

CRINOID GRAINSTONE

ARGILLACEOUS FOSSILIFEROUS WACKESTONE

DOWNSLOPE CORAL/STROMATOPOROID BOUNDSTONE

BRYOZOAN LIME MUDSTONE

INTERBEDDED LIME MUDSTONE + SHALE

SKELETAL GRAINSTONE/PACKSTONE (TURBIDITE)

LAMINATED LIMESTONE + SHALE

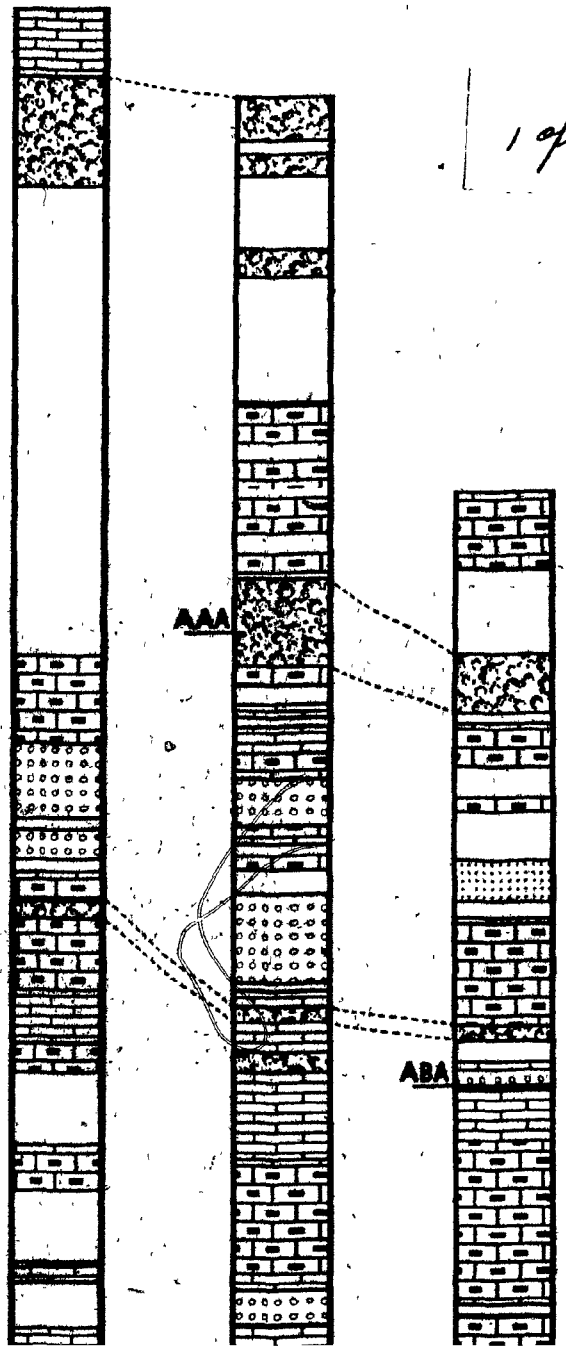
COVERED INTERVAL

SCALE ON ALL STRATIGRAPHIC SECTIONS: 1" = 20 m
(SEE SCALE BAR)

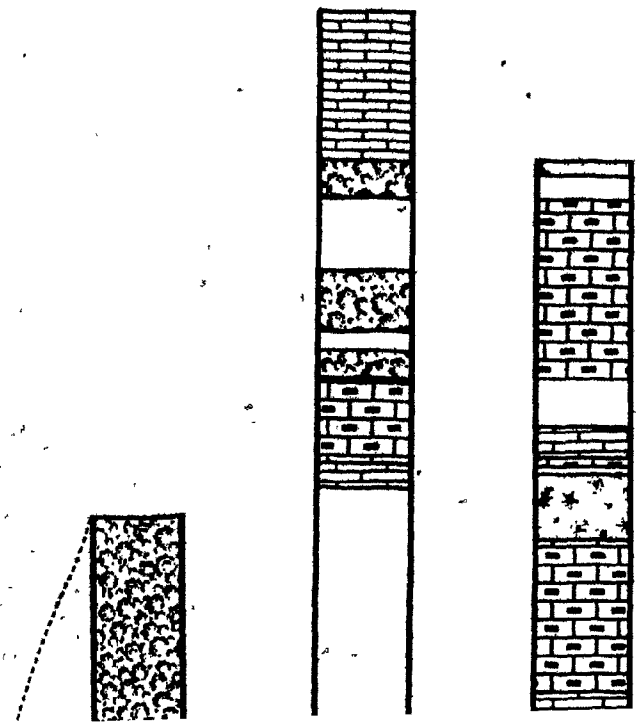
SCALE BAR

200 m
180 m
160 m
140 m
120 m
100 m
80 m
60 m
40 m
20 m
0

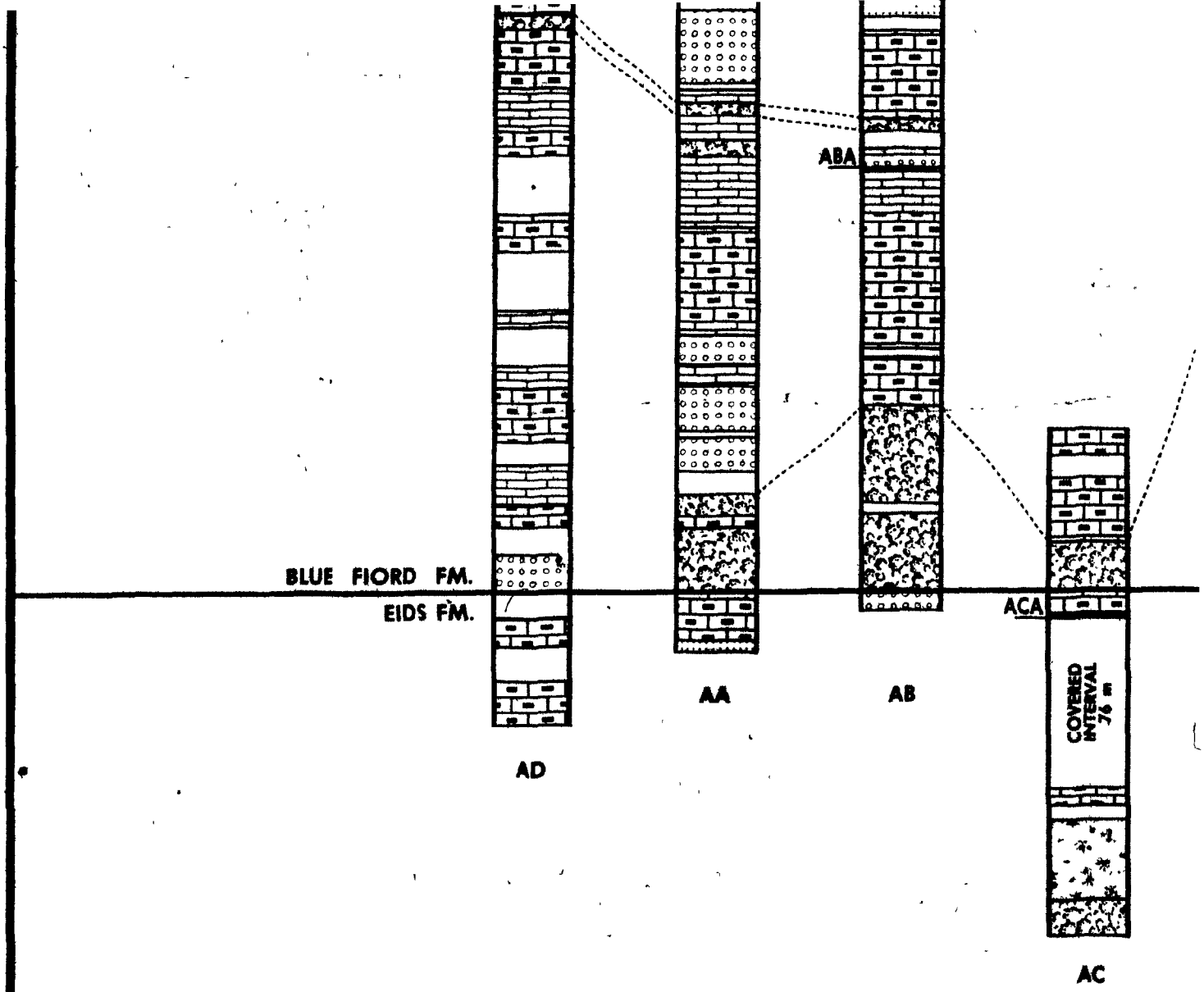
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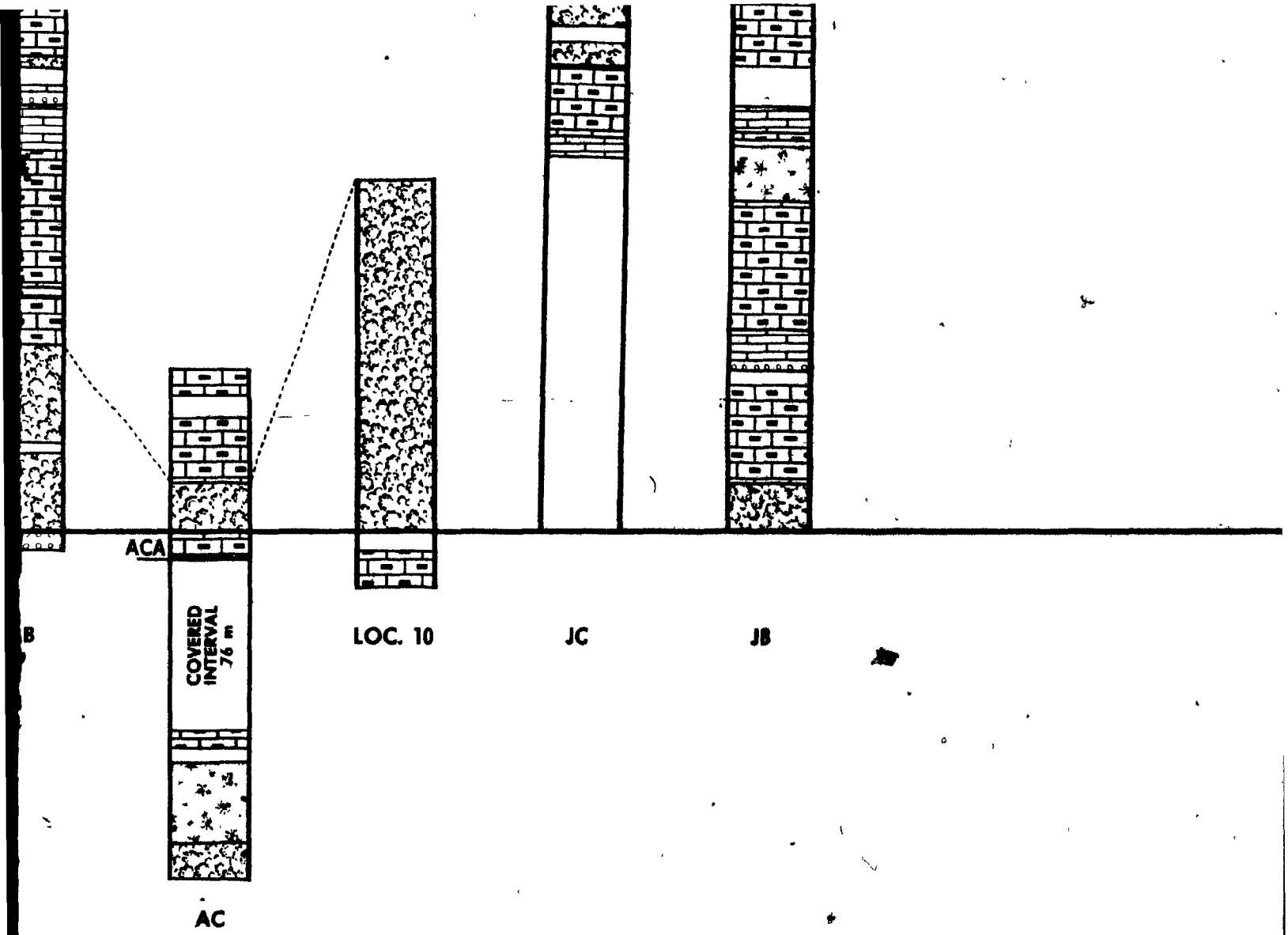
D'



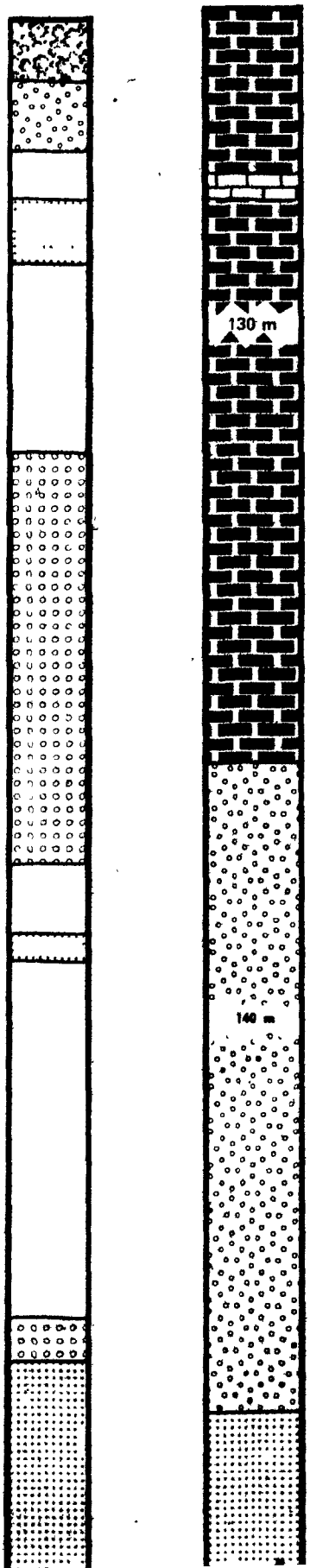
27



3 of


ACA
COVERED INTERVAL 76 m
LOC. 10
JC
JB
AC

C



← DISAPPOINTMENT BAY FM. TONGUE

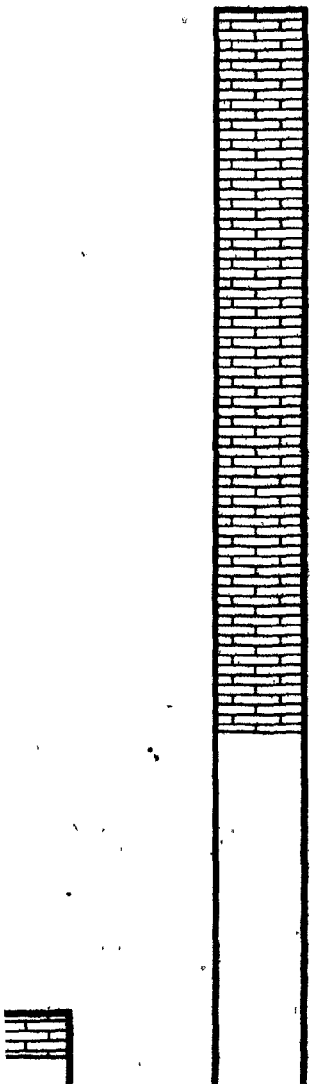
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DISAPPOINTMENT BAY FM. TONGUE

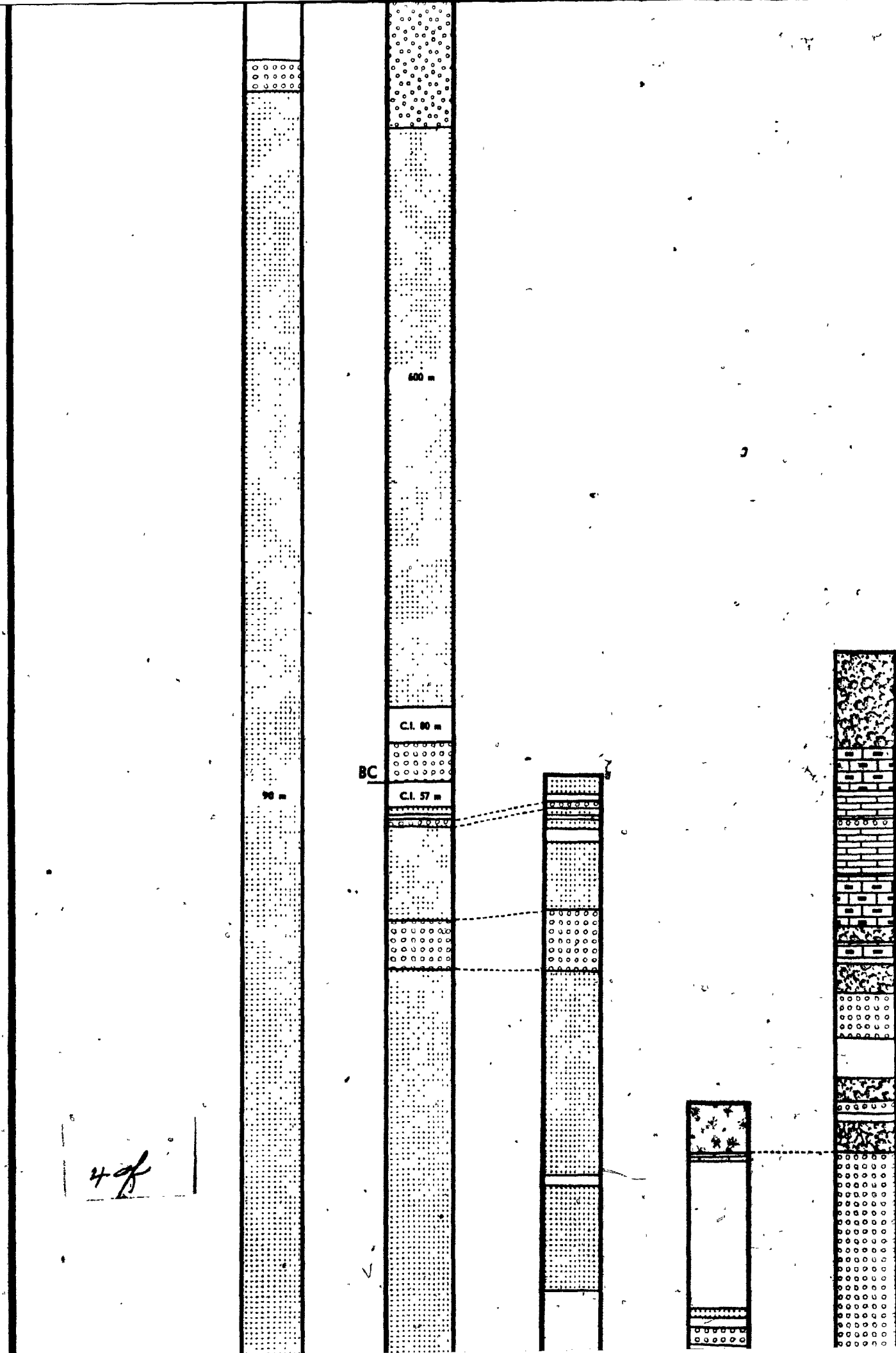
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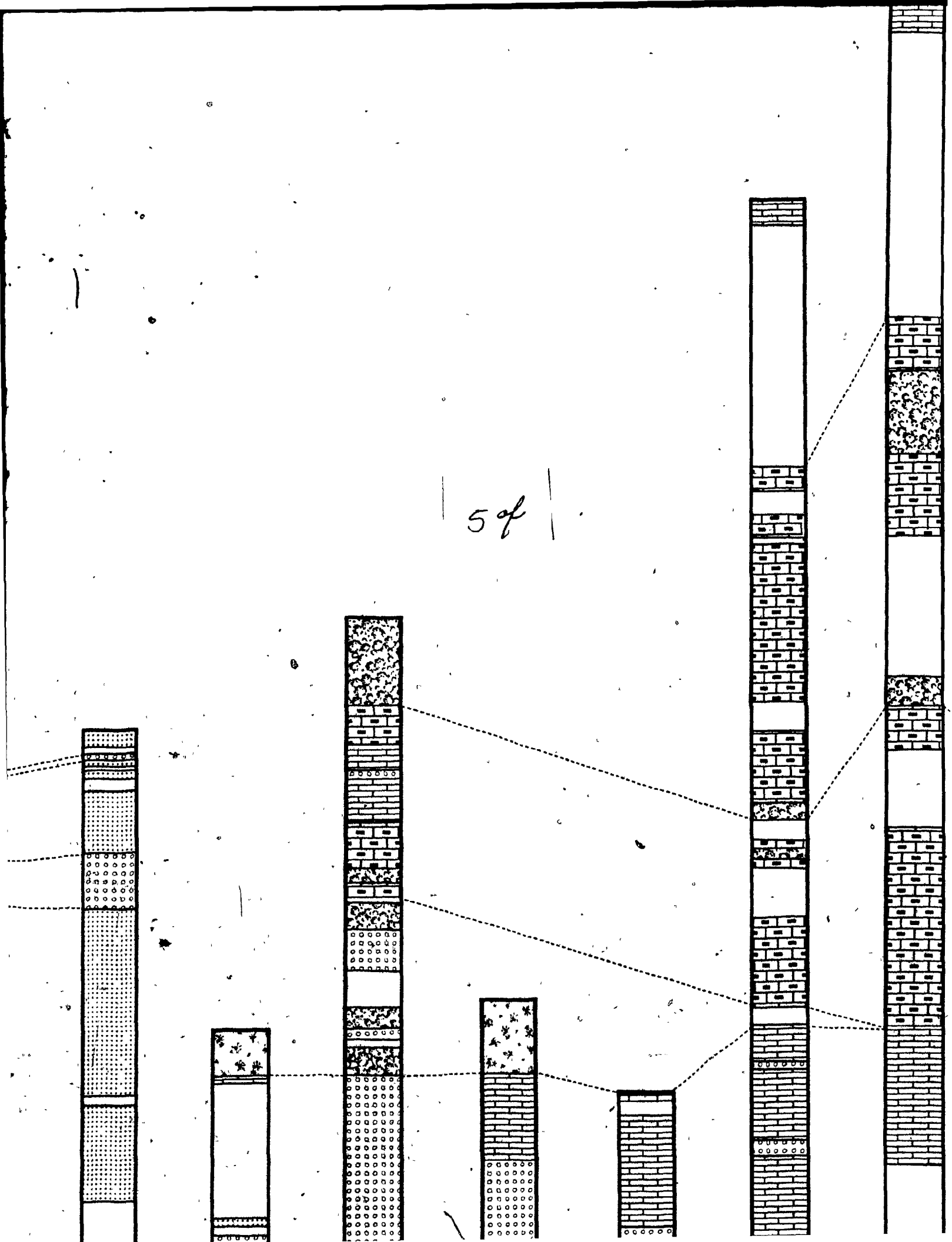


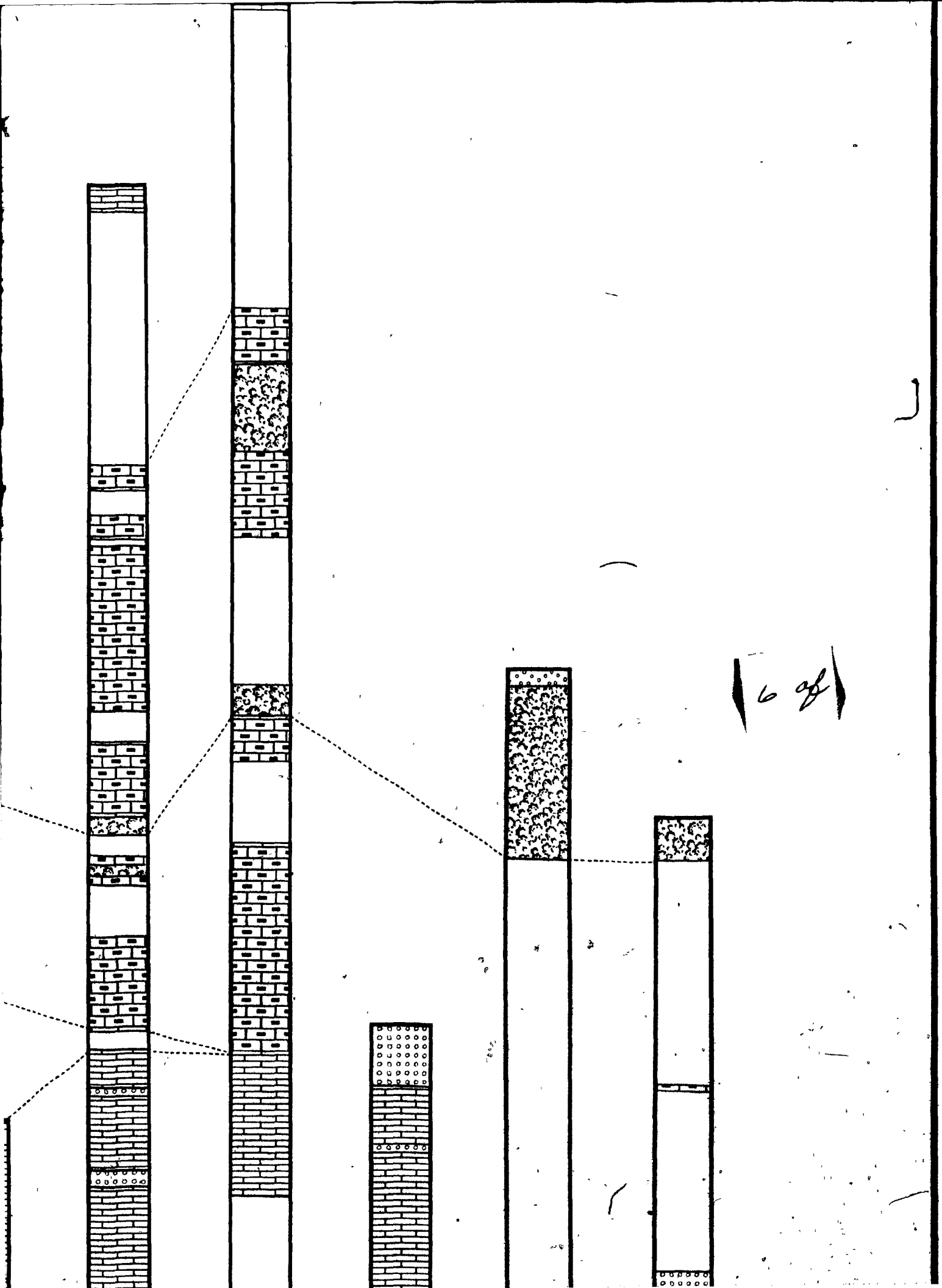
C'

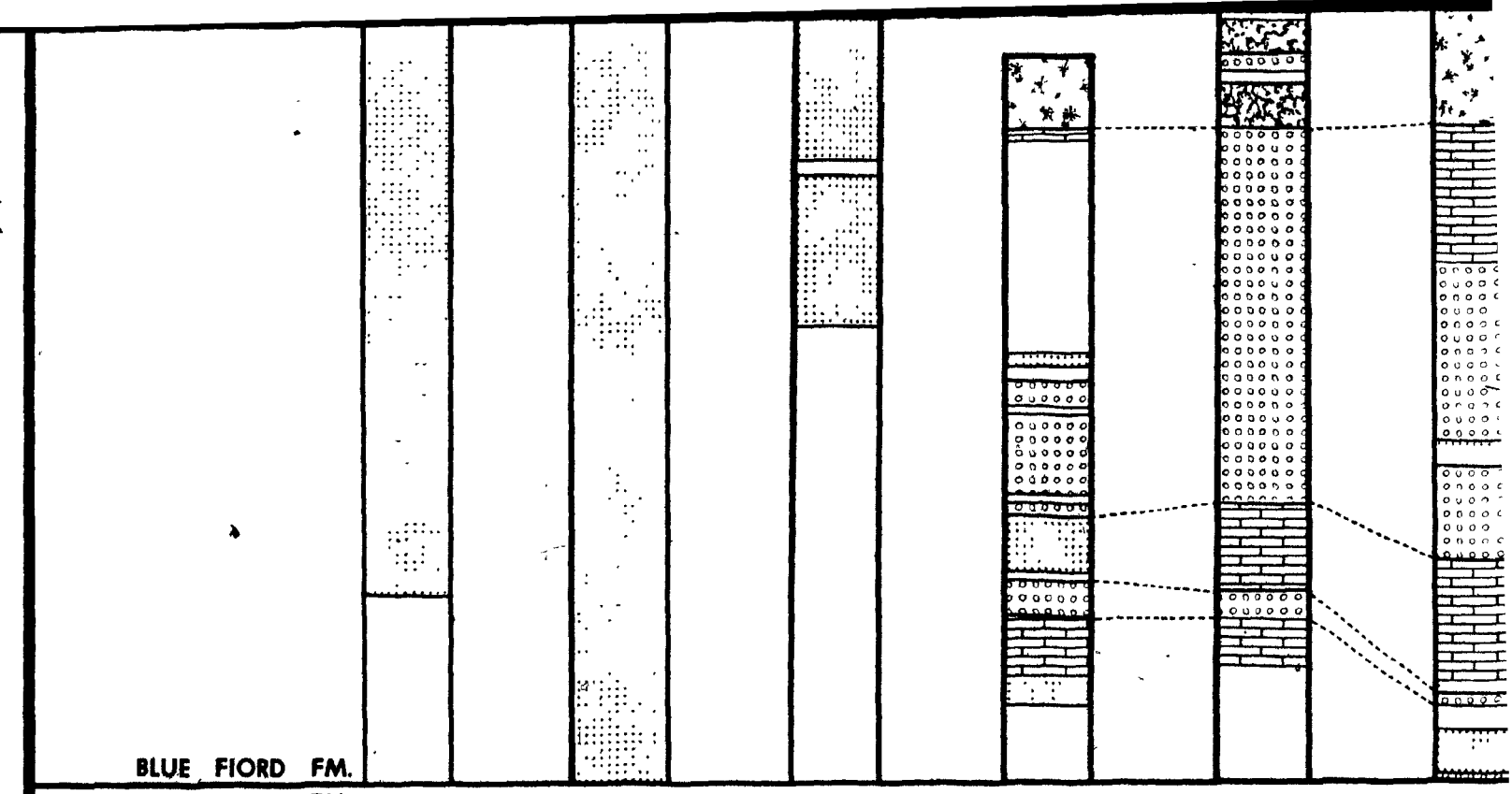


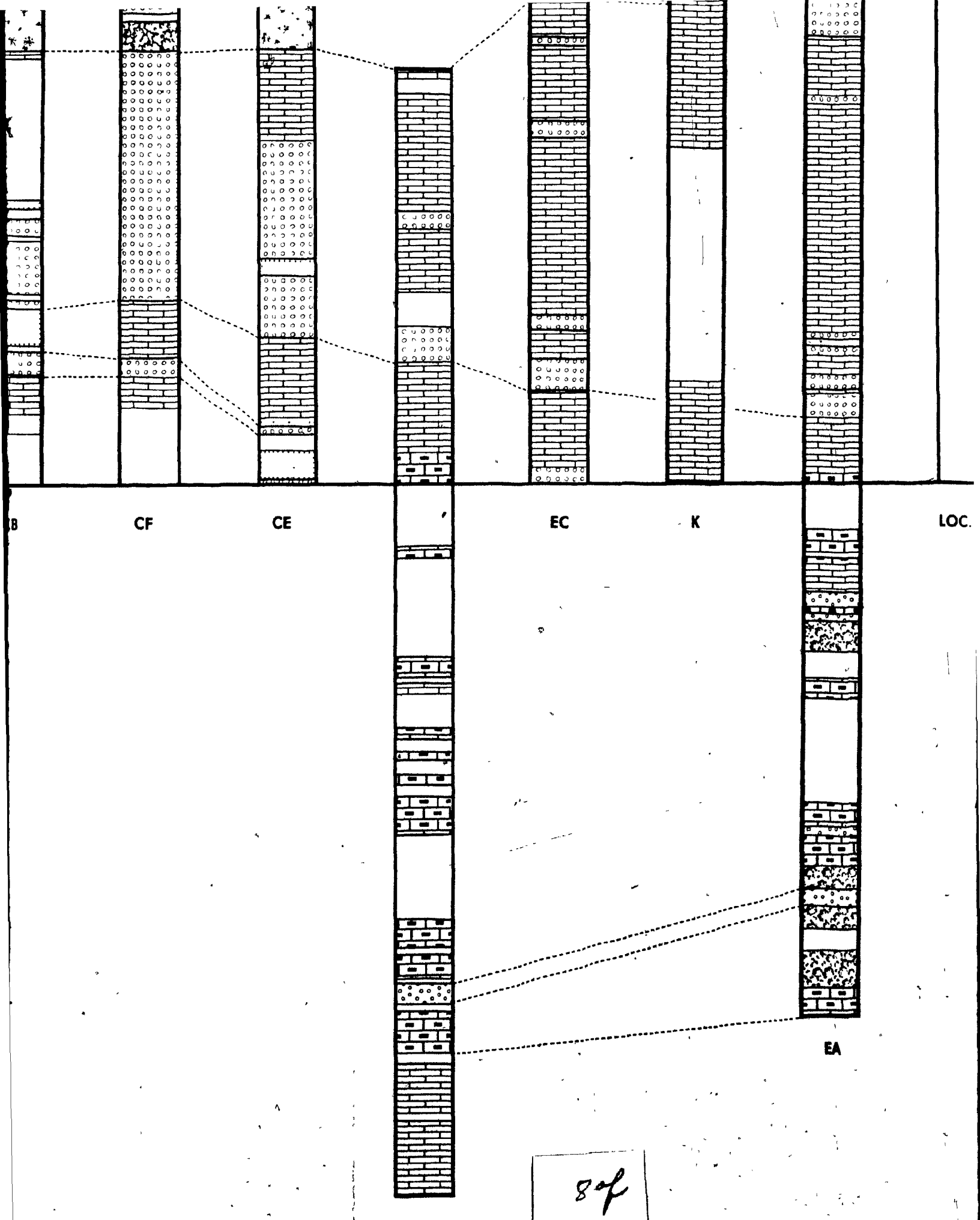
3 4


600 m
C.I. 80 m
BC
C.I. 57 m
90 m

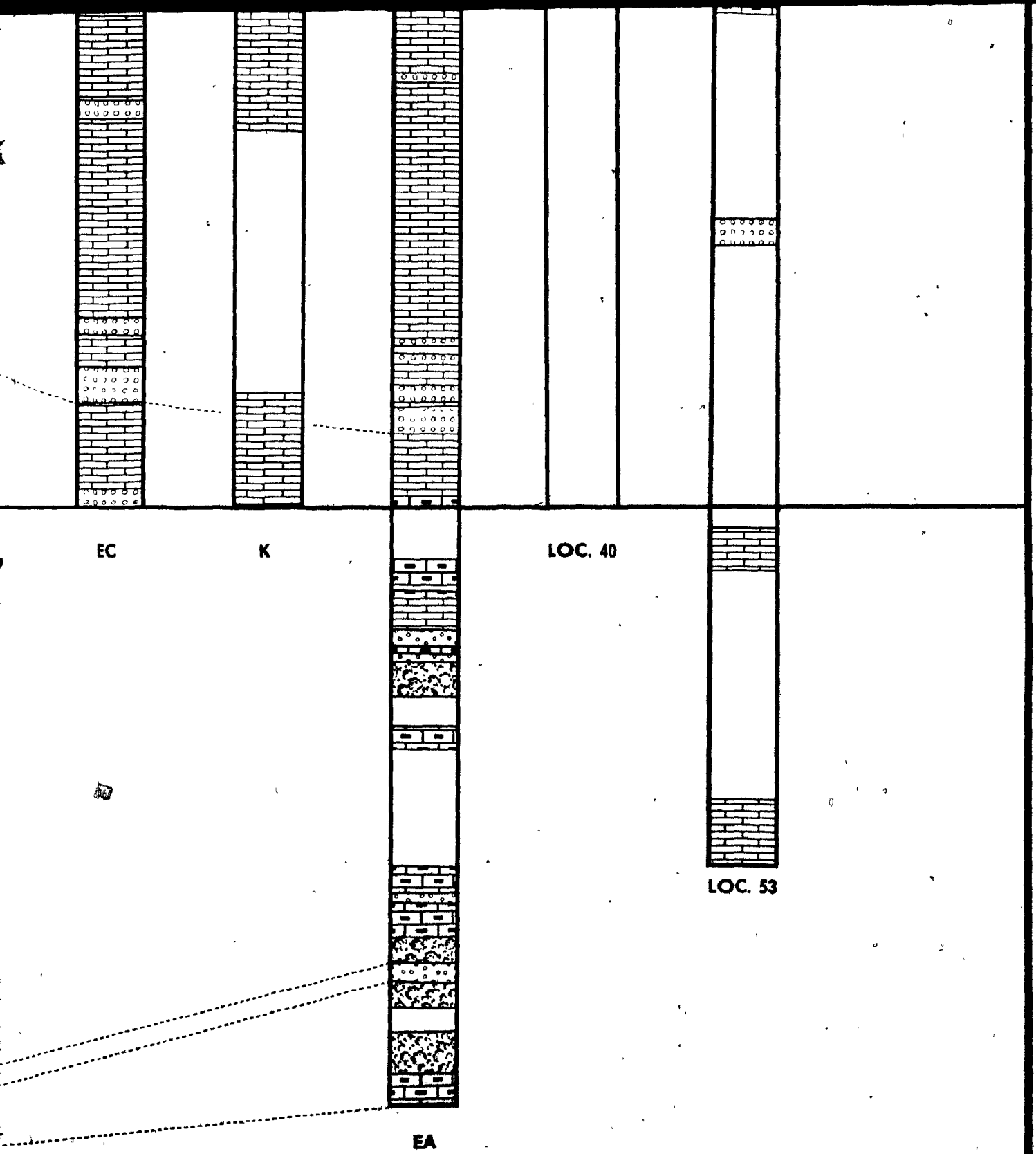


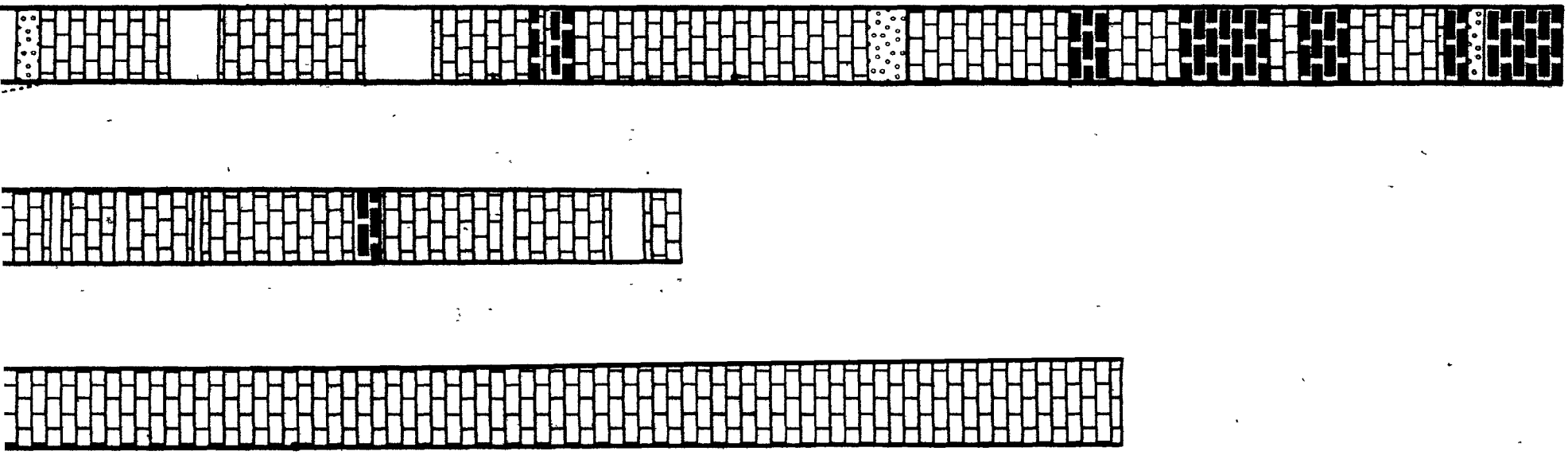



BLUE FIORD FM.
EIDS FM.
JA
BB
BA
CB
CF
CE

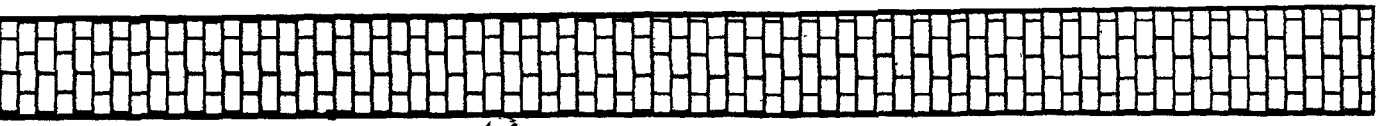


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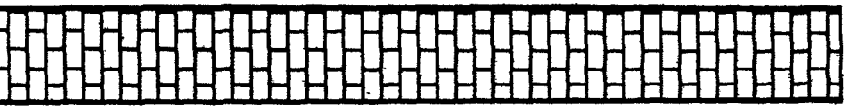

EC
K
LOC. 40
LOC. 53
EA



DISAPPOINTMENT BAY- FM. TONGUE



DISAPPOINTMENT BAY FM. TONGUE











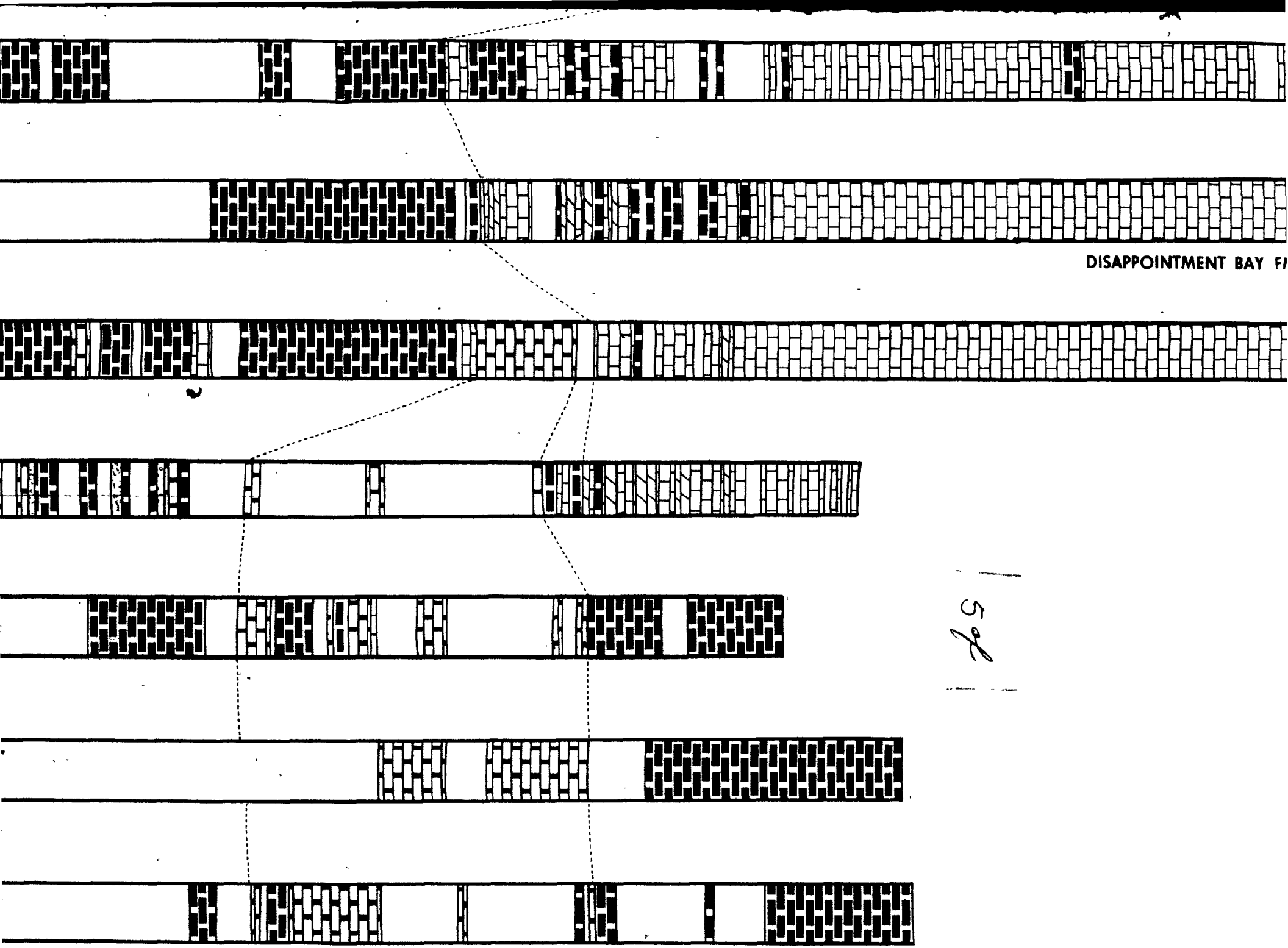
BLUE FIORD FM

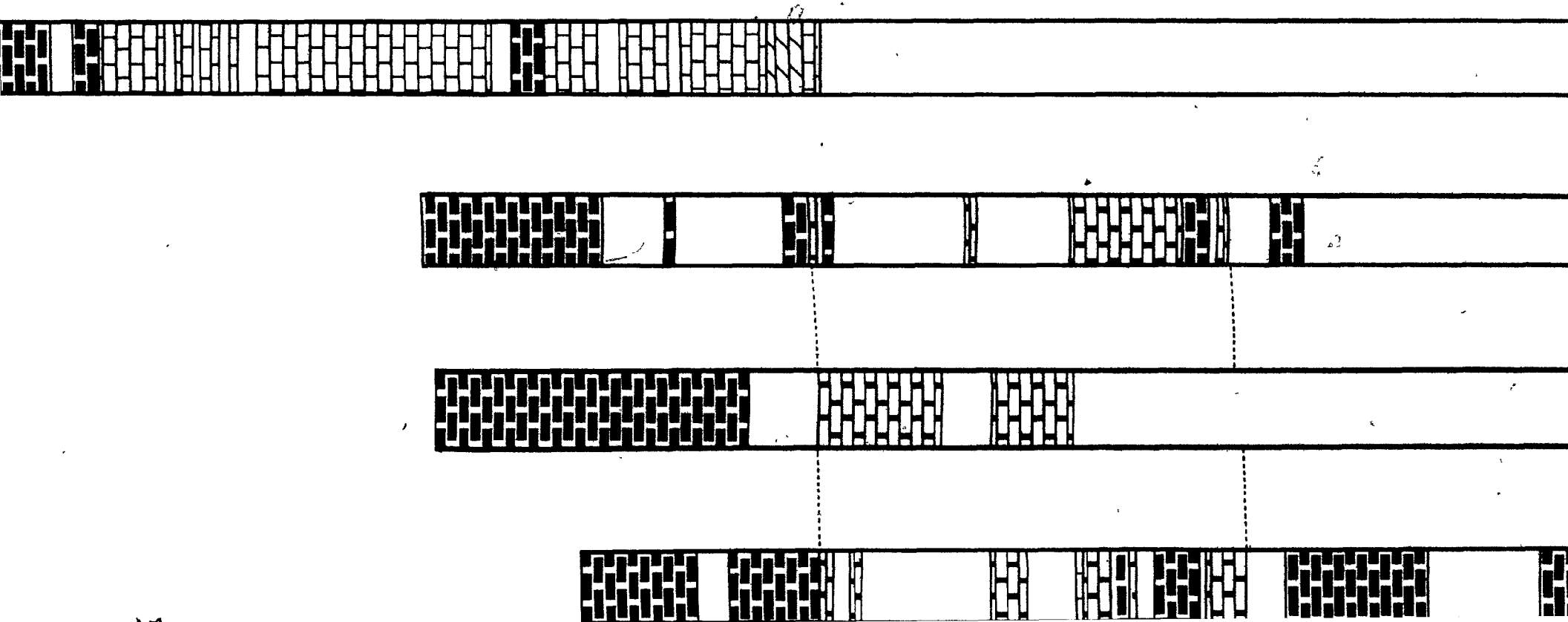
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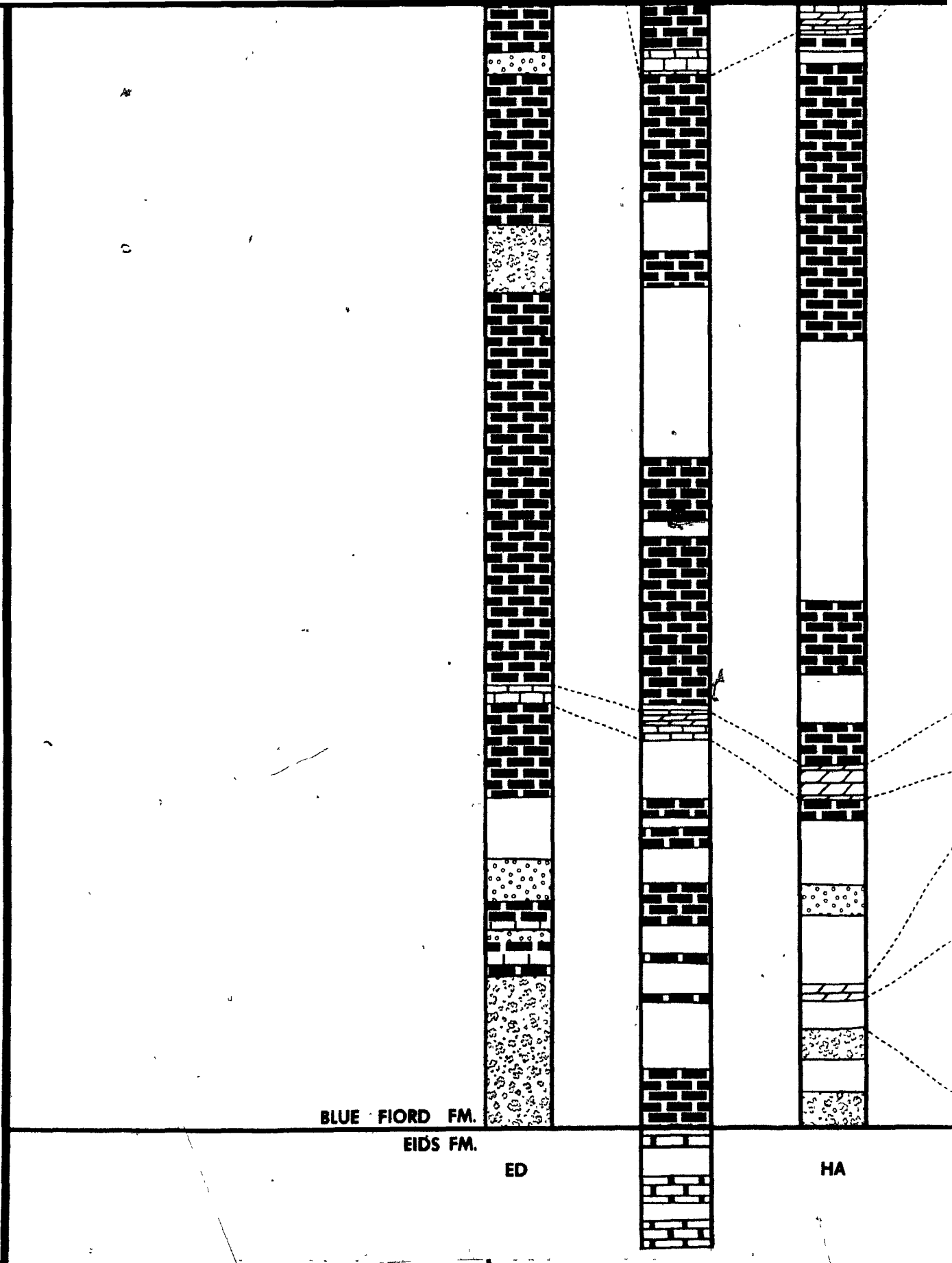
BLUE FIORD FM.

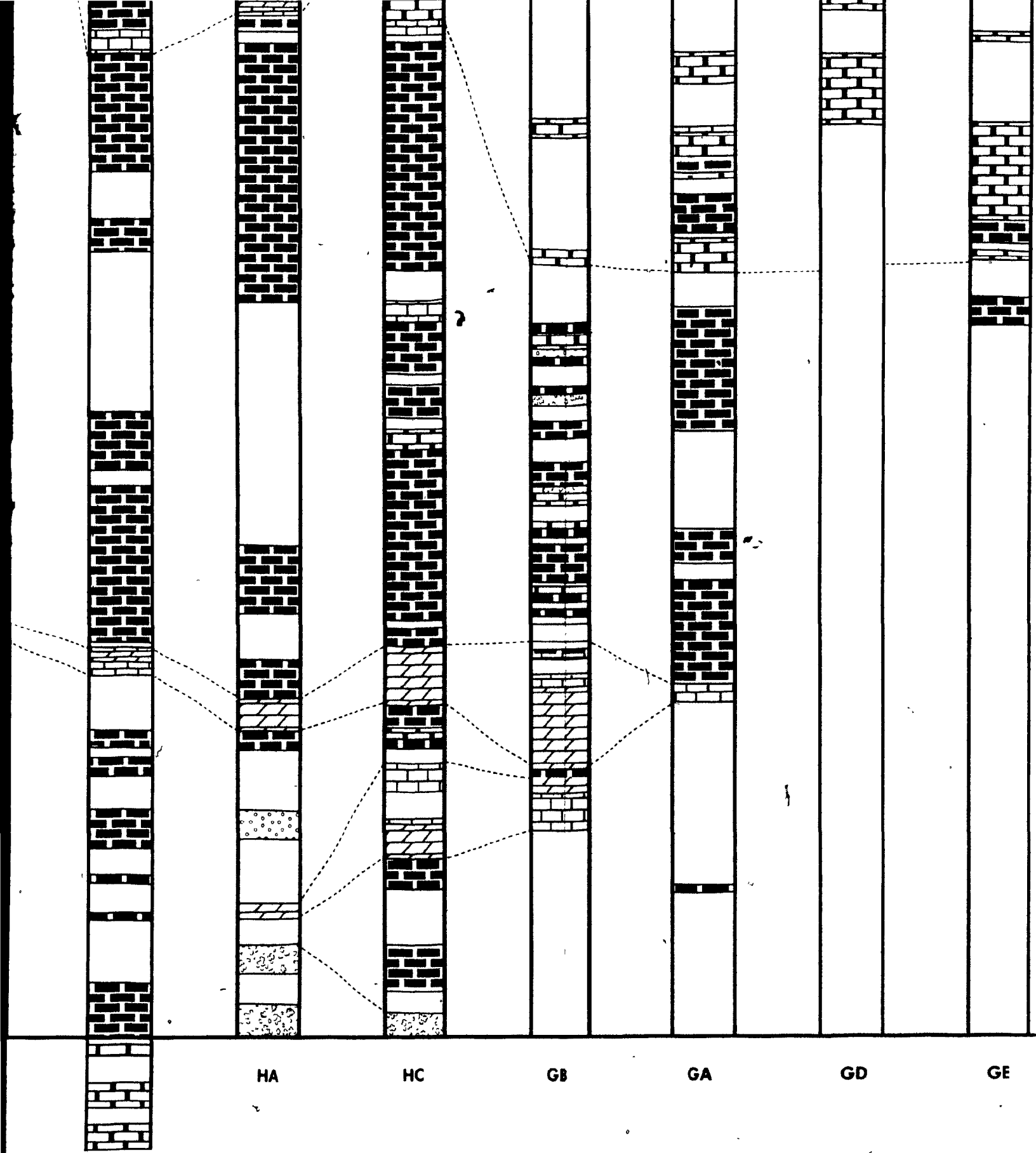
3 3/4

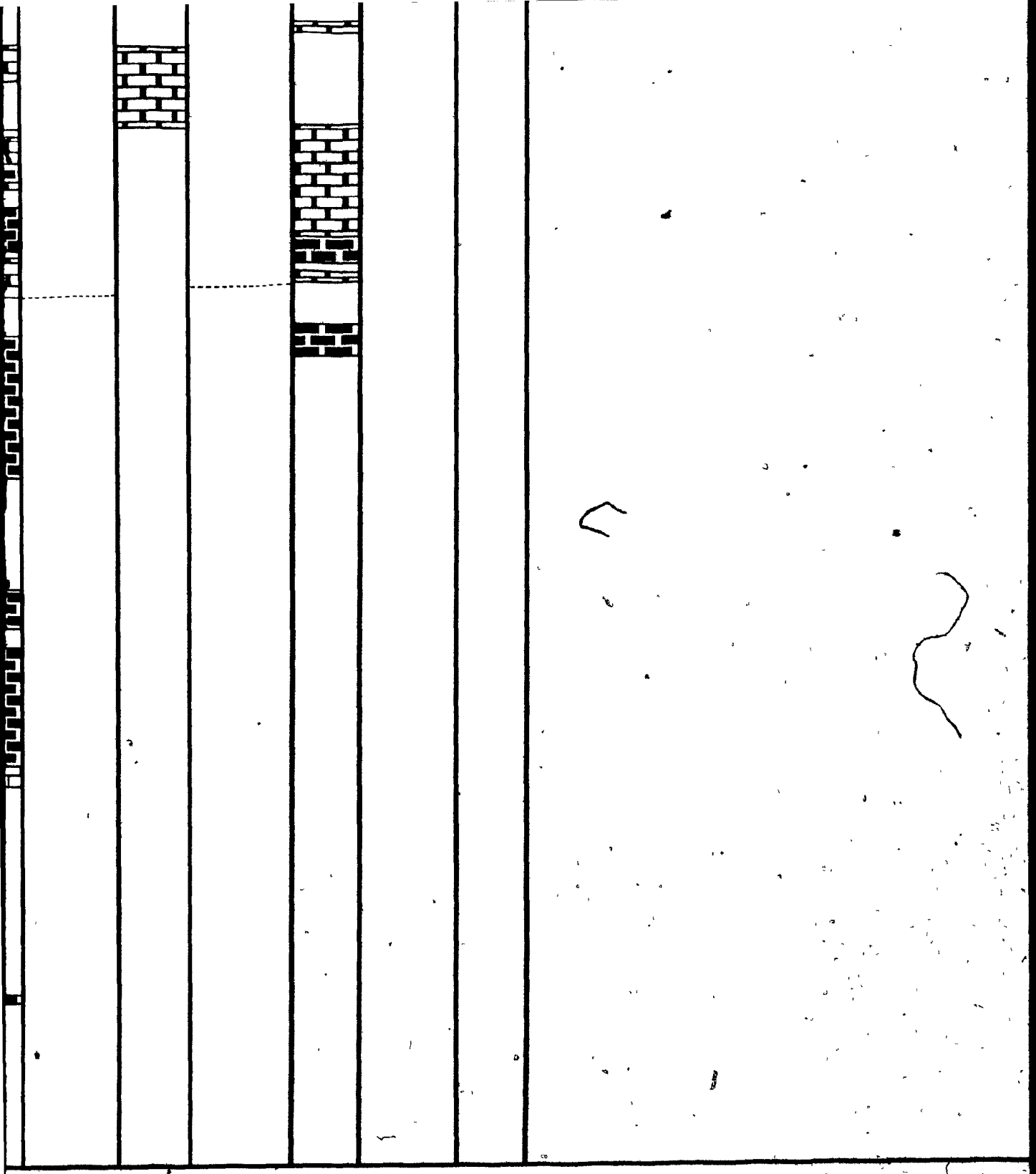
4 of


DISAPPOINTMENT BAY FI

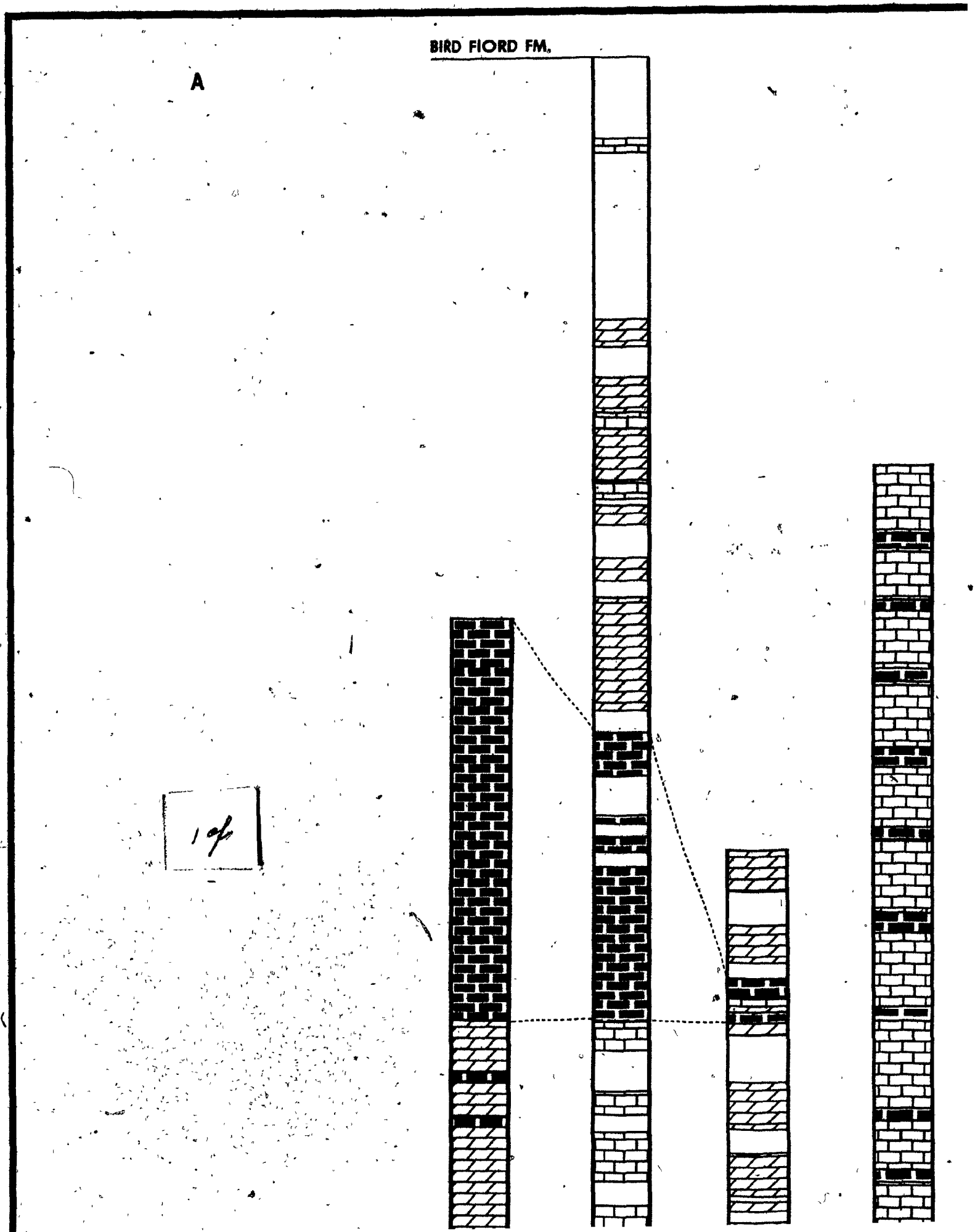


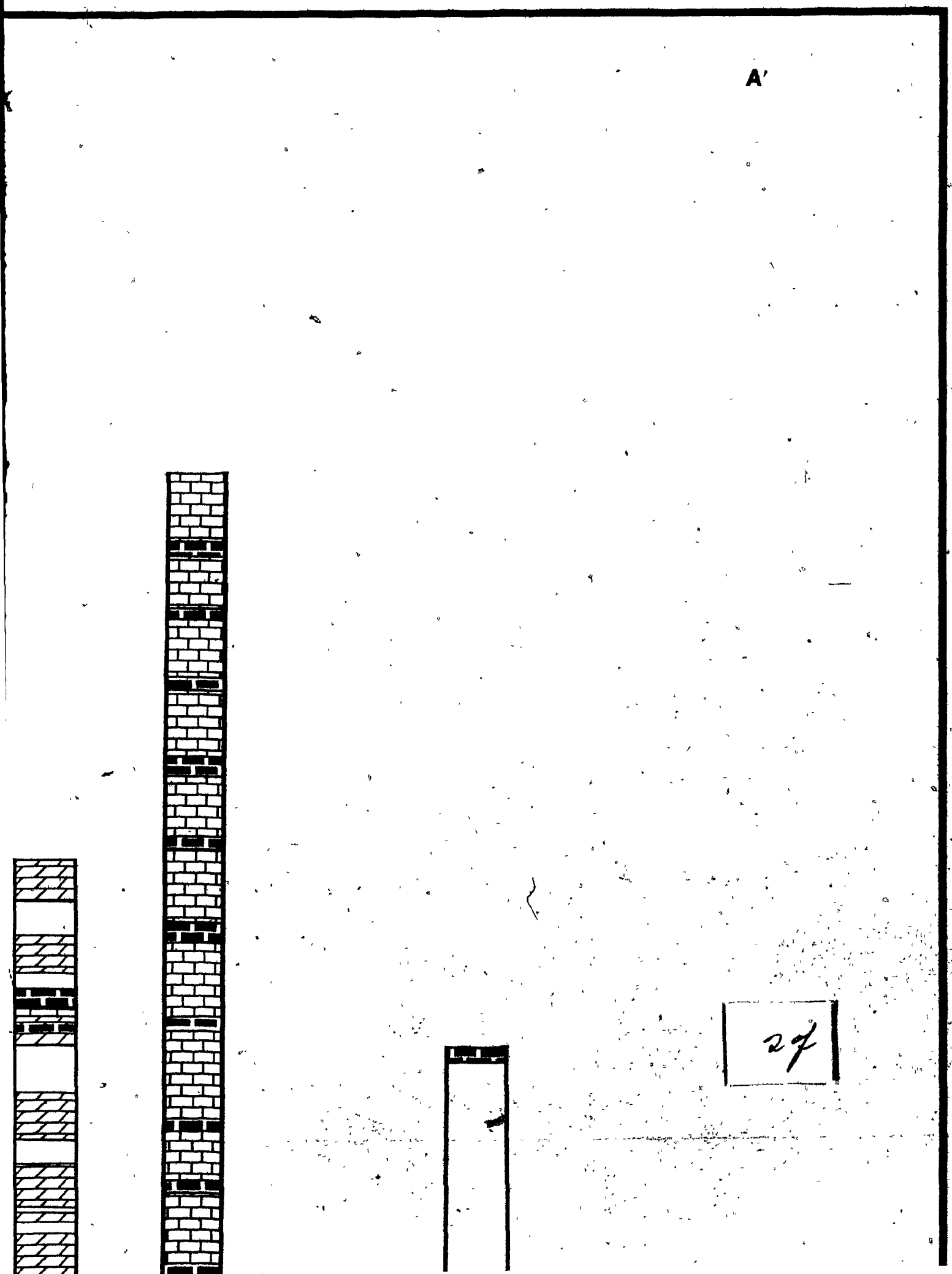

BLUE FIORD FM.
EIDS FM.
ED
HA
HB

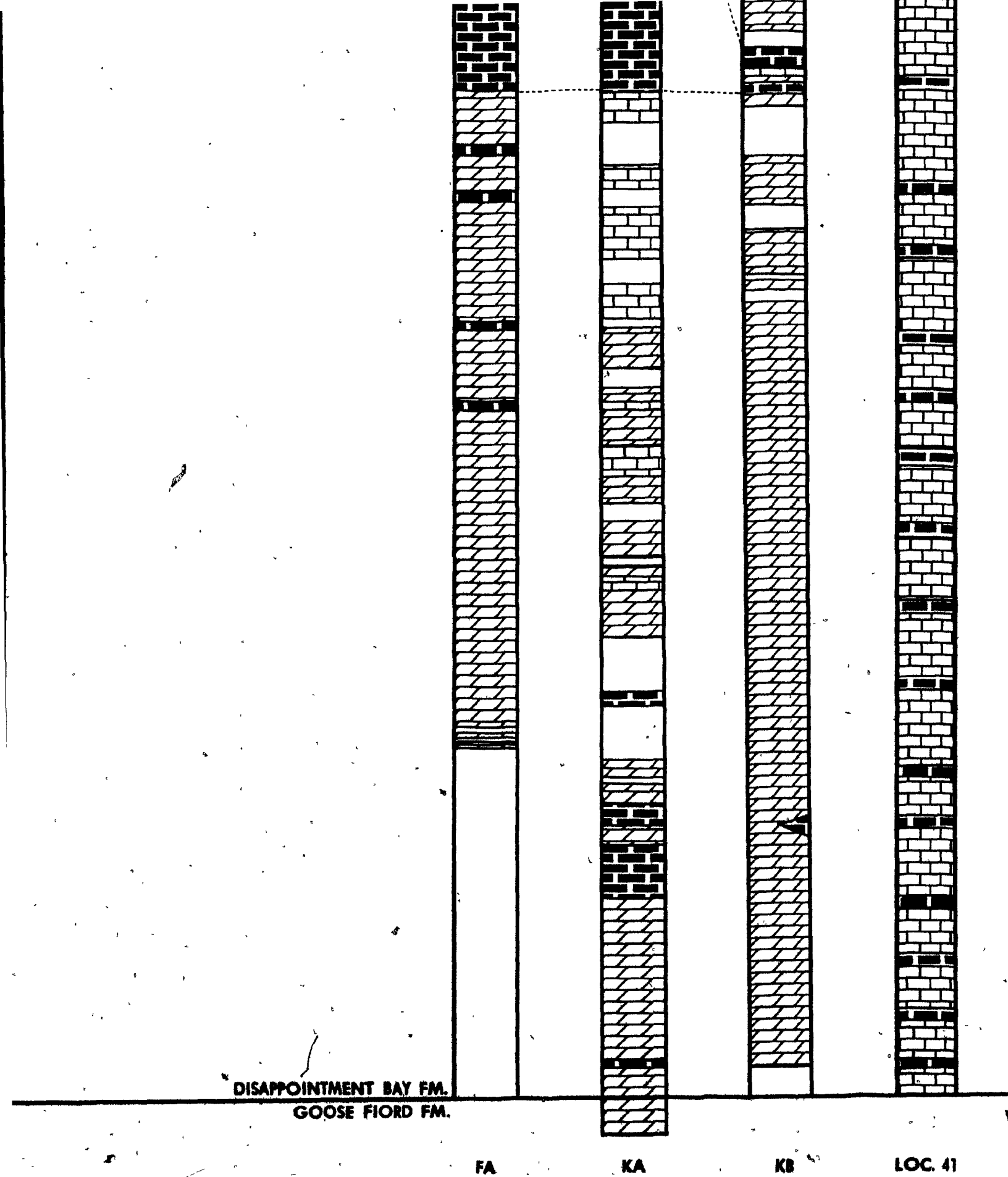

HA
HC
GB
GA
GD
GE
HB

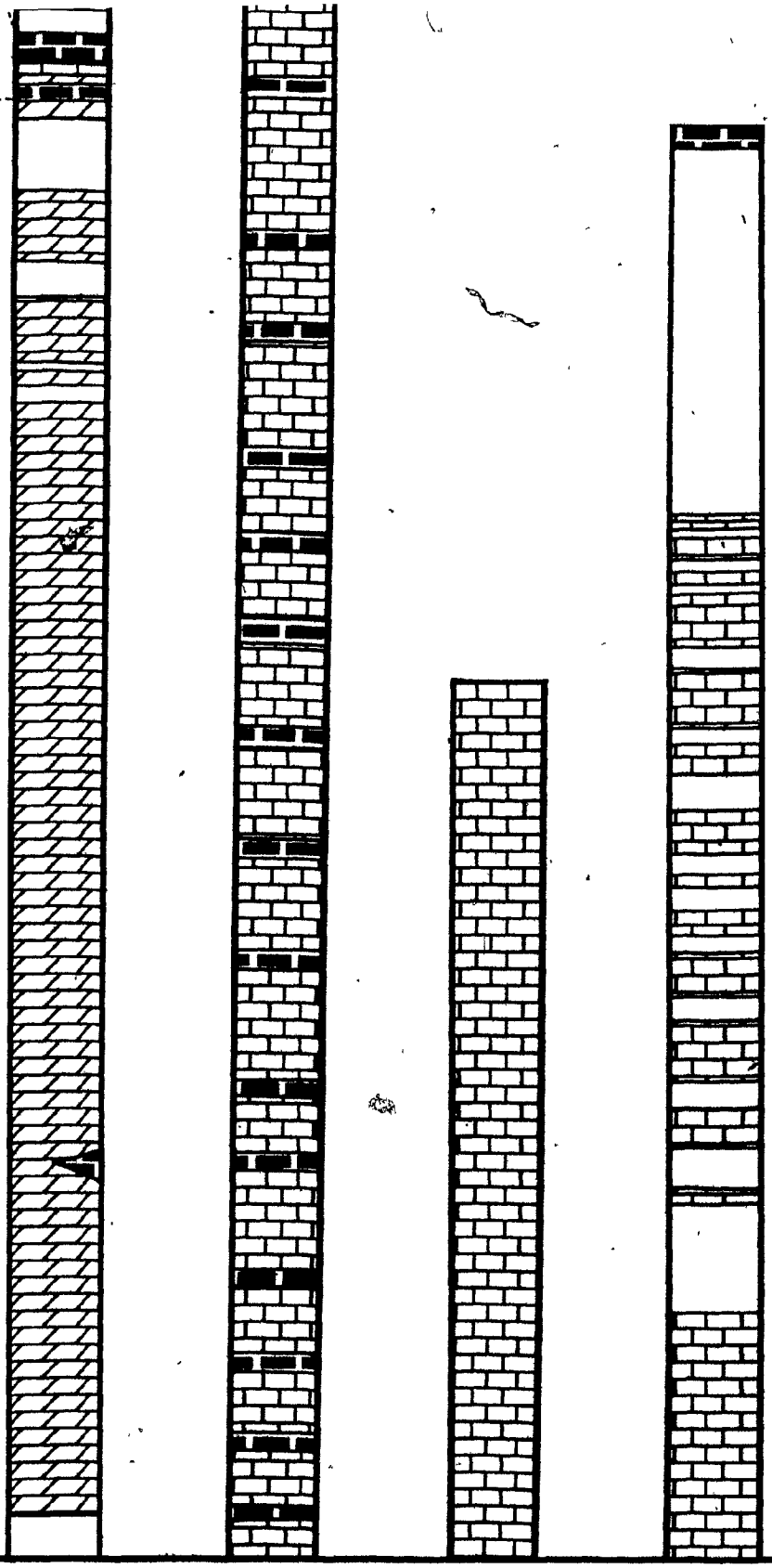


949


BIRD FIORD FM.
A
1 of


A'
27


DISAPPOINTMENT BAY FM.
GOOSE FIORD FM.
FA
KA
KB
LOC. 41



VENDOM FIORD FM.

KB LOC. 41 LOC. 47 LOC. 57