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STRUCTURAL FRAMEWORK OF LANCASTER AULACOGEN, ARCTIC CANADA

J. WM. KERR

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Preface

Lancaster Sound is the eastern entrance of the Northwest Passage and as the likelihood grows of this route being used regularly for commercial traffic the need increases for more detailed information about the physical setting of the region. Lead-zinc ore from the Nanisivik Mine on northern Baffin Island is already being moved through the easternmost part of Lancaster Sound and the development of the Polaris Mine on Little Cornwallis Island will result in further activity. The area is considered to have favourable potential for the occurrence of hydrocarbons and an offshore well has already been proposed. The channel is also part of the proposed route to be followed should liquified natural gas be brought south by tankers from Melville Island and other known natural gas deposits in the western Arctic. The Lancaster Sound area is rich in marine life and although this is vulnerable to environmental hazards that may accompany increased activity by man a thorough knowledge of the geology of the region will assist considerably in reducing such hazards.

Lancaster Sound has long been considered to be a fault-controlled structure, a supposition substantiated by recent geophysical work. The region is one that is crucial to understanding the geological evolution of eastern North America in terms of plate tectonics. In this report the author outlines the remarkable geological history of the area. The structural development was controlled by the interplay of global plate tectonic forces acting on pre-existing features. Structural trends in Precambrian gneisses influenced Paleozoic tectonic events which in turn provided the sites for easy release of the forces developed during the Late Cretaceous to mid-Tertiary plate tectonic breakup. In the resulting down-faulted portion of the crust more than 6000 metres of sediments were deposited and these may contain significant accumulations of hydrocarbons.

Ottawa, July 1979

D.J. McLaren
Director General
Geological Survey of Canada

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Abstract

Lancaster Aulacogen contains up to 6000 m of probable Cretaceous-Tertiary sediments. It is a failed arm of a triple junction that is located in northwestern Baffin Bay. The aulacogen was formed during the Late Cretaceous to early Tertiary Eurekan Rifting Episode, a plate tectonic event. The aulacogen is now covered by water of Lancaster Sound. The main fault on its north side had about 8200 m of vertical displacement during formation of the aulacogen.

Stratigraphic-structural sequences in the Lancaster Sound study area represent different levels of the earth's crust. Sequence 1 is the Canadian Shield, the foundation, and its gneissic trends influenced the pattern of development of all younger sequences.

Sequence 2 is a thick Proterozoic sedimentary and volcanic basin containing Proterozoic basic dykes. This sequence is preserved in a broad basin that includes Lancaster Aulacogen and a wider area. This basin became isolated largely by pre-Paleozoic warping and faulting events, but there was not an aulacogen at that time on the site of the present aulacogen.

Sequence 3 is rock of the Arctic Platform, a widespread lower Paleozoic sedimentary column of rather uniform thickness.

Sequence 4 of the Canadian Arctic apparently was not deposited in the study area.

Sequence 5 is a Lower to Upper Cretaceous sedimentary column. This was a widespread deposit of the cratonic shelf that existed throughout most of the study region before the aulacogen formed.

Sequences 6 to 8 of the study area are divided on land but not at sea. This is an Upper Cretaceous and Tertiary to present-day sedimentary column with probable minor intrusions. It is sparsely present on land, but makes up the widespread column several thousand metres thick within Lancaster Aulacogen. This probably was deposited during and after formation of the aulacogen. Sequences 5 to 8 together may be more than 6000 m thick in the aulacogen.

Sequences 1, 2, 3 and 5 existed on the site of Lancaster Aulacogen before that structure began to form. They were later deeply downfaulted and downwarped into the aulacogen where they are preserved. Sequences 6 to 8 were deposited in the aulacogen during and after its formation.

Lancaster Aulacogen was formed by rifts that were propogated into the Canadian Arctic from the southeast, and broke apart the continental crust in that region. The structure of the aulacogen resulted partly from global stresses that were rotating major plates, but it was guided in a major way by pre-existing structural trends inherited from the Precambrian crystalline basement. Although there are thick pre-Upper Cretaceous rocks in at least parts of the aulacogen, there is no evidence that this structure originated before the Late Cretaceous to Tertiary Eurekan Rifting Episode.

Résumé

L'aulacogène de Lancaster contient jusqu'à 6000 m de sédiments datant probablement du Crétacé-Tertiaire. Ce bras d'une triple jonction située dans le nord-ouest de la baie Baffin a cédé. L'aulacogène a été formé pendant le Crétacé inférieur jusqu'au début de la formation des failles eurêkiennes du Tertiaire, phase de la tectonique des plaques. L'aulacogène est maintenant couvert par les eaux du détroit de Lancaster. La principale faille avait à son extrémité nord environ 8200 m de déplacement vertical pendant la formation de l'aulacogène.

Les séquences stratigraphiques-structurales de la zone étudiée dans le détroit de Lancaster représentent différents niveaux de l'écorce terrestre. La Séquence 1 constitue le Bouclier canadien, soit les fondations, et ses tendances gneissiques ont influencé le mode de développement des séquences plus récentes.

La Séquence 2 est un épais bassin sédimentaire et volcanique contenant des dykes basiques du Protérozoïque. Cette séquence est préservée dans un vaste bassin qui comprend l'aulacogène de Lancaster et une zone plus étendue. Ce bassin a été isolé surtout par des gauchissements et des failles survenus avant le Paléozoïque, mais l'aulacogène n'existait pas à cette époque.

La Séquence 3 est constituée de roches de la plate-forme de l'Arctique, soit une colonne sédimentaire du Paléozoïque inférieur, très étendue et d'épaisseur assez uniforme.

La Séquence 4 de l'Arctique canadien n'a laissé apparemment aucun dépôt dans la zone étudiée.

La Séquence 5 est une colonne sédimentaire du Crétacé inférieur au Crétacé supérieur. Il s'agissait d'un dépôt très étendu de la plate-forme continentale qui couvrait la plus grande partie de la région étudiée avant la formation de l'aulacogène.

Les séquences 6 à 8 de la zone étudiée sont divisées sur terre, mais non en mer. Elles forment une colonne sédimentaire du Crétacé supérieur et du Tertiaire jusqu'à nos jours avec des intrusions mineures probables. Elle apparaît à divers endroits sur terre, mais elle constitue la colonne très étendue de plusieurs milliers de mètres d'épaisseur qui se trouve dans l'aulacogène de Lancaster. Elle a probablement été déposée pendant et après la formation de l'aulacogène. Les séquences 5 à 8 peuvent avoir ensemble plus de 6000 m d'épaisseur dans l'aulacogène.

Les séquences 1,2,3 et 5 ont existé sur le site de l'aulacogène de Lancaster avant que cette structure ait commencé à se former. Par la suite, elles se sont profondément affaissées, avec gauchissement et failles, dans l'aulacogène où elles demeurent. Les séquences 6 à 8 se sont déposées dans l'aulacogène pendant et après sa formation.

L'aulacogène de Lancaster a été formé par des failles qui se sont propagées dans l'Arctique canadien à partir du sud-est, et il s'est séparé de l'écorce terrestre dans cette région. Sa structure résulte partiellement des contraintes globales qui ont fait pivoter d'immenses plaques, mais il a surtout été guidé par les tendances structurales préexistantes attribuables aux roches cristallines du Précambrien. Bien qu'il existe d'épaisses roches antérieures au Crétacé supérieur dans certaines parties au moins de l'aulacogène, il n'existe aucune preuve que cette structure s'est formée avant la période s'étendant de la fin du Crétacé jusqu'à l'épaisseur des failles eurêkiennes du Tertiaire.

STRUCTURAL FRAMEWORK OF LANCASTER AULACOGEN, ARCTIC CANADA

INTRODUCTION

Lancaster Sound is a linear feature that extends westward into the Canadian Arctic Islands from a deeper oceanic area to the east. Wegener (1924) long ago suggested that the sound was fault-controlled. Recent geophysical work has confirmed that the sound is downfaulted (Gregory et al., 1961; Keen et al., 1972; Daae and Rutgers, 1975; Jackson et al., 1977), and also showed the existence of a thick sedimentary fill. Burke and Dewey (1973) suggested that Lancaster Sound was the site of a Precambrian transform fault and in a later cycle became a failed arm. Jackson et al. (1977) applied the term aulacogen to Lancaster Sound, suggesting that it was active in Precambrian time, and subsequently in Cretaceous-Tertiary time. The present paper suggests the name Lancaster Aulacogen and outlines its development which began in Cretaceous time but was largely controlled by the trends of older Precambrian structures.

This structural study of Lancaster Sound was undertaken for the following reasons: its structure is critical to understanding plate movements, because the sound enters into reconstructions that have been made of northern North America (Wilson, 1965; Kerr, 1967b; Ross et al., 1973; Le Pichon et al., 1977; Kerr, 1979); it may be very important economically for it has a favourable petroleum potential. An offshore exploratory oil well has been proposed for the near future. This well, Norlands Dundas K-56 (Fig. 2), will be at Latitude 74°05'38"N, Longitude 81°15'30"W (H.D. Daae, pers. com., 1979). Lancaster Sound is rich in marine life, so environmental hazards accompanying drilling are of concern (Milne and Smiley, 1978). A knowledge of the geological structure and history may minimize such hazards. A lead zinc deposit occurs south of Lancaster Aulacogen (Olsen, 1977) and the present regional study may aid future mineral exploration.

The paper provides a geological framework for future tectonic, economic and environmental studies in and around Lancaster Sound. It summarizes the origin and history of Lancaster Aulacogen, a downfaulted feature within it, by integrating the geology known on land and at sea.

Acknowledgments

The author is grateful to A.C. Grant and R.H.K. Falconer for constructive criticism. He is also grateful to H.R. Balkwill, S.M. Blasco, B.D. Bornhold, H.D. Daae, C.F.M. Lewis, L. Machan, A.D. Miall, D. Monahan, E.R.W. Neale, B.R. Pelletier, J. Pflueger, A.T.C. Rutgers and R. Thorsteinsson for helpful discussions.

Physiography

Lancaster Sound is a linear marine channel that extends from about Longitude 80°W to Longitude 90°W (Fig. 2). It is a westward embayment or projection from Baffin Bay. The depth of the sound increases gradually from about 400 m in the west where it joins Prince Regent Inlet and Barrow Strait, to more than 800 m in the east where it connects with Baffin Bay. Lancaster Sound is part of Parry Channel, a linear marine connection between Baffin Bay and the Arctic Ocean that also includes Barrow Strait, Viscount Melville Sound, and M'Clure Strait (Fig. 1). At the west end of Lancaster Sound, bathymetric lines swing southward to connect more clearly with Prince Regent Inlet than with Barrow Strait (Fig. 2). These physiographic relationships suggest that Lancaster Sound may have a structural connection with Prince Regent Inlet that is more important than its connection with Barrow Strait. That matter will be explored in this paper.

The coasts of all islands in the study region are quite steep, and in most cases are cliffs. The submarine slopes in Lancaster Sound are generally steep near shore and more gradual farther out. These submarine escarpments generally are linear and are parallel to nearby linear coastlines.

Embayments project from Lancaster Sound into the nearby islands and become shallower away from it (Fig. 2), in much the same way as Lancaster Sound itself projects into the continent from Baffin Bay (Fig. 1). Glaciers are located on higher parts of Devon and Baffin Islands. It appears that these glaciers formerly were more widespread when they coalesced to fill the fiords and inlets of those islands.

Geological History

Eight major stratigraphic-structural sequences are recognized in the Canadian Arctic region and are designated by number (Kerr, 1979). Most of them are present in the Lancaster Sound study area where they are designated by the same numbers. The map showing these sequences (Fig. 3) has been compiled from various sources as follows: Devon Island; Kurtz et al. (1952), Glenister (1963), Glenister and Thorsteinsson (1963), Blake and Lewis (1975), Christie (1977), R. Thorsteinsson (pers. com., 1978): Baffin and Bylot Islands; Lemon and Blackadar (1963), Blackadar et al. (1968a, b, c, d), Blackadar (1970), Jackson and Davidson (1975), Jackson et al. (1975), Trettin (1969, 1975): Somerset Island, field work by the writer: Lancaster Sound; Gregory et al. (1961), Barrett (1966), Keen et al. (1972), Keen and Barrett (1973), Lack (1974), Daae and Rutgers (1975), Lewis et al. (1977), Jackson et al. (1977).

The sequences in the Lancaster Sound region occur mainly one above the other and are separated by angular unconformities that represent tectonic events (Tables 1 and 2). The stratigraphic columns on land are already well known. This paper infers that the same sequences and the same unconformities are present within Lancaster Sound. The sequences and the tectonic events that separate them will be described below in chronologic order.

Sequence 1 - Precambrian Shield

The foundation of Lancaster Sound region is part of the Precambrian Shield (Table 2 and Fig. 3), a crystalline basement complex of Aphebian age that belongs to the Churchill Province of the Shield (Stockwell et al., 1970). It was metamorphosed during the Hudsonian Orogeny about 1735 Ma ago, as testified by isotopic ages obtained on both Baffin Island and southeastern Ellesmere Island (Wanless, 1970).

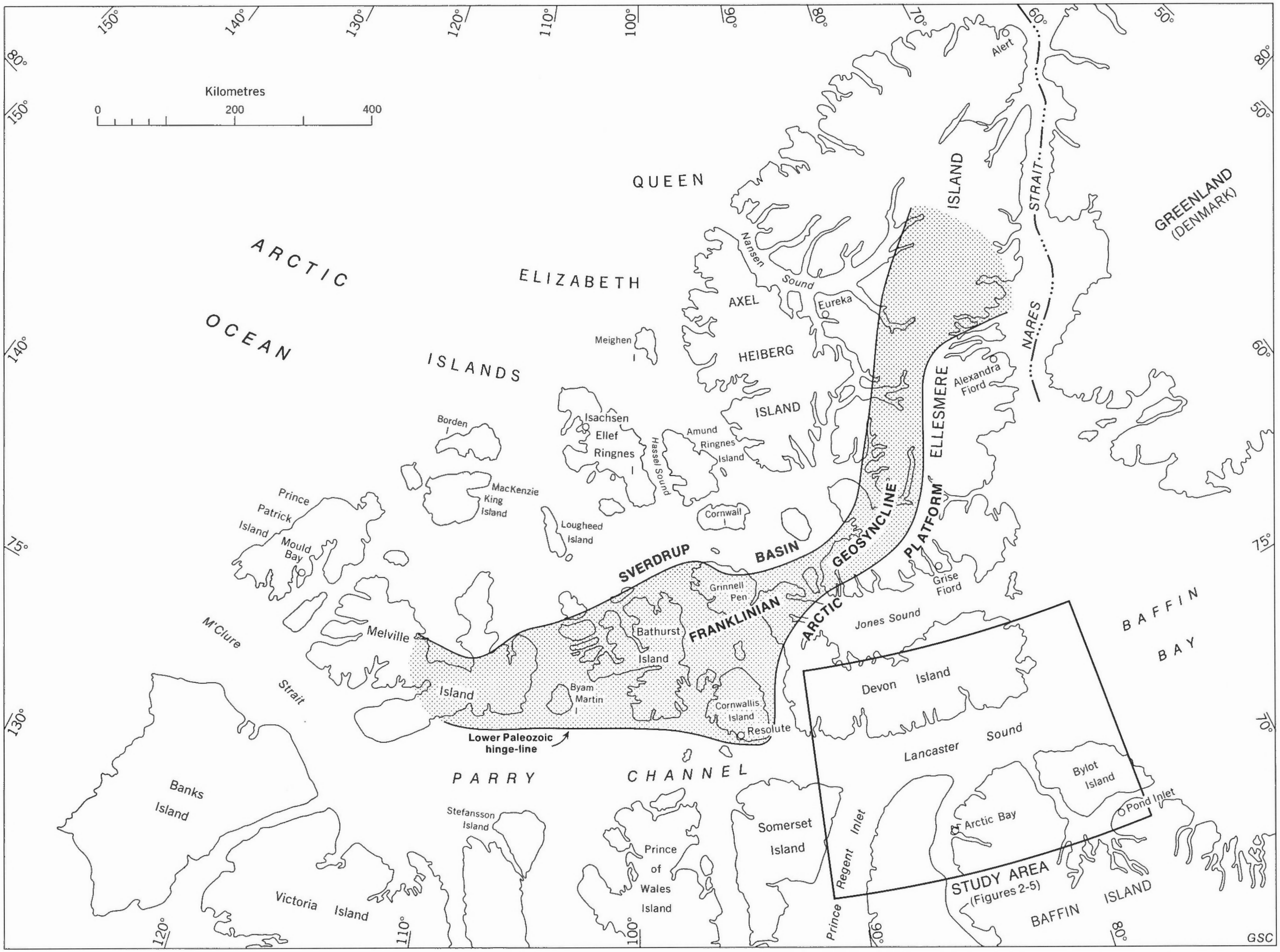


FIGURE 1. *Index map of Canadian Arctic Islands, showing location of the Lancaster Sound study area. The study area is entirely within the region occupied by the lower Paleozoic Arctic Platform.*

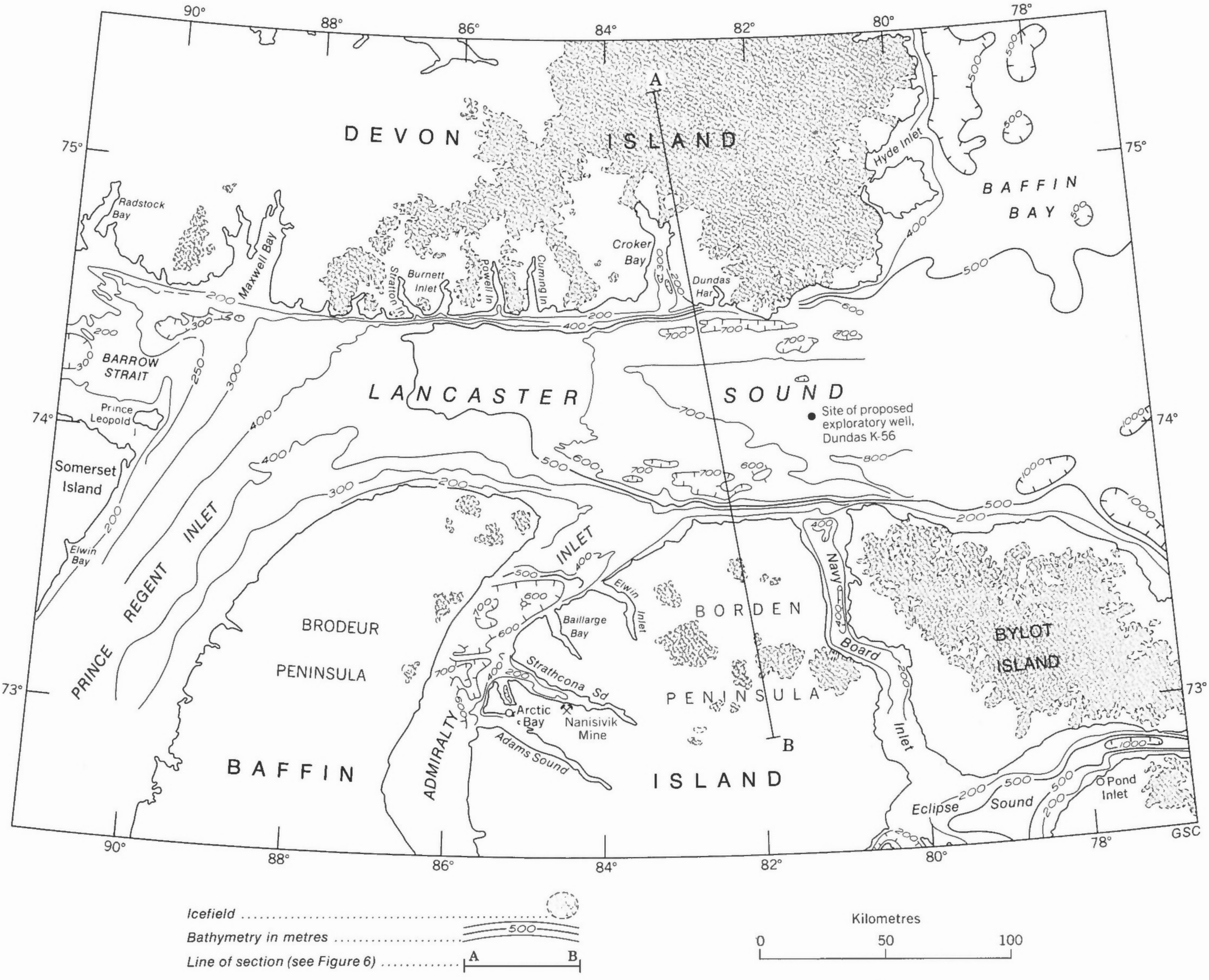


FIGURE 2. *Diagram showing details of glaciers and bathymetry. Base map cartography from part of MCR5, sheet 5 published by the Surveys and Mapping Branch in 1971.*

The Shield south of Lancaster Sound was described by Jackson and Davidson (1975), and Jackson et al. (1975) whose maps indicate a pluton, Bylot Batholith, occupying about half of the Shield area of northeastern Bylot Island. The batholith is U-shaped, about 2600 km^2, consists of monzocharnockite, and was probably emplaced in Aphebian or Archean time and deformed in the Hudsonian Orogeny. Most of the Shield on Bylot Island is part of a huge synformal structure that has a regional plunge of about 25° to the northwest. This synform is outlined by foliations and lineations. Nearby Hudsonian structures within the Shield of northern Baffin Island and Bylot Island have a similar northwest trend (Fig. 3). Jackson and Davidson (1975) concluded that the Hudsonian Orogeny was the last major Precambrian orogenic event of this region, and was responsible for most of the metamorphism and deformation in the crystalline rocks.

The Shield of eastern Devon Island (Fig. 3) is mainly gneissic rock (Christie, 1977), with a westerly structural grain that is presumed to have developed in Hudsonian time.

Hudsonian structures controlled trends in the overlying sedimentary column, and were important throughout the entire history of the region. Shield rocks are exposed only in the northeastern and southeastern parts of the study area (Fig. 3), but are presumed to underlie the entire region where they form the normal, continental granitic crust (thickness approximately 37 km). Equivalent crystalline rocks probably exist beneath Lancaster Sound, presumably attenuated beneath the younger sedimentary sequences.

TABLE 1. *Age of the sequences of the Lancaster Sound study area (this report), and comparison with sequences of the wider Canadian Arctic region (Kerr, 1979). Shading indicates missing rocks.*

AGE		LANCASTER SOUND STUDY AREA	CANADIAN ARCTIC REGION
QUATERNARY	RECENT	SEQUENCES 6-8 UNDIVIDED	SEQUENCE 8
	PLEISTOCENE		
TERTIARY	PLIOCENE		
			?
	MIOCENE		SEQUENCE 7
			?
	OLIGOCENE		SEQUENCE 6
	EOCENE		
	PALEOCENE		
CRETACEOUS	LATE	SEQUENCE 5	SEQUENCE 5
	EARLY	▨	
JURASSIC	LATE	▨	SEQUENCE 4
	MIDDLE	▨	
	EARLY	▨	
TRIASSIC	LATE	▨	
	MIDDLE	▨	
	EARLY	▨	
PERMIAN	LATE	▨	
	EARLY	▨	
PENN.	LATE	▨	
	MIDDLE	▨	
	EARLY	▨	
MISS.	LATE	▨	
	EARLY	▨	▨
DEVONIAN	LATE	▨	SEQUENCE 3
	MIDDLE	▨	
	EARLY	▨	
SILURIAN	LATE	SEQUENCE 3	
	MIDDLE		
	EARLY		
ORDOVICIAN	LATE		
	MIDDLE		
	EARLY		
CAMBRIAN	LATE		
	MIDDLE		
	EARLY		
PROTEROZOIC	HADRYNIAN	▨	▨
	HELIKIAN	SEQUENCE 2	SEQUENCE 2
		▨	▨
	APHEBIAN	SEQUENCE 1 (SHIELD)	SEQUENCE 1 (SHIELD)

GSC

Sequence 2 - Proterozoic Rocks

Sequence 2 consists of a Proterozoic sedimentary and volcanic column, containing Proterozoic dykes (Table 2 and Fig. 3).

Sedimentary and Volcanic Column

Exposures occur widely only on northern Baffin Island and Bylot Island, where the Proterozoic rocks overlie unconformably older Shield rocks (Lemon and Blackadar, 1963; Geldsetzer, 1973; Jackson et al., 1975; Jackson and Davidson, 1975; Jackson et al., 1978; Iannelli, 1979). A thin local remnant of this sedimentary column occurs on southern Devon Island (Thorsteinsson, pers. com., 1979).

The Proterozoic rocks of northern Baffin Island (Table 2) were deposited mainly in a sedimentary basin called the Milne Inlet Trough (Figs. 3-5), which is bounded on the north by the White Bay Fault Zone (Jackson et al., 1978). The trough was folded prior to deposition of the lower Paleozoic cover, but is still preserved as a general trough-shaped body plunging northwestward (Fig. 3). At the base of the Proterozoic column is a volcanic unit, the Nauyat Formation, which lies on a nonconformity and was extruded subaerially along fault zones during a period of fluvial sedimentation (Jackson et al., 1978). Syndepositional faulting played an important role in the sedimentation patterns within the basin. Regional upwarping or faulting interrupted deposition at least three times, with faults trending northwest and north-south active during deposition. The region of northern Baffin Island east of Longitude 86°W and all of Bylot Island (Fig. 3) are part of the North Baffin Rift Zone, which had faulting activity intermittently from late Proterozoic to early Tertiary time (Jackson et al., 1975). Faults on northern Baffin Island tended to be reactivated. Some major faults originated before Proterozoic deposition and were reactivated later. Most of the faulting in the Milne Inlet Trough seems to have occurred after deposition of the Proterozoic sediments; some of this was before Paleozoic deposition and some after it (Jackson et al., 1978).

Geldsetzer (1973) reported the Proterozoic sedimentary and volcanic column on northern Baffin Island to be 5800 m thick, and considered it to be of Helikian age. Jackson et al. (1975) and Jackson et al. (1978) considered this column to be of Neohelikian age. The Proterozoic column has a depositional break within it between the Arctic Bay Formation and overlying Society Cliffs Formation (Table 2). This may be equivalent to the major unconformity in the Proterozoic column of Somerset Island that was accompanied by dyke intrusion (Kerr and de Vries, 1976). Thicknesses of the columns above and below this break are derived from published reports. This depositional break on Baffin Island coincides with a time of substantial change in tectonic patterns, for Geldsetzer (1973) considered that the source area prior to Society Cliffs time was to the east, and from Society Cliffs time onward it was to the west.

Proterozoic Dykes

The Shield and Proterozoic column of northwestern Baffin Island were intruded by Proterozoic diabase dykes that trend generally northwestward (Fig. 3 and Table 2). Blackadar (1970) at first speculated that there were two intrusive events. However, he and later workers (Jackson and Davidson, 1975; Jackson et al., 1975) did not separate two groups of intrusions, as there apparently is no known structural evidence for more than one intrusive episode.

Two swarms of Proterozoic dykes are widespread in the northern part of the Canadian Shield (Fahrig and Jones, 1969; Fahrig et al., 1971). The suggestion that two periods of dyke intrusion are present on northern Baffin Island is supported by the fact that there were two episodes of Proterozoic dyke intrusion on nearby Somerset Island (Kerr and de Vries, 1976). Moreover, correlations suggest that one set preceded and the other followed the Society Cliffs Formation (Table 2). The older event may correlate with the Mackenzie Intrusions (Fahrig and Jones, 1969), and the younger event with the Franklin Intrusions (Fahrig et al., 1971). The trend of the dykes on Baffin Island, mainly northwestward, is parallel to the older structural trends in the Precambrian Shield rocks and probably was influenced by them. Jackson and Davidson (1975) reported that there was an episode of Helikian folding and related block faulting along northwestern lines, with tilting mainly toward the northeast, vertical movements of at least 2400 m, and related solution breccias. These authors stated that the Proterozoic dykes of the northern Baffin Island area were emplaced during a period of renewed block faulting that occurred subsequent to the main folding of the Helikian strata.

Diabase dykes occur in the Shield of eastern Devon Island (Fig. 3), where they were reported by Kurtz et al. (1952), and Christie (1977). Seismic work in Lancaster Sound suggests that the Paleozoic carbonate column is underlain by older strata which are intruded by basic dykes, the whole package presumably of Proterozoic age (H.D. Daae, J. Pflueger, and A.T.C. Rutgers of Norlands Petroleums Ltd., pers. com., 1977).

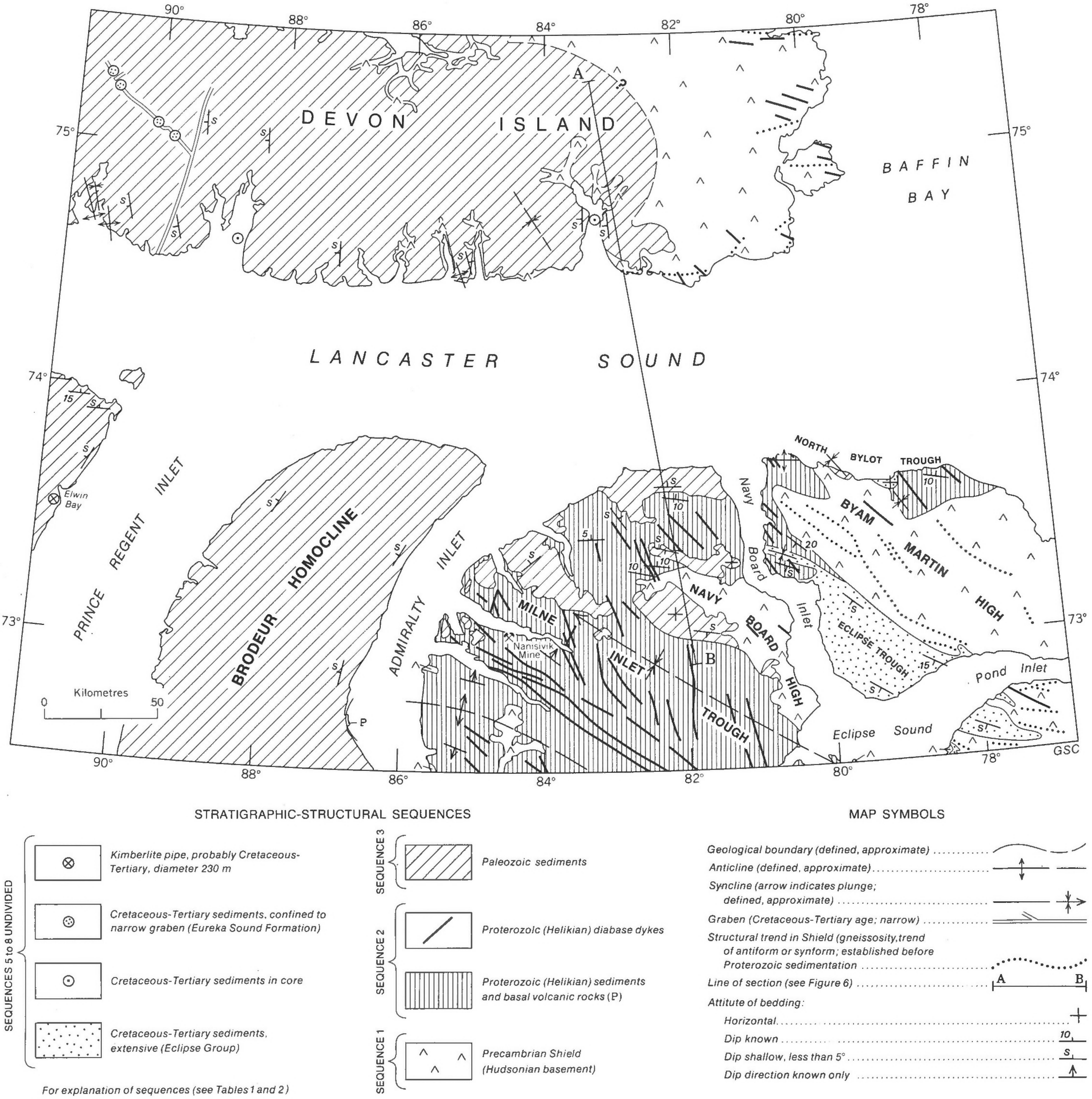
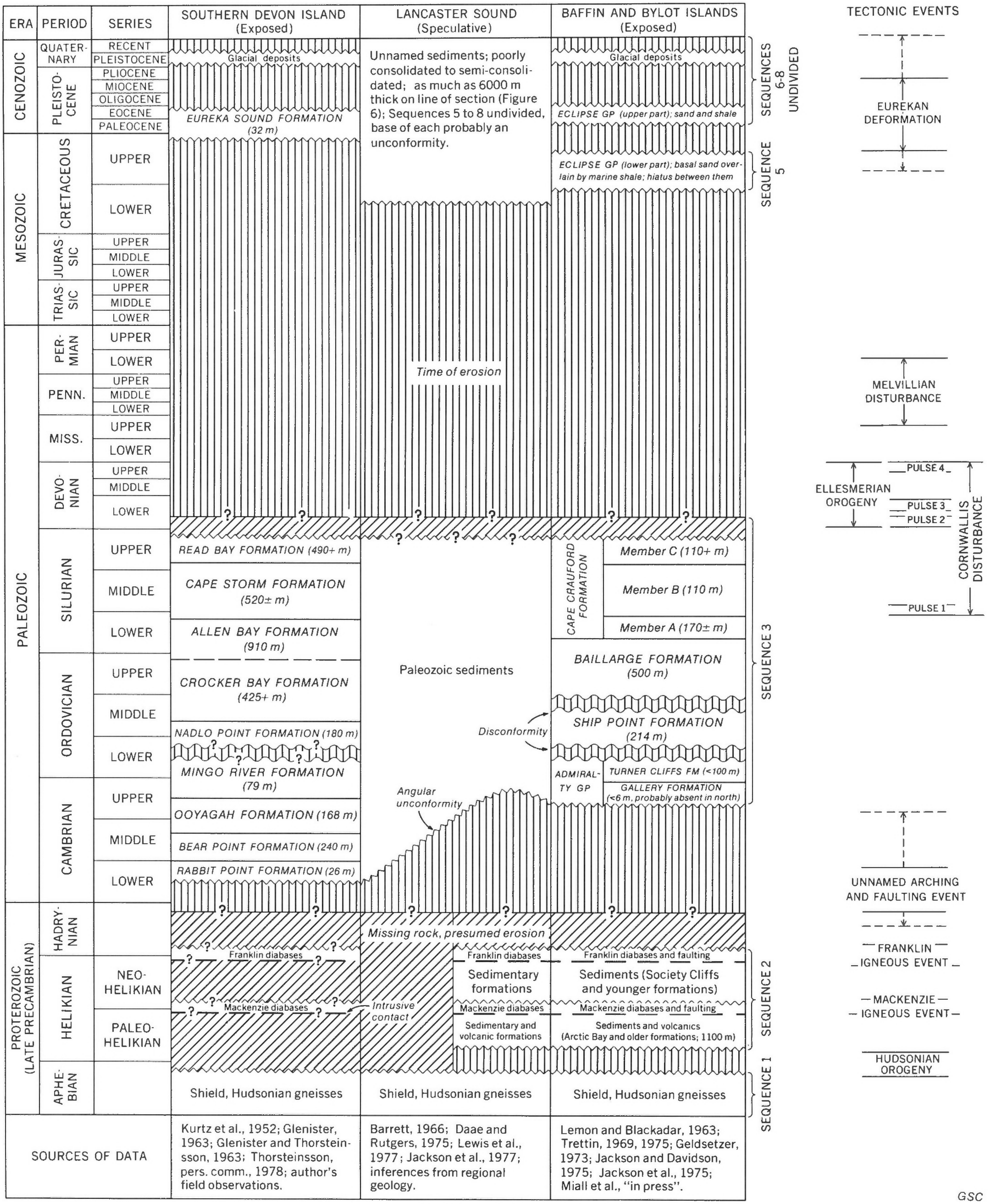


__FIGURE 3.__ Geological map showing stratigraphic structural sequences. The structures of Baffin Island east of Long. 86°W were called the North Baffin Rift Zone (Jackson et al., 1975), and have had intermittent periods of faulting from late Proterozoic to early Tertiary time. (Rough copies of the more detailed original manuscript figure are available on request from the author).

TABLE 2. *Table of Formations in the Lancaster Sound study area. Thicknesses on Devon and Baffin Islands are from sections that are nearest to Lancaster Sound. The stratigraphic-structural sequences shown here are those shown on map (Fig. 3) and cross-section (Fig. 6). The sequences are separated by angular unconformities that were produced by certain of the tectonic events shown at right.*



ERA	PERIOD	SERIES	SOUTHERN DEVON ISLAND (Exposed)	LANCASTER SOUND (Speculative)	BAFFIN AND BYLOT ISLANDS (Exposed)		TECTONIC EVENTS
CENOZOIC	QUATERNARY	RECENT		Unnamed sediments; poorly consolidated to semi-consolidated; as much as 6000 m thick on line of section (Figure 6); Sequences 5 to 8 undivided, base of each probably an unconformity.		SEQUENCES 6-8 UNDIVIDED	
		PLEISTOCENE	Glacial deposits		Glacial deposits		
	PLEISTOCENE	PLIOCENE					EUREKAN DEFORMATION
		MIOCENE					
		OLIGOCENE					
		EOCENE			*ECLIPSE GP (upper part); sand and shale*		
		PALEOCENE	*EUREKA SOUND FORMATION (32 m)*				
MESOZOIC	CRETACEOUS	UPPER			*ECLIPSE GP (lower part); basal sand overlain by marine shale; hiatus between them*	SEQUENCE 5	
		LOWER					
	JURASSIC	UPPER					
		MIDDLE					
		LOWER					
	TRIASSIC	UPPER					
		MIDDLE					
		LOWER					
PALEOZOIC	PERMIAN	UPPER					
		LOWER		*Time of erosion*			
	PENN.	UPPER					MELVILLIAN DISTURBANCE
		MIDDLE					
		LOWER					
	MISS.	UPPER					
		LOWER					
	DEVONIAN	UPPER					ELLESMERIAN OROGENY CORNWALLIS DISTURBANCE: PULSE 4
		MIDDLE					
		LOWER					PULSE 3 PULSE 2
	SILURIAN	UPPER	*READ BAY FORMATION (490+ m)*		*CAPE CRAUFORD FORMATION*: Member C (110+ m)	SEQUENCE 3	
		MIDDLE	*CAPE STORM FORMATION (520± m)*		Member B (110 m)		
		LOWER	*ALLEN BAY FORMATION (910 m)*		Member A (170± m)		PULSE 1
	ORDOVICIAN	UPPER	*CROCKER BAY FORMATION (425+ m)*	Paleozoic sediments	*BAILLARGE FORMATION (500 m)*		
		MIDDLE		*Disconformity*	*SHIP POINT FORMATION (214 m)*		
		LOWER	*NADLO POINT FORMATION (180 m)* *MINGO RIVER FORMATION (79 m)*		ADMIRALTY GP: *TURNER CLIFFS FM (<100 m)*		
	CAMBRIAN	UPPER	*OOYAGAH FORMATION (168 m)*	*Angular unconformity*	*GALLERY FORMATION (<6 m, probably absent in north)*		
		MIDDLE	*BEAR POINT FORMATION (240 m)*				
		LOWER	*RABBIT POINT FORMATION (26 m)*				UNNAMED ARCHING AND FAULTING EVENT
PROTEROZOIC (LATE PRECAMBRIAN)	HADRYNIAN			*Missing rock, presumed erosion*			FRANKLIN IGNEOUS EVENT
	HELIKIAN	NEO-HELIKIAN	Franklin diabases	Franklin diabases Sedimentary formations	Franklin diabases and faulting Sediments (Society Cliffs and younger formations)	SEQUENCE 2	MACKENZIE IGNEOUS EVENT
		PALEO-HELIKIAN	Mackenzie diabases	*Intrusive contact* Mackenzie diabases Sedimentary and volcanic formations	Mackenzie diabases and faulting Sediments and volcanics (Arctic Bay and older formations; 1100 m)		
	APHEBIAN		Shield, Hudsonian gneisses	Shield, Hudsonian gneisses	Shield, Hudsonian gneisses	SEQUENCE 1	HUDSONIAN OROGENY
SOURCES OF DATA			Kurtz et al., 1952; Glenister, 1963; Glenister and Thorsteinsson, 1963; Thorsteinsson, pers. comm., 1978; author's field observations.	Barrett, 1966; Daae and Rutgers, 1975; Lewis et al., 1977; Jackson et al., 1977; inferences from regional geology.	Lemon and Blackadar, 1963; Trettin, 1969, 1975; Geldsetzer, 1973; Jackson and Davidson, 1975; Jackson et al., 1975; Miall et al., "in press".		

GSC

Pre-Paleozoic Uplifting

A pre-Paleozoic uplifting and faulting event caused removal of part of the Proterozoic column (Sequence 2) and produced the latest Proterozoic paleogeography (*see* Fig. 4). The Proterozoic rocks of northwestern Baffin Island were faulted prior to Paleozoic deposition and the underlying Shield rocks were deformed as well. During this event the Navy Board High (Figs. 4, 6) was uplifted and Proterozoic sediments were eroded from it so that on this high Paleozoic rocks lie directly on the Shield. This uplift included faulting and some folding, and may have been at least partly contemporaneous with a Proterozoic intrusive event, as suggested by Jackson and Davidson (1975). The trends of faults in Proterozoic time (Fig. 5) were controlled by and subparallel to structural trends in the Shield (cf. Fig. 3).

Proterozoic sediments are absent from almost all of southeastern Devon Island (Fig. 3 and Table 2), where Cambrian sediments are unconformable on the Shield at Dundas Harbour (Kurtz et al., 1952; Christie, 1977). Only local remnants of Proterozoic sediments occur on southern Devon Island (Thorsteinsson, pers. com., 1979). The suggested distribution of late Proterozoic sediments within the report area (Fig. 4) includes Lancaster Sound as well as the subsurface on some islands. This configuration was achieved largely by pre-Paleozoic uplifting, modified somewhat by later events, including Cretaceous-Tertiary deformation (Fig. 5). For the most part the Proterozoic rocks were more deeply buried in that pre-Paleozoic event, but locally they were removed (Fig. 4). Proterozoic sediments that out-crop on Baffin Island (Fig. 3) probably extend westward beneath the Paleozoic cover to underlie eastern Somerset Island and connect with Proterozoic sediments on northwestern Somerset Island. The strongest evidence of the continuation of these rocks beneath the Paleozoic column is the eastward regional dip of Proterozoic rocks on northwestern Somerset Island and a westward plunge in the Milne Inlet Trough of northern Baffin Island. It is extremely unlikely that the Proterozoic column would be missing in the area between. The Proterozoic sediments probably form a large regional structural basin of which the Milne Inlet Trough is only a part. The southeastern margin of this large regional basin is the Milne Inlet Trough of Baffin Island, which dips regionally northwestward beneath a Paleozoic cover. The western margin of the regional basin is on western Somerset Island near the Boothia Uplift (Kerr, 1977).

Aeromagnetic data indicate that there is a sedimentary column about 1500 to 3000 m thick in the general region encompassing eastern Somerset Island and northwestern Baffin Island (Gregory et al., 1961). Since the Paleozoic part of this column is interpreted to be only about 1220 m thick (Table 2), the older rocks presumably are Proterozoic.

The Proterozoic column of the Milne Inlet Trough is truncated northward beneath lower Paleozoic rocks within Lancaster Sound (Figs. 4, 6). The existence of a northern limit of the thick Proterozoic column in Lancaster Sound is known from the fact that these rocks are present on northwestern Baffin Island, but are thin and sparsely present on southeastern Devon Island. The exact location of the northern limit of thick Proterozoic sediments within Lancaster Sound however is not known precisely. The absence of thick Proterozoic rocks from most of southern Devon Island indicates that the former Devon Island High was active in pre-Paleozoic time (Fig. 4). The absence of Proterozoic sediments there resulted from either erosion or non-deposition, or a combination of the two, but in any case this absence indicates a structural high that developed before deposition of upper Lower Cambrian rocks of the Rabbit Point Formation (Table 2). This formation, whose age is based on contained olenellid trilobite faunas, rests directly on the Precambrian Shield at Dundas Harbour on the south coast of Devon Island (Kurtz et al., 1952). It appears that the Devon Island High continued to be mildly positive later, within early Paleozoic time, because the lower Paleozoic column thins northward beneath Lancaster Sound according to Daae and Rutgers (1975).

A thick Proterozoic sedimentary column probably exists on western Devon Island beneath the lower Paleozoic cover, and may connect to the northwest with the Franklinian Geosyncline. If so, then a zero edge probably trends generally northward farther east on Devon Island (Fig. 4).

The Byam Martin High of Bylot Island (Figs.3-5) may have been active in the pre-Paleozoic uplifting event. The Proterozoic sedimentary column is not present there but is present on the north and south side in the ancestral North Bylot Trough and Eclipse Trough, respectively. Facies changes, possible unconformities, and solution breccias within the Proterozoic column of Bylot Island suggest periodic block faulting activity there and uplift of the Byam Martin High (Jackson and Davidson, 1975), and this may have occurred in pre-Paleozoic time.

Sequence 3 - Paleozoic Rocks

Sequence 3 (Table 2 and Fig. 3) includes all Paleozoic rocks older than the Ellesmerian Orogeny, which began in late Late Devonian and/or early Mississippian time (Kerr, 1979). The oldest rocks of this sequence in the study area are in the upper Lower Cambrian Rabbit Point Formation of Devon Island, and the youngest rocks known in the sequence in the area are the Upper Silurian Read Bay Formation and equivalent rocks. Younger rocks of Sequence 3, possibly of Devonian age, may be present beneath Sound. Upper Proterozoic rocks occur in this sequence outside the report area (Kerr, 1979).

Baffin Island

On Baffin Island, Sequence 3 is a Paleozoic carbonate and quartz clastic succession (Table 2 and Fig. 3). It overlies both the Proterozic strata and the Shield rocks unconformably (Lemon and Blackadar, 1963; Trettin, 1969, 1975). At the base is the Admiralty Group, which has been interpreted as either Middle Cambrian, or Upper Cambrian to Lower Ordovician (Trettin, 1975); however, diagnostic fossils were lacking. The Admiralty Group thins northward on northern Baffin Island, with the basal formation, the Gallery Formation, thinning to near absence on northernmost Borden Peninsula of Baffin Island (Trettin, 1975). The youngest Paleozoic rocks known on northern Baffin Island were assigned to Member C of the Cape Crauford Formation and are Silurian (Trettin, 1969). From their description and setting, the present writer suggests that Members B and C are equivalent respectively to the Cape Storm and Read Bay Formations, which Reinson et al. (1976) reported on nearby northeastern Somerset Island. The upper part of Sequence 3 on northwestern Baffin Island, therefore, is Upper Silurian. Within the Paleozoic column there are disconformities (Table 2), but no marked angular unconformites.

The Paleozoic column rests on folded Proterozoic sediments over most of northern Baffin Island (Fig. 3). On the Navy Board High, however, it rests directly on the Shield, indicating that the high was raised and that Proterozoic sediments were removed before the encroachment of lower Paleozoic rocks.

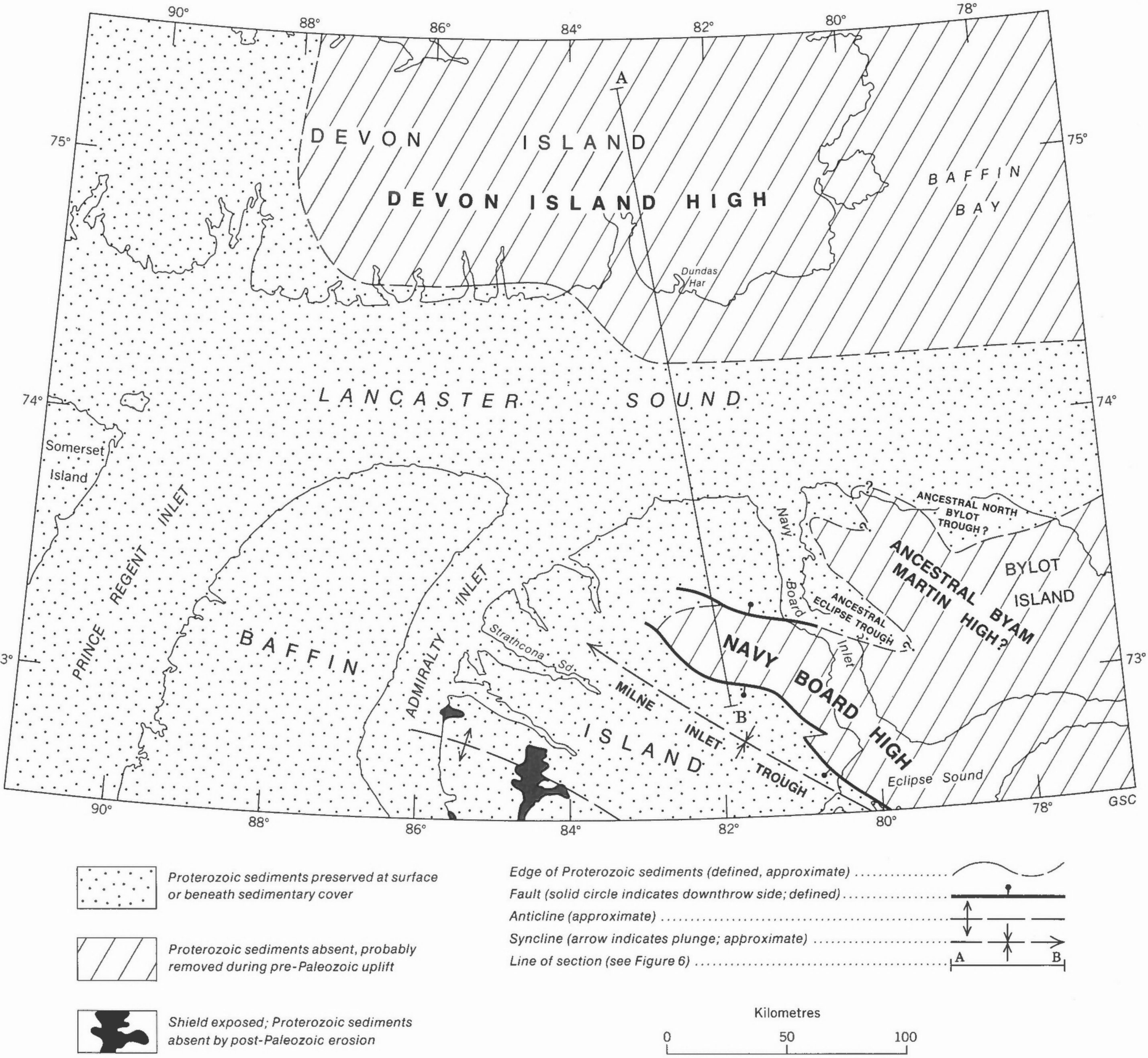


FIGURE 4. *Distribution of Proterozoic sediments (Sequence 2) in the Lancaster Sound study area. It appears that these rocks connected to the north and northwest with a broad Proterozoic basin. The northwest plunging Milne Inlet Trough may be an aulacogen at the southeastern margin of that broad basin. Most of the distribution shown here was achieved before lower Paleozoic deposition.*

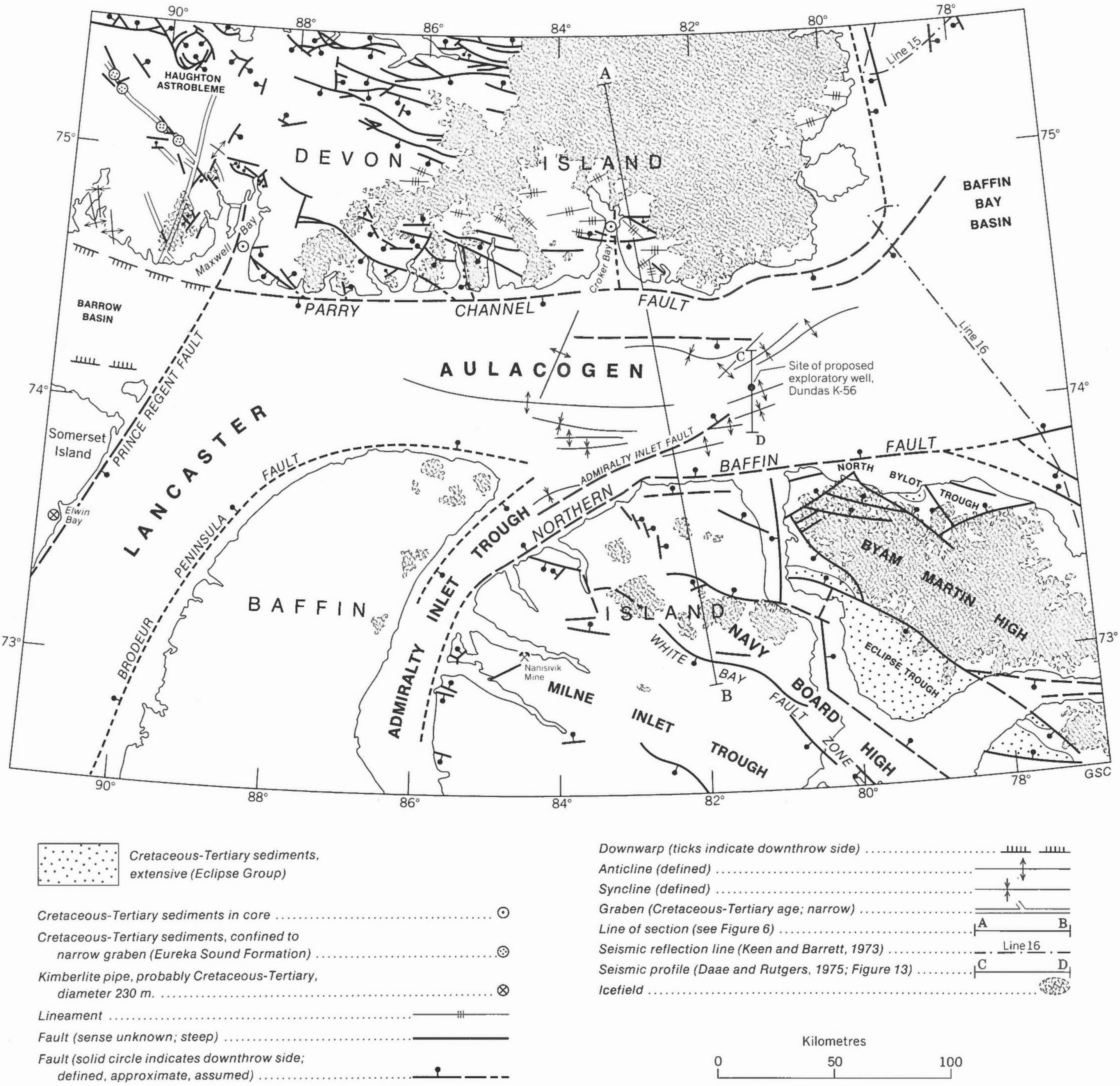


FIGURE 5. *Structures in the Lancaster Sound study area that were active in the Eurekan Deformation and later. (Rough copies of the more detailed original manuscript figure are available on request from the author).*

Devon Island

The base of the Paleozoic column on southern Devon Island, near Dundas Harbour is the upper Lower Cambrian Rabbit Point Formation, a sandstone unit containing olenellid trilobites (Kurtz et al., 1952). The succession continues up to the Middle Ordovician Crocker Bay Formation as mainly carbonates. The younger part of the sequence shown in Table 1 was compiled from field work by Thorsteinsson (pers. com., 1978), and by the writer. The regional dip of Paleozoic rocks of Devon Island is westward from the basal Paleozoic contact (Fig. 3). In the east only the older Cambrian and Ordovician rocks are exposed, but in the west the younger rocks such as the Silurian Read Bay Formation are exposed and the older strata are presumed to be in the subsurface. The rocks of Sequence 3 on Devon Island were deposited as part of the stable Arctic Platform. They are mainly carbonates of rather uniform thickness which formed a sheet uninterrupted by faults. The faults mapped on Devon Island (Fig. 5) formed much later.

Somerset Island

The Paleozoic succession of Somerset Island has been described by Miall and Kerr (1977, and in press), and is very similar to that of Baffin Island. The oldest unit is a basal sandstone of probable Late Cambrian age. It is overlain by a column of several mainly dolomitic units with a marker unit at the top, the Irene Bay Formation, of probably Late Ordovician age which is equivalent to about the top of the Crocker Bay Formation, or high in the Biallarge Formation (Table 2). The lower part of the Cape Crauford Formation (equivalent to Allen Bay), the entire Cape Storm Formation, and lower parts of the Read Bay Formation are present on northeastern Somerset Island, with the youngest rocks being Upper Silurian (Reinson et al., 1976).

The rocks of Sequence 3 on eastern Somerset Island were deposited as a sheet-like body on the Arctic Platform, and were not interrupted by faulting.

Regional Stratigraphic Relationships

Regional relationships within Paleozoic rocks of the study area and elsewhere in the Canadian Arctic assisted in making the following inferences concerning Sequence 3 within Lancaster Sound.

At the time of deposition of the lowermost Paleozoic rocks, the entire study area (Fig. 3) probably was a broad peneplain, slightly above sea level. This included the present islands, as well as those areas now covered by water. That part of the Proterozoic sedimentary, volcanic and intrusive assemblage making up Sequence 2 was depressed structurally within this peneplain. The paleogeography at that time may have been much like that depicted in Figure 4. The Navy Board High and the Devon Island High had been raised and the Proterozoic rocks, if present, were eroded in pre-late Early Cambrian time (pre-Rabbit Point Formation). Lower Paleozoic rocks of Sequence 3 encroached unconformably into the Shield until the whole region was covered. The rocks below Sequence 3 escaped further erosion until at least post-Silurian time. The same sequence of events may have prevailed on an ancestral Byam Martin High (Fig. 4), but there is no concrete evidence of Sequence 3 there.

Sequence 3 encroached onto a peneplain where Aphebian crystalline rocks and Proterozoic sediments were exposed (Fig. 4). The Paleozoic strata were part of a sheet-like mainly carbonate body of the Arctic Platform (Fig. 1), with an extremely gentle dip to the west or northwest, that possibly covered the entire study area. The overall thickness of the Paleozoic column on Devon Island is greater than on Baffin Island, which is consistent with a regional northward thickening toward the Franklinian Geosyncline. Trettin (1975) showed that the basal Paleozoic units of Baffin Island thin northward on Borden Peninsula (*see* Fig. 2), in what he called the Borden Basin. This is considered to be a local reversal of the regional northward thickening.

Thickness variations occurred within the Paleozoic strata, but appear to have been gradual. Lithologies suggest that there was little tectonic activity, except for gradual downwarps forming local basins. Shale is practically absent from the lower Paleozoic sequence on Baffin, Devon, and Somerset Islands, and thus probably also is practically absent from its equivalents in Lancaster Sound.

The youngest rocks assignable to Sequence 3 in the study area are Upper Silurian rocks of southern Devon Island and northern Baffin Island (Table 2). The interval from latest Silurian to Late Devonian is not represented by exposed rocks within the study area. However, it is possible to speculate about the history of that time interval from regional relationships, and conclude that there probably was some Devonian deposition in the area. Lower to Upper Devonian rocks are present northwest of the study area on southern Ellesmere Island (Kerr, 1969), Grinnell Peninsula (Morrow and Kerr, 1977), and Cornwallis Island (Thorsteinsson and Kerr, 1968), that may possibly have had equivalents in the study area (Fig. 1). These youngest rocks of Sequence 3 would be the first to be eroded prior to the Cretaceous-Tertiary downfaulting that developed Lancaster Sound.

Devonian and older rocks in the Canadian Arctic Islands were deformed by southeastward overriding of the mid-Devonian to mid-Mississippian Ellesmerian Orogeny (Kerr, 1979). The orogeny originated in a geanticline far to the northwest of the study area. It affected only the Franklinian Geosyncline and those parts of the Arctic Platform immediately adjacent to it (Fig. 1). Rocks of the eastern Lancaster Sound region probably were not deformed by the Ellesmerian Orogeny because they were too far within the continental interior at that time. Nevertheless, they may have been partly eroded because the orogeny was accompanied by widespread emergence. From regional relationships it seems probable that such erosion did not begin in the study area until Late Devonian time.

Lancaster Sound

Sequence 3 almost certainly exists beneath Lancaster Sound (Figs. 3, 6, and Table 2). It is the downfaulted part of an originally continuous sheet of Paleozoic rocks of the Arctic Platform that formerly covered the entire study area. There originally may have been slight depositional relief on the basal Paleozoic contact, and some original regional dip, but generally it was nearly flat, so that present displacements on it (Fig. 6) would provide an approximate measure of later deformation. The Paleozoic sequence within Lancaster Sound almost certainly includes rocks younger than those that are preserved on either side, because Lancaster Sound has been a structural low and presumably a depositional basin since its border faults were initiated, probably in Late Cretaceous time. During the downfaulting event, Sequence 3 was buried by younger sediments and has not been subjected since to erosion. During that same interval Sequence 3 was exposed on the adjacent islands, presumably allowing its upper part to be eroded away.

Daae and Rutgers (1975) suggested that a column in Lancaster Sound having a seismic velocity of about 6100 m/sec is of Paleozoic age. That column is buried beneath more than 4500 m of semi-consolidated rocks that they interpret as sand and shale of Mesozoic and Tertiary age.

The Paleozoic sequence thins northward within Lancaster Sound toward a basement high. The northward thinning suggests (Fig. 6) that the Devon Island High, which was active in pre-Early Cambrian time, and from which Proterozoic rocks apparently were removed, continued to be mildly active within the region now covered by Lancaster Sound and southern Devon Island during early Paleozoic time. Sequence 3 probably varies only gradually in thickness in Lancaster Sound. There probably is a basal clastic unit similar to those on Baffin and Devon Islands that lies unconformably on older rocks and has a variable thickness. The column appears to truncate northward from Proterozoic rocks into the crystalline Shield within the northern part of Lancaster Sound (Fig. 6). The lower Paleozoic strata in Lancaster Sound probably are chiefly dolomite, limestone, and quartz sandstone. Regional dips of Sequence 3 are to the north or northwest on both Baffin and Devon Islands (Fig. 3). A northward dip was shown on a seismic profile of central Lancaster Sound (Daae and Rutgers, 1975). It is concluded herein that there is a northward regional dip for the full breadth of the sound (Fig. 6). Lack (1974) considered that it was virtually impossible seismically to distinguish between possible Proterozoic and Paleozoic sediments. Daae and Rutgers (1975) made the distinction because they considered that the Proterozoic sediments included dykes, whereas the Paleozoic sediments did not (H.D. Daae, A.T.C. Rutgers, and J. Pflueger of Norlands Petroleums Ltd., pers. com., 1977). Jackson et al. (1977) suggested that the 10 km thickness of sediments in Lancaster Sound included Paleozoic rocks, but they did not specifically distinguish a sequence of that age. Sequence 3 beneath Lancaster Sound doubtless includes Cambrian to Upper Silurian rocks (Table 2) and possibly includes slightly younger Paleozoic rocks.

Sequence 4 - Mississippian to Lower Cretaceous Rocks

Sequence 4 of the Canadian Arctic includes Mississippian to Lower Cretaceous rocks (Kerr, 1979). Rocks of this sequence are not exposed on land in the study area (Tables 1 and 2). The sequence may or may not be present in Lancaster Sound and other marine channels of the study area.

Sequence 4 makes up the lower rocks of the Sverdrup Basin. That basin lies entirely northwest of the study area (Fig. 1), and developed after the Ellesmerian Orogeny (Table 2). The possibility that rocks of Sequence 4 are present in Lancaster Sound will be analyzed below from the facies and history of the Sverdrup Basin.

In the lower part of the Sverdrup Basin is a thick succession that begins with mid-Mississippian (Viséan) rocks and includes strata deposited in much or all of Pennsylvanian and Permian time. During this interval, the basin began to form by crustal fracturing and downwarping. Sedimentation progressed from nonmarine to progressively more marine. It is probable that none of these rocks of the basin extended southward to the Lancaster Sound region, because facies indicate that throughout these times the southern margin of the Sverdrup Basin was approximately the same as the present erosional margin (Fig. 1). Moreover, Mississippian, Pennsylvanian and Permian marine faunas of the Sverdrup Basin show closer affinities with the northern U.S.S.R. than with more southerly parts of North America including the mid-continent region of the U.S.A. This led Nassichuk and Davies (in press) to suggest that marine water entered the Sverdrup Basin from the northwest. In summary, there probably was no marine deposition in the study area (Fig. 3) in Mississippian, Pennsylvanian or Permian time and the region probably was part of a broad exposed continental area (Table 2).

Sverdrup Basin was the site of extensive deposition throughout Mesozoic time, with marine shales alternating with nonmarine sandstone formations. Deposition occurred without major stratigraphic break from Early Triassic until mid-Early Cretaceous time. In Triassic and lowermost Jurassic time, shoreline facies existed along the southern and eastern margins of the Sverdrup Basin, indicating that regions farther southeast were emergent. The oldest unit of the Sverdrup Basin that has an open marine facies as its southeasterly exposure is the Middle Jurassic (Callovian) Savik Formation (H.R. Balkwill, pers. com., 1978). This conceivably could have extended to Lancaster Sound but it seems unlikely that this marine tongue reached that far southeast.

The age of the basal rocks of the post-lower Paleozoic succession in Lancaster Sound is uncertain as is the possible existence there of Sequence 4 of the Canadian Arctic (Kerr, 1979). Facies at most levels in the Sverdrup Basin indicate that the southeastern shoreline of that basin was very near its present southeastern margin (Fig. 1) throughout much of the history of the basin. At such times the study area, including the present Lancaster Sound, would have been exposed.

Sequence 5 - Lower to Upper Cretaceous Rocks

Baffin Island and Bylot Island

Sequence 5 is exposed in the study area only south of Lancaster Sound (Figs. 3, 5). It includes the lower part of the Lower Cretaceous to Eocene Eclipse Group (Jackson and Davidson, 1975; Jackson et al., 1975; Miall et al., in press), preserved in the Eclipse Trough and the North Bylot Trough. The following summary of these rocks was taken from descriptions in the above papers. Several divisions in the Eclipse Group correlate with formations of the Sverdrup Basin.

The two lowest units of the Eclipse Group are here assigned to Sequence 5 (Table 2). The basal unit consists of weakly cemented quartzose sandstone, in places crossbedded and containing coal. It is a sheet-like basal sand body that appears to thin southeastward on Bylot Island. It may represent a beach or uplifted shallow platform sand deposit, with associated swampy depressions in which coal was deposited. The thickness ranges from 10 to 120 m (Miall et al., in press). This basal sand unit is late Early Cretaceous (Albian) in age, apparently equivalent to the Hassel Formation of the Sverdrup Basin. An overlying marine shale has a maximum thickness of 1130 m (Miall et al., in press), with a minor hiatus at the base. This unit may be equivalent to the Upper Cretaceous Kanguk Formation.

Sequence 5 is overlain by a much thicker Tertiary column of Paleocene to Eocene age, with a pronounced angular discordance between indicating tectonism. Sequence 5 is separated from much older rocks by a significant unconformity which included substantial erosion (Table 2).

The study area probably had been emergent for a very long period of time prior to deposition of Sequence 5 (Table 2), as Sequence 4 of the Canadian Arctic apparently is missing (Kerr, 1979). At the onset of deposition of

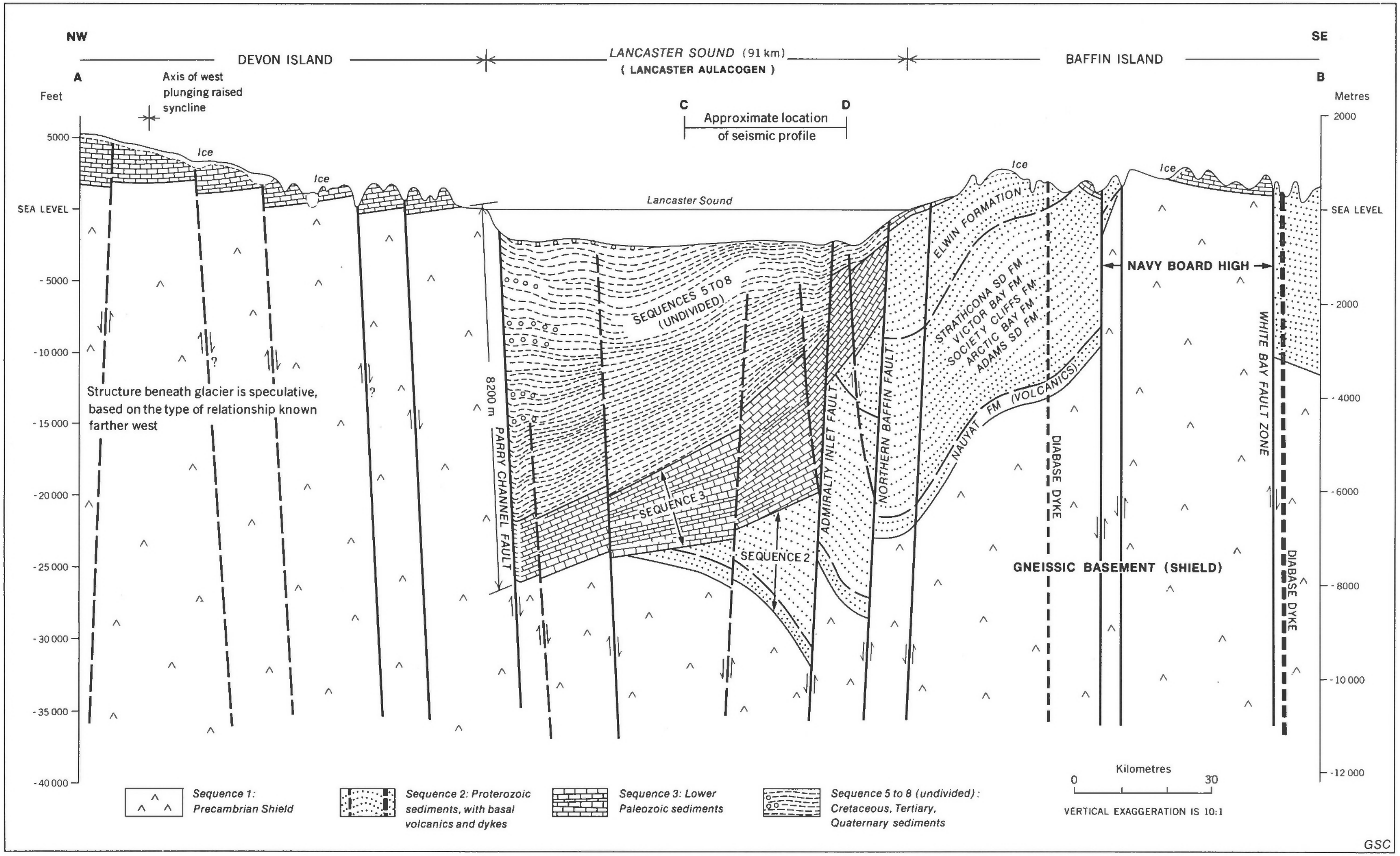


FIGURE 6. *Cross-section of Lancaster Sound, which contains Lancaster Aulacogen. The sequences are those shown in Tables 1 and 2, and Figure 3. The location of this cross-section is shown on Figures 3 to 7. The cross-section utilized a seismic profile of Daae and Rutgers (1975, Fig. 2), that is nearly parallel to it and about 40 km to the east (Figure 5). The equivalent location of that profile is shown there, approximately as CD.*

Sequence 5 the entire study area (Fig. 5) probably was approximately a peneplain. The basal sand of the sequence apparently was deposited as part of a broad Early Cretaceous transgression southeastward onto the cratonic shelf from the Sverdrup Basin. The basal sand is lower Lower Cretaceous in the Sverdrup Basin, and upper Lower Cretaceous in the study area. In the study area the rocks of Sequence 5 were deposited on part of a wide cratonic shelf, probably with local downwarping controlled by minor fault movements. Important rifting deformation apparently had not begun within the study area in Early to Late Cretaceous time while Sequence 5 was being deposited.

Sequence 5 is a transgressive sequence that encroached southeastward from the Sverdrup Basin onto the cratonic shelf (Kerr, 1979). The first deposition of Sequence 5 in the report area appears to have been a broad overlap of a nonmarine upper Lower Cretaceous sandstone (Albian). From what is known on land it appears that the broad Lower Cretaceous overlap forming the lower part of Sequence 5 was a situation which probably prevailed throughout the Lancaster Sound study area (Fig. 3). After a minor hiatus within Sequence 5 in the Eclipse Trough, sedimentation resumed there and shallow marine sediments were deposited until early Late Cretaceous time. The upper part of Sequence 5 in the Eclipse Trough is an organic rich shale equivalent to the Upper Cretaceous Kanguk Formation of the Sverdrup Basin (Balkwill, pers. com., 1978; Kerr, 1979).

The first known encroachment of Sequence 5 rocks within the study area is represented by the basal sandstone of latest Cretaceous (Albian) age in the Eclipse Trough, equivalent to the Hassel Formation of Sverdrup Basin. The overlapping sheet may have reached local parts of the Lancaster Sound study area somewhat earlier (Aptian) and might there be equivalent to the Isachen Formation. If so, then the basal part of the downfaulted column within Lancaster Aulacogen may possibly contain slightly older rocks of Sequence 5 than are present on land.

Lancaster Sound and Other Marine Areas

A thick column of poorly consolidated to semi-consolidated sediments has been delineated in Lancaster Sound by geophysical methods. It is inferred to be mainly sand and shale and is presumed to be of Cretaceous-Tertiary-Quarternary age (Barrett,1966; Keen and Barrett, 1973; Bourne and Pallister, 1973; Lack, 1974; Daae and Rutgers, 1975; Jackson et al., 1977). These rocks are shown in cross-section (Fig. 6), and their age and nature are discussed below. No wells have been drilled into this column so its age and nature are inferred from geophysical work at sea and regional geological knowledge. Sequences 5 to 8 are presumed to exist in this column (Fig. 6), but have not been divided.

It is inferred that rocks of Sequence 5 make up the lower part of the thick column of poorly consolidated to semi-consolidated sediments reported in Lancaster Sound (Fig. 6). This sequence has not been separated and its thickness is unknown. From regional relationships it is inferred that Lancaster Sound began to form as an aulacogen only after deposition of Sequence 5 (Kerr, 1979). Therefore, in the aulacogen, Sequence 5 may be a remnant of a once very widespread sheet-like deposit, similar to the rocks assigned to the sequence on Bylot and northern Baffin Islands.

Daae and Rutgers determined from seismic work that the undivided Cretaceous and younger succession is more than 4500 m thick in central Lancaster Sound at the north end of their seismic profile (Line CD, Fig. 6). This column has a velocity in its lower part of about 3660 m/sec, and in the upper part of about 3050 m/sec. The succession thickens northward within Lancaster Sound to a maximum near the north side (Fig. 6). It lies on lower Paleozoic rocks with presumed unconformity. Inference as to the age of the basal beds and the presence or absence of Sequences 5 and 6 can be made by relating the region to the Sverdrup Basin and to the Eclipse Trough (Figs. 3, 5). Jackson et al. (1977) determined from seismic work that Lancaster Sound contains about 10 km of sedimentary rocks with a seismic velocity of 5280 m/sec. Much of their profile was east of the restored section (Fig. 6), where thicknesses are greater. They did not give a thickness for the supposed Cretaceous and younger part of the column, but stated that faulted sediments were overlain by unfaulted sediments.

A cross-section of Lancaster Sound was constructed from all information available (Fig. 6). From this it was concluded that Sequences 5 through 8 together may be about 6000 m thick on the north side of Lancaster Sound near the Parry Channel Fault.

The existence of Sequence 5, and the age of the basal beds of the Cretaceous and younger succession in Lancaster Sound is not known with certainty, because this part of the column is deeply buried; however, inferences about this can be made from regional geology. The basal rocks appear to have been part of a widespread overlapping sheet that makes up Sequence 5 on northern Baffin Island and Bylot Island. The downfaulted regions such as Lancaster Sound will likely contain the oldest part of this sheet. The oldest rocks of Sequence 5 in the Sound therefore probably are equivalent to or slightly older than the basal sediments of the Eclipse Group in the Eclipse Trough nearby (Fig. 3 and Table 2). Therefore the sequence very probably includes upper Lower Cretaceous (Albian) rocks. The base in Lancaster Sound may be even slightly older than the base of the Eclipse Group of Bylot Island (Fig. 6 and Table 2), and possibly equivalent to the Lower Cretaceous (Aptian) Isachsen Formation. It appears that an unconformable nonmarine sheet that spanned much of Early Cretaceous time spread out from Sverdrup Basin southeastward to the study region, and also covered much of northeastern North America. This includes Aptian rocks of western Greenland (Henderson et al., 1976), and Albian rocks of northern Baffin Island (Jackson et al., 1975; Miall et al., in press). A downfaulted remnant of this sheet probably makes up the oldest rocks of Sequence 5 within Lancaster Sound. The upper part of the sequence may be shales similar to those on Bylot Island (Table 2) and equivalent to the Upper Cretaceous Kanguk Formation. It does not seem likely that Lancaster Sound formed as a deeply subsiding structural or sedimentary basin with its present overall shape at the time of the overlap of Sequence 5. If Sequence 5 is present in Lancaster Sound, it is probably as part of a downfaulted remnant of a formerly more continuous sheet of Lower Cretaceous rocks. The stress pattern that gave rise to the present overall structure of Lancaster Sound as a deeply subsiding faulted basin, or aulacogen, did not develop until somewhat later than this overlap.

Sequences 6 to 8 – Upper Cretaceous to Present Day Rocks

Sequences 6 to 8 of the Canadian Arctic are based partly upon regional relationships (Kerr, 1979). These three sequences have not been clearly separated from each other at all places in the study region because they are largely in the marine area, where well information is not available. The sedimentary body referred to here as Sequences 6 to 8 undivided includes all rock both on land and at sea that is younger than the hiatus at the top of the lower part of the Eclipse Group (Tables 1 and 2).

Baffin Island and Bylot Island

The upper part of the Eclipse Group of the Eclipse Trough has been described by Miall et al. (in press). At the base of the unit is a pronounced angular discordance indicating tectonism. The unit has been dated as Paleocene to Eocene. The thickness of this unit is as great as 2270 m.

The upper part of the Eclipse Group is approximately equivalent to the Eureka Sound Formation, which constitutes Sequence 6 of the Canadian Arctic (Kerr, 1979). Jackson et al. (1975) stated that upper parts of the Eclipse Group represent rapid erosion and deposition in a paralic environment, in response to renewed faulting in the North Baffin Rift Zone. The sequence is gently warped about a northwest trending axis and the steepest dips occur along the northeast margin of the Eclipse Trough. The upper part of the Eclipse Group of the Eclipse Trough may be Sequence 6 and is included in the undivided Sequences 6 to 8 of the study area.

The North Baffin Rift Zone includes the structures east of Longitude 86°W, where Helikian, Paleozoic, and Cretaceous-Eocene rocks are preserved in a series of parallel northwest-trending grabens separated by a horst of crystalline rocks. Thus, all parts of Baffin Island and Bylot Island within the study area (Fig. 5) are within the North Baffin Rift Zone. Most of the bounding faults in the zone dip steeply toward the grabens. For example individual faults along the White Bay Fault Zone constantly dip at about 60° to the southwest in the region immediately south of the study area. There were several episodes of faulting in the North Baffin Rift Zone, having similar northwest trend. The earliest was of probable Helikian age when the Milne Inlet Trough formed, with Proterozoic sediments. Faulting also apparently occurred during deposition of the upper part of the Eclipse Group (Paleocene-Eocene) when the Eclipse and North Bylot Troughs formed, and this faulting was controlled by the older faults and structural trends.

The Eclipse Trough (Fig. 5), containing Sequences 5 and 6, lies within the North Baffin Rift Zone. The trough presumably was depressed by faulting during the Late Cretaceous to Tertiary Eurekan Rifting Episode. Strata of Sequences 5 and 6 are preserved in this trough and are very gently warped about northwesterly axes. The steepest dips occur along the northeast margin of the Eclipse Trough. Sequence 5 apparently was sheet like and covered a wide region prior to the formation of the trough. It is preserved in the trough due to later faulting. This later faulting, which formed the Eclipse Trough, caused the angular discordance between Sequences 5 and 6, and may have continued through deposition of Sequence 6.

The North Bylot Trough also contains Sequence 6 (Fig. 5), and presumably was active during the Eurekan Rifting Episode. The presence of Sequence 6 in both the Eclipse and North Bylot Troughs indicates that their bounding faults were active during its deposition. It is probable that the entire study area (Fig. 5) was a peneplain prior to the onset of deposition of the Eclipse Group, and a thin sedimentary overlap occurred in parts of Early to Late Cretaceous time forming Sequence 5. This was succeeded by tectonism which produced local downwarping and faulting and deposited Sequence 6. Tectonism may have commenced in latest Cretaceous time, but certainly was active in early Tertiary time. This tectonism appears to mark the beginning of the Eurekan Rifting Episode in this region (Kerr, 1979). This was rift associated deformation related to the formation of Baffin Bay and other oceanic areas, in which the Eclipse Trough was an actively subsiding marginal basin.

It is probable that most of the faults in the North Baffin Rift Zone (Fig. 5) were active during the Eurekan Rifting Episode. Many of these faults however do not affect exposures of Sequence 6, so that it is not possible to be certain that they all were active then. For example the Navy Board High (Figs. 5, 6) had been uplifted several thousands of metres in pre-Paleozoic time, when Proterozoic rocks (Sequence 2) were eroded from it. Paleozoic rocks (Sequence 3), which subsequently covered the high, were themselves subject to displacement in still later faulting. This post-Paleozoic faulting, which rejuvenated pre-Paleozoic faults, presumably was part of the Eurekan Rifting Episode (Table 2). Because no Cretaceous-Tertiary rocks are involved, however, this is speculative. The White Bay Fault Zone had its southwest side down in the pre-Paleozoic movements which formed the Navy Board High. Its post-Paleozoic offset, however, had the southwest side up (Fig. 6). The net displacement is south side down, because the earliest movement was greatest.

Most and perhaps all of the faults shown in Figure 5 on northern Baffin Island and Bylot Island probably were active in the Eurekan Rifting Episode, although many of them may have had earlier activity in pre-Paleozoic time as well. Two other deformations occurred in the Canadian Arctic in the interval between the pre-Paleozoic events and the Eurekan Rifting Episode (Kerr, 1979). These were the Cornwallis Disturbance and the Ellesmerian Orogeny (Table 2), but it appears that neither of these produced deformation within the study area (Fig. 5).

Devon Island

Four small exposures of Cretaceous-Tertiary sediments, mainly poorly consolidated sandstone, on southwestern Devon Island (Fig. 3) are unconformable on lower Paleozoic rocks. R. Thorsteinsson (pers. com., 1978) reported that all are within a very narrow northwest trending graben, and he assigned them to the Eureka Sound Formation. Because these four exposures were contemporaneous with or cut by rift associated faulting, they may be assigned to Sequence 6 of the Canadian Arctic (Table 2).

Somerset Island

Cretaceous-Tertiary rocks are present in several narrow linear grabens on Somerset Island, and have been summarized recently (Kerr, 1977). Kimberlite pipes also occur on Somerset Island (Mitchell, 1976), and the Elwin Bay pipe occurs within the present study area (Figs. 3, 5). These pipes have not been dated accurately, but most likely are related to Cretaceous-Tertiary tectonic events. The Cretaceous-Tertiary sediments and the kimberlite pipes of Somerset Island may be assignable to Sequence 6.

Lancaster Sound

The thick sequence of semi-consolidated to unconsolidated rocks delineated in Lancaster Sound by geophysical methods (Fig. 6) is interpreted to be Early Cretaceous and younger and is assigned to Sequences 5 to 8 (Table 2). This is based on cores recovered, geophysical work, and regional geological relationships.

Reasons for suggesting that rocks of Sequence 5 are present at the base of the Cretaceous-Tertiary column were outlined earlier. Reasons for suggesting that Sequences 6 to 8 are present are outlined below.

In the study area Sequence 6 is exposed only in the Eclipse and Bylot Troughs and on Devon Island. Only a relatively short span of geological time is represented by outcrop, being mainly the Paleocene to Eocene part of the Eclipse Group (Fig. 3). Sequence 6 almost certainly is present in Lancaster Sound, as that is the dominant marine channel in the study area. Sequence 6 of Lancaster Sound may resemble the upper part of the Eclipse Group and consist essentially of rocks deposited during an early phase of the Eurekan Rifting Episode. It may be very thick in Lancaster Sound and other main channels, having accumulated there while they were forming in latest Cretaceous and early Tertiary time. Sequence 6 may include older rocks in Lancaster Sound than in the Eclipse Trough, as the former is a more dominant marine channel. In the channel Sequence 6 also may possibly represent a greater span of geological time, both older and younger than the sequence exposed on land. The sequence probably also overlies an unconformity in Lancaster Sound.

Blake and Lewis (1975) reported that a core from Maxwell Bay (Fig. 3) contains an abundant, diversified pollen assemblage of Tertiary-Upper Cretaceous affinity, probably from the Eureka Sound Formation. They also reported that in Crocker Bay (Fig. 3) there is a sedimentary basin from which two cores were obtained. One yielded a pollen assemblage of probable Cretaceous-Tertiary age, and the other Quaternary pollen types; both yielded abundant marine diatoms. Both Maxwell Bay and Crocker Bay are fault-controlled (Fig. 5). It seems reasonable that the Cretaceous-Tertiary rocks in those bays have settings similar to that of the Eureka Sound Formation in the narrow linear grabens nearby on land to the northwest on Devon Island (Fig. 3). It is further suggested that the extensive faulting that produced Lancaster Sound (Figs. 5, 6) was approximately contemporaneous with Late Cretaceous to early Tertiary faulting to the south and north. This time, when Sequence 6 was being deposited, may have been the most active period in the formation of Bylot Trough, and almost certainly, of Lancaster Sound. It is probable that a very large part of the undivided column is of latest Cretaceous to Paleocene-Eocene age, and equivalent to the rocks of Sequence 6 on land.

A sedimentary break within the Eclipse Group south of Lancaster Sound (Table 2) is marked by an angular discordance. Rocks below the break make up Sequence 5 and the rocks above it make up Sequence 6. Sequence 6 is quite thick, partly equivalent to the Eureka Sound Formation, and indicates active tectonism. This appears to have begun in latest Cretaceous and continued to early Tertiary time, presumably part of the Eurekan Deformation (Kerr, 1977). The Cretaceous-Tertiary sediments of Devon Island and Somerset Island are also related to this tectonic event, and the kimberlite pipes of Somerset Island may be as well. This event, an intermediate stage of the Eurekan Rifting Episode, was contemporaneous with deposition of much of the Eureka Sound Formation and the upper part of the Eclipse Group (Table 2). It probably produced much of the downfaulting in Lancaster Sound.

It seems likely that equivalents of all parts of the Eclipse Group are present in Lancaster Sound. Lancaster Sound may have formed contemporaneously with the Eclipse Trough, where sedimentation apparently was contemporaneous with faulting, as the upper part of the Eclipse Group was deposited. The faulting apparently increased in intensity in early Tertiary time (Paleocene-Eocene), and was part of the Eurekan Rifting Episode (Kerr, 1979).

From regional studies Kerr (1979) concluded that there were several phases in the Eurekan Deformation. These probably produced periods when the formation of Lancaster Sound was accelerated. He recognized three sequences whose total range of age extends from the onset of the Eurekan Deformation to the present day. They are: Sequence 6, latest Cretaceous to early Tertiary (Eocene), deposited during an early phase of the Eurekan Deformation; Sequence 7 (Miocene), deposited up to and during the final phase of the Eurekan Deformation; and Sequence 8, deposited after the Eurekan Deformation ceased activity. All three may be present in Lancaster Sound, within that part of the column referred to as Sequences 6 to 8 undivided (Table 2). It is inferred that in Lancaster Sound there will be discordant contacts or unconformities at the base of rocks equivalent to Sequences 6, 7, and 8 (Table 2), as there are in various parts of the Arctic (Kerr, 1979). The reason for this inference is that Lancaster Sound was part of the complex of marine channels from which plate tectonic events affecting both land and sea emanated. Thus the unconformities present on land resulted from events at sea, and these events will be expressed as discordant contacts in channels such as Lancaster Sound.

Lancaster Sound was deeply downfaulted by the Eurekan Rifting Episode. The internal faults were growth faults that apparently began in latest Cretaceous or Paleocene time, and had long intermittent activity. Faulting may have been particularly active in Lancaster Sound in mid-Tertiary time (between Middle Eocene and early Miocene), when the climactic phase of the Eurekan Deformation occurred (Kerr, 1979). The upper 2 km of the column in Lancaster Sound does not exhibit major faulting, but overlies more faulted sediments (Keen et al., 1972; Keen et al., 1974). This upper part presumably was deposited after a pulse of faulting of the Eurekan Deformation. This may have been the final faulting event which offset Miocene rocks of the Beaufort Formation (Sequence 7) on Axel Heiberg Island in the Sverdrup Basin (Balkwill et al., 1975; Balkwill, 1978). This final faulting thus was of Miocene or Pliocene age, and may have been of similar age in Lancaster Sound (Kerr, 1979). Because it has been downfaulted, Lancaster Sound probably contains both older and younger rocks of the undivided column comprising Sequences 6 to 8 than are exposed on land anywhere in the study region (Fig. 2). It also probably has a more continuous sedimentary section of Cretaceous-Tertiary-Quaternary rocks than is exposed on land anywhere in that region.

Structural Geology

The present day geology of the study area (Fig. 3) is the result of several successive tectonic events (Table 2). Each left the area with a particular structural configuration which was modified by succeeding events.

Lancaster Sound itself formed as a result of the Eurekan Rifting Episode (Kerr, 1977, 1979), a Cretaceous-Tertiary tectonic event that produced extensive faulting in this region. The faults that were active in this episode are shown in plan view (Fig. 5) and cross-section (Fig. 6). Some had been active earlier and were rejuvenated in the Cretaceous-Tertiary Eurekan Rifting Episode.

The most striking structural feature of the study area is that Cretaceous-Tertiary faults controlled the shapes of islands and channels. A second feature, which is less obvious, is that those faults themselves follow structural trends in the crystalline basement and Paleozoic cover (cf. Figs. 3 and 5). A major fault trending along the north side of Lancaster Sound is here named the Parry Channel Fault. The existence of a fault here was first suggested by Wegener (1924) in his work on Continental Drift. The fault later was confirmed and delineated by geophysical work (Gregory et al., 1961; Barrett, 1966; Bourne and Pallister, 1973; Keen and Barrett, 1973;

Daae and Rutgers, 1975). By using the above geophysical studies and all available stratigraphic and structural evidence on land, it is concluded that the vertical displacement on the Parry Channel Fault on the line of cross-section (Fig. 6) was about 8200 m, with the south side down.

The Parry Channel Fault cannot be traced west of about Longitude 89°W in Barrow Strait. There may or may not be a fault farther west than that, but the absence of young sediments and a hard reflective bottom make geophysical work difficult. The topography and island shapes suggest, however (Fig. 5), that a flexure or fault exists in that region along the south coast of Devon Island and aligns with the Parry Channel Fault. A similar flexure or fault probably exists north of Somerset Island on the south side of Barrow Strait. It has not been possible to detect faults seismically in these locations because the bottom is hard and reflective. A basin of thin semi-consolidated post-Paleozoic clastic sediments within Barrow Strait but west of the study area (Bornhold et al., 1976) indicates at least a local structural depression. This is the Barrow Basin, a Mesozoic-Tertiary basin, and also a modern day topographic depression in the sea floor, containing a maximum of 1000 m of semi-consolidated clastic sediments (Lewis et al., 1977). This thick accumulation overlies bedrock in deeper water and thins north to less than 5 m in shallower areas. Farther north there are only isolated pebble and cobble mounds on the bedrock, remnants of older sediments, presumably glacial tills and marine muds from which fine material has been winnowed. Circulation in western Lancaster Sound and Barrow Strait at present is too vigorous for fine sediments to accumulate, except in isolated depressions. In easternmost Lancaster Sound the water is sufficiently deep for sedimentation to proceed.

East of the eastern coast of Devon Island, normal faults that were downdropped to the east formed the Baffin Bay Basin. Short sections of these faults are known because they were crossed by seismic profiles (Keen and Barrett, 1973), but the exact connections along strike are uncertain (Fig. 5). Southern and eastern Devon Island is surrounded by faults (Fig. 5). Devon Island itself is extensively faulted but the displacements are not great. The existence of the Eureka Sound Formation in a narrow graben (Figs. 3, 5), suggests that these faults formed during the Eurekan Rifting Episode. Devon Island thus is broken up into blocks separated by faults. Some of these faults are presumed to connect with major faults at sea such as the Parry Channel Fault (Fig. 5). The faults within Devon Island appear to be marginal and secondary features, ancillary to the much larger faults and fault zones of greater displacement in the main channels. The bays and fiords of southern Devon Island are fault-controlled. They are dominated by north-south trending linear ridges and depressions, presumably horsts and grabens. At most, only a few metres of sediments have accumulated on the ridges, but up to 30 m of fine muds and inter-stratified coarse sandy turbidites are common in the depressions in these fiords (Lewis et al., 1977). The bedrock structure of southern Devon Island has a rectilinear pattern. Normal faults, sculptured by erosion, controlled the pattern of inlets, and right-angled intersections are common. That part of the island in the study area (Fig. 5) is basically a very large horst.

The overall structure of Devon Island was influenced greatly by the Eurekan Rifting Episode. It appears that at the onset of rifting, Devon Island was a regional homocline of lower Paleozoic sediments dipping northwestward from the Precambrian Shield. The Shield probably was covered entirely by Paleozoic rocks but it may possibly have been exposed at that time in the eastern part of the island. A west dipping regional homocline in Paleozoic rocks still exists on western Devon Island (Fig. 3), but a younger east-west structural configuration was superimposed on this farther east by faulting of the Eurekan Deformation. The east-west trending normal faults on southern Devon Island preferentially have the south side down, and those in the northern part have the north side down. On both northern and southern Devon Island, blocks step downward toward a marine channel, on the south side toward Lancaster Sound, and on the north side toward Jones Sound (Fig. 1). This faulting and the tilting that accompanied it produced a west-plunging synclinal structure within Devon Island in the lower Paleozoic sediments. Faults have raised the central part of this syncline, causing it to be structurally higher than marginal parts (Fig. 6).

The rectilinear pattern of southern Devon Island appears to be controlled by structural trends within the gneisses of the Shield (Fig. 3). On eastern Devon Island, these gneisses exhibit a prominent east-west trend, parallel to that of the Parry Channel Fault and other main faults of Devon Island. A general east-west trend probably exists in the buried Shield rocks and this may have controlled the strike of faults now observed farther west in the sedimentary cover (Fig. 5). A secondary fault trend that controlled Crocker Bay, Powell Inlet, and Maxwell Bay, is at right angles to the main fault trend, and probably was guided by cross joints in the Shield that are perpendicular to the main gneissic trend.

A basement flexure exists north of Baffin Island with the seaward side downflexed, according to magnetic data (Barrett, 1966). Two major faults were suggested along the south side of Lancaster Sound on the basis of bathymetry (Bourne and Pallister, 1973). They are here named the Northern Baffin Fault, and parallel with it farther north is the Admiralty Inlet Fault (Figs. 5, 6). The Northern Baffin Fault is dominant and is presumed to continue eastward and connect with one of the faults described by Keen and Barrett (1973) northeast of Bylot Island.

Numerous Cretaceous-Tertiary faults occur in northern Baffin Island and Bylot Island (Fig. 5), and that region has been called the North Baffin Rift Zone (Jackson and Davidson, 1975; Jackson et al., 1975). The northwest trends appear to have been controlled by parallel Proterozoic fault trends. In their Cretaceous-Tertiary rejuvenation they appear to be subsidiary to the dominant fault zones to the northwest in Lancaster Sound (Fig. 5).

The Prince Regent Fault is a new name applied to a major fault trending along the east coast of Somerset Island and presumably crossing Parry Channel (Fig. 5). The main evidence of faulting along the Somerset Island coast is the straightness of that coastline. Moreover, at its southern end, this fault connects with a lineament that is a known fault on land (Kerr and de Vries, 1977). The Prince Regent Fault may continue to the north across Parry Channel, where it extends along a line which marks an abrupt increase in submarine depths (Fig. 2). This probably is a fault for on the west side of this line is a hard highly reflective bottom, presumably Paleozoic limestone, whereas to the east are semi-consolidated, presumably Cretaceous-Tertiary-Quaternary sediments that increase in thickness eastward (Daae and Rutgers, 1975; Jackson et al., 1977). Further evidence is that Maxwell Bay, aligned with the fault to the north, appears to be faulted, because this bay contains north-south linear ridges (Lewis et al., 1977), and Cretaceous-Tertiary sediments (Blake and Lewis, 1975). The Barrow Basin is west of this line (Bornhold et al., 1976), but appears to be a more local feature with lesser downwarping. Seismic reflection records combined with sea bottom photography, grab sampling, and coring, show that the sea floor in western Lancaster Sound west of about Longitude 89°W is primarily undergoing erosion, with net accumulation occurring at the present time in only a few, small, isolated basins, principally the Barrow Basin north of Somerset Island, and off northwestern Baffin Island (Lewis et al., 1977).

It is suggested that the northwest coast of Brodeur Peninsula was controlled by a fault here named the Brodeur Peninsula Fault (Fig. 5). A fault in this approximate location is necessary to account for the existence of lower Paleozoic rocks of Sequence 3 on land and younger sediments in the channel to the northwest. Its exact location is unknown.

Several anticlines that are shown within Lancaster Sound (Fig. 5) were first shown by Bourne and Pallister (1973). Those authors also depicted a normal fault about 20 km south of Parry Channel Fault, which coincides with a steep south facing submarine escarpment. H.D. Daae, R.T.C. Rutgers and John Pflueger of Norlands Petroleums Ltd. (pers. com., 1977) suggest, from more recent seismic work, that no fault is present and that the scarp may be the result of ancient submarine glacial scouring. A fault at great depth only is shown in the location of this scarp, but with small displacement (Figs. 5, 6). A large northeast trending anticline occurs within the seismic profile of Daae and Rutgers (1975), whose location is shown as CD (Fig. 5). An exploratory well is proposed on the north flank of this structure.

It is clear that Lancaster Sound is fault-controlled (Figs. 5, 6). Bathymetry and the distribution of presumed Cretaceous-Tertiary-Quaternary sediments suggest that the main structure of Lancaster Sound connects eastward to Baffin Bay and southwestward to Prince Regent Inlet, with the amount of vertical displacement presumably increasing from Prince Regent Inlet through Lancaster Sound to Baffin Bay. There is a structural connection also with Barrow Strait but this appears to be of lesser magnitude, despite the straightness of that connection.

Faulted sediments overlain by undeformed sediments have been reported in Lancaster Sound (Keen et al., 1972); those in the upper 2 km of the section do not exhibit major faulting (Keen et al., 1974). This indicates growth faults (Fig. 6), with displacement diminishing upward from faulting to folding. Thus, these youngest sediments in Lancaster Sound may post-date the Eurekan Rifting Episode and any deformation in them may be minor draping over deeper growth faults.

Burke and Dewey (1973) suggested that Lancaster Sound was the site of a transform fault in Precambrian time, and that a failed arm formed in approximately the same location in Cretaceous-Tertiary time. Jackson et al. (1977) suggested moreover that the sound behaved as an aulacogen during each of those two widely separated time intervals. Lancaster Sound was not a Precambrian aulacogen. It is true that there are thick Proterozoic sediments in the region, in the Milne Inlet Trough (Fig. 3), and beneath parts of Lancaster Sound (Fig. 6). The depositional pattern of these sediments is entirely different to that of the present aulacogen. The Milne Inlet Trough however may have been an aulacogen as suggested by Olson (1977), projecting southeastward from a deeper basin.

The Parry Channel Fault or a flexure near it along the north side of Lancaster Sound was indeed active in Late Precambrian time, and this activity preserved a thick Proterozoic column on the south side and only thin remnants on the north. However the suggestion that Lancaster Sound contained either a transform fault or was an aulacogen (failed arm) in Precambrian time is without foundation. It is clear, however, that Lancaster Sound is now an aulacogen and that it developed as such during the younger Cretaceous-Tertiary Eurekan Rifting Episode. That structure has been recognized by numerous authors (e.g. Wegener, 1924; Kerr, 1967a).

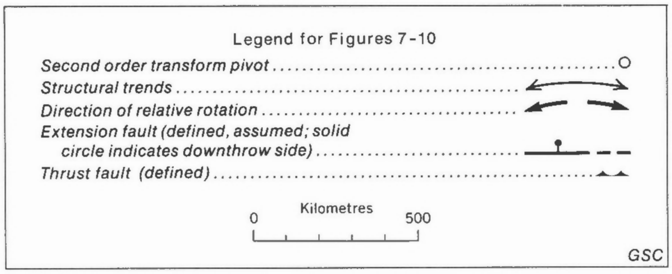
Lancaster Aulacogen

Lancaster Aulacogen is a new name applied in this report to the downfaulted feature that occupies Lancaster Sound and Prince Regent Inlet (Figs. 5, 6). The term aulacogen has been used for many years in the U.S.S.R. (Shatskiy, 1946; Nalivkin, 1965; Salop and Scheinmann, 1969), and was introduced to North America by Hoffman (1973). In recent years the term has become more widely used outside the U.S.S.R. (Burke and Dewey, 1973; Hoffman et al., 1974; de Windt, 1976).

In Hoffman's definition of 1974 the following characteristics identify aulacogens: 1) they are long-lived deeply subsiding troughs, occasionally fault-bounded; 2) they extend at high angles from geosynclines into adjacent foreland platforms; 3) they can be found usually where the geosyncline makes a re-entrant angle into the platform; 4) their fill is contemporaneous with the foreland sedimentary wedge of the geosyncline and is similar in thickness and lithology to it; 5) compressional deformation is possible; however, tectonic movement is mainly vertical; large horizontal translations are rare; 6) abandoned rift arms form juvenile aulacogens when they extend into the continental interior from a re-entrant on the new continental margin; 7) they are attributed to deep-mantle convective plumes that produced three-armed radial rift systems in continents which were stationary with respect to the plumes.

Lancaster Aulacogen meets the criteria listed above. It is a failed arm of a plate junction that was centred in northwestern Baffin Bay. It formed for the first time in the Cretaceous-Tertiary plate tectonic event referred to by Kerr (1977, 1979) as the Eurekan Deformation. This plate junction was four armed, one of which (Jones Sound) was much smaller than the others. This quadruple junction later ceased activity and all arms became nearly dormant, rather than having simply one arm failing as is normally the case. Nares Submarine Rift Valley (Kerr, 1967a) and Lancaster Aulacogen and Jones Sound are arms that failed very early in the history of the plate junction, whereas Baffin Bay developed to a greater degree before failing (Kerr, 1967b).

The Lancaster Aulacogen contains a thick basin of semi-consolidated sediments presumed to be of Cretaceous-Tertiary-Quarternary age, that thickens eastward toward its mouth. In central parts of Lancaster Sound (Fig. 6, Line CD), the semi-consolidated column is as great as 4500 m thick at the north end of a seismic profile and thickens northward (Daae and Rutgers, 1975). When Figure 6 was constructed from all available evidence, it was deduced that there may be as much as 6000 m of this semi-consolidated column on the north side of Lancaster Sound near Parry Channel Fault. The total displacement that occurred on this fault as the aulacogen developed in the Eurekan Deformation was calculated to be about 8200 m (Fig. 6). This was done by estimating the amount of vertical displacement of the basal contact of the Paleozoic column. That contact presumably was first broken when the aulacogen began to form and was offset progressively during development of the aulacogen. All faults that formed Lancaster Aulacogen (Figs. 5, 6) presumably were active in the Eurekan Rifting Episode, though some of them also were active earlier. Faults at sea (Figs. 5, 6) were reported by or interpreted from various



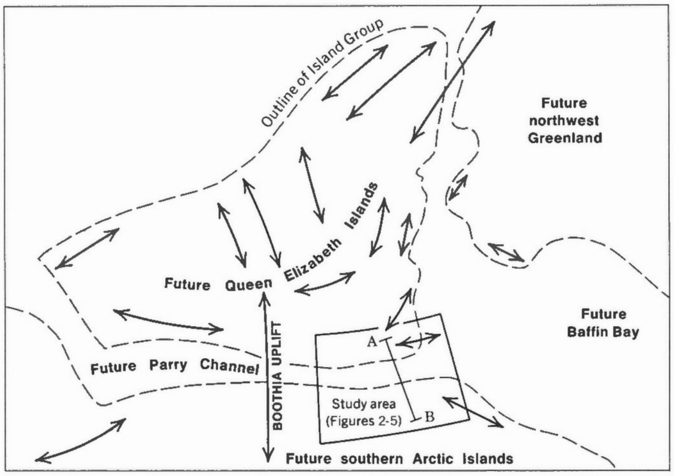


FIGURE 7. *Structural trends of the Precambrian Shield and folded sedimentary cover. These trends influenced the Eurekan Deformation and shapes of islands and channels in the Canadian Arctic (Kerr, 1979).*

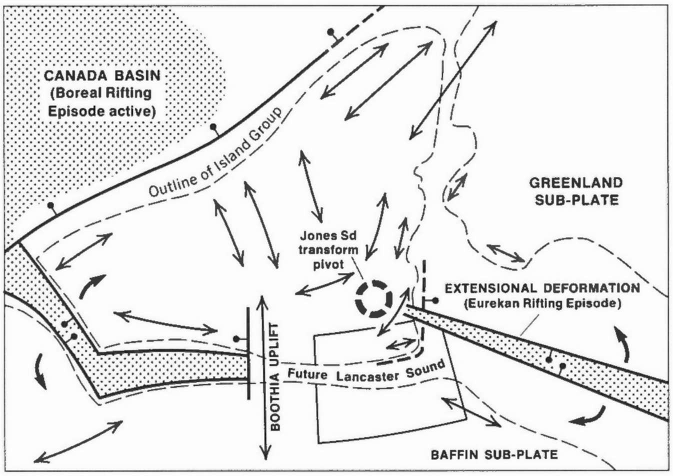


FIGURE 8. *Early phase of the Eurekan Deformation (after Kerr, 1979), in latest Cretaceous to early Tertiary time. Extension faults of the Eurekan Rifting Episode propagating northwestward, began to separate the Greenland and Baffin Sub-plates. These sub-plates rotated apart about the Jones Sound first order transform pivot. Sequence 6 began to be deposited about this time (Tables 1 and 2). The path of rifting was guided by older structural trends, with a branch propagating into Lancaster Sound.*

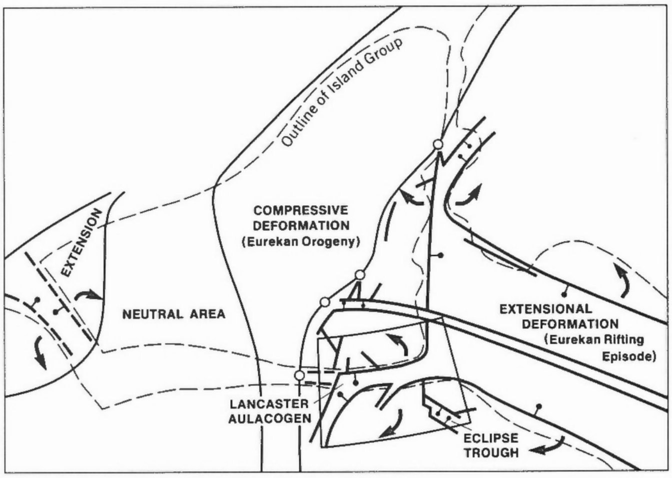


FIGURE 9. *Main period of formation of Lancaster Aulacogen (after Kerr, 1979). This period extended from early to mid-Tertiary time. This figure represents the climactic phase of the Eurekan Deformation. Marked extension in the southeast (Eurekan Rifting Episode) was transformed to compression in the northwest (Eurekan Orogeny) by means of several second order transform pivots. Lancaster Aulacogen was very active at this time. It formed by faults that were deflected westward by gneissic trends in the southeastern Queen Elizabeth Islands (see Fig. 7). The north and south sides of the aulacogen presumably rotated apart, with the amount of separation increasing eastward. The western end of the aulacogen was further deflected to the southwest presumably by the trend of the Boothia Uplift.*

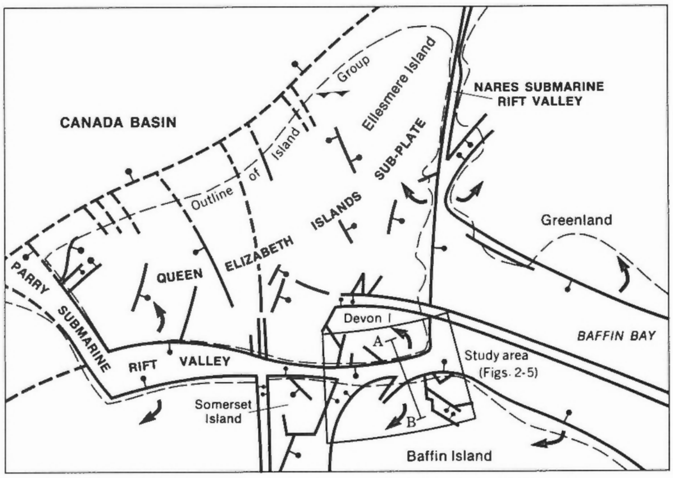


FIGURE 10. *Final phase of structural formation of Lancaster Aulacogen during final phase of the Eurekan Deformation in Miocene or Pliocene time (after Kerr, 1979). At this time the Eurekan Rifting Episode extended farther north and west to obliterate the pivots and supercede the Eurekan Orogeny. Final formation of the aulacogen occurred when faults were able to break westward through the Boothia Uplift. This structural configuration exists today, modified by erosion. AB is location of cross-section (Fig. 6).*

sources, including Gregory et al. (1961), Barrett (1966), Kerr (1967a, b), M.J. Keen et al. (1972), Bourne and Pallister (1973), Daae and Rutgers (1975), Jackson and Morgan (1975), Jackson et al. (1975), Bornhold et al. (1976), Kerr and de Vries (1977), and Jackson et al. (1977). The existence of these faults also is supported by island shapes and bathymetry. The Parry Channel Fault (Fig. 6) was first detected by Gregory et al. (1961), and Barrett (1966) suggested that it has as much as 8 km of vertical movement. It appears that the net vertical displacement of the aulacogen was greatest in the east and diminished toward the west.

On a line of cross-section through Lancaster Aulacogen (Fig. 6) there is as much as 6000 m of poorly consolidated to semi-consolidated sediments. The lower part of this, presumably Sequence 5, may have been deposited before the aulacogen began to form. A thick central part probably accumulated during the period of active rifting and formed the sound. This may include rocks assignable to Sequences 6 and 7 of the Canadian Arctic (Kerr, 1979). The upper and least deformed part of the column probably was deposited after the aulacogen became dormant and may be assigned to Sequence 8. Regional relationships suggest that there may be discordant contacts at the bases of Sequences 5, 6, 7 and 8 in Lancaster Aulacogen.

Eurekan Deformation

The Eurekan Deformation is a major plate tectonic event that affected the Canadian Arctic in Late Cretaceous to mid-Tertiary time, and was primarily responsible for the formation of islands and seaways. The Eurekan Deformation was defined by Kerr (1977) to include both the Eurekan Orogeny (Thorsteinsson and Tozer, 1970), and the Eurekan Rifting Episode. The Eurekan Rifting Episode was mainly in the southeast; it involved extensional deformation that began in the southeast and progressed northwestward. The Eurekan Orogeny was the complementary compressional deformation farther northwest. Several stages are recognized in the Eurekan Deformation of the Canadian Arctic (Kerr, 1979). These are illustrated here but in a more simplified way (Figs. 7-10), in order to show specifically how the Eurekan Deformation formed Lancaster Aulacogen.

Prior to the Eurekan Deformation (Fig. 7), the region now occupied by the Canadian Arctic Islands and Greenland was entirely continental crust, with a crystalline basement layer or Shield (Sequence 1). At the outset of the deformation the crystalline layer was covered in most parts by younger rocks (Sequences 2 to 5). In the large part of the Shield which is now exposed in the southern and eastern Arctic, gneissic trends are known. In regions where the Shield is covered these trends are reflected in the overlying folded sediments (Fig. 7). Structural trends in the crystalline crust had a major influence on plate tectonic events whereas those in the overlying folded sediments had lesser effect. Before the beginning of the Eurekan Rifting Episode much of the Canadian Arctic, including the Lancaster Sound Region, may have contained an unbroken continental crust of normal thickness (Fig. 7). Thin marine sediments of Sequence 5 may have been accumulating in a widespread shallow sea that covered the entire area.

An early phase of the Eurekan Deformation was extension of the Eurekan Rifting Episode (Fig. 8). This apparently began in Late Cretaceous time with normal faults that were propagated to the northwest. This extension took place partly by rotation about a large transform pivot farther northwest. It occurred in the southeast without marked accompanying compressional deformation in the northwest. Extension also existed in the northwest at this time, the Boreal Rifting Episode which emanated from the Canada Basin. There may have been areas of compression at this time, but there is no evidence of the resulting deformation. The two rifting events appear to have been largely independent of each other at this time (Kerr, 1979).

As the Eurekan Rifting Episode continued in the southeast and the two major sub-plates became further separated the situation shown in Figure 8 gradually developed into that shown in Figure 9. Baffin Bay became extensively faulted, because of the combined effect of the bordering sub-plates rotating apart and of the subsidence of a large block within Baffin Bay itself. Tectonism and downfaulting became more widespread, and by early Tertiary time (Paleocene-Eocene) faulting affected the Eclipse Trough where the upper part of the Eclipse Group (Sequence 6) began to be deposited. The downdropping of Lancaster Sound and initiation of the aulacogen there presumably occurred before faulting reached the Eclipse Trough, for the faulting in Eclipse Trough appears to emanate from the larger aulacogen to the north. Thus Lancaster Sound may have begun to form as a water-covered aulacogen in latest Cretaceous time (Fig. 8). By the time faulting reached Eclipse Trough with a thick sedimentary accumulation of lower Tertiary (Paleocene-Eocene) rocks of Sequence 6, an even thicker column may have been forming in Lancaster Sound, where major faults are presumed to have been active.

Extension continued in the southeast and finally in mid-Tertiary time, during the upper part of Sequence 6, the climactic phase of the Eurekan Deformation occurred (Fig. 9, after Kerr, 1979, Fig. 20). Extensional deformation in the southeast (Eurekan Rifting Episode), propagating northwest occurred contemporaneously with compressional deformation in the northwest (Eurekan Orogeny). Extension and compression were axially opposed to each other in a complex fashion. Structures that developed in the Eurekan Deformation (Fig. 9) were very much controlled by pre-exisiting structural trends of the existing continent, particularly the trends of gneisses in the Shield. These played a major role in guiding the structures of Lancaster Aulacogen (cf. Figs. 7 and 9). Trends in the southeast part of Queen Elizabeth Islands initially halted the northwest advance of early rifting and a quadruple junction formed in northwest Baffin Bay. Instead of advancing northwest (Fig. 8) major faults were instead deflected into the mouth of Lancaster Aulacogen (Fig. 9). The strong north trending gneissosity of the Boothia Uplift then deflected the faults forming the aulacogen still farther to the southwest, in Prince Regent Inlet (Fig. 2). The northerly trending Boothia Uplift thus played a major role in controlling Lancaster Aulacogen.

The main faults that formed Lancaster Sound are the Parry Channel Fault, Northern Baffin Fault, and Brodeur Peninsula Fault (Fig. 5). Apparently each was deflected to the southwest, with the Prince Regent Fault developed as an offshoot of the Parry Channel Fault. Faults may have extended westward from Lancaster Sound into Barrow Strait, but major displacement cannot have occurred. Lancaster Aulacogen probably had this angular shape through to the end of the climactic phase of the Eurekan Deformation (Fig. 9). It appears that up to and including the climactic phase, a region in the southeast, including Lancaster Aulacogen, had continued pulsating extension.

The final phase of structural formation of Lancaster Aulacogen took place during the final phase of the Eurekan Deformation (Fig. 10). In this event, which was in mid-Tertiary time (Miocene or Pliocene), extension was prevalent throughout the Canadian Arctic Islands, as the Eurekan Rifting Episode superceded the Eurekan Orogeny. The Boothia Uplift was breached by the Parry Channel Fault which continued westward to connect with older faults and form the long Parry Submarine Rift Valley. At this same time Nares Submarine Rift Valley apparently also broke northward through the continental crust. Lancaster Sound apparently had a lesser branch that extended westward into Barrow Strait (Fig. 5). The Prince Regent Fault Zone appears to the have greater displacement than the faults or downwarps along Barrow Strait, so that the main trend of Lancaster Aulacogen still curves southward into Prince Regent Inlet (Fig. 5). Lancaster Aulacogen forms the eastern entrance or mouth of the longer Parry Submarine Rift Valley.

The first major faults to begin forming Lancaster Aulacogen probably were deflected into that structure from a major spreading centre in Baffin Bay early in the rifting process. This may have been in latest Cretaceous time (Fig. 8). Their activity may have been stepped up in early Tertiary time (Paleocene-Eocene), when Lancaster Sound was rapidly developed and the Eclipse Trough also began to form. The climactic phase of the Eurekan Deformation (Fig. 9) and the time leading up to it involved accelerating extension in Lancaster Sound. The aulacogen may have had its last pulse of extension in Miocene or Pliocene time (Fig, 10), when the final breakthrough of the Arctic Islands occurred and the main rifts reached the Arctic Ocean. Since that pulse, Lancaster Aulacogen may have been largely inactive structurally; however, sedimentation has continued to the present day.

It may be possible to estimate the amount of extensional separation that occurred between the north and south sides of Lancaster Sound. This might be done by using geophysical studies that would map in detail the sequences and the faults within the sound (Fig. 6). The key unit to map is the lower Paleozoic Sequence 3, which presumably was continuous across the region of Lancaster Sound before the aulacogen formed. Any gaps in this sequence will indicate later lateral separation that occurred during faulting. The amount of separation could be calculated by measuring the amount of horizontal displacement on this sequence on all the faults between the two sides of the sound by utilizing the vertical displacement dips of the faults. Using this and regional relationships it then should be further possible to construct a detailed developmental sequence within the time span of the Eurekan Deformation.

Lancaster Aulacogen formed by faults during the Eurekan Rifting Episode. The Parry Channel Fault is the north bounding fault of Lancaster Sound and had the greatest vertical displacement. There are lesser displacements on the south bounding faults. The main aulacogen extends westward through Lancaster Sound and curves southwest into Prince Regent Inlet (Fig. 5). Bounding faults have displacement that diminished gradually to the southwest in Prince Regent Inlet.

Numerous subsidiary fault-bounded structures project off Lancaster Aulacogen. One of these is in Barrow Strait where bounding faults die out much more abruptly westward. In that strait the semi-consolidated column is thin or absent. Admiralty and Navy Board Inlets and the Eclipse and North Bylot Trough are fault-controlled subsidiary structures, as are the inlets on the south coast of Devon Island (Fig. 5). Since Lancaster Sound opened up from the east, the amount of total displacement and total downdropping of the sound increases to the east. The depth to crystalline basement at any place within the sound probably is a direct result of the amount of downdropping, which in turn may be directly proportional to the amount of lateral spread.

It is presumed that there was some lateral separation between the north and south sides of Lancaster Aulacogen, because the downfaulting of the sound could not occur without at least some spread. Vertical displacement increases eastward on Lancaster Aulacogen, and presumably so also did the related horizontal spread. Because the horizontal displacement increases eastward and because the faults presumably die out to the west, this indicates that there also was rotation on the aulacogen, occurring about a pivot somewhere to the west, perhaps within the Boothia Uplift. Horizontal separation of the two sides of Lancaster Sound increases eastward from its head in the west, and is greatest at its mouth where it joins Baffin Bay. The aulacogen had great vertical displacement, but the sides must also have had some horizontal separation or spread, although the horizontal movement probably was not great. Lancaster Aulacogen probably was actively developing as an arm of a triple junction during intermediate and late stages of the Eurekan Deformation (Figs. 9 and 10), when substantial displacement occurred on the bounding faults. Subsequently the entire region became nearly inactive (Kerr, 1979).

Post-Aulacogen to Present Day Deformation

The Haughton Astrobleme (Fig. 5) is a mid-Cenozoic meteoritic impact structure (Robertson and Mason, 1975; Frisch and Thorsteinsson,1978) that formed in Miocene or Pliocene time. This was during a late stage or after the Eurekan Rifting Episode, but the astrobleme was not related to that episode.

The Lancaster Aulacogen region now has only mild seismic activity (Basham et al., 1977), probably reflecting adjustments on existing structures. Free air and Bouguer gravity anomalies (Ross, 1973) indicate that this region is still not in isostatic balance. It is probable that since the final pulse of the Eurekan Deformation, Lancaster Aulacogen has had only slight structural activity; however it probably continued to accumulate sediments.

Future earthquakes that may occur in Lancaster Sound and the nearby region probably will be adjustments on existing faults, with little likelihood that new faults will develop. Many of the faults in Lancaster Sound may not extend upward to the sea bottom, because they are growth faults that are overlain in some cases by poorly consolidated sediments (Fig. 6). Seismic activity on these faults may be dispersed as drape folding within the upper poorly consolidated levels of the Cretaceous-Tertiary-Quaternary sedimentary column (Table 2, Fig. 6). There are rather steep submarine gradients in Lancaster Sound and renewed faulting might trigger submarine slides that could cause turbidity current flows in the poorly consolidated layers. Quaternary sedimentation in Lancaster Sound has been described by Bornhold (1979).

Economic Geology

The Proterozoic rocks of northern Baffin Island are a promising region for base metal exploration. The Nanisivik Mine, an operating lead-zinc mine (Fig. 2), occurs in the Society Cliffs Formation (Olson, 1977). According to Jackson et al. (1978), other lead-zinc occurrences are known in the region.

Lancaster Aulacogen is an extremely promising structure for petroleum exploration. It contains Cretaceous and younger sediments up to 6000 m thick on the line of cross-section (Fig. 6) and these are even thicker to the east. There are indications of bituminous shale in the lower part of this column. A shaly unit that occurs in Sequence 5, in the lower part of the Eclipse Group of Bylot Island (Jackson et al., 1975; Miall et al., in press) may be equivalent to the

Kanguk Formation of the Sverdrup Basin. That shaly unit may also be present in the lower part of the column in Lancaster Aulacogen; if so, it would provide a good petroleum source bed. A possible equivalent unit occurs in western Greenland, the organic rich Senonian Blake shales of Nûgssuaq (Henderson et al., 1976), that have been burning spontaneously for many years. Most of the prospective sedimentary column within Lancaster Aulacogen probably is part of the undivided body comprising Sequences 6 to 8 and of latest Cretaceous to Quaternary age. The most prevalent rock in this sequence of Lancaster Aulacogen probably is sandstone, as it is in Sequence 6 of the Eclipse Trough to the south.

In other parts of the world, aulacogens connected with major triple junctions are known to provide a good habitat for petroleum. Two that have structural settings similar to that of the Lancaster Aulacogen are in the North Sea and Gulf of Suez. The Viking Aulacogen of the North Sea has an ideal combination of reservoir rocks and petroleum source rocks (de Windt, 1976). Two major fields lie within the Viking Aulacogen, and at least two others occur in one of its substructures. The Gulf of Suez was described by Said (1962) as a taphrogeosyncline, and its structure is similar to an aulacogen in current terminology. It is an asymmetrical linear structural depression with major marginal faults that trend along it on either side, and with high bordering escarpments. The graben structure of the Gulf Suez apparently has been an excellent site for petroleum generation. Large oil fields also occur outside the structure but were derived from within it (Said, 1962).

SUMMARY

The configuration of lands and seas in the Lancaster Sound study area (Fig. 2) resulted largely from an episode of plate tectonic breakup that occurred in Late Cretaceous to mid-Tertiary time. The islands and channels are fault-controlled, with the channels downdropped and the islands raised relatively. The region is dominated by Lancaster Aulacogen, a failed arm of a triple junction that was located in northwestern Baffin Bay.

The structure of Lancaster Aulacogen and of the islands nearby was controlled by the interplay of global plate tectonic forces acting upon pre-existing structural trends. These pre-existing structural trends provided sites of easy release in the plate tectonic event. During plate breakup these structures were rejuvenated with new directions of offset, and they effectively controlled the shape of the aulacogen. The structural trends in the gneisses of the Precambrian Shield were the dominant features that guided all later structures of the region. These gneissic structures influenced Paleozoic tectonic events as well as the plate tectonic episode. The similarity in trend between pre-aulacogen structures and the structures of the aulacogen has given rise to the erroneous conclusions (Burke and Dewey, 1973; Jackson et al., 1977) that there was an earlier, Precambrian aulacogen in the same location as the present Lancaster Aulacogen.

A number of events affected the study region (Table 2 and Fig. 2), occurring in succession as follows: (A) Metamorphism during the Hudsonian Orogeny about 1735 Ma ago, when the main gneissosity in the Shield developed. (B) Formation of the Milne Inlet Trough in late Proterozoic (Helikian) time. This involved at least one widespread stratigraphic break and two periods of dyke intrusion. The column of Proterozoic sedimentary and igneous rock constitutes Sequence 2. The Milne Inlet Trough is a deeply faulted basin, with faults active during its formation. It may possibly be an aulacogen emanating from a deeper basin to the northwest. (C) Faulting after Helikian sedimentation raised the Navy Board High. Faulting and/or warping at about the same time also raised the Devon Island High. The faulting or flexing on the south side of the Devon Island High may have been in the approximate location of the Parry Channel Fault in the eastern parts of the Lancaster Sound. (D) There was a widespread planation of the Shield and the Proterozoic rocks of the Milne Inlet Trough and a wider basin in pre-Paleozoic time. (E) The lower Paleozoic column (Sequence 3) was laid down upon this peneplain, and covered the entire study area. This was a thin sedimentary column of the Arctic Platform, nearly flat lying, but presumably dipping very gently northwestward regionally. (F) Late Silurian to late Early Cretaceous rocks are absent from the study area. It is likely that the entire study area was exposed during a larger part of that interval. (G) An undulating sheet of Lower to Upper Cretaceous rocks, Sequence 5, appears to have been spread over much or all of the Lancaster Sound study area. A remnant of this sheet is now preserved locally on land in the younger Eclipse Trough (Fig. 3). Remnants probably also are preserved in the lower part of Lancaster Aulacogen and other marine channels. It appears that the present aulacogen did not form until after this sequence was deposited. (H) Lancaster Aulacogen formed by intermittent downfaulting of the Eurekan Rifting Episode, a plate tectonic event that affected the entire Canadian Arctic. Faults may have begun to form the aulacogen in latest Cretaceous time (Fig. 8). (I) Faults apparently were extremely active in Lancaster Aulacogen in early to mid-Tertiary time when they also affected the Eclipse Trough. The maximum activity of faulting may have coincided with the climactic phase of the Eurekan Deformation in mid-Tertiary time (Fig. 9). (J) The final phase of major faulting that formed Lancaster Aulacogen may have been in Miocene or Pliocene time, when the last known phase of the Eurekan Deformation occurred. (K) After the Eurekan Rifting Episode ended and Lancaster Aulacogen ceased active structural formation, sedimentation continued to the present day.

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