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CRETACEOUS AND TERTIARY SEDIMENTS OF ECLIPSE TROUGH, BYLOT ISLAND AREA, ARCTIC CANADA, AND THEIR REGIONAL SETTING

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CRETACEOUS AND TERTIARY SEDIMENTS OF ECLIPSE TROUGH, BYLOT ISLAND AREA, ARCTIC CANADA, AND THEIR REGIONAL SETTING

Abstract

The Cretaceous-Tertiary sequence in Eclipse Trough has been subdivided into three formations; the reconnaissance term Eclipse Group has been abandoned. The lowermost unit is the Hassel Formation (Albian-Cenomanian), 10-120 m thick, of fluvial origin. It consists of mature, recycled quartzose detritus. Coal seams are present near Pond Inlet. The unconformably overlying Kanguk Formation (Campanian-Maastrichtian) has been divided into two members. The lower mudstone member is 560-590 m thick; the upper sandstone member is 540 m thick on the south coast of Bylot Island, but thins rapidly to the northwest as a result of facies change into the mudstone member and/or erosional truncation. The sandstone member was deposited by a northwesterly prograding alluvial system, and consists of mineralogically immature detritus derived from Archean and Aphebian metamorphic and plutonic rocks of granitic composition. The uppermost unit, the Eureka Sound Formation (upper Paleocene to lower Eocene) contains four members. The lower sandstone member at the base has a maximum thickness of 200 m. It is a mature, quartzose, marine shoreline deposit which onlaps a tilted surface on the Kanguk Formation in the northern part of Eclipse Trough. The lower mudstone (90 to 500+ m) and upper sandstone (1370+ m) members form a gross coarsening upward cycle, representing progradation of a fluvial and river-dominated delta system northwestward, down the axis of Eclipse Trough. Interpreted depositional environments and sandstone petrography are similar to those of the Kanguk Formation sandstone member. The upper mudstone member (200+ m) is preserved in a single outlier. It probably is of marine origin.

Eclipse Trough is one of a series of fault-controlled basins filled with Cretaceous-Tertiary deposits on the margins of both sides of Baffin Bay-Labrador Sea. The basins resulted from a phase of graben formation during crustal attenuation, possibly accompanied by sea floor spreading, in the Early Cretaceous to mid-Eocene Eurekan Rifting Episode. The basin fill in Eclipse Trough is similar to that of the Bjarni area of Labrador Shelf, except that in the latter basin graben development was followed, in mid Eocene to Pliocene time, by regional subsidence and deposition of a thick, seaward-thickening clastic wedge. This is absent in Eclipse Trough, but probably is to be found in nearby offshore basins. Stratigraphic correlations between Labrador Shelf, Eclipse Trough and Sverdrup Basin reflect continent-wide plate tectonic controls and global eustatic sea level changes.

Résumé

La succession Crétacé-Tertiaire de la fosse d'Eclipse a été subdivisée en trois formations; le terme préliminaire groupe d'Eclipse a été abandonné. L'unité la plus basse, d'origine fluviale, la formation de Hassel (Albien-Cénomanien), a une épaisseur de 10 à 120 m. Ile est constituée de débris principalement quartzeux, recyclés, mûrs. On trouve des couches de charbon près de l'inlet Pond. La formation de Kanguk (Campanien-Maestrichtien), recouvrant en discordance la formation précédente, a été divisée en deux niveaux. Le niveau inférieur pélitique, a une épaisseur de 560-590 m; le niveau supérieur, gréseux, a une épaisseur de 540 m sur la côte sud de l'île Bylot, mais il s'amincit rapidement vers le nord-ouest en passant au niveau pélitique ou bien disparaît par arasement. Les grès ont été déposés par un système alluvial avançant vers le nord-ouest et consistent en débris peu transformés provenant de roches plutoniques et métamorphiques de composition granitique, d'âge archéen et aphébien. L'unité la plus haute, la formation d'Euréka Sound (Paléocène supérieur à Eocène inférieur), a été divisée en quatre niveaux. À la base, le niveau inférieur gréseux a une épaisseur maximale de 200 m. C'est un dépôt littoral, mûr, quartzeux, qui recouvre la surface inclinée de la formation de Kanguk dans la partie nord de la fosse d'Eclipse. Les niveaux représentés par les pélites inférieures (90 à 500+m) et les grès supérieurs (1370+m) forment un cycle dont les éléments deviennent plus grossiers vers la partie supérieure, représentant la progression vers le nord-ouest d'un complexe deltaïque formé par des fleuves et cours d'eau le long de l'axe de la fosse d'Eclipse. L'interprétation des milieux sédimentaires et de la pétrographie des grès indique une similarité avec le niveau gréseux de la formation de Kangug. Le niveau supérieur pélitique (200+m) est représenté par une seule butte témoin. Il a probablement une origine marine.

La fosse d'Eclipse fait partie d'une série de bassins déterminés par des failles et remplis de sédiments crétacés et tertiaires sur les marges de la mer de Baffin et de la mer du Labrador. Les bassins se sont formés après une phase d'effondrement pendant l'amincissement de la croûte terrestre peut-être accompagné d'une expansion du fond marin, lors de l'épisode de formation du rift d'Euréka, entre le Crétacé inférieur et l'Eocène moyen. Dans la fosse d'Eclipse, le matériau de remplissage du bassin est le même que celui du secteur de Bjarni sur le plateau continental du Labrador, sauf que dans ce secteur, la phase d'effondrement a été suivie, du Miocène moyen au Pliocène, d'une subsidence régionale et de la formation d'un prisme de sédiments clastiques dont l'épaisisement est dirigée vers la mer. Il n'y a rien de tel dans la fosse d'Eclipse, mais on peut probablement rencontrer la même situation dans des bassins sédimentaires proches, situés au large. Les corrélations stratigraphiques entre le plateau continental du Labrador, la fosse d'Eclipse et le bassin de Sverdrup reflètent l'effet de la tectonique des plaques à l'échelle du continent et des variations eustatiques globales du niveau de la mer.

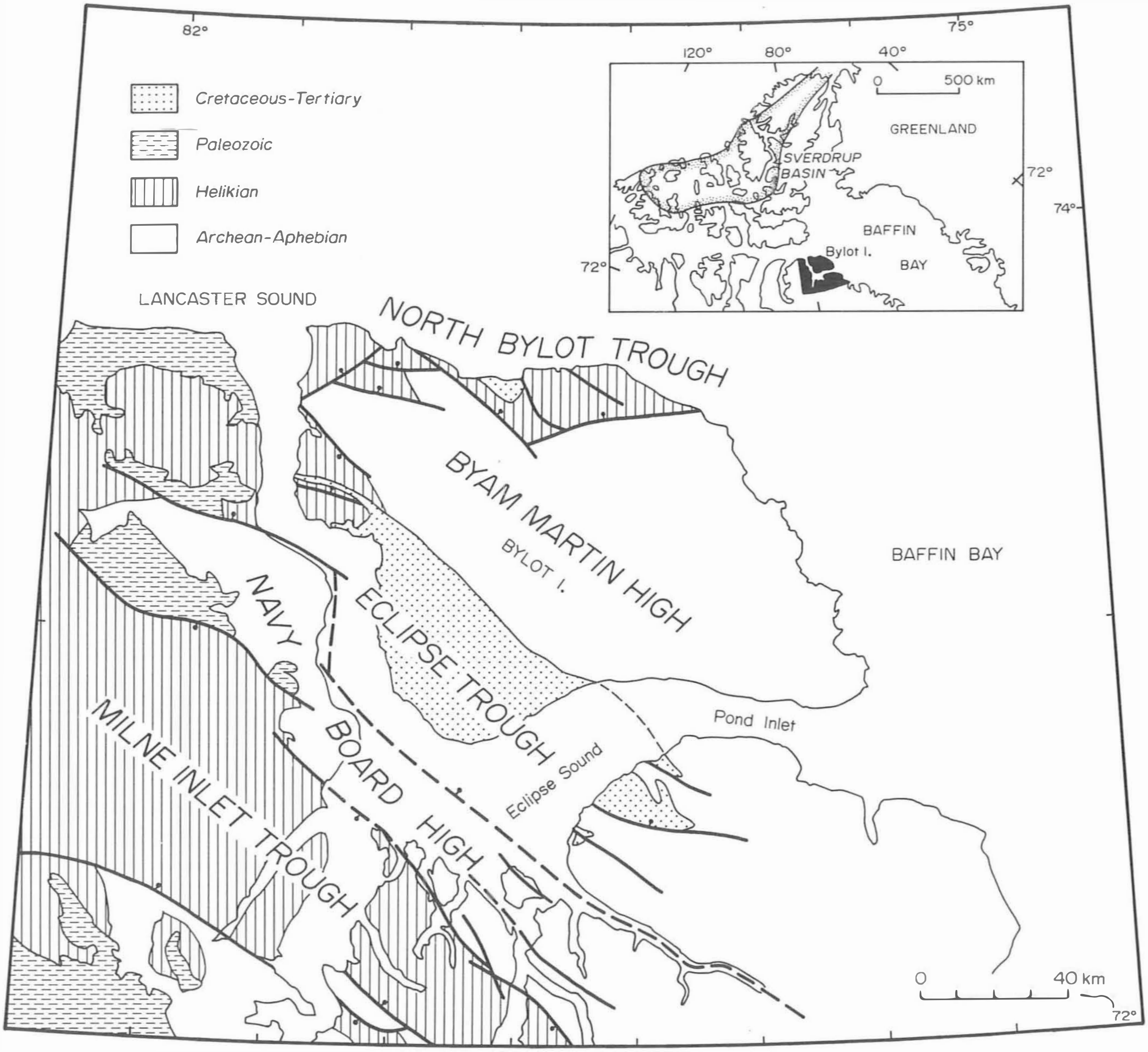


FIGURE 1. Regional setting of Eclipse Trough (after Jackson and Davidson, 1975; Jackson et al., 1975). Inset shows location of Bylot Island and extent of Sverdrup Basin.

CRETACEOUS AND TERTIARY SEDIMENTS OF ECLIPSE TROUGH, BYLOT ISLAND AREA, ARCTIC CANADA, AND THEIR REGIONAL SETTING

INTRODUCTION

Scope of study

Eclipse Trough underlies southwest Bylot Island, the Pond Inlet area of Baffin Island and adjacent parts of Eclipse Sound and Navy Board Inlet (Fig. 1). The outcrop area of the Cretaceous-Tertiary succession extends for 150 km in a northwest-southeastward direction along the long axis of the trough, and the exposed thickness of the trough fill is approximately 3000 m, although an additional thickness may be preserved beneath the waters of Eclipse Sound.

These Cretaceous-Tertiary outcrops are geologically very isolated. There are minor faulted outliers of Upper Cretaceous sediments and a graben filled with Tertiary deposits on Somerset Island 450 km to the west, the main outcrop area of the Sverdrup Basin 500 km to the northwest, and an area underlain by Cretaceous-Tertiary sediments and volcanics on the west coast of Greenland 800 km to the southeast. Nearer at hand reflection seismic profiles indicate that thick Mesozoic and Cenozoic deposits probably underlie Baffin Bay and Lancaster Sound (Daae and Rutgers, 1975; Hea et al., 1979; Kerr, in press, a). The sediments which fill Eclipse Trough therefore provide the only on-land evidence available for deciphering the Cretaceous and Tertiary history of a large part of the eastern Arctic Islands. Their stratigraphic, structural and sedimentological history has a bearing on a variety of geological problems including the age and extent of the Eurekan Orogeny and its associated molasse deposits, the nature of rifts and plate motions in the Baffin Bay area; and the petroleum potential of thick contemporaneous sections in the offshore regions of western Baffin Bay.

Field work for this report was carried out by H.R. Balkwill, W.S. Hopkins, jr. and D. Umpleby working together for one week in July 1977 and by A.D. Miall, who spent two weeks in the area in July 1978. Balkwill and Hopkins compiled two stratigraphic sections through the sequence and made extensive sample collections for biostratigraphic examination. Hopkins carried out palynological studies on the samples and coordinated investigations by other specialists including J.H. Wall (foraminifera), N.S. Ioannides (phytoplankton), D. Bukry and H.P. Foreman (silicoflagellates and diatoms), and F.M. Gradstein (foraminifers, radiolarians, sponge spicules). Miall completed mapping of the deposits and carried out detailed sedimentological investigations. He is also responsible for compiling this report.

Acknowledgments

Field operations were conducted from base camps operated by the Terrain Sciences Division, and the writers are grateful to R.N.W. Dilabio and R.A. Klassen, party chiefs in 1977 and 1978, respectively, for sharing their camp facilities and helicopter flying time with us. Logistic support was provided by the Polar Continental Shelf Project from its base at Resolute. Thanks are due to C.E. Miall for providing field assistance in 1978.

Previous work

The first systematic geological investigation of the report area was carried out by the Geological Survey of Canada in 1968. This was a helicopter-supported reconnaissance project covering the Bylot Island, Pond Inlet and Nova Zembla map areas and the eastern part of the Navy Board Inlet map area (NTS sheets 38C, 38B, 38A and 48D respectively). The work resulted in two reports, each with a geological map at 1:250,000 scale, one by Jackson and Davidson (1975) covering the northern half of the area and the other by Jackson et al. (1975) describing the southern half. In these reports the Cretaceous-Tertiary section was assigned to the Eclipse Group and divided into four map units as follows:

- T shale and mudstone
- KT2 arkosic sandstone
- KT1 subgreywacke, mudstone and siltstone
- K quartzose and arkosic sandstone

Several parties from petroleum companies have visited the area, but none of the data they collected was available to the writers. An unpublished report by Steltner (1972) described the exposures on Salmon River which were at one time worked for coal by the nearby community at Pond Inlet. This report also briefly lists earlier references to the same exposures.

Kerr (in press, a) summarized the regional geology of the area.

Regional setting

Physiographically the report area is part of the Arctic Lowlands, on the edge of the Davis Region of the Canadian Shield (Bostock, 1970). Eclipse Trough occupies a relatively low-lying area with elevations rarely above 600 m. The central part of the trough is occupied by Eclipse Sound. Borden Peninsula to the west, although classified as part of the Arctic Lowlands, is an uplifted dissected plateau (part of Lancaster Plateau of Bostock, 1970) with elevations commonly above 300 m and locally reaching 1250 m.

Eclipse Trough is bordered on the northeast by the Davis Region, an elevated part of the Shield with numerous local ice caps, extending from east central Ellesmere Island to northern Labrador. The Byam Martin Mountains (Byam Martin High in Fig. 1) represent that part of the Davis Region on Bylot Island and are part of the Davis Highlands. They are locally up to 1900 m above sea level and are covered by a continuous ice cap from which emerge numerous valley glaciers.

The structural geology of the report area (Fig. 1) was described briefly by Jackson and Davidson (1975) and Jackson et al. (1975). The area is part of the North Baffin Rift Zone, a series of parallel, northwest-trending horsts and grabens. Eclipse Trough is one of the grabens and is underlain by Helikian and Cretaceous-Tertiary sediments. Paleozoic rocks are present in other grabens to the west and south. The trough is bordered by Navy Board High on the southwest and by Byam Martin High on the northeast. Both are underlain mainly by migmatite, granite and gneiss of Archean and/or Aphebian age.

According to Jackson and Davidson (1975) and Jackson et al. (1975), folding and block faulting have occurred periodically in the area between Helikian time and the present. The pronounced northwest-southeast structural grain in the area probably was established in the Proterozoic and the structures have been periodically rejuvenated since that time. Evidence presented in this report suggests that in Late Cretaceous and Tertiary time Eclipse Trough existed in something like its present shape and orientation as a basin sag developed over a much older graben feature. Mild tectonism continued during and after deposition of the Cretaceous and Tertiary sediments, as indicated by the presence of at least two unconformities in the section, and by the monoclinal dips and gentle folds that have been mapped in the outcrops on southwestern Bylot Island (Fig. 2a).

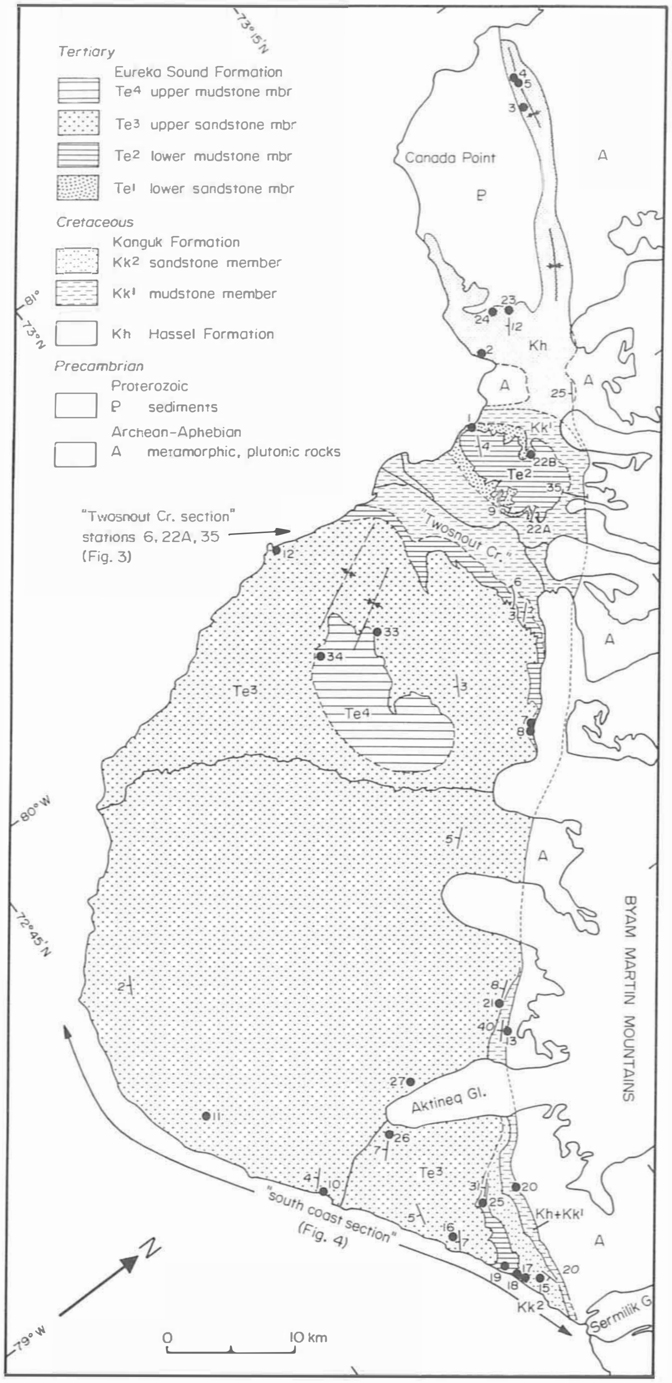


FIGURE 2a. Cretaceous-Tertiary geology of southwest Bylot Island, showing location of field stations (upright numerals) and composite sections.

STRATIGRAPHY

The detailed work carried out by the writers indicates that revisions of the four map units recognized by Jackson and Davidson (1975) and Jackson et al. (1975) are necessary. Three formations have now been recognized, all of which are units widespread in the Arctic Islands. Two of the formations have been subdivided into members within the report area. Because of this stratigraphic reclassification the reconnaissance term Eclipse Group (Jackson and Davidson, 1975; Jackson et al., 1975) is not used in this report. The stratigraphy is summarized in Table 1, the outcrop distribution of the units is shown in Figures 2a and b, two detailed sections are given in Figures 3 and 4, and the regional variations in thickness and facies are shown in Figure 5.

Biostratigraphic interpretations are based upon analyses of terrestrial spores and pollen as well as marine dinoflagellates, foraminifera, silicoflagellates, diatoms, radiolarians and sponge spicules. Age determinations in the Hassel Formation are based entirely on spores; these were the only forms recovered from what appears to be a continental unit. Kanguk age determinations are based essentially on marine taxa while the overlying Eureka Sound has been dated mainly on angiosperm pollen, fungal spores and dinoflagellates.

All of the micropaleontologists involved found the study of these samples exceedingly difficult with the results occasionally contradictory. Recovery of most forms was generally inadequate and frequently preservation was poor. Pollen and spores were commonly corroded and deformed, and indications of reworking were widespread. However, most samples did yield at least some palynomorphs, while conversely many samples did not yield any marine taxa.

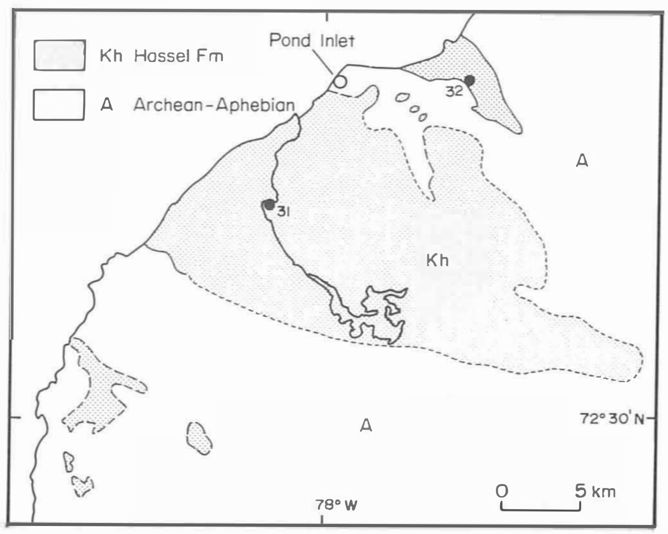


FIGURE 2b. Distribution of Cretaceous outliers near Pond Inlet, showing location of field stations (numbered spots). After Jackson et al. (1975).

TABLE 1. Cretaceous-Tertiary stratigraphy of Eclipse Trough

Map Unit	Age	Formation	Member	Thickness m	Lithology
Te[4]	U. Paleocene - L. Eocene	Eureka Sound	Upper mudstone	200+	mudstone, minor sandstone
Te[3]			Upper sandstone	1370+	immature sandstone, minor siltstone, mudstone
Te[2]			Lower mudstone	80-500+	mudstone, jarositic, minor sandstone
Te[1]			Lower sandstone	0-200	glaconitic sandstone
			Unconformity		
Kk[2]	Campanian-Maastrichtian	Kanguk	Sandstone	0-540	immature sandstone, minor siltstone, mudstone
Kk[1]			Mudstone	560-590	mudstone
			Unconformity		
Kh	Albian-Cenomanian	Hassel		10-120	sandstone, minor mudstone

Samples which contained marine forms occasionally revealed new species whose ranges are not known, or species whose stratigraphic ranges are in conflict. In short, these proved to be exceptionally difficult samples with which to work and to draw firm biostratigraphic conclusions. Ages are therefore based largely on attempts to synthesize results and to resolve the minor conflicting conclusions of the various participants. Lists of taxa and ranges are not provided in this paper because more information will be forthcoming in taxonomic and biostratigraphic manuscripts to be prepared by the individual specialists concerned.

Hassel Formation

Definition, distribution and thickness

The Hassel Formation was defined by Heywood (1955, 1957, p. 13) based on exposures in the vicinity of Isachsen Dome, Ellef Ringnes Island. The formation consists predominantly of sandstone and is more than 500 m thick in the central Sverdrup Basin. It is widespread throughout the Arctic Islands.

The Hassel forms the base of the Cretaceous-Tertiary succession in Eclipse Trough and rests with a profound unconformity on Precambrian rocks. It is overlain disconformably by the Kanguk Formation. It outcrops along the northwest margin of Eclipse Trough, and forms outliers in a major valley and on hillsides in the northwestern part of the trough, near Canada Point. The outliers of Cretaceous sediments near Pond Inlet are also assigned to this unit.

The formation is assumed to be present at the base of the Cretaceous-Tertiary section throughout Eclipse Trough although it is of variable thickness, infilling irregularities in the Precambrian erosion surface, and may be absent locally. The thinnest sections studied are at the "Twosnout Creek"[1] composite section (Fig. 3) and at station 13, where the formation is 15 m thick. In the south coast composite section (Fig. 4) 120 m of beds are assigned to this formation, and this probably is close to the maximum thickness.

As defined here, the unnamed sandstone formation corresponds approximately to map unit K of Jackson and Davidson (1975) and Jackson et al. (1975), except that outcrops of map unit K encircling the base of a hill immediately northwest of "Twosnout Creek" have been reassigned to the basal Eureka Sound Formation.

Lithology

The predominant lithology is fine to very coarse, quartzose sandstone, which is laminated to thick bedded and, in some outcrops, contains abundant crossbedding. Pebbly lenses are rare with clasts up to 6 cm in diameter composed of quartz, metamorphic rocks and (at station 4) rare red sandstone derived from underlying Proterozoic sediments.

In the Pond Inlet area lenses of pink garnetiferous sand are common, intraclasts of siltstone and coal are present and the sandstone is interbedded with coal seams up to 2 m thick.

[1] "Twosnout Creek" is an informal name given to a stream whose headwaters rise at the snouts of two adjacent major valley glaciers (Fig. 2a).

The thickest coal seams are exposed at station 31 in river cliffs bordering the Salmon River, where three or four seams are present, separated by sandstone. No other good exposures of the unnamed sandstone formation are present in this river valley, and so the lateral extent of the coal seams is unknown. At one time the seams were mined by the residents of Pond Inlet, but the workings were abandoned in 1959 or soon thereafter (Steltner, 1972). The section at station 31 is the only one in the Cretaceous and Tertiary rocks of Eclipse Trough which contains a significant thickness of coal.

Sedimentologic (see later section) and biostratigraphic evidence from this formation indicates a nonmarine origin.

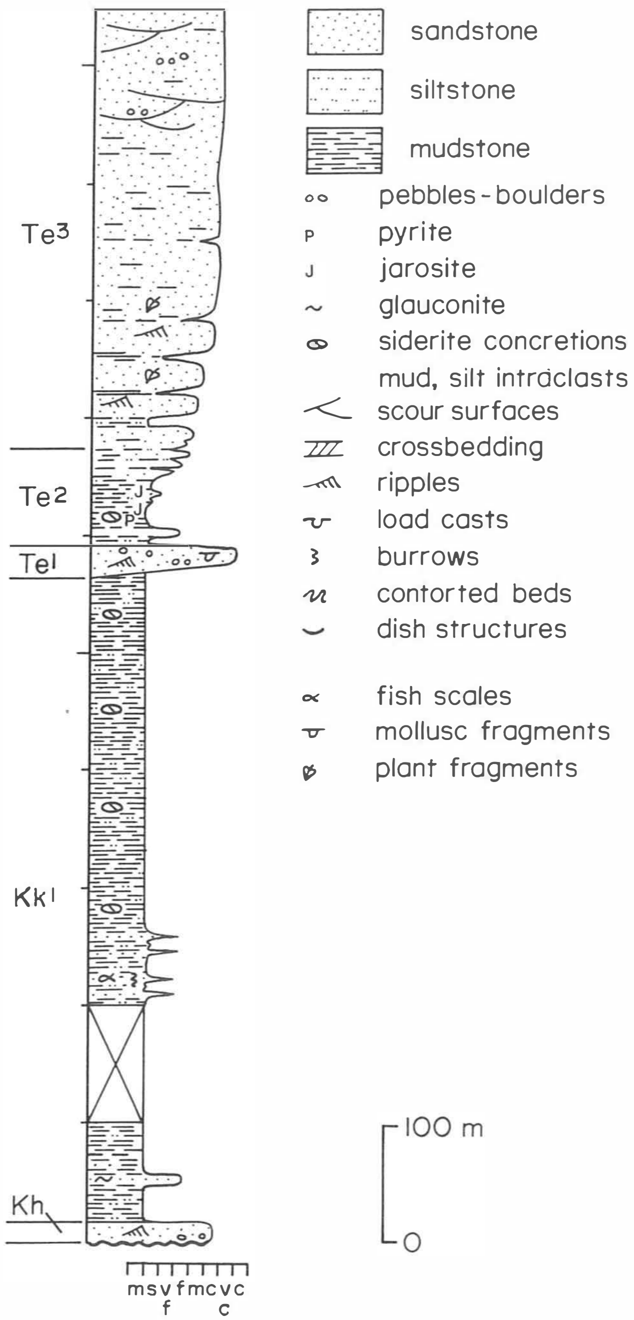


FIGURE 3. Composite stratigraphic section, "Twosnout Creek". Grain size scale: m = mudstone, s = siltstone, sandstone: vf = very fine, f = fine, m = medium, c = coarse, vc = very coarse; c = conglomerate.

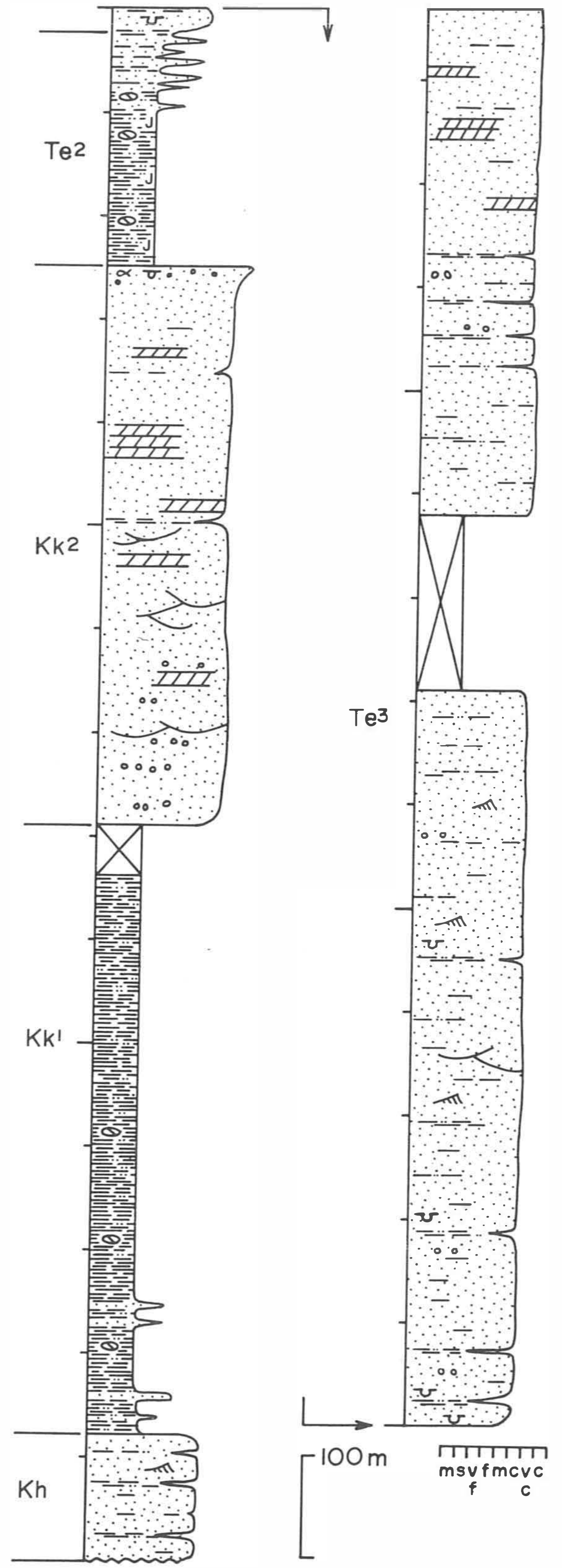


FIGURE 4. Composite stratigraphic sections, south coast of Bylot Island. Symbols as in Figure 3.

Age and correlation

Limited biostratigraphic evidence indicates an Albian to Cenomanian age for the Hassel Formation.

Only four samples were available from this unit, three of which contained well-preserved microflora. The assemblages included such spore genera as Clavifera, Dictyophyllidites, Kuylisporites, Acanthotriletes, Foveosporites, Sestrosporites, Trilobosporites and Appendicisporites. Also present, significantly, are simple tricolpate pollen grains, early representatives of the angiosperms. The recovered microflora is similar to that of the Hassel Formation of the Sverdrup Basin (Hopkins and Balkwill, 1973), and also includes many of the Lower Cretaceous taxa identified in the Albian Christopher Formation of Ellef and Amund Ringnes Island (Hopkins, 1974).

The Hassel Formation of Sverdrup Basin is a thick, widespread unit representing a major fluviodeltaic complex, and containing some marine beds, whereas in Eclipse Trough it is a more proximal deposit, wholly nonmarine, that is the product of a much smaller scale fluvial system. However, in both areas, the formation probably represents a clastic pulse following the same widespread mid-Cretaceous episode of differential epeirogenic movement.

Kanguk Formation

Definition, distribution and thickness

The Kanguk Formation was defined by Souther (1963, p. 442-444) from exposures in the Kanguk Peninsula area of Axel Heiberg Island, where the formation consists of silty shale with minor amounts of sandstone and, at the base, tuffaceous, and bentonitic beds. The Kanguk is widespread in the Arctic Islands and has been correlated with similar units on the Arctic mainland south of Banks Island (Yorath et al., 1975; Miall, 1979). It represents an interval during the Late Cretaceous when fine grained marine sediments were deposited over a wide area of Arctic Canada, probably including much of the craton, from which it has now been eroded.

Elsewhere in the Arctic Islands the Kanguk rests conformably to disconformably on the Hassel Formation and is overlain conformably to disconformably by the Eureka Sound Formation (Balkwill, in press; Miall, 1979). In Eclipse Trough the Kanguk rests disconformably on the Hassel Formation and is followed disconformably by the Eureka Sound. The Kanguk corresponds approximately to map unit KT1 of Jackson and Davidson (1975) and Jackson et al., (1975), although many of the outcrop areas mapped as unit KT1 by those authors are now reassigned to the Eureka Sound Formation.

In the report area the Kanguk Formation has been divided into two members, a mudstone member at the base and a sandstone member above. The mudstone member outcrops along the northeast margin of Eclipse Trough from "Twosnout Creek" to the coast near Sermilik Glacier. It probably underlies the Eureka Sound Formation throughout central Eclipse Trough. Complete thicknesses of the member have been measured only in the two composite sections (Figs. 3, 4) where it ranges from 560 to 590 m. The sandstone member is present only in the area between Aktineq Glacier and the south coast, where it is 540 m thick (Fig. 4). Northwest of Aktineq Glacier the sandstone member is absent, either as a result of erosion below the disconformity with the Eureka Sound Formation, or because of a lateral facies change into the mudstone member. Probably both interpretations are partly correct (Fig. 5).

Lithology

The predominant lithology in the lower member of the formation is soft grey mudstone, locally jarositic. Field measurements indicate a low pH. Thin beds of glauconitic sand are present near the base. Siderite concretions are common, and fish scales and invertebrate burrows have been observed.

The sandstone member consists mainly of white, orange, or pale brown, medium to very coarse grained, friable sandstone. Most of the sandstone is medium to thick bedded, without lamination or crossbedding, but rare intervals are present, for example at station 17, in which planar crossbeds sets 3-14 cm thick are abundant (Fig. 6). Low angle crossbedding surfaces dipping at less than 5° were also recorded. Lenses of pebble and cobble conglomerate and rare boulders are present. Most of the clasts are foliated metamorphic rocks, but fragments of quartzose sandstone and intraclasts of dark grey mudstone have also been observed. Root beds, concretionary, carbonate-cemented sandstone units and scattered pelecypod fragments occur in the sandstone member, particularly near the top of the section.

Age and correlation

Many silicoflagellates and radiolarians and numerous dinoflagellates have been recovered from the mudstone member. Some are new species, some are not especially diagnostic and a few show conflicting published stratigraphic ranges. Foraminifera are not common, probably the result of the low pH of the mudstone. Terrestrial spores and pollen are rare and poorly preserved, their rarity possibly a result of dispersion in the marine environment. The conclusion of workers who studied the marine organisms, and especially the dinoflagellates, is that the mudstone member of the Kanguk Formation of Eclipse Trough is Campanian-Maastrichtian in age, but more precise dating is not possible at this time.

Evidence for the age of the sandstone member is less conclusive but it probably is Maastrichtian. This is similar to the age range of the upper part of the Kanguk Formation in Sverdrup Basin. In Amund Ringnes and Banks Islands the formation is Cenomanian to Maastrichtian (Balkwill, in press; Miall, 1979). In both areas the Kanguk is followed conformably by the Eureka Sound Formation, the base of which is Maastrichtian in most areas, and Paleocene in parts of Banks Basin.

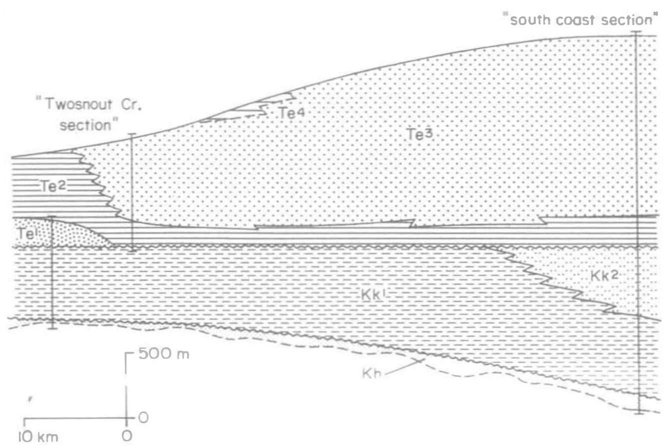


FIGURE 5. Reconstructed stratigraphic cross-section across southwest Bylot Island.

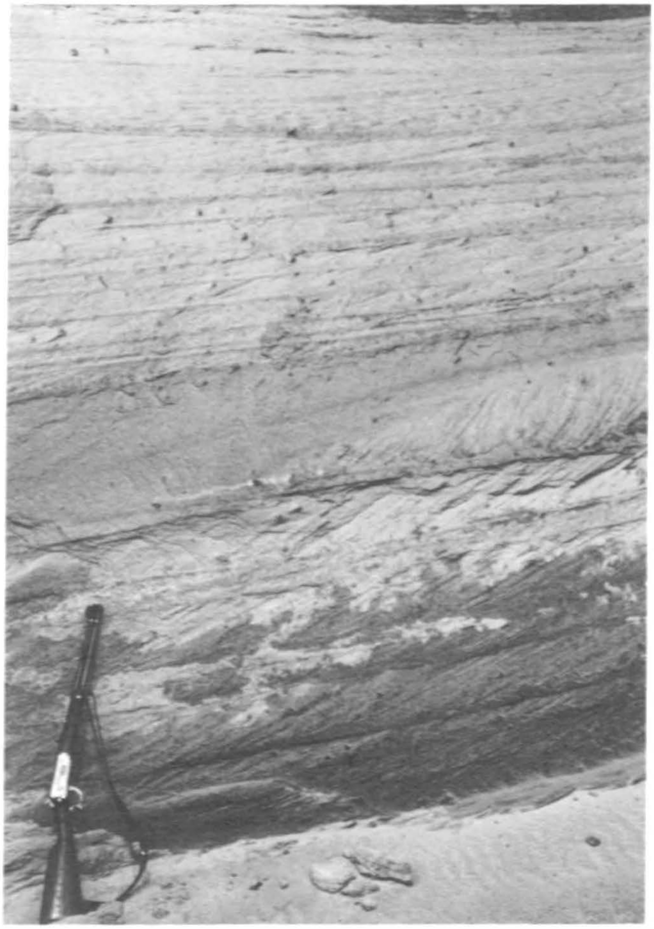


FIGURE 6. Sandstone member, Kanguk Formation, near Aktineq Glacier, showing abundant planar crossbedding with unimodal orientation. ISPG 1148-4.

Lithologically the sandstone member of the Kanguk Formation in the report area is similar to the Eureka Sound Formation, and elsewhere beds of similar age and facies have been assigned to that formation (Balkwill, in press). This correlation is not followed in the present report because, 1. the two members of the formation in Eclipse Trough appear to be genetically related, forming a gross coarsening-upward, regressive cycle, and 2. the formation is separated by a disconformity from overlying beds which are unquestionably Eureka Sound Formation in terms of lithology and age. However, the nomenclature adopted here is not entirely satisfactory. Recent work has shown that the predominantly sandy sequences that have been assigned to the Eureka Sound Formation in different parts of the Arctic Islands are of widely varying age ranges and may encompass one or several unconformities (Balkwill, 1978 and in press; Bustin et al., in press; Miall, 1979, and unpublished data). A major revision of Upper Cretaceous and Paleogene stratigraphy is clearly required, and it is hoped that this will soon be accomplished (work by Miall, in progress).

Eureka Sound Formation

Definition, distribution and thickness

The name Eureka Sound Group was first proposed by Troelsen (1950, p. 78) for a widespread unit of sandstone, shale and lignitic coal of Tertiary age in central Ellesmere Island and Axel Heiberg Island. Tozer (1963, p. 92-95) pointed out that Troelsen had not established any formations within the Eureka Sound and had not designated a type section. Tozer redefined the unit as a formation and stated that "it seems reasonable to regard the outcrops on Fosheim Peninsula, adjacent to Eureka Sound as typical."

The Eureka Sound Formation is a widespread unit in the Arctic Islands, consisting mainly of nonmarine sandstone and shale, locally with abundant coal. Recent work has shown that thick marine intervals also are present (Kerr, 1974; West, et al., 1975; Bustin et al., in press; Miall, 1979 and unpublished data). The formation is Maastrichtian to Eocene, although sections in most places encompass only part of the total age range. A major stratigraphic revision of the Eureka Sound is required to clarify the relationships within this thick (up to 3000 m on Ellesmere Island) and lithologically varied unit (work in progress by Miall).

In Eclipse Trough the Eureka Sound Formation has been divided into four members (Table 1). The lower sandstone member is present only in the "Twosnout Creek" area (Fig. 2a), where it ranges up to 200 m in thickness. The lower mudstone member is more widespread. At the south coast section it is 250 m thick (Fig. 4). It thins to 80 m east of "Twosnout Creek" (Fig. 3) and thickens dramatically to at least 500 m to the west of the Creek (Fig. 5). It appears to be absent between these two main outcrop areas (Fig. 2a), where it may be overlapped or overstepped by the upper sandstone member. The latter is the most widespread of the Cretaceous-Tertiary units. It outcrops over most of the country between "Twosnout Creek" and Aktineq Glacier and reaches a maximum preserved thickness of 1370 m. The upper mudstone member is present only as an outlier capping a hilly area south of "Twosnout Creek" (Fig. 2a) where approximately 200 m of beds are preserved. The maximum thickness of the formation is present along the south coast of Bylot Island, where it totals 1600 m of beds.

The stratigraphic subdivisions used herein cannot be consistently related to the map units erected by Jackson and Davidson (1975) and Jackson et al., (1975). The lower mudstone member corresponds approximately to unit KT1 in the "Twosnout Creek" area. It overlies the lower sandstone member, which was here assigned to unit K by Jackson and Davidson (1975). Map unit KT2 corresponds lithologically to the upper sandstone member, but the outcrop distribution has been radically revised in the present report.

The lower sandstone member decreases northeastward from 200 m to virtually zero thickness within a distance of 3 km on the north side of "Twosnout Creek." This is interpreted as onlap of the member onto the gently dipping unconformity of the Kanguk Formation. The recorded thickness change corresponds to a dip discordance of 4°, which can be observed in outcrop at stations 22A and 22B (Figs. 7, 8). The same interpretation may explain the absence of the lower mudstone member between "Twosnout Creek" and Aktineq Glacier (Fig. 2a), where the upper sandstone member is assumed to lie directly on the Kanguk Formation.

Lithology

The lower sandstone member is characteristically a white, quartzose, glauconitic sandstone containing abundant pelecypod fragments (Fig. 9). Grain size varies locally from very fine to very coarse but fine-grained sandstone predominates. Pebbles up to 1 cm in diameter of metamorphic rock fragments, and shale intraclasts up to 50 cm long, are rarely present. Structures include horizontal feeding trails, sets of mutually interfering ripple marks, scour surfaces with up to 2 m of relief, contorted laminae and dish structures. Most of these features are rare and are restricted to a few intervals within the section, the bulk of the sandstone being structureless and without visible bedding. No crossbedding was observed. Rare thin beds of carbonaceous, silty shale are present. There is an abrupt contact with the overlying lower mudstone member.

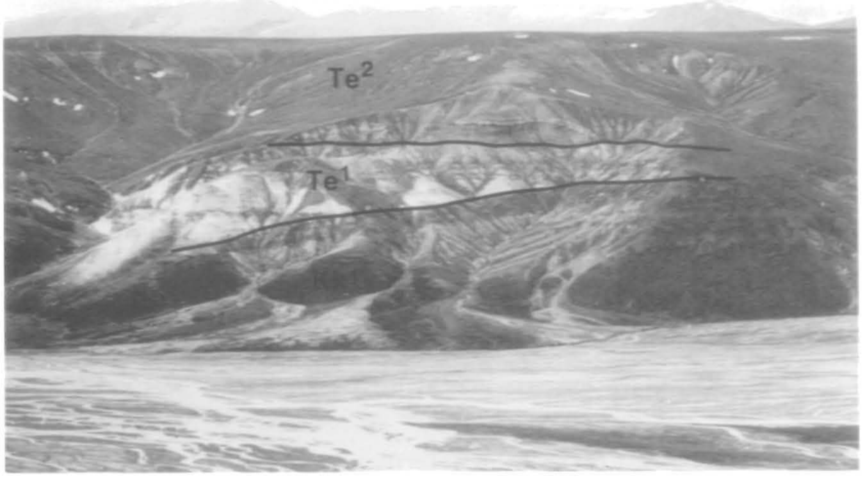


FIGURE 7. Onlap of lower sandstone member, Eureka Sound Formation (Te^1) on to the Kanguk Formation (Kk^1), "Twosnout Creek". ISPG 1148-1.

FIGURE 8. The Eureka Sound Formation, near "Twosnout Creek". ISPG 1149-26.

The lower mudstone member consists of dark grey, jarositic, variably silty, mudstone containing siderite concretions and thin lenses of soft sand or carbonate-cemented sandstone (Fig. 10). Sand beds become thicker and more abundant up the section and the succession show a gradual transition into the overlying upper sandstone member (Figs. 3, 4, 11). Sand units are characteristically fine to medium grained with abundant small scale ripple marks, load casts, groove casts, roots and leaf impressions. The upper part of the member consists of superimposed small scale coarsening-upward cycles 5-25 m thick within the overall upward coarsening of the sequence.

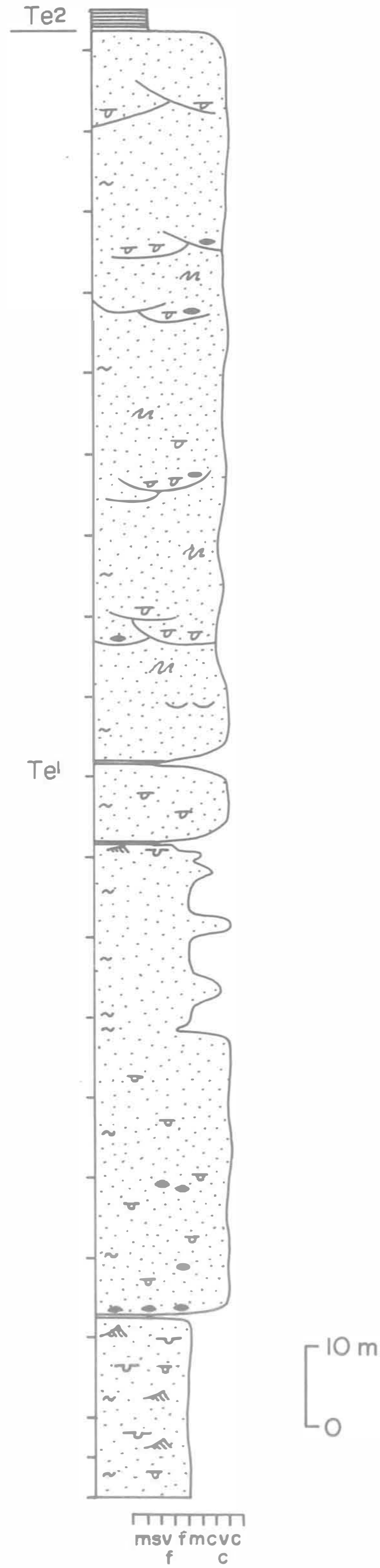


FIGURE 9. Stratigraphic section of lower sandstone member, Eureka Sound Formation, at station 9, "Twosnout Creek". Symbols as in Figure 3.

The upper sandstone member (Figs. 12-14) is composed mainly of white, orange or brown sandstone, characteristically massive and structureless. Silty and argillaceous interbeds are rare and commonly provide the only evidence of bedding (Fig. 12B). In places the sandstone has weathered into spectacular hoodoo forms (Fig. 14B). At station 11 the sandstone is very fine grained to pebbly, contains abundant intraclasts of silty mudstone up to 1 m long and liquefaction features, including flow rolls and dish structures. Faint surfaces dipping at angles of 10-36° with amplitudes of a few metres in the outcrop, may be scours or surfaces of lateral sediment accretion.

Greater lithologic variability is present at the base of the member where there are abundant mudstone and siltstone interbeds (Fig. 12A) and the section comprises a series of stacked fining-upward sequences (Figs. 11, 13). Rare large scale scours representing channel cutbanks are present in the sandstone units (Fig. 14A). At stations 7 and 8 pebble, cobble and boulder conglomerate beds up to 1 m thick are present. Clasts reach 1 m in diameter and are composed of quartz, foliated green gneiss, quartz-feldspar-biotite augen gneiss, red granite and rare biotite-amphibole-plagioclase gneiss. The clasts show weak imbrication structure. Crossbedding is rare throughout the upper sandstone member, but a few planar crossbed sets are present and, at station 21, straight crested ripples are preserved in a sandstone bed. Other features include load casts and rare plant impressions. No coal seams were observed in this member.

At "Twosnout Creek" the lower mudstone and upper sandstone members are in part laterally equivalent. Exposures on either side of the creek (stations 6 and 22A; see Fig. 2a) can be correlated, and show that the lower mudstone member increases in thickness considerably from southeast to northwest, at the expense of the upper sandstone member (Fig. 5). This facies change can also be seen in exposures on the south side of the creek (to the east and west of station 6) as a gradual northwesterly wedging out of sandstone units in the base of the upper sandstone member. The facies change here is shown diagrammatically in Figure 2a.

The contact between the lower mudstone and upper sandstone members is gradational, and is drawn where cyclic sequences change from upward coarsening to upward fining. This marks a significant change in depositional environment, to be discussed in a later section of the report .

The upper mudstone member consists of dark grey, carbonaceous mudstone with rare, thin, concretionary lenses of fine-grained sandstone. The member has a gradational contact with the upper sandstone member, the section at the contact consisting of interbedded sandstone and mudstone containing plant fragments.

Age and correlation

The age of the Eureka Sound Formation has been determined almost exclusively on the basis of spores and pollen and, in the basal one third of the formation, dinoflagellates. Other marine taxa, which are so useful in the underlying Kanguk Formation are absent. Reworking of Cretaceous palynomorphs and dinoflagellates is common, which suggests that at least some Kanguk was incorporated within the Eureka Sound.

No doubt of a Tertiary age exists. Angiosperm genera such as cf. Carpinus, Momipites (= Engelhardtia), cf. Corylus, proto-Carya, Pterocarya, Alnus, Paraalnipollenites, cf. Myrica, Extratiporopollenites?, Platycarya are locally abundant. One specimen of Chenopodium was found near the top of the south coast section as well as the fungal spore genus Pesavis. Proto-Carya, Engelhardtia, Momipites, and Pterocorya would suggest a middle Paleocene or younger age. Pesavis is most common in the Eocene but does extend down into the Paleocene. Undoubtedly Chenopodium and Platycarya first appear in the earliest Eocene. On examination of the evidence, it would appear that Eureka Sound on Bylot Island is probably Paleocene, but it is quite possible that the upper part of the section is Eocene. Dinoflagellate evidence is in complete agreement with this interpretation. This compares with, and is consistent with, the Maastrichtian to Eocene or Paleocene to Eocene age of the formation in most other parts of the Arctic Islands.

FIGURE 10. *Interbedded sandstone and mudstone of lower mudstone member, Eureka Sound Formation, at station 7, near "Twosnout Creek". ISPG 1148-3.*

STRUCTURE

The regional structural grain in the Phanerozoic rocks is oriented northwest-southeast, paralleling foliation in the Archean-Aphebian basement. This grain is followed by Helikian dykes and by major Phanerozoic faults.

Between "Twosnout Creek" and the south coast of Bylot Island the Cretaceous-Tertiary section forms essentially a homocline, dipping toward the southwest generally at an angle of less than 10°. Much of the upper sandstone member of the Eureka Sound Formation is nearly horizontal. Gentle folds have been mapped by Jackson and Davidson (1975) south of the mouth of "Twosnout Creek". Their axes are oriented northwest to southeast, parallel to the axis of Eclipse Trough.

Dips are greater near the margins of Eclipse Trough, reaching 40° to the southwest at station 13, in the outcrop of the Hassel Formation (Fig. 2). In the outlier of this unit northwest of "Twosnout Creek" dips are nearly everywhere away from the outcrops of underlying Precambrian rocks; the linear, valley-fill outlier which extends west-northwest to the coast of Navy Board Inlet has a synclinal structure, with dips up to 8°.

The dip everywhere away from the Precambrian may be an effect of drape over existing topography in the pre-Cretaceous erosion surface. Such an effect would be emphasized by subsequent basin subsidence and compaction. Drag effects over the faults bounding the trough would also produce such dips, if the faults were active during or following sedimentation. The northeast boundary of Eclipse Trough is a prominent near-linear topographic feature which was mapped in part as a fault by Jackson and Davidson (1975) and Jackson et al. (1975), but close examination on the ground indicates that the Hassel Formation is everywhere in sedimentary contact with the Precambrian. Fracturing of the sandstone commonly is intense, but there is no evidence of large scale vertical displacement. The linearity of the Precambrian-Cretaceous contact suggests that a fault probably is present at depth – this would accord with the regional structural style as outlined in "Regional setting – but displacement in the Cretaceous probably was accommodated by attenuation of the sedimentary section, possibly accompanied by gravity sliding along the contact between the basement and the sedimentary rocks. The structure may in part represent a syndepositional fold, of the type described by Miall (1978, p. 1625). A schematic structural cross-section through the basin showing this interpretation is given in Figure 15. If this interpretation is correct, Eclipse Trough is a basin sag rather than a graben at the Cretaceous-Tertiary level.

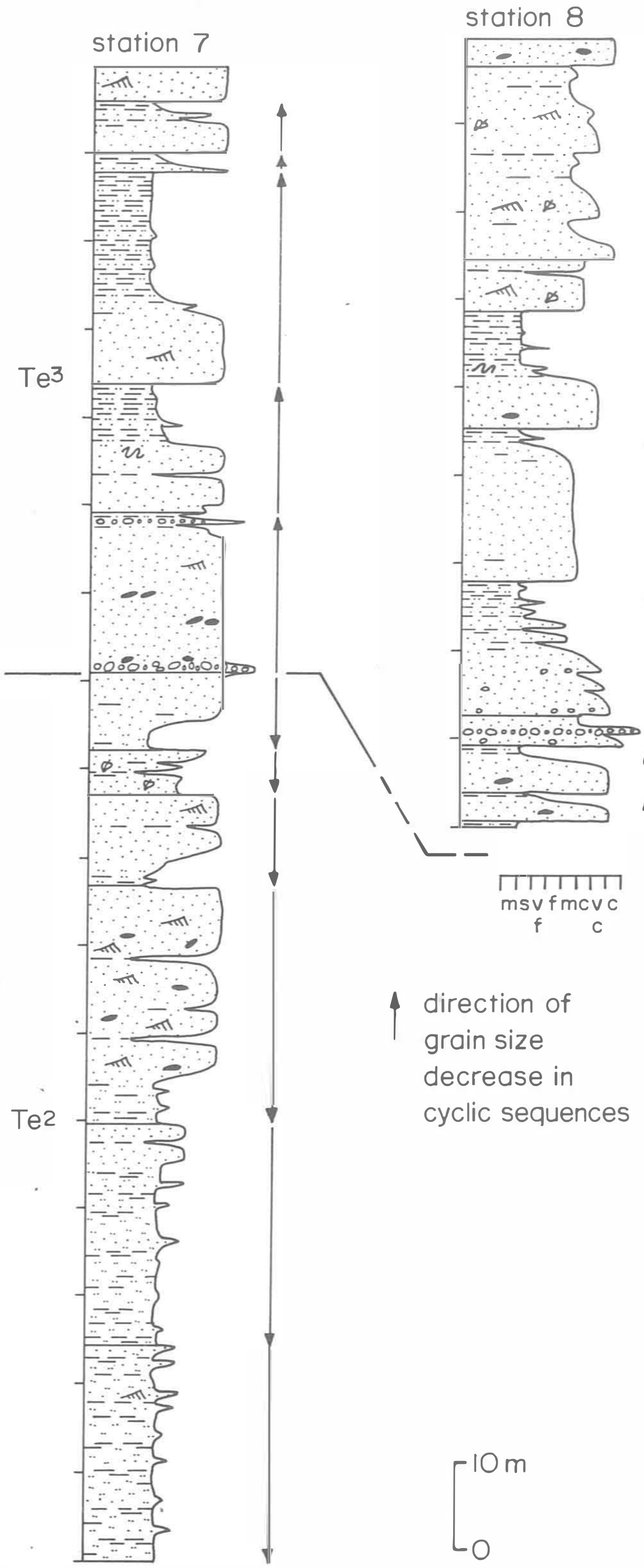


FIGURE 11. Stratigraphic sections of lower mudstone member and upper sandstone member, stations 7 and 8, near "Twosnout Creek". Symbols as in Figure 3.

SEDIMENTOLOGY

It has been found that the most useful sedimentological tools for analyzing the Cretaceous and Tertiary clastic sequences in the Arctic Islands are facies studies, paleocurrent analysis, and petrographic analysis of the sandstones. Synthesis of the data from these sources provides an excellent basis for interpreting depositional environments and paleogeography. In the next two sections the methods and results of paleocurrent and petrographic studies, respectively, are discussed. These data are combined with interpretations of lithofacies types and vertical sequences in the third section in which an attempt is made to interpret depositional environments and the paleogeographic evolution of Eclipse Trough.

Paleocurrent analysis

Paleocurrent determinations were made on a total of 115 sedimentary structures in the Cretaceous-Tertiary sediments of the report area. For a basin the size of Eclipse Trough this is not a large number, but fortunately the results are, for the most part, internally consistent and are readily interpretable.

Sedimentary structures are not common in the sandstone members of the Kanguk and Eureka Sound Formations, many sections being characterized by massive-weathering units virtually devoid of visible bedding, or exhibiting planar bedding or lamination. The most abundant directional features are planar crossbed sets of alpha or omikron type (classification of Allen, 1963). In some sections these occur interbedded with trough crossbeds of theta type. Straight-crested ripples with internal foreset structure were observed at station 21. Clast imbrication was measured in a few conglomerate beds, but few clasts are of the discoidal shape which gives rise to well-developed clast fabric, and it was generally not possible to determine directional trends with any degree of confidence.

Orientations were measured in the field with a magnetic compass. Magnetic declination in the report area is greater than 70°. It varies locally and fluctuates daily, necessitating routine checks of compass accuracy by cross-checking sightings on prominent topographic features against map bearings. Corrections of orientation for structural dip were required at some field stations, and this was carried out in the office using a stereonet. It is assumed that deformation in the area represents a simple "sag" to the southwest, away from Byam Martin High, and that corrections for fold plunge are not necessary.

TABLE 2: Paleocurrent data

Station	Stratigraphic Unit	Structure	n_u	$\bar{\theta}$	L_u	σ^2_u	p_u	Structure	n_w	$\bar{\theta}_w$	L_w	σ^2_w	p_w	T
4	Kh	α	28	062	74	1891	$<10^{-6}$	α	28	052	89	811	$<10^{-9}$	25.4
17	Kk^2	α	28	292	96	264	$<10^{-11}$	α, i	30	290	89	811	$<10^{-10}$	7.4
21	Te^3	r	7	273	86	984	.006	r	7	270	85	995	.006	1.99
23,24	Kh	α	28	201	68	2931	$<10^{-5}$	α	28	257	61	3006	$<10^{-4}$	9.7
31	Kh	α, t	15	004	51	4327	.02	α, t	15	055	61	3137	.004	44.3

Symbols: n = number of readings, $\bar{\theta}$ = vector mean azimuth, L = vector strength, σ^2 = arithmetic variance
p = probability of randomness (Rayleigh test), T = mean crossbed thickness (cm)
subscripts u, w = unweighted, weighted (Miall, 1974)

Structure types: α = alpha (Allen, 1963), t = theta (Allen, 1963), r = ripples, i = clast imbrication

The data were processed by vector methods (Curray, 1956) to derive vector mean azimuth, vector strength and the probability of randomness (Rayleigh test). Arithmetic variance and mean crossbed set thickness were also calculated. Calculations were performed in two passes, the first using raw (unweighted) data, the second weighting each azimuth reading by the cube of set thickness (Miall, 1974). Computations were all performed by a computer program written by Miall (1979) and adapted for current I.S.P.G. hardware by K.N. Nairn. Results are given in Table 2. A total of 108 readings, grouped according to field location, were used in the calculations. The remaining 7 readings were scattered and are not used in Table 2, although the data they provide are in general agreement with that given in the table. Current rose diagrams and mean current directions are given in Figure 16 and paleogeographic interpretations are discussed in a later section.

Petrographic analysis

Thirty-eight thin sections of sandstone samples were made; nine of these were from lithified samples in which matrix, cement, porosity and original texture could be examined. The remainder were made from unconsolidated sand by impregnation with resin. All sections were stained with sodium cobaltinitrite for the identification of potassium feldspars, using Chayes' method (Allman and Lawrence, 1972, p. 107).

The objectives of the analysis were to determine if any contrasts existed between the petrographic character of the various sandstone units, and to identify sediment sources, both factors being of some value in reconstructing the paleogeographic history of the area. Twenty-three of the thin sections were studied in detail with the aid of a point counter for quantification of the petrographic composition. A preliminary study revealed gross petrographic differences between and, to some extent, within the five main sandstone units. These were readily brought out by examining the overall composition, and no attempt was made to control compositional analyses by grain size, a technique which can commonly reveal subtle variations in mineral distribution.

Point count data are given in Table 3, and the composition of the same 23 thin sections is shown graphically in Figure 17.

The sandstones fall into two main groups, the quartz arenites and quartzose arenites of map units Kh and Te^1, and the more immature quartzose, feldspathic and lithic arenites of map units Kk^2, Te^2 and Te^3. All samples contain little or no detrital matrix. Lithified samples are cemented by calcite. More detailed descriptions follow.

Sandstones of map units Kh, Te^1

These sandstones are texturally and mineralogically mature, comprising between 82 and 100% monocrystalline quartz grains. The main secondary components are potassium feldspar and granitic rock fragments. Potassium feldspars are predominantly orthoclase, but microcline and perthite are also present in minor amounts. Granitic rock fragments consist mainly of unfoliated polycrystalline quartz grains, rarely with minor feldspar intergrowths. Opaque grains are black, fine to very fine grained, and probably represent iron ore. Trace quantities of zircon, tourmaline, hornblende and garnet are present. Glauconite is ubiquitous in map unit Te^1, although in minor quantities. It is absent in unit Kh.

Three lithified samples from map unit Kh contain porosity ranging from zero to 14%. The two non-porous sandstones contain up to 34% calcite cement. Cementation in the porous sample (C77626) is provided by minor welding of quartz grains.

These sandstones have all the characteristics of polycyclic deposits. Quartz grains commonly are very well rounded and rounded authigenic overgrowths are locally abundant. The rounding of the overgrowths suggests that they were derived in a previous sedimentary cycle, and one lithified sample from map unit Kh (C77626) shows that grain contacts are commonly between overgrowths rather than grain cores, which confirms this interpretation. Remaining mineral grains are predominantly well rounded, with the exception of the garnet, and only the most stable heavy mineral species are present. Some first-cycle detrital input is indicated by the rare pebbles of metamorphic rocks observed in outcrop, and the angular garnet grains probably belong in this category. At Salmon River, station 31, heavy mineral laminae consisting exclusively of garnet are locally abundant within an otherwise mature sandstone sequence.

Sandstones of map units Kk^2, Te^2, Te^3

These sandstones show gross petrographic similarities and similar paleocurrent patterns, suggesting that they were probably all derived from the same sources.

The most distinctive components are the unfoliated granitic rock fragments. These are of medium to very coarse sand grade, and consist of polycrystalline intergrowths (including graphic intergrowth) of any combination of quartz, plagioclase or potassium feldspar, and in some cases include minor biotite, hornblende and iron ore. Optical tests show that the plagioclase is albite to oligoclase in composition.

Orthoclase is the dominant potassium feldspar. The presence of the two feldspars and quartz in approximately equal proportions, and the minor quantities of biotite and hornblende, indicate that the source rock was of quartz monzonite or adamellite composition. The grains are angular and very fresh, with only minor sericitization of some plagioclase grains, and it is probable that no major mineralogical changes took place between erosion of the source area and deposition of the detritus. The recognition of this class of grain raises some difficulties in point counting, because the components of the granitic rock fragments also occur as single, monomineralic grains that have been counted as feldspar, biotite, etc., where they occur separately. All polycrystalline grains, including quartz, were counted as granitic rock fragments. If these grains are subdivided into their component minerals and the point count modified accordingly, the "total rock fragments" value for each sample is decreased considerably, and the lithic arenites in Figure 17 all become feldspathic arenites. For example, the most lithic of the arenites, sample C77634, changes from a modal composition of $Q_{33}F_{23}R_{44}$ to approximately $Q_{50}F_{39}R_{11}$.

Other grains present in this suite of sandstones include minor to trace quantities of zircon, garnet, epidote(?), allanite(?), tourmaline, pyroxene and detrital calcite. Foliated, chloritic mudrock fragments form up to 15% of the detrital grains, and glauconite is commonly present, in trace amounts in map units Kk^2 and Te^3, but up to 3% in unit Te^2.

Porosity in lithified samples ranges up to 21% with up to 5% clay matrix, of authigenic or detrital origin. Some sandstones contain as much as 35% calcite cement and are essentially non-porous.

These sandstones are clearly first-cycle in origin, as indicated by the abundance of fresh and highly angular granitic fragments. Rounded quartz grains with overgrowths, such as are characteristic of map units Kh and Te^1, are a minor component. The bulk of the sandstones probably were derived from quartz-rich gneisses and granites, which are common as pebbles and boulders in outcrop of units Kk^2 and Te^3.

TABLE 3: Petrographic characteristics of sandstone samples (per cent by number of detrital grains)

Sample	Map Unit	monocrystalline quartz	foliated polycrystalline quartz	unfoliated polycrystalline quartz	chert	quartz sandstone	potassium feldspar	plagioclase	biotite	amphibole	opaque grains	foliated mudstone	garnet	glauconite
C77603	Kh	99	-	.3	-	-	1	-	-	-	-	-	-	-
C77607	Kh	98	-	2	-	-	-	-	-	-	T	-	-	-
C77608	Kh	82	-	2	T	-	16	-	-	-	-	-	-	-
C77626	Kh	99	-	-	-	-	1	-	-	-	T	-	-	-
C77636	Kh	100	-	-	-	-	-	-	-	-	-	-	-	-
C77643	Kh	93	-	6	-	2	3	-	-	-	T	-	T	-
C77646	Kh	100	-	-	-	-	-	-	-	T	T	-	T	-
C77628	Kk^2	84	-	8	.3	-	5	-	-	T	.6	2	T	-
C77631	Kk^2	48	.3	22	-	-	15	6	.5	.3	4	4	.3	-
C77632	Kk^2	48	-	21	-	-	19	7	.7	1	2	1	.3	-
C77601	Te^1	97	-	1	.3	.3	.3	-	-	-	T	.3	-	T
C77618	Te^1	93	-	3	-	-	4	.3	-	-	-	-	-	T
C77619	Te^1	97	-	1	T	-	2	-	-	-	T	-	-	T
C77609	Te^2	60	-	-	T	-	26	2	5	-	.4	3	.4	3
C77610	Te^2	83	-	T	.6	.3	10	T	-	-	3	2	-	2
C77635	Te^2	33	-	12	2	-	28	5	2	.3	1	15	2	T
C77612	Te^3	59	-	3	-	.3	23	2	.8	.3	2	8	2	-
C77615	Te^3	41	-	10	-	-	33	7	.6	2	.3	4	2	-
C77622	Te^3	94	-	2	-	-	1	-	-	-	-	3	T	-
C77624	Te^3	85	-	2	.7	-	3	1	-	-	-	7	-	1
C77630	Te^3	88	-	9	-	-	3	-	.3	-	-	T	-	T
C77634	Te^3	33	-	33	-	-	10	13	3	2	2	3	.7	-
C77648	Te^3	51	-	1	-	-	25	9	5	-	2	6	.3	-

T = trace

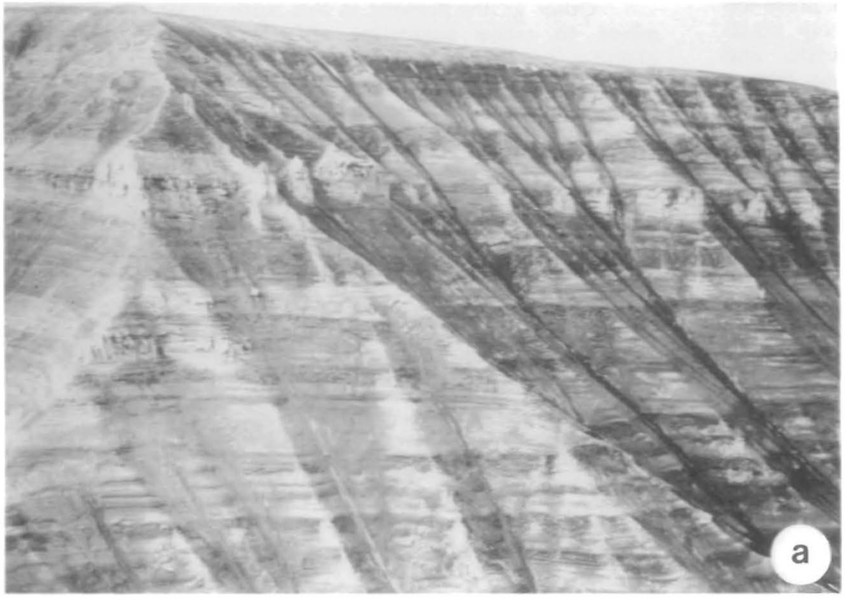


FIGURE 12. Upper sandstone member, Eureka Sound Formation, A: station 7, near "Twosnout Creek" (ISPG 1149-14); B: station 8, near south coast of Bylot Island (ISPG 1149-27).

and therefore inconclusive. Apart from these points the evidence is consistent with a shallow marine, intertidal or beach origin for the Hassel, but on weighing the evidence a fluvial environment seems more probable. Correlative sands in Sverdrup Basin and on the Labrador Shelf (Bjarni Formation) are mainly fluvial or fluviodeltaic in origin.

The crossbedding is a type commonly found in sandy rivers, particularly those of low sinuosity, multiple channel or braided type (lithofacies Sp, St of Miall, 1977). The absence of significant quantities of interbedded fine-grained sediment is also typical of this environment, as it indicates that active channels occupied much of the basin floor, with little room for the floodplain environments where fine-grained material typically is deposited. Local development of a coal swamp near Pond Inlet and the more dispersed paleocurrent distribution in that area suggest the presence of a higher sinuosity, meandering river.

The wide divergence in mean current directions at the three measurement stations in this formation suggests that there probably was not a single through-going river system in Eclipse Trough, but a series of local tributaries, which may or may not have converged into a major trunk stream draining out of the trough. The available exposures of the formation are all along the margins of the trough and more sizeable rivers may have been present nearer the centre. The paleocurrent trends do not parallel any present day structural or topographic trends – they are, for example, oblique to the trend of the Cretaceous-filled valley extending southeast from station 4, which suggests that the present day basin margin configuration has been modified by post-depositional tectonics and erosion. As discussed earlier, the linear northeast boundary of the basin was probably initiated at this time, at least in part as a syndepositional fold or fault, although Kerr (in press, a) argues that the main movement on extensional faults in this area occurred in Late Cretaceous and Tertiary time.

Petrographic evidence indicates that the formation is composed of recycled detritus. The immediate source probably was the upper Proterozoic sequence, which contains several clastic units of sufficient petrographic maturity (Iannelli, 1979). Metamorphic sources contributed to the sandstones near Pond Inlet, where garnet is locally abundant.

Depositional environments and paleogeography

Hassel Formation

This is interpreted as a fluvial deposit. The variation in thickness of the formation suggests that it may have filled irregularities in the underlying erosion surface. The fluvial interpretation is based on the presence of coal, the absence of marine fossils and glauconite and the unimodal distribution of crossbed orientation at stations 4 and 23 to 24. At station 31 distribution is more scattered, but the presence of coal seams interbedded here with the crossbedded sand rules out many other possible depositional environments. The absence of glauconite and marine fossils is negative evidence

Kanguk Formation

The mudstone member is similar to much of the Kanguk Formation in other parts of the Arctic Islands and represents the product of a widespread Late Cretaceous marine transgression. Whether deposition was confined to Eclipse Trough or spread over adjacent regions is unknown. As discussed above, at least one of the faults bounding the trough was by then almost certainly in existence, but it may have had little or no effect in limiting sedimentation at this time, as exposures of the mudstone member along the northeast margin of the trough do not contain any coarse

FIGURE 13. Fining-upward cycle in upper sandstone member, Eureka Sound Formation, station 7, near "Twosnout Creek".

facies suggestive of a nearby elevated sediment source, such as might be expected along an active fault line. Scattered outliers of the Kanguk Formation mudstone have been found elsewhere on the craton, for example, on Somerset Island (Dixon et al., 1973), suggesting that the Kanguk transgression covered much or all of the southern Arctic Islands.

A local sediment source appeared toward the end of Cretaceous time and gave rise to the sandstone member. This is probably a largely nonmarine unit formed mainly by braided streams similar to those which deposited the Hassel Formation. There is a gradational lower contact with the mudstone member, which probably represents a deltaic transition between the alluvial plain and the open sea.

One paleocurrent station was located in this unit, and provided strongly unimodal data with a west-northwest trend (Fig. 16). Though interpretation based on one data set should be regarded as tenuous, it is worth noting that this orientation is approximately parallel to the axis of Eclipse Trough and suggests an alluvial system filling the trough by axial progradation from the southeast end.

Petrographic evidence indicates first-cycle derivation of the sandstone member from plutonic rocks and gneisses of adamellite or quartz-monzonite composition. According to Jackson et al. (1975) the rocks bordering Eclipse Trough on the north, east and south (Byam Martin High, Navy Board High) are mainly Archean and Aphebian migmatities, consisting of massive to foliated quartz monzonite, granodiorite and amphibolite, and these are an obvious detrital source for the sandstone of the Kanguk Formation. It is only surprising that mafic minerals, foliated polycrystalline quartz and metamorphic minerals (other than garnet) are not more common in the Kanguk.

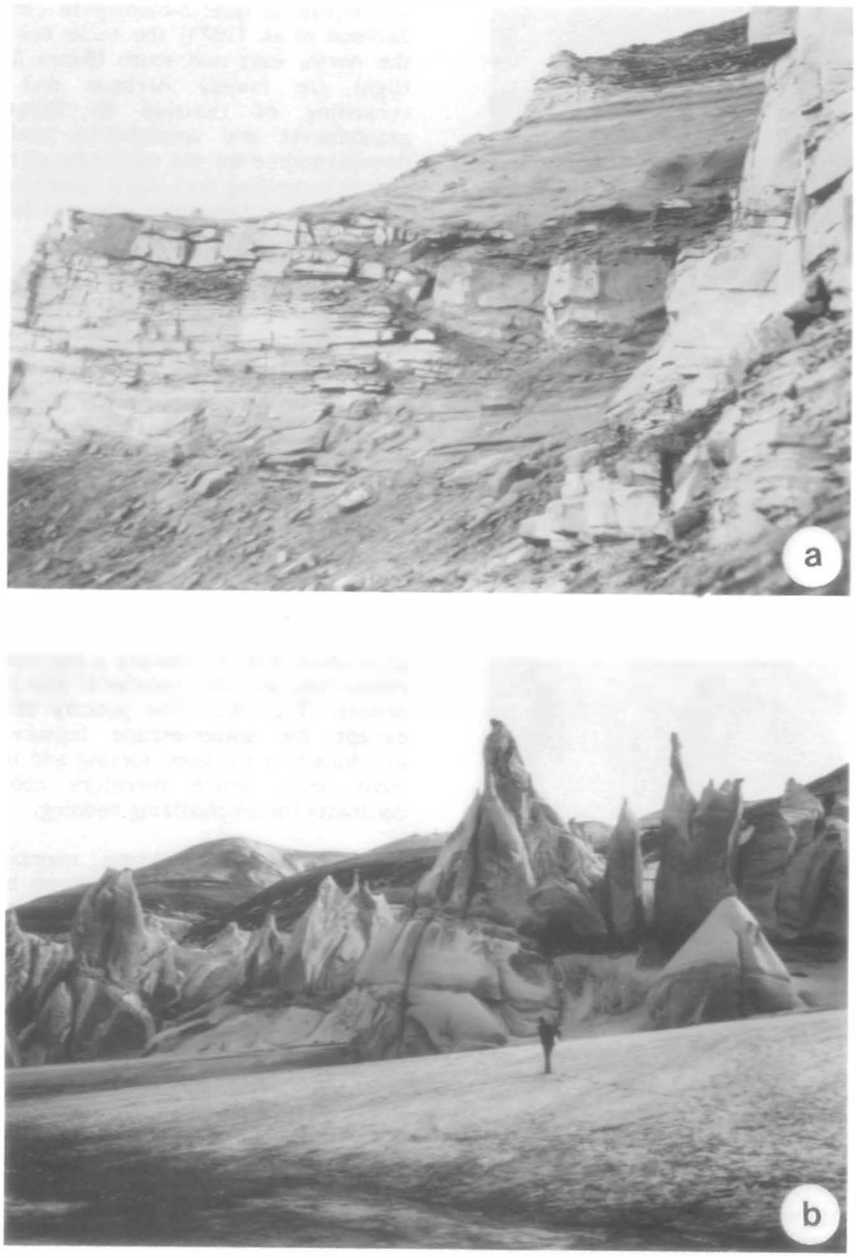
Kanguk sedimentation was terminated by uplift or a regional drop in sea level at the end of the Cretaceous, proceeded or followed by a gentle southwestward tilt of the trough.

Eureka Sound Formation

The lower sandstone member is probably a locally distributed unit, which onlapped the gently tilted top-Kanguk erosion surface at the beginning of a marine transgression in the late Paleocene. The detrital component of the sandstone is very mature, suggesting probably a similar Proterozoic source to that of the underlying Hassel Formation. Abundant pelecypod shell fragments, feeding trails and traces of glauconite (Fig. 9) indicate a probable marine environment of deposition, and the member is interpreted as a shoreline sand deposit (Fig. 18). The paucity of sedimentary structures, except for water-escape features and rare scours, is attributed to the good sorting and mineralogical maturity of most units, which therefore contain minimal lithologic contrasts for emphasizing bedding.

The lower mudstone member rests on the lower sandstone member with an abrupt but probably conformable contact, suggesting a rapid marine transgression. Most of the mudstone member consists of argillaceous beds, probably formed in an open marine environment. However, thin sandstone lenses are present throughout, except west of "Twosnout Creek". These become thicker and more abundant toward the top of the mudstone member, where there is a gradational contact with the upper sandstone member (Fig. 11). Exposure or near exposure to the air during sedimentation of some of the sandstone beds is suggested by occasional rootlets. The presence of leaf impressions suggests nearby vegetated land, but the occurrence of up to 3% glauconite in the sandstones indicates a marine depositional environment. The sandstone beds probably represent shallow water, distal deltaic deposits, perhaps distal distributary mouth splays. The top of the mudstone member contains superimposed coarsening-upward cycles similar to those in the Eureka Sound Formation of Banks Island, which were interpreted as the product of prograding distributaries in a river-dominated deltaic environment (Miall, 1979).

The overlying upper sandstone member is similar in most respects including lithology, sedimentary structures and petrography to the sandstone member of the Kanguk Formation and is interpreted as a fluvial deposit. There is an upward transition from the lower mudstone member delta-



a: station 7, fluvial sandstones with channel cutbank (ISPG 1149-1):

b: station 16, thick-bedded to massive sandstone weathered into hoodoos (ISPG 1148-5).

FIGURE 14. *Upper sandstone member, Eureka Sound Formation.*

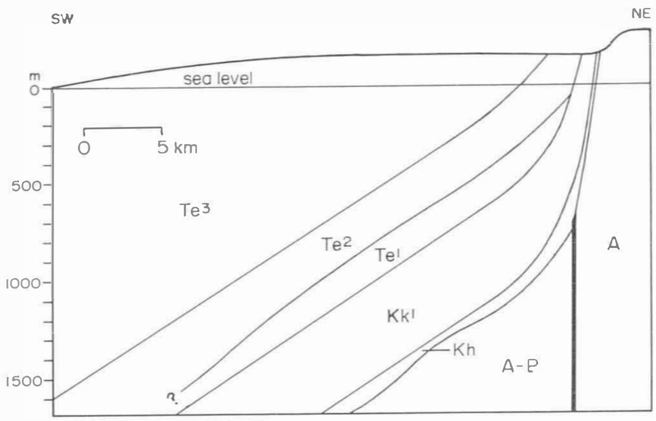


FIGURE 15. Schematic structural cross-section, "Twosnout Creek" area.

front distributary sequences, which coarsen upward, to the fluvial deposits which, at the base, contain fining-upward sequences (Fig. 11). The latter are of probable meandering river origin, by analogy with the Devonian cycles described by Allen (1964). However, the bulk of the upper sandstone member consists of massive, structureless sand with only rare intervals of crossbedding and ripple marks. No cyclicity is apparent; silt and mud are sparse and coal is virtually absent. These characteristics suggest a braided alluvial plain with few well defined channels, and much of the deposition occurring under high-energy flood conditions (the "Bijou Creek" style of sedimentation of Miall, 1977).

Stratigraphic reconstruction (Fig. 5) suggests that the alluvial system which deposited the upper sandstone member prograded along the axis of Eclipse Trough from southeast to northwest. The upper sandstone member passes laterally into the lower mudstone member in this direction, in the vicinity of "Twosnout Creek", and this was probably the location of the delta at the distal fringe of the alluvial plain for much of late Paleocene and early Eocene time (Fig. 18). Such a reconstruction is supported by limited paleocurrent evidence from station 21 and elsewhere (Fig. 16) and is similar to that deduced for the sandstone member of the Kanguk Formation, except that in the younger unit progradation had proceeded at least 40 km further down the axis of Eclipse Trough. Some sediment input from the flanks of the trough may have occurred, and this probably was the origin of the coarse conglomerate beds observed at stations 7, 8 and elsewhere. Unfortunately, paleocurrent evidence for this alternative source direction is not available.

Most of the sandstone detritus of the lower mudstone member and the upper sandstone member probably was derived from the same plutonic and metamorphic sources as the sandstone of the Kanguk Formation.

A renewed marine transgression in early or mid-Eocene time is indicated by the argillaceous deposits of the upper mudstone member of the Eureka Sound Formation. A single outlier of this member is present, and it is not known how extensive this transgression was.

REGIONAL CONSIDERATIONS

Eclipse Trough lies close to a major seaway formed by Labrador Sea, Davis Strait and Baffin Bay. For some years there has been controversy regarding the origin of the Baffin Bay-Davis Strait area. Many have regarded it as an incipient ocean generated by sea floor spreading, a view most recently expressed by Srivastava (1978) who suggested that the magnetic anomaly pattern in Baffin Bay was of the type generated during sea floor spreading, and that it could be correlated with the Labrador Sea area, where evidence for spreading is better documented (Pitman and Talwani, 1972; Kristoffersen and Talwani, 1977). The contrary view is that of Kerr (1967, in press, b) and others, who regard Baffin Bay as submerged, attenuated continental crust. Manderscheid (1979) extends continental crust completely across Davis Strait, and relates much of the geology to that of the Shield regions on either side of the Strait. A complete discussion of this topic is beyond the scope of the present report. However, it is now apparent that there are broad similarities in structural style and stratigraphic fill between many of the onshore and offshore basins which flank both sides of the seaway, indicating the existence of common elements in the history of a considerable part of the Canadian and Greenland continental margins.

The over-riding theme in all these basins has been block faulting and horst and graben formation under an essentially tensional regime, at least since Early Cretaceous time. This indicates the occurrence of crustal extension, a fact which is consistent either with a non-drift, attenuation model or a trailing edge, drift model. In the Wilson cycle of opening and closing oceans crustal attenuation is the precursor to rifting and the development of trailing edge, divergent continental margins, and the controversy regarding the origin of the Baffin Bay-Davis Strait is perhaps not so much between two different hypotheses, but about how far a single complex process has proceeded.

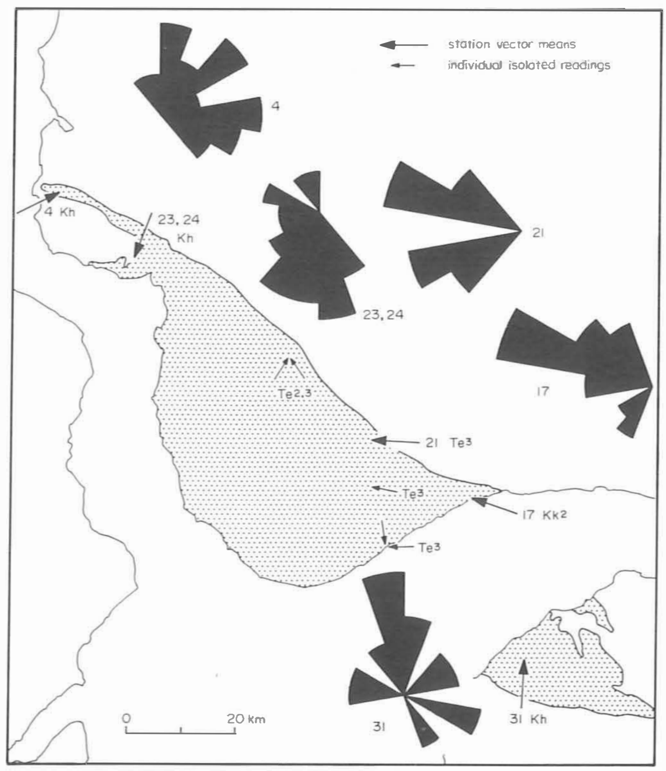


FIGURE 16. Paleocurrent data (from Table 2). Current rose diagrams and vector mean azimuths are given for each of five field stations. A few individual, isolated readings are also shown. Numbers are field stations.

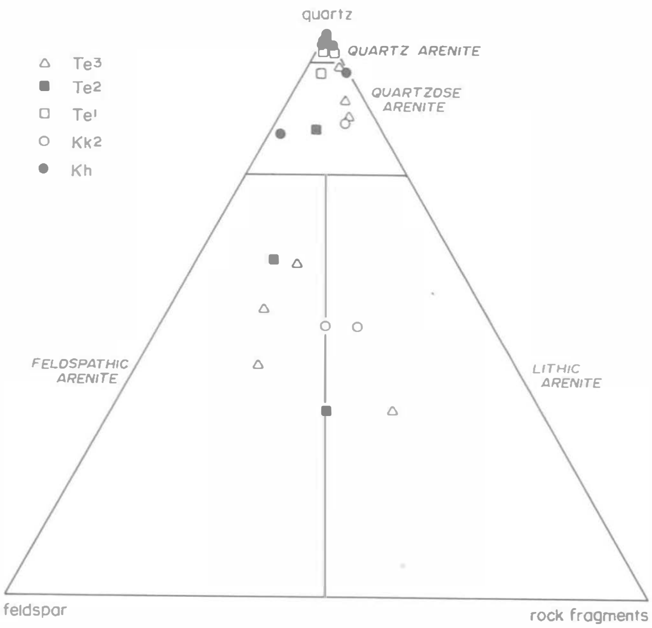


FIGURE 17. Petrographic composition of detrital grains in the sandstones (classification of Okada, 1971).

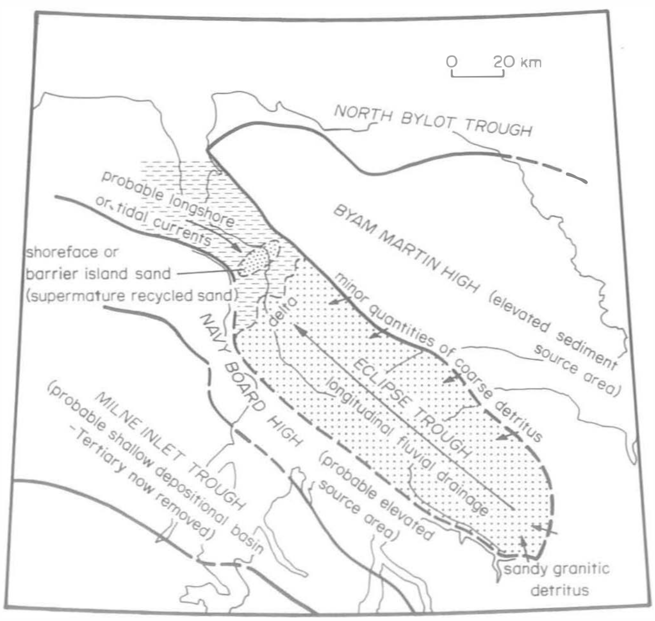


FIGURE 18. Generalized paleogeography of Eclipse Trough during Eureka Sound sedimentation.

Individual fault-controlled basins that have been identified to date (Fig. 19) include, from north to south on the Canadian side, Lancaster Sound (Daae and Rutgers, 1975; Lancaster Aulacogen of Kerr, in press, a), Eclipse Trough (a basin sag above deep-seated faults), an offshore basin east of Cape Dyer (Wallace, 1973), Cumberland Sound and Frobisher Bay in the Baffin Island area (Grant, 1975), and an unnamed basin in the Bjarni area of the Labrador Shelf (McWhae and Michel, 1975; Purcell et al., 1979; Umpleby, in press). On the Greenland side there is the offshore graben of

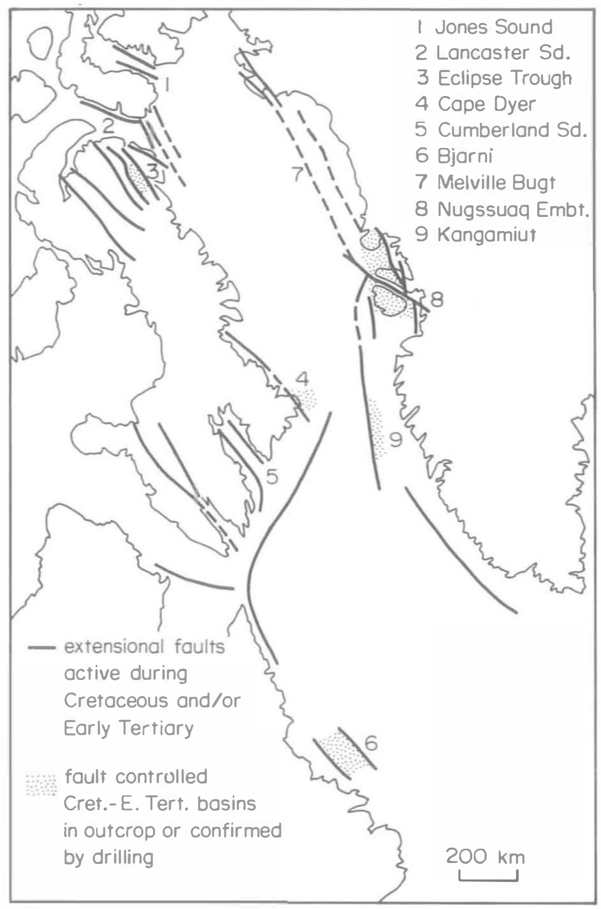


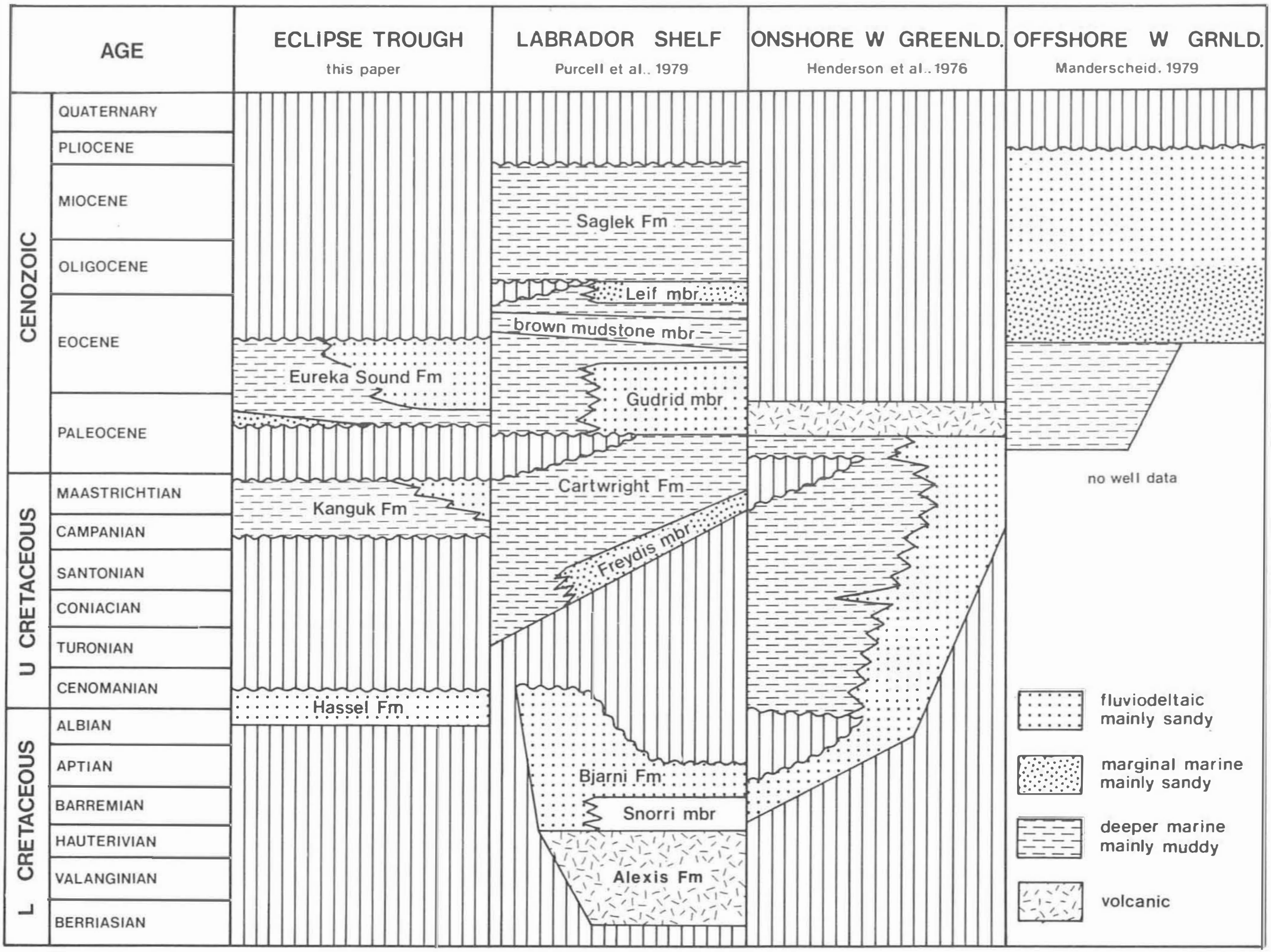
FIGURE 19. Principal Cretaceous-Tertiary faults and fault-bounded basins of Baffin Bay–Labrador Sea continental margins. Data from Henderson (1973), Henderson et al. (1976), Wallace (1973), Grant (1975), Hea et al. (1979), Manderscheid (1979), and Purcell et al. (1979).

Melville Bugt about which little is yet known (Henderson, 1973), the onshore basin of the Disko Island area (Nûgssuaq Embayment of Henderson et al., 1976) and newly described structures in the Ikermiut area, near the narrowest part of Davis Strait (Manderscheid, 1979). In all of these basins north- to northwest-trending faults, parallel to the supposed axial spreading centre of Labrador Sea - Baffin Bay, are the dominant structures. Fahrig et al., (1973) pointed out that Hadrynian dykes in central Baffin Island have the same trend, and suggested that the Baffin Bay Rift Zone may be a very ancient feature.

Evidence from the stratigraphic fill of these basins suggests that they were formed during Cretaceous or Early Tertiary time. Cretaceous-Tertiary sediments are thin or absent in some of the northwest-striking grabens in Baffin Island (Milne Inlet Trough, Frobisher Bay, etc.) but the grabens probably are all of similar age and all probably contained Cretaceous and/or Tertiary sediment at one time. The thickest fill is probably in Lancaster Sound, where Daae and Rutgers (1975) have estimated on the basis of seismic profiles that the Mesozoic-Tertiary sequence exceeds 5000 m.

Stratigraphic columns for four of the marginal basins are given in Table 4. Variation is apparent but several common themes can be traced, a knowledge of which should be helpful in hydrocarbon exploration of other parts of the continental shelf. In at least two of the basins, for which detailed facies and paleocurrent information is available from

TABLE 4: Stratigraphy of marginal basins, Baffin Bay, Davis Strait and Labrador Sea area



onshore outcrops, sediment transport was along the basin axis rather than transverse, toward the present day offshore. In the Nûgssuaq Embayment a deltaic system prograded northward during the Cretaceous (Henderson et al., 1976), and northwesterly prograding fluviodeltaic systems occupied Eclipse Trough during two separate periods in the Late Cretaceous and Early Tertiary. These facts confirm that the basins were active during deposition and are not the product of later faulting. Similar patterns should be sought in the more poorly explored marginal basins.

There are several close stratigraphic similarities between Eclipse Trough and the Bjarni area of Labrador shelf, which is more than 2000 km to the south. The Hassel Formation of the report area, and the Bjarni Formation (McWhae and Michel, 1975; Umpleby, in press) are both fluvial sandstone units that were the first deposits in newly active grabens. (The Bjarni Formation includes strata at least as old as Barremian, and only the upper part is time equivalent to the Hassel Formation). In both areas uplift and erosion in the early part of the Late Cretaceous (Turonian) was eventually followed by renewed subsidence, transgression, and the deposition of open marine silty mudstones. The Cartwright Formation of Labrador Shelf is similar lithologically to the Kanguk Formation of Eclipse Trough. Its age range is similar to that of the Kanguk Formation of Sverdrup Basin. An unconformity corresponding to late Maastrichtian and early Paleocene time has been documented in Eclipse Trough and was also recorded in Labrador Shelf (McWhae and Michel, 1975). It was at about this time (65 Ma B.P.), according to Srivastava (1978), that sea-floor spreading in Labrador Sea changed direction from east-west to north-northeast-south-southwest, with the initiation of a triple point junction off southern Greenland. Formation of the unconformity and generation of the Baffin Bay volcanic rocks (Clarke, 1977) are probably a consequence of crustal movements accompanying this change. A complicating factor is the occurrence of several world-wide changes in sea level during this period, as discussed below.

From mid-Paleocene time on similarities between the two areas are less marked, although thick wedges of partly paralic sandstone interfingering with marine shale are present in the Paleocene sections of both areas (Eureka Sound Formation, of this report, and upper Cartwright Formation with Gudrid Sandstone Member of Umpleby, in press). In the mid-Eocene regional subsidence began on Labrador Shelf, and turbiditic mudstones prograded across the graben and its bounding horst into the deeper waters of Labrador Sea. The resulting deposits of the Saglek Formation thus blanket and bury the old graben. There is no evidence that this event took place in Eclipse Trough, which may have remained a positive area after the mid-Eocene. However, equivalents of the Saglek Formation are undoubtedly present in offshore areas adjacent to Bylot Island, where the subsidence has continued from mid-Tertiary (or earlier) time to the present day. Kerr (in press, a, b) suggests that major downfaulting movements occurred in Lancaster Sound during the mid-Eocene to Miocene or Pliocene, and refers such activity to the climactic phase of the Eurekan Rifting Episode.

Some of these events can be matched on the Greenland side of the seaway. The period of graben formation extended over a similar time period, from mid Early Cretaceous (Barremian) to mid-Eocene, after which blanket deposits appear to have prograded across many of the earlier faults. A major difference is that the main sedimentary phase in Nûgssuaq Embayment, as preserved on land in the Disko area, ceased to be active in the mid-Paleocene, when a major eruptive phase occurred (Henderson et al., 1976). Remnants of sediments possibly as young as Eocene are present in a few areas. Some of the faults which cut the section were active during sedimentation, as indicated by the presence near them of fanglomerates and screes, or by local intraformational unconformities in adjacent deposits. Sedimentation continued offshore into the Neogene, as in the shelf southwest of Disko described by Manderscheid (1979). Contemporaneous (mid-Paleocene) volcanics and thin sediments also occur on the Baffin Island coast opposite Nûgssuaq Embayment (Clarke and Upton, 1971). The sedimentary fill in the Greenland basins is different from that described on the Canadian side. Fluviodeltaic and marine facies similar to those in Eclipse Trough and Labrador Shelf were formed in the Disko area but discrete depositional phases are not as well developed. At least two unconformities are present in the Disko succession, of Aptian-Albian and Maastrichtian age. Both appear to be slightly older than unconformities mapped on the Canadian side.

It is now apparent that there was a broad synchroneity of many events in the Sverdrup Basin and the Baffin Bay-Labrador Sea area. Arctic Islands stratigraphic terminology has been employed in this report for Eclipse Trough deposits, but names such as Bjarni and Cartwright Formations could equally well be used. This is surprising because the areas linked by the correlations are more than 2000 km apart and were in very different tectonic regimes during the Cretaceous and Early Tertiary. In the latter part of this time period the Sverdrup Basin underwent the preliminary phases of the Eurekan Orogeny, which involved the development of broad arches and basins, followed by compressional tectonics (Balkwill, 1978). In contrast, the Baffin Bay-Labrador Sea area was in a tensional regime, undergoing crustal attenuation together with fault movements of the Eurekan Rifting Episode (Kerr, in press, a, b) and, at least in the south, sea floor spreading. That correlations and comparisons can be made in spite of these differences points to continent-scale controls, involving the interaction of the North American plate with spreading systems in the Atlantic and Arctic Oceans.

Correlations of unconformities and stratigraphic units may be in part a reflection of regressions and transgressions caused by global cycles of eustatic sea level changes. Vail et al. (1977, Figs. 2, 3) indicated that major global periods of low sea level occurred during the mid to late Cenomanian, in the early Paleocene, and the mid-Paleocene (peaking at 95, 65 and 60 Ma, respectively), which correspond to three unconformities documented in the report area and/or Labrador Shelf. The correspondence may not be as straightforward as it seems, because the translation of a eustatic sea level change into a transgression or regression depends on the rate of subsidence or uplift of the basin itself. Global sea level changes are probably caused by thermally-induced volume changes of midocean ridges (Pitman, 1978) – sea levels are high during periods of fast sea-floor spreading, and vice versa. Basin subsidence on divergent margins such as Labrador Shelf (and Baffin Bay?) is caused mainly by thermal contraction as the continent is carried away from the spreading centre. Whether the local stratigraphic events in the report area can be correlated with global changes, or relate strictly to local plate movements, remains to be determined. For example, the marine Kanguk and lower Cartwright Formations were formed during a time when active sea floor spreading began in northern Labrador Sea, based on Srivastava's (1978) reconstruction. This correlation seems good, but in fact the stratigraphy probably reflects a more widespread rise in sea level, because the same transgression also occurred throughout the Arctic Islands, well beyond the confines of Sverdrup Basin, and beyond the influence of a Labrador Sea spreading centre. Hays and Pittman (1973) and Vail et al. (1977) record a major global high sea level at about this time. Similarly, the Maastrichtian-Paleocene unconformity is widespread but does not correlate with any known plate tectonic events in the Labrador Sea or North Atlantic system. Sea-floor spreading seems, on the basis of present evidence (Srivastava, 1978; Pittman and Talwani, 1972), to have proceeded there during this period without significant interruption, and the unconformity is probably a reflection of the global eustatic sea level fall recorded by Vail et al. (1977). A further discussion of these points is beyond the scope of the present report and must await more detailed work on seismic stratigraphy and plate tectonic reconstructions for the Baffin Bay and Sverdrup Basin regions.

On a practical level, knowledge of these broad regional stratigraphic and sedimentologic similarities throughout the eastern Arctic should be of use when hydrocarbon exploration moves into the as-yet unexplored offshore basins of western Baffin Bay and Lancaster Sound.

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