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SILURIAN STRATIGRAPHIC SECTIONS AT KAP TYSON, OFFLEY Ø AND KAP SCHUCHERT, NORTHWESTERN GREENLAND

BY

B. S. NORFORD

WITH 8 FIGURES AND 1 TABLE IN THE TEXT,
AND 9 PLATES

KØBENHAVN
C. A. REITZELS FORLAG
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Abstract

The Silurian formations of northwestern Greenland are an intricate assemblage of graptolitic rocks and limestones of varied facies deposited at the seaward edge of a carbonate platform that probably covered most of extreme northern Greenland during Silurian time. Facies changes are abrupt and the formations are in part facies equivalents of each other. The Offley Island Formation consists of biostromal and biohermal limestones and associated calcarenites and limestone conglomerates. The cores of the biostromes and bioherms are primarily formed by stromatoporoids, algae and colonial corals. The Cape Schuchert Formation predominantly is composed of slightly argillaceous calcisiltites but includes minor biostromal and biohermal limestones and related calcarenites. The graptolitic rocks are assigned to the Cape Phillips Formation and consist of calcareous shales and mudstones, cherts, argillaceous limestones and locally developed small bioherms. The term Cape Tyson Formation is considered obsolete. All the rocks exposed at the studied localities are about Late Llandovery in age but younger and older Silurian rocks may be present elsewhere in northern Greenland.

Small amounts of lead and zinc mineralisation are present within the Cape Schuchert Formation at Kap Schuchert. Petroleum residues are preserved within a prominent bioherm within the Offley Island Formation at Kap Tyson. The bioherm is about 1,100 feet (350 metres) thick and has a relief of about 800 feet (250 metres).

Extensive development of biostromal and biohermal rocks may be characteristic of the seaward edge of the Silurian carbonate platform in Greenland and the Canadian Arctic Islands. The position of the edge can be traced from Greenland to east-central Ellesmere Island and probably runs southwestward through Ellesmere Island and Grinnell Peninsula to Cornwallis Island, from there westward south of Bathurst Island and Melville Island.

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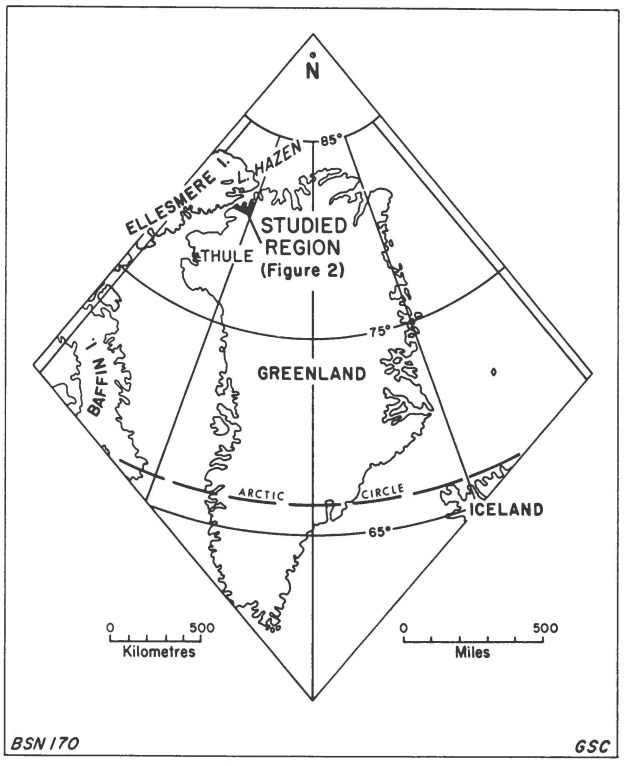

Figure 1. Index map.

INTRODUCTION

The northwest coast of Greenland is one of the most remote regions of the world. Geological field work is difficult, expensive, and, until recently, hazardous. In the past, access has been by sledges drawn by men and by dogs, and by ship through the pack-ice.

In 1965 and 1966, the Geological Survey of Canada mounted a large mapping operation in northeastern Ellesmere Island under the leadership of R. L. CHRISTIE. Two aircraft were used in 1965 and three in 1966. A small helicopter was used in both summers and the other aircraft were small fixed-wing planes equipped for landings on unprepared terrain.

The Geological Survey of Canada invited Grønlands Geologiske Undersøgelse to make use of support available from CHRISTIE's operation for geological studies in parts of Greenland adjacent to northeastern Ellesmere. J. H. ALLAART and P. R. DAWES worked in Hall Land in 1965 and studied sections in both folded and unfolded rocks, including the type localities of the rock formations at Kap Tyson, Offley Ø and Polaris

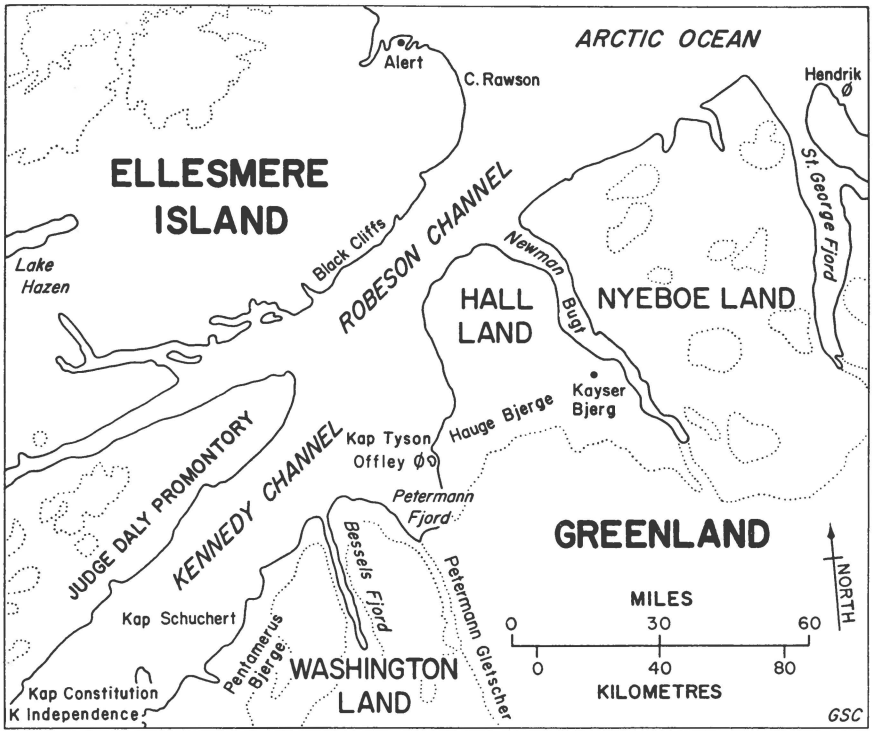

Figure 2. Locality map, northwestern Greenland and adjacent Ellesmere Island.

Harbour. The following year DAWES extended the mapping to the east in Nyeboe Land and Hendrik Ø. Also in 1966, B. S. NORFORD of the Geological Survey of Canada spent ten days studying Silurian stratigraphic sections at three localities in northwestern Greenland: Kap Schuchert in northern Washington Land, and Kap Tyson and the nearby Offley Ø in southwestern Hall Land (fig. 2).

A narrow strip of land is exposed in northwestern Greenland between the Arctic Ocean and the Inland Ice. Steep cliffs at the coast and along deep fjords permit rapid reconnaissance of the broad outlines of the geology, and the excellent air-photographs that are available allow interpretations of detailed stratigraphy.

The belt of Silurian outcrops of Washington Land and southern Hall Land shows biostromes, bioherms and related detrital limestones developed at the seaward edge of a carbonate platform that probably covered most of northernmost Greenland during much of Silurian time (fig. 8). Facies changes are complex and abrupt at the edge of the platform. A pattern of regional facies change is apparent with the carbonate rocks yielding to shaly rocks of the Cape Phillips Formation farther seaward. Outcrops of these latter rocks are locally present on the Green-

land coast: at Kap Schuchert, Kap Constitution, Kap Tyson and elsewhere. To the northwest, the Cape Phillips Formation gives way to rocks of greywacke facies that are present in the northern part of Hall Land and in northeastern Ellesmere Island. TRETTIN (1971) discontinued use of the term Cape Rawson Group for these rocks on Ellesmere Island where instead he distinguished four discrete formations. The development of Cape Rawson rocks in northwestern Greenland may be largely equivalent to the Imina Formation (TRETTIN, 1970, p. 15). In Early Silurian time, the axial trough of the Franklinian Geosyncline trended northeast-southwest through northeastern Ellesmere Island (TRETTIN, 1967).

PREVIOUS WORK

The first scientific studies of this region of northwestern Greenland were by members of the polar expeditions led by HALL (1871–1873), NARES (1875–1876), and GREELY (1881–1884). Following the Nares Expedition, FEILDEN and DE RANCE published an outline of the geology of the coasts of northeastern Ellesmere and adjacent Greenland in 1878. The term Cape Rawson Beds was proposed for slates, quartzites, grits, and impure limestones on the coasts of Ellesmere, northern Hall Land and Nyeboe Land with a type locality in Ellesmere. Fossils collected by the Nares Expedition and described by ETHERIDGE (1878) included material from the coast of northwestern Greenland, primarily from Offley Ø and Bessel Fjord.

Investigations by LAUGE KOCH (1920, 1925, 1929) included reconnaissance studies of the coasts of Washington Land and Hall Land in 1917 and 1920 to 1922. He proposed stratigraphic nomenclature for the Silurian rock units of Washington Land and southern Hall Land: in ascending order the Cape Schuchert, Offley Island, Cape Tyson, and Polaris Harbour Formations (fig. 3). Unconformities and basal conglomerates were reported at the bases of the Cape Schuchert, Offley Island, and Cape Tyson Formations. KOCH produced a stratigraphic framework that was based on a concept of layer-cake stratigraphy with little allowance for the effects of facies changes. The present study has failed to recognize unconformities at the base of the Cape Tyson Formation at its type locality and at the base of the Offley Island Formation at Kap Schuchert. Limestone conglomerates and breccias are common within the sequences at Kap Tyson and Kap Schuchert but are interpreted as detrital rudites from the flanks of nearby bioherms.

Most of the fossils collected by KOCH were described by POULSEN (1934, 1941, 1943) as faunas that were thought to be stratigraphically distinct and separated by significant unconformities. The present study suggests that many of the unconformities described by KOCH are either absent or only locally developed and that most of the Silurian formations of northwestern Greenland are in part facies equivalents of each other. Similar limestones are repeated at different stratigraphic horizons and KOCH may have misidentified his units at some localities. KOCH did not

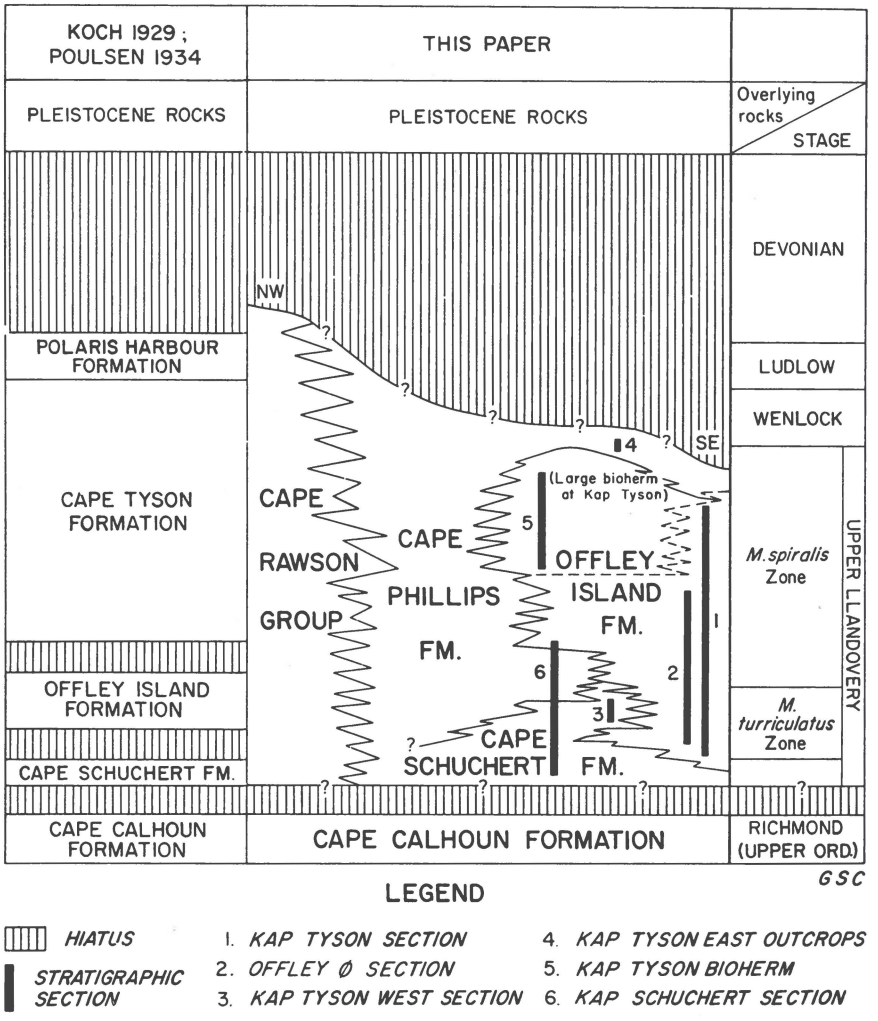

Figure 3. Schematic stratigraphic relations of the Silurian formations, Kap Tyson and Kap Schuchert regions, northwestern Greenland.

position his fossil collections within the formations and, until all of his localities are restudied, the collecting data on the fossils must be regarded as unreliable. Each of the assemblages described by POULSEN may prove to be a mixture of several different faunas that are stratigraphically distinct.

Recent work by ALLAART (1965, unpublished) and DAWES (1966, 1971) has shown that the Cape Rawson Group at the coast of northern Hall Land concordantly overlies a series of limestones and dolomites that is, at least partly, of Ordovician age. Part of the Cape Rawson Group was demonstrated to be the facies equivalent of the Silurian

limestones to the south. Facies changes were recognised between reefal and flanking rocks in the upper part of Kap Tyson and elsewhere in the Hauge Bjerge. This reef development was traced from Kap Tyson northeastwards and eastward into Nyeboe Land, Warming Land and Wulff Land and developments of bioherms and flanking shales were recognised also at Kap Constitution and Kap Independence. ALLAART followed KOCH (1929, p. 240) in using the term Cape Tyson Formation to include both limestones and clastic rocks, DAWES considered that KOCH's Cape Tyson Formation was a large bioherm at Kap Tyson in Hall Land but found it impossible to recognise the Offley Island and Cape Tyson Formations as distinct units in Nyeboe Land and concluded that KOCH's stratigraphic nomenclature needed critical revision (DAWES, 1966, p. 13; 1971, p. 211). ALLAART and DAWES also showed that the rocks exposed at the type locality of KOCH's Polaris Harbour Formation are recent gravels and Pleistocene deposits.

KERR (1968, with the assistance of preliminary results from NORFORD's 1966 field work) interpreted the geological literature on coastal Washington Land and suggested that the Silurian rocks were analogous to Silurian rocks of east-central Ellesmere where facies changes could be demonstrated between carbonate banks and graptolitic shales.

STRATIGRAPHY

The present study in northwestern Greenland was undertaken in 1966 to ascertain the stratigraphic relations between KOCH's Silurian formations and the stratigraphic positions of the Silurian species described from northwestern Greenland. The brief field work did not attempt a regional survey of the Silurian rocks of northwestern Greenland but consisted of detailed studied in two critical areas: Kap Tyson and Kap Schuchert. The supporting aircraft were based at Lake Hazen, northern Ellesmere Island, and study of outcrops of the Cape Schuchert Formation near Kap Independence proved to be logistically impracticable, as did examination of outcrops farther south showing the contact relations between the Cape Schuchert and the Upper Ordovician Cape Calhoun Formations.

Kap Tyson Locality

Kap Tyson (fig. 4) overlooks Offley Ø and all the strata that outcrop on Offley Ø are also exposed in the lower part of the cliffs at Kap Tyson (fig. 5). KOCH (1929, p. 238–239) gave "Offley Islands" (presumably Offley Ø itself and adjacent small islets) and Kap Tyson as the respective type localities for the formations.

At Kap Tyson, upper and lower divisions of carbonate rocks can be distinguished (Plate 1). The lower division is 993 feet thick (302 metres) and includes beds higher than any exposed on Offley Ø. Some beds of the lower division that outcrop on the beach are probably lower than any on Offley Ø. These lower division beds at both localities consist of thickly bedded biostromal limestones, calcarenites and limestone conglomerates, and sparse low bioherms. Characteristically the unit has a banded appearance in distant views due to alternation of the different rocks (Plate 4, Figure 1). The lower part of the lower division has fewer bioherms than the higher beds and northwestward partly changes facies into darker grey somewhat argillaceous calcisiltites and calcarenites that outcrop on the beach at the northwest extremity of the cape (Plate 2, Figure 2). These dark limestones resemble rocks in the lower part of the section at Kap Schuchert and are referred to the Cape Schuchert Formation.

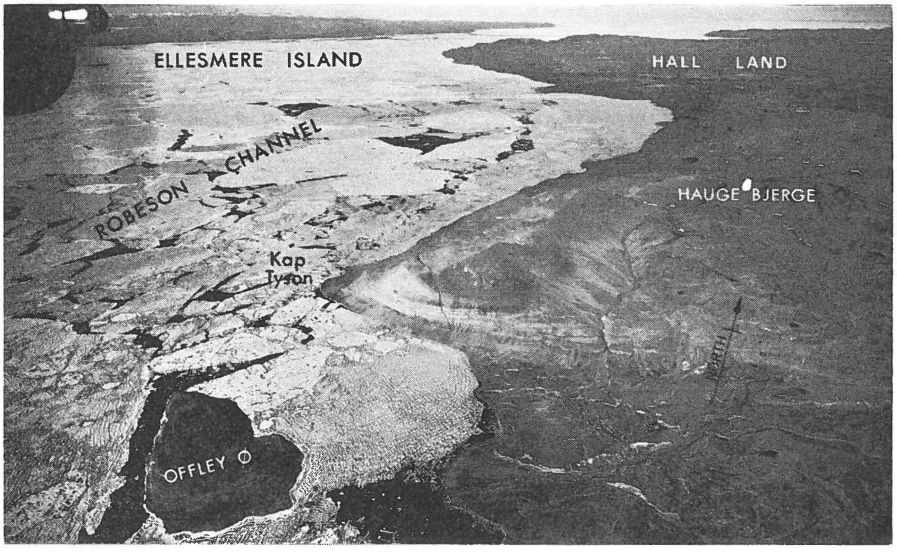

Figure 4. Aerial view of Kap Tyson and Offley Ø from the south. Upper part of Kap Tyson is a large bioherm of the Offley Island Formation that trends eastwards forming the Hauge Bjerge. (Reproduced by permission of the Geodætisk Institut, Copenhagen A. 26/72. Photograph 546 D-N 11459).

Although KOCH (1929, p. 239) cited Kap Tyson as the type locality for the Cape Tyson Formation, he did not specify which strata of those exposed at the cape were to form the type section. An upper limit to the lower division can be readily selected, but above this horizon three distinct depositional environments are represented. The central part of the cape consists of a huge bioherm some 1,100 feet (350 metres) thick (Plate 1). Steep depositional dips can be measured on both flanks but most of the northwest part of the bioherm has been removed by erosion in relatively recent times. The bioherm forms the Hauge Bjerge, a chain of hills trending eastnortheast across Hall Land (fig. 2). A mile southeast of the central part of the bioherm at Kap Tyson, the same stratigraphic interval is represented by about 327 feet (100 metres) of rocks. Most of this interval consists of thick beds of limestone conglomerates and calcarenites that are primarily composed of reef detritus, less thickly bedded pelletoidal calcarenites, and minor calcareous shales and slightly argillaceous calcisiltites. These are transitional rocks of a reef-flank environment, deposited between the bioherm and laterally equivalent shales and argillaceous limestones. The uppermost strata of this division includes calcisiltites and calcilutites that may represent a back reef environment. The third depositional environment is not well represented at Kap Tyson, but a few poor outcrops are present on the upland east of Kap Tyson and are stratigraphically higher than both the

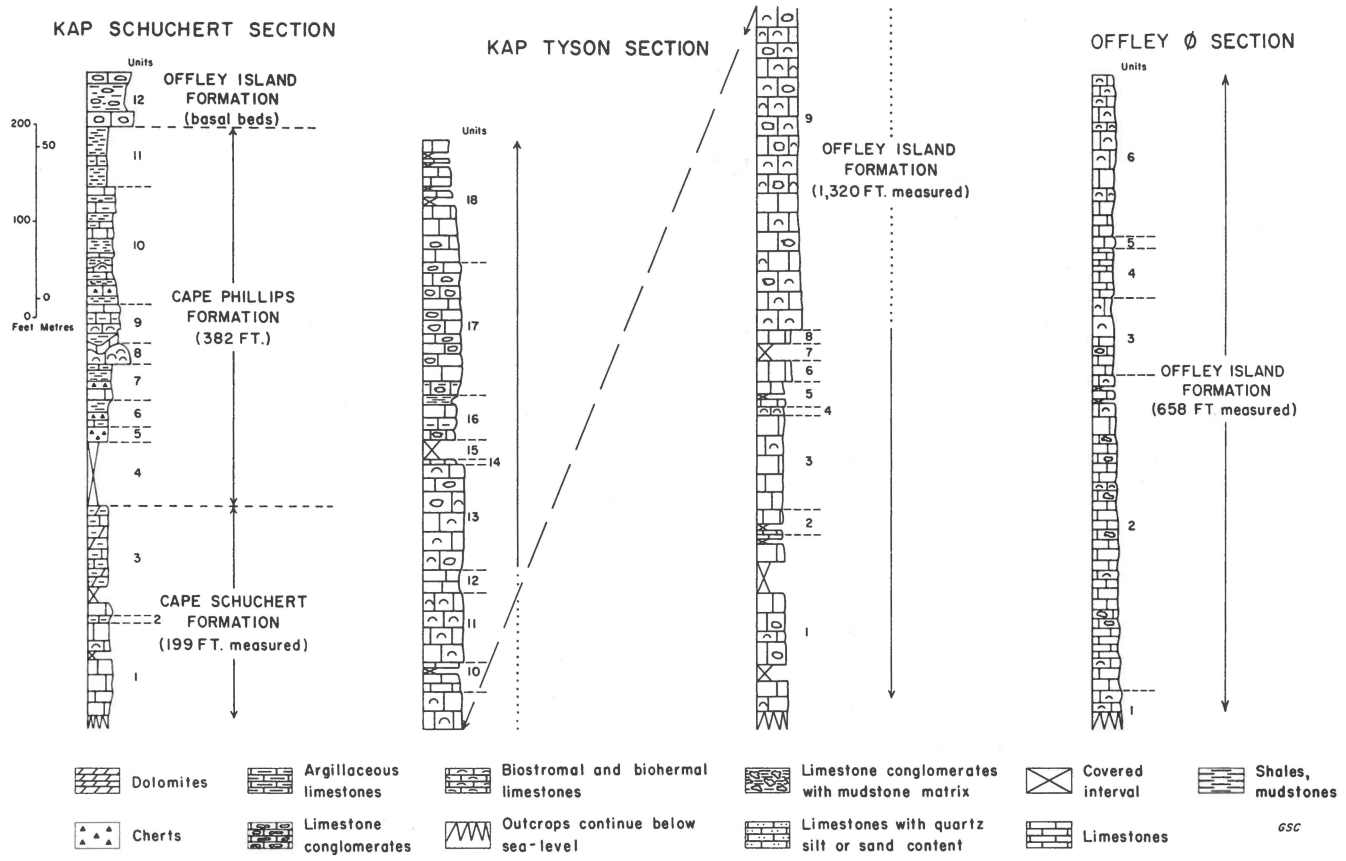

Figure 5. Schematic stratigraphic sections at Kap Schuchert, Kap Tyson and Offley Ø.

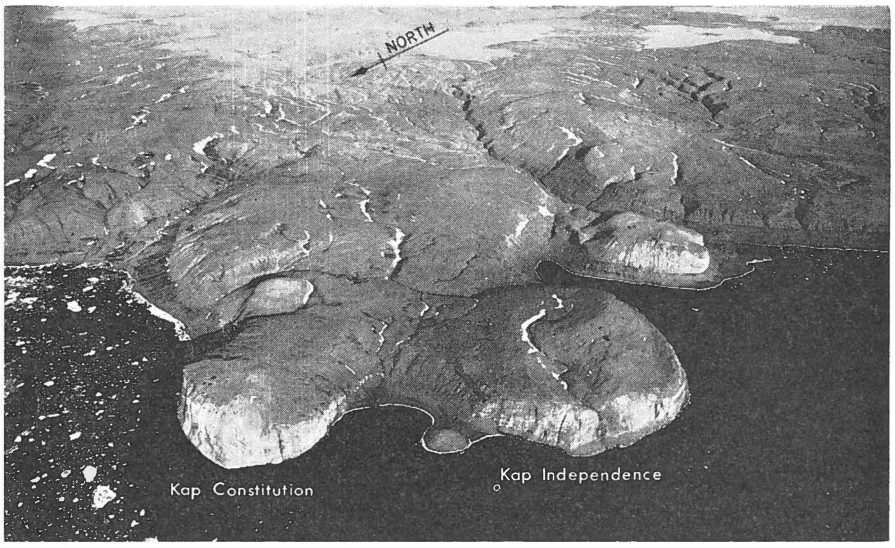

Figure 6. Aerial view from the northwest of bioherms of the Offley Island Formation at Kap Constitution and Kap Independence, margined by the Cape Phillips Formation. (Reproduced by permission of Geodætisk Institut, Copenhagen A 26/72. Photograph 545 K1-SØ 2258).

transitional rocks and the bioherm. These outcrops consists of calcareous graptolitic shales and mudstones and minor thin beds of platy limestones.

KOCH's descriptions (1929, p. 240) of the lithology of his Cape Tyson Formation were based on observations made in many parts of Hall Land, Washington Land and Peary Land. He referred to limestone breccias and conglomerates, shales, graptolitic shales and arenaceous shales, pure limestones and thin bands of dark limestones. However, the rocks well exposed at the type locality are the lower division (here referred to the Offley Island and Cape Schuchert Formations) and the biohermal and transitional rocks of the upper division. The name Cape Tyson could be restricted to these latter lithologies, the upper division at Kap Tyson, using the name Offley Island Formation for the lower division. However, biohermal complexes are developed in several parts of the Silurian sequence of northwestern Greenland. To give formal stratigraphic nomenclature to one such biohermal complex and not to others is neither consistent nor constructive. In Nyeboe Land, DAWES (1966, p. 13) found it impossible to recognise the Offley Island and Cape Tyson Formations as distinct units and later included limestones and associated rocks of KOCH's Cape Tyson Formation within the Offley Island Formation (1971, p. 215).

The term Offley Island Formation is used here for all the biostromal, biohermal and related limestones exposed at the type section of Offley Ø,

at Kap Tyson and throughout Hall Land and coastal Washington Land. To use the name Cape Tyson Formation for the graptolitic facies (based on the poor outcrops on the upland east of Kap Tyson) would radically change the term from KOCH's original usage, and DAWES (1971, p. 215) has used the term Kap Tyson Reef Bioherm to designate the geological feature (within the Offley Island Formation) that trends from Hall Land to Wulff Land. The name Cape Phillips Formation (THORSTEINSSON, 1959) has been used for rocks of graptolitic facies from the type locality on Cornwallis Island to eastern Ellesmere Island and should also by used for similar rocks on the east side of Kap Tyson and elsewhere in northwestern Greenland. The name Cape Tyson Formation can be considered obsolete.

Kap Schuchert Locality

The paragraph on type locality in KOCH's (1929, p. 237) proposal of the Cape Schuchert Formation only mentioned one named locality "just south of Cape Independence in Lafayette Bay." In the following paragraph KOCH referred to Kap Schuchert as the best locality for the formation and TROELSEN (1956, p. 21) cited Kap Schuchert as the type locality. According to Prof. V. Poulsen (Grønlands Geologiske Undersøgelse, personal communication) TROELSEN's statement reflected the opinions of both LAUGE KOCH and CHRISTIAN POULSEN. Thus the type locality of the Cape Schuchert Formation can be considered to be Kap Schuchert and not the locality near Kap Independence.

Kap Schuchert (fig. 7) lies in a region of intricate facies changes within the Silurian rocks. The beach and the cliffs above show a threefold sequence (fig. 5). The lower part of the succession consists of about 200 feet (about 60 metres) of brownish grey and dark grey slightly argillaceous limestone and minor dolomites with local light grey bioherms and biostromes. The middle part consists of about 400 feet (about 120 metres) of graptolitic shales, argillaceous limestones, and cherts, with numerous bioherms at about 150 feet above the base (Plate 6, Figures 1 and 2) and some biostromes higher in the sequence. Calcarenites and minor limestone conglomerates are associated with the reefs. The upper part of the succession consists of thickly bedded limestone breccias and conglomerates that are probably related to other reefs developed near Kap Schuchert. Only the basal portion (about 50 feet, 15 metres) of these upper rocks are exposed at Kap Schuchert. Stratigraphically higher outcrops some distance from Kap Schuchert were not examined in the present study.

KOCH's (1929, p. 237–238) description of the formation is a composite of observations made in various places in Washington Land and Warming Land. He reported a basal conglomerate that included pebbles of

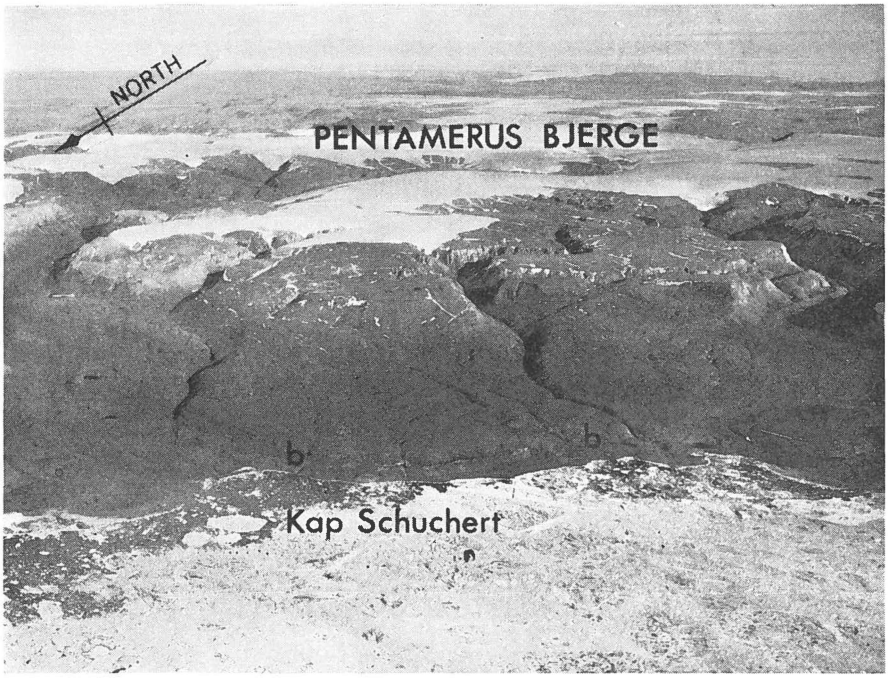

Figure 7. Aerial view of Kap Schuchert from the northwest. A string of bioherms (b-b) can be seen within the Cape Phillips Formation at Kap Schuchert but are not developed inland and to the southwest. (Reproduced by permission of Geodætisk Institut Copenhagen A. 26/72. Photograph 545 K1-SØ 2241).

Ordovician limestones and older rocks and passed gradationally upward into dark limestones. These dark limestones were overlain by black fossiliferous shales that were followed in some localities by black limestones.

The beach outcrops at Kap Schuchert do not show a basal conglomerate but the base of the formation is not exposed and such a unit could be too low to outcrop. All of the lower part of the succession probably corresponds to KOCH's dark limestones. The middle part corresponds to his black fossiliferous shales but KOCH made no reference to the patch bioherms that are developed. KOCH's black limestones are not developed at Kap Schuchert unless they correspond to dark argillaceous limestones developed within the sequence of graptolitic rocks. It is difficult to decide which horizon KOCH picked as the top of the Cape Schuchert Formation at Kap Schuchert. He assigned some rocks at Kap Schuchert to the Offley Island Formation (1929, p. 239). These may have been the rocks in the upper part of the succession, or the bioherms and biostromes within the middle part, or possibly a bioherm within the lower part.

The base of the upper beds is the most consistent horizon to map near Kap Schuchert and is taken to represent the base of the Offley Island Formation. However KOCH's investigations may have been limited to the beach outcrops at Kap Schuchert and he could have selected the base of the bioherms in the middle part of the succession as the base of the Offley Island Formation and the top of the Cape Schuchert Formation. A mile inland these bioherms are not developed and the horizon cannot be mapped.

The Cape Schuchert Formation was poorly defined by KOCH. At Cape Schuchert the rocks of graptolitic facies can be separated from the lower rocks and assigned to the Cape Phillips Formation. Each of the small patch bioherms within the Cape Phillips Formation at Kap Schuchert could be considered as a separate development of the Offley Island Formation, but are better considered as minor local growths within the Cape Phillips Formation. The Cape Schuchert Formation should be restricted to the lower part of the succession at Kap Schuchert together with what lower beds may be present near Kap Independence and elsewhere above Ordovician rocks.

Stratigraphic Framework

Although the present study has not attempted to map the Silurian rocks of Washington Land and adjacent Hall Land, the most important localities designated by KOCH have been critically examined and a modified stratigraphic framework can be presented (fig. 3). Knowledge of the stratigraphy could be amplified by detailed studies of the abrupt facies changes at Kap Independence and Kap Constitution (fig. 6) and of the thick stratigraphic sections that are well exposed along Bessels Fjord (fig. 2). Study of air photographs indicates that a composite section representing about 3,300 feet (1,000 metres) could be pieced together along Bessels Fjord. Very possibly a considerable part of this section consists of Ordovician and perhaps older rocks.

In Silurian time the present coast of northwestern Greenland lay close to the boundary between platform sedimentation of carbonate rocks and deeper water deposits of muds, shales, and platy limestones. The transition between these two regions was the site of intricate facies changes and numerous bioherms were developed at the seaward edge of the platform.

Fig. 3 shows the stratigraphic nomenclature suggested for Washington Land and southern Hall Land. The Cape Schuchert Formation consists of somewhat argillaceous calcisiltites and associated calcarenites that are in part equivalent to the lower part of the Offley Island Formation.

Biostromes and bioherms are locally developed. The basal beds of the Cape Schuchert Formation were reported by KOCH to be conglomeratic and to overlie the Ordovician Cape Calhoun Formation with disconformity (KOCH, 1929, p. 237; POULSEN, 1934, pp. 6 and 44). Graptolitic rocks overlie the Cape Schuchert Formation at Kap Schuchert and these rocks contain the oldest Silurian graptolites yet reported from Washington Land and southern Hall Land, but considerably more field work is needed to ascertain whether the Cape Schuchert Formation is entirely older than the rocks of graptolitic facies in northwestern Greenland, or whether the rock units are in part facies equivalents.

The rocks of graptolitic facies can be assigned to the Cape Phillips Formation. Small bioherms and biostromes are locally developed within the formation. Most of the graptolites collected from these rocks indicate Upper Llandovery but POULSEN (1934, p. 45) reported *Monograptus bohemicus* (BARRANDE) without designating a locality and this identification suggests the presence of a low Ludlow horizon somewhere in northwestern Greenland. The Cape Phillips Formation ranges from Upper Ordovician to Lower Devonian in the Canadian Arctic Islands and similar stratigraphic range can be expected in Greenland.

Most of the Silurian carbonate rocks can be assigned to the Offley Island Formation that consists of biostromal limestones, less common bioherms, calcarenites and limestone conglomerates primarily composed of reef detritus, and pelletoidal calcarenites. Stromatoporoids, algae and colonial corals are the most important framework builders in the bioherms and biostromes. A prominent bioherm can be mapped within the upper part of the Offley Island Formation on both sides of Petermann Fjord (fig. 2) and to the eastnortheast and east beyond Newman Bugt into Nyeboe Land, Warming Land and Wulff Land (DAWES, 1971, p. 211).

ALLAART (1965, unpublished) and DAWES (1966, p. 13) have shown that the Polaris Harbour Formation is not bedrock. At present the Cape Phillips Formation is the youngest formation known in Washington Land and southern Hall Land.

Biostratigraphy

The limestones of the Offley Island and Cape Schuchert Formations are abundantly fossiliferous. The cores of the biostromes and bioherms are primarily formed by stromatoporoids, algae and colonial corals, but large thick-shelled brachiopods, clams and gastropods dwelt among the living reefs and locally form coquinas. Accessory fossils include solitary corals, bryozoans, echinoderm fragments, trilobites and ostracods. Foraminifera are rare, but *Haplophragmella* sp. is known from the large bioherm at Kap Tyson and *Ammodiscus* sp. from a bioherm within the

Cape Phillips Formation at Kap Schuchert (identifications by T. P. CHAMNEY).

Many species of fossils have been described from the Silurian rocks of northwestern Greenland (ETHERIDGE, 1878; POULSEN, 1934, 1941, 1943; JACKSON & ETHERINGTON, 1969) but most of this work was based on collections of uncertain stratigraphic position. The large collections made in the present study eventually should allow the zonation of the stratigraphic sections by means of brachiopods, corals and trilobites. However, D. E. JACKSON's studies of the graptolites collected in this study from the Cape Philips Formation essentially date all the rocks examined at Kap Schuchert, Kap Tyson and Offley Ø as Late Llandovery. The only exception is the uppermost Cape Phillips Formation above the Offley Island Formation at Kap Tyson. These beds probably include both uppermost Llandovery and low Wenlock strata.

GSC Loc. No.	Kap Schuchert Section
73973 555–575 ft. (footages from base of measured section)	*Cyrtograptus* aff. C. *canadensis* JACKSON and ETHERINGTON *Monograptus* cf. *M. greistoniensis* (NICOL) *Monograptus* ex gr. *M. linnarssoni* TULLBERG *Monograptus* cf. *M. marri* PERNER *Monograptus priodon* (BRONN) *Monograptus* ex gr. (?) *M. regularis* TÖRNQUIST *Monograptus vomerinus* (NICHOLSON) Correlation: upper part of *Monograptus spiralis* Zone
73972 523–531 ft.	*Monograptus greistoniensis* (NICOL) *Monograptus priodon* (BRONN) *Monograptus spiralis* (GEINITZ) *Retiolites* sp. Correlation: *Monograptus spiralis* Zone
73971 460 ft., 0–3 inches	*Monograptus* ex gr. *M. priodon* (BRONN) *Monograptus* cf. *M. linnarssoni* TULLBERG *Monograptus spiralis* (GEINITZ) Correlation: *Monograptus spiralis* Zone
73969 409–410 ft.	*Monograptus* ex gr. *M. priodon* (BRONN) *Monograptus spiralis* (GEINITZ) Correlation: *Monograptus spiralis* Zone
73968 370 ft., 0–6 inches	fragments of dendroid graptolite *Monograptus* cf. *M. exiguus* (NICHOLSON) *Monograptus turriculatus turriculatus* (BARRANDE) Correlation: *Monograptus turriculatus* Zone,
73967 290–295 ft.	*Monograptus decipiens* TÖRNQUIST *Monograptus turriculatus minor* BOUČEK Correlation: low in *Monograptus turriculatus* Zone
73966 277–284 ft.	? *Climacograptus* sp. *Monograptus decipiens* TÖRNQUIST *Monograptus* cf. *M. regularis* TÖRNQUIST

	Monograptus turriculatus minor BOUČEK
	? *Orthograptus* sp.
	? *Petalograptus* sp.
	? *Retiolites* sp.
	Correlation: low in *Monograptus turriculatus* Zone
	Kap Tyson East Outcrops
73947 from 5 ft. interval, 1,545 ft. above sea level	indeterminate dendroid graptolite
	? *Dictyonema* sp.
	Cyrtograptus sp.
	Monograptus cf. *M. priodon* (BRONN)
	Correlation: *Monograptus spiralis* Zone to lower Wenlock
73946 from 2 ft. interval, 1,535 ft. above sea level	*Cyrtograptus* sp.
	Monograptus cf. *M. priodon* (BRONN)
	Correlation: *Monograptus spiralis* Zone to lower Wenlock
73945 from 2 ft. interval, 1,525 ft. above sea level	*Monograptus* cf. *M. linnarssoni* TULLBERG
	Monograptus priodon (BRONN)
	? *Monograptus* sp.
	Correlation: *Monograptus spiralis* Zone to lower Wenlock
73944 from 2 ft. interval, 1,495 ft. above sea level	? *Cyrtograptus* sp.
	anaspid fish (identified by R. THORSTEINSSON)
	Correlation: *Monograptus spiralis* Zone to lower Wenlock
73943 from 2 ft. interval, 1,485 ft. above sea level	*Monograptus* cf. *M. probosciformis* BOUČEK
	Monograptus sp.
	Correlation: *Stomatograptus grandis* Subzone of *Monograptus spiralis* Zone
73942 from 2 ft. interval, 1,480 ft. above sea level	*Cyrtograptus lapworthi* TULLBERG
	Monograptus cf. *M. priodon* (BRONN)
	Correlation: *Monograptus spiralis* Zone or *Stomatograptus grandis* Subzone

The uppermost Llandovery graptolite zone recognised in Canada is the *Monograptus spiralis* Zone (NORFORD *et al.*, 1970). In many areas of northern and western Canada a stratigraphic interval with *Stomatograptus grandis* is found at the top of the *spiralis* Zone but beds with *S. grandis* have been found interbedded with occurrences of *M. spiralis* in the Whittaker Formation of southwestern District of Mackenzie (JACKSON & ETHERINGTON, 1969). Similarly, in the Tegart Formation of southeastern British Columbia, occurrences of *S. grandis* are interbedded with those of *Monograptus walcottorum* RUEDMANN which is closely related to *M. spiralis* and may be conspecific (NORFORD, 1962). The *S. grandis* interval is considered to be a Subzone within the *spiralis* Zone rather than as a discrete Zone above the *spiralis* Zone.

The ages provided by the graptolite faunas of the Cape Phillips Formation at Kap Schuchert date the underlying Cape Schuchert Formation as early *turriculatus* Zone or older. Brachiopods from the lowest collection (GSC Locality 73959) made in the Cape Schuchert Formation at Kap Schuchert are considered by A. J. Boucot probably to indicate lower Upper Llandovery (C_1–C_2). The uppermost collection from the Cape Phillips Formation in the Kap Schuchert Section is *spiralis* Zone and the thin overlying Offley Island Formation is assumed to be of similar age.

The graptolite occurrences at Kap Tyson East are stratigraphically higher than all the rocks of the Offley Ø and Cape Schuchert Formations at Offley Ø and Kap Tyson. The stratigraphic interval represented by the collections is uncertain because of slumping of outcrop but is doutbless less than 120 feet. Part of this interval is uppermost *spiralis* Zone (*Stomatograptus grandis* Subzone), but the top beds probably extend into the lower Wenlock. The trilobite and brachiopod faunas from low in the Offley Island Formation at the Kap Tyson main Section (fig. 3) are Upper Llandovery and thus all of the Offley Island and Cape Schuchert Formations at Kap Tyson and Offley Ø can be considered to be Upper Llandovery.

Elsewhere in Hall Land and Washington Land there may be occurrences of Silurian rocks stratigraphically higher and lower than the Upper Llandovery rocks of Kap Tyson, Kap Schuchert and Offley Ø but very probably almost all the Silurian carbonate rocks of northwestern Greenland are Upper Llandovery.

ECONOMIC GEOLOGY

Subsurface development of the biostromal and biohermal rocks of the Offley Island Formation would form a potential reservoir for oil and gas. The large bioherm exposed at Kap Tyson has a relief of 800 feet over a distance of half a mile and is mantled by shaly beds of the Cape Phillips Formation that would have formed a seal for any fluids in the bioherm. To the northwest, the Offley Island Formation changes facies into the Cape Phillips Formation which may have been a source rock for oil and gas. Samples of calcisiltite and mudstone from the Cape Phillips Formation at Kap Schuchert contain significant amounts of organic carbon (Table 1, samples 2, 3).

Porosity is rare in the outcropping limestones of the Cape Schuchert and Offley Island Formations, although vugs filled with sparry calcite are common. If localities exist with such vugs free of calcite then the porosity of the limestones would be substantial. Minor dolomitisation is present in the Cape Schuchert Formation at Kap Tyson and at Kap Schuchert. Some vugs in the large bioherm at Kap Tyson are incompletely filled with calcite, the residual porosity contains dark material (Plate 9, Fig. 1) that is rich in organic carbon and sulphur (Table 1, sample 4) and represents a petroleum residue.

The extreme biostromal and biohermal developments in the Offley Island Formation may be localised near the seaward edge of the carbonate platform. The edge can be traced laterally to the northeast and east in northern Greenland and also southwest towards the Scoresby Bay and Canyon Fjord regions of central Ellesmere Island where similarly bioherms are present within the Allen Bay and Read Bay Formations and are mantled by the Cape Phillips Formation (Kerr, 1968, p. 495–499). Biohermal developments are present at the edge itself and also some distance in front as isolated developments that persisted within sediments, as at Raglan Range and Weatherall Bay, Melville Island (Tozer & Thorsteinsson, 1964, p. 61–62). The seaward edge of the carbonate platform perhaps can be projected farther south and west, through southwestern Ellesmere Island and northwestern Devon Island to link up with the prominent facies change between the Allen Bay and Read Bay Formations and the Cape Phillips Formation on Cornwallis Island (Thor-

Table 1. Mineralogical, carbon and sulphur analyses of selected bituminous rocks, by A. E. Foscolos.

Sample Number	1	2	3	4
Formation	Cape Phillips	Cape Phillips	Cape Phillips	Offley Island
Locality	Kap Schuchert Section, 375 ft.	Kap Schuchert Section, 375 ft.	Kap Schuchert Section, 425 ft.	Kap Tyson Bioherm, 800 ft. from top of outcrop
Lithology	bituminous calcarenite with limestone pebbles	laminated bituminous calcisiltite	limy mudstone	vuggy pelletoidal calcarenite
Calcite[1]	98 %	77 %	42 %	98 %
Dolomite[1]	–	3 1/2 %	2 %	–
Quartz[1]	–	12 %	56 %	–
Feldspar[1]	–	2 1/2 %	–	–
Pyrites[1]	1 %	1 1/2 %	trace	–
Illite[1]	–	3 %	–	–
other minerals[1]	1 %	–	–	2 %
mineral carbon[2]	11.79 %	8.94 %	4.60 %	11.27 %
organic carbon[2]	0.39 %	2.29 %	2.15 %	0.33 %
sulphur[2]	0.05 %	0.87 %	0.20 %	0.43 %

[1] These fractions are expressed as percentages of each mineral of the total weight of the minerals of each analysed sample.

[2] These fractions expressed as percentages of each element of the total weight of each analysed sample.

Mineralogical analyses determined by Phillips x-ray diffractometer using CuK α radiation in conjunction with LiF curved crystal monochromator. Scanning rate 1 degree per minute, chart speed 1 cm per minute; settings 40 kilovolts, 20 milliamperes.

All values are semiquantitative percentages based on peak-height ratios. Total carbon determined by Leco induction furnace; organic carbon determined by Leco induction furnace after treatment by excess HCL of same weight sample to remove carbon of the carbonates; mineral carbon calculated from difference. Sulphur was determined with a Leco induction furnace using fully automatic sulphur determination unit.

steinsson, 1959; Thornsteinsson & Kerr, 1968). The edge probably trends westward from Cornwallis Island and south of Bathurst Island and Melville Island (fig. 8), where the Cape Phillips Formation is present in the Bathurst Caledonian River J-34 and Winter Harbour No. 1 wells (Bryant & Koch, 1970; Norford *et al.*, 1970, p. 17–18).

Lead and zinc mineralisation is present in beach outcrops just below Kap Schuchert itself, a mile north of the site of the measured

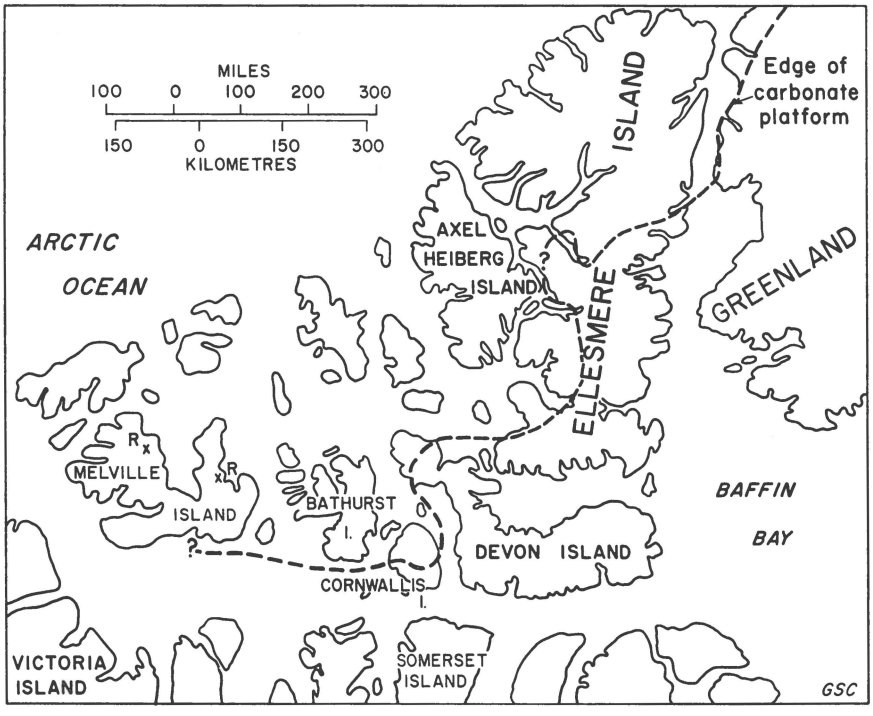

Figure 8. Position of seaward edge of Lower Silurian carbonate platform in Arctic Islands and northwestern Greenland. R indicates probably isolated developments at Raglan Range and Weatherall Bay, Melville Island.

stratigraphic section. The mineralisation forms vug fillings within limestone conglomerates and calcarenites in the upper part of the Cape Schuchert Formation and thin veins (thickness up to 2 inches, 5 cm) cutting these rocks. Galena, sphalerite, calcite, quartz, pyrite, and "pyrobitumen" were identified by D. F. SANGSTER from samples collected from the veins and vugs. J. J. LYNCH gave the following analysis of impurities (in parts per million) in the galena crystals: Fe 57, Zn 20, Cd14, As less than 10, Ni 7, Cr, Sb and Co less than 5, Cu 3, Mn less than 3. These impurities and the textures of the sulphides are similar to those found in the Pine Point lead-zinc deposit in Devonian carbonates at Great Slave Lake, District of Mackenzie (SANGSTER, pers. comm., 1970).

The volume of mineralisation present at Kap Schuchert is very small, but similar mineralisation may be present elsewhere in the Silurian carbonate rocks of northwestern Greenland. Detailed investigations may be able to determine whether any deposits of economic significance are present.

STRATIGRAPHIC SECTIONS

Kap Tyson Section

The lower cliffs at Kap Tyson are cut in nearly horizontal beds of the Offley Island Formation. Many of the rocks are biostromal and some small bioherms are developed. The upper cliffs are formed by biohermal and reef flank rocks of the Offley Island Formation in which depositional dips are strongly developed (Plate 1). The lowest 388 feet of the section was studied in exposures in the northwestern part of the cliffs and on the beach below (81°21′ N., 61°45′ W.; Map Sheet 120 S 1/2, Canada, Dept. of Mines and Technical Surveys 3rd Editon, preliminary). The rest of the nearly horizontal part of the section was measured in a prominent gully in the southeastern part of the cliffs (81°21′ N., 61°40′ W.; Map Sheet 120 S 1/2 *ibid*). The reef flank rocks of the upper part of the Offley Island Formation were studied in the cliffs just east of this gully, with the highest outcrops being examined in a small intermittent stream above the cliffs.

Neither the base nor the top of the Offley Island Formation is exposed in the stratigraphic section but the uppermost beds are structurally lower than outcrops of the Cape Phillips Formation to the east in the upland part of Kap Tyson (fig. 4).

Unit No.		Thickness in feet	
		Unit	Total from base
	Offley Island Formation (1,320 feet measured). *Bioherm flank and back-reef deposits (327 feet)*		
18	Calcisiltites, some beds with common shell fragments, most beds with sparry calcite cement; light olive-grey, weather light olive-grey and light grey; bedding 1/2 to 3 feet, some beds with sparry calcite filling vugs and fine veins, stylolites present in some beds (Plate 7, Figure 5). Rare calcilutites with sparry calcite stringers and vugs; light olive-grey, weather light olive-grey; bedding 1 to 2 feet; stylolites. Pelletoidal calcarenites with common shell fragments, matrix variably calcisiltite and sparry calcite; brownish grey and light olive-grey, weather grey and light grey; bedding 1 to 4 feet. Rare limestone	125	1,320

	conglomerates. At 1,205–1,208′, mottled limestones, weather dark brownish grey and olive-grey. Covered intervals at 1,313–1,314′, 1,301–1,306′, 1,294–1,297′, 1,267–1,270′, 1,253–1,262′. Stromatoporoids, corals, brachiopods and straight cephalopods; mostly in the limestones conglomerates (GSC Locality 73941, 1,277–1,300′).		
17	Limestone conglomerates, pebbles and cobbles of shells, calcarenites, pelletoidal calcarenites and other limestones set in sparry calcite and calcarenite matrix; dark grey and grey, weather dark grey and dull grey, resistant; bedding 2 to 15 feet, some beds weather rubbly, some beds with minor vuggy porosity, some with calcite stringers and vugs (Plate 9, Figure 3). Calcarenites, some pelletoidal, common fossil fragments, matrix variably of sparry calcite and calcisiltite; light grey and brownish grey, weather light grey and yellowish grey; bedding 6 to 12 inches. Rare algal structured limestones with vug fillings of sparry calcite; dark brownish grey, weather olive-grey and dark grey; bedding 3 to 18 inches. Corals, stromatoporoids, brachiopods, algae, gastropods, clams, bryozoans, echinoderm fragments, straight cephalopods (GSC Localities 73940 1,175–1,195′, 73939 1,057–1,070′). Top of Unit 15 picked at upper limit of common conglomeratic limestones, base picked above highest calcareous shale.	138	1,195
16	Limestone conglomerates and calcarenites, abundant shell fragments (mostly brachiopods, corals, echinoderms) in calcisiltite and local sparry calcite matrix, some pebbles of calcisiltite; dark grey, weather dark grey and dark brownish grey; bedding 2 to 8 feet; sparse authigenic quartz. Platy calcisiltites with common shell fragments, slightly argillaceous; very dark brownish grey, weather dull dark brownish grey; bedding 1 to 6 inches; amounting to about 20 per cent of interval. Paper shales, calcareous, with abundant small limestone concretions; dark brownish grey, weather greyish black; bedding 1/2 to 3 inches; amounting to about 2 per cent of interval. Straight cephalopods very common in paper shales and platy limestones; corals, brachiopods, echinoderm fragments, clams, straight cephalopods, trilobites in other rocks (GSC Localities 73938 1,039–1,055′, 73937 1,027–1,027 1/2′, 73936 1,016–1,025′).	44	1,057
15	Covered interval (Plate 2, Figure 2 taken at this horizon).	19	1,013
14	Calcisiltites, slightly argillaceous, with common coarser shell fragments; dark brownish grey, weather dull dark grey, recessive; bedding 1 to 3 inches (Plate 7, Figure 6).	1	994

	Echinoderm fragments, brachiopods, corals, gastropods, bryozoans (GSC Locality 73935 993–994′). Contact with Unit 13 concordant.		
	Biostromal and associated deposits (993 feet measured)		
13	Stromatoporoid and coral constructed limestones; pale and very pale yellowish brown, weather same and light grey, massive, resistant. Calcarenites and limestone conglomerates with abundant shell fragments, matrix mostly sparry calcite but some calcisiltite; pale yellowish brown, weather light grey, very light grey and light olive-grey, massive, resistant (Plate 3, Figure 1); some beds with sparse authigenic quartz. Stromatoporoids abundant, corals, very large clams, gastropods, pentamerid and other brachiopods, echinoderm debris, calcareous algae (GSC Locality 73934 950–990′).	112	993
12	Calcarenites, pelletoidal with sparse shell debris, matrix variably sparry calcite and calcisiltite; brownish grey and light brownish grey, weather olive-grey and dark grey; bedding 1 to 5 feet, some beds with stylolites. Very large clams common but poorly preserved.	24	881
11	Calcarenites with abundant shell fragments, pelletoidal, with sparry calcite matrix; very pale yellowish brown, light brownish grey and light olive-grey, weather grey, light grey and very light grey, resistant, massive. Stromatoporoid and coral constructed limestones; pale yellowish brown, weather grey, massive. Stromatoporoids, corals, very large clams (GSC Locality 73933 784–795′).	73	857
10	Calcarenites, pelletoidal with sparry calcite matrix; brownish grey and olive-grey, weather olive-grey; bedding 1/2 to 5 feet. Some algal constructed limestones. Covered interval at 776–778′. Very large clams common in some beds (GSC Locality 73932 780–784′). Contact with Unit 9 gradational within a bed.	25	784
9	Calcarenites and limestone conglomerates, pebbles and cobbles of shells and pelletoidal calcisiltites set in calcarenite (pelletoidal in some beds, mostly shell fragments and rock fragments in others) with sparry calcite matrix; light brownish grey, pale and very pale yellowish brown, weather very light grey, very pale orange and brownish olive-grey, resistant, massive; some beds with calcite stringers, vugs and veins (Plate 9, Figure 4). Stromatoporoid, tabulate coral and algal constructed limestones, with layers of calcisiltite; pale yellowish brown and very pale orange, weather very light grey and olive-grey, massive. Very fine calcarenites, pelletoidal with shell fragments, matrix mostly sparry	371	759

	calcite, some calcisiltite; pale yellowish brown, weather grey. Stylolites present. Rock types of Unit 9 very variable in relative proportions laterally. Stromatoporoids, corals, algae, pentamerid brachiopods, echinoderm debris, very large clams, bryozoans, gastropods, straight cephalopods, ostracods, trilobites (GSC Localities 73930 and 73931 716–717′, 73929 607–630′, 73928 468–482′, 73927 388–408′).		
8	Calcarenites, pelletoidal, sparry calcite matrix; brownish grey, weather dark grey; bedding 1 to 6 feet; most beds with grains and sparse pebbles of shells and limestones. Stromatoporoids, tabulate corals, echinoderm debris.	12	388
7	Covered interval.	18	376
6	Calcarenites, pelletoidal with sparry calcite cement; brownish grey, weather yellowish brown; bedding 1 to 5 feet, some beds poorly laminated, probably algal; calcite stringers and veins in many beds. Very rare stromatoporoids.	22	358
5	Calcarenites, pelletoidal with sparse shell fragments and calcisiltite pebbles, rare quartz sand and silt, brownish grey, weather olive-grey and brownish grey, slightly flaggy; massive; some beds with calcite stringers and vugs.	26	336
4	Stromatoporoid constructed limestone with calcarenite layers with limestone pebbles and sparry matrix; very pale yellowish brown, weather yellowish grey; massive. Stromatoporoids, solitary corals, echinoderm fragments.	10	310
3	Calcarenites, some pelletoidal, abundant sparry calcite matrix, rare fine quartz sand; dark grey and brownish grey, weather dark grey, dull grey and slightly rubbly; bedding 1 foot to massive; some beds with calcite veins and stringers. At 294–298′, abundant very large thick-shelled clams. At 275′, brownish grey weathering calcarenites with limestone pebbles and rolled fossils (Plate 8, Figure 1). Echinoderm debris calcarenites at 272–276′ and 254–255′. Stromatoporoids common at 262–268′. At 217–219′, very light weathering limestones. Stromatoporoids, corals, very large clams, gastropods. (GSC Localities 73926 263–268′, 73925 241–249′).	94	300
2	Calcarenites with very sparse limestone pebbles, pelletoidal with sparry calcite cement and rare fine quartz sand; dark grey, weather very light grey and light grey; bedding 4 to 7 feet. Covered interval at 182–190′. Rare stromatoporoids and solitary corals.	27	206
1	Calcarenites with shell fragments, some pelletoidal, rare beds with sparse oolites, sparry calcite matrix; brownish grey, pale and very pale yellowish brown,	179	179

weather light olive-grey, brownish grey, yellowish grey and yellowish brown; bedding poorly developed; calcite veins and stringers. Limestone conglomerates, pebbles of shells, calcisiltites and pelletoidal calcarenites set in calcarenite with sparry calcite matrix, rare fine quartz sand; pale and very pale yellowish brown and brownish grey, weather dull dark brownish grey and yellowish brown; bedding thick, poorly developed; calcite stringers and vugs. Algal constructed limestones with laminae of sparry calcite matrix; pale yellowish brown, weather yellowish brown. Very minor dark grey weathering limestones that become more common northwestward. At 23–28′ oolites, poorly sorted, pelletoidal, with about 5 per cent pebbles of pelletoidal limestones, oolitic limestones and shell fragments, abundant sparry calcite cement; light brownish grey weather grey and dull dark grey; a five foot bed (Plate 8, Figure 4). Covered intervals at 170–174′, 120–151′. Pockets and layers of dominantly brachiopod coquina are present within Unit 1 a short distance west of line of section (Plate 3, Figure 2). Stromatoporoids, algae, brachiopods, corals, echinoderm fragments, straight cephalopods, gastropods, trilobites (GSC Localities 73924, 2ft. of beds within 100–160′; 73923, 1/2 ft. of beds within 115–145′; 73922 81–89′; 73921, 30 ft. of beds within 50–110′; 73920, 2 ft. of beds within 0–10′).

Kap Tyson West Section

A short sequence of beds that can be assigned to the Cape Schuchert Formation is exposed in a couple of very shallow folds along the beach at the western extremity of Kap Tyson, at 81°22′ N., 61°50′ W. (Map Sheet 120 S 1/2, Canada, Dept. of Mines and Technical Surveys, 3rd Editon, preliminary). The base of the section is at sea level, the top is in the core of a shallow syncline. A few hundred yards of talus cover separates the section from the main Kap Tyson Section to the southeast but the 102 feet of beds can be judged to be lateral equivalents of part of the interval 215 to 397 feet of the main section, consisting of calcarenites, biostromal limestones and limestone conglomerates of the Offley Island Formation (fig. 4).

Unit No.		Thickness in feet	
		Unit	Total from base
	Cape Schuchert Formation (102 feet exposed)		
2	Calcisiltites, argillaceous and siliceous with laminae of dark brown carbonaceous (?) material; dark grey, weather dark grey, dull brownish grey, olive-grey and yellowish grey; bedding 1 foot to massive, poorly deve-	57	102

	loped, most beds weather rubbly and nodular. Sparse chert nodules at 94–97′. Corals, brachiopods, stromatoporoids, straight cephalopods.		
1	Calcisiltites, some slightly argillaceous and dolomitic, with shell debris and minor pelletoids, matrix locally sparry calcite; grey and dark brownish grey, weather dark brownish grey; thin bedding poorly shown in the beach outcrops (Plate 2, Figure 2). Calcarenites, pelletoidal with shell debris and sparry calcite matrix; brownish grey, weather dull brownish grey and yellowish brown; calcite vugs and stringers present. A bed of echinoderm debris calcarenite at 44 1/2–45′. Sparse layers of irregular greyish black chert nodules at 14–37′. Corals (some obviously not in growth position), brachiopods, stromatoporoids, echinoderm fragments (GSC Localities 73919 44–45′, 73918 24′0–1″, 73917 0–3′).	45	45

Kap Tyson Bioherm

A large bioherm is developed within the upper part of the Offley Island Formation at Kap Tyson and can be mapped to the northeast as a range of hills, Hauge Bjerge. This feature has been named the Kap Tyson Reef Bioherm of the Offley Island Formation (DAWES, 1971, p. 215). The accessible parts of the bioherm consist of massive limestones in which bedding is rarely discernible, but relatively steep depositional dips can be seen from a distance (Plate 1). A reconnaissance study at the north end of the west edge of the cliffs at Kap Tyson, at and to the south of the reef core, gave an approximate thickness of 1,100 feet (350 metres) for the bioherm. This interval thins to 327 feet (100 metres) at the south end of the cliffs (Kap Tyson Section) about half a mile away. The base of the bioherm rests on biostromal beds of the Offley Island Formation, apparently gradationally. The bioherm is overlain by graptolitic beds of the Cape Phillips Formation that outcrop on the southeast flank of Kap Tyson but the actual contact is not exposed. The core of the bioherm trends northeast, slightly to the northwest of the high part of the cape. Depositional dips in the southeast flank are clearly shown by Plate 1; shallower dips are present in the northwest flank, just beyond the core.

The rocks of the bioherm are light olive-grey and pale yellowish brown and weather in these colours, light grey and very light grey. The most common rocks are poorly sorted calcarenites, some pelletoidal, with fine to coarse shell fragments and debris. Sparry calcite filling voids and acting as matrix amounts to 5 to 15 per cent of most samples. Vuggy porosity is rarely preserved but some such vugs are coated with dark brown organic carbon that represents petroleum residue. Very minor authigenic quartz is present in some samples, as are rare rounded quartz

sand grains. Less common are stromatoporoid constructed limestones which are interpreted as creating the structure of the bioherm. Beds of cobble and boulder limestone conglomerates are present and these and the calcarenites show the depositional dips that are clearly visible from Offley Ø. Stromatoporoids, algae, colonial and solitary corals, echinoderm debris, gastropods and ostracods are the common fossils found in the various rock types of the bioherm (GSC Locality 73949 from middle third of bioherm).

Kap Tyson East Outcrops

A few small discontinuous outcrops of the Cape Phillips Formation are present on the upland surface on the southeast flank of the reef at Kap Tyson. The outcrops are somewhat slumped, but show gently eastward dipping calcareous shales and mudstones with interbedded sparse thin platy limestones. Graptolites are common in the argillaceous rocks and the limestones contain brachiopods and sparse corals; rare fish are found associated with the graptolites.

All of the outcrops are stratigraphically higher than the large bioherm at Kap Tyson, and their dips are interpreted as depositional on top of the flank of the reef. Only a small proportion of the upland has outcrop and no worthwhile stratigraphic section can be measured. Collections of fossils were made in stratigraphic sequence from 1,480 feet to 1,545 feet altitudes above sea level. The altitudes were measured with a barometer with control points at sea level and the summit of Kap Tyson. The total stratigraphic thickness represented by this sequence of collections is difficult to gauge because of the slumped nature of the outcrops, but is certainly less than 125 feet (38 metres) and probably considerably less than this figure.

Offley Ø Section

Offley Ø is a rocky islet formed of almost flat-lying beds of the Offley Island Formation. Many of the beds are biostromal and some small bioherms are present. The island lies at the mouth of Petermann Fjord in the path of the Petermann Gletscher. The outcrops are very freshly glaciated and the weathering characters of the rocks are poorly developed. The lowest beds are exposed at sea level at the southwestern tip of the islet and the stratigraphic section was measured from there to the highest beds seen, which outcrop in the central part of the islet at 81°19′ N., 61°50′ W. (Map Sheet 120 S $^1/_2$, Canada, Dept. of Mines and Technical Surveys, 3rd Edition, preliminary). Neither the upper nor the lower boundary of the Offley Island Formation is exposed on Offley Ø, the type locality.

Very fossiliferous biostromal rocks are exposed on the beach near the northwest tip of the islet and this spot is probably KOCH's locality "North coast of Offley Island" (POULSEN, 1941, pp. 13, 18, 21, 22; 1943, pp. 23–35, 54, 56–59). GSC Locality 73958 is this locality, fossils were collected from sea level to about 20 feet above, from beds that correspond to the lower part of Unit 2 of the measured section.

Unit No.		Thickness in feet	
		Unit	Total from base
	Offley Island Formation (658 feet measured)		
6	Calcarenites, most rocks pelletoidal, shell debris abundant, sparry calcite matrix; brownish grey, dark grey and pale yellowish brown, weather dull olive-grey, grey, pale yellowish brown and very light grey, resistant; bedding 1 foot to massive; calcite stringers and vugs (Plate 8, Figure 3). Biostromal beds (predominant in upper part of Unit 6; Plate 4, Figures 1 and 2), stromatoporoid constructed limestones, very pale yellowish brown and light grey; bedding 2 to 10 feet; many beds with 20 to 40 per cent stromatoporoids visible on rock surfaces. At 606′, several low bioherms, up to 60 feet wide and 5 feet high. At base of Unit 6, 15 inches of coarsely recrystallised limestone. Stromatoporoids, colonial and solitary corals, algae, echinoderm fragments, brachiopods, straight cephalopods, very large clams (GSC Localities 73957 607–650′, 73956 570–580′, 73955 523–535′).	165	658
5	Calcarenites, common shell debris, some pelletoidal, sparry calcite matrix; dark grey, weather dark grey and dark brownish grey, resistant; a single massive bed. Very large clams common at base of bed, stromatoporoids and tabulate corals common above.	12	493
4	Calcarenites, pelletoidal, matrix mostly sparry calcite, locally calcisiltite; olive-grey and light grey, weather light grey and rarely very light grey; bedding 1 foot to massive; some rocks with calcite stringers and vugs. At 460–462′, dark olive-grey weathering limestones with rare tabulate corals.	50	481
3	Calcarenites, pelletoidal, sparry calcite matrix, rare rocks with sparse fine quartz sand and silt; dark grey and brownish grey, weather dark grey, dark brownish grey and dark olive-grey; bedding 1 to 6 feet, some beds weather slightly platy (Plate 7, Figure 2). Subordinate stromatoporoid constructed limestones and limestone conglomerates, shell fragments set in calcarenite with sparry calcite matrix; pale yellowish brown, weather very light and light grey, massive. From a distance Unit 3 has a banded appearance but less so than Unit 2.	82	431

	Stromatoporoids, colonial and solitary corals, algae, brachiopods, echinoderm fragments, very large clams (GSC Locality 73954 394–402′).		
2	Calcarenites and rare calcisiltites, mostly pelletoidal with rare shell fragments and pebbles of pelletoidal calcarenite, a few beds with rare quartz sand grains, sparry calcite cement; pale yellowish brown, brownish grey and pinkish white, weather very light grey, light grey and off white; bedding 1/2 to 10 feet; calcite stringers and vugs common, some beds with stylolites (Plate 8, Figures 5 and 6). Limestone conglomerates, pebbles of shells and pelletoidal calcarenite, matrix mostly sparry calcite; pale yellowish brown and brownish grey, weather olive-grey, grey and light grey; bedding 2 to 7 feet; common calcite vugs (Plate 9, Figure 2). Stromatoporoid and algal constructed limestones, the latter preserved as laminae of sparry calcite separated by laminae of calcilutite and pelletoids; light brownish grey, weather olive-grey and dark grey; bedding 1 to 10 feet. Unit 2 has a banded appearance when weathered. Coquina of pentamerid brachiopods at 66–67′. Covered intervals at 333–337′ and 319–321′. Stromatoporoids, colonial and solitary corals, algae, brachiopods, large gastropods, clams (GSC Localities 73953 309–317′, 73952 124–128′, 73951 66–70′).	321	349
1	Calcarenites, pelletoidal with common shell fragments, sparry calcite matrix; light brownish grey, weather grey and dark grey; bedding indistinct, probably massive; calcite stringers and vugs. Outcrop continues below sea level. Fossils abundant in most beds (Plate 5, Figure 2), stromatoporoids, colonial and solitary corals, pentamerid brachiopods (GSC Locality 73950 10–15′).	28	28

Kap Schuchert Section

Kap Schuchert is a low headland (80°48′ N., 65°10′ W.; Map Sheet 120 S 1/2, Canada, Dept. of Mines and Technical Surveys, 3rd Edition, preliminary) just south of a large delta formed by two large creeks that drain the eastern Pentamerus Bjerge. The cape is formed by flat-lying Silurian rocks which exhibit abrupt facies changes and contain strings of small bioherms (developed within Units 1, 3, 8, 9, and 10 of the measured section).

A mile south of Kap Schuchert the rocks dip very gently northward and the lowermost 100 feet of the section were measured there along the strand. The base of the Cape Schuchert Formation is structurally too low to outcrop. The section continues up through raised beaches and through the cliffs behind the beach and ends just below the upland surface that is covered by felsenmeer and lacks reliable outcrop. The

upper part of the stratigraphic interval is also well exposed in the gorge of the southerly of the two creeks, about two miles northeast of the measured section. In the gorge no bioherms are developed in Units 8, 9, and 10, which are thus more typical of the Cape Phillips Formation.

Unit No.		Thickness in feet: Unit	Thickness in feet: Total from base
	Offley Island Formation (basal beds)		
12	Limestone conglomerates, resistant, very thickly bedded, thicknesses of beds laterally variable. Polymict limestone pebbles to boulders (Plate 5, Figure 1); rock types include pelletoidal limestones, calcarenites, algal limestones and shell fragment limestones (Plate 9, Figure 5). Middle 30 feet with mudstone matrix, rest of unit with calcarenite and sparry calcite matrix that includes abundant quartz silt, fine quartz sand and authigenic quartz. These conglomerates are probably reef detritus from bioherms. Coarse porosity developed in some beds. Contact with Unit 11 abrupt, but concordant, and without obvious erosion of underlying beds. Corals, stromatoporoids, brachiopods, algae (?) and echinoderm debris noted in boulders.	50 (about)	
	Cape Phillips Formation (382 feet)		
11	Shales, calcareous, with common quartz silt, fine sand and authigenic quartz; dark grey weather dark grey, recessive; amounting to 90 to 99 per cent of beds. Platy argillaceous limestones; grey and dark grey, weather grey; bedding 1/4 to 2 inches; amounting to 2 to 8 per cent of beds. Thinly bedded limestones, bedding 1 to 3 inches; only present near base and top of unit where they amount to 2 to 5 per cent of beds. Graptolites (GSC Localities 73973 555–575′, 73972 523–531′).	64	581
10	Very argillaceous calcisiltites, some beds with common quartz silt and very fine sand; dark brownish grey and brownish black, weather dark grey, grey, and yellowish grey, some beds platy, recessive; bedding 1/4 to 2 inches (Plate 7, Figure 4). Calcisiltites, some argillaceous, some pelletoidal, some with sparry calcite matrix and common biogenic fragments; brownish grey, weather dull brownish olive-grey and light brownish grey; in beds 1 to 18 inches thick and as layers within the argillaceous limestones. Calcarenites, some pelletoidal, some with common shell debris, sparry calcite matrix; dark grey and dark brownish grey, weather dull brownish grey; bedding 8 inches to 4 feet. Limy shales, with common quartz silt and very fine sand, very fissile; dark grey, weather dark grey and dark brownish grey,	115	517

	recessive; bedding 1 to 2 inches. Very minor cherts; greyish black, weather greyish black and dark grey; bedding 1/4 to 3 inches. At 323′, small bioherm, 3 feet high, thinning laterally to zero within a few yards, mantled by a calcarenite bed. Graptolites, brachiopods, echinoderm debris (GSC Localities 73971 460′0–3 inches, 73970 455–459′, 73969 409–410′).		
9	Calcarenites, fine to very fine, pelletoidal with biogenic fragments, matrix variably of lime mud and sparry calcite, fine quartz silt common; yellowish brown and olive-grey, weather light grey and yellowish grey; bedding 1/4 to 3 feet. Argillaceous calcisiltites, finely laminated; dark brownish olive-grey, weather drab olive-grey, platy; bedding 1 to 10 inches (Plate 7, Figure 3). Calcarenites, fine to very coarse, with abundant echinoderm debris; light grey and light brownish grey, weather olive-grey, very light grey, and yellowish grey; bedding 1/4 to 5 feet. Minor limy shales, dark brownish grey, weather dark grey and brownish grey; some beds with nodules of limestone. At 362–364′ biostromal limestone, thickness varies 1 to 4 feet laterally; weathers very light grey; abundant stromatoporoid and (?) algal colonies; some reworked in basal part of bed to form a conglomerate. Basal beds of Unit 9 drape over bioherms of Unit 8. Graptolites, trilobites (GSC Locality 73968 370–370½′).	49	402
8	Bioherm of limestone with layers of stromatoporoid and algal colonies; light olive-grey and grey, weathers very light grey, massive. Much of rock consists of fossiliferous calcilutites, some pelletoidal; sparry calcite present as void fillings. Some calcarenites present and some of these include pebbles of biohermal limestones. Unit 8 is very variable laterally (Plate 6, Figures 1 and 2): in places away from the line of section, bioherms are present up to 100 feet high, in some places in the cliff no bioherms are developed and Unit 9 rests directly on Unit 7. Rare foraminifera present. Abrupt base to Unit 8 but no erosion of underlying beds.	13	353
7	Argillaceous limestones, some beds with quartz silt; dark grey and grey, weather dull olive-grey and dark grey, recessive; bedding 1/4 to 1 inch, some beds laminated. Limestones, very fine calcarenites, some pelletoidal, calcisiltites and fossiliferous calcilutites, some beds with quartz silt; light brownish grey and olive-grey, weather light grey; bedding 1/2 to 6 inches; these limestones more common in upper part of Unit 7. Calcareous shales, moderately to very fissile; dark olive-grey and dark grey, weather dark grey, olive-grey and dusky yellow, recessive; bedding 1/2 to 2 inches; some beds contain limestone nodules. Calcarenites, fine to medium coarse, with echinoderm debris; light	35	340

	grey, weather light grey; bedding 3 to 8 inches. Rare greyish black cherts, bedding 1/2 to 1 inch. Gradational contact with Unit 6. Barren.		
6	Limy mudstones with abundant carbonate silt and rare thin layers of calcarenite; dark grey and greyish black, weather olive-grey, light grey, and yellowish grey, recessive; bedding 1/8 to 18 inches. Limy shales, very fissile; dark brownish grey, weather dark brownish grey. Black bedded cherts amounting to 5 per cent of lower part of Unit 6, absent above 295′. Trilobites, graptolites, inarticulate brachiopods, echinoderm debris, ostracods (GSC Localities 73967 290–295′, 73966 277–284′).	25	305
5	Cherts; greyish black, weather greyish black and black, commonly with a dusting of a white mineral, recessive; bedding 1/8 to 2 inches. Subordinate limy mudstones and shales with abundant carbonate silt and common biogenic debris, slightly cherty, poorly fissile; dark grey, weather dark grey; bedding 1/8 to 1/2 inches. Graptolites.	18	280
4	Covered interval, probably mostly similar to Unit 5. Some beds of the upper part of this interval outcrop on hillside 1/4 mile south of section, where about 30 feet of cover separate beds like Unit 3 from about 60 feet of thinly bedded cherts and minor limy shales.	63	262
	Cape Schuchert Formation (199 feet measured)		
3	Calcisiltites with common biogenic fragments (mostly echinoderm, bryozoan and algal) and biogenic calcarenites, some pelletoidal, matrix mostly calcisiltite and calcilutite but locally sparry calcite; both rock types slightly argillaceous; dark grey with brownish grey and dark brownish grey dolomitic mottles and layers, weather dull olive-grey, grey, and yellowish brown, somewhat recessive; bedding poorly expressed in the beach outcrops; weather rubbly and nodular. About 30 per cent of interval 119–126′ consists of dolomites, slightly argillaceous and with very fine authigenic quartz; brownish grey and dark brownish grey, mottled, weather very pale yellowish brown and greyish orange; bedding 2 to 8 inches, well developed, stylolites present; with about 2 per cent intercrystalline and vuggy porosity. Covered interval at 104–119′. A mile to the north, below Kap Schuchert itself, more resistant, thickly bedded fossiliferous calcarenites (some pelletoidal) and limestone conglomerates are present in the upper part of Unit 3, and contain calcite-filled vugs and veins, sparse drusy cavities and rare chert nodules. Calcarenites formed of echinoderm debris are interbedded with these limestones. Lead and zinc mineralisation is present	108	199

	within these rocks in the drusy cavities and veins. Corals, stromatoporoids, brachiopods, echinoderm debris, gastropods, algae, bryzoans and trilobites are sparse in the measured section (GSC Localities 73965 175–195′, 73964 147–164′), but locally abundant in pockets and layers at Kap Schuchert (GSC Locality 73974 from 10 feet of beds at Kap Schuchert within upper part of interval 91–197′).		
2	Argillaceous limestones; dark grey, weather dark grey, recessive, platy; bedding 1/4 to 3 inches. Covered interval at 83–87′. Brachiopods (GSC Locality 73963 87–91′).	8	91
1	Calcarenites, fragments mostly of bryozoans, echinoderms, ostracods and algae with variably sparry calcite and calcisiltite matrix; light brownish grey and pale yellowish brown, weathering colours not developed, somewhat recessive; bedding indistinct in the beach outcrops; with calcite stringers, veins, and vugs. Some algal constructed limestones. Covered intervals at 61–64′, 48–56′. Outcrop continues below sea level. Just south of the measured section a mound of massive very light grey weathering limestones outcrops. The contact relations of this mound with the bedded rocks of Unit 1 are obscured by raised beach gravels, but the mound is interpreted as a bioherm developed within interval 10–90′. Stromatoporoids, algae, corals, brachiopods, and trilobites sparse in bedded rocks (GSC Localities 73962 79–83′, 73961 71–71 1/2′, 73960 46–46 1/4′), common in layers and pockets in the bioherm (GSC Locality 73959 from 40 ft. of beds within interval 10–90′).	83	83

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B. S. Norford,

Geological Survey of Canada,
3303, 33rd. St., Calgary, N.W., Canada
July 21st. 1970

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PLATES

Plate 1

Kap Tyson from Offley Ø to the southwest; the summit of Kap Tyson is 719 metres (2,360 feet) above sea level. Lower half of cliff consists of flat-bedded biostromal and associated limestones of the Offley Island Formation, some bioherms can be detected within this sequence. Upper half of cliff consists of a prominent bioherm in the upper part of the Offley Island Formation, centered to the left of the high point of the cliffs, with strong depositional dips clearly visible on the right of the centre. These beds grade laterally into a much thinner sequence of reef flank limestones on the right of the picture. The Kap Tyson Section was measured from sea level in the left of the picture up to and along the top of the talus, then up the prominent gulley on the right of the picture and ends in the shadowed area. The Kap Tyson Bioherm was studied in the core region in the left of the picture up to the crest of the cliffs. The Kap Tyson East outcrops of the Cape Phillips Formation can be seen in the upland just below the shoulder of the ridge to the left of the shadowed area. The Kap Tyson West Section in the Cape Schuchert Formation was measured on the beach just to the left of the limits of the photograph. The prominent bedding plane in the middle of the cliffs is at 993 feet of the Kap Tyson Section and is also shown in Plate 2 Figure 1.

(GSC Photographs 119039 and 119041).

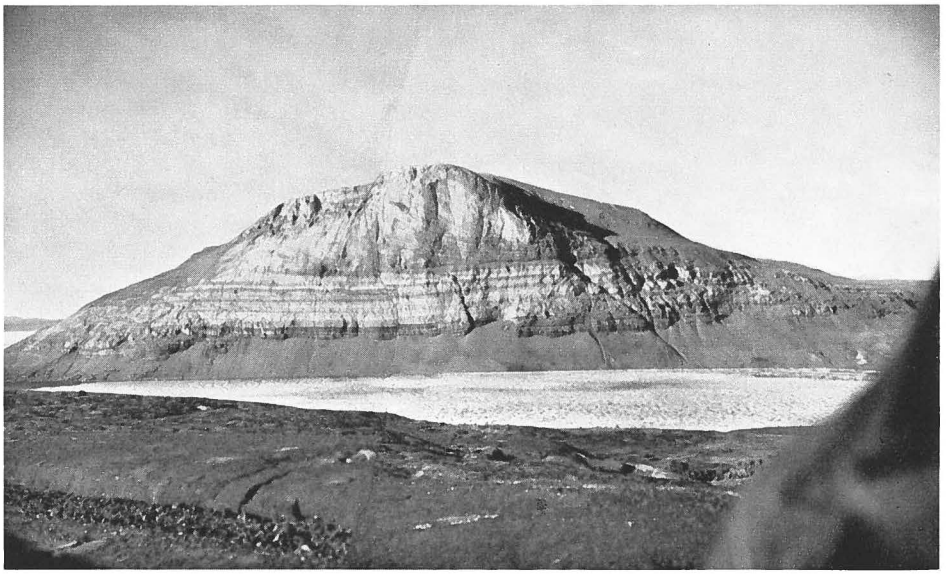

Plate 2

Figure 1. Top of the biostromal limestones of Unit 13 of the Offley Island Formation at 993 feet above the base of the Kap Tyson Section. The recessive interval represents Units 14 and 15 (20 feet thick); above are limestone conglomerates, calcarenites, calcisiltites and limy shales of Units 16 and 17 of the reef flank deposits of the Offley Island Formation. Ellesmere Island in the background. (GSC Photograph 119030)

Figure 2. Thinly bedded calcisiltites of the Cape Schuchert Formation, Unit 1 of the Kap Tyson West Section. (GSC Photograph 119014)

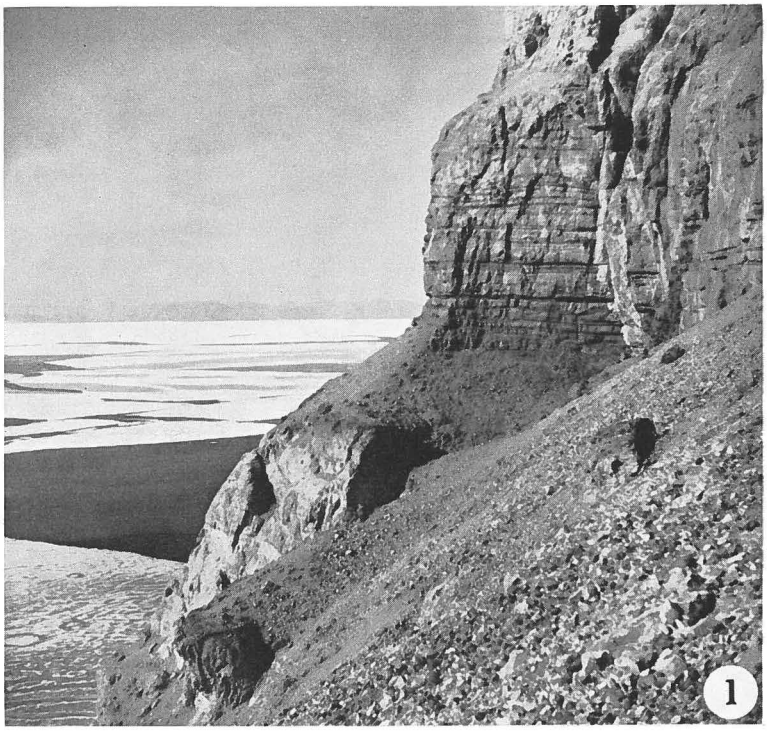
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Plate 3

Figure 1. Thickly bedded biostromal limestones, limestone conglomerates and calcarenites of Unit 13 of the Offley Island Formation of the Kap Tyson Section.

(GSC Photograph 119031)

Figure 2. Layers of brachiopod coquina within Unit 1 of the Offley Island Formation of the Kap Tyson Section.

(GSC Photograph 119033)

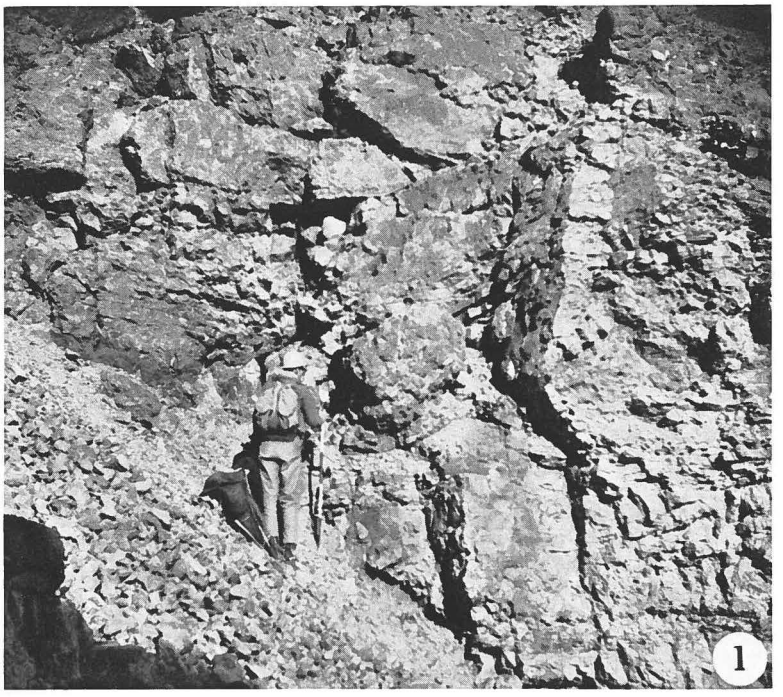
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Plate 4

Figure 1. Cliffs on the northeast side of Offley Ø; the high point of the island is just less than 200 metres (less than 650 feet) above sea level. All the rocks belong to the Offley Island Formation: the banded cliffs are formed by Units 2 and 3 of the Offley Ø Section, the upland behind the cliffs includes many rounded bioherms of Unit 6.

(GSC Photograph 119016)

Figure 2. Small stripped bioherm in the upper part of Unit 6 of the Offley Island Formation at Offley Ø (at 606 feet of the Section).

(GSC Photograph 119044)

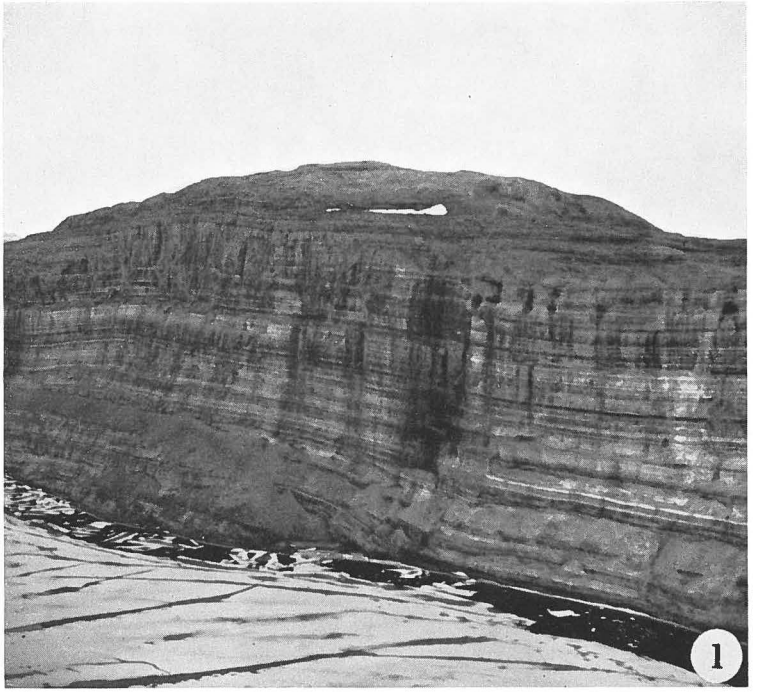
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Plate 5

Figure 1. Boulder derived from the limestone conglomerates of the Offley Island Formation that overlie the Cape Phillips Formation at Kap Schuchert; beach at the Kap Schuchert Section.
(GSC Photograph 119063)

Figure 2. Abundant pentamerid brachiopods in Unit 1 of the Offley Island Formation at Offley Ø (at 25 feet of the Section).
(GSC Photograph 119045)

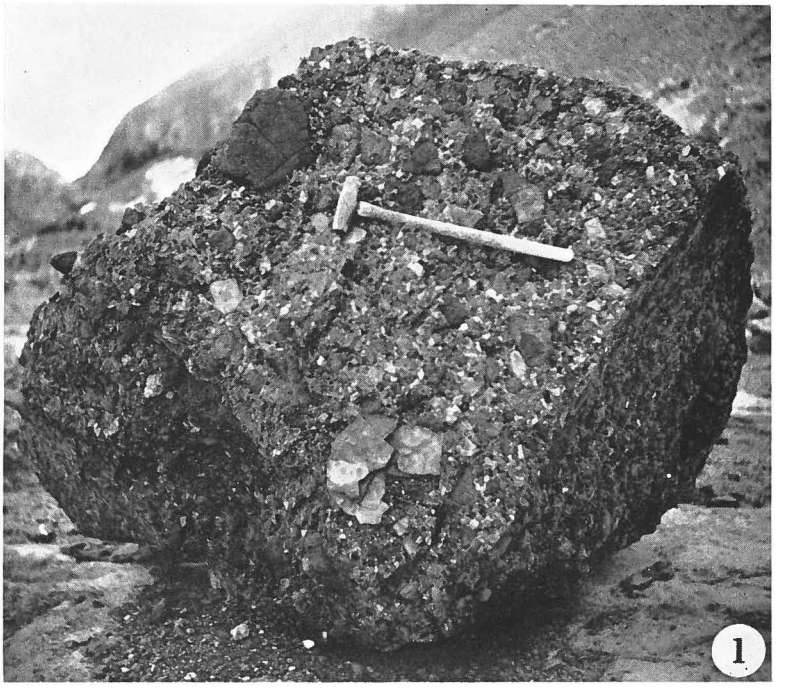
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Plate 6

Figure 1. Stromatoporoid and algal bioherms within the Cape Phillips Formation. Unit 8 of the Kap Schuchert Section (340–353 feet above base). About 30 feet of beds are shown in the photograph; Ellesmere Island in the distance.

(GSC Photograph 200167-B)

Figure 2. Stromatoporoid and algal bioherms within the Cape Phillips Formation, Unit 8 of the Kap Schuchert Section (340–353 feet above base). Unit 8 is up to 100 feet thick through local reef pinnacles, in contrast to the 13 feet thickness shown by Fig. 1, some few hundred yards to the northeast. Overlain by Units 9, 10 and part of 11 of the Cape Phillips Formation.

(GSC Photograph 200167-E)

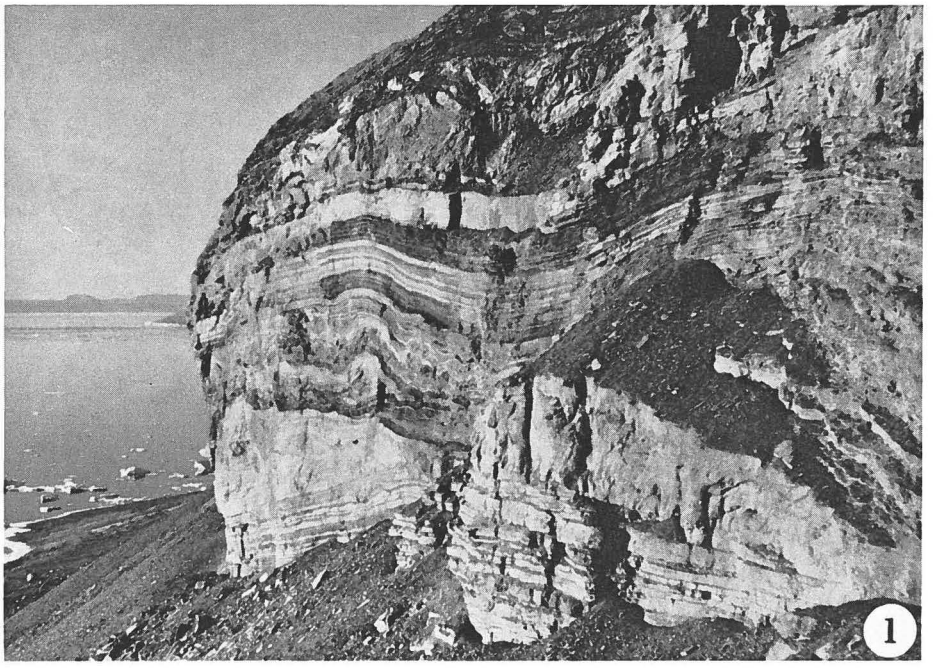
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Plate 7

Thin sections of rocks of the Offley Island and Cape Phillips Formations; normal light, all figures X5.

Figure 1. Pelletoidal fine calcarenite with sparry calcite matrix. Offley Island Formation, Unit 8 (at 380 feet) of the Kap Tyson Section.

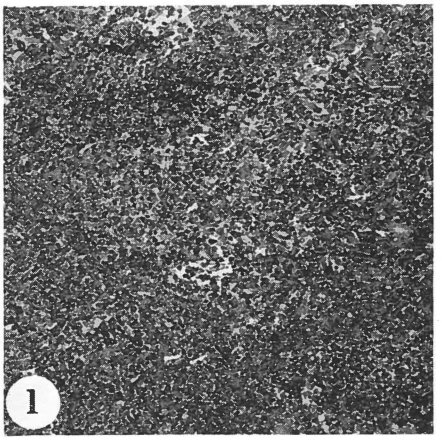
Figure 2. Pelletoidal fine calcarenite with sparry calcite matrix and a pebble from a stromatoporoid colony. Offley Island Formation, Unit 3 (at 350 feet) of the Offley Ø Section.

Figure 3. Laminated calcisiltite. Cape Phillips Formation, Unit 9 (at 375 feet) of the Cape Schuchert Section. Table 1 gives analyses by A. E. Foscolos of this sample in which calcite comprises 77 per cent and quartz 12 per cent of the minerals; organic carbon amounts to over 2 per cent of the weight of the sample.

Figure 4. Laminated calcisiltite. Cape Phillips Formation, Unit 10 (at 475 feet) of the Kap Schuchert Section.

Figure 5. Calcisiltite with sparry calcite filling vugs, stringers and "birds-eyes". Offley Island Formation, probably backreef deposit, Unit 18 (at 1,320 feet) of the Kap Tyson Section.

Figure 6. Calcisiltite with common shell debris. Offley Island Formation, bioherm-flank deposit, Unit 14 (at 994 feet) of the Kap Tyson Section.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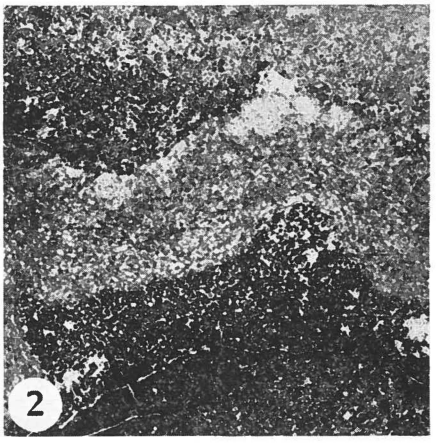
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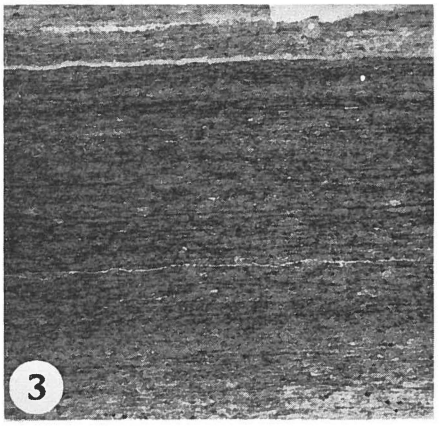
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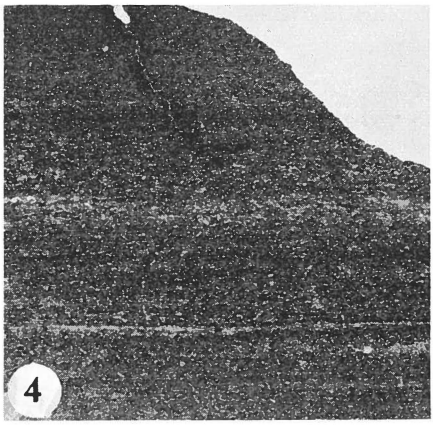
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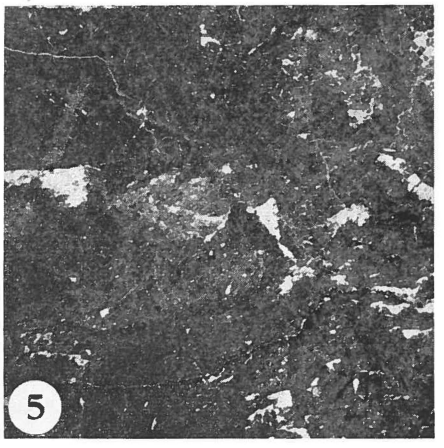
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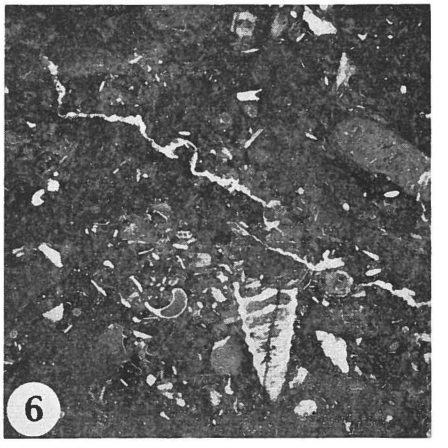
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Plate 8

Thin sections of rocks of the Offley Island Formation; normal light, all figures X5.

Figure 1. Calcarenite with sparse pebbles of limestone and shell fragments; sparry calcite matrix. Offley Island Formation, Unit 3 (at 275 feet) of the Kap Tyson Section.

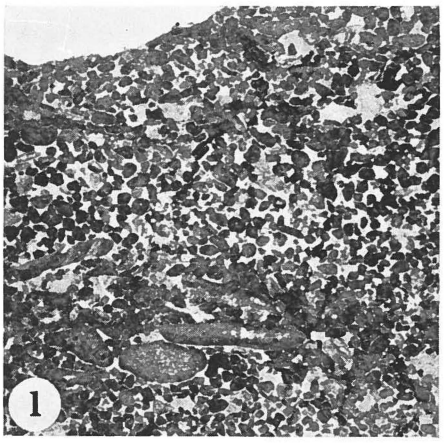
Figure 2. Pelletoidal oolite with sparry calcite matrix. Almost all of the ooliths have recrystallised, losing their concentric texture; most ooliths have pellets of lime mud as nuclei. Offley Island Formation, Unit 1 (at 120 feet) of the Kap Tyson Section.

Figure 3. Pelletoidal calcarenite with abundant shell debris; sparry calcite matrix. A stylolite crosses the middle of the figure. Offley Island Formation, Unit 6 (at 550 feet) of the Offley Ø Section.

Figure 4. Pelletoidal oolite with pebbles of pelletoidal and oolitic limestones; sparry calcite matrix. Offley Island Formation, Unit 1 (at 25 feet) of the Kap Tyson Section.

Figure 5. Pelletoidal calcarenite with sparry calcite matrix. Lamination perhaps may be due to sediment binding action of blue-green algae. Stylolite at top of figure. Offley Island Formation, Unit 2 (at 275) feet of the Offley Ø Section.

Figure 6. Pelletoidal calcarenite with rare shell fragments; sparry calcite matrix; stylolites present. Offley Island Formation, Unit 2 (at 300 feet) of the Offley Ø Section.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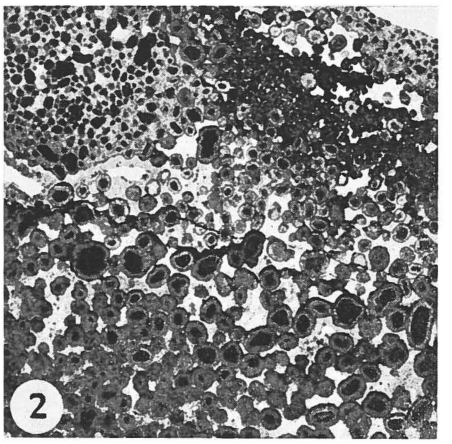
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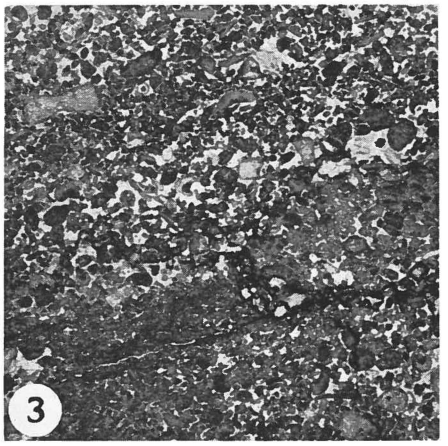
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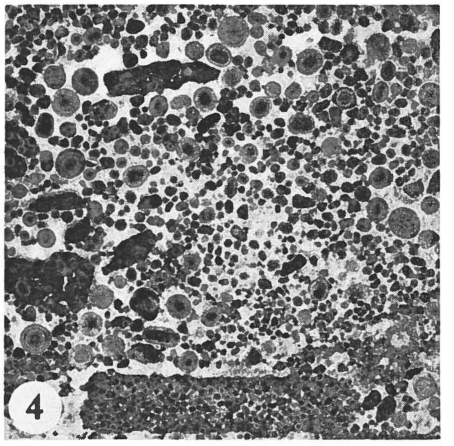
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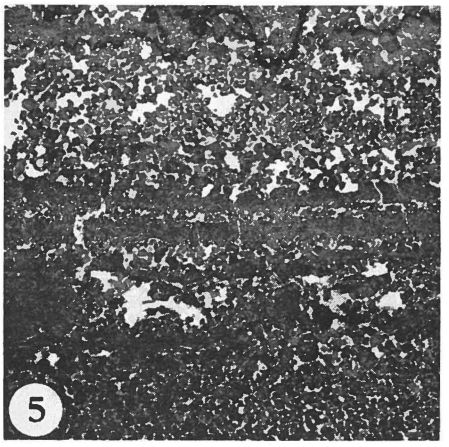
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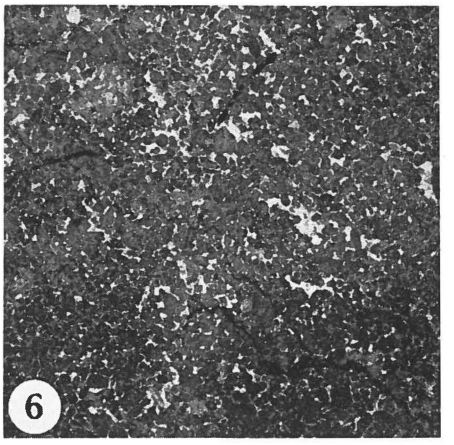
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Plate 9

Thin sections of rocks of the Offley Island Formation; normal light, all figures X5.

Figure 1. Pelletoidal calcarenite with rare shell fragments; sparry calcite matrix. Large vugs comprise about 10 per cent of rock, largely filled by sparry calcite but some porosity remains and is lined by a dark substance that is primarily composed of organic carbon and sulphur and represents a petroleum residue. Table 1 gives analyses of calcite crystals coated with the dark substance taken from vugs in this sample. Offley Island Formation, middle part of the large bioherm in the upper part of the formation at Kap Tyson.

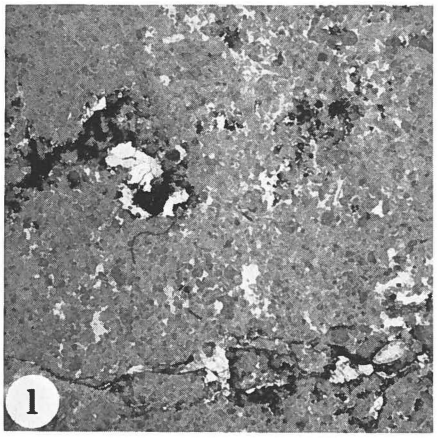
Figure 2. Limestone conglomerate, pebbles of pelletoidal calcarenites, calcareous algae (a), brachiopods and other shells; sparry calcite and some calcarenite matrix; abundant sparry calcite-filled vugs. Offley Island Formation, Unit 2 (at 100 feet) of the Offley Ø Section.

Figure 3. Limestone conglomerate, pebbles of pelletoidal calcarenites, calcisiltite, corals, algae, bryozoans (b), echinoderm fragments (e) and other shells; matrix largely calcisiltite but some sparry calcite. Offley Island Formation, bioherm-flank deposit, Unit 17 (at 1,100 feet) of the Kap Tyson Section.

Figure 4. Calcarenite with some pebbles of shells and pelletoidal limestone. Grains primarily shell fragments (echinoderm fragments, bryozoans (b), algae, stromatoporoids and other groups) but include some pelletoids. Offley Island Formation, Unit 9 (at 450 feet) of the Kap Tyson Section.

Figure 5. Limestone conglomerate, pebbles of calcisiltites, pelletoidal calcarenites, algal limestones and shell fragments; matrix very fine calcarenite and calcisiltite. Offley Island Formation, basal bed (at 581 feet) overlying the Cape Phillips Formation, Kap Schuchert Section.

Figure 6. Stromatoporoids (s) constructed limestone with rare calcareous algae (a); sparry calcite matrix with sparse calcarenite. Offley Island Formation, upper part of the large bioherm in the upper part of the formation at Kap Tyson.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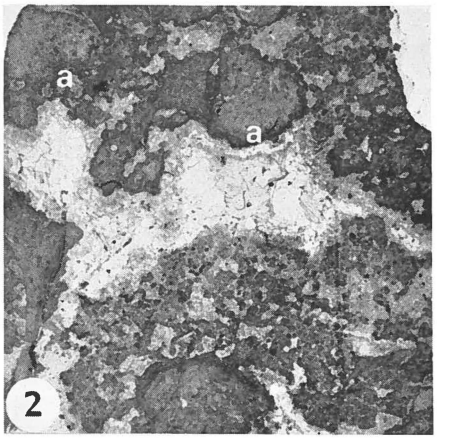
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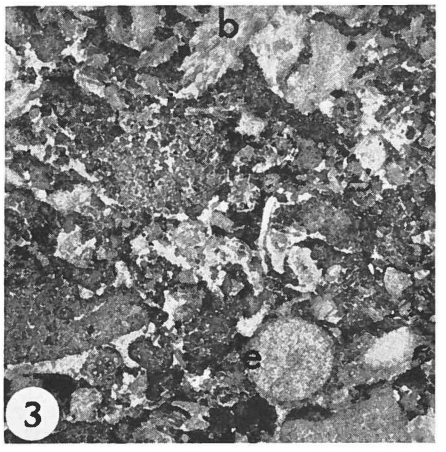
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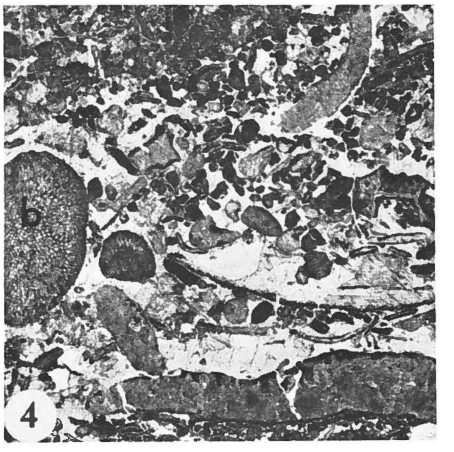
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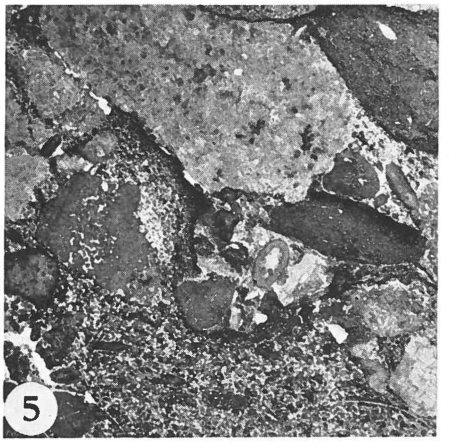
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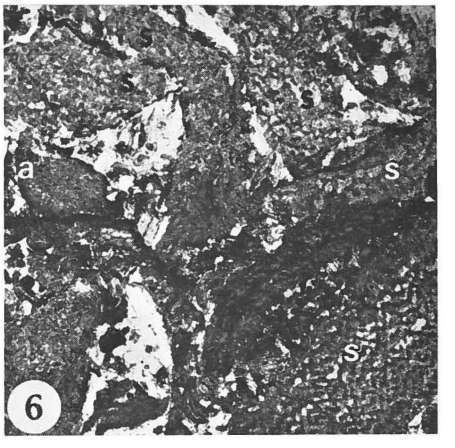
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