Cambrian–Ordovician platform stratigraphy: correlations around Kane Basin

JOHN S. PEEL and ROBERT L. CHRISTIE

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Cambrian and Ordovician platform strata in western North Greenland and adjacent Ellesmere Island were deposited on an elongate platform lying to the south of the Franklinian Trough. The sequence is dominated by carbonates with prominent evaporite horizons and subsidiary shales and sandstones. A transect across the platform shows changes in facies and increase in thickness from inner platform sequences in Inglefield Land and Bache Peninsula, to the south, to outer platform sequences in the Judge Daly Promontory area; clastic trough deposition characterises sections in northern Ellesmere Island. This paper briefly describes and correlates these sequences occurring around Kane Basin. The regional framework and close similarity of Cambrian and Ordovician sequences in Greenland and Canada indicate that substantial transcurrent net displacement has not taken place along Nares Strait. Of special note are narrow belts of Ordovician evaporites which cross Nares Strait from Ellesmere Island into Greenland without displacement at the present day. The continuity of these environmentally specialised belts of deposition demonstrates that net transcurrent displacement along Nares Strait since the Early Ordovician has not exceeded 50 km.

J. S. Peel, Grønlands Geologiske Undersøgelse, Øster Voldgade 10, DK-1350 Copenhagen K, Denmark and R. L. Christie, Department of Energy, Mines and Resources, Geological Survey of Canada, Institute of Sedimentary and Petroleum Geology, 3303–33rd St. N.W., Calgary, Alberta, Canada, T2L 2A7.

The Cambrian and Ordovician strata discussed here were deposited on a broad marine platform, the Arctic Platform, located between the Precambrian Shield to the south-east, and the Franklinian Trough of Ellesmere Island and northern Greenland to the north and north-west (Fig. 1). This platform regime corresponds to the Central Stable Region (the inner platform) and the Franklinian miogeosyncline (the outer platform) of Kerr (1967a: fig. 2). In general, the Cambrian and Ordovician sequence of the platform is rich in carbonates and thickens away from the Precambrian Shield towards the clastic trough sequence to the north. Basal Cambrian sandstones and conglomerates and thick Ordovician evaporites are present with the carbonates, and there is considerable variation in thickness and facies.

A transect through the Cambrian and Ordovician of the platform is best demonstrated in Ellesmere Island (Figs 2 and 3) where inner platform sequences on Bache Peninsula (Christie 1967) pass northward into outer platform sequences on Judge Daly Promontory (Kerr 1967a, b, c, 1968) and, finally, into Franklinian Trough sequences in the Hazen Plateau region (Trettin 1971, Trettin & Balkwill 1979, Trettin et al. 1979). Inner platform deposition in adjacent Greenland is well represented by sequences in Inglefield Land and southern Washington Land, but deposits of the outer platform are covered by overlying Silurian strata (see Hurst & Kerr, this volume). At the northern extremity of Nares Strait, Cambrian and Ordovician strata outcrop in the northern parts of Hall Land, Nyeboe Land and Wulff Land (Dawes, this volume, Hurst & Kerr, this volume) and in the latter two areas these rocks have been interpreted as indicative of the transition from the outer platform to the trough.

Cambrian and Ordovician platform stratigraphy in northern Greenland

The oldest Cambrian sediments occurring in platform sequences in Greenland adjacent to Kane Basin are sandstones with subsidiary conglomerates and siltstones of the Dallas Bugt Formation in Inglefield Land, and the Humboldt Formation of Washington Land (Figs 3–5). Older Cambrian strata may occur in the Nyeboe Land – Wulff Land area within the Nyeboe Land fault zone (Dawes, this volume). To the east in Wulff Land and Peary Land (Fig. 1) equivalent sandstones are given the name Buen Formation (Fig. 5) and are underlain by Lower Cambrian dolomites of the Portfjeld Formation

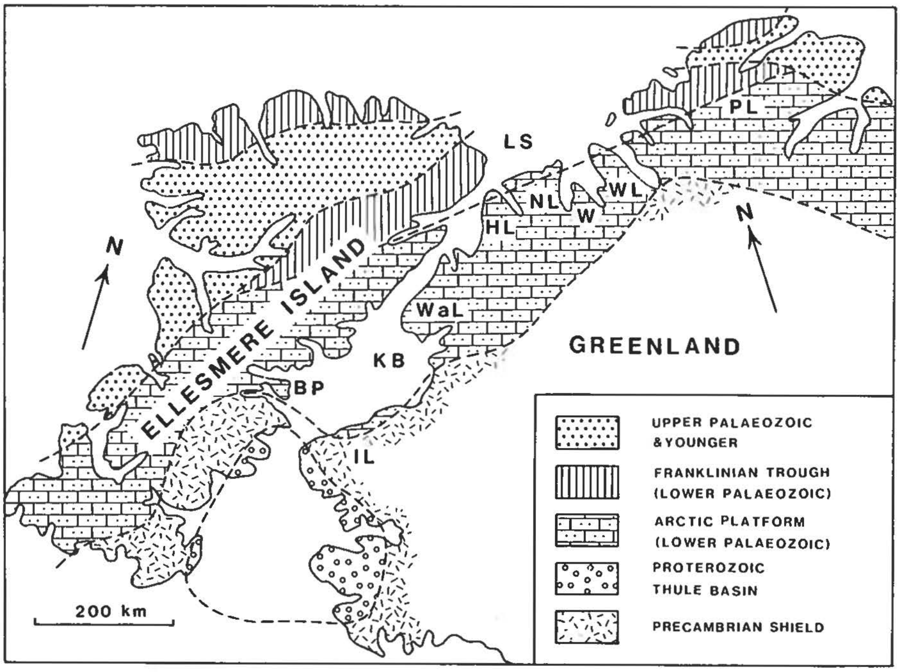


Fig. 1. Main structural units of North-West and North Greenland and Ellesmere Island. BP, Bache Peninsula; IL, Inglefield Land; KB, Kane Basin; WaL, Washington Land (including Daugaard-Jensen Land); HL, Hall Land; NL, Nyeboe Land; W, Warming Land; WL, Wulff Land; PL, Peary Land; LS, Lincoln Sea.

(Jepsen 1971, Hurst & Peel 1979, Ineson & Peel 1980). The absence of the Portfjeld Formation to the west of Wulff Land is attributed to overstep by the overlying clastics as the Cambrian sea transgressed on to the Precambrian Shield.

The Dallas Bugt Formation (maximum thickness 145 m) overlies late Proterozoic clastics and Precambrian crystalline rocks in Inglefield Land, Greenland (Fig. 6), and on Bache Peninsula, Ellesmere Island. It is more fully discussed elsewhere in this volume (Peel et al.). The equivalent Humboldt Formation of Washington Land (Fig. 4) is slightly thicker, but is also reported to overlie crystalline basement immediately north of the Humboldt Gletscher (B. R. Pelletier in Palmer & Peel 1981: 7). Both these formations contain *Skolithos* and *Cruziana/Rusophycus,* although the uppermost beds of the Humboldt Formation have also yielded an olenellid trilobite indicative of an Early Cambrian age.

Well-bedded dolomites of the Kastrup Elv Formation, 140 m thick and of Early–Middle Cambrian age, overlie the Humboldt Formation in Washington Land (Figs 4 and 5) (Henriksen & Peel 1976). The overlying Telt Bugt Formation (Middle Cambrian) consists of 5–100 m of thin-bedded lime mudstones with silty mottling and laminations. To the south-west (Figs 3 and 4), these two formations are correlated with the Cape Leiper, Cape Ingersoll, Wulff River, Cape Kent and Cape Wood Formations of Inglefield Land (C. Poulsen 1927, Koch 1929b, 1933, Troelsen 1950, V. Poulsen 1964). The Cape Kent Formation forms a distinctive marker unit of oolitic limestone in both Inglefield Land and Bache Peninsula (Fig. 6). Limestones of the underlying Wulff River Formation (Early Cambrian) and the overlying Cape Wood Formation (Middle Cambrian) are lithologically indistinguishable from those of the Telt Bugt Formation, demonstrating the diachronous boundary between a lower dolomite facies and an upper limestone facies in the Lower and Middle Cambrian around Kane Basin (Fig. 4).

The Cass Fjord Formation (Poulsen 1927) has recently been redescribed in the type area of southern Washington Land (Figs 1, 3 and 7) where it attains a thickness of up to 470 m (Henriksen & Peel 1976, Peel & Cowie 1979, Palmer & Peel 1981). Grey-green, lenticular lime mudstones with thin beds of intraformational conglomerate are characteristic, but a variety of thin-bedded carbonates are present, together with evaporites and thin quartzites. The Cass Fjord Formation, which also occurs in Inglefield Land (Troelsen 1950) and on Bache Peninsula (Christie 1967), has previously been considered to be entirely of Ordovician age. However, Late Cambrian (Dresbachian, Franconian and Trempealeauan) trilobites occur through most of the thickness in Greenland (Henriksen & Peel 1976, Palmer & Peel 1981); a few tens of metres at the base and top of the formation are of Middle Cambrian and Early Ordovician age.

The Cambrian sequence in Peary Land to the east (Figs 1 and 5) bears little similarity to the Washington Land and Inglefield Land sequence described above. The Buen Formation can be correlated with the Humboldt and Dallas Bugt Formations, but rocks equivalent to the Portfjeld Formation of Peary Land have not been recognised adjacent to Nares Strait. Overlying Lower,

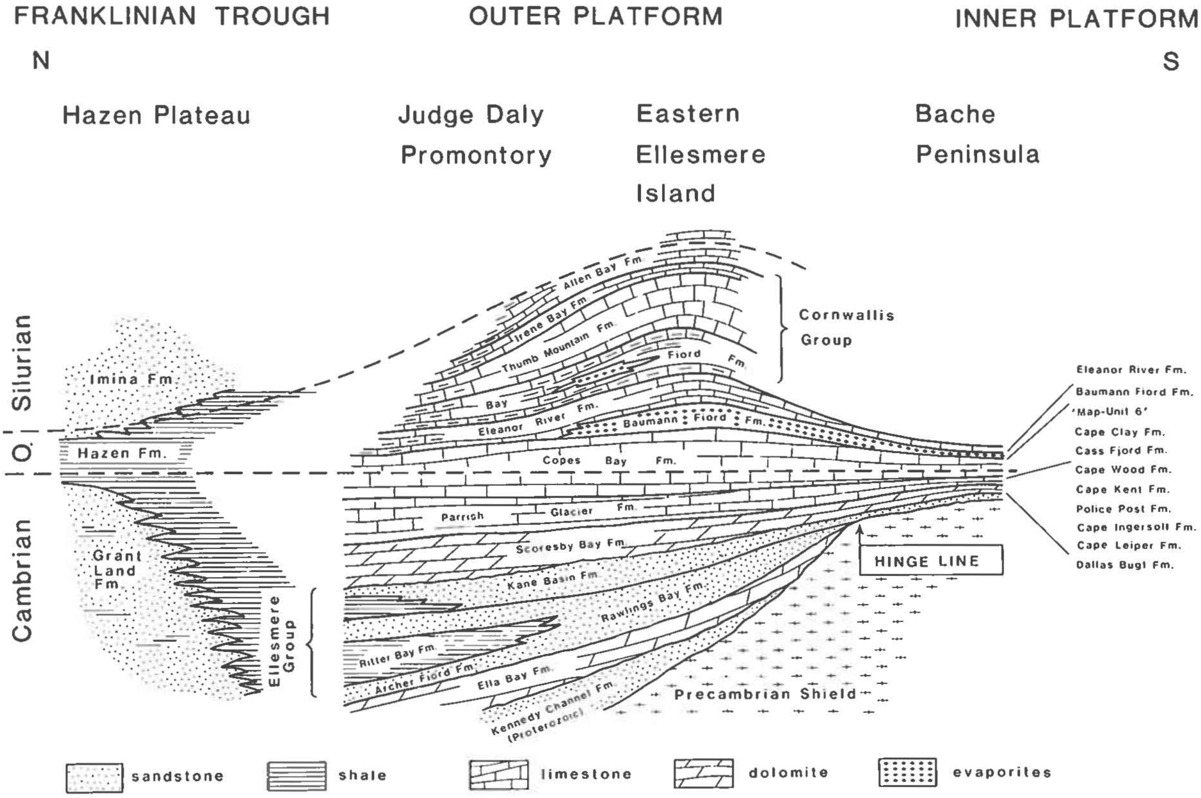


Fig. 2. Schematic geological section through the Cambrian and Ordovician of Ellesmere Island showing the transition from the Arctic Platform into the Franklinian Trough. Thin carbonate sequences of the inner platform (Bache Peninsula) pass through thick carbonate-dominated sequences of the outer platform (eastern Ellesmere Island and Judge Daly Promontory) into clastic sequences of the trough (Hazen Plateau).

Middle and Upper Cambrian carbonates and subsidiary clastics in Peary Land are referred to the Brønlund Fjord and Tavsens Iskappe Groups, which have a combined thickness of almost 1 km. Early Middle Cambrian faunas (*Glossopleura, Clavaspidella*), present in western North Greenland, are absent in Peary Land, apparently as a result of the widespread regional unconformity of the Hawke Bay Event (Palmer & James 1980). Only Dresbachian strata are as yet demonstrated within the Upper Cambrian sequence of Peary Land, although higher mainly unfossiliferous strata within the Tavsens Iskappe Group may extend into the Franconian or Trempealeauan. The Brønlund Fjord and Tavsens Iskappe Groups essentially form a south–north prograding sequence on the southern margin of the Greenland segment of the Franklinian Trough (Ineson 1980, Surlyk et al. 1980). The two groups are subdivided into 13 formations, reflecting pronounced lateral variation and diachronism (Ineson & Peel 1980).

The Ordovician sequence in Washington Land, more than 1 km thick, is divided into 12 formations, in sharp contrast with that in Peary Land where the platform Ordovician is referred to only three formations with a total thickness of about 850 m (Fig. 5). The uppermost Early Ordovician beds of the Cass Fjord Formation are succeeded by pale, massive weathering limestone of the Cape Clay Formation (50 m) (Fig. 7) yielding a rich fauna of Early Ordovician age. The Christian Elv Formation (Fig. 8) is a banded unit some 140 m in thickness, consisting of grey limestones, intraformational conglomerates, dolomites and cross-bedded sandstones (Henriksen & Peel 1976). Early Ordovician fossils are common in the middle part.

The Poulsen Cliff Formation (Figs 8 and 9), a recessive unit of shales, dolomites and thin sandstones with conspicuous beds of evaporites, is about 100 m thick in central southern Washington Land, but appears to increase in thickness by about one third in more western outcrops. The Nygaard Bay Formation (Fig. 9) is about 40 m thick on the south coast of Washington Land and can be sub-divided into a lower resistant unit (20 m) of thin intraformational limestone conglomerates and limestones, and an upper evaporitic unit (20 m). The Canyon Elv Formation (Fig. 9), the former Cape Weber Formation of Troelsen (1950, see Peel & Cowie 1979), is a 50 m thick unit of purple-tinged, grey limestones

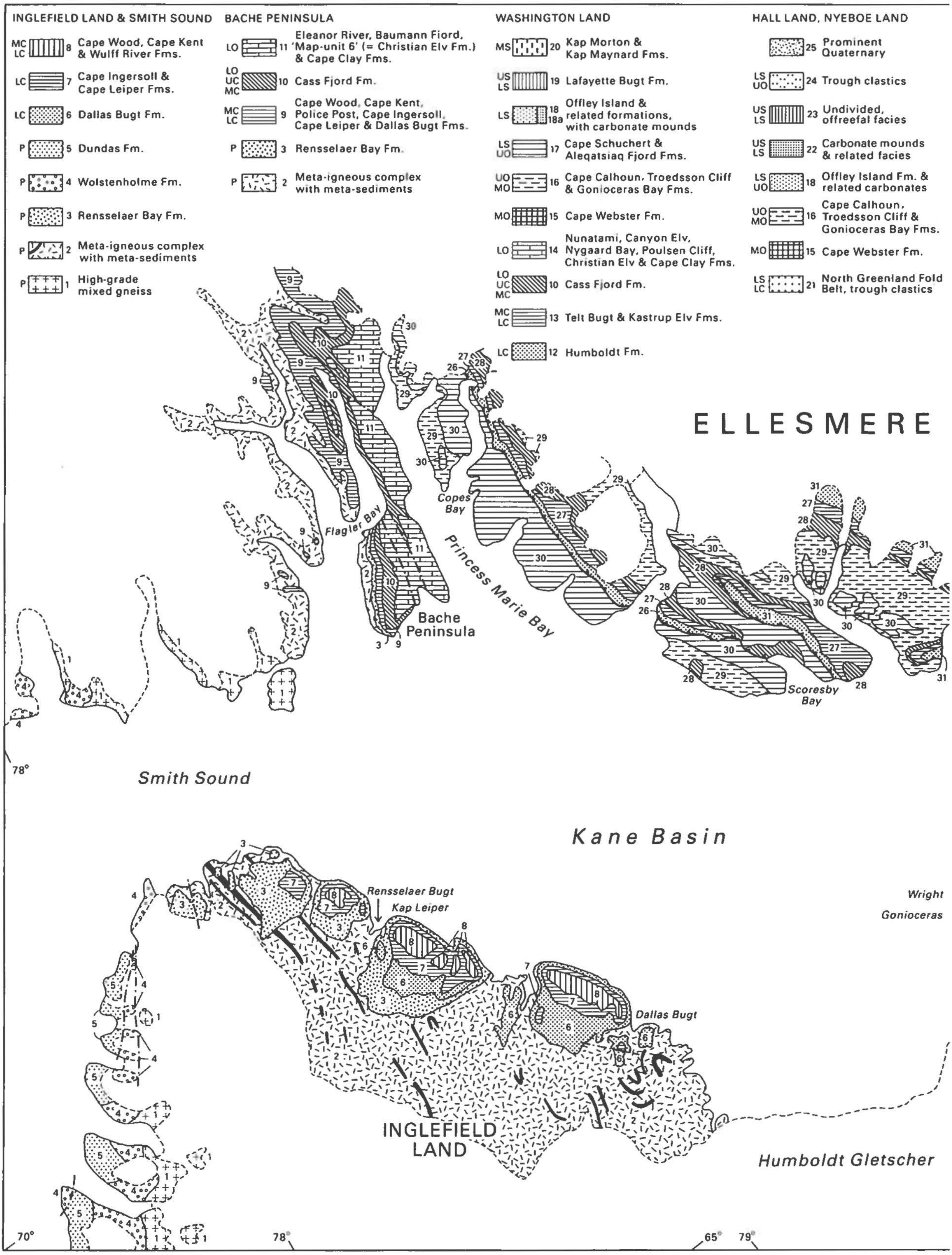
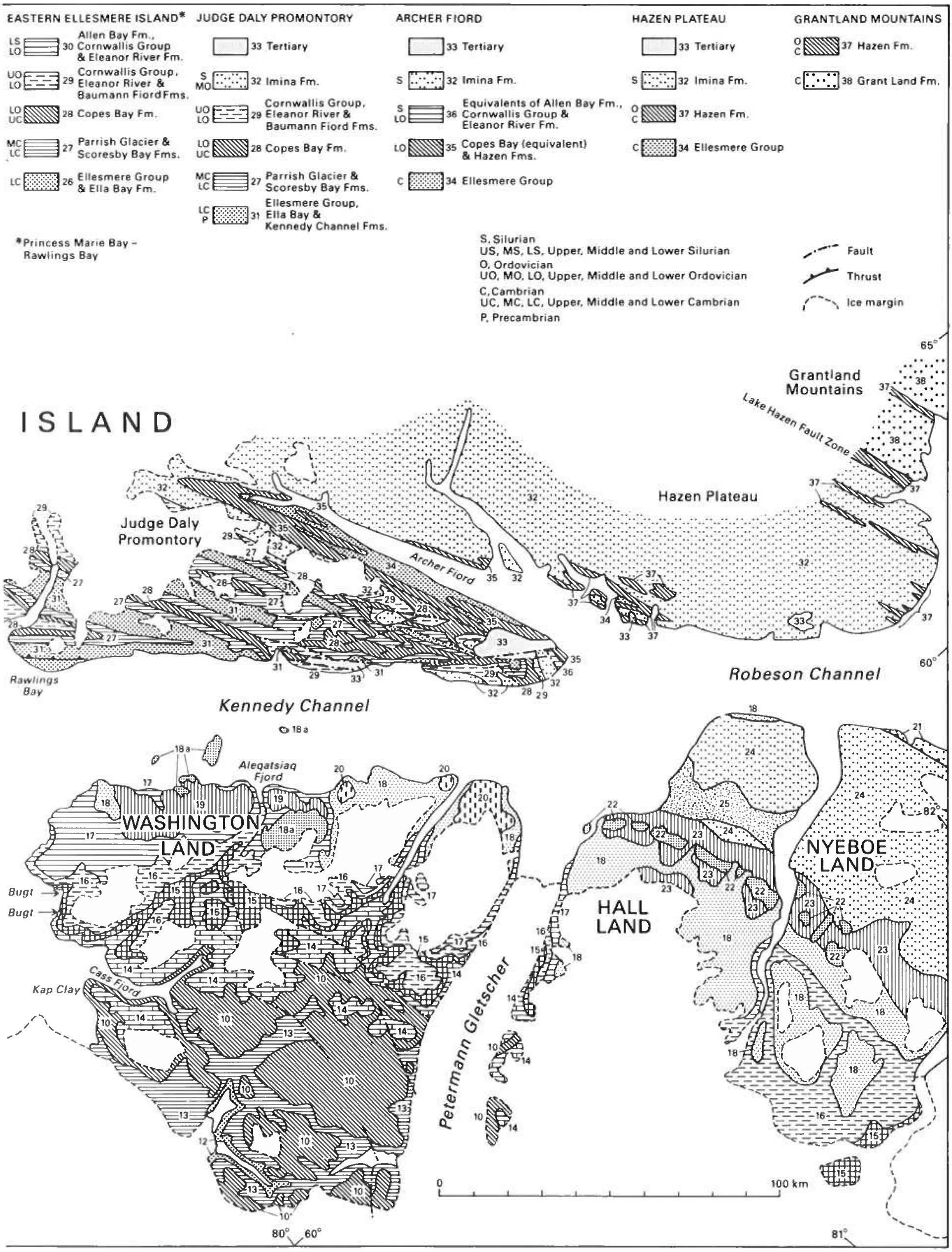


Fig. 3. Geological map of the Nares Strait region drawn from published and unpublished GGU and GSC sources. Main unpub-
Sea, map at 1:250 000 by H. P. Trettin, 1981.



lished sources: Greenland, map at 1:1 000 000 by P. R. Dawes, 1980; Canada, north-west Judge Daly Promontory to Lincoln

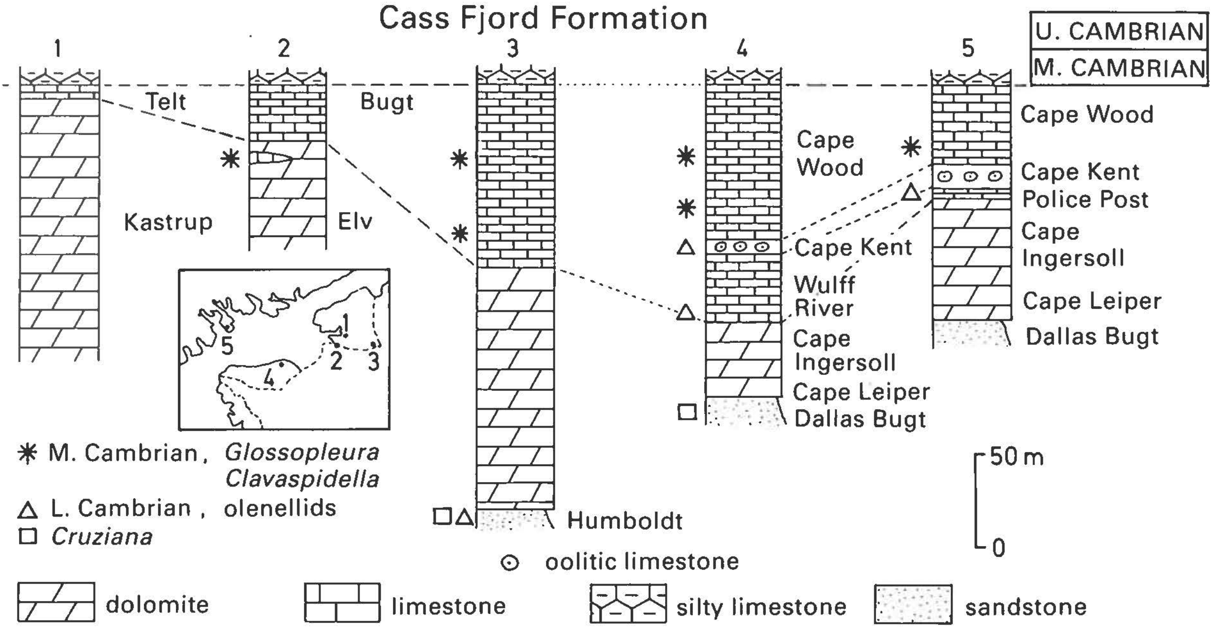


Fig. 4. Lower and Middle Cambrian stratigraphy around Kane Basin showing the diachronous relationship between dolomite and overlying limestone facies. Localities 1–3, Washington Land; 4, Inglefield Land; 5, Bache Peninsula.

which outcrop in the foot of the prominent cliff formed by the overlying Nunatami Formation (160 m). The latter formation is a richly fossiliferous (Poulsen 1927), well-bedded unit of thin- to medium-bedded, grey weathering limestones and intraformational limestone conglomerates of late Early Ordovician age.

The Cape Webster Formation (c. 280 m) is a poorly exposed and generally recessive unit of pale, thin-bedded evaporites, shales, dolomite and greenish siltstones of early Middle Ordovician age (Fig. 10), overlain by cliff-forming, dark weathering limestones of the Morris Bugt Group (Peel & Hurst 1980). The latter (Fig. 11A, B) contains the revised Gonioceras Bay, Troedsson Cliff and Cape Calhoun Formations, and the Aleqatsiaq Fjord Formation (Hurst 1980, see also Hurst & Kerr, this volume). The Gonioceras Bay Formation (c. 75 m) and the Troedsson Cliff Formation (c. 250 m) are brownish weathering, brown or grey lime mudstones. The former tends to be massive weathering, while the latter typically consists of alternating 1 m thick beds of nodular, rubbly weathering limestones and more massive, prominent, nodular limestones. The overlying Cape Calhoun Formation (c. 65 m) is a distinctive greenish weathering unit of pale grey lime mudstone with green shaly partings (Fig. 11B). These three formations have yielded rich Middle and Upper Ordovician faunas (Troedsson 1926, 1928). The Aleqatsiaq Fjord Formation (250 to 360 m thick) ranges in age from Late Ordovician to earliest Silurian (Hurst 1980). The formation is cliff-forming and composed mainly of grey-brown weathering lime mudstones and wackestones.

The Ordovician platform sequence of Peary Land lacks strata of early and middle Early Ordovician age (Fig. 5). The Wandel Valley Formation rests unconformably on the Late Cambrian Tavsens Iskappe Group or older units, and its lower beds are correlated on the basis of the occurrence of *Ceratopea unguis* with the Nunatami Formation of Washington Land of late Early Ordovician age (Peel & Yochelson 1979). The Cape Webster Formation of Washington Land can be traced eastwards to Warming Land (Peel 1980) where it is equivalent to the upper two thirds of the Wandel Valley Formation (350 m), although the latter lacks evaporites. The transition from recessive, dolomitic strata below to cliff-forming limestones, witnessed by the transition from the Cape Webster Formation to the Morris Bugt Group in Washington Land, can similarly be traced to Peary Land where the Wandel Valley Formation is succeeded by the Børglum River Formation (450 m). The latter cannot be subdivided in a similar manner to the Morris Bugt Group, but it has a generally similar lime mudstone lithology. The Ordovician–Silurian boundary in Peary Land lies within a dolomite unit, the un-named Silurian(?) dolomite formation of Christie & Peel (1977) and Armstrong & Lane (1981).

Cambrian and Ordovician platform stratigraphy of Bache Peninsula

The stratigraphic nomenclature of the Cambrian and Ordovician sequence on Bache Peninsula employs a number of names originally defined in adjacent Greenland, reflecting field work undertaken in both areas by Troelsen (1950). Subsequent description by Christie (1967) forms the basis of the present discussion.

Cambrian sandstones and conglomerates, the Sverdrup and Bache Peninsula Members of Christie (1967) now referred to the Dallas Bugt Formation (Collinson et al. in press, Peel et al., this volume), overlie late Proterozoic sandstones with basic intrusions of the Rensselaer Bay Formation and, ultimately, the crystalline basement. Dolomites of the Cape Leiper and Cape Ingersoll Formations (Figs 2, 4 and 12), formally named by Troelsen (1950) in Inglefield Land, also occur on Bache Peninsula. The overlying Police Post Formation, a grey-green arenaceous limestone (4–5 m), was not recognised in Greenland by Troelsen (1950: 38) but can be readily correlated with the Wulff River Formation on account of similar late Early Cambrian age and stratigraphic position between the Cape Ingersoll Formation and the overlying Cape Kent Formation. The distinctive marker unit of dolomite, sometimes oolitic, formed by the Cape Kent Formation in Inglefield Land (Fig. 6), was also noted by Troelsen (1950) on Bache Peninsula (Fig. 12) where Christie (1967) noted a thickness of 10–15 m.

		EASTERN ELLESMERE ISL.	WASHINGTON LAND	PEARY LAND
Sil.		Allen Bay	Aleqatsiaq Fjord	dolomite
ORDOVICIAN	U.	Irene Bay	Cape Calhoun	Børglum River
		Thumb Mountain	Troedsson Cliff	
			Gonioceras Bay	
	M	Bay Fiord	Cape Webster	Wandel Valley
		Eleanor River	Nunatami	
			Canyon Elv	
	L.	Baumann Fiord	Nygaard Bay	
			Poulsen Cliff	
		Copes Bay	Christian Elv	
			Cape Clay	
CAMBRIAN	U		Cass Fjord	Tavsens Iskappe Group
	M	Parrish Glacier	Telt Bugt	Brønlund Fjord Group
		Scoresby Bay	Kastrup Elv	
	L.	Ellesmere Group	Humboldt	Buen
		Ella Bay		Portfjeld

Fig. 5. Correlation of Cambrian–Ordovician platform sequences in eastern Ellesmere Island, Washington Land (western North Greenland) and Peary Land (eastern North Greenland).

The Cape Wood Formation (Middle Cambrian) is at least 40 m thick on Bache Peninsula (Fig. 12) and consists of a grey-brown, brown weathering dolomite and limestone. Faunas of this and other units have been described and compared to Greenland faunas by Poulsen (1946). Troelsen (1950: 48) commented that

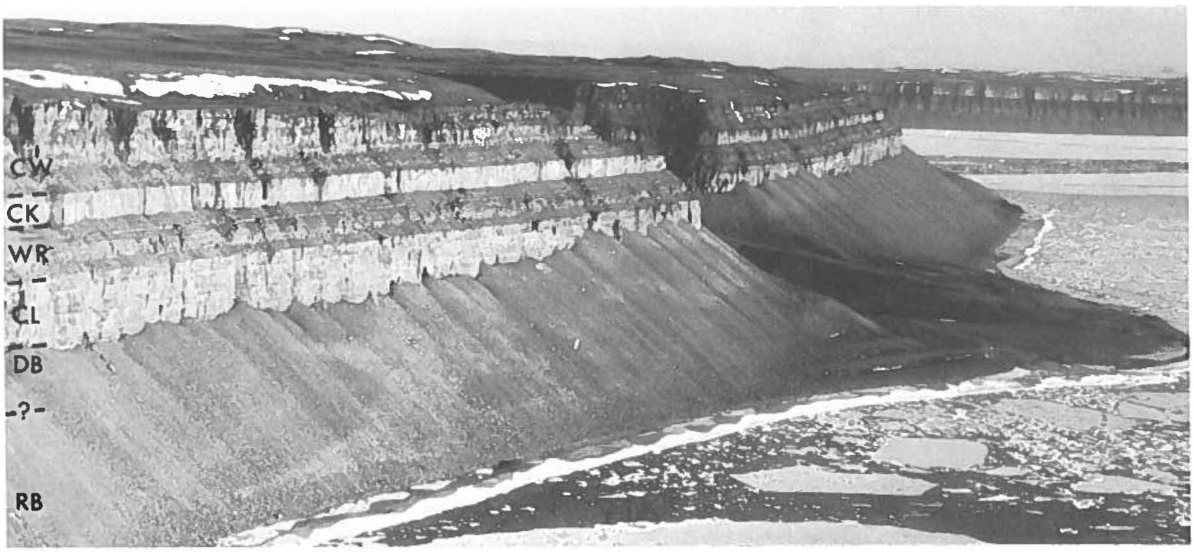


Fig. 6. Cambrian carbonates overlying Lower Cambrian sandstones of the Dallas Bugt Formation (DB) and Proterozoic sandstones of the Rensselaer Bay Formation (RB), view looking south-west toward Kap Leiper, with Rensselaer Bugt beyond, Inglefield Land. CL, Cape Leiper and Cape Ingersoll Formations; WR, Wulff River Formation; CK, Cape Kent Formation; CW, Cape Wood Formation. The closely similar sequence on Bache Peninsula is illustrated in Fig. 12, where the Police Post Formation is equivalent to the Wulff River Formation.

Fig. 7. Cambrian and Lower Ordovician carbonates, innermost Cass Fjord, Washington Land. Resistant Ordovician limestones of the Cape Clay Formation and uppermost Cass Fjord Formation (CC) overlie the Middle–Upper Cambrian Cass Fjord Formation (CF) and dolomites of the Lower–Middle Cambrian Kastrup Elv Formation (KE). The Cass Fjord Formation is about 450 m thick in this section. Horizons a and b in the Cass Fjord Formation can be recognised in Fig. 13, Flagler Bay, Ellesmere Island.

"there can be no reasonable doubt about the identity of the limestone and conglomerates [above the Cape Wood Formation on Bache Peninsula] with the Cass Fjord formation of southern Washington Land ...". The formation attains a thickness of about 450 m at Flagler Bay (Fig. 13), similar to the thickness in Washington Land (Fig. 7). However, the upper two thirds of this unit, together with younger Cambrian and Ordovician formations, are not preserved in Inglefield Land.

The Cape Clay Formation (Early Ordovician) consists of about 90 m of pale, cliff-forming dolomite (Fig. 13). This is almost twice the thickness recorded from near the type section in southern Washington Land where original limestone persists (Fig. 7). However, dolomitised Cape Clay Formation is also present in Washington Land, east of the Cass Fjord area, and Poulsen (1946) has stressed the close faunal similarity between outcrops of this formation on both sides of Nares Strait.

Fig. 8. Lower Ordovician strata near the head of Cass Fjord, Washington Land. Pale weathering, evaporite-rich Poulsen Cliff Formation (PC) overlying banded limestones, dolomites and sandstones of the Christian Elv Formation (CE, 140 m thick) and pale limestones of the Cape Clay Formation (CC).

Christie (1967) referred about 90 m of limestones conformably overlying the Cape Clay Formation to 'Map-unit 6' (Fig. 2) and suggested a correlation with some or all of the Poulsen Cliff Formation to the Nunatami Formation sequence recorded by Troelsen (1950) from southern Washington Land. It is now evident that 'Map-unit 6' can be referred to the Christian Elv Formation (Fig. 8) of Henriksen & Peel (1976), the existence of which was unknown to Troelsen (1950) and Christie (1967).

Christie (1967) referred gypsum-rich strata overlying 'Map-unit 6' (Fig. 14) to the Cornwallis Group but in a footnote (p. 49) commented that this correlation on the basis of the gypsum horizon was even then known to be

Fig. 9. Lower Ordovician strata, north side of Cass Fjord, Washington Land. Cliff-forming limestones of the Nunatami Formation (N) and the Canyon Elv Formation (CE) overlying evaporite-rich carbonates and shales of the Nygaard Bay Formation (NB) and the Poulsen Cliff Formation (PC). The evaporites of the Poulsen Cliff Formation and the upper Nygaard Bay Formation are separated by dark, cliff-forming limestones of the lower Nygaard Bay Formation (c. 20 m in thickness). An equivalent section on Bache Peninsula is shown in Fig. 14, where evaporite-bearing strata are referred to the Baumann Fiord Formation.

Fig. 10. Lower–Middle Ordovician sequence at Gonioceras Bugt (left of picture), southern Washington Land. Cliff-forming, dark limestones of the Gonioceras Bay Formation (GB) overlie the pale, recessive, evaporite-bearing Cape Webster Formation (CW). Equivalent evaporites in Ellesmere Island are referred to the Bay Fiord Formation. Cliffs in the foreground (c. 200 m) capped by limestones of the Nunatami Formation (N) show the sequence illustrated in Fig. 9. Aerial photograph 545K$_1$–SØ, no. 2301; copyright Geodætisk Institut, Denmark.

incorrect. Member A of the Cornwallis Formation as used by Christie (1967) is referred to the Baumann Fiord Formation, while Member B is referred to the Eleanor River Formation; both units are discussed below.

Cambrian and Ordovician platform stratigraphy of eastern Ellesmere Island and Judge Daly Promontory

The following account of Cambrian and Ordovician stratigraphy in eastern Ellesmere Island and Judge Daly Promontory draws heavily on the studies of Kerr (1967a, b, c, 1968).

Cambrian strata include the Ellesmere Group (the Archer Fiord, Ritter Bay, Rawlings Bay and Kane Basin Formations), the Scoresby Bay and Parrish Glacier Formations and the lower part of the Copes Bay Formation (Figs 2 and 5). These units have been correlated with some confidence with distinctly thinner units on Bache Peninsula (Kerr 1967b, c), discussed in the previous section (Fig. 2).

The Lower Cambrian Ellesmere Group (140–1400 m) rests with regional angular unconformity upon the predominantly carbonate Ella Bay Formation. Kerr (1967b) considered this latter unit to be of late Proterozoic age, but a correlation with the Early Cambrian Portfjeld Formation of Greenland is possible (Fig. 5). The Ellesmere Group is everywhere marked at its base by a basal pebble conglomerate or by sandstone. A gradation occurs from rather pure quartzose sandstone in the south-east to shalier sandstones and ultimately to shaly sandstones and black phyllite toward the north-west, nearer to the axis of the trough (Fig. 2).

Near the former hinge line north of Bache Peninsula (Fig. 2) the Ellesmere Group consists of only two formations (the Rawlings Bay and Kane Basin Formations). The lower, Rawlings Bay Formation, contains coarse pebble conglomerates in this region: to the west it thickens and the lower part grades into black phyllites of the Ritter Bay Formation. The Archer Fiord Formation, quartz sandstone with pebbly beds at the base, underlies the Ritter Bay Formation to form a basal, north-westerly protruding tongue of the Rawlings Bay clastic unit. The Kane Basin Formation is a fine-grained, quartzose sandstone in the thin sections near Bache Peninsula and grades through shaly siltstone to black shales and phyllites in thicker sections to the north-west (Fig. 2).

Overlying the predominantly clastic Ellesmere Group

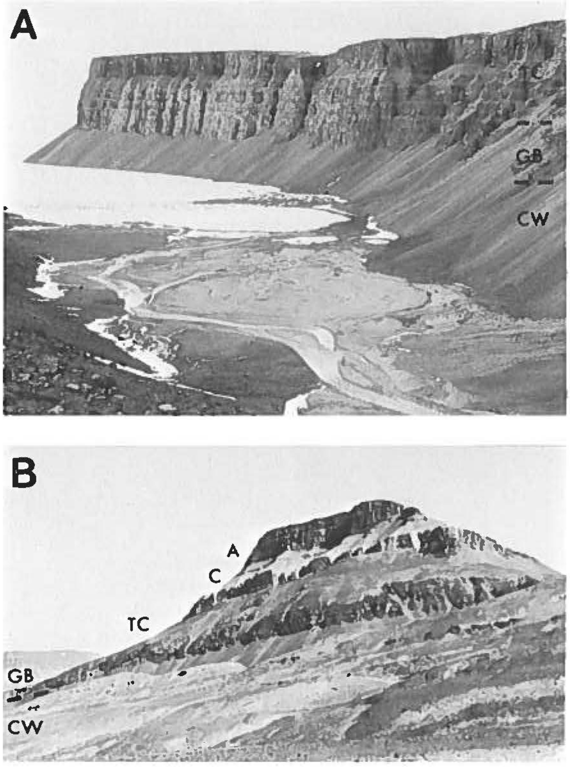


Fig. 11. Middle Ordovician – Silurian limestones of the Morris Bugt Group (GB, TC, C, A) overlying the Cape Webster Formation (CW), Washington Land. A: Gonioceras Bay (GB) and Troedsson Cliff (TC) Formations, Middle–Upper Ordovician, overlying the Cape Webster Formation (CW) at Wright Bugt, Washington Land. Height of the cliffs is in excess of 300 m. B: Gonioceras Bay (GB) and Troedsson Cliff (TC) Formations overlain by the recessive Cape Calhoun Formation (C) and the cliff-forming Aleqatsiaq Fjord Formation (A), Aleqatsiaq Fjord, Washington Land. Uppermost beds of the Aleqatsiaq Fjord Formation are of Early Silurian age. In Ellesmere Island, limestones of the Gonioceras Bay and Troedsson Cliff Formations are referred to as the Thumb Mountain Formation, while the recessive Cape Calhoun Formation is known as the Irene Bay Formation. The Aleqatsiaq Fjord Formation of Greenland is termed the Allen Bay Formation in Canada. Height of the section is c. 600 m.

is the Lower Cambrian Scoresby Bay Formation (260–860 m), composed mainly of limy, sugary, mottled dolomite (Figs 2 and 5). The Scoresby Bay Formation rests conformably on the Ellesmere Group except in northern exposures where it is locally unconformable. The formation thickens gradually and rather uniformly to the north-west across the platform.

The Parrish Glacier Formation (265–647 m) consists of a variety of brightly coloured, mainly carbonate lithologies. It conformably overlies the Scoresby Bay Formation and similarly thickens gradually and uniformly towards the north-west.

The Cambro-Ordovician boundary lies within the Copes Bay Formation (Figs 2 and 5) which was tentatively considered to be entirely Early Ordovician in age (Kerr 1968). Recently, however, faunas of Late Cambrian age have been discovered in the Copes Bay Formation and the equivalent Cass Fjord Formation of Greenland (Henriksen & Peel 1976, Mayr 1978, Peel & Cowie 1979, Palmer & Peel 1981). The Copes Bay Formation is a thick shallow water succession, mainly composed of limestone, argillaceous limestone, flat-pebble conglomerate and minor amounts of evaporites. The unit is thickest (1400 m) at the type section, about 30 km north of Bache Peninsula; it thins markedly southward, toward the craton, and more gradually northward, toward the trough. Its lithology is fairly uniform across the basin, but evaporites are most prominent (i.e. more and thicker evaporite beds) at the type section, which evidently lay near a basinal axis. Thin evaporites are also present in the equivalent Cass Fjord Formation of Washington Land (Henriksen & Peel 1976).

Ordovician to Early Silurian platform sedimentation west of Nares Strait was dominated by carbonate and evaporite deposition, with the Baumann Fiord and Eleanor River Formations, the Cornwallis Group, and the Allen Bay Formation overlying the Copes Bay Formation (Figs 2, 3 and 5).

The Baumann Fiord Formation, named in central Ellesmere Island (Fig. 16), is mainly evaporites (Fig. 14). The formation attains a maximum thickness of 475 m but thins to the north-west, across the platform and south-eastward toward the craton. The evaporites disappear north-eastward on Judge Daly Promontory, where they perhaps are in part replaced by a disconformity (Fig. 2). The Baumann Fiord Formation thus appears to be an elongated lens in form, the trend of the former basin paralleling the north-easterly regional structural direction (Fig. 15).

The nature of the north-western termination of the Baumann Fiord Formation is not well known at the present stage of knowledge. The possibility of a regional disconformity around the edge of the basin has been noted (Kerr 1968: 25), but it is clear that the Baumann Fiord Formation is equivalent to part of the (mainly) overlying Eleanor River Formation. An upper evaporitic member of the Baumann Fiord Formation (member C in Fig. 14) grades into the Eleanor River Formation, and the middle limestone member B is indistinguishable from, and passes into, the Eleanor River Formation. The very much thicker, lower evaporite member A passes into enclosing formations at the margin of the Baumann Fiord basin, at least in part by gradation. The north-eastern boundary of the evaporite facies crosses Nares Strait north of Rawlings Bay (see Fig. 15); it is represented in Washington Land by the Poulsen Cliff and Nygaard Bay Formations.

The Eleanor River Formation, a Lower and Middle Ordovician limestone unit that forms numerous prominent bluffs on Ellesmere Island (Fig. 14), overlies the Baumann Fiord Formation or, where evaporites are missing, the Copes Bay Formation. The Eleanor River

Fig. 12. The Lower–Middle Cambrian sequence, ravine behind 'Police Post', southern coast of Bache Peninsula. DB, Dallas Bugt Formation; CL, Cape Leiper Formation; CI, Cape Ingersoll Formation; PP, Police Post Formation; CK, Cape Kent Formation; CW, Cape Wood Formation. The similar sequence of Inglefield Land is illustrated in Fig. 6.

Formation is lensoid or trough-formed, similar to and parallel with the Baumann Fiord Formation and reaches a maximum thickness of about 1 km. The Eleanor River Formation thins north-westward both across the platform and south-eastward toward the craton in similar fashion to the underlying Baumann Fiord Formation. Whether or not the Eleanor River Formation is separated from the Copes Bay Formation by a disconformity on the outer platform is unclear: the units are structurally conformable and the Baumann Fiord Formation evaporites may be represented by basal beds of the Eleanor River Formation (Fig. 2).

The lithological characteristics of the Eleanor River (and other Ordovician units) change north-westward across Judge Daly Promontory toward the Franklinian Trough. However, the changes are gradual and the nature of the facies boundary is not yet fully known.

The youngest group of rocks considered here is the Cornwallis Group, which comprises three distinctive carbonate and evaporite units that conformably overlie the Eleanor River Formation. The succession of formations, from the lowest, is: the Bay Fiord Formation, recessive shaly limestone, siltstone, evaporites and dolomite; the Thumb Mountain Formation, cliff-forming dark grey limestone; and the Irene Bay Formation, recessive greenish weathering shaly limestone (Fig. 5). The Cornwallis Group ranges in age from Middle to early Late Ordovician. The equivalent formations in

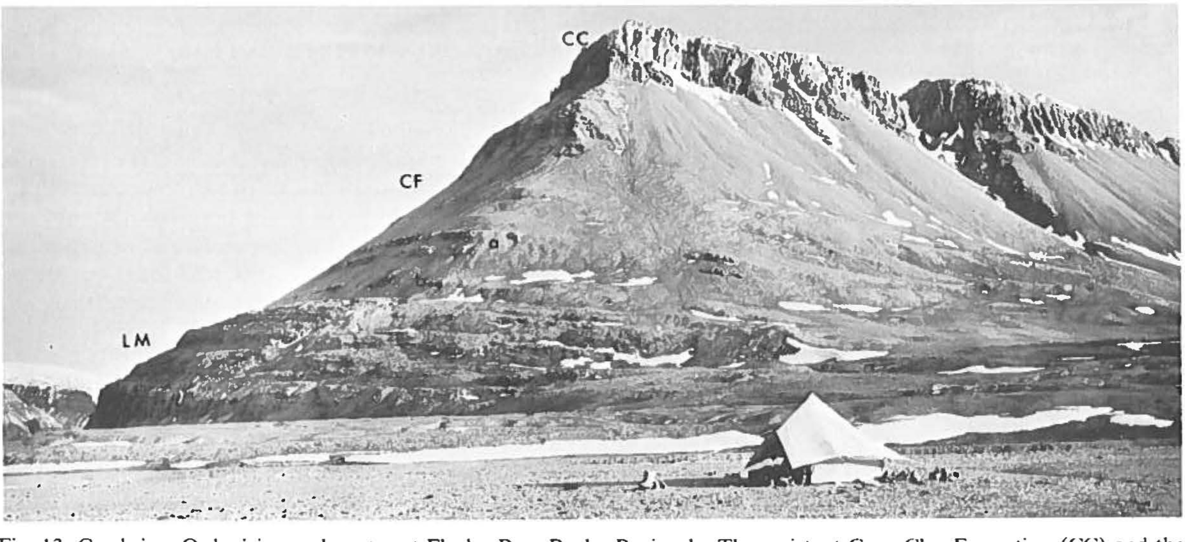


Fig. 13. Cambrian–Ordovician carbonates at Flagler Bay, Bache Peninsula. The resistant Cape Clay Formation (CC) and the uppermost Cass Fjord Formation form a cap-rock to pale, recessive outcrops of the Cass Fjord Formation (CF) and the Lower–Middle Cambrian carbonate sequence (LM) illustrated in Fig. 12. Horizons a and b can be recognised in Fig. 7 in Washington Land.

Fig. 14. Lower Ordovician evaporites of the Baumann Fiord Formation (BF), Sanddöla Creek, western Bache Peninsula. The recessive evaporite members A and C are separated by the cliff-forming member B. Cliff-forming carbonates of 'Map-unit 6' (M, equivalent to the Christian Elv Formation of Washington Land) and the Eleanor River Formation (ER) occur below and above, respectively, the 265 m thick evaporite formation. An equivalent section in Greenland is shown in Fig. 9, where the Eleanor River Formation is known as the Canyon Elv and Nunatami Formations and the Baumann Fiord Formation as the Poulsen Cliff and Nygaard Bay Formations.

Greenland showing characteristic weathering patterns are illustrated in Figs 10 and 11.

The Bay Fiord Formation (330–1100 m) exhibits marked lateral changes in lithology. A conspicuous evaporite component occurs in a narrow, north-east trending belt near the south-eastern margin of the platform (Fig. 2); limestone grades north-westward into shaly limestone and argillite in the north-western part of the platform, toward the trough. The Bay Fiord evaporite belt of Ellesmere Island is a narrowing north-eastern extension of a broad evaporite basin on Bathurst, Cornwallis and Devon Islands; in Greenland the evaporite basin is represented within the Cape Webster Formation (Figs 10 and 11).

The upper formations of the Cornwallis Group, the Thumb Mountain and Irene Bay Formations, form a somewhat lensoid body with an axis of maximum thickness trending north-east, parallel to earlier depositional trends. The depositional axis of the combined Thumb Mountain and Irene Bay Formations roughly coincides with that of the combined Eleanor River Formation and the Cornwallis Group. The Thumb Mountain Formation (150–600 m) becomes somewhat more shaly and less resistant in outcrop to the north-west, repeating in a less distinct way the 'shaling-out' feature of the underlying Bay Fiord Formation. The overlying Irene Bay Formation (36–83 m) similarly is replaced northward and westward by beds of dark grey to black shale and in places is indistinguishable as a separate formation of the Cornwallis Group. The Thumb Mountain Formation is equivalent to the revised Gonioceras Bay and Troedsson Cliff Formations of Washington Land (Peel & Hurst 1980); the Irene Bay Formation correlates with the Cape Calhoun Formation (Figs 5, 10 and 11).

Cambrian and Ordovician of the Franklinian Trough

Description of Cambrian and Ordovician trough sequences is beyond the scope of this paper and the brief discussion given here is only intended to supplement Figs 1–3. Recent summaries of the trough sequence in northern Ellesmere Island are given by Trettin & Balkwill (1979) and Trettin et al. (1979), and in Greenland by Dawes & Soper (1979), Soper et al. (1980), Surlyk et al. (1980), Friderichsen et al. (1982) and Higgins et al. (in press).

The Grant Land Formation of northern Ellesmere Island (Figs 2 and 3) is a thick sequence of alternating sandstones and phyllites, much of which was deposited by braided rivers. The boundary with the overlying Hazen Formation is strongly diachronous, from Early to Late Cambrian age, and the Grant Land Formation can be correlated with much of the Ellesmere Group of Judge Daly Promontory, to the south.

The Hazen Formation is a condensed sequence of carbonates, fine clastics and cherts which ranges in age from Early Cambrian to Early Silurian (Trettin et al. 1979). Its upper and lower boundaries are diachronous, the contact with the overlying turbidites of the Imina Formation being near the Ordovician–Silurian boundary.

Rocks of these three formations can be traced to the shores of Nares Strait. The same sequences, although referred to different formations, make up the trough succession across northern Greenland (Dawes & Soper 1979, Hurst & Surlyk 1980, Surlyk et al. 1980, Dawes, this volume, Surlyk, this volume).

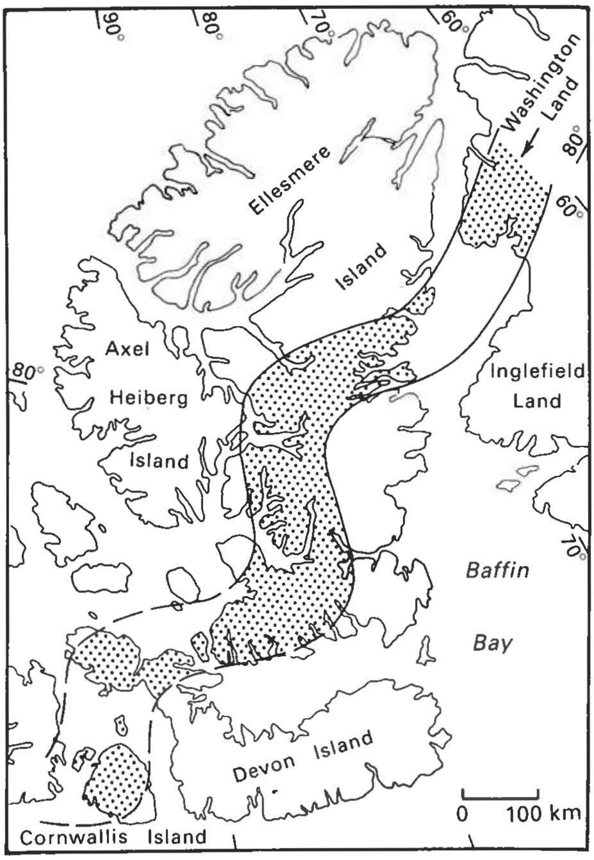


Fig. 15. Lower Ordovician evaporites of the Baumann Fiord Formation (Arctic Canada) and the Poulsen Cliff and Nygaard Bay Formations (North Greenland). Adapted from Mossop (1979).

Geological correlation across Nares Strait

The considerable similarity between Cambrian and Ordovician platform sequences on either side of Nares Strait is evident from even cursory examination of published accounts, and a ready correlation is possible (Fig. 5). Where geological field work has been undertaken across the Strait, the same stratigraphic terminology has been employed in both Greenland and Ellesmere Island (Troelsen 1950). If new information from the 'classic' sequences in Greenland, originally described by Koch (1925, 1929a, b, 1933), Troedsson (1926, 1928), Poulsen (1927) and Troelsen (1950), had been available to Kerr (1967a, b, c, 1968) it would undoubtedly have been possible to employ many of the older stratigraphic terms from Greenland in Ellesmere Island instead of formulating new names. The dual system of nomenclature also reflects the presence of a national frontier between Greenland and Ellesmere Island.

It is emphasised that much of the geological information available is of a regional character. However, such detailed studies as are currently on hand strengthen the correlation between Ellesmere Island and Greenland; a convincing example is the recent study by Mossop (1979) of Lower Ordovician evaporites forming the Baumann Fiord Formation in Ellesmere Island.

The Baumann Fiord Formation is subdivided into three members: member A is a thick, recessive, anhydrite-bearing unit; member B is a resistant limestone unit; member C is a thin, recessive anhydrite-bearing unit (Fig. 14). The formation is overlain by resistant limestones of the Eleanor River Formation. Member A of the Baumann Fiord Formation is correlated conclusively with the Poulsen Cliff Formation of Washington Land, while members B and C equate with the lower and upper members of the Nygaard Bay Formation (Fig. 9).

Mossop (1979) noted that the evaporites of the Baumann Fiord Formation extended in a narrow, sinuous belt some 1100 km long, from Cornwallis Island in the south-west to Ellesmere Island in the north-east (Fig. 15). Following the recognition of evaporites in the Poulsen Cliff Formation (Henriksen & Peel 1976), this

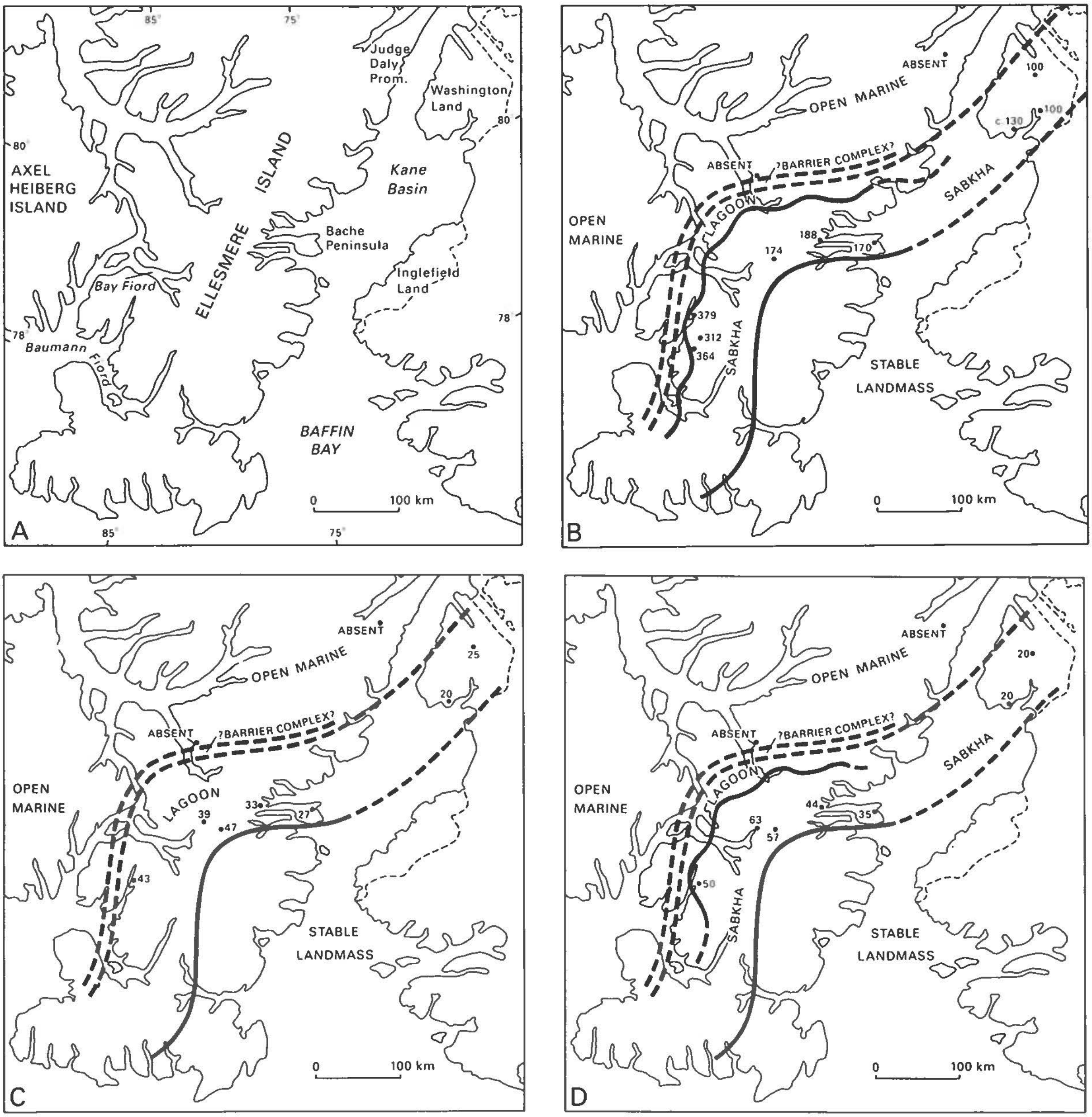


Fig. 16. Palaeogeography of Lower Ordovician evaporites in Ellesmere Island and adjacent Greenland. A: locality map; B: member A of the Baumann Fiord Formation of Ellesmere Island and the Poulsen Cliff Formation of Washington Land; C: member B of the Baumann Fiord Formation and the lower member of the Nygaard Bay Formation of Washington Land; D: member C of the Baumann Fiord Formation and the upper member of the Nygaard Bay Formation. In B and D evaporites were deposited on a sabkha plain passing seawards into a lagoon which formed behind a postulated barrier complex. In C lagoonal carbonates were deposited throughout the area with no accumulation of evaporites. Thicknesses in metres; the diagram is extended into Greenland from figs 24–26 of Mossop (1976).

distribution can now be extended some 250 km across Washington Land to Petermann Gletscher. Ice covers Ordovician outcrops to the east of Washington Land until the Warming Land and Wulff Land area of central North Greenland (Fig. 1); here evaporites of Early Ordovician age have not been recognised (Peel 1980).

Mossop (1979: figs 24–26) drew three palaeogeographic maps, one for each of the members of the Baumann Fiord Formation. These form the basis of Fig. 16 where recent, previously unpublished, information from the Poulsen Cliff and the Nygaard Bay Formations of Washington Land is included. Of particular note is the tendency for Washington Land units to be thinner, supporting the inference from Peel's (1980) observations that the evaporite basin is dying out toward the east. The continuity of the strata in question across Nares Strait is self-evident but it is unfortunate that Silurian cover prevents establishment of a north-western boundary to the evaporite-bearing sequence in Greenland of the type recognised in Ellesmere Island.

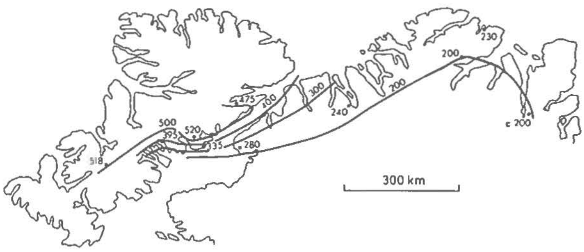


Fig. 17. Isopach map for the Bay Fiord Formation of Ellesmere Island and the Cape Webster Formation (and equivalents) of North Greenland showing the regional continuity of the Ordovician deposition across Nares Strait. Thicknesses in metres; sections in Ellesmere Island from Kerr (1967a, 1968).

The question of displacement along Nares Strait

The comparison and correlation of Cambrian and Ordovician platform sediments around Kane Basin contribute several parameters to the discussion of how much post-depositional, net transcurrent displacement, if any, has taken place between Ellesmere Island and Greenland.

1. Regional depositional framework

The close similarity between sections in Ellesmere Island and adjacent Greenland, discussed in the previous section, indicates that both regions formed part of the same sedimentary platform in Cambrian and Ordovician times. This platform has a wide regional extent but is relatively narrow, with a well-developed trough (the Franklinian Trough) forming its northern margin and crystalline basement rocks lying to the south. The continuity at the present day of these three components of the regional geology, the Franklinian Trough, the Arctic Platform and the Precambrian Shield, indicates that net sinistral displacement along Nares Strait of the order of 200 km or more has not occurred. This argues against conventional plate tectonic, sea-floor spreading models of the region (e.g. Keen et al. 1972, Herron et al. 1974, Sclater et al. 1977, Srivastava 1978, Srivastava et al. 1981, Srivastava & Falconer, this volume) as well as those interpretations of the geology of the Nares Strait region put forward in support of such models (e.g. Newman 1977, this volume, Newman & Falconer 1978, Miall 1981, Peirce, this volume).

2. Geological correlation

A feature of Cambrian and Ordovician sequences around Kane Basin is the close correlation between sections on the Canadian and Greenlandic sides of the basin (compare, for example, Figs 9 and 14). Thus, Cambrian sections on Bache Peninsula correlate most closely with those in Inglefield Land (Figs 4, 6 and 12). Correlation from Bache Peninsula south across Ellesmere Island is less satisfactory, as is correlation from Inglefield Land eastward to Washington Land and across North Greenland. Sections are readily correlated across the platform toward the Franklinian Trough, i.e. from the inner platform sequences of Bache Peninsula to the outer platform sequences of Judge Daly Promontory, but considerable changes in facies and thickness are evident (Fig. 2). This close similarity of Cambrian sequences on Bache Peninsula and in Inglefield Land, and decreasing ease of correlation away from Kane Basin, strongly suggests that these two areas were closely juxtaposed during Cambrian times and that they have not subsequently suffered large-scale net displacement.

It is clear that not all Cambrian and Ordovician stratigraphic units permit meaningful comment concerning transcurrent displacement along Nares Strait. In the Middle Ordovician, the incoming of limestones of the Thumb Mountain, Gonioceras Bay and Børglum River Formations (Fig. 5) is a regional event which can be recognised throughout much of the Canadian Arctic and Greenland. The limestones are uniform in character and can be traced unchanged over large distances, although they are absent from the Franklinian Trough. In the absence of detailed stratigraphic and sedimentological studies, comparison of these limestones across Kane Basin can neither confirm nor deny displacement along Nares Strait.

3. Isopach maps

Kerr (1967a) used isopach maps to compare sequences of Cambrian and Ordovician sediments around Kane Basin, although much information concerning general stratigraphy and thicknesses from Greenland at that time was of necessity derived from older imprecise literature. These maps can now be replotted, using new information from Greenland combined with Kerr's (1967b, c, 1968) data from Ellesmere Island, and a typical example is given here (Fig. 17, see also Peel et al., this volume: fig. 12). Few major departures from Kerr's maps were noted, but it soon became evident that comparison of isopach maps across Kane Basin at this regional scale could provide little *precise* evidence concerning displacement along Nares Strait. However, very large-scale displacements (200 km or greater) in a post-depositional sinistral sense are judged extremely unlikely. The lack of precise control concerning possible

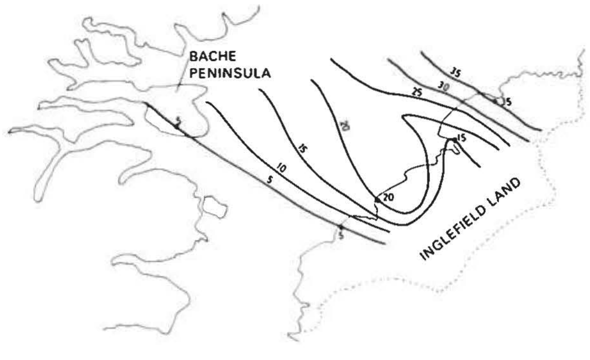


Fig. 18. Isopach for the Police Post Formation of Bache Peninsula and the Wulff River Formation of Inglefield Land. Thicknesses in metres.

displacement is partly due to the lack of 'down-dip' exposure of the Cambrian and Ordovician in Greenland where most exposures tend to follow the regional strike, and partly due to the large distances over which extrapolation is necessary.

More detailed isopach maps can play a role in assessing relationships across Nares Strait (Fig. 18). Again, large-scale movements can be ruled out, but the scarcity of control points at the present time can neither confirm nor deny smaller movements.

A relatively constant feature of the regional isopach maps (Fig. 17, Peel et al., this volume: fig. 12) is an embayment over western North Greenland. If it is rather unrealistically assumed that the basin of deposition originally had a straight margin, the embayment can be cited as evidence for substantial post-depositional dextral displacement of Greenland relative to Ellesmere Island. This sense of movement is opposite to that which could be inferred, equally unrealistically, from the northward swing in tectonic belts described by Higgins et al. (this volume). It is also opposite to the direction of net displacement invoked by proponents of large-scale displacement between Greenland and Ellesmere Island from the early ideas of Taylor (1910) and Wegener (1915) to modern plate tectonic pre-drift fits, for example of Srivastava (1978), Irving (1979), Miall (1981) and Srivastava & Falconer (this volume). The change in trend of the isopachs is clearly an original feature, as is the swing in tectonic trends discussed by Higgins et al. (this volume), and in part reflects the influence of the Bache Peninsula area as a tectonic high.

4. Lower Cambrian hinge line

A transect from Bache Peninsula northward through eastern Ellesmere Island to Judge Daly Promontory (Fig. 2) shows a rapid increase in thickness of Lower Cambrian sediments just north of Bache Peninsula. The Dallas Bugt Formation of the former area, deposited on the inner platform, passes into the outer platform Ellesmere Group, which is underlain by carbonates of the Ella Bay Formation, across a relatively well-developed hinge line. This hinge line is not so obvious in adjacent Greenland, due to cover by stratigraphically younger sediments. However, it is evident that the thin clastic sequences of the Dallas Bugt and Humboldt Formations in Inglefield Land and Washington Land lie to the south-east of the hinge line; carbonates equivalent to the Ella Bay Formation are also absent from Inglefield Land and Washington Land, as well as from Bache Peninsula.

The presence of inner platform Lower Cambrian sediments in southern Washington Land indicates that large-scale (200 km or more) post-depositional net dextral movement of Greenland relative to Ellesmere Island has not taken place. If such a movement had occurred it would be expected that thick clastic sequences of the outer platform would be preserved in southern Washington Land, as is patently not the case. Post-depositional sinistral displacement cannot be ruled out on this criterion alone. However, the inner platform clastics in Greenland thin rapidly from Washington Land to the south-west across Inglefield Land (see Peel et al., this volume: figs 3 and 12) in comparable fashion to thinning seen toward Bache Peninsula in Ellesmere Island. Displacement of 150 km or more would produce an unacceptable dislocation between the successions on either side of Nares Strait.

5. Ordovician evaporites

Evaporites are a conspicuous feature of the Lower and Middle Ordovician of Ellesmere Island and western North Greenland. Two units are present, represented by the Baumann Fiord, Poulsen Cliff and Nygaard Bay Formations (Figs 5, 8, 9, 14, 15 and 16) and by the Bay Fiord and Cape Webster Formations, respectively (Figs 5, 10, 11 and 17). Evaporites are the product of a specialised sedimentological environment and the stratigraphic continuity of these deposits from Ellesmere Island into North Greenland once again stresses the considerable geological similarity between the two regions.

The recent detailed study of the *Lower Ordovician* evaporites (Baumann Fiord Formation) in Ellesmere Island by Mossop (1979) is readily extended into Washington Land. Mossop considered that the evaporites were deposited on a sinuous sabkha plain approximately 100 km wide which can now be traced some 1350 km from Cornwallis Island in the south-west to Washington Land in the north-east (Figs 15 and 16). Equivalent evaporites occur throughout Washington Land from Kane Basin to Petermann Gletscher, within the Poulsen Cliff and Nygaard Bay Formations (Figs 3, 8 and 9).

The undoubted continuity of this relatively narrow sabkha plain from Ellesmere Island to Greenland places severe constraints on the magnitude of possible transcurrent movements along Nares Strait and suggestions

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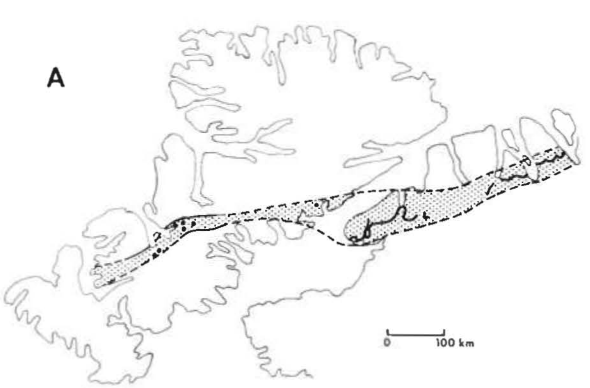

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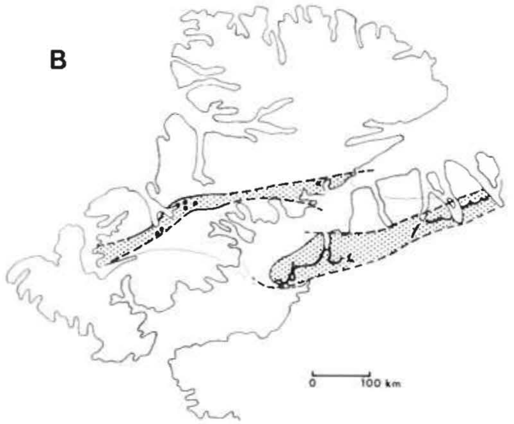

Fig. 19. Middle Ordovician evaporites of the Bay Fiord Formation (Ellesmere Island) and the Cape Webster Formation (Greenland). Outcrops in Greenland are indicated by solid black; sections with evaporites noted by Kerr (1968) in Ellesmere Island are indicated by black dots. A: present distribution; B: distribution with Greenland displaced 200 km dextrally. This totally unacceptable dislocation of the evaporite belt corresponds to the pre-drift position of Greenland relative to Ellesmere Island required by proponents of a 200 km sinistral displacement along Nares Strait. Conventional plate tectonic reconstructions of the region commonly invoke sinistral displacement of 200–300 km or more. Similar diagrams can be constructed for the Baumann Fiord Formation evaporite belt (Fig. 16), that also demonstrate the impossibility of these large-scale displacements.

of displacement of 200 km or more can be refuted. Natural reconstruction of the Lower Ordovician sabkha plain, taking full account of regional structural and environmental trends, requires no net displacement between Ellesmere Island and Greenland (Fig. 16). Minor sinistral displacement of the evaporite belt may have taken place, but it is judged that this movement, if present, could not have exceeded 50 km. This value is without positive geological support and merely reflects the inevitable limitations of any correlation across an area of this size.

The evaporites in the lower part of the *Middle Ordovician* Bay Fiord Formation of Ellesmere Island have not been subjected to the same detailed study as their Lower Ordovician counterparts. Kerr (1968) speculated that the Bay Fiord Formation could be correlated with the Cape Webster Formation of Greenland, although evaporites were not known at that time from this formation. Evaporites are now known to occur within the Cape Webster Formation from Washington Land to Wulff Land (Peel 1977, 1980), and the correlation is now secure. Kerr (1968: fig. 9) considered the Bay Fiord Formation evaporites to occur in a very narrow belt across Ellesmere Island, but the general recessive character of the formation, and consequent poor exposure, makes precise delimitation of such a belt difficult. In Washington Land white weathering evaporites are prominent at the base of the Cape Webster Formation as in Ellesmere Island, but darker coloured evaporites are diffused throughout the formation in strata which appear to be poorly exposed shales to a cursory glance. In the absence of more detailed observations it is not considered possible to delimit the evaporite belt as narrowly as Kerr (1968) would suggest, since data from the Canadian and Greenlandic sides are not strictly homogenous. However, the continuity of this specialised sedimentary environment from Ellesmere Island to Greenland refutes large-scale (200 km or more) net post-depositional sinistral displacement along Nares Strait (Fig. 19). Indeed, any sinistral displacement at all would be difficult to accommodate.

Conclusions

Correlation of Cambrian and Ordovician platform sequences around Kane Basin provides no evidence to suggest that net transcurrent displacement has occurred between Ellesmere Island and Greenland. The continuity of regional depositional environments evident from the close similarity of geological units on either side of Nares Strait refutes plate tectonic models invoking large-scale lateral displacements (200 km or more). The reconstruction of the Lower Ordovician evaporite basin permits a maximum net strike-slip displacement in either a sinistral or dextral sense of up to 50 km along Nares Strait, but even this value is a measure of tolerance within the model itself, rather than an indication that any movement has taken place.

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