Lithostratigraphy and geological setting of Upper Proterozoic shoreline-shelf deposits, Hagen Fjord Group, eastern North Greenland

Lars B. Clemmensen and Hans F. Jepsen

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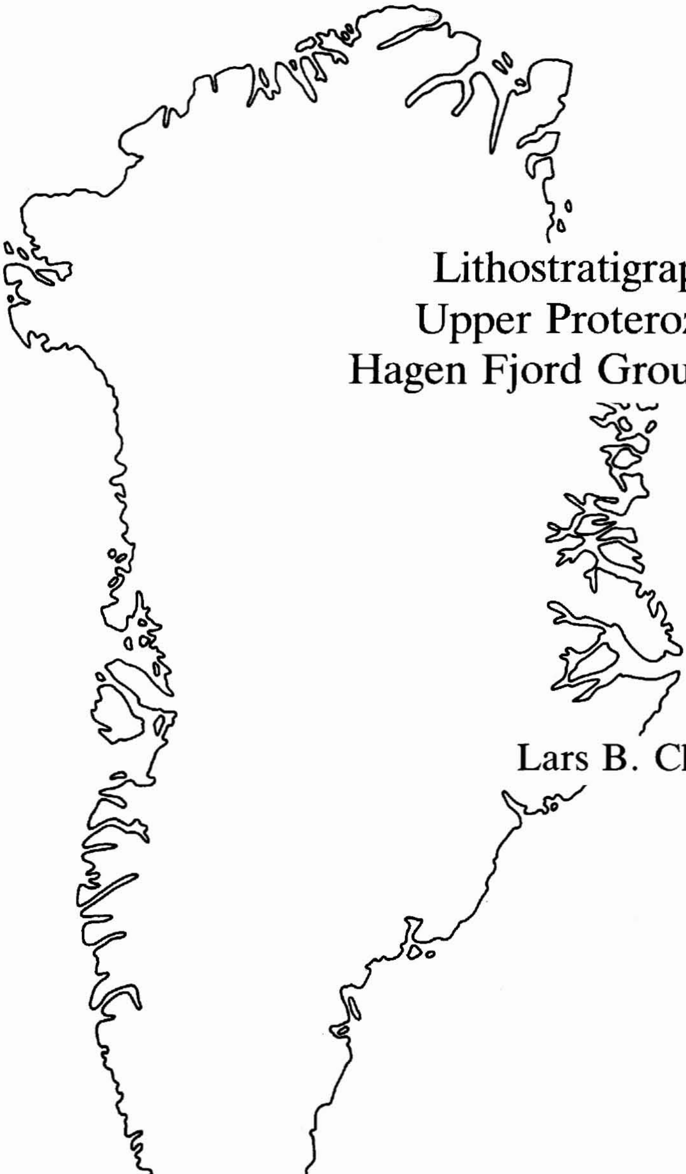

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During the Late Proterozoic a more than 1000 m thick succession of sediments was deposited on the shelf fringing the north-eastern corner of the Greenland craton. These sediments were classified together with an underlying turbidite sequence in the Hagen Fjord Group (Haller, 1961), which is here redefined to contain only Upper Proterozoic, mainly shallow marine shelf deposits outcropping between Independence Fjord and Kronprins Christian Land in eastern North Greenland. Both siliciclastic and carbonate sedimentation occurred during the Late Proterozoic, and the changing tectonic environment along the northern and eastern shelf-margin of Greenland at that time is well recorded within the sediment sequence. Correlation of the Hagen Fjord Group with similar shelf deposits elsewhere along the eastern and northern margin of the Canadian–Greenlandian Shield is discussed.

Authors' addresses:

L. B. C., Institute of General Geology, University of Copenhagen, Øster Voldgade 10, DK-1350 Copenhagen K, Denmark.

H. F. J., Geological Survey of Greenland, Øster Voldgade 10, DK-1350 Copenhagen K, Denmark.

Dansk sammendrag

Mod slutningen af Proterozoikum blev der på den marine shelf langs det nordøstlige hjørne af det grønlandske kraton aflejret en mere end 1000 m mægtig sedimentlagserie. Disse sedimenter blev af John Haller (1961) grupperet sammen med en underliggende turbiditsekvens under navnet Hagen Fjord Group.

Herværende artikel redefinerer Hagen Fjord Group til kun at inkludere marine kyst- og shelfsedimenter aflejret i området mellem Independence Fjord og Kronprins Christian Land. Lagserien består af sandsten, siltsten og karbonater, og den geotektoniske udvikling langs Grønlands nordlige og nordøstlige rand for 600 til 800 millioner år siden er tydeligt afspejlet i sedimentationsforløbet.

Imaqarnersiuineq

Proterozoikumip naalernerani Kalaallit Nunaata qaarsuvittaata avannamut kangimukanneq tiqeqquata immap narqata sivingarnganut sedimentit (kinnganerit) 1000 m sinnerlugu issussuseqartut kiviorarsimapput. Sedimentit taaku ujarassiuup John Hallerip 1961-mi nalunaarusiamini kinnganernut immap naqqani sisusimasunut Hagen Fjord Groupimik taallugit ilanngussimavai.

Nalunaarusiami matumani Independence Fjordip aamma Kronprins Christian Landip imartaatata akornanni sedimentit immap sivingarnganut kiviorarsimasut kisimik Hagen Fjord Group ilanngullugit allaatigeqqinneqarput. Sedimentit qaleriiaartut tassaapput sillisissat, ujaqqallu sioraaqqanik qeqormillu sananeqaatillit. Kalaallit Nunaatalu avannaatungaata avannamullu kangiatungaata ukiut 600–800 milliunit matuma siornatigut ujaqqat pissusaat eqqarsaatigalugit ineriartorsimanera sedimentit kiviorarsimanerisa erseqqilluinnartumik paasinarsisippaat.

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The Geological Survey of Greenland (GGU) is a research institute affiliated to the Mineral Resources Administration for Greenland (MRA) within the Danish Ministry of Energy. As with all other activities involving the non-living resources in Greenland, GGU's investigations are carried out within the framework of the policies decided jointly by the Greenland Home Rule Authority and the Danish State.

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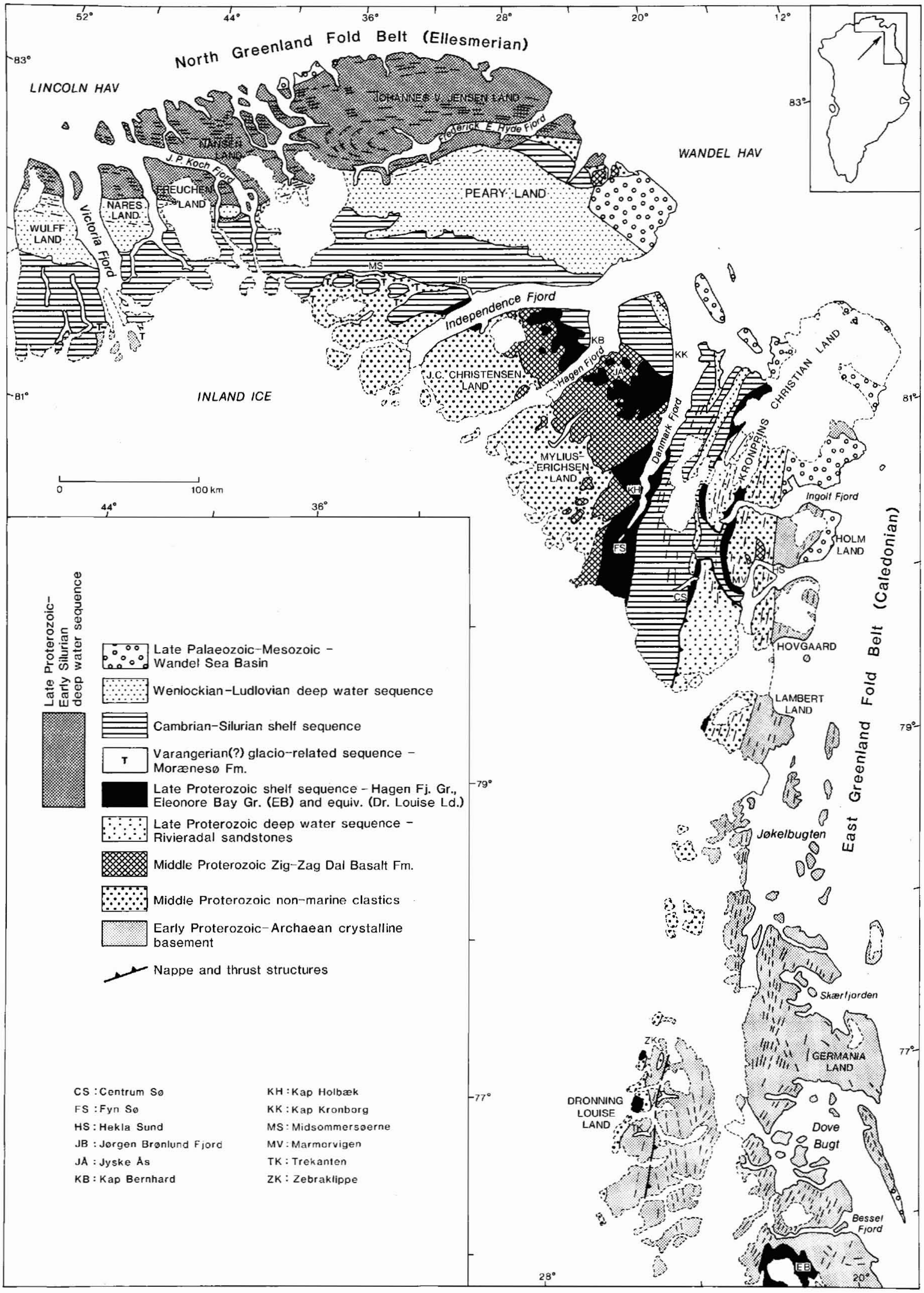


Fig. 1. Simplified geological map of the north-eastern part of Greenland.

Introduction

Precambrian crystalline basement and cover rocks in the region between Peary Land and Dronning Louise Land in North and North-East Greenland (Fig. 1) were studied by several geological field-teams during the period from 1947 to 1958. Troelsen (1949) and Ellitsgaard-Rasmussen (1950), as members of the Danish Pearyland-Expedition 1947–50, examined the Proterozoic and Lower Palaeozoic sequence in the Peary Land region. Peacock (1956, 1958) and Wyllie (1957), participants in the British North Greenland Expedition 1952–54, examined crystalline basement rocks with their Proterozoic sediment cover in Dronning Louise Land. During The Danish Expeditions to East Greenland 1947–58, Adams & Cowie (1953) and Fränkl (1954, 1955) examined the Proterozoic and Lower Palaeozoic sediments in the Kronprins Christian Land region, and systematic aerial reconnaissance was carried out by Haller (e.g. 1971) in the region between Peary Land and Dronning Louise Land.

While compiling and summarising geological data collected by geologists during this period (1947–1958), Haller (1961, 1970, 1971) put forward the idea of a Late Precambrian orogeny (the Carolinidian Orogeny) which was supposed to have affected Lower Proterozoic strata (the so-called Thule Group *sensu lato*, now referred to the Independence Fjord Group). After the deformation Upper Proterozoic/Lower Palaeozoic shelf and geosyncline sediments were deposited along the north-eastern margin of the Canadian–Greenlandian Shield. Based on this tectonic interpretation, Haller (1961) gave the name Hagen Fjord Group to the unfossiliferous strata unconformably overlying the deformed Thule Group and which are themselves overlain by fossiliferous Lower Palaeozoic sediments.

Recent work by geologists participating in the North Greenland Project (1978–80) organised by the Geological Survey of Greenland has added much new knowledge to the geology of the Proterozoic sedimentary basins of central and eastern North Greenland (Figs 1, 2). New geological maps, at scale 1:500 000 and covering the area north of latitude 81°N, have been compiled (Bengaard & Henriksen, 1986; Henriksen, 1989). Also maps at scale 1:100 000 covering selected areas are published (Jepsen & Henriksen, 1986; Pedersen & Henriksen, 1986).

Taking this new information into account, the present paper presents a reassessment of the definition and significance of the Upper Proterozoic Hagen Fjord Group shoreline-shelf sequence in central and eastern North Greenland.

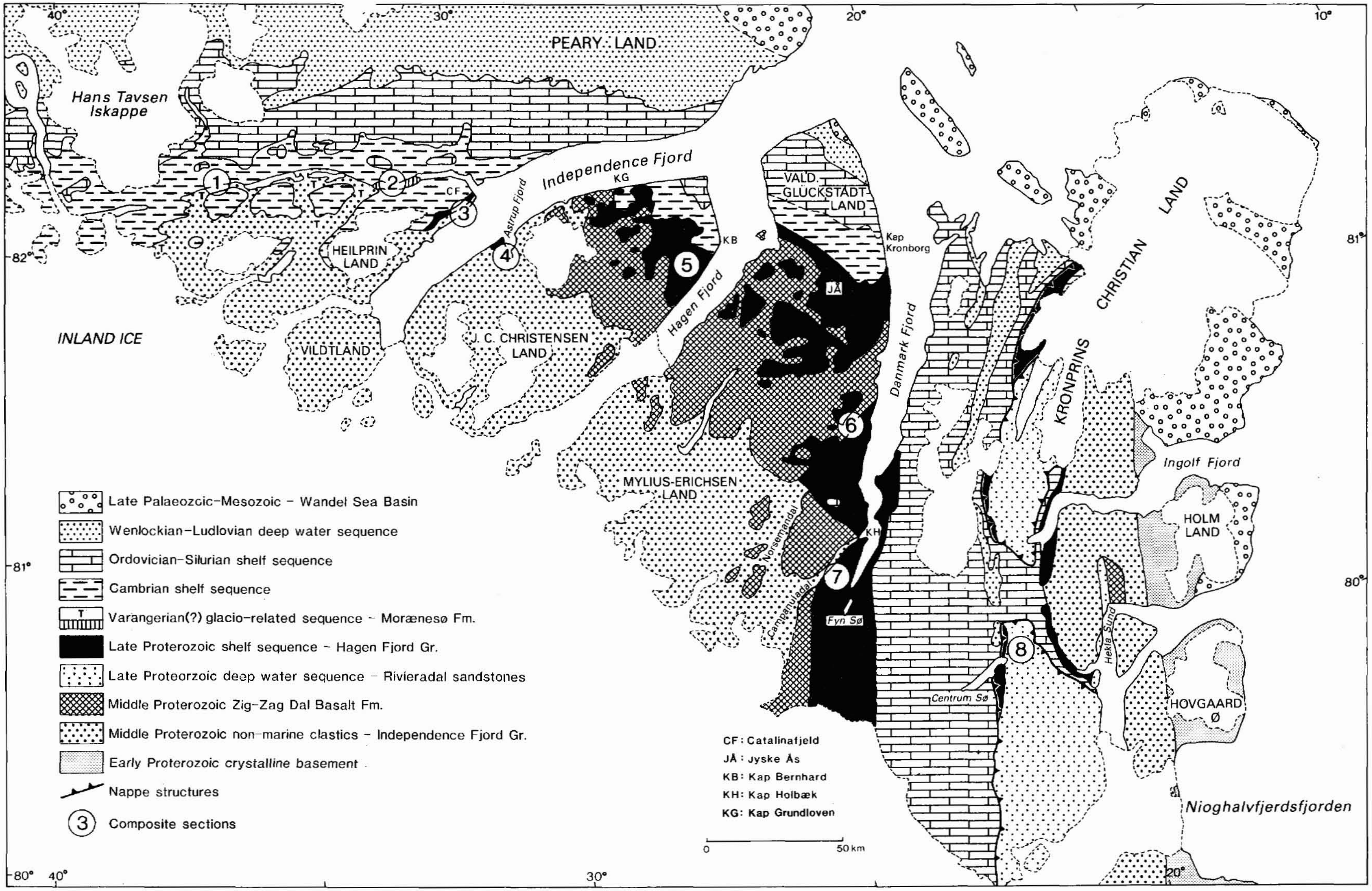


Fig. 2. Simplified geological map of the investigated area in North Greenland showing the outcrop pattern of the Upper Proterozoic Hagen Fjord Group.

Geological setting

The Late Proterozoic (850–650 Ma) Hagen Fjord Group was deposited on a shelf bordering the north-eastern corner of the Canadian–Greenlandian Precambrian shield. Towards the end of the Proterozoic the shelf was bounded by developing fold belts along its eastern and northern margins (Fig. 1). Although the shelf itself was only mildly disturbed by tectonic movements, some major stages of the tectonic history of these fold belts are well recorded in the sediment succession which makes up the platform sequence (Fig. 3).

In eastern North Greenland, crystalline basement rocks are not exposed *in situ*, but numerous erratic blocks of gneiss and amphibolite in the area north-east of the ice margin must be derived from basement exposed below the Inland Ice. Basement is exposed in western North Greenland; nunataks and adjacent land areas at the margin of the ice at the head of Victoria Fjord (Fig. 1) are composed of Archaean gneisses (Hansen *et al.*, 1987). Lower Proterozoic gneisses are exposed in the fjord zone along the east coast of Kronprins Christian Land (Jepsen & Kalsbeek, 1985) and further south along the coast.

The crystalline basement in central and eastern North Greenland (partly hidden below the ice cap) is overlain with profound unconformity by mostly non-marine, clastics of the Independence Fjord Group (Collinson, 1980) recording a period of intracratonic sag sedimentation (Sønderholm & Jepsen, 1991). This was followed by a major event of basic volcanism around 1230 Ma and the Midsommersø Dolerites and the Zig-Zag Dal Basalt Formation were emplaced at that time (Kalsbeek & Jepsen, 1983, 1984). This volcanism is probably associated with a Middle Proterozoic period of rifting related to the initial opening of an ocean (Poseidon Ocean) along the northern margin of the Canadian–Greenlandian shield (Jackson & Ianelli, 1981).

The upper boundary of the Middle Proterozoic sediments and volcanics is an erosional unconformity of regional extent upon which the Late Proterozoic Hagen Fjord Group was deposited. No record of the geological evolution of the shelf from the intervening time-interval (*c.* 1250–850 Ma) is preserved in North Greenland. However, information from northern Ellesmere Island, Canada suggests that plate collision took place during Grenvillian time (1100–1000 Ma) along the northern margin of the Canadian–Greenlandian shield, resulting in intense deformation, amphibolite-grade metamorphism and intrusion of granitic plutons (Trettin, 1987). Although no obvious traces of this Grenvillian orogeny are known from North Greenland (Jepsen & Kalsbeek, 1985), it may have influenced the degree of uplift and erosion prior to the deposition of the Hagen Fjord Group.

In the Late Proterozoic (at about 850 Ma or later) the shelf basin of central and eastern North Greenland was submerged and the Hagen Fjord Group shelf sequence and its possible deep-water predecessor, the Rivieradal sandstones (Fränkl, 1954, 1955; Hurst & McKerrow, 1985), were deposited in a marginal or several marginal basins facing the Iapetus Ocean in the east (cf. Surlyk, 1991).

Towards the end of the Proterozoic, the western part of the basin area around Independence Fjord and Hagen Fjord was uplifted, and here the Hagen Fjord Group strata were transected by NNW–SSE trending normal faults with development of graben structures. Subsequent erosion removed large parts of the succession and west of Independence Fjord only minor remnants of the Hagen Fjord Group are preserved. This tectonic disturbance was probably related to the initial rifting and opening of the Pelagus Ocean along the northern plate margin.

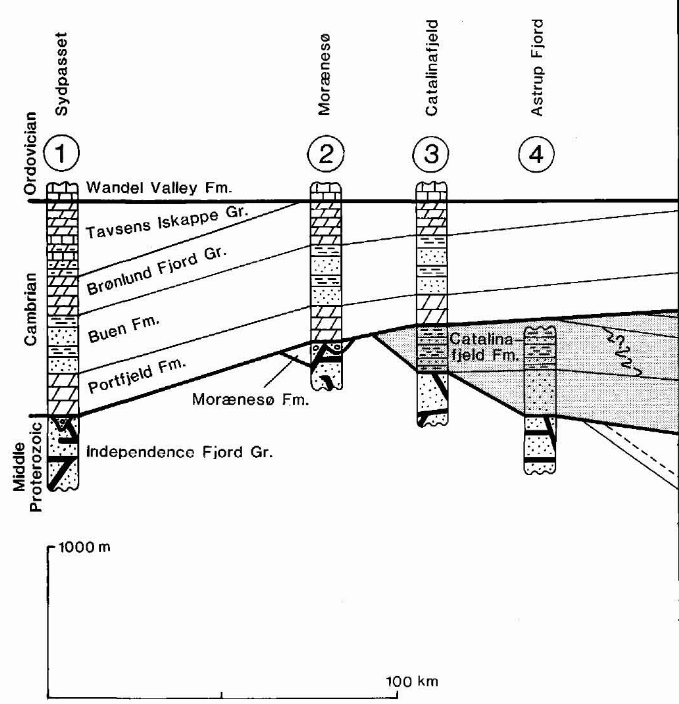
The Moræneso Formation of glacial affinity (Collinson *et al.*, 1989) was probably deposited during or shortly after the period of Late Proterozoic uplift, i.e. towards the end of the Hagen Fjord Group sedimentation. It is exposed in widely separated palaeo-valleys on the eroded top of the Independence Fjord Group and on top of the crystalline basement in the area around the head of Victoria Fjord (Fig. 1). The formation is only found in the area west of Independence Fjord and its relation to the Hagen Fjord Group is nowhere revealed.

After deposition of the Morænesø Formation, probably close to the Cambrian boundary (Collinson *et al.*, 1989), the sea transgressed the peneplained top of all the Proterozoic sequences of central and eastern North Greenland and a sequence of Cambrian strata more than 1000 m thick was deposited (Higgins *et al.*, 1991). The length of the time gap represented by the erosional unconformity on top of the Morænesø Formation is not known. However, if the glaciation, related to the Morænesø Formation, can be correlated with the Varangian glaciation of East Greenland and northern Scandinavia, as seems likely (Hambrey, 1988), then not more than 50 m.y. can reasonably have elapsed before the deposition of the Cambrian succession.

At the beginning of the Ordovician, initial closure of the Iapetus Ocean in the east resulted in a regional uplift of the shelf basin of central and eastern North

Greenland. In eastern Kronprins Christian Land, the consequent erosion removed an unknown thickness of Cambrian strata and possibly also the uppermost part of the Hagen Fjord Group, as the Early–Middle Ordovician Wandel Valley Formation (Peel & Smith, 1988) directly overlies the Hagen Fjord Group.

During the Early–Middle Silurian, Caledonian deformation along the eastern coast of Greenland resulted in westward transport of large nappe structures (Fränkl, 1954, 1955). The nappes are partly composed of Hagen Fjord Group sediments which may have been deposited east of the present coastline (Hurst & McKerrow, 1985).



Hagen Fjord Group
redefined

History. The Hagen Fjord Group was introduced by Haller (1961) simultaneously with his first definition of the Carolinidian Orogeny in the north-eastern part of Greenland. Haller's definition of the group is closely linked to his theories concerning this presumed Late Proterozoic orogeny.

According to Haller, unfossiliferous Proterozoic sediments in the north-eastern part of Greenland can be divided into two groups of strata: an older group (the Thule Group *sensu lato*) deposited before, and deformed during, the Carolinidian Orogeny, and a younger group (the Hagen Fjord Group) unconformably deposited on top of the denudated 'Carolinidian trunk'.

Later work by Jepsen & Kalsbeek (1985) in eastern North Greenland, failed to confirm that a pre-Caledonian orogenic episode had affected the oldest Proterozoic strata in the area. However, it was well documented that strata belonging to the Middle Proterozoic Thule Group, now referred to as the Independence Fjord Group (Collinson, 1980), and the Middle Proterozoic Zig-Zag Dal Basalt Formation (Jepsen & Kalsbeek, 1983, 1984), are unconformably overlain by younger Proterozoic strata.

Haller's description of the Hagen Fjord Group was most fully expressed in his book on the East Greenland Caledonides (Haller, 1971). From southern Peary Land he included within the group strata described by Troelsen (1949, 1956) and now referred to the Upper Proterozoic (Varangian?), Morænesø Formation and the Lower Cambrian Portfjeld and Buen Formations (Jepsen, 1971; O'Connor, 1979; Peel, 1988; Collinson *et al.*, 1989). From the area around the head of Danmark Fjord he included Upper Proterozoic, shallow water sediments which Adams & Cowie (1953) had named Campanuladal Sandstones and Limestones and Fyns Sø Dolomites. In the area between Independence Fjord and Danmark Fjord Haller erected a speculative stratigraphy based on observations made during reconnaissance flights without ground control. He included in the Hagen Fjord Group strata which are now known to comprise the Middle Proterozoic Zig-Zag Dal Basalt Formation, the Upper Proterozoic, shallow marine Campanuladal and Fyns Sø Formations (Clemmensen, 1979) and the Lower Cambrian Portfjeld Formation (O'Connor, 1979). In the Hekla Sund area of eastern Kronprins Christian Land he referred to Fränkl's (1954, 1955) description of a sequence of parautochthonous and allochthonous, Upper Proterozoic, shallow water and deep water sediments, all of which, he included in the Hagen Fjord Group. From Dronning Louise Land the possible Upper Proterozoic shallow water siliciclastics of the 'Zebra Series' (Peacock, 1956, 1958) were also included within the Hagen Fjord Group.

The present paper redefines the Hagen Fjord Group to include only Upper Proterozoic, mainly shallow marine sediments outcropping in an area extending from Independence Fjord in the north-west to Kronprins Christian Land in the east; the possibly equivalent sequences in Dronning Louise Land are discussed at the end of this paper. The Upper Proterozoic Morænesø Formation deposited as post-glacial valley fills (cf. Collinson *et al.*, 1989) is thus excluded from the Hagen Fjord Group as is the deep water sequence described by Fränkl (1954, 1955) in eastern Kronprins Christian Land. This deep water sequence comprises the Ste-

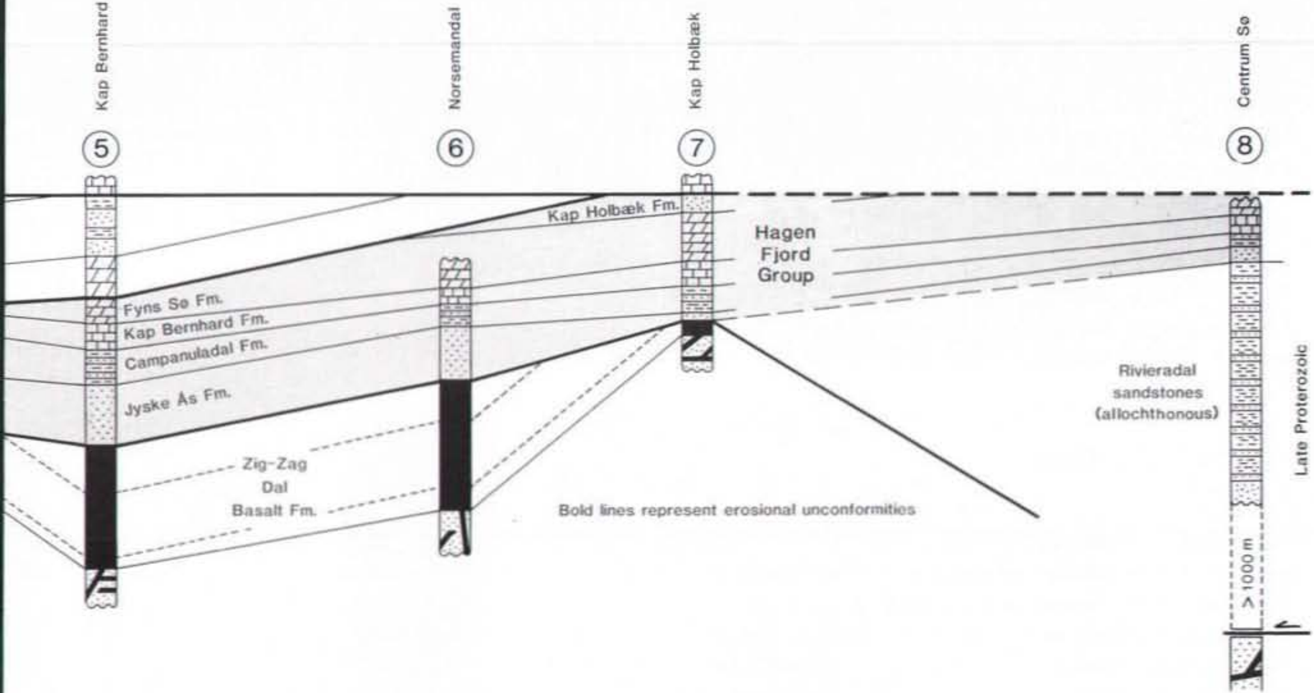


Fig. 3. Composite stratigraphic cross-section from central Peary Land (1) to Kronprins Christian Land (8) (see Fig. 2).

nørkenen phyllites, Sydvejdal marbles, Taagefjeldene greywackes, Rivieradal sandstones, and Ulvebjerg sandstones and tillites (Fränkl, 1954, 1955). According to Hurst & McKerrow (1985), all these units described by Fränkl are part of a single unit of deep water turbidites, mud and resedimented conglomerates, collectively referred to as the Rivieradal sandstones.

Name. After Hagen Fjord, the large fjord located between J. C. Christensen Land and Valdemar Glückstad Land (Fig. 2).

Type locality. Adams & Cowie (1953) measured a composite section through the Hagen Fjord Group in the area around the head of Danmark Fjord, and this area is regarded as the type area of the group (Figs 2, 3, 4).

Reference sections. During GGU fieldwork carried out in the period from 1978 to 1980 and 1989, additional sections through the Hagen Fjord Group were measured throughout the distribution area from Independence Fjord to Hekla Sund. Possible Late Proterozoic shelf deposits in Dronning Louise Land were also examined. Of special interest is a composite section at Kap Bernhard, J. C. Christensen Land (Figs 2, 3, 5), where the contact to the underlying Zig-Zag Dal Basalt Formation is exposed, and where the group (Jyske Ås Formation, Campanuladal Formation, Kap Bernhard Formation, and Fyns Sø Formation) is well exposed. At Astrup Fjord, J. C. Christensen Land and at Catalinafjeld, Heilprin Land, a grey mudstone dominated unit is described as a new formation (Catalinafjeld Formation).

Thickness. Upwards the group is bounded by unconformities which represent two periods of uplift and erosion during which parts of the Hagen Fjord Group was removed. The western region was affected prior to deposition of the Early Cambrian succession and the eastern region was eroded at the beginning of the Ordovician period (Fig. 3). Consequently, the thickness varies greatly, e.g. west of Independence Fjord a maximum of 300 m is preserved, whereas the thickness at the reference sections at Kap Bernhard is approximately 1000 m.

Lithology. The group is composed of mainly marine, shallow water sediments. A basal red and yellow, medium-grained sandstone association is overlain by a multicoloured sandstone-siltstone association. These siliciclastic deposits are overlain by a red limestone association which gradually changes into yellow dolostones with abundant stromatolites near the top. The stromatolitic dolostones are followed by a quartzitic, medium-

Fig. 4. Type area of the Hagen Fjord Group, Campanuladal, south-west of the head of Danmark Fjord. CD = Campanuladal Formation, KB = Kap Bernhard Formation, FS = Fyns Sø Formation. Height of mountain *c*. 300 m.

grained sandstone association with minor siltstone horizons.

Boundaries. Between Heilprin Land and Danmark Fjord, the Hagen Fjord Group unconformably overlies strata of Middle Proterozoic age. In Heilprin Land and in western J. C. Christensen Land the group overlies the Independence Fjord Group with its intrusive Midsommersø Dolerites, whereas in eastern J. C. Christensen Land and northern Mylius-Erichsen Land the group overlies the Zig-Zag Dal Basalt Formation (Fig. 3). A very low-angle unconformity is present; it is not evident within a single outcrop but can be calculated on a regional scale. Further towards the east, two types of contacts exist. In the area north and south of Centrum Sø (Fig. 1) the Hagen Fjord Group, located in nappe structures, conformably overlies the Upper Proterozoic Rivieradal sandstones. In the area of Prinsesse Caroline-Mathilde Alper the group overlies the Independence Fjord Group with a marked unconformity and here a few metres thick, basal conglomerate is present.

The upper boundary of the Hagen Fjord Group is an erosional unconformity. In the area between Heilprin Land and Danmark Fjord it is overlain by the Lower Cambrian Portfjeld Formation which progressively oversteps the Hagen Fjord Group westward (Fig. 3). Thus, in northern Mylius-Erichsen Land, the Portfjeld Formation is in contact with the Fyns Sø Formation and in Heilprin Land, the contact is with the Catalinafjeld Formation. In the area around Danmark Fjord and further east the group is overstepped in an easterly direction by the Lower–Middle Ordovician Wandel Valley Formation and at Kap Holbæk, the Wandel Valley Formation is in contact with the Kap Holbæk Formation (Fig. 3). In central Kronprins Christian Land the upper boundary is nowhere exposed.

Distribution. The Hagen Fjord Group crops out in a discontinuous, 340 km long triangular area stretching from the western shores of Independence Fjord in the

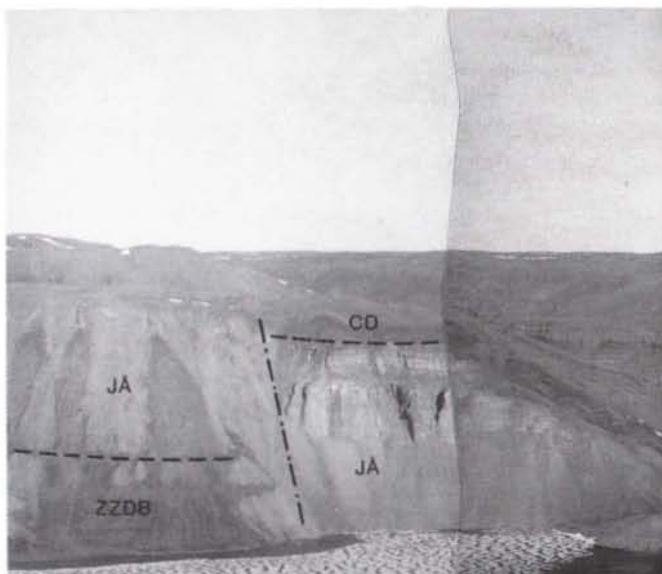


Fig. 5. Reference section of the Hagen Fjord Group, Kap Bernhard, J. C. Christensen Land. JÅ = Jyske Ås Formation, CD = Campanuladal Formation, KB = Kap Bernhard Formation, FS = Fyns Sø Formation, PF = Portfjeld Formation (Lower Cambrian), BU = Buen Formation (Lower Cambrian). Height of cliff *c*. 600 m.

north-west to Hekla Sund in the east and Lambert Land in the south-east (Figs 2, 3). In central Kronprins Christian Land the group is located in allochthonous nappe structures which may have had an origin east of the present day coastline (Hurst & McKerrow, 1985). The present definition of the group does not include the possible Late Proterozoic 'Zebra Series' of Dronning Louise Land, which is discussed further below.

Age. Acritarch assemblages from the upper part of the underlying Rivieradal sandstones are dominated by Late Proterozoic taxa, and a single specimen of *Chuaria circularis* indicates a maximum age of Late Riphean. Similar acritarch assemblages from Scandinavia and North America have associated isotope ages of 810 Ma (Vidal, 1979; G. Vidal, written communication, 1980). Acritarch assemblages in the lower part of the Kap Holbæk Formation at Kap Holbæk suggest a Late Proterozoic (Vendian?) age (Peel & Vidal, 1988) and the presence of long *Skolithus*-like tubes in this formation indicates an age not older than Late Vendian (Ediacaran). Cyanobacteria from the overlying Portfjeld Formation argue for a possible Early Cambrian age for this formation (Peel, 1988). The Hagen Fjord Group may thus have been deposited within the period spanning from Late Riphean to latest Vendian (*c.* 850–650 Ma). Whether deposition occurred during the whole period, interrupted by periods of non-deposition and erosion or whether it was restricted to a short interval within that period is presently uncertain (see also section on the age of Kap Holbæk Formation).

Sub-division. The Hagen Fjord Group is divided into six formations, of which three are new (formations are listed in ascending order):

(youngest)	Kap Holbæk	Formation
	Fyns Sø	Formation
	Kap Bernhard	Formation (new)
	Catalinafjeld	Formation (new)
	Campanuladal	Formation
(oldest)	Jyske Ås	Formation (new)

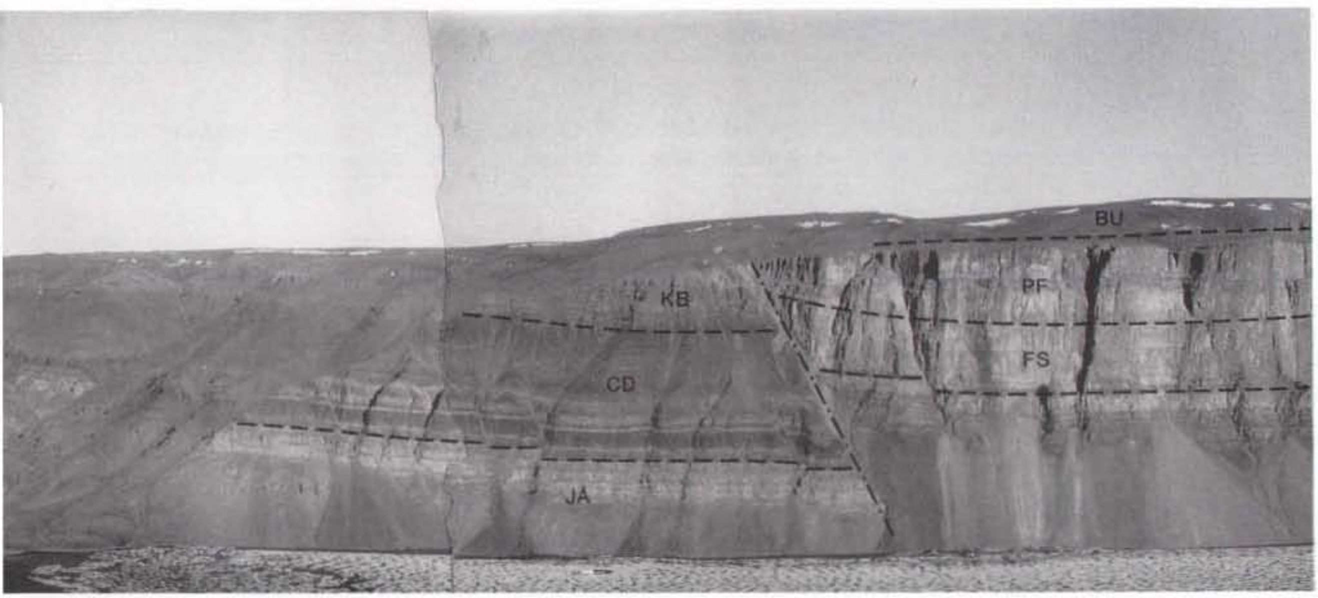
Jyske Ås Formation
new formation

History. Adams & Cowie (1953) included the sandstones of this formation in the basal part of their Campanuladal Sandstones and Limestones which was renamed the Campanuladal Formation by Clemmensen (1979). He described the sandstones as a basal sandstone facies association of the Campanuladal Formation.

Name. From Jyske Ås, a characteristic NW–SE trending range of hills in northern Mylius-Erichsen Land, the upper part of which is almost entirely composed of sandstones of this formation (Fig. 6).

Type locality. The east face of unnamed mountain approximately 5 km NE of Jyske Ås, northern Mylius-Erichsen Land (Figs 2, 6, 7).

Reference sections. The coastal cliff south of Kap Bernhard, J. C. Christensen Land (Fig. 8), the cliffs on the



east coast of northern Mylius-Erichsen Land (Fig. 9), Campanuladal south-west of the head of Danmark Fjord (Fig. 10), at Astrup Fjord, J. C. Christensen Land (Fig. 11), and at Kap Grundloven north-western J. C. Christensen Land (Fig. 12). It should be noted that because of the isolated nature of the outcrop at Astrup Fjord, it can only be inferred that the sandstones at this locality belong to the Jyske Ås Formation.

Thickness. The thickness of the formation varies considerably across the region. At the type section the formation is 475 m thick, south of Kap Bernhard *c.* 500 m, at the east coast of northern Mylius-Erichsen Land *c.* 400 m, in Campanuladal 50 m, at Astrup Fjord *c.* 300 m and in north-western J. C. Christensen Land *c.* 150 m thick.

Lithology. The formation is dominated by medium-grained sandstones. In the lower half they are red; upwards there is a gradational transition to orange or yellowish grey sandstone. Small scattered pebbles or granules occur rarely and only in the lower red part. Thicker (several metres) dark greenish grey mudstone units occur intercalated with the yellow sandstones in the upper part. Trough or tabular large-scale cross-bedding with set thicknesses between 5 and 20 cm (Fig. 13) is the dominant sedimentary structure in the whole formation. Foresets are sometimes draped by thin mud-films and thin concentrations of intraformational mud clasts also occur in the foresets. Herringbone cross-bedding is present and the overall foreset orientation indicates a bimodal NE–SW palaeocurrent pattern, with a dominant sediment transport towards NE (n = 141, five localities). Additional structures include: small-scale current-formed cross-lamination, small-scale wave-formed cross-lamination, horizontal lamination, mud pebble conglomerates and mudcracks. In general the formation lacks a sequential pattern. Locally, however, thick coarsening-upward sequences occur (e.g. at Kap Bernhard). At Astrup Fjord the formation differs somewhat from the general picture. At this locality it is composed of red medium-grained to coarse-grained sandstones with horizontal lamination and a few scour-and-fill structures.

Depositional environment. The basal red portion of the formation probably includes some fluvial deposits, but the main part of the formation seems to have been deposited in siliciclastic beach to shallow shelf environments. The dominance of sediment transport towards the NE is thought to reflect ebb tidal, or storm-enhanced offshore-flowing tidal currents. At Astrup Fjord, however, the whole of the formation appears to be fluvial.

Boundaries. In the area west of Danmark Fjord, the sandstones unconformably overlie the Middle Protero-

Fig. 6. Type area of the Jyske Ås Formation (JÅ) in northern Mylius-Erichsen Land. The Jyske Ås Formation is underlain by the Middle Proterozoic Zig-Zag Dal Basalt Formation (ZZDB), and is overlain by the Campanuladal Formation (CD). Section illustrated in Fig. 7 is indicated. Aerial photograph 665 B-Ø, no. 15203; copyright Kort- og Matrikelstyrelsen, Denmark (A.200/87).

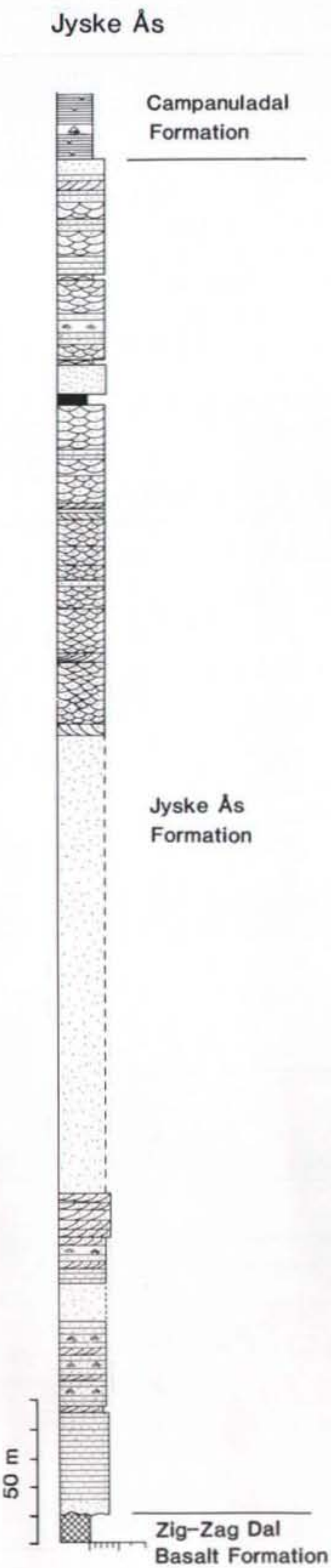
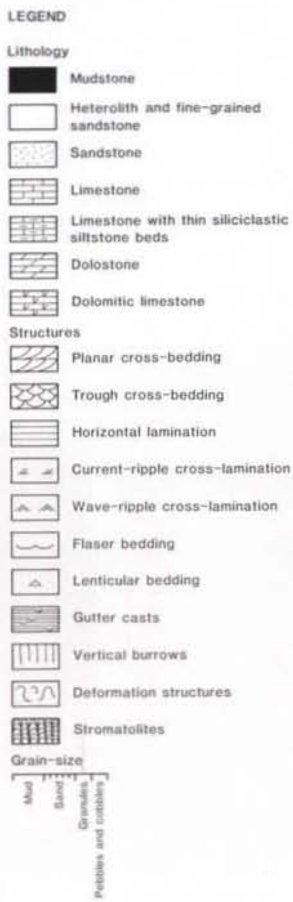


Fig. 7. A. Stratigraphic section at Jyske Ås, northern Mylius-Erichsen Land. Type section for the Jyske Ås Formation.

B. Legend covering all figures in the text.



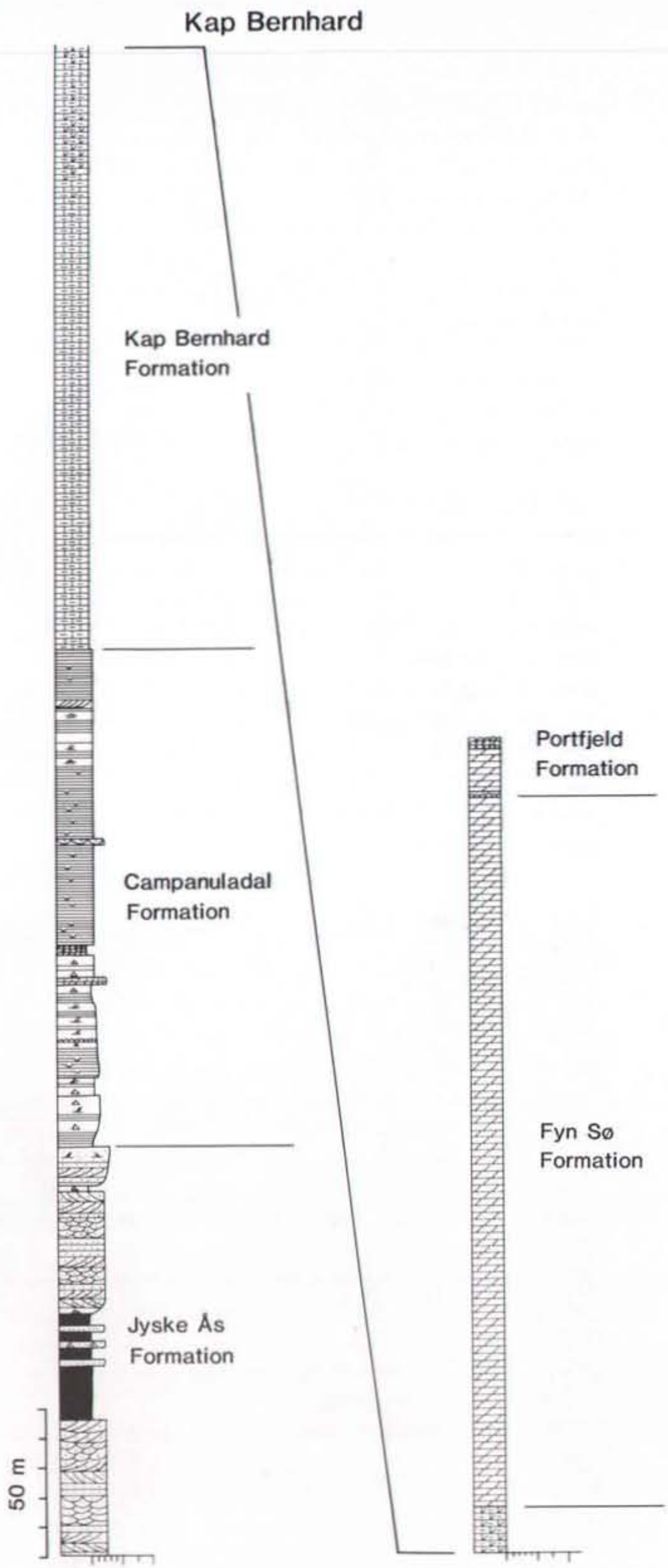


Fig. 8. Stratigraphic section at Kap Bernhard, J. C. Christensen Land. Type section for the Kap Bernhard Formation.

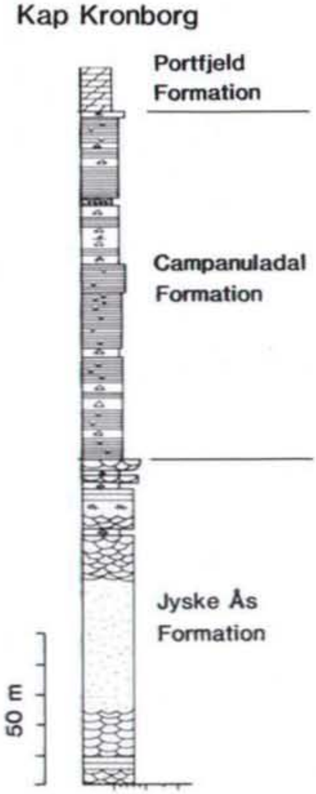


Fig. 9. Stratigraphic section at Kap Kronborg, north-eastern Mylius-Erichsen Land.

zoic Zig-Zag Dal Basalt Formation (Fig. 3). Although no basal conglomerates have been observed, the boundary is a low-angle erosional unconformity cutting through the basalt flows (Kalsbeek & Jepsen, 1984). In the Astrup Fjord area it overlies the Independence Fjord Group with intruded Midsommersø Dolerites. In the area east of Danmark Fjord, the sandstones conformably overlie resedimented boulder conglomerates which themselves conformably overlie the turbidites of the Upper Proterozoic Rivieradal sandstones (Hurst & McKerrow, 1985; Hurst, 1980 (Field Notes, GGU internal report)). Whether these conglomerates represent a massflow bed in sedimentary continuity with the turbidite sequence or represent an erosional unconformity of regional extent is not clear.

The upper contact is characterised by the gradual disappearance of yellow medium-grained sandstones. Most commonly the formation is overlain by multicoloured fine sandstones and siltstones of the Campanuladal Formation (Figs 7, 8, 9, 10) but at Astrup Fjord it is overlain by dark grey mudstones and associated sandstones of the Catalinafjeld Formation (Fig. 11). In north-eastern J. C. Christensen Land grey dolostones of the Portfjeld Formation unconformably overlie the sandstones (Fig. 12).

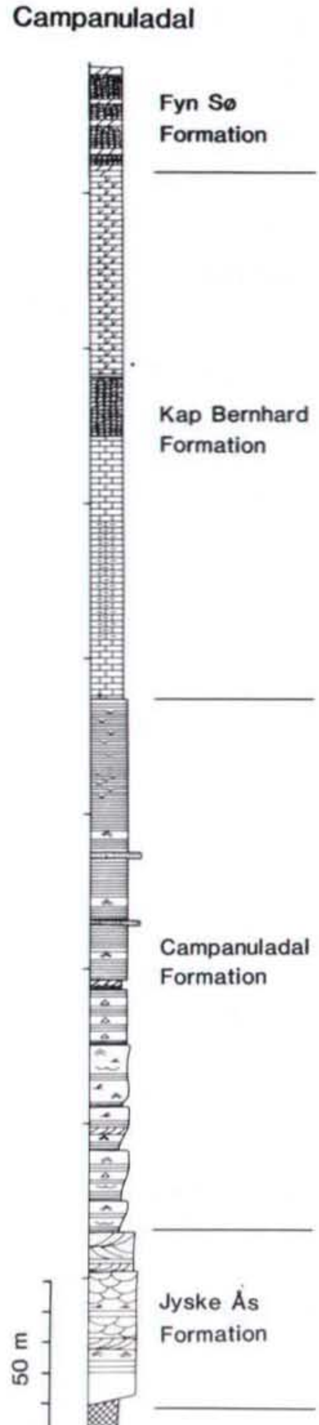


Fig. 10. Stratigraphic section at Campanuladal, Mylius-Erichsen Land. Type section for the Campanuladal Formation.

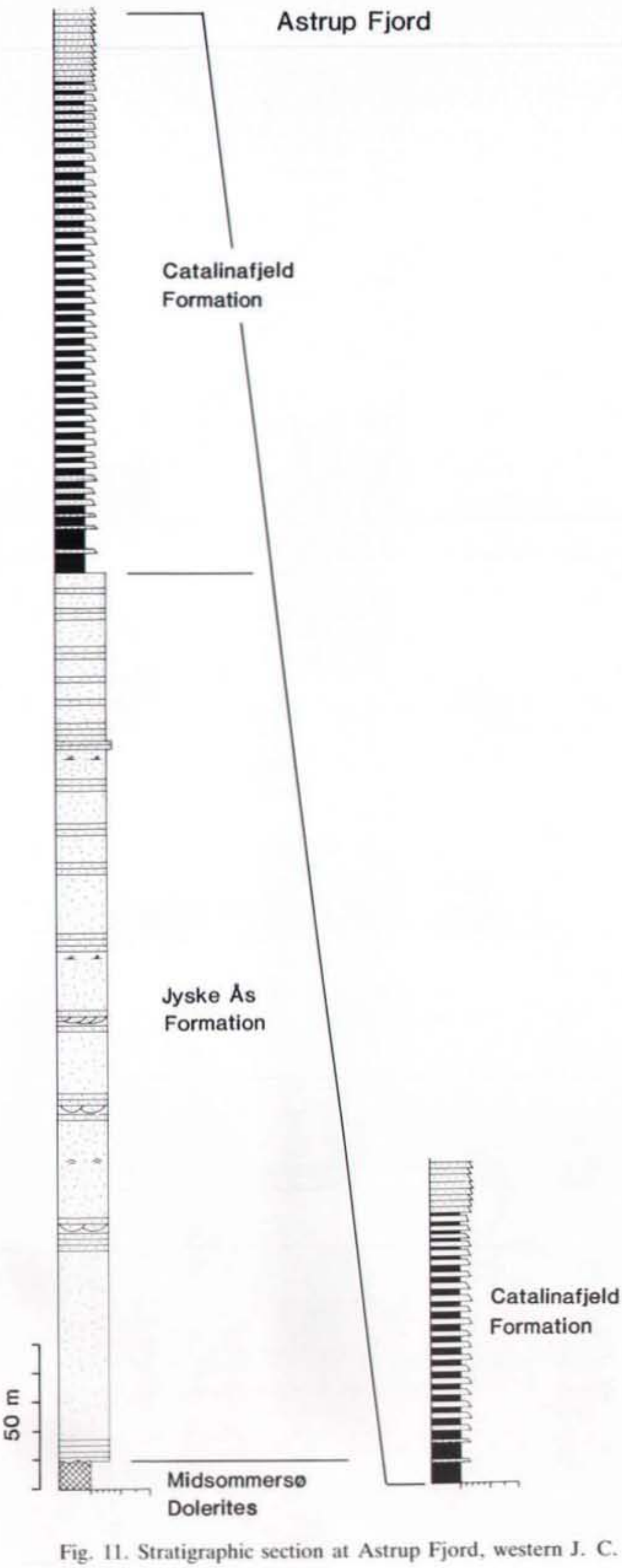


Fig. 11. Stratigraphic section at Astrup Fjord, western J. C. Christensen Land.

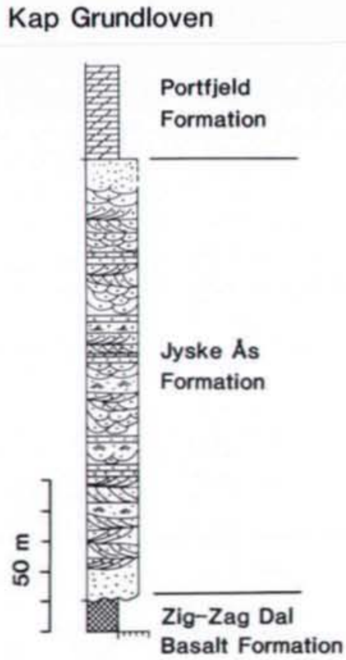


Fig. 12. Stratigraphic section at Kap Grundloven, north-western J. C. Christensen Land.

Distribution. The formation occurs in northern J. C. Christensen Land and in northern, central and eastern Mylius-Erichsen Land. East of Danmark Fjord it is located in allochthonous nappe structures.

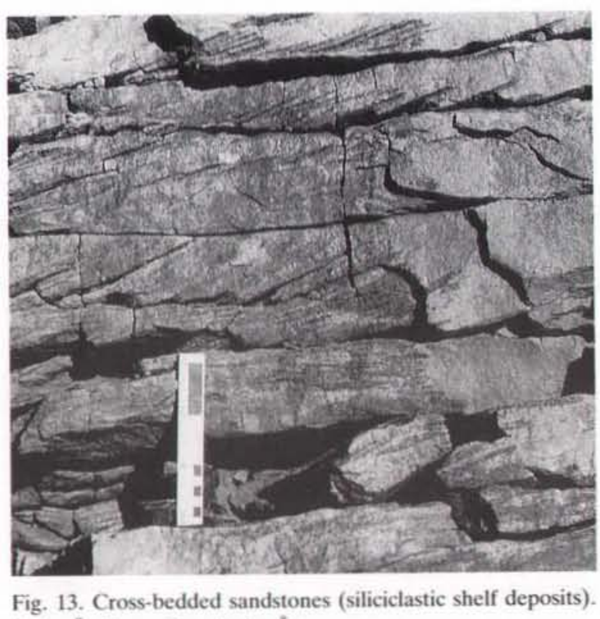


Fig. 13. Cross-bedded sandstones (siliciclastic shelf deposits). Jyske Ås Formation, Jyske Ås.

Campanuladal Formation
redefined

History. Adams & Cowie (1953) included the multicoloured fine sandstones and siltstones of this formation into their Campanuladal Sandstones and Limestones. Clemmensen (1979) described the sediments as a middle facies association of the Campanuladal Formation. This unit is here redefined as a formation on account of its wide distribution and characteristic field-appearance.

Name. From the valley Campanuladal south-west of the head of Danmark Fjord (Fig. 4).

Type locality. Mountain slope forming the south-eastern margin of Campanuladal (Figs 2, 10).

Reference sections. The coastal cliff south of Kap Bernhard, J. C. Christensen Land (Fig. 8), in Neergaard Dal in the central part of northern J. C. Christensen Land (Fig. 14), and at Kap Kronborg in north-eastern Mylius-Erichsen Land (Fig. 9).

Thickness. At the type locality the formation is 170 m thick, south of Kap Bernhard the thickness is 175 m, in Neergaard Dal in northern J. C. Christensen Land it is 110 m thick, and in north-eastern Mylius-Erichsen Land the thickness is 110 m.

Lithology. The formation is dominated by green and red fine-grained sandstones, siltstones, and heteroliths; subordinate lithologies are yellow stromatolitic dolostones and yellow quartzitic medium-grained sandstones (Fig. 8). The lithologies are arranged in a characteristic sequence consisting of five informal units, which can be distinguished at most localities: 1, a basal variegated, or predominantly green sandstone and siltstone unit; 2, a red sandstone and siltstone unit; 3, a variegated or predominantly green sandstone and siltstone unit; 4, a yellow stromatolite and associated dolostone unit and 5, an upper green sandstone and siltstone unit with one or two yellow, medium-grained quartz sandstones. The thickness of the various units varies somewhat from locality to locality. The yellow stromatolite unit and one of the quartz sandstones near the top form excellent marker horizons throughout large parts of the area.

Sedimentary structures in the red fine-grained sandstones and siltstones include horizontal lamination, small-scale, current-formed cross-lamination, wave ripples and associated wave-generated structures, lenticular and flaser bedding, numerous desiccation cracks and common mud-pebble conglomerates (Figs 15, 16). There is a crude rhythmic interbedding between coarse-

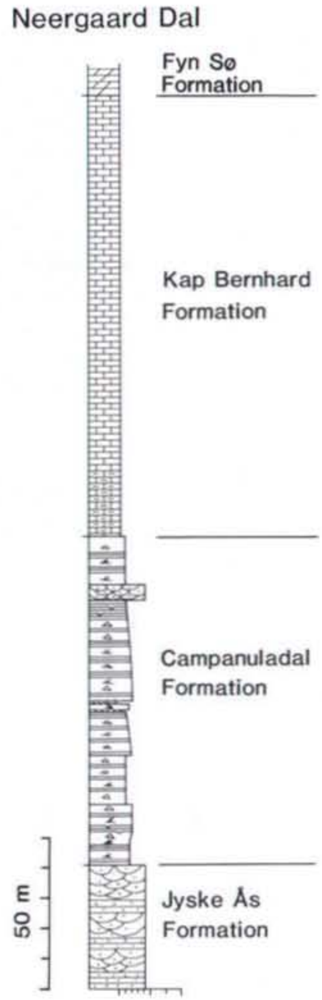


Fig. 14. Stratigraphic section at Neergaard Dal, central-northern J. C. Christensen Land.

Fig. 15. Red, fine-grained sandstones with wave ripples and desiccation cracks (tidal flat deposits). Campanuladal Formation, south of Kap Kronborg.

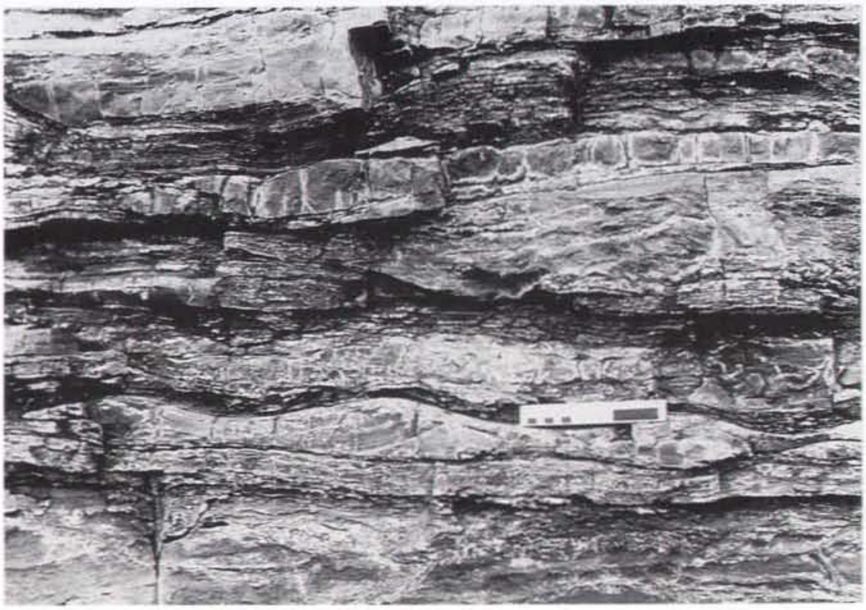


Fig. 16. Red, wave-rippled fine-grained sandstones and mudstones (tidal flat deposits). Campanuladal Formation, south of Kap Kronborg.

grained and fine-grained lithologies. The green sandstones and siltstones display also a rhythmic interbedding and contain similar structures, although with a clear predominance of horizontal lamination and lenticular bedding. Desiccation cracks are less common in these units. Gutter casts are very frequent on the soles of the green sandstone beds (Figs 17, 18) showing a preferred orientation (NE–SW) at most localities.

Depositional environment. The formation was probably deposited in various relatively low-energy, siliciclastic shoreline and shallow-marine environments characterised by alternating periods of subaerial exposure and sediment transport by tidal currents and wave processes. This interpretation is supported by the occurrence of marine acritarchs near the top of the formation. The red sandstones and siltstones with numerous desiccation cracks seem to have been deposited in supratidal to intertidal environments, whereas the green sandstones and siltstones with relatively rare desiccation cracks most likely were deposited in intertidal to subtidal environments. The spectacular gutter casts of these latter units represent sand-filled casts of grooves possibly formed in connection with brief storm events, and their persistent orientation probably indicates that the open sea was situated towards the NE. The stromatolitic dolostones probably developed in shallow subtidal environments during reduced clastic influx.

Boundaries. The lower boundary is placed where variegated fine sandstones and siltstones sharply overlie the yellow medium-grained sandstones of the Jyske Ås Formation (Figs 7, 8, 9, 10, 14). The upper boundary is,

Fig. 17. Green, fine-grained sandstones and mudstones with gutter casts (lower intertidal to subtidal deposits). Campanuladal Formation, south of Kap Kronborg.

Fig. 18. Lower surface of sandstone showing a meandering gutter cast (lower intertidal to subtidal deposits). Campanuladal Formation, Campanuladal.

at most localities, defined by the incoming of dark red limestones of the Kap Bernhard Formation (Figs 8, 10, 14). At Kap Grundloven on the east coast of Mylius-Erichsen Land the formation is unconformably overlain by the grey dolostones of the Portfjeld Formation (Fig. 12).

Distribution. The formation crops out over most of northern J. C. Christensen Land and northern and eastern Mylius-Erichsen Land. It is missing, however, at several localities in western J. C. Christensen Land. East of Danmark Fjord the formation is located in allochthonous nappe structures.

Catalinafjeld Formation
new formation

History. The mudstone sequence and underlying thin limestone unit at Catalinafjeld were originally included in the Moræneso Formation by Jepsen (1971). Clemmensen (1979) regarded this sequence as an informal member of the Campanuladal Formation and also included a succession at Astrup Fjord consisting of red sandstones overlain by mud-rich sediments in this stratigraphic unit. The grey mud-rich sequence at both localities is here redefined as the new Catalinafjeld Formation.

Name. From the mountain Catalinafjeld, which forms the easternmost portion of Heilprin Land (Fig. 19).

Type locality. Catalinafjeld, eastern Heilprin Land (Figs 2, 19, 20).

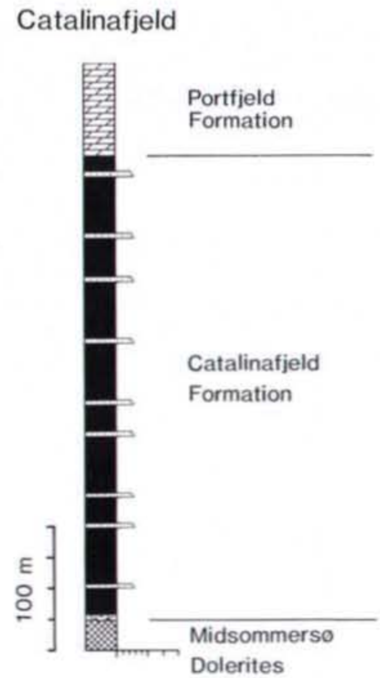


Fig. 20. Stratigraphic section at Catalinafjeld, Heilprin Land. Type section of the Catalinafjeld Formation.

Reference section. The peninsula between Independence Fjord and Astrup Fjord, J. C. Christensen Land (Figs 2, 11, 21).

Thickness. The thickness of the formation is only known from two localities; at the type locality it is *c*. 350 m thick and at Astrup Fjord the formation is *c*. 260 m thick.

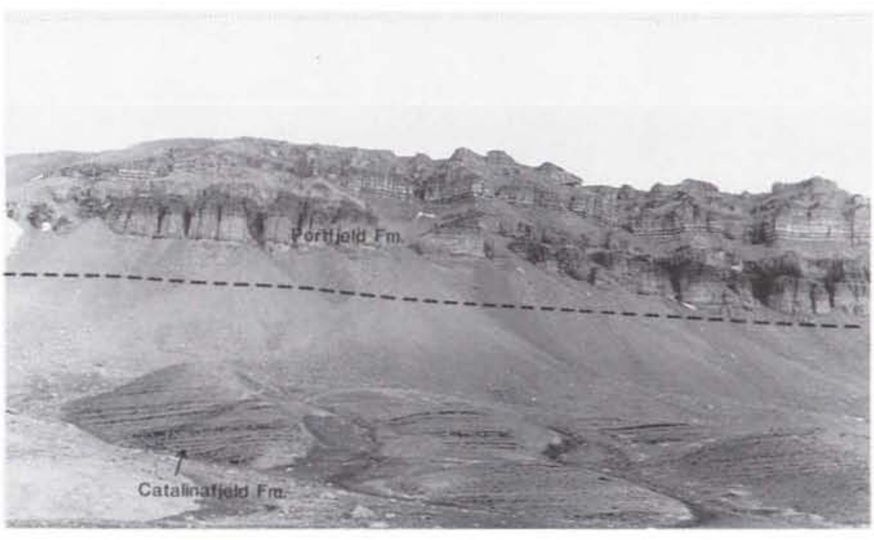


Fig. 19. Type section of the Catalinafjeld Formation, Catalinafjeld, eastern Heilprin Land. Height of mountain *c*. 600 m.

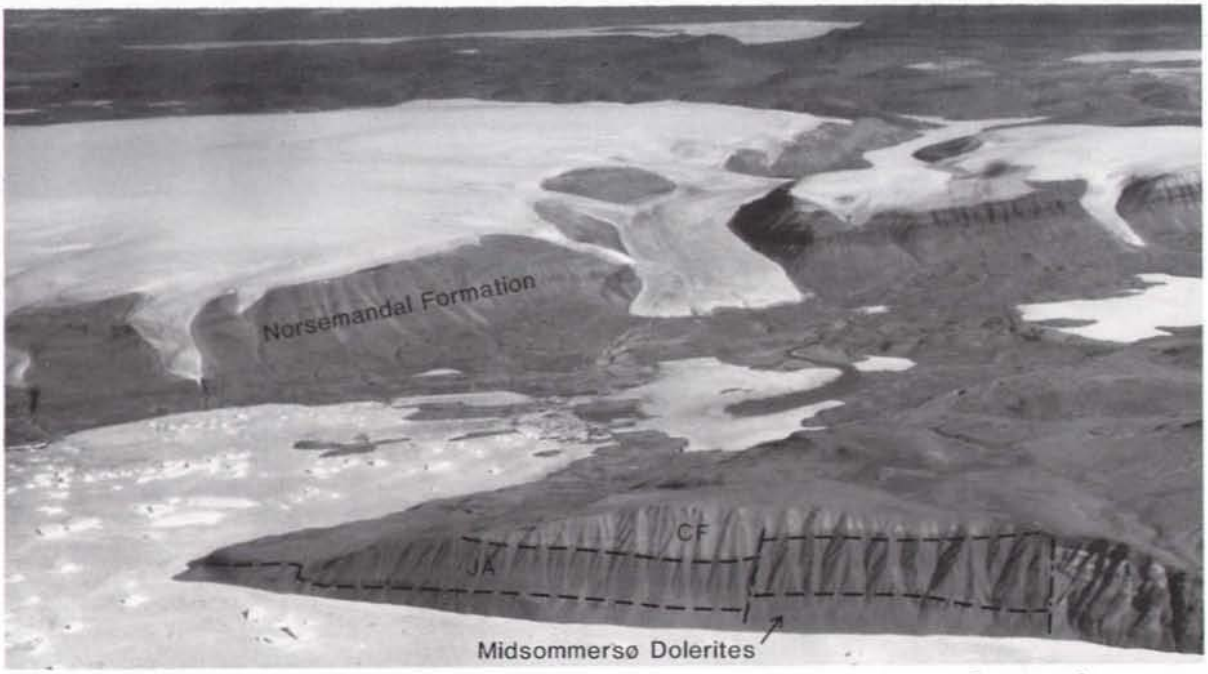


Fig. 21. Reference section of Catalinafjeld Formation, Astrup Fjord, eastern J. C. Christensen Land. JÅ = Jyske Ås Formation, CF = Catalinafjeld Formation. Aerial photograph 548 J-Ø, no. 15745; copyright Kort- og Matrikelstyrelsen, Denmark (A.200/87).

Lithology. At the type locality the formation is mainly composed of grey, laminated mudstones with thin, graded sandstone beds (Fig. 20). The mudstone–sandstone ratio varies between 100:1 and 20:1. The graded sandstone beds are 2–20 cm thick, fine-grained to medium-grained and commonly display sole marks. Internally they may possess a basal massive division overlain by horizontally laminated sand and topped by sand with small-scale, current-formed cross-lamination (Fig. 22). The mudstones are distinctly horizontally laminated with alternating coarse silty or fine-grained sandy and thin clayey laminae (Fig. 23). Each lamina is up to a few millimetres thick with the coarse layer being the thickest. There appears to be a gradual transition between the sandy laminae in the mudstones and the more well-defined graded sandstone beds. Measurements on small-scale cross-lamination (n = 23) indicate local palaeotransport towards the east. At the base of the siliciclastic unit at Catalinafjeld there is a thin (6 m) pale red limestone unit.

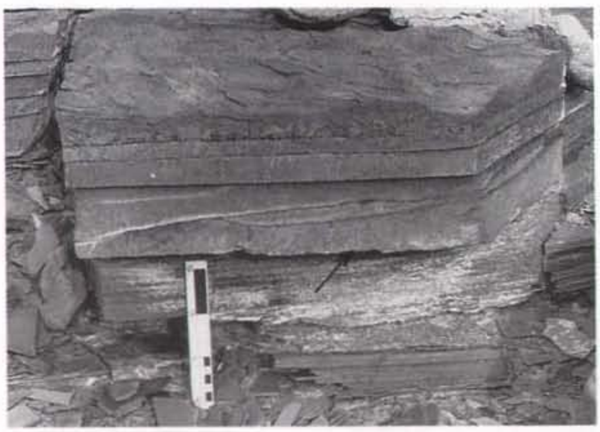


Fig. 22. Graded sandstone beds overlying horizontally laminated mudstone (siliciclastic shelf deposits). Lower erosional base of sandstone indicated by arrow. Catalinafjeld Formation, Catalinafjeld.

At Astrup Fjord the formation forms one, or perhaps two, thick coarsening-upwards sequences (Fig. 11). The basal part of the sequence is composed of variegated mudstones with thin graded sandstone beds. Upwards the colour of the mudstones changes to grey or dark grey and sandstone beds become thicker and more frequent. At the top of the coarsening-upwards cycles sandstone beds dominate and are only separated by thin mudstones. The sandstones frequently display sole marks; they are often graded and in their topmost part possess small-scale, current-formed cross-lamination. A few beds with structures interpreted as hummocky cross-stratification also occur.

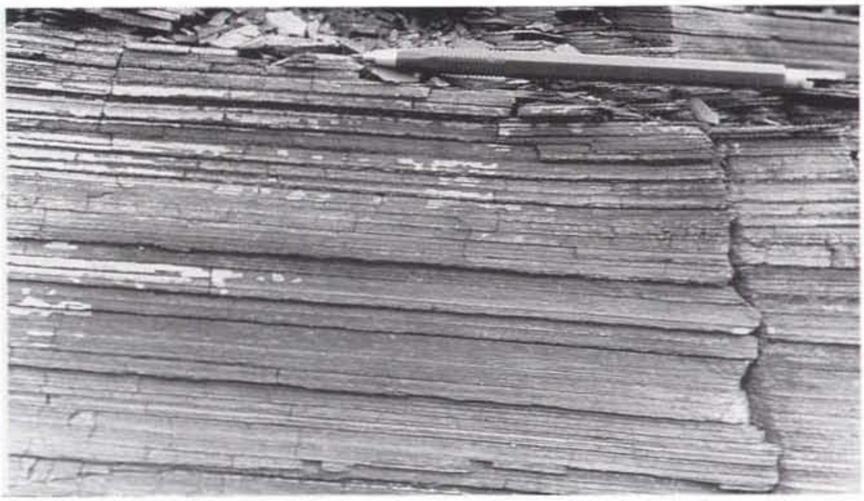


Fig. 23. Horizontally laminated sandy shelf mudstones (clastic shelf deposits). Catalinafjeld Formation, Catalinafjeld.

Depositional environment. The formation presumably was deposited in siliciclastic marine shelf to shoreface environments. The mud-rich sequences well-seen at Catalinafjeld apparently were deposited on a muddy shelf affected by brief storm events forming the graded sand beds seen. The sand-rich units well seen at Astrup Fjord were presumably deposited in more high-energy shoreface environments and record one or two episodes of shoreline progradation.

Boundaries. At the type locality the formation overlies the Independence Fjord Group. The formation is here unconformably overlain by the Portfjeld Formation (Fig. 20). At Astrup Fjord the formation sharply overlies red sandstones of the Jyske Ås Formation (Fig. 11), but the upper boundary is not exposed.

Distribution. The formation has only been recognised along the shores of the central part of Independence Fjord. It is interpreted to represent a lateral deeper water equivalent of the Campanuladal Formation. Due to the local occurrence of the Catalinafjeld Formation it should be stressed, however, that the exact stratigraphic position of this formation within the Hagen Fjord Group is poorly known.

Kap Bernhard Formation

new formation

History. Adams & Cowie (1953) included the sediments of this formation into their Campanuladal Sandstones and Limestones, where it comprised the upper reddish-brown limestone unit. Clemmensen (1979) described these sediments as an upper facies association of the Campanuladal Formation but here the sediments are formally designated as a new formation.

Name. From Kap Bernhard, a prominent cliff on the north-eastern coast of J. C. Christensen Land (Fig. 2).

Type locality. Some 5 km south of Kap Bernhard, where the coastal cliff is transected by a small ravine (Figs 2, 5, 8).

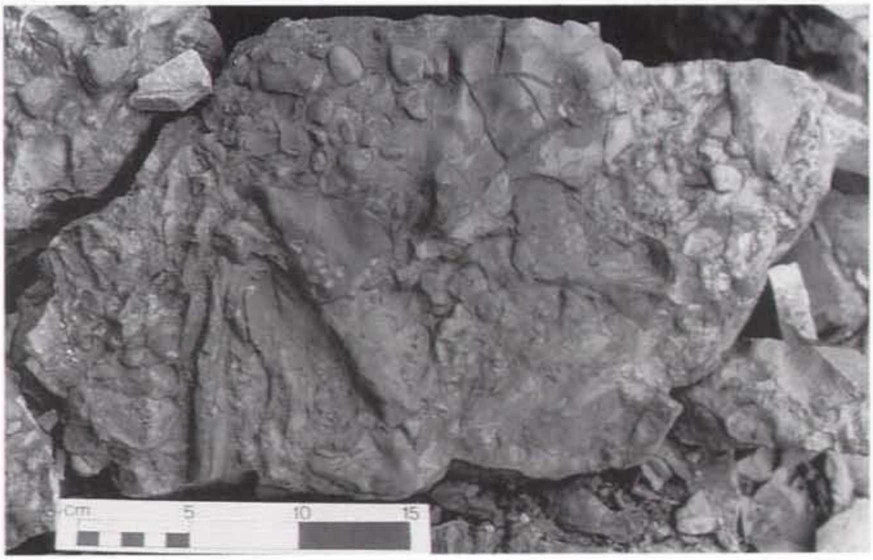
Reference sections. Mountain forming the south-eastern margin of Campanuladal and a south-facing slope of an unnamed valley, 8 km east of the central part of Neergaard Dal, J. C. Christensen Land (Figs 10, 14).

Thickness. At the type locality the thickness is 215 m, elsewhere *c*. 150 m.

Lithology. The formation is dominated by reddish-brown limestones with minor amounts of terrigenous silt. Associated lithologies are thin siliciclastic siltstone beds. A basal unit (*c*. 40 m) contains abundant soft-sediment deformation structures and small faults associated with conspicuous intraformational breccias (Fig. 24). Higher up in the sequence, the degree of deformation gradually decreases and intervals with horizontal lamination, wave ripples, and small pockets with intraformational, edgewise breccias appear (Fig. 25). In its upper part, the formation locally contains up to 20 m thick stromatolitic units (Fig. 26).

Depositional environment. The formation seems to have been deposited mainly in a subtidal lagoon (incipient carbonate platform). The sudden shift in lithology from siliciclastic deposits in the underlying formation to car-

Fig. 24. Red-brown limestone with desiccation cracks and intraformational breccias (carbonate platform deposits). Kap Bernhard Formation, south of Kap Bernhard.



bonates may indicate a climatic change towards more arid conditions.

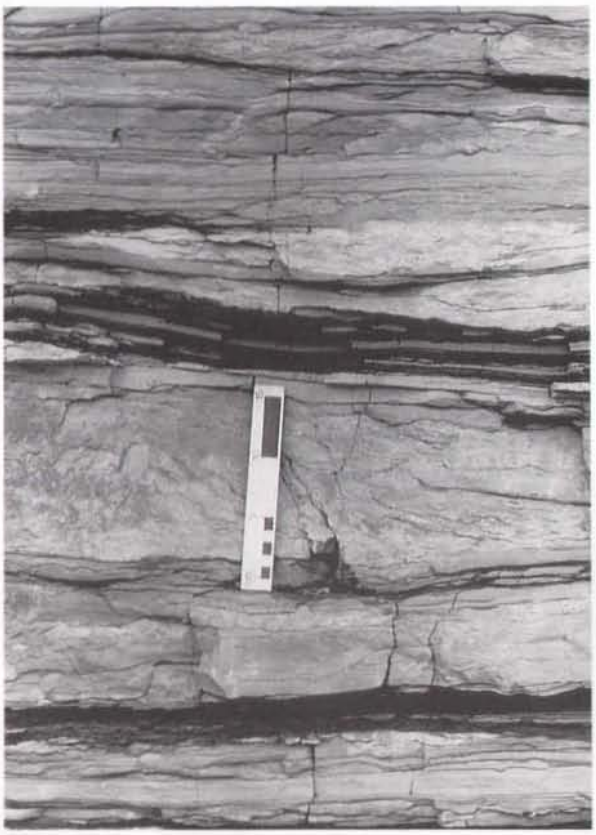


Fig. 25. Red-brown limestone with intraformational edgewise conglomerates (carbonate platform deposits). Kap Bernhard Formation, south of Kap Bernhard.

Boundaries. The lower boundary is defined by the sudden appearance of reddish-brown limestones on top of the multicoloured siliciclastic deposits of the Campanuladal Formation (Figs 8, 10, 14). The upper boundary is more gradational and drawn at the base of the cliff-forming yellow dolostones of the Fyns Sø Formation (Figs 8, 10).

Distribution. The formation outcrops in north-eastern J. C. Christensen Land and around the inner part of Danmark Fjord. It also occurs in central Kronprins Christian Land where it is located in allochthonous nappe structures with a possible origin east of the present coastline (Hurst & McKerrow, 1985).

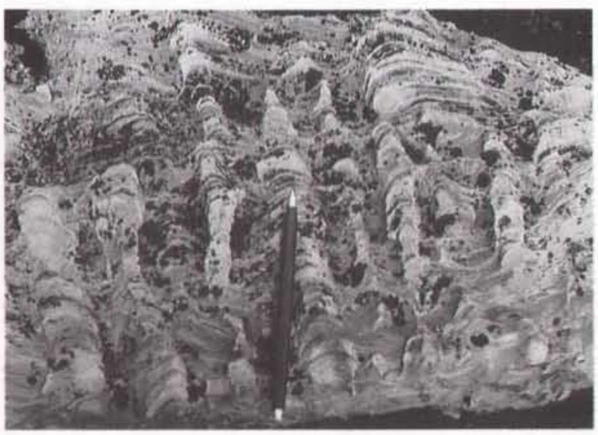


Fig. 26. Loose block with columnar-layered stromatolitic limestone (carbonate platform deposits). Upper part of Kap Bernhard Formation, Campanuladal.

Fyns Sø Formation

Adams & Cowie, 1953

History. The formation was first defined as the Fyns Sø Dolomite by Adams & Cowie (1953). Clemmensen (1979) changed the name to Fyns Sø Formation but otherwise the definition of the formation is in accordance with Adams & Cowie (1953).

Name. From the lake Fyn Sø, south of Danmark Fjord (Fig. 2).

Type locality. Mountains around Fyn Sø south of Danmark Fjord (see Adams & Cowie, 1953 and Figs 2, 4).

Reference section. In Campanuladal (Fig. 10), and at Kap Bernhard, J. C. Christensen Land (Fig. 8).

Thickness. The formation is 324 m thick at the type locality (Adams & Cowie, 1953). At Kap Bernhard, where the upper boundary is an erosional unconformity, the thickness is reduced to *c.* 170 m. In central J. C. Christensen Land the formation is completely eroded away beneath the westward overstepping Portfjeld Formation.

Lithology. The formation consists of a spectacular cliff-forming, mainly yellow weathering dolostone sequence (Figs 4, 5). The dolostones are massive or they contain well-developed stromatolites (Fig. 27). Conical columnar stromatolites were originally described as cone-in-cone structures by Adams & Cowie (1953) but later Cowie (1961) recognized them as organo-sedimentary structures. Other sedimentary structures in the dolostones include slump structures, intraformational breccias, and rare ripple marks. In the upper part of the formation the dolostones are frequently interbedded with thin red or green terrigenous siltstones.

Depositional environment. The formation probably represents subtidal sedimentation on a well-developed carbonate platform in connection with an overall arid climate.

Boundaries. The lower boundary to the red limestones of the Kap Bernhard Formation is gradational (Figs 8, 10); the upper boundary is covered (1.5 m) at Fyn Sø but the formation appears to be overlain conformably by variegated siltstones and thin sandstones of the Kap Holbæk Formation. Further towards the west the upper boundary is an erosional unconformity at the base of the Portfjeld Formation, which progressively oversteps the formation westwards.

Fig. 27. Columnar-layered stromatolitic limestone (carbonate platform deposits). Fyns Sø Formation, Fyn Sø.

At Kap Bernhard, O'Connor (1979) described a siliciclastic interval between the Fyns Sø and the Portfjeld Formations. Later fieldwork, however, demonstrated that these clastics belong to the basal part of the Cambrian Buen Formation which, at this locality, is in fault contact with the Fyns Sø Formation.

Distribution. The formation crops out in north-eastern J. C. Christensen Land and on both sides of the inner part of Danmark Fjord. Further towards the east it is found in an autochthonous position along the western foothills of the Prinsesse Caroline Mathilde Alper, while it is located in allochthonous nappe structures in central Kronprins Christian Land.

Kap Holbæk Formation

Adams & Cowie, 1953

History. This formation was first described by Adams & Cowie (1953) as the Kap Holbæk Sandstone. They informally subdivided the formation into five units: Lower Sandstone, Lower Quartzite, Middle Sandstone, Upper Quartzite and Upper Sandstone. The formation is now referred to as the Kap Holbæk Formation (Peel, 1980; Peel & Vidal, 1988). Fränkl (1955) described the occurrence of pockets of the formation from the area around Hekla Sund, Kronprins Christian Land and

Hurst & MacKerrow (1985) described its occurrence in allochthonous nappes in central and northern Kronprins Christian Land.

The age of the formation has been debated (see Peel & Vidal, 1988) and it has for a long time been correlated with the Lower Cambrian Buen Formation (Jepsen, 1971) of the Peary Land region but the Kap Holbæk Formation is now assigned an Upper Proterozoic age (Peel & Vidal, 1988).

Name. From Kap Holbæk, a prominent headland at the head of Danmark Fjord (Fig. 2).

Type locality. Kap Holbæk, at the head of Danmark Fjord (Figs 2, 28).

Thickness. The formation has a thickness of *c*. 150 m at the type locality.

Lithology. The formation is initiated by at least 5 m of variegated mudstones and thin sandstone beds. The overlying part of the formation is composed of fine-grained to medium-grained sandstones associated with coarse-grained sandstones and mudstones (Fig. 28). Glauconite is common in the uppermost deposits. The degree of cementation in the sandstones varies somewhat and the tightest cemented sandstones form cliffs (= the Quartzite units of Adams & Cowie, 1953). The sandstones are structureless or contain large-scale trough cross-bedding, and rare wave ripples. One interval has very irregular bedding associated with water escape structures. In a few levels long *Skolithos*-like burrows occur (Fig. 29). The burrows constitute densely spaced vertical cylindrical tubes with a diameter up to 1 cm and a length of 0.5 m or more. The sandstones and associated lithologies are apparently randomly interbedded in the lower part, but form one well-developed coarsening-upward sequence near the top of the formation.

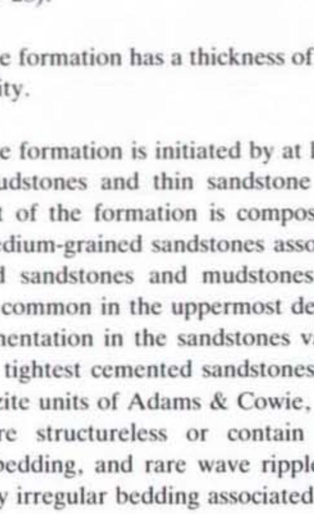


Fig. 28. Stratigraphic section at Kap Holbæk. Type section of the Kap Holbæk Formation.

Fig. 29. Densely spaced long vertical burrows in shoreline sandstones. Kap Holbæk Formation, Kap Holbæk.

Depositional environment. The formation records the return of siliciclastic sedimentation and was apparently deposited in beach to shallow shelf environments. The long vertical burrows suggest deposition of the associated sand in a high-energy, near shore environment.

Boundaries. The formation overlies stromatolitic dolostones of the Fyns Sø Formation with a well-defined but in detail obscured contact. At Fyn Sø the boundary is covered (1.5 m) and the sandpockets at Hekla Sund which Fränkl correlated with the Kap Holbæk Formation rest on a karstic top of the Fyns Sø Formation. The upper boundary is a sharp, very low-angle erosional unconformity. At Kap Holbæk this unconformity is exposed beneath a dark cherty dolostone-cliff belonging to the Lower Ordovician Danmark Fjord Member of the Wandel Valley Formation (Fig. 3; see also Peel & Smith, 1988 and Sønderholm & Jepsen, 1991).

Distribution. The formation crops out around the inner part of Danmark Fjord and in northern Kronprins Christian Land, where it is located in an allochthonous nappe structure (Finderup Land Nappe, Hurst & McKerrow, 1985).

Age. Acritarch assemblages from 120 m below the top of the Kap Holbæk Formation suggest a Late Proterozoic, Vendian(?) age (Peel & Vidal, 1988). The presence of *Skolithos*-like tubes indicates an age not older than latest Vendian (Ediacaran). Such a very late Proterozoic age indicates that the clastic Kap Holbæk Formation is younger than the glacial derived Morænesø Formation (Varangian?) in southern Peary Land. This has some implication on the interpretation of the age of the underlying part of the Hagen Fjord Group: It is possible that an unconformity is present at the base of the Kap Holbæk Formation representing a period of non-deposition of unknown length, and that Kap Holbæk Formation accordingly is substantially younger than the underlying Fyns Sø Formation. Alternatively the Kap Holbæk Formation may follow directly on top of the Fyns Sø Formation suggesting that the whole of the Hagen Fjord Group is of Vendian age (cf. Sønderholm & Jepsen, 1991). The presence, in the Morænesø Formation of decimetre-sized boulders of stromatolitic dolostone of the characteristic Fyns Sø Formation lithology (Collinson, personal communication, 1979) could be taken in support of the former interpretation indicating that the Fyns Sø Formation and the underlying parts of the Hagen Fjord Group predates the Varangian(?) glaciation.

To resolve the question of age of the Hagen Fjord Group shelf sequence and the associated deep-water Rivieradal sandstones more fieldwork is needed in order to gain a better understanding of the tectono-stratigraphic framework of the nappe structures in eastern Kronprins Christian Land and to collect more material for biostratigraphical work.

Correlation with Dronning Louise Land

In western Dronning Louise Land (Figs 3, 30) the crystalline basement is unconformable overlain by the 'Trekant Series' (Peacock, 1956) which is a several hundred metre thick sequence of fluvial and lacustrine sandstones intruded by basic rocks. They are correlated with the Middle Proterozoic Independence Fjord Group and with the Midsommersø Dolerites of North Greenland. The 'Trekant Series' is unconformably overlain by a minimum 200 m thick sequence of quartzitic sandstones, mudstones and dolomitic limestone named the 'Zebra Series' (Peacock, 1956). The series contains trace fossils and *Skolithos* tubes (Friderichsen *et al.*, 1990) indicating an age close to the Late Proterozoic/Cambrian boundary. Therefore, based on this similarity in stratigraphic position, it is probable that the 'Zebra Series' represents a southward extension of the Hagen Fjord basin; as the beds are disturbed by Caledonian deformation and the sections less complete than farther north, it is not possible to correlate directly with one specific formation within the Hagen Fjord Group, but with reference to the presence of *Skolithos* we favour a correlation with the uppermost part of the group.

Correlation with other areas

The Hagen Fjord Group of eastern North Greenland represents sedimentation on a passive margin facing the Late Proterozoic Iapetus Ocean (cf. Surlyk, 1991). Other shallow-water shelf sediments of Late Proterozoic age are exposed in several regions along the eastern, north-eastern and northern rim of the Canadian–Greenlandian shield (Fig. 30). The strata were deposited in marginal basins or aulacogens bounded or dissected by faults, some of which may have been active during deposition.

Like the Hagen Fjord Group, these successions are characterised by medium-grained sandstones, interlayered fine-grained sandstones and siltstones, lime mudstones and stromatolitic dolostones. As a rule, the

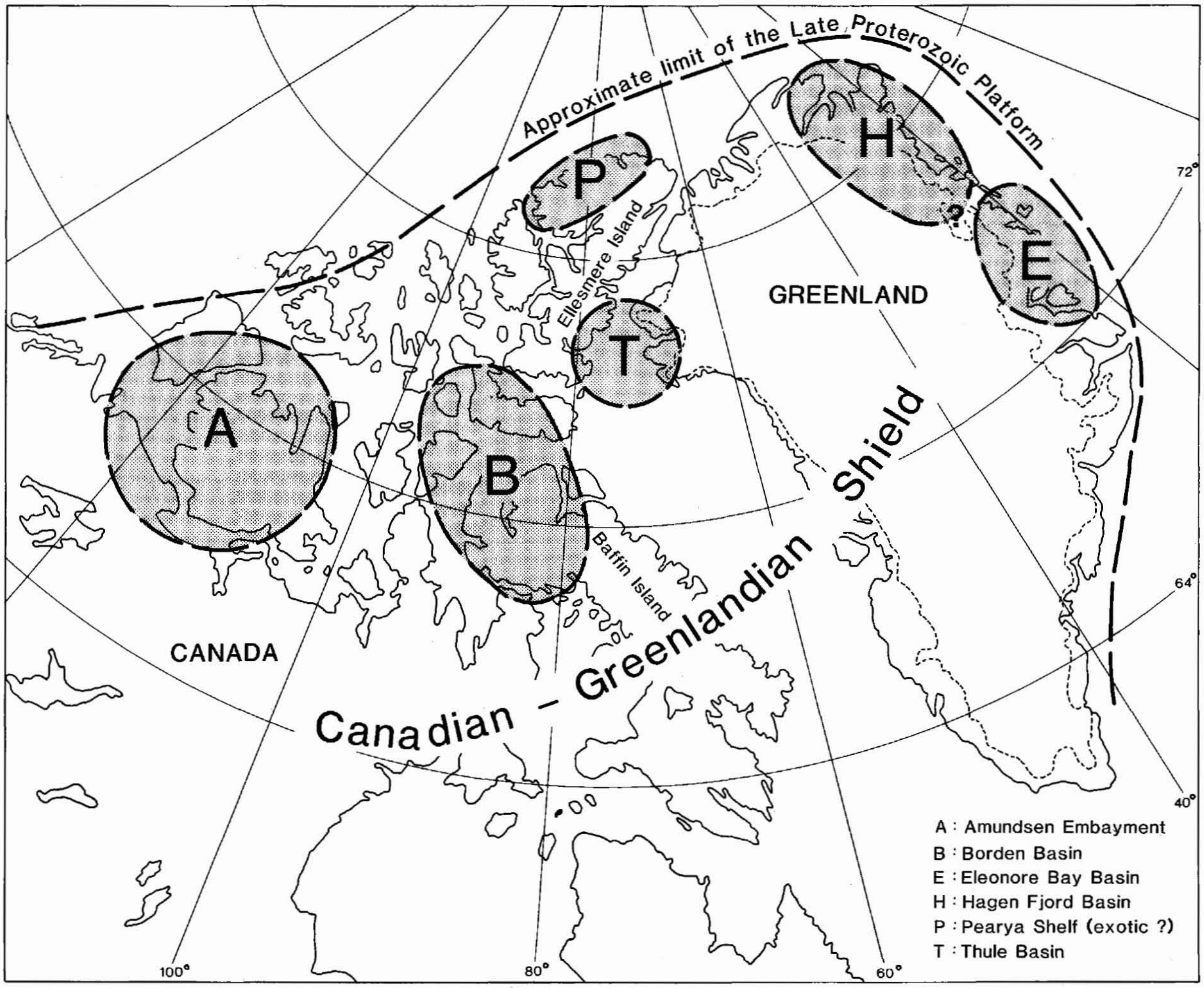


Fig. 30. Map of the northern and north-eastern rim of the Canadian–Greenlandian Shield showing the location of Late Proterozoic sedimentary basins.

limestones and stromatolitic dolostones are most abundant near the top of the sequences.

In central East Greenland, the uppermost parts of the c. 16 km thick Eleonore Bay Group (Haller, 1971; Vidal, 1979; Caby & Bertrand-Sarfati, 1988; Sønderholm & Tirsgaard, in press) may be coeval with the Hagen Fjord Group. Here the substratum is composed of medium-grade schists and gneisses which yield Grenvillian isotopic ages (Higgins *et al.*, 1981). The Eleonore Bay Group is overlain by the glaciogenic Tillite Group of Varangian age.

The Thule Basin, North-West Greenland (Dawes *et al.*, 1982; Dawes & Rex, 1986) and the Borden Basin, Canada, covering part of Bylot Island, northern Baffin Island and Somerset Island (Jackson & Ianelli, 1981; Stewart, 1987) are composed of Middle Proterozoic siliciclastic sediments and volcanics overlain by Upper Proterozoic (Upper Riphean – Vendian) shallow-water sequences similar to and possibly coeval with the Hagen Fjord Group. Further west, the Amundsen Embayment, Victoria Island (Young, 1981) is another example of an Upper Proterozoic marginal basin comprising shallow-water siliciclastic sediments, limestones and stromatolitic dolostones (Fig. 30).

The age of the upper part of the Borden Basin sequence is debatable. Based on palaeomagnetic evidence (sediment cores) Fahrig *et al.* (1981) conclude that the whole sequence is of Middle Proterozoic age (Neohelikian in North American terms), whereas Jackson & Iannelli (1981), based on lithostratigraphic similarity, correlate the youngest part of the sequence with the upper part of the Thule Basin succession that is of proven Upper Riphean – Vendian age (Hadrynian in North American terms; Dawes & Vidal, 1985).

In northern Ellesmere Island, Canada, the Grenvillian basement of Pearya was overlain, probably with profound unconformity, by an Upper Proterozoic(?) shallow-water shelf-succession composed of limestones, dolostones, quartzites, and mudrocks with overlying diamictites and related greywackes and mudrocks that are probably glaciogenic (Trettin, 1987). The diamictites are possibly contemporaneous with the Morænesø Formation of North Greenland (Varangian(?)–Hadrynian in North American terms; the underlying shelf-succession may correlate with parts of the Hagen Fjord Group. Trettin (1987) argues that the presence of Upper Silurian, SW–NE trending strike-slip faults separating the Pearya terrane from the Franklinian Basin and Middle Ordovician ophiolitic rocks, suggest that Pearya may be an exotic terrane. As part of the Caledonian mobile belt until Upper Ordovician time, Pearya could have been brought into place in northern Ellesmere Island by major strike-slip sinistral movements along the northern margin of the Canadian–Greenlandian Shield.

Correlation with regions outside the Canadian–Greenlandian Shield is more speculative. Upper Proterozoic sequences, possibly coeval with the Hagen Fjord Group, are known from Svalbard (Veteranen Group, Akademikerbreen Group and Kongsvegen Group) and from northern Scandinavia (Vadsø Group and Tanafjord Group). Summaries of these groups are presented by Hambrey (1988). Both on Svalbard and in northern Scandinavia, the Upper Proterozoic shelf-sequences are overlain by glaciogenic sediments of Varangian age.

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