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# The Proterozoic Thule Supergroup, Greenland and Canada: history, lithostratigraphy and development

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**Keywords**
Neohelikian–Hadrynian sediments and volcanics, intracratonic Thule Basin, history of research, lithostratigraphy, basin development, North-West Greenland, Ellesmere Island, Canada

**Cover**
The middle Proterozoic (Neohelikian) Nares Strait Group on the east side of Kissel Gletscher, Northumberland Ø, Greenland. The succession is dominated by shallow water siliciclastic strata with one main basaltic interval containing effusive, hypabyssal and pyroclastic rocks (Cape Combermere Formation, in centre). This succession represents the early fill of the central part of the Thule Basin. The initial recognition that the central basin straddled Nares Strait was based on the correlation of this succession with that at Clarence Head on the south-eastern coast of Ellesmere Island, Canada (see Fig. 49). The highest ice-capped summit is just below 1000 m a.s.l.; the sea is visible to the left. For map location, see Fig. 48.

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# Abstract

Dawes, P. R. 1997: The Proterozoic Thule Supergroup, Greenland and Canada: history, lithostratigraphy and development.
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A new lithostratigraphic scheme for the Proterozoic (Neohelikian–Hadrynian) intracratonic Thule Basin of northern Baffin Bay is presented. This basin, preserved between 76º and 79ºN in Greenland and Ellesmere Island, Canada, contains little deformed and unmetamorphosed strata at least 6 km thick that are referred to the Thule Supergroup. The succession is composed of continental to shallow marine sediments with prominent red bed units, and one main interval of basaltic volcanic rocks. Diabase sills representing both the Mackenzie (Neohelikian) and Franklin (Hadrynian) magmatic episodes occur at certain levels.

The bulletin has three main parts. The forerunner of the new supergroup, the Thule Group, is infamous for the nomenclatorial chaos that has surrounded its use. Consequently *the first part* is a historical summary as background to the definitive nomenclatorial revision. The *second and main part* on lithostratigraphy splits the Thule Supergroup into 36 formal divisions: 5 groups, 15 formations and 16 members. Twenty geological maps show the regional distribution of the defined units that are represented by 78 stratigraphic logs and sections. The *third part* summarises basin development as a restricted or semi-restricted depocentre on the northern margin of the Canadian–Greenlandic shield. Evolution was controlled by block faulting and basin sagging in a divergent plate regime.

The *Smith Sound Group*, up to 700 m thick, represents the northern platform and basin margin equivalent of the Nares Strait and Baffin Bay Groups of the central basin. Composed of sandstones and shales with subordinate stromatolitic carbonates, the Smith Sound Group represents an overall shelf environment with long-lasting conditions for shallow water to subaerial deposition. Supratidal to marginally marine and intermittently lacustrine sedimentation prevailed.

The *Nares Strait Group*, up to 1200 m thick and representing the basal strata of the central basin, is composed of sandstones and basaltic volcanics including flows, sills and volcaniclastic deposits, as well as shale- and carbonate-dominated intervals. The group represents deposition in alluvial plain, littoral and offshore environments, with accompanying terrestrial tholeiitic volcanicity.

The *Baffin Bay Group,* overlying conformably the previous group, represents the most widespread strata of the Thule Basin reaching a maximum thickness of up to 1300 m. Sandstones and quartz-pebble conglomerates, with important intervals of shales and siltstones, represent mixed continental to marine shoreline environments with an interval of deeper water deposition, possibly in a prodelta or offshore basin.

The *Dundas Group,* 2 to 3 km thick and following the previous group along a gradational contact, comprises sandstones, siltstones and shales with lesser amounts of carbonate and evaporite. Deposition was in an overall deltaic to offshore environment.

The youngest strata, the *Narssârssuk Group*, 1.5 to 2.5 km thick, are preserved in a graben on the south-eastern margin of the basin. The cyclic carbonate – red bed siliciclastic sequence with evaporites represents deposition in a low-energy, hypersaline, peritidal environment in conditions perhaps analogous to modern coastal sabkhas.

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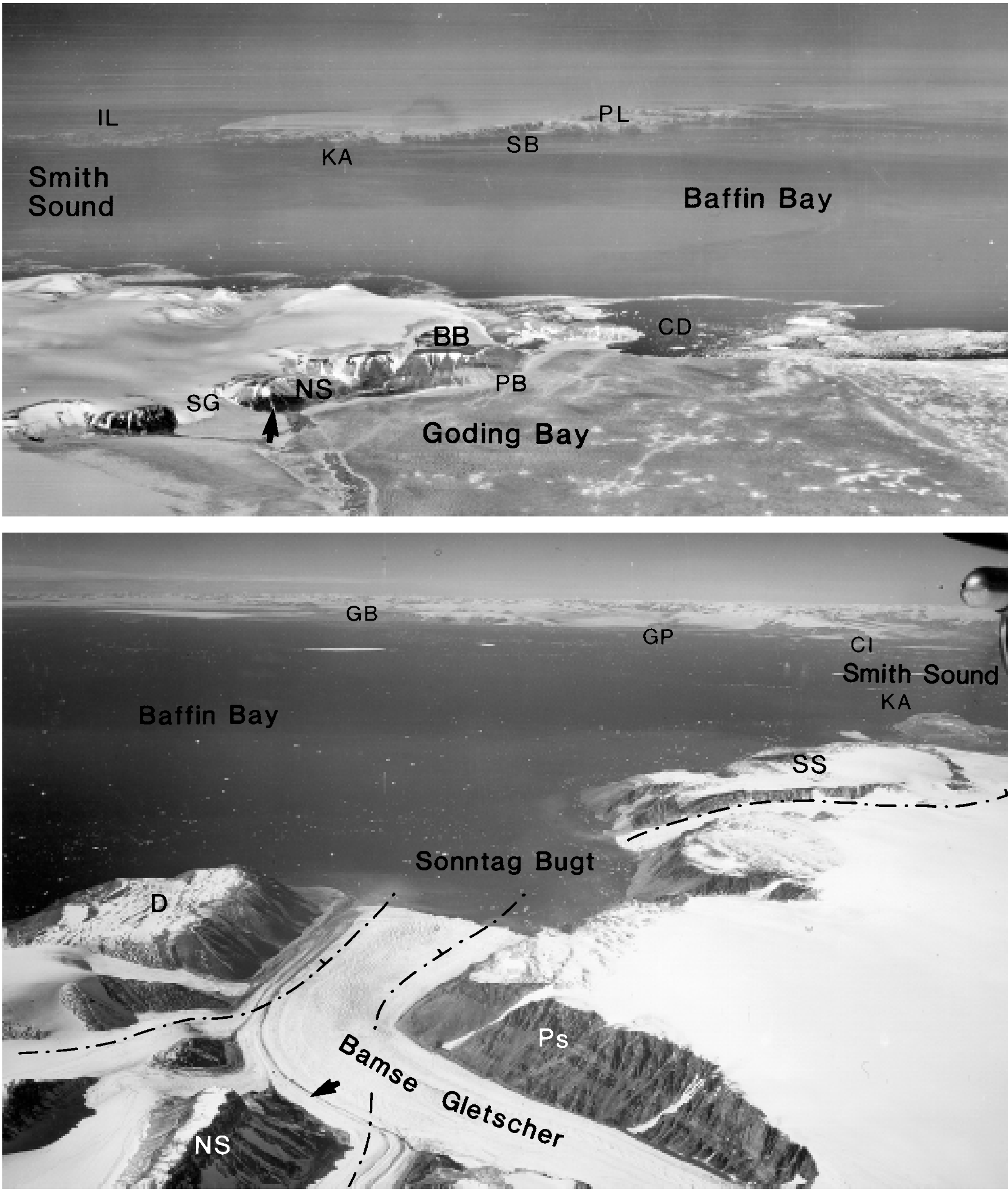



Fig. 1. The Thule Supergroup on opposite sides of northern Baffin Bay – Smith Sound. **Above**, view to Greenland from Goding Bay Canada; **below**, view to Canada from Sonntag Bugt, Greenland, with a distance of less than 50 km between Kap Alexander (KA) and Cape Isabella (CI; see Fig. 2). Height of plateau surface in both views is between 500 and 700 m (see geological maps, Figs 27, 80). The sections arrowed, through the Nares Strait Group (NS), at Sparks Glacier (SG) and Bamse Gletscher are comparable: dark basaltic rocks of the Cape Combermere Formation overlain by the recessive Josephine Headland Formation and topped by the pale cliff-forming sandstones of the Clarence Head Formation (for section detail, see Figs 64, 81B). In Greenland, main faults illustrate coastal down-faulting with Dundas Group (D) as the youngest strata in the outer coastal block (see Figs 5B, 27). Ps = Precambrian shield, SS = Smith Sound Group, BB = Baffin Bay Group; locations: CD = Cape Dunsterville, GP = Gale Point, GB = Goding Bay, IL = Inglefield Land, PB = Paine Bluff, PL = Prudhoe Land, SB = Sonntag Bugt. Aerial photos: above, T403 R-41 National Air Photo Library, Ottawa, Canada; below, 543 E-V 5729, Kort- og Matrikelstyrelsen, Copenhagen, Denmark.

# Introduction

This bulletin describes the unmetamorphosed middle to late Proterozoic (Neohelikian–Hadrynian) strata of the Smith Sound – northern Baffin Bay region. The strata outcrop between 76º and 79ºN in Greenland and Ellesmere Island, Canada (Figs 1, 2). A new formal lithostratigraphic scheme is presented in which the strata are referred to the Thule Supergroup.

The Thule Supergroup, comprising little-disturbed sedimentary and magmatic rocks, overlies the Precambrian shield with profound unconformity. Apart from fault-block tilting, minor local warps and broad flexures, the strata are not deformed. The rocks were laid down in the intracratonic Thule Basin on the northern margin of the Canadian–Greenlandic shield (Dawes *et al.*, 1982a).

The Thule Supergroup outcrops as three main successions: a basinal succession forming the dominant part both in Greenland and Canada, to the north a thin basin margin and platform succession, and to the east and south-east, only occurring in Greenland, a basin margin section with a superimposed graben sequence. The basinal succession, represented by the Nares Strait, Baffin Bay and Dundas Groups, is preserved mainly in fault-bounded blocks as essentially flat-lying to shallow dipping sections. The south-eastern marginal succession occurs as thin, scattered outliers composed of the Baffin Bay and Dundas Groups, and as a thick graben section composed of the Narssârssuk Group. These two successions are limited upwards by Quaternary and Recent deposits and by the present erosion surface. In contrast the platformal and northern margin succession represented by the Smith Sound Group is overlain in northernmost outcrops disconformably by Lower Palaeozoic deposits of the Franklinian Basin (Fig. 2).

The Thule Supergroup is most fully developed in Greenland where it has a composite thickness exceeding 6 km. Its outcrops cover more than 6500 $km^2$. Of the five groups, the Baffin Bay Group has the most extensive geographic distribution; the Narssârssuk Group is the most restricted, occurring only in the Bylot Sund area of Greenland. In Canada, only the lower part of the succession is preserved, composed of the three oldest groups, viz. the Smith Sound, Nares Strait and Baffin Bay Groups (Fig. 2). Formal subdivision and description of these three groups form the main part of this bulletin.

## Field work

Field work by the author is based on Greenland exposures, which were mapped during five summers in the 1970s with some later observations in the environs of Qaanaaq and Pituffik (Thule Air Base) during transit visits in the early 80s. Outcrops in Canada, studied photogeologically and formally referred to the new lithostratigraphical scheme, have been mapped by geologists of the Geological Survey of Canada (Christie, 1962a, b, 1967, 1975; Frisch *et al.*, 1978; Frisch & Christie, 1982; Jackson, 1986).

The stratigraphic data from Greenland were collected during reconnaissance mapping of the entire region between 75º and 78º30′N. This region, in addition to the Proterozoic cover strata, is composed of extensive exposures of the Precambrian shield (Fig. 2). The field work was directed at the production of a 1:500 000 geological sheet of the national map coverage (Dawes, 1991a). The main exposures of the Thule Supergroup are covered by maps at 1:100 000 deposited in the archives of the Geological Survey of Denmark and Greenland in Copenhagen.

The stratigraphical work and logging of sections were undertaken concurrently with the geological mapping. Most of the early work, carried out in reconnaissance style using local boat transport, allowed for only brief examination of coastal sections. This work concentrated on recognition of mappable units rather than detailed examination and stratigraphic logging. Occasional foot traverses were made inland. Much section correlation was achieved by binocular study or from aerial photographs. In 1978 and 1980, use of a helicopter gave access to inland sections as well as to Inglefield Land north of normally navigable waters. This allowed for detailed stratigraphic work to be carried out.

This expansion of logistic support also allowed for the participation of two other geologists: Thomas Frisch (Geological Survey of Canada, Ottawa), who in 1977 mapped corresponding strata in Ellesmere Island (Frisch *et al.*, 1978), and Bernard O'Connor (then of the University of Minnesota, USA). In 1978 and 1980 Frisch undertook comparative studies of both Greenland and Canadian sections, reconnoitring with the author from Bylot Sund northwards to Inglefield Land (Fig. 2). Key sections were visited, including the lower part of the succession on Northumberland Ø, and this consoli-

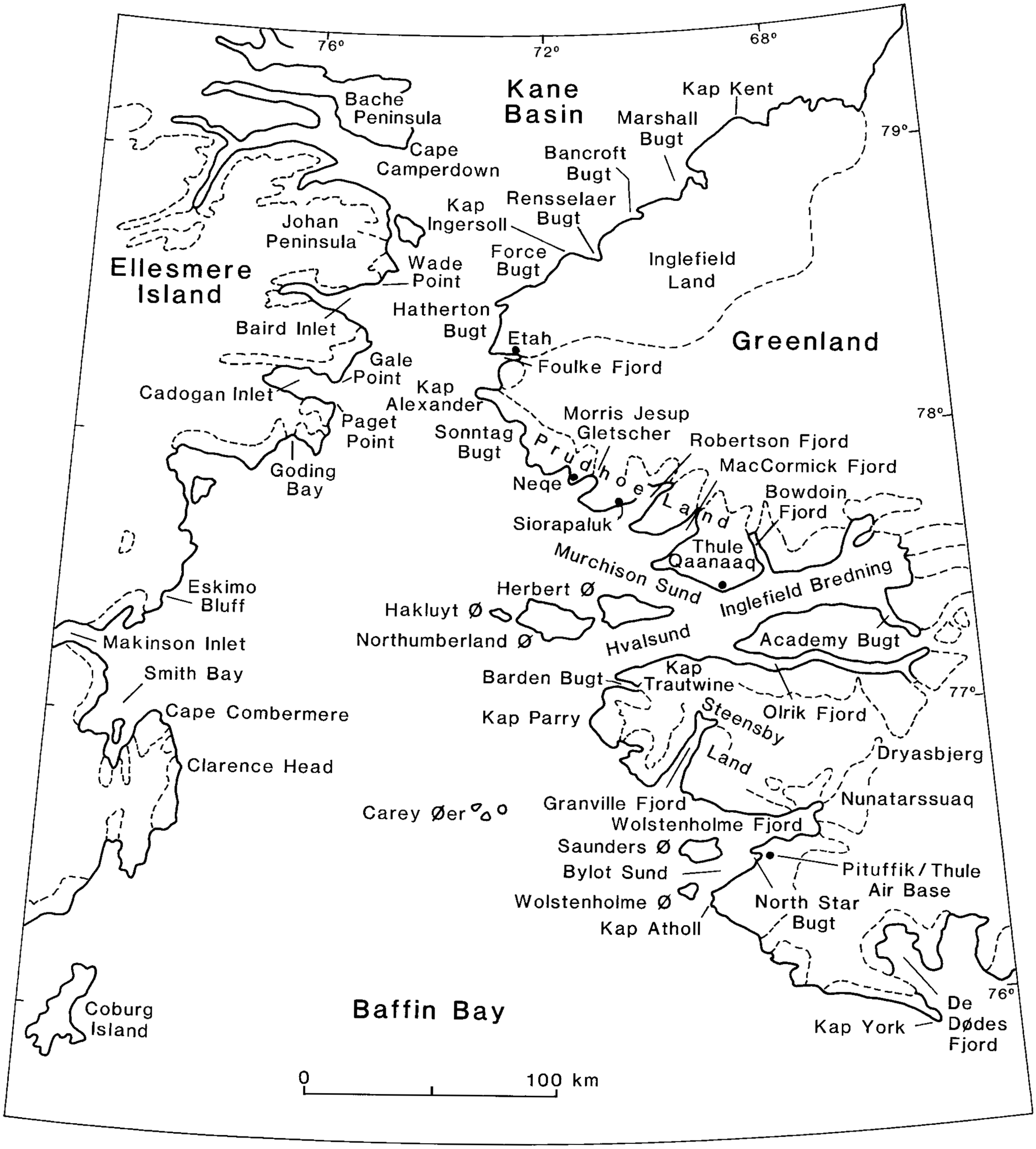



Fig. 2. Maps of the northern Baffin Bay – Smith Sound region. **Left:** Toponymic map. Other place names are shown on Figs 10 and 12, and on the 20 geological maps indexed on the geological map on the facing page. **Right:** Geological and location map showing the distribution of the five groups of the Thule Supergroup. Stars mark small isolated outcrops. A = Academy Gletscher, C = Clarence Head, F = Freuchen Nunatak, M = Magnetitbugt, Mc = MacMillan Glacier, R = Rampen, S = Sun Gletscher. Numbered frames refer to the 20 geological maps included as figures in the text.

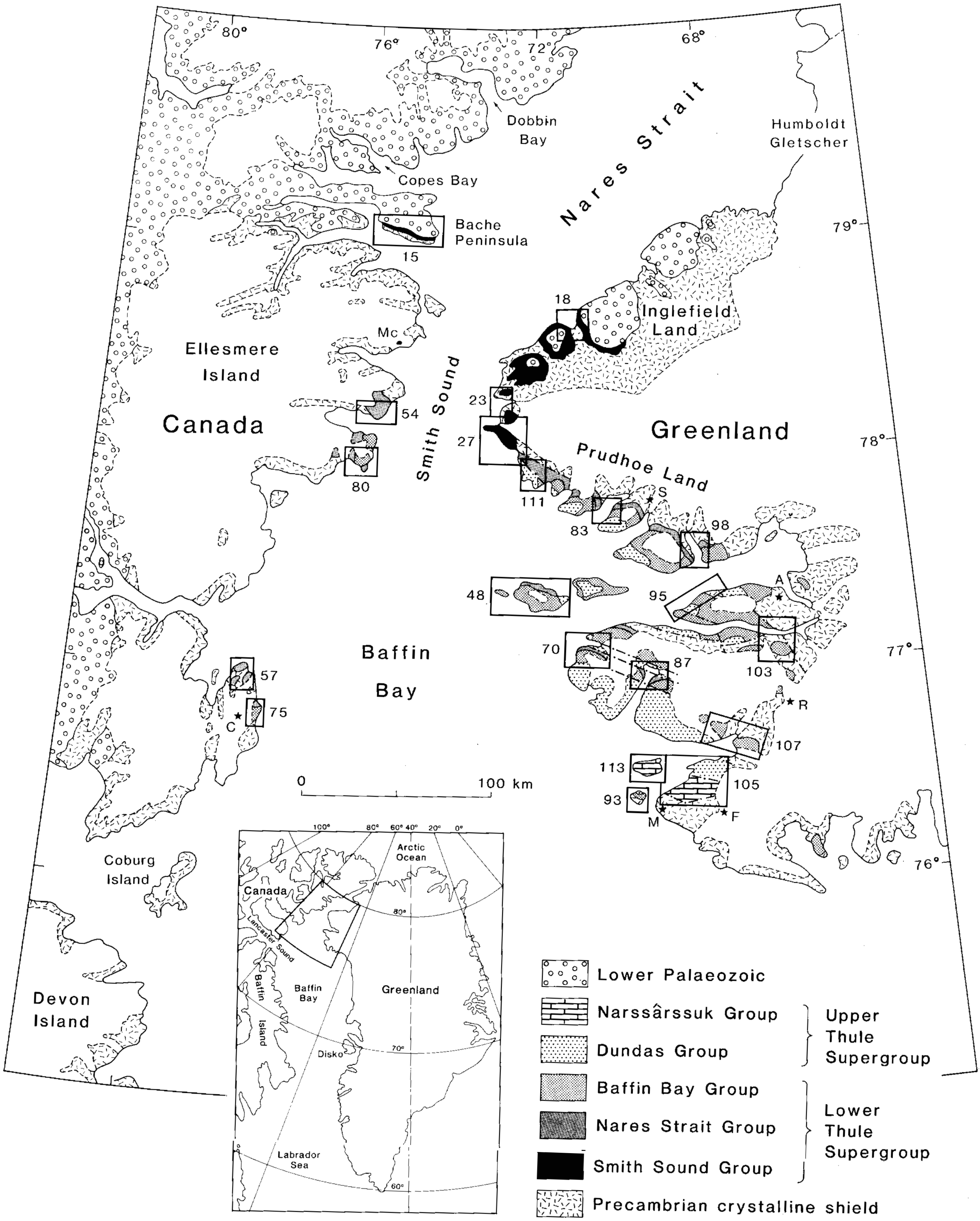



*Fig. 2. See facing page.*

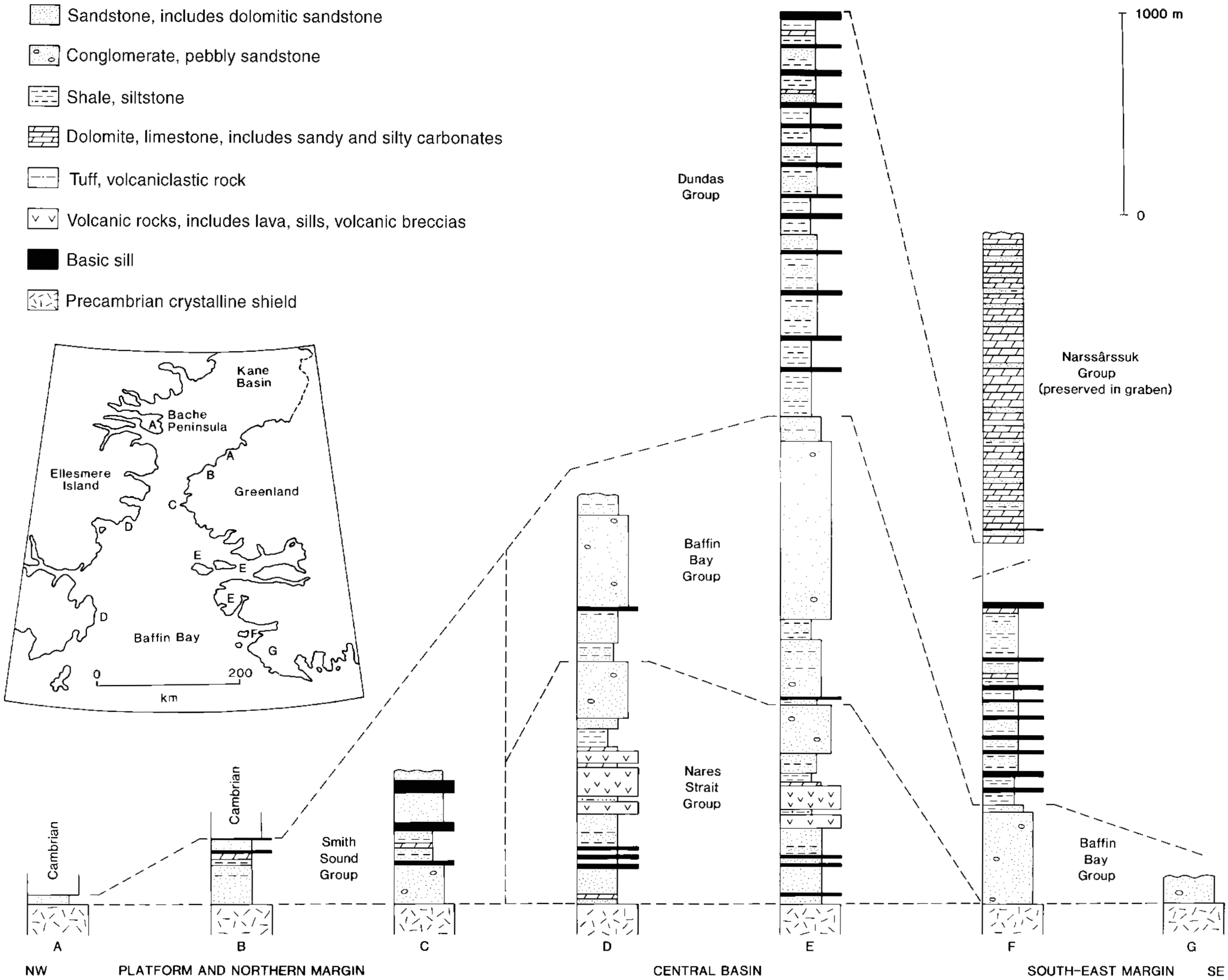



Fig. 3. Schematic columnar sections of the Thule Supergroup. The central basin sections are composite: the Greenland section (E) is based on Northumberland Ø, Herbert Ø and Steensby Land; that of Ellesmere Island, Canada (D) is from Gale Point, Goding Bay and Clarence Head.

dated the unit to unit correlation of the Thule Basin succession across Nares Strait (Dawes *et al.*, 1982a). In 1980, O'Connor undertook stratigraphical and sedimentological work for five weeks. Measurement of the sections at Saunders Ø, Hartstene Bugt, Etah, Dodge Gletscher and Rensselaer Bugt was undertaken jointly with the author; later work at Narssârssuk, Barden Bugt, Robertson Fjord and Kap Powell was carried out by O'Connor alone. This paper draws on the field notes of O'Connor (1980).

The use of data from O'Connor and Frisch in the compilation of stratigraphic sections and geological maps is acknowledged in the relevant figure captions. Photograph credits to these coworkers, and to others, particularly of Canadian geology, are also given in the relevant figure captions.

## Scope of this study

Observations on Thule strata go back to the last century during North Polar exploration along Nares Strait. Stratigraphical nomenclature, introduced by Koch (1929a) with the term Thule Formation, has had a very involved history. Nothing less than nomenclatorial chaos surrounds the use of this term and its successors, the Thule Group of Troelsen (1949, 1950a) and the Thule Group of Koch (1961) and Haller (1961, 1970, 1983). In the light of this, and because no synthesis of research into Thule strata has been published, this bulletin provides a detailed account of previous work and concepts as a background to the nomenclatorial revision.

In presenting a new lithostratigraphic scheme for

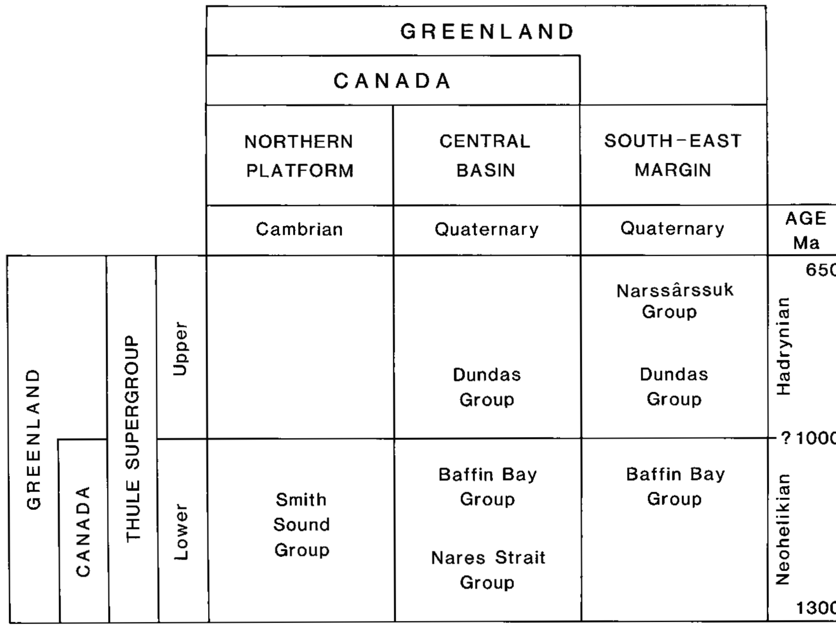



Fig. 4. Lithostratigraphic scheme of the Thule Supergroup showing location and regional setting of the five groups, and general ages.

the Thule Supergroup, formal description at formation and member level is for convenience restricted to the lower Thule Supergroup (Smith Sound, Nares Strait and Baffin Bay Groups) that defines the geographical limits of the Thule Basin straddling Nares Strait (Figs 1–4). The thicker and youngest strata of the Thule Supergroup (Dundas and Narssârssuk Groups), more restricted in outcrop and occurring only in Greenland, are subdivided but not formally defined here.

This study supersedes all previous accounts by the author of the middle to late Proterozoic strata in North-West Greenland, both progress reports written after field seasons (e.g. Dawes, 1972, 1975, 1976b, 1979a) and regional syntheses (e.g. Dawes, 1976a; Dawes *et al.*, 1982a). In terms of correlation and stratigraphic nomenclature it also supersedes publications dealing with Canadian outcrops, viz. Christie (1962a, b, 1967), Christie *et al.* (1981b), Frisch & Christie (1982), Dawes *et al.* (1982a), Jackson (1986) and Frisch (1988); the reader is referred to these works for a full description of the western outcrops of the Thule Basin. I have reinterpreted Canadian outcrops and stratigraphy, and this in part is based on the unpublished notes and sections of Christie (1975).

Peel *et al.* (1982) adapted a revised nomenclature for the platform succession in Inglefield Land (Greenland) and Bache Peninsula (Canada), and referred the formal unit description to a sequel paper quoted as Collinson *et al.*, 'in press'. Unfortunately that paper was not published as planned. This bulletin supersedes the revision mentioned in Peel *et al.* (1982).

The stratigraphical revision of the Thule strata has been heralded (e.g. Dawes *et al.*, 1982a) and Thule Supergroup terminology is found in Hansen & Dawes (1990), Escher & Kalsbeek (1990), Dawes (1991a, b) and Escher & Pulvertaft (1995).

## The name Thule and place-name terminology

In usage, the name Thule is unique among place-names of Greenland. Remarkably, Thule has been the authorised Danish name for two settlements located 100 km apart (Fig. 2). This varying geographical position, and the presence of a military air base also known by the name Thule is unfortunate.

In this bulletin the name Thule is used geologically, both formally (Thule Supergroup) and informally (Thule strata), as well as toponymically, in the sense of its original usage, i.e. the site of the now abandoned trading station at North Star Bugt (Figs 2, 105). Dundas, the abandoned Danish settlement at the trading station site, is retained as a stratigraphic term, and the Greenlandic name Qaanaaq, present-day Thule and capital town of Avanersuup municipality situated on Inglefield Bredning, is introduced as a new stratigraphical name. Qaanaaq is used when referring to the capital town; the Greenlandic name Pituffik is used for Thule Air Base. Sioraq, Greenlandic for 'sandy plain', is the lowland on which the air base is located; Pitugfiup kûgssua is the river draining the lowland (see Fig. 105).

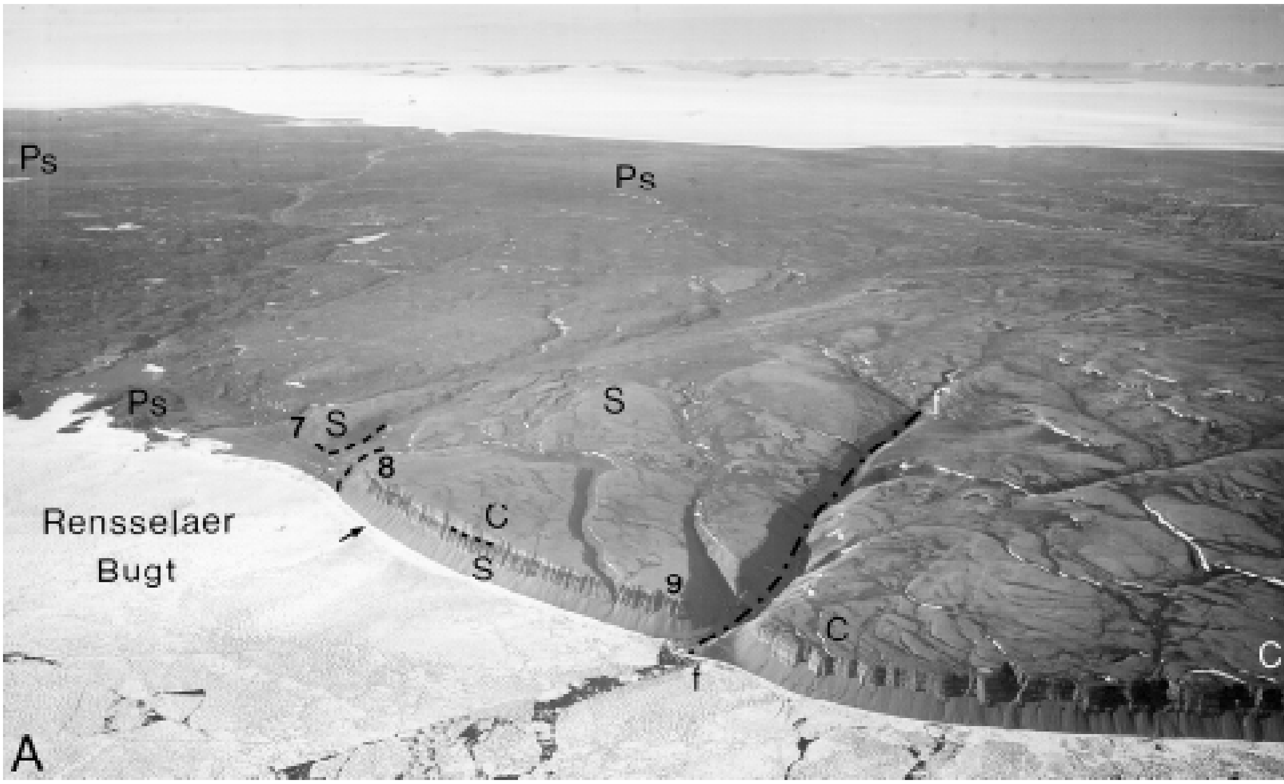



Fig. 5. Contrasts in physiography and exposure of the Thule Supergroup. **A:** plateau landscape in Inglefield Land with the Smith Sound Group (S) overlying the Precambrian shield (Ps). View is south over Rensselaer Bugt to Prudhoe Land with plateau elevation south-west of Rensselaer Bugt up to 400 m. The disconformity with the Cambrian (C) of the Franklinian Basin is just below the pale marker (for stratigraphic detail, see Fig. 32). In the down-faulted westerly block the Smith Sound Group is mostly scree covered. Outcrop of the Precambrian shield at sea-level is arrowed (see geological map, Fig. 18); section locations 7, 8 and 9 are indicated.

The 'Thule region or district' is used herein informally to describe the entire country from Kap York to Kap Alexander; Inglefield Land is used in its authorised sense as the land between Kap Alexander and Humboldt Gletscher.

Place-names are located in Figs 2, 10, and 12, and on the geological maps indexed in Fig. 2. For the spelling of place names used stratigraphically, e.g. Narssârssuk, see section on *Lithostratigraphy*.

## Physiography and exposure

The northern Baffin Bay region, magnificently sculptured by glacial erosion, is dominated by uplands and mountainous highlands covered to varying degrees by ice; contrast is provided by Inglefield Land in the north, which forms a dissected plateau of rolling relief. Much of the region is underlain by the Precambrian shield. The overlying Thule Supergroup mainly occupies the outer coastal region preserved mainly in down-faulted blocks or, as in Inglefield Land, as platform outcrops (Fig. 5). In Greenland, Thule strata form continuous outcrops between 76º25′ to 78º50′N; in contrast, in Canada the strata occur as relatively small, widely separated outcrops (Fig. 2).

The Thule Supergroup is generally well exposed. Of the five groups the Dundas Group and Smith Sound Group, with predominant fine-grained clastic lithologies, are most prone to erosion. The Dundas Group forms several poorly exposed lowland areas but it is invaded by resistant dolerite sills. In places these produce miniature mesas that preserve good sedimentary sections beneath their dolerite caps. The celebrated landmark of the Thule district, Dundas Fjeld, is one such landform (see Fig. 105). In Inglefield Land coastal and inland scree-covered slopes are prevalent (Figs 5A, 8, 9).

Supposedly, large areas of Thule strata are hidden by ice and permanent snow. Ice-caps cover central areas of the peninsulas in Prudhoe Land and large parts of Steensby Land, while the Inland Ice encroaches over exposures inland of Pituffik. Recently ice-released land is often covered by thick drift.

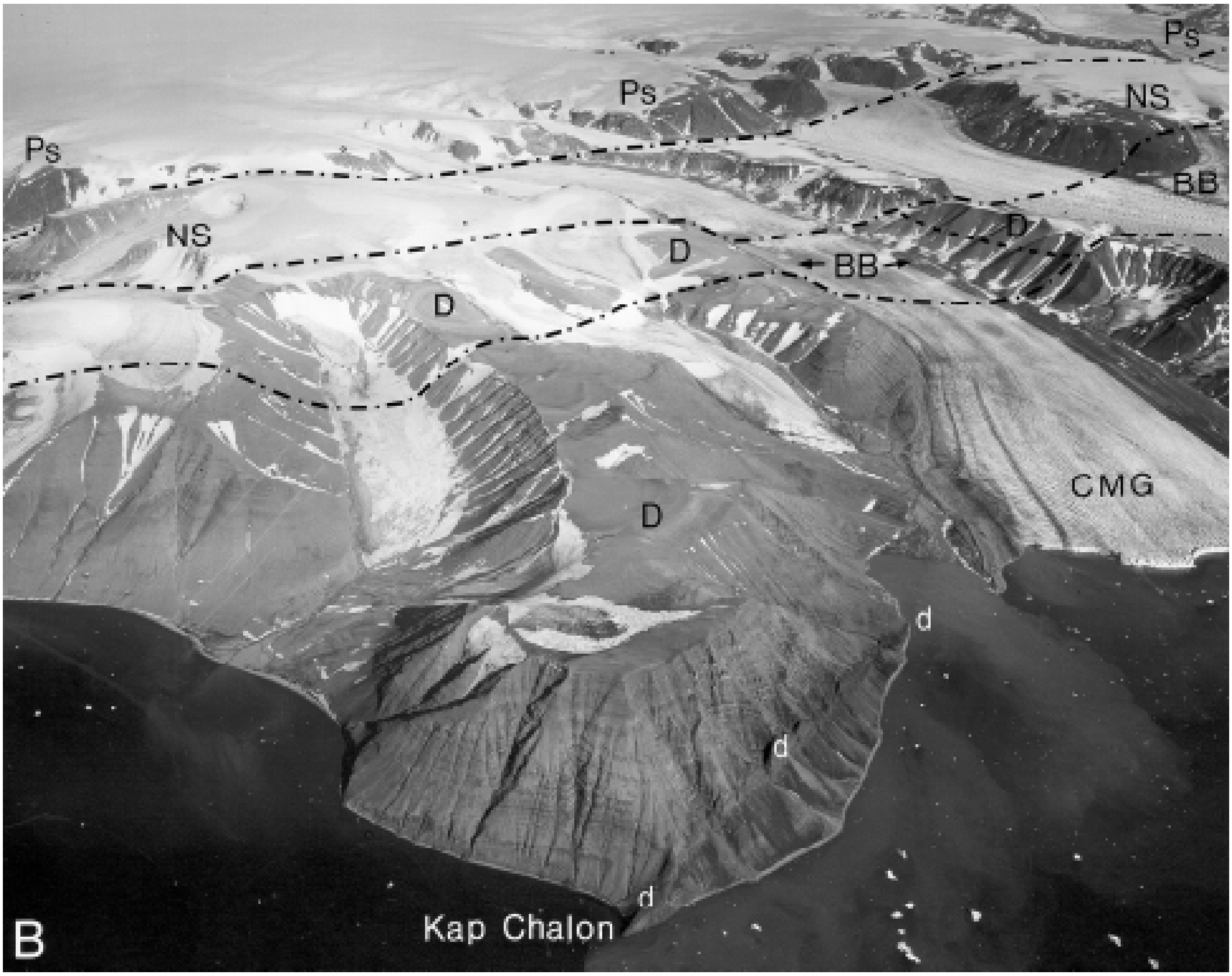



*Fig. 5 cont.* **B:** The Nares Strait (NS), Baffin Bay (BB) and Dundas (D) Groups in the central basin outcropping in coast-parallel fault blocks with the Precambrian shield (Ps) inland. View is east over Clements Markham Gletscher (CMG), Prudhoe Land. Main faults controlling outcrops at group level are shown. Kap Chalon, cut by a late Hadrynian basic dyke (d), is about 600 m high. For geological map, see Fig. 111. Photos: A, 544A/9297, July 1949; B, 543 B-NØ/2727, July, 1950; Kort- og Matrikelstyrelsen, Denmark.

The Thule strata form rolling uplands to dissected plateau landscape, with upper surface elevations between 400 and 800 m and with partial ice cover (Figs 1, 5). More locally, ice-covered rugged mountains and nunataks are over 1000 m high. The fault-block structure of the region in many places forms spectacular, steep and cliffed coasts, exposing magnificent sections where thin stratal units can be followed over large distances. However, the homoclinal structure produces many sections that are precipitous and inaccessible. Talus can also be profuse.

On the rolling uplands and dissected plateaux, good exposures can occur along glaciers and in river valleys, but on hill tops and plateau surfaces exposures are scarce due to frost-shattered rubble, solifluction deposits or substantial Quaternary deposits. Valleys are usually broad and shallow but steeper valleys, in places canyon-like, occur locally, for example in the carbonate-rich Narssârssuk Group, south of Pituffik. In the high and rugged mountainous terrain, for example Northumberland Ø and Cape Combermere, characterised by closely-spaced cirque glaciers, there are good cliffed inland sections, some of which are accessible from the ice-fields (see Figs 48, 57).

Many fjords and major valleys are fault-controlled. Notable lowlands developed as such and supporting Quaternary and Recent deposits, e.g. the narrow coastland of outer Steensby Land or the broad valley at Pituffik, have limited exposures.

# History and status of geological research

Recorded observations of the strata now called Thule Supergroup fall into three periods: (1) 1852–1909 when sporadic observations were made primarily from ships; (2) 1910–1945 when specific geological work was carried out, typically by dog-sledge and boat, and launched from wintering bases; and (3) 1946 onwards, summer exploration made possible by aircraft.

## Ship-borne exploration (1852–1909)

Following William Baffin and Robert Bylot's charting of northern Baffin Bay in 1616, Smith Sound, the narrow seaway seen to the north, remained unexplored for more than two centuries. Then, a succession of British and American expeditions heading for the far north visited the Thule district. Information establishing the presence of flattish-lying, multicoloured sedimentary and volcanic strata resting on crystalline granitoids is scattered through the journals of these expeditions, e.g. Inglefield (1853), Kane (1856), Haughton (1859), Hayes (1867), Nares (1878) and Bessels (1879). Sandstones, with grits, conglomerates and calcareous rocks, intercalated with layers of igneous rocks termed 'greenstones', 'traps', 'basalts' or 'greenstone-porphyry' were recorded. Of particular note are the observations of P. C. Sutherland (1853a, b) who, as surgeon of E. A. Inglefield's expedition in 1852, sketched in detail coastal cliff sections passed by their ship. He described the shallowly-dipping dark sandstones – also called 'slaty quartzose grits' – around 'Mount Dundas', Wolstenholme Fjord and Granville Bugt recognising the association with layers and dykes of basalt (see Figs 105, 106) – an early description of the Dundas Group of this bulletin.

Attempts at stratigraphical division based on observations from ships, essentially by laymen, were not the order of the day, but it is interesting that Nares (1878, vol. 1, p. 47) was impressed by the alternating units of bright red and light yellow sandstone making up the picturesque high, perpendicular cliffs of Northumberland Ø and Hakluyt Ø, viz. formations of the Nares Strait and Baffin Bay Groups: "the whole series dipping at an angle of 4º or 5º to the south" (see Fig. 77).

Expeditions led by Robert E. Peary wintered in the Thule district in 1891–92 and 1893–95, during which the coasts between 76º and 78ºN were surveyed. Brief references to geology occur in Peary's (1898) narrative and Thule strata are illustrated. However, it was left to the summer auxiliary expedition of 1894 to attempt a geological synthesis when glaciologist T. C. Chamberlin made the first subdivision of Thule strata based on the country around Inglefield Bredning.

"The clastic series embraces three distinguishable members" wrote Chamberlin (1895, p. 172; Fig. 6). Lower red and middle lighter coloured sandstone units are overlain by an upper unit of "more thin-bedded sandstones and shales of reddish-brown and dark hues". This tripartite division corresponding to units of the Baffin Bay and Dundas Groups is well seen on the south coast of Inglefield Bredning (see Fig. 95). Chamberlin stressed that the unit boundaries are conformable and that the succession may represent a consecutive sedimentation. Although "the full extent of this clastic series could not be determined … because it reached back under the ice cap", Chamberlin (1895, p. 172) was able to deduce that the strata form a coastal belt bordered by crystalline basement. This is the first reference that Thule strata form a coastal basin.

Ideas of this period about the age of the Thule strata were based on resemblance to successions of known (or supposed) age elsewhere. Thus the combination of undeformed sandstones and basalts led to correlation with Tertiary strata of Disko in West Greenland (Fig. 2; Sutherland, 1853a, b; Feilden & De Rance, 1878; De Rance & Feilden, 1878; Dawson, 1887). Comparisons were also made with strata farther south in Canada. Thus, for sandstone and conglomerate around Thule a Silurian age was initially inferred by reference to Lower Palaeozoic beds in Lancaster Sound (Haughton, 1858, 1859). The first notes on Thule strata in Canada were made by H. W. Feilden, senior naturalist on the Nares expedition 1875–76. At Bache Peninsula he described 'coarse basement beds' comparable to those at 'Wolstenholme Sound' in Greenland overlain by mural cliffs of limestone (Feilden & De Rance, 1878; Fig. 7). Fossils from the limestone prompted a Silurian age designation for the clastic rocks beneath, and by inference for the strata at Wolstenholme Fjord. Chamberlin (1895), however, remarking on the conspicuous absence of fossils, reserved opinion noting that Thule strata may be of more than one age; a discernment also seen in Feilden & De Rance (1878).

Per Schei, in 1898, and A. P. Low, in 1904, briefly examined the coastal geology around Foulke Fjord, Inglefield Land (see Fig. 23). Schei also visited Bache Peninsula and he correlated the homoclinal successions across Smith Sound, demonstrating strata at least as old as Cambrian at Bache Peninsula (Schei, 1903, 1904; Holtedahl, 1913, 1917). Low, in misinterpreting metamorphosed carbonate and clastic rocks at Sunrise Pynt, north of Foulke Fjord, assigned the Thule strata to the Huronian system of mainland Canada (Low, 1906, p. 208). Thus, as it happens, the placing of the Thule strata in the correct system (Precambrian) was made on spurious evidence. Willis (1912) adhered to a Precambrian (Huronian or Algonkian) age but followed Feilden & De Rance (1878) in maintaining a Tertiary age for thinner sections around Kap Alexander.

## Exploration from stations (1910–1945)

The establishment of the Thule trading station at North Star Bugt in 1910 by Knud Rasmussen and Peter Freuchen heralded a new chapter in scientific exploration. The first expedition launched from this base (1st Thule expedition, 1913) did little geological work around Thule, but Freuchen (1915) and Bøggild (1915) described from Independence Fjord in eastern North Greenland sandstones and diabase that were later to be included in the Thule Formation by Koch (1929a; see Fig. 10). It was on the 2nd Thule expedition (1916–18) that the first regional geological survey was embarked on by Lauge Koch (1918, 1919, 1920), a study continued on the Bicentenary Jubilee expedition 1921–23 (Koch, 1923a, b, 1925, 1926, 1929a, 1933). Koch compiled maps at 1:700 000 and *c.* 1:1 000 000 of Inglefield Land and the Thule district, respectively (Koch, 1933; Dawes & Haller, 1979), and illustrated the faulted nature of the Thule district by cross-sections of Prudhoe Land (Koch, 1926).

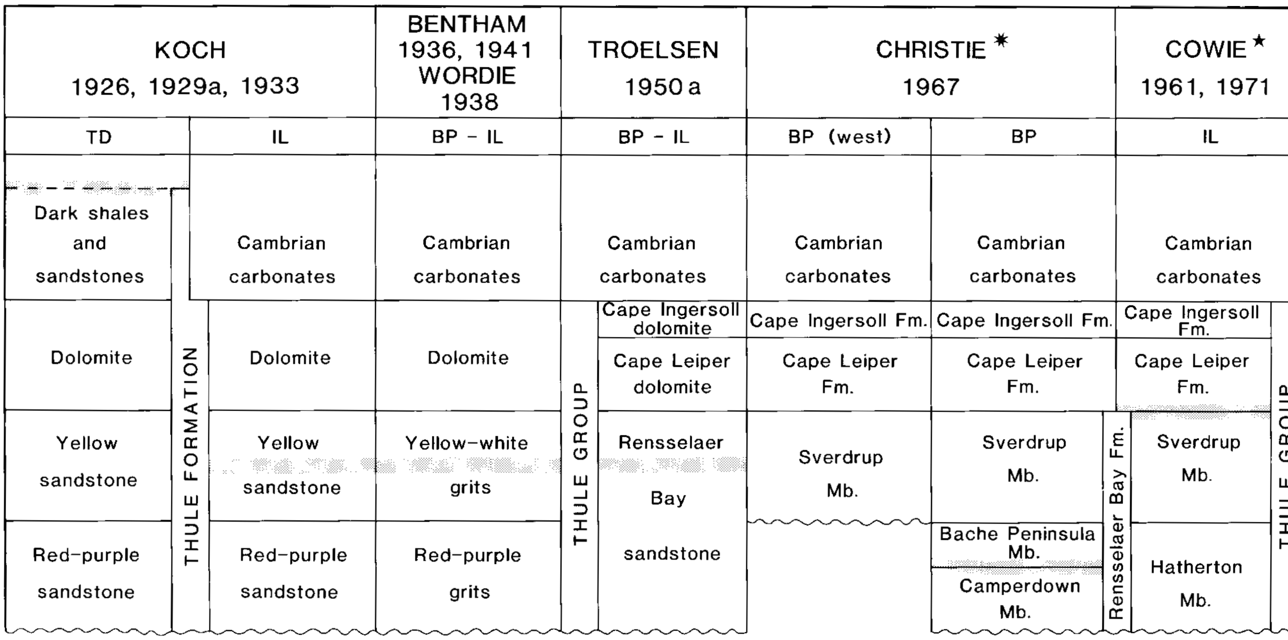
The name Thule Formation was introduced by Koch (1929a, p. 220) to cover late Precambrian strata with a type locality at "Wolstenholme Fjord, around Thule" (see Fig. 105). He included in this clastic and intrusive rocks in Canada and as far away as the east coast of Greenland (see section below on *Stratigraphic nomenclature*). Koch noted the thickness difference between the type area where the formation was said to exceed 800 m (now known to be much more), and Inglefield Land where "150 to 200 meters is the usual thickness". In North-West Greenland he adopted Chamberlin's tripartite subdivision (Koch, 1926, p. 304), although he erected a sub-unit of dolomites (Figs 6, 95).

A summary of Koch's stratigraphy from North-West Greenland (Koch, 1925, 1926, 1929a, 1933) is: a 'lower sandstone' of red, purple and brown colours, including arkose and conglomerates, with *Cryptozoon* reefs, an 'upper sandstone' of yellow and red yellowish sandstone with some conglomerate, and 'an uppermost series' of cliff-forming pale dolomites overlain by dark grey micaceous hard sandstone, black shale and slate. Dolomites in Inglefield Land were noted to contain *Cryptozoon* and chert. Important here is Koch's observation that the dark grey sandstones and shales, so conspicuous around Thule (Dundas Group) and for him representing the youngest strata, are absent in Inglefield Land, cliff-forming dolomites there being disconformably overlain by Lower Cambrian carbonates (Koch, 1933; Figs 6, 8).

Koch mapped a fourth unit – diabase – that he showed penetrating the Thule Formation in all areas except north-east Inglefield Land (Dawes & Haller, 1979, plate 1). Koch could but speculate on the absence of diabase in north-eastern Inglefield Land: only decades later did it become evident that the intrusion-free strata are Lower Cambrian and therefore post-date the Proterozoic magmatism (Peel *et al.*, 1982).

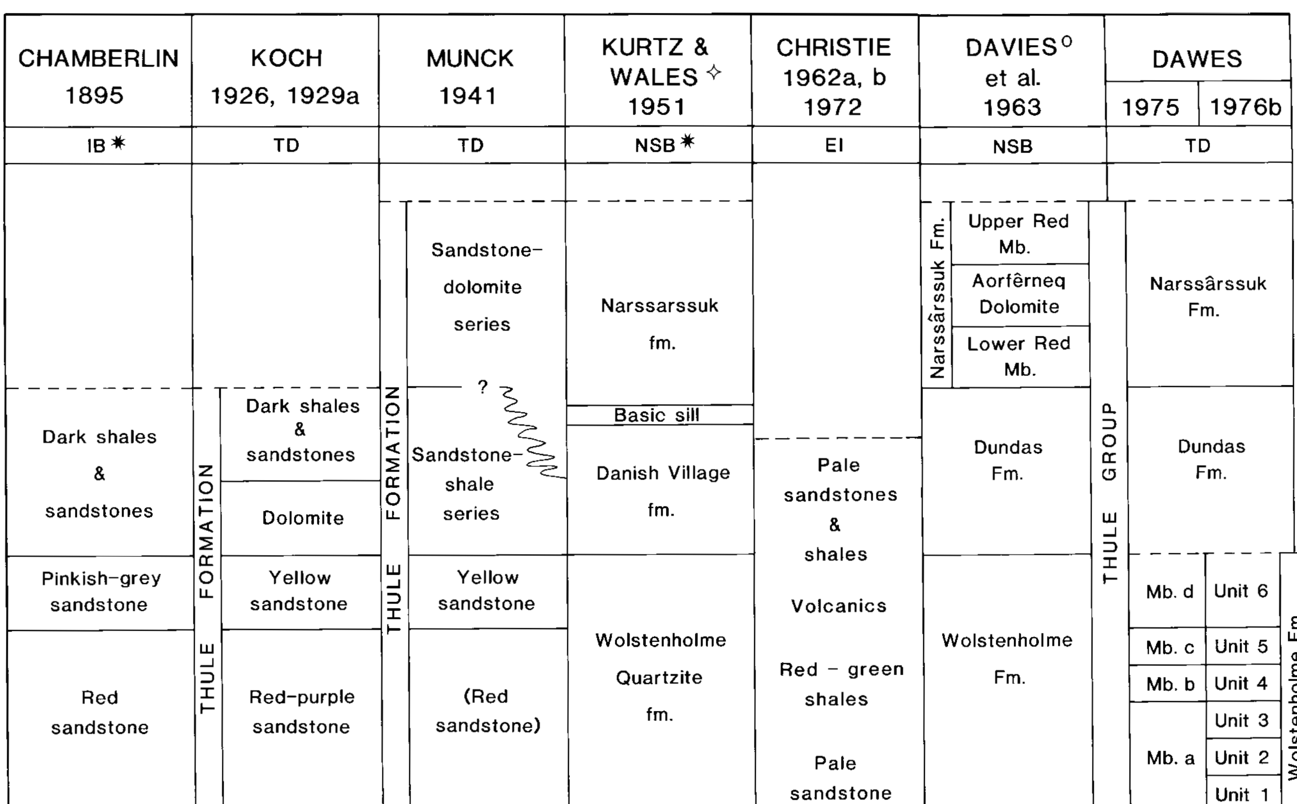
Koch applied Chamberlin's tripartite scheme widely in the Thule district and, with modification, in Inglefield Land, but he had difficulty in maintaining it fully. In the south, around Bylot Sund, the presence of a thick carbonate-rich red bed succession (Narssârssuk Group) was difficult to reconcile with the scheme. The problem was rooted in his assumption that the succession's southern boundary, with the crystalline shield, is a stratigraphic contact and not a master fault (Narssârssuk Fault; see Fig. 105). Koch's interpretation is very understandable: he mapped an unconformity on Wolstenholme Ø (see Fig. 93) and assumed the same relationship on the mainland. Hence, strata regarded today as the youngest (Narssârssuk Group) were referred to the basal part of the succession, and Saunders Ø and adjacent mainland (between Narssârssuk and Sioraq) were regarded as recording a complete section through the Thule Formation.

Koch (1918) initially suggested an Algonkian or Lower Cambrian age for the Thule strata. Later, on the basis of Holtedahl's (1913, 1917) assessment of Bache Peninsula, he switched to a Cambrian–Ordovician age (Koch, 1920). Finally, after the discovery in Inglefield Land (Kap Kent) of Lower Cambrian strata disconformably above clastic strata referred by him to the Thule Formation, he designated a Precambrian (Algonkian) age (Koch, 1926, 1929a). (It should be noted that these



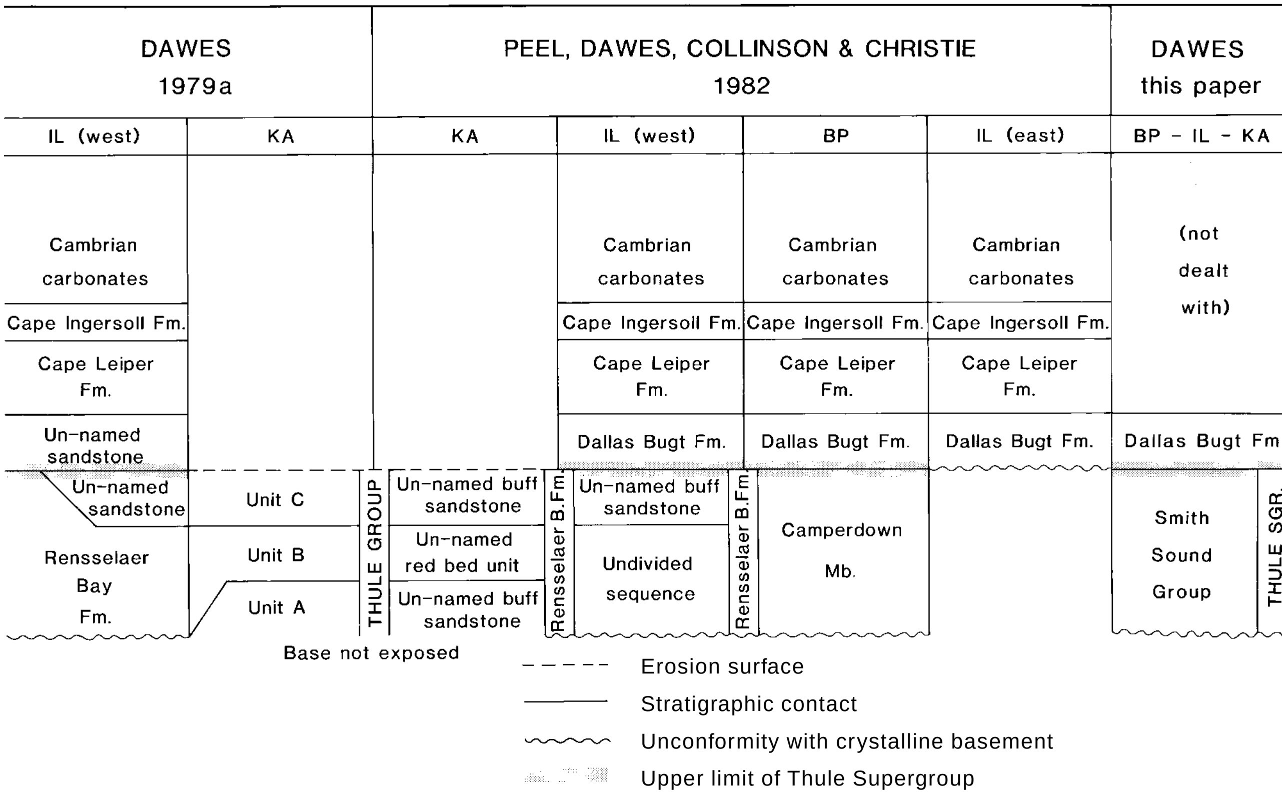

TD – Thule district
BP – Bache Peninsula
IL – Inglefield Land
KA – Kap Alexander

✷ Christie (1967) purposely did not use the name Thule Group
★ Cowie (1961) referred the section to the Thule Group; later he (Cowie, 1971) refrained from using the term




IB – Inglefield Bredning area
TD – Thule district
NSB – North Star Bugt area
EI – Ellesmere Island

✧ Kurtz & Wales did not refer the succession to the Thule Group
✷ The stratigraphic entity of these units is based on investigations in a restricted part of the Thule Basin
o Davies (1954) referred to the three formations as, in ascending order, "Quartzite Series", "Black Shales" and "Red Beds"; Davies (1957) also mentions the formational nomenclature



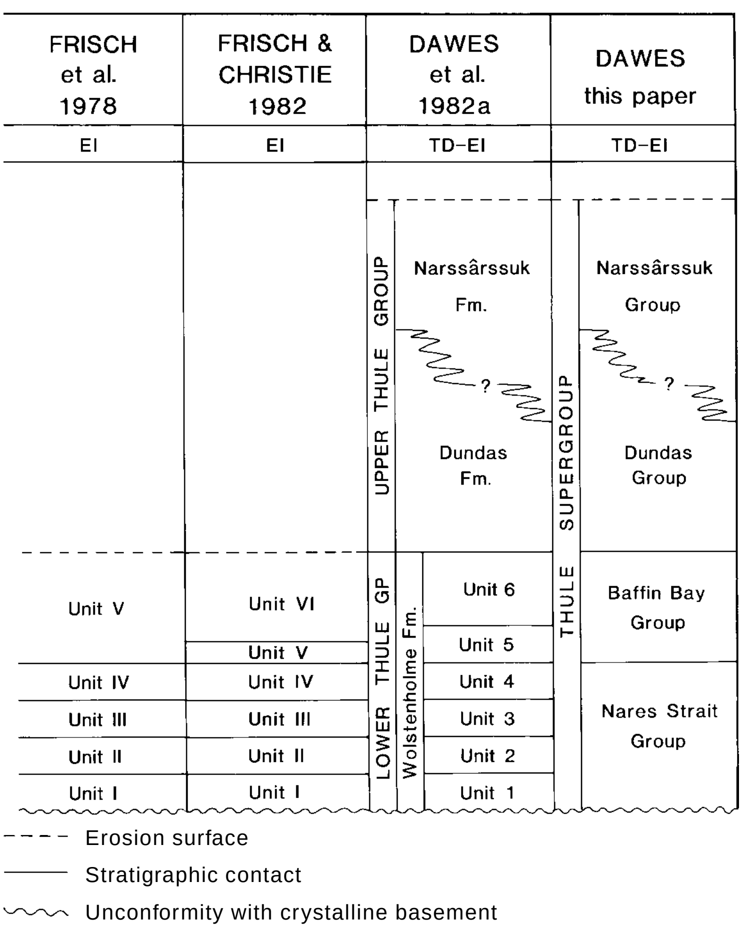
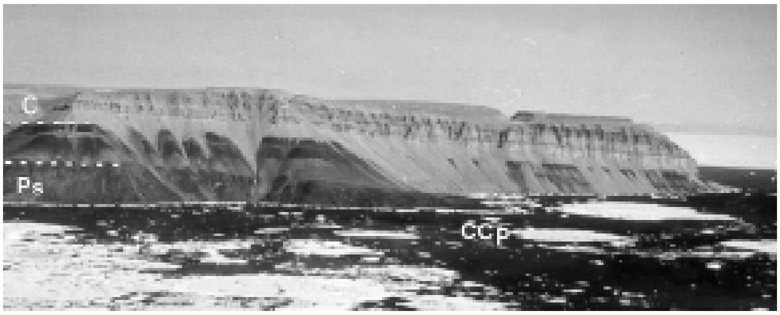




Fig. 6. Previous and present lithostratigraphic schemes for Thule strata from the northern Baffin Bay – Smith Sound region.
**Above:** strata of the platform and northern margin of the Thule Basin, with Koch's (1929a) subdivision from the Thule district (TD) for comparison.
**Below:** central basin and south-east margin deposits.



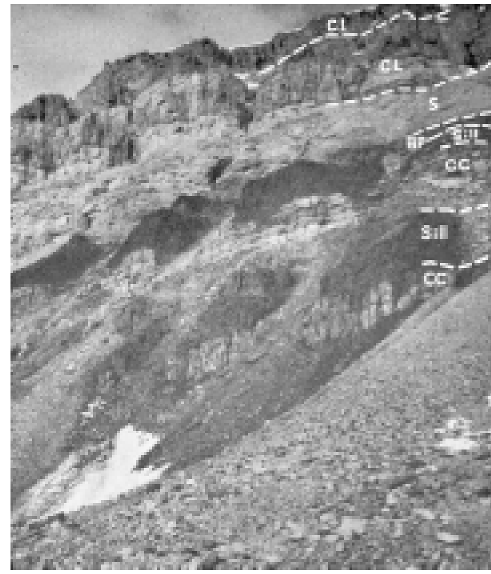




Fig. 7. South coast of Bache Peninsula, Canada. **Above:** Thule Supergroup (Smith Sound Group) overlying the peneplaned shield (Ps) and capped by Cambrian strata (C). This view illustrates the geology initially described by Feilden & De Rance (1878): the thin dark Thule strata (recessive but with basic sills) regarded for almost a century as basal red beds conformable with the Palaeozoic. **Right:** section west of Cape Camperdown (CCp) shows Christie's (1967) tripartite division of the Rensselaer Bay Formation; Cape Camperdown (CC), Bache Peninsula (BP) and Sverdrup (S) Members. CL = Cape Leiper Formation; CI = Cape Ingersoll Formation. The Thule Supergroup includes strata CC with the disconformity to the Cambrian on or just above the upper basic sill (cf. Fig. 8). Height of cliffs about 600 m (see Fig. 15)

particular clastic strata at Kap Kent have turned out to be Cambrian and not part of the Thule Supergroup.)

During a short summer cruise in 1936, Sole Munck studied the Thule Formation at several localities (Munck, 1941). Of the sections examined, two were measured: one at Siorapaluk (500 m thick), the other at Uvdle, Wolstenholme Fjord (400 m thick); her work represents the first section logging. Munck remarked on the lithological distinctiveness of the sequence forming the coastal cliffs between Narssârssuk and Sioraq (called the sandstone-dolomite series, viz. the Narssârssuk Group of this paper). Noteworthy here are Munck's inferences about the Chamberlin–Koch stratigraphical scheme (Fig. 6). The recognition of the importance of dolomites with stromatolites south of Sioraq and the conformable contact at Uvdle between Koch's lower sandstones and the upper sandstone-shale series, led to the rightful conclusion that the sandstone-dolomite series must overlie the sandstone-shale series (not underlie as previously thought) or represent "different facies within contemporaneous depositions" (Munck, 1941, p. 28).

Robert Bentham on two expeditions, 1934–35 and 1936–38, wintering in both Greenland and Ellesmere Island, recognised the continuity of the Thule strata between the two lands. He correlated both sedimentary units and basic sills remarking astutely that parts of the Bache Peninsula section "are indistinguishable from the Thule Formation of Inglefield Land" (Bentham, 1936, p. 336). Bentham referred the clastic part of the Bache section to the Thule Formation.

J. M. Wordie and H. I. Drever made a brief visit to Inglefield Land and Bache Peninsula in 1937. Finding no break in the succession and Lower Cambrian trilobites in carbonates directly above the clastic section, they "decided that at Bache the Thule beds are merely the basement lower Cambrian" (Wordie, 1938, p. 399; Fig. 7). Bentham (1941) adhered to this age assignment.

J. C. Troelsen wintered in northern Prudhoe Land in 1939 and 1940, working on both sides of Nares Strait (Troelsen, 1950a). He recognised the lithological complexity of the Thule Formation, noting the basic differences between the thin sections of Bache Peninsula and Inglefield Land (Smith Sound Group), and the basinal succession to the south with its greater lithological variety. Although he concentrated his efforts on Inglefield Land, in northern Prudhoe Land he measured through nearly 1 km of sandstones and conglomerates without observing either top or the bottom, viz. Baffin Bay and Dundas Groups of this bulletin. He raised the Thule strata to group status by defining in Inglefield Land three formations, from base to top: Rensselaer Bay sandstone, Cape Leiper dolomite and Cape Ingersoll dolomite (Figs 6, 8). Stressing the importance of an erosional disconformity with fossiliferous Cambrian beds, Troelsen assigned the group an Eo-Cambrian age. Following Koch (1929a), he extended the Thule terminology to eastern North Greenland, although his use of it was radically different (Troelsen, 1949, 1950b, 1956a, b; see later under *Stratigraphic nomenclature*).

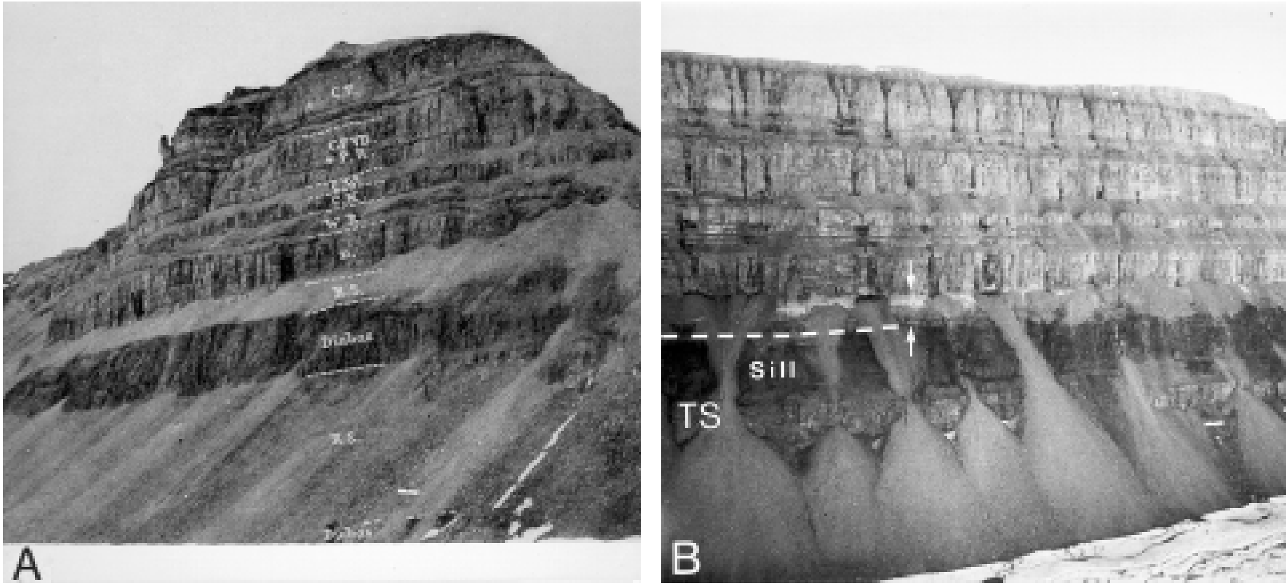



Fig. 8. Kap Ingersoll, Inglefield Land, Greenland, showing past and present definitions. **A:** Koch's (1933) Algonkian *Thule Formation*, RS = Red sandstone with diabase sills and D = dolomite, overlain by Lower Cambrian (WR = Wulff River Formation). Troelsen (1950a) based his Eocambrian *Thule Group* on this section defining the Rensselaer Bay sandstone (RS) and splitting D into two formations, the Cape Leiper and Cape Ingersoll dolomites. **B:** *Thule Supergroup* (TS) includes only *part* of the oldest formation of Troelsen's Thule Group. Strata between arrows, viz. thin red beds overlain by pale sandstones, make up the Cambrian Dallas Bugt Formation that disconformably overlies Thule red beds and a Neohelikian sill. In places in Inglefield Land the erosional hiatus truncates the sill (see Figs 32, 44). Cliffs are about 250 m high. For comparison with Bache Peninsula, see Fig. 7.

## Modern investigations (1946 and onwards)

The vast lowland, Sioraq, came into focus as an aircraft landing site during the Second World War, and between 1951 and 1953 a military air base was constructed. Geological investigations were carried out in connection with its planning and construction and later as a consequence of its support facilities. Thus the first helicopter work was in 1949 when Kurtz & Wales (1951) made a 10-day survey of the Bylot Sund area. Three formations were recognised, from base to top: the Wolstenholme Quartzite formation of "coarse, red to white, crossbedded, massive, partially conglomeratic orthoquartzite", the Danish Village formation of "dolomites, shaly dolomites, and black bituminous shales" and the Narssarssuk formation of "red siltsones, coarsely crystalline, grey, porous dolomite, and fine-grained, shaly dolomite, arranged in cyclical fashion" (Fig. 6). Unfortunately, Kurtz & Wales (1951) made no mention of J. C. Troelsen or of the Thule Group; Troelsen's field work from 1939–40 remaining essentially unpublished until 1950 (see Troelsen, 1940, 1949). However, these authors did not even refer to prior work on the very strata studied by them: work that included Koch's (1926) mapping of stratigraphic units and Munck's (1941) descriptions. Fortunately, their published sketch-map provides a means for stratigraphic comparison. Hence the Narssarssuk formation in essentials equates with the sandstone-dolomite series of Munck, and the Danish Village formation represents her sandstone-shale series (Fig. 6). Munck (1941) had pondered on the relationship of these two series, recognising that the contact might be found around Sioraq; Kurtz & Wales (1951) assumed a conformable relationship and chose a diabase sill north of Sioraq as the boundary.

Kurtz & Wales (1951) mapped several faults on Wolstenholme Ø and adjacent mainland (see Figs 93, 105). The Narssârssuk Fault, juxtaposing the Narssarssuk formation and crystalline basement, was suggested to represent a downthrow of at least 3 km. Kurtz and Wales' discovery that *both* stratigraphic and tectonic contacts of Thule strata with crystalline basement were present in the Bylot Sund area, allowed them to complete a fundamental stratigraphic revision that had been astutely hinted at by Munck.

Geologists of the U.S. Geological Survey surveyed parts of the Thule district by helicopter in the summer


Fig. 9. Geology of Hatherton Bugt, Inglefield Land, showing the peneplaned Precambrian shield (Ps) and the bipartite division of the Thule strata (Smith Sound Group): recessive Rensselaer Bay Formation (RB) and cliff-forming Sonntag Bugt Formation (SB) with basic sills. These units equate with the Hatherton and Sverdrup Members of Cowie (1971); the Sverdrup Member at the type locality in Bache Peninsula in Canada is now known to be Cambrian. Section above the peneplain is about 200 m thick.

of 1953. W. E. Davies and colleagues described the North Star Bugt area (Davies, 1954, 1957; Davies *et al.*, 1963), compiling a geological map at 1:100 000; a smaller area, Nunatarssuaq, to the north-east was reported on by Goldthwait (1954) and Fernald & Horowitz (1954, 1964). The latter authors made the first report of fucoidal markings in Thule strata (Fernald & Horowitz, 1964, p. 32).

The three-fold division erected by Kurtz & Wales (1951) was adopted by Davies *et al.* (1963) who referred the succession to the Thule Group. The Danish Village formation was renamed the Dundas Formation and the Narssârssuk Formation was divided into three members, viz. the Lower red member of cyclic-bedded red siltstone and grey dolomite with some limestone, shale and gypsum; the Aorfêrneq dolomite member of grey vuggy dolomite with some limestone and gypsum (Arferfik member of Davies, 1957); and the Upper red member with lithology similar to that of the lowest member but with prominent grey-green sandstones. The Narssârssuk Formation was shown to be restricted to the Bylot Sund area, while the lower formations were traced north into Prudhoe Land (Davies *et al.*, 1963; fig. 2). Davies and coworkers regarded the Narssârssuk Formation as overlying the Dundas Formation and, despite the limited exposure, they speculated that the relationship was an unconformity (Davies *et al.*, 1963, p. 31).

The first study of Thule beds in Inglefield Land in the post-war period was by John Cowie in 1957: one month's field work mainly on foot (Cowie, 1961). Measured sections at Kap Ingersoll, Etah and Hatherton Bugt were referred to Troelsen's (1950a) Rensselaer Bay, Cape Leiper and Cape Ingersoll Formations (Fig. 6), but Cowie adhered to Koch's (1929a) Precambrian age assignment.

The important discovery of Thule strata in Canada south of Bache Peninsula was made by R. L. Christie who mapped south-eastern Ellesmere Island in 1960–61. Working essentially by dog-sledge, Christie (1962a, b, 1972, 1975) mapped the 2 km thick succession of multicoloured sandstone, shale and basaltic rocks overlying the crystalline basement between Clarence Head and Gale Point (Figs 2, 6). He compared the strata to the Thule Group of the Thule district and assigned them a Precambrian age.

Christie (1967) made also a detailed study of Bache Peninsula, subdividing the Rensselaer Bay Formation into three: in ascending order, the Camperdown Member of variously coloured sandstones and shale with calcareous beds and basic sills; the Bache Peninsula Member of purplish brown sandstone and conglomerate; and the Sverdrup Member of yellowish sandstones that contain 'scolithid-like sand pipe structures' (Figs 6, 7). The two upper members were shown to overlap westwards, with the Sverdrup Member overlapping the crystalline basement. Kerr (1967a) also recognised *Skolithus* in the Bache Peninsula Member and this, as well as the suggested correlation between strata at Bache Peninsula and Cambrian geosynclinal rocks of the Franklinian Basin to the north, led to the inference that the Rensselaer Bay Formation was Lower Cambrian (Kerr, 1967a, b; Thorsteinsson & Tozer, 1970; Cowie, 1971). Christie (1967, 1972), more cautious, argued that the basal strata with basic sills may be older.

The Rensselaer Bay Formation in Greenland was formally subdivided by Cowie (1971) into two members, the upper one being transferred from Canada. A lower Hatherton Member, 100 m of recessive maroon red and purple sandstones with conglomeratic beds and dolomite with stromatolites, equates, at the type area around Hatherton Bugt, with Koch's (1929a, 1933) lower sandstone while the overlying Sverdrup Member, 50 m of pale sandstone and siltstone, equates with the upper yellow sandstone of Koch (Figs 6, 9). The recognition of the Sverdrup Member in Greenland was to prove unfortunate. In Greenland the unit contains basaltic sills while in the type area at Bache Peninsula, it is intrusion-free (Figs 7, 9). This is chronostratigraphically significant; it is now known that the two units are of profoundly different ages (Proterozoic and Cambrian, see below).

The concept of a discrete basin subsidence in the Thule district in contrast to the platform to the north, initially broached by Koch (1929a, p. 271), was expounded on by Troelsen (1956a, p. 75) who defined a structural high between Inglefield Land and Bache Peninsula bounding the basin on the north. Christie's (1962a, b) discovery in Canada of thick Thule strata south of 78°N influenced thinking on the Proterozoic depositional framework: a major intracratonic sedimentary basin straddled Nares Strait. Kerr (1967a) introduced the names 'Thule basin' for the depocenter and 'Bache Peninsula arch' for the northern structural high. The Thule Basin concept quickly found a place in the literature (e.g. Cowie, 1971; Dawes, 1971; Christie, 1972; Dawes & Soper, 1973).

## *Advances in the last two decades*

By 1970 the gross distribution of Thule strata was known. In the last two decades new outcrops were discovered only in the inner part of Inglefield Bredning and at De Dødes Fjord in Melville Bugt (Dawes, 1976b) and in Canada, at MacMillan Glacier and on inland nunataks (Frisch *et al.*, 1978; Frisch & Christie, 1982). On the other hand the stratigraphic limits and stratal age of the Thule Group were conjectural. The main advances in the last two decades can be summarised as follows:

1. The basic sills and dykes closely associated with the Thule strata have been dated isotopically as Precambrian (Dawes *et al.*, 1973). Preliminary results have been confirmed both on the Greenlandic and Canadian material; distinct periods of magmatism are of Neohelikian and Hadrynian age (Dawes *et al.*, 1982b; Frisch & Christie, 1982; Dawes & Rex, 1986; LeCheminant & Heaman, 1991).

2. The Proterozoic ages inferred from radiogenic dating have been confirmed by microfossils. The upper part of the Wolstenholme Formation (now Robertson Fjord and Qaanaq Formations of the Baffin Bay Group) and the main part of the Dundas Formation (now Dundas Group) have yielded typical Riphean (Neohelikian–Hadrynian) acritarch assemblages while possible Vendian (late Hadrynian) acritarchs occur in the upper Dundas Formation and the Narssârssuk Formation (now Narssârssuk Group) (Vidal & Dawes, 1980; Dawes & Vidal, 1985).

3. The Wolstenholme Formation in Greenland has been shown to be many times thicker, and considerably more complex in gross composition, than previously thought showing marked thickness variations. The wide variety of lithological types includes basaltic effusive and volcaniclastic strata (Dawes, 1975, 1976b). Unit to unit correlation has been established with the succession mapped and logged by Frisch *et al.* (1978) and Frisch & Christie (1982) in Ellesmere Island (Dawes *et al.*, 1982a).

4. A major erosional disconformity was detected in Inglefield Land within Troelsen's Rensselaer Bay Formation (Peel, 1978; Dawes, 1979a; Peel *et al.*, 1982; Figs 6, 8). This hiatus separates an intrusion-invaded clastic sequence of Proterozoic age that includes the Hatherton and Sverdrup Members of

Cowie (1971), from overlying clastics containing the trace fossils *Skolithos* and *Rusophycus*. Peel *et al.* (1982) refer the upper sequence to the Dallas Bugt Formation. This basal Cambrian formation oversteps the Proterozoic succession so that in central and north-eastern Inglefield Land it is in direct contact with crystalline basement (Fig. 2). Thus it was proved that the Thule Formation of Koch (1929a, b; 1933) and Thule Group of Troelsen (1950a) in the Kane Basin region compose two sandstone sequences of widely different age.

5. Stratigraphic correlation has been achieved between the basinal section and the thin Inglefield Land strata to the north; clastic units in the Wolstenholme Formation of the basin (Nares Strait and Baffin Bay Groups of this paper) thin and extend northwards to interfinger with the lower part of the Rensselaer Bay Formation (Smith Sound Group of this paper) (Dawes, 1972, 1976a, 1979a).

In addition to the above, field work on Thule strata has been carried out by two other groups. In 1978 Strother *et al.* (1983) examined the Narssârssuk Formation south of Pituffik collecting carbonaceous cherts for micro-organic study, while in 1982 a group from the Geological Survey of Canada studied sections at Goding Bay, Clarence Head, Northumberland Ø and in the North Star Bugt area (Jackson, 1986). Material collected by Jackson and others forms the basis of a microfossil study by Hans Hofmann (G. D. Jackson, personal communication, 1993).

# Stratigraphic nomenclature

The Thule Formation (Koch, 1929a) and Thule Group (Troelsen, 1949, 1950a) – the forerunners of the Thule Supergroup – are perhaps those Greenlandic stratigraphic terms used with the highest degree of inconsistency. The terms have covered strata of different ages and of different geological settings, correlating outcrops from Baffin Bay to the Greenland Sea, a distance of some 2000 km (Fig. 10). Strata designated 'Thule' include:

- intracratonic basin and platformal strata in Ellesmere Island and North-West Greenland (Koch, 1929a, 1933; Troelsen, 1950a);
- a shelf carbonate-clastic sequence, including tillites in southern Peary Land (Troelsen, 1949, 1950b, 1956a, b);
- folded and thrusted shelf and miogeosynclinal strata in Ellesmere Island (Blackadar, 1957; Blackadar & Fraser, 1961; Thorsteinsson, 1963);
- platformal rocks of the North Greenland homocline (Koch, 1929a);
- autochthonous and allochthonous, in part metamorphic, strata of both geosynclinal and platformal parts of the East Greenland Caledonian fold belt (Koch, 1961; Haller, 1961, 1970, 1971, 1983).

The highly irregular nomenclatorial practice surrounding the Thule terminology is detailed chronologically below.

1. The Thule *Formation* (or formation) was coined by Koch (1929a) with a type area around Thule. However, it duly became part of the 'Grönlandium' (Greenlandian), viz. the vast homoclinal Precambrian strata overlying the peneplained shield in North, North-East and East Greenland as far south as 76ºN (Koch, 1935b; Fig. 10).

2. The initial use of Thule *Group* (or group) was by Troelsen (1949, 1950a, b) who simply remarked that "the Thule group was named in 1929 by Lauge Koch …" (Troelsen, 1949, p. 9) and that "the group was first defined by Koch …" (Troelsen, 1950a, p. 35). This informal use implies a straightforward raising in rank of Koch's Thule Formation. This is highly misleading; Troelsen's Thule Group is not a synonym of Koch's Thule Formation.

3. Troelsen's (1950a) definition of the Thule Group was not made at or near the type area of the Thule Formation but 250 km distant in Inglefield Land. This led several authors (e.g. Christie, 1967, 1972; Kerr, 1967a, b; Cowie, 1971; Dawes, 1971) to abandon

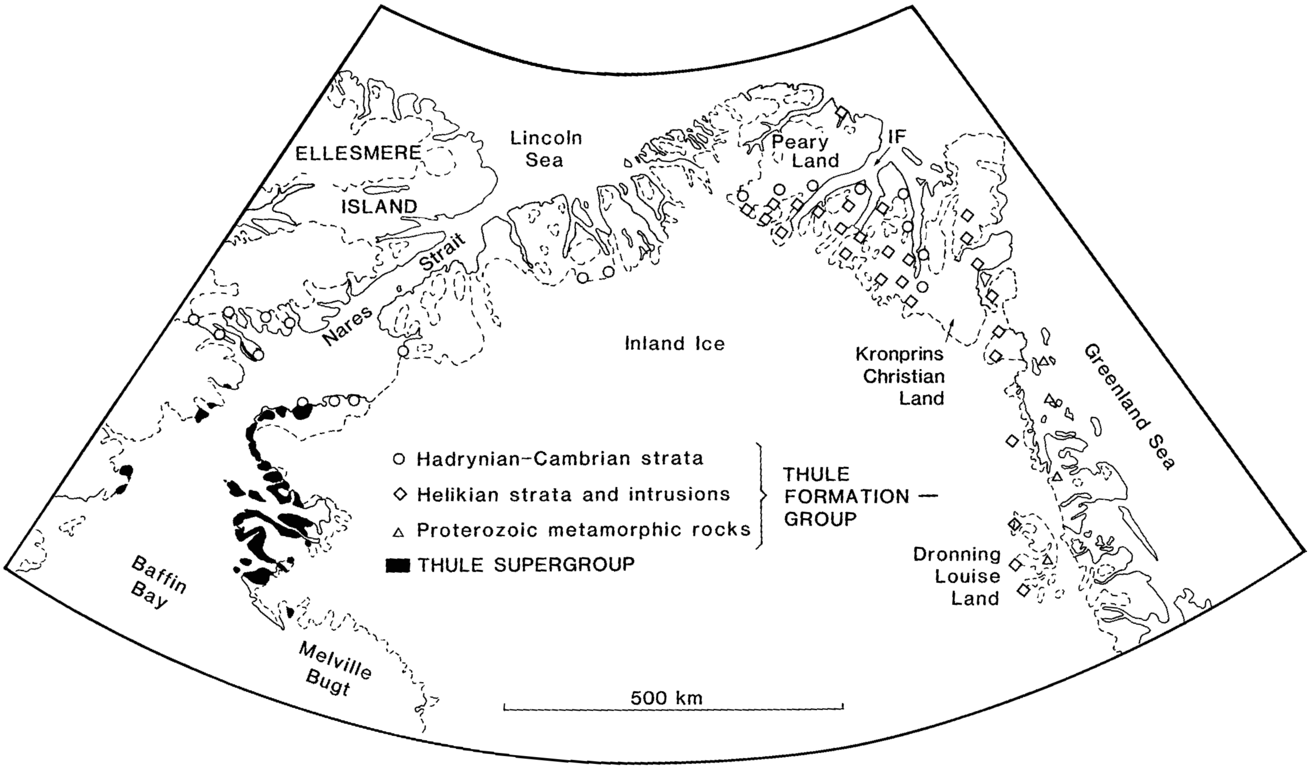



Fig. 10. Geographical distribution of the Thule Supergroup compared to that of its forerunners, the Thule Formation and Thule Group. IF = Independence Fjord.

the use of the name Thule in the very region (Inglefield Land) where its group status was defined.

4. Troelsen (1949, 1950b) used the name Thule in eastern North Greenland for a succession that post-dates Koch's (1930, 1934, 1935b) Grönlandium. Troelsen's Thule Group is a carbonate-shale sequence overlain by Cambrian dolomite but underlain by basalt-invaded sandstone that, in fact, is Koch's Thule Formation. Red beds at the base of Troelsen's Thule Group were recognised as a tillite and referred to the Varangian glaciation (Troelsen, 1950b, 1956a, b). Thus, remarkably, the terms Thule Formation and Thule Group came to be used by different schools for integral parts of a bipartite succession: Koch's Thule Formation of supposed Precambrian age below, Troelsen's Eocambrian Thule Group above. Later, and again confusingly, Troelsen (1956a, b) reverted to formational status and used the name in a third concept, viz. to cover both parts of the bipartite succession.

5. The initial naming of stratigraphic units of formational rank in the type area was made by Kurtz & Wales (1951) without reference to the established and mapped units of Koch (1926, 1929a) or to the Thule Group of Troelsen (1949, 1950a) or to its tripartite division.

6. The annexation of sections in Canada, north of Bache Peninsula, to the Thule Group (Blackadar & Fraser, 1961; Thorsteinsson, 1963; Fig. 10) and the incorporation of part of the Bache–Inglefield succession in the Cambrian Ellesmere Group (Kerr, 1967a) were made at a time when the age of the Thule Group at the type area was unknown.

7. Geologists working in North-East Greenland adhered to Koch's rather than Troelsen's use of Thule Formation/Group by restricting the name to the basalt-invaded strata at the base of the succession (e.g. Nielsen, 1941; Fränkl, 1954, 1955, 1956; Haller, 1961; Koch, 1961; Haller & Kulp, 1962; Harland, 1969). The Thule Group came to be redefined by Haller (1961, 1970) after local geological conditions and it came to assume a chronostratigraphic significance that was not applicable to the far distant type area around Thule. Redefined, the Thule Group covered

> a specific phase of late Precambrian sedimentation in North and North-East Greenland – the so-called pre-Carolinidian (orogeny) cycle. The strata were subdivided into a Lower and an Upper Thule Group and informally referred to as 'Thulean beds'. Although these rocks have age equivalents in the Thule Basin, the Carolinidian orogeny was not demonstrable in North-West Greenland and has since been disputed even in the type area of Kronprins Christian Land (Jepsen & Kalsbeek, 1981; Haller, 1983).

For a detailed history of the use of Thule Formation/Group in North and North-East Greenland, the reader is referred to the papers cited above and to the discussion in Adams & Cowie (1953, pp. 16–17), Berthelsen & Noe-Nygaard (1965, p. 227), Jepsen (1971, pp. 7–10) and Dawes (1971, pp. 204–210, 1976a, pp. 265–267). More recently Collinson (1980) has introduced the Independence Fjord Group to cover sediments of Koch's Thule Formation as defined in Peary Land and areas to the south-east. In Haller (1983) Thule Group is retained although it is placed in inverted commas.

### Selected nomenclatorial practice

This bulletin raises the Thule Group to supergroup status and drastically restricts its geographical distribution. Paradoxically, however, the supergroup includes only *part* of *one* of three formations that compose the initial Thule Group of the Smith Sound area; a part that has been referred to another stratigraphical unit, viz. the Ellesmere Group of Kerr (1967b). These facts plus the considerable nomenclatorial confusion that has surrounded the Thule Group constitute a case for the abandonment of the name Thule in any definitive revision. However, the name is considered to be so entrenched in the literature that its replacement would be confusing.

There is also a case for reuniting nomenclatorially Proterozoic successions across northern Greenland. Investigations in eastern North Greenland (Collinson, 1980; Jepsen *et al.*, 1980; Kalsbeek & Jepsen, 1984), reviewed by Sønderholm & Jepsen (1991), confirm that clastic and basaltic rocks, originally part of Koch's (1929a) Thule Formation, are of the same age and type as the lower Thule Supergroup. Koch's initial correlation across northern Greenland can be maintained. Thus, the Independence Group of Collinson (1980) and the Zig-Zag Dal Basalt Formation of Jepsen *et al.* (1980) might be referred to the lower Thule Supergroup, with the overlying Hagen Fjord Group (Clemmensen & Jepsen, 1992) as part of the upper Thule Supergroup. This is not done here, however, since direct links between exposures in North and North-West Greenland are lacking and the Thule Basin is regarded as a discrete depocenter, one of several on the northern margin of the North Atlantic craton (Dawes *et al.*, 1982a). Present practice tends to restrict nomenclatorial names to successions that can be correlated within individual depocentres, rather than between the separate basins (see Young, 1979; Campbell, 1981).

## Lithostratigraphy

The formal units of the lithostratigraphic scheme are discussed in general ascending stratigraphic order and starting with the relatively thin northern platform and basin margin succession. Lithostratigraphic schemes of the Thule Supergroup are given in Figs 4 and 11; regional stratigraphy is summarised in Fig. 3. Generalised stratigraphic sections for 26 stations through the lower Thule Supergroup are displayed in Fig. 12 and the stratigraphical relationships of the groups and formations are illustrated in a schematised cross-section given in the last chapter (see Fig. 120).

*Stratigraphic sections.* The stratigraphic sections presented have been compiled from data of variable detail; some are based on detailed logs; elsewhere, only qualitative reconnaissance sections are available. The precise thickness of the Thule Supergroup is unknown. The sheer extent of the succession (seen in relation to the scope of the field work) and in many places the steepness of slope, have prevented systematic measurement. Some unit measurements are estimates based on partially measured sections. As far as possible the material has been standardised and it is presented both