The Bjørnehiet Formation: a faulted preglacial conglomerate, Washington Land, North Greenland

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Jepsen, H. F. 1982. The Bjørnehiet Formation: a faulted preglacial conglomerate, Washington Land, North Greenland. – In: Dawes, P. R. & Kerr, J. W. (eds), Nares Strait and the drift of Greenland: a conflict in plate tectonics. – Meddr Grønland, Geosci. 8: 151–155.

A new occurrence of a Tertiary or Quaternary fluvial conglomerate from North Greenland is described, and named the Bjørnehiet Formation. The main lithology is a carbonate-clast, matrix-supported, oligomictic conglomerate with some coarse sandstone beds. The composite thickness of the formation is about 45 m.

The conglomerate is known only from one locality in Washington Land, about 40 km from the shore of Nares Strait. The deposit has been affected by post-depositional faulting and is considered to be preglacial in age. By comparisons with Arctic Canada, the conglomerate is regarded as an equivalent of either the Palaeogene Eureka Sound Formation or the Neogene Beaufort Formation, both of which contain important fluvial conglomerate units.

The conglomerate represents the only evidence of post-Palaeozoic, preglacial deposits in this part of Greenland. The occurrence is thus particularly important and provides a way of recording Cenozoic fault movements. If the deposit can be accurately dated, and when its full distribution is known, the formation and the structures affecting it will provide significant data about the Cenozoic palaeogeography and tectonics of the Nares Strait region.

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In 1977, during the regional geological mapping programme of the Lower Palaeozoic rocks of Washington Land, North Greenland (Fig. 1), a fluvial conglomerate was discovered on the steep slopes of a V-shaped valley eroded into the Ordovician bedrock. The locality was discovered late in the field season and it was unfortunately only briefly examined. Its discovery is mentioned in Peel (1978).

The aim of this paper is to describe the main features of the conglomerate occurrence and to formally designate the strata as the Bjørnehiet Formation. The deposit occurs in the Nares Strait region and it is affected by faulting; thus it is pertinent to the present symposium. However, this paper is written, not as a contribution to the question about strike-slip or other movement along the Strait, but rather to focus attention on a new rock occurrence that, with more field and laboratory work, will provide important data on the Cenozoic depositional and tectonic history of the Nares Strait region.

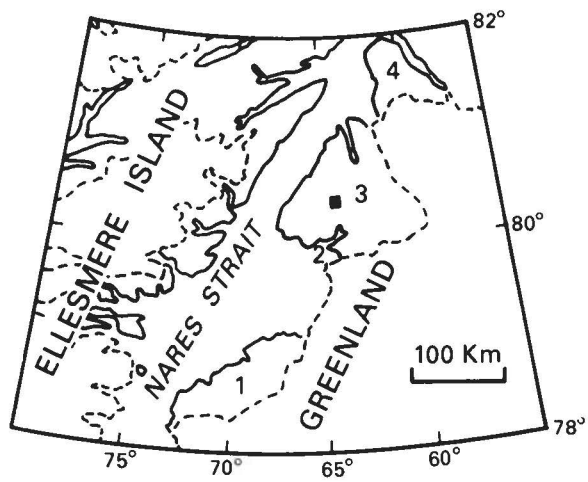

Fig. 1. Index map showing the position of Washington Land in the Nares Strait region. The black square illustrates the area shown in Fig. 2 and the location of the Bjørnehiet Formation. 1 = Inglefield Land, 2 = Cass Fjord, 3 = Washington Land, 4 = Hall Land.

Location and type locality

The Bjørnehiet Formation is located in central Washington Land about 10 km north of the hill called Bjørnehiet, at the head of Cass Fjord (Fig. 1). The formation has only been seen to outcrop along the banks of a westerly and southerly flowing river system, but it is thought to extend over at least 15 km² (Fig. 2). The strata form a flat fluvial plain at about 350 m above sea level in a watershed area between northerly and southerly flowing rivers. The outcrop is bounded by hills composed of Lower Palaeozoic strata that constitute the whole of Washington Land.

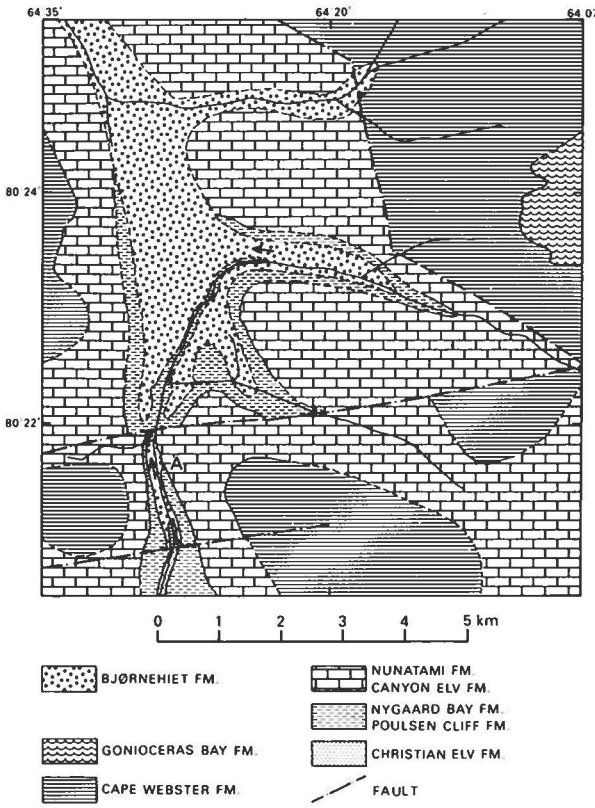

Fig. 2. Geological map showing the setting of the Bjørnehiet Formation. A: location of the type section; the arrows indicate the palaeotransport direction of the formation at two localities.

The type locality of the new formation is situated in a river canyon (marked A in Fig. 2) where the conglomerate outcrops as erosional remnants adjacent to the steep canyon walls (Fig. 3).

Stratigraphical position

The Bjørnehiet Formation rests with erosional unconformity on deeply excavated flat-lying strata belonging to the Ordovician Poulsen Cliff, Nygaard Bay, Canyon Elv and Nunatami Formations that are reported on elsewhere in this volume (Peel & Christie). The formation is covered sporadically by a few metres of non-consolidated glacial outwash and solifluction material of Holocene age.

Thickness and lithology

The Bjørnehiet Formation attains a composite thickness of 44 m in the type section where four members can be recognised (Table 1). Rapid lateral thickness and facies changes are common and it is uncertain if the formation ever reaches the composite thickness in any one outcrop

Fig. 3. Type section locality of the Bjørnehiet Formation seen from the south. The section has been measured along the west side (left) of the canyon. The height of the cliff left of centre is about 25 m.

along the river. The maximum thickness measured in a single outcrop is 25 m.

The formation is typically a brown-weathering, easily eroded, matrix-supported conglomerate with minor sandstone incursions (Figs 3 and 4). Apart from the basal part of the sequence, where metamorphic and granitic rocks (assumed Precambrian) form part of the clast content, the conglomerate is oligomictic, being composed of locally-derived carbonate pebbles, cobbles and boulders of the Lower Palaeozoic bedrock. Clast size varies appreciably and boulders up to 50 cm are common in the lower parts of the sequence. The clasts are predominantly rounded to well-rounded but some, particularly the locally-derived larger blocks, are angular. The matrix is a carbonate-cemented, coarse-grained sandstone and this lithology also forms thin lenses and beds intercalated with the rudaceous material, the largest of which is about 2 m thick in the middle of the sequence (Fig. 5).

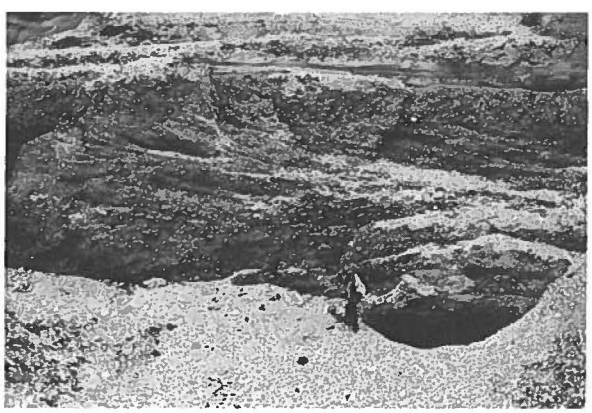

Fig. 4. Cross-bedded fluvial conglomerate with some sandstone lenses. The direction of transport in this outcrop is towards the north (right). Part of the lower stratified conglomerate — member 2 of Table 1.

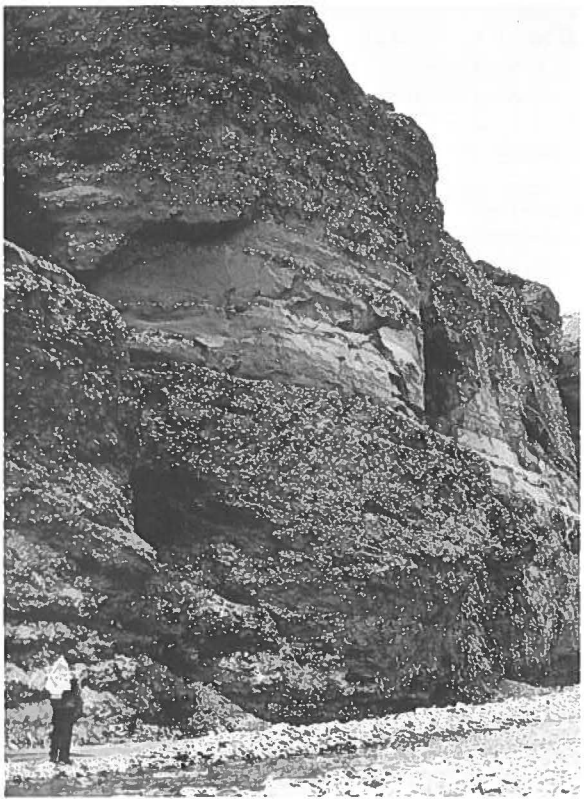

Fig. 5. The central *c.* 25 m of the Bjørnehiet Formation including the 2 m thick coarse-grained sandstone bed — member 3 of Table 1.

Table 1. Type section log of the Bjørnehiet Formation

Member 4, 21 m	Stratified matrix-supported conglomerate with angular and rounded carbonate blocks up to 30 cm in diameter. Large-scale cross-bedding and imbrication of tabular blocks. Carbonate-cemented coarse-grained sandstone matrix.
Member 3, 2 m	Coarse-grained carbonate-cemented sandstone with cross-bedding. Some pebbly sandstone and thin conglomerate horizons.
Member 2, 18 m	Stratified matrix-supported conglomerate with well-rounded carbonate clasts up to 20 cm in diameter. Includes a few coarse-grained dm-thick sandstone lenses. Large-scale tabular cross-bedding. Carbonate-cemented coarse-grained sandstone matrix.
Member 1, 3 m	Unstratified matrix-supported conglomerate with blocks and boulders up to 50 cm in diameter. Ten per cent of the clasts are well-rounded and derived from crystalline basement including quartzo-feldspathic gneiss and coarse-grained amphibolite. The rest of the clasts are angular or subrounded blocks derived from the local Palaeozoic carbonates. Carbonate-cemented coarse-grained sandstone matrix.

The lithology of the formation at the type locality is given in Table 1.

Frequent tabular cross-bedding in the sandstones and imbrication structure in the conglomerates indicate a consistent northward transport direction at the type locality (Fig. 2). This contrasts with the flow direction of the present-day river. About 3 km north-east of the type section the transport direction is towards the west. This suggests a southerly and easterly provenance for the deposit so that the main part of the formation lying to the west and north-west of the outcrops examined may well consist of a north-westerly outwash plain. The presence of crystalline rocks as clasts in the basal part of the formation is also readily explained by this provenance; the known outcrops of Precambrian Shield are to the south (Inglefield Land) and the regional structure suggests that extensive areas of the Shield outcrop under the Inland Ice to the east of Washington Land.

Regional distribution

The conglomerate occurrence in central Washington Land is the only known outcrop of the Bjørnehiet Formation. However, other outcrops may well be discovered in western North Greenland as systematic field work continues. Thus, it is of some interest that Koch (1929), who travelled extensively in this part of Greenland, described from the region immediately north of Washington Land (Hall Land and area to the east, Fig. 1), a loose, coarse clastic deposit, several hundred metres thick, as the youngest preglacial strata of western North Greenland. He referred the strata to the Polaris Harbour Formation of Lower Palaeozoic age.

The true nature and age of the coarse clastic deposits described by Koch (1929) have been a matter of debate for some time, mainly because Koch's lithological description of the deposit is difficult to reconcile with the Lower Palaeozoic bedrock in the distribution area, including the type locality, of the Polaris Harbour Formation. Thus Dawes & Haller (1979) suggested that the coarse clastic deposits recorded by Koch may well be stratigraphic equivalents of the Washington Land fluvial deposits referred in this paper to the Bjørnehiet Formation. The systematic mapping of western North Greenland planned for 1983 should clarify the question of the Polaris Harbour Formation and define the distribution limits of the Bjørnehiet Formation.

Faulting

The area where the Bjørnehiet Formation outcrops is cut by several faults. The most important is an east–west-trending normal fault just north of the type section (Fig. 2). This fault has displaced, with a vertical downthrow to the south, the Ordovician strata by about 140 m. Movement along this fault, and also along a parallel fault to the south, has affected the Bjørnehiet Formation; the northern fault block has been uplifted by at least 40 m.

Block faulting with minor tilting of the homoclinal Lower Palaeozoic strata is typical of the structure in parts of south-eastern Washington Land (Jepsen & Dueholm 1978). While the relationships of such fault tectonics to those affecting the Bjørnehiet Formation are uncertain, it is now clear that some faults mapped in the Lower Palaeozoic platform terrain have been reactivated by relatively late (Tertiary or Quaternary) fault movements.

Age

The age of the Bjørnehiet Formation is uncertain. No fossils have been collected from the conglomerate matrix. However, throughout the area where the formation is present branches and trunks of non-carbonised fossil conifer wood, up to 15 cm in diameter, are common. The wood has not been found in situ but from its distribution it seems likely that it has been washed out from the formation. Carbon-14 dating of wood samples from the outcrop area (Teledyne Isotope Inc.) has given ages older than 40 000 years B. P., suggesting that the Bjørnehiet Formation is of preglacial age.

Fossil wood of similar age is known about 50 km south-east of the type area of the Bjørnehiet Formation (Weidick 1978) where it has been found in a river valley about 245 m above sea level. No occurrence of deposits similar to the Bjørnehiet Formation has been reported at this locality.

Correlation

No comparable beds to the Bjørnehiet Formation of Washington Land are known anywhere else in western North Greenland. However, in coastal Ellesmere Island on the opposite shore of Nares Strait, a Tertiary (Paleocene) conglomerate with minor, thin sandstone beds of the Eureka Sound Formation form scattered outcrops indicating an extensive depositional area (see Mayr & de Vries, this volume). This conglomerate, like the Bjørnehiet Formation, is mainly oligomictic and characterised by locally-derived carbonate clasts. The Ellesmere Island conglomerate sequence reaches a thickness of up to 1000 m and it has been severely affected by thrusting and faulting of the Tertiary (Eurekan) orogeny.

Another possible correlative of the Bjørnehiet Formation is the rather unconsolidated, coarse alluvial deposits of the Beaufort Formation that post-date the Eurekan orogeny (Craig & Fyles 1960). This formation is widespread in Arctic Canada, but it has not been recorded from eastern Ellesmere Island (Thorsteinsson & Tozer 1970). The Beaufort Formation is characterised by its wood- and plant-bearing content by which it has been dated as late Tertiary (Miocene–Pliocene) or earliest Pleistocene. Thus, like the Bjørnehiet Formation, it is regarded essentially as a preglacial deposit.

At present it is unknown whether the Greenland fluvial deposit can be correlated with either of the two Cenozoic sequences from Canada; thus it remains uncertain whether the Bjørnehiet Formation is of Palaeogene or Neogene age. Its wood-bearing character perhaps strengthens the alliance with the Beaufort Formation, in which case Washington Land becomes particularly important for the presence of late Cenozoic faulting. On the other hand, if the Greenland deposit is a Eureka Sound Formation equivalent, the faulting affecting the deposit may represent the outer effect of the Eurekan orogeny that affected northern Ellesmere Island and large parts of northern Greenland. In addition, an early Tertiary age designation would be particularly significant for the present discussion of this symposium, since the degree of facies continuity so established across Nares Strait would provide comparative sedimentation and tectonic data which would lead to a much more complete Cenozoic palaeogeographic model of the Nares Strait region than is now possible, based solely on the eastern Ellesmere Island outcrops.

Conclusion

The Bjørnehiet Formation is a fluvial conglomerate of probable preglacial age which pre-dates at least some fault movements. Its present known distribution is restricted to central Washington Land, but other outcrop areas may exist farther north in western North Greenland.

The age of the formation, and thus its correlation with the Palaeogene or Neogene deposits of Arctic Canada, is uncertain. However, whatever its precise age, the conglomerate occurrence provides important Cenozoic, preglacial palaeogeographical data for a region of Greenland otherwise lacking this part of the stratigraphic record. If the formation can be accurately dated, its importance to the understanding of the palaeogeography and tectonic history of the Nares Strait region will be substantially increased.

Acknowledgements

The author thanks P. R. Dawes, A. K. Higgins and J. M. Hurst for critical reading of the paper which is published with the permission of the Director of the Geological Survey of Greenland.

References

Craig, B. G. & Fyles, J. G. 1960. Pleistocene geology of Arctic Canada. – Pap. geol. Surv. Can. 60–10: 21 pp.

Dawes, P. R. & Haller, J. 1979. Historical aspects in the geological investigation of northern Greenland. Part 1: New maps and photographs from the 2nd Thule Expedition 1916–1918 and the Bicentenary Jubilee Expedition 1920–1923. – Meddr Grønland 200(4): 38 pp.

Jepsen, H. F. & Dueholm, K. 1978. Computer supported geological photo-interpretation. – Rapp. Grønlands geol. Unders. 90: 146–150.

Koch, L. 1929. Stratigraphy of Greenland. – Meddr Grønland 73, 2(2): 205–320.

Mayr, U. & de Vries, C. D. S. 1982. Reconnaissance of Tertiary structures along Nares Strait, Ellesmere Island, Canadian Arctic Archipelago. – This volume.

Peel, J. S. 1978. Geological investigations in Lower Palaeozoic terrain of northern Greenland between 78°30'N and 81°30'N. – Rapp. Grønlands geol. Unders. 90: 14–16.

Peel, J. S. & Christie, R. L. 1982. Cambrian–Ordovician platform stratigraphy: correlations around Kane Basin. – This volume.

Thorsteinsson, R. & Tozer, E. T. 1970. Geology of the Arctic Archipelago. – In: Douglas, R. J. W. (ed.), Geology and economic minerals of Canada. – Econ. Geol. Rep. geol. Surv. Can. 1: 547–590.

Weidick, A. 1978. C^{14} dating of Survey material carried out in 1977. – Rapp. Grønlands geol. Unders. 90: 119–124.