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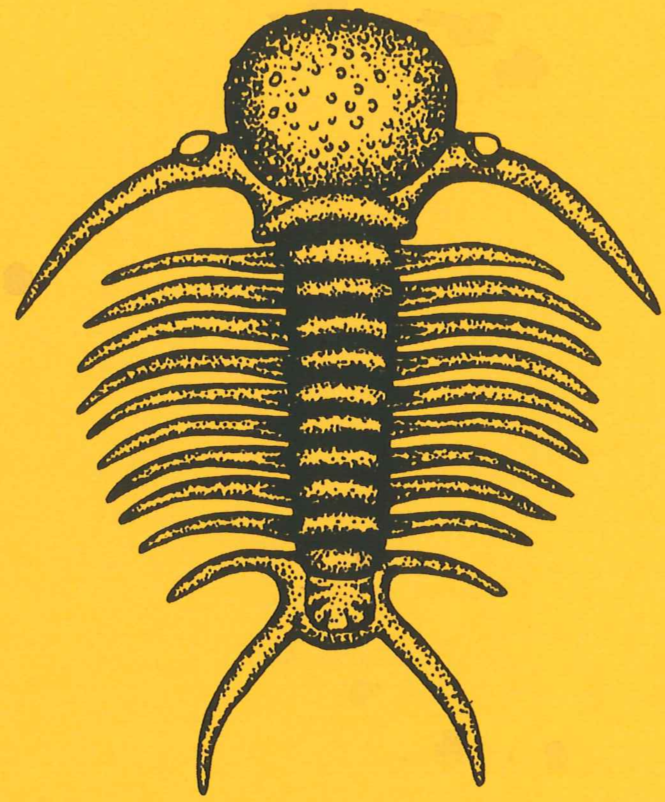

The Brennvinsfjorden Group of southern Botniahalvøya, Nordaustlandet, Svalbard - structure, stratigraphy and depositional environment

Johan Nilsson

Lund 1997 Examensarbete, 20 p Nr 92
Geologiska Institutionen, Lunds Universitet

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page 15	Second column, second line, after "Fault" and 7 lines further down, the text is duplicated from previous columnn.
Plate 1	Along the Goosbukta Anticlinal, south of the Gottwaldhøgda Fault, add a symbol for a dextral, strike-slip fault.

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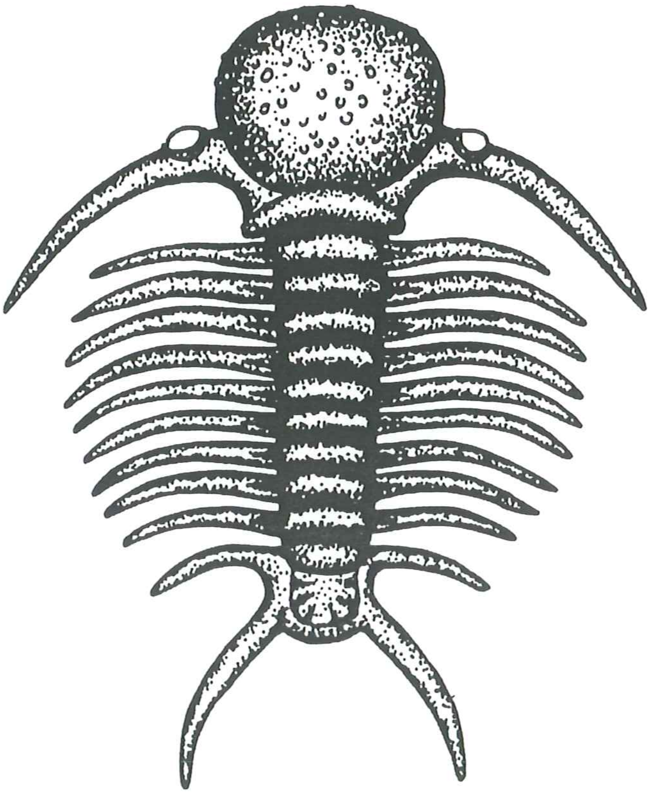

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Abstract: The Brennvinsfjorden Group of the Botniahalvøya peninsula of western Nordaustlandet unconformably underlies a Grenvillian age volcanic and volcanoclastic succession (the Kapp Hansteen Group). The studies of the Brennvinsfjorden Group presented here has provided a new stratigraphy and a more precise location and interpretation of the structures occurring below the Kapp Hansteen basal conglomerate. New evidence defines an overturned, near isoclinal, W-vergent major fold in inner Goosbukta (The Goosbukta Anticline) which can be followed south of a major E-W striking fault (the Gottwaldhøgda Fault) to Jäderinfjorden. The Gottwaldhøgda Fault dextrally displaces the basal Kapp Hansteen unconformity and the Goosbukta Anticline. All though relationships to Neoproterozoic strata are not exposed in this part of Nordaustlandet. It is inferred that the folding of the Kapp Hansteen Group is Caledonian in age and that of the Brennvinsfjorden Group Grenvillian or earlier. The Brennvinsfjorden Group is subdivided in three formations; A, B and C, dominated by quartzites, turbidites and dark phyllites respectively. The depositional environments in Brennvinsfjorden Group are thought to reflect a transgression from a shallow water to a deep-water environment.

Keywords: The Brennvinsfjorden Group, the Goosbukta Anticline, the Gottwaldhøgda Fault, the Kapp Hansteen Group, Botniahalvøya, Nordaustlandet, Svalbard.

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The Svalbard archipelago is located north of the Scandinavian peninsula in the high Arctic between latitudes 74° N and 81° N, and longitudes 10° E and 35° E (Fig. 1). The general geology on Svalbard consists of Devonian Old Red Sandstones (ORS) and younger strata (Late Palaeozoic, Mesozoic and Tertiary) deposited on an early Palaeozoic and Precambrian basement, generally referred to as the Hecla Hoek Complex. The ORS occur mainly in north-central Spitsbergen and younger sedimentary rocks cover large parts of the southern and central areas. Major N-S-trending strike-slip faults, the Billefjorden Fault Zone (B), the Breibogen-Bockfjorden Fault (BB) and the Raudfjorden Fault (R), separate the pre-Devonian rocks of Svalbard into three provinces (Fig. 2), the Eastern, Northwestern and Southwestern Terranes (Gee 1986). These terranes are thought to have been regions brought together, during Caledonian orogeny, by major strike-slip faulting (Harland 1972, 1985).

Svalbard Caledonides

The pre-Devonian rocks have generally been deformed by the Caledonian orogeny and eastern Svalbard has been described as the type area for the Hecla Hoek succession, inferred to have accumulated in a geosyncline (Harland 1985).

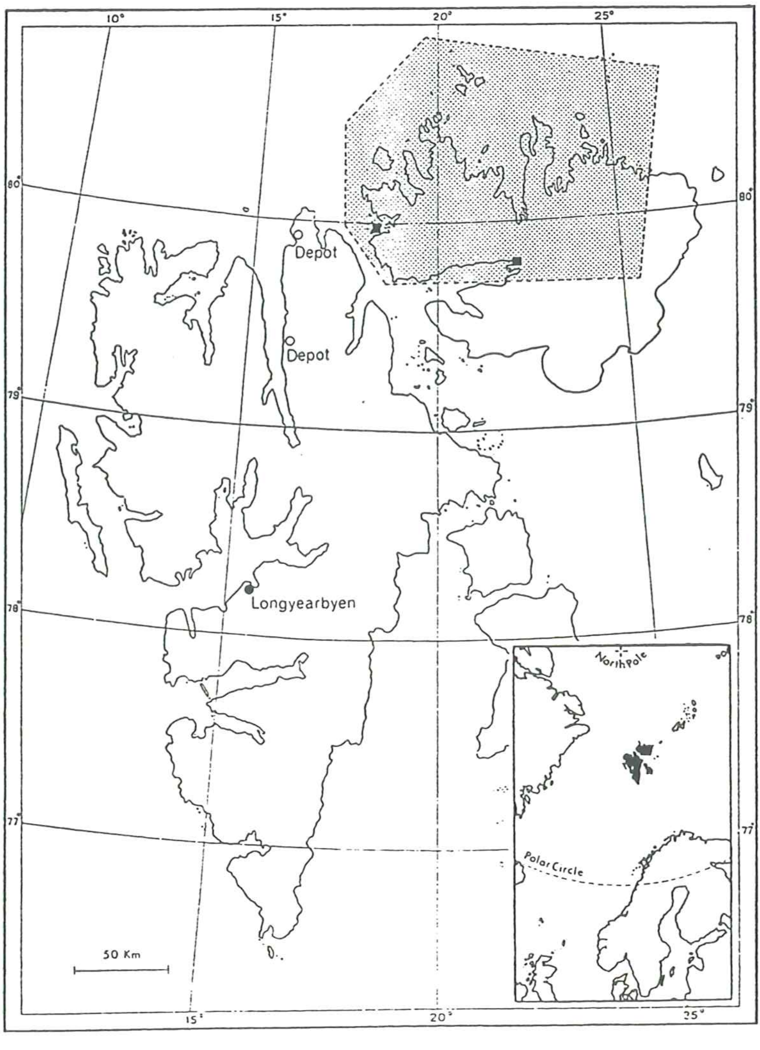


Fig 1. Location of Svalbard. After Flood et al. (1969).

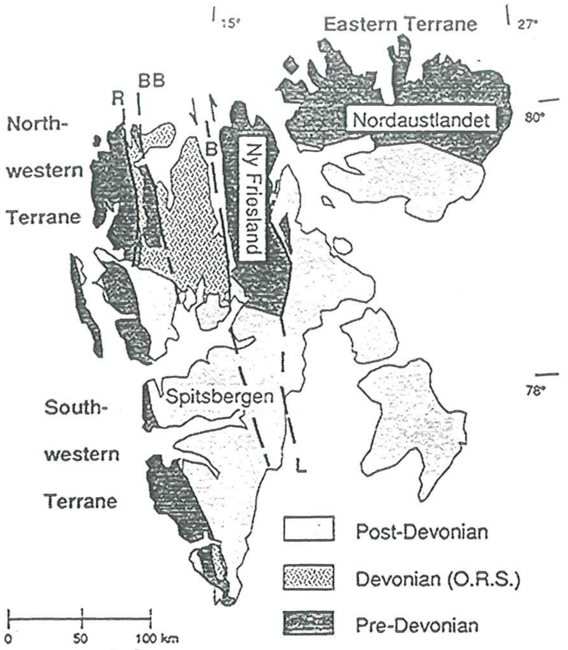


Fig 2. Major faults and terranes on Svalbard. After Gee (1986). B= Billefjorden Fault, BB= Breibogen-Bockfjorden Fault, R= Raudfjorden Fault.

The Eastern Terrane is exposed in the northeasternmost parts of the archipelago in Ny Friesland and Nordaustlandet (Fig. 2). In Ny Friesland it consists of the 18 km thick Hecla Hoek succession, previously thought to be of Neoproterozoic and Early Palaeozoic age (Harland 1985), but now known to be a thrust stack of tectonized granites of Paleoproterozoic age, intercalated with younger metasedimentary rocks (Gee et al. 1994). On Nordaustlandet, a basement of Grenvillian age has been demonstrated (Gee et al. 1995), unconformably overlain by Neoproterozoic strata.

Nordaustlandet

Much of Nordaustlandet is covered by ice caps and snow. Outcrops are exposed in the northern parts, in the central areas between Austfonna and Vestfonna and along the coast. The Hecla Hoek rocks are unconformably overlain by Carboniferous strata in the south and along the southern coast of the Wallenbergfjorden (Flood et al. 1969).

An old migmatite complex has been shown to occur below the Hecla Hoek succession on Nordaustlandet. This complex is intruded by granites (Gee et al. 1995) which also intrude a metasedimentary succession (the quartzites and phyllites of Brennvinsfjorden Group) and probably also the overlying volcanic rocks (the Kapp Hansteen Group). The unconformably overlying Murchinsonfjorden Supergroup of the classical Hecla Hoek stratigraphy (Kulling 1934), consist of sandstones, shales, dolomites and limestones. The Sveanor Formation with tillites and overlying Cambrian sandstones and limestones represent the top of the Hecla Hoek succession on Nordaustlandet (Kulling 1934; and Harland 1985).

The succession below the Neoproterozoic Murchinsonfjorden Supergroup (Kapp Hansteen and Brennvinsfjorden groups) is well exposed on Botniahalvøya, northwestern Nordaustlandet, and it is in this area that the new work has been concentrated.

Thesis problems on Botniahalvøya

Kulling (1934) was the first to recognise both volcanic and sedimentary rocks on Botniahalvøya, but not until 1965 were the different rock units described in any detail (Flood et al. 1969). Otha (1982) revised the stratigraphy, but left a number of structural and stratigraphical problems unresolved. Investigations to establish more about the relationships on Botniahalvøya were undertaken in the summers of 1993 and 1994 by Swedarctic field parties from Lund University. This thesis presents a description of the sedimentary sequences in the Brennvinsfjorden Group and an interpretation of their depositional environments. A new map is also presented, showing the structures and the different rock units. The major unconformity, separating the Brennvinsfjorden and Kapp Hansteen groups, has been mapped in some detail.

Previous work on Nordaustlandet

Swedish exploration in the last century provided the foundation for our understanding of much of Svalbard's geology, particularly the eastern areas.

In the middle of the nineteenth century, Nordenskiöld (1864, 1866) visited Ny Friesland and Nordaustlandet and carried out the first geological reconnaissance in the latter area. He established the presence of a crystalline complex which he inferred to be Archean

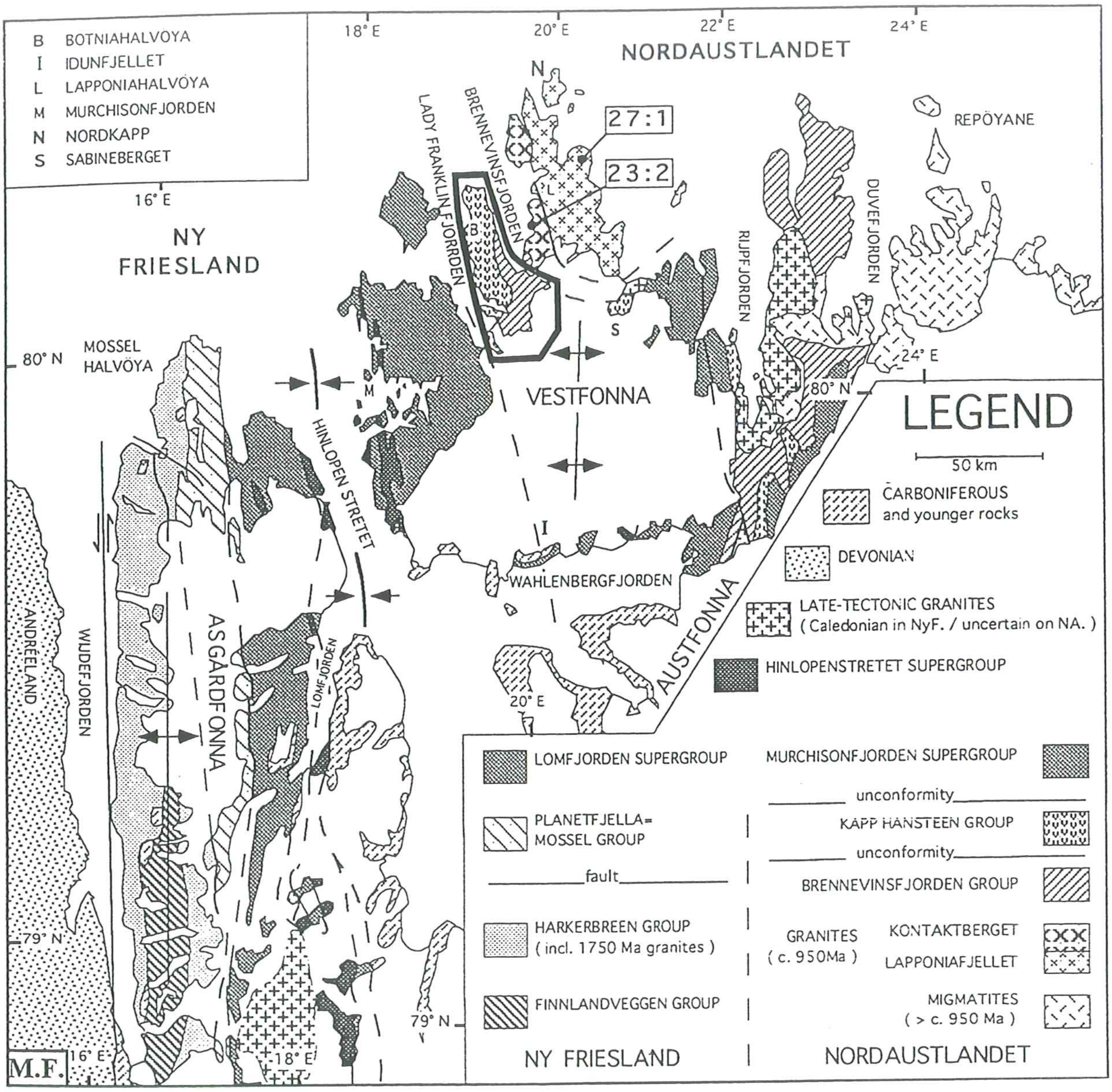


Fig 3. Eastern Svalbard. After Gee et al. (1995).

"Urberg" in age, overlain by unmetamorphosed successions of the Hecla Hoek Formation and younger Carboniferous strata (Nordenskiöld 1864). At the same time Blomstrand (1864) made a more detailed study of northern Ny Friesland, and established the distribution of "Archean crystalline rocks" and the younger Hecla Hoek. He also showed that the latter pass transitionally downwards from well-preserved sedimentary strata into phyllites, schists and gneisses of the "Archean".

Later pioneering studies on Nordaustlandet were undertaken by de Geer (1909), Nathorst (1910) and Kulling (1934). The latter also described tillites and Cambrian strata in the upper part of the Hecla Hoek succession.

Closer examination of the relationships on Nordaustlandet identified greenschist facies metasedimentary units, intruded by granites and apparently involved in the migmatization. It was concluded that metasediments were parts of the Hecla Hoek succession and that the migmatization was of Caledonian age (Kulling 1934). Kulling recognised both volcanic and sedimentary rocks on Botniahalvøya, together called the Kapp Hansteen Formation, providing the foundation for later work and this study.

From the 1920's to 1950's Sandford continued the exploration of Nordaustlandet and provided new evidence for the structural complexity of the granite-migmatite areas. The con-

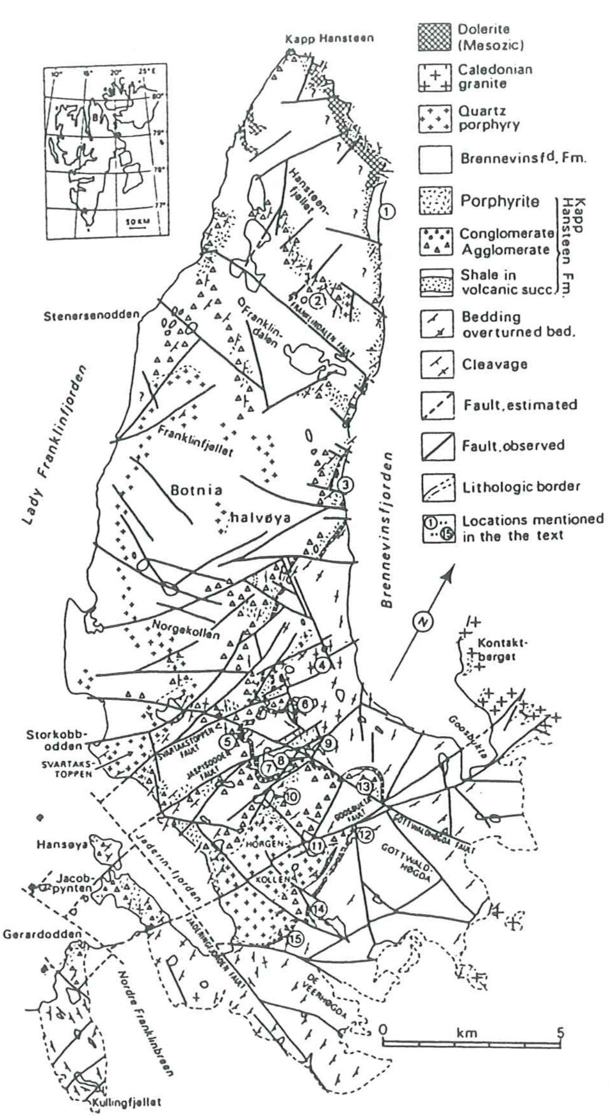


Fig 4. Geological map of Botniahalvøya. After Otha (1982).

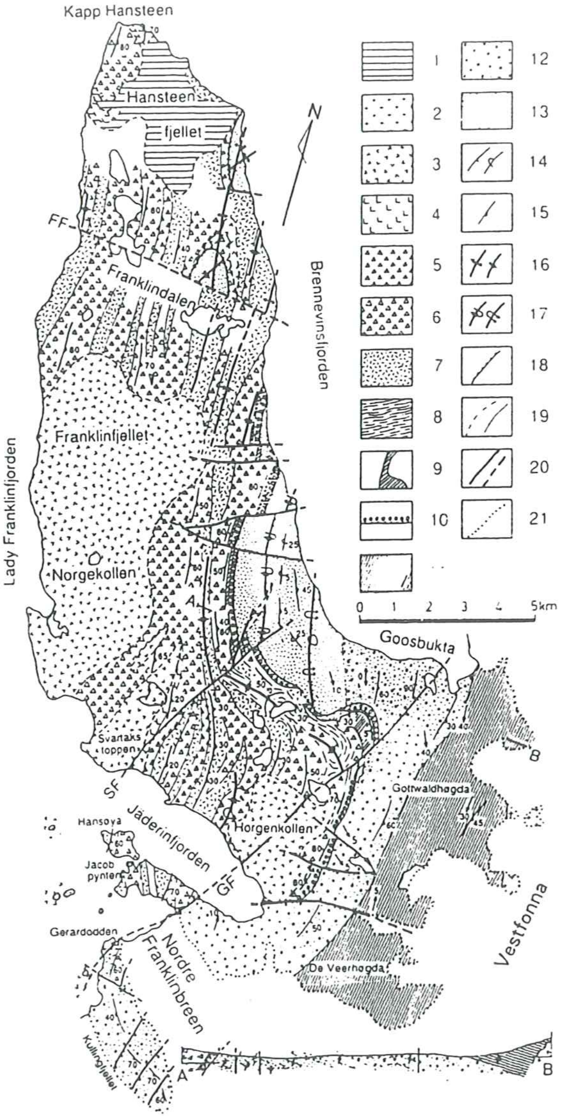


Fig 5. Botniahalvøya geology, based on Otha (1982), with minor revision, showing the major unconformity. 1=Mesozoic dolerite; 2=Kontaktberget granite; 3=quartz porphyry; 4-10 Kapp Hansteen Group (4=Ignimbrite; 5=andesit; 6=porphyrite; 7=tuff, tuff breccia and agglomerate; 8=shale; 9=columnar porphyrite; 10=basal conglomerate); 11-13 Brennvinsfjorden Group (11=upper sandstone-shale formation; 12=middle quartz-shale formation; 13=lower shale-sandstone formation); 14=bedding (overturned); 15=cleavage; 16=upright anticline and syncline; 17=overturned anticline and syncline; 18=unconformity; 19=intrusive boundary, covered and observed; 20=fault, observed and inferred; 21=glacier margin. FF=Franklindalen Fault; GF=Goosbukta Fault; SF=Svarthakstoppen Fault. After Gee et al. (1995).

trast between the latter and the overlying, cylindrically folded Hecla Hoek succession, persuaded Sandford (1956) that the high grade units must indeed compose a basement of the Neoproterozoic strata. Nevertheless, direct evidence of a major unconformity was not found.

In 1965, Norsk Polarinstitutt made an extensive, helicopter-supported survey of Nordaustlandet, favoured the basement hypothesis for the migmatite complex, but provided no conclusive evidence for the latter. East of Bengtssonbukta, a conglomerate was found near the base of a Neoproterozoic succession, but a regional unconformity was not recognised (Flood et al. 1969).

On Botniahalvøya (Fig. 3), Flood et al. (1969) recognised that the sub-Murchinsonfjorden rocks composed two mappable units, the Brennvinsfjorden and Kapp Hansteen formations; together, these were referred to as the Botniahalvøya Group (Flood et al. 1969). A conglomerate was found between the two formations and the former was thought to be younger than the latter.

Otha (1982) mapped Botniahalvøya in some detail (Fig. 4) and made an careful examination of the Botniahalvøya conglomerate. He concluded that the Brennvinsfjorden Formation underlies the Kapp Hansteen Formation. The unconformity also provided evidence of Precambrian (pre-c. 800 Ma) deformation of the older rocks (Otha 1982).

Gee et al. (1995) provided new evidence on the Botniahalvøya unconformity (Fig. 5) and demonstrated the Grenvillian age of the igneous activity (Gee et al. 1995); this implied that the Lapponiahalvøya granites, together with the contact metamorphosed Brennvinsfjorden sediments, compose a basement to the Neoproterozoic succession on Nordaustlandet (Fig. 6).

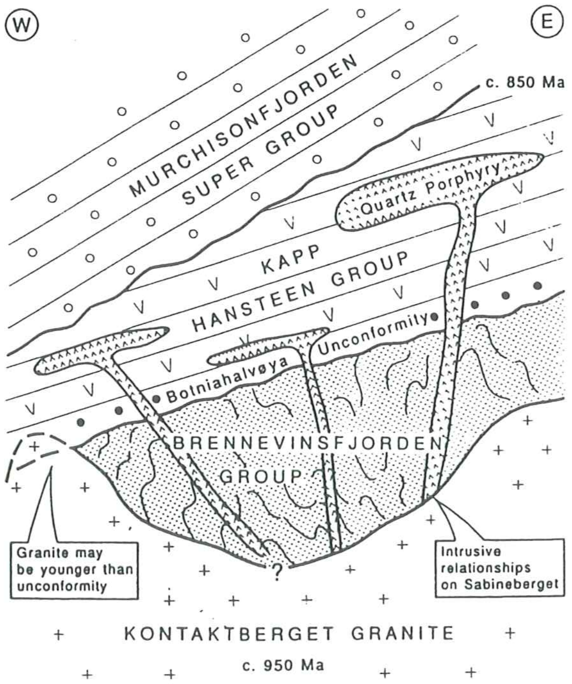


Fig 6. Summary sketch of the geological evolution of northwestern Nordaustlandet. After Gee et al. (1995).

The older metasedimentary succession was described to contain three formations, all in the Brennvinsfjorden Group. The Kapp Hansteen unit was also shown to be composed of several formations and therefore referred to as a group. Because of the major unconformity between the two groups, the name Botniahalvøya Group (Flood et al. 1969) was abandoned (Gee et al. 1995).

New work on Botniahalvøya

In order to find out more about the relationship between the Brennvinsfjorden and the Kapp Hansteen groups, a Swedarctic investigation was started in the summer of 1993. The field party was led by Patric Carlsson and Fredrik Hellman, with the author as assistant.

The 1993 work revised the previous maps (see Otha 1982 and Gee et al. 1995) and provided the basis for a more detailed work by the author in 1994. The study focused on the stratigraphy, structure and the sedimentary facies of the Brennvinsfjorden Group. Outcrops in a 300 km^2 area were investigated, samples were collected for laboratory analysis, and the 1993 map was improved in detail (Pl. 1), with more precise location of major folds and faults. Two camps on different locations were used; one on the southwest coast of Brennvinsfjorden and another in inner Jäderinfjorden.

Botniahalvøya

The Botniahalvøya peninsula (Fig. 3) is located between Lady Franklinfjorden and Brennvinsfjorden. The topography rises gently from the coast of Brennvinsfjorden towards the highest contours of 300-350 m along the western coast of Botniahalvøya. Large areas are covered with short transported congelifracted rocks, which have been used as evidence of underlying lithologies, where outcrops are lacking.

The volcanic and volcanoclastic rocks, referred to as the Kapp Hansteen Group (Gee et al. 1995) dominate the peninsula, generally dipping moderately west and northwestwards. The Brennvinsfjorden Group covers the southeastern part and comprises a sequence of quartzites and phyllites (metamorphosed sandstones and shales). Both the Kapp Hansteen Group and the Brennvinsfjorden Group are faulted and intruded by quartz-porphyry dykes (Otha 1982).

New and old maps

The previous mapping of the Botniahalvøya peninsula is shown in Fig. 4 (Otha 1982) and Fig. 5 (Gee et al. 1995). These maps both differ considerably from the new map (Pl. 1), where the more detailed outcrop observations and a better topographic base have allowed a more accurate presentation of the structure and interpretation of the stratigraphy. The Gee et al. (1995) map (Fig. 5) was based on Otha´s previous work (1982), but showed an oversimplified outcrop pattern for the contact zone between the Brennvinsfjorden and Kapp Hansteen groups.

The vertical aerial photographs provide evidence of a wide range of linear structures crossing Botniahalvøya. Many of these coincide with faults marked on Otha´s (1982) map (Fig. 4). The new mapping has in general not found evidence for fault movements on these linear structures and they have therefore not been shown on the new map. However, one major fault, approximately coinciding with Otha´s Gottwaldhøgda Fault, has been shown by the new work to dominate the structure. It explains many of the differences between Fig. 4 and Fig. 5.

The new geological map (Pl. 1) provides evidence for major pre-Caledonian folding of the Brennvinsfjorden Group with an anticline located near Goosbukta and a syncline further to the southeast. Neither of these folds coincide with major folds shown on previous maps. The map by Gee et al. (1995) showed the presence of an overturned anticline, with an axis located c. 2 km west of the Goosbukta Anticline. We have much way-up evidence to show that this fold does not exist; it´s location is within an overturned E-dipping sequence, in the western limb of the Goosbukta Anticline.

The structural mapping, with the identification of the Goosbukta Anticline has resulted in a new interpretation of the Brennvinsfjorden stratigraphy. Gee et al. (1995) proposed that the sequence of the three formations could be distinguished, with the uppermost units along the Vestfonna margin and successively lower units further to the west in an inverted sequence. The new work has defined three new formations, the oldest of which occurs in the core of the Goosbukta Anticline and the younger strata in both limbs, the uppermost formation being pre-sent only in the area northeast of Norgekollen.

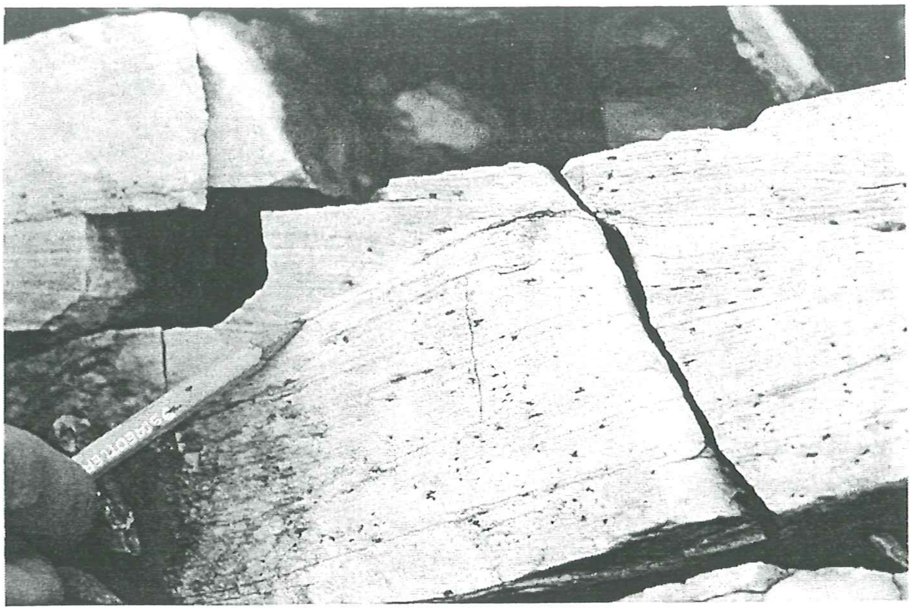
Stratigraphy

Kapp Hansteen Group

Kulling (1934) visited Botniahalvøya during the Sveanor expedition of the summer of 1931 and introduced the name "Cape Hansteen Formation" for the volcanic rocks. The sequences of sedimentary rocks on Botniahalvøya were incorporated in the same formation by Sandford (1950, 1956). Later Flood et al. (1969) restricted the contents of the Kapp Hansteen Formation to the volcanic rocks and referred the sedimentary units to the Brennvinsfjorden Formation. Gee et al. (1995) changed the name of the Kapp Hansteen units to a group, since it is composed of several mappable formations.

Fig 7. Basal Conglomerate of Kapp Hansteen Group northeast of Horgenkollen.

Fig 8. Cross-bedding in Formation A, close to the shore of Brennvinsfjorden.



Only the basal formations in the Kapp Hansteen Group have been mapped during the 1993-1994 field seasons on Botniahalvøya.

Basal conglomerate

The conglomerate (Fig. 7) that unconformably overlies the Brennvinsfjorden Group, composing the base of Kapp Hansteen Group, stretches from the east coast of Botniahalvøya, in southeastern Franklindalen, southwards to the Jäderinfjorden fault in Lady Franklinfjorden. In the northern areas the conglomerate has a gentle dip to the west and southwest, but further southeast, the dip is almost vertical. A synclinal axis is located north of Horgenkollen (the Horgenkollen Syncline).

The basal conglomerate formation is generally a few metres (up to 20 metres) thick. Locally, in the hinge of Horgenkollen Syncline (see Pl. 1), the conglomerate appears to be much thicker (c. 200 meters). In the basal parts, it is generally clast supported and monomict, with quartzite pebbles and boulders (size up to one meter) dominating. The clasts are subrounded to well-rounded and the matrix is mainly of volcanic origin. Higher in the formation, the clasts become dominated by volcanic pebbles and boulders and, locally, the latter are matrix-supported.

Overlying formations

The volcanic and volcanoclastic Kapp Hansteen rocks overlying the basal conglomerate, dip generally westwards and southwestwards at moderate angles (Gee et al. 1995) and consist of material ranging from volcanic breccia and agglomerates to tuffs and tuffaceous rocks. Porphyritic rocks are also frequent and columnar jointed porphyry (see Flood et al. 1969 p. 43, fig 12) conformably overlies the basal conglomerate in northern areas; the columns are oriented normal to the underlying bedding surface. These porphyries are overlain by acid tuffs and then by agglomerates. Ignimbrites occur northwest of Horgenkollen.

The estimated thickness of the Kapp Hansteen Group is 1000 m (Gee et al. 1995) and the top is not seen. The new work has not concerned the Kapp Hansteen Group in general and unfortunately we do not have enough information to draw any boundaries between the lithologies, with the exception of the basal formations.

Brennvinsfjorden Group

The Brennvinsfjorden Group is delimited by the overlying conglomerate in the west and south, and by the intrusive Kontaktberget granite in the east (Kulling 1934). The southeastern border to the granite is located beneath Vestfonna and is exposed only at one locality on the edge of the icecap (Pl. 1).

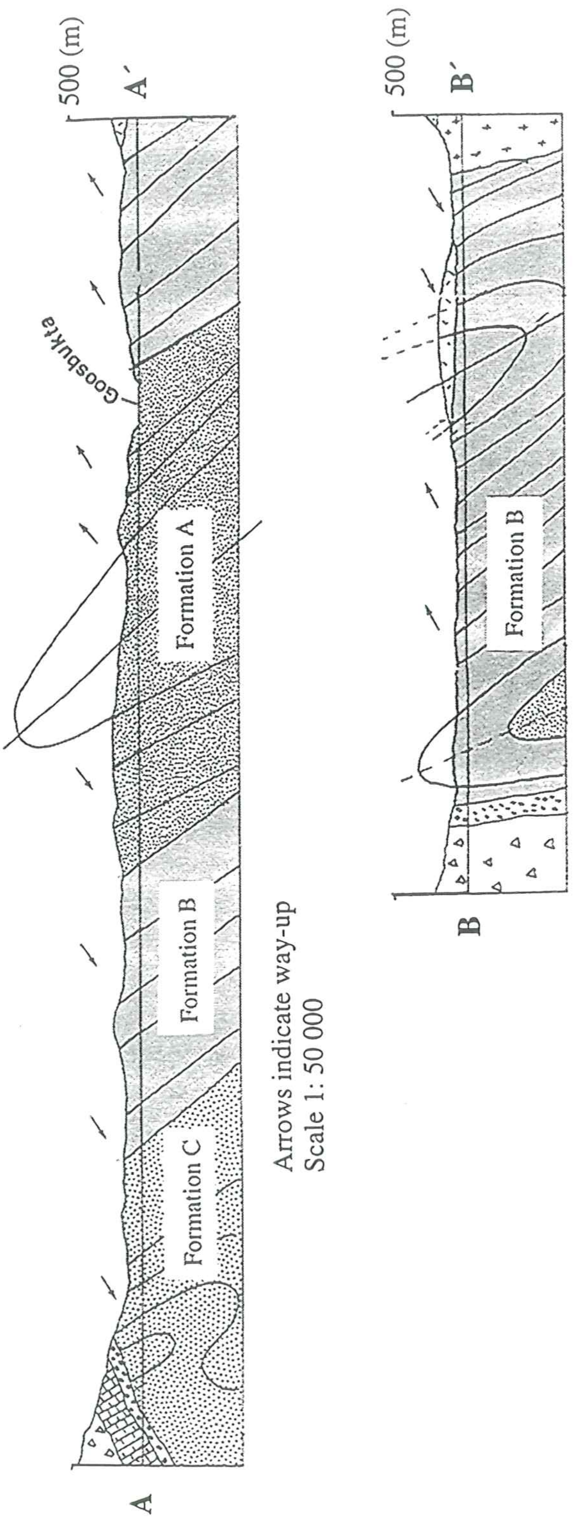


Fig 9a-b. W-E sections through southeastern Botniahalvøya.

The Botniahalvøya Group is dominated by fine-to medium grained sandstones, phyllites and quartzites. Sedimentary structures, such as ripple marks, cross-bedding, loadcasts and graded bedding, often provide evidence of way-up; much of the section is inverted (Fig. 8), generally striking about north-northwest, with steep to moderate dips to the east. In inner Goosbukta, near the icecap, the strata are the right-way-up; further west they are inverted and a major foldaxis is located in Goosbukta. This structure, the Goosbukta Anticline, is nearly isoclinal and with an axial-plane dipping c. 50° E (Fig. 9a-b).

Due to lack of time, the area south of the De Veerhøgda Fault (Pl. 1) was not mapped in the same detail as the rest of the Brennvinsfjorden sediments, but the Goosbukta Anticline is recognised close to Jäderinfjorden and a syncline at the edge of Vestfonna. Quartzite beds with large scale cross-bedding are found in the core of the anticline near Jäderinfjorden; they are thought to be Formation A units.

Mapping has identified that the Brennvinsfjorden Group incorporates three formations (treated below): a lower quartzite with very subordinate phyllites (Formation A), a middle fine sandstone with grey phyllites (Formation B) and an upper dark phyllite (Formation C).

Formation C: Upper dark pyllites

The strata are fine-grained and laminated on a mm- to cm scale. The youngest unit consists of black phyllites with a slaty cleavage (Fig. 10) and usually a crenulation. Way-up has been established generally on the bases of graded beds or ripple-drift cross-lamination. Calcareous lenses are frequent. The outcrops are situated east and northeast of Norgekollen The formation occurs only in the western limb of the Goosbukta Anticline. It has a minimum thickness of c.. 1400 m.

Formation B: Middle fine to medium grained sandstone and grey phyllites

Beds of c. 10 cm-thick medium-grained quartzite, intercalated with graded grey phyllites comprises this formation. The sequence is characterised by well developed Bouma sequences. It contains characteristic calcareous lenses (Fig. 11). The formation outcrops south of the Gottwaldhøgda Fault and north of the latter in both limbs of the Goosbukta Anticline. Formation B passes regularly and transitionally into

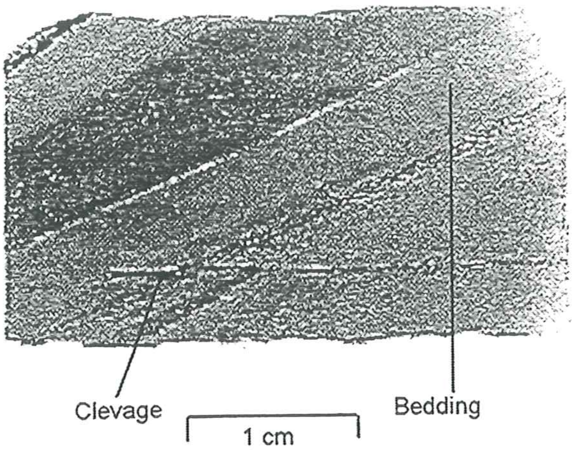


Fig 10.Cleavage in thin-section from Formation C.

both the overlying and underlying formation. It has an estimated thickness of c. 1400 m.

Formation A: Lower quartzite and subordinate phyllites

Thick quartzite beds (up to 1 meter) with large-scale cross-bedding characterise this formation. They are interbedded with subordinate medium grained sand laminae, 2-5 cm thick. Well-preserved wave ripples (Fig. 12) and mud-cracks (Fig. 13) are found in the core of the Goosbukta Anticline.

This formation is largely conferred to the area north of the Gottwaldhøgda fault and is intruded by the Kontaktberget granites in the north. However, similar lithologies are also found, east of inner Jäderinfjorden. Formation A has a minimum thickness of c. 2300 m.

Depositional environment of the Brennvinsfjorden Group

Depositional environments can be recognised by a combination of lithologic, palaeontologic and sedimentary features as well as sedimentary structures. In the case of the Brennvinsfjorden Group, palaeontological features are not present because of the age of the rocks. Since the lower units of Formation A are not exposed it is difficult to establish the environment of deposition, only to describe the subfacies and suggest the depositional environments.

The sedimentary structures and texture of Formation A show a mature sediment with sand dominating large-scale cross-bedding, interlaminated with wave-rippled finer sand and silt beds, occasionally with mud-cracks. These evidence suggest shallow water deposition, close to the coast.

The upper part of Formation A changes transitionally into Formation B, where medium and thin, medium grained and moderately mature beds with sharp basal contacts have a normal upward-fining grain-size profile (Fig. 14). Internally, the beds are massive, laminated and cross-laminated. Dewatering structures are common. These structures and textures are indicative of Bouma sequences which result from sediments transported by density currents trigged by sedimentary, tectonic, topographic or sea-level effects.

The sediment in the top of the Brennvinsfjorden Group composes a variety of fine laminated

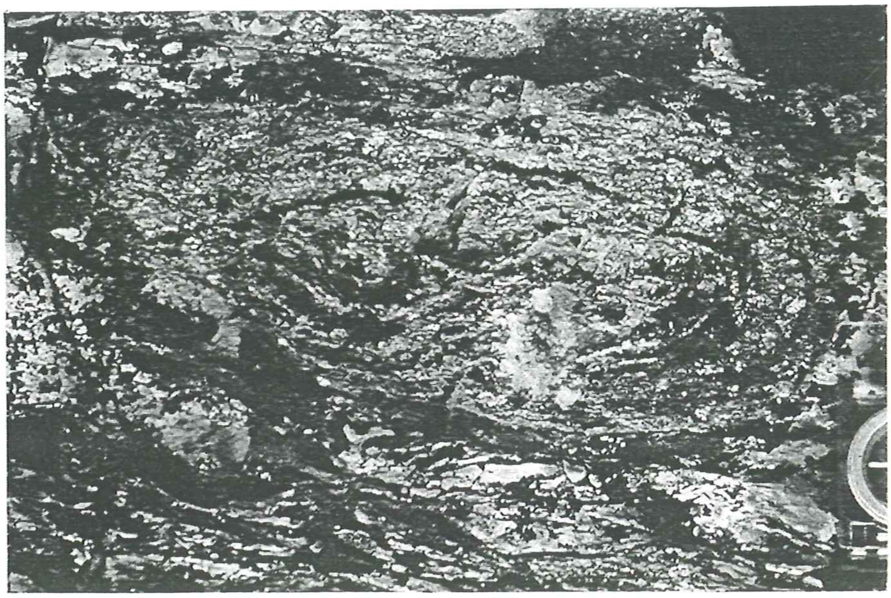


Fig 11.Calcareous lens in Formation B, north of the Gottwaldhøgda Fault.

Fig 12.Wave-ripples in Formation A, in the core of Goosbukta Anticline.

siltstones and shales interbedded with small-scale cross-laminated sandstones. Suspension-deposited clay and silt might have its source by distal turbidites. Thinly interlaminated silt and clay are common in Formation C, especially the upper units. Examples of this sediment type occur in deep marine basins or lacustrine environments. The latter produce "varved" deposits (Selley 1976) but such deposits have not been found in Formation C. The transition from the Bouma beds of Formation B to the finely laminated sediments of Formation C suggests that the latter are also deep-water deposits.

Intrusions

Granites

U-Pb zircon data on the granite intrusions from Lapponiahalvøya have demonstrated ages of 939 ± 8 Ma on the Kontaktberget granite and 961 ± 17 Ma on the Lapponiafjellet granite (Gee et al. 1995). It is not clear from the outcrops of the contact along Vestfonna whether

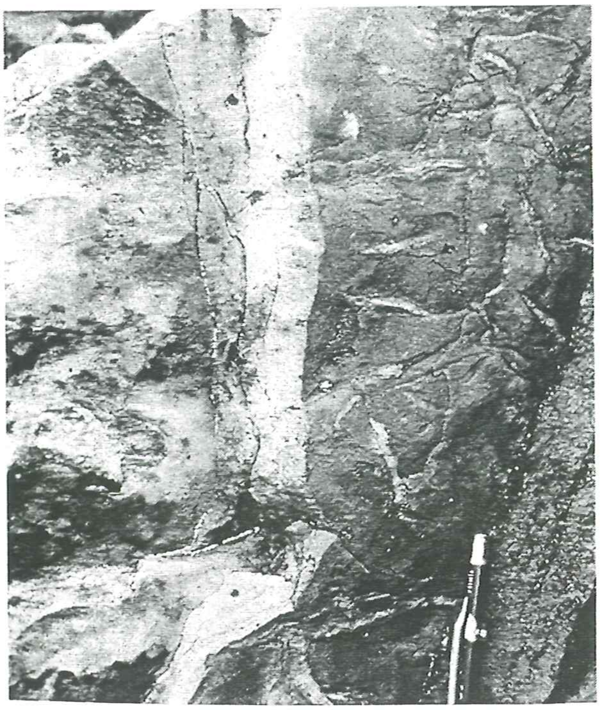


Fig 13.Mud-cracks in Formation A, in the core of Goosbukta Anticline.

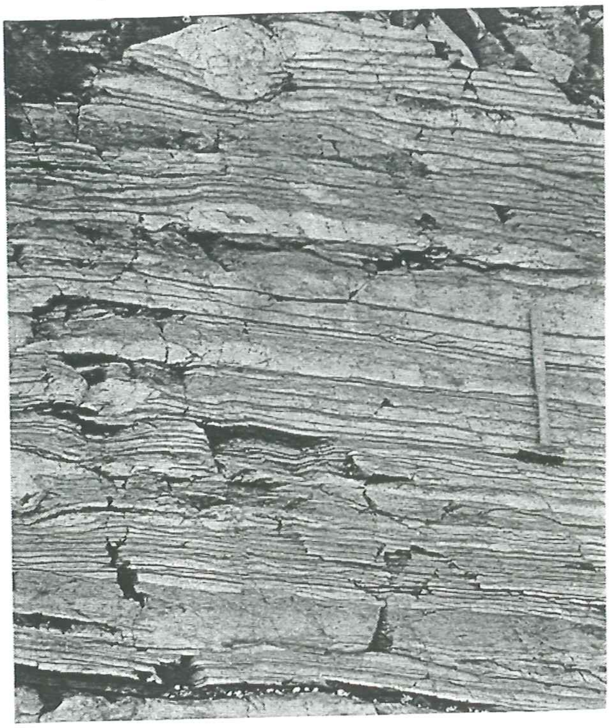
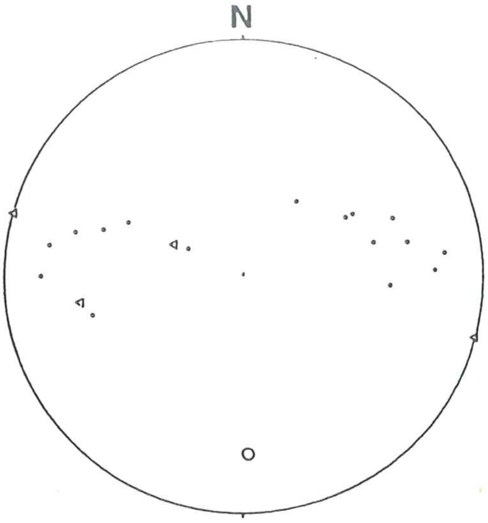
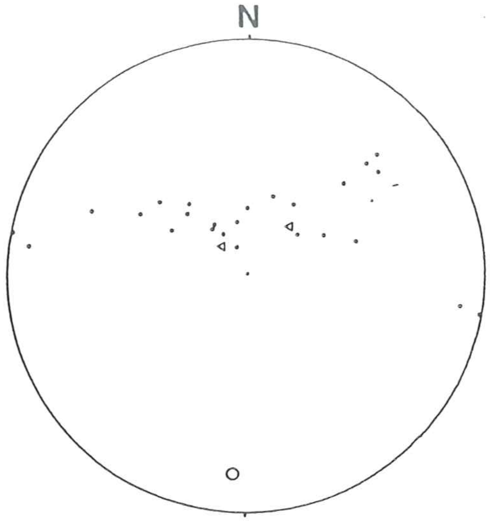


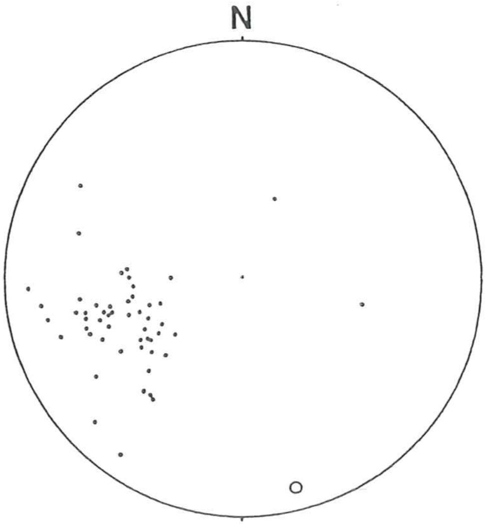
Fig 14.Sequence from Bouma-bed in the eastern limb of the Goosbukta Anticline, north of the Gottwaldøgda Fault.



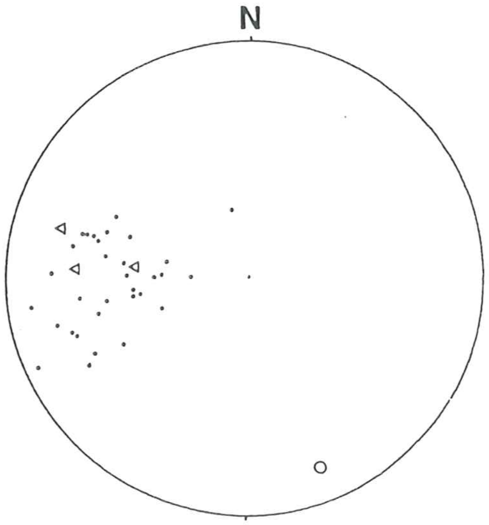
The basal formations of
the Kapp Hansteen Group
north of the Gottwaldhøgda Fault



The basal formations of
the Kapp Hansteen Group
south of the Gottwaldhøgda Fault

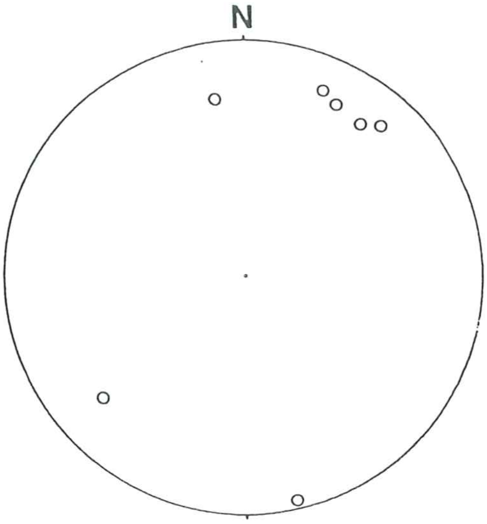


The Brennvinsfjorden Group
north of the Gottwaldhøgda Fault



The Brennvinsfjorden Group
south of the Gottwaldhøgda Fault

Poles to bedding/cleavage plotted in a equal area net.
● Bedding ◁ Cleavage ○ Fold axis



Small scale folding of Brennvinsfjorden
Group north of Gottwaldhøgda Fault

Fig 15. Stereographic plots of structural data.

Fig 16. Small scale folding of the Brennvinsfjorden Group. Looking north in the western limb of the Goosbukta Anticline.

the intrusion was before or after the folding of the Brennvinsfjorden Group.

Quartz porphyries

A grey quartz porphyry dyke intrudes both the Kapp Hansteen and Brennvinsfjorden groups. It can be followed from the coast of Brennvinsfjorden southwards in to the Kapp Hansteen volcanites. Single zircon Pb-evaporation analyses yield an age of 949 ± 9 Ma for the quartz porphyry intrusion on Botniahalvøya (Gee et al. 1995).

Structures

On Botniahalvøya two groups of folds can be distinguished, along with a variety of mainly E-W striking faults. The first group of folds influences only the Brennvinsfjorden Group sedimentary rocks; their age is Grenvillian or older. The second group of folds deform all the rocks on Botniahalvøya; they are assumed to be Caledonian in age although definite evidence is lacking because relationships between the Kapp Hansteen Group and the overlying Murchinsonfjorden Supergroup strata are not exposed in western Nordaustlandet.

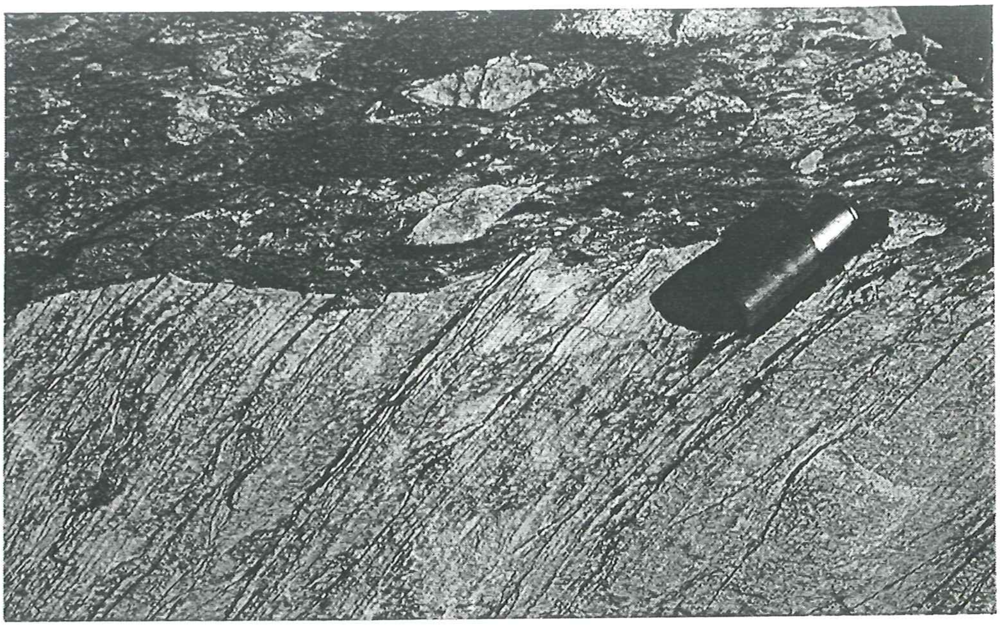
West of Lady Franklinfjorden, the Neoproterozoic Murchinsonfjorden Supergroup and the overlying Vendian to early Palaeozoic Hinlopenstretet Supergroup are folded by major cylindrical, upright to W-vergent structures with associated high-angle E-dipping axial plane cleavage (Flood et al. 1969). The relationship between the Murchinsonfjorden Group sedimentary rocks and the underlying Kapp Hansteen volcanites (Table 1) is only exposed in central Nordaustlandet, where it is known to be a regional unconformity (Gee & Tebenkov 1996).

Folding of the Kapp Hansteen Group

As is apparent from the geological map (Pl. 1), the Kapp Hansteen units generally dip to the west and southwest. In the southern parts (Horgenkollen), the basal formations are approximately vertical to high angles west dipping; further north they are folded in the hinge of the Horgenkollen Syncline and from this area to the northwest, on both sides on Gottwaldhøgda Fault, the Kapp Hansteen formations dip at low to moderate angles to southwest and west.

On Fig. 15 the poles to bedding in the basal formations of the Kapp Hansteen Group are plotted (separately for north and south of the Gottwaldhøgda Fault). These diagrams show the geometry of the Horgenkollen Syncline to be an open upright structure plunging c. 15° S with an axial surface dipping at a high angle to the east. There is local evidence of small scale folding of the unconformity. A particularly good example is seen in the northwestern exposures of the basal conglomerate on west side of Brennvinsfjorden (Fig. 16) where an upright syncline and anticline, plunging at very low

Fig 17. Botniahalvøya Unconformity north of Horgenkollen.



angles southwards, is well exposed. The finer grained lithologies of the Kapp Hansteen Group and some of the agglomerates show a distinct cleavage with a general dip at high angles eastwards.

Pre-Kapp Hansteen Group folding of the Brennvinsfjorden Group

The major unconformity (Fig. 17) at the base of the Kapp Hansteen Group (Gee et al. 1995) provides clear evidence of the folding of Brennvinsfjorden Group before deposition of the older sedimentary volcanic rocks. Throughout most of the area, the Brennvinsfjorden strata are inverted beneath the unconformity, with the beds dipping at moderate angles eastwards. The new work defining the major anticline (Goosbukta Anticline) in the Brennvinsfjorden Group in the area south of Goosbukta has also shown that this fold can be followed south of the Gottwaldhøgda Fault to Jäderinfjorden. In the extreme westernmost Brennvinsfjorden Group outcrops, beneath the Kapp Hansteen unconformity, a syncline has been mapped. To the east of the Goosbukta Anticline, south of the Gottwaldhøgda Fault, another syncline is located along the edge of Vestfonna. The geometry of the Goosbukta Anticline can be seen from the sections (Fig. 9a-b). The data on poles to bedding and foldaxes in Brennvinsfjorden Group have been plotted on Fig. 15 separately for areas north and south of the Gottwaldhøgda

Fault, another syncline is located along the edge of Vestfonna. The geometry of the Goosbukta Anticline can be seen from the sections (Fig. 9a-b). The data on poles to bedding and foldaxes in the Brennvinsfjorden Group have been plotted on Fig. 15 separately for areas north and south of the Gottwaldhøgda Fault.

They show that the major folds are nearly isoclinal (c. 10°-20° interlimb angle) overturned to the west, with axial planes dipping c. 40°-50° E. The small scale folds of the Brennvinsfjorden Group, north of Gottwaldhøgda Fault (Fig. 15), vary greatly in axis, suggesting that the pre-Kapp Hansteen folding is more complex than shown by the major structure.

Cleavage is generally well developed in the finer grained Brennvinsfjorden Group sedimentary rocks (Fig. 10) and this secondary structure is often crenulated, giving a phyllitic appearance. In the cleavage white mica and chlorite crystallise.

In the area north of the Gottwaldhøgda fault, the folds in the Brennvinsfjorden Group plunge regularly c. 10° to SSE (165°). The overlying Kapp Hansteen conglomerate dips regularly c. 15° to SSW. This implies that at the time of deposition of the Kapp Hansteen conglomerate, the plunge of the folds in the underlying rocks was approximately horizontal (Fig. 15). In the area south of the Gottwaldhøgda Fault,

	NORDAUSTLANDET								
	WESTERN	CENTRAL	WESTERN	CENTRAL	WESTERN	CENTRAL	WESTERN	CENTRAL	
	(Kulling 1934)	(Sandford 1956)	(Flood et al. 1969)		(Otha 1982 a&b)	(Ohta 1982c)	(Gee et al. 1995)	(This paper)	
Lower part of MURCHISON BAY FORMATION	NORVIK Series (shales)	NORVIK Series	NORVIK Fm	NORVIK Fm	NORVIK Fm	NORVIK Fm	NORVIK Fm		Lower part of MURCHISONFJORDEN Supergroup
	FLORA Series (quartzites) Successions below repeated by recumbent folding.	FLORA Series	FLORA Fm	FLORA Fm	FLORA Fm	FLORA Fm	FLORA Fm		
			KAPP LORD Fm (shales)	KAPP LORD Fm	KAPP LORD Fm	KAPP LORD Fm	KAPP LORD Fm		
			WESTMANBUKTA Fm (shales)	WESTMANBUKTA Fm	WESTMANBUKTA Fm	WESTMANBUKTA Fm	WESTMANBUKTA Fm	WESTMANBUKTA Fm	
			PERSBERGET Fm (quartzites)	PERSBERGET Fm	PERSBERGET Fm	PERSBERGET Fm	PERSBERGET Fm	PERSBERGET Fm	
					MEYERBUKTA Fm (shales, sst & subord. lst)	AUSTFONNA Group (INNVIKHØGDA DJEVLEFLOTA and BASAL QZITE formations)	MEYERBUKTA Fm	DJEVLEFLOTA Formation with basal conglom.	
			? unconformity ?				inferred		
	CAPE HANSTEEN Formation (Phyllites, qz porphyries andesites agglomerates & conglomerates)	CAPE HANSTEEN Formation	BRENNEVINSFJORDEN (metased.) & KAPP HANSTEEN (volcanite) formations	AUSTFONNA & KAPP PLATEN formations KAPP HANSTEEN & BRENNEVINSFJORDEN Undiff. (migmitates & granites intrude BOTNIA-HALVØYA Group)	KAPP HANSTEEN Formation	KAPP HANSTEEN Group	KAPP HANSTEEN Group	SVARTRABBENE Formation	
		Metamorphic complex (migmatites & granites)			BRENNEVINSFJORDEN Formation	BRENNEVINSFJORDEN Formation	BRENNEVINSFJORDEN Group (Intruded by ca. 950 Ma granites)	HELVETESFLYA Formation (Intruded by ca. 1050 Ma granites)	
					Caledonian migmatites & granite intrusions				

Table 1. Stratigraphic correlation of the Meso- and Neoproterozoic succession of central and western Nordaustlandet. After Gee & Tebenkov (1996).

the basal conglomerate and the other Kapp Hansteen formation rocks are folded in a major syncline (Horgenkollen Syncline) and, in the eastern limb of this structure, the conglomerates dip steeply to the west; locally they are overturned. Interestingly, the orientation of the folds in the underlying Brennvinsfjorden Group is not influenced by this folding. This implies that the rotation of the Kapp Hansteen conglomerate into the vertical in the eastern limb of the Horgenkollen Syncline must have been accompanied by the faulting in the underlying strata. A fault that may explain this movement is seen on Pl. 1, immediately south of the Gottwaldhøgda Fault, in the hinge of the Goosbukta Anticline. It is thought to continue to the south where the Brennvinsfjorden sedimentary rocks, east of Horgenkollen, are highly folded and faulted in the hinge zone of the anticline.

Age of the folds on Botnia-halvøya and their deformation

Age of rocks

Andesitic rocks in Kapp Hansteen Formation demonstrate an age of c. 963 ± 12 Ma (A. Larionov unpublished data) and the quartz porphyry intrusions an age of 949 ± 9 Ma. This together with the Kontaktberget granites (961 ± 17 Ma) and detrital zircons from Brennvinsfjorden Group (c. 1500 Ma) (Gee et al. 1995), implies that the Brennvinsfjorden sediments are younger than 1500 Ma and older than 960 Ma. More work with detrital zirkons, might help to construct the age of the Brennvinsfjorden Group.

Age of deformation

Fold geometry in the Kapp Hansteen Group suggests Caledonian age of deformation and folding of the Brennvinsfjorden rocks pre-960 Ma is probably Grenvillian.

Conclusions

Mapping of the Gottwaldhøgda Fault and the location of the Goosbukta Anticline has resulted in revision of the previous stratigraphy. It is now concluded that the Brennvinsfjorden Group is folded in a W-vergent, near isoclinal structure and faulted by W-E striking faults and that the stratigraphy of the Brennvinsfjorden Group is composed of three newly defined informal formations. The sequence is probably a result of a gradual transgression from a coastal, shallow water deposition (Formation A) to a deep-water environment (Formation B & C).

The structural data of the two groups support the interpretation that the folding in the Kapp Hansteen Group is of Caledonian age and the intrusion of granite at c. 960 Ma makes the folding of the Brennvinsfjorden Group to be Grenvillian or earlier in age.

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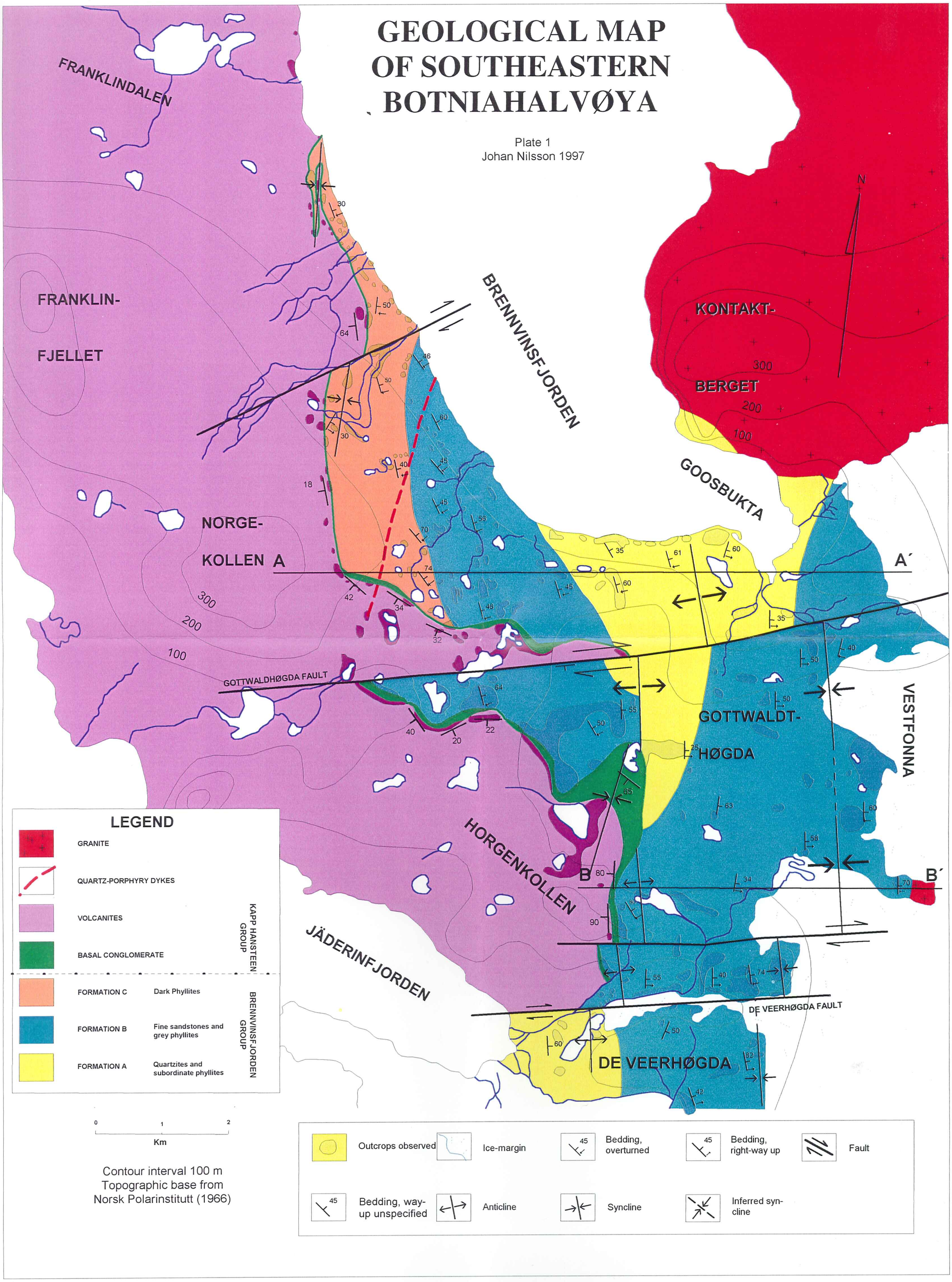
GEOLOGICAL MAP OF SOUTHEASTERN BOTNIAHALVØYA

Plate 1
Johan Nilsson 1997



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