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An Outline of the Pre-Carboniferous Geology of Nordaustlandet*

By Audun Hjelle**

Abstract: The general features of the pre-Carboniferous geology of NE Svalbard are summarized in this paper and are based mainly on work done by four Norsk Polarinstitutt expeditions in 1957, 1965, 1976 and 1978.
The supracrustal strata, which are of late Precambrian to Cambro-Ordovician age, have all undergone Caledonian metamorphism; the lowest part of the succession generally occurs as paragneisses, or has been more or less migmatized.
Isotopic ages suggest an orogenic episode around 530 m. y. ago. Posttectonic granites which cut the migmatites have revealed ages of 350 to 450 m. y.
Syn- to late tectonic intrusives include a range from granite to quartz diorite; in the NE extensive gabbros and diorites are also found.

Zusammenfassung: Die allgemeinen Grundzüge der präkarbonen geologischen Entwicklung von NE-Svalbard sind kurz zusammengefaßt; sie basieren vor allem auf den Geländearbeiten der vier Expeditionen des Norwegischen Polarinstitutes in den Jahren 1957, 1965, 1976 und 1978.
Die Schichten der suprakrustalen Gesteine besitzen ein spätpräkambrisches bis kambro-ordovizisches Alter und haben alle eine kaledonische Metamorphose erlitten. Der stratigraphisch tiefste Teil der Folge ist als Paragneis ausgebildet oder mehr oder weniger migmatisiert. Isotopenalter sprechen für ein orogenes Ereignis um 530 Mill. Jahre. Posttektonische Granite, die die Migmatite durchschlagen haben, zeigen Alter zwischen 350 und 450 Mill. Jahren. Syn- bis spättektonische Intrusionen umfassen Granite bis Quarzdiorite, im NE auch ausgedehnte Gabbros und Diorite.

Introduction

Up to the 1920's only a little geological work had been done on Nordaustlandet and the adjacent islands. With the Oxford University expeditions of 1923 and 1924 (SANDFORD, 1926) and the detailed work of the Swedish-Norwegian expedition of 1931 (KULLING, 1934) new and important results emerged, but wide areas were still almost unknown, especially in the northern and north-eastern parts of Nordaustlandet.

Although earlier material is also included, the present paper is mainly based on published and unpublished information obtained by the geologists of four Norsk Polarinstitutt expeditions: 1957 A. Hjelle and T. S. Winsnes, 1957 B. Flood, D. G. Gee, A. Hjelle, T. Siggerud and T. S. Winsnes, 1976 T. Gjelsvik, A. Hjelle, Y. Ohta and T. S. Winsnes, 1978 A. Hjelle, Ø. Lauritzen, Y. Ohta and T. S. Winsnes.

During the 1957 expedition reconnaissance work was done in the central and northwestern parts of Nordaustlandet. This work was continued and extended towards the north in 1965 (FLOOD et al., 1969). The 1976 expedition mainly surveyed the little known areas eastwards of Duvefjorden, including the islands of Storøya and Kvitøya (HJELLE, OHTA & WINSNES, 1978). In 1978 detailed work was carried out in selected areas: between Murchisonfjorden and Wahlenbergfjorden, and in Lågøya, Botniahalvøya, Sjuøyane and Rijpdalen.

REGIONAL DESCRIPTION

Stratigraphy

The pre-Carboniferous supracrustal rocks of Nordaustlandet all belong to the Hecla Hoek Complex which comprise pre-Downtonian meta-supracrustal and igneous rocks and earliest Devonian igneous rocks.

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The youngest beds, those of the Lower Paleozoic Kapp Sparre Formation, are exposed in the extreme west at Hinlopenstretet (Fig. 1, Tab. 1 A). A thickness of more than 1100 m can be measured, and Lower Cambrian and Lower Ordovician fossils are recorded from the area of Kapp Sparre and from a small island to the west of Krossøya in Murchisonfjorden.

Below the Kapp Sparre Formation follows the Sveanor Formation of late Precambrian age, with mainly marly and sandy beds in the lower and middle part, and tillite in the upper part. The maximum recorded thickness of the formation is 330 m, the boulder tillite beds showing considerable variations in thickness, ranging from a few metres to c. 100 m.

The rest of the area to the west and south-west of Lady Franklinfjorden, the north shore of Wahlenbergfjorden and smaller areas west of Rijpfjorden and Rijpdalen itself are occupied by rocks of the late Precambrian Murchisonfjorden Supergroup of more than 5000 m in thickness. The beds have only been moderately metamorphosed and mainly show well preserved primary structures.

The supergroup is divided into three groups: these are, in descending order, the Roaldtoppen, Celsiusberget and Franklinsundet groups. The Roaldtoppen Group (c. 1250 m) is composed of calcareous beds, c. 50% dolomite and c. 50% limestone. Dolomite containing stromatolites is common in the upper part.

The Celsiusberget Group (c. 2150 m) is a predominantly sandstone and shale succession, the upper third containing alternating layers of shale, dolomite and sandstone, with increasing proportions of sandstone towards the bottom; the lower two thirds are almost invariably composed of sandstones.

The Franklinsundet Group (1800 m +) is remarkable for its large amount of finely laminated red and green mudstone. The beds which also contain shale and limestone horizons and some quartzite, comprise the lowermost beds of the Murchisonfjorden Supergroup and rest with a basal conglomerate unconformably on the Botniahalvøya Group.

The Botniahalvøya Group (2000 m ±) is divided into two formations: an upper, the Kapp Hansteen Formation composed mainly of volcanic rocks, and a lower, the Brennevinsfjorden Formation, with a monotonous sequence of quartzites, siltstones and shales (see also p. 69). The volcanic rocks include intermediate to basic extrusives, acidic cross-cutting quartz porphyries, as well as tuffs and agglomerates.

Extensive outcrops of Botniahalvøya Group rocks occur in Botniahalvøya, in Rijpdalen and to the south of Kapp Platen; the latter, which have not been investigated in detail, are probably correlatives of the Brennevinsfjorden Formation.

In the areas of mobilized and highly metamorphic rocks to the north and east, a number of uncertainties arise when considering their stratigraphy. In the western half of Nordaustlandet the regional structures suggest a main anticlinorium of NNE-SSW trend, with increasing stratigraphical depth towards the NNE (FLOOD et al., 1969), and the supracrustals in the migmatite areas to the east and north-east of Brennevinsfjorden are therefore assumed to be of pre-Botniahalvøya Group age. In the gneiss/migmatite areas around Duvefjorden and to the east of this region, the outcrops of well preserved supracrustal rocks are too small and scattered to permit a detailed stratigraphy. However, due to the lithology of the beds and their metamorphic grade they are considered to belong to a succession preceeding the Botniahalvøya Group.

The supracrustals most frequently met with in the gneiss/migmatite areas are micaceous quartzite/siltstone and siliceous mica schist; less frequently are they marble and concordant amphibolite layers. In the Nordkapp-Sjuøyane area beds of tuffaceous appearance also occur in alternation with quartzite.

Stratigraphical correlation with Ny Friesland and Olav V Land

In the upper part of the Hecla Hoek succession of Nordaustlandet there is little doubt about a correlation with the areas west of Hinlopenstretet (KULLING, 1934). With younger beds towards the strait on both sides a wide north-south trending synclinorium is suggested. Cambro-Ordovician beds, which closely resemble those of the Kapp Sparre Formation, occur only 11 km to the south-west of Kapp Sparre, at the north-eastern outlet of the Valhallfonna glacier (FORTEY & BRUTON, 1973). The Sveanor tillite, with the extensive underlying calcareous strata containing stromatolites and oolites, compares well to the Polarisbreen and Akademikerbreen groups of Olav V Land, while the Celsiusberget Group can be compared to the Veteranen Group in southern Ny Friesland (HARLAND, WALLIS & GAYER, 1966), (Tab. 1 A). The Franklinsundet Group, with its claystones, mudstones and calcareous horizons in the upper part, might then be correlated with the lower part of the Veteranen Group and the upper part of the Planetfjella Group in Ny Friesland, both of which have a similar lithology. The volcanic and sedimentary rocks of the Botniahalvøya Group are correlated with the middle and lower part of the Planetfjella Group with its acid pyroclastics and thick psammitic/pelitic beds. Going down in the Hecla Hoek succession, metamorphism and migmatization make correlation less reliable. If one assumes that the supracrustal rocks which occur to the north and east of Brennevinsfjorden and to the east of Duvefjorden are of pre-Botniahalvøya Group age, then these rocks might be correlated with beds lower than the Planetfjella Group, i. e. with the Harkerbreen Group of Ny Friesland. The common occurrence of quartzitic mica schist, the concordant amphibolites and tuffaceous (?) beds would seem to justify this correlation.

Gneiss, migmatite, syntectonic intrusions

A wide range of gneisses and migmatites — from paragneisses of supracrustal appearance through agmatitic and schollen migmatite to nebulitic varieties, which often grade into weakly foliated granites — can be observed. Two-mica gneisses of granitic to quartz dioritic composition frequently occur in all the main gneiss areas of Nordaustlandet. The mineral assemblages of the migmatite paleosomes of pelitic composition are sillimanite, cordierite, garnet and two-micas, indicating an upper amphibolite facies series of low pressure and high temperature; however, diallage orthopyroxene in some of the basic paleosomes suggests that the highest grade was of the granulite facies series. The mineralogy of the migmatite metatect shows that migmatization took place under lower amphibolite facies conditions.

The paleosomes are often intensely folded, while the granitic metatect and most of the grey granites related to the migmatization show only weak foliation and must therefore be regarded as late tectonic intrusives. In the eastern part of Nordaustlandet and in Karl XII øy, Storøya and Kvitøya, the late tectonic intrusives also include amphibolites, gabbros and basic dykes.

Post-tectonic intrusions

All the pre-Carboniferous post-tectonic intrusions recorded are of granitic composition.

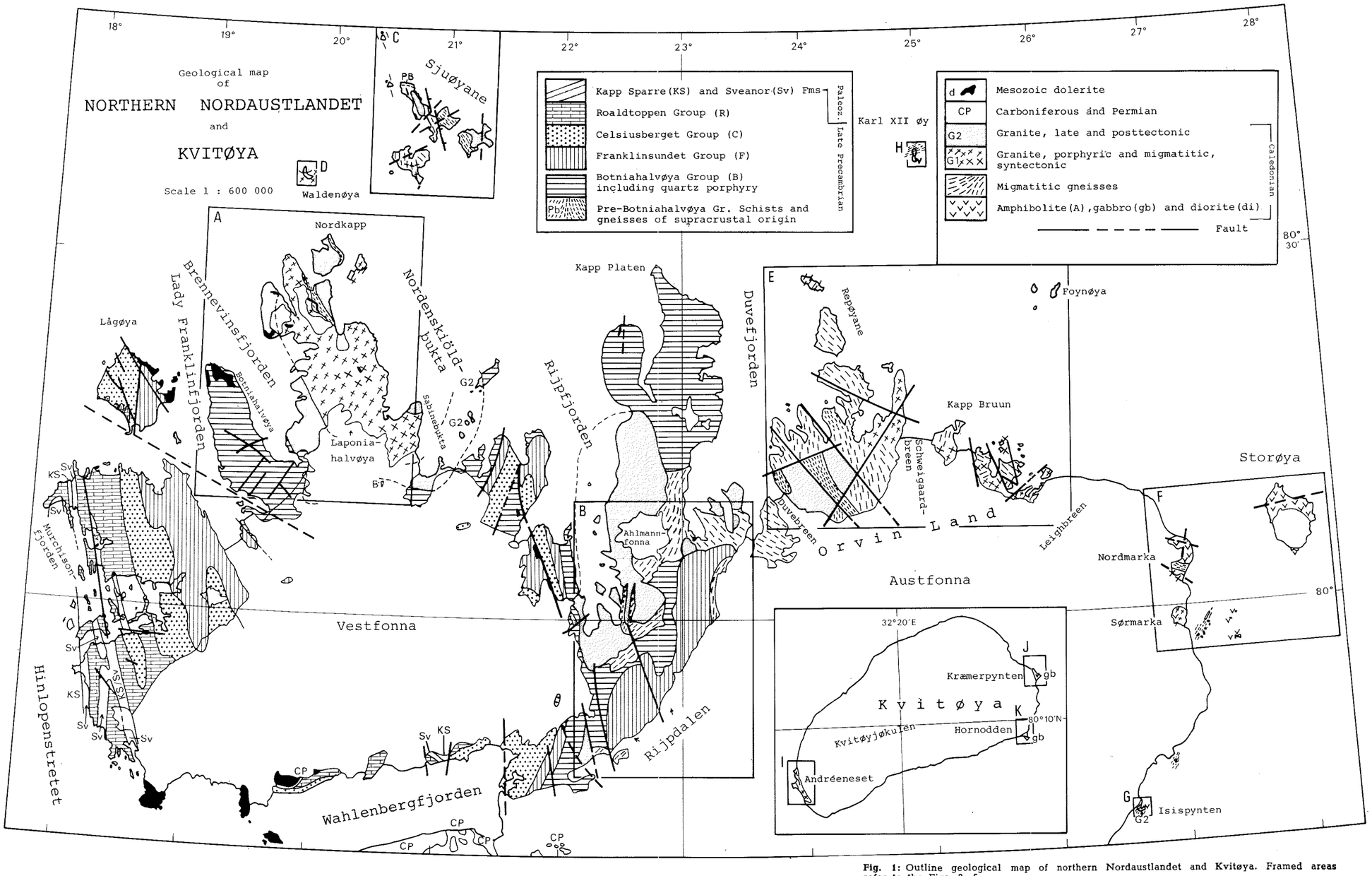

Fig. 1: Outline geological map of northern Nordaustlandet and Kvitøya. Framed areas refer to the Figs. 3—5.

Abb. 1: Geologische Übersichtskarte vom nördlichen Nordaustlandet und von Kvitøya. Umrandete Gebiete beziehen sich auf Abb. 3—5.

A

	Groups	Formations		
	Ny Friesland and Olav V Land	Nordaustlandet		
UPPER H. H. SGR.	Oslobreen			
	Polarisbreen	Kapp Sparre		
		Sveanor		
MIDDLE HECLA HOEK LOMFJORDEN SUPERGROUP	Akademikerbreen	Roaldtoppen	Ryssö Hunnberg	MURCHISONFJORDEN SUPERGROUP
		Celsiusberget	Raudstup-Sälodd	
			Norvik	
	Veteranen		Flora	
		Franklinsundet	Kapp Lord	
			Westmanbukta Persberget	
			Meyerbukta	
LOWER HECLA HOEK STUBENDORFBREEN SUPERGROUP	Planetfjella	Botniahalvøya	Kapp Hansteen	
			Brennevinsfjorden	
	Harkerbreen	pre-Botniahalvøya Group paragneisses and meta-supracrustals		

(H. SGR. = Hinlopenstretet Supergroup)

B

	(FLOOD et al., 1969)					(OHTA, 1978)
	65 BF 58	65 BF 29	65 Hj 100	65 Hj 103	57 Ws 71	76 YO
SiO_2	57.80	73.79	78.4	70.8	73.6	51.59
TiO_2	0.75	0.23	0.08	0.36	0.12	0.92
Al_2O_3	15.57	13.98	12.2	14.7	15.0	14.56
Fe_2O_3	0.93	0.52	0.5	0.4	0.4	0.84
FeO	5.40	0.99	0.7	2.0	0.5	7.08
MnO	0.13	0.02	0.02	0.04	0.02	0.17
MgO	5.11	0.29	0.1	0.7	0.1	9.75
CaO	6.73	1.21	0.2	1.4	0.5	13.71
Na_2O	1.54	1.85	2.6	2.7	3.8	1.40
K_2O	1.92	5.80	4.6	5.0	4.7	0.07
P_2O_5	0.08	0.11	0.17	0.13	0.27	0.02
H_2O+	3.86	1.08	0.9	1.2	1.0	0.98
	99.82	99.87	100.47	99.43	100.01	101.09

65 BF 58: Plagioclase porphyritic rhyodacite in the Kapp Hansteen Formation
65 BF 29: Quartz porphyry, intruding Kapp Hansteen Fm.
65Hj 100: Late Caledonian, post-tectonic granite, east shore of Brennevinsfjorden
65Hj 103: Syn-tectonic (?) porphyritic biotite granite, Laponiahalvøya
57 Ws 71: Late Caledonian post-tectonic two-mica granite, Rijpdalen
76 Y. O.: Late-kinematic pyroxene-hornblende gabbro, Storøya

Tab. 1: A: Stratigraphical correlation Nordaustlandet — Olav V Land/Ny Friesland. B: Chemical analyses of the main types of igneous rocks in Nordaustlandet.

Tab. 1: A Stratigraphische Korrelation Nordaustlandet — Olav V Land/Ny Friesland. B: Chemische Analysen der Haupttypen der Magmatite in Nordaustlandet.

The most extensive of these are found in the Rijpfjorden-Duvefjorden area, where reddish medium-grained two-mica granite crops out along the eastern and southern shore of Rijpfjorden, north of Duvebreen and in the southern part of Rijpdalen. Another prominent granite occurs along the eastern side of Brennevinsfjorden; this has cross-cutting contact with the sedimentary rocks of the Brennevinsfjorden Formation.

In the Rijpfjorden-Duvefjorden area numerous pink dykes of two-mica aplite and pegmatite accompany the main granite; however, the occurrence of pink to grey two-mica granite aplite dykes is a characteristic feature in all the gneiss-migmatite and granite areas of Nordaustlandet and the adjacent islands from Nordkapp to Kvitøya.

Radiometric ages

The bulk of data obtained till now are K/Ar ages (GAYER et al., 1966), and two thirds of all the determinations lie in the Caledonian range of 350—450 m. y. ago (Fig. 2 H). An Rb/Sr isochrone age of 1275 m. y. from a granite boulder in the Sveanor tillite north of Wahlenbergfjorden — the oldest age recorded from Nordaustlandet (EDWARDS, 1976) — agrees with the late Precambrian age of the tillite and indicates an intrusive

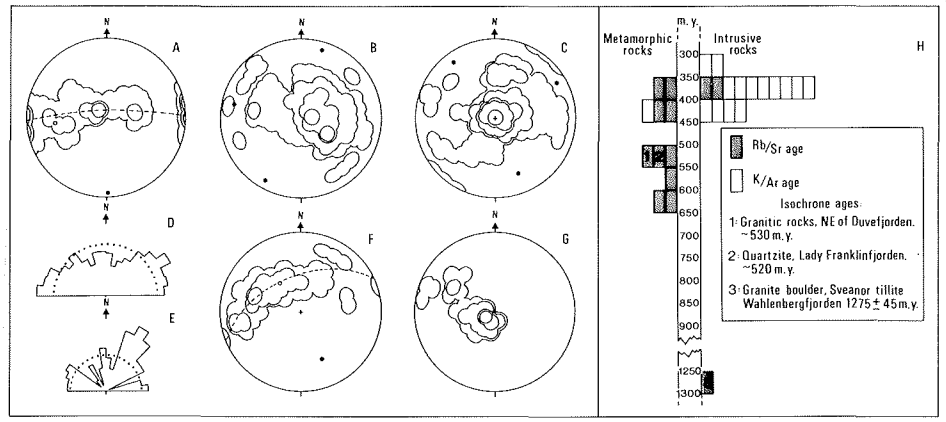

Fig. 2: A—C and F—G show planar structures in stereographic projection, lower hemisphere, contours in % per 1% area. Filled circles: Local β's, open circles: max. of cleavage.
A: Bedding in the supracrustal rocks between Hinlopenstretet and Brennevinsfjorden. 2—4—5%, 662 obs.
B: Gneissosity, layering and bedding in Sjuøyane and Laponiahalvøya. 1—2—4—6%, 550 obs.
C: Gneissosity, layering and bedding in Orvin Land (area shown in Fig. 4 E). 1—2—4—8—16%, 317 obs.
F: Bedding in the Rijpdalen and Rijpfjorden area (shown in Fig. 3 B). 2—4—6%, 293 obs.
G: Gneissosity, layering and bedding in Sørmarka, Nordmarka, Storøya and Kvitøya. 2—4—8—12%, 49 obs.
D and E show direction of vertical or almost vertical joints and dykes (≥ 70°) in the pre-Carboniferous of Nordaustlandet. Demicircle indicates 5% of total counts. Reference meridian: 23° E.
D: Joints, 900 obs. E: Post-tectonic granite aplite and pegmatite dykes, 108 obs.
H: Radiometric ages of Nordaustlandet rocks.

Abb. 2: A—C und F—G stellen Flächen-Elemente in stereographischer Projektion dar; untere Halbkugel; Umrißlinien geben die Besetzungsdichte in % pro 1% der Fläche an. Volle Kreise: lokale β-Achsen, offene Kreise: Maxima der Schieferungsflächen.
A: Schichtung in den suprakrustalen Gesteinen zwischen Hinlopenstretet und Brennevinsfjorden. Besetzungsdichte: 2—4—5%, 662 Messungen.
B: Gneisschieferung, Schichtung und Lagigkeit in Sjuøyane und Laponiahalvøya. Besetzungsdichte 1—2—4—6%, 550 Mess.
C: Gneisschieferung, Schichtung und Lagigkeit im Orvin Land (Gebiet dargestellt in Abb. 4 E). Besetzungsdichte: 1—2—4—8—16%, 317 Mess.
F: Schichtung im Rijpdalen- und Rijpfjorden-Gebiet (dargestellt in Abb. 3 B). — Besetzungsdichte: 2—4—6%, 293 Mess.
G: Gneisschieferung, Lagigkeit und Schichtung in Sørmarka, Nordmarka, Storøya und Kvitøya. Besetzungsdichte: 2—4—8—12%, 49 Mess.
D und E zeigen die Richtungen der vertikalen oder nahezu vertikalen Klüfte und Gänge (über 70°) im Präkarbon Nordaustlandets. Halbkreise zeigen 5% der Gesamtzahl an. Bezugsmeridian: 23° Ost.
D: Klüfte, 900 Messungen. E: Posttektonische Granite, Aplite und Pegmatitgänge, 108 Mess.
H: Radiometrische Alter von Gesteinen Nordaustlandets.

episode in the basement. Except for these boulders, no indisputable basement rocks have yet been found in the Nordaustlandet area. In the eastern part of Orvin Land, hypersthene gneiss paleosomes found in migmatite might be relics of basement rocks.

Six Rb/Sr ages lie between 500 and 650 m. y. and suggest at least one orogenic episode in the late Precambrian-early Paleozoic time. Two of the determinations are preliminary isochrone ages from granitic material north-east of Duvefjorden (c. 530 m. y.), and from shales of the Franklinsundet Group (c. 520 m. y.) (Analyst A. Råheim, Geologisk Museum, University of Oslo). The apparent lack of fossil evidence from the Middle and Upper Cambrian on both sides of Hinlopenstretet (KULLING, 1934; FORTEY & BRUTON, 1973; pers. comm. from Ø. LAURITZEN and T. S. WINSNES, 1978) seems to confirm the assumption of an orogenic episode around 520—530 m. y. ago.

Structure

The earliest structural events involved homoaxial folding of the late Precambrian/early Paleozoic supracrustal formations, accompanied by cross-jointing, and are prominently displayed in the western and central areas (Fig. 2 A, F). This folding of the north-south trend has affected the Cambrian and Ordovician beds of the Kapp Sparre Formation, but occurred before the development of the migmatites which contain rotated inclusions of folded supracrustal rocks. The relatively simple pattern of the first series of folding was partly obliterated during migmatization and new structural elements were introduced, (Fig. 2 B, C, G) with folds trending in an east-west direction.

The third main event was the post-tectonic intrusion of granitic rocks which cut the migmatites. In the Rijpfjorden-Duvefjorden area at least, the intrusions seem to be related to the east-west arching and subsequent exposure of deeper sections. After the intrusions took place faulting occurred as the last distinguishable structural event in the pre-Carboniferous rocks of Nordaustlandet. Some structures might have been reworked at a relatively late period, such as a number of tectonic lines clearly shown on satellite photographs. These have a north-south trend, are thought to have been caused by faulting and traverse both the post-tectonic granite, the meta-supracrustals of Rijpdalen and the Permo-Carboniferous strata in the southernmost part of Nordaustlandet.

Thus the main structural events are:

1) Early Caledonian homoaxial folding of north-south trend.
2) Middle to late (?) Caledonian migmatization with formation of east-west trending folds and of dome structures.
3) Late Caledonian post-tectonic granite intrusions, with associated block faulting.
4) Post-Paleozoic faulting. Possibly also reworking of fault lines initiated in Caledonian times.

SHORT DESCRIPTIONS OF CERTAIN AREAS

The Nordkapp-Franklinfjorden area

Syntectonic (?) gneiss granite

A wide area of coarse, weakly foliated porphyric and porphyroblastic granites occurs between Nordenskiöldbukta and Brennevinsfjorden (Fig. 3 A; Tab. 1 B, no. 65 Hj 103). To the north and east migmatitic varieties occur locally. Due to the generally weak foliation of the granite and a more or less transitional contact to the post-tectonic granites, the possibility of the coarse-grained granite representing deeper levels of the post-tectonic granite, rather than being of syntectonic origin, is not precluded.

Post-tectonic granite

Granite of an indisputable post-tectonic age occurs along the eastern shore of Brennevinsfjorden and to the north and south of Beverlysundet. At the latter locality, the granite is accompanied by prominent pegmatite and aplite dykes of a NNW trend, and is in contact with, and includes quartzitic schists of assumed pre-Botniahalvøya Group age. Folded pelitic schists of the Brennevinsfjorden Formation are cut and hornfelsed by post-tectonic granite at the head of Brennevinsfjorden (Tab. 1 B, no. 65 Hj 100).

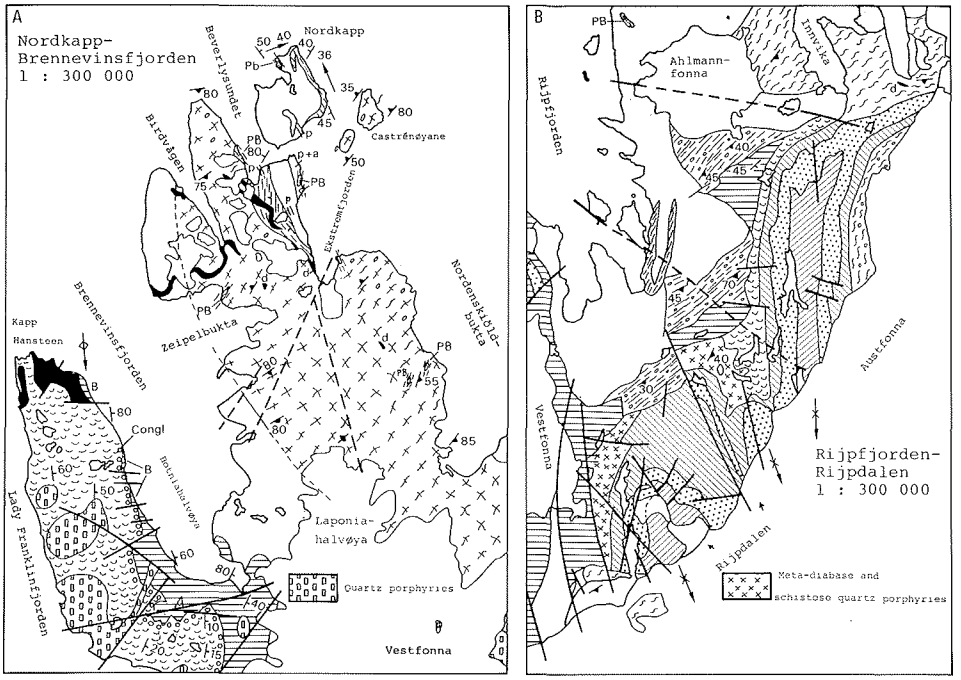

Fig. 3: Geological maps of A: the Nordkapp-Franklinfjorden area, B: the Rijpdalen-Rijpfjorden area (for legend see Fig. 4). The Meyerbukta Formation comprises the lowermost part of the Franklinsundet Group; new name proposed by Y. OHTA (pers. comm. Dec. 1978).

Abb. 3: Geologische Karten von A: Nordkapp-Franklinfjorden-Gebiet, B: Rijpdalen-Rijpfjorden-Gebiet (Legende vgl. Abb. 4). Die Meyerbukta Formation umfaßt den tiefsten Teil der Franklinsundet Gruppe; neue Bezeichnung von Y. OHTA (pers. Mitt., Dez. 1978) vorgeschlagen.

The Brennevinsfjorden Formation

This formation, which consists mainly of siliceous shale and sandy quartzites, was earlier thought to be the upper formation in the Botniahalvøya Group (FLOOD et al., 1969). However, in 1978 a locality was found in the north-eastern part of Botniahalvøya where agglomerates and tuffaceous rocks of the Kapp Hansteen Formation rest on non-inverted shales and quartzites of the Brennevinsfjorden Formation. In the southern part of Botniahalvøya the volcanics show lateral changes into shale, of which some beds occur above the volcanics. However, the main part of the shale/quartzites succession to the south of Brennevinsfjorden seems to be overlain by the volcanics and thus to belong to the Brennevinsfjorden Formation (pers. comm. from Y. OHTA, March 1979).

The Kapp Hansteen Formation

A basal quartzite conglomerate of 5—30 m in thickness marks the boundary with the

underlying Brennevinsfjorden Formation. Agglomeratic horizons almost invariably follow above the conglomerate. At some places two conglomerate horizons occur, separated by c. 20 m of porphyrite, the upper conglomerate containing both quartzite and porphyrite pebbles. The main part of the formation consists of fragmentary volcanic material, ranging from agglomerates with fragments up to 1 m in diameter to tuffs and tuffaceous rocks. Massive homogeneous or porphyritic rocks of intermediate composition also occur frequently.

The quartz porphyries

The main exposures of quartz porphyries are found along the west coast of Botniahalvøya and the east shore of Sabinebukta, mainly as plugs and dykes (Tab. 1 B, no. 65 BF 29). The quartz porphyries are of rhyolitic composition and cut the beds of both the Brennevinsfjorden and the Kapp Hansteen formations. The intrusive contact with the Botniahalvøya Group rocks and the occurrence of biotite in the quartz porphyries suggest that they are sub-volcanic rocks representing the last igneous activity of the Kapp Hansteen Formation.

The Rijpdalen and Rijpfjorden area

Gneisses, migmatites

On the eastern margins of the post-tectonic granite, around the head of Duvefjorden and to the south of it, gneisses occur in contact with both post-tectonic granite and low grade meta-supracrustals (Fig. 3 B). The general association with the post-tectonic granites might suggest that the gneisses are infrastructural units of pre-Botnihalvøya Group age, brought to a higher level by arching and fault movements during the late Caledonian granite intrusion. The gneisses just east of the main granite to the south of Ahlmannfonna are relatively homogeneous augen-bearing pelitic-arcosic paragneisses, while nebulitic to agmatitic migmatites prevail around the head of Duvefjorden.

Adjacent to the migmatites and granites the low grade assemblages of the Botniahalvøya Group elsewhere, change inton high grade garnet-biotite bearing schist. Along the eastern border with the migmatite the high grade schist occurs in a zone several kms wide, and is considered to have developed during the main Caledonian migmatization period; to the north, near Duvefjorden the zone is narrow, suggesting thermal metamorphism during the late Caledonian granite intrusion period.

The Botniahalvøya Group and the Franklinsundet Group

The lowest strata, the Brennevinsfjorden Formation, only occur on the western flanks of the synclines in Rijpdalen. Stratigraphically higher schistose quartz porphyries and metadiabases indicate sub-volcanic activity and a transition into the Kapp Hansteen Formation. A pyroclastic appearance of some of the porphyries might indicate that extrusion have also taken place.

The upper beds of the synclines in Rijpdalen consist entirely of Franklinsundet Group rocks, of which the most conspicuous are the quartzites of the Persberget Formation.

Post-tectonic granite

Most of the specimens of the Rijpfjorden granite which were examined show a somewhat cataclastic texture with strained quartz and bent twin lamellae of plagioclase, and with micro-fissures carrying iron hydroxide and fluorite. Bodies and agmatitic zones of schists and gneisses often cap the granite hills. (Tab. 1 B, no. 57 Ws 71).

The magnetic susceptibility of the granite is generally very low; however, a high magnetic anomaly was recorded during a magnetic survey made from the air in 1970. This implies that the granite might have the shape of a sheet intrusion (ÅM, 1973: 95).

Sjuøyane

Migmatite and granitic gneiss

Coarse-grained granitic rocks, more or less foliated and containing varying quantities of supracrustal inclusions, make up most of Parryøya, the smaller islands to the north and west and parts of Phippsøya (Fig. 4 C). In texture and composition the less foliated of these rocks closely resemble the coarse-grained gneiss granites to the west of Nordenskiöldbukta, on the mainland of Nordaustlandet. The supracrustal inclusions in the migmatitic varieties comprise quartzitic schists, amphibolitic and skarn rocks. No inclusions of Kapp Hansteen volcanics are recorded. A sillimanite-cordierite-almandine paragenesis of pelitic paleosomes indicates conditions of high temperature-low pressure type of amphibolite facies prior to migmatization.

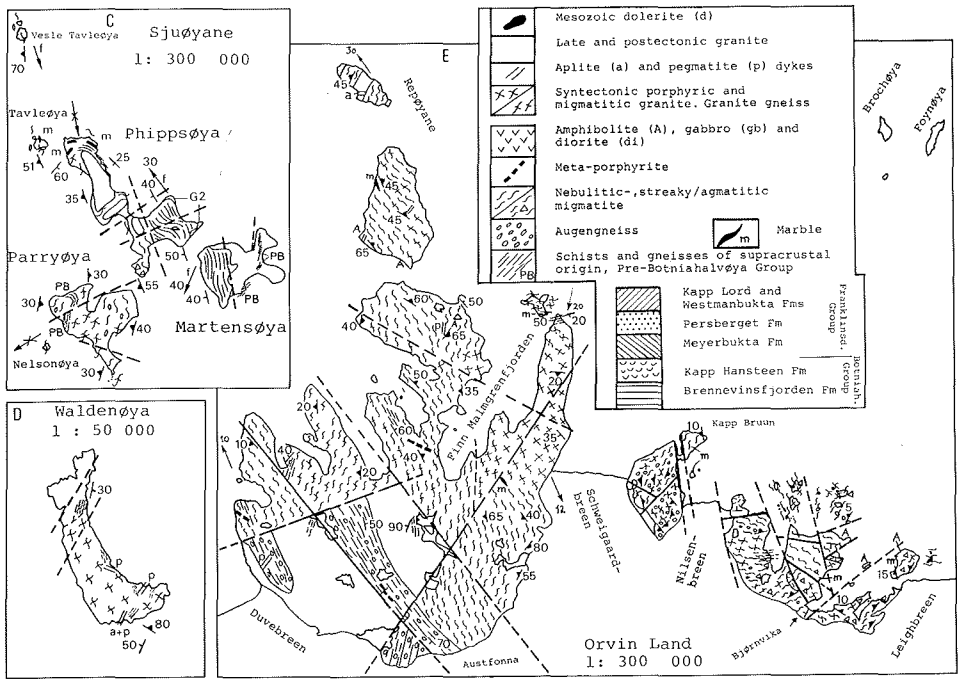

Fig. 4: Geological maps of C: Sjuøyane, D: Waldenøya, E: Orvin Land.

Abb. 4: Geologische Karten von C: Sjuøyane, D: Waldenøya, E: Orvin Land.

Supracrustal rocks

The "eastern migmatite" zone in SE Phippsøya and W Martensøya, evaluated after the first brief reconnaissances in 1965 and 1976 (HJELLE, 1978), was further investigated in 1978. The zone has proved to consist of more or less continuously exposed beds of supracrustal rocks, composed of mainly grey to green quartzites or quartzitic sandstones, occasionally with lenses or nodules containing skarn minerals. Mica schist and tuffaceous

(?) beds of intermediate to basic composition are intercalated in the quartzites. The thickness of the succession is estimated to be 200—1000 m, possibly more than 1000 m.

In Tavleøya and in the northern part of Phippsøya at least one set of marble + quartzite strata occur, mainly as broken-up layers in migmatite gneiss. The maximum thickness of one marble layer varies from 18 to 25 m. Due to the general structure of this area, the strata are thought to be stratigraphically lower than the main quartzitic succession in the south-east. A distinct lineament of NNE trend in the southern part of Phippsøya, with migmatite and granite to the west and the meta-supracrustals to the east, suggests a major fault here with downthrow of the rocks to the east of the fault.

Considering 1) the regional structures of the western half of Nordaustlandet, which suggest increasing stratigraphical depths towards the NNE (FLOOD et al., 1969, Fig. 48) and 2) the higher metamorphic grade of the Sjuøyane meta-supracrustals compared to that of the Botniahalvøya Group rocks, the stratigraphical position of the Sjuøyane meta-supracrustals is assumed to be lower than the Botniahalvøya Group.

Late and post-tectonic granites

A two-mica monzogranite with occasional faint foliation occurs in the highest northern part of Phippsøya and in the eastern part of Martensøya. A somewhat cataclastic texture of the granite is evident in thin sections; the composition and texture resemble the Rijpfjorden granite. Structural observations indicate that the Sjuøyane granites mainly occur as sills with a 20—50 g dip towards the W or WSW, i. e. parallel to the main bedding/foliation. Taking into account the faintness of the foliation, the granites are considered to be late tectonic.

Post-tectonic aplite and pegmatite dykes cut all he rocks mentioned above.

Waldenøya

The southern two-thirds of the island is composed of a coarse-grained grey biotite gneiss granite, somewhat porphyritic in nature. Inclusions of quartzitic schist, less than 1 m in diameter, occasionally occur, and grey and pink aplite and pegmatite dykes cut all the other rocks (Fig. 4 D).

The northern third of Waldenøya is composed of unfoliated pink aplitic granite. This post-tectonic granite is apparently closely related to the aplitic dykes to the south, contains inclusions of the coarse-grained granite gneiss and is clearly younger than the latter.

In the southern part of the post-tectonic granite, a relatively large amount of meta-sediments occurs, mainly as micaceous quartzite. One boudinaged layer of skarn, 1/2 m thick, is also recorded.

Orvin Land

Migmatite, gneiss and syntectonic gneiss granite

The migmatites range from agmatite and nebulite to feldspar porphyroblastic varieties with gradual transitions. Siliceous and pelitic paleosomes are far the most common; they frequently occur as stretched layers. Pelitic paleosomes often contain garnet and cordierite. Marble and amphibolite inclusions are only recorded eastwards of Adlersparrefjorden (Fig. 4 E). The amphibolites are gneissose or schistose and some contain garnet and orthopyroxene. The migmatite metatects are of granitic to quartz dioritic

composition, often somewhat porphyritic in nature. The coarse-grained porphyritic granites show many similarities in composition and texture to the migmatite metatects and gradual transitions are frequently seen, suggesting that highly mobilized parts of the migmatite are closely related to these granites.

Coarse-grained, two-mica potash feldspar augen gneiss occurs within, and adjacent to the post-tectonic granite to the west; mica schist is often associated with this gneiss and it seems likely that the development of the augen gneiss is related to the emplacement of the granite.

Meta-gabbros

Gabbroic bodies, a few hundred meters in length, were found in the eastern part of Orvin Land. Most are of a clinopyróxene + hornblende — gabbro to diabasic type; however, in the north-west of Bjørnvika a gabbro containing randomly orientated large biotite flakes occurs.

The gabbros show retrogressive metamorphism along margins and fracture cleavages and fresh rock is only occasionally preserved in the cores. The lithology of the gabbros and a discordant relation to the migmatite structure show that they are late or post-cinematic intrusions, influenced by the latest migmatisatition activity.

Post-tectonic granite, dyke rocks

In the south-western part of Orvin Land a post-tectonic, reddish, two-mica granite of the Rijpfjorden type predominates (FLOOD et al., 1969). Observations from near the front of Duvebreen suggest a near horizontal intrusion, probably more than 100 m thick and capped locally with schistose augen gneiss (see also p. 71). Dykes of pink aplite and muscovite pegmatite also occur, particularly in the northern and western parts of the area; Foynøya, Brochøya and Schübelerøya are almost entirely composed of post-tectonic granite.

Fragments of late tectonic, plagioclase porphyrite dykes, 1—5 m in width and trending NW—SE, were found in gneiss to the north of Duvebreen and near the head of Goffreybukta. Porphyrite dykes of the same trend are also recorded in the Isispynten area (p. 75).

Structure, stratigraphy

The general trend of the gneissosity/layering is north-south, with local deviations due to block faulting. In the western part of the area the pattern of the main β's suggests a refolding of older north-south structures by later NE—SW trending folds. The later folding was probably related to orogenic upwelling which preceded the granite intrusion. The pattern of block faults indicates a north-south compression which conforms with the stress field of later folding (Fig. 2 C).

An assumed easterly plunge of the later folds suggests that the mica schist occurrences to the west are stratigraphically lower than the marbles and concordant amphibolites recorded in the eastern part of the area.

North-eastern Nordaustlandet and Storøya

Gabbros

A partly gneissose mass of meta-gabbro occurs in Nordmarka, showing a synform structure with an east-west axial trend. The mode of metamorphism is very similar to that of the gabbroic rocks of eastern Orvin Land and the meta-gabbro is considered to be a late tectonic intrusion (HJELLE et al., 1978).

The unnamed islands to the south-east of Frostøyane are entirely composed of a gabbro similar to that in Nordmarka (Fig. 5 F).

The gabbro-diorite complex of Storøya, which is less strongly metamorphosed than the gabbro in Nordmarka and which has kept its primary layered structure, is considered to be a stratiform basic complex. The rocks comprise various gabbros and diorites, ranging from olivine bearing anorthositic to quartz dioritic facies. The distribution of the different facies is affected by shear zones and faults of mainly east-west trend. Small exposures of gabbro along the southern ice edge contain inclusions of marble and hornfelsed schist. In the easternmost part of Storøya a quartz dioritic facies predominates, with inclusions of dark fine-grained blocks of gabbro. Layered gabbro which occurs along the nothern and western coast are presumably earlier differentiates of a magma; the eastern dioritic rocks are later. Thus the estimated total thickness of the basic complex is of the order of a few km.

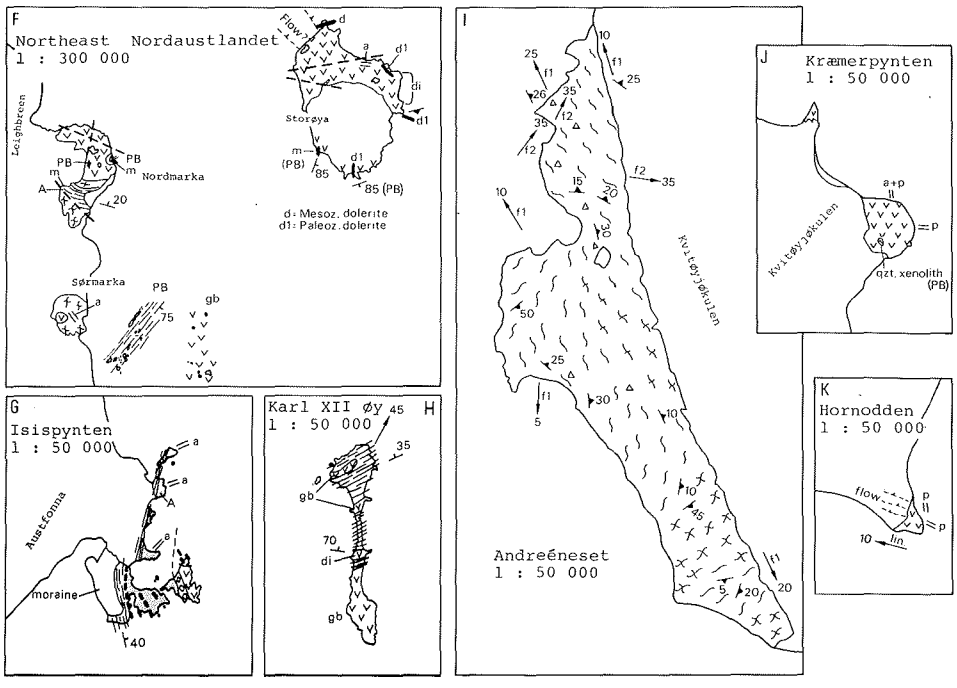

Fig. 5: Geological maps of F: NE-Nordaustlandet and Strorøya, G: Isispynten, H: Karl XII øy. I: Andréeneset, J: Kræmerpynten, K: Hornodden (for legend see Fig. 4).

Abb. 5: Geologische Karten von F: NE-Nordaustlandet und Storøya, G: Isispynten, H: Karl XII øy, I: Andréeneset, J: Kræmerpynten, K: Hornodden (Legende vgl. Abb. 4).

Retrogressive metamorphosed dolerite dykes of assumed pre-Mesozoic age cross-cut the basic rocks of Storøya and the whole complex must have been formed at the late tectonic stage of the Caledonian period. The relatively unaltered appearance of the rocks suggests that the Storøya gabbros and diorites are younger than the Orvin Land and Nordmarka meta-gabbros.

Porphyritic granite

This rock which occurs in the southern part of Nordmarka and in the whole area of

Sørmarka is a homogeneous, coarse-grained, faintly gneissose two-mica granite, with many large idiomorphic potash feldspars. The potash feldspar porphyroblastesis, which is seen to continue into the gneisses to the north, is later than the gneisses themselves, but may be older than the gabbros if the basic dykes cutting this granite are of the same origin as the meta-gabbros of Nordmarka. A late Caledonian age of c. 375 m. y. is reported for the pegmatite and aplite dykes associated with the granite (HAMILTON & SANDFORD, 1964).

Paragneisses

Paragneisses occur in the southern part of Nordmarka and in south-east Sørmarka. The northern gneisses are mainly biotite garnet ones, with some quartzite and thin marble beds; in the south, two-mica gneisses prevail, some of them containing garnet and cordierite. Minor layers of schistose amphibolite occur in both localities.

A gneissose amphibolite and a meta-porphyrite layer occurs in the Nordmarka gneiss, with a trend slightly oblique to the gneissosity. They are cut by the granite metatect of the gneiss, but have preserved original igneous textures and are probably late-kinematic intrusions. The gneissose amphibolite resembles the meta-gabbro to the north, and the meta-porphyrite is certainly similar to that of Isispynten mentioned below.

Isispynten

Paragneisses

The gneisses are mainly of a two-mica type, with or without garnet and locally siliceous; a banded marble of 15 m thickness occurs in the gneiss to the south-west (Fig. 5 G), with boudinaged skarn of diopside, garnet, hornblende and epidote. In the gneisses to the north muscovite replaces biotite and sillimanite overgrows cordierite.

Paragneisses also occur in the continuation of the N.N.E. strike on four small islands about 9 km to the NNE (not shown on the 1:50000 map); here a fine-grained biotite gneiss contains relic rhombic pyroxene.

Amphibolite

A coarse-grained clinopyroxene-bearing amphibolite, which occurs to the east and north, includes gneissic xenoliths and is cut by aplitic dykes. The amphibolite itself occurs as agmatitic xenoliths in the grey granite.

Grey granite, various dykes

A homogeneous biotite granite has instrusive contacts both with gneiss and amphibolite. Broken-up dykes af basic meta-porphyrite occur in the grey granite, but cut the coarse-grained amphibolite. The meta-porphyrite apparently intruded into the granite as dykes before complete consolidation of the granite had taken place.

Numerous grey-white and pink dykes, which intruded almost simultaneously, cut all the rocks mentioned above. The grey-white type shows close similarities in lithology to parts of the grey granite. Accordingly, the intrusions of grey granite and the three types of dyke rocks are closely related in time.

Karl XII øy

To the north, in the highest part of the island, finely-layered psammitic and pelitic rocks prevail (Fig. 5 H). Sillimanite occurs abundantly in some of the pelitic layers. The beds dip 30—60 g towards the N. or N.N.W. and a stratigraphical thickness of more than

300 m is possible. Gabbroic sills and dykes, ½ m to 50 m wide and of an E to ENE trend intrude the beds to the north and in the low-lying areas in the middle of the island; the southern third is apparently composed wholly of gabbro. Mesoscopic folds, which in general plunge 15—50 g towards the NNW might have been caused by the gabbroic dyke intrusions.

Adjacent to the gabbros tourmaline has developed as clots and veins, and contact metamorphism is evident with hornfelsing of the layered metasediments.

Two generations of gabbroic rocks occur: 1) medium-grained massive with 2) agmatitic inclusions of dense, dark varieties, both showing signs of retrogressive metamorphism. In the middle of the islands, gabbroic rocks are occasionally intruded by dioritic material, which forms agmatites closely resembling those in the eastern part of Storøya.

Kvitøya

Gneiss, migmatite, syntectonic granite

These rocks are confined to Andreéneset, to the south of the Kvitøyjøkulen ice cap (Fig. 5 I). The main rocks are banded and nebulitic granitic migmatites, with discontinuos biotite gneiss layers, with or without garnet, and with a small number of amphibolite paleosomes. Lamprophyre-like rock of alnöite/damtjernite lithology also occurs as paleosomes.

In the southern part of Andreéneset faintly gneissose grey and pink two-mica granites predominate.

Two generations of folds were recorded, the older having a north-southern trend, the younger an east-west trend.

Gabbro, diorite

Except for minor dykes and inclusions, the small exposures in the north-eastern part of Kvitøya consist only of rocks of basic and intermediate composition.

In contrast to the Storøya gabbros no olivine has been found here, and the earlier cognate derivatives were included in the main gabbros and converted into pyroxene hornfels (OHTA, 1978). No epidote, sphene or actinolite were seen and a relatively high temperature of re-crystallization is assumed. The degree of re-crystallization is stronger than in the gabbros of Storøya.

Kræmerpynten, the northernmost exposure (Fig. 5 J), is composed of medium- to coarse-grained rocks of noritic to dioritic composition. Inclusions of quartzite and calcareous skarn are found in the south-western part of this exposure.

In Hornodden (Fig. 5 K) the main rock is a coarse-grained gneissose gabbro containing blocks and schlieren of fine-grained dense gabbroic rocks. Gabbro pegmatite occurs as network veins which grade into gneissose gabbro. Pink granite aplite and muscovite-tourmaline pegmatite dykes cut the gabbros and diorites in both localities,

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