NGU

Norges geologiske undersøkelse

1858

Nr. 377

Bulletin 68

Tim Pharaoh, Donald Ramsay & Øystein Jansen:
Stratigraphy and Structure of the Northern Part of the Repparfjord–Komagfjord Window, Finnmark, Northern Norway

Universitetsforlaget 1983
Trondheim - Oslo - Bergen - Tromsø

NGU
Norges geologiske undersøkelse

Geological Survey of Norway

Norges geologiske undersøkelse (Geological Survey of Norway), Leiv Eirikssons vei 39, Trondheim. Telephone: national (07) 91 58 60, international + 47 7 91 58 60. Postal address: Box 3006, N–7001 Trondheim, Norway.

The publications of *Norges geologiske undersøkelse* are issued as consecutively numbered volumes, and are subdivided into two series, Bulletin and Skrifter.

Bulletins comprise scientific contributions to the earth sciences of regional Norwegian, general, or specialist interest.

Skrifter comprise papers and reports of specialist or public interest of regional, technical, economic, environmental, and other aspects of applied earth sciences, issued in Norwegian, and with an Abstract in English.

EDITOR
Førstestatsgeolog Dr. *David Roberts*, Norges geologiske undersøkelse, P.O.Box 3006. N–7001 Trondheim, Norway.

PUBLISHER
Universitetsforlaget, P.O.Box 2959, Tøyen, Oslo 6, Norway.

DISTRIBUTION OFFICES
Norway: Universitetsforlaget, P.O.Box 2977, Tøyen, Oslo 6, *United Kingdom:* Global Book Resourses Ltd., 109 Great Russell Street, London WC1B, 3ND.
United States and Canada: Colombia University Press, 136 South Broadway, Irvington on Hudson, New York 10533.

EARLIER PUBLICATIONS AND MAPS
The most recent list of NGU publications and maps, 'Publikasjoner og kart 1879–1980', appeared in 1981. Copies can be obtained from the Publisher.

The most recent maps available from NGU are listed inside the back cover.

MANUSCRIPTS
Instructions to contributors to the NGU Series can be found in NGU Nr. 273, pp. 1–5. Offprints of these instructions can be obtained from the editor. Contributors are urged to prepare their manuscripts in accordance with these instructions.

Stratigraphy and Structure of the Northern Part of the Repparfjord–Komagfjord Window, Finnmark, Northern Norway

TIM PHARAOH, DONALD RAMSAY AND ØYSTEIN JANSEN

Pharaoh, T.C., Ramsay, D.M. & Jansen, Ø. 1983: Stratigraphy and structure of the northern part of the Repparfjord–Komagfjord Window, Finnmark, Northern Norway. *Norges geol. Unders. 377*, 1–45.

In the northern district of the Repparfjord–Komagfjord Window, supracrustal and intrusive rocks of Early Proterozoic age are unconformably overlain by a thin sequence of Vendian sediments. Both of these units are overthrust by allochthonous rocks of the Caledonian Kalak Nappe Complex. The Proterozoic basement is composed of greenstone lavas, tuffs and sediments of the Raipas Supergroup and intrusions of the Raudfjell Suite, regionally metamorphosed at greenschist facies during the polyphase Svecokarelian Orogeny, c. 1840 Ma. The c. 8 km thick supracrustal sequence is divided into four groups and eleven formations on a lithostratigraphic basis. The lithological characteristics of these units are described and compared with rocks of similar age elsewhere in N. Norway. The stratigraphy and sedimentology of the thin (<200 m thick), autochthonous, ?Vendian cover sequence is also described. The Caledonian Orogeny resulted in complex deformation of the autochthonous cover as well as considerable reactivation of the underlying basement.

T. C. Pharaoh, Department of Geology, The University, Newcastle-upon-Tyne, NE1, 7RU, U.K.
D.M. Ramsay, Department of Geology, The University, Dundee, DD1 4HN, U.K.
Ø.J. Jansen, Geologisk Institutt, avd. A., Universitetet i Bergen, N–5014, Bergen, Norway.

CONTENTS

Introduction

The Komagfjord (Reitan 1963) or Repparfjord–Komagfjord (Oftedahl 1980) Tectonic Window forms a large (c. 910 km^2) basement culmination within the Caledonides of West Finnmark (Fig. 1). The first detailed investigation of the district was by Reitan (1963), who delimited the boundaries of the window and described the main lithologies present. Earlier investigations had been of a more localised, reconnaissance nature, particularly concerned with the sulphide mineralisation in the Precambrian Raipas rocks (Reusch et al. 1891, Witt 1907, Vogt 1907, Strand 1952, Vokes 1957).

Reitan (1963) informally divided the Precambrian rocks into two groups, the Repparfjord and Saltvann groups (Fig. 2). The Repparfjord group comprises greenstones and sediments (Holmvann formation), overlain by quartzitic sandstones of the Doggeelv formation, which in turn is partly gradational upwards into grey shales and sandstones of the Lomvann formation. In the vicinity of the Vargsund, Reitan distinguished units of dolomitic and quartzitic sediments which he believed to be an integral part of the Holmvann formation. He correlated the overlying black slates and phyllites of the Kvalsund formation with the Lomvann formation, which he was able to map along the east and south-east margins of the window (Fig. 3).

The Saltvann group includes the distinctive metasandstone and conglomerate sequences of the Steinfjell formation, which contains the copper sulphide mineralisation at Ulveryggen, and the overlying Djupelv and Fiskevann formations (Fig. 2). Reitan was unable to determine the stratigraphic relationship between the Saltvann and Repparfjord groups and postulated faulted contacts, although he believed that the Saltvann group was the younger because it contained clasts of lithologies similar to those in the Repparfjord group. He introduced the name *Raipas suite* to embrace these two groups of supracrustal rocks. He also described the metamorphic and structural history of the Raipas suite and various intrusive

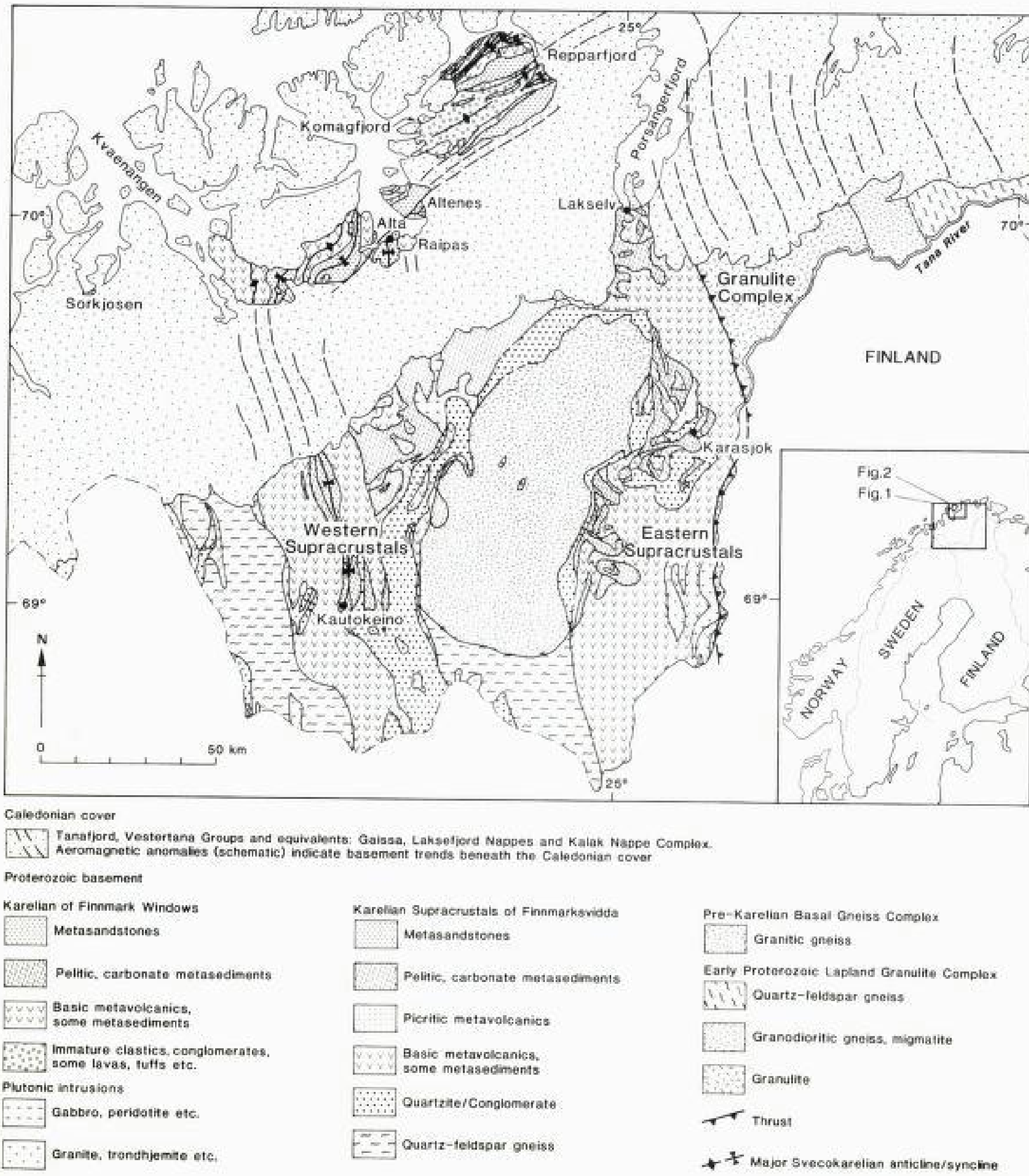


Fig. 1. The Precambrian basement of West and Central Finnmark. Data from 1:1 m Geological map of Norway; 1:250,000 Geological map-sheets Hammerfest, Karasjok, Enontekio; 1:250,000 Aeromagnetic map-sheets Hammerfest, Nordreisa, Kistrand; Holmsen et al. (1957), Wennervirta (1969), Gautier (1977), Oftedahl (1980).

rocks (ultrabasics, gabbros and trondhjemites) emplaced during a Precambrian orogeny, which he suspected was of Svecokarelian (Middle Proterozoic) age.

In separate publications, Reitan described the structure of the Ulveryggen area (Reitan 1958) and revised the correlation of the Doggeelv and Lomvann formations, suggesting they might be equivalent to Eocambrian sediments in the Alta district (Reitan 1965). Prior to Reitan (1963), most workers appear to have referred to the window as the Repparfjord Window (e.g. Vokes 1957), a term which reflects the economic focus of the district and has historical precedence. Oftedahl (1980) introduced the name Repparfjord–Komagfjord Window, which has many advantages. However, for reasons of brevity and because the name is now firmly entrenched in the literature, we refer to the district in this publication as the Komagfjord Window or more simply, the window. Rhodes (1976) described the geology of a small area of the window west of Skaidi.

This paper summarises the stratigraphic and structural results of our mapping in the northern district of the window during the field seasons 1972–1977. The mapping was carried out using aerial photographs at 1:20.000 scale and provisional editions of 1:50.000 scale NGO topographic maps (series M711, second edition) on which geographic features were not named. A revision of the stratigraphic nomenclature (Fig. 2) carried out by Pharaoh (1980) utilised much of the terminology informally established by Reitan (1963), as well as erecting new formation names on the basis of geographic names used on series M711 first edition maps. At a very late stage in the preparation of the manuscript, the final colour printed version of M711, second edition, with geographic names became available to us. Unfortunately, so many of the former geographic names have been changed on the new maps that it has proved impossible to define formally much of the old nomenclature. Accordingly, the new stratigraphic nomenclature established in this paper and formally defined in the appendix utilises geographic names from the new topographic maps (Fig. 2). The loss of lithologic names informally established by Reitan (1963), e.g. Steinfjell formation, Djupelv formation, Fiskevann formation and Doggeelv formation, is particularly unfortunate but unavoidable if these stratigraphic units are to be formally defined. Moreover, as the 1:50.000 geological maps eventually to be published by NGU, will be based on the new NGO topographic maps, a revised lithostratigraphy adopting the new official names is clearly warranted.

Stratigraphy of the Early Proterozoic Raipas Supergroup

Our investigations have revealed that the Repparfjord group of Reitan (1963) is a compound stratigraphic unit, containing sequences of Karelian (Early Proterozoic) and probable Vendian age, and is thus considered invalid. The Holmvann formation of Reitan (1963) is now elevated to the status of a group and referred to as the Holmvatn Group. Greenstone lavas and dolomitic/pelitic metasediments in the Vargsund district which Reitan (1963) included in his Holmvann formation are lithologically distinct, and are correlated with the Nussir and Porsa Groups, respectively. The Kvalsund Formation is shown to be an integral component of

Reitan (1963, 1965)		Pharaoh (1980)		This work	
		Lomvann Formation		Lomvatn Formation	
			Major Unconformity		Major Unconformity
		Langörvann Formation Kvalsund Formation Vargsund Formation	PORSA GROUP	Bierajav'ri Formation Kvalsund Formation Vargsund Formation	PORSA GROUP
		- - - - -	Disconformity?	- - - - -	Disconformity?
Fiskevann Formation Djupelv Formation Steinfjell Formation	SALTVANN GROUP	Högfjell Formation Asavann Formation	NUSSEREN GROUP	Svartfjell Formation Krokvatn Formation	NUSSIR GROUP
- - - - - -	Relationship Uncertain		Conformable		Conformable
Kvalsund (NW) Formation Lomvann (E) Formation Doggeelv Formation	REPPARFJ. GROUP	Fiskevann Formation Djupelv Formation Steinfjell/ Doggeelv Formation	SALTVANN GROUP	Stangvatn Formation Dypelv Formation Ulverygg / Dåg'gejåkka Formation	SALTVATN GROUP
			Unconformity		Unconformity
Holmvann Formation (with carbonate rocks and quartzite layers)		Magerfjell Formation Båtdalselv Formation Markfjell Formation	HOLMVANN GROUP	Magerfjell Formation Båtdalselv Formation Markfjell Formation	HOLMVATN GROUP

Fig. 2. Usage of stratigraphic nomenclature in the northern part of the Repparfjord–Komagfjord Window.

the Porsa Group (Fig. 2), and cannot be correlated with the Lomvann formation (Reitan 1963) which is probably of Vendian age (Pharaoh 1980). The Saltvann group (Reitan 1963) is retained (Saltvatn Group) although it now includes the Doggeelv formation of Reitan (1963). The combined thickness of the Early Proterozoic Holmvatn, Saltvatn, Nussir and Porsa Groups is at least 8 km. We consider that the Raipas system (Dahll 1868), Raipas Formation (Holtedahl 1918), Raipas Suite (Reitan 1963), or Raipas Group (Gautier 1977, Fareth 1979) should be elevated to the status of a supergroup, in accord with the recommendations of the International Stratigraphic Guide (Hedberg 1976).

HOLMVATN GROUP

Rocks of the Holmvatn Group outcrop extensively in the southern half of the Komagfjord Window (Fig. 3) but occupy only a small area of Plate 1. Reconnaissance mapping (Jansen 1976, Pharaoh 1980) has revealed that the

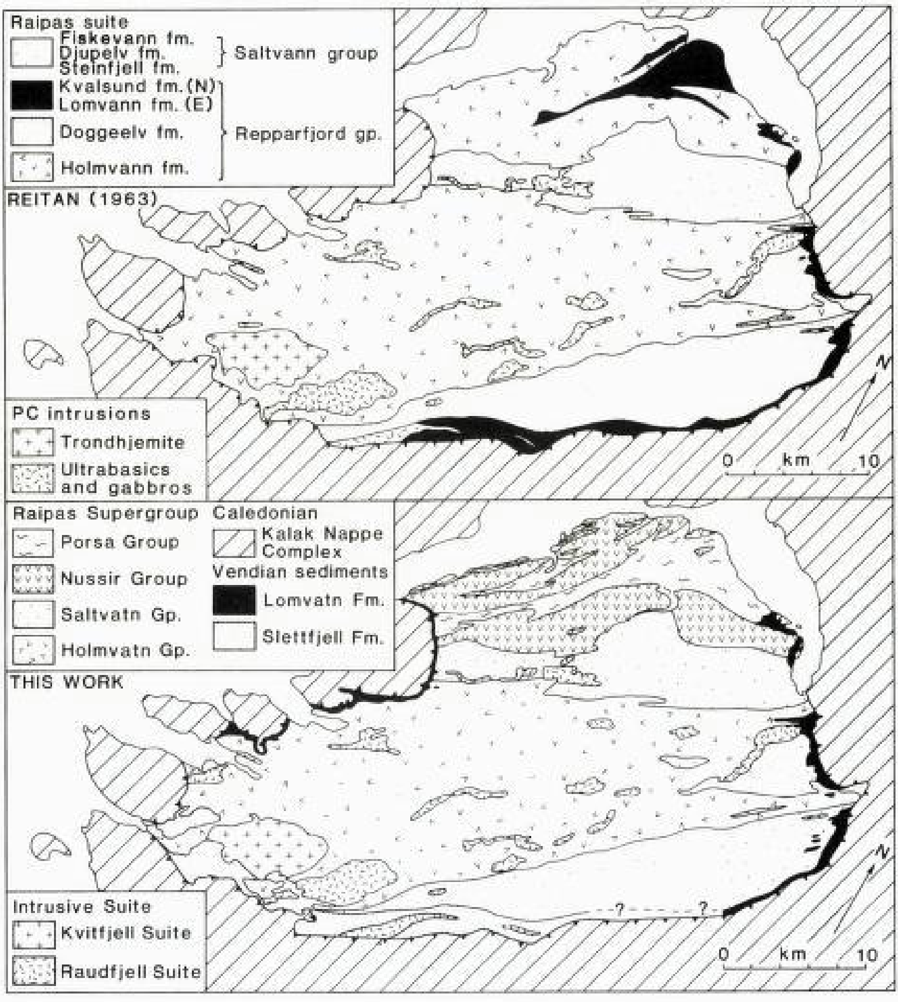


Fig. 3. Simplified geological maps of the Repparfjord–Komagfjord Window to contrast the lithostratigraphic schemes used by Reitan (1963) and in this work.

Holmvatn Group consists of a thick (at least 3 km) sequence of highly immature metasediments, e.g. polymict conglomerates, volcaniclastic sediments, feldspathic sandstones etc., interbedded with metavolcanic horizons of basic and intermediate composition. As Reitan (1963) recognised, most of the Holmvatn Group was complexly deformed and metamorphosed under upper greenschist or epidote-amphibolite facies conditions during the Svecokarelian Orogeny. Most of the lithologies are schistose and heavily recrystallised.

Although intense deformation has led to widespread transposition of the depositional fabrics, primary textures are usually sufficiently preserved to permit lithological mapping and three formations can be distinguished. These, however, are not distinguished in Plate I, and are described only briefly below.

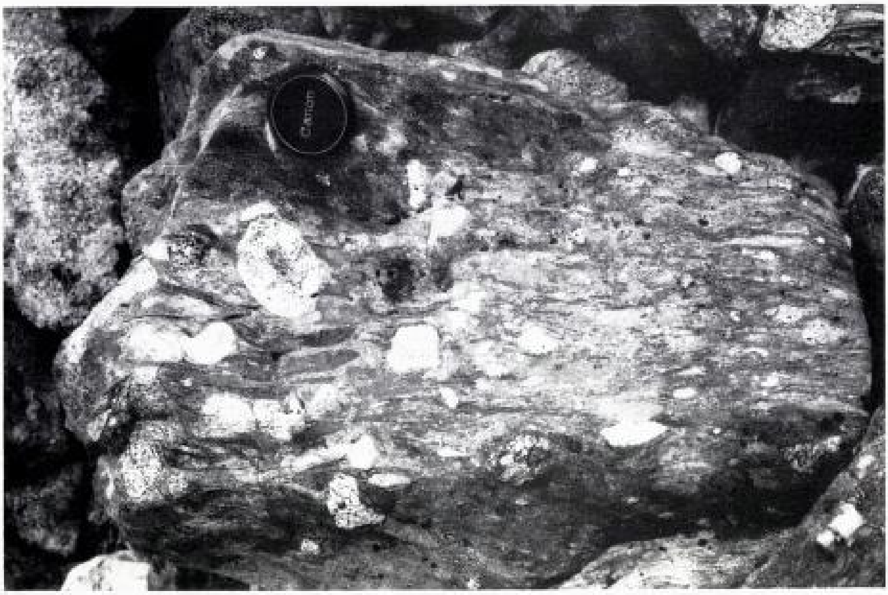


Fig. 4. Loose boulder of polymict metaconglomerate from the Markfjell Formation. Pebbles of granite, granitic-gneiss and vein quartz are little deformed, while clasts of greenstone are strongly flattened within the schistose matrix.

Markfjell Formation

Nowhere in the Komagfjord Window is the basement to the Karelian supracrustal sequence exposed, as recognized by Reitan (1963). The lowest unit of the Precambrian stratigraphy is the Markfjell Formation, a thick unit of polymict conglomerates interbedded with subordinate horizons of poorly sorted volcaniclastic sediments and metavolcanics particularly well exposed on Markfjell (FD 119012), outside the area described here. This lithology was first described by Holtedahl (1918) who estimated that at least 200–300 m of 'greenstone conglomerate' were present in the Korsfjord district. Pharaoh (1980) estimated that a much greater thickness was present, perhaps as much as 1500 m, with no base exposed. Jansen (1976) included this conglomerate within the upper part of his Store Lerresfjord Formation but we consider it preferable to give the conglomerate separate formational status.

The polymict conglomerates (Fig. 4) of the Markfjell Formation contain well rounded clasts of greenstone lithologies, quartzo-feldspathic schist and boulders of gneiss and granite which occasionally exceed 1m in diameter. Bedding and other sedimentary structures are rarely recognisable although this may be a consequence of intense tectonic deformation (Jansen 1976, Pharaoh 1980). The matrix consists mainly of quartzo-feldspathic clastic material with a variable admixture of volcanogenic material, and the clasts are for the most part matrix-supported.

Båtdalselv Formation

The Markfjell Formation passes up conformably into the Båtdalselv Formation, in which conglomeratic lithologies are absent. The sequence is mainly composed

Fig. 5. Basic metatuffites of the Båtdalselv Formation near Angelvann. The primary layering is partially transposed to a tectonic fabric (S_1k) and folded by later folds (F_2k).

of quartzo-feldspathic schists, some of which contain cross-bedding. The upper part of the formation is dominated by amphibolitic schists which may display graded layering (Fig. 5) and amygdales. Thin beds of dolomite up to 25 cm thick are interbedded with the amphibolites east of Holmvatn and on the eastern slopes of the Øvre Ariselv Valley. All of these lithologies show strong facies variation.

The strong deformation which has affected the Båtdalselv Formation leads to difficulty in calculating its primary stratigraphic thickness. In the vicinity of the headwaters of the Båtdalselv, to the south of the area described here, the formation is of the order of 700 m thick. Geochemical analysis of the amphibolitic schists has shown that these lithologies were probably lavas and tuffs of basaltic and andesitic composition prior to metamorphism (Pharaoh 1980).

The Båtdalselv Formation is a partial equivalent of the Angelvann Formation of Jansen (1976). As the latter is truncated tectonically by the Lerresfjordelv Fault, it cannot be considered an adequately defined stratigraphic unit. Rhodes (1976) recognized two members within the Holmvann formation of Reitan (1963) in the area south-west of Skaidi, mostly composed of clastic sediments and metavolcanics. These also must be partial equivalents of the Båtdalslev Formation.

Magerfjell Formation

The uppermost formation of the Holmvatn Group is a sequence of metabasaltic lavas frequently containing pillow texture, with subordinate horizons of mafic volcaniclastic rocks. The formation is highly variable in thickness, attaining its thickest development in the vicinity of Magerfjell (LU 906127) where it is about

1000 m thick, but thinning eastwards towards Arisvatn and westwards towards Indrevatn where it is locally absent. Geochemical analysis shows that the metabasalts were of tholeiitic composition prior to metamorphism (Pharaoh 1980).

Interpretation

The strong polyphase deformation and metamorphism which this sequence suffered during the Svecokarelian Orogeny hinders sedimentary facies interpretation. The poor sorting of the Markfjell Formation conglomerates, together with the scarcity of sedimentary structures and the evidence for matrix-support suggests that they may have originated as debris-flow deposits. The presence of very large boulders of gneiss and granite implies the existence of a nearby, possibly fault-bounded source area composed of these lithologies. Volcanic activity was spasmodic throughout the deposition of the Holmvatn Group, yielding both the tuffaceous component of the matrix fraction and greenstone clasts in the conglomerates, and eruptive tuffs and lavas in the upper part of the sequence. The environment of deposition appears to have been subaqueous in view of the presence of sporadic carbonate development, rarely preserved cross-bedding in sediments and pillow-structure in lavas, although evidence for the depth of water is equivocal. The vesicular volcanics may have been erupted in quite shallow water. The local absence of the Magerfjell Formation is here considered to be a consequence of the unconformity recognized by Reitan (1963, 1965) at the base of his Doggeelv formation.

SALTVATN GROUP

The Saltvann group, as originally defined, comprises three formations, the Steinfjell, Djupelv and Fiskevann formations (Reitan 1963). This group is now formally named the Saltvatn Group, in accordance with modern Norwegian usage. Although Reitan described the contact of the Saltvann group and his Holmvann formation as being everywhere tectonic (Reitan 1963, p. 21) this is, in fact, only locally the case. It is possible to demonstrate that the Saltvatn Group overlies the Holmvatn Group in the area south-west of Øvre Saltvatnet (FD 085105) where the contact between the two groups is folded in a major upward-facing coupled fold with a wavelength of 1.5 km. Cross-bedding in the Saltvatn Group is well preserved and youngs away from a primary depositional contact with the Holmvatn Group (Plate 1), clearly demonstrating that the latter is the older of the two groups. On the northern flank of Magerfjell, the contact is deformed by folds of near isoclinal style, although the age relationship is still demonstrable. South of Ulveryggen mine, the primary nature of the contact has been obscured by high strain and is tectonic, with the local development of mylonite, as recognized by Reitan (1963).

Ulverygg Formation

The Ulverygg Formation is a sequence of white or grey, lithic, feldspathic and quartzitic sandstones and polymict conglomerates at least 1000 m thick. This unit

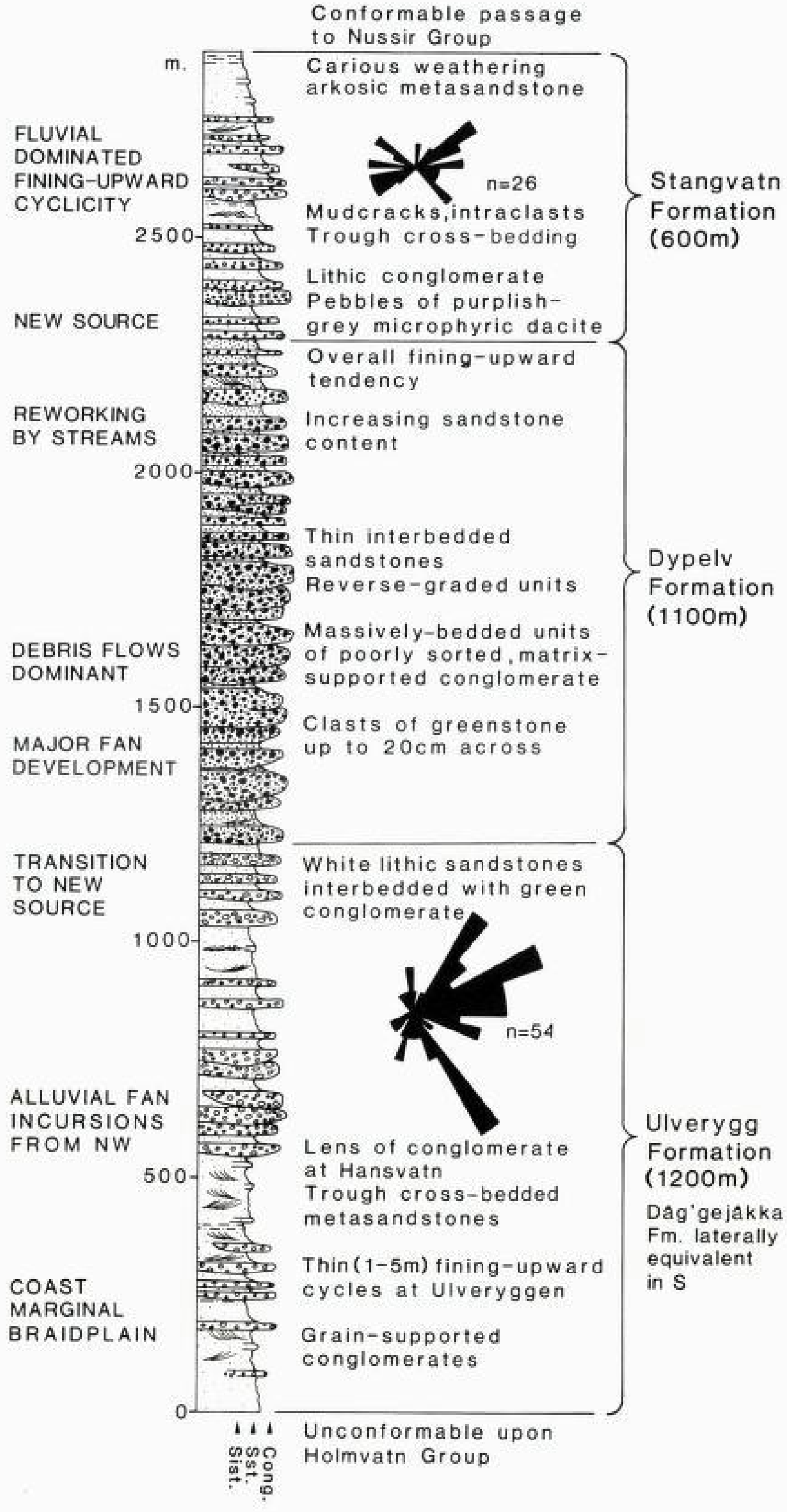
Fig. 6. Trough cross-bedding in quartzitic metasandstones of the Ulverygg Formation near Ulveryggen mine.

was originally informally named the Steinfjell formation (Reitan 1963) but continued usage of the term on a more formal basis would be highly confusing in view of the revision of geographical place names carried out in the second edition of series M711 topographic maps (see appendix for further details).

Conglomerates are most common in the middle part of the formation, particularly in the vicinity of Hansvatn where they form massive lensoid bodies up to 500 m thick and exhibit rapid lateral facies variation. The clasts are sub-rounded to rounded pebbles of vein quartz and greenstone up to 10 cm in diameter, set in a quartz-rich sandy matrix. The relative abundance of these clast types varies from place to place. In the vicinity of Ulveryggen mine, thin grain-supported conglomerate beds occur at the base of well developed fining-upward cycles 0.3–2 m thick. Typically, 10–15 cm of conglomerate is followed by coarse-grained trough cross-bedded sandstones (Fig. 6) which may fine upward into pale greenish or greyish siltstones. Occasionally the sandstones are of quartzitic purity. In the Hermannvatn district the Ulverygg Formation is more massively bedded and trough cross-bedding is less common.

Palaeocurrent directions were determined from trough cross-bedding in the lower half of the Ulverygg Formation at several localities from Hansvatn in the west to Ulveryggen in the east. The data were corrected for tectonic dip by rotation on a Lambert equal-area stereonet and are plotted together in Fig. 7. The combined

Fig. 7. Schematic lithostratigraphy for the Saltvatn Group in the vicinity of Saltvatnene. N.B. – Individual beds shown are not to scale thickness.


Conformable passage
to Nussir Group
m.
Carious weathering
arkosic metasandstone
FLUVIAL
DOMINATED
FINING-UPWARD
CYCLICITY
n=26
Mudcracks,intraclasts
Trough cross-bedding
2500
Lithic conglomerate
Pebbles of purplish-
grey microphyric dacite
NEW SOURCE
Stangvatn
Formation
(600m)
Overall fining-upward
tendency
REWORKING
BY STREAMS
Increasing sandstone
content
2000
Thin interbedded
sandstones
Reverse-graded units
Dypelv
Formation
(1100m)
DEBRIS FLOWS
DOMINANT
Massively-bedded units
of poorly sorted, matrix-
supported conglomerate
1500
MAJOR FAN
DEVELOPMENT
Clasts of greenstone
up to 20cm across
TRANSITION
TO NEW
SOURCE
White lithic sandstones
interbedded with green
conglomerate
1000
n=54
ALLUVIAL FAN
INCURSIONS
FROM NW
Ulverygg
Formation
(1200m)
Lens of conglomerate
at Hansvatn
500
Trough cross-bedded
metasandstones
Dåg'gejåkka
Fm. laterally
equivalent
in S
COAST
MARGINAL
BRAIDPLAIN
Thin (1-5m) fining-upward
cycles at Ulveryggen
Grain-supported
conglomerates
0
Unconformable upon
Holmvatn Group
Cong.
Sst.
Slst.

data show a bimodal tendency indicating deposition by currents flowing from west and north-west, mirroring the pattern seen in individual outcrops (Pharaoh 1980).

The contact between the Ulverygg Formation and the overlying Dypelv Formation is transitional in nature, as noted by Reitan (1963). At the base of the transition member, dark green sandstones with or without pebbles of vein quartz are interbedded with white or greyish lithic sandstones of Ulverygg type. Considerable facies variation is evident in outcrop, and there are numerous examples of scour-and-fill. Towards the top of the 100–150 m-thick transition member, green sandstones and polymict conglomerates, typical of the majority of the Dypelv Formation, are dominant (Fig. 7).

Dypelv Formation

This unit was originally named the Djupelv formation by Reitan (1963) but this stream is now known as Dypelva on the second edition of series M711 topographic maps. The unit is formally defined in the appendix.

The formation consists of a monotonous sequence of poorly bedded green polymict conglomerates and thin interbedded sandstones. Most of the clasts in the conglomerate are pebbles, cobbles and boulders of metabasaltic lava, metatuffite and vein quartz, the former up to 35 cm in size. Rare pebbles of quartzite, jasper, dolomite and intermediate volcanic rocks also occur. All of these lithologies are present in the underlying Holmvatn Group. The clasts are sub-rounded to sub-angular in shape and set in a poorly sorted schistose matrix composed of greenstone fragments and quartzo-feldspathic material. These pebbles are invariably orientated with their long axes parallel to the schistose foliation, indicating distortion during deformation. The lower part of the sequence is dominated by massively bedded units of poorly sorted, matrix-supported conglomerate typically 1–10 m thick. Most of these conglomerates are poorly graded, but some shown reverse grading, coarsening towards the top of the bed. Erosional bases are rather common. Sandstones with cross-bedding are impersistently developed in the lower part of the sequence but become increasingly abundant and thicker towards the top of the sequence, the whole assemblage displaying an overall fining-upward tendency. Some of the conglomerates in the upper part of the formation are better organised and may show grain support.

The Dypelv Formation exhibits marked thickness variation (Plate 1). At the western extremity of its outcrop, it is apparently 2500 m thick, but thins markedly to about 800 m on the south flank of Nussir. This may well reflect primary thickness variation but is mainly a consequence of deformation, with thickening in the hinge of the Nussir structure and strong attenuation on its limb. The original thickness was probably about 1100 m as shown in Fig. 7.

Stangvatn Formation

The Dypelv Formation passes up fairly sharply into the Stangvatn Formation, a sequence of purple polymict conglomerates and arkosic sandstones. This formation was originally named the Fiskevann Formation by Reitan (1963) but more formal usage of this name would cause confusion in view of the revision of geographical

Fig. 8. Channel with irregular, erosional base cut in parallel and trough cross-bedded sandstones and infilled by conglomerate. Stangvatn Formation, near Nedre Saltvatn.

names on the revised edition of series M711 topographic maps (see appendix for further details). We propose that this unit be formally named the Stangvatn Formation.

The conglomerates are dominated by clasts of purplish-grey coloured microphyric lavas of dacitic composition. The source of these highly distinctive porphyrite clasts has not so far been recognized within the Precambrian of northern Norway, as noted by Reitan (1963).

The sequence is dominated by at least 3 major-scale fining-upward cycles (Fig. 7)., each 100–300 m thick. At the base of each cycle, grain-supported conglomerates 0,5–4 m thick, frequently with erosional bases (Fig. 8), fine upwards into thinner interbedded units of trough cross-bedded arkosic sandstone. The ratio of conglomerate to sandstone decreases in the upper part of each major cycle, where trough cross-bedded and parallel-bedded arkosic sandstone are dominant. At the top of the second major cycle, silty sediments contain rare mudcracks, and intraclasts of shale and siltstone are found within the sandstone. The upper part of the third cycle, shown separately on Plate 1, consists of well-cleaved purplish-grey arkosic sandstones and siltstones and is virtually conglomerate-free.

Thin-section analysis reveals that the carious weathering nature of these arkosic metasandstones is a consequence of their carbonate cement.

Palaeocurrent data deduced from trough cross-bedding in the lower part of the formation in the area south-east of Stangvatn are presented in Fig. 7. The data are clearly bimodal in orientation but it is not possible to distinguish between transport to north or south. Fortunately, two complete channel bodies were discovered which originally had palaeoslopes towards the north, indicating a southerly provenance for the Stangvatn Formation. The original depositional thickness of the Stangvatn Formation was probably about 600 m, although considerable variation occurs between the hinge and the limb of the Nussir fold.

Dåg'gejåkka Formation

This formation was originally informally named the Doggeelv formation by Reitan (1963). The stream Doggeelv is renamed Dåg'gejåkka on the second edition of series M711 maps and it is preferable that the formation should be formally named following the present geographical usage.

The Doggeelv formation was included within the Repparfjord group by Reitan (1963), but was subsequently correlated (Reitan 1965) with the Bossekop Group which unconformably overlies the Raipas rocks in the Alta district (Føyn 1964). The formation, which is only exposed over a small area of Plate 1 (Fig. 3), has been shown to unconformably overlie the Holmvatn Group (Reitan 1965, Rhodes 1976, Pharaoh 1980).

The Dåg'gejåkka Formation is a monotonous sequence of white quartzitic metasandstones at least 1500 m thick. The assemblage is massively bedded, typically on the scale of 10–40 cm. The sediment is very well sorted, the only impurities being grains of muscovite mica and sodic feldspar, both now in the form of metamorphic porphyroblasts. Thin and impersistent pebbly lenses with clasts of vein quartz, chert and occasionally acid banded gneiss have been reported from the lower part of the formation (Reitan 1963, Rhodes 1976), but are rather rare. In the valley of the Repparfjordelv, south of the area described here, sedimentary structures are well preserved and include parallel bedding and planar cross-bedding, the latter indicating a remarkably persistent unimodal pattern of sediment transport towards the south-west (Pharaoh 1980).

The apparent low grade of deformation exhibited by the Dåg'gejåkka Formation is extremely deceptive, however. The formation, in fact, exhibits a polyphasal deformation history comparable with that found in the underlying Holmvatn Group (Rhodes 1976, Pharaoh 1980). The Dåg'gejåkka Formation is overlain with strong angular unconformity by the much less deformed Lomvatn Formation along the Dåg'gejåkka itself (Rhodes 1976, Pharaoh 1980). The contact is not therefore gradational as suggested by Reitan (1963), p. 17, nor is the stratigraphic top of the formation exposed. We consider that the Dåg'gejåkka Formation is part of the Precambrian Raipas Supergroup and do not support correlation of the formation with the Upper Riphean Bossekop Group (Føyn 1964) of the Alta district, as suggested by Reitan (1965) and Roberts & Fareth (1974).

Mapping has revealed that the Dåg'gejåkka and Ulverygg Formations are at a comparable structural and stratigraphic level within the Komagfjord Window (Pharaoh 1980), forming the envelope of a major F_1k anticlinal fold with the Holmvatn Group in the core (Fig. 3). Both formations are thick (c. 1,5 km) sequences of massively bedded metasandstones and quartzite, with subsidiary conglomerate. Palaeocurrent directions within the formations are different but not discordant (Pharaoh 1980). R. Hovland, while mine geologist at Ulveryggen Mine, mapped the Repparfjord district in connection with prospecting work and considered the Doggeelv and Steinfjell formations of Reitan (1963) to be time-equivalents (R. Hovland, pers.comm. 1976). Rhodes (1976), working independently, came to the same conclusion. We also favour correlation of the Dåg'gejåkka and Ulverygg Formations and therefore include the former in the Saltvatn Group as well as the latter.

Interpretation

Mapping shows that the Saltvatn Group locally oversteps the Magerfjell Formation to rest upon the Båtdalselv Formation. This is believed to be a consequence of an erosional unconformity at the base of the Saltvatn Group, although the angular discordance is unlikely to be very great. A similar discordance has been described by Reitan (1963, 1965) at the base of the Dåg'gejåkka Formation along the southern boundary of the Holmvatn Group outcrop.

The Saltvatn Group is interpreted as a thick (ca. 3 km) sequence of clastic sediments deposited under predominantly fluviatile conditions. The moderately mature Ulverygg Formation appears to have been deposited by braided streams flowing from a siliceous source area to the west and north, probably fault-bounded. The general relationships suggest the development of a braidplain environment (Allen 1975), periodically and locally disturbed by the incursion of alluvial fans which are preserved in the form of lensoid conglomerate bodies. The Dypelv Formation reflects the change to a new source area, dominated by greenstone volcanics. The predominance of coarse conglomerates and poor sorting indicate that this source was rather closer than that of the Ulverygg Formation sediments. The matrix-supported conglomerates in the lower part of the sequence may have been generated as volcaniclastic debris flows in a terrestrial environment. Rhodes (1976) has suggested that some of the conglomerates are fanglomerates produced by subaerial mudflows on alluvial fans. Interbedded sandstones were probably deposited by braided streams reworking the surface of the fan, a process which became increasingly important towards the upper part of the formation. The Stangvatn Formation again reflects a change of provenance, this time to a southerly source area dominated by intermediate and acid volcanic rocks. The environment of deposition appears to have been similar to that of the Ulverygg Formation, dominated by ephemeral braided streams. The large-scale cyclicity may reflect rejuvenation of the source area by tectonic uplift.

Rhodes (1976) suggested that the Djupelv and Fiskevann formations of Reitan (1963) might be much younger in age than the Steinfjell formation, possibly part of a Caledonian depositional cycle. We find his arguments for a younger age unconvincing, however, and in our view the sedimentological and structural evidence (summarised by Pharaoh 1980) favour Reitan's interpretation of the Saltvatn Group as a continuous sequence of Karelian age.

According to the map of Reitan (1963) the Dåg'gejåkka and Ulverygg Formations approach to within about 0,5 km just south of Repparfjord. More recent mapping by Rhodes (1976) incorporated in Plate 1, suggests that this distance is closer to 2 km, as Reitan (1963) appears to have mistaken the coarse clastic basal member of the Lomvatn Formation for the Dåg'gejåkka Formation in this district. Prior to Svecokarelian deformation, this distance would have been even greater, perhaps as much as 8–10 km in view of the tight folding found in the Dåg'gejåkka Formation. Thus, although we agree with Reitan (1963) that considerable lithological differences exist between the Ulverygg and Dåg'gejåkka Formations, these differences may be reconciled by invoking facies variation. Evidence for this is very clear in the Ulverygg Formation, as has already been described.

The model proposed for the deposition of the Ulverygg and Dåg'gejåkka Formations shares many similarities with the sedimentological model proposed by Rhodes (1976). The Ulverygg Formation is interpreted as less mature sediment deposited in floodplains and minor alluvial fans flanking a fault-bounded upland to the north-west. Most of the sediment was deposited in braided stream channels winding across a coast-marginal braidplain. Just offshore to the south-east, the more mature sandstones of the Dåg'gejåkka Formation appear to have been deposited in a shallow marine environment dominated by persistent long-shore drift towards the south-west (Pharaoh 1980).

NUSSIR GROUP

Reitan (1963) correlated the greenstone lavas outcropping to the north of the Saltvann group with those to the south, in the Holmvann formation. He also regarded the contact between the northern lavas and the Saltvann group as being entirely tectonic, invoking a layer-parallel thrust on the southern flank of Nussir to explain the structural relationships there (Reitan 1963, Fig. 13B). More recently, Jansen (1976) concluded that the greenstones of his Angelvann Formation, outcropping to the south of the Saltvann group, could not be correlated with the lavas of the north. Mapping by one of us (T.C.P.) has revealed that although there is good evidence for a faulted contact from Hermannvatn in the west to Nussirjav'ri, there is little evidence for a tectonic contact along the southern flank of Nussir. On the contrary although it is not well exposed, this contact appears to be a normal stratigraphic boundary (Pharaoh 1980) with a conformable passage up from the Stangvatn Formation into the metavolcanic lithologies of Nussir (Plate 1). Accordingly, we follow Jansen (1976) in concluding that the lavas of Nussir cannot be correlated with the lavas of the Holmvatn Group as defined above, and assign them to a new stratigraphic unit, the Nussir Group.

Krokvatn Formation

The lowest formation of the Nussir Group is exposed only along the southern flank of Nussir (Plate 1). Most of the formation is composed of tuffaceous greenstones interbedded with thinner units of metabasalt (Fig. 9) giving rise to a highly distinctive ridge and slack topography (Fig. 10) west of Fiskevatn (LU 963203). A variety of types of tuffaceous rock are recognized. At several horizons, striped, well-bedded, mafic tuffites are developed in units up to 50 m thick (Fig. 9). These sediments are graded lithic sandstones in which virtually all the clastic material is of mafic volcanogenic origin, interbedded with finer-grained material from the same source. The lithic sandstones occasionally contain thin lenses of quartz grains

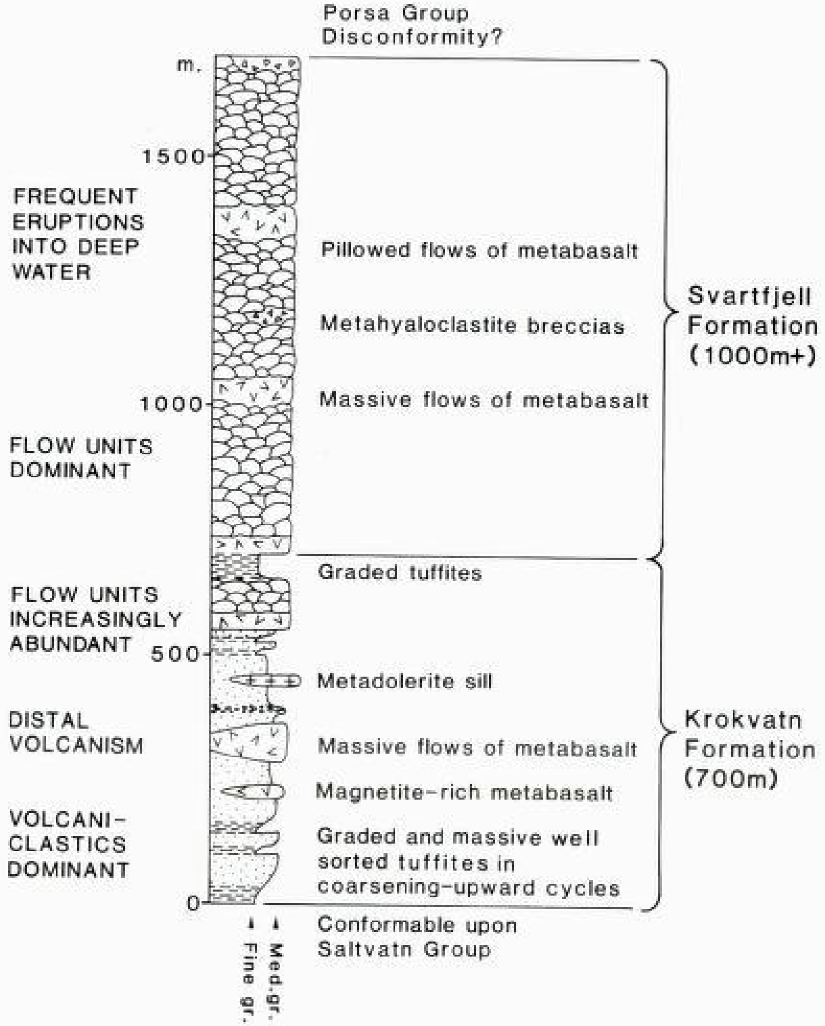


Fig. 9. Schematic lithostratigraphy for the Nussir Group in the vicinity of Nussir.

derived from a non-volcanic source and may have erosional bases, while the finer grained sediment often contains parallel- and ripple-lamination. Geochemical analysis reveals that these 'greenwackes' have a bulk chemical composition closely reflecting their basaltic ancestry (Pharaoh 1980). Interbedded with the tuffites are less well bedded, but better sorted and generally coarser-grained green mafic tuffs, composed of highly altered fragments of metabasalt mostly less than 5 mm in size. In some places, intraclastic blocks of bedded tuffs up to 1 metre across are found in this lithology. Serpentinous fragmental lithologies are also found in this sequence, usually unbedded. A thin unit of dolomite (3 m thick) is interbedded with the tuffites near the base of the formation in the west. Intercalated with the tuffs and tuffites described above are lensoid units of metabasalt up to 100 m thick.

Fig. 10. Southern flank of Nussir, looking east towards Repparfjord, showing the distinctive ridge and slack topography on the Krokvatn Formation. Exposures in the foreground and the distant ridges are composed of pillowed metabasalt, while the poorly exposed slacks are developed on basaltic metatuffites.

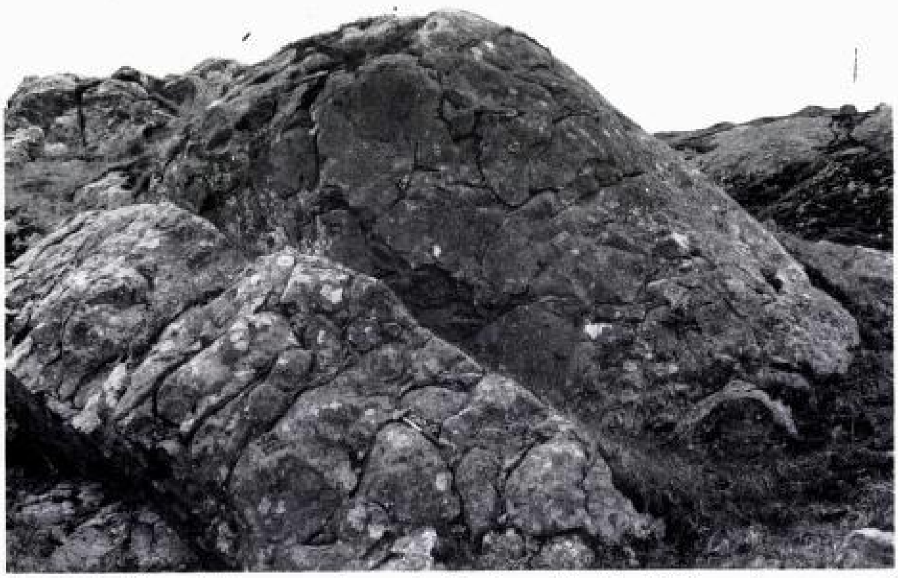
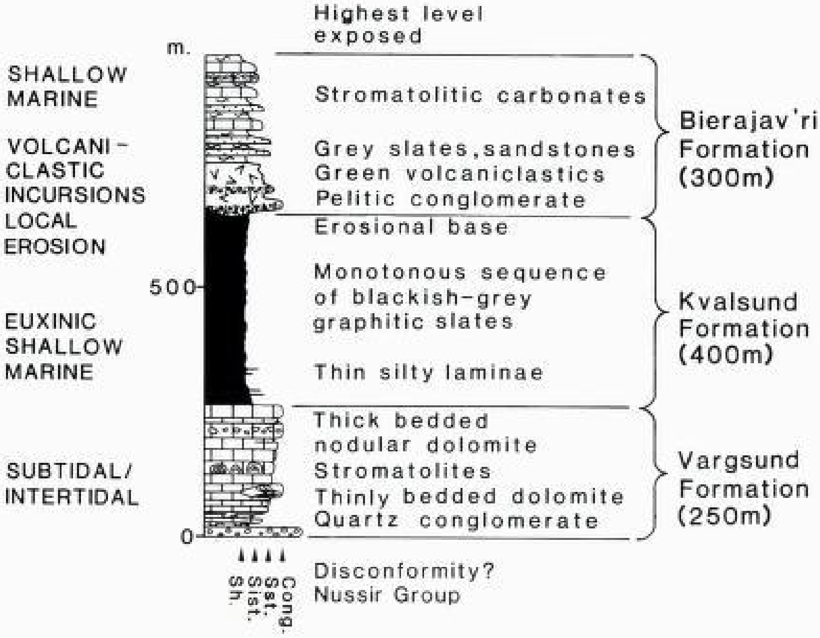


Fig. 11. Undeformed pillow texture in metabasaltic lavas of the Svartfjell Formation, summit of Nussir.

The earliest flow units are massive, but pillow texture is commonly developed in later flows. Only the first thin flow unit is obviously vesicular. Primary textures such as grading, ripple-lamination, pillow textures and cleavage-bedding relationships show that the 700 m thick Krokvatn Formation is right-way-up throughout.



Schematic lithostratigraphy for the Porsa Group in the Tappen–Bierajav'ri district. N.B. Individual beds shown are not to scale thickness.

Svartfjell Formation

This unit includes all the metabasaltic lavas exposed in the cores of prominent anticlinal structures in the Vargsund district, forming the hills of Stortinden, Segelnesfjellet, Skinnfjellet and Nussir. The base of the formation is exposed only on the southern flank of Nussir, and is defined as the top of the highest tuffaceous horizon of the Krokvatn Formation. On Nussir, the Svartfjell Formation consists of a monotonous succession of metabasalt lava flows at least 1 km thick. Most lavas show pillow texture (Fig. 11), are non-vesicular and plagioclase-microphyric. Intercalated with the pillowed flows are units of massive, unpillowed metabasalt, and local thin horizons of metabasaltic tuff and meta-hyaloclastite breccia. The latter lithologies are well developed in the vicinity of the summit of Skinnfjellet and north-east of Fiskevatn.

Interpretation

The primary textures of the Nussir Group lavas and tuffs are well preserved and indicate an origin by extrusive volcanism in a subaqueous environment. Tuffs and tuffites of the Krokvatn Formation are interpreted as aquagene tuffs (Carlisle 1963) generated by the fragmentation of chilled basaltic lava in a submarine environment. The spectrum from hyaloclastite breccia to poorly bedded tuff and well bedded, graded tuffite is considered to represent increased sedimentary reworking of the fragmented basalt with distance from the source area. A small amount of clastic quartz from some other non-volcanic source was also incorpor-

Fig. 13. Stromatolitic domes in dolomite of the Vargsund Formation, near Tappen. The form of the domes is emphasised by laminae of cherty quartz.

ated in the tuffitic sediments. The depth of water in which the tuffs were deposited is not known. The early vesicular lavas interbedded with tuffites containing a dolomite horizon may have been erupted in relatively shallow water. The later lavas are non-vesicular and were probably erupted in deeper water.

PORSA GROUP

The map of Reitan (1963) shows extensive belts of carbonate and quartzitic sediments in the district adjacent to the Vargsund. Reitan did not recognize a consistent stratigraphy within these metasedimentary units, however, considering them to be interbedded with the metabasalt. He did, however, differentiate a unit of black graphitic slates overlying the greenstones which he termed the Kvalsund formation, and correlated with his Lomvann formation. Detailed mapping has shown that a consistent stratigraphy does, in fact, exist for this metasedimentary sequence, which overlies lavas of the Nussir Group and includes a number of lithologies, e.g. shales and volcaniclastic rocks, not differentiated on Reitan's map.

Vargsund Formation

Greenstones of the Nussir Group are discontinuously overlain by a grain-supported conglomerate containing sub-angular pebbles of vein quartz and jasper set in fine-grained, phyllitic matrix. In most places this is thin, often a metre or less thick, but it is particularly well developed at the northern end of Skinnfjellet, where it is several metres thick. Cobbles of acid gneiss have been found in this conglomerate east of Neverfjord. As this basal conglomerate is relatively thin and discontinuous it is not given separate formational status but is instead simply regarded as the basal member of the Vargsund Formation.

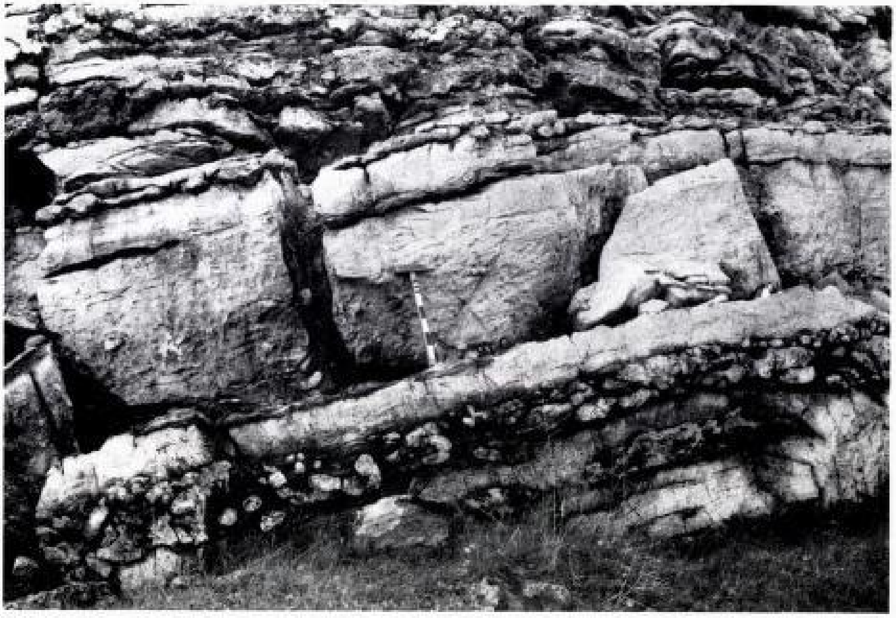


Fig. 14. Massively bedded dolomite containing nodules of cherty quartz in the upper part of the Vargsund Formation, SW of Finnvatn. Bedding is inverted on the overturned limb of a major Svecokarelian fold.

The conglomerate passes up into a sequence of thinly interbedded limestones, dolomites and purplish shales, some of which show ripple-lamination. The remainder of the Vargsund Formation is composed almost entirely of dolomite, the beds becoming thicker and more massive up the sequence (Fig. 12). The dolomite is coarsely crystalline as a consequence of recrystallisation during deformation. Ripple- and parellel-lamination are occasionally found, revealed by thin sandy laminae within the sediment. Original or little-modified bed thicknesses and sedimentary structures are well preserved in the crestal areas of the large folds, but are obliterated in the highly strained limbs. Beds of planar cross-bedded quartzitic sandstone up to 60 cm thick occur within the dolomite at certain horizons. At a number of localities, domes produced by stromatolitic blue-green algae (Fig. 13) have been identified. These are particularly well developed at a locality about 2 km east of Kvalsund village (LU 897250). Here, on the crest of the Tappen Anticline, the Vargsund Formation is about 250 m thick, and stromatolites are best developed at a horizon about half way up the sequence. The dolomite is finely laminated on a scale of 0,5–2 mm and the overall shape of the domes is revealed by laminae of sugary white quartz. Most of the stromatolites are laterally linked hemispheroids. Some *Conophyton*-like domes achieve an amplitude in excess of 30 cm. Nodules of cherty silica overgrow bedding and sedimentary structures in the dolomite, particularly towards the top of the formation, where bedding-parallel layers and irregular veins of cherty quartz are well developed (Fig. 14).

Fig. 15. Erosional channel and slumping in laminated tuffaceous metasediments of the Bierajav'ri Formation, near Garg'o.

Kvalsund Formation

Mapping has revealed that the Kvalsund Formation (Reitan 1963) is a stratigraphically consistent two-sided formation within the Porsa Group, overlying the Vargsund Formation from Kvalsund in the north to Saraby in the west. It is overlain in turn by a sequence of volcaniclastic sediments, shales and carbonates which we refer to as the Bierajav'ri Formation and which will be described below. There is no evidence for an unconformity at the base of the Kvalsund Formation, and it was deformed for the first time by the same Svecokarelian Orogeny which affected the underlying metabasalts and metasediments. Reitan (1963) and Rhodes (1976) have correlated the Kvalsund Formation with the Lomvatn Formation. As will be shown below, however, the Lomvatn Formation rests unconformably on the Kvalsund Formation in the vicinity of Storvatnet, so the above correlation cannot be sustained.

The Kvalsund Formation is a greyish-black graphitic slate or phyllite, locally rich in pyrite. It is a well cleaved, rather monotonous lithology with few sedimentary structures visible except where silty laminae are present. It is difficult to estimate the original thickness of the formation because of the well developed slaty cleavage. As Plate 1 shows, the outcrop pattern of the Kvalsund Formation reflects considerable thickening of the sequence in the hinges of macroscopic Svecokarelian folds, and strong attenuation on their limbs. Reitan (1963) estimated the minimum thickness of the formation in the Kvalsund district to be about 500 m. The formation is rather thinner to the south-west, and in the vicinity of Neverfjord appears to be completely absent as a consequence of erosion prior to deposition of the Bierajav'ri Formation.

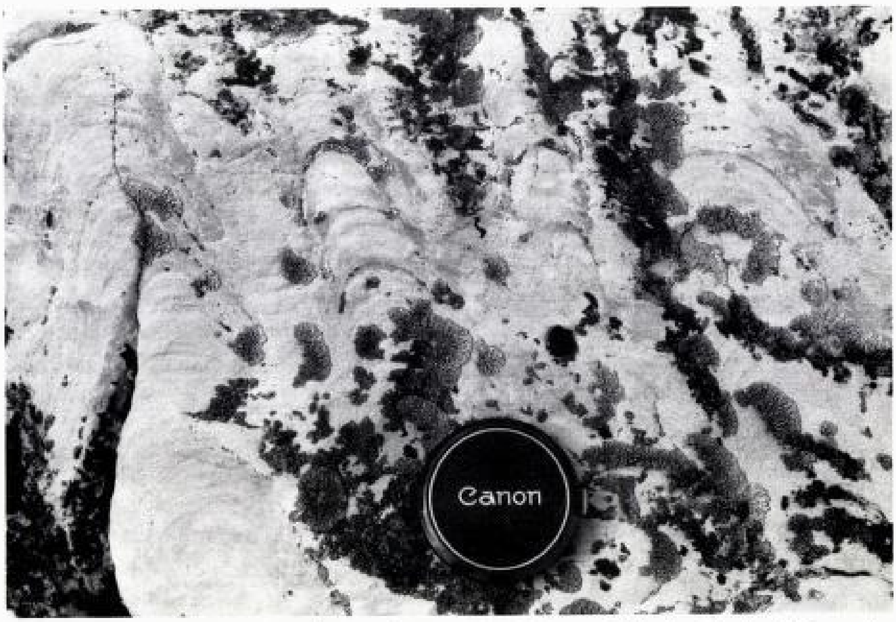


Fig. 16. Columnar stromatolites developed in a micritic horizon within the Bierajav'ri Formation in Kvalsunddal. The intercolumnar fill locally contains clasts of black shale eroded from the underlying Kvalsund Formation.

Bierajav'ri Formation

Over most of the Vargsund district, graphitic slates of the Kvalsund Formation are overlain, apparently conformably, by a mixed sequence of green tuffaceous volcanic lithologies, grey slates, sandstones and thin carbonate horizons. The sequence is best exposed in the deep syncline involving the Porsa Group in the vicinity of Bierajav'ri (LU 900222), and along Kvalsunddalen.

The lower part of the Bierajav'ri Formation is dominated by greenish-coloured sediments of volcaniclastic origin. These sediments contain fragments of dolomitic carbonate probably eroded from the underlying Vargsund Formation and have a carious weathering appearance. A variety of sedimentary structures are present, including scours (Fig. 15), slumps, and parallel- and ripple cross-lamination. The upper part of the formation consists of grey slates with thin sandstones, carbonate horizons and volcaniclastic units. Horizons of bluish-grey micritic limestones in beds up to 30 cm thick locally contain simple, low-amplitude domes and unbranched short columnar stromatolites (Fig. 16), some of which are not in growth position. The sediment infilling the intercolumnar space often contains fragments of black shale, probably eroded from the Kvalsund Formation. The Bierajav'ri Formation is at least 300 m thick in the type area and represents the highest level of the Raipas Supergroup exposed in the Komagfjord Window.

Interpretation

The sedimentary structures and lithofacies of the Porsa Group suggest that the entire sequence was deposited in shallow water. The sediments are immediately underlain by pillow lavas of the Nussir Group which were probably erupted in deep water. It seems likely that the basin of deposition suffered shallowing prior to deposition of the Porsa Group. The presence of a well developed basal conglomerate may even imply erosion of the substrate, although angular discordance is difficult to demonstrate.

The most significant palaeoenvironmental indicator in the Vargsund Formation is the widespread development of algal stromatolites throughout the district. The depth of water is of critical importance for algal photosynthesis and the Vargsund Formation is unlikely to have been deposited in water of any great depth. The abundant silicification of the dolomite, particularly in the form of cherty nodules, may reflect replacement of evaporite minerals, although convincing evidence for this is hard to find. A peritidal environment cannot be ruled out. Cross-bedded sandy horizons probably reflect higher energy conditions of deposition.

The Kvalsund Formation was probably deposited in slightly deeper water, in a basin with sluggish circulation promoting euxinic conditions. The deposition of the Bierajav'ri Formation marked a return to conditions of more active marine circulation. This environment was periodically disturbed by the influx of volcaniclastic material. The abundance of scours and slumps suggests that these volcaniclastic deposits were deposited with some violence. The presence of clasts eroded from both the Vargsund and the Kvalsund Formations, and the local absence of the latter in the Neverfjord area, imply erosion prior to deposition of the Bierajav'ri Formation. The sediments in the upper part of the formation are mostly shales and stromatolitic carbonates indicating a shallow-water environment with low current energy.

Regional Correlation

Detailed correlation of the Raipas Supergroup in the Komagfjord Window with the Raipas of the Alta–Kvænangen Window and equivalents on the Finnmarksvidda is fraught with difficulty because of the laterial facies variation which these Karelian rocks display even over very small distances. If the aulacogen rift model proposed by Torske (1978) for the deposition/eruption of the Karelian supracrustal rocks is valid, attempts at detailed correlation may even be conceptually unwise.

We feel, however, that the similarities of the Karelian supracrustals in the Finnmark windows and on Finnmarksvidda warrant at least some comment. In the Alta district of the Alta–Kvænangen Window, Zwaan & Gautier (1980) have divided the Raipas Group into two sub-groups (Fig. 17). The Lower Raipas Group is composed of metabasaltic pillow lavas, tuffs and tuffitic sediments with minor intrusions of diabase, overlain by a thin sequence of argillite and dolomite, the latter bearing stromatolites at Storvik (Holtedahl 1918, Geukens & Moreau 1960). In terms of gross morphology, these lithological units are remarkably similar to the Nussir and Porsa Groups, respectively, of the Komagfjord Window, and show similarities to the Turelv Formation of Altenes, described by Fareth (1979). There are also many similarities with the Časkias Group (Holmsen et al. 1957) of the Finnmarksvidda. The Upper Raipas Group of Alta consists of two

Repparfjord-Komagfjord Window (this work)	Altenes Window (Fareth 1979)	Alta-Kvænangen Window (Zwaan and Gautier 1980)	Finnmarksvidda (Holmsen et al. 1957, Oftedahl 1980)	East Finnmark (Bugge 1960, Oftedahl 1980)
		Luovusvarri formation Skoadduvarri sandstone — UPPER RAIPAS SUBGROUP	Sandstone arkose and conglomerate Argillite and dolomites — ČARAVARRE GROUP	
		Conformable		
Bierajav'ri Formation Kvalsund Formation Vargsund Formation — PORSA GROUP	Dolomite, dolomitic shales and slates Metabasaltic lava, tuff — TURELV FORMATION	Storviknes dolomite (and slates) Kvenvik greenstone — LOWER RAIPAS SUBGROUP		Beds of mica schist, limestone, tuffs and acidic lavas Skogfoss greenstone Neverskrukk conglomerate — PETSAMO GROUP (Early Proterozoic)
Disconformity?				
Svartfjell Formation Krokvatn Formation — NUSSIR GROUP			'Transition beds' 'Greenstones' Lavas, pyroclastics and intrusions — ČASKIAS GROUP	
Conformable	Relationship uncertain			
Stangvatn Formation Dypelv Formation Ulverygg / Dåg'gejåkka Formation — SALTVATN GROUP	Arkosic and quartzitic sandstones, conglomerate — RUSSELUFT FORMATION		Quartz, schists etc Quartzite Conglomerate — MASI GROUP	
Unconformity	Conformable		Unconformity	Unconformity
Magerfjell Formation Båtdalselv Formation Markfjell Formation — HOLMVATN GROUP	Lavas, tuffs and agglomerates — KVIBY FORMATION			Ørnevann gneisses (metadacites) Iron ore, Gneiss, schist Bjørnevann conglomerate — BJØRNEVANN GROUP (Late Archaean)
				Unconformity
Pre-Karelian basement not exposed	Pre-Karelian basement not exposed	Pre-Karelian basement not exposed	Granite-gneiss complex (Archaean)	Banded gneiss and granites — JARFJORD COMPLEX (Archaean)

Fig. 17. Speculative correlation scheme for the Karelian supracrustal sequence of N. Norway. N.B.–Fareth (1979) prefers to correlate the Kviby Formation with the Lower Raipas Group of Alta, and the overlying Russeluft Formation with the Upper Raipas Group.

formations of lithic sandstones and subordinate dolomite up to 1100 m thick (Zwaan & Gautier 1980), comparable to the Čaravarre Group (Holmsen et al. 1957) of Finnmarksvidda. The Saltvatn group of the Komagfjord Window shows some similarities to these clastic sequences and has been correlated with them in previous schemes, e.g. Barth & Reitan (1963). As has been described above, however, the Saltvatn Group appears to underlie the Nussir (? = Časkias) Group greenstones and is therefore more likely to be a correlative of the Masi Group than the Čaravarre Group (Fig. 17). The Dåg'gejåkka Formation (now correlated with the Saltvatn Group) contains pure quartzites rather similar to those of the Masi Group. We consider that equivalents of the Upper Raipas/Čaravarre Group have been removed by erosion in the Komagfjord Window. The Holmvatn Group, including the highly distinctive Markfjell Formation conglomerate, does not appear to have any equivalent in the Karelian of West Finnmark. This is not altogether surprising, for the Komagfjord Window exposes a much deeper level of the Karelian crust (as indicated by metamorphic grade) than is found in the other Finnmark windows, although equivalent structural levels are exposed in

Finnmarksvidda. Recently, however, a greenstone unit has been found stratigraphically below the Masi conglomerate on Finnmarksvidda (A. Solli, pers.comm. 1981) and this may be an equivalent of the Holmvatn Group greenstones.

Svecokarelian structural history

INTRODUCTION

The volcanic and sedimentary supracrustal rocks of the Raipas Supergroup were deformed for the first time during the Svecokarelian orogeny, about 1840 Ma ago (Pharaoh et al. 1982). In the area described here, comparatively simple tectonic structures were produced and metamorphism remained within the greenschist facies. Further south, however, rocks are strongly recrystallised, containing mineral assemblages diagnostic of the epidote-amphibolite facies and possibly the amphibolite facies (Reitan 1963) and complexly deformed by three phases of Middle Proterozoic deformation (Jansen 1976, Pharaoh 1980). In the following description, these Svecokarelian structures are distinguished using the letter 'k' (e.g. F_1k), to separate them from later Caledonian structures (e.g. F_1c).

MAJOR STRUCTURES OF THE FIRST DEFORMATION (D_1k)

The structure of the Vargsund district is dominated by numerous NE-SW trending, upright, periclinal F_1k folds with wavelengths of 1–5 km (Plate 2). the distinctive ridge and valley topography of the district is a consequence of erosion along the synclinal cores of these folds which are occupied by comparatively soft sediments (dolomites, shales etc.) of the Porsa Group. The intervening anticlines are cored by more resistant greenstones of the Nussir Group and the axial culminations form whale-back ridges such as Stortinden, Middagstinden and Midterfjellet. Some of these structures are rather persistent. For example, the broad Kvalsund Syncline is continuous for 20 km from the coast of the Kvalsund to Storvatnet where the structure passes beneath the Caledonian nappes.

Folding of the Saltvatn Group is most obvious at the boundary with the Holmvatn Group. East of Indrevatn the primary contact has been folded into a major NE-plunging coupled fold with axial planes dipping steeply SE and a wavelength of about 2,5 km. North of Magerfjellet, the folding of the contact is increasingly tight and further northeast, south of Ulveryggen Mine, the contact is no longer primary in nature due to the imposition of large strains. The Ulverygg Formation is most intensely folded in the Ulveryggen area where fold wavelengths of 200–700 m are common. Some of these folds are broken by faults along their axial planes, and subsequently intruded by sheets of metagabbro.

One of the most significant structures in the area is the major thrust separating the Nussir Group greenstones on Skinnfjellet from the Saltvatn Group metasediments to the south, referred to here as the Nussirjav'ri Thrust. Between Skinnfjellet and Nussir, bedding in the Saltvatn Group exhibits a right-angle discordance to the thrust contact (Plate 1). The thrust is usually poorly exposed but on the east flank of Skinnfjellet it is possible to approach to within a few metres of the dislocation. South of the contact Dypelv Formation conglomerates have been

Fig. 18. Early Svecokarelian (F_1k) folds of similar style affecting layering in thinly interbedded siltstones (light) and dolomitic sandstones (dark) of the Bierajav'ri Formation.

converted to phyllonitic greenschists by strong shearing along the dislocation. An intense foliation (S_1k) dips steeply SE and is coated with slickenside fibres which indicate overthrusting to NW according to the interpretation of Durney & Ramsay (1973). In the vicinity of the thrust zone, pebbles in the conglomerates have prolate shapes. The principal extension axis plunges steeply in the foliation and indicates strong sub-vertical extension during the thrusting movements. Towards Nussir-jav'ri, the displacement on the thrust decreases and is minimal along the northern flank of Nussir.

In our view, there is little evidence in the field for the major north-westward dipping thrust along the contact between the Saltvatn and Nussir Group on the southern flank of Nussir, proposed by Reitan (1963), p. 21, Fig. 13B. All other Svecokarelian structures indicate that the transport direction involved over-turning/overthrusting towards the NW, and not SE as required by Reitan's intepretation. Reitan's postulated thrust is, moreover, unlikely to be a product solely of the Caledonian orogeny which did involve SE-directed translation. We prefer to interpret this contact as a normal stratigraphic boundary, as described earlier.

MINOR STRUCTURES OF THE FIRST DEFORMATION (D_1k)

Mesoscopic folds of the first generation (F_1k) are only well developed in finely bedded metasediments of the Porsa Group in which multilayer systems of highly contrasting ductility are present. The underlying Holmvatn, Saltvatn and Nussir Groups consist for the most part of poorly layered metabasaltic lavas and massive

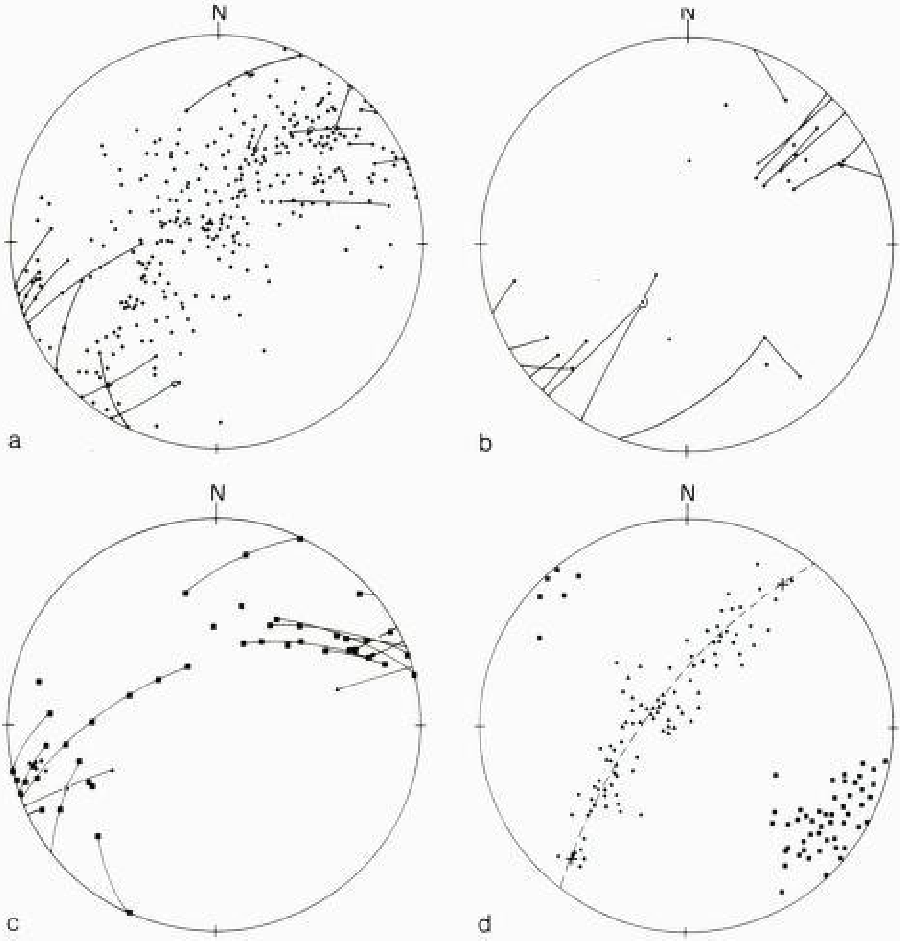


Fig. 19 a: Stereonet of minor fold axes (F_1k) from the northern part of the Komagfjord Window. Tie lines indicate range of variation at individual localities. The projection used for this and subsequent stereonets is the Lambert Equal Area Projection.
b: Stereonet showing the orientation of major fold axes (F_1k) in the northern part of the Komagfjord Window. Tie lines indicate range of variation within individual folds.
c: Stereonet of minor fold axes (F_1k) from the Bierajav'ri syncline. Tie lines indicate range of variation on individual noncylindrical folds. ● folds in crest ■ folds in limb.
d: Stereonet of early Karelian (D_1k) structures in the Kvalsunddal Syncline. Broken line indicates modal attitude of axial plane.
● minor fold axis + major fold axis ▲ fibre lineation ■ cleavage.

metasandstones which behaved in a competent fashion, so that mesoscopic structures are rarely developed.

Fold style varies from open concentric folding in thick competent sandstone and dolomite beds to tight, upright, similar folds (Fig. 18) in thin dolomite or sandstone bands interbedded with shale or limestone. Many folds exhibit strong limb attenuation and pronounced hinge thickening in a general transposition of the bedding into the S_1k tectonic fabric. A synoptic diagram (Fig. 19a) of minor

F_1k folds from the northern part of the window shows fold axes distributed into a broad NE-SW trending girdle coinciding with the modal axial planes to the major folds. The minor fold population displays a greater range of orientation than the large host folds (Fig. 19b). Figs 19c and 19d are typical examples of this incongruous relationship between parasitic minor folds and the host structure. In the Bierajav'ri Syncline (Fig. 19c), however, some of the minor folds in the hinge zone of the main fold are congruous with the host and it is in the much more highly strained limbs that they become incongruous. This is the relationship termed 'aberrant' by Ramsay & Sturt (1973), falling between the regularity of the Pumpellyan relationship and the apparent disorder of the incongruous relationship.

TECTONIC FABRICS PRODUCED DURING THE FIRST DEFORMATION

To the south of the area described here, the Raipas Supergroup is recrystallized in the epidote-amphibolite facies (Reitan 1963). Study of inclusions in porphyroblasts of garnet and hornblende reveals that the peak of regional metamorphism (M_1k) was attained under static conditions soon after the end of the first phase of folding (Pharaoh 1980). Locally a second schistosity (S_2k) is penetrative in development. In the area described here, however, there is only one penetrative foliation, a tectonic fabric (S_1k) of variable intensity produced during the first phase of deformation.

The S_1k cleavage is best developed in pelitic metasediments of the Porsa Group, particularly the Kvalsund and Bierajav'ri Formations, in which a penetrative slaty cleavage (S_1k) is developed axial planar to minor folds, with some refraction in multilayer sequences. The slaty cleavage is defined by the strong parallel alignment of sericitic mica. There is no indication that metamorphism exceeded low greenschist facies conditions. In carbonate-rich lithologies, e.g. dolomites of the Vargsund Formation and carbonate horizons of the Bierajav'ri Formation, pressure-solution may give rise to a spaced cleavage, in which carbonate-rich domains are separated by stripes of insoluble micaceous material 0.1–0.5 mm wide. Cleavage is less obvious in sandy horizons, and again takes the form of a spaced cleavage. In the Vargsund district the S_1k cleavage in the Porsa Group metasediments dips steeply NW. Throughout the remainder of the window, the S_1k foliation dips towards the SE except where refolded by F_2k. The north-westerly dip of S_1k in the Vargsund district is therefore anomalous and is believed to be a consequence of Caledonian rigid body rotation. A steeply plunging fibre lineation on S_1k cleavage surfaces, sometimes emphasised by trains of idioblastic magnetite grains, is found throughout the area.

Metabasalts of the Nussir Group generally show only a poor foliation, except in localised zones of high strain, e.g. in the vicinity of the thrust contact with the Saltvatn Group. In fine-grained tuffs and tuffites, the S_1k cleavage may be well developed, while nearby metabasalts contain only a very poor fabric. Reitan (1963) recognised that the primary basaltic mineralogy is totally recrystallised to a paragenesis typical of spilitic rocks, i.e. chlorite + albite + actinolitic amphibole $\pm$ epidote $\pm$ sphene $\pm$ opaques. The original igneous texture is frequently well

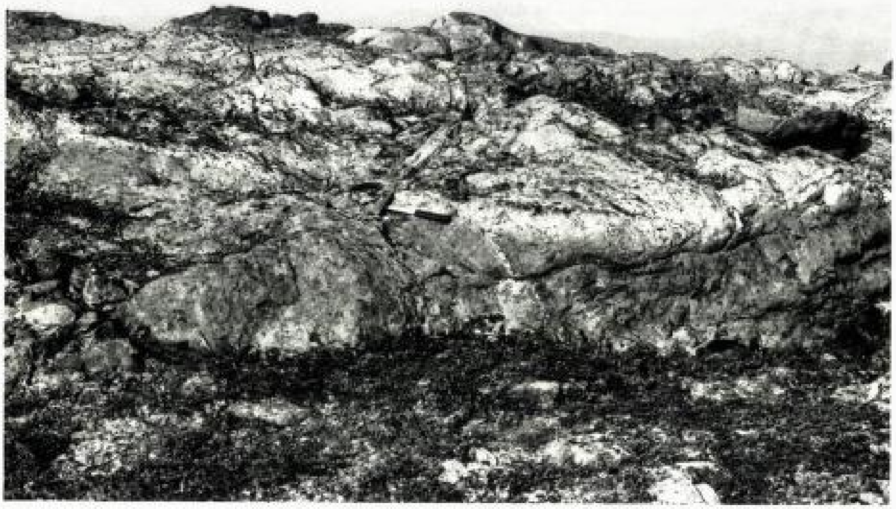


Fig. 20. Intrusive contact of a metagabbro of the Raudfjell Suite (dark weathering, in foreground) emplaced into metaquartzites of the Ulverygg Formation, south of Hansvatn.

preserved, although calcic plagioclase is now pseudomorphed by albite. Similarly, original pyroxene has been completely replaced by actinolite in 'uralite' pseudomorphs. These spilitic assemblages are attributed to greenschist facies regional metamorphism rather than sea-floor alteration or metamorphism.

The Saltvatn Group metasediments show a highly variable development of the S_1k foliation. In sandy or silty horizons at the top of fining-upward cycles, a penetrative schistosity is developed, which passes into a spaced, anastomosing cleavage in coarser grained lithologies. The foliation is defined by narrow zones of mica in strong preferred orientation, separating quartz-rich domains in which the processes of grain-rotation and pressure-solution/precipitation were dominant. Muscovite is found throughout the outcrop of the Ulverygg Formation, while the Dypelv Formation conglomerates invariably have a high chlorite content. In the Ulveryggen district, the Ulverygg Formation contains the assemblage quartz + albite + epidote + biotite indicative of the upper greenschist facies.

The Holmvatn Group supracrustal lithologies are almost entirely in the upper greenschist facies in the area under investigation and contain more intense fabrics than the other groups. About 2 km south of Holmvatn, blue-green hornblende recrystallises from actinolitic amphibole, a process which, together with metamorphic differentiation and bedding transposition, leads eventually to the destruction of primary textures. In this district, the S_1k schistosity dips steeply to SE and may contain a steeply plunging mineral lineation (L_1k). Blue-green hornblendes collected from a number of localities in the vicinity of Breidalen and

Småhaugene, south of the area described here, yield $^{40}K-^{40}Ar$ ages of about 1840 Ma, interpreted as a cooling age for the Svecokarelian orogeny (Pharaoh et al. 1982).

STRUCTURES PRODUCED BY LATER DEFORMATION

In the area described, mesoscopic folds of the second Svecokarelian phase of deformation (F_2k) are rather rare and are restricted almost exclusively to the vicinity of the Nussirjav'ri Thrust and the more intensely deformed rocks of the Holmvatn Group. The intensely penetrative phyllonitic foliation developed in the footwall and hanging wall of the thrust is folded by a second generation of folds, most having the style of chevron or kink-folds. These are virtually coaxial with the F_1k folds and are associated with crenulation cleavages which dip steeply to SE. F_2k folds are developed in the Holmvatn Group rocks in the south of the area of Plate 1, and become increasingly common southwards. Associated with the F_2k folds is an axial planar crenulation cleavage (S_2k) which dips to SE, and is accompanied by upper greenschist facies retrogression of the amphibolitic rocks. In some places, this S_2k fabric is of penetrative intensity. A later generation of folds associated with intense axial planar crenulation cleavages in the Vargsund district, which are well displayed in the road-cuttings from Kvalsund to Neverfjord, is probably of Caledonian rather than Svecokarelian age.

Svecokarelian synorogenic intrusions

During the Svecokarelian orogeny, a large number of basic and ultrabasic intrusions were emplaced, particularly in the southern part of the area described. Many of these intrusions are shown on the map of Reitan (1963), e.g. intrusive complexes at Raudfjell and south of Skinnfjellet and many minor intrusions, particularly in the Ulveryggen district. As Reitan recognized, the grade of metamorphism of the intrusions is comparable to that of the host rocks, and this led him to propose that the intrusions were of Precambrian age.

Our mapping has revealed the presence of a number of previously undiscovered intrusions, including a large metagabbroic body which occupies much of the summit of Skinnfjellet, the highest mountain in the district. It has been shown that the intrusions were injected along planes of weakness produced during the first phase of deformation, post-dating the F_1k folding (Pharaoh 1980). In view of their metamorphic grade, the intrusions must have been emplaced during the M_1k static regional metamorphic peak, immediately after the end of the first phase of folding. Some of the intrusions are affected by later (F_2k) folding. Petrological and geochemical studies have revealed that the peridotities, norites and gabbros of this intrusive suite are coeval and cogenetic (Pharaoh 1980). We refer to this group of intrusive rocks as the Raudfjell Suite. The petrological and geochemical variation visible in the Raudfjell Suite can be explained by closed-system fractionation of bodies of tholeiitic basaltic liquid derived by partial melting of the upper mantle. The present level of exposure provides a series of sections at various levels through a number of separate basic/ultrabasic layered intrusive complexes (Pharaoh 1980). In the southern district of the window, intrusions of trondhjemitic composition are also found injected into the supracrustal rocks (Fig. 3), as recognized by Reitan (1963). Intrusions of this Kvitfjell Suite (Pharaoh 1980) have not so far been identified within the area of Plate 1, however.

It must be emphasised that the close association of pillow lavas, layered gabbros and peridotites is a purely coincidental one. Contrary to the opinion of some workers (e.g. Gayer, pers. comm. in Rhodes 1976) the association of Raipas pillow lavas and Raudfjell Suite intrusions cannot be interpreted as an ophiolitic assemblage, for these magmatic suites are temporally and chemically distinct (Pharaoh 1980).

Stratigraphy of the ?Vendian Lomvatn Formation

Reitan (1963) mapped the Lomvann formation as a thin metasedimentary sequence resting unconformably upon the Raipas rocks and confined to the north-east and south-east margins of the Komagfjord Window (Fig. 3), truncated by the Kalak Thrust plane. In a later paper (Reitan 1965) he suggested that the Lomvann formation might be equivalent to the Borras Group (Føyn 1964) of the Alta district. A similar correlation was made by Roberts & Fareth (1974). Jansen (1976) demonstrated that the Lomvann formation also occured in the west of the Komagfjord Window and was able to map it as a continuous formation from Saraby in the north to Korsfjord in the south. He was able to demonstrate the occurrence of an angular unconformity beneath the Lomvann formation at a locality west of Hermannvatn. Rhodes (1976) demonstrated similar relationships at localities on the Dåg'gejåkka, where the Lomvann formation overlies the Dåg'gejåkka Formation with strong angular unconformity. In this paper, we formally rename the Lomvann formation of Reitan (1963) the Lomvatn Formation, in accordance with modern Norwegian usage. The present study divides this formation into two members.

Hermannvatn Member

At Hermannvatn (FD 006083), metasandstones of the Ulverygg Formation are overlain with strong unconformity by the basal sequence of the Lomvatn Formation, as described by Jansen (1976). A 0.3–1.0 m-thick bed of well-sorted, grain-supported, quartz conglomerate is followed by up to 15 m of well-bedded pale grey-greenish quartz arenites, which become more feldspathic upwards (Fig. 21). Some of these sandstones exhibit planar cross-bedding. As Jansen (1976) has shown, this sequence demonstrates inconstant thickness. At Storvatn, 2.5 km further north (ED 995102), this member is about 24 m thick and rests unconformably on the Kvalsund Formation. The basal conglomerate is 2 m thick and is dominated by well-rounded pebbles of vein quartz and metasandstone, with subsidiary amounts of greenstone fragments and slate. All of these lithologies are present in the subjacent basement. A thin, grey, matrix-supported conglomerate (diamictite) is of localised development in this area.

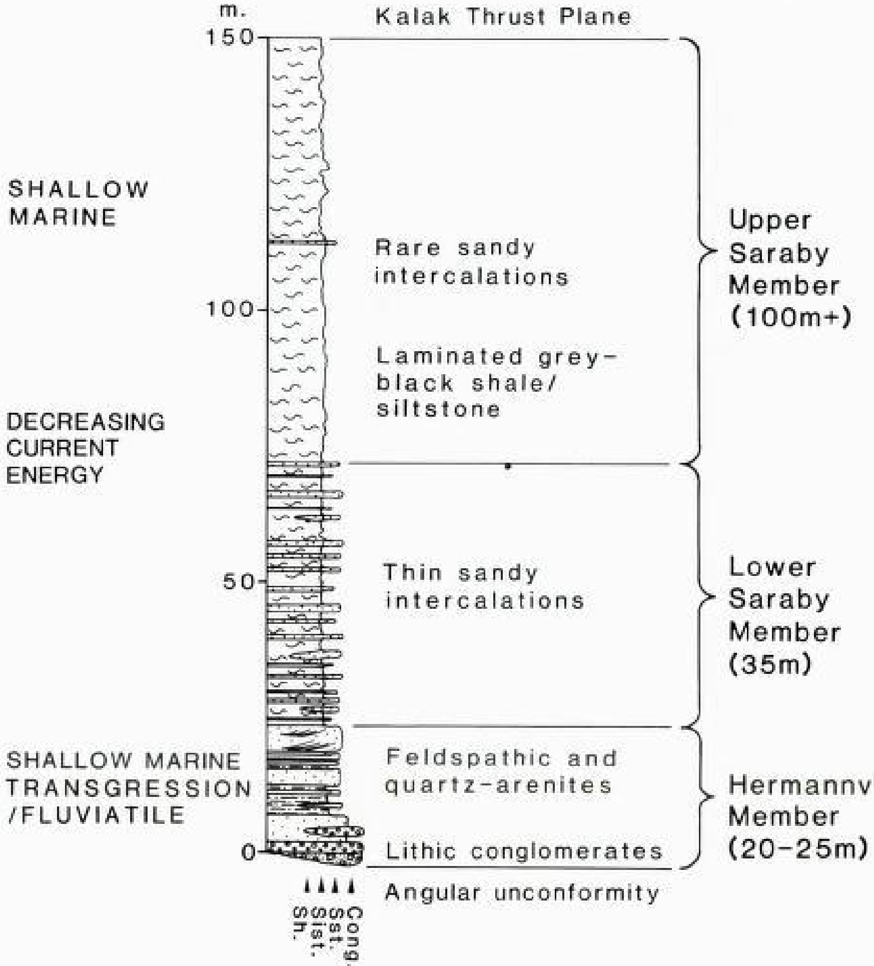


Fig. 21. Lithostratigraphic column for the Lomvatn Formation in the Storvatn–Hermannvatn district.

Just to the south of the area shown in Plate 1, in the vicinity of the Dåg'gejåkka (MU 053088), this same basal member is preserved by folding and imbrication into the underlying Dåg'gejåkka Formation. The angular unconformity of the Lomvatn Formation upon the Dåg'gejåkka Formation has been demonstrated by Rhodes (1976). At this locality, the sequence consists of at least 5 fining-upward cycles, each typically 2–5 m thick. Polymict, well-sorted and grain-supported conglomerates dominated by well-rounded pebbles of vein quartz, metasandstone and subordinate greenstone pass upward into brown-weathering, carbonate-cemented, feldspathic sandstones with tabular and trough cross-stratification, followed by grey feldspathic siltstones and sandstones. Higher in the sequence, some sandstones contain convolute lamination. The minimum thickness preserved is at least 16 m. On Raudfjell (MU 005163) the basal conglomerates and sandstones contain veinlets and cubic crystals of galena.

Saraby Member

The base of this member, which is well exposed beneath the Kalak Thrust plane east of Saraby (ED 987108), is taken at the top of the highest massive sandstone bed in the Hermannvatn Member. The Saraby Member is predominantly composed of grey or blackish parallel-laminated shales and siltstones finely interbedded with thin, pale-grey feldspathic sandstone bands, giving the member a distinctly striped appearance. The sandstones are usually less than 5 mm thick, but beds up to 2 cm thick are common and occasionally attain 20 cm in the lower part of the member. The sandstones are well-sorted and show little sign of grading. Both top and bottom contacts of sandstones are sharp. Sedimentary structures are rare, although ripple cross-lamination is occasionally found in the sandstones. The upper part of the member is virtually devoid of sandstone beds, and usually strongly affected by Caledonian deformation with a distinctly phyllitic appearance. The development of a strong slaty cleavage and truncation by the Kalak Thrust plane makes estimation of the depositional thickness for this member difficult, but at least 150–200 m are present in the Lomvatn area. This estimate is in close agreement with those of Jansen (1976) and Rhodes (1976), but not of Reitan (1963) who believed that at least 1000 m was present. The Lomvatn Formation has not yielded body or trace fossils to date.

Interpretation

Interpretation of the sedimentary character of the Lomvatn Formation is difficult because of the paucity of sedimentary structures and locally intense Caledonian deformation. The quartz conglomerate at the base of the Hermannvatn Member is interpreted as a basal conglomerate associated with a shallow marine transgression, many of the clasts being of local derivation (Jansen 1976). The overlying sequence of moderately mature sandstones was probably deposited in a shallow marine, near-shore environment. The variability in thickness of the Hermannvatn Member is possibly a reflection of irregularities in the palaeotopography. The fining-upward cycles recognized in the Dåg'gejåkka district may have been deposited in a fluviatile regime, as suggested by Rhodes (1976). Thicker sandstones with convolute lamination and siltstones at the top of the member were probably deposited in shallow-water marine conditions, as was the striped silty-shale/sand lithology of the Saraby Member.

Only the Markopp outcrop of the Lomvatn Formation is considered to be of parautochthonous status. All other outcrops contain a complete stratigraphy and appear to be fully autochthonous (cf. Rhodes 1976). In the absence of palaeontological evidence, the only positive evidence for the age of the Lomvatn Formation are the lead sulphide disseminations, which as Scott (1976) has described are found in the basal part of the Vendian-Cambrian sequence throughout the Caledonian foreland from S. Sweden to N. Norway. The Lomvatn Formation unconformably overlies the Kvalsund Formation west of Storvatn (Plate 1) and thus cannot be correlated with the latter, as proposed by Reitan (1963) and Rhodes (1976).

Recent work by T.C.P. in the area between Korsfjord and Skillefjord in the south-west of the Komagfjord Window has revealed the presence of a thin

Fig. 22. Tight early Caledonian (F_1c) folds of silty and sandy laminae within the Lomvatn Formation, Borsielv.

sequence of autochthonous sediments at low metamorphic grade, resting unconformably upon epidote-amphibolite facies rocks of the Raipas Supergroup (Fig. 3). This autochthonous sequence, locally tillite-bearing and here referred to as the Slettfjell Formation, has been correlated with the Vendian-Cambrian Vestertana Group (Reading 1965) of East Finnmark (Pharaoh 1980). Although the Slettfjell and Lomvatn Formations exhibit considerable lithological differences (Pharaoh, in press), they occupy very similar stratigraphic and structural positions with respect to the Early Proterozoic basement. We therefore support the Vendian age implied for the Lomvatn Formation by the correlations of Reitan (1965) and Roberts & Fareth (1974).

Caledonian structural history

INTRODUCTION

During the Caledonian orogeny, the Lomvatn Formation and underlying Precambrian basement in the Komagfjord Window formed part of the Caledonian autochthon. The cover sequence was interfolded with the reactivated Svecokarelian basement and then overthrust by a thick sequence of Caledonian thrust sheets.

FIRST PHASE OF DEFORMATION (D_1c)

The most significant major and minor-scale fold structures in the Lomvatn Formation were produced during the first deformation of the Caledonian autochthon (D_1c). The folding was strongly controlled by the mechanical

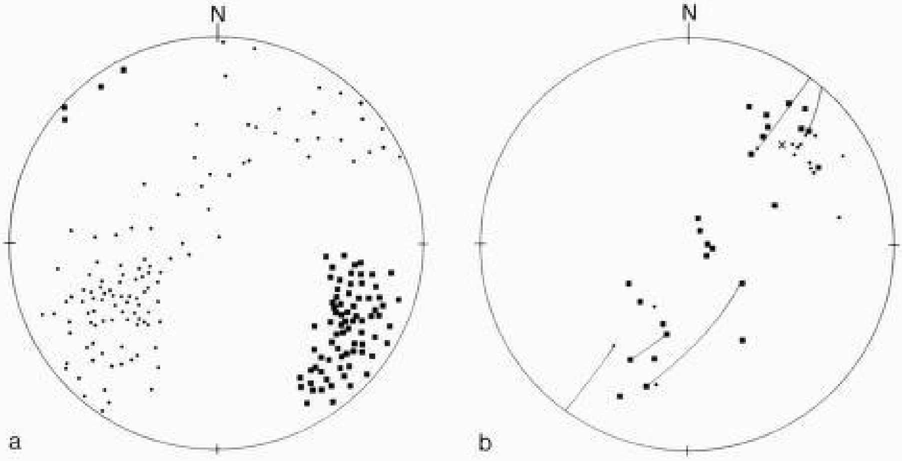


Fig. 23 a: Stereonet of early Caledonian (D_1c) structures in the Lomvatn Formation of the Storvatn–Hermannsvatn district ● minor fold axis ■ S_1c cleavages and fold axial plane.
b: Stereonet of early Caledonian (D_1c) structures in the Lomvatn Formation of the Borsielv–Raudfjell district. ● minor folds in crest ■ minor folds in limbs × host fold axis.

properties of the underlying Precambrian basement, leading to rather inhomogeneous strain in the cover sequence.

In the vicinity of the Vargsund, the deep synclinal cores of Porsa Group metasediments suffered further compression, with extension and break-thrusting in the limbs, during the Caledonian orogeny, and are associated with the deepest downfolds of the Lomvatn Formation. The cover in these zones is tightly folded by mesoscopic F_1c folds with axial planes which dip steeply north-westward. The orientation of fold axes is highly variable (Fig. 23a) and incongruous with respect to the host folds. In the coupled Borsielv fold the large host folds plunge north-eastwards at 15° (Fig. 23b). Congruous parasitic folds are developed in the hinges but diverge by up to 50° from that of the host in the highly strained steep limbs and approach the orientation of the fibre lineation (X'). In pelitic rocks, a penetrative slaty cleavage (S_1c) is developed virtually coplanar with the S_1k cleavage in the underlying Precambrian basement. At first sight these cleavages appear to have been produced by the same deformation, but the unconformity at the base of the Lomvatn Formation reveals that this clearly cannot be the case. In the Holmvatn Group, close to the contact with the Lomvatn Formation in the Raudfjell area, local strain complexities during the Caledonian deformation resulted in crumpling of the S_1k cleavage and development of an axial plane crenulation cleavage parallel to S_1c. Similar effects have been observed in the basement and cover west of Storvatn (Pharaoh 1980). The S_1c cleavage is a consequence of the preferred growth of sericitic white mica parallel to the Caledonian plane of flattening, no other metamorphic effects are recognized.

Radiometric data for the age of formation of the S_1c cleavage have not yet been obtained from the window, although this event is likely to have been contemporaneous with cleavage development in the autochthon of East Finnmark, dated by the Rb/Sr (λ ^{87}Rb x $1.39 \times 10^{-11}a^{-1}$) whole rock isochron method at 515 ± 7 Ma (Pringle 1973).

Nearer to Vargsund, Raipas dolomites and slates are strongly affected by cataclasis. The map of Reitan (1963) shows 'zones of closely spaced thrusts' in this area. Throughout the district, a planar fabric of variable but often mylonitic character is associated with a steep, north-westerly plunging stretching lineation. Where the basement is composed of more competent lithologies, however, e.g. metasandstone or greenstone, the cover sequence is noticeably less deformed and the cleavage less well developed. Along the coast of the Vargsund, a number of Caledonian thrusts are present in the basement. The most spectacular example is on the headland north of Porsa, where a break-thrust has developed on the limb of a pre-existing Svecokarelian anticline (Section A, Plate 1).

SECOND PHASE OF DEFORMATION (D_2c)

The emplacement of the Kalak Nappe Complex (Roberts 1974), a pile of thrust slices, containing components of pre-Caledonian basement and Caledonian metasedimentary cover (Sturt et al. 1978, Zwaan & Roberts 1978) post-dated the first phase of deformation (D_1c) in the Komagfjord Window. By the time this nappe complex reached the area of the window it had already suffered protracted and complex deformation involving polyphase folding and upper greenschist/amphibolite facies regional metamorphism (Sturt et al. 1978).

The post-D_1c age of emplacement is unequivocally indicated by the truncation of F_1c axial planes and S_1c cleavage in the Lomvatn Formation by the Kalak Thrust plane (Fig. 24). This late D_1c–D_2c event produced no recognisable folding on the major scale in the vicinity of the window. Mesoscopic F_2c kind-bands fold the S_1c cleavage in the Lomvatn Formation and refold F_1c folds of bedding. Quartz-filled extension fractures, frequently sigmoidal in shape, also cross-cut the S_1c cleavage and appear to have been produced in the same stress field as the kink-folds, with strong compression from the NW and subvertical extension. It is considered that these structures are manifestations of the stress field associated with the emplacement of the Kalak Nappe Complex across the autochthon. Pharaoh (1980) has interpreted the extension fractures as dilational fractures developed in the zone of high pore fluid pressure in the footwall of the Kalak Thrust plane.

Locally the Lomvatn Formation is involved in small parautochthonous nappes, underlain by thrusts with minor displacements imbricate to the Kalak Thrust plane. The parautochthonous nature of the Lomvatn Formation at Markopp was recognized by Reitan (1963) and shown as such on his map. As Rhodes (1976) has described, the Markopp Nappe exhibits a more complex strain history than the autochthonous Lomvatn Formation. F_1c folds are isoclinal in style and are associated with an axial plane phyllitic foliation which dips gently north-east, at a much lower angle than the S_1c cleavage in the autochthonous sediments. The first foliation is folded by two further generations of mesoscopic folds. At the base of the Markopp Nappe, a zone of intense shearing has led to truncation of the normal Lomvatn stratigraphy, resulting in the absence of the basal sandstone

Fig. 24. Basal Caledonian (Kalak) Thrust plane at Storvatn. Pale-weathering Precambrian dolomites are exposed around the lake and are unconformably overlain in the middle distance by the dark-weathering Lomvatn Formation. The Kalak Thrust is exposed at the base of the prominent line of crags (arrowed) and truncates the sub-vertical S_1c cleavage in the Lomvatn Formation.

member. Rhodes (1976) has suggested that the majority of the Lomvatn Formation in the east of the window is in fact of parautochthonous status. In our view, the evidence for this is much less clear than that for the Markopp Nappe, and we regard the Lomvatn Formation of the Borsielv–Lomvatn district as fully autochthonous. It seems likely that reactivation of early Caledonian thrusts imbricate to the Kalak Thrust plane occurred as the Caledonian nappes were emplaced.

THIRD PHASE OF DEFORMATION (D_3c)

A final phase of deformation affected the Lomvatn Formation subsequent to the emplacement of the Kalak Nappe Complex for the Kalak Thrust Plane is folded by a series of gentle folds on SW-NE axes. These large-scale, low-amplitude structures are responsible for the disposition of basement culminations such as the Repparfjord–Komagfjord and Alta–Kvænangen Windows (Fig. 1) within the Finnmark Caledonides. The outward radial dip of the autochthonous Vendian sediments is one consequence of these late, major-scale folds. No small-scale structures or fabrics are identified in association with this deformation. SW-NE trending normal faults with minor displacements which cut the Kalak Thrust plane probably developed in a relaxational phase after this third deformation. The present form of the Komagfjord Window is a consequence of post-Caledonian erosion of a D_3 culmination.

Summary

An extensive revision of lithostratigraphic nomenclature for Early Proterozoic 'Raipas' supracrustal rocks exposed in the Repparfjord–Komagfjord Window is presented. The Holmvann formation of Reitan (1963) is formally elevated to group status (Holmvatn Group) and divided into three lithostratigraphic formations, comprising a sequence of metamorphosed conglomerates, lithic sandstones and volcanic rocks at least 3 km thick. The Saltvatn Group rests unconformably upon the Holmvatn Group and contains at least 3 km of metamorphosed lithic conglomerates and sandstones developed in three formations. The Doggeelv formation (Reitan 1963) or Dåg'gejåkka Formation (this work) is considered to be of Karelian age and is correlated with the Saltvatn Group. Sedimentological differences between the formations are explained by a model invoking facies variation in a coast-marginal/shallow-marine environment. Volcanic rocks of the Nussir Group (new term) overlie the Saltvatn Group on Nussir, although the relationship is obscured by faulting elsewhere. The Nussir Group comprises two formations of metamorphosed submarine basaltic lavas and volcaniclastic rocks, about 2 km thick in total. Carbonate and pelitic sediments, including the Kvalsund Formation (Reitan 1963), are dominant in the 1 km-thick Porsa Group (new term) which overlies the Nussir Group. These sediments were deposited under shallow-marine conditions.

All of the above stratigraphic units (4 groups, comprising 11 formations) are part of the thick (c. 8 km) supracrustal sequence previously described as the Raipas system (Dahll 1868), formation (Holtedahl 1918), suite (Reitan 1963) or Raipas Group (Gautier 1977, Fareth 1979). We consider that the Raipas merits sufficient standing on the above grounds to warrant the formal stratigraphical status of a supergroup. In view of the considerable volcanic and sedimentary facies variation displayed by these supracrustal lithologies, detailed correlation with rocks of similar age elsewhere in northern Norway seems imprudent. However, some consideration is given to the general similarities of the rock suites.

The supracrustal lithologies described above were polyphasally deformed during the Svecokarelian orogeny, c. 1840 Ma ago. The first phase of folding established the major tectonic framework of the area investigated. Prograde regional metamorphism, which attained its peak soon after the end of the first fold phase, cause severe recrystallisation of the primary mineralogy under greenschist facies metamorphic conditions. Metamorphic grade increased from NW to SE and just to the south of the area described, locally reached the epidote-amphibolite facies. At about the same time, large volumes of basaltic magma were emplaced into the upper levels of the Svecokarelian orogen and underwent closed-system fractionation to yield differentiated peridotite-norite-gabbro intrusions of the Raudfjell Suite. Later Svecokarelian deformation was diaphthoretic in aspect and rather localised in development.

The Lomvatn Formation unconformably overlies the Raipas Supergroup around the northern margin of the Repparfjord–Komagfjord Window. The formation consists of a thin (<200 m thick) unfossiliferous sequence of conglomerates, sandstones and siltstones deposited under shallow-marine conditions. Comparison

with autochthonous sedimentary sequences in the southern part of the window and the neighbouring Alta–Kvænangen Window suggests that the Lomvatn Formation is of probable Vendian age.

Both the Svecokarelian basement and the ?Vendian cover were deformed during the Caledonian orogeny. In the first phase of deformation the Lomvatn Formation was folded and cleaved, while considerable reactivation of the Proterozoic basement occurred. The emplacement of the allochthonous Caledonian metamorphic nappe complexes seems to have accomplished surprisingly little deformation in the autochthon. The final phase of Caledonian deformation produced low-amplitude and long-wavelength flexures of the Kalak Thrust plane. These folds were subsequently eroded to produce the observed outcrop pattern of the window.

Acknowledgements. – We gratefully acknowledge the assistance given to us by Erling Svendsen and Rolf Storvik of Porsa and Werner Daniloff of Neverfjord during the course of the fieldwork. We also thank Anne Thwaites and Yvonne Hall who typed the manuscript and Christine Cochrane who prepared the folding plates and some of the diagrams. Maurice Tucker and Fred Hubbard reviewed the manuscript and suggested many improvements. The authors also wish to acknowledge financial support from the Natural Environment Research Council and the Research Fund of the University of Newcastle upon Tyne.

REFERENCES

Allen, P. 1975: Wealden of the Weald: a new model. *Proc. geol. Assoc. 86*, 389–437.

Barth, T.F.W., and Reitan, P.H. 1963: In Rankama, K (ed.) The Precambrian Vol. 1. Interscience Publ., New York, 27–80.

Carlisle, H. 1963: Pillow breccia and their aquagene tuffs, Quadra Island, British Columbia. *J. Geol. 71*, 48–71.

Dahll, T. 1868: Om Finnmarkens geologi. *Vidensk. Selsk. Forh. 1867*, 213–222.

Durney, D.W. & Ramsay, J.G. 1973: Incremental strains measured by syntectonic crystal growths: pp. 67–96 in *Gravity and Tectonics*, K.A. De Jong and R. Scholten (eds), Wiley, New York, 502 pp.

Fareth, E. 1979: Geology of the Altenes Area, Alta–Kvænangen Window, North Norway. *Norges geol. Unders. 351*, 13–29.

Føyn, S. 1964: Den tillitførende formasjon gruppe i Alta – en jevnføring med Øst-Finnmark og med indre Finnmark. *Norges geol. Unders. 228*, 139–150.

Gautier, A.M. 1979: *Géologie de la fenêtre Précambrienne d'Alta–Kvaenangen (Partie N.E.), W. Finnmark, Laponie Norvégienne. D.Sc. Thesis. No. 1740*, l'Université de Genéve.

Geukens, F. & Moreau, J. 1960: Contribution á la géologie de la region de Talvik. *Int. Geol. Cong. XXI. Pt. IX*, 192–200.

Hedberg, H.D. (Ed.) 1976: International stratigraphic guide. *A guide to stratigraphic classification, terminology and procedure.* John Wiley and Sons, New York.

Holmsen, P., Padget, P. & Pehkonen, E. 1957: The Precambrian Geology of Vest-Finnmark, Northern Norway. *Norges geol. Unders.* 201, 107 pp.

Holtedahl, O. 1918: Bidrag til Finnmarkens geologi. *Norges geol. Unders.* 84, 314 pp.

Jansen, O.J. 1976: *Strukturell og metamorf utvikling i den vestlige del av Komagfjord vinduet og overliggende dekker.* Unpublished Cand. Real. Thesis, University i Bergen.

Oftedahl, C. 1980: *Geology of Norway.* Contribution to the 26th International Geological Congress. *Norges geol. Unders.* 356, 3–114.

Pharaoh, T.C. 1976: *Geological report on the Komagfjord Tectonic Window, Finnmark, Norway.* Unpublished report, Geology Department, University of Dundee.

Pharaoh, T.C. 1980: *The Geological History of the Komagfjord Tectonic Window, Finnmark, Northern Norway.* Unpublished Ph. D. Thesis, University of Dundee.

Pharaoh, T.C., Macintyre, R.M. & Ramsay, D.M. 1982: K-Ar age determinations on the Raipas suite in the Komagfjord Window, Northern Norway. *Norsk geol. Tidsskr.* 62.

Pringle, I.R. 1973: Rb-Sr age determinations on shales associated with the Varanger Ice Age. *Geol. Mag. 109*, 465–472.

Ramsay, D.M. 1976: *A geological report on the Repparfjord–Neverfjord district*. Unpublished report, Geology Department, University of Dundee.

Ramsay, D.M. & Sturt, B.A. 1973: An analysis of non-cylindrical and incongruous fold patterns from the Eocambrian rocks of Sørøy, N. Norway: I and II. *Tectonophysics 18*, 81–121.

Reading, H.G. 1965: Eocambrian and Lower Palaeozoic geology of the Digermul Peninsula, Tanafjord, Finnmark. *Norges geol. Unders. 234*, 167–191.

Reitan, P.H. 1958: The structure in the area of mineralisation on Ulveryggen, Repparfjord, Finnmark. *Norges geol. Unders. 203*, 76–79.

Reitan, P.H. 1963: The geology of the Komagfjord tectonic window of the Raipas suite, Finnmark, Norway. *Norges geol. Unders. 221*, 71 pp.

Reitan, P.H. 1965: Correlation of the Doggeelv and Lomvann Formations, Komagfjord tectonic window, Finnmark: An alternative suggestion. *Norges geol. Unders. 234*, 192–5.

Reusch, H., Dahll, T. and Corneliussen, O.A. 1891: Det nordlige Norges geologi. *Norges geol. Unders.* 4, 204 pp.

Rhodes, S. 1976: *The geology of the Kalak Nappe and its relationship to the N.E. margin of the Komagfjord Tectonic Window, Finnmark, Norway*. Unpublished Ph.D. Thesis, University College of Wales, Cardiff.

Roberts, D. 1973: Hammerfest: Beskrivelse til det 1:250.000 berggrunns geologisk kart. *Norges geol. Unders. 301*, 66 pp.

Roberts, D. & Fareth, E. 1974: Correlation of autochthonous stratigraphical sequences in the Alta–Repparfjord region, West Finnmark. *Norsk geol. Tidsskr. 54*, 123–9.

Scott, B. 1976: Zinc and lead mineralisation along the margins of the Caledonian orogen. *Trans. Instn. Ming. Metall. 885*, ,B200–204.

Strand, T. 1952: Raipas og kaledon i strøket omkring Repparfjord, Vest-Finnmark. *Norges geol. Unders. 183*, 22–31.

Sturt, B.A., Pringle, I.R. & Ramsay, D.M. 1978: The Finnmarkian Phase of the Caledonian Orogeny. *J. geol. Soc. Lond. 135*, 597–610.

Torske, T. 1978: En proterozoisk aulakogen i Nord-Norges grunnfjell. Abstr. XIII Nord. Geol. Vinterm., Jan. 1978, Copenhagen, 72–73.

Vogt, J.H.L. 1907: *The Ripperfjord copper-ore-field at the Ripperfjord bay in Kvalsund*. Unpublished N.G.U. file.

Vokes, F.M. 1957: Some copper sulphide parageneses from the Raipas formation of Northern Norway. *Norges geol. Unders. 200*, 74–111.

Wennervirta, H. 1969: Karasjokområdets geologi, *Norges geol. Unders. 258*, 131–184.

Witt, T. 1907: Report about the visit at Ripperfjord in June 1907. Unpublished N.G.U. file.

Zwaan, K.B. & Gautier, A.M. 1980: Alta and Gargia. Description of the geological maps (AMS – M711) 1834I and 1934IV – 1:50.000 *Norges geol. Unders. 357*, 1–47.

Zwaan, K.B. & Roberts, D. 1978: Tectonostratigraphic succession of the Finnmarkian Nappe sequence, Northern Norway. *Norges geol. Unders. 343*, 53–71.

Appendix

The name *Raipas Supergroup* is proposed in the main text of this paper for the Early Proterozoic supracrustal (metasedimentary and metavolcanic) lithologies exposed in the tectonic windows of West Finnmark. The name Raipas was first used by Dahll (1868) who named his Raipas System after the mountain Lille Raipas in the Alta Window. Holtedahl (1918) and Reitan (1963) subsequently extended usage of the term to the remainder of the Alta Window and also the Repparfjord–Komagfjord Window. In the latter district, Reitan (1963) recognized two groups (and seven formations) of rocks, and therefore proposed that the Precambrian rocks of both windows be known as the Raipas suite. Although the name Raipas Group is currently in usage in the Alta–Kvænangen Window (Gautier 1977, Fareth 1979, Zwaan & Gautier 1980) we feel that recognition of four distinct lithostratigraphic groups and eleven formations in the Repparfjord–Komagfjord Window merits elevation of the Raipas to higher lithostratigraphic rank.

1. HOLMVATN GROUP

Name: Holmvatn is a small lake in the centre of the Repparfjord–Komagfjord Window, about 12 km south-west of Repparfjord. The name Holmvann formation was introduced informally by Reitan (1963) but it is proposed here that this unit be elevated to a group formally named the Holmvatn Group, and containing the following three formations.

a. Markfjell Formation

Name: Markfjell (FD 119012) is a mountain in the interior of the window, about 20 km SW of Repparfjord. This name was first proposed by Pharaoh (1980) in an unpublished thesis. The lithology was first described by Holtedahl (1918) who called it the 'greenstone conglomerate'.
Type area: slopes around Markfjell.
Thickness: unknown, but probably greater than 1500 m (Pharaoh 1980).
Lithology: polymict schistose conglomerate containing clasts of greenstone, granite, gneiss and metasediment in a sandy or tuffaceous matrix, with thin interbedded units of poorly sorted volcaniclastic sediments and lavas. Strongly deformed and largely metamorphosed in the epidote-amphibolite facies.
Boundaries: lower boundary has not been found. The upper boundary is taken at the top of the uppermost conglomerate bed.

b. Båtdalselv Formation

Name: Båtdalselv is a tributary of the Repparfjordelv, about 15 km SW of Repparfjord. The name was first proposed by Pharaoh (1980) in an unpublished thesis. This lithology has been referred to as the Angelvann Formation by Jansen (1976) and probably corresponds to the Borsielv and Brattelv Members of Rhodes (1976), though none of these units is adequately defined.
Type area: valley sides east and west of the Båtdalselv.
Thickness: difficult to estimate due to deformation, but at least 700 m.
Lithology: quartzo-feldspathic, dolomitic and amphibolitic schists containing structures indicative of a sedimentary or volcaniclastic origin, strongly deformed in places and largely metamorphosed in the upper greenschist or epidote-amphibolite facies.
Boundaries: lower boundary is the top of the uppermost conglomerate in the Markfjell Formation. The upper boundary is the base of the massive unit of metamorphosed pillow lavas described below as the Magerfjell Formation.

c. Magerfjell Formation

Name: Magerfjell (LU 906127) is a mountain just northeast of Holmvatn and about 10 km southeast of Repparfjord. The name was first proposed by Pharaoh (1976) in an unpublished report.
Type area: slopes below the summit of Magerfjell.
Thickness: rather variable. At least 1000 m in the type area, but thinning markedly away from this and locally absent due to pre-Saltvatn Group erosion.
Lithology: basaltic pillow lavas with subsidiary tuffaceous horizons metamorphosed in the upper greenschist or epidote-amphibolite facies.
Boundaries: lower boundary is at base of the pillow lavas which overlie metasediments and metavolcanics of the Båtdalselv Formation. The upper boundary is an unconformity at the base of the Saltvatn Group.

2. SALTVATN GROUP

Name: Saltvatnene are 2 large lakes (Øvre Saltvatn and Nedre Saltvatn) which lie about 10 km west of Repparfjord. The name Saltvatn group was introduced informally by Reitan (1963) but this unit is here formally renamed Saltvatn Group in accordance with modern Norwegian usage.

a. Ulverygg Formation

Name: Ulveryggen is a mountain about 3 km southwest of Repparfjord. Reitan (1963) informally introduced the name Steinfjell formation for this unit after the mountain Steinfjell shown southwest of Ulveryggen on the first edition of series M711. Unfortunately, this mountain is renamed Guoiratrašsa on the second edition of series M711, and the name Steinfjellet applied to another mountain, 5 km further north. To avoid confusion, the Steinfjell formation of Reitan (1963) is here formally renamed the Ulverygg Formation.
Type area: Ulveryggen.
Type profile: NW–SE traverse at Ulveryggen.
Thickness: at least 1000 m estimated by Reitan (1963).
Lithology: white or grey lithic, feldspathic and quartzitic sandstones containing lensoid bodies of lithic conglomerate. Moderately folded and metamorphosed in the greenschist facies.
Boundaries: where the contact is untectonised, the Steinfjell Formation rests unconformably upon the Holmvatn Group. The upper boundary is only primary between Repparfjord and Stangvatn. West of this, the boundary between the Ulverygg Formation and the Nussir Group is tectonic.

b. Dypelv Formation

Name: Dypelva is a small stream which drains the waters of Asajav'ri into Repparfjord. Reitan (1963) informally introduced the name Djupelv formation for this unit. On the second edition of M711, the stream is renamed Dypelva, however, so we propose that this unit be formally renamed the Dypelv Formation.
Type area: Saltvatn–Asvag'gi district.
Type profile: SW–NE traverse just to the northwest of Nedre Saltvatn.
Thickness: variable. At least 800 m in the type area but thicker in the west as a consequence of tectonic thickening.
Lithology: poorly bedded, green, polymict, lithic conglomerates containing pebbles of greenstone with interbedded sandstones, metamorphosed in the lower greenschist facies and strongly deformed in places (Reitan 1963).
Boundaries: the lower boundary is transitional (Reitan 1963) but a convenient base for the formation is the top of the highest bed of grey Ulverygg Formation sandstone. The upper boundary (poorly exposed) is the base of the first bed of Stangvatn Formation purple porphyrite conglomerate.

c. Stangvatn Formation

Name: Stangvatn is a small lake about 6 km southwest of Repparfjord and 2 km north of Nedre Saltvann. Reitan (1963) informally introduced the name Fiskevann Formation for this unit. On the new edition of M711, the lake named Fiskevann on the first edition map (as referred to by Reitan) is now renamed Asajav'ri, and the name Fiskevatn is transferred to another lake about 1 km to the northeast. The name Asavann has already been used as a stratigraphical name by Pharaoh (1980) in an unpublished thesis. To avoid confusion we prefer to rename this unit Stangvatn Formation.
Type area: district south of Stangvatn.
Type profile: SW-NE profile south of Stangvatn.
Thickness: at least 600 m in the type area (Pharaoh 1980).
Lithology: well-bedded, purple, lithic conglomerate containing pebbles of porphyritic dacite with interbedded arkosic sandstones, metamorphosed in the lower greenschist facies.
Boundaries: the lower boundary (poorly exposed) is taken at the top of the uppermost bed of green Dypelv Formation sandstone. The upper boundary is the top of the uppermost bed of purple arkosic sandstone underlying green banded tuffites of the Nussir Group. Although this upper contact is not well exposed, there is no evidence for a tectonic boundary as invoked by Reitan (1963).

d. Dåg'gejåkka Formation

Name: Dåg'gejåkka is a tributary of the Repparfjordelv which drains Dåg'gejav'ri, a large lake southeast of Repparfjord. The name Doggeelv formation was introduced informally by Reitan (1963) but as this stream is now renamed Dåg'gejåkka on the latest topographic maps, this unit is here formally named the Dåg'gejåkka Formation.
Type area: valleys of the Dåg'gejåkka and Repparfjordelv.
Thickness: Reitan (1963) estimated a thickness of at least 1500 m.
Lithology: well-bedded, white, quartzitic metasandstones metamorphosed in the lower amphibolite facies and strongly deformed.
Boundaries: the lower boundary is a primary contact, the Dåg'gejåkka Formation unconformably overlying the Holmvatn Group as recognized by Reitan (1963, 1965). Locally, however, the contact is tectonic. The upper boundary has not been found.
Correlation: the Dåg'gejåkka Formation is correlated in the main text with the Early Proterozoic Ulverygg Formation, although previous correlations (e.g. Reitan 1965, Roberts & Fareth 1974) have implied a Late Proterozoic age for the former formation.

3. NUSSIR GROUP

Name: Nussir is the hilly massif lying to the southwest of Repparfjord. The name Nusseren Group was first proposed by Pharaoh (1980) but the hill Nusseren is renamed Nussir on the latest edition of the topographic survey maps. The Nussir Group comprised the greenstone lavas, tuffs and tuffites which are shown in the main text to overlie the Saltvatn Group along the southern flank of Nussir. Reitan (1963) originally included these greenstones within his Holmvann formation, but as the Holmvatn Group (as defined above) underlies the Saltvatn Group, these two greenstone sequences can no longer be correlated.

a. Krokvatn Formation

Name: Krokvatn is a small lake on the southwest flank of Nussir, about 5 km southwest of Repparfjord. The name Asavann Formation was informally proposed by Pharaoh (1980) for this unit, but the lake named Asavann on the early edition of series M711 is renamed Fiskevatn on the new edition. The use of the name Fiskevatn Formation would be highly confusing in view of the terminology of Reitan (1963) so we prefer to rename this unit Krokvatn Formation.
Type area: southern flank of Nussir.
Type profile: N–S traverse across the southern flank of Nussir, east of Krokvatn.
Thickness: the original thickness was propably about 700 m (Pharaoh 1980).
Lithology: green mafic tuffs and tuffites interbedded with lensoid units of metabasalt up to 100 m thick. Metamorphosed in the lower greenschist facies.
Boundaries: lower boundary is at the base of the green banded tuffites which conformably overlie the Stangvatn Formation. The upper boundary is at the top of the highest interbedded tuffaceous horizon.

b. Svartfjell Formation

Name: Svartfjell is a mountain lying just east of the main Nussir massif, and about 2 km southwest of Repparfjord. The name Høgfjell Formation was first proposed for this unit by Ramsay (1976) in an unpublished report, after the mountain Høgfjell shown on the first edition of topographic series M711, about 2 km east of Neverfjord. In the new edition, however, this mountain is renamed Stortinden. The lower boundary of this unit is only exposed in the Nussir–Svartfjell district, so we prefer to rename this unit the Svartfjell Formation, rather than Stortinden Formation.
Type area: summits of Nussir and Svartfjell.
Type profile: N–S traverse across the summit of Nussir, just east of Krokvatn.
Thickness: at least 1000 m.
Lithology: a monotonous sequence of metabasaltic lavas, commonly exhibiting pillow texture, with subordinate horizons of tuff and breccia, and metamorphosed in the lower greenschist facies.

Boundaries: the lower boundary is only exposed along the southern flank of Nussir and is taken at the top of the highest interbedded tuffite horizon in the Krokvatn Formation. The upper boundary is considered to be an erosional contact with the Porsa Group disconformably overlying the Nussir Group (see main text).

4. PORSA GROUP

Name: Porsa is a village on the Vargsund coast, 18 km southwest of Kvalsund. The name was first proposed by Pharaoh (1980) for metasediments which overlie the Nussir Group in the northern part of the window. Some of these metasediments were incorporated within the Holmvann formation by Reitan (1963) but they are shown (in the main text) to overlie the Nussir Group and must therefore be allocated to a separate lithostratigraphic unit. Jansen (1976) suggested the name Porsavann Group for these metasediments and the underlying Høgfjell Formation lavas, but here we prefer to distinguish separate metavolcanic (Nussir Group) and metasedimentary (Porsa Group) units.

a. Vargsund Formation

Name: the Vargsund is the broad sound separating the island of Seiland from the mainland. The name was first proposed by Ramsay (1976) in an unpublished report.
Type area: Kvenvika, on the Vargsund coast.
Type profile: NW–SE profile just south of Kvenvika.
Thickness: variable. About 250 m east of Kvalsund, 80 m at Kvenvika and locally absent altogether. This variation is probably a consequence of both deformation and depositional variation.
Lithology: well-bedded dolomite, locally stromabolitic, with occasional thin shaly or quartzitic intercalations and a basal quartz pebble conglomerate. The dolomite is recrystallized and strongly silicified in places.
Boundaries: the lower boundary is the eroded surface of the Svartfjell Formation. The upper boundary is at the base of the graphitic slates of the Kvalsund Formation.

b. Kvalsund Formation

Name: Kvalsund is the name of the narrow sound separating the island of Kvaløy from the mainland,

and also of the chief harbour on that sound. The name Kvalsund formation was informally introduced by Reitan (1963).
Type area: district to the south and southwest of Kvalsund village.
Type profile: NW–SE traverse from Kvalsund.
Thickness: difficult to estimate because of deformation. Reitan (1963) estimated a minimum thickness of between 200 and 500 m.
Lithology: a monotonous sequence of greyish-black, well-cleaved, graphitic slates containing few sedimentary structures.
Boundaries: the lower boundary is sharp and is taken at the top of the highest dolomite bed in the Vargsund Formation. The upper boundary is also sharp and locally erosional in nature.

c. BIERAJAV'RI FORMATION

Name: Bierajav'ri (LU 900222) is a small lake about 3 km southeast of Kvalsund village and 3 km southwest of Repparfjord. The name Langørvann Formation was first proposed for this unit by Ramsay (1976) in an unpublished report. In the latest edition of topographic series M711, Langørvann is renamed Bierajav'ri. We propose that this unit be formally renamed the Bierajav'ri Formation.
Type area: valley to the east of Bierajav'ri.
Type profile: NW–SE profile east of Bierajav'ri.
Thickness: at least 300 m in the Bierajav'ri area, but thinner elsewhere.
Lithology: a rather heterogeneous lithological unit containing green tuffaceous lithologies, grey shales, sandstones and carbonates (locally stromatolitic).
Boundaries: the lower boundary is sharp as a consequence of local erosion of the Kvalsund Formation. The upper boundary has not been found.

Unconformable upon the Raipas Supergroup around the margin of the Repparfjord–Komagfjord Window are unfossiliferous sediments of supposed Late Proterozoic (Vendian) age.

LOMVATN FORMATION

Name: Lomvatn is a small lake about 3 km southeast of Repparfjord. The name Lomvann formation was informally introduced by Reitan (1963). This unit is formally named the Lomvatn Formation, in keeping with modern Norwegian usage.
Type area: district between Borsielv and Lomvatn.
Type profile: NW–SE traverse from Borsielv to Lomvatn.
Thickness: probably less than 200 m, although Reitan (1963) believed that at least 1000 m was present.
Lithology: the basal Hermannvatn Member consists of well-sorted quartz pebble conglomerates and feldspathic arenites, which pass upward into dark grey silty slates with thin sandstone laminae in the overlying Saraby Member.
Boundaries: the lower boundary is the angular unconformity at the base of the Lomvatn Formation. The upper boundary is not found due to tectonic truncation by the Kalak Thrust plane.

RECENT MAPS PUBLISHED BY NGU

(A list of earlier maps appears on the inside back cover of all Bulletins and Skrifter from and including Bulletin 20, NGU nr. 300)

MAPS PRINTED IN COLOUR (On sale from Universitetsforlaget, Nkr. 30,—)

1:250 000	Nordkapp		Bedrock geology
	Vadsø		—»—
	Mosjøen		—»—
1: 50 000	2028 I	Beiardalen	Bedrock geology
	1413 IV	Botsvatn	—»—
	1720 II	Brekken	—»—
	1716 I	Bruflat	—»—
	1719 II	Elgå	—»—
	1819 III	Grøthogna	—»—
	1916 IV	Hamar	—»—
	1916 I	Løten	—»—
	1720 III	Røros	—»—
	1918 III	Stor-Elvdal	—»—
	1918 II	Storsjøen	—»—
	1414 II	Sæsvatn	—»—

1:50 000	2028 I	Beiardalen	Quaternary geology
	2028 II	Bjøllådal	—»—
	2035 I	Børselv	—»—
	1816 IV	Dokka	—»—
	1816 II	Eina	—»—
	2435 II	Ekkerøy	—»—
	1717 III	Fullsenn	—»—
	2128 II	Graddis	—»—
	1916 IV	Hamar	—»—
	2128 III	Lønsdal	—»—
	1713 IV	Nordagutu	—»—
	1521 IV	Snillfjord	—»—
	1621 III	Støren	—»—

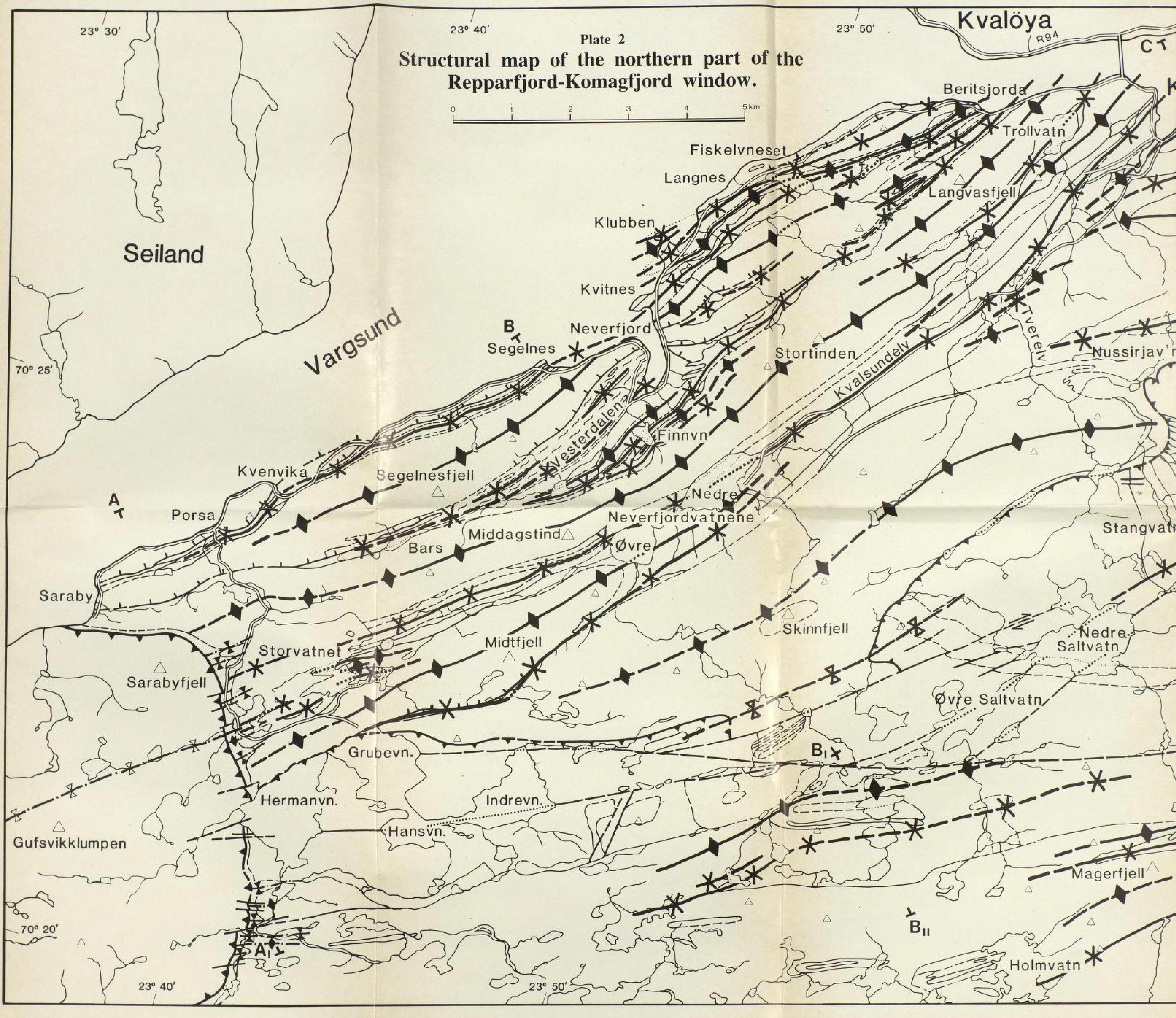
1: 20 000	Brandbu	CKL 057058–20	
	Elvenes	HUV 271727–20	
	Fåberg	CKL 073074–20	
	Gran	CMN 055056–20	
	Helgja	BWK 029030–20	
	Helgådal	CWX 135136–20	
	Jømna	CWX 065066–20	
	Kulstad	DMN 183184–20	
	Levanger	CST 133134–20	
	Lunner	CMN 053054–20	Quaternary geology
	Lygna	CMN 057058–20	—»—
	Mosjøen	DMN 181182–20	—»—
	Olderskog	DOP 181182–20	—»—
	Rokosjøen	CUV 065066–20	—»—
	Stiklestad	CUV 135136–20	—»—
	Tromsdalen	CUV 133134–20	—»—
	Vadsø	HST 281282–20	—»—
	Vardefjell	DOP 183184–20	—»—
1: 10 000	Helgja	BW 030–10	Quaternary geology

MAPS IN BLACK AND WHITE (on sale direct from NGU either as paper-copies (Nkr. 12,—) or as transparent-copies (Nkr. 60,—))

1:250 000	Kristiansund		Bedrock geology	(preliminary)
	Lillehammer		—»—	—»—
	Røros		—»—	—»—
	Stavanger		—»—	—»—
	Sveg		—»—	—»—
	Tromsø		—»—	—»—
1: 50 000	2135 I	Adamsfjord	Bedrock geology	(preliminary)
	1611 IV	Arendal	—»—	—»—
	1818 IV	Atnsjøen	—»—	—»—
	1313 I	Blåfjell	—»—	—»—
	1517 III	Borgund	—»—	—»—
	1414 III	Breive	—»—	—»—
	1814 II	Drøbak	—»—	—»—
	1512 III	Evje	—»—	—»—
	1218 II	Fimlandsgrend	—»—	—»—
	2017 III	Julussa	—»—	—»—
	1417 III	Kaupanger	—»—	—»—
	1417 I	Lustrafjorden	—»—	—»—
	1927 I	Mo i Rana	—»—	—»—
	1418 II	Mørkrisdal	—»—	—»—
	1824 I	Namsskogan	—»—	—»—
	1915 III	Nannestad	—»—	—»—
	1214 IV	Onarheim	—»—	—»—
	1520 I	Rennebu	—»—	—»—
	1818 I	Sollia	—»—	—»—
	2029 III	Strømøen	—»—	—»—
	2017 II	Søre Osen	—»—	—»—
	2135 II	Ul'lugai'sa	—»—	—»—
	2128 IV	Junkerdal	Quaternary geology	(preliminary)

Plate 2

Structural map of the northern part of the Repparfjord-Komagfjord window.



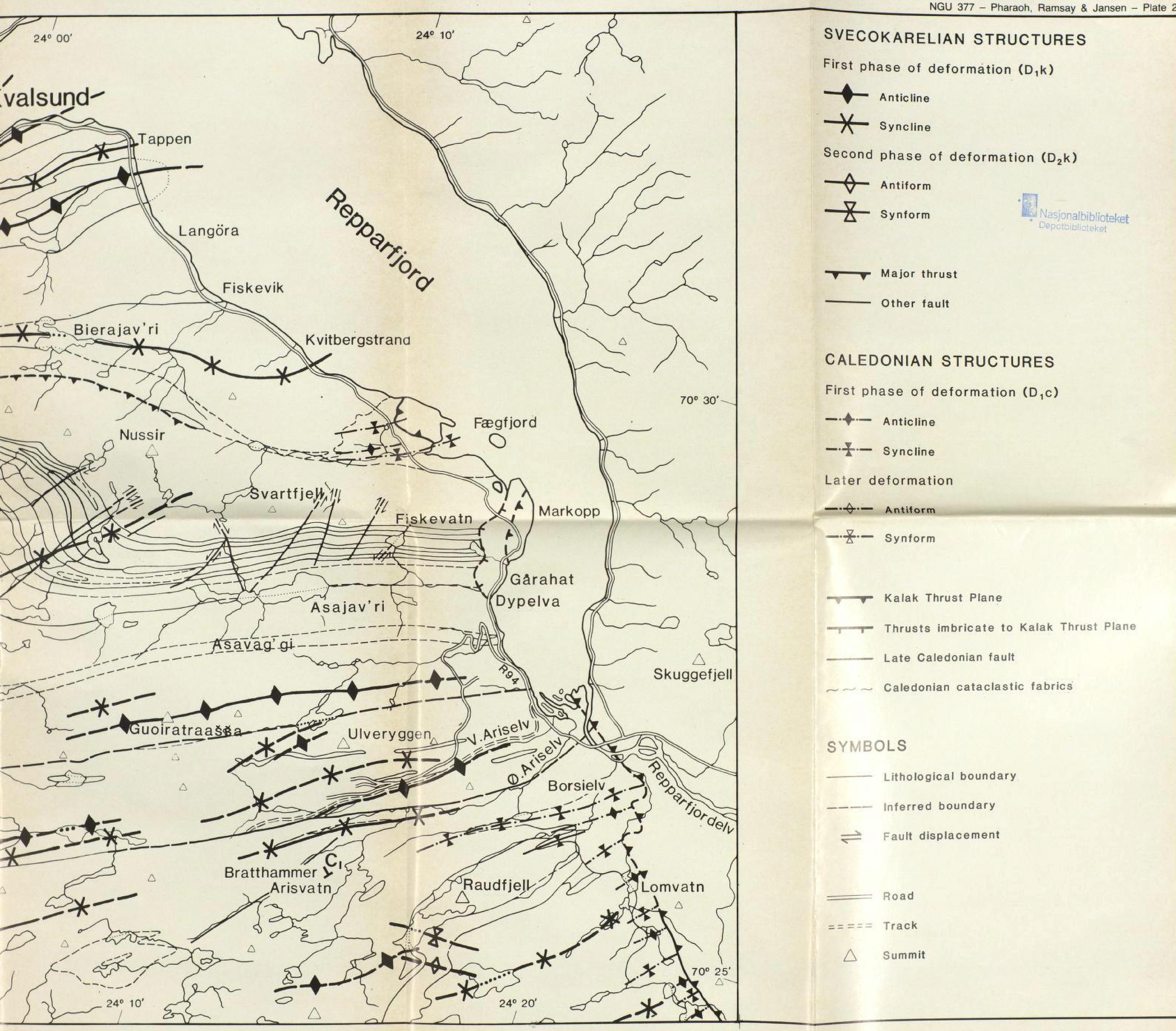
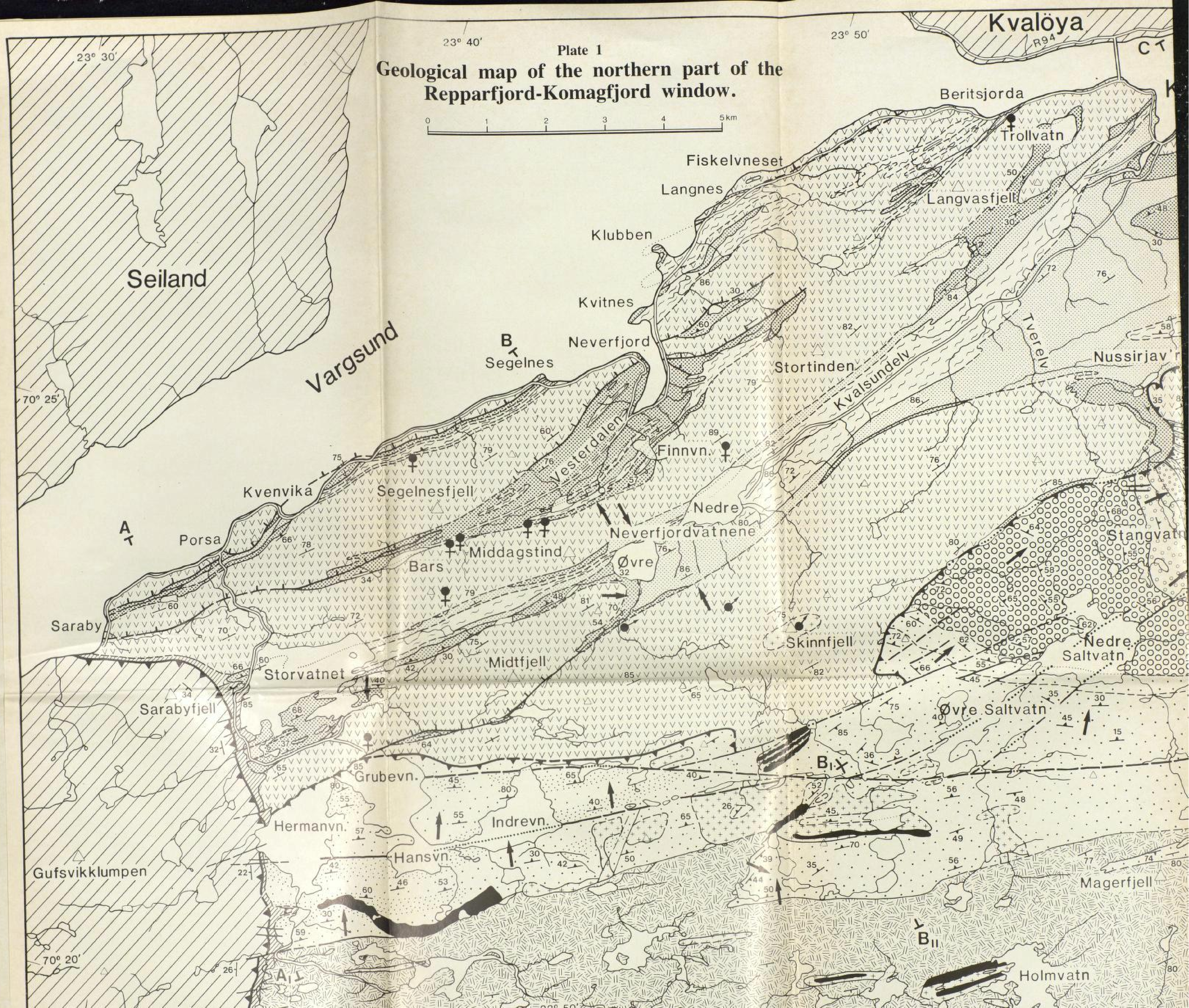
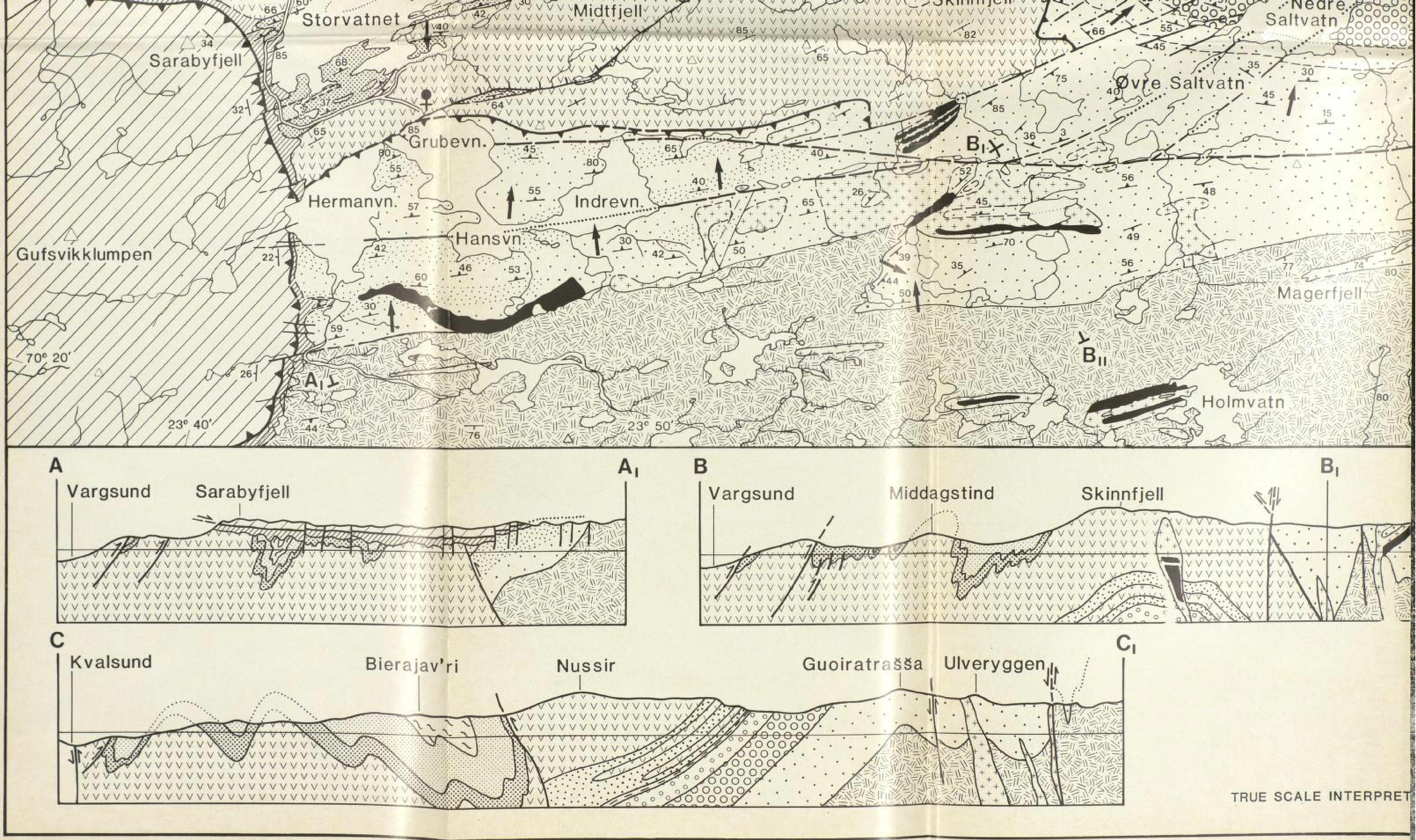

24° 00'
24° 10'
valsund
Tappen
Langöra
Repparfjord
Fiskevik
Bierajav'ri
Kvitbergstrand
Nussir
Fægfjord
70° 30'
Svartfjell
Fiskevatn
Markopp
Gårahat
Dypelva
Asajav'ri
Asavag'gi
R94
Skuggefjell
Guoiratraašša
Ulveryggen
V. Ariselv
Ø. Ariselv
Borsielv
Repparfjordelv
Bratthammer
Arisvatn
Raudfjell
Lomvatn
70° 25'
24° 10'
24° 20'
SVECOKARELIAN STRUCTURES
First phase of deformation (D1k)
Anticline
Syncline
Second phase of deformation (D2k)
Antiform
Synform
Major thrust
Other fault
CALEDONIAN STRUCTURES
First phase of deformation (D1c)
Anticline
Syncline
Later deformation
Antiform
Synform
Kalak Thrust Plane
Thrusts imbricate to Kalak Thrust Plane
Late Caledonian fault
Caledonian cataclastic fabrics
SYMBOLS
Lithological boundary
Inferred boundary
Fault displacement
Road
Track
Summit

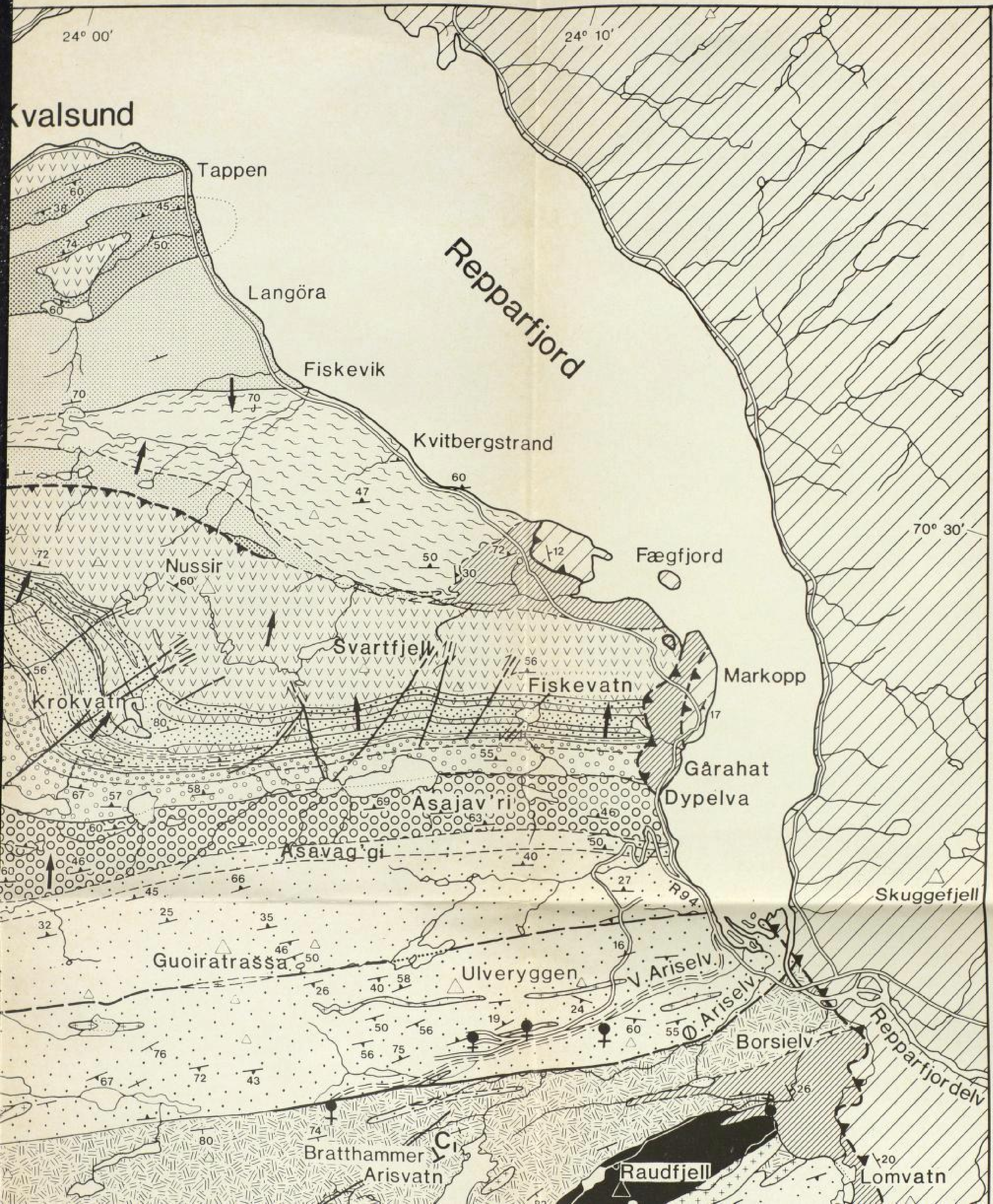
Plate 1

Geological map of the northern part of the Repparfjord-Komagfjord window.





Storvatnet
Midtfjell
Skinnfjell
Nedre Saltvatn
Sarabyfjell
Øvre Saltvatn
Grubevn.
Hermanvn.
Indrevn.
Hansvn.
Gufsvikklumpen
Magerfjell
Holmvatn
70° 20′
23° 40′
23° 50′
A
A1
B
B1
B11
C
C1
Vargsund
Sarabyfjell
Middagstind
Skinnfjell
Kvalsund
Bierajav'ri
Nussir
Guoiratrašša
Ulveryggen
TRUE SCALE INTERPRET



KALAK NAPPE COMPLEX (CALEDONIAN)

Psammitic schists (cover)
Gneiss, schist (basement) — Intrusions of Seiland Complex

AUTOCHTHONOUS METASEDIMENTS (? VENDIAN)

Siltstones/sandstones — Łomvatn Formation

RAIPAS SUPERGROUP (EARLY PROTEROZOIC)

Porsa Group

Metamorphosed shales, sandstones, tuffs, carbonates — Bierajav'ri Formation

Graphitic slates — Kvalsund Formation

Stromatolitic dolomite, thin orthoquartzites and basal conglomerate — Vargsund Formation

Nussir Group

Metabasaltic lavas, mostly pillowed, some massive — Svartfjell Formation

Bedded mafic metatuffite — Krokvatn Formation

Unbedded mafic tuffs

Saltvatn Group

Arkosic metasandstone
Metamorphosed purple porphyrite conglomerate — Stangvatn Formation

Metamorphosed greenstone conglomerate — Dypelv Formation

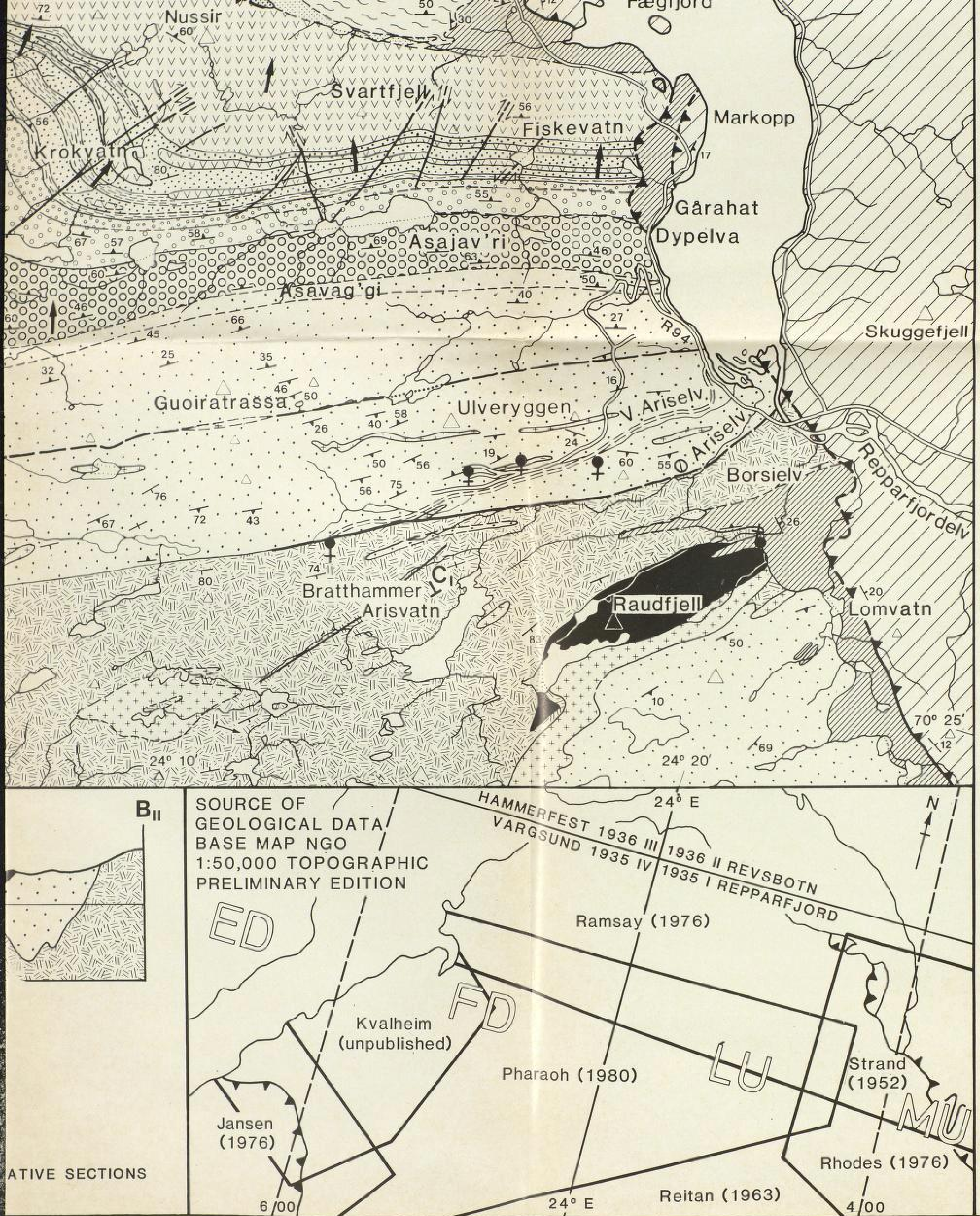
Conglomeratic horizons
Metamorphosed quartz/lithic arenites — Ulverygg Formation (Dåg'gejåkka Formation equivalent in S)

Holmvatn Group

Metamorphosed lavas, tuffs and sediments — Magerfjell Formation, Båtdalselv Formation, Markfjell Formation (undifferentiated)

SVECOKARELIAN INTRUSIVE ROCKS

Metagabbro



Nussir Group

Metabasaltic lavas, mostly pillowed, some massive	Svartfjell Formation
Bedded mafic metatuffite	Krokvatn Formation
Unbedded mafic tuffs	

Saltvatn Group

Arkosic metasandstone Metamorphosed purple porphyrite conglomerate	Stangvatn Formation
Metamorphosed greenstone conglomerate	Dypelv Formation
Conglomeratic horizons Metamorphosed quartz/lithic arenites	Ulverygg Formation (Dåg'gejåkka Formation equivalent in S)

Holmvatn Group

Metamorphosed lavas, tuffs and sediments	Magerfjell Formation Båtdalselv Formation Markfjell Formation (undifferentiated)

SVECOKARELIAN INTRUSIVE ROCKS

Metagabbro	Raudfjell Suite
Serpentinite	

SYMBOLS

Lithological boundary	Faulted contact
Inferred boundary	Inferred fault
Bedding, primary layering	Foliation
Overturned bedding	Younging direction
Road	Copper sulphide prospect
Track	Lead sulphide occurrence
Summit	Magnetite occurrence