GEOLOGICAL SURVEY OF NORWAY

EXCURSION GUIDE TO THE BEDROCK GEOLOGY OF VARANGER PENINSULA

by
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with contributions by David Roberts

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Sammendrag:

The Varanger Peninsula is underlain by weakly metamorphosed sedimentary rocks of Late Precambrian to Early Cambrian age. The rocks occur in two regions: the allochthonous Barents Sea Region (BSR) (northeastern half of the peninsula) and the autochthonous Tanafjorden-Varangerfjorden Region (TVR) (southwestern part of the peninsula), juxtaposed along a complex NW-SE-trending fault zone, the Trollfjorden - Komagelva Fault Zone (TKFZ). The sedimentary sequences of the two regions have accumulated under different conditions of deposition in separate sedimentary basins. In the TVR, the presence of tillites testifies to two separate periods of Late Precambrian glaciation. Rocks of the BSR were brought to their present position by dextral strike-slip movement along the TKFZ.

The sedimentary sequences in the two regions have been affected to a variable extent by the main Caledonian deformation, and they are dissected by dolerite dykes representing at least two periods of magmatism. Differences in the grade of metamorphism in the BSR and the TVR suggest that the rocks of the Barents Sea Region were affected by a deeper sedimentary and tectonic burial prior to their juxtaposition with rocks of the TVR.

Descriptions and interpretations of the sedimentary sequences of both basins are presented in the guide and 42 localities are described in which various parts of the stratigraphic sections may be studied.

Emneord		
berggrunnsgeologi	prekambrium	stratigrafi
sedimentologi	strukturgeologi	

CONTENTS:

The guide contains a key map of the excursion localities, several sketch maps and is illustrated with 16 plates with colour photographs.

PREFACE

This excursion guide starts with a brief description of the bedrock geology of the Varanger Peninsula in the county of Finnmark, Northern Norway. The development of geological research in this area and current understanding and interpretation of the geological history are presented. The section on tectonic deformation has been written by David Roberts. The bulk of the excursion guide consists of descriptions of 42 excursion localities. Stratigraphy and sedimentological aspects are emphasized in the locality descriptions and are supplemented with information on the structural geology. The localities, with few exceptions, are situated along the main roads and all have references to east and north coordinates and to the numbers and names of the 1:50,000 topographic maps produced by Norges geografiske oppmåling. A simplified map of bedrock geology in the scale 1 : 500,000 with indicated excursion localities is enclosed in the guide. However, it is recommended to have a copy of the 1: 250,000 bedrock geological map-sheet Vadsø (Siedlecki 1980) on hand, as a supplement to the guide.

The described excursion localities are situated along the following three main routes:

(1) From the southern part of inner Varangerfjorden to Hamningberg, along E6, highway 98 and a local dirt road. The total driving distance is c. 173 km (starting c.100 km from Kirkenes). Localities nos. 1 - 17 are located along this route (locality 1 requires walking, but it may also be reached by boat).

(2) From Varangerbotn to Berlevåg along E6 and highway 890. The total driving distance is about 132 km.
Localities 18 - 36 are situated along this route.

(3) From Gædnjajav'ri to Båtsfjord along highway 891 and further on to Syltefjord along a local dirt road. The total driving distance is about 60 km. Localities 37 - 41 are located along this route. Locality 42 requires c. 35 minutes walking.

Descriptions of the localities are organised according to a fixed standard. Each locality is described on a separate page and, in addition to the references to topographic maps, comprises key words referring to lithostratigraphic units and important stratigraphic and tectonic boundaries which may be examined at this particular locality. In addition, each description is provided with a stratigraphic correlation table in which the units seen in the locality are indicated by arrows, thus reminding the visitor at any time in which geological region and in which stratigraphic position the examined rocks occur. References are given to papers in which may be found more detailed descriptions, interpretations and discussions on various topics relevant to the observed rocks and their characteristics.

The standardised way of describing localities leads to some unavoidable repetitions.On the other hand, however, the visitor may choose to examine only a few of the 42 localities, depending on time and interest. All localities may be visited in the course of about 8-10 days.

The English version of the excursion guide was written in connection with the collaboration programme between the Soviet Academy of Sciences, Kola Branch, and the Geological Survey of Norway, project 'Correlation of the Middle-Upper Proterozoic sedimentary successions of the northern coastal areas of the USSR and Norway'. The guide is thus designed for professional geologists with main interests in stratigraphy, sedimentology, basin development and subsequent deformation. However, the guide may also prove to be useful for field courses and for the training of geology students in stratigraphy, sedimentology and some aspects of tectonics and structure.

It has been decided to illustrate the excursion guide with several colour photographs which not only are a very valuable supplement to the text but also give an impression of the excellent exposure of the colourful rocks, in particular in the coastal sections, the state of preservation of various structures and, finally, help to show the picturesque beauty of this northernmost part of Norway.

Anna Siedlecka

Trondheim, May 1990.

THE BEDROCK GEOLOGY OF THE VARANGER PENINSULA

The Varanger Peninsula of Finnmark is underlain by predominantly terrigenous rocks which are extensively exposed in coastal sections. Early mapping (Holtedahl 1918, Føyn 1937) along the coast and in the southwestern areas provided the first detailed descriptions of the sedimentary sequences, in particular of tillites and associated formations. During this important early period of work the foundations of lithostratigraphy were also outlined. The suggested Late Precambrian age of these rocks was confirmed by the discovery of Cambrian fossils on the Digermulen Peninsula, west of Tanafjorden (Strand 1935).

The discovery, in the mid-sixties, by Siedlecka & Siedlecki (1967) of a complex NW-SE-trending fault zone across the Varanger Peninsula was the next important step in the geological research of this area. This most prominent structural feature of the peninsula, **the Trollfjorden-Komagelva Fault Zone (TKFZ)** separates two geological regions **the Tanafjorden-Varangerfjorden Region** to the southwest of this major tectonic feature, and **the Barents Sea Region** towards the northeast. The fault zone separates sedimentary successions which, although roughly time equivalent, were accumulated in separate basins under different tectonic conditions. The sedimentary sequence of the Tanafjorden-Varangerfjorden Region rests unconformably upon the Karelian metamorphic substratum and was thus accumulated in an **autochthonous basin** developped on the northern margin of the Fennoscandian Shield. The sedimentary sequences of the Barents Sea Region, on the other hand, were deposited in a basin located at some unknown distance from their present location. Based on palaeomagnetic data, a minimum of 500 km of dextral translation along the Trollfjorden-Komagelva Fault Zone was suggested for this **allochthonous basin** and its sedimentary pile (Kjøde et al. 1978), although the extent and sense of this strike-slip movement has been questioned by Pesonen et al. (1989). This foreign tectonic element was brought into its present position after sedimentation in both basins had been completed. Rocks of both regions and the fault zone were clearly affected by the Caledonian deformation,

more strongly in the case of units to the north of the TKFZ. While the rock units of the Tanafjorden-Varangerfjorden Region are, in the west, included in the lowermost part of the Caledonian nappe pile and parautochthon, no certain equivalents of the rocks of the Barents Sea Region have ever been recognised in the nappes of central Finnmark even though various correlations have been proposed (e.g. Føyn 1969, Laird, 1972, Siedlecka & Siedlecki, 1972). Rice et al.(1989a), however, have interpreted the rocks of the Barents Sea Region as a part of the Lower Allochthon, strike-slip emplaced along the TKFZ over a distance of more than 400 km.

The Tanafjorden-Varangerfjorden Region is underlain by a c. 3800 m thick sequence subdivided into three groups, **the Vadsø Group** (590-960 m), **Tanafjorden Group** (1448-1665 m) and **Vestertana Group** (1317-1665 m). There is a gradual transition between the Vestertana Group and the Cambro-Ordovician **Digermulen Group** which occurs on the Digermulen Peninsula, west of the Tanafjorden.

Sedimentation of the lithostratigraphical sequence of the Tanafjorden-Varangerfjorden Region was dominated by fluvial, coastal marine and shallow-marine conditions , and it is characterised by several erosional breaks. In general terms, the Vadsø Group consists mostly of deposits accumulated in braided streams, the Tanafjorden Group is primarily shallow-marine, while the Vestertana Group includes both fluvial and marine deposits and comprises two tillite horizons testifying to two periods of glaciation. The first major depositional break, detected by micropalaeontological work (Vidal 1981), occurs in the upper Vadsø Group between the Golneselva Formation and the Ekkerøya Formation (for lithostratigraphic names see the enclosed tables). The most pronounced break is shown by **the pre-tillitic angular unconformity** at the base of the Vestertana Group. A slight pre-glacial tilting towards the north (discovered already by Holtedahl(1918)), resulted in a progressive southward removal of the Tanafjorden Group and the entire Vadsø Group. Thus, the uppermost formation of the Tanafjorden Group, the Grasdalen Formation, is preserved only in the northwest,

close to the Trollfjorden-Komagelva Fault Zone, while on the southern side of Varangerfjorden the tillite-bearing Smalfjord Formation rests directly on the Veidnesbotn Formation, the lowermost formation in the Vadsø Group. West of the head of Varangerfjorden, a very thin tillite of the Smalfjord Formation, or even the Nyborg Formation, rests directly on the Karelian metamorphic substratum.

Three lines of evidence have been applied in establishing the chronostratigraphy of the rocks of the Tanafjorden-Varangerfjorden Region: (1) The two tillite horizons, present in the lower Vestertana Group and considered for a long time to be of Eocambrian, Late Precambrian, Vendian (Varangerian) age and representing 'the Varanger Ice Age'. (2) Findings of Platysolenites antiquissimus (Føyn 1967, Hamar 1967), trace fossils (Banks 1970) and, more recently, acritarchs (Vidal 1981) and stromatolites (Bertrand-Sarfati & Siedlecka, 1980), suggesting that the Vadsø Group is Upper Riphean and the Tanafjorden Group along with the bulk of the Vestertana Group originated in Vendian time. The Cambrian-Precambrian boundary is placed by Vidal (1981) within the Manndrapselva Member in the upper Vestertana Group. (3) Radiometric ages: Rb-Sr whole-rock isochron ages of 654±7 Ma for the Nyborg Formation in the Vestertana Group, and 807±19 Ma for the Klubbnes Formation in the Vadsø Group (Sturt et al. 1975).

The Late Riphean sedimentation thus started on an eroded Karelian (Archaean and lower Proterozoic) basement after a period of almost 700-1000 million years of erosion (Siedlecka 1985). The direction of sediment transport was variable; to the north, northeast or northwest with a less commmon ESE direction (Banks et al. 1974). There were several marine incursions during this fluvial accumulation, perhaps the most prominent marine transgression being recorded in the uppermost Vadsø Group. This transgression was, however, preceded by a considerable non-depositional/erosional break, which embraces the Riphean-Vendian boundary (Vidal 1981). Banks et al.(1974) pointed out the eastward thickening of the formations of the upper Vadsø Group, independent of sedimentary environment and transport direction, and suggested a higher rate of subsidence in the east.

After the last transgression and the development of the regressive sequence of the Lower Vendian Ekkerøya Formation (Johnson 1978), a new transgression followed and long-lasting marine sedimentation was re-established. This period of sedimentation resulted in the formation of the whole of the Tanafjorden Group. The formations of this group are typically widespread, sheet-like, sediment bodies which may easily be recognised in the lower Caledonian nappes, far to the west. Johnson (1975) has shown that this marine sedimentation occurred in tide-dominated environments and that there were several transgressive-regressive episodes resulting in sedimentation changing from accumulation of near-shore, coastal and shallow-marine sands (sub-tidal to tidal sand bars, beaches and sheet sand complexes) to offshore sand-mud facies of a continental shelf. There is a large variation in palaeocurrent directions, suggesting a complex configuration of the shoreline rather than any predominant direction of sediment transport.

Uplift and northward tilting in approximately mid-Vendian time resulted in erosion becoming progressively deeper to the south and affecting the previously deposited Upper Riphean-Lower Vendian sequence of strata. The minimum erosion is about 2300 m. The striated pavement at Bigganjar'ga suggests that at least the final erosion was of glacial origin (Edwards 1984).

After this major intra-Vendian break, a new period of sedimentation started with the 'Varanger Ice Age' sediments and continued almost uninterruptedly into Cambrian time. The older, glacially-influenced period of sedimentation resulted in the accumulation of glacial, fluvioglacial, fluvial and proglacial, probably marine sediments, recording several episodes of advance and retreat of the ice (Edwards 1984). Almost all of this Smalfjord Formation was accumulated in the Varanger paleovalley, in the present Varangerfjorden. The formation thins out towards the east and is absent east of Mortensnes.

The interglacial (post-Smalfjord) Nyborg Formation marks a marine transgression; it is thickest in the west (c. 300m) and thins out eastwards. The formation is composed mainly of interbedded purple shale and brownish-grey sandstone

accumulated by turbidity currents. Tidal-flat dolomite and shallow-marine clastics are minor constituents. The second period of glaciation was heralded by tillite cutting progressively southwards through the Nyborg Formation. This homogeneous glacial deposit is overlain by transgressive deposits and, with minor fluctuations, the marine conditions continued throughout the time of deposition of the remainder of the Vestertana Group. There is evidence that the ice sheets during both glaciations advanced both from the south and from the north, while the water-transported sediments were mostly derived from the southerly areas of the Fennoscandian Shield (Edwards 1984).

The Barents Sea Region comprises the following major lithostratigraphic units: (1) the **Barents Sea Group;** (2) **the Løkvikfjellet Group,** which rests on the Barents Sea Group transgressively and with an angular unconformity; and (3) the low-grade greenschist-facies **Berlevåg Formation,** which is thrust upon the rocks of the two former groups and has been suggested to be part of the Kalak Nappe Complex (Levell & Roberts, 1977). This thrust unit of the Berlevåg Formation is referred to informally as the Tanahorn Nappe (Roberts, in prep.).

The Barents Sea Group is c. 9000 m thick (basal parts and substratum unknown). It has been subdivided into four formations comprising sedimentary rocks which originated in different and gradually shallower environments of deposition. Lowest is the **Kongsfjord Formation**, an up to 3500 m thick sequence of interbedded, graded-bedded sandstones and shales deposited by turbidity currents. These flysch-like turbidites have been interpreted as having accumulated on a passive margin submarine fan (Siedlecka 1972, Pickering 1981). There is, in the Kongsfjord Formation, an abundance of sedimentary structures and several sedimentary facies associations which, together, were crucial for outlining of the model of the Kongsfjord Submarine Fan. In this, inner, middle and outer fan deposits were recognised as well as facies transitional to basin slope and basin plain (Pickering 1981). In general terms the Kongsfjord Formation represents a thinning-and-fining-upward sequence from inner, through middle to outer fan, reflecting a decrease in the rate of the submarine fan growth (Pickering 1981).

This trend of development may have resulted from an increasing subsidence rate in the receiving basin and/or trapping of sediments in the prograding delta; **the Båsnæringen Formation**. There is a gradual transition between these two formations and Pickering (1981) has recognised a c. 100m thick progradational sequence in this transitional zone. The Båsnæringen Formation was interpreted as a major prograding delta (Siedlecka & Edwards 1980). This up to 3500 m thick sequence has a general coarsening-upward motif and comprises sediments interpreted as having accumulated in prodelta (lowermost part of the formation), delta front and braided delta plain environments. Palaeocurrent directions in both the Kongsfjord Formation and the Båsnæringen Formation indicate transport of sediment towards the northeast and east-northeast across a NW-SE - oriented slope margin (Pickering 1981, Siedlecka & Edwards 1980). The delta-plain braided stream deposits of the top part of the Båsnæringen Formation are sharply overlain by an interbedded terrigenous-carbonate sequence of **the Båtsfjord Formation**. This c. 1500 m thick unit consists in its lower, c.300 m thick member of sandstones, mudstones, shales, dolomites and limestones and includes stromatolite biostromes. This member has been interpreted as originating on tidal flats which developed on and in the marginal zone of the delta, possibly after a major switch of the prograding delta lobe (Siedlecka 1978, Siedlecka & Edwards 1980). Upwards in this formation, and in the overlying **Tyvjofjellet Formation,** purple and green beds appear and the number of carbonate beds decreases (they are present in the upper Båtsfjord Formation, but absent in the Tyvjofjellet Formation). At the same time there was a gradual increase in sand supply. There is an abundance of sedimentary structures in this variegated sequence of the upper Båtsfjord and Tyvjofjellet Formations, testifying to a shallow-water sedimentation. A shallow-marine environment with increasing energy and possible fluvial incursions may tentatively be envisaged for this uppermost part of the Barents Sea Group.

The rocks of the Barents Sea Group have yielded a varied assemblage of acritarchs, thus providing some more detailed information on the stratigraphic position of the group and its formations. The Båtsfjord Formation, in particular,

yielded several time-diagnostic taxa showing that the Riphean-Vendian boundary is located within the lower Båtsfjord Formation (Vidal & Siedlecka 1983).

The Løkvikfjellet Group rests upon various parts of the Barents Sea Group with a slight angular unconformity (about 12° according to Siedlecki & Levell 1978). This contact provides evidence of uplift and tilting of the Barents Sea Group prior to the Løkvikfjellet transgression. The Løkvikfjellet Group is c.5700 m thick. It is entirely terrigenous and has been subdivided into five formations (Siedlecki & Levell 1978). The lowermost **Sandfjorden Formation**, and the highest three, the **Skjærgårdnes Formation, Stordalselva Formation and Skidnefjellet Formation,** are shallow-marine deposits, while the intervening **Styret Formation** has been interpreted as fluvial (Levell 1978). No breaks in deposition have been recorded. The Sandfjorden Formation consists of pink and yellowish-grey arkoses and conglomerates and is the most widespread. The Styret Formation has been recognised in two separate areas (Siedlecki 1980), while the remaining formations are preserved only in the northwestern corner of the Varanger Peninsula. The Styret Formation is characterised by an interbedding of greenish-grey sandstones and mudstones; the sandstones are typically lenticular and erosively based, they may be coarse to conglomeratic, and they decrease in amount upwards. Paleocurrents in this formation, interpreted as fluvial, are dominantly towards the southeast (Siedlecki & Levell 1978). The Skjærgårdnes and Stordalselva Formations consist of interbedded grey sandstones and dark-grey mudstones and siltstones. The sandstone beds have a tabular geometry and are laterally fairly persistent. Grain-size varies but is generally coarse, even conglomeratic. Cross-bedding is abundant and indicates transport of material mostly towards the northeast. Wave ripples are also common and orthogonal to the cross-bedding. Levell (1980) emphasized the importance of wave- and current-generating storms in transport and deposition of these shelf deposits. The Skidnefjellet Formation which terminates the Løkvikfjellet Group is strikingly similar to the Sandfjorden Formation, consisting of pale-coloured cross-bedded and wave-rippled sandstones and small-pebble quartz-quartzite conglomerate.

The Berlevåg Formation is thrust upon the Løkvikfjellet Group (as the Tanahorn nappe) and has been subdivided by Roberts (1988) into three mappable units: (1) a (lowermost) phyllite unit consisting of dark, greenish-grey phyllite interbedded with subordinate metasiltstone and fine-grained metasandstone; (2) a metasandstone unit consisting primarily of coarse to conglomeratic, grey, cross-bedded metasandstone with some phyllite interbeds; and (3) an interbedded metasandstone-phyllite series. In parts of this sequence graded bedding is abundant.

Levell & Roberts (1977) recognised both the tectonic contact between the Berlevåg Formation and the subjacent Løkvikfjellet Group, and the significant differences in the structural and metamorphic histories of the two units.
Results of studies of illite crystallinity have suggested, however, that the Berlevåg Formation suffered only a slightly higher grade of epizone metamorphism than the remaining units of the Barents Sea Region and that it may possibly belong to the Lower Allochthon (Rice et al. 1989b).

Metadolerite and dolerite dykes are the only manifestation of magmatism on Varanger Peninsula. Both types of dykes occur in the Barents Sea Region while in the Tanafjorden-Varangerfjorden Region only a few dolerite dykes have been recorded. The metadolerite dykes are particularly abundant in the Kongsfjorden and Båtsfjorden areas, occurring in spectacular swarms. The metadolerite dykes in the outer Båtsfjorden area cut across the unconformity between the Barents Sea Group and the Sandfjorden Formation of the Løkvikfjellet Group. The K-Ar age of these dykes is around 640 Ma (Beckinsale et al. 1975). K-Ar dating of the metadolerite dykes intruding the Kongsfjord Formation in the Kongsfjorden area gave ages at around 1000 Ma and 1900 Ma. The reliability of these dates is, however, uncertain because of very low potassium contents. Only one sample which yielded an age of 1946±58 Ma had a reasonable potassium content (Beckinsale et al. 1975). A cleaved metadolerite dyke in the Berlevåg Formation yielded a K-Ar age of 542±17 Ma. In general, the field relationships suggest that the metadolerite dykes were emplaced prior to and perhaps also during the initial stage of the compressional Caledonian deformation. Examples have been found of

metadolerites cutting across the prominent folds, but which also carry the penetrative axial surface cleavage to these same folds (D.Roberts, unpubl. data).

The comparatively fresh dolerite dykes occur throughout both regions (they also cut the Cambrian to Tremadoc sediments on Digermul Peninsula), but they are not abundant. They post-date all the Caledonian structures. Their K-Ar ages are around 355 Ma (latest Devonian to Early Carboniferous). Major and trace element geochemistry of the metadolerites has shown them to be similar to magmas transitional between abyssal and continental tholeiites. The younger dolerites are comparable to continental tholeiites, and enrichment in some trace elements suggests that magma generation at a greater depth than at which the metadolerites originated (Roberts 1975).

The recent studies of illite crystallinity and metamorphic index minerals have revealed that there is a clear difference between the rocks of the autochthonous/parautochthonous Tanafjorden-Varangerfjorden Region, which have been affected only by diagenesis, and the bulk of the Barents Sea and Løkvikfjellet Groups which have been metamorphosed in low greenschist facies (Bevins et al. 1985, Rice et al. 1989b). This suggests that these two groups of the Barents Sea Region were affected by, e.g., deeper sedimentary and tectonic burial, prior to their strike-slip juxtaposition with diagenesis-grade rocks occurring southwest of the TKFZ.

The information on the bedrock geology of the Varanger Peninsula briefly reviewed above is fundamental in reconstructing the development of the sedimentary basins in both regions and their subsequent deformation. Crucial in this interpretation is the polyphase history of the Trollfjorden-Komagelva Fault Zone and the timing of events based on radiometric ages and biostratigraphic data.

The development of the autochthonous basin (the Tanafjorden-Varangerfjorden Region) started in Late Riphean time and the sediments, supplied primarily from

a southerly source, were accumulated in fluvial and a variety of coastal and shallow-marine environments, with two periods of glaciation recorded by tillites. A major depositional break and tilting occurred in mid Vendian time and after this terrigenous sedimentation was re-established and continued uinterruptedly into the Early Palaeozoic.

The development of the allochthonous basin (the Barents Sea Region) started in the (?)Early/Middle Riphean in a basin located far to the northwest of its present position. A combined model of normal and reverse faulting with subsequent lateral translation along the same fault line was proposed by Siedlecka (1985) for the developing basin. A >9000 m sedimentary wedge accumulated along the southwestern fault margin of this basin during gradually shallowing conditions, in Late Riphean and Early Vendian time. Subsequent uplift and tilting resulted in erosion of a part of the accumulated sequence. The eroded area was invaded by a shallow sea which persisted at least throughout the Vendian and accumulated mainly terrigenous shelf deposits. Subsequent spreading and extension or transtension resulted in the emplacement of swarms of dolerite dykes, although in part this overlapped with compressional tectonism. After this phase of magmatism, the ancient buried fault line was reactivated as a major dextral strike-slip fracture and the basin was translated to its present position (cf.Kjøde et al. 1978). The translation occurred prior to the main Caledonian deformation which has affected both juxtaposed basins, though to differing degrees.

The tectonic deformation of the rocks in the Varanger Peninsula has been described by Roberts (1972), though with emphasis on the Barents Sea Region. General features of local structural geology are contained in Siedlecka & Siedlecki (1971), Teisseyre (1972), Levell & Roberts (1977) and Johnson et al. (1978), but the overall picture is most readily seen from Siedlecki's (1980) 1:250,000 map compilation. Patterns of faulting, also offshore faults, have been discussed by Lippard & Roberts (1987).

As noted earlier, the Trollfjorden-Komagelva Fault Zone provides a natural

division of the peninsula, and contrasts are seen in structural history, fold axial trends and metamorphic grade across this major fault zone. In the Barents Sea Region there is a general increase in intensity of Caledonian deformation from southeast to northwest (Roberts 1972). In the southeast, prominent mesoscopic and macroscopic concentric folds trend c. N-S and verge towards the west; and they carry an axial plane slaty cleavage. In the extreme northwest, in the Berlevåg Formation of the Tanahorn Nappe, similar folds varry a fine-grained, axial plane schistosity, are tight to locally sub-isoclinal, generally NE-SW trending, and overturned at moderate angles towards the southeast. Fold axial trends, however, may be extremely variable. In the Berlevåg district, second-generation folds deform the more common early folds and carry a crenulation cleavage. Such folds are rarely encountered in central and eastern areas of the BSR. Later gentle folds with c. ENE-SWS axes occur throughout the region and help to produce spectacular fold interference culminations and depressions (Roberts 1972, fig. 22, Siedlecki 1980). Extensional faults trending NE-SW to E-W represent one of the latest phases of deformation (Lippard & Roberts 1987).

To the soutwest of the TKFZ, in the Tanafjorden-Varangerfjorden Region, tectonic deformation as a whole is less intense than in the BSR. In the northwest, close to Tanafjorden, folds and reverse-faults trend NE-SW, and an axial surface cleavage is prominent. These particular rocks may (Townsend et al. 1986) or may not (Rice et al. 1990) form part of the Gaissa Nappe Complex. Further southeast, folds are more open, trending both NNE-SSW and ESE-WNW (Siedlecki 1980). A more detailed structural assessment of this region has been presented by Rice et al. (1990).

The age of the folding and associated schistosity or slaty cleavage on the Varanger Peninsula is still not fully resolved. Although a Late Cambrian/Early Ordovician (Finnmarkian) age has been suggested by Rb-Sr whole-rock isochron studies on Kongsfjord Formation cleaved pelites (520 $\pm$ 47 Ma: Taylor & Pickering 1981) from the BSR,and on Stappogiedde Formation rocks from Tanafjord (504 $\pm$ 7 Ma: Sturt et al. 1975), 40Ar-39Ar dating from Lower allochthon in central Finnmark favours a Silurian (Scandian) age (Dallmeyer et al. 1989). Quite clearly, more isotopic dating work is required, both on cleavages and on the metadolerite dykes, and some is already in progress.

Much has been written on the Trollfjorden-Komagelva Fault Zone and its significance in the Caledonian and later structural history of this region (e.g., Siedlecka & Siedlecki 1967, Kjøde et al. 1978, Lippard & Roberts 1987, Rice et al. 1989a). Briefly, it will suffice here to note that there is abundant structural and metamorphic evidence for a major dextral strike-slip translation of the BSR along the TKFZ, and that this occurred at some stage, or stages, during the Caledonian orogeny, sensu lato. Late-Caledonian strike-slip movements are clearly post-metamorphic and probably pre-355 Ma. Younger components of movement, extensional and/or strike-slip, almost certainly extend up into the Mesozoic (Gabrielsen 1984, Lippard & Roberts 1987) and there is also some evidence of recent, post-glacial reactivation along part of the fault zone (O. Olesen, pers. comm. 1989).

THE TANAFJORDEN - VARANGERFJORDEN AREA

Locality 1. Highway E6, road-cut at 658 770, map-sheet M 1:50,000 2335 III Varangerbotn.

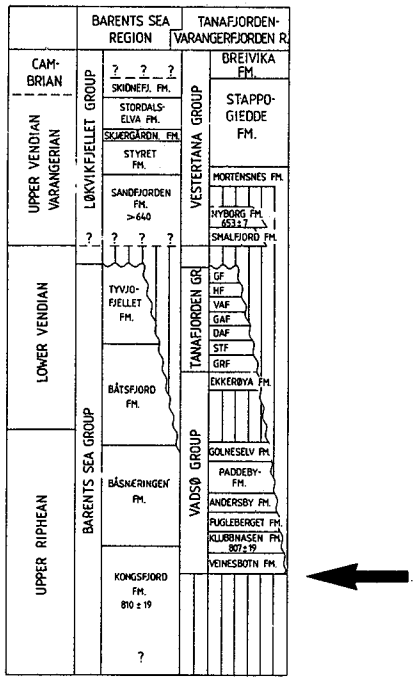
Veinesbotn Formation, lower part.

Sandstone, red, feldspathic, coarse- to medium-grained in medium-thick, cross-bedded, lenticular beds. Subordinate, 2-3 cm-thick mudstone beds are interbedded with the sandstone layers. Cross-bedding indicates a uniform flow direction towards north-northeast.

The beds are flat lying with a few degrees dip towards the north.

The lower part of the Veinesbotn Formation has been interpreted as having accumulated in shallow interlocking channels in a braided stream environment (Hobday 1974, pp. 40-41).

Immediately southeast of this exposure there is a topographic depression, on the other side of which gneisses of assumed Archaean age are exposed. The shortest distance between the exposures of the sedimentary rocks (the Veinesbotn Formation) and their crystalline basement is about 25 m.

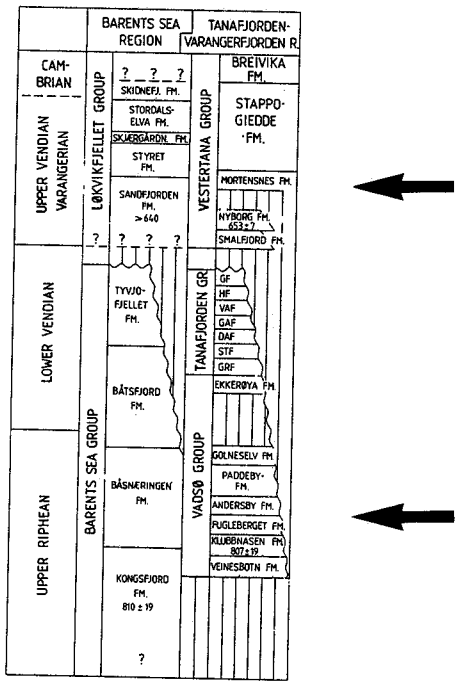


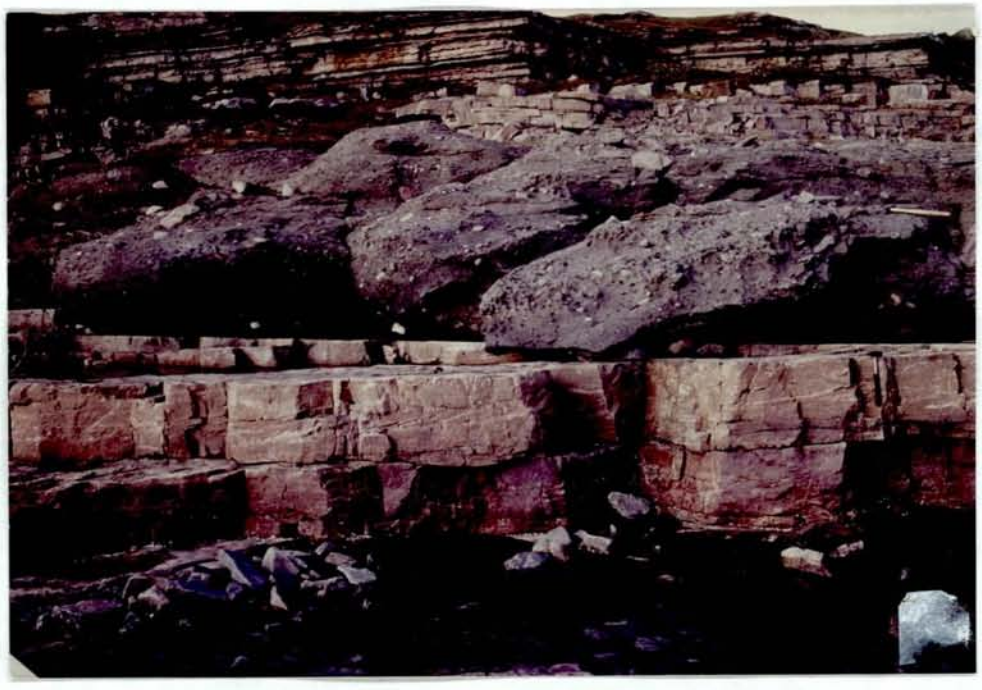
Locality 2. Oaibaccanjar'ga (Bigganjar'ga), coastal exposure at 632 816, map-sheet M 1:50,000 2335 III Varangerbotn. A c. 45 min. walk from the secondary school at Karlebotn.The locality is protected; sampling and hammering are not allowed.

Contact between the Veinesbotn Formation and the Smalfjord Formation. Unconformity and a major erosional hiatus.

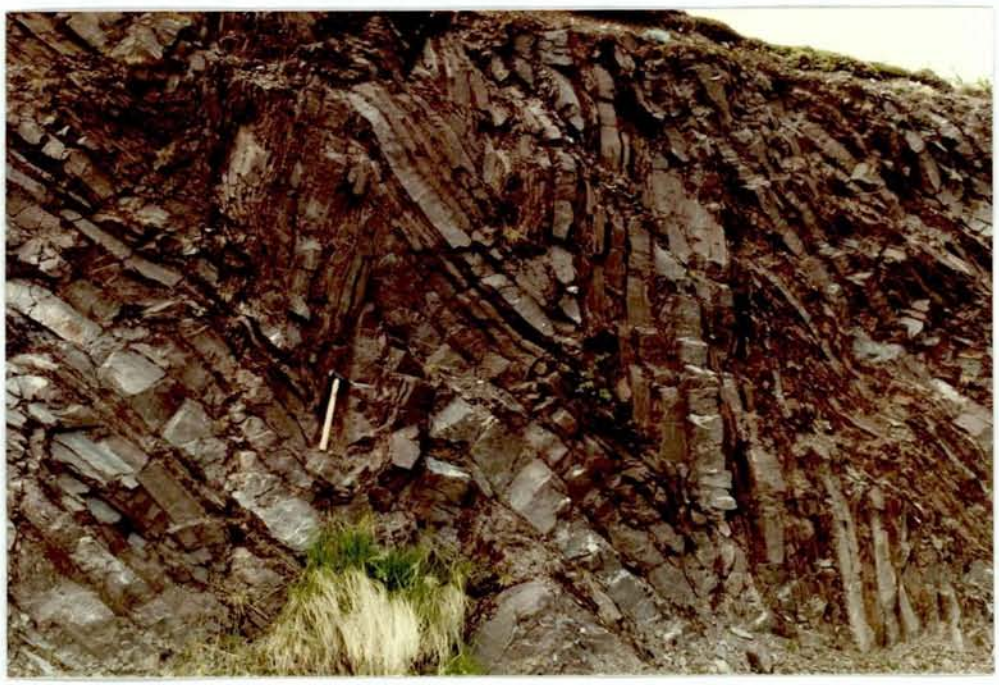
A walk along the path paralleling the southern coast of Selesnjar'ga to the famous coastal exposure known in the geological literature as 'Reusch's moraine' or as 'Bigganjar'ga tillite'.

Light-grey quartzitic sandstone of the middle part of the Veinesbotn Formation, interpreted by Hobday (1974) as a shallow-marine shelf accumulation, is sharply overlain by a c. 3 m-thick diamictite. A unique striated pavement may be observed on the erosional surface of the sandstone. The striations are interpreted as glacial scours, and the overlying diamictite as a till left by a retreating glacier (Edwards 1984, p.8). The tillite contains fragments mainly of crystalline rocks. The remainder of the Smalfjord Formation on Selesnjar'ga (c.100 m) consists of sandstones representative of various accumulations in a near-shore to fluvial environment (Edwards 1984).





Locality 2. Selesnejar'ga (Bigganjar'ga), sharp erosional contact between sandstone of the Veinesbotn Formation and tillite of the Smalfjord Formation.



Locality 3. Zig-zag folds in the Nyborg Formation.

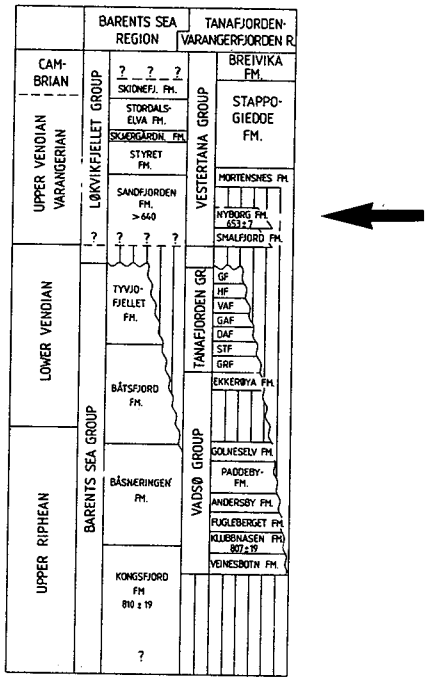
Locality 3. Highway E6, road-cut at 596 847, map-sheet M 1:50,000 2335 III Varangerbotn.

Nyborg Formation.

Thin to medium-thick beds of grey sandstone interbedded with purple clayey shale. The sandstone beds are parallel-sided, poorly sorted and massive to graded-bedded. This facies of the Nyborg Formation has been interpreted by Edwards (1984) as a relatively deep-water deposit of a submarine fan.

The Nyborg Formation as a whole is complex, consisting of various facies interpreted in terms of several different environments of deposition as shown by the enclosed reconstruction made by Edwards (1984). The lithology seen in this locality is particularly wides pread and is well exposed along the highway.

The Nyborg Formation is a structurally incompetent unit resting on the competent Smalfjord Formation (and older competent rocks) and it is therefore usually tightly folded. The zig-zag folds are asymmetrical, with approximately E-W to ENE-WSW oriented axial planes which generally dip steeply to the north.

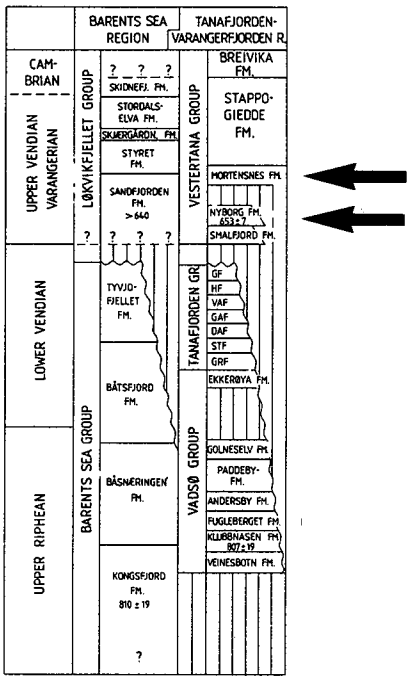


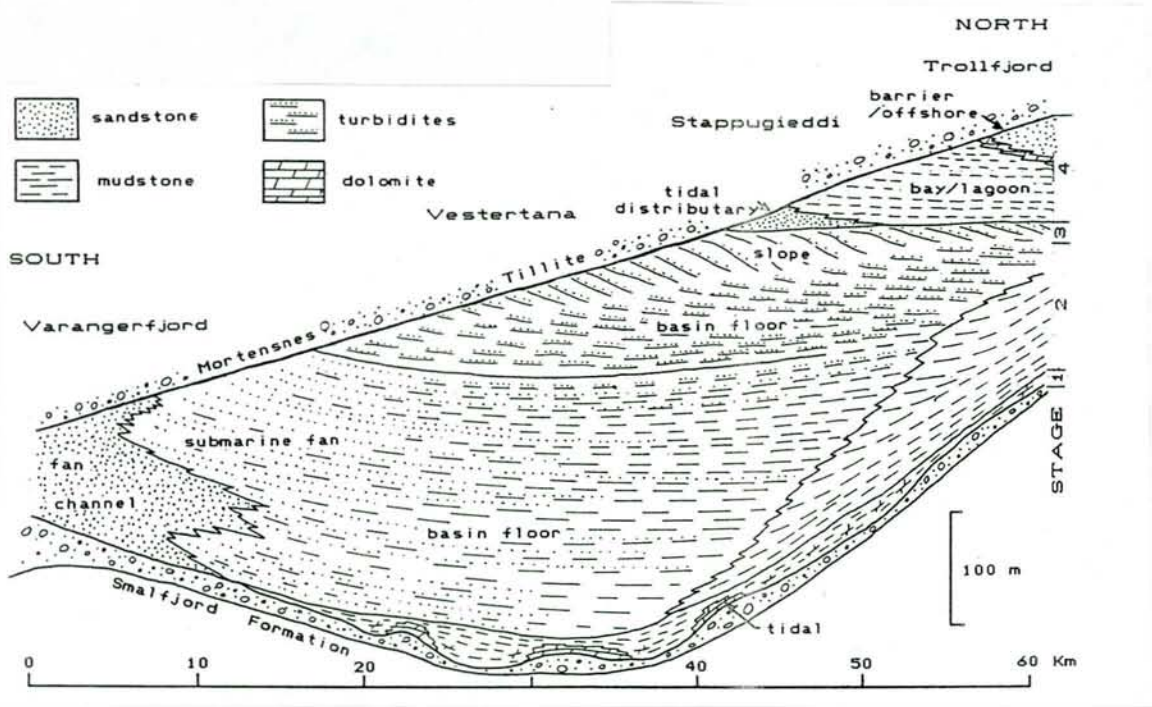
Locality 4. Highway 98, above the road on its northern side at 726 836, map-sheet M 1:50,000 2335 II Nesseby.

Nyborg Formation overlain by the Mortensnes Formation.

Violet clayey shale interbedded with subordinate thin beds of grey sandstone is exposed in the lower part of the outcrop. This interbedded unit is overlain by a few metres of thick- and thin-bedded grey sandstone, poorly sorted and graded-bedded. This sandstone is, in turn, abruptly overlain by a massive, cliff-forming tillite. The contact between the tillite and its substratum is planar. Mapping in the area, however, has shown that the Mortensnes Formation rests unconformably on an erosional surface, which in places cuts down to the Vadsø Group. In this locality the massive tillite marking the bottom of the Mortensnes Formation rests on the middle portion of the Nyborg Formation (member B of Edwards, 1984), the remainder of this formation having been removed by pre-glacial erosion.

The tillite contains fragments mainly of crystalline rocks, but chert, dolomite and other rock-types may be found. Edwards (1984) has interpreted this tillite as a lodgement till deposited by a large glacier or a continental ice sheet, because of its widespread occurrence, blanket geometry, and locally derived matrix material and clasts, some of which show striated and faceted surfaces.





Reconstruction of the stratigraphy and environments of deposition of the Nyborg Formation (from Edwards 1984).

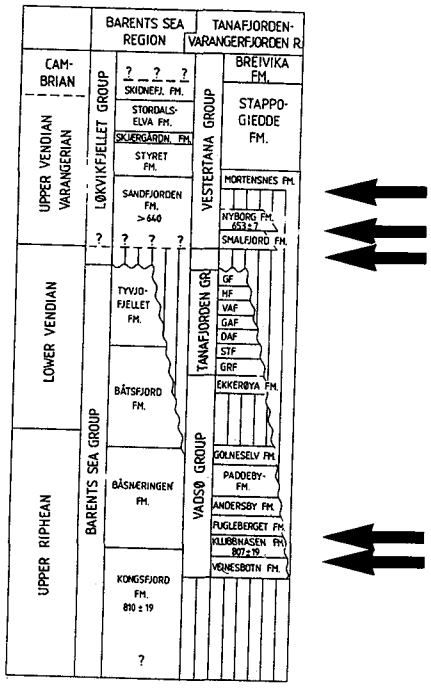
Locality 4. Contact between the sandstone and shale of the Nyborg Formation and tillite of the Mortensnes Formation.

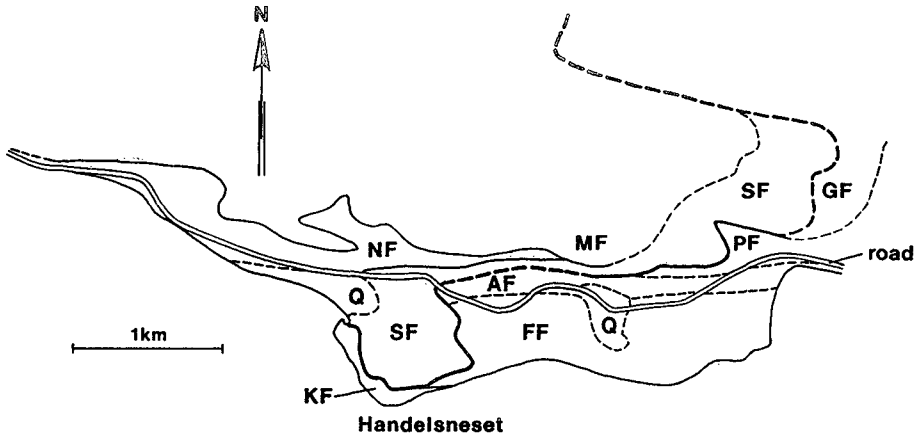
Locality 5. Handelsneset (Mortensnes), section from ca.811 767 to 821 768, map-sheet M 1: 50,000 2334 II Nesseby.

Klubbnasen Formation, Fugleberget Formation, Smalfjord Formation, Nyborg Formation and Mortensnes Formation. Unconformity, pre-Mortensnes erosional surface with pronounced relief, major hiatus.

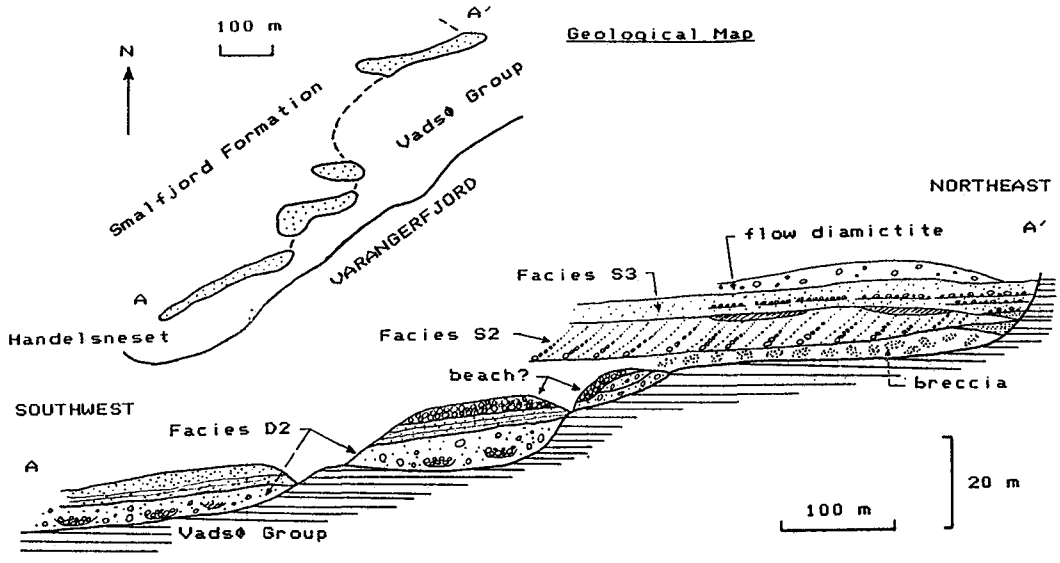
A short walk from highway 98 down to the coast, to the bottom of the section. The Klubbnasen Formation is composed of grey, clayey shale and micaceous mudstone and sandstone, with the sandstone beds increasing upwards in number and thickness. There is a gradual transition into the cross-bedded or flat-bedded, grey, feldspathic sandstones of the Fugleberget Formation. The Klubbnasen - Fugleberget coarsening upward sequence has been interpreted as a ESE-prograding delta (Banks et al. 1974).

The Mortensnes Formation rests upon the eroded surface of this deltaic sequence. The sharp contact and the topographic relief of the unconformity surface may be observed here. Diamictite, stratified conglomerates and pebbly sandstones (massive, parallel- or cross-bedded) constitute the rocks of the Mortensnes Formation at this locality. Pebbles of crystalline rocks, dolomite and chert are the most common. Edwards (1984) has interpreted the deposits observed here as glacial, glacideltaic, glacifluvial and coastal. North of the highway the Mortensnes Formation is succeeded by the Nyborg Formation, a sequence consisting of interbedded purple clayey shale and sandstone. Hill slopes bordering the highway to the north are covered with the scree of these rocks and are partly vegetated. These slopes are capped by an up to several metres high cliff of reddish-brown diamictite of the Mortensnes Formation. (At Handelsneset and on Fugleberget there are several interesting archaeological sites, including a sacrificial stone (1500 years old), house sites (3000 years old) and more than 250 graves (from before Christ to 1100 after Christ).





Sketch map of locality 5. Explanation: KF-Klubbnasen Fm., FF-Fugleberget Fm., AF-Andersby Fm., PF-Paddeby Fm., GF-Golneselva Fm., SF-Smalfjord Fm., NF-Nyborg Fm., MF-Mortensnes Fm., Q-Quaternary deposits.



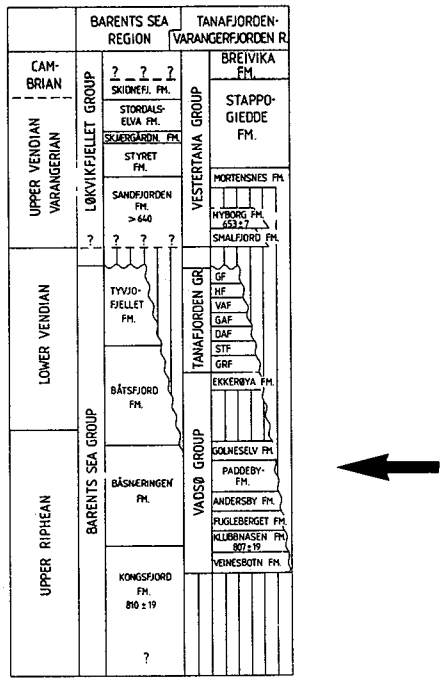
Foreshortened section of the Smalfjord Formation at Handelsneset (from Edwards 1984).

Locality 6. St.Vadsøya, SW coast, c.034 761, map-sheet M 1:50,000 2435 III Vadsø.

Fugleberget Formation

The middle part of the Fugleberget Formation is excellently exposed along the southwestern coast of the island (unfortunately close to a garbage dump and combustion stove). Lenticular, erosively-based beds of pink feldspathic sandstone are interbedded with brownish-red, parallel-laminated mudstone. The sandstone beds are either massive or cross-bedded, and inverted cross-bedding and loading structures are abundant.The upper part of the Fugleberget Formation is best observed in an abandoned quarry nearby. Pebbly sandstones and conglomerates with fragments of mudstone and pebbles of sandstone may be seen interbedded with subordinate mudstone lenses.
Carbonate concretions are abundant in some conglomerate and sandstone beds.

The sequence exposed on St.Vadsøya is interpreted as fluvial, accumulated mostly as banks in a braided river where, occasionally, meanders developed (Hobday 1974, Røe 1975).



Locality 6. Fugleberget Formation. Deformed cross-bedding in sandstone. Parallel-bedded mudstone in the upper part.

Locality 6. Fugleberget Formation. Sandstone with mudstone fragments and carbonate concretions.

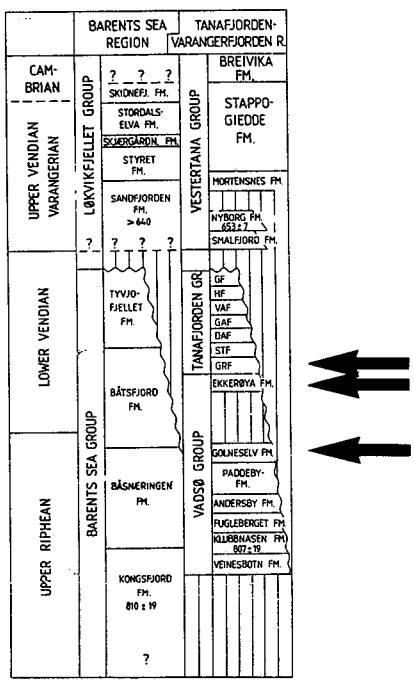
Locality 7. St.Ekkerøy, c. 900 764, map-sheet M 1: 50,000 2435 II Ekkerøy.

Golneselva Formation, Ekkerøya Formation, Grønnesset Formation. Disconformities and gaps between the formations are indicated by regional mapping and micropalaeontological work.

Dolerite dyke, K-Ar age 342±10 Ma (Beckinsale et al. 1975).

Grey feldspathic sandstones of the Golneselva Formation are exposed in the southwestern part of the island, e.g. at the trenches from World War II. The brown film on the rock surface and sulphur-yellow spots may be weathering products of iron sulphides. The Ekkerøya Formation is best studied in SSW-facing cliffs c. 50 m northeast of the southwesternmost tip of the island, as well as in the coastal exposure at Flågan. The Ekkerøya Formation consists of red mudstone and siltstone interbedded with greenish-grey sandstone and subordinate conglomerate. The boundary between the Golneselva and Ekkerøya Formations is at the base of an up to 2 m-thick transgressive conglomerate (Johnson 1978). Mudstone beds predominate in the lower part of the formation, and there is an upward increase of sandstone beds in which 'ball-and-pillow' structures and slump folds may be observed. The Ekkerøya Formation is interpreted as starting with a transgression with a subsequent progradation of a tide-dominated delta (Røe 1975, Johnson 1978).
A vertical dolerite dyke cuts through the Ekkerøya Formation at Flågan and is clearly visible in the topography of the coastal cliffs.

(Flågan is a nature reserve with a rich and varied community of seagulls and other birds).



Locality 7. St. Ekkerøy. Coastal section at Flågan. Beds of the Ekkerøya Formation cross-cut by a dolerite dyke at the far right.

Locality 7. 'Ball-and-pillow' structures in the Ekkerøya Formation.

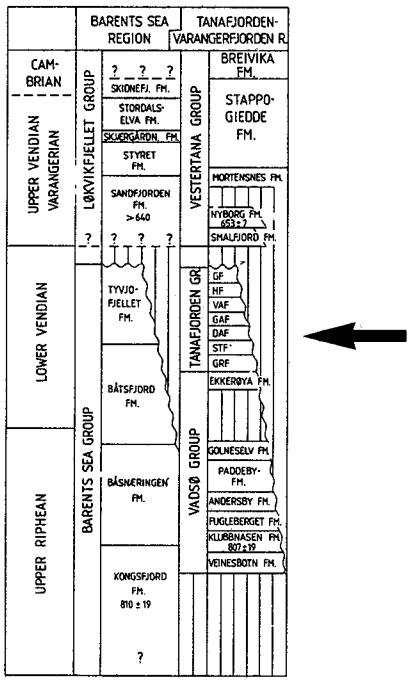
Locality 8. Quarry at Skallnes, 085 835. map-sheet M 1:50,000 2435 II Ekkerøy.

Dakkovarre Formation

The upper part of the Dakkovarre Formation is exposed in a quarry located c. 50 m west of the main road. The rocks are also well exposed along the coast, east of the highway 98. The light-grey feldspathic sandstone, medium- to very thick-bedded, exposed here is either massive or cross-bedded. Current and oscillation ripples are well exposed on the bedding surfaces. The sandstone contains spots of dark-brown iron oxide which are probably oxidation products of iron sulphide or siderite. The same brown coloration occurs as bands (weathering crust) along joints and at bedding planes.

Hobday & Reading (1972) and Johnson (1978) interpreted these sandstones as shallow-marine storm deposits.

The sandstone was quarried for building stone for harbour constructions at Svartnes near Vardø.



Locality 8. Quarry in sandstones of the Dakkovarre Formation at Skallnes.

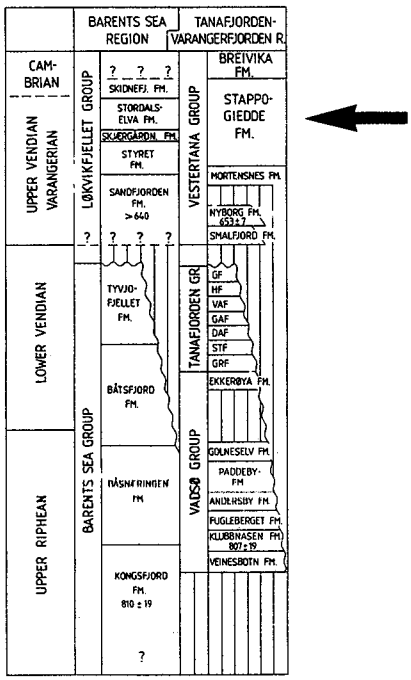
Locality 9. Komagnes. Blue-green shale of the Stappogiedde Formation cross-cut by a dolerite dyke.

Locality 9. Komagnes, c. 042 912, map-sheet M 1:50,000 Ekkerøy.

Stappogiedde Formation, Innerelva Member.
Dolerite dyke, K-Ar age 353 ± 10 Ma (Beckinsale et al. 1975).

Clayey and muddy shale, blue-green, in places reddish-grey, is a typical rock of this member. The shale exhibits two kinds of sedimentary structures: parallel horizontal lamination and small ripple cross-stratification sets, both testifying to a very quiet environment of sedimentation, either from suspension or from weak bottom currents. The member is widespread in the Tanafjorden - Varangerfjorden Region (and in the Gaissa Nappe) without any important facies change. It is interpreted as a shelf deposit influenced by tidal currents (Banks 1973).

A dolerite dyke several metres thick intrudes the shales at this locality and is clearly seen in the slopes north of the highway.



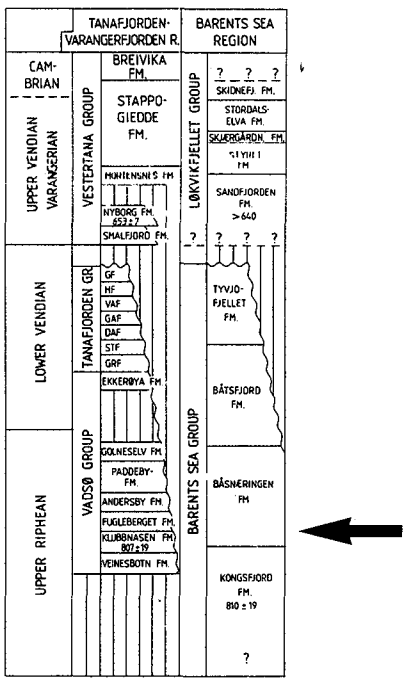
BARENTS SEA REGION

Locality 10. Svartnes, coastal exposure at 169 962, map-sheet 1:50,000 2535 IV Vardø.

Båsnæringen Formation, Næringselva Member

Thick-bedded grey to dark-grey sandstones crop out extensively in the coastal section at Svartnes, c. 1km SSE from the lake Svartnesvatnet along highway 98. The sandstone beds exhibit large-scale trough cross-bedding and ripple marks on the bedding surfaces. Structures resulting from soft sediment deformation are abundant, in particular large, spectacular 'ball & pillow' structures.

The Båsnæringen Formation as a whole is interpreted as a major delta (Siedlecka & Edwards 1980, Siedlecka et al. 1989). In this context, the sandstones exposed at Svartnes are considered as shallow-marine delta-front accumulations.



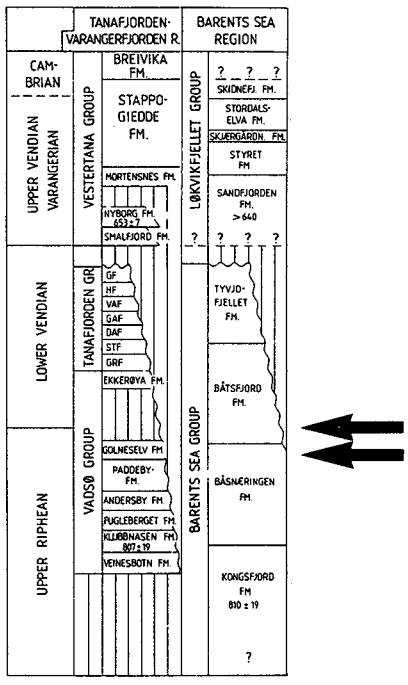
Locality 11. Persfjorden, SE side, 177 150, map-sheet M 1:50,000 2535 IV Vardø.

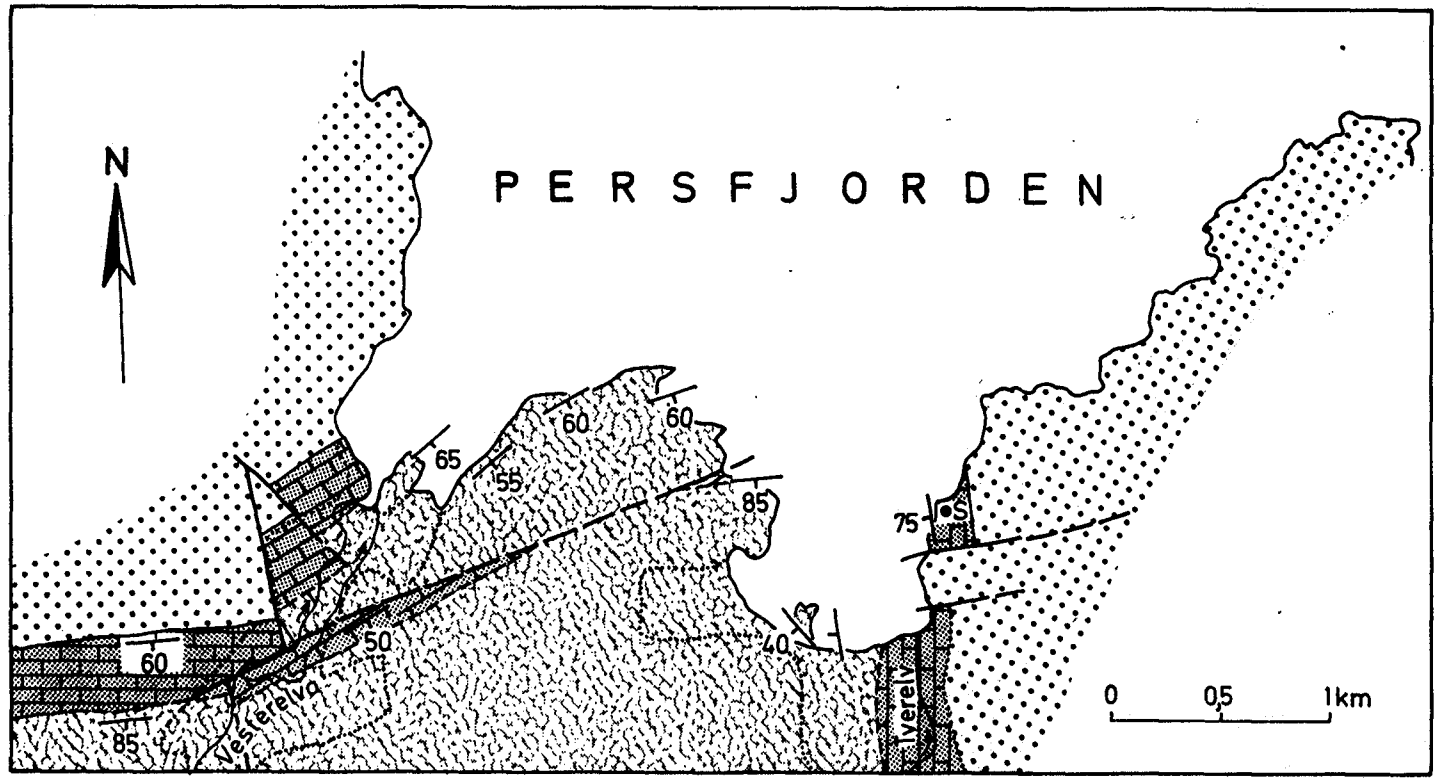
Båsnæringen Formation, Hestman Member, Båtsfjord Formation, Annijokka Member in mutual contact in the eastern limb of the Persfjorden syncline.

Thick-bedded, red to pink, feldspathic sandstone is typical for the Hestman Member. It may be observed from a distance in the steep slopes of the Hestman mountain and in road-cuts just before reaching the locality 11. The sandstone, c.800 thick in this area, is interpreted as a braided delta-plain deposit terminating the deltaic deposition of the Båsnæringen Formation (Siedlecka & Edwards 1980, Siedlecka et al. 1989).

The contact between the Båsnæringen and Båtsfjord Formations is exposed at the coast; the exposure is best studied at low tide. The uppermost Båsnæringen Formation is represented by a few metres of pink and light-grey, quartz-rich, thick-bedded sandstone interbedded with thin sandstone beds and with sandy shale. This is succeeded by a series of interbedded, blackish-grey, clayey shales, thin-bedded grey sandstones, greenish-grey mudstones and grey, yellow-weathering dolomite. In addition, there are subordinate, stromatolite-bearing limestone beds. These deposits contain an abundance of flaser and lenticular bedding, shrinkage cracks, desiccation cracks and intraformational breccias, and have been interpreted as tidal-flat deposits (Siedlecka 1975, 1980). Stromatolites, confined to a few horizons, vary from wavy to bulbous structures up to 0.5 m in size.

The boundary between the Båsnæringen and Båtsfjord Formations is interpreted as marking a change in depositional regime and an abandoning of the Båsnæringen delta lobe, and/or a transgression (Siedlecka & Edwards 1980).





Skovika Member

Annijokka Member

Båsnæringen Formation

• S Occurrence of stromatolites

..... Boundary of the areas totally covered with Holocene deposits.

North of locality 11. Båsnæringen Formation, Hestman Member.

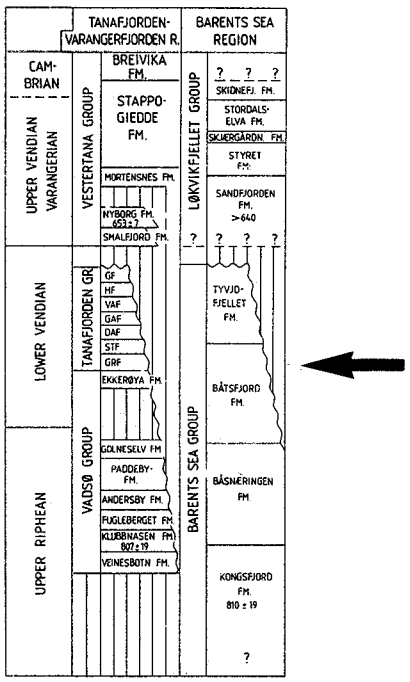
Locality 11. Persfjorden. Contact between the Hestman Member of the Båsnæringen Formation (right) and the Annijokka Member of the Båtsfjord Formation.

Locality 12. Persfjord, coastal exposures, c.150 155, map-sheet M 1: 50,000 2535 IV Vardø.

Båtsfjord Formation, upper part (Skovika Member).

An interbedded multicoloured series of violet and green mudstone, grey and pink sandstone, yellow-grey dolomite and grey limestone is extensively exposed in coastal cliffs in the western part of the Persfjorden syncline. Crinkled (?)algal lamination, desiccation cracks, 'birds eye' structures, intraformational breccias, ripple cross-lamination, (?) tepee structures, etc. may be observed. Cracks deformed by compaction, sealed with calcite, are a widespread, enigmatic structure.

The sequence shows a penetrative slaty cleavage (S1) paralleling the axial surfaces of the D1 folds 145°/60°) (Roberts 1972).



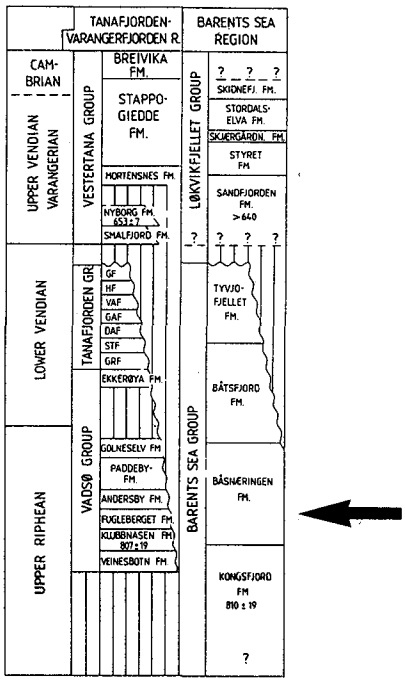
Locality 13. Seglkollen, 152 194, map-sheet M 1: 50,000 2535 IV Vardø.

Båsnæringen Formation, Seglodden Member.

A section across the southern slope of Seglkollen shows medium- to thick-bedded, lenticular, erosively-based beds of violet and grey-green sandstone. The sandstone is cross-bedded, mostly medium-grained and feldspathic.

(A short walk down to the coast at Seglodden provides a good opportunity to see an excellently exposed section at about 155 198 - 157 195).

The sandstones have been interpreted as having accumulated on a braided delta plain (Siedlecka & Edwards 1980).

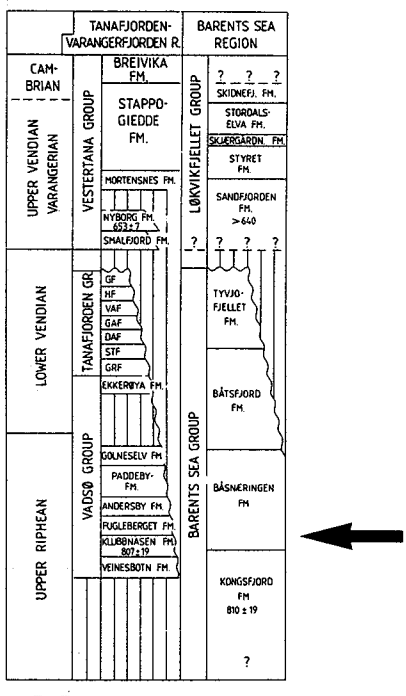


Locality 14. Road-cut at 149 202, map-sheet M 1: 50,000 2535 IV Vardø.

Båsnæringen Formation, Næringselva Member.

Medium-thick beds of greenish-grey, fine-grained sandstone and mudstone may be observed here. The beds are mostly parallel-sided and exhibit parallel horizontal lamination and graded-bedding in thin, 3 - 5 cm units. Current ripples are visible both in section and on bedding planes. Deformational structures resulting from loading of unconsolidated, water-saturated sediment are common.

Rocks of the Næringselva Member were deposited in a prodelta-delta front setting (Siedlecka & Edwards 1980; see also locality 10). The Næringselva Member as a whole represents a major coarsening-up sequence. Northwest from locality 14 (stratigraphically downwards), a gradual increase of thin-bedded laminated and rippled mudstone at the expense of sandstone beds may be observed.

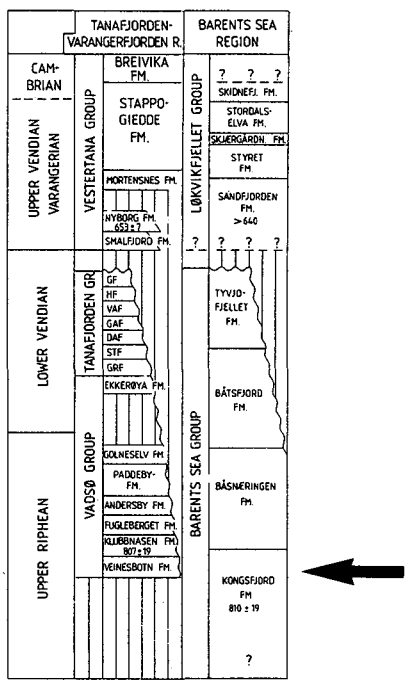


Locality 15. Road cut at 139 214, map-sheet M 1: 50,000 2535 IV Vardø.

Kongsfjord Formation

Very thick-bedded, dark-grey turbidite beds may be observed in this road-cut and in several other exposures along the road towards Sandfjord. Graded-bedding in sets from a few centimetres to over 1 metre (in amalgamated beds) may be seen along with parallel horizontal lamination at the tops of the graded units.

The Kongsfjord Formation is interpreted as a flysch sequence accumulated on a submarine fan (Siedlecka 1972, Pickering 1981). The beds observed at this locality are thought to represent outer fan deposits which accumulated rapidly on active lobes (Pickering 1981).



Locality 12. Persfjorden. Båtsfjord Formation, upper part.

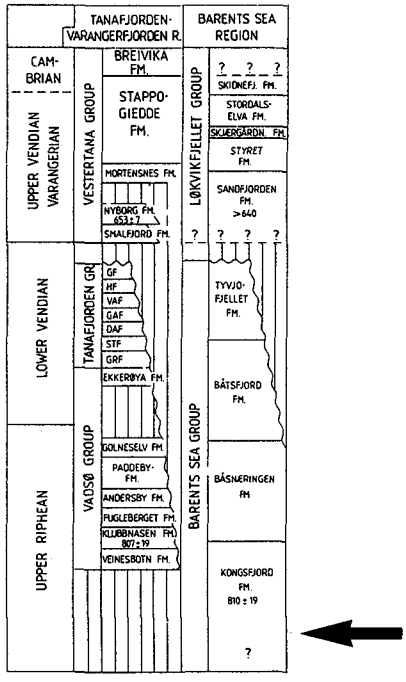
Locality 16. Dolerite dyke cross-cutting turbidites of the Kongsfjord Formation.

Locality 16. Exposures on the slopes of coastal cliffs and on both sides of the road at 108 237, map-sheet M 1: 50,000 2436 II Syltefjord.

Kongsfjord Formation. Dolerite dyke.

A steeply dipping dyke of dolerite up to 9.5 m thick cuts through turbidites of the Kongsfjord Formation. The turbidite beds form thick, sandy and thin, muddy packages of graded-bedded and parallel-laminated beds. In the overall interpretation of the Kongsfjord Formation as a submarine fan, these beds are probably representing lateral margin fan deposits as suggested by Pickering (1981).

It is not clear whether this particular NE-SW trending dyke has been dated because the precise map co-ordinates were not given by Beckinsale et al. (1975). However, taking into consideration that it is uncleaved and little altered, an age similar to the post-tectonic dyke dated on Ekkerøy by the K-Ar method at about 350 m.y. is a reasonable assumption.

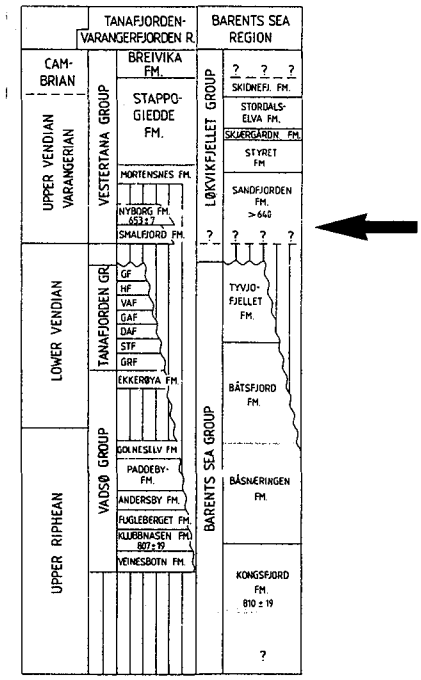


Locality 17. Kvannvikbukta, road-cut at 107 259, map-sheet M 1: 50,000 2436 II Syltefjord.

Løkvikfjellet Group, Sandfjorden Formation.

Thick beds of coarse-grained feldspathic sandstone with large-scale cross-bedding. These beds represent the typical development of the Sandfjorden Formation.

The Sandfjorden Formation is interpreted as having accuulated in a shallow-marine environment strongly influenced by tidal currents (Levell 1980).

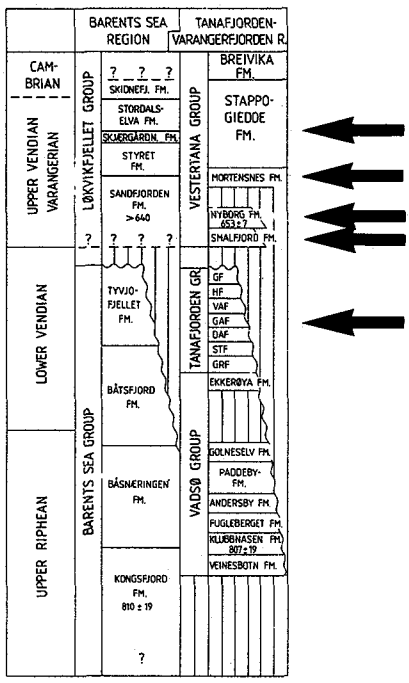


TANAFJORDEN - VARANGERFJORDEN REGION

Locality 18. Scenic view 458 103, map-sheet M 1: 50,000 2335 IV Tana.

Vestertana Group and Tanafjorden Group.

The steep western slopes of Blåberget (Blue Mountain) on the eastern side of the road are covered with scree of blue-green and purple mudstones and clayey shales belonging to the Stappogiedde Formation (Innerelva Member) and Nyborg Formation, respectively. Both units are exposed in the upper portion of the slopes. In addition, the Lillevatn Member, Mortensnes Formation and Smalfjord Formation are exposed. The tillites may be recognised from the road by their yellow coloration. All rocks are steeply dipping to vertical and are heavily cleaved because of proximity to a major reverse fault. Rocks of the Gamasfjellet Formation (Tanafjorden Group) are juxtaposed along this fault, and form the spectacular cliffs of Raudberget (Red Mountain) at a distance of several kilometres, starting about 3 km north of this stop. In the far distance to the north, rocks of the Tanafjorden Group can be seen beyond the mouth of the Tana river, on the eastern side of the Tanafjorden.



Western slopes of Blåberget seen from the north (see description of locality 18).

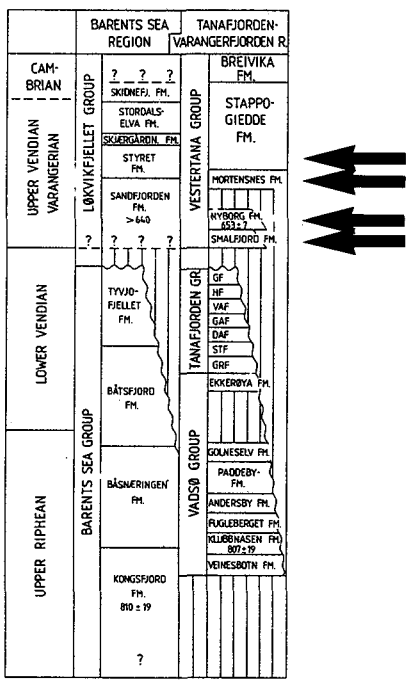
North of locality 18. View towards western slopes of Raudberget (right side of the picture) and various formations of the Tanafjorden Group in the distance, on the eastern side of Tanafjorden.

Locality 19. Section c. 1km long on the western side of the road, c.539 190, map-sheet M 1: 50,000 2335 IV Tana.

Smalfjord Formation, Nyborg Formation, Mortensnes Formation, Lillevatn Member, Stappogiedde Formation. The stratigraphic sequence crops out in a gentle anticline with the Smalfjord Formation in the core.

A light-grey, yellow-weathering dolomite, c. 1 m thick with stromatolitic structures is conspicuous here. It belongs to the lowermost part of the Nyborg Formation. Algal-laminated dolomite is a widespread facies at the bottom of the Nyborg Formation and has been interpreted by Edwards (1984) as a tidal-flat deposit which originated during a post-glacial transgressive episode. The dolomite rests on a grey mudstone c. 1 m thick, which overlies abruptly a massive tillite with a few, < 1 cm large dolomite fragments (derived from erosion of the Grasdalen Formation). The dolomite is overlain by a violet and grey mudstone (Nyborg Formation) which, in turn, is followed by a grey tillite with fragments of crystalline rocks (Mortensnes Formation). This sequence can be seen over a distance of c. 400 m northwards, along the road (northern limb of the anticline). It is repeated southwards from the Nyborg dolomite where, over a distance of c. 500 m, there is also exposed dark-grey mudstone interbedded with coarse to conglomeratic feldspathic sandstone forming lenticular beds. These fluvial deposits form the basal part of the Stappogiedde Formation. The Nyborg Formation and the Mortensnes Formation are thin here compared with their thicknesses in neighbouring areas, which may be caused both by facies development and by interformational erosion.

(Before reaching locality 19 it is recommended to make a short stop at 543 209 to view the stratigraphy of the upper Tanafjorden Group in the Giemaš anticline, described further on as locality 21).

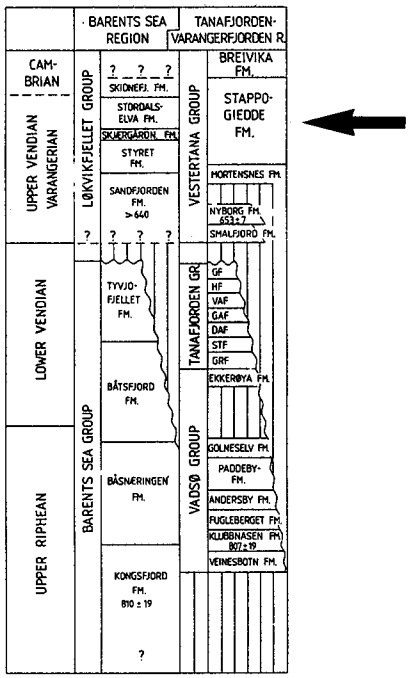


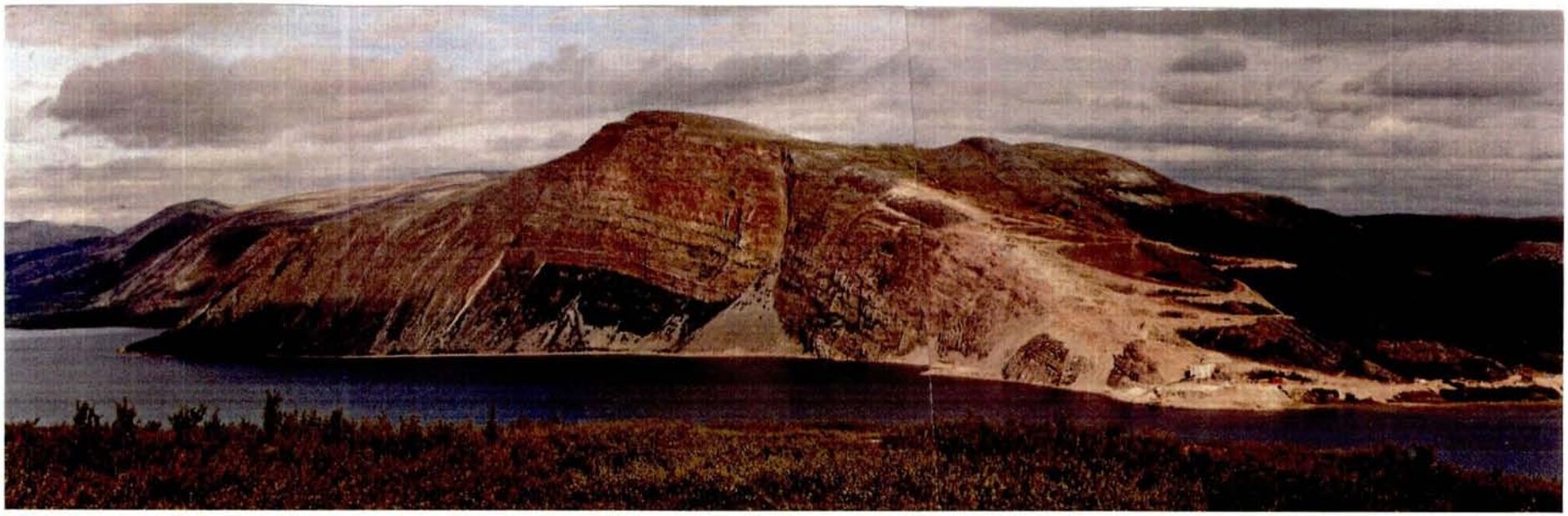
Locality 20. Road-cut, c.800 m long, from 548 134 southwards, map-sheet M 1: 50,000 2335 IV Tana.

Stappogiedde Formation, Innerelva Member.

Blue-green mudstone, parallel-laminated due to separation of silt and clay. Siltstone with ripple cross-stratification occurs in subordinate layers. This is a typical development widespread over large areas on Varanger Peninsula and west of the Tana river. The mudstone sequence has been interpreted by Banks (1973) as a shelf deposit.

The mudstone is strongly cleaved along steep, NNE-SSW oriented cleavage surfaces and dissected by almost vertical, E-W-trending sets of joints. It is typical that the rock splits along the joint and cleavage planes rather than along the bedding surfaces.



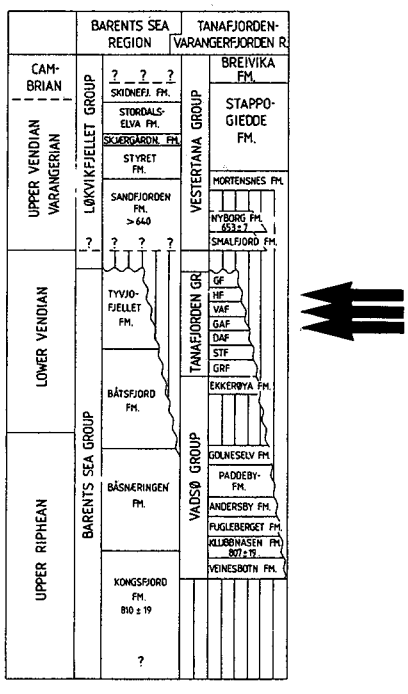


Locality 21. Giemas anticline. Gamasfjellet Formation, Vagge Formation and Hanglecærro Formation.

Locality 21. Quartzite quarry at 555 193 and the slope above it, map-sheet M 1 : 50,000 2335 IV Tana.

Gamasfjellet Formation, Vagge Formation, Hanglecærro Formation.

Sections through all three formations may be conveniently studied in the quarry at various levels along the roads. The Gamasfjellet Formation consists of red-violet (in the lower part of the formation) and pink quartzitic sandstone which is quarried mainly for ferro-silicium. It is mostly medium-bedded, massive or cross-bedded, and consists of rounded quartz grains cemented by quartz and haematite. At the top the formation contains interbeds of arenaceous grey shale and grades into the Vagge Formation. This formation consists mainly of interbeds of grey, thin-bedded sandstone and arenaceous or muddy shale. The sandstones are rusty-brown on weathered surfaces. Symmetrical ripples and ripple cross-laminations and rippled bedding surfaces are abundant. Trace fossils and desiccation cracks may be found, but are uncommon. Close to the top, the Vagge Formation contains a few medium-thick beds of grey, cross-bedded quartzitic sandstone. It is then overlain by the Hanglecærro Formation. This formation consists exclusively of medium- to thick-bedded quartzitic sandstone, blue-grey in the lower part and almost white higher up. The beds are mostly massive, locally cross-bedded, and the quartz grains are cemented by quartz overgrowths. None of the formations has been studied in detail. However, their blanket-like geometry without any facies change over large areas and the high textural and mineralogical maturity of the Gamasfjellet and Hanglecærro quartzitic sandstones suggest a shallow-marine environment. A wave-dominated environment has been proposed for the Hanglecærro Formation and tide-dominated for the Gamasfjellet Formation. For the Vagge Formation an offshore setting influenced by storm processes has been suggested (Johnson et al. 1978).



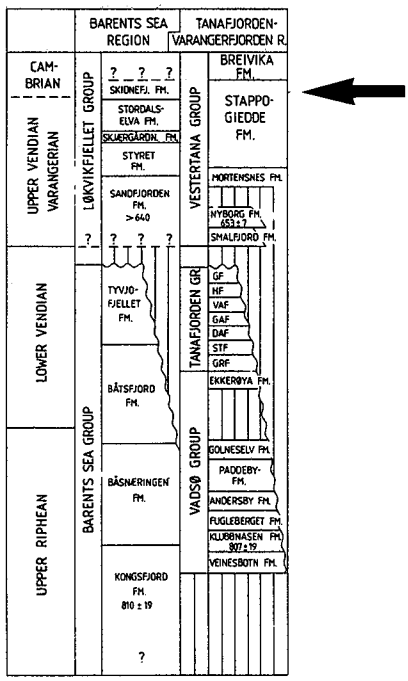
Locality 22. Slope on the NW side of the road, 679 196, Map-sheet M: 50,000 2335 I 0urdujav'ri.

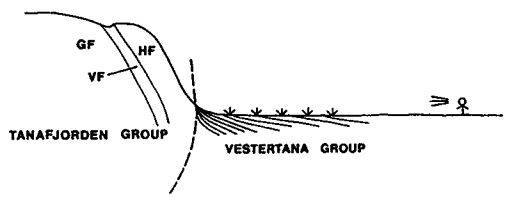
Stappogiedde Formation, Manndrapselva Member.

Sandstone beds, almost horizontal, interbedded with red clayey shale may be observed on a low slope near an unnamed creek. The sandstone is thin- or medium-bedded, pink, greenish-grey or reddish-brown; it is fine-grained, and haematite- and clay-rich. Desiccation cracks occur on the bedding planes of shale. Ripple cross-stratification may be seen in the sandstone and in some beds there are abundant horizontal and vertical burrows (cf. Banks 1970).
These beds were interpreted as shallow-marine accumulations (Reading 1965, Banks 1971).

Beds of the Manndrapselva Member very probably represent the terminal part of Precambrian sedimentation and, as suggested by Vidal (1981), the Precambrian-Cambrian boundary may be located within this unit.

(About 2 km further to the northeast there is a scenic view: in the foreground, a 300-350 m high plateau, partly vegetated and underlain by rocks of the upper Vestertana Group and, in the background, a white, barren. c.300 m high 'wall' of quartzites of the Hanglecærro Formation.).





Locality 19. S tromatolitic dolomite at the base of the Nyborg Formation. Photo C.O. Mathiesen.

Near locality 22. White quartzite of the Hanglecærro Formation in the background, red sandstones of the upper Stappogiedde Formation in the foreground.

TANAFJORDEN - VARANGERFJORDEN REGION - BARENTS SEA REGION

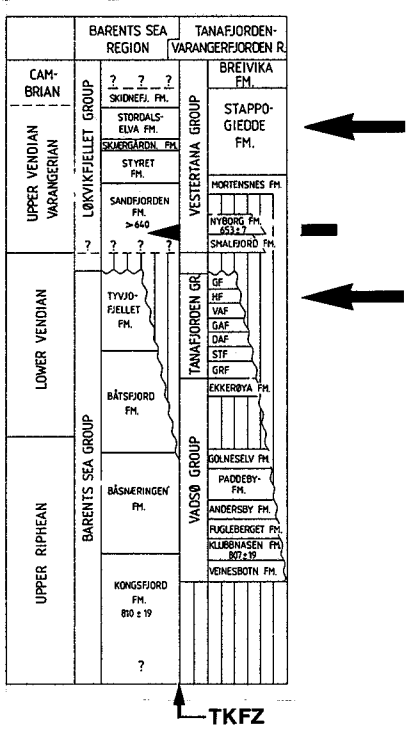
Locality 23. Gædnjajav'ri, southeastern side of the lake at c.772 235 and northeastern side of the lake at c.770 235, map-sheet M: 50,000 2336 II Kongsfjord (topographic map and map of bedrock geology, Siedlecka 1989).

Stappogiedde Formation and Hanglecærro Formation in tectonic contact, Trollfjorden-Komagelva Fault Zone, Sandfjorden Formation.

Blue-green mudstones of the Innerelva Member of the Stappogiedde Formation crop out, but mostly as scree, on the sides of the road. A small hill, 271 a.s.l., northwest of the road, consists of quartzitic sandstone of the Hanglecærro Formation, separated from the subjacent mudstones of the Innerelva Member by a reverse fault. Folded and fairly poorly exposed rocks of the upper Tanafjorden Group may be seen along the ridge bordering the lake to the southwest. White quartzitic sandstone may be seen in a small quarry on the slope of this ridge at 766 242.

The Trollfjorden-Komagelv Fault Zone extends from the southeast, beneath the Gædjajav'ri lake towards the northwest, and is clearly marked in topography. Exposure along the fault zone in this area is generally very poor.

The rocks exposed on the other side of the lake belong to the Sandfjorden Formation. The formation's coarse-grained to conglomeratic, reddish-yellow arkoses may be observed in the slope northwest of the road (c.770 255). The Sandfjorden Formation rests transgressively on various formations of the Barents Sea Group and covers a large area in the central part of Varanger Peninsula.



Locality 24. Tranga, road-cuts over a distance > 1 km, 778 351-785 356, map-sheet M 1: 50,000 2336 II Kongsfjord (topographic map and map of bedrock geology, Siedlecka 1989).

Sandfjorden Formation, Båtsjord Formation, Båsnæringen Formation.

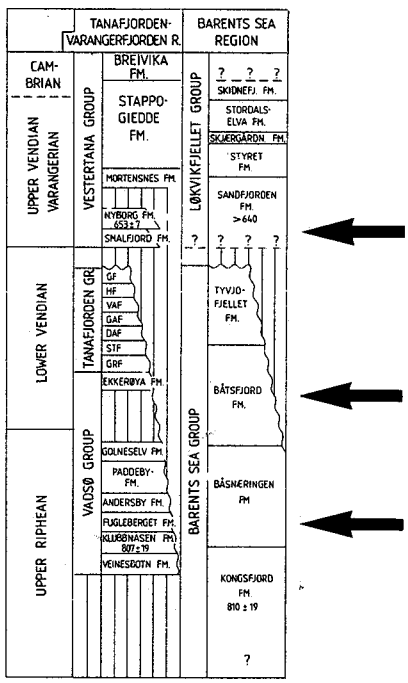
The Gædnja river crosses a NW-SE ridge underlain by arkoses of the Sandfjorden Formation, which rests unconformably on the Båtsfjord Formation. Road-cuts provide a good section through the thick-bedded, cross-stratified, pink and yellowish-grey, medium- to coarse-grained and conglomeratic arkoses. Sand grains and small pebbles of white quartz and red jasper are well-rounded and cemented with quartz and carbonate cement and subordinate sericite and chlorite. Zircon, tourmaline, rutile and garnet are the principal heavy minerals (Siedlecki & Levell 1978).

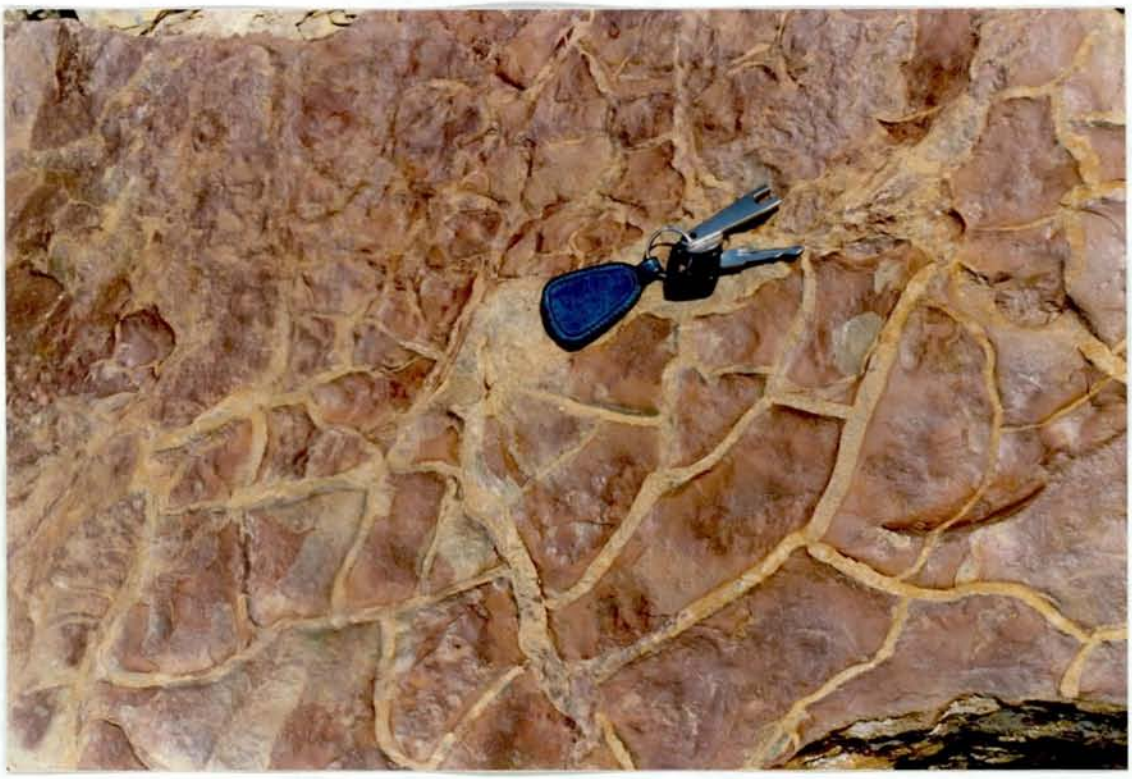
The Sandfjorden Formation is interpreted as a shallow-marine deposit accumulated in an area dominated by strong tidal currents (Levell 1980).

The Båtsfjord Formation crops out north of the ridge in small road-cuts. The unconformity is not exposed. Grey and yellowish-grey carbonate-bearing sandstone interbedded with blackish-grey clayey shale and red muddy shale is best seen on the eastern side of the road. Current ripples and desiccation cracks are common on the bedding surfaces of these beds, providing evidence of shallow-water sedimentation with temporary exposure above water level.

About 400 m farther to the north the road crosses an E-W-trending fault. North of this fault there crop out rocks of the upper Næringselva Member of the Båsnæringen Formation. Medium- to very thick beds of a dark-grey, fine-grained to medium-grained sandstone are exposed in a c.300 m long road-cut. The sandstone beds are mostly massive, but some exhibit parallel lamination. These beds have probably originated in a prodelta environment of the Båsnæringen deltaic system (Siedlecka & Edwards 1980).

The rocks are dissected by a tightly spaced system of steep joints, oriented approximately E-W to WNW-ESE.





Locality 24. Desiccation cracks in the Båtsfjord Formation.

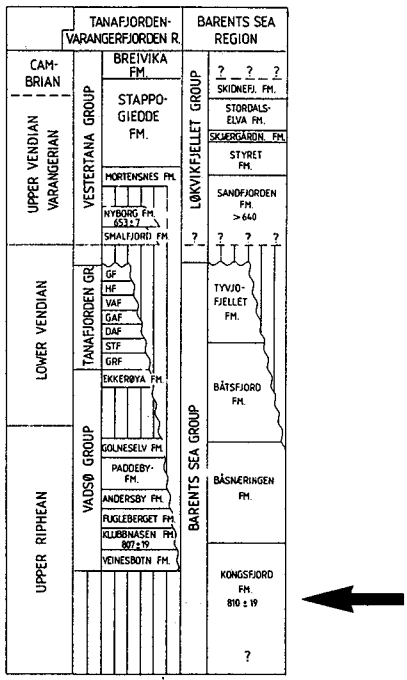
Locality 25. Turbidites of the Kongsfjord Formation, Risfjorden Member.

Locality 25. Rundvatnet, road-cuts at 842 443, map-sheet M 1: 50,000 2336 II Kongsfjord (topographic map and map of bedrock geology, Siedlecka 1989).

Kongsfjord Formation, Risfjorden Member.

Thin beds of grey sandstone interbedded with dark-grey muddy shale are exposed in high road-cuts on both sides of the road. Medium-thick and thick beds of sandstone are subordinate. The sandstone beds show some graded bedding, and parallel lamination may be observed in the upper parts of some graded beds. The sandstone beds are sharply and erosively based and their owermost portions may contain fragments of shale. This flysch-like turbidite sequence is interpreted as having accumulated on a submarine fan, possibly in its middle to lower part (Siedlecka 1972, Pickering 1981).

The beds are inclined steeply towards the northwest and are folded, the folds carrying an axial plane cleavage.



Locality 26. Kongsfjorden, Djupbukta, cliffs at c.844 466, map-sheet M 1:50,000 2336 II Kongsfjord (topographic map and map of bedrock geology, Siedlecka 1989).

Kongsfjord Formation, Risfjorden Member, metadolerite dykes.

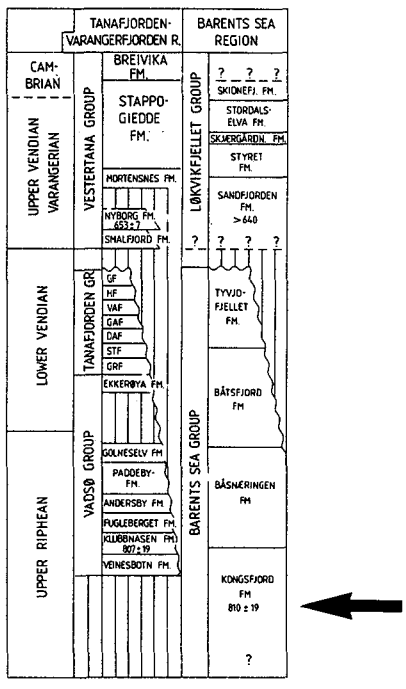
Coastal cliffs in the inner part of Kongsfjorden, cut by the road, provide excellent exposure of turbidites of the Kongsfjord Formation dissected by a swarm of metadolerite dykes.

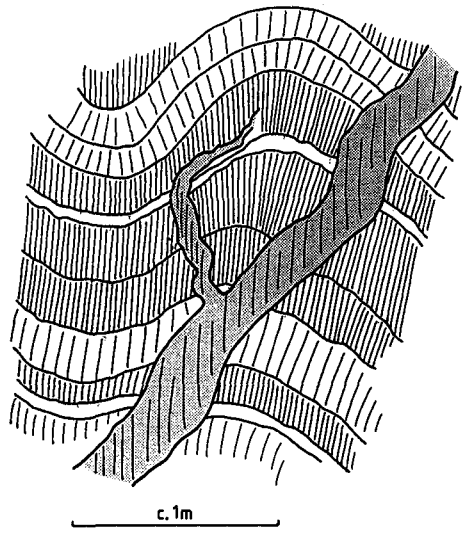
The Kongsfjord Formation is represented here by thin-bedded and fine-grained turbidites in which graded-bedding and parallel lamination are ubiquitous and various sole marks may be observed (Siedlecka 1972). These turbidites were interpreted by Pickering (1981) as having accumulated mostly as unchannelled, distal deposits in an outer fan.

The ENE-WSW-trending metadolerite dykes, generally a few metres in thickness, are almost vertical and are prominent in the coastal landscape, standing out as ribs. They are cleaved to a varying degree and metamorphosed, consisting mainly of strongly altered plagioclase and chloritised clinopyroxene (Roberts 1972). Relict ophitic to sub-ophitic texture is present in the central parts of many dykes. Geochemical data indicate that the metadolerites are representative of magmas transitional to those producing abyssal and continental basalts (Roberts 1975). Quartz and calcite veins, commonly arranged in a 'fieder-spalten' pattern, are associated with the metadolerite dykes.

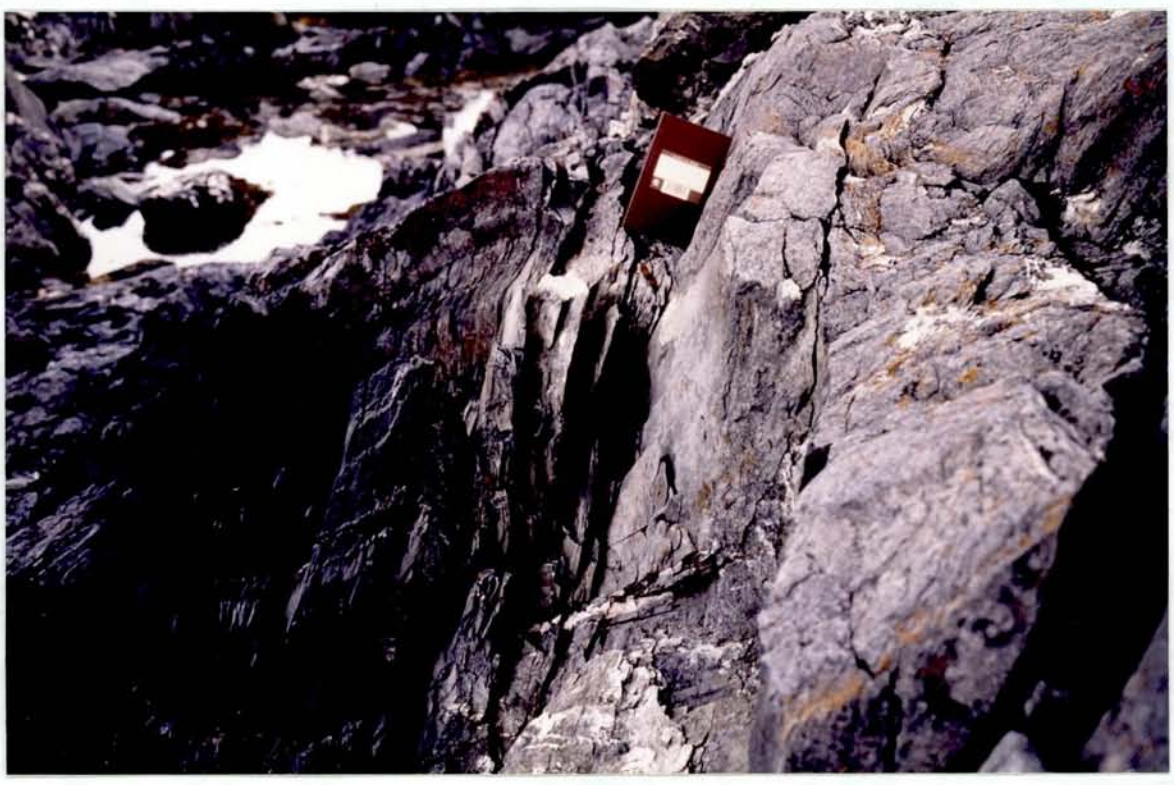
One dyke along this section (precise location unknown) was dated by the K-Ar method to 1184±36 Ma (Beckinsale et al. 1975). However, the value of this determination is uncertain because of the very low potassium content.

The metadolerite dykes have been interpreted as broadly 'syntectonic', though pre-dating the prominent cleavage which is axial planar to the common open to tight folds (Roberts 1972). Although it is tempting to consider the dykes as wholly pre-tectonic, related to a phase of rifting, the fact that some of them cut obliquely across folds (but are themselves cleaved; see sketch below) argues against this possibility.





Veineset in Kongsfjorden. Metadolerite dyke cross-cutting turbidites of the Kongsfjord Formation, Risfjorden Member. Båsnæringen in the background to the right.



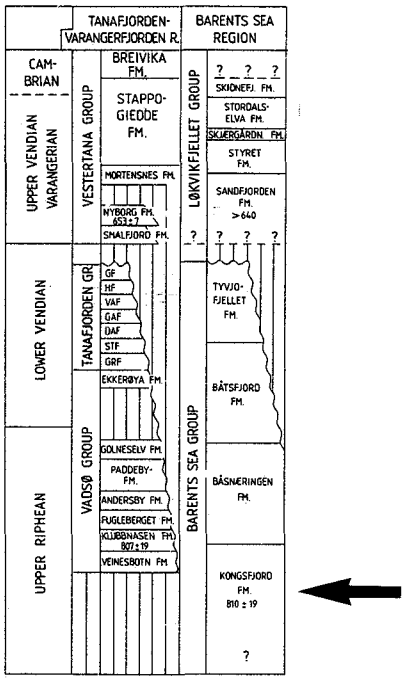
Veineset in Kongsfjorden. Contact between the cleaved turbidites of the Kongsfjord Formation, Risfjorden Member and a metadolerite dyke. Notebook marks the contact surface.

Locality 27. Kongsfjorden, Hergevika, 854 489, map-sheet M 1: 50,000 2336 II Kongsfjord (topographic map and map of the bedrock geology, Siedlecka 1989).

Kongsfjord Formation, Risfjorden Member, metadolerite dyke.

Turbidites of the Kongsfjord Formation are well exposed on the southern side of the bay, along the coast below the road. These outer fan deposits (Pickering 1981) exhibit an abundance of sedimentary structures such as graded bedding, parallel lamination, load casts, pseudonodules and clastic dykes. Intraformational mud-chip breccias may also be observed. The clay-rich portions of beds are dissected by a tightly spaced axial plane cleavage.

A bifurcating metadolerite dyke crops out in the northern part of the bay. The cleaved contact between the metadolerite and the host rocks is well exposed. A network of white quartz-calcite veins transect the dyke. A metadolerite dyke exposed in the vicinity of Hergevika (precise location unknown) has been dated by the K-Ar method to 935±28 Ma. The reliability of this figure, however, is doubt of because of a very low potassium content (Beckinsale et al. 1975).



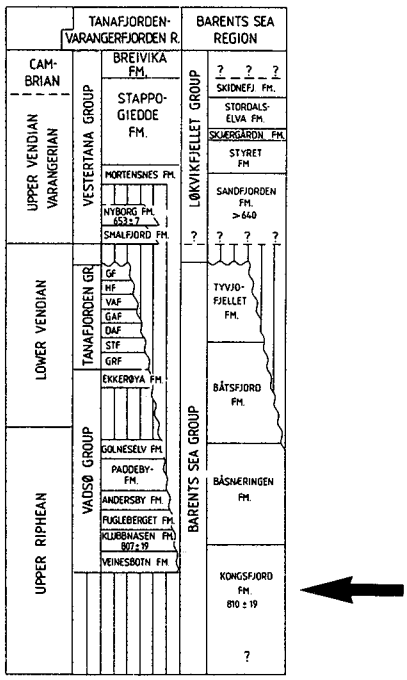
Locality 28. Western part of Risfjorden, mouth of the Meresjåkka river, 842 510, map-sheet M 1: 50,000 2336 II Kongsfjord (topographic map and map of the bedrock geology Siedlecka 1989).

Kongsfjord Formation, Nålneset Member

Thick, graded-bedded turbidite beds crop out on the northern side of the road. Load casts, flute casts and groove casts are visible on the bottom surfaces of the beds. These beds represent deposits accumulated in large channels of the middle fan environment of Pickering (1981).

The predominantly thick-bedded sequence exposed here is dissected by a system of joints oriented N-S and E-W with easterly and southerly dips, respectively.

Dykes of metadolerite may be observed along the northwestern coast of Risfjorden. However, they are noticeably fewer in number compared with the Kongsfjorden area further to the southeast.



Northwestern side of Risfjorden, close to locality 28. Kongsfjord Formation, Nålneset Member. Thick-bedded channel deposits and thin-bedded inter-channel accumulations.

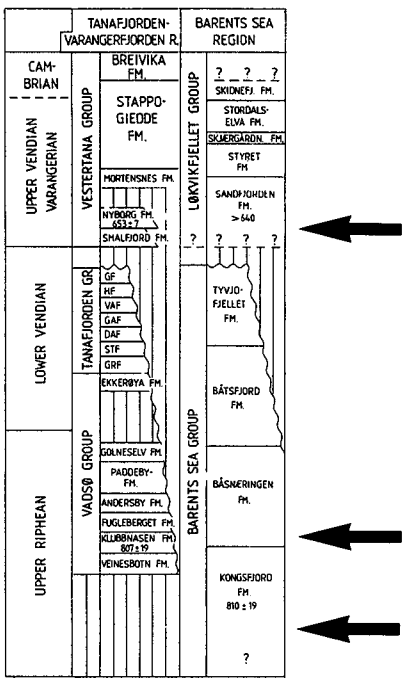
Locality 30. Matrix-supported conglomerate interpreted as a subaqueous debris flow.

Locality 29. Stop between Kongsfjorden and Sandfjorden at c.861 550,map-sheet M 1: 50,000 2336 I Berlevåg. View towards localities 29 and 30.

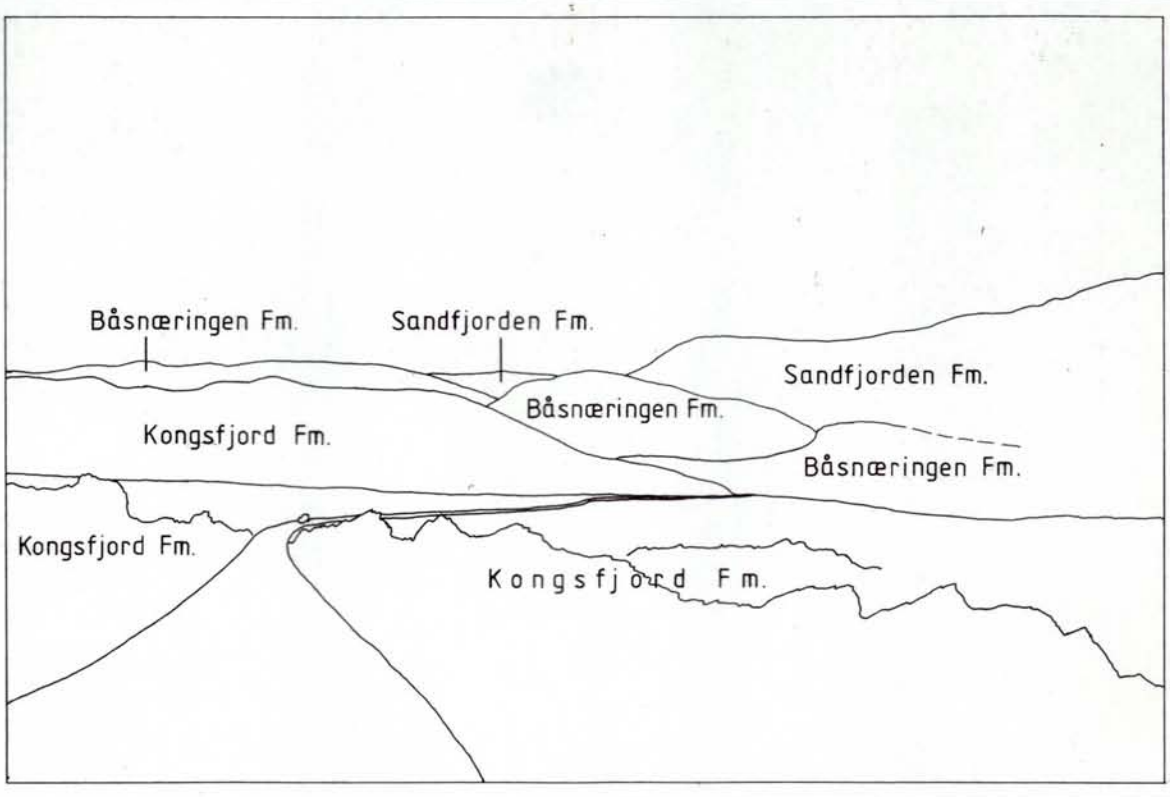
Contact between the Barents Sea Group (Kongsfjord Formation and Båsnæringen Formation) and the Løkvikfjellet Group (Sandfjorden Formation).

Excellent view towards northwest (see pictures on the next page). The coastal plain to the right of the road and the low hill to the left of the road in the foreground are underlain by the Kongsfjord Formation (inner fan of Pickering 1981). A somewhat higher hill in the middleground is underlain by the Næringselva Member of the Båsnæringen Formation, Næringselva Member. Finally, the high, light-coloured ridge on the opposite side of Risfjorden and the plateau in the background consist of the Sandfjorden Formation of the Løkvikfjellet Group.

The unconformable contact between the Barents Sea Group and the Løkvikfjellet Group in this coastal area is dissected by faults. It is rather poorly exposed in a few places inland.



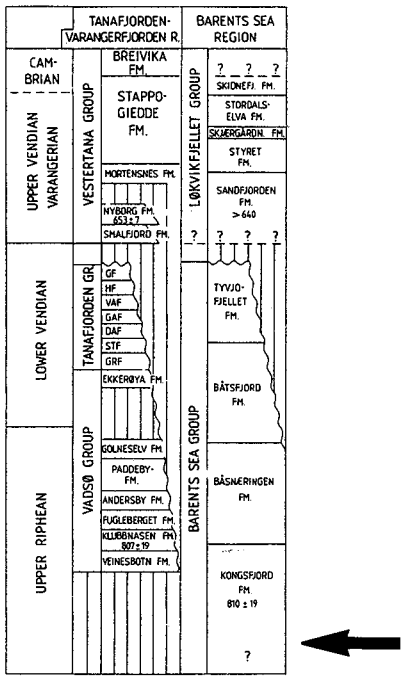
View towards the contact between the Barents Sea Group and the Løkvikfjellet Group at Sandfjorden.



Locality 30. Laukvika, stop at the bridge at 844 556, map-sheet M 1: 50,000 2336 I Berlevåg.

Kongsfjord Formation, Nålneset Member

A few hundred metres walk towards the outer parts of Laukvika and Tarevika provides an opportunity to examine a section through the proximal part of the Kongsfjord submarine fan (Pickering 1981). The section contains medium- to coarse-grained sandstones and fine quartz conglomerates. Graded turbidite beds are interbedded with erosively based, lenticular conglomerate and coarse-grained sandstone beds which accumulated in channels. The conglomerates are either sandy and grain-supported, i.e. water-transported and deposited as bed load, or matrix-
supported and unstratified, and accumulated by subaqueous debris-flow. The interbedded, parallel-sided turbidites were probably deposited in the inter-channel areas.

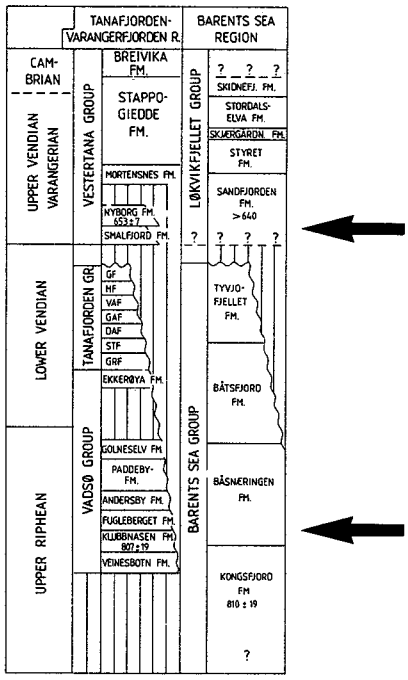


Locality 31. Sandfjorden,NW side, c.831 572, map-sheet M 1: 50,000 2336 I Berlevåg.

Båsnæringen Formation, Næringselva Member, in tectonic contact with the Sandfjorden Formation.

The road crosses blue-green, laminated mudstone and mudshale, heavily cleaved and jointed. The same rocks, belonging to the Næringselva Member, are also well exposed in the low cliffs nearby.
A few tens of metres further to the northeast the road crosses medium- to thick-bedded pink arkose and conglomerate of the Sandfjorden Formation. These rocks are particularly well exposed just below the road. The Sandfjorden Formation can be seen along the road over a distance of several kilometres as pink, greenish-grey arkoses and grey sandstones. The arkoses and sandstones are well-sorted with well-rounded grains. The conglomerate pebbles consist primarily of milky quartz, quartzite, black chert and red jasper. The beds are parallel-sided, and commonly trough cross-bedded. The feldspars are mostly microcline and perthite. Heavy minerals include zircon, rutile, tourmaline, garnet and other stable minerals (Siedlecki & Levell 1978).
The Sandfjorden Formation has been interpreted as a a shallow-marine deposit which accumulated under the influence of tidal currents (Levell 1980).

There is a fault separating the Båsnæringen Formation and the Sandfjorden Formation at this locality. The actual contact, however, is not exposed.

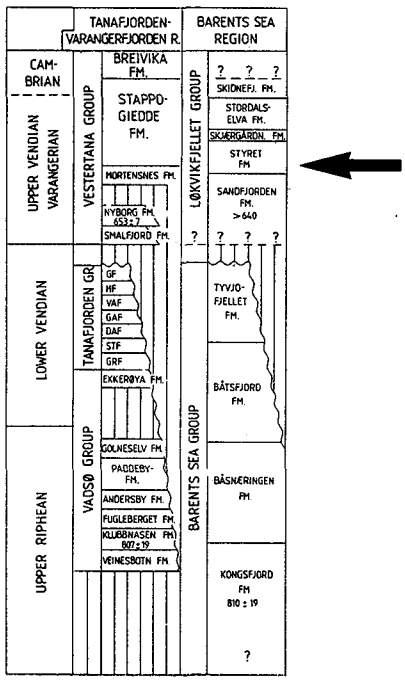


Locality 32. Styret, c.831 599, map-sheet M 1: 50,000 2336 I Berlevåg.

Styret Formation, lower part.

Thick beds of greenish-grey, in places reddish-grey, trough cross-bedded sandstone crop out in road-cuts. Typically, the sandstone beds are lenticular and erosively based, in places with considerable relief (Levell & Siedlecki 1978).
Pebbles and feldspar are less common than in the Sandfjorden Formation. There is a gradual transition between the Sandfjorden and the Styret Formations and the boundary was placed on the basis of studies of sedimentary structures rather than on overall lithological appearance. The Styret Formation was interpreted by Levell (1980) as largely of fluvial origin.

Upwards in the sequence assigned to the Styret Formation there is a gradual increase of clayey and muddy shale beds interbedded with the sandstone, and at the same time the thickness of the sandstone beds decreases. This gradual change in lithological composition is clearly visible in the cliffs bordering Styrsletta from the southwest. The upper Styret Formation may also be examined at c.828 604 (western side of the road) about 200 m south of the Styrelva river.



Locality 33. Skjærgårdnes, 823 611,(optional: Mellanes c.822 620) map-sheet M 1: 50,000 2336 I Berlevåg.

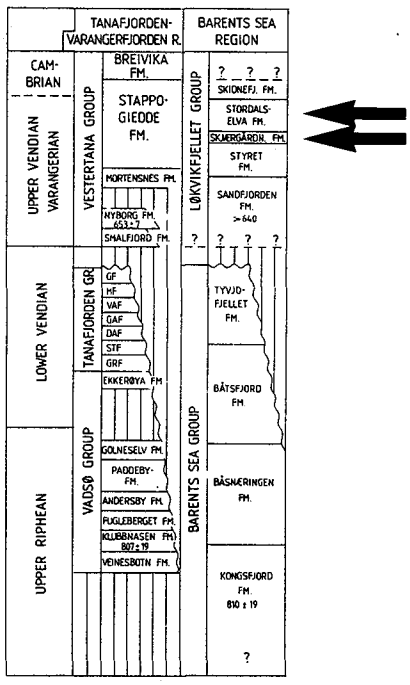
Skjærgårdneset Formation, Stordalselva Formation.

Dark-grey, thick-bedded sandstone interbedded with muddy shale crops out along the road and in the coastal section. Typical for the sandstone is tabular, herring-bone cross-bedding, reflecting varying palaeocurrent directions. The sandstones are moderately well sorted and sub-arkosic in composition and were interpreted by Levell (1980) to be of shallow-marine origin.

Between Skjærdgårdnes and Kjølnes Fyr further to the northwest, the road crosses a syncline with rocks belonging to the **Stordalselva Formation** in its core, and with the **Skjærgårdneset Formation** reappearing at Kjølnesaksla and Kjølnes Fyr.

There are no road-cuts in the Stordalselva Formation, but good coastal exposures occur close to Mellanes. The axial zone of the syncline is located about 150 m south of the tip of Mellanes.
The uppermost part of the Stordalselva Formation visible in the Mellanes section, consists of thick trough cross-bedded, coarse-grained sandstones underlain by dark-grey, laminated mudstone interbedded with rippled arenaceous shale and ripple cross-stratified, thin- to medium-bedded sandstone.

Interbeds of thick, coarse sandstones with mixed mudstone-sandstone units are typical of this formation, interpreted as a shallow-marine deposit (Levell 1980).



Locality 34. Vargvika, c.794 622, map-sheet M 1: 50,000 2336 I Berlevåg.

Tectonic contact between the Styret Formation of the Løkvikfjellet Group and the phyllite-metasandstone interbedded unit of the Berlevåg Formation (Tanahorn Nappe).

The high-angle thrust-fault separating the Løkvikfjellet Group from the Berlevåg Formation was mapped and described by Levell & Roberts (1977). The NE-SW-trending thrust-plane is not exposed along the road but it may be observed in the cliffs towards the southwest. There, a 7-10 m thick mylonite zone marks the contact, and the Styret Formation sandstones are partly vitrifred in a narrow zone below the mylonite. In this northwestern part of Varanger Peninsula, the metasandstones and phyllites of the Berlevåg Formation form three mappable units, and at locality 34 an interbedded unit of blackish-grey phyllite, metasiltstone and meta thin-bedded sandstone is thrust upon the coarse sandstones of the (lower) Styret Formation.

There is a perceptible difference in metamorphic grade between the very weakly metamorphosed rocks of the Løkvikfjellet Group and the greenschist-facies metasediments of the Berlevåg Formation (Levell & Roberts 1977). In terms of illite crystallinity (Rice et al. 1989b), the difference in metamorphic grade appears to be less marked. However, the Berlevåg Formation has suffered a more complex deformational history than the Løkvikfjellet Group and, in contrast to the latter, contains abundant metadolerite dykes.

Locality 35. Road-cuts at c.784 621, map-sheet M 1: 50,000 2336 I Berlevåg.

Berlevåg Formation, coarse-grained metasandstone unit.

Steeply NW-dipping beds of metasandstone interbedded with subordinate phyllite are exposed in high road-cuts on both sides of the road. The metasandstone is coarse-grained, thin- to medium-bedded and exhibits a weakly developed graded-bedding.

Rocks belonging to the same unit may be conveniently examined in a quarry about 0.5 km south of the main road (776 618). Here, in addition to the coarse-grained sandstone (and subordinate semipelitic rocks), fine-grained quartz conglomerate is exposed. Pebble lineation shows a steep plunge to the northwest.

The rocks in this area are strongly cleaved, the cleavage (or schistosity) being axial planar to tight D1 folds which plunge steeply to the northwest. Second generation folds are locally common, plunging NNW, and in places have developed a fairly prominent axial surface crenulation cleavage. A third generation of structures is represented by kink bands.

Locality 36. Valen, coastal section north of the road at c.763 647, map-sheet M 1:50,000 2336 I, Berlevåg.

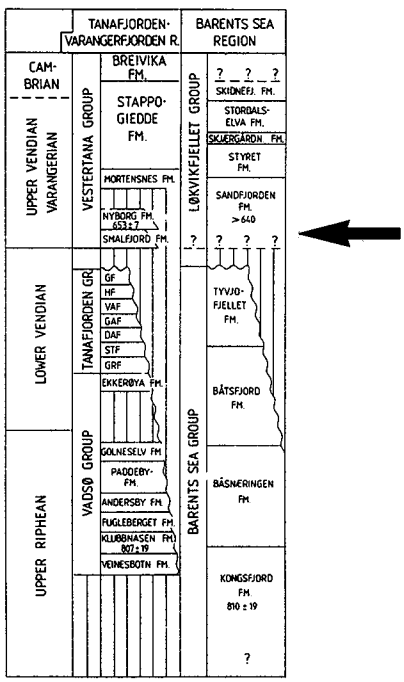
Berlevåg Formation, upper metasandstone-phyllite interbedded unit.

The steeply westward-dipping rocks of this unit crop out in a low, partly vegetated coastal area. The sequence consists of thin- to medium-bedded, grey metasandstone beds, each bed sharply based and with an upward gradual transition into blackish-grey phyllite. Thin-bedded sandstone beds are usually ripple cross-stratified while the medium-thick layers are graded-bedded. Other primary structures present include convolutions, ball-and-pillow, and slump units. Segregations of carbonate (siderite) are present in some sandstone beds. Several metadolerite dykes, trending c. NE-SW, occur along this coastline. Mesoscopic folds are common, generally plunging NNE, and carry a penetrative axial planar slaty cleavage or schistosity. Minor folds which post-date the schistosity are also present.

Locality 37. Adamsvatnet, c. 910 287, map-sheet M 1:50,000 2436 III Båtsfjord (topographic map and map of bedrock geology, Siedlecka 1987).

Løkvikfjellet Group, Sandfjorden Formation.

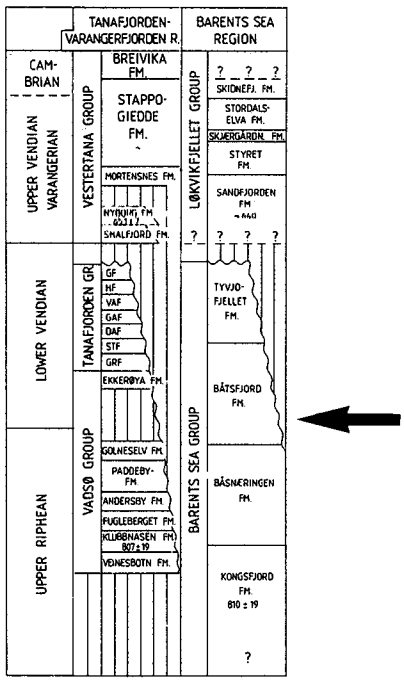
Medium-thick and thick beds of pink arkose crop out in the hillslope about 50 m north-west of the road. This arkose, coarse-grained to conglomeratic, with quartz, quartzite and red jasper granules and pebbles, is a typical rock of the lower Sandfjorden Formation. The roundness of grains, good sorting, stable heavy minerals (e.g. zircon, tourmaline, rutile, garnet) and the quartz-quartzite dominated composition of the pebbles are characteristics which led to the interpretation of this unit as a shallow-marine deposit Levell 1981).



Locality 38. Annejåkka, section in a c. 2 km long road-cut (middle at c.970 330), map-sheet M 1: 50,000 2436 III Båtsfjord (topographic map and map of bedrock geology, Siedlecka 1987). (The old road is marked on the maps: the new road with the exposed section has a different location !).

Båtsfjord Formation, transition between the Skovika Member and the Annijokka Member.

This multicoloured sequence, composed of purple mudstone interbedded with grey, pink or red sandstone beds and sporadic yellowish-grey dolomitic layers, is typical of the upper Båtsfjord Formation. Although the uppermost (westernmost) part of the exposure is rather poor, sedimentary structures such as, e.g., rippled surfaces, ripple cross-lamination and desiccation cracks may be observed, testifying to a shallow-water deposition. Eastwards, and stratigraphically downwards in the section, there is a gradual transition into an interbedded sequence of greenish-grey mudstone, pink and greenish-grey carbonate-bearing and clayey sandstone and greenish-grey dolomite, bright-yellow on weathered surfaces. This sequence, typical of the Annijokka Member, is exposed in the lower (eastern) c. 600 m-long part of the road-cut. The beds are typically medium-thick, parallel-laminated and wavy laminated or rippled. Mud-chip breccias and desiccation cracks may be observed.
The Annijokka Member has been interpreted as having accumulated in a marine coastal area, largely on tidal flats (Siedlecka 1978).

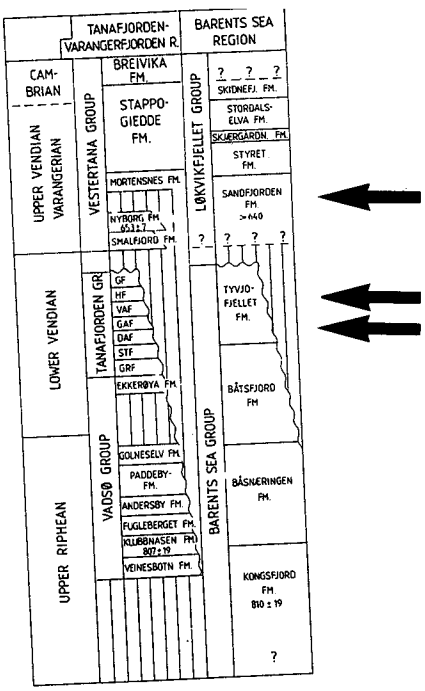


Locality 39. View-point, NW side of Båtsfjorden, northeast of Båtsfjord settlement, c. 017 405, map-sheet M 1: 50,000 2436 III Båtsfjord (topographic map and map of the bedrock geology, Siedlecka 1987).

Unconformity between the Sandfjorden Formation of the Løkvikfjellet Group and the Tyvjofjellet Formation and the Båtsfjord Formation of the Barents Sea Group. Dolerite dykes.

In clear weather the view towards the cliffs on the southeastern side of Båtsfjorden shows the angular unconformity between the Barents Sea Group and the Løkvikfjellet Group. The purple and yellowish-pink banded mudstone and sandstone sequence of the Tyvjofjellet Formation and the uppermost Båtsfjord Formation (the latter seen best in the NW-cliffs of the inner Båtsfjorden) are sharply overlain by a homogeneous, pink sandstone sequence of the Sandfjorden Formation.

The unconformity is cut by a swarm of steep, nearly vertical, metadolerite dykes. Three of these dykes were dated by the K-Ar method to around 640 Ma (Beckinsale et al. 1975). Geochemical data are available on these particular dykes but have not yet been published (D.R.).



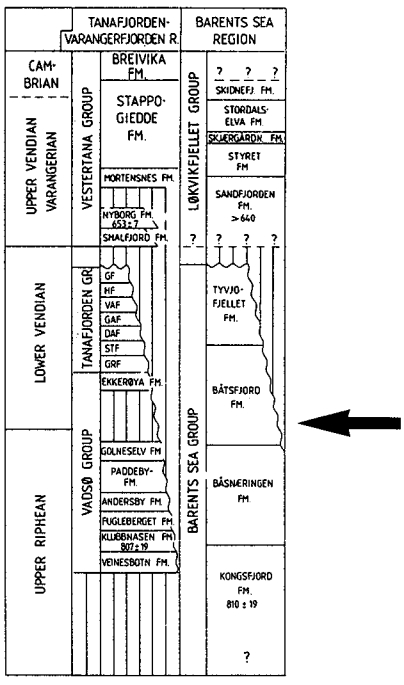
Locality 40. Arusjåkka, road cut at c. 987 327, map-sheet M 1: 50,000 2436 III Båtsfjord (topographic map and map of the bedrock geology, Siedlecka, 1987).

Båtsfjord Formation, Annijokka Member.

A section through the (upper) Annijokka Member is exposed in a c.400 m-long road-cut, along a marked bend in the road to Syltefjord. The section consists of interbeds of blue-green to greenish-grey, thick-bedded, banded mudstone, dark-grey clayey shale and yellowish-grey arenaceous dolomite. These rock-types form recurrent sandstone-shale-mudstone-dolomite cycles. The cycles are particularly well-exposed in the eastern part of the road-cut. At the same time there appear purple-coloured mudstones and reddish-grey sandstones typical of the upper Båtsfjord Formation. There is an abundance of sedimentary structures preserved in these beds: parallel horizontal lamination, ripple cross-stratification, ripple marks, desiccation cracks, intraformational mud-chip breccias and 'birds eye' structures.

The Annijokka Member was interpreted by Siedlecka (1978) as a coastal marine deposit accumulated mainly on tidal flats (Siedlecka 1978), with the terrigenous-carbonate sequences reflecting shallowing-up conditions.

The above sedimentary sequence is dissected by a c. 0.5 m thick dyke of metadolerite and associated abundant quartz-calcite veins.



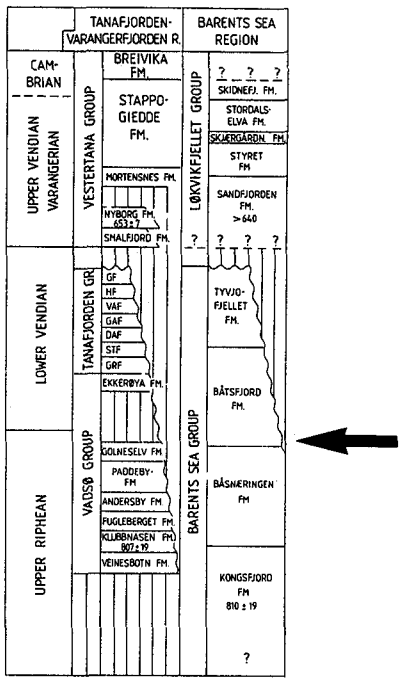
Locality 41. Straumen, road-cuts and exposure in the hillslope of Veineset, c.900 282, map-sheet M 1:50,000 2436 II Syltefjord.

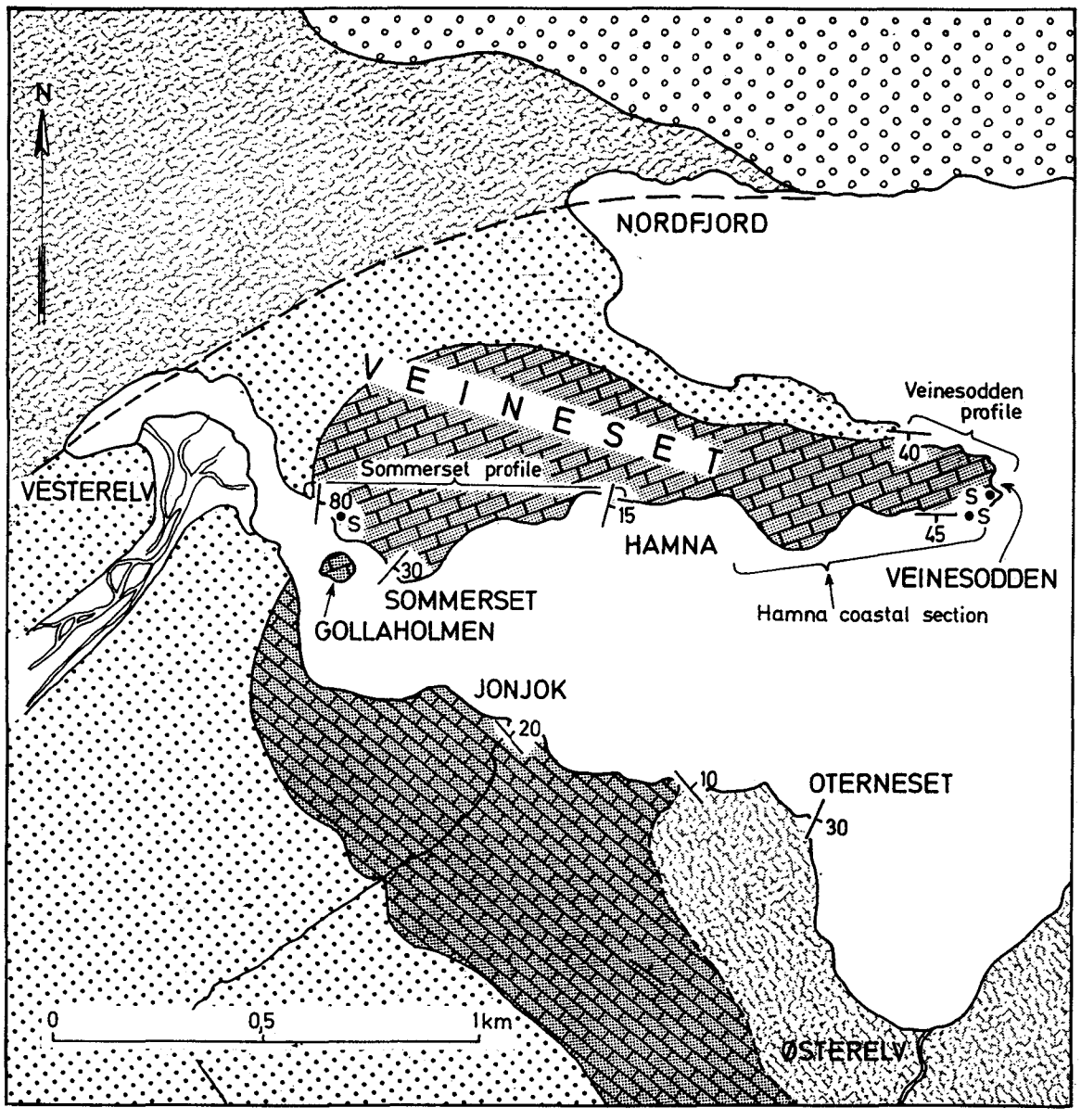
Stratigraphic contact between the Båsnæringen Formation and the Båtsfjord Formation, section of the Annijokka Member, stromatolites.

The local dirt road to Hamna in Syltefjord crosses the stratigraphic contact between the Hestman Member of the Båsnæringen Formation and the Annijokka Member of the Båtsfjord Formation. The contact is clearly visible from a distance in the southwestern slope of Hamnefjellet, and the rocks of both units may be examined along the road.
A c. 200 m-thick section of the Annijokka Member is exposed along the road and the coast over a distance of more than 4 km (the Sommerset profile of Siedlecka, 1978). The section consists of siliciclastic and carbonate rocks arranged in recurrent cycles each a few metres thick. The cycles start with sandstone grading into siltstone, claystone and dolomite with limestone. At the same time there is a gradual upward increase in carbonate rocks at the expense of terrigenous beds, testifying to a gradual transition from terrigenous to carbonate deposition. There is, in these rocks, an abundance of sedimentary structures such as cross bedding, ripple cross-stratification, commonly bimodal, parallel lamination, desiccation cracks, mud-chip breccias and 'birds eye' structures in dolomite. In addition, there are at least two stromatolite biostromes containing non-columnar stromatolites.

A terrigenous-carbonate tidal flat environment of sedimentation for this succession has been proposed by Siedlecka (1978). The stromatolites were interpreted as having formed in supratidal, fresh-water to schizohaline ponds (Siedlecka 1982).

Calcareous concretions, developed and superimposed on rippled and laminated terrigenous-dolomitic sediment, may also be observed in this section.





Annijokka Member

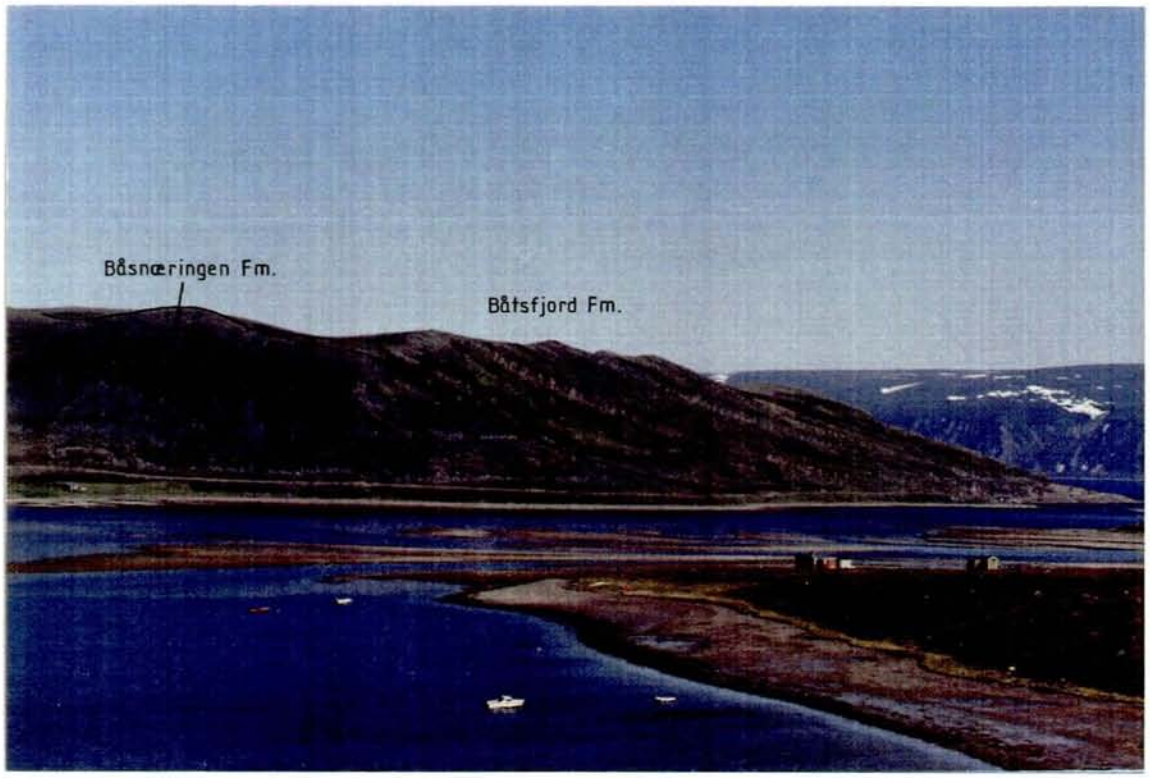
Skovika Member

Båsnæringen Formation

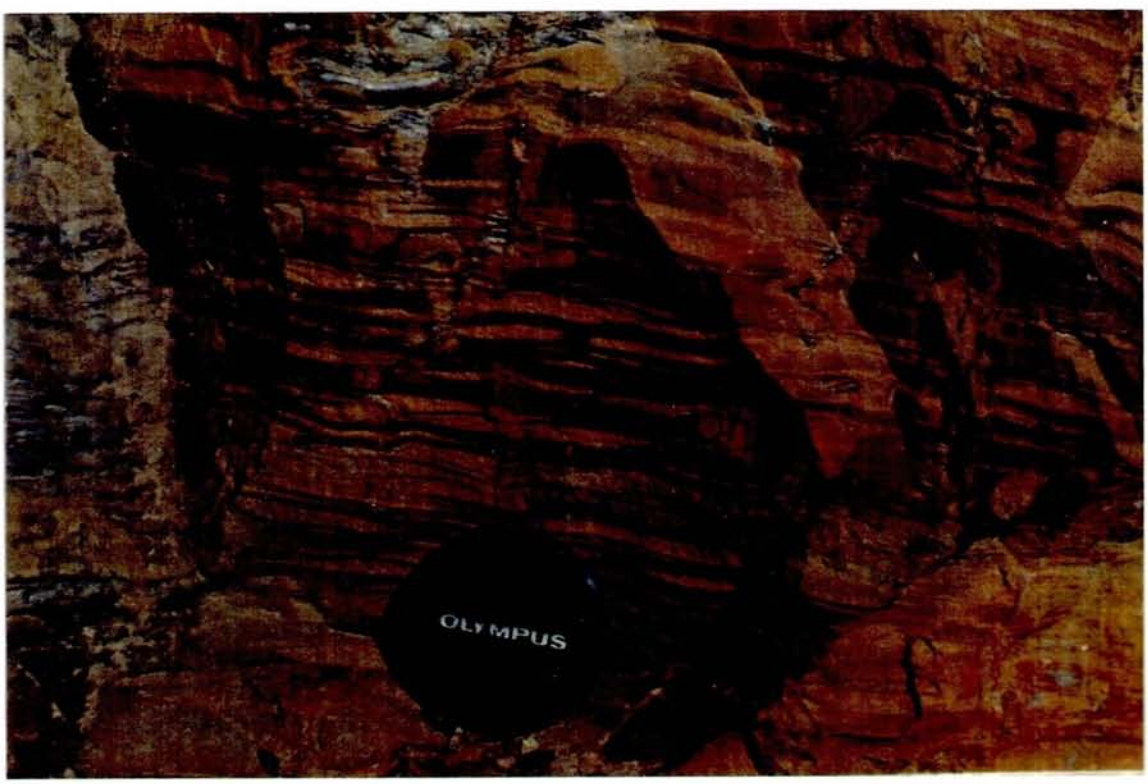
Løkvikfjellet Group

• S Occurrence of stromatolites

Bedrock map of Hamna area, inner Syltefjorden



View towards Veineset. Contact between the Båsnæringen Formation and the Båtsfjord Formation. Locality 41 is close to the road at the far right.

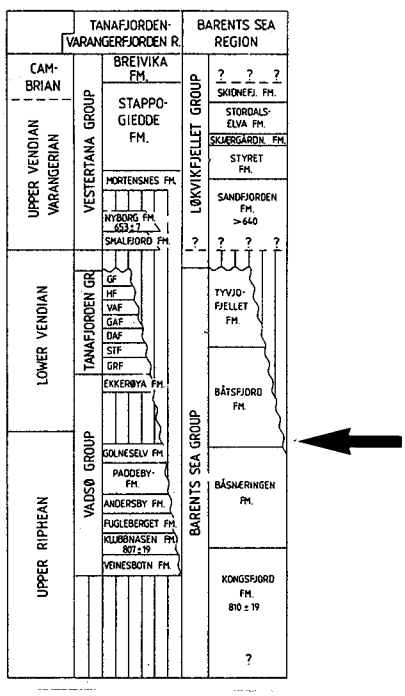


Locality 41. Terrigenous dolomitic beds with flaser and lenticular bedding interpreted as tidal-flat deposit.

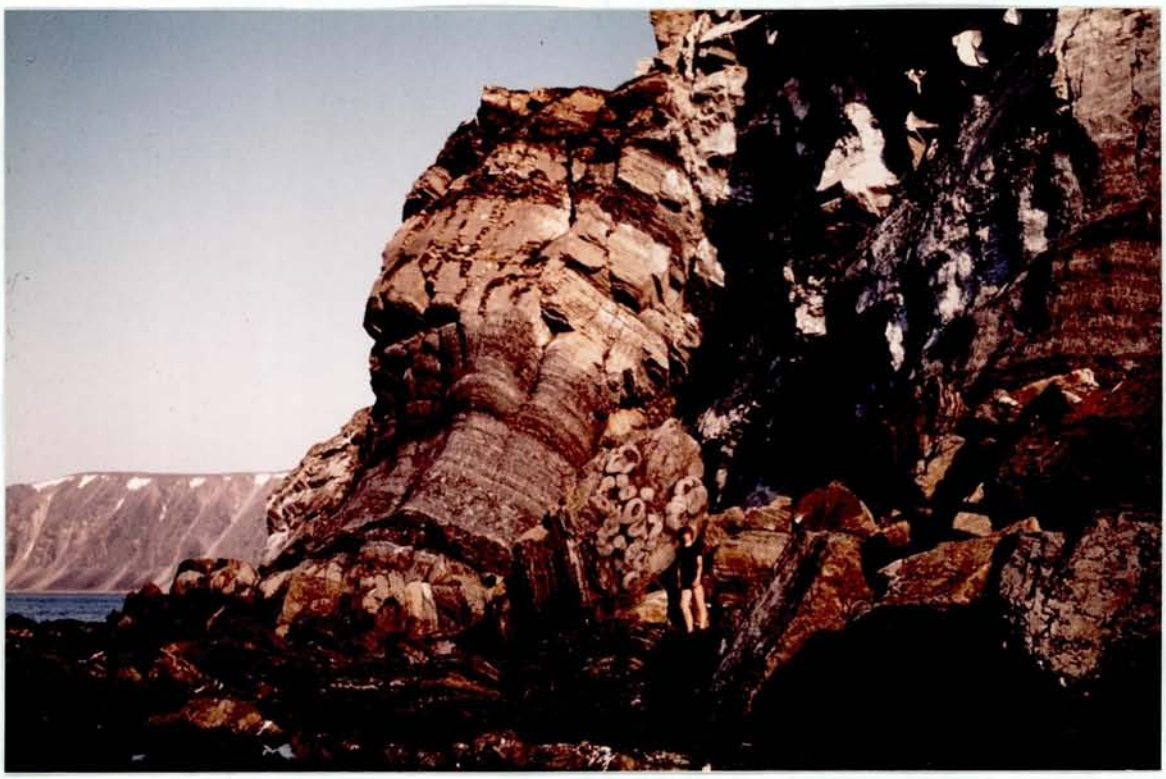
Locality 42. Veinesodden, section at c.936 283, map-sheet M 1: 50,000 2436 II Syltefjord.

Hestman Member of the Båsnæringen Formation in stratigraphic contact with the Annijokka Member of the Båtsfjord Formation; section of the Annijokka Member, stromatolites.

From the end of the road at Hamna (922 281) a c. 30 min. walk over the hill towards the east, to the northern coastal section of Veinesodden (last part of the walk along a rather steep sheep path !). The section is continuously exposed and it is recommended to examine it at low tide. In this Veinesodden profile of Siedlecka (1978), several interesting features may be observed. The red feldspathic sandstone marking the top of the Båsnæringen Formation is overlain by a series of interbedded greenish-grey claystone and siltstone, grey sandstone and shaly sandstone and siltstone, blackish-grey claystone and carbonate rocks in which six stromatolite biostromes have been recorded. The rocks are, as in the Sommerset profile, arranged in recurrent terrigenous fining-up to carbonate cycles. There is an abundance of sedimentary structures such as cross-bedding, ripple cross-stratification, flaser- and lenticular bedding, parallel lamination, desiccation cracks and intraformational mud-chip breccias. The structures testify to shallow-water sedimentation and a tidal-flat environment of deposition was suggested by Siedlecka (1978), with the cycles reflecting repeated shallowing-up events. Particularly interesting are synæresis cracks which occur in abundance and penetrate deeply into clay-rich beds. The stromatolites have unusual 'wash-bowl' shapes, form calcareous horizons within terrigenous and dolomitic beds within the upper parts of the cycles, and were interpreted by Siedlecka (1982) as having originated in supratidal, fresh-water to shizohaline ponds.



Locality 41. Limestone concretions in terrigenous-dolomitic beds of the Annijokka Member, Båtsfjord Formation.



Locality 42. Annijokka Member of the Båtsfjord Formation at Veinesodden. Note the block with stromatolites.

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Lithostratigraphy of the Tanafjorden Group and the Vadsø Group in the Tanafjorden - Varangerfjorden Region (mainly after Siedlecka & Siedlecki 1971 and Banks et al. 1974)

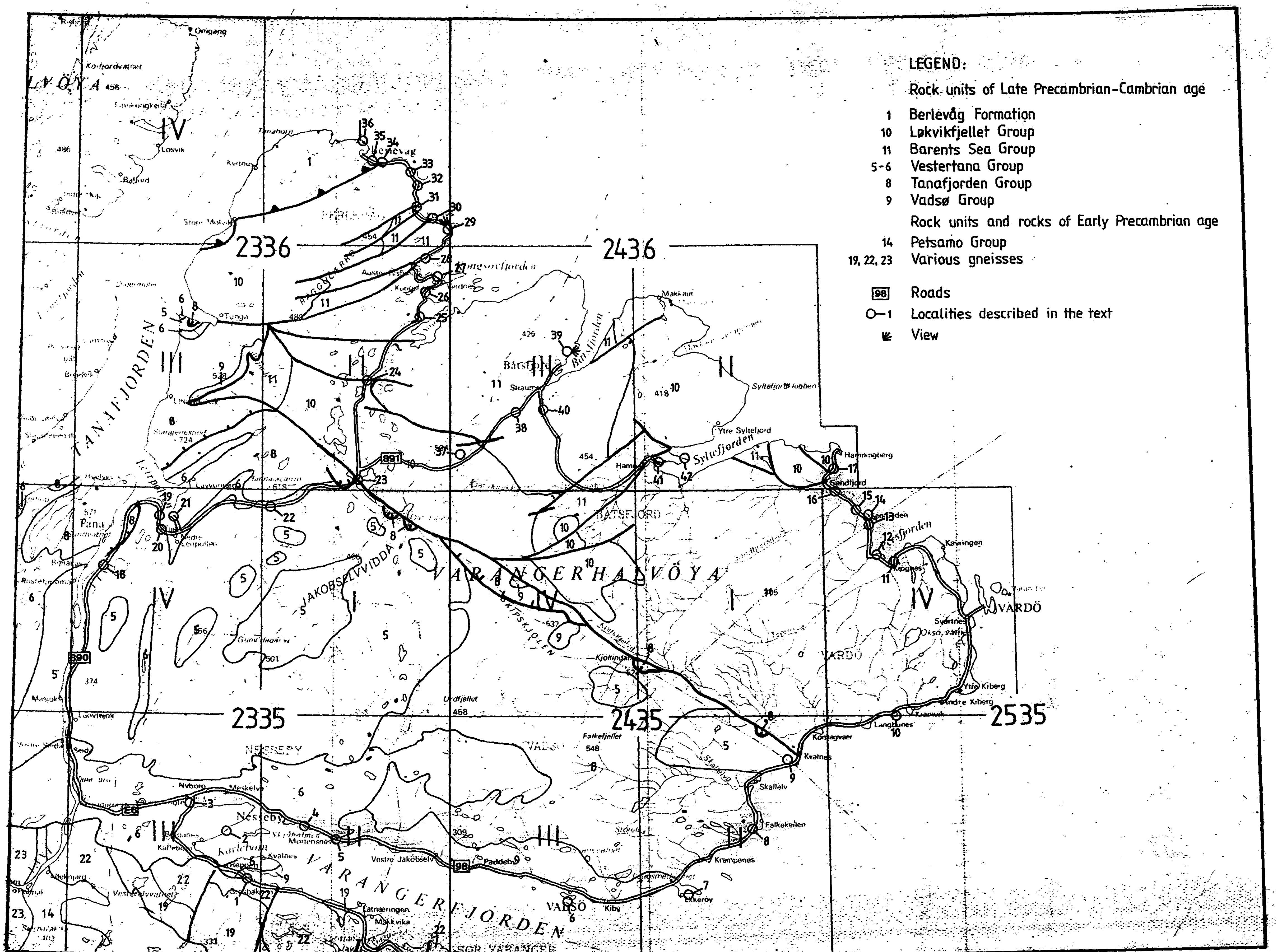
Age	Lithostratigraphic units and their thicknesses		
VENDIAN	TANAFJORDEN GROUP 1448 - 1665 m	Grasdalen Formation 280 m	Upper member Lower Member
		Hanglecærro Formation 200 m	
		Vagge Formation 80 m	
		Gamasfjellet Formation 280-300 m	
		Dakkovarre Formation 273-350 m	Ferruginous sandstone member 130 m "k" member 62 m "j" member 46 m "i" member 35 m Quartzitic sandstone member 60-80 m
		Stangenes Formation 205-255 m	
		Grønneset Formation 130-200 m	
RIPHEAN	VADSØ GROUP, 590-960 m	Ekkerøya Formation 15-190 m	
		Golneselva Formation 50-135 m	
		Paddeby Formation 25-120 m	
		Andersby Formation 25-40 m	
		Fugleberget Formation 125 m	
		Klubbnasen Formation 50 m	
		Veinesbotn Formation 300 m	

Lithostratigraphy of the Løkvikfjellet Group and Barents Sea Group in the Barents Sea Region (after Siedlecka 1978, 1989, Siedlecka & Edwards 1980, Siedlecka & Siedlecki 1967, Siedlecki & Levell 1978).

Age		Lithostratigraphic units and their thickness	
RIPHEAN - VENDIAN ?	LØKVIKFJELLET GROUP 5710-5810 m	Skidnefjellet Formation > 800 m	
		Stordalselva Formation 1200 m	
		Skjærgårdneset Formation 210 m	
		Styret Formation 1500-1600 m	
		Sandfjord Formation 2000 m	
	BARENTS SEA GROUP 8900 - > 10000 m	Tyvjofjell Formation 1500 m	
		Båtsfjord Formation 1400-1600 m	Skovik Member 1100-1300 m Annijokka Member 300 m
		Båsnæring Formation 2500-3500 m	Hestman Member 600-1300 m Godkeila Member 490-1450 m Seglodden Member 100-350 m Næringselva Member 500-1200 m
		Kongsfjord Formation > 3500 m	Nålneset Member 2000 m / Risfjorden Member 1000-1500 m

Lithostratigraphy of the Digermulen Group and the Vestertana Group (after Reading 1965).

Age	Litostratigraphic units and their thicknesses		
VENDIAN—CAMBRIAN—ORDOVICIAN	DIGERMULEN GROUP 1510 – 1555 m	Berlogaissa Formation 300 m	
		Kistedalen Formation 710-735 m	Grey quartzite member 200 m Black shale member 200 m Black quartzite member 10-35 m Sandstone and shale member 200 m Quartzite and shale member 100 m
		Duolbasgaissa Formation 500-520 m	Massive-bedded quartzite member 300 m Thin-bedded quartzite member 200-220 m
	VESTERTANA GROUP, 1317 – 1655 m	Breivika Formation 600 m	
		Stappogiedde Formation 505-545 m	Manndrapselva Member 190 m Innerelva Member 275 m Lillevatnet Member 40-80 m
		Mortensnes Formation 10-60 m	
		Nyborg Formation 200-400 m (654 ± 7)	
		Smalfjord Formation 2-50 m	


LEGEND:
Rock units of Late Precambrian-Cambrian age
1 Berlevåg Formation
10 Løkvikfjellet Group
11 Barents Sea Group
5-6 Vestertana Group
8 Tanafjorden Group
9 Vadsø Group
Rock units and rocks of Early Precambrian age
14 Petsamo Group
19, 22, 23 Various gneisses
98 Roads
Localities described in the text
View
2336
2436
2335
2435
2535
VARANGERHALVÖYA
VARANGERFJORDEN
TANAFJORDEN
VARDÖ
VADSÖ
Båtsfjord
Berlevåg
Nesseby