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BEDROCK GEOLOGY OF THE PORSANGER – TANA REGION, FINNMARK: AN EXCURSION GUIDE

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RAPPORT

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Thirty-one selected localities are briefly described along a traverse from Porsangerfjorden to Tanafjorden. The localities provide a general impression of representative rock types and their deformation in the Gaissa and Laksefjord Nappe Complexes, as well as the mylonitic rocks in the basal thrust zone of the overlying Kalak Nappe Complex. Attention is paid to the stromatolite biostromes in the Porsanger dolomite. These biostromes, which are a somewhat unique feature of Norwegian geology, are beautifully exposed in parts of Porsangerfjorden.

Emneord: Berggrunn	Stratigrafi	Strukturgeologi
Sedimentær bergart	Dolomitt	Prekambrium

CONTENTS

BEDROCK GEOLOGY OF THE PORSANGER — TANA REGION, FINNMARK:

AN EXCURSION GUIDE

INTRODUCTION

This guide has been written in connection with fieldwork, excursions and sample collection carried out as part of the Norwegian/Russian collaborative project 'Correlation of the Middle-Upper Proterozoic sedimentary successions of the northern coastal areas of the USSR and Norway'. Short reviews are presented on the bedrock geology in the three main areas covered in the guide (Fig.1):

1. The Porsangerfjorden area

Here, visitors may study the stratigraphy and structure of rocks of the Gaissa Nappe Complex as well as the tectonic contact with the overlying Kalak Nappe Complex. The itinerary also provides an opportunity to see the rocks of the Lower Precambrian basement and the autochthonous, Upper Precambrian cover. The main objective of this excursion is the study of formations within the Gaissa Nappe Complex. Attention is focused on the lithostratigraphic units of the Tanafjorden Group which, although here occurring in allochthonous position, are easily correlatable with the autochthonous units in East Finnmark. Special attention is paid to the sections of the Porsanger Dolomite Formation which is a somewhat unique unit in the geology of Finnmark.

2. The Laksefjorden area

The Laksefjord Nappe Complex is well exposed at the head of the fjord. Crystalline basement occurs here in allochthonous position and is overlain by Upper Proterozoic sedimentary rocks of the Laksefjorden Group. The general stratigraphy and structure within the Laksefjord Nappe Complex is the main objective of this part of the excursion.

3. The Tanafjorden area

Formations of the Vestertana and Tanafjorden Groups constitute the Gaissa Nappe Complex in the inner Tanafjorden area. Sedimentary facies changes, in particular in the Tanafjorden

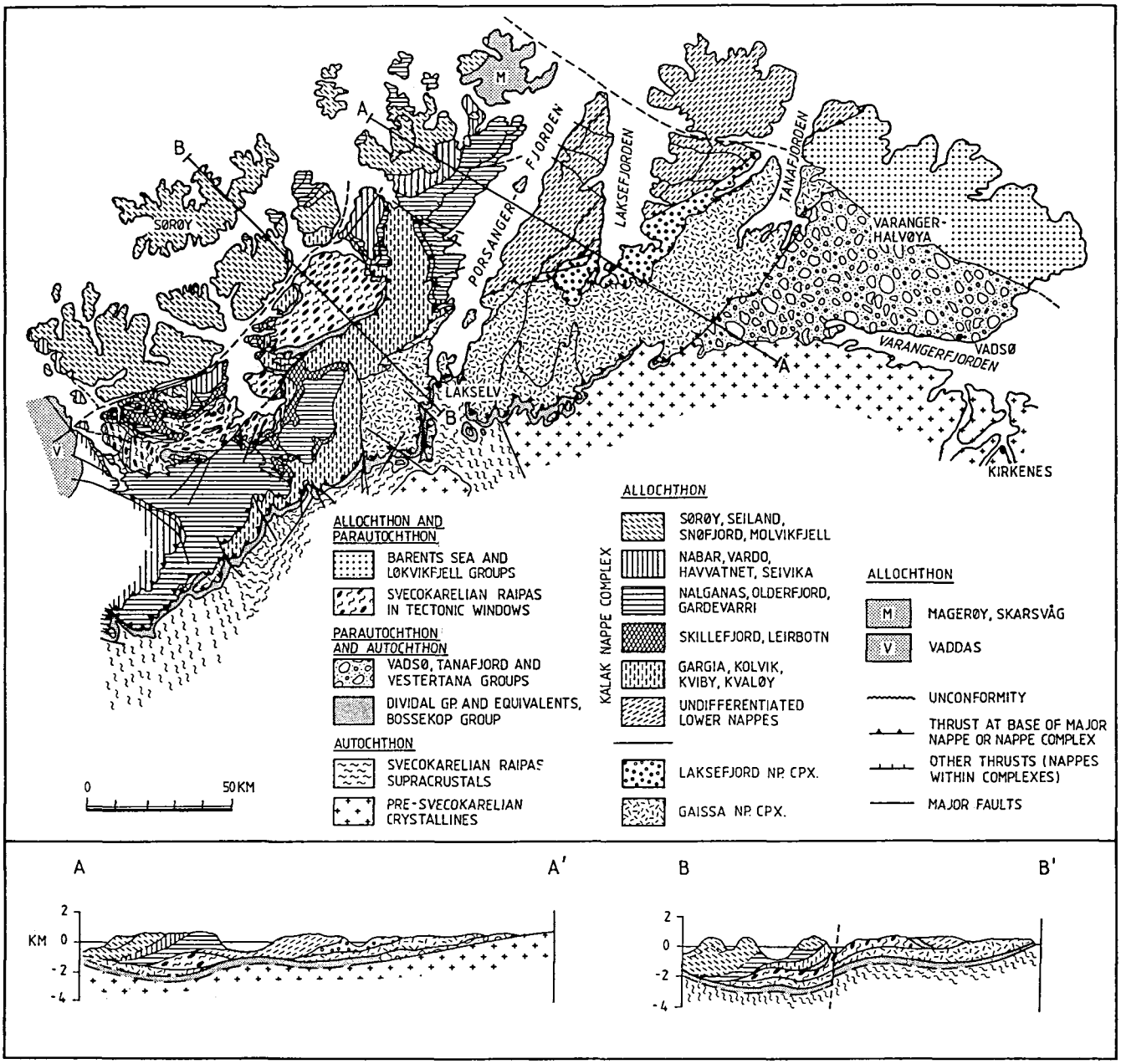

Fig.1. Tectonostratigraphy of the Finnmark Caledonides. The two cross-sections have a X5 vertical exaggeration. Modified from Roberts (1985),Plate 1.

Group, are negligible as compared with those seen in the parautochthonous and autochthonous occurrences of the same units on the Varanger Peninsula. The rocks, however, show much more tectonic deformation. Mesoscopic folds, minor faults and thrusts and a pervasive cleavage, fracturing and veining are present in abundance.

THE PORSANGERFJORDEN AREA

Introduction

The area around Lakselv, at the head of Porsangerfjorden, exposes a basement complex of Karelian supracrustal rocks with minor intrusions, overlain unconformably by a thin cover of Vendian-Cambrian Dividal Group sediments (Fig. 2).

It also affords the most easy access to the basal thrust sheet of the Caledonian allochthon, the Gaissa Nappe Complex, as well as to the overlying regionally extensive Kalak Nappe Complex. Only the 'middle allochthon', the Laksefjorden Nappe Complex, is lacking, although slices have been reported from the plateau area 15 km west of Lakselv.

The sole thrust to the Gaissa Nappe, generally dipping at 2 - 2.5° to NNW, is exposed at sea-level just northeast of Lakselv. Here, lower pelitic members of the Dividal Group are cut by a knife-sharp thrust surface below very low-grade metasandstones with intercalated siltstones of the Grønneset Formation, part of the Tanafjorden Group. Thrust-sheet displacement, towards SE-SSE, is at least 35 km.

The uppermost formation of the Tanafjorden Group, the Porsanger Dolomite, is extensively exposed beneath the overlying Kalak Nappe Complex. This c. 250 m-thick carbonate unit contains several form genera of columnar stromatolites.

Lithologies of the Kalak Nappe Complex in the Porsangerfjord district are medium-grade metasandstones and pelites. The basal thrust forms a prominent topographic feature and is well exposed at Kolvik where it floors a sequence of quartz-mylonites and, in places, blastomylonites. The thrust contact is also excellently exposed north and northwest of Børselv. Moving up, away from the intensely ductile high-strain zone, cross-bedding is present in many of the thicker psammite layers.

Some of the excursion stop descriptions in the Porsangerfjorden area are based on an earlier excursion guide (Sturt et al. 1981).

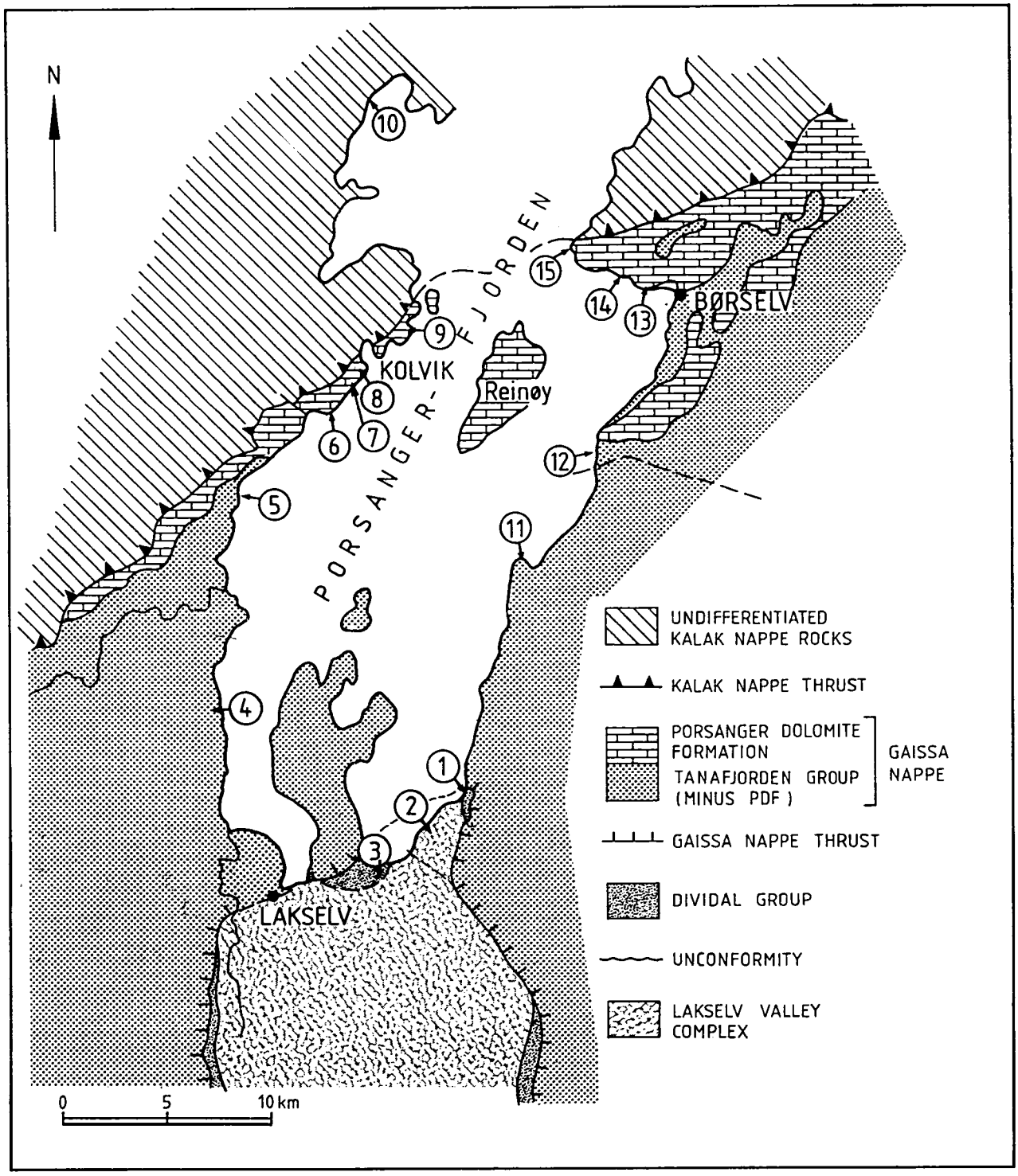

Fig.2. Simplified geological map of inner Porsangerfjorden showing excursion localities 1 - 15.

INNER PART OF PORSANGERFJORDEN

Karelian basement, Dividal Group, Gaissa Nappe Complex.

Stop 1 **Thrust contact between sandstones of the Gaissa Nappe and the autochthonous Dividal Group**

Locality: Road-cut, highway 6, NE side of the bay Handelsbukt, 12.3 km ENE of Lakselv. It is also possible to see the contact in the wall of a canyon, c. 2 km SE of Handelsbukt.

Sandstones of the Gaissa Nappe are here in thrust contact with subjacent pelitic rocks of the autochthonous cover sequence, the Dividal Group. At this locality the Dividal Group is represented by Member II, the next oldest (Vendian) of 6 members of an informal stratigraphy erected by Føyn (1967). This can be examined most conveniently along the shore at low tide — a series of grey-green, blue-green and reddish mudstones and shales with thin siltstone layers. The Dividal pelites are very gently dipping, between N and NW, and are mesoscopically folded along c. 300° axes, with a bedding-surface slip lineation roughly normal to this axial trend. The Dividal Group is correlative with the Stappogiedde and Breivik Formations in East Finnmark.

The sandstones above the thrust are part of the Grønneset Formation. These are greyish-green to buff quartzitic sandstones, locally with cross-bedding which indicates a normal disposition. Open to tight, upright, early-phase folds, along 045° axes, are sharply truncated below by the thrust plane, visible in the long road-cut. Interference patterns resulting from the later 300° folds are detectable. A small imbricate thrust is also present above the main thrust surface.

If time permits, a visit to the gorge Cas'kilavze is worthwile. This can be approached by driving up the gravel road on the south side of the river Cas'kiljåkka, to the upper terrace, and walking for c. 5 minutes to the western edge of the N-S trending part of the gorge. Here, behind a high waterfall on the eastern side of the gorge, the Gaissa Nappe rocks can be seen lying with thrust contact upon Dividal Group pelitic sediments. In the river bed below, sandstones of Member I of the Dividal Group can just be seen if the water level is low.

Stop 2 **Basal conglomerate of the Dividal Group lying unconformably upon Karelian basement.**

Locality The small promontory Čas'kilnjar'ga 600 m NW of highway 6, c. 11 km ENE of Lakselv.

Several thin patches of conglomerate are exposed on the ice-scoured and wave-washed outcrops on this point. The largest exposures, approx. 100 m x 6 m in area, are on a small island accessible by foot only at low tide (very muddy — rubber boots a necessity).

The basal conglomerate of the autochthon here appears to have been deposited on an irregular surface of polydeformed Karelian rocks. In places it is clearly seen to fill small elongate troughs and pockets in the pre-depositional surface. The conglomerate reaches a maximum visible thickness of c. 35 cm and is composed of closely packed pebbles mainly of quartzite and quartz, but also of gneiss, granite, gabbro, serpentinite,metasandstone and mudstone. The pebbles are up to 16 cm across, though generally ≤ 10 cm, and are mostly subangular to subrounded. On the small island the conglomerate contains slabs of metasandstone up to 1 m across.

The Precambrian rocks include quartz-feldspar gneisses, hornblende schists and gneisses and amphibolites. Although no modern structural or petrological study is yet available, it is clear that the gneisses are multiply deformed, their principal foliation surface here dipping at 20-40° to ESE. This rock sequence extends southwards as part of the Iddjajav'ri Group of the Karasjok Greenstone Belt.

Stop 3 **Dividal Group; sandstones and mudstones of Members I and II.**

Locality: Outcrops just north of highway 6 near Fredheim, 6.1 km east of Lakselv.

Reddish-violet to greenish-grey mudstones with siltstone interbeds of Føyn's (1967) Member II. Just to the east there are cross-bedded quartz sandstones of Member I. These exposures presumably represent an outlier of the Dividal Group resting upon the Karelian basement, but the actual contact is everywhere obscured by weathering material and drift.

Looking southeast from here, the Gaissa sole thrust is traceable below the mountain ridge Čas'kilvarri. There, the Gaissa Nappe rests directly upon the Karelian supracrustals, the

Dividal Group reappearing further to the south. In this region the older Precambrian rocks thus appear to form a basement culmination.

Near Alka, along the shore ca. 1 km north of Fredheim, there are some interesting exposures of the Dividal Group, directly beneath the Gaissa Nappe which here includes a slice of Karelian greenstone.

WESTERN SIDE OF PORSANGERFJORDEN (Fig. 3).

Dakkovarre Formation, Igeldas Shale Member of the Stabbursdalen Formation, Porsanger Dolomite Formation.

Stop 4 **Folding and minor thrusting in Gaissa Nappe sandstones and shales; Dakkovarre Formation.**

Locality: Road-cut and small quarried recess along highway 6, near Čaccebak'ti, 10.3 km north of Lakselv.

The Dakkovarre Formation here consists of a sequence of interlayered sandstones and shales/siltstones. The sandstone beds, mostly 0.5 m in thickness, are lenticular, wedging out over a distance of a few metres. Lenticular interbeds of thin sandstone - mudstone units with an abundance of synæresis cracks filled with sand and deformed by compaction, constitute the predominant facies in this outcrop. The strata are quite strongly folded along NNW-SSE axes into mesoscopic, eastward-facing, asymmetric anticlines and synclines with small thrusts in the middle limbs. A more competent sandstone unit is thrust above the minor-folded mixed sequence. In the latter there are numerous clastic dykelets projecting from the sandstone beds into the pelites.

The folds are structures developed during the earliest (D1) of three principal deformation episodes recognised in the Gaissa (Williams 1979), and carry an incipient, axial surface spaced cleavage in the pelites. Reverse-faulting and thrusting developed as this early folding progressed, and many intra-nappe thrusts are listric structures. Nappe detachment commenced during this early deformation phase, truncating the D1 folds, as we have seen at Stop 1.

Stop 5 **Igeldas Shale Member of the Stabbursdalen Formation; also Porsanger Dolomite Formation.**

Locality: Road-cuts and coastal section north of Igeldas, c. 5 km north of the bridge on the river Stabbursdalselva.

The contact between these two units is exposed in a tectonically disturbed section along the road. The purple mudstones-sandstones of the Igeldas Member are excellently exposed along the shore where various sedimentary structures may be observed including spectacular clastic dykes. The occurrence of chert nodules is of particular interest here. The nodules are present in both the mudstone and intraformational conglomerate of the Igeldas Member, and in the dolomite. They are oval, ca. 1 - 10 cm in size and occur in irregular beds which may also merge laterally into larger irregular bodies. Also present is a silicified (?)karst breccia. The nodules were interpreted by Siedlecka (1976) as silica-replaced evaporite (anhydrite), testifying to a sabkha-type sedimentary environment. This interpretaton is in line with the opinions of J.D. Roberts (1974) and Tucker (1976).

Stop 6 **Porsanger Dolomite Formation; units A, B and C of White (1969). The proposed formal names of the units are shown in Table 1.**

Locality: Coastal exposures opposite the island Anopsetholmen.

The purple mudstone of the Igeldas Member is overlain by the Porsanger Dolomite Formation. The contact is exposed just opposite to Anopsetholmen. Along the coast, south of the bay and the stream flowing from the small lake east of the lake Gåradakvatnet, units A,B and C of White (1969) may be examined (see Fig. 3 and Table 1). Units A and C comprise dolomicrites, cryptalgal laminites, flakestones, grainstones and oolites (Tucker 1977). Unit B, the lowermost stromatolite biostrome, only c. 3 m thick but extensive laterally, is rather poorly exposed and is best observed in low cliffs in the tidal zone. Linella acaniella has been described from unit B (Bertrand-Sarfati & Siedlecka 1980).

Both unit A and unit C contain chert horizons.

Table 1 **The lithostratigraphical units of White (1969) and Roberts (1971 b, 1974) from West and East Porsanger, respectively, are shown here together with the formal member names for each unit. The facies associations A,B and C refer to (A) tidal flat cryptalgal laminites, dolomicrites and thin flakestones, (B) low intertidal/shallow subtidal cross-bedded flakestones, grainstones and oolites, locally with stromatolite bioherms, and (C) subtidal stromatolite biostromes, locally with channel fills (from Tucker 1977).**

White's unit West Porsanger	Roberts' unit East Porsanger	Informal Member Names	Facies Association	Formal Member Names
		fourth biostrome	B C B	Hestnesfjell M.
H		third biostrome	C	Suolovarre M.
G	Σ	upper quartz sand unit	B A/B B	Holmvatn M.
F	δ	second biostrome	C	Skjaanes M.
E			B A/B B	Orkanbukta M.
D	γ	lower quartz sand unit	A/B	Gaaradak M.
C	β		B A/B B	Ladnjavatn M.
B		first biostrome	C	Dahtikilva M.
A	α		B A	Svartkollen M.

Stop 7 **Porsanger Dolomite Formation; dolomites with stromatolites and cherts, units D - G.**
Unit F — an important stromatolitic unit !

Locality Coastal exposures south of Kolvik.

North of the bay and the stream flowing from the small lake east of Gåradakvatnet, coastal exposures, and exposures in the cliffs over a distance of c. 1 km towards Kolvik provide an instructive section through units D to G. Stromatolite reefs, in particular in unit F, may be conveniently studied in the southwestern part of the cliffs about half-way up from the shore. There, top surfaces of, and sections through Gåradakia jacutophytonica are, in places, spectacularly exposed.

Stop 8 **Mylonites in the basal thrust zone of the Kalak Nappe: Also, tectonic deformation structures in the underlying dolomite.**

Locality: Roadside outcrops above the shore, near the first house in the bay Kolvik. For the dolomite, walk south 50-150 m along the shore.

Mylonites of the basal part of the Kalak Nappe Complex — glassy quartz-mylonites, blastomylonites and mylonitic pseudo-psammites — are well exposed in a long roadside outcrop. Reworked mylonites are expressed by minor, strongly flattened folds deforming the mylonitic banding, and by later extensional faults. The topographic feature of the Kalak rocks, thrust upon Porsanger Dolomite, is prominent on the northeastern side of Kolvik bay.

Proceed down to the shore and bear right (south) to examine the deformation features in the dolomite. There is an intensely brecciated facies closest to the thrust. Further away there are numerous examples of bedding-plane thrusts and small ramp-thrusts. Note also the presence of lenses and discontinuous bands of chert in the dolomite.

Stop 9 **Porsanger Dolomite Formation, units E and F.**

Locality: Cliffs south of Trollholmsundet.

The most complete section of unit F is exposed in this area. This unit is an extensive biostrome comprising a variety of columnar stromatolites which are important for stratigraphic work. Bertrand-Sarfati & Siedlecka (1980) subdivided unit F into seven horizons and described several new stromatolite forms. This biostrome and other biostromes

present in the Porsanger Dolomite were all developed upon high-energy sediments and were interpreted by Tucker (1977) as subtidal, contrasting with tidal-flat cryptalgal laminites.

Stop 10 **Tectonic and sedimentary folds in cross-bedded psammites of the Kalak Nappe.**

Locality: Roadside outcrops, highway 6, Indre Veinesbukta. 46.1 km north of Lakselv. Park in a small lay-by north of the long road-cuts.

Medium-bedded, pale grey to creamy-white feldspathic psammite of the Billefjord Formation (Williams et al. 1976), part of the Klubben Psammite Group (Ramsay et al. 1981 a), showing trough cross-bedding and channelling indicating that the strata are the right way up.

In the second major road-cut south of the lay-by, penecontemporaneous folding of cross-bedding foresets may be seen. Such primary, syn-depositional folding is common in the Billefjord Formation and correlative units over large areas of Finnmark; in some cases isoclinal folds of 1 - 2 m amplitude are present, these being truncated by the overlying sandstone bed.

On the road-cut face nearest the lay-by there are examples of cross-bedding deformed by prominent tectonic folds where one can observe the results of differential strains affecting bedding around fold hinges.

From here, the basal thrust of the Kalak Nappe can be seen on the eastern side of Porsangerfjorden, north of Børselv, again with the white Porsanger Dolomite directly beneath.

EASTERN SIDE OF PORSANGERFJORDEN

Various formations of the Tanafjorden Group, Gaissa Nappe Complex.

Stop 11 **Grønneset, Dakkovarre and Gamasfjellet Formations.**

Locality: Coastal exposures from the inner part of the bay Råd'denjargåp'pi to Fuglenes.

This stop involves a c.2 km walk from the road north- and northwestwards along the coast to Fugleneset. The Grønneset Formation, one of the oldest formations in the Tanafjorden Group, is exposed in the core of a c.N-S trending anticline.

The banded sandstones and pelites of the Dakkovarre Formation show many examples of clastic dykes, mostly on the cm and mm scale, penetrating down from sandstone beds into the darker pelites. On the western limb of the major anticline, this formation is quite strongly folded in some places, also with minor thrusting. A crude axial surface cleavage can be seen in the pelitic beds. The Grønneset Formation is characterised by quite thick-bedded, grey, redddish-grey to orange-grey sandstones with cross-bedding and rippled top surfaces. Brown ferriginous spots are a typical feature.

The Gamasfjellet Formation occurs on the ridge and promontory Fuglenes. It is a massive quartzitic sandstone with cross bedding. A characteristic feature is that of purply-red to maroon staining along joints and other fractures. The Gamasfjellet Formation is also well exposed in the road-cuts along the eastern side of the bay Råd'denjargåp'pi. Looking south, quite large-scale folds can be seen in the hillside. For information on the structural geology in this eastern Porsangerfjorden area the visitor is referred to Townsend et al. (1986).

Stop 12 Stabbursdalen and Porsanger Formations

Locality: The hill Čap'pirčåk'ka and exposures just west of the sharp bend in the road.

The Stabbursdalen Formation can be inspected in a very small, abandoned quarry just to the west of the road, about 100 m south of the big bend. The formation is represented mainly by alternating greenish-grey siltstone and silty shale and maroon or reddish-brown cleaved mudstone. Clastic dykes are quite common throughout the sequence. An outlier of dolomite of the Porsanger Formation occurs on the top of Čap'pirčak'ka in a synclinal structure, just east of a small fault. For dolomite and stromatolite specialists, don't use too much time here; the next three stops should keep you happy for hours!

Just to the north of Čap'pirčak'ka there is an excellent example of a series of raised beaches.

Along the coast northwest of Børselv and on the slopes of Hestnesfjellet and Sinopivarre mountains there are several good outcrops in which stromatolitic dolomites may be examined. Three stops are suggested below (Fig. 2).

Stop 13 Porsanger Dolomite Formation; equivalent to unit F on the western side of Porsangerfjorden.

Locality: Børselv, small quay west of Jernbukt.

A c. 4 m high stromatolite reef growing on a calcarenite and an intraformational conglomerate. Solitary and ramified columns, oncolites and Jacutophyton-like forms may be observed.

Stop 14 **Porsanger Dolomite Formation; equivalent to unit F on the western side of Porsangerfjorden (see Fig. 2 and Table 1).**

Locality: Approximately 1 km northwest of stop 13, on the coast.

A stromatolite horizon c. 4 m thick crops out here. From the bottom: a coarse calcarenite with oncolites constitutes the substratum to columnar stromatolites which in the upper part of the reef have conical, Conophyton-like forms. Large domal stromatolites form the top of this horizon.

Stop 15 **Porsanger Dolomite Formation; equivalent to unit F on the western side of the fjord.**

Locality: Coast at Båtneset.

In several places along the shore and in coastal cliffs there are spectacular exposures of columnar and conical stromatolites, the latter usually in the upper parts of the biostrome. Intraformational conglomerates and oncolites are present in the substratum of the biostromes (similar to stops 13 and 14).

A short walk just north of Båtneset brings us to the mylonitic basal contact of the Kalak Nappe Complex, where the footwall again comprises the Porsanger Dolomite. Rb-Sr whole-rock and thin-slab dating of the thrust-zone mylonites from a small quarry just east of the road has produced an age of c.385 Ma (Roberts & Sundvoll 1990). This is interpreted as the age of the youngest, east-directed, thrust movements in the Kalak.

THE LAKSEFJORDEN AREA (Fig. 4)

Introduction

In this area, the Laksefjorden Nappe Complex has been subdivided into three separate thrust sheets, as follows:
The Upper Laksefjorden Nappe is restricted to the northern area and comprises terrigenous metasedimentary rocks of parts of the Laksefjorden Group.
The Middle Laksefjorden Nappe is a widespread unit consisting of metasedimentary terrigenous rocks of the Laksefjorden Group resting unconformably on crystalline basement.
The Lower Laksefjorden Nappe consists of carbonate rocks resting with an assumed unconformity on the crystalline basement and occurs in the Storfjorden - Adamsfjorden area.

The excursion itinerary is based on Føyn, Chapman & Roberts, 1983, pp.60-64.

Stop 16 Lower Laksefjorden Nappe, gneiss and dolomite.

Locality: Kunes, 1 km east of the road junction and the bridge over Suossjåkka: hillside, looking north.

Here, pale-yellow dolomite is tectonically interposed between darker granitic gneisses. The precise contacts are not exposed. The lower boundary between the dolomite and the gneiss may be a tectonised unconformity whereas the upper contact is a thrust-fault.

Eastwards along the road there are exposures of cleaved shales of the Breivika Formation and red sandstones of the Manndraperelva Member, which here form part of the Gaissa Nappe beneath the Lower Laksefjorden Nappe.

Stop 17 Dolomitic limestone and siltstone, Lower Laksefjorden Nappe.

Locality: Bridge at the Adamsfoss waterfall.

The beds are more or less vertical here, striking N-S. West of the bridge, looking north an 'S' fold may be seen, suggesting that there is an anticline to the west and a syncline to the east.

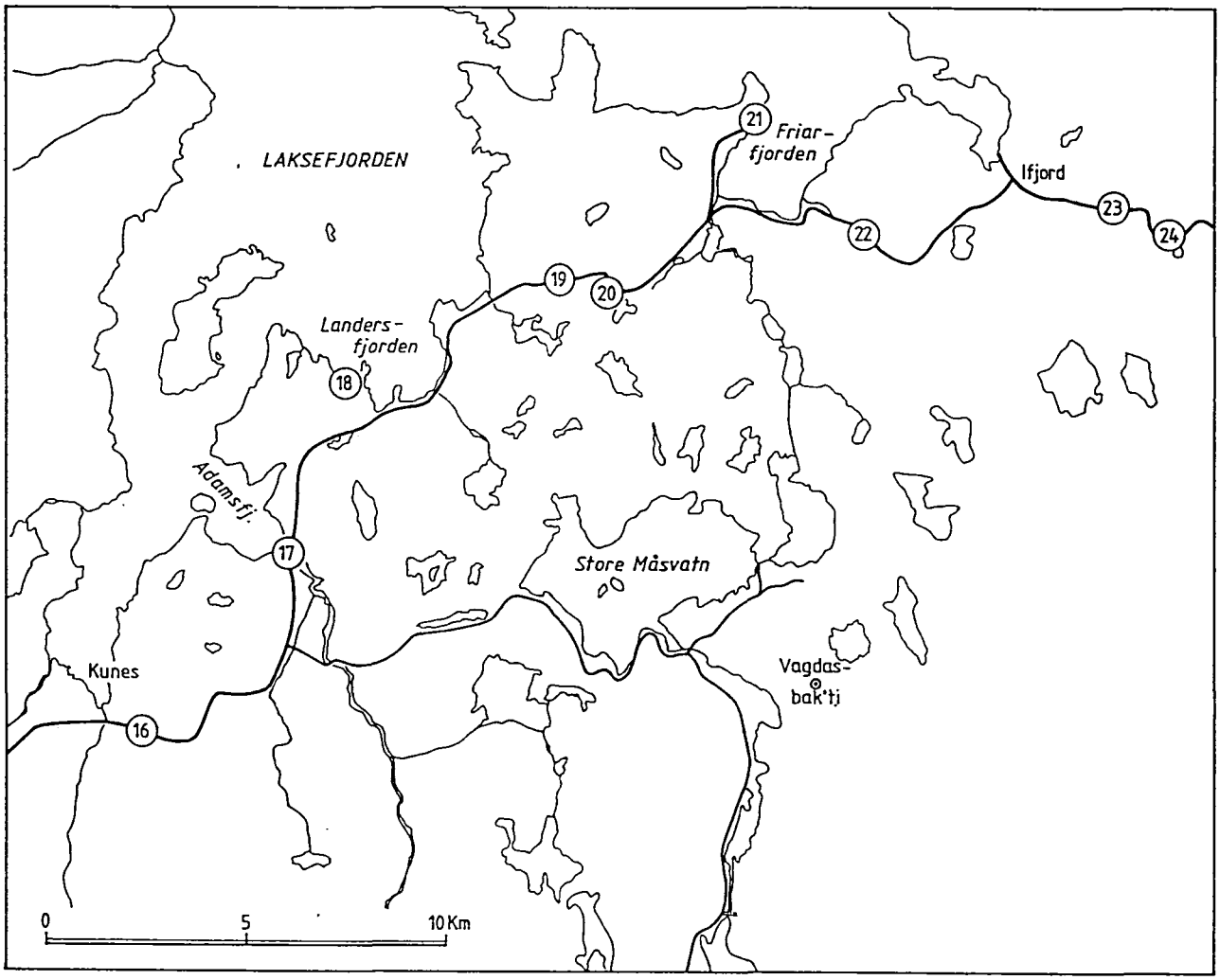

Fig.4. Excursion localities 16 - 23, inner Laksefjorden area.

Stop 18 **Landersfjorden Formation, Middle Laksefjorden Nappe.**

Locality: Landersfjordneset. Park the car just east of Landersfjordvatn and follow a path to the north for c. 1.5 - 2 km.

A section through vertical beds of the Landersfjorden Formation is exposed along the coast. Follow the section from west to east, moving stratigraphically up the sequence.

On the hill west of the coastal section, there is a coarse conglomerate of the Ifjord Formation. The Landersfjorden Formation is composed primarily of cross-bedded feldspathic metasandstones of fluvial origin with palaeocurrent orientations suggesting transport from the southeast. Beds of conglomerate are also present with scattered pebbles or pebble pavements. The clasts may be matched with the basement rocks. Soft-sediment deformation structures are also well developed in this profile.

Siltstones and sandstones of the middle part of the formation exposed on Seivikneset, east of Landersfjordneset, are intruded by a vertical, metadolerite dyke of presumed Caledonian age, which is cut by a series of E-W faults showing strike-slip offsets.

Stop 19 **A major thrust within the Middle Laksefjorden Nappe.**

Locality: West end of the lake Baktejav'ri.

The NNE-SSW oriented thrust-fault brings into contact older rocks of the Landersfjorden Formation (west of the thrust) with slate and subordinate sandstone of the lower part of the Friarfjorden Formation (east of the thrust). The thrust-fault here dips at about 50° to the WNW; however, it is believed that this is a listric, downward-shallowing fault.

Stop 20 **Middle Laksefjord Nappe; upper part of the Friarfjorden Formation, synmetamorphic folds.**

Locality: East end of the lake Baktejav'ri.

Minor, synmetamorphic S1 folds may be seen in the road-cut on the southern side of the road. These 'S' folds are overturned towards the southeast and indicate that a tight synform is present to the northwest and an antiform to the southeast. Sedimentary structures observed in other localities show that these fold structures are, in fact, a syncline and an anticline.

Stop 21 **Middle Laksefjord Nappe; upper part of the Friarfjorden Formation.**

Locality: A quarry north of Nyheim on the western side of Friarfjorden.

Black-grey roofing slate has been periodically quarried here mainly for local use. The quality of the product is dependent on the angle between the primary lamination and the cleavage; a very low angle is favourable. The spacing of cleavage is also important in evaluating the quality of this slate.

At the moment the quarry is in operation, but only on a modest scale.

Stop 22 **Middle Laksefjord Nappe; lowermost part of the Ifjorden Formation (Gožavarre Member).**

Locality: Several road-cuts, starting about 4 km west of Ifjord.

A poorly sorted metaconglomerate (diamictite) may be studied in several road-cuts. The conglomerate consists predominantly of fragments of quartzite and granite which are flattened and elongated within the S1 foliation. The degree of deformation of the pebbles gradually increases eastwards as one comes nearer to the sole thrust of the Middle Laksefjorden Nappe. In this locality the deformation approximates to plane strain; eastwards it falls in the flattening field of the strain ellipsoid.

The conglomerate has been interpreted as a glacial deposit and correlated with the Varangerian tillites. Later, however, this interpretation was questioned and the conglomerate reinterpreted as a debris-flow deposit accumulated on an alluvial fan in a high-relief landscape under arid to semi-arid conditions (Laird 1972, Chapman 1980).

Stop 23 **Mylonites in the Ifjord Formation, Middle Laksefjorden Nappe.**

Locality: Several road-cuts between c. 2.0 km and 3.5 km east of the road junction in Ifjord.

The rocks here are strongly deformed conglomerates of the Ifjord Formation, at the base of the Laksefjorden Group. The rocks have a glassy and flaggy appearance; although compositional layers can be distinguished that might reflect extended boulders and cobbles, this cannot be proven. Excellent high-strain quartz fabrics are preserved within these rocks, suggesting that deformation occurred at relatively low temperatures.

Stop 24 **Folded rocks of the Lower Cambrian Breivika Formation, Vestertana Group, Gaissa Nappe Complex.**

Locality: c. 200 m west of Soag'nuluobbal, 4 km east of Ifjord.

Sandstones and mudstones of the Lower Breivika Formation are here deformed into complex and disharmonic folds, largely due to the difference in competence between the sandstone and mudstone layers.

The Breivika Formation has been interpreted as a shallow-marine (lower part) to quiet basin deposit and contains trace fossils dominated by Phycodes, Rusophycus, Cruziana. The body-fossil Platysolenites have also been found in this formation (Føyn 1967, Banks 1970, Banks et al. 1971).

THE TANAFJORDEN AREA (Fig. 5).

In this guidebook, the itinerary in the Tanafjorden area is restricted to Vestertana, i.e. west of the inner Tanafjorden and the river Tana. For an examination of the geology east of the river and fjord it is recommended to follow the published guide to the geology of the Varanger Peninsula (Siedlecka & Roberts 1992). Some of the stop descriptions are modified from Rice et al. (1991).

Stop 25 **Folds in the Nyborg and Mortensnes Formations of the Vestertana Group in the Gaissa Nappe Complex.**

Locality: Drive to the west side of Vestertana, park in the obvious large lay-by overlooking Suossjåkka. Walk back up hill from the lay-by.

At this outcrop, green mudstones and sandstones of the upper part of the Nyborg Formation are folded, but the overlying Mortensnes Formation does not display such fold structures. The amplitude of the folds dies away towards the contact, which may have functioned as a minor thrust surface due to the differential shortening. The fold axes trend c. 180°-195°.

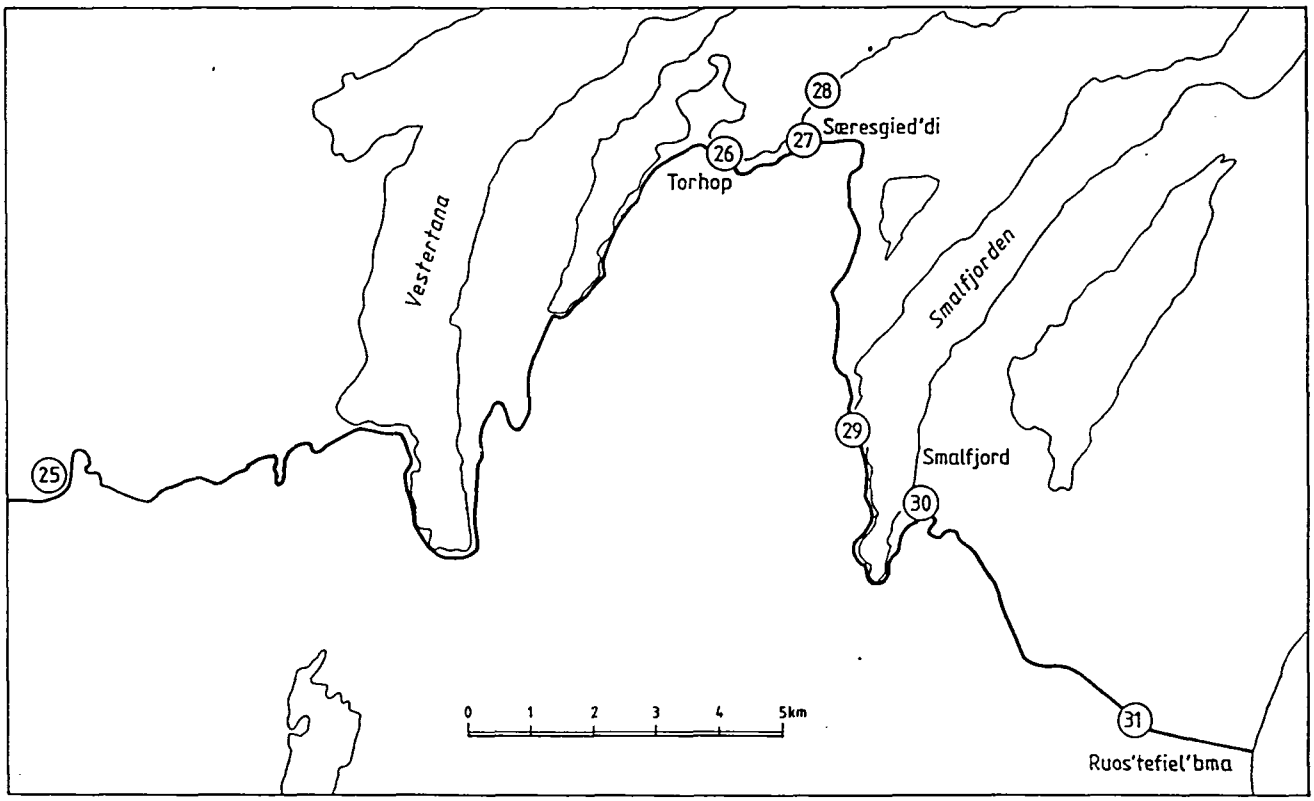

Fig.5. Excursion localities 25 - 31, Vestertana-Tanafjorden area.

Within the Nyborg Formation, note the rhythmic banding and graded bedding of these turbiditic sediments. The contact with the tillite is sharp and marks a regional unconformity. The lower member of the Mortensnes tillite has been interpreted by Edwards (1984) as a lodgement tillite transported by large glaciers from the south.

In the tillite, note the variable clast sizes and composition — there are fragments of granitoid basement rocks and of oolitic dolomite. These clasts are essentially undeformed, although some cracks are present. Good low-strain shadows can be seen in some cases, with curved extension cracks. In weathered outcrops the unstrained material has a different colour than in the surrounding cleaved matrix.

Stop 26 Dakkovarre Formation, Tanafjorden Group, Gaissa Nappe Complex.

Locality: Road-cuts at Torhop.

This locality exposes massive purple sandstones of the uppermost part of the Dakkovarre Formation, the ferruginous sandstone member of Siedlecka & Siedlecki (1971). The beds are up to 3 m thick and massive, and locally there are small pyrite crystals present. Johnson (1975), who studied the sedimentology of the Dakkovarre Formation in some detail, interpreted the purple sandstones as near-shore, tidal sand bars.

Stop 27 Vestertana Group, Smalfjord Formation, dolomitic facies of tillite; Dakkovarre Formation, quartzitic sandstone; Gaissa Nappe Complex.

Locality: Approximately 500 m west of Særesgied'di.

The roadside outcrops here show tillite of the Smalfjord Formation dominated by detritus derived from dolomitic rocks, presumably the Grasdalen and Porsanger Formations at the top of the Tanafjorden Group. Both the clasts and the matrix (which is essentially composed of very fine clasts) are dolomitic and the rock has a distinctive orange colour which can be recognised from a considerable distance.

This tillite, and tillites of the Smalfjord Formation in general in the Tanafjorden area, was deposited as a lodgement till during the second phase of glaciation characterised by the advance of large ice sheets from the north (Edwards 1984). Although predominantly massive, in places the tillites show a banding mimicking depositional lamination and originated by an intermixing of local and exotic debris in the lower part of the glacier.

In the 'dolomitic tillite', clasts up to 0.75 m in size show an extensive fracturing and veining; in the more 'typical' tillite the clasts are generally undeformed. The fractures in the clasts

are normal to the enveloping cleavage. Note the low-strain zones in the strain-shadow areas adjacent to the clasts. Clasts consisting of columnar stromatolites have been collected at this locality.

Pale-grey quartzitic sandstone of the Dakkovarre Formation crops out in the eastern part of the road-cut. The actual contact (unconformity) is not seen, there being a c. 2 m stratigraphic gap in the exposure.

Note minor low-angle faults, with an extensive fibre growth which indicates extensional movement towards the northwest (at grid ref. 3805 2015).

Stop 28 **Tanafjorden Group (Gamasfjellet Formation) thrust over inverted Vestertana Group (Smalfjord and Nyborg Formations); Gaissa Nappe Complex.**

Locality: Approximately 0.5 km east of stop 27 there is a minor turn-off to the north. Drive north to an obvious white-capped small hill.

A wide range of features can be seen at this outcrop. Stratigraphically, the sequence is inverted, although it is not clear whether the quartzites are themselves overturned since bedding is poorly preserved and no sedimentary structures have been recorded so far (but keep looking!). The underlying rocks are an inverted sequence of grey, highly sheared tillite of the Smalfjord Formation. These rocks are preserved largely within 'arches' in the quartzite and are underlain by pale dolomites typical of the base of the Nyborg Formation and then by red and green shales/sandstones of the Nyborg Formation.

These strata form the inverted limb of a footwall syncline to the thrust; the axis of the syncline lies within the vegetated area to the east and can be traced easily from fold structures occurring at the coast.

Stop 29 **Dakkovarre Formation, Tanafjorden Group; Gaissa Nappe Complex.**

Locality: Just south of Steinvik, western side of Smalfjord.

The rocks here are typical massive quartzites of the Dakkovarre Formation; these have a yellow colour in some parts. Note that in this locality all the deformation has been accommodated along several minor, brittle, thrust surfaces which dip gently to the west.

Stop 30 **Dakkovarre Formation, Tanafjorden Group; Gaissa Nappe Complex.**

Locality: Eastern side of Smalfjord, a local road going north to the fishing settlement of Smalfjord.

This exposure is a typical outcrop of the Dakkovarre Formation, with interbanded thin sandstones and black or dark grey shales and more massive sandstones and quartzites. Sedimentary structures indicative of a shallow-marine environment are abundant and trace fossils can be found along some bedding surfaces.

The steep eastward dip of the rocks reflects the formation of a major syncline along the ridge to the north-northeast in which the Gamasfjellet Formation is overlain by tightly infolded rocks of the Smalfjord and Nyborg Formations. Fold axes trend somewhat east of north-south. This locality is on the boundary between an area to the north in which folds trend NE-SW and an area to the south where they trend more N-S.

Stop 31 **Overfold in the Nyborg, Mortensnes and Stappogiedde Formations; the Gaissa Nappe Complex.**

Locality: At Langarâtto, c. 2 km west of Ruostefielbma, close to bends in the old road, at the obvious red outcrops beside the road.

The rocks exposed here form part of a medium to large-scale eastward-facing open to tight fold. The top of the hill is composed of tillites of the Mortensnes Formation underlain by red shales of the Nyborg Formation within which small-scale parasitic folds have developed with variable axial planar cleavages. At road level, and downhill towards the east, the tillites re-appear; note a very large sandstone lens or clast within the tillite at road level. Despite the folding the strain is low within the Nyborg Formation and abundant sedimentary structures can be seen, including graded bedding and foresets. Bedding planes are uneven and beds are relatively thick.

Walking down the hill along the north side of bends in the old road, take a path at the eastern end of one of the bends. Walk north until a small overgrown quarry is reached. The rocks here are the lower part of the Stappogiedde Formation (Lillevatn Member) comprising sandstones, grits and conglomerates. Climb up over these and walk westwards to outcrops of red shales typical of the base of the Innerelv Member. These are finely banded and show evidence of high strain; still further west, almost at the base of the hill, grits and quartzites of the Lillevatn Member are again encountered, overturned and lying on top of the Innerelv Member. The steep hill to the west is composed largely of tillite.

The Nyborg Formation is represented here by basinal facies, the regressive and shallow-marine deposits of the upper part of the formation having been removed by the pre-Mortensnes erosion. The subglacial Mortensnes tillite is overlain by deltaic and fluvial beds of the lower Stapogiedde Formation grading into fine-grained shelf deposits of the higher parts of this formation, the Innerelva Member (Edwards 1984).

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