Vendian-Cambrian stratigraphy and Caledonian tectonics in the area between Laksefjorden and Guor'gabmir, Finnmark, North Norway

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Guor'gabmir is a klippe consisting of Precambrian crystalline rocks thrust upon sedimentary formations of the Vestertana and Tanafjord Groups. Southeast of the mountain, outcrops of sandstone and shale have an ambiguous stratigraphic relationship; lithological features indicate that they belong to the Vestertana Group. It is suggested that the lower part of this group may have been deposited on an uneven surface of the Tanafjord Group, perhaps between and partly upon hills of Porsanger Dolomite. In an area about 5 km ESE of Guor'gabmir the two uppermost formations of the Tanafjord Group were completely removed by erosion in Vendian time, the Smalfjord Formation being deposited directly upon beds of the Hangleċærro Formation. In that area a sheet of Porsanger Dolomite with conformably overlying Smalfjord Tillite is present, thrust upon rocks of the Smalfjord Formation. In a third area, at Stuorrajåkka 6 km NNE of Guor'gabmir, the geological situation may be interpreted in a similar way to that in the area southeast of Guor'gabmir.

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Introduction

Some 10 km southwest of the head of Laksefjorden the rugged klippe Guor'gabmir rises to 327 m a.s.l. (Plate 1). The mountain top comprises Precambrian crystalline rocks belonging to the Lower Laksefjord Nappe (Chapman 1980, Føyn et al. 1983), below which there are parautochthonous sedimentary rocks of the Gaissa Nappe (Table 1). This contribution concerns stratigraphic and tectonic problems mainly in the area southeast of Guor'gabmir (Plates 1 and 2 and Fig. 1). In addition two other areas will be discussed; one, an area south of Šuoššjåkluob'balat ca. 5 km ESE of Guor'gabmir (Fig. 2), and the other an area at the river Stuorrajåkka ca. 6 km to the north-northeast (Fig. 3). My field investigations in these areas have been confined to a few reconnaissance trips during some of the summers 1955–1977 and are not sufficient to allow definite conclusions to be made. Moreover, the comparatively few rock specimens available have precluded any thorough, comparative study of the various lithologies. Thus, although the paper has the character of a preliminary report, the fact is that my age prevents me from carrying out further fieldwork; I am therefore presenting observations and some attempts at interpretation, in the hope that someone will eventually use the information as a base for additional fieldwork and lithological studies in order to resolve the problems outlined.

The map area (Plates 1 and 2) covers ground on both sides of the boundary between the 1:50 000 topographic map-sheets *Adamsfjord* (M 711–2135 I, geological map by Føyn, Chapman & Roberts 1983) and *Viek'sa* (M 711–2135 IV).

The thrust basement rock of Guor'gabmir

A specimen taken from the southeastern flank of Guor'gabmir is of a medium-grained monzonitic rock containing plagioclase and microcline as the main constituents, with subordinate quartz and some grains of pyrite or pyrrhotite. The rock is pervaded by joints and cracks, and the feldspar twin lamellae are bent and fractured. These features are considered to relate to the thrusting in Caledonian time.

The sedimentary rocks

The succession occurring within the map area is shown in Table 1. The Breivik Formation is of Lower Cambrian age, while the lower formations of the Vestertana Group are of Vendian and the

Table 1. The stratigraphical succession of the Laksefjorden-Guor'gabmir area. The indicated thicknesses apply only to this map area. An unconformity is present between the Tanafjord and the Vestertana Group. Details of lithologies are contained in the legend to Plate 1

VESTERTANA GROUP			
Breivik Formation			?100 m
Stappogiedde Formation	Manndraperelv Member	Ca.	25 m
	Innerelv Member	Ca.	75 m
	Lillevatn Member	Ca.	100 m
Mortensnes Formation		Max.	50 m
Nyborg Formation		Max.	25 m
Smalfjord Formation	Diamictite member	Max.	50 m
	Non-clast member	Max.	40 m
TANAFJORD GROUP			
Porsanger Formation			?
Stabbursdal Formation		Ca.	80 m
Hangleċærro Formation		Ca.	80 m

Tanafjord Group of late Riphean or Vendian age. The contact between the Vestertana and Tanafjord Groups is known to be an unconformity, denoting a period of tilting and denudation prior to deposition of the sediments of the Smalfjord Formation (Føyn 1937, Edwards et al. 1973, Føyn & Siedlecki 1980, Føyn et al. 1983). The succession was folded during the Caledonian orogeny; two main fold phases have been established, with fold axes ca. N–S and ca. ENE–WSW.

The *Hangleċærro Formation* underlies the area of the southwestern part of the map area (Plates 1 and 2). The beds are fairly flat-lying with only weak undulations, and in general they dip towards the north or north-northeast.

Williams (1974) observed a normal sedimentary contact between the Hangleċærro Formation and the *Stabbursdal Formation* ('Stabbursdal Interbedded Member' of Williams 1974) SSW of Guor'gabmir. According to Williams (1976), the Stabbursdal Formation «has a maximum thickness of some 80 m». His Vuonjaljåkka section (1974) shows the lower ca. 25 m of the formation. A sequence of ca 40 m of younger beds occurs in a small valley (grid ref. 747966) west of the southernmost point of the basement klippe. Characteristic for this sequence are red and yellow shales and siltstones with intercalations of white quartzite. In the highest parts interbedded light-coloured sandstone and yellowish-grey dolomite are present; these sandstones and dolomitic beds form a transition into the massive, white Porsanger Dolomite, which thus must be considered to have a conformable stratigraphical lower boundary, marking depositional continuity.

Easily identifiable beds of the Stabbursdal Formation are also observed in close association with Porsanger Dolomite to the ESE of Guor'gabmir (grid refs. 754967, 756965, 763957).

The *Porsanger Formation* occurs as a massive dolomite of light grey colour with a white coating on weathered surfaces. *Stromatolite* structures have been observed at several places in the map area.

All five formations of the *Vestertana Group* occur on Stuorraskai'di, the ridge between the valleys of Stuorrajåkka and Šuoššjåkka. The sequence as a whole is deformed in a central anticlinorium with a synclinorium in the northern part of the ridge and another synclinorium to the southwest (see Plate 2 and section AB Plate 1). The best place for studying the sequence from the Smalfjord Tillite to the Innerelv Member is along a tributary to Šuoššjåkka, grid ref. 800999–805994.

The *Lillevatn Member* constitutes the dominant unit on the Stuorraskai'di ridge, the major part of the area being underlain by this ca. 100 m-thick unit.

The boundary between the competent, massive *Mortensnes Formation* and the underlying, weak Nyborg Formation appears as a well marked step in the western slope of the Šuoššjåkka valley south-southwestwards from the tributary. The step can be traced in the landscape for an additional couple of kilometres towards the southwest after the bend of the boundary in that direction. The fact that the nearest outcrop of the Mortensnes Tillite to Guor'gabmir is as far as 1.5 km from that mountain indicates, in my opinion, that the thickness of the unit decreases towards Guor'gabmir. North of Guor'gabmir, however, on the northern limb of the syncline, an exposure of the Mortensnes Tillite occurs close to the Lillevatn Member, and below the thrust plane of a local tectonic slice of dolomite (grid ref. 754979).

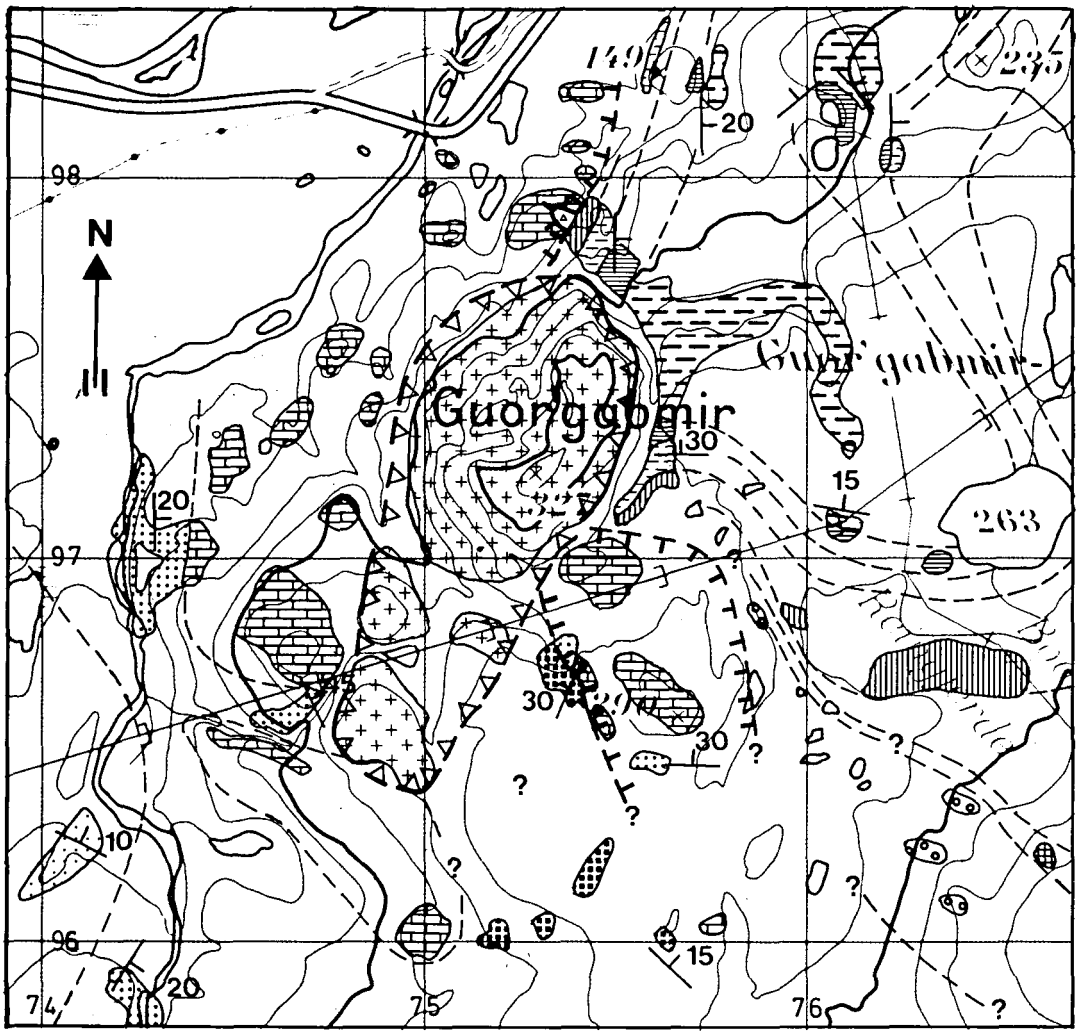

Fig. 1. The area around Guor'gabmir at a scale of ca. 1:20.000. Grid interval 1000 m. Contour interval 20 m. Ornament as in Plate 1, tectonic symbols as in Plate 2.

Outcrops of the thin interglacial unit, the *Nyborg Formation,* have been observed in only a few places in the east and south, but not near Guor'gabmir.

South of Stuorraskai'di the thickness of the *Smalfjord Tillite* diminishes considerably towards Guor'gabmir, and lithologically the rock changes from a polymict diamictite into an almost monomict dolomite breccia. Exposures of the lower, *non-clast-bearing member* of the Smalfjord Formation exist only in the southeastern corner of the map area. The finely laminated mudrocks there lie directly on beds of the Hanglečærro Formation, the Porsanger and Stabbursdal Formation thus being absent (see p. 43).

The area southeast of Guor'gabmir

This area (Fig. 1) is extensively covered by ablation moraine from the Quaternary glaciation and the outcrops are too scattered to allow the establishment of a continuous stratigraphy. Geographically, one should expect to find a continuation of the Stabbursdal Formation eastwards

into the area, situated between outcrops of the Hanglečærro Formation to the south and of the Smalfjord Formation to the northeast. Outcrops of rocks of the Stabbursdal Formation do in fact exist (se p.40), but the rocks of other exposures in this area – white, pink or red sandstone, and grey, green or red shales – are more reminiscent of the Lillevatn, Innerelv and Manndraperelv Members. At grid 752960 a reddish brown conglomeratic sandstone with white quartz granules is exposed; a rock such as this has not been observed in the Stabbursdal sequence southwest of Guor'gabmir, nor has it been reported by Williams (1974, 1976) from areas further to the west. Granule conglomeratic sandstones are known, however, from the Lillevatn Member.

Thick beds of white sandstone and beds of red shale exposed on hill '352' (767952) dip gently northward towards a depression with karstic Porsanger Dolomite in its core. Stratigraphical relationships between these two units are not known; and a possible tectonic contact, if present, is hidden by the Quaternary cover. Eastward from hill '352' the strike of the sandstone/shale unit curves towards the northeast and the dip is towards the northwest. Also the surface of the Smalfjord Tillite of hill '364'(773954) dips towards the northwest and seems to continue *beneath* the sandstone/shale unit. That this unit is probably younger than the Smalfjord Tillite is also indicated by the occurrence of several large erratics of dolomitic tillite on the gentle slope towards Bår'gasjåkka to the south. As the movement direction of the Quaternary ice-sheet was towards the north, these blocks should have been derived from occurrences of tillite situated south of hill '352' at a lower level, geographically and stratigraphically, than the northward dipping sandstone/shale beds.

Thus, the sandstone/shale unit of hill '352' seems to be younger than the Smalfjord Tillite Formation.

As the formation directly above the Smalfjord Tillite is the Nyborg Formation, it could be suggested that the sandstone/shale unit may belong to the latter. Thick beds of white coloration are however, alien to the Nyborg Formation of the map area. It is therefore more probable that the sandstone/shale unit represents part of the Lillevatn Member of the Stappogiedde Formation. If this view is correct, the question arises: is the occurrence of members of the Stappogiedde Formation due solely to tectonic causes or have primary morphology and deposition also played a part?

Local thrusts are indisputably present in the area of interest. Thus, the dolomite (755966) with associated Stabbursdal strata certainly represents a thrust unit, its western boundary being undoubtedly tectonic. The dolomite and Stabbursdal rocks occurring further southeast towards the karst depression may also belong to the same nappe.

The present author finds it hard to believe, however, that tectonic movements alone should be responsible for the occurrence of Stappogiedde strata in the area southeast of the southern part of Guor'gabmir, including hill '352' It is a fact that the Porsanger Dolomite and the entire Stabbursdal Formation thins out and disappears within the area from the west side of Guor'gabmir eastwards to Šuoššjåkka, i.e., over a distance of less than 5 km. Southwest of Guor'gabmir the Hanglečærro Formation is overlain by the Stabbursdal Formation followed by the Porsanger Dolomite, while at Šuoššjåkka the non-clast member of the Smalfjord Formation has been deposited directly upon the Hanglečærro surface. There is clear evidence of regression, weathering and erosion prior to the glaciation. After a climatic change, glacial erosion and deposition followed. Thus the depositional/erosional hiatus and unconformity is quite marked in this particular area.

Even if the thickness of the Porsanger Dolomite may have been smaller in this area than at Porsangerfjord (minimum 234 m at Kolvik west of the fjord (White 1969) and 220–(?)320 m at Børselv to the east (J.D. Roberts 1974)), a karst topography of impressive dimensions may have been developed prior to the glaciation, with the formation of channels and hollows. Glacial erosion then followed. The change in lithological character of the Smalfjord Tillite into an almost monomict dolomite breccia is indicative of strong erosion of the Porsanger Dolomite at the time of Vendian glaciation.

As mentioned above (p. 41), the Nyborg Formation is thin within the map area (max. 25 m); and the thicknesses of the two tillite formations also seem to be small (hardly more than 15 m each) near Guor'gabmir. The space between hills (which may perhaps have been cliff-like) of dolomite may locally have been only partly filled by deposits of these three formations. Subsequently, the thick deposits of the Lillevatn Member, representing a post-glacial transgression (Banks et al. 1971), covered the entire area.

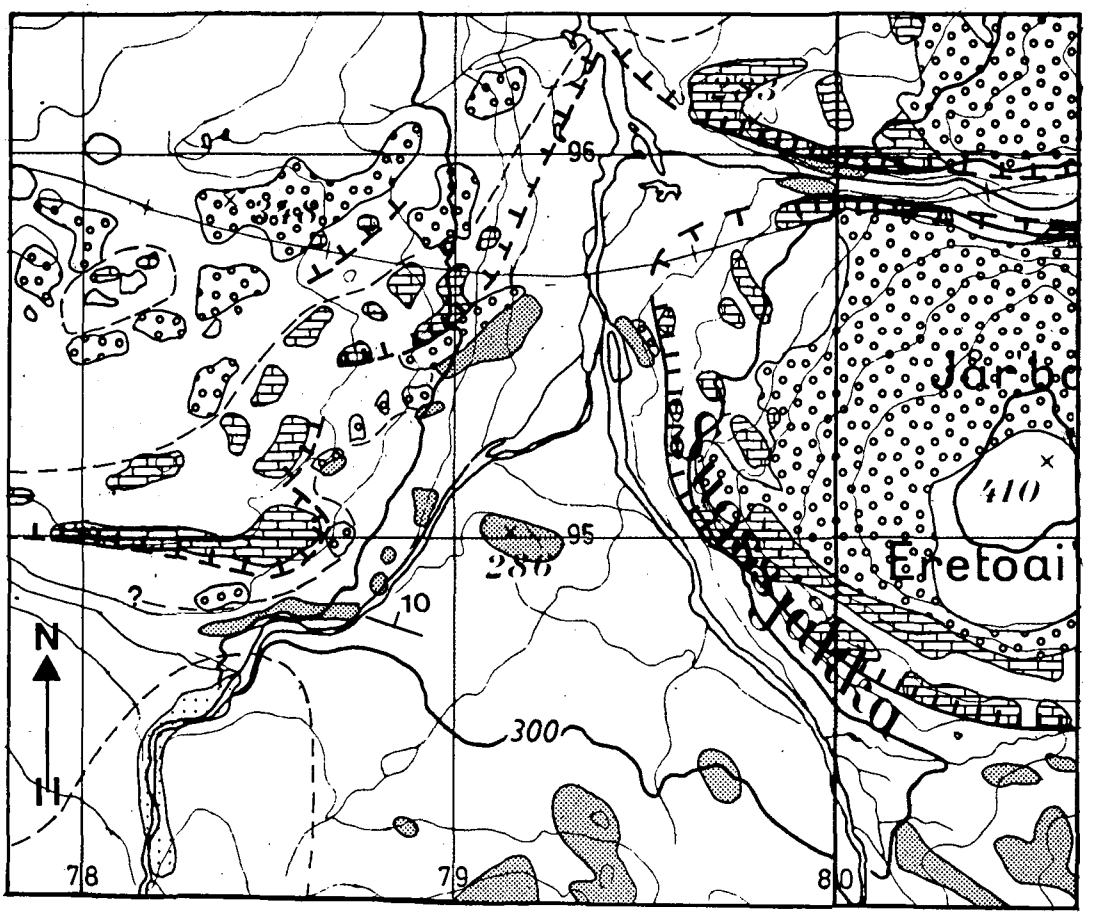

Fig. 2. The area south of Šuoššjåkluob'balat at a scale of ca. 1:20.000. Grid interval 1000 m. Contour interval 20 m. Ornament as in Plate 1, Tectonic symbols as in Plate 2.

The area south of Šuoššjåkluob'balat

The most prominent geological features in the southeastern corner of the map area (Plates 1 and 2 and section CD) are the following (Fig. 2): 1. Stratigraphically, the fact that the Smalfjord Formation appears to rest directly on beds of the Hanglečærro Formation. 2. Tectonically, the occurrence of a thrust sheet and a klippe of Porsanger Dolomite with overlying Smalfjord Tillite.

The Hanglečærro formation is exposed along a tributary stream to Šuoššjåkka at ca. 783945. The beds dip gently, ca. 10° towards the northeast. About 100 m downstream the river cuts a sequence of dark grey claystone and siltstone with intercalations of sandstone. On the weathered surface a fine lamination is seen. The beds are plane parellel. Although jointing occurs the sequence is little disturbed tectonically, and there can be little doubt that the sequence, which represents the lower, non-clast member of the Smalfjord Formation, is autochthonous in relation to the Hanglečærro strata.

The non-clast sequence is overlain by a diamictite. Thin-sections of sandstones in the non-clast member show quartz as the main mineral with subordinate plagioclase and microcline. Significant features are the grain-size variation, from 1 mm to less than 0,07 mm, and the fact that the larger grains are rounded or subrounded and dispersed randomly among the smaller, angular grains. These features are particularly characteristic of the sandstones interbedded with the diamictites of the Smalfjord Formation (Føyn & Siedlecki 1980); on the contrary, they have never been observed in any lithology of the Stabbursdal Formation. It is thus clear that the entire Stabbursdal Formation and Porsanger Dolomite, which are present west of Guor'gabmir, were

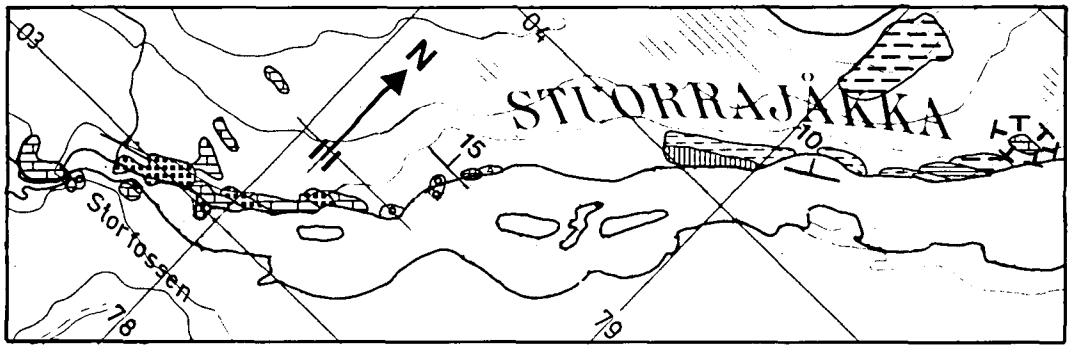

Fig. 3. The area along Stuorrajåkka downstream from Storfossen at a scale of ca. 1:20.000. Grid interval 1000 m. Contour interval 20 m. Ornament as in Plate 1, tectonic symbols as in Plate 2.

removed by erosion 4,5 km to the east at Šuoššjåkka before the start of deposition of the glacially dominated Smalfjord Formation. Some stratigraphical consequenses of this were noted earlier in this paper (p. 42).

As stated above, no autochthonous dolomite occurs in the area south of Šuoššjåkluob'balat. Allochthonous or parautochthonous dolomite with conformably overlying clast-bearing tillite is present, however, thrust upon rocks of the autochthonous Smalfjord Formation. The lower contact of this dolomite is exposed on the slope west of Šuoššjåkka (790955) and on the north side of the gorge (800960) north of Jår'ba Eretoai'vi. At the former locality diamictite is overlain by about 10 m of red, green and grey claystones which may belong to either the Smalfjord Formation or the lowermost part of the Nyborg Formation. The dolomite overlies these claystones apparently concordantly and with no pronounced disturbances along the contact. At the second locality the dolomite rests on finely laminated siltstones of the Smalfjord Formation (non-clast member) which contain microscopic, angular fragments of a fine-grained carbonate rock. The siltstones are weakly disturbed close to the contact, which is apparently concordant. For stratigraphical reasons, however, it is evident that in both these localities the dolomite and overlying tillite must have been emplaced into their present position by thrusting. West of Šuoššjåkka morphologic features indicate the presence of local disturbances, e.g. a second thrust at about grid ref. 787957.

The lack of metamorphism in the allochthonous dolomite and tillite of the Šuoššjåkluob'balat area and the insignificant disturbances along the contacts indicate that the distance of thrusting must have been relatively short. The nearest occurrence of autochthonous dolomite is west of Guor'gabmir, about 5 km west of Šuoššjåkka. However, as the general direction of thrusting in this part of the Caledonides in Finnmark is towards SE or SSE, the thrust sheets of dolomite and tillite probably derive from an area some few kilometres to the north of Guor'gabmir.

The area along Stuorrajåkka from Laksefjorden to Storfossen

The western bank of Stuorrajåkka (Fig. 3) northeast of Storfossen is underlain by units of the Breivik and Stappogiedde Formations. (An occurrence of dolomite (795047) must be due to tectonic movements.) Quaternary fluvial deposits separate these units from the equivalent rocks occurring on the northwestern slope of Stuorraskai'di. The rocks of these two areas may possibly belong to different tectonic units, separated by a fault or thrust along the Stuorrajåkka valley, now hidden by the sand and gravel deposits.

At Storfossen (ca. 776028) Porsanger Dolomite and dolomitic tillite (Smalfjord Formation) occur on both sides of the river at two localities. Dolomite is also exposed at several places northeast of Storfossen over a distance of about 1 km, with intervening beds of sandstone and dark grey siltstone. One of the sandstones has a reddish-brown colour and contains granule conglomerate, reminiscent of the lithology observed south-southeast of Guor'gabmir (see p. 42). The granules consist of quartz and are up to 5 mm in diameter. The rock shows signs of strain. The contacts between the dolomite and the sandstone/siltstone unit are everywhere obscured because of Quaternary drift.

The geographical proximity between the dolo-

mite and the sandstone/siltstone unit could be interpreted to indicate that the latter may belong to the Stabbursdal Formation. However, as in the area southeast of Guor'gabmir, the lithology of the sandstone/siltstone is similar in character to that of the Stappogiedde Formation, in particular of the Lillevatn Member. Noake (1974) considered the sandstone/shale strata to belong to the Lillevatn Member, and he interpreted their present locations between the outcrops of dolomite to relate to a system of faults. While I agree that tectonic movements have affected the rocks of the area, I am, however, inclined to believe that the pattern of outcrops of these two stratigraphical units can not be ascribed solely to tectonics. The explanation may possibly be the same as suggested for the area southwest of Guor'gabmir. Prior to the Vendian glaciation the Porsanger dolomite was subjected to subaerial weathering and erosion resulting in the development of a karst topography which was later modified by glacial erosion. Valleys and hills, perhaps with local cliffs, came into being, and the depressions and interspaces were filled with material belonging to the lower parts of the Vestertana Group. The area was then covered by deposits of the Lillevatn Member and younger units.

Conclusions

1. Southwest of Guor'gabmir the three uppermost formations of the Tanafjord Group (Hangleċærro, Stabbursdal and Porsanger Formations) are present, with intervening normal, conformable, depositional boundaries.

2. Within a distance of ca. 5 km towards the ESE the Porsanger Dolomite and the Stabbursdal Formation were removed by erosion in Vendian time. This is demonstrated by the fact that in the Suoššjåkluob'balat area the Hangleċærro Formation is overlain by sediments of the Smalfjord Formation.

3. The stratigraphical position of sandstones and shales occurring in the area southeast of Guor'gabmir is ambiguous. Whereas the geographical location indicates an association with the Stabbursdal Formation, their lithology, however, denotes affinity with the Stappogiedde Formation. The latter relationship is favoured by the present author. The lower parts of the Vestertana Group may have been deposited on an uneven surface of the Tanafjord Group, perhaps between hills of the Porsanger Dolomite. Younger formations, including the Stappogiedde, then covered the entire area.

4. South of Šuoššjåkluob'balat a sheet of Porsanger Dolomite with conformably overlying diamictite is thrust upon Smalfjord Tillite. The distance of thrusting is assumed to be relatively short.

5. At Storfossen in Stuorrajåkka outcrops of Porsanger Dolomite alternate with isolated outcrops of a sandstone/siltstone sequence, probably belonging to the Lillevatn Member. The geological situation may be interpreted in a similar way to that suggested for the area southeast of Guor'gabmir, the Lillevatn sediments filling depressions between hills of dolomite.

Acknowledgements. I thank Trude Elgsæther for the preparations of the illustrations, Evelyn Magnussen for the typing of the manuscript, and David Roberts for improving the English text. Valuable suggestions from Timothy J. Chapman, David Roberts and Anna Siedlecka are gratefully acknowledged.

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Plate 1 (NGU - BULL. 395 1984, 39–46)

GEOLOGICAL MAP OF THE AREA LAKSEFJORDEN-GUOR'GABMIR

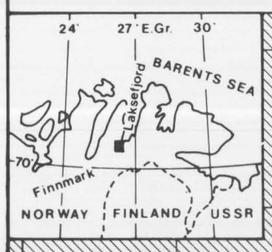
By

SVEN FØYN

Based on the topographical map sheets M 711-2135 I and III

Grid interval 1000 metres

0 1000 2000 m



LEGEND

MIDDLE LAKSEFJORD NAPPE

Areas underlain by low-metamorphic sedimentary rocks

LOWER LAKSEFJORD NAPPE

Areas underlain by crystalline basement rocks

VESTERTANA GROUP

Breivik Formation. Grey-green or red-brown thin-bedded mudrocks alternating with sandstone

Stappogiedde Formation

Manndraperelv Member. Red quartzite

Innerelv Member. Blue-green (lowermost beds red-violet) laminated mudrocks

Lillevatn Member. Dark grey-green siltstone in lower part; in upper part beds of light-coloured quartzitic sandstone, in places conglomeratic, alternating with dark grey or reddish mudrocks

?Stappogiedde Formation or *?Stabbursdal Formation.* White, reddish or red quartzitic sandstone, in some places granule-conglomeratic, and red or grey-green mudrocks

Mortensnes Formation (Upper tillite). Red-brown or grey-green moraine conglomerate

Nyborg Formation. Red-brown or grey-green sandstone and red or green mudrocks

Smalfjord Formation (Lower tillite, diamictite member). Grey-green or buff moraine conglomerate

Smalfjord Formation (Lower tillite, non-clast-bearing member). Dark grey laminated mudrocks with subordinate light-coloured sandstone

TANAFJORD GROUP

Porsanger Formation. White-grey dolomite

Stabbursdal Formation. Grey, green, buff or red mudrocks, and grey or white sandstone

Hanglečærro Formation. White quartzite

White areas: Alluvial and glacial Quaternary deposits, lakes and Laksefjorden

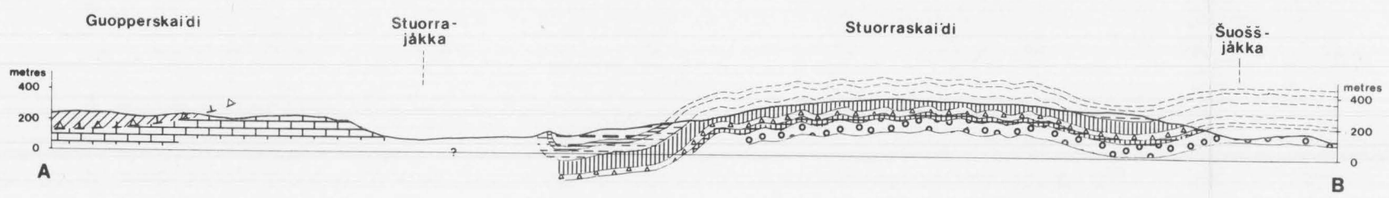
GEOLOGICAL SYMBOLS

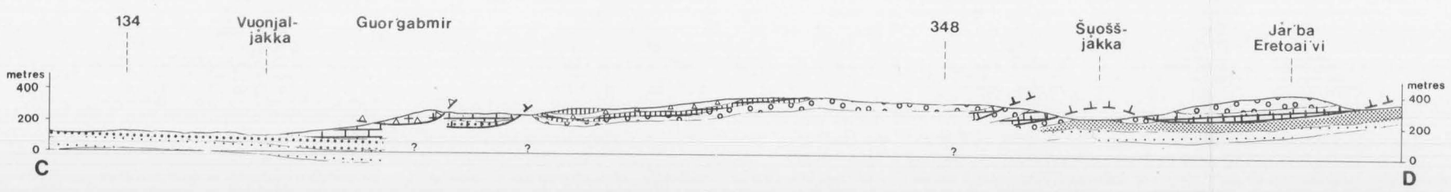
Rock boundary (definite, probable)

Thrust boundary of Middle Laksefjord Nappe

Thrust boundary of Lower Laksefjord Nappe

Local thrust





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Based on the topographical map sheets
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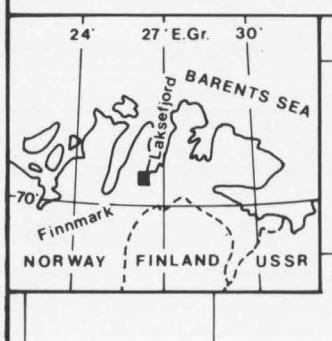

MAP OF ROCK EXPOSURES AND TECTONICS

- Rock exposures. (The areas of the Laksefjord Nappes are not concerned with, except for Guor'gabmir)
- Rock boundary (definite, probable)
- Thrust boundary of Middle Laksefjord Nappe
- Thrust boundary of Lower Laksefjord Nappe
- Local thrust
- Strike and dip of layering (inclined, vertical, overturned). 90°- vertical
- Strike of axial planes in strongly folded rocks
- Axis of anticlinorium
- Axis of synclinorium