LATE PRECAMBRIAN SEDIMENTARY ROCKS OF THE TANAFJORD—VARANGERFJORD REGION OF VARANGER PENINSULA, NORTHERN NORWAY

by

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Abstract

The late Precambrian Older Sandstone Series of Føyn (1937) underlies relatively large areas of the Tanafjord—Varangerfjord region of Varanger Peninsula (Siedlecka & Siedlecki, 1967). Geological mapping carried out by the authors in the last few years has shown that this rock-sequence crops out conveniently for lithostratigraphic studies in two particular areas: 1) east of the Tanafjord, between Trollfjord, Leirpollen and

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Gednjevannet and 2) in the central part of Varanger peninsula close to Skibskjølen and Kjøltindene. Geological maps of these two areas are enclosed.

Based on a study of the type-profiles and supported by information obtained from geological mapping, a formal lithostratigraphical classification of the Older Sandstone Series is introduced. The name Tanafjord Group is propòsed for the entire sequence; adopting local geographical names the Tanafjord Group is then divided into seven formations defined according to the rules of lithostratigraphical nomenclature and classification. Descriptions of all the lithostratigraphical units supplement the classification.

Finally, main features of the structures of the mapped areas and of Varanger Peninsula in general are reviewed briefly in the light of the results of the recent studies.

INTRODUCTION

The shores of Varanger Peninsula and of adjacent areas of eastern Finnmark have been visited by numerous geologists, but since Reusch (1891) published his observations on the morainic conglomerates with striated boulders lying upon a striated pavement at the head of Varangerfjord it has usually been the Eocambrian glacial deposits which have attracted the most attention. Detailed and systematic investigations on Varanger Peninsula were initiated by Holtedahl (1918) who also reviewed the older geological literature concerning the geology of Finnmark. Holtedahl's (1918) studies of the geology of Varanger and adjacent areas were continued by Føyn (1937), Rosendahl (1935, 1941) and more recently by Reading (1965), Beynon et al. (1967), Banks et al. (1970), Røe (1970) and by the present authors (Siedlecka & Siedlecki, 1967).

During his investigations along the coastal sections of Varanger Peninsula, Holtedahl (1918) established the occurrence of two broad lithostratigraphical units: an older unit, consisting of various terrigenous deposits and including carbonate rocks, and a younger one characterized by the appearance of tillite horizons. Holtedahl (1918) also observed that in the area close to Varangerfjord there is and erosional surface and slight angular unconformity between these two major rock-sequences.

The stratigraphy of the younger, tillite-bearing, Eocambrian rock-sequence was the main object of Føyn's (1937) study in the Tana district. He also described the underlying sedimentary succession from some localities on the eastern side of Tanafjord and named it the "Older Sandstone Series on the Tanafjord". This same Eocambrian tillite-bearing sequence, together with overlying Palaeozoic rocks, appearing on Digermul Peninsula has been investigated in detail in recent years by Reading (1965). The "Tillite-bearing Series" of Føyn (1937) was renamed

Vestertana Group, and the Palaeozoic (Cambrian and Ordovician) succession referred to as the Digermul Group. The Vestertana Group has been described from a small area near Leirpollen by Beynon et al. (1967), and a sedimentological study of glacial and glacio-fluvial deposits from this group carried out by Reading and Walker (1965).

Føyn (1967) discovered fragments of Platysolenites in the youngest formation of the Vestertana Group, the Breivik Formation, in the Leirpollen area. Consequently the Breivik Formation must be considered as belonging to the lowermost part of the Cambrian.

In chronostratigraphical terms we regard the Older Sandstone Series as late Precambrian, adopting the term Eocambrian, in its restricted sense, well defined e.g. by Føyn (1967, p. 7) as "the time and sedimentary sequence starting with the lower tillite and reaching up to the boundary of the fossiliferous Cambrian, in conventional meaning of the term "fossiliferous" ". The boundary between late Precambrian and Eocambrian is well defined by the earlier mentioned erosional surface and slight angular unconformity.

In a lithostratigraphical classification of the Latest Precambrian and Eocambrian rocks of Norway proposed recently by Bjørlykke, Englund and Kirkhusmo (1967), a suggested formal lithostratigraphical classification of the Older Sandstone Series was also presented.

During the last few years field-work the authors have established (A. Siedlecka & S. Siedlecki, 1967) that Varanger Peninsula consists of two different geological regions divided from each other by a large thrust fault (or set of faults) trending in a NW-SE direction, from Trollfjord to the mouth of the Komagelv river (see Fig. 1). Rocks of the Vestertana Group and of the Older Sandstone Series appear only in the region situated south-west of this tectonic boundary — the Tanafjord—Varangerfjord region. The north-eastern Barents Sea region consists of thick sedimentary sequences which are quite dissimilar to those present in the Tanafjord—Varangerfjord region.

The present paper is concerned mainly with the formal lithostratigraphical classification of the Older Sandstone Series based on measurements of sections and on mapping of areas underlain by this succession within the Tanafjord—Varangerfjord region.

Two particular areas serve to illustrate the lithological sub-division of the Older Sandstone Series. The first, regarded by us as a type area, is that situated east of Tanafjord between Leirpollen, Trollfjorden and Gednjevannet (Fig. 1 and Pl. I). In the north-east of this area the Older

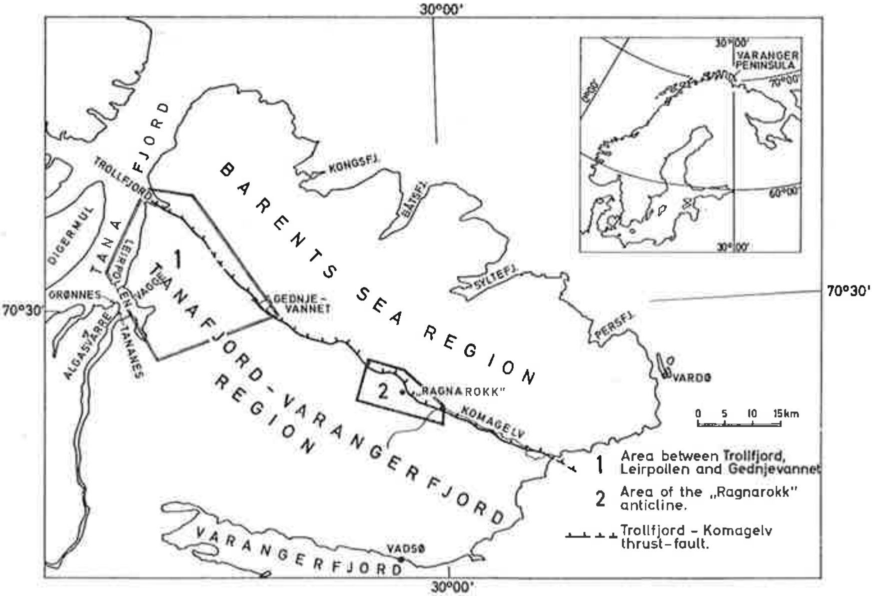

Fig. 1. Location map.

Sandstone Series has a tectonic contact with rocks of the Barents Sea region, while in the south and south-east it dips beneath younger rocks belonging to the Vestertana Group.

The second, quite well exposed area of Older Sandstone Series is that of the Ragnarokk*) anticline. This is situated within the innermost parts of Varanger Peninsula, roughly east of Skibskjølen and to the north of Kjøltindene (Fig. 1 and Pl. III).

A broad and irregular belt of minor outcrops of the Older Sandstone Series links the two above-mentioned areas and extends in a south-easterly direction close to the Trollfjord—Komagelv thrust-fault. The hills on the south-western side of Gednjevannet and Ordovannet also occur within this belt. These several minor exposures of the Older Sandstone Series are not conducive to detailed stratigraphical studies because of their restricted and incomplete nature and also because of the presence of tectonic disturbances. The lithostratigraphical units distinguished in the type-area can,

*) The name Ragnarokk was introduced by us while mapping the area to the north of Kjøltindene, where other geographical names on maps are non-existent. Near the core of the anticline there is a little hut, "Ragnarokk", owned by the "Varanger kraftlag", Vadsø, and this name has been adopted here.

however, be traced without any distinct change of facies throughout this belt of outcrops.

Rocks of the Older Sandstone Series appear also on the northern side of Varangerfjord (Banks et al., 1970; Røe, 1970). They underlay a large area between Kjøltindene, Skalneset, Vadsø and Mortensnes and there is a continuation between this latter area and that of the Ragnarokk anticline. Bulk of lithologies of the Older Sandstone Series cropping out in the area north of the Varangerfjord may well be correlated with those of the Tanafjord area (Røe, 1970).

TYPE-SECTIONS OF THE OLDER SANDSTONE SERIES

A section of the Older Sandstone Series was measured in detail by Føyn (1937) at Tananes, a locality situated in the inner part of Tanafjord, west of the mouth of the Tana river (see Fig. 1). Føyn (1937) also described briefly the coastal section on the eastern side of Tanafjord between Stangenes, Vagge and Lavvonjargga (NE of the mouth of the Tana). Both sections transsect the same structures (SW-NE trending folds) but the section Stangenes—Vagge—Lavvonjargga is somewhat more complete than the Tananes profile. The steep NW limb of the syncline in the valley of Vaggeelven (Fig. 2 and Pl. I) provides a convenient profile for detailed lithostratigraphic measurements and studies, and the ca. 1230 m thick sedimentary succession which appears there represents the bulk of beds of the Older Sandstone Series. Strata strike perpendicularly to the sea-shore and dip nearly vertically. This section, named the "Vagge Profile", has been measured in detail by the authors and is regarded as the type-section.

The uppermost part of the Older Sandstone Series comprising carbonate rocks is absent in the Vagge profile. Føyn (1937) has described, in brief, these carbonate-bearing strata which crop out on the shore at the mouth of Grasdalen. The present authors have observed similar beds on the northern slopes of the mountains bordering Trollfjorddalen (Sørelven) from the south. These two localities are referred to and described below as the "Trollfjord and Grasdal Profile".

Vagge Profile
(Pl. V and Fig. 2)

An assemblage of interbedded dark grey sandstones, siltstones and shales with subordinate intercalations of variegated silty and shaly beds and some conglomerates, crops out at the mouth of the unnamed valley between

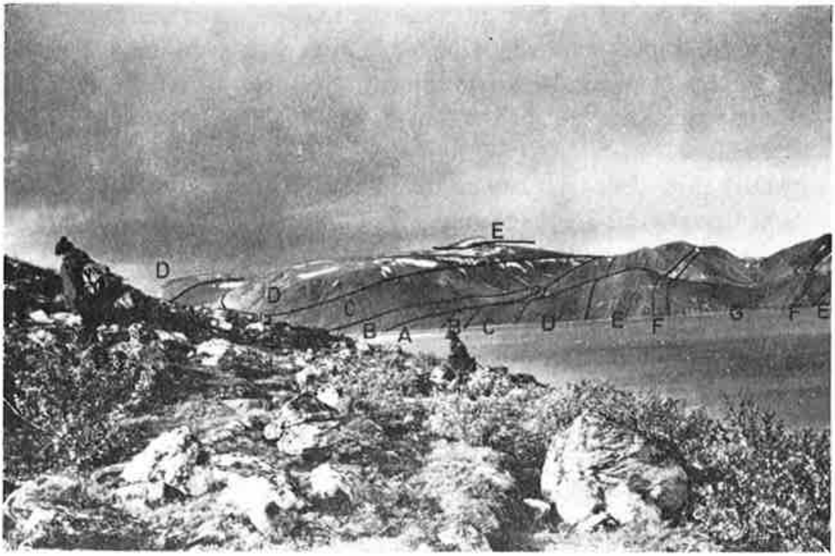

Fig. 2. View of Stangenestind and Vagge valley from Tananes.
A — interbedded layers of grey sandstones, grey and variegated arenaceous shales and some conglomerates; B — Grønnes Formation; C — Stangenes Formation; D — Dakkovarre Formation; E — Gamasfjell Formation; F — Vagge Formation; G — Hanglečærro Formation. (Photo St. Siedlecki)

Stangenes and Vagge. These beds, the oldest in the described section, constitute the core of an anticline (Fig. 2, A), are distinctly tectonically disturbed, and are not exposed well enough to permit detailed measurement. Only the very top of this rock — assemblage has been measured and included as unit No. 1 in the following description:

1. 12,00 m —
   Interbedded layers (ca. 5 - 50 cm) of grey sandstone and dark grey arenaceous shale. The sandstone exhibits rusty brown spots while the shale becomes variegated in places. Cross-bedding and ripple-marks are common in this sandstone and slumping structures have also been observed.
2. 130,00 m —
   Light grey and whitish quartzitic sandstone with feldspar admixture, medium- to coarse-grained, massive, sporadically exhibiting cross-bedding. Layers of this sandstone are up to 1,5 m thick. In the lowermost part (a few metres above the bottom surface) the sandstone is coarse-grained and conglomeratic. Pebbles of quartz, usually sub-

angular, are up to 4 cm in diameter and are either scattered through the sandstone or arranged in bands situated usually near the bottom surfaces of particular layers. Slump structures have been observed in some conglomeratic beds.

3. 20,00 m —
Dark grey shale, arenaceous and argillaceous, with some intercalations of fine-grained grey sandstone exhibiting distinct lamination and shaly partings. The shale is brownish coloured on weathered surfaces.
4. 15,00 m —
Quartzitic sandstone, light grey and yellowish, fine- to medium-grained, interbedded with grey arenaceous and argillaceous shale.
5. 220,00 m —
Greenish grey shale, in some parts a reddish colour, arenaceous and argillaceous, brown on the weathered surfaces. Shale layers are interbedded with siltstone beds or even with thin-bedded, dark grey, laminated sandstone. In the argillaceous or silty beds distinct cleavage is present. Up to 3 m-thick intercalations of massive, grey, quartzitic sandstone appear in the upper part of of this unit (40 m, 20 m and 11 m from the top). The sandstone displays prominent current-ripples.
6. 60,00 m —
Quartzitic sandstone and feldspathic sandstone, medium- and fine-grained, grey, some layers with numerous rusty spots. Thicknesses of sandstone layers range from ca. 0,2 to 1,0 m. On weathered surfaces the sandstone is light grey or white, differs markedly from adjacent brownish coloured, soft shale beds and produces a conspicuous topographic feature. Cross-bedding is common and minor slump structures are occasionally observed. Upper and lower boundaries of this unit are sharp.
7. 35,00 m —
Shale, arenaceous and argillaceous, grey and greenish grey, with subordinate thin layers of shaly sandstone. On the weathered surfaces the shale becomes brownish grey in colour.
8. 16,20 m —
Sandstone, medium- and fine-grained, grey. Thickness of sandstone layers is usually 0,2 - 0,5 m, occasionally up to 1,0 m. Cross-bedding occurs frequently. Subordinate intercalations of dark grey arenaceous shale and grey shaly sandstone are also present.
9. 2,30 m —
Shale, dark grey, arenaceous and argillaceous. Mud-cracks, deformed

by compaction, are often present on the top surfaces of some layers of shale.

10. 2,30 m —
Sandstone, medium- and fine-grained, grey, with an admixture of feldspar grains; sometimes with also small rusty ferruginous spots. Cross-bedding is common. Thicknesses of the layers of sandstone vary from ca. 0,3 to 1,0 m.

11. 2,20 m —
Arenaceous shale, dark grey, with thin intercalations of fine-grained grey sandstone.

12. 27,50 m —
Feldspathic sandstone, medium- and fine-grained, grey, with rusty spots in some layers. Cross-bedding common; in some places slump structures have been observed. Dark grey arenaceous shale and thin-bedded sandstone constitute subordinate lithologies within this unit.

13. 4,60 m —
Interbedded layers of fine- and medium-grained grey or reddish brown sandstone and arenaceous dark grey shale; the latter lithology is predominant.

14. 4,60 m —
Arenaceous shale, grey, with subordinate thin-bedded, fine-grained sandstone. The latter is often disrupted by subaqueous sliding into isolated, kidney-shaped bodies.

15. 8,80 m —
Sandstone, fine- and medium-grained containing feldspar grains, massive, light grey, occasionally with rusty spots. Thickness of sandstone layers vary from ca. 0,2 to 1,0 m.

16. 8,80 m —
Shale, arenaceous and argillaceous, dark grey, including subordinate intercalations of grey sandstone.

17. 7,70 m —
Interbedded thin layers of grey, fine-grained sandstone and grey to dark grey arenaceous shale. Slump structures appear sporadically in the sandstone layers.

18. 20,00 m —
Arenaceous and argillaceous shale with subordinate intercalations of grey, fine-grained sandstone. There are transitions between this bed and the adjacent beds.

19. 3,90 m —
Feldspathic sandstone, grey, often with rusty spots, fine- and medium-grained, in layers up to 0,5 m thick. In the lower part the sandstone is thin-bedded and shaly gradually passing into the subjacent shale bed. Cross-bedding is common.
20. 11,80 m —
Grey shale, arenaceous and argillaceous.
21. 3,00 m —
Ferruginous sandstone, cemented with haematite and limonite, medium- or fine-grained, thin-bedded. Some layers are quartzitic (grey) and do not contain ferruginous cement.
22. 3,50 m —
Shale, arenaceous, greenish-grey with a prominent admixture of muscovite. Some thin intercalations of grey fine-grained sandstone occur in this bed.
23. 3,50 m —
Thick beds of massive sandstone, medium-grained, with ferruginous (mostly haematitic) cement. The sandstone is brown and violet, while some layers are grey and quartzitic with numerous rusty spots.
24. 12,20 m —
Interbedded layers (0,5 - 1,5 m thick) of thin-bedded, medium- and fine-grained grey sandstone and dark grey arenaceous and argillaceous shale.
25. 9,20 m —
Thick, haematite-red beds of medium-grained sandstone. In the lower (about 1,50 m from the bottom) and uppermost (0,5 m from the top) parts the sandstone is thin-bedded and grey in colour.
26. 6,50 m —
Ferruginous sandstone, haematite-cemented, in layers up to 0,3 m in thickness.
27. 2,20 m —
Medium-grained, thin-bedded grey sandstone passing upwards into a haematite-cemented red-violet sandstone.
28. 8,50 m —
Haematite-bearing sandstone, red-violet, massive, medium-grained; layers of sandstone are 0,5 - 1,5 m thick. The uppermost 0,70 m-thick layer is grey in its upper part.
29. 2,20 m —
Light grey, medium-grained, massive sandstone with few feldspar

grains. The sandstone is whitish coloured on weathering surfaces. Current-ripples have been observed on the top surface of the uppermost bed.

30. 15,60 m —
Greenish grey argillaceous shale with subordinate intercalations of grey arenaceous shale. A 0,80 m-thick lens of brownish ferruginous fine-grained sandstone appears in the lower part of this bed.

31. 1,30 m —
Sandstone, grey with brownish spots in the lower part; red-violet and haematite-bearing in the upper part.

32. 11,00 m —
Shale, arenaceous and argillaceous. The shale is soft, disintegrates easily and crops out rather poorly. It forms a topographic depression which is filled with a talus of shale and quartzitic sandstone and bordered by ridges of the adjacent, resistant quartzitic sandstones.

33. 4,50 m —
Light grey and pinkish grey thick beds of quartzitic sandstone.

34. 6,80 m —
Shale, arenaceous and argillaceous, grey and brownish grey, with thin intercalations of quartzitic sandstone. This shale is also soft and forms a scree-covered topographical depression.

35. 12,50 m —
Haematite-bearing quartzitic sandstone. Certain layers (0,2 - 1,2 m thick) contain variable amounts of iron-oxides, and are stained red and brown. The layers occurring in the middle of this bed appear to be those most haematite-rich.

36. 12,20 m —
Fine- and medium-grained feldspathic sandstone in 0,3 - 1,0 m thick layers. In the lowermost part the sandstone is haematite-rich and stained red-violet.

37. 3,80 m —
Arenaceous shale and thin-bedded fine-grained sandstone.

38. 3,00 m —
Thick beds of grey, hard, medium- and coarse-grained quartzitic sandstone with an admixture of sericitized feldspar grains. The sandstone turns a yellowish colour on weathering.

39. 10,20 m —
Grey arenaceous shale, brown on weathered surfaces. This shale is poorly exposed and forms a topographical depression.

40. 280,00 m —
This is a monotonous, light-coloured usually medium-grained, massive quartzitic sandstone containing more or less distinct admixture of disintegrated feldspar grains, and stained pink or reddish-pink with iron-oxides. The internal structure of many layers, e.g. lamination or cross-bedding, is often emphasized by the reddish-violet banding. The sandstone layers are 0,3 m - 2,0 m thick, those above 1 m in thickness being most common. Cross-bedding occurs frequently and ripple-marks are occasionally observed. Some fine-grained layers, exhibiting a shaly parting, occur irregularly among the prevailing massive, quartzitic sandstone; the former, being less resistant, disintegrate more easily forming depressions between the prominent ribs of sandstone. Within this 280 m thick unit no argillaceous interbeds have been observed. The lower boundary of this thick unit is marked by a grey arenaceous shale (unit no. 39 in this description) immediately upon which rests a thick layer of massive, pink quartzitic sandstone. The upper boundary is marked by the appearance of the grey arenaceous shale of the next unit.

41. 64,00 m —
Thin-bedded, very fine-grained grey sandstone, often with shaly partings, interbedded with arenaceous and argillaceous shale. The sandstone, usually quartzitic, is partially stained brown by iron-oxides and ferruginous carbonates. The shale is grey or dark grey, and the argillaceous type a greenish-grey. The brownish colour is generally predominant on the weathering surfaces or along fissility planes and joint surfaces, and this colour being characteristic for these beds when seen in the field. Black, manganese films have also been observed. Ripple cross-lamination, current-ripples, flute-casts and compaction deformed mud cracks also occur.

42. 0,70 m —
One layer of fine- and medium-grained light grey sandstone with numerous ferruginous rusty spots.

43. 17,50 m —
Scree of shales and fissile fine-grained grey sandstones which turn brown on disintegrating. These lithologies are similar to those of unit no. 41.

44. 150,00 m —
Quartzite and quartzitic sandstone, medium-grained (occasionally coarse-grained), white, light grey or yellow. Dark grey layers occur

infrequently and this colour seems to result from an admixture of carbonaceous matter (? graphite). The quartzite and quartzitic sandstone are compact, resistant to weathering and appear usually in layers ca. 0,2 - 1,0 m thick. The prominent features of this unit are its white colour, hardness and homogeneity. Cross-bedding and, occasionally, current ripples have been observed.

The above-described white quartzite and quartzitic sandstone constitute the uppermost lithologies in the Vagge Profile. Their thickness of about 150 m is incomplete in this particular profile as they appear in the core of a syncline (the Vagge syncline). The complete thickness of this lithological unit observed in other localities is about 200 m.

The youngest beds of the Older Sandstone Series, not present at this locality, appear in sections at Trollfjord and Grasdal and are described below.

Trollfjord and Grasdal Profile (Pl. V)

The geological profile appearing on the northern slopes of the mountains bordering Trollfjorddalen (Sørelven) from the south is partially covered with scree and the different lithologies observed there could not be measured with any accuracy; the thicknesses given below are estimated and must be regarded as approximate. The description, in ascending order, starts with a unit of light quartzitic sandstone corresponding to the uppermost unit of the Vagge profile (unit no. 44).

ca. 150-200 m —

White and light grey quartzitic sandstone, usually medium-grained and massive, appearing in ca. 0,5 - 1 m-thick layers. The top 10 m of this unit consists of light grey medium- to coarse-grained sandstone. This sandstone grades upwards into the next bed.

20 m —

Grey, arenaceous shale exhibiting an uneven wavy parting. The shale is brownish or rusty coloured on weathered surfaces. Intercalations of arenaceous marly beds up to 0,5 m thick are present, these consisting of alternating green (arenaceous with an admixture of carbonate) and red (marly) laminae; the green laminae become yellow with disintegration and weathering.

20 m —

Marly shale consisting of interbedded grey and green parallel laminae, the latter becoming yellow on disintegrating surfaces. The laminae are ca. 2,5 mm thick. Layers of yellow-stained arenaceous marlstone appear as intercalations; these also show parallel lamination.

50 m —

Light grey dolomitic calcarenite and calcirudite, white on weathered surfaces. The calcarenite consists of both rounded and angular lithoclasts. The calcirudite is composed of ellipsoidal, flat-lying fragments. Beds and irregular bodies of dark grey to black flint are present in the calcarenite and calcirudite.

Dark grey and black shale occurs above the calcarenite. The boundary between these lithologies is not exposed and over a distance of about 100 m from the top part of the calcarenite one may only observe elongated and prolate fragments of the grey shale. A dark grey to black arenaceous shale then appears 'in situ'. Upwards a typical lower tillite may be observed.

The same succession as in the Trollfjord Profile appears at the mouth of Grasdalen and the mouth of an unnamed valley between Grasdalen and Lille Molvik. Both localities were described briefly by Føyn (1937) and a drawing of the profile of the uppermost part of the Older Sandstone Series at Grasdalen was given by this writer; the thickness of the dolomite and shale zone at this locality was estimated by Føyn (1937) at about 50 m.

South of the mouth of Grasdalen a light grey and white quartzitic sandstone is present which corresponds to the unit No. 44 in the Vagge Profile (see p. 256). Small, isolated outcrops of black arenaceous shales then occur over a distance of about 50 m along the sea-shore. These are overlain by:

ca. 30 m

(partly covered by recent sediments) — dark grey siltstone and slate with thin (ca. 10 cm) intercalations of greywacke. Cross-bedding, scour channels and lenses of sandy material within siltstone are common. This unit is yellowish coloured in its upper part.

1 m

Grey quartzitic sandstone with, in the upper part, thin (2-3 cm) bands and subrounded fragments (up to 2 cm in the east) of a calcareous rock (? dolomite).

ca. 5 m

Grey, yellow and pink dolomitic calcirudite.

ca. 15 m

Light grey dolomitic lithocalcarenite and calcirudite with some stromatolithic structures. Two red-coloured zones of silicification occur locally in this unit. These zones are several metres thick near the seashore and seem to disappear eastwards.

The dolomitic lithocalcarenite grades upwards into:

ca. 15 m

dark grey, sandy and calcareous (dolomitic) shale and mudstone with numerous bands of yellow dolomite 0,30 - 20 cm thick. Some of these bands are disturbed by a plastic gliding of sediment while others have been strongly disrupted. The dolomitic bands occur mostly in the central part of the shale bed, gradually disappearing upwards and downwards.

ca. 20 m

Shale similar to that described above; exposures are poor and discontinuous. The lower tillite appears directly above this unit.

On the basis of these various observations in the uppermost part of the Older Sandstone Series the following conclusions may as far be deduced:

1) The uppermost part of the Older Sandstone Series consists of shales, mudstones and carbonate rocks.

2) The carbonate rocks appear either as bands within argillaceous and arenaceous deposits or as independent larger bodies of dolomitic calcarenites and calcirudites. The two last-mentioned lithologies often comprise stromatolithes and seem to form a discontinuous horizon of lenticular bodies.

3) The thickness of the whole unit may be roughly estimated at about 100 m; the upper boundary of this unit is an erosional surface.

LITHOSTRATIGRAPHICAL CLASSIFICATION

Introductory notes

The late Precambrian assemblage of rock strata which forms the basis of this present paper was informally named by Føyn (1937, p. 67) "The Older Sandstone Series on the Tanafjord". Føyn (1937) also introduced the names "Stangenes shale", "Vagge quartzite" and "Vagge shale" to describe some prominent lithologies within the Older Sandstone Series. A recently published paper entitled "Latest Precambrian and Eocambrian Stratigraphy of Norway" (Bjørlykke, et al., 1967) includes, among other things, a suggested formal lithostratigraphical classification of Føyn's (1937) Older Sandstone Series. In this publication, the geographical names "Stangenes" and "Vagge" were used as names of formations and new terms "Algasvarre Formation" and "Grasdal Dolomite Formation" were also introduced. The entire Older Sandstone Series was renamed the "Tana Subgroup". In addition, Reading's (1965) Vestertana Group embracing mainly Eocambrian deposits was renamed the "Varanger Subgroup" and the youngest Breivik Formation was excluded from this subgroup. Both "Subgroups" constitute the Finnmark Group which is correlated with the Hedmark Group of Southern Norway.

This concept of a new, formal classification of the Older Sandstone Series, as reviewed above, was however established without any new field observations on this particular sequence of rocks. Some alterations and supplements to this suggested classification would therefore seem to be justified and expedient.

The first main problem which we considered during the preparation of the present lithostratigraphical classification was the correct establishment of ranks of particular lithostratigraphical units which, because of their lithological characteristics, are easily distinguishable and mappable in the field. Nomenclature was the second main problem deliberated during the preparatory work on classification.

Several criteria for lithostratigraphical classification were taken into account by the present authors, and these may be divided into three principal groups:

1) Data obtained during geological mapping, especially studies on:
   a) stability or variability of facies;
   b) homogeneity or heterogeneity of lithology;
   c) relative constancy of thickness;
   d) lateral extension;
   e) character of the top and bottom surfaces;
   f) mappability.

   These apply to every mapped lithologic unit in the field. In addition, studies on particular geological profiles and measurements of type-profiles were carried out.

2) Comparative analyses of the results with those of previous authors, especially of Føyn (1937);
   a) correlation with the section at Tananes;
   b) correlation with the section at Grasdalen;
   c) comparison of lithological and petrological properties of particular units.

Account has also been taken of classifications introduced previously (informal classification of Føyn, 1937, suggested classification of Bjørlykke et al., 1967: lithostratigraphical classification of the Eocambrian of Reading, 1965).

3) Application of the rules of lithostratigraphical classification and nomenclature (American Commission on Stratigraphic Nomenclature, 1955; American Commission on Stratigraphic Nomenclature, 1956; American Commission on Stratigraphic Nomenclature, 1961: Hedberg, 1961: Henningsmoen, 1961; Norwegian Committee on Stratigraphical Nomenclature (Komitéen for Stratigrafisk Nomenklatur), 1961: George et al., 1967; George et al., 1969).

The most precisely defined rules of lithostratigraphical classification are to be found in the Code of Stratigraphic Nomenclature published in 1961 by the American Commission on Stratigraphic Nomenclature and the present authors have conformed as far as possible to the rules of this code. Consequently, we regard a *formation* as a fundamental lithostratigraphical unit used in description and interpretation of the geology of an area and we apply the rank of formation to particular units following articles of the code. Furthermore, we found it useful to differentiate between two informal members within one of the formations.

The term Tanafjord Group has been introduced by us to replace the Older Sandstone Series of Føyn (1937) and Tana Subgroup of Bjørlykke et al. (1967). Usage of the geographical name "Tanafjord" seems to be most appropriate because this particular lithostratigraphical unit crops out extensively and most conveniently for geological observation along the eastern border of the Tanafjord, and the type area of this unit extends east from inner Tanafjord. Holtedahl (1918, p. 222) writes "Denne underavdelingen findes fra strøket omkring Porsangerfjorden i et belte mot øst, hvor den anstaar ved den indre del av Tanafjorden". Later Holtedahl (1932, p. 267) introduced the name "Tana sandstone series". Although this term may be regarded as having priority, the name "Tanafjord" appears eminently more suitable particularly as Føyn (1937, p. 67) adopted the designation "Older Sandstone Series on the Tanafjord", and Holtedahl (1960, p. 116) used the name "Tanafjord district" so imparting immediate information about the type area of Eocambrian and late Precambrian rocks of East Finnmark. The rank "group" seems to be more suitable than the "subgroup" proposed by Bjørlykke et al. (1967) because it emphasizes the stratigraphical and regional independency of this lithostratigraphical unit and separates it distinctly from the younger beds (Vestertana Group of

Reading, 1964; Varanger Subgroup of Bjørlykke et al., 1967). Besides, the prefixes "sub" "super" are always somewhat artificial and should, if possible, be avoided.

The Tanafjord Group is overlain with slight unconformity by Eocambrian rocks, the Vestertana Group of Reading (1965). As mentioned previously (p. 260), Bjørlykke et al. (1967) proposed to rename this unit the "Varanger Subgroup" and also to exclude from it the youngest Breivik Formation, the latter then being incorporated into the fossiliferous Cambro - Ordovician Digermul Group. This alteration, however, seems to be still under discussion (see Bjørlykke et al., 1967, pp. 11-12) and is not decisive in the consideration of which name, "Varanger" or "Vestertana" should be used; the criterion of priority seems to be that attracting most attention. Apart from the problem of the upper boundary of this unit, which has to be fixed arbitrarily within a continuous sequence of sedimentary rocks, the name "Vestertana Group", well defined by Reading (1965), seems to the present authors to be more correct than the Varanger Subgroup proposed by Bjørlykke et al. (1967). The name "Varanger" has been used many times previously by several authors with different meanings. Some examples of the earlier use of this name are as follows:

(a) Dahll (1867) introduced the term "Varanger-systemet" for *all* sedimentary rocks ("brown conglomerate, brown sandstones and brown shales") appearing in the area between Polmak and Vardø. A unit defined in this manner embraces a part of the Barents Sea Group (Siedlecka & Siedlecki, 1967), a part of the Tanafjord Group (this paper) and a part of the Vestertana Group (Reading, 1964). Consequently, Dahll's (1867) usage of the name "Varanger" cannot be regarded as having any priority in the lithostratigraphical nomenclature of the Eocambrian tillite-bearing succession.

(b) Holtedahl (1918, p. 222) used the name "Varanger-avdelingen" for "... sandsten - skifer - dolomitt-seriene i strøket Kongsfjord - Vardø - Vadsø ..." and this term also embraces many different lithostratigraphic units from two different geological regions, the Barents Sea region and the Tanafjord—Varangerfjord region (Siedlecka & Siedlecki, 1967). "Varanger series" of Holtedahl (1919, p. 86) embraced all sedimentary rocks of Varanger Peninsula *except* the "tillite-bearing sandstone series".

(c) "Varangerformation" of Wegmann (1929) embraces *all* pre-Quaternary sedimentary rocks underlying the Varanger Peninsula and the Rybachy Peninsula.

(d) Rosendahl (1931) used the term "Varangerformasjonene" rather loosely to describe sedimentary rocks cropping out at the head of Varangerfjord and also to the north and west of this fjord. Defined in this way, "Varangerformasjonen" may include some rocks of the Vestertana Group together with older deposits.

Stratigraphy of the Eocambrian tillite-bearing succession is known best from the area west of the lower part of the Tana river in the district of Vestertana (Føyn, 1937, Reading, 1965). This succession is also relatively extensively developed in this area, a fact which led Reading (1965) into introducing the name "Vestertana Group". Profiles of all formations and members of the Vestertana Group as defined by Reading (1965) may be studied in the Vestertana area. The Eocambrian tillite-bearing succession appearing at the head of Varangerfjord is less complete than that in Vestertana and correlation between the two areas is still not quite clear. Particular lithologies and localities at the head of Varangerfjord are famous and have been known for many years e.g. Bigganjarrga tillite of Reusch (1891), but systematic comparative studies and sedimentological investigations have only lately been in progress in this area (Bjørlykke, 1967a, Reading, 1970).

On account of these various facts it should be emphasized that the ground close to the Varangerfjord cannot be regarded as a type-area for the lithostratigraphy of the Eocambrian tillite-bearing rock-assemblage, and that the adoption of name "Varanger Subgroup" cannot be regarded as suitable.

In conclusion, we regard the Tanafjord Group and Vestertana Group as the two main lithostratigraphical units underlying the Tanafjord—Varangerfjord region of Varanger Peninsula, and extending westwards to neighbouring areas. These two groups represent two independend time-stratigraphical units: Late Precambrian and Eocambrian (including the lowermost Cambrian) separated by a period of erosion and tectonic movements. We do not at present intend introducing into our classification any unit higher than group, and do not accept the term "Finnmark Group" as defined and introduced by Bjørlykke et al. (1967). Our points of view in this latter question may be outlined with the following arguments:

The "Finnmark Group" as introduced by Bjørlykke et al. (1967) is the formal name for Holtedahl's (1918) "Finnmark Sandstone Series". This latter "series", i.e. "Finmarkens sandstensformasjoner" of Holtedahl (1918, p. 221 and p. 229 in the English summary), embraces the recent Vestertana Group, Tanafjord Group (Varanger Subgroup and Tana Subgroup of Bjørlykke et al., 1967) *and* all the sedimentary successions of the Barents Sea region (Siedlecka & Siedlecki, 1967). Late Precambrian rocks of the

Porsangerfjord and Laksefjord areas were also included under this term (i.e. Finmarkens sandstensformasjoner). Consequently, if one adopts the term Finnmark Group one should include within it not only "Varanger Subgroup" and "Tana Subgroup" but also the late Precambrian deposits of western Finnmark (Porsanger and Alta areas), furthermore the Barents Sea Group and perhaps the Raggo Group (Siedlecka & Siedlecki, 1967) as well as the Laksefjord Group, on correlation grounds (Føyn, 1960, 1969). Unfortunately, we do not know, as yet, the lithostratigraphic correlation between the sedimentary succession of the Barents Sea region and those of the Tanafjord—Varangerfjord region. Future investigations will presumably help to elucidate this problem and only after that will it be permissible for a unit, or units, higher in hierarchy than group — and embracing the sedimentary successions appearing stratigraphically above Precambrian and below Cambrian — to be created. The name "Finnmark" should be reserved for one general unit embracing several groups constituting the "Finmarkens sandstensformasjoner" and in this way Holtedahl's term will be used correctly.

The present authors, as mentioned above, consider formations as fundamental units in lithostratigraphy. The formations of the Tanafjord Group, introduced here, are described below in ascending order. Their lithologies, thicknesses and lateral extensions are illustrated by the type-profiles and geological maps (Pl. I-V). The classification introduced by Føyn (1937), the suggested formal classification of Bjørlykke et al. (1967) and the lithostratigraphy proposed by the present authors are correlated in Table 1.

Tanafjord Group

This group is 1345 m thick (in the Vagge Profile) and includes the seven formations listed below:

7. Grasdalen Formation (youngest),
6. Hangleččærro Formation,
5. Vagge Formation,
4. Gamasfjell Formation,
3. Dakkovarre Formation,
2. Stangenes Formation,
1. Grønnes Formation.

Dark grey and greenish sandstones, siltstones and shales with some interbeds of variegated or red siltstones and shales and including some conglomerates appear immediately below the Grønnes Formation and constitute the lowermost beds known in the Tanafjord area. This

LITHOSTRATIGRAPHIC CLASSIFICATIONS OF THE LATE PRECAMBRIAN SEDIMENTARY SEQUENCE IN TANAFJORD-VARANGERFJORD REGION, VARANGER PENINSULA, NORTHERN NORWAY.

	FØYN (1937)		OLDER SANDSTONE SERIES ON THE TANAFJORD	BJØRLYKKE et al. (1967)	TANA SUBGROUP	Present paper	TANAFJORD GROUP, ca. 1310 m
	50 m	SHALE AND DOLOMITE		GRASDAL DOLOMITE		GRASDAL FORMATION 100 m	
	ca.150 m	WHITE QUARTZITIC SANDSTONE „VAGGE QUARTZITE"		VAGGE FORMATION		HANGLEČÆRRO FORMATION 150 m	
q	ca. 80 m	DARK-COLOURED ARENACEOUS SHALE „VAGGE SHALE"				VAGGE FORMATION 80 m	
o,p	300 m	LIGHT-COLOURED SOMEWHAT REDDISH QUARTZITIC SANDSTONE		ALGASVARRE FORMATION		GAMASFJELL FORMATION 280 m	
n	22 m	INTERBEDDED SST. AND SILTSTONE LAYERS				DAKKOVARRE FORMATION 350 m: FERRUGINOUS SANDSTONE MEMBER, 130 m; QUARTZITIC SANDSTONE MEMBER, 60 m	
m	20 m	DARK-COLOURED ARENACEOUS SHALE					
l	38 m	DARK-VIOLET SANDSTONE					
k	62 m	SANDSTONE AND SHALE					
j	46 m	QUARTZITIC SST. ALTERNATING WITH SLATY SST.					
i	35 m	DARK-COLOURED ARENACEOUS SHALE					
h	50 m	LIGHT-COLOURED QUARTZITIC SANDSTONE					
g	10 m	ARENACEOUS SHALE				STANGENES FORMATION 255 m	
f	10 m	QUARTZITIC SANDSTONE					
e	185 m	SILTSTONE „STANGENES SHALE"		STANGENES SHALE			
d	100 m?	QUARTZITIC SANDSTONE				GRØNNES FORMATION 130 m	
c	20 m?	ARENACEOUS SHALE				INTERBEDDED LAYERS OF GREY SANDSTONE, GREY ARENACEOUS SHALE, VARIEGATED ARENACEOUS SHALE, SOME CONGL. (BOTTOM SURFACE UNKNOWN)	
b	15 m?	QUARTZITIC SST. WITH VIOLET AND BROWN POINTS					
a		ARENACEOUS SHALE (BOTTOM SURFACE UNKNOWN)					

Table 1.

several hundred metres thick and usually strongly tectonically disturbed rock-assemblage underlies relatively large but poorly accessible areas, e.g., east of Lille Molvik, east of Trollfjord (see the geological map, Pl. I) and in the core of the Ragnarokk anticline (Pl. III). The base of this assemblage is unknown and no section suitable for detailed measurements has yet been found. Because of this no formal lithostratigraphic name and rank will at the moment be given to this particular "grey, partially variegated, sandstone-siltstone-shale assemblage". Lying on top of this assemblage is a ca. 130 m thick, light-coloured quartzitic sandstone, which includes conglomerate in its lower part. The lower boundary of the Tanafjord Group has been drawn at the bottom surface of this conglomerate-bearing sandstone: this, however, should be regarded as a temporary measure, and will depend on the results of future investigations which will certainly help to decide whether the Tanafjord Group should also include beds underlying the light conglomerate-bearing quartzitic sandstone (described as Grønnes Formation in the presented below classification) or whether or not a new group should be created.

Because there is an erosional contact with a slight angular unconformity between the Tanafjord Group and Vestertana Group, the geometrical definition of the upper boundary of the Tanafjord Group is somewhat difficult. At the moment, one can say that it is situated on the top surface of the youngest bed known below the unconformity, that is, on the top surface of the carbonate-rocks cropping out in Trollfjord and on the eastern border of the Tanafjord between Trollfjord and Lille Molvik. This boundary will clearly have to be moved up if any still younger beds happen to be discovered below the unconformity. The problem of the upper boundary of the Tanafjord Group is only of a theoretical nature and does not arise practically, in geological field work, since the lithologies occurring below and above the unconformity are quite different and distinguishable; the nature of the unconformity, moreover, may be revealed by systematic mapping.

The Tanafjord Group extends east-south-eastwards from the Tanafjord area and reaches the northern coast of Varangerfjord without any important change in thickness and lithology (see also Røe, 1970).

A uniform scheme of description has been applied to all formations of the Tanafjord Group. Each formation is described fully and independently, though as a result of this there is some occasional but unavoidable repetition.

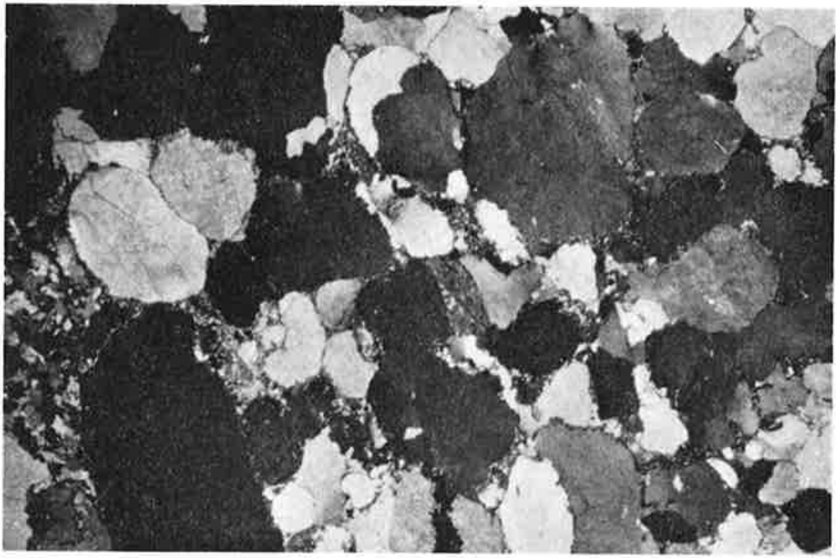

Fig. 3. Coarse-grained sandstone with feldspar and sericite. Grønnes Formation, lower part. Vagge Profile, specimen V-15. Crossed nicols, × 33,5.

Grønnes Formation

Name of the formation: Grønnes is a promontory at the northern point of an unnamed peninsula between Tanafjorden and the Tana river (Fig. 1). The "Section of Tananes" of Føyn (1937, p. 71) starts near Grønnes where the lowermost bed of the Tanafjord Group and subjacent beds are exposed. The name Grønnes has not been used previously in the geological terminology of the area.

Type profile: The Vagge Profile. The Grønnes Formation is described in this profile as unit No. 2. In the Tananes section (Føyn, 1937) the Grønnes Formation is described as unit "d".

Type area: The area extending east from the eastern shores of Tanafjord between Trollfjorden, Leirpollen and Gednjevannet (Pl. I).

Thickness: 130 m in the type profile, (?) 100 m in the Tananes section; it may increase up to 200 m.

Lithology: The Grønnes Formation consists of light grey to white quartzitic sandstone with scattered feldspar grain; in some places it grades into feldspathic sandstone (Figs. 3, 4, 5). Feldspars occurring in these sandstones are more or less altered, mostly into sericite. Concentrations of sericite form part of the cement which consists predominantly of secondary quartz overgrowths. The sandstone varies from fine- to coarse-grained and

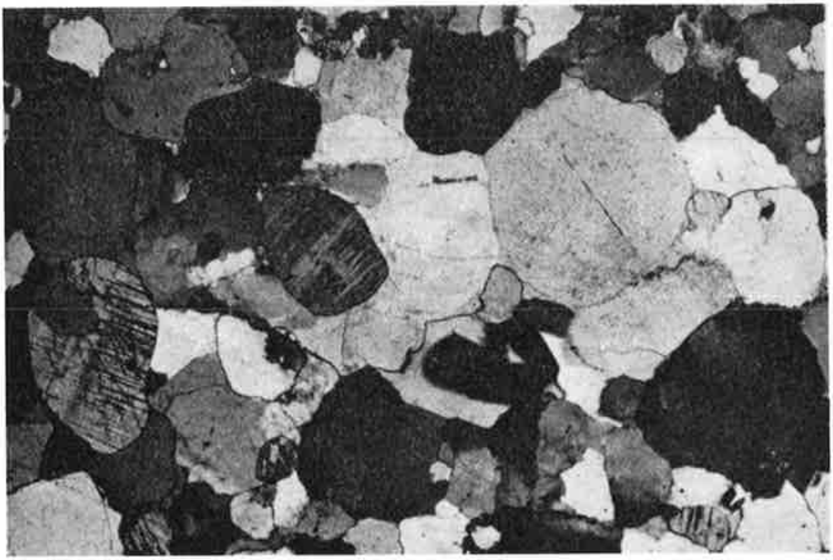

Fig. 4. Quartzitic sandstone with feldspar. Note well rounded grains and quartz overgrowths. Grønnes Formation. Lille Molvik, specimen F-203. Crossed nicols, × 33,5.

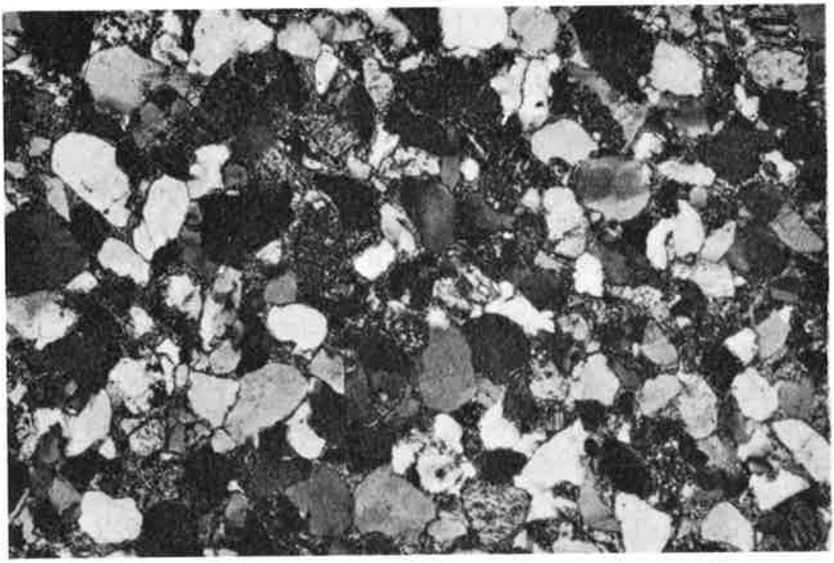

Fig. 5. Feldspathic sandstone, sericite-cemented. Grønnes Formation. Tananes section, specimen F-318. Crossed nicols, × 33,5.

appears in medium to thick layers. Conglomerate is present in lower part (10-20 m) of the Grønnes Formation but is discontinuous, being absent in some localities. The conglomerate consists principally of pebbles of a whitish quartz: some pebbles of dark grey to black quartzite and, occasionally, of red jasper have been recorded. The pebbles are sub-rounded and although reaching up to 5 cm in size are usually about 1 - 2 cm across. Quartzitic or feldspathic sandstone constitutes the matrix of the conglomerate. The matrix is often coarse-grained and feldspar grains up to 8 mm across have been observed. In general, the Grønnes Formation is homogeneous and does not exhibit any marked facies change, while the conglomerate in its lower part constitutes a characteristic lithology absent in all other formations of the Tanafjord Group. Cross-bedding and slumping occur frequently throughout the Grønnes Formation.

Boundaries: (a) The lower boundary is placed below the lowermost conglomerate layer (or below the white quartzitic sandstone where the conglomerate is lacking) and above the "grey, partially variegated sandstone-siltstone-shale association". This boundary is sharp and also constitutes the lower boundary of the Tanafjord Group. (b) The upper boundary is drawn below the first bed of grey and brown arenaceous shale appearing above the compact homogeneous sandstone (between units No. 2 and No. 3 in the type-profile).

Mappability: The Grønnes Formation constitutes one of the index formations for geological mapping. Even in poorly exposed parts of the area it may be easily recognized as it has given rise to topographical ridges and steps covered with white blocks of sandstone *and* quartz-conglomerate.

Extension: The Grønnes Formation can be traced towards the ESE outside the type-area, reaching the northern coast of Varangerfjord.

Stangenes Formation

Name of the formation: Stangenes is a promontory on the east side of Tanafjord, north of the mouth of the Tana river (see Pl. I). The term "The Stangenes shale" was introduced by Føyn (1937, p. 70) for a uniform siltstone bed " . . . conspicuous at Stangenes". Later the term "Stangenes Shale" was adopted by Bjørlykke et al. (1967) as the formal name for a formation. The present authors use "Stangenes Formation" instead of "Stangenes Shale" in order to standardize the revised nomenclature. Stangenes is regarded as the type locality in accordance with Føyn's (1937) opinion.

Type profile: The Vagge Profile. The Stangenes Formation is described

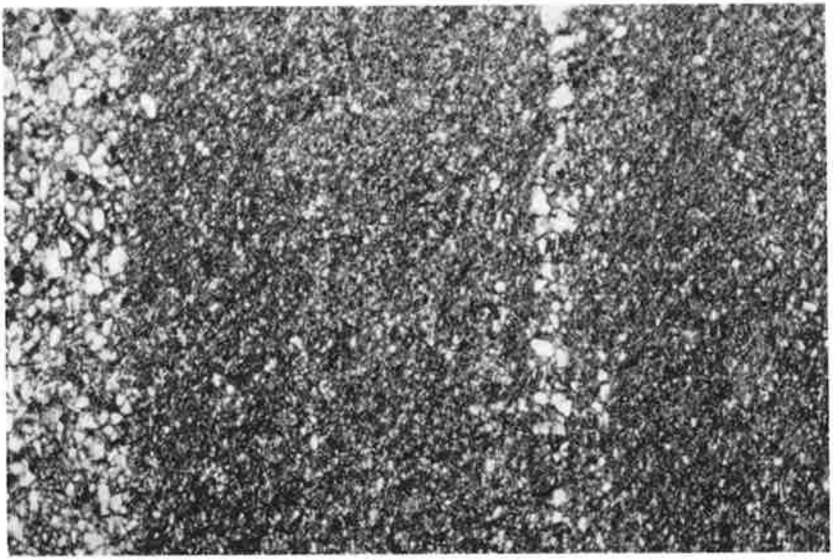

Fig. 6. Laminated siltstone. Note the cleavage trend visible in the silty laminae. Stangenes Formation. South of Buevannet, specimen F-187. Plane polarized light, × 33,5.

in this profile as units No.: 3, 4 and 5. In the Tananes section (Føyn, 1937) bed "e" was named the "Stangenes shale"; the Stangenes Formation of the present authors also embraces beds "f" and "g" of Føyn (see Table 1).

Type area: The area extending east from the eastern shores of Tanafjord between Trollfjord, Leirpollen and Gednjevannet (Pl. I).

Thickness: 255 m in the type profile; in the Tananes section (Føyn, 1937) - 205 m (beds "e", "f" and "g").

Lithology: The Stangenes Formation consists essentially of siltstones, mudstones and shales (or slates). These rocks are usually dark grey and display reddish, greenish, or rusty brown colours on weathered surfaces. Red and green banding within the mudstones is prominent in some localities, especially in the type locality at Stangenes. Fine graded bedding and lamination are frequently observed (Fig. 6). The laminae are 1 - 5 mm thick, and some are discontinuous and somewhat lenticular. Clayey laminae are dark grey and usually become reddish on weathering; sandy laminae are grey or light grey, turning greenish grey on disintegrating surfaces. In many localities closely spaced cleavage planes are present inclined at some angle to the bedding planes, as pointed out previously by Føyn (1937). Quartz and flaky minerals, mainly chlorite, are principal constituents of these rocks, and iron-oxides are also common.

Boundaries: (a) The lower boundary is fixed above the compact homogeneous sandstone of the Grønnes Formation (unit No. 2 in the type profile). (b) The upper boundary is drawn below a light quartzitic sandstone (unit No. 6 in the Vagge profile) belonging to the overlying Dakkovarre Formation; (see description of the type profile, Table 1, and Pl. V).

Mappability: Topographically, the Stangenes Formation underlies relatively wide, elongated depressions or flat areas covered with a scree of rusty brown shales; the formation may also be recognized on the mountain slopes as bands of shaly talus of brown, green, red and yellow coloration.

Extension: The Stangenes Formation can be traced south-eastwards from the Trollfjord, Lille Leirpollen and Gednjevannet area although its continuity is interrupted several times by tectonic disturbances along the Trollfjord —Komagelv thrust-fault; the formation reappears on the northern side of Varangerfjord (Røe, 1970).

Dakkovarre Formation

Name of the formation: Dakkovarre is a 528 m high mountain situated east of Tanafjord between the Storelven valley and Trollfjord (Pl. I). The Dakkovarre Formation crosses the Dakkovarre mountain in a SW-NE direction and is excellently exposed between Dakkovarre and Storelvfjell, and on the southern slope of the latter mountain (see Fig. 7, D). The name Dakkovarre has not previously been used in the geological nomenclature.

Type profile: The Vagge Profile; units No.s 6 - 39 of this profile and beds "h" to "n" of the Tananes section belong to the Dakkovarre Formation.

Type area: The area extending east of Tanafjord between Trollfjord, Leirpollen and Gednjevannet.

Thickness: 350 m in the type profile, 273 m in the Tananes section, variable in other sections.

Lithology: The Dakkovarre Formation is heterogeneous, including feldspathic, quartzitic and ferruginous sandstones (occasionally containing some glauconite grains) interbedded with arenaceous and argillaceous shales. Colours of the sandstone are light grey, brownish-grey, red-violet, and often a mottled rusty. The shales are grey, brownish grey or yellowish grey. Sandstone is the prevalent lithology in the Dakkovarre Formation (ca. 60 % in the type profile) though it is mostly concentrated in the lower and upper parts of the formation; the central part consists of an interbedded sandstone-shale assemblage with the sandstone and shale occurring in equal

Fig. 7. Southern slopes of Storelvfjell and Dakkovarre mountains on the Tanafjord east side, north-east of Lille Molvik. A — interbedded layers of grey sandstones, grey and variegated arenaceous shales and some conglomerates. B — Grønnes Formation: C — Stangenes Formation; D — Dakkovarle Formation (Da — Quartzitic sandstone member, Db — Ferruginous sandstone member): E — Gamasfjell Foormation. (Photo St. Siedlecki)

amounts. Two informal members have been differentiated within the Dakkovarre Formation:

1) The quartzitic sandstone member, is a homogeneous unit 60 - 80 m thick and constitutes the lowermost lithology of the Dakkovarre Formation, its boundaries being well marked by the adjacent shales. It consists essentially of a light grey, whitish, yellowish or pinkish coloured quartzitic sandstone containing feildspar grains (Fig. 8). This highly-resistant, light-coloured, lithologic unit often forms prominent, white, vegetation-free ridges, similar to those represented by the sandstone and conglomerate of the Grønnes Formation. These two principal ridges are separated by the depression developed in the easily disintegrating rocks of the Stangenes Formation, and are most useful features in regional geological mapping.

2) The ferruginous sandstone member appears in the upper part of the Dakkovarre Formation and consists of sandstone (ca. 55 %) and shale (ca. 45 %). Ferruginous, mostly haematite-stained*) red-violet sandstone (Fig. 9) is a prominent lithology

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*) Chemical analyses show that these sandstone contain about 4 - 7 % Fe_2O_3 and less than 1% of FeO.

Fig. 8. Quartzitic sandstone with sericitized feldspar. Dakkovarre Formation, Quartzitic sandstone member. Between Buevannet and Gednjevannet, specimen F-184. Crossed nicols, × 53,5.

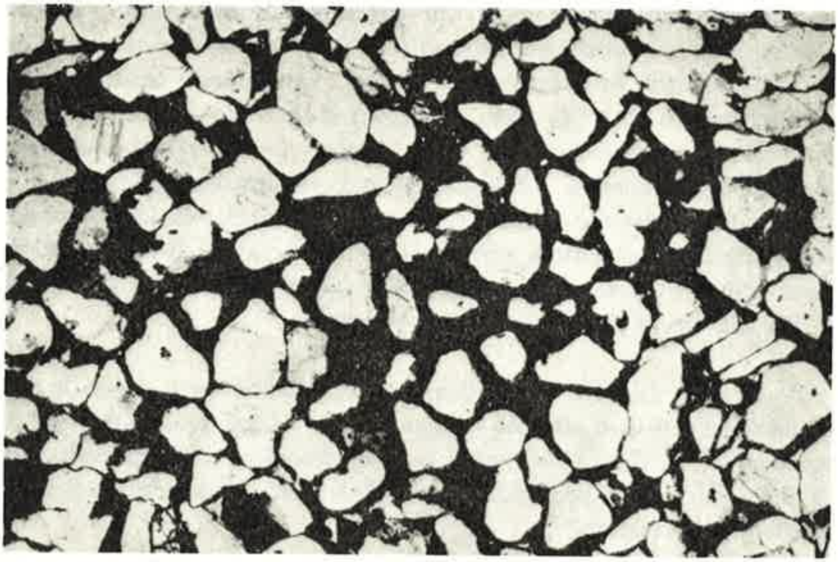

Fig. 9. Ferruginous sandstone. Dakkovarre Formation, Ferruginous sandstone member. Gamasfjell, lowermost part of the N limb of the Gamasfjell anticline, ca. 2,5 m above sea-level; specimen F-109c. Plane polarized light, × 31,2.

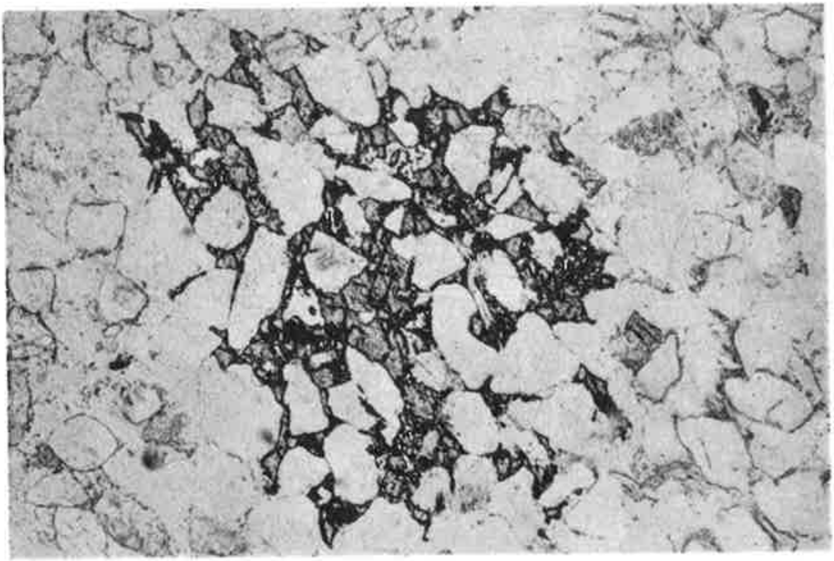

Fig. 10. Grey feldspathic sandstone with rusty spots consisting of ferruginous carbonates and iron-oxides. Dakkovarre Formation, Vagge Profile, bed. no. 12, specimen V-14. Plane polarized light, × 53,5.

in this unit and unique within the entire Tanafjord Group. The strong coloration of this sandstone makes it easily recognizable in the field, even in areas covered by weathering products. Ferruginous sandstone layers are interbedded with (1) grey, arenaceous shale, and (2) grey, feldspathic or quartzitic sandstone which often displays brown spots consisting of ferruginous carbonates (? siderite) and iron-oxides (Fig. 10). The ferruginous sandstone member is about 130 m thick, its lower boundary being fixed at the bottom surface of the lowermost red-violet sandstone layer (No. 21 in the type profile). The upper boundary of this member is also the top of the Dakkovarre Formation.

Boundaries: (a) The lower boundary is placed between the shale of the Stangenes Formation and the bottom surface of the "quartzitic sandstone member". (b) The upper boundary is drawn along the top surface of a ca. 10 m-thick shale bed underlying a pink quartzitic sandstone belonging to the next formation.

Mappability: The members of this formation are easily recognized in the field on account of their topographical or coloration features (see the lithological description above).

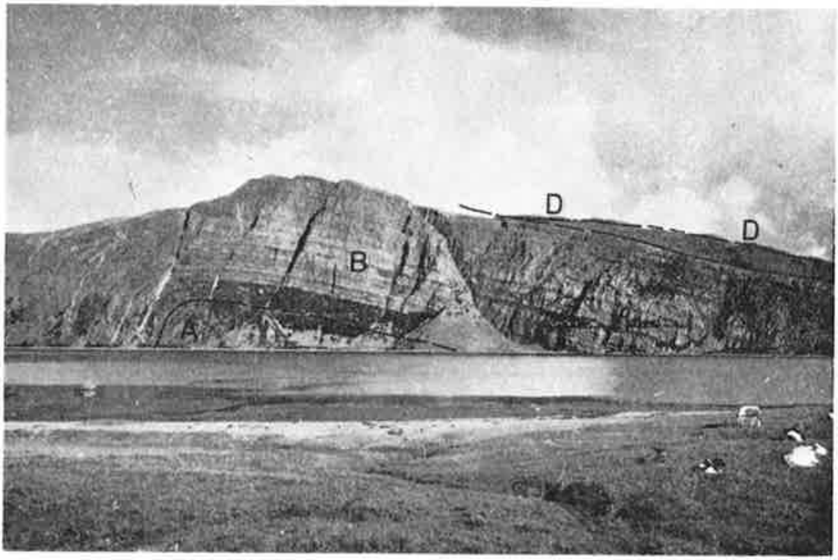

Fig. 11. Gamasfjell anticline, between Leirpollen and Lille Leirpollen, eastern side of the Tanafjord. A — Dakkovarre Formation (uppermost part); B — Gamasfjell Formation; C — Vagge Formation; D — Hanglečærro Formation (lowermost part).
(Photo St. Siedlecki)

Extension: Outside the type area this formation appears in the central and south-eastern parts of the Varanger Peninsula, especially in the Ragnarokk anticline (Pl. III).

Gamasfjell Formation

Name of the formation: Gamasfjell is a 445 m high mountain situated between Leirpollen and Lille Leirpollen (Pl. I) and built up mainly of rocks of the Gamasfjell Formation. Pink quartzitic beds of this unit are there deformed in an asymmetrical anticline and are prominently exposed on the steep western slope of Gamasfjell (Fig. 11). This formation was referred to as the "Gamasfjeldets sandstensserie" by Holtedahl (1918, p. 178).

Type profile: The Vagge Profile; unit No. 40 of this profile constitutes the Gamasfjell Formation. In the Tananes section this formation embraces beds "o" and "p" described by Føyn (1937) as "light-coloured somewhat reddish quartzitic sandstone".

Type-area: The area between Trollfjorden, Leirpollen and Gednjevannet. Extensive exposures of this formation may also be observed in the neigh-

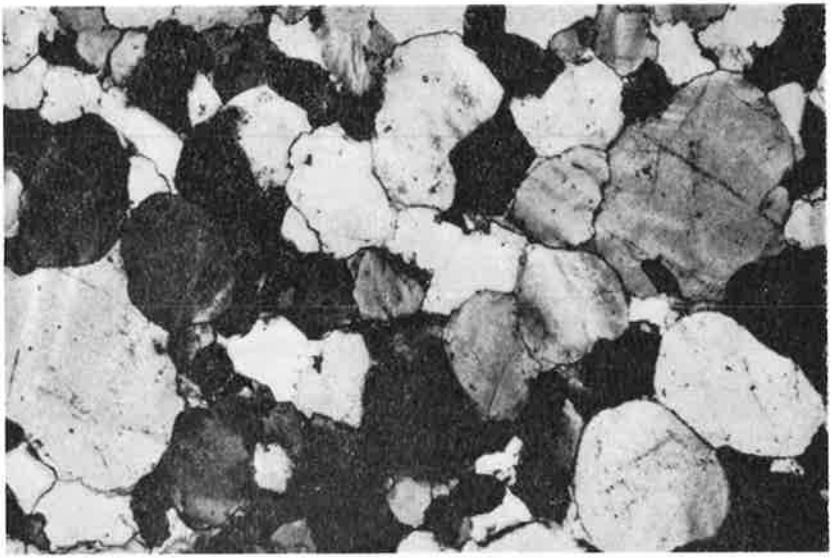

Fig. 12. Quartzitic sandstone. Note well rounded quartz grains. Gamasfjell Formation, Trollfjorddalen, specimen F-137. Crossed nicols, × 31,2.

bourhood of the Ragnarokk anticline (Skibskjølen, Kjøltindene) and in Grythaugen, Skallelvskaret and Falkefjellet.

Thickness: 280 m in the type profile, 300 m in the Tananes section. The thickness of this formation is quite constant throughout the investigated areas.

Lithology: This homogeneous unit consists of pink and reddish quartzitic sandstone and quartzite containing an admixture of feldspar grains. Cross-bedding is a common feature of these rocks, which are generally thick-bedded. Quartz grains (from ca. 0,1 to more than 1 mm in diameter) are usually exceptionally well rounded and cemented by secondary over-growths; a few interstitial voids are filled with sericite. The quartz grains are also frequently covered with a film of iron-oxides, mostly haematite, which is responsible for the pink and red staining of the quartzite and quartzitic sandstone (Figs. 12, 13). The pink and reddish layers may occur alternately, so producing the characteristic banding of parts of the formation. Often cross-bedding is emphasized by the concentrations of iron-oxides and then a "cross-banding" may by observed. The amount of iron-oxides present decreases towards the top of the formation; consequently the reddish and red-violet colours, typical of the lower part of the formation, are gradually replaced upwards by a pink or pink-white coloration.

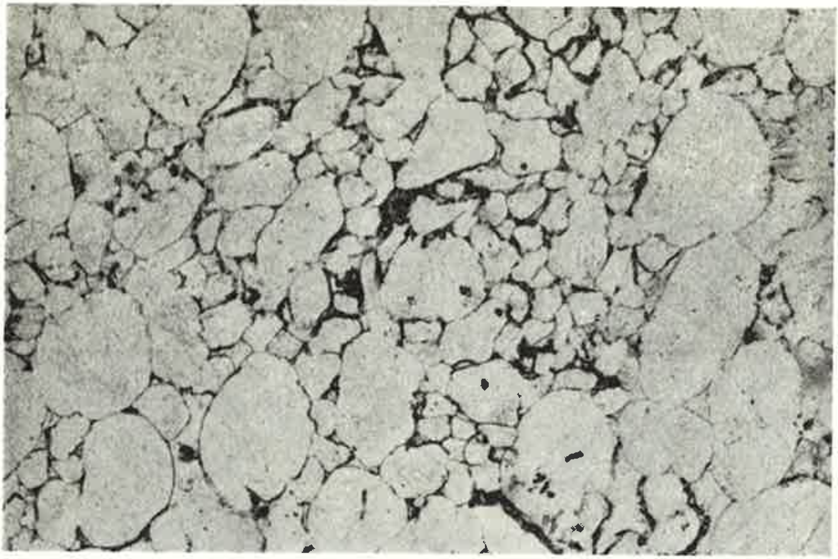

Fig. 13. Pink quartzitic sandstone stained with haematite. Gamasfjell Formation. SW side of the Komagelvdalen, specimen F-68/13. Plane polarized light, × 33,5.

Generally, these light colours are characteristic of the Gamasfjell Formation.

Boundaries: The boundaries of this formation have been fixed at the shale beds which appear immediately below and above the homogeneous assemblage of pink quartzitic rocks. These natural lithological boundaries are easily recognizable in outcrops, sections and topography. The Gamasfjell Formation is underlain by a ca. 10 m thick shale constituting the top of the Dakkovarre Formation and overlain by a shale of the Vagge Formation.

Mappability: This thick, homogeneous formation is easy to recognize in the field,; it forms culminations, mountain ridges and wide, relatively flat elevated areas (see Fig. 14) covered with angular blocks of pink and red-violet banded quartzitic sandstone. Areas underlain by the Gamasfjell Formation are usually nearly devoid of vegetation.

Extension: This is one of the most extensively exposed formations of the entire Tanafjord Group cropping out widely in the type area as well as in the central and south-eastern parts of the Tanafjord—Varangerfjord region of Varanger Peninsula.

Vagge Formation

Name of the formation: Vagge is a locality on the eastern shore of Tanafjord between Stangenes and Lavvonjarrga, at the mouth of the Vagge

Fig. 14. Flat-lying thick beds of quartzitic sandstone of the Gamasfjell Formation. Grythaugen, inner part of the Varanger Peninsula. (Photo St. Siedlecki)

river (Vaggeelven). This name was introduced into the geological nomenclature by Føyn (1937) who differentiated "Vagge shale" and "Vagge quartzite", both of which appear at that locality. The Vagge Formation of Bjørlykke et al. (1967) embraced Føyn's (1937) Vagge shale and Vagge quartzite, these being regarded as two members: 1) the lower shale member and 2) the upper quartzite member. The present authors have raised both these lithological units to the rank of formation, the Vagge shale (= lower shale member) now being known as the Vagge Formation.

Type-profile: The Vagge Profile; units No.s 41, 42 and 43 of this profile (see p. 256) constitute the Vagge Formation. Føyn's (1937) "Vagge shale" embraced "dark-coloured slaty sandstones and arenaceous shales" constituting the uppermost "q" bed in the Tananes section.

Type-area: The area between Leirpollen, Trollfjorden and Gednjevannet.

Thickness: 82,20 m in the type-profile. Føyn (1937, p. 72) estimated the thickness at this same locality as being about 80 m.

Lithology: This formation consists of dark grey and brown arenaceous shales, thin beds of dark grey siltstones and fine-grained thin-bedded sandstones. These rocks often display a rusty colour on disintegrating. Lamination is a common feature of the sandstones and siltstones, and structures resembling organic trails have also been recorded. Mud cracks are frequently

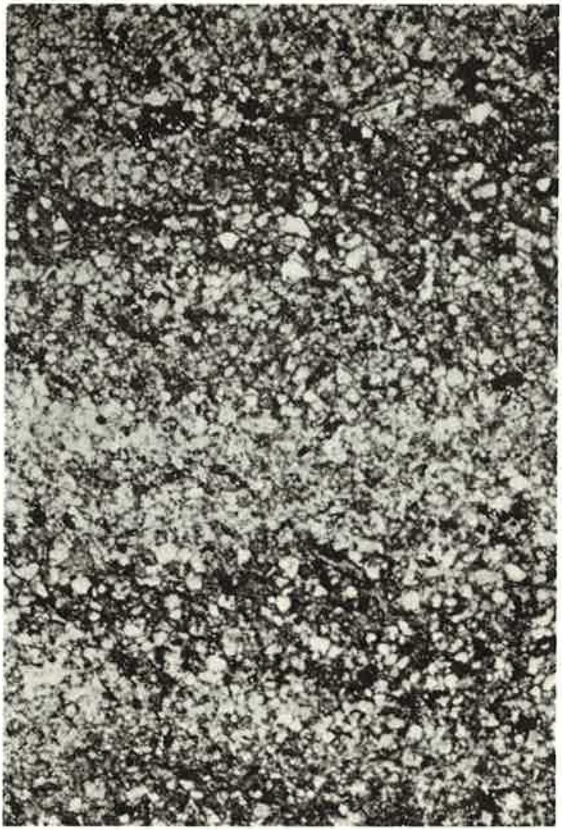

Fig. 15. Arenaceous shale with rusty bands of iron-oxides. Vagge Formation, Vagge Profile, bed no. 41, specimen V-1c. Plane polarized light, × 33,5.

observed, their sand infillings often penetrating into the laminated layers; these infillings are usually curved and curled so providing evidence of subsequent compaction.

Shales consist mainly of terrigenous quartz dust, a few feldspar grains (plagioclase, microcline), sericite and an irresolvable mixture of authigenic silica and clay minerals (Fig. 15). Iron-oxides produce the rusty staining in this rocks. Black laminae which appear in these dark grey or brownish grey shales are found to be rich in carbonaceous matter.

Fine-grained sandstone (0,05 - 0,15 mm) and siltstone consist of closely packed quartz grains cemented by thin and incomplete rim overgrowths of quartz. A few relatively fresh grains of plagioclase have been observed. The sandstone and siltstone often exhibit rusty brown spots which are found to consist of iron-oxides and ferruginous carbonates (Fig. 16). Sometimes these iron-bearing minerals are arranged in laminae. A pale

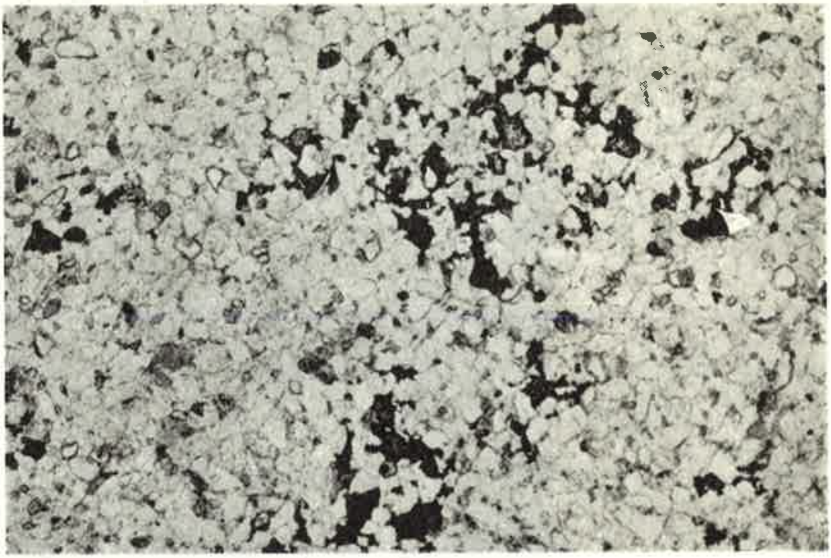

Fig. 16. Fine-grained sandstone. Iron-oxides and ferruginous carbonates are present which stain the sandstone rusty-brown. Vagge Formation. North of Lille Molvik, specimen F-214. Plane polarized light, × 33,5.

green (?) glauconite has occasionally been observed, usually being corroded by carbonates.

Boundaries: Boundaries of the Vagge Formation are natural and very distinct; the lower boundary is marked by the appearance of grey fine-grained shaly sandstone above a pink-quartzitic sandstone of the Gamasfjell Formation. The upper boundary is established below a white quartzite bed typical of the succeeding Hanglečærro Formation.

Mappability: The Vagge Formation is usually represented topographically by an elongated depression covered with brownish shaly talus and bordered by ridges comprising the relatively resistant lithologies of the Gamasfjell and Hanglečærro Formations (Fig. 17). Although this pattern of exposure is somewhat similar to that shown by the Grønnes, Stangenes and lower part of the Dakkovarre Formations (see p. 272), the lithologies of the Hanglečærro and Gamasfjell Formations are unique and the thickness of the latter formation is considerably greater than that of any other lithology in the entire Tanafjord Group. Moreover, shales of the Stangenes Formation are usually more or less variegated, in green and red colours, a feature which is never observed in the Vagge Formation.

Extension: The Vagge Formation crops out in the area between Leir-

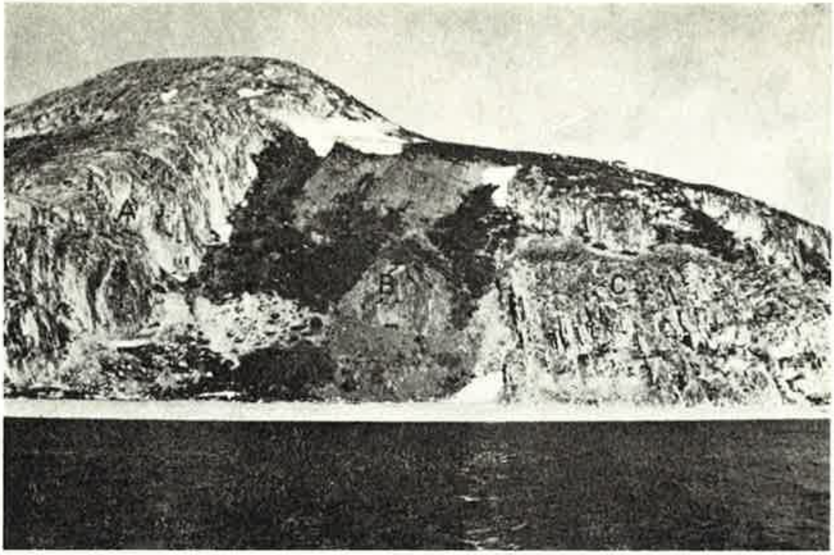

Fig. 17. Tanafjord, eastern side. Northern limb of the Vagge syncline. A — Gamasfjell Formation; B — Vagge Formation; C — Hanglečærro Formation.
(Photo St. Siedlecki)

pollen, Trollfjorden and Gednjevannet (Pl. I) and in the south-eastern and western periphery of the Ragnarokk anticline (Pl. III).

Hanglečærro Formation

Name of the formation: This unit was observed by Føyn (1937) at Vagge and named "Vagge quartzite". The present authors suggest that the name "Hanglečærro" should replace "Vagge" in order to avoid confusion with the Vagge Formation which is essentially Føyn's (1937) shale. Besides, Hanglečærro, a 618 m high mountain situated in the southern part of the area between Leirpollen, Trollfjorden and Gednjevannet (Pl. I), is an excellent locality for this formation, the southern slopes being devoid of vegetation and scree and consisting of nothing but layers of quartzite of the Hanglečærro Formation (Fig. 18).

Type-profile: The Vagge Profile, unit No. 44 of this profile (see p. 256-257) constitutes the Hanglečærro Formation.

Type-area: The area between Leirpollen, Trollfjord and Gednjevannet.

Thickness: 150-200 m in the type area.

Lithology: The Hanglečærro Formation consists of white or light grey quartzite and quartzitic sandstone usually in ca. 0,2 - 1,0 m-thick layers.

Fig. 18. Southern slope of the Hanglečærro mountain. A — white quartzite beds of the Hanglečærro Formation. B — blue-green shale and red quartzitic sandstone members of the Stapogiedde Formation. (Photo St. Siedlecki)

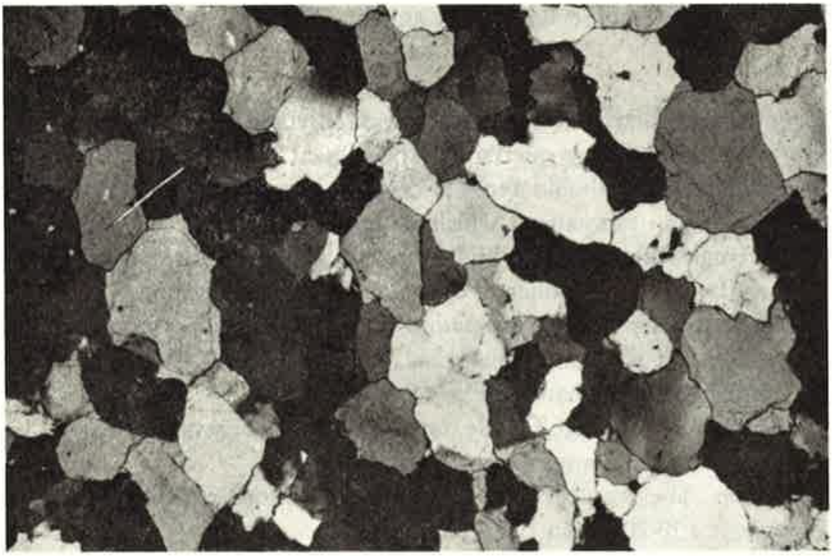

Fig. 19. Quartzite. Hanglečærro Formation, lower part. Southern slope of Hanglečærro, specimen I. Crossed nicols, × 33,5.

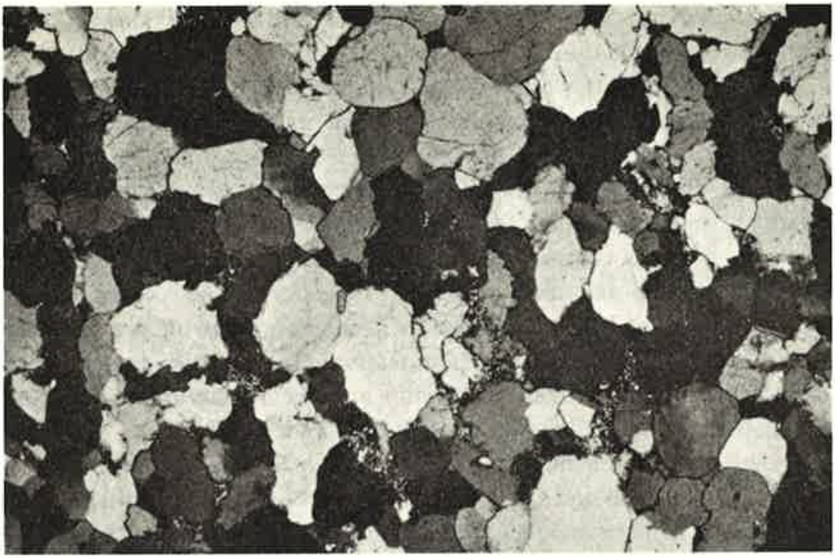

Fig. 20. Quartzitic sandstone with some sericite (altered feldspar), Hanglečærro Formation. Southern slope of Hanglečærro, specimen IX. Crossed nicols, × 33,5.

Dark grey and black quartzite, stained with carbonaceous matter, constitutes a subordinate lithology in this formation. The quartzites are mostly massive and some layers exhibite cross-bedding. Ripple marks are also occasionally present. Closely packed and relatively well rounded quartz grains are usually easy to distinguish because of the presence of hydromicas coating the terrigenous grains (Fig. 19). Iron-oxides and sericitized feldspars occur only rarely, and then in small amounts, in some impurer varieties of the quartzitic sandstones (Fig. 20). Generally however, quartzitic rocks of the Hanglečærro Formation are exceptionally clean consisting of 98-99 % SiO_2. This high percentage of silica, the white colour and homogeneity are the characteristic features of rocks of this formation.

Boundaries: The lower boundary of this formation is marked by the distinct change in lithology from grey shaly beds of the Vagge Formation to the white massive quartzitic beds of the Hanglečærro Formation. The upper boundary is transitional; white quartzitic sandstones grades into grey sandstone and then into grey arenaceous shale exhibiting a wavy parting. This arenaceous shale is considered as the lowermost lithology of the overlying Grasdal Formation. The latter formation, however, has suffered from denudation and erosion and in many places has been completely removed, such that the erosional surface cuts down into the Hanglečærro Formation.

Mappability: This white, massive lithology of quite constant thickness is usually very conspicuous in the field. It is underlain by the easily disintegrating shaly rocks of the Vagge Formation and, because of the restricted occurrence of the Grasdal Formation, is usually overlain by relatively soft and darker coloured lithologies of the Vestertana Group. There is a sharp contrast in landscape between areas underlain by the Tanafjord Group and those consisting of rocks of the Vestertana Group (see e.g. Fig. 18). The Hanglečærro Formation constitutes a geomorphological boundary between bare mountains consisting of the largely resistant formations of the Tanafjord Group and the vegetation-covered gently undulating hills underlain by the Vestertana Group.

Extension: This formation occurs extensively in the area between Leirpollen, Trollfjorden and Gednjevannet. To the south and south-east of this area it was in part removed by a pre-Eocambrian erosion and in part is covered by beds of the Vestertana Group.

Grasdal Formation

Name of the formation: Grasdal is a locality on the eastern side of Tanafjord (Pl. I) where Holtedahl (1918), and later Føyn (1937), observed and described the carbonate-bearing lithologies which we now refer to as the Grasdal Formation.

Type-profiles: The Trollfjord and Grasdal Profiles (see p. 257).

Type area and extension: The area ca. 2-5 km south of Trollfjord is the only area in the entire Tanafjord—Varangerfjord region where this formation appears.

Thickness: The thickness of this formation may tentatively be estimated at about 100 m. Poor outcrops and the erosional character of the upper surface of this formation precluded and accurate measurement of thickness.

Lithology: This formation is heterogenous consisting of terrigenous and carbonate-bearing rocks, the latter being an exceptional lithology in the Tanafjord Group. Fine-grained, grey and rusty sandstone and siltstone appearing in the lower part of the Grasdal Formation contain feldspar grains and muscovite flakes and are cemented mainly by clay minerals. In some parts of the sandstones minute shale clasts are present. Overlying variegated marly and arenaceous shale often exhibits indications of gliding of sediment, the argillaceous laminae being truncated and interrupted and their fragments incorporated into the arenaceous part of the deposit

Fig. 21. Shale, arenaceous and marly. Note disturbed and broken marly laminae within the arenaceous sediment. Grasdal Formation, Trollfjord Profile, specimen F-129. Plane polarized light, × 33,5.

(Fig. 21). In addition, some beds of pelitic marlstone usually exhibiting a fine lamination have been recorded. This assemblage of beds is overlain by grey dolomitic lithocalcarenite and intraformational conglomerate which constitute the most prominent lithologies of this particular formation. The intraformational conglomerate consists of fragments of a pelitic carbonate rock. The fragments are usually rounded, angular particles being subordinate. The conglomerate is poorly sorted, the clasts varying from sand-sized grains to pebbles about 4 cm across. Lateral and vertical transitions from the intraformational conglomerate into a quite well sorted calcarenite can be demonstrated. The dolomitic calcarenite consists dominantly of well rounded and closely packed ellipsoidal fragments of pelitic carbonate rock. Fragments of oolitic carbonate rock as well as individual ooliths are also present (Figs. 22, 23). Stromatolites, often columnar, were recorded in several places in this unit. Dark gray flint layers and segregations observed

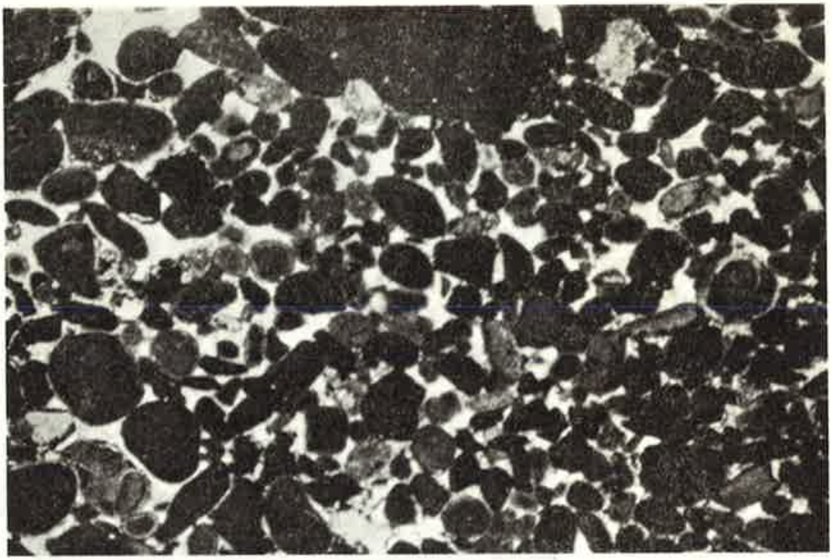

Fig. 22. Lithocalcarenite, dolomitic. Grasdal Formation. North of Grasdalen, specimen F-16. Plane polarized light, × 12,5.

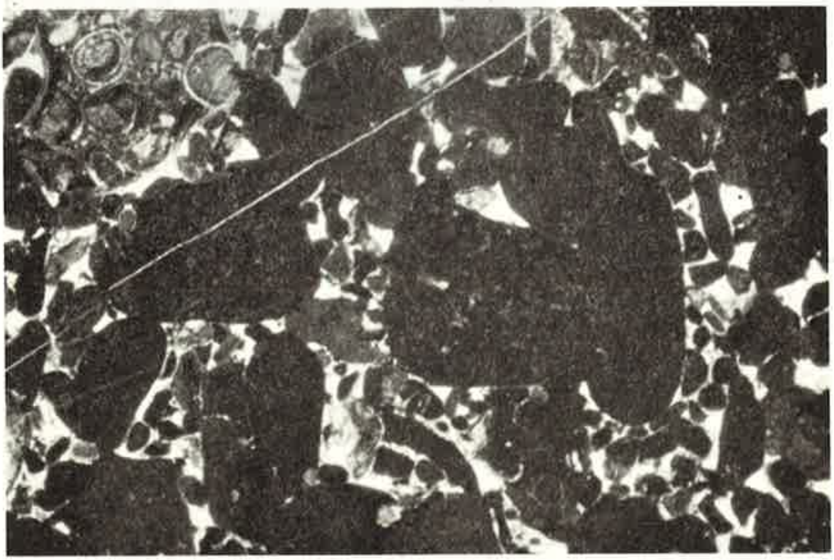

Fig. 23. Lithocalcarenite, dolomitic. Note the clast of oolitic limestone. Grasdal Formation, N of Grasdalen, specimen F-128. Plane polarized light, × 12,5.

Fig. 24. Tanafjord, eastern side, ca. 0,5 km north of Grasdalen. Interbedding of thin light-grey and yellowish layers of carbonate rock and dark-grey shale, Grasdal Formation (upper part).
(Photo St. Siedlecki)

in these carbonate rocks are well outlined, the concentrations growing across the clasts and cement of the calcarenites and conglomerates. Their origin seems to be connected with a late stage of diagenesis.

In the section near Grasdal the intraformational conglomerate and lithocalcarenite grade upwards into grey shale and mudstone with thin interbedding of yellow homogeneous dolomite (Fig. 24). These last-mentioned lithologies have also been observed in an isolated outcrop on the southern shore of inner Trollfjord.

Boundaries: The lower boundary of this formation is well marked by the appearance of a white quartzitic sandstone of the subjacent Hanglečærro Formation. The upper boundary is erosional (see p. 266 — remarks on the upper boundary of the Tanafjord Group).

Mappability: The grey calcarenite and intraformational conglomerate become white on weathering and being as they are unique lithologies in the Tanafjord Group are easy to identify. Other lithologies of this formation, however, unless they are accompanied by the above-mentioned carbonate rocks, may be difficult to recognize.

NOTES ON TECTONIC STRUCTURES

In the chapter with the description of the Tanafjord Group sucession, the topographical characteristics of each formation were noted and it was at once apparent that a pattern of alternating ridges and depressions characterizes the greater part of the Trollfjorden — Leirpollen — Gednjevannet area. To a large extent the topographical pattern is a reflection of the principal tectonic structures, anticlines usually forming a row of hills and synclinal cores occupying the main depressions. The existence of faults has also determined the development of some valleys, for example the Trollfjorden valley and its south-eastward continuation.

Several geological profiles drawn across the area are shown on Pl. II and IV and serve to illustrate the general style of folding in this region. On the mesoscopic scale, folds are found to be of parallel flexural-slip type. Most are asymmetrical, a feature also demonstrable on the macroscopic scale; some larger-scale folds are, however, reasonably symmetrical and almost semi-circular in cross-section (e.g. the anticlines of Lille Leirpollfjell Østre and Hanglečærro). Axial planes of the asymmetrical folds are invariably inclined steeply to the north-west, the only major exception appearing to be that of the Gamasfjell anticline (Fig. 11 and Pl. II, section A-B) which develops a steep south-easterly dip possibly due to its proximity to the major reverse fault in Lille Leirpollen.

Most folds plunge gently towards the south-west, a feature already reported by Rosendahl (1954, p. 332). This can be recognized from the outcrop patterns on the map (Pl. I), e.g. the Lille Leirpollen syncline and Vagge syncline which both plunge at about 3° to the south-west. Towards the north-east amplitudes of almost all major folds in this Trollfjord—Leirpollen—Gednjevannet area decrease with limbs appearing to flatten out, the belt of folds passing gradually into a zone of regional SW dip. Faults, which are quite abundant in the west, also die out towards the north-east with the exception of the NW-SE trending Trollfjord—Komagelv fault system.

Although a detailed tectonic study has not been attempted in this Trollfjord—Leirpollen—Gednjevannet area, an examination of the maps has revealed four main tectonic directions or trends. These embrace both fold

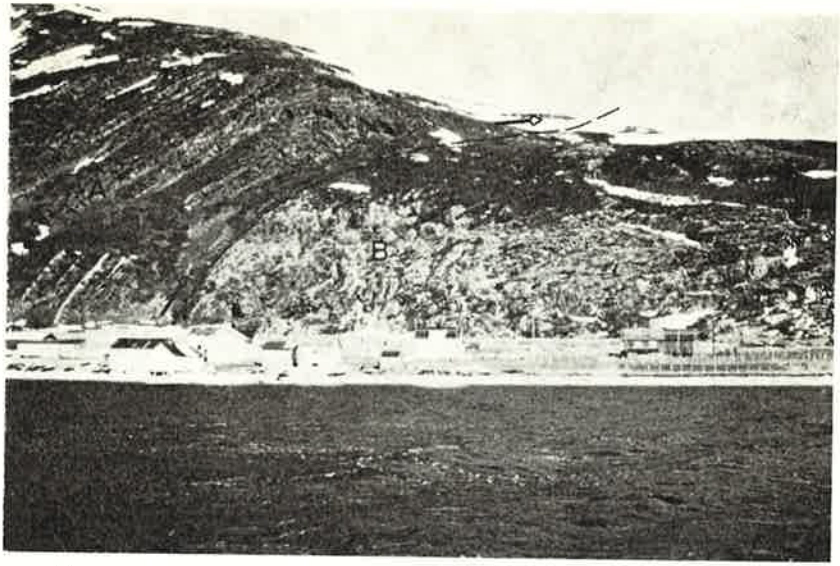

Fig. 25. Tanafjord, east side, Lavvonjarrga. Ferruginous sandstone and grey shale of the Dakkovarre Formation (A) thrust above white quartzite beds of the Hanglečærro Formation (B). Arrows indicate direction of overthrusting. (Photo St. Siedlecki)

and fault trends, and no time significance is attached to this division of the tectonic elements.

I The 055° trend. Most of the macroscopic and mesoscopic folds in the area display this approximate NE-SW axial orientation. Of the various structural elements present, this trend is thought to be the earliest. Some faults also share this direction, e.g., the fault on the southern limb of the Lille Leirpollen syncline, as do the high angle thrust-faults in the vicinity of Lavvonjargga (Fig. 25). These faults, however, appear to post-date the development of the 055° folds.

II The 030-035° trend. The axis of the anticline on the 589 m mountain north-east of Stangenes is aligned in this direction, and some faults south of Gamasfjell also show this trend. Although the 030°-035° trend is only locally developed within the map-area, it is of importance in the neighbouring Vestertana area where several fold axes and a thrust-fault follow this direction.

III The 080°—085° trend. This is represented by certain high-angle thrust-faults at Lille Molvik (Fig. 26) and just north of Dakkovarre, and

Fig. 26. Tanafjord, east side. Coastal section starting immediately south of the Lille Molvik valley. A — tectonically strongly disturbed beds of the Dakkovarre and (in part) Stangenes Formations thrust above B — pink and reddish quartzitic sandstone of the Gamasfjell Formation. Arrows indicate direction of overthrusting. (Photo St. Siedlecki).

also by faults and minor folds south of the Hanglečærro anticline which itself displays this near east-west trend. At Lille Molvik the 085° faults clearly post-date the 030° and 055° folds.

At this juncture it should be pointed out that although folds and faults following the above three trends can easily be recognized in the field, no evidence of fold superposition has been observed. Indeed, many folds can be seen to pass gradually from one axial trend to another such that they could be regarded as belonging to one period of Caledonian movements. Faults transect the folds, but since they are closely associated with the fold trends they may be looked upon as late expressions of this same deformation episode.

IV The 130° trend. This fourth main structural trend is represented by the Trollfjord—Komagelv fault system, the principal thrust plane of which can be traced across Varanger Peninsula from Trollfjorden to the mouth of Komagelven (Fig. 1; see also Siedlecka and Siedlecki, 1967). In the present area, folds of the 030°, 055° and 085° axial trends are clearly deformed in the vicinity of the thrust front, and in some cases 'cross folds' of approximate NW-SE trend have been developed. In the hills immediately south-west of Gednjevannet an anticlinal cross-fold is present, its western limb partly inverted and even affected by local thrusting.

The several faults in the Trollfjord area belong to the same NW-SE system. Thrusting is less prominent just here: in the other hand, dextral strike-slip faulting is more in evidence. Tectonic investigations in this Trollfjord area are still at a preliminary stage and therefore no detailed discussion can be presented here.

In the area of the *Ragnarokk anticline* (Pl. III) a distinct dome-shaped structure can be recognized. This appears to have developed as a culmination at the intersection of the 055° and 130° tectonic trends; it is also deformed by the main NW-SE high-angle thrust-fault. Locally, SW-directed overturned folds have been developed in the Tanafjord Group sediments as a consequence of the thrusting (Pl. IV, section C-D). No evidence has yet been found in this Ragnarokk area of faulting normal to the Trollfjord—Komagelv thrust-fault. In a preliminary sketch-map of the Varanger Peninsula published by the authors (Siedlecka and Siedlecki, 1967), a possible 055°-trending fault was inferred as cutting the main thrust-fault. Recent investigations have shown, however, that the Trollfjord—Komagelv thrust-fault is not in fact affected by later fracturing, and would appear to be the youngest deformation feature in the tectonic picture of the Varanger Peninsula.

APPENDIX

The lecture presented by the authors at the Symposium in Cardiff, January 1970, was concerned essentially with lithostratigraphical classification of the late Precambrian "Older Sandstone Series" occurring in the Tanafjord—Varangerfjord region of Varanger Peninsula. The concluding remarks in this lecture touched upon some new observations which the writers had made in the Barents Sea region during the 1969 field-season. These observations from this latter region, together with some general conclusions concerning the geology of the entire Varanger Peninsula and comparisons with other Arctic regions, were reported in a lecture presented at the IX Nordiske Geologiske Vintermøde in Copenhagen, January 1970.

The main topic of the Cardiff lecture naturally constitutes the subject-matter of the present paper, while the new observations from the Barents Sea region are not considered. However, since the discussion which followed this lecture was mostly concerned with the latter region, it would seem expedient to add a few sentences about the new geological data from the Barents Sea region as presented in the lecture at Copenhagen.

The field investigations of 1969 have shown that:

(1) Only one "multicoloured" unit occurs in the Barents Sea Group, not two as previously supposed. In other words, the Syltefjord Formation and the Båtsfjord Formation are one and the same stratigraphical unit and for this we have preserved the name Båtsfjord Formation. Casts (pseudomorphs) of salt-crystals have been found in this formation.

(2) Feldspathic sandstones, including conglomerates, named the Makkaur Formation (Siedlecka & Siedlecki, 1967) have a tectonic contact with formations of the Barents Sea Group and are now regarded as a part of a thrust segment of the Løkvikfjell Formation (Raggo Group).

(3) The Båtsfjord Formation is overlain by a thick succession of red and pinkish-grey sandstones, the authors' Tyvjofjell Formation. This crops out only in the inner part av the Varanger Peninsula and has not previously been described by any geologist.

(4) There are some indications that the Barents Sea Group is stratigraphically overlain by the Tanafjord Group. Since these observations are from a strongly tectonically disturbed area and are of a reconnaissance nature a final opinion on this matter must await the completion of detailed investigations.

(5) There is good evidence (supporting the suggestion of Holtedahl, 1932) that the Barents Sea Group can be considered as lithostratigraphically analogous to the Eleonore Bay Group of NE Greenland.

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DISCUSSION

Dr. H. G. Reading asked the authors if they could give any indication of how the Tyvjofjell Formation in the Barents Sea Group was deposited; could it possibly be of fluvial origin? It is possible that the upper part of the Barents Sea Group lies directly below the lower part of the Tana Group. The lower part of the Tana Group shows a fluvial episode and thus on sedimentological grounds this correlation would be sounder if the Upper Barents Sea Group were fluvial.

Dr. Anna Siedlecka replied that she did not regard the Tyvjofjell Formation as being fluvial. This formation was lithologically similar to the old Båsnæring Formation, and consisted of red, pink and grey quartzitic and clayey sandstones. It seemed most likely that it was shallow marine, but more detailed observations were required from this part of the succession before a definite opinion could be voiced.

Dr. R. A. Gayer expressed interest in the Barents Sea Group and commented on the very thick (ca. 19 km) sequences of late Precambrian sediments in East Greenland (Eleonore Bay Formation) and in Spitsbergen (Hecla Hoek), and asked the authors for their opinions on possible relationships between the Barents Sea Group and these other Arctic lowermost Caledonian sequences.

Dr. Anna Siedlecka said that the authors considered it possible to correlate the Barents Sea Group and the Eleonore Bay Formation — they were quite similar, particularly in their upper parts. As yet they had not been able to compare the Barents Sea Group with the Hecla Hoek, but had on the other hand tried to compare the Barents Sea Group with similar late Precambrian successions in the Urals. Some of the sections in the Riphaean were quite similar, but it was impossible to be sure of correlation.

Dr. Stanislaw Siedlecki added that it was too early to make broad syntheses. It was possible that in Spitsbergen, particularly in central north Spitsbergen, a more eugeosynclinal facies characterized the Late Precambrian whereas in the Varanger Peninsula and on the other side in north-east Greenland there was a more mio-geosynclinal facies, and therefore it was earlier to find similarities between Varanger and East Greenland. There was no volcanic material in the Varanger succession as there was in Spitsbergen. Correlation will have to await the results of more detailed work.

Mr. J. D. Roberts also spoke.

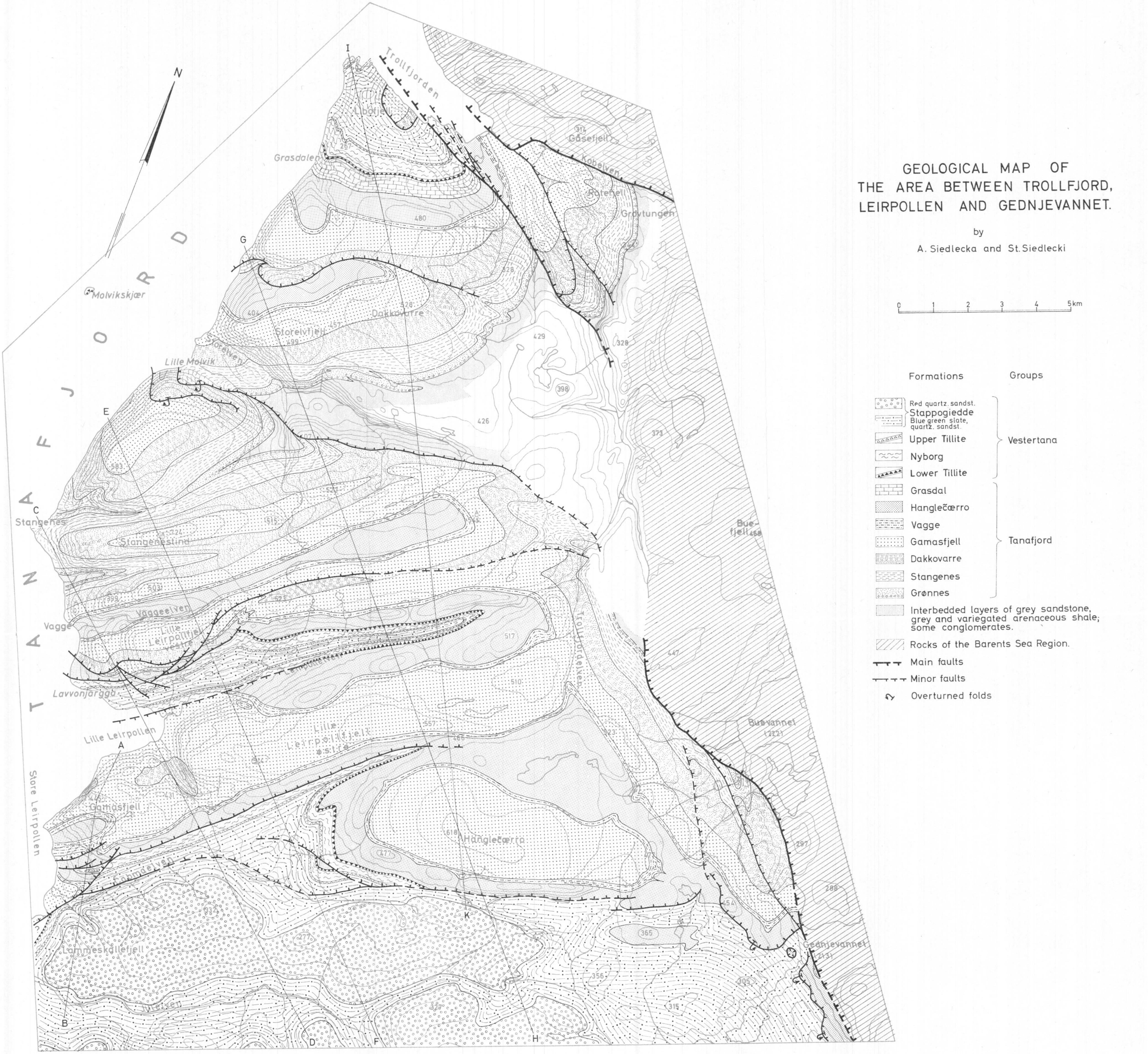
GEOLOGICAL MAP OF
THE AREA BETWEEN TROLLFJORD,
LEIRPOLLEN AND GEDNJEVANNET.
by
A. Siedlecka and St. Siedlecki
0 1 2 3 4 5km
Formations
Groups
Red quartz sandst.
Stappogiedde
Blue green slate, quartz. sandst.
Upper Tillite
Nyborg
Lower Tillite
Vestertana
Grasdal
Hanglečærro
Vagge
Gamasfjell
Dakkovarre
Stangenes
Grønnes
Tanafjord
Interbedded layers of grey sandstone, grey and variegated arenaceous shale; some conglomerates.
Rocks of the Barents Sea Region.
Main faults
Minor faults
Overturned folds
N
TANAFJORD
Molvikskjær
Trollfjorden
Gåsefjell
Kobelven
Rotefjell
Grøvtungen
Grasdalen
Dakkovarre
Storelvfjell
Storelven
Lille Molvik
Stangenes
Stangenestind
Vagge
Vaggeelven
Lille Leirpollfjell vestre
Lavvonjargga
Lille Leirpollen
Lille Leirpollfjell østre
Trollfjordelven
Buefjell
Buevannet
Store Leirpollen
Gamasfjell
Hanglečærro
Gednjevannet
Lammeskallefjell
A
B
C
D
E
F
G
H
I
K

Plate I

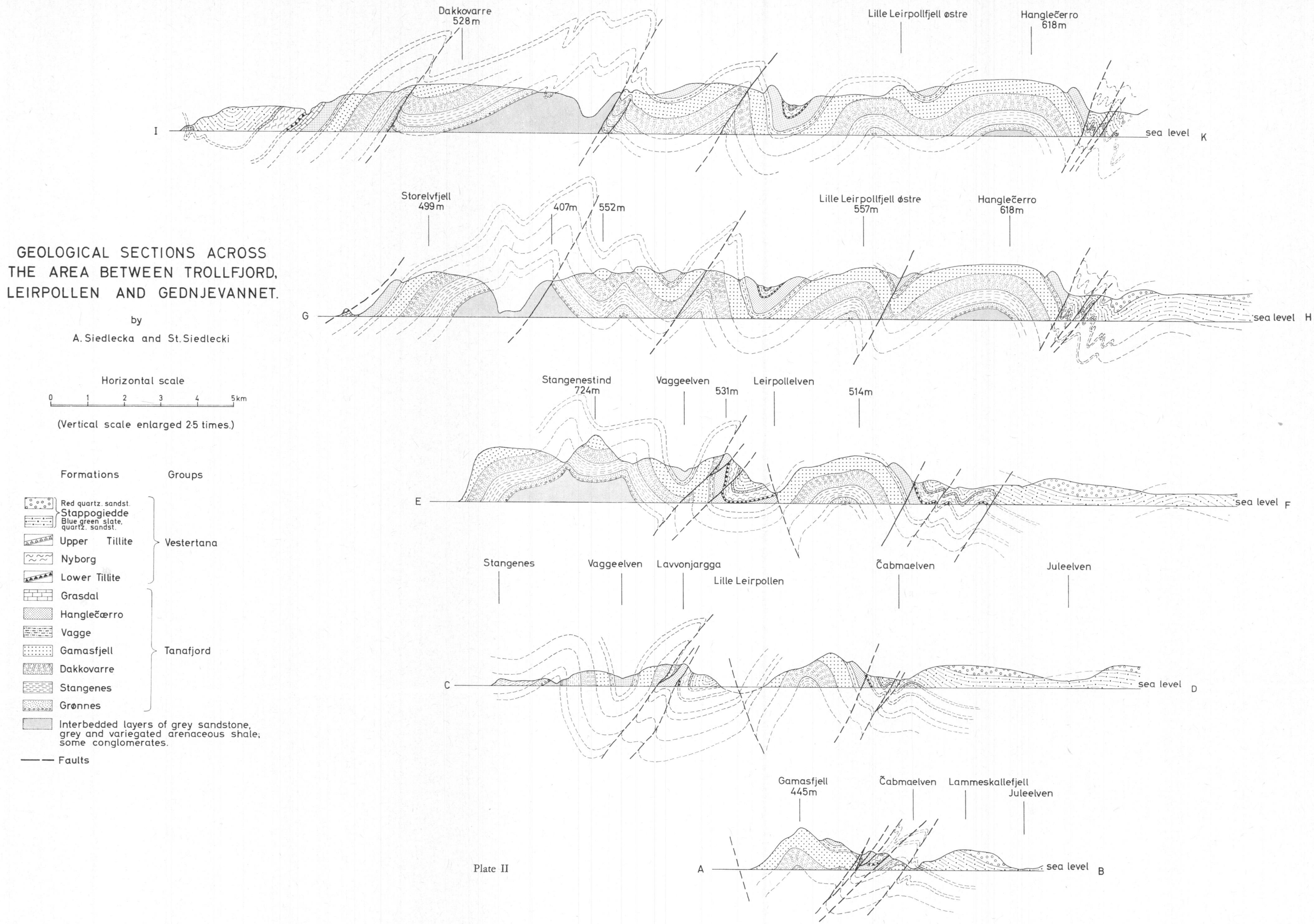
GEOLOGICAL SECTIONS ACROSS THE AREA BETWEEN TROLLFJORD, LEIRPOLLEN AND GEDNJEVANNET.
by
A. Siedlecka and St. Siedlecki
Horizontal scale
0 1 2 3 4 5km
(Vertical scale enlarged 2·5 times.)
Formations
Groups
Red quartz. sandst.
Stappogiedde
Blue green slate, quartz. sandst.
Upper Tillite
Nyborg
Lower Tillite
Vestertana
Grasdal
Hanglečærro
Vagge
Gamasfjell
Dakkovarre
Stangenes
Grønnes
Tanafjord
Interbedded layers of grey sandstone, grey and variegated arenaceous shale; some conglomerates.
Faults
Dakkovarre
528m
Lille Leirpollfjell østre
Hanglečerro
618m
I
sea level
K
Storelvfjell
499m
407m
552m
Lille Leirpollfjell østre
557m
Hanglečerro
618m
G
sea level
H
Stangenestind
724m
Vaggeelven
531m
Leirpollelven
514m
E
sea level
F
Stangenes
Vaggeelven
Lavvonjargga
Lille Leirpollen
Čabmaelven
Juleelven
C
sea level
D
Gamasfjell
445m
Čabmaelven
Lammeskallefjell
Juleelven
A
sea level
B

Plate II

GEOLOGICAL MAP OF THE „RAGNAROKK" ANTICLINE AREA.

by

A. Siedlecka and St. Siedlecki

0 1 2 3 4 5 km

Formations — **Groups**

- Stappogiedde — Vestertana
- Hanglečærro
- Vagge
- Gamasfjell
- Dakkovarre
- Stangenes
- Grønnes

(Hanglečærro – Grønnes: Tanafjord)

- Interbedded layers of grey sandstone, grey and variegated arenaceous shale; some conglomerates.
- Rocks of the Barents Sea Region.
- Main fault, Minor faults — of the Trollfjord - Komagelv thrust-fault zone.

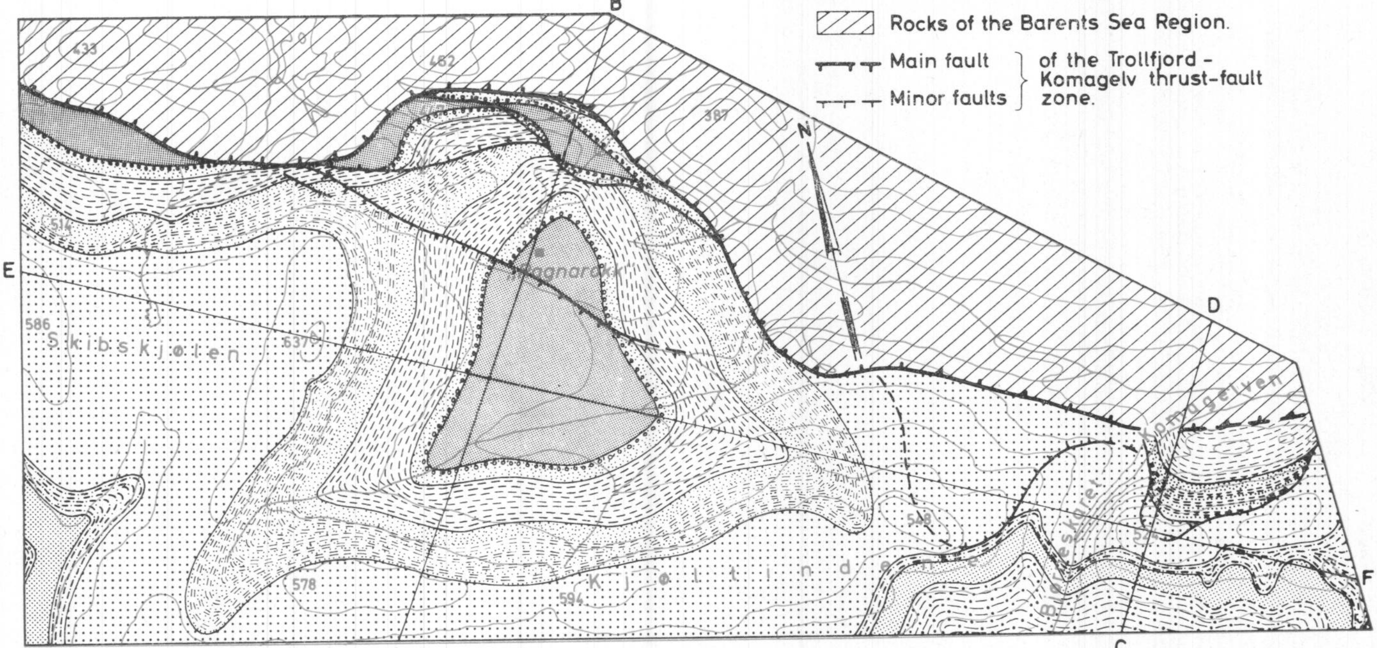

Plate III

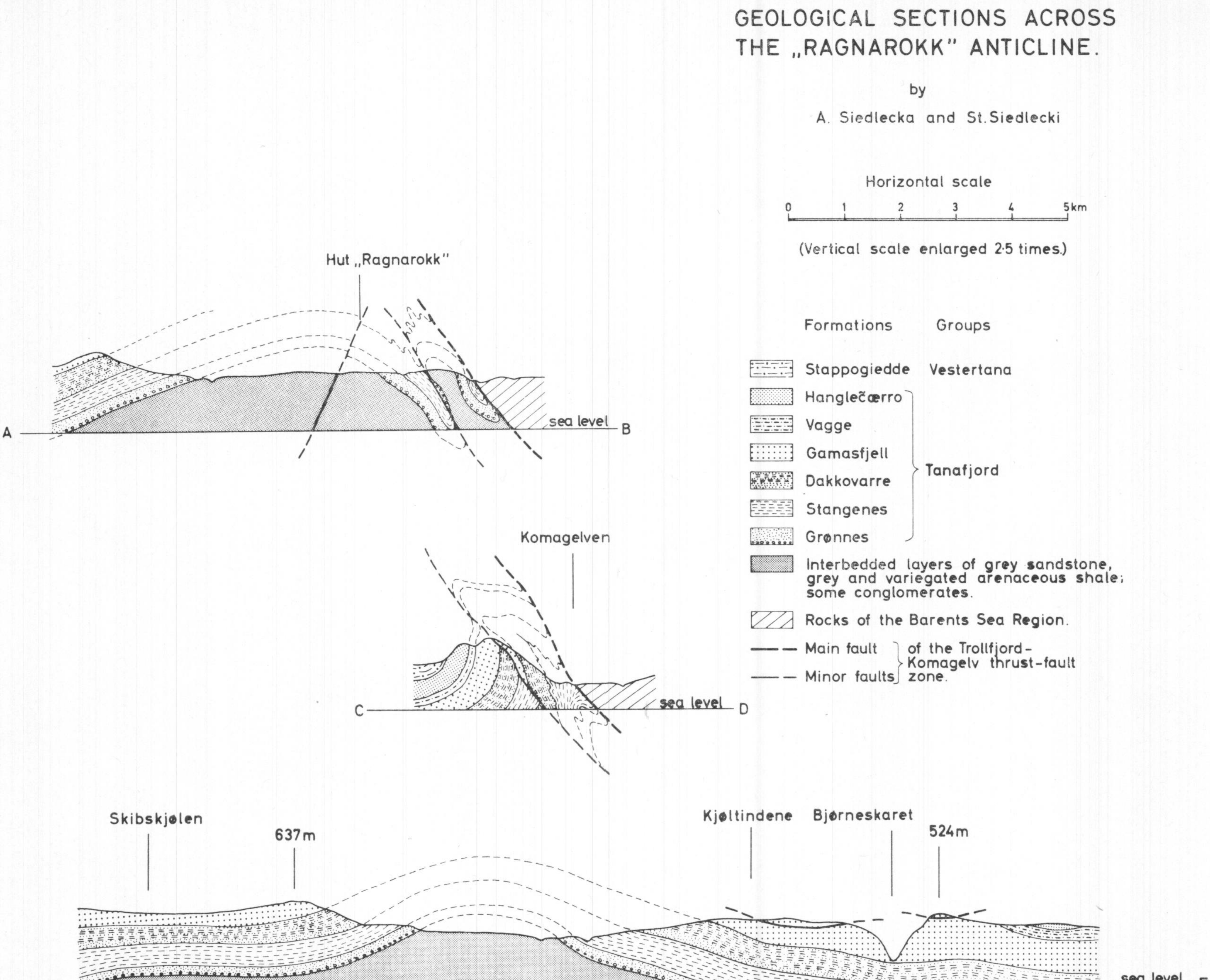
GEOLOGICAL SECTIONS ACROSS
THE „RAGNAROKK" ANTICLINE.
by
A. Siedlecka and St. Siedlecki
Horizontal scale
0 1 2 3 4 5km
(Vertical scale enlarged 2·5 times.)
Formations
Groups
Stappogiedde
Vestertana
Hanglečærro
Vagge
Gamasfjell
Dakkovarre
Stangenes
Grønnes
Tanafjord
Interbedded layers of grey sandstone, grey and variegated arenaceous shale; some conglomerates.
Rocks of the Barents Sea Region.
Main fault
Minor faults
of the Trollfjord-Komagelv thrust-fault zone.
Hut „Ragnarokk"
sea level
A
B
Komagelven
sea level
C
D
Skibskjølen
637m
Kjøltindene
Bjørneskaret
524m
sea level
E
F

Plate IV

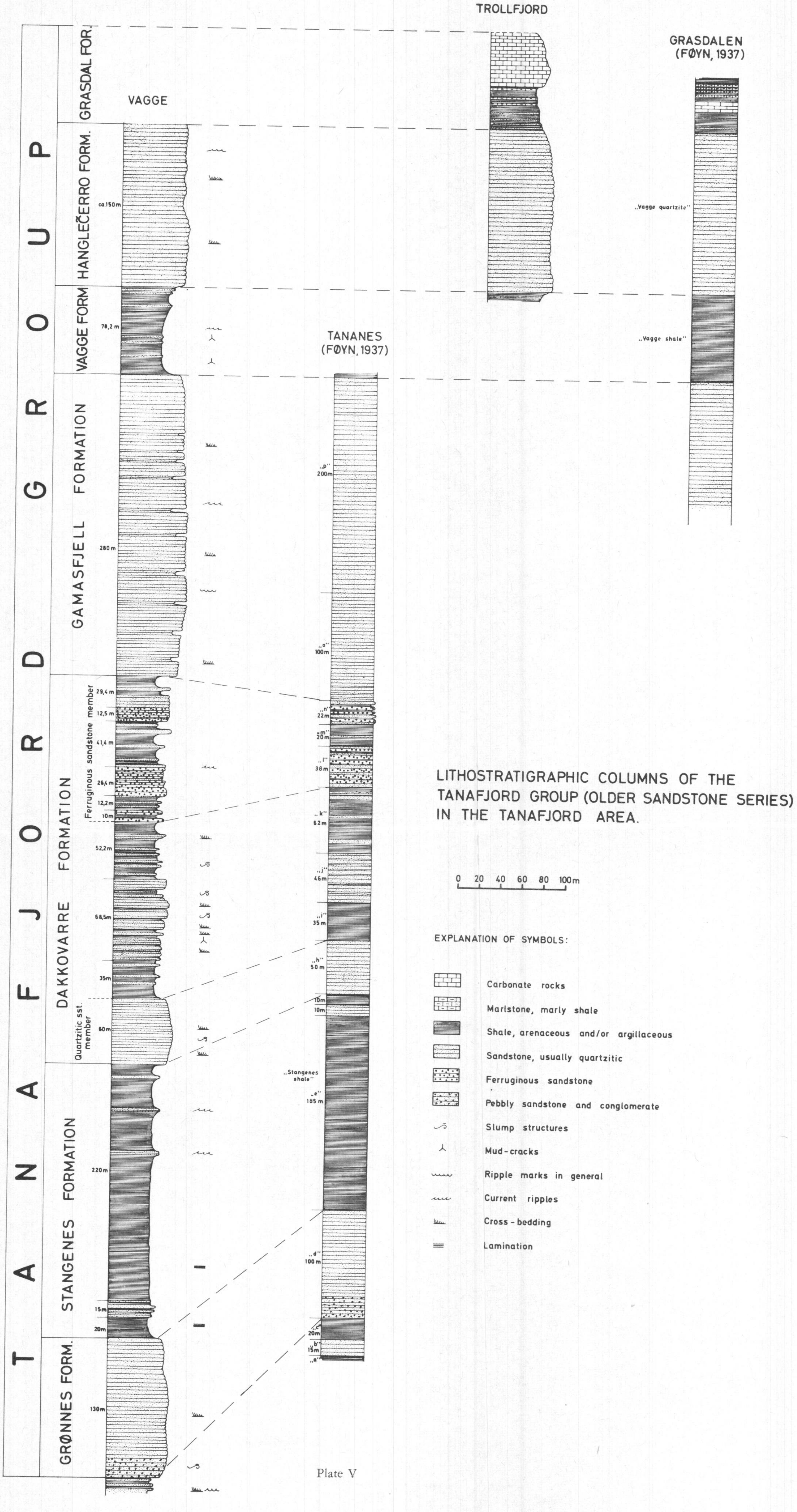
LITHOSTRATIGRAPHIC COLUMNS OF THE TANAFJORD GROUP (OLDER SANDSTONE SERIES) IN THE TANAFJORD AREA.
TANAFJORD GROUP
GRASDAL FOR.
HANGLEČERRO FORM.
VAGGE FORM
GAMASFJELL FORMATION
DAKKOVARRE FORMATION
Ferruginous sandstone member
Quartzitic sst. member
STANGENES FORMATION
GRØNNES FORM.
VAGGE
TROLLFJORD
GRASDALEN (FØYN, 1937)
TANANES (FØYN, 1937)
„Vagge quartzite"
„Vagge shale"
„Stangenes shale"
0 20 40 60 80 100m
EXPLANATION OF SYMBOLS:
Carbonate rocks
Marlstone, marly shale
Shale, arenaceous and/or argillaceous
Sandstone, usually quartzitic
Ferruginous sandstone
Pebbly sandstone and conglomerate
Slump structures
Mud-cracks
Ripple marks in general
Current ripples
Cross-bedding
Lamination

Plate V