Stratigraphy and Major Structures of the Grong District, Nord-Trøndelag

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The rock sequence of the Grong district, which occurs in a depression within the Norwegian Caledonides between two Precambrian massifs, Børgefjell to the north and the Grong culmination in the south, can be divided into three main tectonostratigraphical units: an Eastern and lower, a Central, and a Western and upper Complex. The Eastern Complex consists of the Seve Nappe of probable Precambrian (?to Cambrian) age, and a Lower Køli Nappe above with Ordovician and Silurian rocks. The Central Complex of the Rantser Nappe is thought to be inverted and of Cambrian to Ordovician age. The Western Complex is inverted and comprises the Limingen Nappe, composed of Ordovician rocks, and the overlying Helgeland Nappe consisting of rocks of assumed Precambrian (?to Cambrian) age. In the southwestern part of the district, near Grong, it is difficult to detect whether thrusting of younger rocks of Precambrian basement has taken place. Likewise it is here difficult to confirm the presence of the Helgeland Nappe. The Precambrian (?to Cambrian) rocks of the Seve and the Helgeland Nappes have striking lithological similarities and also have a higher metamorphic grade than the centrally situated, younger rocks. They are thought to have been deposited in the same basin. In contrast, all the groups of the Lower Køli, Rantser and Limingen Nappes are markedly different in lithology and none of them can be correlated.

Ore occurrences in the district are mostly within volcanic formations belonging to different groups, though the majority are found in the Gjersvik Group of the Western Complex. Here they occur at many different stratigraphical levels.

In the final chapter, the lithostratigraphy of the Grong district is compared with that in neighbouring areas in Norway and Sweden — from the Trondheim region in the south to the Sulitjelma district in the north. Rock successions in the Grong and Trondheim regions are similar in many respects, to the extent that prevailing fold-tectonic models for the latter region linking eastern and western areas may be questioned. In the Sulitjelma district the Vasten Nappe is considered to correspond to the Rantser Nappe of the Grong district.

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Introduction

The main features of the geology of the Grong district are known through the mapping of Steinar Foslie during the 1920's and 1930's. After his death in 1951 his 1:50,000 manuscript maps were prepared for publication by Norges geologiske undersøkelse as the 1:100,000 map-sheets Namsvatn, Tunnsjø, Sanddøla, Trones and Nordli (Foslie 1956, 1958, 1960). Over the past two decades these excellent maps have proved invaluable to all workers in the Grong region, the present author included.

When prospecting activity in the district was intensified during the 1970's there was an immediate need for a more detailed geological map coverage. During the years 1972–76 the present author worked with an exploration programme in the Grong district, called the 'Grong Project', undertaken by the

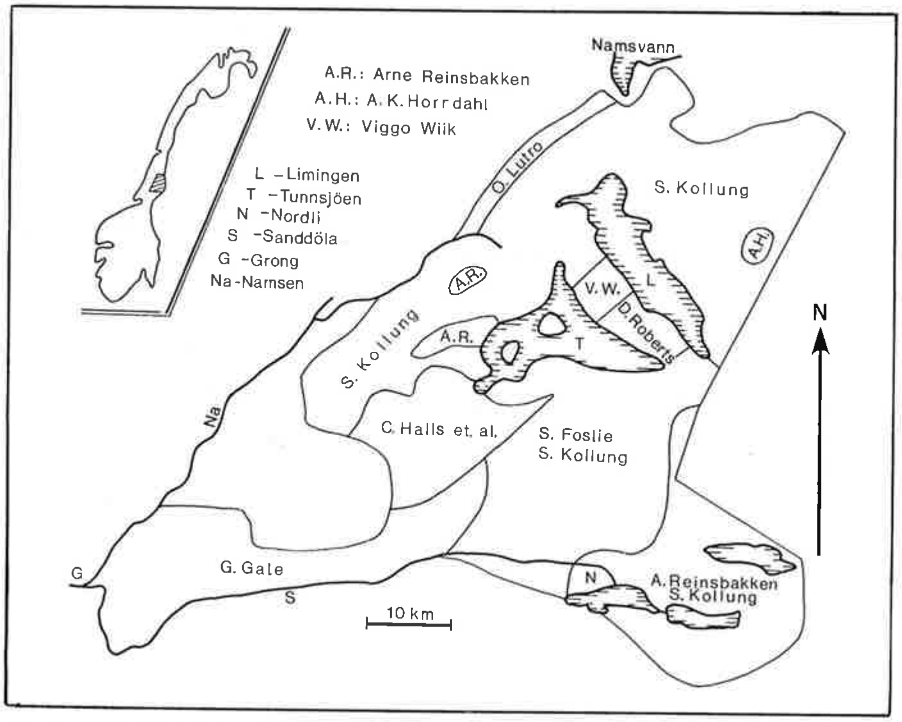

Fig. 1. Areas mapped by the main contributors to the geological map, Plate 1.

mining companies Grong Gruber A/S and Skorovas Gruber A/S, in co-operation with Norges geologiske undersøkelse (until 1975), and was given the task of compiling a new geological map of the district. This covers the area southeast of Namdalen from Namsvann–Huddingsdalen in the north to Grong–Sanddøla–Nordli in the south, and bounded in the east by the Swedish border. Fig. 1 shows the area where the main contributors to the map have worked. Various students have mapped smaller areas. Most of my own detailed work was done in the areas north and west of Limingen and Tunnsjøen as far south as Tunnsjødal, and in the Nordli area, with control-mapping and reconnaissance in the areas mapped by the other contributors. The least well mapped area is that between Tunnsjøen and Sanddøla/Nordli, but this has a relatively simple geology with thick rock units. Here, a combination of Foslie's maps and my own reconnaissance mapping has been used for the compilation. My original maps are at a scale of 1:50,000. The map presented here (Plate 1) is a simplified one, at 1:150,000.

In the area between Nordli and the eastern end of Limingen the greater portion of the bedrock is covered by Quaternary deposits. Elsewhere, recent deposits are mainly restricted to low-lying areas, leaving the higher ground well exposed.

Apart from the section on 'Mineralizations' descriptions are almost exclusively based on my own observations; where this is not the case, references are given in the text. Most of the rock formations described have been studied microscopically.

Foslie unfortunately published very little of his own work (1923, 1924, 1926). The northernmost map-sheet, 'Namsvatnet med en del av Frøynings-fjell', was described by Strand (Foslie & Strand 1956), with some later additional remarks (1963). Chr. Oftedahl discussed some main features of the tectonics (1956) and described the ore occurrences of the district (1958).

Other persons who have worked in the district in recent years and whose maps have been utilized in the compilation include R. Kvien (between Huddingsdalen and Limingen) and A. Reymer (Nordli area). R. Greiling (1975) did a tectonic study based an photogeology in the area north of Huddingsdalen, and Halls et al. (1977) have published the results of some of their work from the Skorovatn area.

From a neighbouring area to the north, Gustavson (1973) has compiled and described the map-sheet 'Børgefjell'. An adjacent area in Sweden, near Blåsjø, was mapped by Nilsson (1964). Zachrisson has mapped the Remdalen area (1964), and treated the broader aspects of the geology of northern Jämtland and southern Västerbotten (1969). In recent years, Sjöstrand (1978) has studied an area between Jormsjöen and Kvesjöen in Jämtland, immediately southeast of Limingen.

Geological setting

The Grong district forms a large depression within the Norwegian Caledonides, with great thicknesses of eugeosynclinal deposits of assumed Precambrian to Silurian age. It is bounded by the Børgefjell massif in the north and the Grong culmination in the south, both of which are composed mainly of Precambrian rocks. The geology and its interpretation is complicated by the scarcity of continuous, clear tectonic lines, a lack of fossil finds and the local abundance of isoclinal folding. The interpretation presented here is nevertheless considered to be a reasonable one; in arriving at this interpretation, comparisons with neighbouring districts in Norway and Sweden have proved helpful.

The main stratigraphical and tectonic units of the district are shown in Fig. 2. Supposed Precambrian psammitic sediments of the Dærgafjell Group are thick in the north, but seem to be lacking in the south. They are probably thrust over the Precambrian basement. Rocks of uncertain age, but probably mainly Precambrian (Reymer 1978, Råheim et al. 1979), mostly pelitic schists, almost entirely surround the district, partly in Sweden. In the east they belong to a lower tectonic unit, the Seve Nappe, whereas in the northwest, between Steinfjell and Tunnsjødal, they occupy a high tectonic position: these are the Hartkjølen Group and the Namsen Group, respectively. In the extreme southwest, near Grong, they have a similar position to the Hartkjølen Group rocks in Nordli, above the basement. The area between Tunnsjødal and Grong has unfortunately not been mapped, but according to the map-sheet Trones (Foslie 1960) the Namsen Group rocks are continuously exposed across this ground. In all these areas the rocks are of similar lithology and of a higher metamorphic grade than the rocks of the central part of the district, and are thought

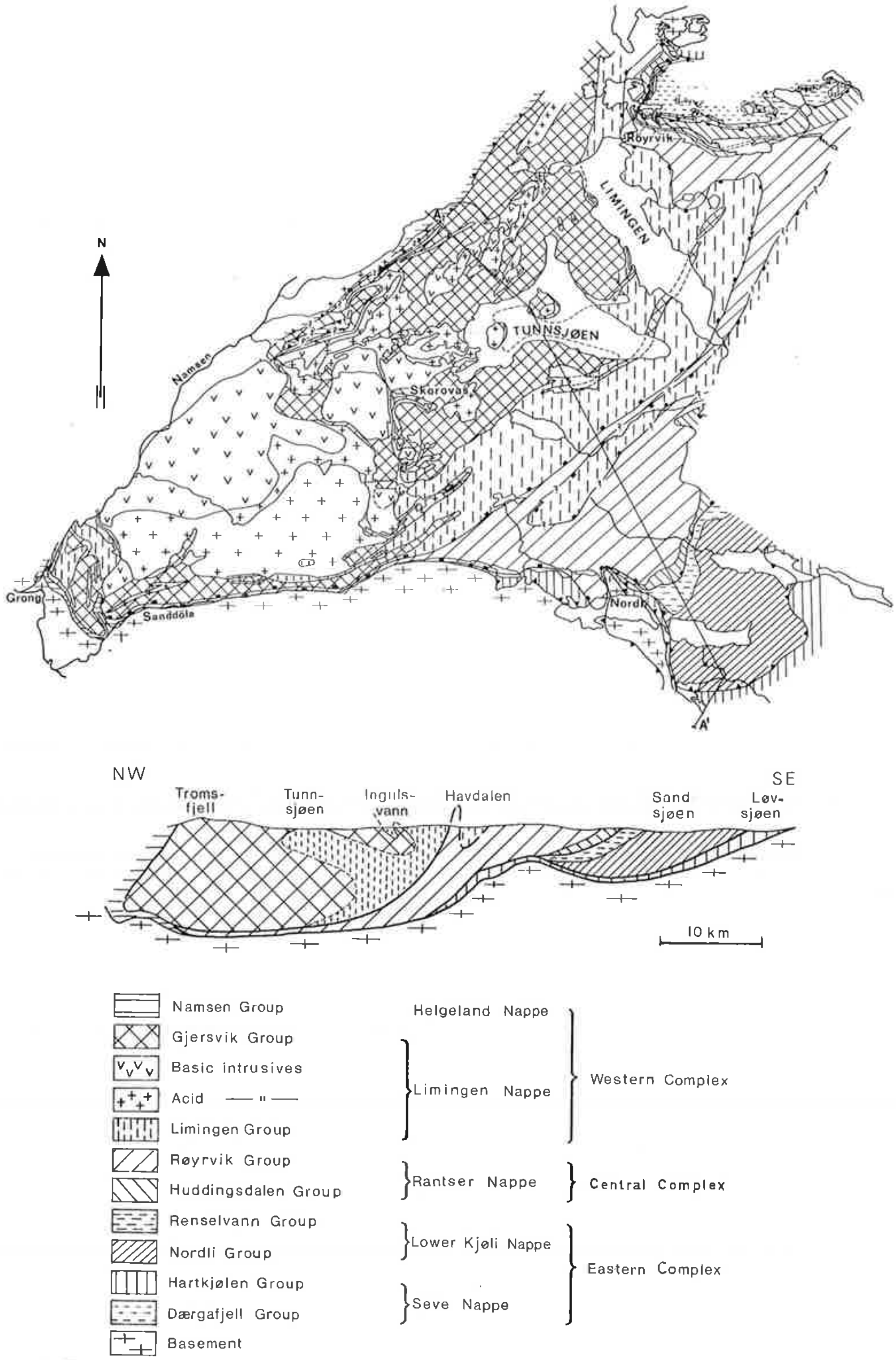

Fig. 2. Tectono-stratigraphical synopsis of the Grong district, with section A–A′ Tromsfjell–Nordli.

to have originated in the same basin. While the Hartkjølen Group is evidently thrust over the Precambrian basement, the relationship of the Namsen Group to the underlying rocks is less clear. In the northwest the Namsen Group is considered to be thrust over younger rocks to the east, and belongs to the Helgeland Nappe (Ramberg 1967, Gustavson 1973). Another plausible interpretation, however, could be that the Namsen Group originally belonged to the same low tectonic unit as the Hartkjølen Group, and that its present position is due to later regional folding (Råheim et al. 1979).

A Cambrian age is considered likely for the central Røyrvik Group. During Ordovician time the depositional basin is thought to have been split up into three minor basins. The reason for assuming this is that on moving inwards from the Hartkjølen and Namsen schists there are quite different lithologies in the western and eastern parts of the district. None of the larger units (groups) can be correlated with one another. Through thick rock successions, metamorphic grade decreases westwards in the east and eastwards in the west with the rocks becoming progressively younger; that is, inverted in the west and right way up in the east. Throughout the area there is a sharp boundary between the Limingen Group and the Røyrvik Group, and the latter is of higher metamorphic grade. Accordingly, these two groups are thought to be separated by a major tectonic line; this is in agreement with the views of Halls et al. (1977).

In Gauldalen in the southeastern part of the Trondheim region, there is a fossil find from the lowermost Ordovician (Størmer 1941, Vogt 1941). According to Rui (1972) the fossil-bearing rocks are located near the eastern contact of, and probably within, the Gula Group, which the present author considers probably corresponds to the Røyrvik Group. A thick volcanic unit, here assumed to be a correlative of a volcanic formation within the Huddingsdalen Group, tectonically underlies the Gula Group. In the Meråker district farther north in the Trondheim region, the same volcanic unit, the Fundsjø Group, is tectonically underlain by the Lille Fundsjø Conglomerate which contains clasts of the Fundsjø Group rocks, and accordingly is younger (Chaloupsky & Fediuk 1967).

Somewhat to the east of the Huddingsdalen Group equivalent there are fossil finds from uppermost Ordovician and Lower Silurian (Kulling 1933) in a neighbouring area in Sweden. These fossils are in formations which are partly or entirely lacking in Norway, in the Slätdal Limestone and the overlying Broken Series, with the youngest fossils in the latter. These formations constitute the lower parts of the Lasterfjäll Group (Zachrisson 1969), the unit to which the Renselvann Group of the present area belongs. In all probability the rock succession becomes progressively younger higher up in the Renselvann Group. In the Blåsjö Phyllite north of Qvarnbergsvattnet in Sweden, a unit corresponding to Kulling's Løvfjell Phyllite overlying the Broken Series, structural evidence suggests that the strata are progressively younger up the sequence. This is also the view held by Gee & Zachrisson (1974). In conclusion, a tectonic contact is considered to exist between the Renselvann Group and the Huddingsdalen Group.

Table 1. Stratigraphic and tectonic units described in this paper compared with those used on the five 1:100.000 map-sheets of Foslie (or Foslie & Strand)

This paper			Namsvatnet med en del av Frøyningsfjell (1956), Trones (1960)			Tunnsjø (1958), Sanddøla (1958), Nordli (1960)	
Western Complex	Helgeland Nappe	Namsen Group	Cambro–Silurian high-grade metamorphic rock series in the west				
	Limingen Nappe	Gjersvik Group	Eocambrian (?) and Cambro–Silurian low-grade metamorphic, sedimentary and volcanic rock series	Gjersvik Nappe (of phyllite–greenstone Series)		Gjersvik Nappe	
		Limingen Group		Limingen Group		Limingen Group	
Central Com-	Rantser Nappe	Røyrvik Group		Phyllite–greenstone series (lower tectonic unit)	Limestone (= Huddingsvann L.)	Eastern Cambro–Silurian rocks	
					Røyrvik Division		
		Huddingsdalen Group					
Eastern Complex	Lower Køli Na.	Renselvann Group			Calcareous schist		
		Nordli Group					
	Seve Nappe	Hartkjølen Group			Partly mapped as Røyrvik Division, partly as Børgefjell Massif		
		Dærgafjell Group			Dærgafjell Quartzite		
Basement			Børgefjell Massif			Seve Nappe, Precambrian	
						Olden Nappe	Cambro–Ordovician
							Precambrian

Following these considerations, an Eastern, a Central and a Western Complex are distinguished (Fig. 2). Within any one of these complexes, thrust units are probably in their correct stratigraphical position relative to one another, but this is not the case between the complexes themselves. The *Eastern Complex* is divided into two nappes. No signs of thrusting have been recognized between the Dærgafjell Group and the Hartkjølen Group; both groups are thus tentatively placed in the Seve Nappe. The Lower Køli Nappe consists of the assumed Ordovician Nordli Group of mixed sedimentary–volcanic origin and the wholly sedimentary Renselvann Group which probably passes up into the Silurian. The *Central Complex* comprises the Rantser Nappe which itself consists of the Røyrvik and Huddingsdalen Groups of assumed Cambrian to

Ordovician age. Both these groups are mixed sedimentary–volcanic units. The Western Complex consists of two nappe units, the Limingen Nappe (the Gjersvik Nappe of Halls et al. 1977) and the Helgeland Nappe. The Limingen Nappe comprises the mainly eruptive Gjersvik Group and the mainly sedimentary Limingen Group, both of probable Ordovician age. The rocks of the Helgeland Nappe in the present area are termed the Namsen Group.

In Table 1 the stratigraphic and tectonic units are compared with those of Foslie.

Stratigraphy

PRECAMBRIAN BASEMENT

The term 'basement' is used here in a somewhat relative sense, as it is partly allochthonous in the south (Oftedahl 1956).

Only the upper portions of the basement were studied. For the most part it consists of granitic gneiss to gneiss–granite, often with feldspar augen. In the Sanddøla–Grong area metasediments of minor thickness, namely micaceous gneisses and locally also quartzite, are often situated between the granitic rocks and the schists of the Namsen Group, such that the contact relationships in this area are less clear. Between Gollomvann and Namsenvann in the north, the uppermost part of the basement is gneiss–granite while lower down there are micaceous gneisses alternating with granitic gneisses.

EASTERN COMPLEX

Table 2 shows the stratigraphy of the Eastern Complex. The internal stratigraphy of the Nordli Group is uncertain due to the likely presence of isoclinal folds. The rocks of the Eastern Complex continue northwards into Sweden from the Nordli area, to reappear in Norway east of Huddingsdalen (Plate 1). The southern and northern areas are treated separately in the description which follows.

The Dærgafjell Group

This consists of quartz-rich sediments of probable Precambrian age which occur in great thickness (several hundred metres) north of Huddingsdalen. Foslie & Strand (1956) named this unit the Dærgafjell Quartzite. In addition to quartz and micas, most of the rocks carry abundant feldspar, and should therefore more correctly be ranked as metasandstones (or arkoses). Rather pure quartzites do occur, but only in relatively subordinate amounts.

North of Grong a ca. 100 m-thick quartzite, with bands of mica schist, is exposed in the Namsen river between granitic basement rocks and typical Namsen schist. This may therefore correspond to the Dærgafjell Quartzite.

The Hartkjølen Group

Southern area. The group attains its maximum thickness in the eastern part of the Nordli area but thins drastically from south of Sandsjøen, wholly or portly

Table 2. Stratigraphy of the Eastern Complex

Nordli	North of Huddingsdalen	Group and assumed age
Quartz-rich calcareous phyllite Hornblende porphyroblast schist	Quartz-rich calcareous phyllite Highly calcareous phyllite Banded, highly calcareous phyllite/sandstone Dark phyllite, quartz schist Quartz-rich calcareous phyllite	Renselvann Group. Ordovician–Silurian
Upper garben schist Amphibolites, keratophyres, quartzites, garben schist, fine-grained porphyroblast schists, polymict conglomerates, thin limestones Lower garben schist Kvemo porphyroblast schist	Upper amphibolite Porphyroblast schist, locally garben schist, amphibolite Lower amphibolite, keratophyre	Nordli Group. Ordovician
Alternating amphibolite and mica schist Quartzite Mica schist, minor amphibolite Granitized micaceous gneiss	Mica schist Granitized mica schist	Hartkjølen Group. ?Precambrian
	Metasandstone, quartzite	Dærgafjell Group. Precambrian

due to tectonic movements. The westernmost exposure observed was at Gosen, where it is only about 50 m thick (Plate 1).

Between Kvesjøen and the mountain Hartkjølen the group is fairly sharply divided into two parts, a lower granitized and an upper non-granitized part.

The *lower, granitized part* is gneissic and evidently of higher metamorphic grade than the upper part. Most of the gneisses are fairly rich in mica, a feature which helps to distinguish them from the granitic basement rocks farther to the west in Nordli, and also indicates a sedimentary origin. Light quartzo–feldspathic and dark amphibolitic bands and schlieren are abundant. The granitic bodies, many of them pegmatitic, vary from small veins and lenses to larger bodies several metres across.

Some of the larger concordant amphibolites near Kvesjøen have a rather massive appearance and coarse texture. One occurs in the core of a large anticline and represents the structurally lowest rocks in this area.

According to Foslie's map (1960) this granitized part of the Hartkjølen Group ends somewhat east of Løvsjøen in a structure overfolded towards the south.

The *upper, non-granitized* part of the group is divided into 3 distinct units within the area from east of Løvsjøen to north of Laksjøen. From bottom to top these are: 1. Mica schist, 2. Quartzite, 3. Alternating mica schist and amphibolite. The lower mica schist, which is rather homogeneous, is coarser and lighter than the upper one, due to its higher content of muscovite. Both of these schists are garnet-bearing. Over long distances the quartzite is not exposed and thus might not be continuous. Towards the west the upper unit (3) is well developed at least as far as to the eastern end of Skjelbredvann. In the lower unit (1) there are some relatively massive amphibolites, the outlines of which are drawn from Foslie's map. Towards the east, in the area north of Hartkjølen, there is a thick brownish mica schist with garnet porphyroblasts up to 1 cm across. Amphibolite bands are rather abundant and often the schist contains thin quartzo–feldspathic bands and schlieren. At Kvesjøen, there are also thicker amphibolites and the schist is partly dark and graphitic. Owing to the amphibolite facies metamorphism it is impossible to determine the precise origin of these amphibolites, but they might well be volcanics. On the other hand, the more massive and coarse amphibolites may be metagabbros.

Intrusives are represented by lens-shaped bodies of serpentinite. The Hartkjølen Group is, in fact, the unit in the entire Grong district which has the strongest concentration of serpentinites. Numerous bodies are found within the area between Hartkjølen and Kvesjøen, and they appear in both parts of the group. Their outcrop size ranges from about 500 m down to about 10 m.

Northern area. North of Huddingsdalen the Hartkjølen Group is mostly rather thin and discontinuous. It attains its greatest thickness (over 100 m) in the very easternmost part of the area, at Henriksvannet. Foslie and Strand placed these rocks either in the Børgefjell Precambrian massif or together with lower-grade schists. The rocks are, however, of the same character as those in the Nordli area, and their higher grade metamorphism clearly distinguishes them from stratigraphically younger pelitic rocks.

Granitized micaceous schists occur on the western side of Fiskløsvann. Strand (in Foslie & Strand 1956) considered the granitized mica schists as belonging to the Børgefjell massif, the granitization distinguishing them from stratigraphically higher schists. The granitized schists at Fiskløsvann are, however, in contact with non-granitized schists of the Hartkjølen Group. It is therefore probable that they correspond to the lower part of this group in the Nordli area. The present author is acquainted with only the peripheral parts of the Børgefjell massif, and therefore cannot comment on the general validity of Strand's placing them within the massif and thus regarding them as basement rocks.

The remainder of the mapped Hartkjølen schists in this northern area belong to its upper, non-granitized part. As in the Nordli area the schists are mostly pelitic, but often with quartzo-feldspathic bands deriving from sandy sediments. In some places there are bands with feldspar augen. Abundant biotite, giving the schists a brownish colour, together with some garnet porphyroblasts distinguish them from calcareous phyllites of the Renselvann Group with which they are in contact where rocks of the Nordli Group are lacking. Whether these schists have been metamorphosed in upper greenschist facies (garnet zone) or in lower amphibolite facies is still an open question.

The Nordli Group

Southern area. In Nordli the group is thick and rather complex. Like the Hartkjølen Group it thins westwards before disappearing north of Laksjøen on the east side of a basement antiform.

The Nordli Group includes approximately equal amounts of amphibolites and schists; the amphibolites are considered to be volcanics. The schists are of 3 different lithologies: 1. Garnet–biotite porphyroblast schist. 2. Fine-grained schist, often with biotite porphyroblasts. 3. Coarse hornblende porphyroblast schist. Quartzites, the thickest of which are within the amphibolites and the others in schist (2), are a subordinate lithology. The metamorphism is within the garnet zone.

Tectonically, the group may be divided into 3 main zones: 1. A lower one with schist (1) ± schist (3). 2. A middle zone with the amphibolites and schists (2) and (3). 3. An upper zone with schist (3).

North of Kvesjøen and only exposed on the Swedish side of the border, there is a conglomerate at the very base of the group, the *Ro Conglomerate*, with clasts of quartzite and ultrabasic rock.

1. Garnet–biotite porphyroblast schist. This *Kvemo Schist* occurs at the base of the Nordli Group although towards the west it is cut out tectonically at the western end of Løvsjøen. It is a banded mica schist/quartzite with a pronounced schistosity and has been quarried north of Kvesjøen. Locally, hornblende porphyroblasts are present. Dark, graphitic schists occur fairly frequently and there are also some amphibolites which may possibly have been infolded from the overlying unit.

2. Fine-grained schist. This brownish, rather thin-bedded schist very often contains biotite porphyroblasts. Part of the unit is somewhat coarser. Thin graphitic schists occur locally and in some places there are calcareous schists. Layers of quartzite are common, with thicknesses up to about 10 metres. Thin limestones of about 1–5 m thickness occur locally on both sides of Kvesjøen.

An intraformational polymict conglomerate occurs at the northeastern end of Sandsjøen. In a matrix of mica schist there are clasts, up to 50 cm across, of gabbro, quartzite and trondhjemite. Similar conglomerate also occurs along the southern side of the lake.

3. Coarse hornblende porphyroblast schist. The schist, which is thought to have been derived from marly sediments, is composed of quatrz, feldspar, muscovite, calcite, hornblende, biotite and garnet. Hornblende forms prisms up to 5 cm in length. Though this rock has been designated 'garben schist', typical garben textures are not common. Quartz and plagioclase are fine-grained, often concentrated in diffusely bounded bands. Thin graphitic schists occur locally.

4. Amphibolites. The amphibolites display great variation from rather massive and somewhat coarse-grained to strongly schistose; and from rather homegeneous to strongly banded. Mineralogically they range from plagioclase-hornblende rocks to types with additional calcite ± epidote. Garnet may occur, though mostly this is in minor amounts. The calcareous amphibolites constitute about half of these rocks. In these amphibolites thin limestones (≦50 cm thickness) may be present. The non-calcareous amphibolites sometimes have a pronounced banded structure; these are thought to have been tuffs originally. The lightest, keratophyric bands consist mostly of plagioclase and quartz with only a little hornblende. Rather massive, homogeneous amphibolites north of Kvesjøen were mapped as gabbro by Foslie. They probably represent lavas, however, as they are quite different from the typical coarse gabbros of the area.

Local variants of the amphibolites reveal a more complex mineralogy, with muscovite, garnet and calcite in addition to hornblende and plagioclase. The hornblende partly appears as larger porphyroblasts. These hornblende rocks are well exposed in road-cuts west of Løvsjøen, at the base of the amphibolites. A 50–100 m-thick keratophyre occurs to the north of Kvesjøen, in the lower part of the amphibolites.

Two intraformational, polymict conglomerates occur between Kvesjøen and Sandsjøen. The lower one, on the south side of Kvesjøen beneath schist (2), has a calcareous amphibolitic matrix, while most of the clasts are of gabbro and limestone. The other conglomerate occurs north of Sandsjøen, in the upper part of the amphibolites; this has clasts of quartzite, trondhjemite and gabbro in a green, fine-grained matrix.

A quartzite up to 50 m thick forms a distinct zone within the upper part of the amphibolites. It is only seen north of Sandsjøen and is not continuous. Most of this rock-type is fairly rich in mica, a minor part being purer with a glassy appearance.

The section depicted in Fig. 3 shows a central part of the area, between Sandsjøen and Kvesjøen, where garben schists of identical appearance occur at 3 different tectonic levels. The lowest garben schist, overlying the Kvemo Schist, is not present north of Kvesjøen, while south of Sandsjøen it thins out at Lutra river. North of Kvesjøen a garben schist occurs at a somewhat higher level. The middle garben schist wedges out before Kvesjøen, and is not seen south of Sandsjøen. The upper garben schist is continuous across the area. The fine-grained schist (2), in a position somewhat below the middle garben schist, thins out at Lutra towards the south and before Kvesjøen to the north. It reappears north of Kvesjøen, but there, in a more strongly folded area, it is also found at a higher level, between the thick quartzite and the upper garben schist.

Considering the identical appearance of the 3 garben schists, the frequent thinning out of the units and the fact that the different types of amphibolite occur at several levels, a possible interpretation of the stratigraphy, demanding the presence of large isoclinal folds, might be as follows:

1. Kvemo Schist

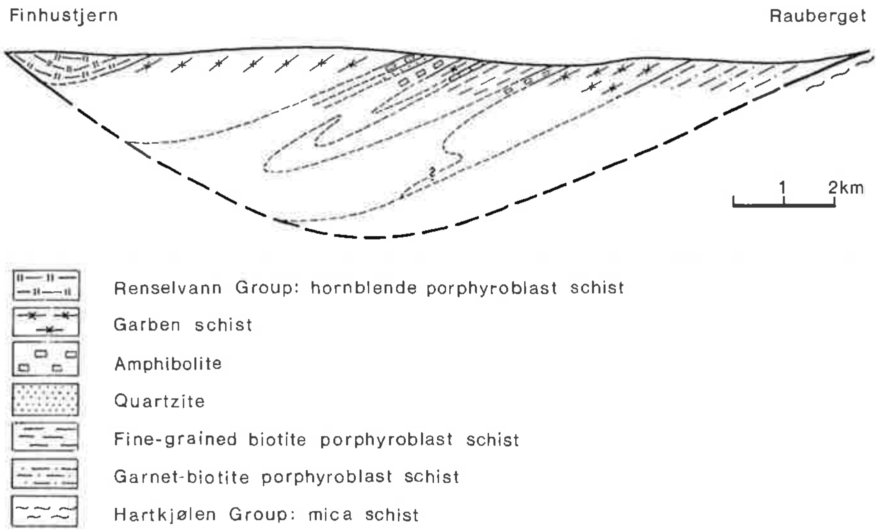

Fig. 3. Section B–B′ through the Nordli Group north of Sandsjøen, Nordli. The section line is indicated in Plate 1.

2. Amphibolites with a locally deposited fine-grained schist in the middle of the sequence.
3. Garben schist (youngest)

An argument against this interpretation would be that the quartzite within the amphibolite is only found at a higher tectonic level. The interpretation also demands that the amphibolites are cut out tectonically between Lutra and Kvesjøen, where garben schist lies directly on the Kvemo Schist. Field observations are of no help here, as the contact between the two schists is nowhere exposed.

Intrusives. Ultrabasic, basic and acid intrusives are found within the Nordli Group.

Some serpentinites, most of them small bodies, are met with in lower parts of the group, mainly in the Kvemo Schist; only two were seen above this level, one in amphibolite north of Kvesjøen and one in fine-grained schist on the south side of Sandsjøen. As in other parts of the Grong district, serpentinites seem to be restricted to lower stratigraphic levels.

Hornblende gabbros, many of them also rich in biotite, occur at all levels. They are massive, coarse-grained rocks, appearing as lenticular to circular bodies up to several hundred metres across.

Other probable intrusives include scattered round bodies up to 10 m across of a more acid composition. These occur within amphibolite, most of them in the area from Løvsjøen and eastwards to Lutra. They are heterogeneous rocks with a characteristic schlieren structure and are often rusty weathering. The main minerals are plagioclase, quartz, hornblende, chlorite and garnet.

In the amphibolites there are a few trondhjemites, two of them larger bodies. One, ca. 400 m thick, occurs south of Sandsjøen and the other at the western end of Kvesjøen. The trondhjemites are lens-shaped, concordant and folded together with the amphibolites.

Northern area. North of Huddingsdalen the Nordli Group is rather thin and impersistent. Most of the group consists of volcanics which vary from dark amphibolites to light keratophyres, the latter often with abundant hornblende and garnet porphyroblasts. The group is thickest and most complex in the Gollomvann area, where metasediments in the form of dark grey phyllites with garnet and biotite porphyroblasts are present, locally with a thin cap of limestone. This phyllite is at a higher stratigraphic level than the heterogeneous volcanic unit. Southwest of Gollomvann, however, it is overlain by a dark, homogeneous amphibolite. The phyllite is thought to correspond to the fine-grained schist at Nordli. A rather thin but more thickly bedded biotite porphyroblast schist just north of Krokvann (to the west of Gollomvann) at the base of the group may well correspond to the Kvemo Schist.

Another, smaller area with a more complex Nordli Group lithostratigraphy is situated 1 km northeast of Kjerrnes farm in Huddingsdalen. Here volcanics — amphibolite and keratophyre — constitute the lower and upper parts of the sequence, whereas the central part mostly consists of alternating calcareous garben schist and biotite porphyroblast schist.

The Renselvann Group

These supposedly youngest rocks in the Grong district, of probable Ordovician to Silurian age, are exclusively sedimentary, consisting mostly of calcareous pelites. Their metamorphism is somewhat higher in the southern area than in the north, in the garnet and biotite zones, respectively. The group is fairly thick in both areas though in contrast to the two underlying groups more complex in the north.

Northern area. In the eastern parts of this area 5 fairly distinct units can be recognized; from assumed oldest to youngest these are:

1. *Older quartz-rich calcareous phyllite.* This is a hard and rather massive grey schist with numerous quartz lenses.

2. *Dark grey phyllite and light quartz schist.* The two members occur in highly varying amounts, from only phyllite through alternating phyllite and quartz schist to predominantly quartz schist. The phyllite is mostly non-calcareous.

3. *Banded, highly calcareous phyllite/metasandstone.* Abundant biotite porphyroblasts are characteristic for this unit. The colour is brownish to greenish. It corresponds to the *Blåsjø Phyllite* in neighbouring areas of Sweden (Nilsson 1964).

4. Highly calcareous phyllite. The colour is brownish to greenish, the structure fairly massive.

5. Quartz-rich calcareous phyllite. As with unit (1), it is hard and rather massive with numerous quartz lenses, but with a greenish colour due to the presence of a dark chlorite.

The main minerals of the phyllites are quartz, chlorite, muscovite and calcite with some biotite and plagioclase, the latter more abundant in the sandy layers of unit (3). Graphite may be present in phyllite (2).

Of the 5 units, (2) and (3) are of more local occurrence; the two highest units, (4) and (5), are the thickest. Because of lack of space, units (1) and (2) are drawn as one on the enclosed map, as are units (3) and (4).

Southern area. In Nordli only units (3) and (5) have been recognized: of these only unit (3) has been traced north of Kvesjøen. Owing to a higher metamorphic grade, unit (3), the Blåsjø Phyllite, is different in appearance from the corresponding schist at Huddingsdalen. It is a brownish biotite-rich schist with abundant hornblende and minor garnet porphyroblasts. Its banded character is somewhat less prominent than at Huddingsdalen.

Unit (5) is mainly a hard, quartz-rich schist similar to that at Huddingsdalen, but it also has layers of softer, partly graphitic phyllites.

As noted earlier (p. 5), fossils are found in a neighbouring area in Sweden (Kulling 1933) in the Bjørkvattnet–Virisen area of Västerbotten. In the Slätdal Limestone, fossils indicate an uppermost Ordovician (Ashgillian) age. In an overlying formation with graphitic schists and quartzites, the Broken Series, there are fossils from the Lower Silurian (Middle and Upper Llandoverian). It is uncertain whether correlatives of these rocks are present in the Grong district. The Broken Series could conceivably correspond to unit (2) of the Renselvann Group in Huddingsdalen.

In the Blåsjø Phyllite north of Qvarnbergsvattnet in Sweden, a unit corresponding to Kulling's Løvfjell Phyllite, overlying the Broken Series, displays good graded bedding in places, and the penetrative schistosity is often aligned obliquely to the bedding. Most of the criteria suggest that the strata are progressively younger up the sequence, though some indicate the opposite. On balance, it seems likely that the sequence is the right way up, an opinion also held by Gee & Zachrisson (1974).

Intrusives. Characteristic for units (4) and (5) at Huddingsdalen are elongate, concordant sheets of medium-grained, mostly rather massive hornblende gabbro. West of Renselvann a sheet of ca. 10 m thickness can be traced for 1 km.

In the Nordli area there are some minor hornblende gabbros in unit (3), of the same coarse and massive type as in the Nordli Group. A larger concordant trondhjemite body in the same unit occurs north of the western end of Sandsjøen. It lies in an open synclinal structure and is folded together with the enclosing schists.

Table 3. Stratigraphy of the Central Complex

North of Limingen	Nordli area	Group and assumed age
Rantser phyllite, quartzite		Huddingsdalen Group.
Tuffites with keratophyre, limestone	Tuffites with kerato-phyre, limestone	Ordovician
	Phyllites	
	Portfjell quartzite conglomerate, quartzite	Røyrvik Group Cambrian –
Phyllite, sandstone Greenstone Quartzite } ?	Phyllite with minor sandstone, greenstone, quartzite	Lower Ordovician

CENTRAL COMPLEX

The Central Complex comprises one nappe unit, here called the *Rantser Nappe,* which consists of a tectonically lower Huddingsdalen Group (new, informal name), and an upper Røyrvik Group. It is considered probable that the internal nappe sequence is inverted, the Røyrvik Group being the older unit. Table 3 shows the stratigraphy of the Central Complex.

A formation tectonically overlying the Røyrvik Group, the Brakkfjell Phyllite (Nilsson 1964), is here tentatively placed within the Limingen Group of the Western Complex, an interpretation differing from that of Sjøstrand (1978).

The Røyrvik Group

The rocks of this group consist of phyllites, metasandstone, quartzite and greenstone with a quartzite conglomerate (quartzite) at its tectonic base and assumed stratigraphical top. The sequence is several hundred metres thick in northern areas. In the upper part of Sanddøla it is thinning westwards and finally pinches out at Trangen in the lower part of the valley.

Marked facies variations occur from north to south. North of Limingen the different lithologies are often rapidly alternating. Here the group is folded in open structures, the Borvann antiform and the Joma synform. In the Grense synform farther to the southeast, where the Brakkfjell Phyllite is lying in the fold core, the Røyrvik Group occupies the western limb of the fold on the Norwegian side of the border, as far south as Østnes. Beyond this the eastern limb is also extensively exposed in Norway.

In the area around Huddingsdalen there are only minor amounts of sandstone present. From there the proportion of sandstone to phyllite increases eastwards towards Sweden and southwards in Limingdalen.

The amounts of greenstone and quartzite present diminish rapidly south of Limingen. Towards Nordli only scattered bands of these rocks are encountered. The amount of sandstone is decreasing again, too, and in the lower parts of Sanddøla phyllite predominates. Metamorphism seems mostly to be within the biotite zone, but with transitions into the garnet zone in southern areas.

Garnet has been observed here locally: west of Kveli, on the northern side of Laksjøen and in lower parts of Sanddøla.

1. Phyllites and metasandstone. The Røyrvik Group phyllites may be divided into three main types: 1. *Soft, grey to black phyllite.* The darkest are rich in graphite, otherwise these phyllites are mineralogically rather homogeneous. 2. *Banded* phyllite. This type consists of alternating thin bands of phyllite and fine-grained sandstone to siltstone. The bands range in thickness from millimetres to decimetres. The sandstone bands are light grey, the phyllitic layers darker grey and sometimes graphitic. 3. *Quartz-rich phyllite.* This is a rather massive, hard rock with transitions into quartzite.

The metasandstone units vary from about 1 m up to 100 m in thickness. They are somewhat coarser grained than the sandstone layers in the banded phyllite. Greywacke with fragments of phyllite occurs at Østre Vallervann.

Phyllite (1) is the most widespread type. Phyllite (2) is most abundant in Limingdalen where it is generally non-graphitic in the western part but more graphitic in the east. It is most typically associated with sandstone and quartzite, whereas phyllite (1) is usually occurring with greenstone. Phyllite (3) has a more local distribution, restricted to the area from Røyrvik to east of Jomafjell (northern part). It is always associated with quartzite.

2. Quartzite. The quartzite is a somewhat schistose, light grey coloured rock with darker stripes rich in muscovite, chlorite and biotite. A dark variety rich in graphite is mainly restricted to the easternmost parts of Limingdalen. There, an eastern graphitic quartzite outcropping not far from the Brakkfjell Phyllite can be followed from the southernmost part of the valley and northwards to west of Sidesvannet. A more westerly situated quartzite becomes increasingly graphitic northwest of Raudekklumpen. This quartzite can be followed northwards to eastern Vallervann. These two units constitute the 'bituminous' quartzite of Foslie, who incorrectly interpreted them as one horizon.

3. Greenstone. The greenstones are considered to represent metamorphosed lavas. Most of them have a light green colour and chemical analyses show them to be rich in calcium and magnesium, and poor in iron. The mineral composition is acid plagioclase, actinolite, chlorite, epidote ± muscovite. An iron-rich variety with a brownish colour due to the presence of abundant biotite has a more restricted occurrence. A more acid variety has abundant plagioclase/quartz aggregates, possibly representing original phenocrysts.

Weakly deformed greenstones are massive to moderately schistose. In some places, however, especially where they are thin, the greenstones may be strongly deformed and here contain abundant muscovite; such deformed and often deeply weathered greenstones occur in areas to the east and south of Joma, and can be difficult to recognize as true greenstones.

Pillow lavas are seen only locally, mostly in the lower greenstones near Sidesvasselva. They also occur in a greenstone close to the Limingen Group boundary east of Tunnsjøen; these have been described by Zachrisson (1966). Often, agglomerates and pillow lavas occur together. Tuffs are subordinate and of minor thickness, but a greenstone with a higher proportion of tuffs is exposed in a road-cut just to the north of Joma mine. This greenstone is close to the tuffs of the Huddingsdalen Group and can be followed eastwards to the Vallervann area.

Apart from this lowest greenstone which is not seen to the west of Joma, there are greenstones at 3 or 4 main tectonic levels in the area between Røyrvik and Joma. It is these greenstones which can be followed farther to the south in Limingdalen, on the west side of the Grense synform. None of the units is quite continuous, though the lowest one is only absent over a distance of 300 m northeast of Seterklumpen. This greenstone, situated in the 'outer arc' of the Joma synform, and the one above in the 'inner arc' which contains the Joma ore, are both very thick in the core of the synform. This is due to folding; some of the thickening may be primary, however, at least in the case of the ore-bearing inner arc which thins out rapidly westwards. Southwards in Limingdalen the greenstones interdigitate with other rocks, and the uppermost greenstone is in contact with phyllites of the Limingen Group.

In trying to establish the original stratigraphy of the Røyrvik Group, the small number of lithologies and their configuration are important features. Also, only a limited number of localities with good younging criteria have been found.

Between Røyrvik and Joma the group may be divided tectonically into two parts. The lower part consists mainly of phyllite though with increasing amounts of quartzite towards Røyrvik. In one area to the west of Huddingsvann, the phyllite is intimately folded with volcanics of the Huddingsdalen Group. The upper part is composed of alternating greenstone, phyllite and quartzite. Apart from the quartz-rich phyllite of type (3) above, which is closely associated with quartzite, the phyllites in both tectonic units are mainly of type (1). Aside from the uppermost greenstone which has Limingen phyllite above, the greenstones are associated with a quartzite which either lies directly on the greenstone or, more commonly, has some phyllite in between. In strongly folded areas, as e.g. northeast of Seterklumpen, the greenstones mostly form antiforms and the quartzites synforms. As mentioned above, the lower greenstone at the base of the upper tectonic unit is discontinuous in this area, but it is clear that the phyllite from the lower unit is connected with the one from the upper unit by folding and that the absence of the greenstone is not attributable to non-deposition.

A plausible interpretation of the stratigraphy would be the following: 1. Quartzite. 2. Greenstone. 3. Phyllite. Fig. 4 shows a cross-section from Huddingsvann to Jomafjell. If one assumes inversion of the group, the quartzite would be the oldest unit; this is, in fact, supported by way-up evidence. Firstly, well-developed pillow structures in the uppermost part of the lower greenstone west of Sidesvasselva show that it is progressively younger upwards towards the overlying phyllite to the west. Secondly, a ca. 100 m-thick zone of banded phyllite on the eastern side of a quartzite just south

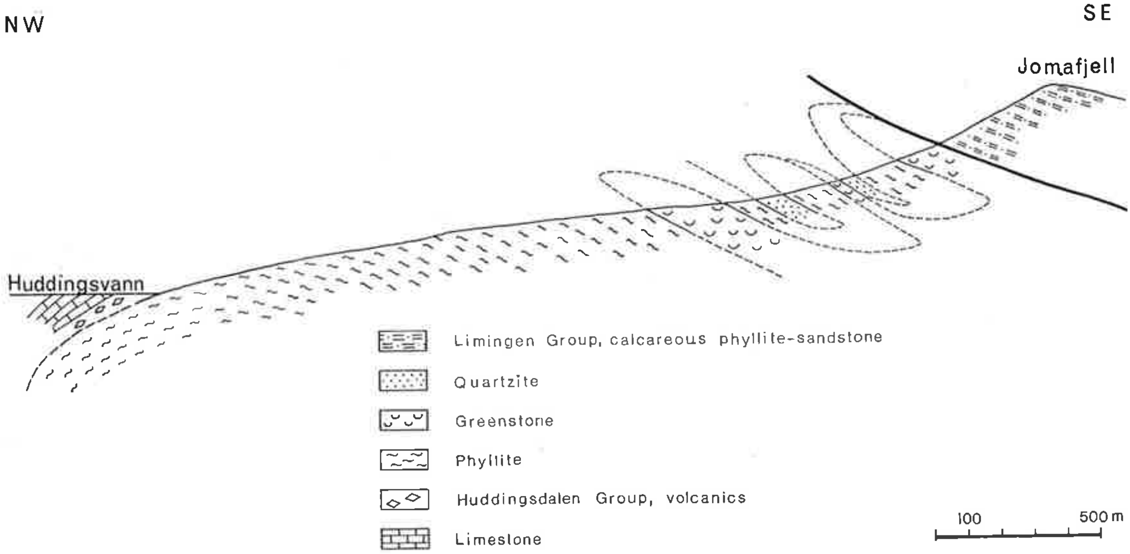

Fig. 4. Section C–C′ through the Røyrvik Group Jomafjell–Huddingsvann. The section line is shown in Plate 1.

of Botneelva shows graded bedding with progressively younger beds away from the quartzite.

This simple stratigraphy would demand the presence of early isoclinal folding on all scales. This is also a view held by Roberts (pers. comm. 1974). The occurrence of fairly profuse, small-scale F_1 folds, especially in the area from north of Botneelva and southwards to Limingdalen, is confirmatory evidence for this interpretation. If the picture given above is correct, the banded phyllite (2) and sandstones, which are mostly associated with quartzite, would represent an older part of the phyllite unit. The homogeneous phyllite (1) would then represent a younger part. The graphite-rich rocks in eastern Limingdalen reveal an eastward increase in organic material.

The position of the above-mentioned greenstone near the Huddingsdalen Group could be explained either by tectonic displacement or by its representing a younger volcanic event.

4. *The Portfjell quartzite conglomerate/quartzite* occurs only in the southern area. The conglomerate has closely spaced, flattened clasts of quartzite in a mica-rich semi-pelitic matrix. Southwards, the clast content decreases and finally disappears, and the rock there is a medium-banded quartzite.

Intrusives are scarce in the Røyrvik Group. Just east of Joma there is a large elongate body of serpentinite, while southwest of Gåsvann there are small metagabbros and serpentinites.

The Huddingsdalen Group

A thick pile of volcanic rocks, here termed the Huddingsdalen Volcanics, occurs in both the southern and the northern areas. In the former (Nordli), there is a supposedly older sedimentary unit between the volcanics and the Røyrvik Group, whereas in the northern area (Huddingsdalen) there is a sedimentary formation, informally called the Rantser Formation, between the volcanics and the calcareous phyllites of the Renselvann Group. In the south the Huddingsdalen Group pinches out southwestwards to the north of Laksjøen.

1. *Older schists in the southern area.* North of Sandsjøen there are mica schists rich in lime-silicates (hornblende, epidote) ± calcite. In part they are strongly banded with alternating brown layers rich in biotite and green layers rich in lime-silicates. A thin limestone occurs locally.

2. *Huddingsdalen Volcanics.* The Nordli and Huddingsdalen outcrops of this formation, which corresponds to the ore-bearing Stekenjokk Volcanics in Sweden, are rather similar. Green, basic tuffs, often strongly banded with acid, keratophyric tuffs, are the main constituents. Phyllitic bands are common too, as seen in road-cuts in Huddingsdalen, and locally there are thick keratophyres (up to 50 m). Massive lava is a minor constituent. Thin, magnetite chert or jasper bands occur locally, and in Nordli there are also thin graphite phyllites. The metamorphic grade is within the biotite zone. The green tuffs are more or less calcareous, with the mineral composition: plagioclase, calcite, chlorite, epidote ± actinolite ± muscovite ± biotite.

A persistent limestone called the Huddingsvann Limestone (Oftedahl 1974) occurs in the lowermost part of the formation, though between Vekteren and Vestre Vallervann it has tuffs on both sides. It is a banded white/grey, medium-grained and relatively pure limestone. Its greatest thickness, about 100 m, is attained near Huddingsvann; to the west it thins to about 10 m or less.

In the otherwise covered area west of Huddingsvann, several limestone horizons are exposed in some streams. They might well be one and the same unit, repeated by folding. In Nordli the limestone is rather thin and impersistent.

3. *The Rantser Formation — northern area.* This formation is essentially composed of phyllite, with a few quartzites east of Renselvann. North of Vekteren, the entire formation lies between the calcareous phyllites of the Renselvann Group and the Huddingsdalen Volcanics, whereas farther east it is folded together with the volcanics.

Some of the phyllites resemble the most widespread Røyrvik phyllite; soft, grey to black and often graphitic. Most of these phyllites lie close to the Renselvann Group. The most common type, however, is a harder, rather quartz-rich, grey to greenish phyllite with characteristic streaky appearance from alternating quartz and phyllosilicates. This type may be graphitic too. In part the phyllites are somewhat calcareous. The quartzites are greenish and can be transitional into green phyllite.

The Rantser Formation might possibly be considered as equivalent to the

Table 4. Stratigraphy of the Western Complex

8. Calcareous phyllite–sandstone, often conglomeratic 7. Polymict greenstone conglomerate 6. Banded calcareous phyllite/sandstone or siltstone 5. Highly calcareous arkose, partly conglomeratic 4. (Calcareous) arkose, partly conglomeratic 3. Calcareous phyllite, sandstone, siltstone, often banded. Local greenstone, greenschist 2. Highly calcareous conglomerate 1. Polymict conglomerate Local limestone	Limingen Group. Middle (?) and Upper (?) Ordovician
6. Younger greenstone. Mostly Mg/Ca-rich lavas. Minor tuffs and agglomerates. Keratophyres. 5. Middle greenstone. Mostly Fe-rich lavas. Minor tuffs and agglomerates. Keratophyres. Between Limingen and Ingulsvann with phyllite, sandstone, siltstone. Finnbu Formation in Sanddøla: tuff, phyllite, hornblende porphyroblasts schists, quartzite, limestone. 4. Older greenstone. Amphibolitic towards south. Mostly tuffs, minor lavas, local agglomerates. Keratophyres. 3. Homogeneous amphibolitic greenstone 2. Banded amphibolite 1. Banded hornblende gneiss	Gjersvik Group. Lower (?) Ordovician
Mica schist or gneiss, with limestone and amphibolite	Namsen Group. ?Precambrian

Røyrvik Group, its present position being due either to folding or to its belonging to another thrust unit, as is evidently the opinion of Zachrisson (1969: Remdalen Group within the Gelvernokko Nappe). There are, however, reasons for considering them non-equivalent: 1. Other lithologies typical for the Røyrvik Group are lacking, i.e. lava, sandstone, banded phyllite. 2. The distinctly different characters of the most widespread Rantser phyllite and that of the Røyrvik Group.

Intrusives are rare in the Huddingsdalen Group. Small trondhjemites occur southwest of Portfjellet and east of Rantserelv.

WESTERN COMPLEX

Three distinctive groups in an inverted position constitute the Western Complex; the Namsen Group, the Gjervik Group and the Limingen Group.

The litho-stratigraphy of the complex is shown in Table 4.

The Namsen Group

The Namsen Group has been studied in 3 separate areas: on Steinfjell, west of Tromsfjell to Tunnsjødal, and near Grong. In the first two areas only the stratigraphically uppermost parts were visited. The group lies within the *Helgeland Nappe*, at least in the northern part of the district.

On Steinfjell there are brownish garnetiferous mica schists with one or more limestones and several bands of amphibolite. The uppermost limestone is near or at the very top of the sequence. Metamorphism is of lower amphibolite facies. Detailed descriptions of the rocks of the Steinfjell area and their metamorphism have been given by Lutro (1977).

Metamorphism increases southwards and in the Tromsfjell–Tunnsjødal area the rocks are gneissic. The mica gneisses are rather heterogeneous with feldspar-rich bands and numerous pegmatitic veins. They are heavily intruded by granodiorite, the latter sometimes accounting for half of the rock mass. On the south side of Tunnsjødal there is a different, rather homogeneous augen mica gneiss which occupies the core of an isoclinal fold.

In the Grong area, where the group is relatively thin, there are high-grade brownish mica schists which in addition to garnet can also contain kyanite. This is the Namsen Formation of Gale (1975).

The Gjersvik Group

The Gjersvik Group was originally considered as a separate nappe — the Gjersvik Nappe (Foslie & Strand 1956, Oftedahl 1956). Later, Halls et al. (1977) extended the term to include the Limingen Group. The present author prefers to use the name *Limingen Nappe* for these two groups. The Gjersvik Group has been of special interest for prospecting, as it contains most of the mineralizations of the district. It is here divided into 6 fairly distinct units, shown in Table 3. In no area, however, do all the six units occur together.

The group consists predominantly of volcanic rocks, with large masses of intrusives. Basic volcanics, i.e. greenstones and amphibolites, are most widespread but there are also abundant acid and some intermediate volcanics.

Metamorphism increases southwards and westwards, at increasing stratigraphical depths. In the Steinfjell–Gjersvik area, where unit (1) is lacking, units (2) and (3) are probably hornblende rocks within the garnet zone, whereas the three youngest are within the biotite zone with transitions to the chlorite zone. Units (2) and (3) do not appear in the southern parts of the district. The increase of metamorphism is evident in unit (4) which, south of Tunnsjødal, is in the garnet zone. In the Grong area the volcanics are probably in amphibolite facies.

Unit 1. Banded hornblende gneiss. The gneiss occurs from west of Tromsvann southwards as far as Grøndalen. It has a well-developed foliation with alternating bands varying from dark amphibolitic to light quartz–dioritic, the latter also hornblende-bearing.

Although the origin of these high-grade rocks is uncertain, they could well be volcanics; if this is the case, their strongly banded character would suggest that they are tuffs.

Unit 2. Banded amphibolite. The unit is continuous from the northern end of the district to south of Lille Tromselv. It is compositionally and structurally heterogeneous, with bands varying from fine-grained dark amphibolite to rather coarse and massive quartz–dioritic composition. The coarse-grained material often forms irregular schlieren and lenses. Cross-cutting relations were not seen and a possible intrusive origin could not be established; the rock-type is perhaps a product of recrystallisation. Within this unit there are also numerous light keratophyric bands.

Unit 3. Homogeneous amphibolitic greenstone. This unit has a relatively restricted occurrence, from north of Bjørkvann to Tromsfjell. From southern Steinfjell to Tromsdal it is deformed, together with unit (2), in large isoclinal folds. It is a dark green to greenish black, fine-grained rock with a well-developed schistosity. It has a sharp contact with the banded amphibolite (2), but may show a rather diffuse transition into unit 4.

Unit 4. Older greenstone. This greenstone unit is continuous over long distances. It is thickest on Steinfjell, between Tromsfjell and Grøndalen and in the far southwest between Møklevann and Grong.

The unit differs from the two younger greenstone units in that it generally displays a marked banded structure. In the northwest, there is a weak foliation with alternating thin streaks of lighter and darker green material. Actinolite is the main amphibole. Subordinate massive greenstone layers forms a distinctive lithology. Southwestwards towards Tunnsjødal the banding of parts of the greenstone becomes much stronger. In this area the metamorphic grade has increased and dark hornblende replaces actinolite. The bands — mostly of millimetre thickness — are of 3 main types: 1) Light bands, rich in plagioclase ± quartz. 2) Green bands, rich in epidote ± chlorite. 3) Dark bands, rich in hornblende. Brownish, biotite-rich bands are less common. This strongly banded greenstone occurs together with a weakly foliated variety. It seems reasonable to conclude that these rocks were originally tuffs where later metamorphic segregation has accentuated the banding. Segregations in adjacent lavas may also be pronounced, but are much less regular.

In the Skiftesmyr area east of Grong, the unit consists of approximately equal amounts of lava and tuff, the latter exhibiting a very prominent banding. The unit is here subdivided, from oldest to youngest, into: 1. Mainly lava. 2. Mainly tuff. Both these units are non-calcareous. 3. Alternating lava and tuff, mostly calcareous. This division becomes much less pronounced to the west of the Skiftesmyr area.

Acid volcanics, keratophyres, are fairly abundant, and most are markedly schistose and rich in mica; they are thought to have originated as tuffs. They sometimes occur in alternating bands with basic and intermediate material. Somewhat massive homogeneous lavas, metadacites, are subordinate. Agglomerates occur locally.

A thick keratophyre unit, up to 500 m, occurs in 3 areas along strike from each other: in the Tromsfjell area, on both sides of Tunnsjødal, and in Grøndalen. It is found at successively lower horizons within the greenstone. On

Tromsfjell the unit is strongly banded, consisting of acid and intermediate to basic material. Here it comes into contact with the middle greenstone and therefore seems to be the youngest part of the older greenstone. In Tunnsjødal, where the unit is predominantly acidic, it has basic tuffs on each side. In Grøndalen the keratophyre unit clearly underlies the basic tuffs both stratigraphically and tectonically, and is here divided into two parts: an older part with highly micaceous keratophyres, and a younger, strongly banded part of similar complex character to that on Tromsfjell.

From Skorovatn southwards on the east side of Grøndalsfjell the same types of banded volcanics occur. In the Skiftesmyr area there is also a thick keratophyre in the middle tuff unit.

Unit 5. Middle greenstone. This is the thickest unit of the Gjersvik Group. The main, northwestern outcrop is continuous southwards to the upper part of Nesådalen, where it is intruded by a large trondhjemite. To the southeast, three greenstone units within Limingen Group sediments are considered by the present author to be correlatives of unit (5) of the Gjersvik Group. These occur (a) from near Borvann to Ingulsvann, (b) from Gaizervann til Skarfjell and (c) from Blåmuren to the Grong area.

Lavas of basaltic to andesitic composition are the main constituents. They are typically fine-grained and dark green and most are massive to moderately schistose; strongly deformed greenstones may have a pronounced schistosity. Amygdaloid textures are common, very often with epidote as a main mineral. Porphyritic textures also occur, with plagioclase or amphibole as phenocrysts. Epidote-rich segregations are extremely numerous in parts of the volcanics, though mostly rather small (up to 1 dm). Larger examples may possibly represent pillows. Good pillow structures are rare, but are more abundant in the Skorovas area. They have been reported by Lutro (1977) from the Bjørkvann–Gjersvik area.

In the main, northwestern greenstone, basic tuffs and agglomerates are rarely seen. On Møkkelvikfjell and Gudfjelløy, however, they are fairly common. On the southeastern side of Skorovasklumpen tuffs alternate with lavas. In the Gaizeren–Skarfjell belt and in the belt southeast from Blåmuren, tuffs are a major constituent according to Gale (1975). In the latter area, however, they were seen to be subordinate to lavas in the lower parts of Sanddøla. Tuffs are also present in the Borvann–Ingulsvann belt.

In northern parts of the district metamorphism is in the chlorite zone of greenschist facies with transitions to the biotite zone. The greenstones in Grøndalen, which are thought to belong to this unit, are probably garnet zone. The precise metamorphic grade in Sanddøla has not been determined. Main minerals are plagioclase, chlorite, epidote ± amphibole (mostly actinolite) ± quartz ± stilpnomelane ± calcite. The plagioclase is secondary albite, typically with anhedral form and little altered. Both the stilpnomelane-rich greenstones with their characteristic brownish colour, and the quartz-bearing ones are widespread. Biotite may also be present, sometimes together with stilpnomelane.

A high content of opaque minerals, especially magnetite and pyrite, is common, often about 10% of the rock.

Keratophyres are abundant in the northwest, but subordinate in the southeastern belts. They are fine-grained to dense and vary from massive to schistose. The most common minerals are acid plagioclase, quartz, muscovite, chlorite and pyrite. Plagioclase may occur as small phenocrysts. Colour varies from light grey to green. The darker green varieties, which are chlorite-rich, may be transitional to quartz-rich greenstones.

Whether the keratophyres originated from tuff or lavas is often a difficult question to answer, but their typically very persistent occurrence indicates that a greater part are pyroclastics. This view has earlier been advocated by Oftedahl (1958). Locally they are agglomeratic with a somewhat more basic material in the clasts than in the matrix. In a ca. 100 m-thick keratophyre south of Bjørkvann a large part of it is agglomeratic. Thin beds of quartz-rich cherts, containing magnetite or hematite are often associated with the acid volcanics. Other sediments are only seen in the northeastern belt of greenstone within the Limingen Group. At Ingulsvann a major part of the unit consists of phyllites and metasiltstone or sandstone. Like the greenstone they are dark green and thus differ from the adjacent Limingen phyllites. According to D. Roberts (pers. comm. 1975), who considers this particular unit to belong to the Limingen Group, in the area between Tunnsjøen and Limingen approximately half of it consists of similar green sediments with thin layers of tuff and lava. The sediments, like the volcanics, are rich in magnetite.

A further stratigraphical division of unit (5) was attempted in the northwestern area, as far south as Møkkelvikelv. Here a stilpnomelane greenstone, when present, is found between trondhjemite/gabbro intrusives and a thick but impersistent keratophyre. The intrusives are stratigraphically low down in the sequence, not far from the base of the unit. The stilpnomelane greenstone is separated from the intrusives, and generally also from the keratophyre, by the most common greenstone. Thick keratophyres occur west of Tunnsjøen, at Rørvann, between Rørvann and Limingen, and at Gjersvik. The keratophyre at Gjersvik, which is close to an ore body, is situated just below the Limingen Group. Farther west, the thick agglomeratic keratophyre at Bjørkvann is thought to be at the same level. Keratophyres farther to the northwest (Gammelanlia) are also probably located at this stratigraphic level.

The Finnbu Formation. This is a local but thickly developed unit between Bergfoss and Trangen in Sanddøla. It is a tuffitic–sedimentary sequence up to 1000 m thick situated between the middle greenstone and the Røyrvik Group, and consists of greenschists, calcareous schists, phyllites, thin lavas, keratophyres, quartzites and a persistent limestone. Hornblende porphyroblasts are characteristic for large parts of the sequence.

Unit 6. Younger greenstone. This greenstone generally occurs in direct contact with the Limingen Group. Northwest of Gjersvik it is infolded within the middle greenstone. Near Ingulsvann and Skorovatn it occurs in complex folds together with unit (5); in both these areas it has not been mapped in detail, and at Skorovatn only as far west as Øverste Nesåvann.

Unit (6) is typically somewhat lighter and coarser-grained than the middle greenstone, and schistosity varies from weak to penetrative. Mineralogically it differs from unit (5) in usually having much calcite and little or no magnetite and pyrite. Locally, calcite may be lacking, but then the greenstone is rich in actinolite. Stilpnomelane has nowhere been seen. Quartz is usually absent or occurs only in small amounts.

As in the middle greenstones basaltic lava is the dominant lithology. Pillow structures are very common from Ingulsvann to Nesådalen. In many places the pillows are closely packed, constituting the greater part of the rock. Epidote segregations are also widespread in this unit as are amygdales. In addition to epidote, the amygdales are often rich in calcite.

Basic tuffs and agglomerates are more local in occurrence. A ca. 100 m-thick agglomerate is situated west of Havdalsvann.

Acid igneous rocks are abundant. Some are fine-grained keratophyres, similar to those in units (4) and (5), and are thought to have originated as tuffs. A greater part of these rocks, however, are somewhat coarser and mostly show a porphyritic texture. In some places they penetrate adjacent rocks and are thus clearly intrusive. Most of them, however, are considered to be of extrusive origin. Intercalated with the acid rocks there are also thin agglomerates and layers of magnetite–quartz-bearing chert or jasper. The great majority of the acid rocks seem to belong to one and the same stratigraphical level. In the Ingulsvann–Skorovas–Nesådalen area they occur at the base of unit (6) and in the west they are more continuous than the greenstone itself.

Amphibolites near Grong. To the west of a basement anticline at Trangen the volcanics of the Gjersvik Group are at their highest metamorphic grade (amphibolite facies), and it is difficult to decide to which unit they belong Approaching the anticline from the east, the middle greenstone is thinning whereas the older one is thickening; this suggests that the greater part of the amphibolites belong to unit (4). Near their base there is a distinctive unit rich in calcite, with abundant hornblende porphyroblasts, which well might be a continuation of the Finnbu Formation. A limestone which occurs locally between the amphibolite and the Namsen schists might correspond to the limestone of the Finnbu Formation, or possibly to the limestone found in the Namsen Group on Steinfjell.

Intrusives. The volcanics of the Gjersvik Group are intruded by a large variety of plutonic rocks; indeed, the intrusives are approximately as widely distributed as the volcanics. Acid and basic rock-types predominate, but there are also intermediate members. The basic rocks have gabbroic to dioritic compositions, often with minor amounts of quartz. Metagabbros are most widespread, gabbros occurring only in the southwest. The acidic rocks are trondhjemites and granodiorites. Quartz diorites, somewhat more basic than the trondhjemites, show transitions to diorite.

The intrusives were emplaced either earlier than, or contemporaneously with, the first deformation phase. They often show a foliation parallel to the schistosity of the adjacent rocks.

For purposes of description, the intrusives can be divided into 3 provinces: northwestern, northeastern and southern.

1. Northwestern province. The intrusives of this province are medium- to fine-grained granodiorites and metagabbros/diorites and occur within units 1 to 4. The granodiorites are mostly pink in colour due to the presence of microcline, though the latter is subordinate to acid plagioclace and its content may be as low as 5%. The intrusives form concordant sheets, some of great size (Plate 1). The granodiorites also occur as numerous small bodies. They also penetrate the metagabbros and are thus the youngest intrusive rocks. In addition to these basic to acid intrusives there are some minor serpentinites in the banded amphibolite of unit 2 on Steinfjell.

2. Northeastern province. Trondhjemites and metagabbros/diorites, often in close association in the same massif, are the main intrusives. They occur within the greenstone units 4 to 6.

The intrusives form large plates sub-concordant with the enclosing rocks. They are mostly in the lower parts of unit (5) and partly (in southern areas) between this and the older greenstone. However, some eastern trondhjemites, on Lillefjelløya and Gudfjelløya in Tunnsjøen, and on Slåtfjellet north of the lake, occupy a higher position. Both on Lillefjelløya and on Slåtfjellet the trondhjemites are in contact with the Limingen Group: on Slåtfjellet the contact is tectonic. In Nesådalen small trondhjemite bodies penetrate the Limingen sediments.

The trondhjemites are light grey and mostly medium-grained to rather coarse. A characteristic feature is that of quartz aggregates. Most of the trondhjemites are strongly acidic. Somewhat less acidic parts of a large massif at Tunnsjøflyene are hornblende-bearing. Fine-grained and even dense varieties may occur in the outer zones of large massifs or in smaller bodies. As in the northwestern province, trondhjemite may penetrate adjacent greenstone and metagabbro as numerous small bodies.

The metagabbros/diorites are probably shallow intrusives. They are typically fine-grained and may be difficult to distinguish from greenstone. Some of the massifs are heterogeneous, varying from very fine-grained and greenstone-like to somewhat coarser, from equigranular to more or less porphyritic. True greenstones occur as inclusions. Smaller bodies of medium-grained metagabbro may have sharp contacts against the fine-grained rocks.

The amphibole in the metagabbros is always dark green hornblende and the plagioclase varies in composition from oligoclase to labradorite. These minerals are subhedral and strongly altered, in contrast to the amphibole and feldspar in the adjacent greenstones. One of the gabbro massifs, on Skorovasklumpen, has been studyed by Halls et al. (1977). On account of the fine grain nature of these rocks and the fact that they may exhibit amygdale-like textures, Halls et al. considered them to be recrystallized greenstones, and also claimed the existence of pillow structures. A greater part of these rocks, however, have a markedly porphyritic texture. The megacrysts are of plagioclase and are subrounded, and the amygdale-like forms are well-rounded aggregates. The aggregates contain the same minerals as the main host gabbro, although quartz is more abundant and hornblende much less common.

It would seem unwise to state categorically that such textures, in higher grade rocks, are amygdales. Recrystallized phenocrysts could be another interpretation. In the Grong district porphyritic textures are commonly more or less rounded and they may be recrystallized to grain aggregates. Even if they were real amygdales, this does not necessarily preclude a shallow intrusion origin. In the present author's opinion, it seems unreasonable to consider such large masses of higher grade rocks of gabbroid textures, closely associated with acidic intrusives and distinctly bounded from the lower-grade rocks, as recrystallization products of the latter.

In the southernmost of these composite intrusives, the so-called Skorovas arc, the metagabbro is mainly medium-grained.

3. Southern province. This province consists of two massifs, the Grøndalsfjell massif and a large southern massif which is predominantly basic in its northern part (the Heimdalshaugen Gabbro), but mostly acidic in the south and east (Foslie 1958, 1960).

Both these massifs, though mainly in their interiors, contain gabbros with layered structures. According to Halls et al. (1977) the composition of the layered rocks in the Grøndalsfjell massif varies from olivine gabbro (troctolite) to hypersthene gabbro. Most of the intrusives, however, are altered to hornblende gabbro or diorite. They are predominantly medium-grained, but fine-grained, dark metagabbro of the same type as in the northeastern province is found in peripheral zones. In the Grøndalsfjell massif, at Skorovaselv, the medium-grained, paler gabbro penetrates the fine-grained gabbro.

In the northern peripheral part of the Grøndalsfjell massif, north of Skorovaselv, there is a quartz diorite with transitions into the basic rocks. It is less acidic than the trondhjemites from the northeastern province, with abundant hornblende and less quartz. It also lacks the characteristic quartz aggregates of the trondhjemites.

Along and to the south of Skorovaselv, the Grøndalsfjell massif is clearly thrust over the Skorovasklumpen metagabbro. At the northern end of the massif, at Småvatnan west of Tunnsjøflyene, the relations are different. Here, quartz diorite from the Grøndalsfjell massif and trondhjemite from a large massif at Tunnsjøflyene occur in synforms and are underlain by the fine-grained Skorovasklumpen metagabbro, which is associated with the Tunnsjøflyene trondhjemite. Dykes from the quartz diorite in the west and from the trondhjemite in the east, penetrate the gabbro. It therefore seems that here the two massifs are closely connected.

The acidic rocks of the large, southern massif are trondhjemites similar to those in the northeastern province (Foslie 1958). Some parts are hornblende-bearing. Further information on these rocks must await their detailed mapping.

The Limingen Group

This group is composed mainly of sediments deposited under relatively unstable conditions. These include calcareous phyllites, metasandstones, siltstones, arkoses and conglomerates. Banded phyllite/metasandstone or metasiltstone is a characteristic lithology. Conglomerates occur in many horizons throughout most of the group, and contain boulders and pebbles from the underlying Gjersvik Group. Volcanic rocks are considered to be rare. Eights units have been distinguished in the Limingen Group (Table 3).

In banded rocks, graded bedding may be well developed, as is the case in the unit (3) tectonically underlying the Gjersvik Group on the north side of Limingen. The graded bedding shows that, in general, the sequence is inverted but in certain zones it is the right way-up, indicating the presence of isoclinal folding. Cross-bedding may be frequent in arkoses.

None of the 8 units is continuous throughout the district. Some of the units show a nearly consistent lithology along the strike, whereas others display strong facies variations. The group as a whole is lacking over a short distance in the lower parts of the Sanddøla area but it reappears near Grong.

The metamorphic grade in the Limingen rocks is the lowest found in the Grong district. It seems to be mainly within the chlorite zone, the lowest part of the greenschist facies. The main minerals in samples from north of Limingen are quartz, muscovite, chlorite ± calcite ± plagioclase. Tourmaline is a characteristic accessory mineral. Clastic textures are common, especially in the arkoses. Near Grong the metamorphism is distinctly higher, and biotite is common. As the rocks in this area are difficult to place within the stratigraphy shown in Table 3, they are described separately.

Unit 1. In the Ingulsvann–Havdalsvann area there is a thin, impersistent limestone at the base. The rest of the unit consists mostly of a polymict conglomerate with a dark green matrix rich in chlorite. The clasts are mainly of eruptive rocks, greenstone, gabbro and trondhjemite; others are of jasper, quartzite and highly calcareous rocks. At Havdalsvann the conglomerate has thin calcareous sandstones interbedded.

The conglomerate is lacking over long distances. It is continuous only from Ingulsvann to Øvre Nesåvann, where it also attains its greatest thickness, up to ca. 500 m. At Nesåvann the clasts are smaller and the conglomerate grades into an arkose.

Unit 2 is a calcareous conglomerate with limestone clasts in a matrix varying from impure limestone to highly calcareous phyllite. The clasts may be fairly angular, so that the rock shows transitions to a breccia. Beds of limestone occur locally in the middle of the conglomerate. At Havdalsvann, thin calcareous sandstones and phyllites are interbedded. The conglomerate has a restricted occurrence, but where it appears it is usually very thick, up to 500 m or more. Like the basal conglomerate it is continuous from south of Ingulsvann to Øvre Nesåvann. It is also thick in the area from Nouna to south of Vekteren, where it thins markedly and eventually pinches out.

Unit 3 shows pronounced lateral facies variations. Between Nouna and Vekteren there is a basal zone with dark green phyllite and greenstone, partly conglomeratic. The rest of the unit north of Limingen is mainly a lighter green banded phyllite and metasandstone. A local greenstone, dark green and fine-grained, is similar to the Gjersvik greenstone, unit (5). At Småtjern this greenstone lies close to the Gjersvik greenstone and may possibly represent an infolded part of the latter. (The area between these units is drift-covered.)

Farther south this unit (3) lithology becomes gradually less dominant while thin-bedded grey phyllites and siltstones, the latter often highly calcareous, increase. South of Limingen they are the predominant lithologies. These facies variations show that the depositional conditions were quieter in southern parts of the district. In the Sanddøla area there are also green schists rich in plagioclase in this unit; these are probably tuffs.

Unit 4 is a light grey to greenish-grey meta-arkose to sandstone, which is quite homogeneous throughout the whole district. It is partly conglomeratic, the clasts consisting of quartzite, locally phyllite, and varius eruptives. Zones rich in trondhjemite clasts are characteristic. In the area between Havdalsfjell and Blåhammeren a thin phyllite overlies the arkose.

This arkose is the sediment within the Limingen Group which, apart from the basal conglomerate, has least calcite; the mineral may be completely absent.

Unit 5. This lithology is similar to unit 4, with sandstone to arkose, but is highly calcareous and greenish to brownish in colour. In places it is conglomeratic with clasts of quartzite and some eruptive rock-types.

Unit 6 is a brown to green, banded phyllite/metasandstone or siltstone. The banding varies from the millimetre to the metre scale.

Unit 7 is a polymict conglomerate but has in fact been termed a greenstone conglomerate (Foslie 1958); it is continuously exposed from Borvann to south of Havdalsvann. It has a dark green matrix. The clasts, which are closely spaced, are mainly of greenstones and other eruptive rock-types but also include jasper, epidote and quartzite.

Unit 8 is a relatively uniform lithology and continuous from the far north to the upper part of Sanddøla. It is a green-grey sandstone to phyllite, often rather massive and resistant. Large parts of it, especially the upper beds, are more or less conglomeratic. Most of the clasts are light-coloured; quartzite, trondhjemite, keratophyre, limestone and other calcite-bearing rocks. Less abundant are dark-coloured clasts of gabbro, greenstone and jasper.

At this point it is worth noting a controversial issue; that of the stratigraphical position of the greenstone which is situated centrally within the Limingen Group sediments between Borvann and Ingulsvann. As noted earlier (p. 23, 24) in the present interpretation this mixed greenstone/metasediment is considered to be a correlative of the middle greenstone (unit 5) of the Gjersvik Group. D. Roberts (pers. comm. 1974–75), mapping in the area between Limingen and Tunnsjøen, found many examples of cross-bedding in the arkoses (units 4 and 5 of the Limingen Group) on both sides of the greenstone. These structures appear to indicate that the greenstone/sediment unit forms part of a continuous succession with more or less consistent southeastward younging, thus agreeing with the stratigraphies of Foslie (1958) and Oftedahl (1956, 1974).

While these observations are difficult to deny, the present author still believes that this mainly volcanic unit (the Devik greenstone of Oftedahl, 1974) is part of the Gjersvik Group. Isoclinal folding is considered to be the main explanation, producing repetition of the arkose units, even though this is partly in conflict with the sedimentary structural evidence. Also, on the east side of the greenstone one has the same sequence of Limingen sediments (units 3–8) as that flanking the main mass of the Gjersvik greenstones. South of Ingulsvann the greenstone/sediment unit — here terminating in an antiformal fold — dips beneath unit 6 of the Gjersvik Group which in turn underlies the basal conglomerate of the Limingen Group. Figs. 5a and 5b show cross-sections through the Limingen Group; Fig. 5a is from the area between Limingen and Tunnsjøen, and Fig. 5b from north of Limingen.

Intrusives. In Nesådalen a trondhjemite occurring in the Gjersvik Group locally penetrates the Limingen Group sediments.

The Limingen Group near Grong. The higher-grade aspects of the Limingen metasediments west of the Trangen anticlinal is especially noticeable in the pelitic rocks, which are often rich in biotite. Other lithologies are sandstones, conglomerates and arkoses. The conglomerates generally lie close to the amphibolites of the Gjersvik Group (Gale 1975). As in other parts of the Grong district the metasediments are often calcareous. On the map (Plate 1), the Limingen Group in this area has not been subdivided.

The Brakkfjell Phyllite. This phyllite, occupying the core of the large Grense synform and tectonically overlying the Røyrvik Group, is a rather monotonous, brownish-grey, banded, calcareous phyllite/sandstone. It is thus of a similar lithology to some of the units of the Limingen Group; however, it is not identical to any of them and is quite different from unit 8 which is the nearest Limingen unit in the Joma synform. It is perhaps closest in lithology to unit 6.

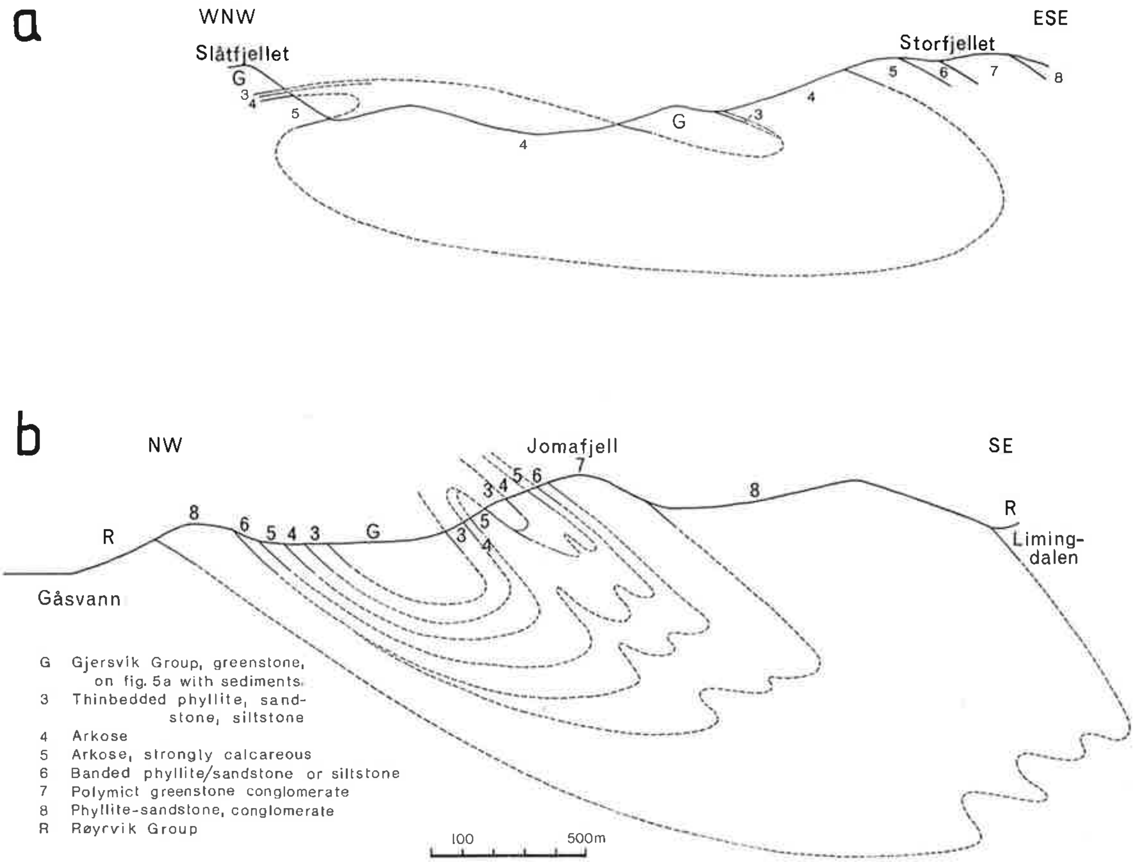

Fig. 5. Sections through the Limingen Group. a) D–D′ midway between Limingen and Tunnsjø. b) E–E′ Gåsvann–Limingendalen. Section lines in Plate 1.

In common with the Limingen phyllites it has a lower greenschist facies mineral composition of quartz, plagioclase, muscovite, calcite and chlorite. Tourmaline is among the accessories. Clastic textures are common.

In some places, way-up criteria near the contact with the Røyrvik Group were noted. South of Østre Vallervann on the west side of the synform and in Sweden on the east side, there is often discordance between bedding and schistosity. These criteria show inversion. The same is true of good younging evidence — graded bedding and erosion channels — at Seterbekken east of Limingdalen (4 km north of Limingen). These criteria indicate that the phyllites are in a similar tectonic position to the inverted Limingen Group in the Joma synform. It would seem improbable that the Brakkfjell Phyllite can be older than the Røyrvik Group, because of its lower-grade metamorphism; it is therefore tentatively placed within the Limingen Group. It should, however, be noted that nowhere has any marked tectonization been recognized along the contact with the Røyrvik Group. A tectonic boundary must be assumed if the Brakkfjell Phyllite really does belong to the Limingen Group.

MINERALIZATIONS

The Grong district has a great number of ore occurrences, though most of them are small. The two largest, Joma and Skorovas, are being mined today, but production at the latter is likely to cease in 1980. Two others, Gjersvik and Skiftesmyr, which have been investigated in detail, were found to contain marginal ore quantities. Joma is situated within the Røyrvik Group, the other three in the Gjersvik Group.

Mineralizations occur within three main associations: volcanic, intrusive and sedimentary. The volcanic one is indisputably the most important. The mineralzations are mainly stratiform and most of them are regarded as syngenetic, originating from volcanic exhalations and deposited as chemical sediments. A majority of the mineralizations are situated within the Gjersvik Group. Here they are generally closely associated with acidic, keratophyric tuffs and lavas, agglomerates and jasper or magnetitic chert. Other mineralizations, including those in the Røyrvik Group, have no association with acid volcanics.

The so-called 'vasskis' or Leksdal type mineralizations (Carstens 1920) have a distinctly primary aspects. They are rather thin but often very persistent. Typically, they lack base metals, consisting only of pyrite and/or magnetite, often strongly banded. From this type there are many transitions to the abovementioned large deposits, rich in minor elements such as copper and zinc. Earlier, these larger deposits were regarded as epigenetic, but Oftedahl (1958a, 1958b) considered them to be of primary exhalative–sedimentary origin, taking into account among other things their mainly concordant occurrence and commonly banded appearance. Their dimensions were explained by their proximity to the original source of the metals.

The Skorovas ore body has been studied by Gjelsvik (1960, 1968) and Halls et al. (1977). These authors reported a rather complex mineral distribution pattern and noted local discordances. Gjelsvik preferred an epigenetic mode of formation. Halls et al. recognised distinct primary sedimentary textures, but also textures which have to be explained by later deformation. The local discordances were explained by isoclinal folding.

The fact that both the Joma and the Skiftesmyr deposits are situated in large fold structures should indicate that they were affected tectonically. The Gjersvik deposit also occur within a large fold, but this is a rather symmetrical and open structure.

In this account, the mineralizations are dealt with in stratigraphical order as far as possible. No other systematic study has been undertaken. Besides the writer's observations, information from other contributors to the project has been used, together with observations from Oftedahl (1958a). Abbreviations used in text are: mt – magnetite, py – pyrite, po – pyrrhotite, cpy – chalcopyrite, sph – sphalerite, ga – galena, pn – pentlandite.

I. Hartkjølen Group.

Musutangen, near the eastern end of Kvesjøen. Mineralizations in amphibolite, possibly intrusive, in the core of an antiform, below granitized gneisses. Po, py, cpy, pn.

II. Nordli Group.

A. Volcanic association. Løvsjøli. Mineralizations in calc-rich hornblende rocks, with po and/or py, cpy. At one of the prospects most of the mineralization is within a small body of massive quartz–garnet–hornblende rock of intrusive appearance. Outside this area there are many rusty, poorly impregnated zones in amphibolites, in some places with massive rocks similar to those at Løvsjøli.

North of Huddingsdalen, local py or po impregnations in keratophyre within banded volcanics.

B. Sedimentary association. Only in the Nordli area: in the Kverno Schist (1) south of Kvesjøen extensive zones with poor py impregnation, and in the fine-grained schist (2) locally massive, but thin po beds.

III. Renselvann Group.

On the western side of Renselvann in calcareous phyllite, unit 4, several small, but locally rich mineralizations, with po, cpy and sph.

IV. Røyrvik Group.

A. Volcanic association. Joma deposit. Within the greenstone of the 'inner arc', where this is very wide, close to the axis of the Joma synform. Py, po, cpy, sph. Mineralizations also above and below the main horizon.

The 'outer arc' on Orklumpen is slightly mineralized, the richest locality being at the base of the greenstone, with po and minor cpy. Between Jomafjell and Seterklumpen scattered, thin py impregnations, most of them near the top of the greenstones.

One rich prospect, in Borvasselv, with po, py, cpy, sph and ga. This is one of the very few occurrences in the Grong district which contain Pb in more than trace amunts.

B. Sedimentary association. In graphite phyllite in Limingdalen and between Joma and Seterklumpen, impregnations of po or py, partly also thin, massive po layers, occasionally minor cpy.

V. Huddingsdalen Group.

Only small and poor mineralizations with no base metals in the volcanic formation in the Nordli area.

VI. Namsen Group.

North of the Steinfjell tunnel, small occurrences, with py and minor amounts of cpy.

VII. Gjersvik Group.

A. Volcanic association.

1. Unit 3. From northern Steinfjell to Lille Tromsvann, scattered

layers with py ± mt, often associated with thin graphite schists.

2. Unit 4.
   a) Mineralizations in the Skiftesmyr area. Many localities with varying mineralization in a large, antiformal structure. The richest ones, including the main deposit, have py, po, cpy and sph. Most of them are associated with a large, central keratophyre. Mineralizations associated with smaller, peripheral keratophyres have predominantly py.
   b) Mineralizations associated with a thick keratophyre unit in 3 areas west of Tunnsjøen: at Grøndalselv, Småvatnan and Lille Tromselv. The keratophyre appears successively higher up in the greenstone, from south to north, from the base of the unit at Grøndalselv to near unit 4 greenstone at Lille Tromselv. At Grøndalselv two adjacent prospects, with py and/or po, cpy and sph. In the Småvatnan area small occurrences with only py or po.
      At Lille Tromselv one main Pb-bearing prospect, with py, cpy, sph and ga. Other prospects have only py ± mt. Also extensive py impregnations.
   c) Mineralizations close to unit 5, associated with thin keratophyres. A southernmost area at Grøndalsdammen at the east of Tunnsjøflyene. Small prospects with py, po and minor cpy, and an adjacent zone with py impregnation. In the Småvatnan area small occurrences with py ± mt ± po.
      Prominent zone in a large synformal structure from Voldtjernbekken northeast of Småvatnan around Møkkelvikfjell to Hausvik. Mineralization varies from only py ± mt to po- and cpy-bearing types. Near Hausvik unit 4 greenstone seems to pinch out. The southern part of the zone at Hausvik is, at least tectonically, at a higher level than the rest of the zone. Northwest of Bjørkvann thin zones, one of them cpy-bearing.
3. Unit 5.
   a) Lower part, northwestern belt. Mineralizations are mostly close to large intrusives, all of them poor with little or no base metals. Examples are: Selbekken southeast of Bjørkvann, py and mt. Langvann north of Tunnsjøflyene, py, po, minor cpy. West and north of Stalvik, py.
      On the western side of Østre Lillefjellet, south of Grøndalen, persistent zone with py and mt with adjacent py impregnations. Geochemically, the area has unusually high Zn-values.
   b) Upper part, northwestern belt. A great number of occurrences, many of them associated with thick keratophyres. At Gjersvik, the keratophyre is close to the boundary with the Limingen Group.
      Most of the zones have py and/or mt, minor po and little or

no base metals. Two parallel zones northeast and east of Bjørkvann, Gammelanlia and Halvveisberget, respectively. Ausvatn farther north, with py and minor cpy. More zones at Holmmo west of Tunnsjøen and on Mariafjell northeast of the lake.

Gjersvik deposit. In an open symmetrical synform, with py, po, cpy and sph. At Lillefjell, north of Gjersvik, extensive py impregnations.

Gjersviktjern south of Gjersvik. Py, sph and cpy.

Visletta northeast of Tromsfjell. Parallel zones with py, sph and cpy.

c) Southeastern belts. These have only minor keratophyre. Northern belt. South of Borvann more zones with py and mt. One of the occurrences, at Devikvann, also with cpy.

Gaizeren – Skarfjell belt. Extensive py impregnations between Langløftvann and Reinsjøen, and on Skarfjell. Rich, but thin mineralizations south of Sydlige Gaizervann.

Southern belt. West of Langtjern, cpy. Finnbuelv, py, cpy, sph.

d) Finnbu Formation, Sanddøla, Finnbu deposit. In greenschist east of Finnbuvann: Py, cpy and sph. Godejord. Persistent zone in calcareous hornblende schists (volcanics?). The main deposit in the eastern part has a very complex mineralogy, atypical for the Grong district. Py, cpy, sph, ga, bornite, tetrahedrite–tennantite, Cu–Sn sulphide, Ag–Cu–Te sulphide, electrum (Bergstøl & Vokes 1974, Bergstøl 1977). Farther west only py and cpy. Stordalshaugen. North of the western end of the Godejord zone, py and sph.

4. Unit 6. Skorovatn area. Long, intermittent zone associated with acidic pyroclastics and lavas between Ingulsvann, Skorovatn and Nesådalen (Halls et al. 1977). In western parts of the area the unit 6 greenstone is often lacking, so that the acidic rocks are occurring within unit 5 greenstone. Skorovas deposit. Py, cpy and sph. Outside the ore body mostly only py ± mt or hematite, cpy locally.

   Mariafjell. A large number of occurrences, with mt ± py.

   Kirma nortwest of Gjersvik. Persistent zone with py, po and mt.

5. Amphibolites near Grong. Rosset. Close to the Limingen Group. Py, cpy and sph. Hotjern south of Gartland.

B. Intrusive association.

1. Basic intrusives. Storpluten, Mariafjell. At the contact between greenstone and a small metagabbro. Py, po, pn and ccp.

   Lillefjellklumpen deposit. Within the Skorovasklumpen metagabbro, at the contact with a greenstone xenolith. Po, pn and cpy, Pe-bearing (Foslie & Johnson Høst 1932).

Within the Grøndalsfjell massif and on Nesåpiggen in the large southern massif in banded gabbro, scattered, minor mineralizations with po, pn, cpy, py and mt (Halls et al. 1977).

2. Acid intrusives. In or near trondhjemites in the Gaizeren–Sanddøla area, molybdenite in quartz veins or as thin films on small fractions, together with py ± cpy (Gale 1975). A northern area is at Sydlige Gaizervann, a southern one southwest of Skarfjell in the large, southern trondhjemite massif.

VIII. Limingen Group.
Langvika south of Tunnsjøen. Cpy impregnations in arkose (unit 3?).

Structural geology

During the course of the author's mapping in the district, little attempt was made to make any systematic study of the tectonic structures on mesoscopic and microscopic scales. This account is therefore concerned mainly with the larger-scale structures — folds, thrusts and nappes — which bear upon the regional geological interpretation.

FOLDS

From Plate 1 it can be seen that the main strike trend over most of the district is NE–SW. Dips are generally towards the NW, although in a central belt from Jomafjell southwestwards to between Skorovas and Skarfjell, the dip is mainly southeasterly. These relationships are shown in the cross-section in Fig. 2. In the Huddingsdalen and Sanddøla areas dips are mostly towards the north.

This generalized picture is much complicated by abundant folds. In the absence of detailed structural studies, these will here be divided simply into (a) early folds and (b) late folds. In brief, the 'early' structures are those which formed at the same time as the main schistosity whereas the 'late' folds include a variety of structures which post-date the schistosity.

Early folds, F_1. These are tight to isoclinal folds with the main schistosity paralleling their axial planes. Over large areas and especially in the massive greenstones, small-scale F_1 folds are generally difficult to recognize. Most commonly they are seen in banded formations, tuffs or sediments. Other structures of this deformation phase include mineral lineations, stretched pebbles in conglomerates and boudinage.

In the central belt, broadly coinciding with that mentioned above but a continuation into the Sanddøla–Grong area, the main trend of F_1 folds and lineations is ca. NE–SW. To the west and east, F_1 axes are mostly from N to NW; north of Huddingsdalen directions are from NW to W.

The extent of larger-scale F_1 folds is often difficult to estimate. Within the Gjersvik Group, on Lillefjell, the stilpnomelane greenstone and ordinary greenstone of unit 5 appear to be involved in early folding, while on southern Steinfjell large isoclinal folds affecting the amphibolites of units 2 and 3 and cut by a thrust may belong to this early phase. Between Møkkelvikfjell and Småvatnan there are smaller F_1 folds in the thick keratophyre of unit 4. In a large antiform of later age in Grøndalen, greenstones of unit 4 and 5 are repeated, probably due to F_1 folding.

In a central area, from Huddingsdalen to Nesådalen, early folding plays a more important role. In the Mariafjell area between Limingen and Tunnsjøen, and in the Skorovatn area, zones of acid rocks of the Gjersvik Group, clearly affected by F_1, can be followed over long distances (Halls et al. 1977). Reconnaissance mapping of the greenstone units 5 and 6 north and west of Ingulsvann also appears to demonstrate the existence of large-scale F_1 folds.

In the Røyrvik Group in the Huddingsdalen–Limingdalen area, large-scale F_1 folds are believed to account for repetition of the stratigraphy (p. 18). The outcrop pattern of the uppermost quartzite zone southwest of Joma also indicates the presence of medium-scale early folds. Over a distance of 2 km about 20 quartzites are lying lit-par-lit. Repetition of some lithologies within the Nordli Group in the Nordli area is considered to relate to F_1 folding. In the Sanddøla–Grong area no definite large-scale F_1 folds have been recoznized (Gale 1975).

Late folds. Folds which deform the regional schistosity are of a variety of styles and trends. In the Grong–Sanddøla area Gale (1975) distinguished 5 separate phases of post-schistosity folds. Lutro (1977) has described 4 such fold phases from the Gjersvik area.

The most common folds of this group, here named F_2, are small-scale, open to tight folds varying from symmetrical to highly asymmetrical. Axial planes are moderately to steeply dipping and axes mostly trend NE–SW. North of Huddingsdalen fold axes are mostly E–W, locally with N–S cross-folds.

Folds with gently inclined axial planes, up to 20–30°, may be abundant in the Limingen Group (including the Brakkfjell Phyllite), the Røyrvik and Huddingsdalen Groups. In the Limingen Group they are often the dominant small-scale folds. These folds nowhere attain larger dimensions, and are considered to be gravitational structures formed on the flanks of larger F_2 folds (D. Roberts, pers. comm. 1974) and post-dating the latter.

Later folds, here called F_3, are less common. They are gently to open folds with vertical axial planes. In the Sanddøla–Grong area the axial trend is NW–SE. At Skiftesmyr, they are more common and are seen to have refolded the F_2 folds. In the Nordli area some of these folds are aligned roughly N–S, others about E–W, and may belong to diferent phases. Farther north, between Skorovatn and Gjersvik, there are some very open folds aligned about N–S, i.e. somewhat oblique to the main axial direction of the F_2 folds.

Large-scale post-schistosity folds have not been separated on an age basis in this account. The axial planes traces of the major 'late' fold structures are shown in Fig. 6. Some of the principal folds are as follows:

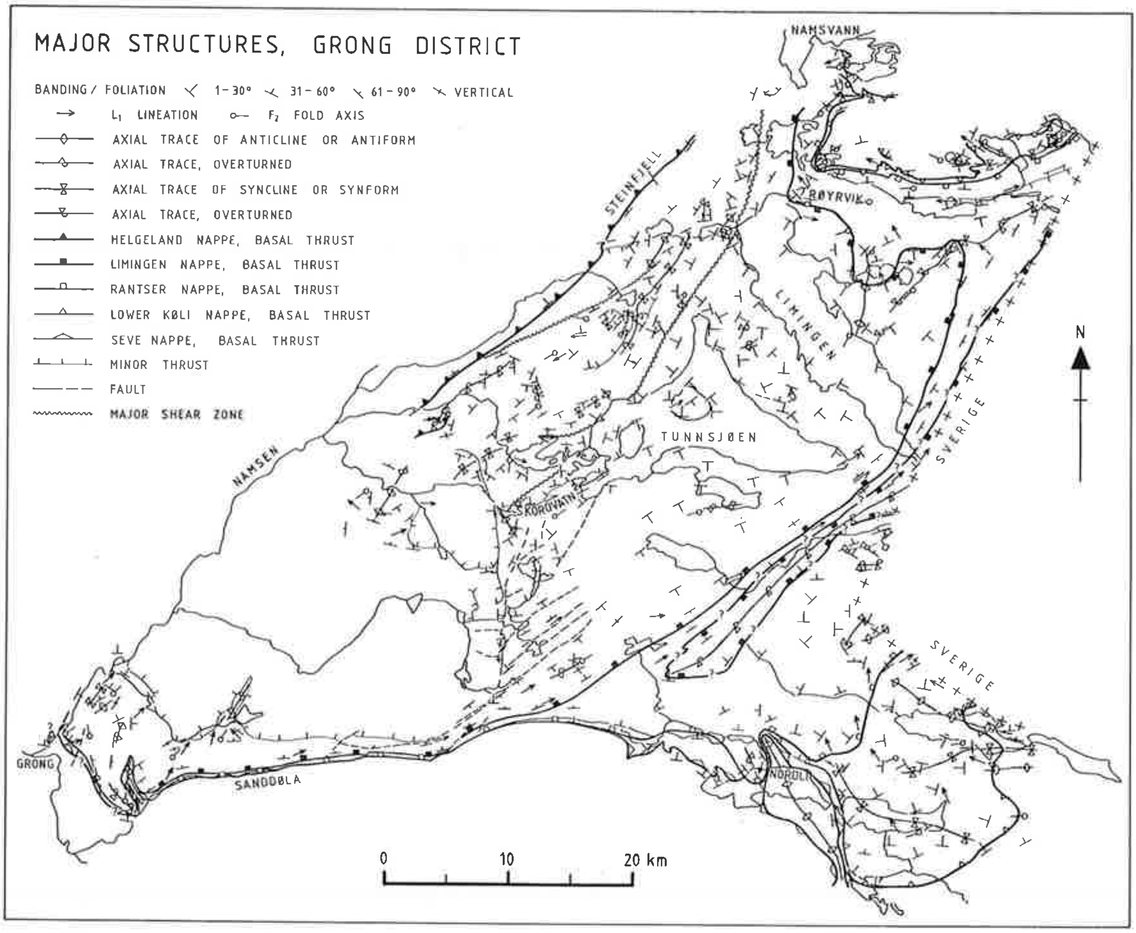

Fig. 6. Major tectonic structures of the Grong district.

1. In the Nordli area, open to close folds on E–W to SE–NW axes cause marked swings in the outcrop pattern. At Laksjøen, Nordli, Precambrian basement occupies an antiformal core.
2. The Grense synform, with Brakkfjell Phyllite in its core (p. 30). This has a NE–SW trend and is overturned mostly towards the southeast. It extends into Sweden where it has been described by Nilsson (1964).
3. Several synforms and antiforms with E–W axial trend occur in the area north of Huddingsdalen.
4. Between Huddingsdalen and Limingen the stratigraphy is inverted, with the Limingen Group overlying the Røyrvik Group. This inverted succession is deformed by the N–S-trending, open, symmetrical Gåsvann antiform and the NE–SW-trending, asymmetrical Joma synform. In the northeast the Joma synform is mostly overturned towards the southeast whereas south of Jomafjell the overturning is to the northwest. South of Limingen the mixed greenstone/sediment, here considered as unit 5 of the Gjersvik Group (p. 23), is believed to lie in the extension of this synform.

5. In the Gjersvik Group west of Limingen and Tunnsjøen, open synforms and antiforms have axes trending from E–W to NE–SW. Many of the synforms have trondhjemite and metagabbro in their cores. On Mariafjell and south of Skorovatn, F_1 folds are deformed by late folds including the major NW–SE antiform which folds the Skorovatn 'intrusive arc'.
6. Other major synforms and antiforms occur southwest of Tunnsjøflyene, south of Tunnsjødal and south of Grøndalen.
7. In the Sanddøla–Grong area, a NNE–SSW antiform at Møklevann is overturned to the east. Nearer Grong, late folds trend from NNW–SSE in the south to NE–SW in the north. Those in the south are near-isoclinal and are overturned to the west: an anticline near Trangen exposes basement gneisses in its core.

THRUSTS

As mentioned earlier, clear and continuous tectonic boundaries are scarce in the Grong district. It is believed, however, that several thrusts are present, and that the lack of visible tectonization is due to later recrystallization eradicating the effects of the earlier phase of thrusting. Thrust planes are also deformed by late folds.

In Fig. 2 and Plate 1, the main thrusts which separate the complexes are distinguished from those separating groups within the same complex. Some features in the basal parts of the nappes are considered below. Stratigraphical arguments which justify the existence of these nappes have already been mentioned and will not be repeated here. Minor nappes are also described.

The Seve Nappe. This nappe separates crystalline basement from younger rocks. The boundary between the basement and the Hartkjølen Group in Nordli is strongly tectonized on the eastern limb of the Laksjøen antiform. The same is true at Otersjøen, farther west, where the contact is again exposed. At Gosen, however, tectonization is not much in evidence.

The relationship between the Precambrian basement and the Namsen Group near Grong is less clear. A pronounced mylonite zone which may represent a thrust occurs along the eastern side of the Trangen anticline. Farther west there is little or no tectonization to be seen, and the contact may be less sharp, possibly due to later granitization.

At Gollomvann in the north, the contact between the Børgefjell massif and overlying rocks is moderately to weakly tectonized. No direct discordance was recognized, but the fact that different stratigraphic levels are in contact with the massif indicates a slight regional discordance. Farther northeast, according to Strand (1953, 1956), clear discordant tectonic boundaries are present in some places.

No tectonization has been recognized between the Dærgafjell Group and the Hartkjølen Group; consequently they are both placed within the Seve Nappe. This differs from relations reported in neighbouring areas in Sweden where according to Zachrisson (1969) the Dærgafjell Group equivalent belongs to a lower nappe.

The Lower Køli Nappe. Along the eastern side of the Laksjøen antiform the tectonic character of the rocks of the Nordli Group is very pronounced with mylonitization and large discordances at the base of the nappe. One rock unit after the other is cut out. The area farther east is unfortunately very sparsely exposed. The contact to the underlying Hartkjølen Group is exposed in Hartkjølselva east of Sandsjøen, but no tectonization has been observed there.

North of Huddingsdalen there are clear tectonic contacts at Storbekktjernene southwest of Dærgafjell; discordance can be seen at one locality, to the west of the lakes. Above the thrust are rocks of either the Nordli or the Renselvann Group, below it either the Dærgafjell or the Hartkjølen Group. Outside this area only minor tectonization is present. An indication of the existence of a nappe is given, though, by the occurrence of a thin and impersistent Hartkjølen Group. Greiling (1975) also recognized a thrust at this level. Contrary to Strand's (1956) view he considered all the rocks underlying this thrust to be autochthonous. His interpretations, however, were mostly based on aerial photo studies and only rather superficial field investigations.

The Rantser Nappe. On the north side of Huddingsdalen the boundary between calcareous phyllites of the Renselvann Group and the Rantser phyllite of the Central Complex is very well marked topographically. The calcareous phyllites form a cliff, and the boundary is rather straight with distinct tectonization in some places. In the Nordli area the contact between the calcareous phylllites and the overlying Huddingsdalen volcanics is only rarely exposed.

Within the Rantser Nappe rather extensive thrusting has obviously taken place at the northern and eastern contacts of the Huddingsvann Limestone with the volcanics. Both in Lybekkdalen in the east and between Skånali and Krokvann in the extreme northwest the limestone is mylonitized, in the latter area together with the underlying volcanics. In one section in Lybekkdalen, in a stream northeast of Vestre Vallervann, the volcanics are strongly mylonitized in a rather wide zone (more than 100 m), but here at some distance from the limestone.

The Limingen Nappe comprises the Limingen Group and the Gjersvik Group. Although it corresponds to the redefined Gjersvik Nappe of Halls et al. (1977), the term Limingen Nappe is preferred, both to stress that it is not the same as the Gjersvik Nappe as originally defined by Oftedahl (1956), and because the Limingen Group occurs at the thrust front. The tectonic character of the boundary between the Røyrvik and the Limingen Groups was first recognized by Foslie at Seterklumpen and Jomafjell (1923, p. 34, 38). Later this view was accepted by Strand (1956), for the area north of Huddingsdalen, and by Oftedahl (1956). The boundary between the two groups is generally very well marked topographically. Often the Limingen schists form a cliff in the landscape. Mylonitization in a narrow zone (minimum 1 dm thick) close to the contact is common and can be seen, though not everywhere, from Vekteren in the north to the Trangen area in Sanddøla. Further detailed mapping of the

Røyrvik Group in the area north of Limingen has revealed minor discordances. At Gåsvann and in Limingdalen, rocks of the Røyrvik Group strike obliquely to the contact and are cut out. Direct discordance along the contact has been seen at only locality, southeast of Seterklumpen.

Oftedahl's (1956) Gjersvik Nappe consisted of just the Gjersvik Group. In general, however, there is no tectonization to be seen between the Gjersvik and Limingen Groups, and the basal conglomerate of the Limingen Group with its clasts of Gjersvik Group rocks is evidently in its original position. Oftedahl (1956) recognized tectonic contacts at the northern side of Limingen, between Limingen and Tunnsjøen, and at Nesåpiggen. However the tectonization at Limingen is along a late, steep shear zone which only locally follows the boundary between the two groups, and the thrusting between Limingen and Tunnsjøen, and at Nesåpiggen, is located below intrusives. These intrusive rocks are very often bordered by minor thrusts due to a different competency compared with the supracrustals.

A thrust contact is thought to be present between the two groups at Nouna near Namsvann. There, a calcareous conglomerate is tectonically overlain by Gjersvik greenstone. This thrust possibly continues southwards from Nouna. Rocks of the Gjersvik Group are striking NE–SW, whereas the boundary between the two groups trends N–S. Discordance at the very contact has not been recognized, but the contact is rarely exposed. A late shear zone also partly follows the boundary here. Possibly it represents a reactivation of an earlier thrust plane.

Minor thrusts, most of them occurring below intrusives, are rather common from the Tromsvann area and southwards to Møkkelvikdalen. The Grøndalsfjell massif farther south is at least partly in thrust contact with adjacent rocks. There is also a distinct tectonic contact along the western side of the Skorovas intrusive arc; in the south greenstones overlie the intrusives, but further north according to maps by Halls et al., rocks from the Skorovasklumpen massif are overlying the arc. These authors extended the thrust contact under the massif to the north of the arc.

The large, southern intrusive massif also locally has tectonic contacts with the surrounding rocks. Where the rocks have steep attitudes it is often difficult to determine whether tectonization is due to early thrusting or late faults. Possibly, later faulting may have been controlled by earlier thrust planes.

An E–W thrust on Steinfjell is distinguished from the other thrusts by its younger age. It transects different units of the Gjersvik Group, which in this area are isoclinally folded.

The Helgeland Nappe. On Steinfjellet the rocks along the boundary between banded amphibolites of the Gjersvik Group and the Namsen schist are tectonized over a fairly wide zone. The contact between the two groups may be rather diffuse, both lithologically and topographically. There are amphibolite bands in the Namsen schist, and the difference in metamorphism is less marked. The boundary often runs along the tops of small hills or in the hillside. The nappe character is thus indistinct. This is different from areas farther to the north, where according to Strand (1956) and Gustavson (1973) there is a very distinct thrust contact. Gustavson observed, however, that the intensity of thrusting diminished southwards.

In an area farther south, from Tromsdalen to Tunnsjødalen, the thrust character is even less clear; no distinct tectonization has been recognized. In this area both the Namsen schist (gneiss) and the adjacent hornblende gneiss of the Gjersvik Group are intruded by numerous small bodies of granodiorite. These are deformed by structures of the F_1 phase. Thrusting should accordingly be older than this deformation.

Similarly, in the vicinity of Grong no marked tectonization has been observed along this boundary. Outside the mapped area, however, in Gartlandsdalen (ca. 10 km north of Grong) and Fiskemdalen (ca. 1 km north of Grong), very distinct tectonization may be seen in road-sections. In Gartlandsdalen, there is mylonitic limestone and Namsen schist, whereas the Gjersvik Group, which is supposed to overlie the limestone to the east, is not exposed. In Fiskemdalen west of Harran, the contact between mylonitic limestone and overlying rock is exposed. This latter is a medium-grained, foliated hornblende rock, a possible intrusive. It was called hornblende gneiss by Foslie, and mapped as the continuation from Grøndalen of the banded hornblende gneiss of unit 1 of the Gjersvik Group. However, the Grøndalen gneiss is markedly different from the hornblende rock in Fiskemdalen. In conclusion it is recommended that the continuation of the Helgeland Nappe southward from Steinfjell towards Grong should be studied more closely.

FAULTS

Most parts of the district seem to be little influenced by late high-angle faulting, but larger fractures of different trends are common. In many areas, E–W fractures predominate. The majority exhibit little or no tectonization and only small displacements have taken place. This is also the case with some extensive and prominent NE–SW shear zones in the northwestern area. The shear zones are somewhat oblique to the rock boundaries.

The area most influenced by faulting is that between Skorovas and Sanddøla. The majority of the faults trend between N and NE. According to Halls et al. (1977) most of the faults in the area north of Nesåpiggen have only small displacements of the order of metres, but along a fault between greenstone and basal Limingen conglomerate displacement was estimated to be about 500 m. Some faults in the Sanddøla area show displacements in the order of 100 m and one along the border of the trondhjemite is estimated at 1000 m (Gale 1975).

Comparisons with neighbouring districts

In Table 5 the the tectono–stratigraphic succession of the Grong district is compared with that in the adjacent Västerbotten–Jämtland region in Sweden (Zachrisson 1964, 1969, Sjöstrand 1978) and with the sequence in the northern *'able 5.* Stratigraphic correlation with neighbouring districts in Sweden, and with northern parts of the Trondheim :gion. Abbreviations: Form – Formation, amph – amphibolite, calc. – calcareous, cgl – conglomerate, phy – phyllite, asch – garben schist, gsch – greenschist, gst – greenstone, ke – quartz keratophyre, lst - limestone, msch – mica :hist, sch – schist, sh – shale, sst – sandstone, volc – volcanics, qu – quartz, quartzite

	Grong district (this paper)	Northern Jämtland (Sjöstrand 1977)	Northern Jämtland – southern Västerbotten (Zachrisson 1964, 1969)	Meråker–Stjørdal area (Wolff 1967)
?Precam.	NAMSEN GROUP msch, lst			GULA GROUP msch
Ordovician	GJERSVIK GROUP gst, ke LIMINGEN GROUP phy, sst, arkose, cgl			STØREN GROUP gst, ke HOVIN GROUP sst, phy, lst, sh, cgl, volc.
Cambrian	RØYRVIK GROUP phy, sst, qu, gst Brakkfjellet calc., phy, sst. Ordovician	Røyrvik Group phy, gst Brakkfjället calc., phy Brännälven Formation phy, gst, gsch, cgl	REMDALEN GROUP phy, gsch, qu, porphyry, lst, calc., phy	SONVATN GROUP msch
	Portfjell qu. cgl	Portfjället qu, cgl	Remdalen qu. cgl	Gudå qu.cgl
Ordovician	HUDDINGSDALEN GROUP phy, lst, gsch, ke Rantser phy, qu	Skogsbäcken Volc. Form. phy, lst, gsch, ke Haraön phy	LASTERFJÄLL GROUP ke, gsch phy, gsch	FUNDSJØ GROUP gst, ke SULÅMO, l. Fundsjø cgl GROUP calc. sst, phy, gst.
Ord.–Sil.	RENSEL-VANN GROUP calc. phy, sst	Blåsjö Form. calc. phy	Lasterfjäll calc. phy	KJØLHAUGEN GROUP phy, sst, cgl SULÅMO GROUP. Silurian sh, sst
Ordovician	NORDLI GROUP gasch amph, qu, cgl, amph, msch, qu, cgl, gasch, lst amph, ke, gasch Kvemo sch	gasch Holand Form. amph. ke Kvemoruet qu Björnhögen Form. Ankarede Volc. Form. Kvemo msch Kvarnbäcken qu, cgl	? Bellovare Form. gsch, lst, Voitja qu, qu.cgl. TJOPASI GROUP phy, sst, cgl, lst gsch, ke phy serp. and qu.cgl	
		Lillvattnet Form. gasch msch, amph	Varied sed. and volc. rocks	
?Precam.	HARTKJØLEN GROUP msch, amph, qu, mica gneiss	SEVE UNITS		

part of the Trondheim region (Chaloupsky & Fediuk 1967, Wolff 1967). Because of supposed repetition of units in northernmost Jämtland, Zachrisson distinguished the higher Gellvernokko and Leipik Nappes above a Lower Køli Nappe. Rocks from the Lasterfjäll Group, including the Blåsjø calcareous phyllite (in this paper within the Renselvann Group) and the overlying volcanics of the Huddingsdalen Group, were claimed to occur within both the Lower Køli and the Gellvernokko Nappes. The Remdalen Group, correlated with the Røyrvik Group, and with the Portfjell Conglomerate at its tectonic base, was thought to be repeated in all three nappes.

The present author's mapping in the Huddingsdalen area combined with reconnaissance investigations farther northeast, from Orrevannet to east of Leipikvattnet, casts doubt on this tectonic repetition interpretation. The presence of calcareous phyllites of the Renselvann Group within the Gellvernokko Nappe could not be ascertained. As Zachrisson (1969) also noted, the gabbro intrusions, so typical for the calcareous phyllites of the lower nappe, are lacking. On the other hand, phyllites corresponding to the Rantser Phyllite of the Huddingsdalen Group are very widespread. As noted earlier, these are partly calcareous and arguments were put forward against their correlation with the Røyrvik Phyllite (p. 20).

A second main constituent of the Gellvernokko Nappe are the volcanics of the Huddingsdalen Group. The phyllites and volcanics occur in alternating zones. As these two lithologies are so clearly folded together at Huddingsdalen, this interpretation was also thought to apply in the Swedish area. In addition to typical Rantser Phyllite there is, however, also a banded phyllite/sandstone unit atypical for this formation, and other phyllites which from their field appearance could equally well belong to the Røyrvik Group as to the Rantser Formation.

The rock unit previously mapped as the Portfjell Conglomerate has been studied south of the eastern end of Orrevannet, here belonging to Zachrisson's Lower Køli Nappe, but there is clearly no Portfjell Conglomerate present in this area. In a lithology belonging to the Rantser Formation, with alternating quartzitic and phyllitic layers, the quartzitic layers are often sheared out tectonically, thus giving the rock the appearance of a conglomerate.

The importance of Zachrisson's Leipik Nappe is difficult to estimate, but it is probably of minor order. At its base, at Leipikvattnet, there are mylonitized volcanics, corresponding to the Huddingsdalen volcanics. The mylonite zone is at least 100 m in width, from the Bjurälv Limestone (the continuation of the Huddingsvann Limestone) and downwards. Most probably this is a continuation of the mylonite zone exposed in a stream northeast of Vestre Vallervann, which could not be followed further west. But as mentioned above there are also thin mylonites at the base of the limestone.

The basal unit of Zachrisson's Lasterfjäll Group is the Voitja Conglomerate. From Sjöstrand's map and descripions (1978) this Voitja horizon is the continuation of the quartzite occurring within the amphibolites of the Nordli Group. Included in Sjöstrand's Blåsjø Formation is the uppermost of the garben schists in Nordli. From the relationships in the Nordli area this would not seem to be acceptable, for two reasons. Firstly, the same type of garben schist is repeated further down in the Nordli Group. Secondly, the real Blåsjø Phyllite, which is found only at one level, is quite different from the garben schist. A feature which they have in common is that of the presence of hornblende porphyroblasts, but these are larger in the garben schist. The groundmass of the Blåsjø Phyllite is much richer in biotite and poorer in muscovite and calcite than that of the garben schist.

Between the Blåsjø Formation and the Skogsbäcken Volcanic Formation, Sjöstrand reported the occurrence of phyllites, called the Haraön Phyllites, which are only partly calcareous. From the present studies these phyllites are thought to correspond to the Rantser Phyllite.

Above the base of the Køli rocks Sjöstrand did not recognise any major tectonic line. He considered there to be a line of inversion in the central part of the Blåsjø Phyllite separating rocks in normal position to the east from rocks in inverted position to the west.

Moving south to the Trondheim region, the author is personally familiar only with the southwestern parts, the Surnadal–Meldal–Rennebu–Trollheimen area. From literature studies and discussions with I. Rui it is evident, however, that the region as a whole has a somewhat similar rock succession to that of the Grong district.

The region has a complex structure with a central antiform and flanking synforms (Roberts 1978), with the Gula Group, probably corresponding to the Røyrvik Group, in the axial zone. Contrary to the Røyrvik Group, the central parts of the Gula Group are high-grade rocks of amphibolite facies. To the west of the Gula Group the volcanic Støren Group and the mainly sedimentary Lower and Upper Hovin Groups have been correlated with the Gjersvik and the Limingen Group, respectively (Oftedahl 1974), though they occur in different tectonic situations. Whereas the Limingen Group is in direct contact with the Røyrvik Group, the Hovin Groups occupy synclinal structures within the Støren Group, partly with the youngest Horg Group, of Silurian age, in their cores (Vogt 1945). To the west of these groups, which together constitute the Trondheim Supergroup (Gale & Roberts 1974), there are high-grade mica schists and amphibolites, which should in all probability be correlated with the Namsen Group.

To the east of the Gula Group there is a volcanic unit, the Fundsjø Group or Hersjø Formation, in the same position as the Huddingsdalen volcanics. This formation is followed by mainly sedimentary units which are comparable with the Rantser Phyllite — the Sulåmo Group in the Meråker area (Chaloupsky & Fediuk 1967), and similar formations in the Røros area. Farther east are gabbro-intruded schists of the Kjølhaugen Group and the Røros Formation, respectively, which are probably correlatable with the Renselvann Group.

Above the Kjølhaugen Group in the Meråker area there is a unit containing dark phyllites, the Slågan Group (Siedlecka 1967), in which fossils of Llandoverian age have been found (Getz 1890). Based on sedimentary structures

Siedlecka (1967) concluded that Kjølhaugen schists on either side of the Slågan Group are older than the latter.

The Slågan Group probably correlates with the Broken Series of Kulling (1933) in the Björkvatnet–Virisen area in Västerbotten; both these units are of similar age and lithology. This would then mean that there would be disagreement between this interpretation and the right-way-up structures in the Blåsjø Phyllite to the west of and above the Broken Series. This was also mentioned by Gee & Zachrisson (1974). The Kjølhaugen Group is in thrust contact with rocks considered to be of Precambrian age; that is, the base of Wolff's (1967) Trondheim Nappe.

Since the early investigations of Kjerulf (1871) the tectonic structure of the Trondheim region has been controversial. Most workers have linked the rocks on either side of the central Gula Group by fold structures, some advocating synclinal models, others anticlinal (for a review, see Roberts 1967). Thus the Støren volcanics have been correlated with the volcanics to the east of the Gula Group, and the Hovin and Horg Groups with the easternmost formations, the entire sequence constituting the Trondheim Supergroup of Gale & Roberts (1974). The Gula Group has also been correlated with the high-grade rocks to the west of the Støren volcanics. A diverging theory was put forward by Wegmann (1925) who regarded the Gula Group as being thrust over the rocks now occurring to either side of it. Gale & Roberts (1974), on the contrary, concluded that the ocean floor volcanics of their Støren Nappe were thrust upon the Gula prior to the later, Silurian folding. In recent years an anticlinal or antiformal model with flanking synclines has been preferred (Wolff 1967, Roberts 1967, 1968, Olesen et al. 1973); here the Gula is the oldest unit, itself constituting a nappe (Roberts 1978). I Rui, who studied the Røros–Gauldalen area, has also considered the rock sequence to be younging away from the Gula Group (1972, 1975). He considered the Gula Group to occupy the core of a large recumbent fold (in E. Rohr-Torp 1972). Recently, however, based on sedimentary structural evidence, he has doubted this inversion (pers. comm. 1978).

From a study of the literature, it is difficult to know if the differences between the western and eastern parts of the Trondheim Supergroup in the Trondheim region are as great as in the Grong district. To emphasize the difference between the volcanics on either side of the Røyrvik Group it should be mentioned that due to the strongly banded character of the Huddingsdalen volcanics, Foslie & Strand (1956) failed to recognize them as volcanics at all, and mapped them as Limingen schists. In marked contrast to these are the massive Gjersvik greenstones to the west of the Røyrvik Group. The Limingen Group and the rocks to the east of the Huddingsdalen volcanics are essentially quite different, although banded Limingen Phyllite have a similar lithology to the Blåsjø Phyllite.

Within the Trondheim region, correlated western and eastern rocks are nowhere seen to meet directly. This is also the case with the central Gula Group and the high-grade western Gula schists, which should probably be compared with the Namsen Group. In the Sanddøla area the Røyrvik Group meets the Namsen Group, but the contact is tectonic and the two groups are of different metamorphic grade.

Additional support for considering the western and eastern rocks of the Trondheim region as being of different derivation appears to be provided by faunal evidence. Lower to Middle Ordovician fossils from western parts of the region are known to have predominantly American affinities (Strand in Holtedal 1960, p. 157, Neuman & Bruton 1974). Fossils are unfortunately scarce in the eastern part of the region, but in the extreme south–east the Otta serpentinite conglomerate contains a fauna of predominantly Baltic affinity, with only a subordinate American element (Jaanusson 1973). Using this information Gee & Zachrisson (1974) considered that the Gula and Fundsjø Groups were separated by a thrust. This is at a different level to the proposed thrusts in the Grong district. At that time these authors correlated, as has been customary, the Gula Group with the high-grade rocks to the west of the Støren Group. In a later paper Gee (1977), however, extended the Seve Nappe into these western rocks. This is a similar conclusion to that drawn in the Grong district, where the eastern Hartkjølen Group of the Seve Nappe is considered to be correlated with the western Namsen Group; but as stated earlier, the thrust character of the basal contact of the Namsen Group is far from clear and moreover the group here extends into the high-positioned Helgeland Nappe.

The Namsen Group is of great thickness, contains large intrusive massifs of granodioritic to gabbroic composition, and can be followed to the coastal parts of northern Namdal and southern Helgeland (the Lower Cambro–Silurian division of Kollung, 1967). In Namdal it is isoclinally folded with Precambrian basement. Low-grade rocks within the Helgeland Nappe, both sediments and volcanics, occur on island of Leka (Prestvik 1974). From an area farther north in Helgeland, at Skålvær, Gustavson (1975) has described low-grade rocks within the Helgeland Nappe surrounded by high-grade rocks. These may possibly be correlated with eastern Køli rocks.

Still farther north in the Sulitjelma district (known personally to the author), schists corresponding to the Renselvann Group occur in great thicknesses, as the Sjønstå and Furulund Groups, with the Sjønstå Group tectonically below. In the Sjønstå Group the Muorki Schist is a hard and massive, greenish, somewhat calcareous phyllite with intercalated volcanics, which shows a striking similarity to unit 5 of the Renselvann Group. The lower part of the Furulund Group consists mainly of thin-bedded grey phyllites, with green calcareous phyllites and volcanics. An upper formation consists of brownish calcareous mica schists with hornblende and garnet porphyroblasts, the greater part of which are strongly banded pelitic/psammitic, like the typical Blåsjø Phyllite or unit 3 of the Renselvann Group.

Corals of uppermost Ordovician or lowermost Silurian age have been found by J. D. Harrison (1976) in the uppermost part of the Muorki Schist. Fossils known from earlier time (Vogt 1927) occur in the lowest part of the Furulund Group; their age is uncertain, from Middle Ordovician to lowermost Silurian.

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