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REGIONAL GEOLOGICAL FIELD MAPPING

IN

THE AREA SOUTH OF KNALLERDALEN (AREA I)

AND

THE AREA OF SALEFJELL (AREA II)

BY

R. H. FINDLAY, B. A: (Oxon)

10.7. - 27.8.1972

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1. THE WORK

Mapping in the region of Baashaugen between Knaller-dalen to the N and Storfjellet 1189 in the SW, and Balvann to the SE was carried out between July 10th and August 15th. As field assistant I had mr. K. Olsen, a norwegian student. Accommodation was in a tent above Balvann, later moved to LK 838 near Balvann.

During this period I used a 360° compass/clinometer, mr. Olsen used a 400° compass/clinometer making the appropriate correction until he lost the instrument. No spare clinometer being available in Sulitjelma, he used a 360° compass for direction, and guesswork for dip.

Between August 15th and 27th the above area was tied into one bounded by Skaitidalen, Salefjell and the NW-shore of Balvann, this area had previously been mapped by Stoakes (1969). Continual cloud cover above 800 to 1000 m prevented mapping on the top of Salefjell.

For field assistant I had mr. H. Finne, a norwegian physics student. Accomodation was in the Skaiti hut, we used 360° compass/clinometers.

Whilst working as field assistant to Kollung (1970.) I had seen all rock groups from basement to the top Skaiti group units in areas bounding the regions. I also had considerable expendience of the Furulund and Muorki groups east of the Sulitjelma region from Muorkivann to Balvann.

The maps have been made from aerial photographs on a scale of approx 1: 16 500. For the area round the Salefjell it is obvious that the plane banked steeply during flight strip R, considerable distortion occurring across photos R 28 - R 30 in panticular. It has been impossible to make precise correction and the map in this region is a "best fit".

2. GEOLOGICAL ABSTRACT

For cace of reference the report is split into 2 parts: Area I, being the area bound by Knaller-dalen to the N, Storfjellet 1189 to the SW, and the NW shore of Balvann. Area II, that bound by Skaitidalen, Salefjell and the NW shore of Balvann.

The regional stratigraphy is given from top to bottom.

Upper Skaiti Group
Lower Skaiti Group
Furulund Group
Muorki Group
Pieśke Marble Group
Lower Mica Schist Group
Turon Quartzite)
Basement) not seen

In are I:

Rocks from the lower mica schist group to the Furulund group are seen, lateral correlation to the eastern regions of Sulitjelma are discussed in chapter 5.

A new unit, a sparagmite/gneiss is seen between the top of lower mica schist group and the base of the Pieśke, just to the N of Baashaugen. This unit thickens across into Knallerdalen.

Immediately to the north of Baashaugen, a part of the Muorki has been folded into the Pieśke group to form a flat lying syncline facing NNW and cross folded by N and NW, trending anticlinal axes. The lower limb of the Pieśke group is sheaved out toward Knallerdalen.

At least 3 phases of deformation are visible in the field, creating complex interference folds on large scale near LK 838.

Metamorphism is of fainly high grade shewring

garnet - biotite - chlorite assemblages in pelitic rocks, and generally epidate - amphibole - chlorite assemblages in basic rocks. Garnet occurs in amphibolite at one horizon, this is atributed to compositional variation and not to increased pressure/temperature conditions. Cyanite is seen at one locality within the Mourki.

Chlorite is seen to pseudomorph garnet commonly, no pseudomorphs of cyanite were seen, although in fine grain. These would be nearly impossible to detect.

Zones of pyrite impregnation occur in the lower mica schist group, and at one locality in the Furulund. They have little economic value.

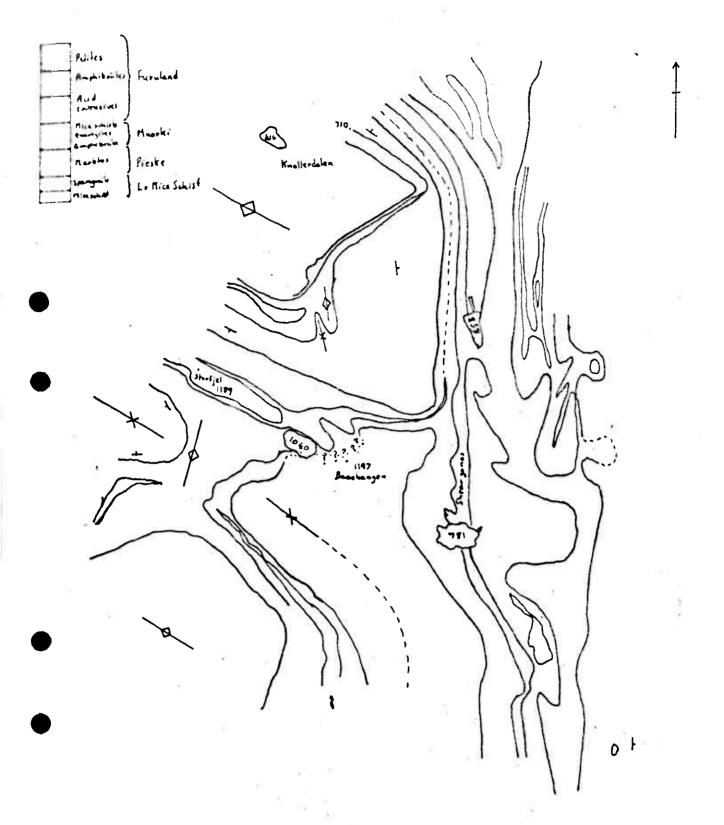
In area II; units from the top upper Skaiti to the top Furulund are seen. The lower Skaiti staurolite schists (Kollung 1971) are found in the stratigraphical position of the Furulund gneiss at Skaitibukta. In the higher units of the upper Skaiti, many Trondhjemite occur at a similar level to Kollung's 1971 augen gneiss zone.

The top units of the Skaiti group lie in a flat lying north facing syncline, the lower limb shearing out towards the NW shore of Balvann, and the top unit here westing on the Furulund.

Gneiss. Cross folding of the syncline is evident at least 3 phases of deformation are apparent in the field.

Metamorphism of high grade shewring commonly staurolite - garnet - biotite assemblages in pelitic rocks, pseudomorphs of cyanite have been seen by presions workers in this and reighbouring areas. Good bladed cyanite was seen by Kollung and myself in 1970 around LK 1053.

Mineralization in the form of finaly disseminated pyrites is seen throughout units of the Skaiti group, a quartzite - sericite zone about 1 to 2 metres wide at about 900 metres height on Salefjell shews pyrites and possibly chalcopyrite. Malachite stones were seen by Finne in shist on the SE of Salefjells. A follow-up proved negative.



Sketch Map, Area 1.

3. THE AREA SOUTH OF KNALLERDALEN - AREA I

3.1. Stratigraphy

The stratigraphy within Furulund and Muorki groups is uncertain on account of tight isoclinal folding and shearing. The Furulund has for convenience been divided into a "Great" and an "Inferior" these two terms are not to be used to imply lateral correlation with any "Lower", "Middle", or "Upper" stratigraphic units suggested by previous authors. For the Muorki, and attempt is made to fit the rocks to a scheme suggested by Kollung (1970) into worked on the same rocks just to the south.

From top to bottom the units are.

Great Furulund

- 1) Biotite muscovite pelites and phyllites.
 Graphite schists. Thin
 quartzites.
- 2) Calcareous banded biotite - muscovitesemipelite. Amphibolite lenses.

Inferior Furulund

Various acid extriesives, Amphibolites.

Muorki

1) Coarse garnet - chlorite rich biotite schist. Biotite-quartz schist + rare garnets and blebs of oxidized pyrites.

- 2) Brown quartzitic shists, yellow weathering (fresh) garnet Z-mica quartz schists, often with biotite porphyroblasts crossing schistosity, and garnet biotite, often chloritic, schists. These units are intimately bedded.
- 3) Brown quartzitic schists, with rare calcareous horizons, and metaconglomerates.
- 4) Grey to green weathering chloritic garnet Z-mica schists, with amphibolite and graphite schist interbeds.

Pieske Group

Marbles, with quartz Z-mica schists near top, and schistose micaceous quartzites near base. A thin amphibolite is seen near the top.

Lower mica schist group

- 1) Sparagmite gneiss with rusty horizons.
- 2) Rusty mica schists, often with rusty sericite horizons, sheering very coarse garnet. Also garnet chlorite Z-mica schists similar to the Muorki. Note: No amphibolites no graphiteschists.

3.2. Petrography

Great Furulund

Biotite - muscovite quartz <u>pelite</u>, grey
weathering, moderately
fossile, well schistose,
often shewring grey
phyllitic bands and
small dark garnet.
Aligned dark amphibole
on schistosity surfaces
is common.

Yellow to rusty grey
weathering biotite
muscovite phyllite, well
fissile, well schistose,
the schistosity planes
shewring much fine
grained muscovite.
Garnet and aligned
amphibole are often
present.

Rusty brown weathering interbed of graphite schists, often looking similar to the phyllites, they are distinguished by a dark fresh break, deeper nesty weathering, a slight purplish tinge in bright sunlight, and are often slightly sulphurous. They sometimes carry garnet.

Grey - brown careous weathering calcareous - banded biotite - muscovite semi - pelite.

Usually reaching with acid, the rock is fine grained well schistose and moderately fissile. Radiating amphibole needles are seem, espesially near the Muorki boundary.

All the above rocks shew quartz streaks and bounding, in numerous instances quartz isocline fold(noses) are seen.

The amphibolites are found within the calcareous banded schist, at the contact with the schist the amphibolite being developed parallel to the schistosity, whilst deeper in the unit a coarser texture is developed with randonly amphibole lying in feldspar.

Inferior Furulund

The acid extrusives are variable, one unit shewring considerable lateral variation.

The most uniform unit is

typically a white to yellow

weathering sheaved fine

grained quartzo - feldspathic

rock shewring little to no

dark mineral and believed to

be a rhyolite. In places

primary light/dark banding is

visible, the dark bands being

due to a prepenclerance of fine

biotite.

The unit may shew dark grey + much biotite on fresh break, and was thought to be a separate rock type until detailed mapping shewed lateral passage to the lighter rock. No thin sections were made.

The variable unit shews the following facies.

- I) Light grey brown weathering, light grey in fresh break, fine grained schistose quartzo feldspathic rock shewring randomly oriented green amphibole needles (10 to 15 %) of variable grain size from 1 to 4 mm. Initial composition perhaps andesitic.
 - II) The above is found to pass into a greenish - brown weathering quartzo - feldspathic schistose rock shewring illsorted clasts with development of crude bedding and fining directions. The clasts are both acidic and basic, the acid look similar to the rhyolitic rock, the basic clasts are amphibolitised. Size is variable from a few millimetres to several inches, long axes parallel to schistosity Schearing of clarts is evident. This unit is thought to be pyroclastic in origin.

- III) Rusty brown weathering
 quartzo feldspathic rock,
 similar to the rhyolitic rock,
 but more bictite, shewring
 development of enough very
 fine magnetite to affect a
 compass needle.
- IV) To the north, passage into a brown careous weathering, medium grained, moderately massive in outcrop, moderately fissile schist occurs. Careous weathering is common, althoug no reaction to acid is detectable The rock typically shews development of yellow weathering amphibole bearing feldspathic bands of maximum thickness l inch, separated by schistose units of 6 inches. The schist shews medium grained biotite muscovite - quartz with development of garnet and amphibole being common. Biotite may occur as perphyroblasts cutting schistosity. In places this unit has been seen to pass into the yellow weathering garnet Z-mica quartz schists of the Muorki, and is therefore maybe the lowest Furulund unit.

The basic igneous rocks are represented by Z-units, an amphibolite and a garnet amphibolite.

The amphibolite is greenish weathering, fine grained shewring large quantities of fine grained green amphibole oriented parallel to schistosity. A variant shews clost of biotite parallel to schistosity lying in a light grey - green feldspatho - amphibolitic matrix. The relations between the 2 variants is uncertain, the fine dark amphibolite is common in areas of intense folding, the biotite bearing variant has been seen at the contact with acidic extrusives, passing into dark green amphibolite away from the contact.

The garnet amphibolite shews much vegetation, weathers brown, and carries red garnet, plagioclare, and black amphibole oriented parallel to schistosity. The outcrop is restricted, association with the streaked variant of the brown extrusive is common. Composition may initially been dacitic to andesitic.

These basic igneous rocks are thougt to represent lava flows of a basaltic nature. No primary textures remain, no thin sections more made.

Muorki

The Muorki shews pelites, amphibolites and graphitic schists. The order of description follows structural and possibly stratigraphical succession.

A greenish weathering chlorite rich biotite quartz schist of
medium to coarse grain size, often
bearing garnet, often shewring
oxidised pyrites. The texture and
structures of this unit are
reminiscent of the green phyllite
described at this level by Kollung
(1970). The unit disappears to the N.

A yellow in fresh break garnet
Z-mica (musc. > biotite) quartz
schist, often having biotite
porphyroblasts cutting schistosity
and interbedded with brown quartzites
sometimes calcareous, sometimes
garnetiferous, also as interbeds
occur grey to green weathering,
garnet - biotite - muscovite,
chlorite - quartz schists, sometimes
carrying amphibole.

The above passes down to a facies rich in white to brown quartzites and quartzitic schists favoured by sparse vegetation.

A grey green garnet - biotite muscovite - quartz schist (biotite>
muscovite) of medium grain size,
shewring thin grey interbeds of
a poorly garnetiferous coarse
biotite - muscovite quartz schist,
and very thin interbeds shewring
ill sorted quartz grains in a grey
background. No bedding structures
were seen.

At a low level within the above. graphitic schists and amphibolites are seen. The graphite schists weather intense rusty brown, shew qwartz fold relics and carry a grey mica. Sulphurous weathering is seen. Association with amphibolites is general and discussed under "Metamorphism". They have been mapped as graphite schists by Knox (1967) and Kollung (1970), this practice is adhered to good graphite schists are seen. Sporadically thoroughout the Muorki. these weather similar to the above, but shew finer grain, little mica, and few quartz relics.

The amphibolites shew generally coarse dark green amphibole in a calcareous sometimes epidate bearing feldspathic and often calcareous matrise. No garnet is seen, it is thought there amphibolites may have been more calcic than those of the Furulund. Their origin is discussed in "Metamorphism".

Coarse 2 mica non garnetiferous non chloritic quartz schists carrying coarse plates of grey mica that may shew a purplish tinge in strong sunlight are common at the top, confusion with the lowest Muorki schists is possible, and the top of the Pieśke was taken as the first marble seen. This was thin.

Pieśke

The Pieśke marble is a brown weathering blue-grey fresh coarsely crystalline crumbly marble, the grains react to HU without crushing and are therefore thought calcic. Fine biotite is seen throughout plates of coarse muscovite confer a schistosity and quartz isocline fold relics are common. Clats of diopside are seen sporadically throughout

Lower in the unit schistose muscovite - biotite bearing quartzites of medium grain size are seen. There interbed with the marble and with Z-mica quartz schists. A pyrite - bearing nesty sericite schist of no economic import is seen at this level.

Lower mica schist: In structural and probably stratigraphic at succassion accur two main units, the top are (sparagmite/gneiss) thickening into Knallerdalen from 20 feet to approx 150 feet.

A massive, grey weathering in outcrop, grey fresh medium to coarse grained schistose often finely fissile crumbly quartz - muscovite sparagmite, shewring commanly white to pink feldspar. Feldspathic bands and streaks occur, 1 to 2 inhes thick, parallel to schistosity and shewring arthoclase. These confers a gneissic texture to the rock, and it was first thouht that this unit was basement gneiss, it does not look in any way similar to the basement gneiss seen near Kragdalen in 1970.

Within this unit at Knallerdalen are found four or five units of a rusty orange weathering quartzitic - sericite schist shewring development of fine pyrites. These units are 2 to 4 metres thick, and thought to be of little economic importance. The rusty schist of the sparagmite unit is first seen as one horizon between the Pieške and sparagmite, its replication and the thickening of the sparagmite towards Knallerdalen is thought due to folding.

The mica schists of lower mica schist are generally very rusty - orange weathering and carry garnet up to 1 inch across. Other minerals present are biotite and muscovite, also seen are grey garnet - biotite - muscovite, chlorite schists similar to those of the Muorki. Within the Muorki mica schists are quartsitic - sericite horizons, of two to four metres thickness occasionally carrying finely disseminated pyrites. There are thought to be of little economic importance.

3.3 Metamorphism

The highest "isograd" seen in all units is the "garnet isograd". The assemblages present in pelitic rocks of the Furulund, Muorki and Lr. mica schist groups are garnet - biotite - muscovite, biotite - muscovite - quartz and garnet - biotite - muscovite - clorite. At one locality in the garnet chlorite schists of the Muorki good bladed cyanite was seen associated spatially with F4 deformation structure.

Cyanite had been seen commanly in certain units of the Skaiti group, but has yet to be described from units below. This has provoked speculation concerning large scale tectonics. Of interest are four points.

- I) Badkar (1972) describes cyanite from the Laphelleren schists above Sulitjelma.
- II) Cyanite seen within the Skaiti group appears to be restricted to one rock type.
- III) These is abudant evidence throughout Mourki and Skaiti groups of retrograde metamorphism.
- IV) The assemblages garnet biotite muscovitechlorite - biotite - muscovite, are stable in pelitic roks pressures and temperatures of the "cyanite isograd", if the initial pelite composition is alumina-deficient cyanite will not form until well above the "cyanite isograd".

The presence of cyanite at one locality within the Muorki and throughout the Lapphelleren schists suggest that these rocks reached "cyanite isograde" conditions, but that either retrograde metamorphism has observed the cyanite in the Muorki, or that the initial composition was such to prevent formation of cyanite at the "cyanite isograd".

Rocks of initially basic composition within the Furulund shew generally a dark green amphibole - chlorite - biotite - plagioclase assemblage, with rare red garnet. A good garnet - amphibole - plagioclase assemblage is seen in the garnet amphibolite of the Inferior Furulund. Within amphibolites of the Muorki and amphibole - epidote - biotite - chistose - plagioclase - calcite assemblage is developed. No garnets are seen. The difference between amphibolites of the Muorki and the Furulund is thought to be one of initial composition, and not of an increase in metamorphic grade upwards.

The calcareous schist of the Furulund shew diopside associated with small quartz filled tension fractures near Knallerdalen. The Pieske shews clots of diopside.

Finally of note are the amphibolite graphite schist contacts seen within the Muorki. Over a distance of two to three feet the garnet - biotite muscovite - chlorite schists become spoltly rusty weathering, with an increase in rustiness nearer the amphibolite garnet may be lost, grey mica develops along with a graphitic appearance, and finally at the contact with the amphibolite on intense rustiness is seen, with commanly much sulphurous weathering. The "graphite schist" may be in one side or both sides of the amphibolite.

This feature has also been observed by Badkar at Sisovann.

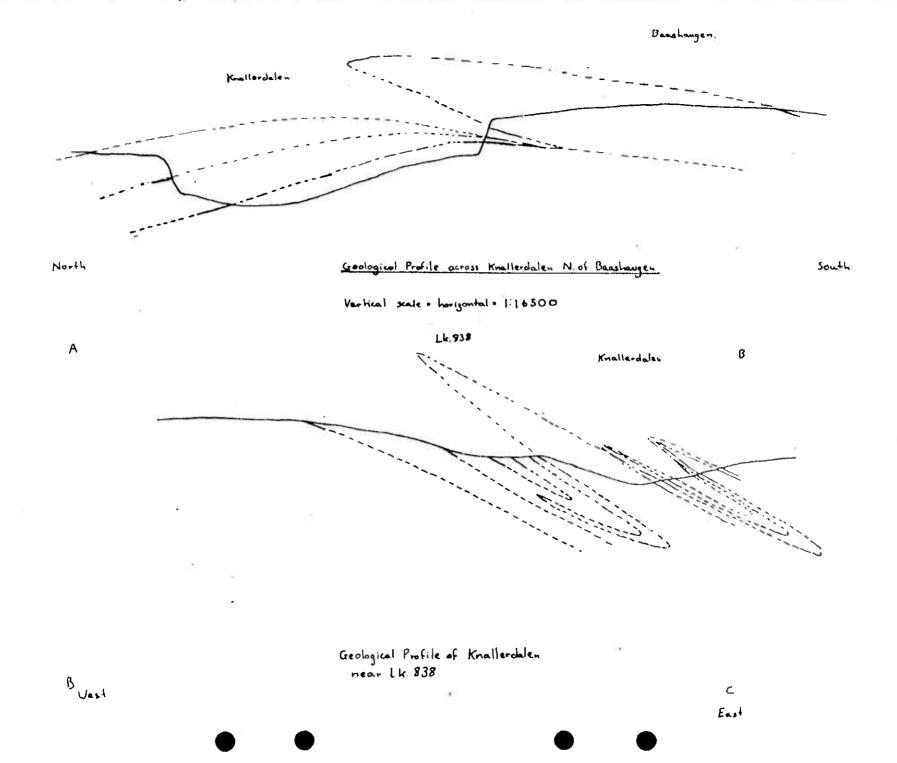
It is thought that this is due to either contact metamorphism of argillaceous units during deposition/intrusion of the basic rock, or that during metamorphism a reaction occurd between the amphibolite and the country rock. If the former is the case then wether graphite schist is an ore or both sides of the amphibolites may be indicative as to whether the amphibolite represents a lava or an intrusive unit.

3.4 Structure

4 phases of deformation are evident in the field.

- F₁. Isoclinal deformation throughout giving rise to isoclinal folds of scale millimetres to kilometres and developing a strong axial plane schistosity.
- F₁ and F₂. Refolding of F₁ isoclines and schistosity by folds of tight to open style. Small scale chevron folds may develop with initiation of a new schistosity, isocline folds on outcrop scale have been seen folding schistosity, and regionally, open folds are developed. Two axial directions are evident NW/SE, and N/S. The time relations between F₂ and F₃ are unclear.
- F₄. Tension craks filled with quartz and dipping 40° to 80 towards 110° 130°, kinking schistosity.

The regional structure is shewn in the sketch map of area!



Within the "Inferior Furulund"

"Christmas Tree" interference patterns are developed, believed due to interference of F_2 and F_3 folds. To the north of LK 838 the calcareous banded pelite of the Furulund is folded into the inferior Furulund extrusive, as these units may have been folded isoclinally prior to development of the present. West-facing isoclines (see profil BC) only a structural succession can be proposed from top to bottom.

Great) Calc banded pelite Furulund)

Inferior) Amphibolite, garnet amphibolite

Furulund) Acid extrusives

Shearing out of units has taken place during folding, as seen just south of LK 838 at the Furulund Muorki bondary. Evidence of isoclinal folding prior to the development of the west facing isoclines of profile B-C is seen in amphibolites close to LK 781, where a rhombohedral fracture pattern is developed, believed to due to the intersection of F_1 and F_2 axial plane clearage at the fold noses.

Profile A-B shews a north-facing syncline, Mourki being infolded into the Pieśke the lower limb of Pieśke being shewred out close to the fold closure. The sparagmite/gneiss thickens across Knallerdalen, probably due to hight folding. Within the Pieśke, schistosity is conferred by large plates of mica, and is seen to be refolded by both open and flatlying tight similar folds. Also evident within the marble are isocline relics picked out by quartz, and in places refolded with the folding of schistosity.

The general structure between Knallerdalen and Kragdalen shews an up-daming around Baashaugen and Kragdalen whilst the Muorki occupies a cross-folded trough between Storfjellet and Kragdalen there structures are ascribed to intersection of F_2 and F_3 , the axial directions being NW/SE and N/S.

3.5 Mineralization and economic importance

Within the lower mica schist group occur several rusty sericitic horizons that shew fine pyrites associated with quartz rich areas. Coarse garnets upto 1½ inches are associated with these bands. Little economic value is attached to these beds. They are of width approximately 6 metres, access is difficult and heavy machinery would have to be flown in. Drilling is expected to yield little of economic use.

A horizon within the inferior Furulund shewed much rust on a white sericitised unit (marked on map) near LK 838. No pyrites was seen on the several occarious, the outcrop was visited. Further exploration here is thought unnecessary, although this unit probably occupies a similar stratigraphical position to the Kong Oscar zone of mineralization seen east of Calmebelle.

Magnetite and pyrite were seen occasionally in the Muorki infold in the Pieśke. Further exploration would be useful in establishing the structure beyond daubt, there is no economic value, although search might be made at Botnvann for magnetite - bearing sand.

3.6 Suggestion for further work

Detailed work on the metamorphics of the Muorki would be useful in solving the "Cyanite Question". Further detailed structural mapping would be useful in establishing a detailed stratigraphy of the inferior Furulund.

Access to the area is best by way of Balvann from Sulitjelma. A direct ascent of Knallerdalen is impossible during met weather as the river rises rapidly and dangerously, one waterfall at least has to be climbed. A tourist track from Saltdal to Baldoaivve exists, the stream into Knallerdalen has to be crossed. This is not advisable in met weather.

4. NORTH OF SALEFJELL, AREA II

4.1 Stratigraphy

Remapping shewed the stratigraphy given by Stoakes (1969) to be incorrect, the revised stratigraphy is given below, from top to bottom.

Upper Skaiti Group Diopside rock (Stoakes' Banded Rock)
Thin quartzite
Rusty crinkled schists (+ cyanite)
Augen gneiss (Trondhjemite found
at similar level)
Rusty crinkled schists (+ cyanite)
Grey staurolite - garnet - biotite
schists
Rusty crinkled schists (+ cyanite)

Tectonic discontinuity

Lower Skaiti Group

Staurolite schist

Tectonic discontinuity

Furulund

Furulund gneiss
Furulund amphibolite
Furulund pelites, graphite schists
and amphibolite horizons

4.2 Petrography

Upper Skaiti group. The diopside rock is a dark weathering dark grey in fresh break fine grained moderately fissile fine biotite bearing semi-pelite. Sometimes found are calcareous bands, at low levels in the unit, apparently related to tight folding are found fine grained light green bands carrying diopside, with sometimes dark green amphibole being developed.

Quartzite. This unit is thin and has been seen to be strongly sheared in place of tight folding. Rare garnet may be developed. The rock is dark hackly weathering in outcrop, and generally dark in fresh break. Grain size is variable. No sedimentary structures remain.

The rusty crinkled schists throughout the V. Skaiti shew great similarity, being rusty red weathering, grey in fresh break, finely fissile, well schistose shewring fine grey mica microfolded to give typically a crinkled apparance. Within this unit are dark in fresh break quartz rich pelitic horizons of several inches to several feet width, often shewring intense rusty brown weathering, and carrying very finely disseminated pyrites. Also seen are marble, thickness varying from inches to several feet, and occasional fine to coarse grained amphibolites. The marbles and amphibolites are generally found near the top of these schists.

An augen-gneiss zone has been described associated with the diopside rock by Kollung (1971). The augen-gneiss lies in the upper unit of the rusty crinkled schist at a similar level to the many Trondhjemites seen. Kollung (1971) has described the mineralogy of both, further comments in this report are made in the structural chapter.

The grey staurolite - garnet - biotite schists are massive in outcrep, grey to rusty weathering grey in fresh break, fissile schistose rocks, shewring isoclinally folded bands in intricate contact rich in either staurolite garnet, or biotite.

Thin bands of a garnet - amphibole - plagioclare rock are also found. It is thought that this unit corresponds to Kollungs 1971 "gneiss - mica - schist". Fine plagioclare being probably distributed sparsely throughout this unit.

Lower Skaiti group. At the stratigraphic level of the Furulund gneiss at Skaitibukta is developed a massive schistose grained biotite - muscovite - quarts schist carrying occasional quartz. Feldspathic blebs and streaks possible small quartz - muscovite psendomorphs after cyanite, and S-surfaces hexagonal lumps up 1" across of what may be staurolite. Coarse muscovite is seen to cross schistosity. This unit has been mapped laterally into the Lr. Skaiti staurolite schist of Kollung (1970,71).

Furulund. At Skaitibukta the top unit is a finaly fissile graphite schist, laterally passing into sericitic zones. About 2 miles west of Skaiti the Furulund gneiss forms the top Furulund unit, passing westward to Storfjellet 1187. Generally a massive rusty weathering biotite gneiss, this unit carries tourmaline and garnet. A very fine grained grey type is developed, associated with tight folding and shearing. At the base of Salefjell, above Loggejokka, the gneiss is sheared and boundinaged with development of much chlorite.

The Furulund amphibolite is a fine grained dark green amphibole bearing amphibolite shewring also biotite, plagioclase, chlorite and rare epidote. If is underlain by a graphite schist, in places sericitised, shewring sulphurous weathering, but no mineralization of note.

The Furulund pelites have been described adequately in this region by Kollung 1970 and 1971.

4.3 Metamorphism

In pelitic rocks the Furulund group shews no higher grade assemblages than garnet - biotite - muscovite. The higher Skaiti group shews cyanite - biotite - muscovite, cyanite, - staurolite - biotite - muscovite, staurolite - garnet - biotite - chlorite - muscovite. Cyanites shews psendomorphing by quartz and muscovite, garnet by chlorite and quartz.

Within the upper Skaiti intimately folded bands shew the following assemblages, staurolite - biotite, garnet - biotite - chlorite, biotite, muscovite is developed throughout. Cyanite may be developed with the staurolite schist. From this evidence it is suspected that composition has been important in determining metamorphic assemblages, and that there is no metamorphic (in terms of pressure and temperature) jump from the Furulund to the Skaiti.

The marbles seen are calcic, no diopside was seen.

The diopside rock shews diopside developed in regions of hight folding, elswhere calcite is more common.

4.4 Intrusives

The dominant intrusive is a Trondhjemite sometimes garnetiferous. This was found in the form of bondins generally near the diopside rock lower boundary. Despite strong deformation in the schists (the schistosity curring round the bondins) little penetrative deformation has occurred other than near the boundary with the schistose, where a gneissose texture is developed. A crude 2 to 1 inch frakture clearage is sometimes developed, muscovite may sometimes be seen parallel in schistosity of the surrounding rock.

Near locality a) close attention was paid to texture as here Kollung's (1975). Augen gneiss zone is seen. There was no evidence that the Trondhjemite passed laterally into augen gneiss.

The augen gneiss has been described outcropping eastward from locality a) to Skaitidalen, and is found at a similar level to the Trondhjemite. The diopside rock here shews considerable deformation and development of diopside, it is possible that the augen gneiss represents a Trondhjemite likeness deformed more work is needed.

Finally, Kollung (1971) states, "the SO-called Furulund gneiss is not found in the Furulund group, but on the contrary in the lower part of the Skaiti". This statement is not further qualified, there is no evidence that the augen gneiss represents the Furulund gneiss, and the Furulund gneiss was not recognized in the lower Skaiti at Skaitibukta.

4.5 Structure

The regional structure of Salefjell is best shewn by Fig. 3, Fig. 4 and profiles (i) and (ii).

The north face of Salefjell shews a flat lying north facing syncline of the diopside rock within the rusty crinkled schists, the axis trending NW/SE, and the lower limb being sheared out. Diopside rock carrying to rest on tectonised Furulund gneiss at locality b), Fig. 3.

From locality c) westward, no units of the lower Skaiti were seen, and from here eastward the Furulund gneiss is nursing. There are two possibilities.

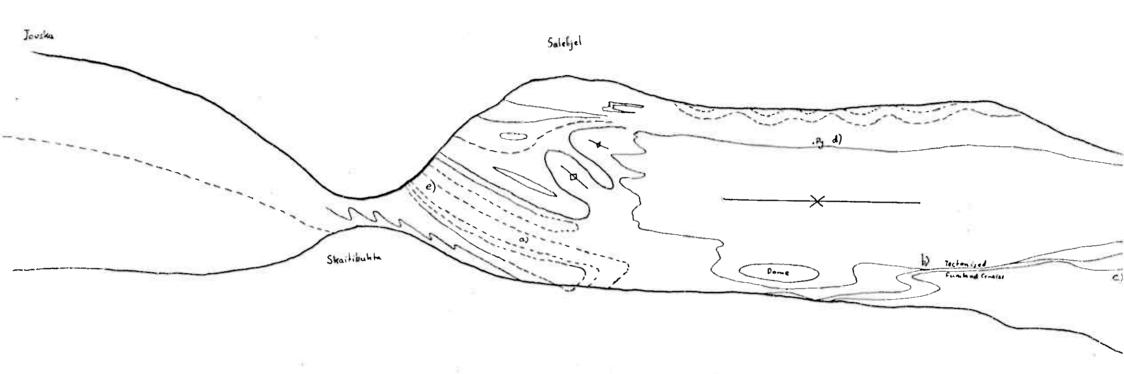
- i) At Skaitibukta the Lr. Skaiti staurolite schist has been mistaken for e new unit when in fact it is the Furulund gneiss.
- ii) The Lr. Skaiti Group has been sheared out allowing units of the upper Skaiti group to rest immediately on the Furulund.

The latter is thought the most probable.

In detail, Stoakes (1969) has claimed 4 phases of deformation, his D (ii) is not recognized. Three deformations appear obvious in the field.

F₁ - Stoakes' D (i) isoclinal, with development of axial plane schistosity.

 F_2 and F_3 , isoclinal and open folds of symmetrical and asymmetrical style. The axes trending N/S. The Salefjell NW/SE syncline shews at NW/SE trending axis, that of the proposed Skaitidalen antiform (see fig. 3 and profile (i) is N/S. The folds postulated in profile (i) are thought to be F_2/F_3 .



Balvann

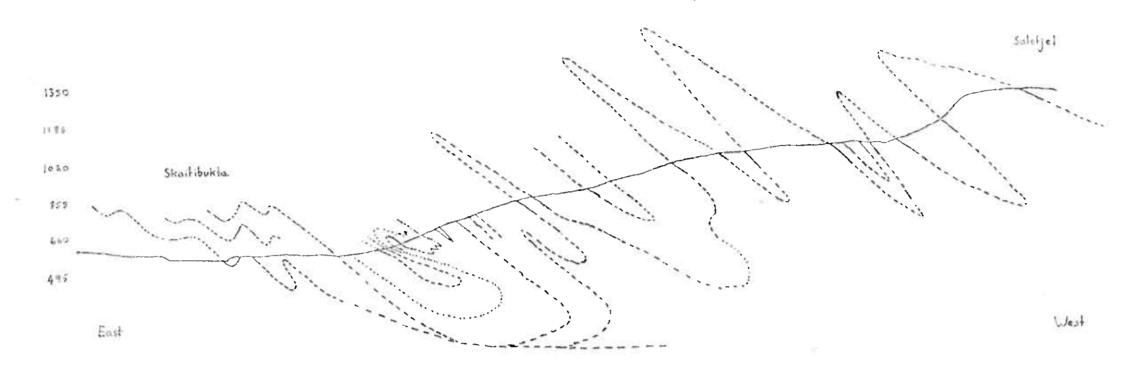
Fig3 Structure, Salefjel.

Geological profiles of Salefiel (1)

NEW

Harizontal scale = vertical = 1:16500

SWest



Geological profiles of Salefiel (i)

Horizontal scale = vertical =1:16500

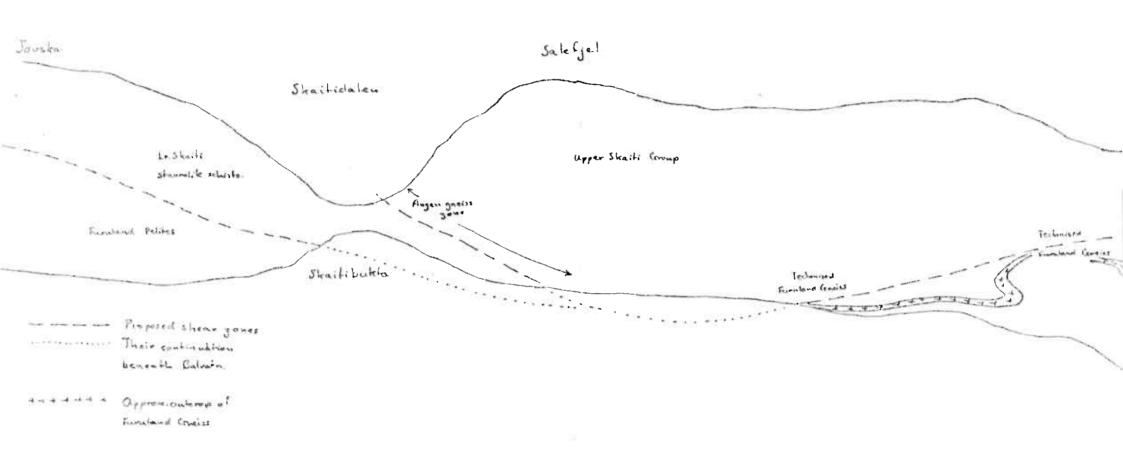


Fig4 Structural relations, Salefjel.

4.6 Mineralization

Throughout the rusty crincled mica schists finely disseminated pyrites is seen in quantities upto 5 %. This is of no value.

High up on Salefjell outcrops a zone 4 to 6 feet wide shewring cubic pyrites up to 7 mms, sometimes tectonised in a crumbly sulphurous quartzitic sericitic schist lying structurally 30 feet higher than the diopside rock (ie 30 feet lower stratigraphically), and which is expected to outcrop laterally eastward from locality d) Fig. 3. It is possible that it may occur low-down on Salefjell in the same stratigraphic position, although it would be drift covered. Further exploration is recommended.

At locality c) some malachite staining was found by Finne. A follow-up proved negative.

At locality c) a sericite zone was seen immediately below the Furulund amphibolite. This maps laterally to below Storfjellet 1187 (see Kollung 1970), some pyritic and possibly malachitic mineralization being seen there. Nothing of economic importance is expected of this horizon, although at the level of the ore-rock at Sulitjelma.

4.7 Suggestion for further work

Little could be done on the top of Salefjell, cloud cover being at 900 m. If this top is to be mapped a high-level waterproof camp is recommended, as advantage could be taken of breaks in the local bad weather. If is expected that mapping the top would yield little of economic use some structural detail concerning the rusty crinkled - mica schist and the massive grey staurolite - garnet - biotite - units.

Further exploration of the mineralized zone at locality d) might prove it to be the elusive zone searched for by Kollung and myself in 1970, Stoakes in 1969, and first described by Dybdahl (1954?).

The purchase of a copy of P. Hess' paper on the petrogenetic grid in contributions to mineralogy and petrology 1969 might prove a useful guide to the interpretation of metamorphic assemblages, a collection of up - to date papers on experimentat metamorphic petrology would be useful. Finally, it would have been useful if airphotos, field maps, and notebooks of previous workers were kept with the reports in Sulitjelma. It is suggested that this practice be started.

REGIONAL GEOLOGICAL FIELD MAPPING

THE AREA SOUTH OF KNALLER DALEN (Area I)

AND

THE AREA MORNING OF SALEFJELL (Area II)

6y

R.H. FINDLAY, B.A. (Oxon)

10.7 - 27.8.1972

T.S.H. R.H.F

As SULITIFIMA GRUBER

APPENDIX I

To discuss corelation of units between Langvann, Lairotoppen and Balvann and between Storfjellet 1338, Kragelva and Balvann, mapped by Kollung (myself as field assistant) in 1970, with units mapped by myself in Area I and II, this report.

Information from reports an areas in which I have not worked has also been drown on. I have tried to reconcile the observations of Knox and Needham 1967 working to the west of Storefjellet 1189 with my own observations to the east of this mountain. For inforamtion concerning the units above the Furulund group I have used my own observations from 1970 and 1972, Kollungs work in 1970, 1971, Stoakes and Moorhouse 1969, Badkar 1972, Cunningham 1971 and Wilsons Thesis.

The stratigraphy set out by Nicolson and Rutland, 1969 provides a basic framework, and is as follows:

Fauske Marble Group
Sulitjelma schist sequence
(with Sulitjelma Gabbro)
Amphibolites
Furulund Group
Sjønstå Group
Pieske Marble
Turon Qvartzite
Basement Gneiss

From observations in Area I, this report and from between Kragelva, Storfjellet 1338 and Balvann, the ollowing points are to be noted.

- i) The Turon quartzite above the basement near Kragelva is a few inches thick, and is overlain by a thick sequence of garnet Z-mica schist. This unit has been termed lower mica schist (undre glimmerskifer), Kollung 1970, and myself (Area I, this report). In Area I, the top unit of the lower mica schist is a sparagmite, sometimes gneissose, termed the sparagmite-gneiss (this report). The unit thickens greatly N across Knallerdalen.
- ii) The Sjønstå group has been called the Mourki Group to the east of Sulitjelma. This practice has been adhered to by both Kollung and myself whilst working south and west of Balvann.
- iii) I have not seen units above the Furulund in the region of Sulitjelma itself, save for brief observations during a fishing expedition.

Of the units above the Furulund to the south of Balvann I have seen only the Skaiti Group (Kollung 1970, 1971).

For the terms of this discussion the stratigraphy is therefore as below:

Fauske Marble
Skaiti Group
Furulund Group
Muorki - Sjønstå Group
Pieske Group
Lower Mica Schist Group
"Turon Quartzite"
Basement

From Sulitjelma east to the swedish border, units below the Muorki - Sjønstå group are not seen. Between Sulitjelma, Lairotoppen and Balvann units above the Furulund and absent.

Within the Furulund and Muorki - $Sj\phi$ nstå groups the following stratigraphy has been erected (Kollung 1970).

Furulund: Upper - brown, fine grained schist

Middle - variable, often parphyroblastic schist

Lower - grey phyllite

Muorki : - grean to grey hard phyllite

East of Calamabelle the region of the Muorki/Furulund boundary shews both acid and basic effusives, with some metasediments in the region of the Kong Oscar Mine.

At Lairotoppen a sequence of rocks of both sedimentary and volcanic origon has been described in the lower part of the Furulund by Vogt 1921, and was visited in 1970 by Kollung and myself. Although under the impression that these unit were mainly sedimentary in 1970, it is now felt that this region shews acid effusives. (Specimens 25 FI and 25 F II are thought to be keratophyric and that this passes to a finer unit about 100 yards thick. See Finlay 1970, Station 218).

Kollungs 1970 map shews the acid effusives dying out towards Balvann. They are seen again bounding the Mourki - Sjønstå in Area I, the southerly continuation is not shewn on Kollungs map of 1970. Calcareous schists are seen with the acid effusives, in Area I this is ascribed to folding, whilst Kollungs 1970 map of the area Sulitjelma - Lairotoppen - Balvann shews a relationship ascibable to either folding of icoclinal nature or to primary facies variation.

Finally, associated with the acid effusives of Area I are seen fine grained apphibolites and a light biotite porphyroblastic greenstone.

Similar rocks are seen within the acid effusives between the Lomivann and Balvann. Some thin fine grained greenstones are seen in the region of Lairotoppen. These are thought to represent basic extrusives.

The top of the Muorki - Sjønstå has been put at the base of the lowest unit of the effusives, this appears to be a reasonably useful position, and the Furulund has been divided into two, the greater and inferior Furulund.

Greater Furulund	Schists + gabbro		
Inferior Furulund	Acidic and basic effusives		
Muorki - Sjønstå			

Within the inferior Furulund, metasediments have been seen in Aria I at Kong Oscar Mine, east of Calmebelle and at Lairotoppen. Lateral eqivalence is impossible to determine at the present, fossils within the Lairotoppen metasediments give an Ordovician age (Vogt 1921).

The greater Furulund shews a series of Z-mica, often calcareous, pelitic schists and phyllites with bondens (Findlay, Fagerli Gabbro Report 1972) of a gabbro - textured amphibolite. They occur within the Calcareous Banded Schist of Area I, and within the Lower and Middle Schists of Kollungs Lomivann - Balvann report (1970). They were not seen in the Lairotoppen region, although this is probably due to the lower stratigraphic level of this area. Amphibolites at trines shewring gabbroic "kalkglimmerskifer" just N. of Storfjellet 1338.

The stratigraphy of the greater Furulund is best rationalised as follows. No such detail can be given for the inferior Furulund, and details of the Furulund gneiss and amphibolite are discussed later.

	Lomivann - Balvann	West of Balvann
Upper	Brown fine grained Z mica pelitic s and graphitic thin interbeds.	chist, also phyllitic
Middle	Variable, generally, phyllitic schists, shewring biotite parphyroblasts. Shews gabbro boundins	Grey - brown, generally phyllitic schists, often carrying biotite parphyroblasts
Lower	Calcareous pelitic schist. May have phyllitic bands? In places associated with gabbro bondins. Note-possibly folded into middle greater Furulund Lairotoppen shews a thick graphite schist above the inferior Furulund. The calcareous schists appear to be	Calcareous pelitic schist, shews gabbros and amphibolitic. Note - possibly infolded into inferior Furulund.
	Middle	Brown fine grained Z mica pelitic s and graphitic thin interbeds. Middle Variable, generally, phyllitic schists, shewring biotite parphyroblasts. Shews gabbro boundins Lower Calcareous pelitic schist. May have phyllitic bands? In places associated with gabbro bondins. Note-possibly folded into middle greater Furulund Lairotoppen shews a thick graphite schist above the inferior Furulund. The

The Muorki - Sjønstå group has a stratigraphy less easy to work out.

Between Lairotoppen, Sulitjelma and Balvann the Mourki - Sjønstå is recognized by a strong development of a quartz - chlorite coarse grained phyllite (Green Phyllite, Kollung 1970) shewring graphitic schist and magnetite - bearing effusives, lensing out immediately) from Dorrovann and southwards.

7 kms to the NNE. Between Storfjellet 1338, Kragdalen and Balvann, Kollung has divided the Muorki - Sjønstå as follows.

Upper schist - grey garnet mica-schist, sometimes chlorite
rich
- Feldspathic quartz schist

The Area immediately north of this (Area I) shews the following structural succession.

1) Garnet chlorite - rich biotite schist

Lower schist - grey to brown garnet mica schist

- Brown quartzitic schist, yellow garnet Z-mica schists
- 3) Brown quartzitic's schist

and the second s

4) Grey to green chlorite garnet Z-mica schists

Unit 1), apart from shewring garnet, is similar in texture and overall appearance to the chlorite quartz phyllite in the area Lairotoppen - Sulitjelma - Balvann, and is taken as equiralent. The lower units of the Muorki - Sjønstå (2, 3, 4) are not seen in this region. The Muorki - Sjønstå shews no good regional markers, save for amphibolites and associated graphite schists near the Pieśke/Muorki/Sjønstå boundary. As Kollung's (1970) "Feldspathic Quartz Schist" has been found a distructive marker horizon fainly low down in Area I (unit 3) it is used as a top marker for a "Lower Muorki - Sjønstå" unit.

Stratigraphi of Muorki - Sjønstå Group

Upper	Chlorite - quartz Phyllite, shewring also graphite schists, acid and basic effusives and meta conglerates	Chlorite - biotite quartz schist, sometimes garnetiferous	Balvann Grey garnet mica schist, sometimes chlorite rich
		Brown quartzitic schists, yellow (fresh break)garnet Z-mica schist interbeds	
	Not seen		Felspathic quartz schist
Lower		chlorite Z-mica schist	Grey to brown garnet mica schist. Also shews amphibolites and graphite schists just above base of Muorki

In 1967, an area north and west of Knallerdalen was mapped by Knox and Needham. The map of Area I ties in with their work. As their descriptions of rock types are inadequate, and their map of poor quality, little can be done to tie in their stratigraphic divisions with the area above. Their stratigraphy is given, together with a reconcilation with that of Kollung 1970 and myself 1972, the following points from their work are to be noted.

- i) The Inferior Furulund is missing or not recognized.
- ii) The Steinkjerringo Group should be discarded, as the Pieske Marble is a major unit in its own right and the amphibolites and graphite schists belong to the Muorki Sjønstå.

Stratigraphy of Muorki - Sjønstå Group after Knox and Needham 1967

Furulund		Needham Calcareous schist + amphibolites	Knox Calcareous schist + amphibolites
Sjønstå	Upper	Interbedded arkosic sandstone and gneiss	Psammites + Garnet, amphibolites
9)	Lower	TRANSITIONAL Coarse grained rusty garnet gneiss	Garnetiferous gneiss, graphitic schist, biotite schist lensing out on SW Storfjellet 1189
9		Amphibolites	Amphibolite, graphite in places
Steinkjerri	ingo	Mica Schists, gneiss, graphite schists	Graphite schists
		77.	Pieśke Marble

Stratigraphy of Muorki - Sjønstå

	Lairotoppen Balvann	Area I	Kragdalen- Storfjellet 1338 - Balvann	Needham	Knox
Upper	Chlorite - quartz phyllite, graphite schists, acid and basic effusives, psammites and metaconglomerates	Chlorite-biotite quartz-schist, sometimes garnetferous	Grey garnet mica schist, sometimes chlorite rich		Psammites
5		Brown quartzi- tic schist, with interbedded garnet Z-mica schists		Inter- bedded arkosic sandstone and gneis	
Lower		Brown quartzitic schists probably feldspathic	Feldspathic quartz schist	garnetfer	ained rusty ous gneiss, hite schist
		Grey to green garnet chlorite Z-mica schist amphibolite schists just above base	Grey to brown garnet mica schist. Amphibolites and graphite schists just above base	Amphiboli Mica schi graphithe	sts, gneiss
Pieśke Group		4 Mar	bles		

The stratigraphy of the Pieśke Group is straight forward, the Group consists of coarsely crystalline marbles with Z mica quartz schist interbeds at the top and micaceous quartzites lower down. It has not been seen to the east of Sulitjelma.

The units below the Pieśke marble are only seen in the region of Kragelva to Storfjellet 1338, Knallerdalen to Storfjellet 1189, and in the area west of Knallerdalen mapped by Knox and Needham. Althoug known as the "Turon Quartzite", the only quartzite seen is a 6 inch band above the basement gneiss (Kollung 1970). It is felt that Kollungs term "Lower Mica Schist" is the most useful as this descriptive of the major part of the "Turon Quartzite".

Needham (1967) describe a "Liggefjell Complex" in the stratigraphic position of the Lower Mica Schist, and his petrographic descriptions, although poor are adequate enough to shew this unit to be the same as the Lower Mica Schist. It must noted that this unit is similar petrographically the Muorki - Sjønstå, but shews two features that provide good criteria for a separate unit.

- i) the presence of rusty schists with garnets up to li inches
- ii) the lack of graphite schists and amphibolites

Knox (1967) describes under "Other Rock Units", a "basement granite or sparagmite" under the Pieśke marble. It is suggested that this be the sparagmite-gneiss of the lower mica schist group, and is placed accordingly. Among Knox's "Other Rock Units" are "certain rock types which are difficult to come late". These tie terms the "Midtifjellet Succession", and contain the groups "Hornblende, Psammites and Synclinal Psammite Facies. His petrographic description being poor, and his placing of them in a structural position between the Muorki - Sjønstå and Furulund leads to the suggestion that they might be volcanics of an Inferior Furulund in that region. Further investigation is called for.

A stratigraphy for the lower mica schist is given below, the term Ligefjell complex (Needham) and "Other Rock Units" has been dropped in favour of Kollungs (1970) more practicel term.



Lower Mica Schist

	Kragelva	Knallerdalen	West of Knallerdalen	
		1 1815 831 95 1	Needham	Knox
ists		Sparagmite-gneiss, thickens North by fold repetition	Coarse gneisses containing quartz, rusty in places	"Granites" (Sparagmite- Gneiss?)
er Mica Schi	Z mi c a s c h i sts + garnet	Z mica schists + garnet	Containing garnet	
Lower		E. Troppin		e.
	Turon Quartzite (6 inches)	Base not seen		
	Basement Gneiss	Not seen	Not described	•

Finally, some mention must be made of the Skaiti Group. This has been described by Kollung (1970, 71) and in this report. There is evidence of local tectonism of both the Upper and Lower Skaiti Units.

The metamorphic "grade" of both is higher than that of the underlying Furulund Units Cyanite being seen in discrete bands (Badkar pers. comm. 1972) in the Laphelleren schist of the Sulitjelma Schist Group, and also in the Skaiti Group again, cyanite is found as evidence for composition rather than PIT conditions determining the mineral assemblage, and the idea of "metamorphic inversion" of units above the Furulund should be dropped until more detailed work is available.

Correlation of these higher units is not readily made as information in english is lacking. The Baldoaivve schists shews a lower rusty unit overlain by calcareous banded schists. The underlying Furulund Gneiss south of Baldoaivve shews a cross culting relationship (on the regional map) into the rusty schist. This is felt to be a mistake, for Furulund schist units have been observed close to Fuglevann where the Baldoaivve rusty schists have been mapped.

It can be suggested that the Baldoaivve calcareous schist be equivalent to the "Banded Rock" (Stoakes and Moorhouse 1969) or belter named "Diopside Rock" Kollung 1970, 71 and myself, Area II, the underlying rusty schists might then be equivalent to the rusty cyanite schists below the diopside rock of the upper Skaiti group. In this case the lower Skaiti may be missing.

The Sulitjelma schists lie in the same position above the Furulund gneiss as do the Skaiti and Baldoaivve schists. Attention must be drown to Fig. 3.1, P. 17 of Wilsons Thesis. A marble - psammite group is described lying above cyanite, bearing schists, the Lappehelleren schist (Mason 1966), (Wilson 1968). Above these units are a "Rusty Psammite" and a "Duoldagop Banded Group --- "extremely a pelitic mineralogy" (Wilson 1968). If is temting to propose that the Lapphelleren schists are equivalent to the rusty schists of the upper Skaiti, and that the psammitic marble group be equivalent to the diopside rock. As I have seen neither the Baldoaivve nor the Sulitjelma schists, this is dangerous speculation, and futher work is necessary. The correlation is tabulated below.

Correlation of the Skaiti group

	Jouska	Salefjell/Storfjellet 1338	Baldoaivve	Sulitjelma Schists
Upper Skaiti	Top not seen	Top not seen	li v	Duoldagop Banded Group Rusty Psammites
	Diopside Rock	Diopside rock Trondhjemite + Augen gneiss	Calcareous Band schist	Marble Psammites
ü	Rusty schists	Rusty schists (+ Ky) with grey Banded schists	Rusty schist (+ Ky) + Furulund Gneiss	Laphelleren schist (+ Ky) + Furulund Gneiss
Lower Skaiti	Staurolite schist + amphibolite	Lower Skaiti sheaved out, or absent	Not seen	Not seen
	Tectonic discon	tonic discontinuity seen NW corner of Balvann		
Furulund Group	Schists	Furulund Gneiss + amphibolite	Furulund Gneiss + amphibolite (from regional map)	Amphibolite (Sulitjelma amphibolite of Wilson 1968)

Furulund Schist sequence

The pocition of the amphibolite between the Skaiti and the Furulund groups occupies one stratigraphic level. Below Storfjell 1338 and Salefjell it is immediately overlain by the Furulund granite or gneiss, and at the NW corner of Balvann shews what is best described as a "tectonic-mélange" relationship to the amphibolite.

Above Sulitjelma the Furulund granite lies within the Laphelleren schist (Wilson 1968, Badkar 1972). Drilling has shewn there to be several horizons of gneiss separated by schists. It is felt that the Furulund can not be used as a regional stratigraphic marker, as if it probably has a slightly cross cutting relationship to the country rock, and that it may represent a number of separate intrusive events, the last of which may have involved the Trondhjemites of Salefjell and Storfjell 1338. More work is needed.

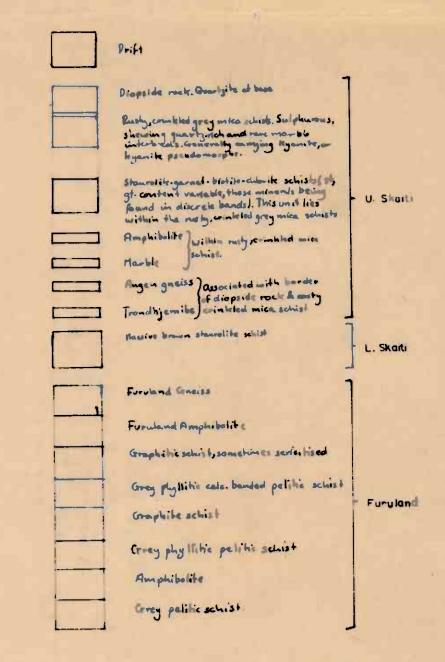
Summing up, it is apparent that there is no evidence for (Kantsky's)(1953)"Pieske nappe" within the area Knallerdalen - Kragelva - SE Balvann - Lairotoppen - Sulitjelma. There may be a tectonic discontinuity above the Furulund group, although invocation of such must be based on structural grounds rather than "metamorphic jumps" until the processes by which metamorphic reactions occur are better known.

In conlusion, it is hoped that the somewhat sketchily described stratigraphy here outlined may provide a working model for the future, and that it will be improved upon.

Boundary 95% certain
70%
50%
diff covered

Suggested structure lines
from air photo
Anticline
Antickine
Henceline
To Henceline
Greneral dip

The Rocks



R. H. Fridlay Aug 1972

