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Report on the geology of the ore-bearing area around Ingeborg vann.

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Sammendrag

Generell berggrunnskartlegging ved Ingeborg, spesielt med tanke pa kopperforekomstene i omradet. Stratigrafisk tilhorer bergartene Furulund-skifrene. Lavest finnes kalkrik to-glimmerskifer, dels biotittrik. Tynne amfibolittband. Overst finner en glimmerskifre, gneiss og amfibolitter. Spor av fem forskjellige malmhorisonter er pavist, alltid i amfibolittband eller stratigrafisk pa samme niva som disse.

Report on the geology of the ore - bearing area around Ingeborgvann summer 1967.

by R. Elsdon.

Introduction.

This report forms part of a study which is aimed towards determining the extent of copper-bearing deposits in the Sulitjelma area.

Copper minerals have been mined north of Ingeborgvann in previous times. Two mines can be seen but both are abandoned. In 1965 N. Raith and H. Thalenhorst mapped the area on a scale 1:50 000 as part of a more extensive study of the geology of the Saltdal - Sulitjelma - Balvatn area (report number 103). In the early summer of 1967 an electrical conductevety survey was carried out on the rocks around Ingeborgvann, Staurdalen and extending towards Botnvann, and the results gave an indication of the distribution of metallyerous ore deposits. The present study was performed in the early part of September 1967, with mapping on a scale 1:2 000; the accuracy of the mapping was facilitated by the presence of posts in the ground marking a 100-metre grid, with posts at 100, 50 and 25 metre intervals, left by the geophysics team. It is hoped that the results will provide detailed information for future diamond-drilling in the ore - bearing areas.

The author whishes to thank A/S Sulitjelma Gruber for the opportunity to study the rocks around Ingeborgvann, and for providing first-class facilities. He also whishes to thank Mother Nature for the weather, which was unusually very good.

Stratigraphy.

All the rocks studied lie within the Furulund schist formation. Raith and Thalenhorst have divided the Furulund into upper and lower parts; the bottom of the upper Furulund is taken as the first carbonate - free biotite - rich schist, and the lower Furulund contains none of these carbonate - free schist. North of Ingeborgvann, where exposures are good, this boundary can be traced quite easely, but to the west, in thickly wooded country, it is impossible to follow it with any degree of certainty, but the author feels that it does not cross the river between Ingeborgvann and Botnvann.

Lower Furulund.

The dominant rock type is a calc-muscovite-biotite-schist (calcglimmerschiefer), soft and medium-grained, pale grey in colour on fresh surfaces but weathering a faint rusty brown colour. Garnetiferous varieties were not found.

Interbedded with this rock, one also finds:

1. Biotite-rich schists, sometimes finely crenelated. These are more finely cleaved than the calc-mica-schists, and may contain garnet. They also sometimes contain coarse biotite aggregates in small pockets 1 - 2 cm in diameter.

2. Amphibolites, thin but usually continuons bands a few cm to 5 metres thick. Generally they are fairly coarse-grained, but the grain size can be variable even within the volume of hand specimen also the modal mineral is not constant, so feldspar-rich and feldspar-poor varieties are encountered. Biotite- and garnet-bearing amphibolites are present. In forticular, garnet may be present in certain parts of a given amphibolite but absent from others. There is no consistent pattern to this variation, and it is possible that the appearance of garnet may be controlled by the chemical-composition rather than metamorghic grade. This also applies to the biotite-rich schists which, however, contain garnet more often than to the amphibolites.

Upper Furulund.

1. Calc-mica-schists - common in the lower part, simular to that in the lower Furulund.

2. Biotite-rich schists - with or without carbonate, more common than in the lower Furulund. These may contain garnet, often up to 1 cm in diameter, and are very finely cleaved.

3. Psammitic schists - light coloured quartz-feldspar-mica schists, and quartzites, which are quite common above the horizon of the Furulund gneiss.

4. Furulund gneiss - coarse grained quartz orthoclase - mica gneiss, often with large forphyroblastic feldspars, which stand out as white blebs on weathered surface, a criterion which enables the gneiss to be easily indentified in the field. There are two bands of gneiss in the mapped area, both apparently concordant. The southern band is 10 metres thick at 5400 N/990 V but thins gradually westwards and is only 5 metres

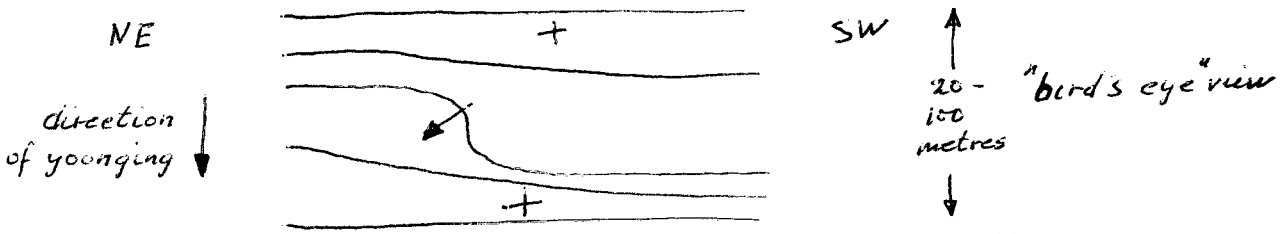
thick at 3900 N/1 000 V, at 3 890 N/1 000 V this band suddenly disappears. An isolated exposure of a gneissic-looking rock 2 metres thick was found at 3 400 N/1 150 V but could not be traced in either direction, and it is a matter of conjecture whether it is physically connected at any level with the main gneissband. The northern gneiss band is thinner - 5 metres at 5 400 N/1 020 V and at 4 800 N/1 125 V though up to 10 metres thick in between. At the latter point it, too, apparently disappears at the present level; it should be noted, however, that little attempt was made to locate it further west since it is rather remote from the ore horizons.

5. Amphibolites - some have the characteristies already enumerated for the amphibolites of the lower Furulund. Others are very fine grained and dark; these "amphibolites" are usually very thin (a few cm thick), and some may be fine-grained chloritic rocks.

Quartz lenses, generally elongated parallel to the schistosity, occur irregularly throughout. The ore horizons will be considered in a later section.

Structure.

According to Raith and Thalenhorst, the mapped area forms part of the western limb of the Ingeborg anticline. In general the rocks are approximately vertical, and may be overturned, especially north of Ingeborgvann, but the dips vary to some extent both down-dip and down-strike. Throughout the area are small scale ~~monoclinal~~ *meridional* folds. North of Ingeborgvann these are well exposed and generally result in a SE → NW shift in the beds affected:



Thus it can be seen that, at the centre of these folds, the dips are towards the east and North-east, and the beds are completely overturned.

South of the river between Ingeborgvann and Botnvann none of these folds can be seen in its entirety but some isolated dip measurements showing north-eastward dips may represent these folds, but this is uncertain in view of imperfect exposures. Also south of the river there are some simple monoclinal folds of similar magnitudes, with axial planes very steep and parallel to the strike.

Within the estimated accuracy of measurement, the strike directions are fairly uniform and show that there is a broad, gentle folding structure which has now been tilted into a vertical position. Average strike values -

1 N of river 140°
2 N of lake 125°
3 NE of lake 135°
4 W end of lake 125°
5 S of river 140°

Some smaller - scale structures are also seen at times -

1. Very fine crenulation of biotite schists in the lower Furulund.
2. Small tight folding of quarts veins and lenses.
3. A universal well-developed schistosity, apparently parallel to the bedding.

Ore-horizons.

Metallyferous ores, or signs of them, were found at 5 different horizons within the Furulund. All occur within amphibolite bands or at stratigraphic horizons where amphibolites occur nearly along the strike. Each horizon, beginning at the one which is stratigraphically lowest, will now be described, and conclusions will then be attempted regarding the occurence of ore.

1. The zone extending from 5 400 N/560 V westwards to 2 650 N/750 V. This zone can usefully be divided into two parts, extending from 5 400 N/560 V to the point where it crosses the river at the west end of Ingeborgvann, and from thence westwards to 2 650 N/750 V. The first part of the zone, on which both the aforementioned abandoned mines are situated. For most of its length it is 10 metres thick, but thins rapidly at the river; the eastern end was not studied in detail beyond 5 400 N grid line. It is set in dark, schistose, coarse-grained

amphibolite, which sometimes contains garnet, interbedded with coarse-grained biotite-garnet-schists. In the middle of this band is set a brown-weathering zone, about 2 metres wide, of quartz-muscovite-schist and sometimes a massive, very coarse-grained quartz-muscovite rock. On the surface it shows signs of brown disseminated limonitic material, and occasionally bright-green or blue oxidized copper minerals in the form of "crusts". Where excavations have been made, and on the waste heaps outside the two mines, are blocks of massive, fine-grained quartz-rich rock containing varying amounts of chalcopyrite, pyrite and pyrrhotite (or zinc-blende), with a distinctive deep purplish brown weathered surface. The amount of ore in this rock is variable, but some is very ore-rich, although not all the ore is chalcopyrite.

West of the river there is no sign of the amphibolite, but the ore horizon persists to 2 650 N, although in places eg. 3 600 N - 3 000 N it is very difficult to follow. It is set in a medium-grained quartzite, which is weathered on the surface to a pale brown colour. Two excavations in the hillside at 2 800 N/675 V and 2 890 N/675 V show chalcopyrite and pyrrhotite concentrated in bands in the quartzite. The bands are thin and the copper content of the rock cannot be very high.

2. The ore zone in the Ingeborg River at 3 420 N/970 V. This zone extends across the river for a distance about 15 metres but cannot be followed up the hillside in either direction. It is 10 metres wide and is set in coarse amphibolite without garnet. There is no fresh ore to be seen here and the ore rock is a coarse quartz rock with much finely disseminated brown limonitic material. The amphibolite, however, contains a little fresh ore.

3. The ore zone in the hillside north of the Ingeborg River at 3 200 N/1 120 V. This band is only 2 - 3 metres thick and cannot be traced far in either direction. It contains only a little chalcopyrite ore, which is disseminated throughout the host-rock which is a coarse-grained-dark-garnet-amphibolite. This rock has a purplish brown weathered surface.

4. The zone running from 2 880 N/1 585 V to 3 600 N/1 090 V. For the majority of its lenght it consists of a 5 - 7 metre wide coarse amphibolite, sometimes containing biotite, in which is set pockets of coarse quartz rock containing brown disseminated limonitic material. At 3 600 N/ 1 090 V, however, the limonitic material is disseminated through a light-coloured quartz-felspar-biotite schist. Further east there is an ore-free-amphibolite at the same stratigraphic horizon.

5. A solitary exposure of disseminated pyrite in a dark, fine-grained amphibolite at 4 800 N/950 V.

It is interesting to compare the observed distribution with the results of the geophysical survey.

1st zone - a large anomaly exists east of the Ingeborg River as far as 5 500 N, in a position corresponding to the surface distribution of the ore zone. West of the river the surface anomaly disappears at 3 550 N, but is present weakly between 3 000 N and 2 700 N. However, a strong anomaly at depth persists in a south-westerly direction.

2nd zone - a large anomaly is present across the river at 3 400 N/ 940 V but does not extend very far south west or north east. A strong anomaly extends south-westwards underground as far as 3 000 N/ 950 V.

3rd zone - there is no geophysical anomaly apparent correspomding to this ore zone.

4th zone - a weak anomaly exists between 3 300 N/ 1 180 V and 3 600 N/ 1 080 V.

5th zone - no apparent anomaly.

This in some cases geophysical work agrees well with the detailed field work, but where the ore is badly weathered or present in small (through still discernible in hand specimen with the naked eye) quantities the electrical conductivity survey fails to reveal its presence. Finally it should be noted that many very small anamalies present on the conductivity survey diagrams correspond with outcrops of amphibolite in which no ore can be seen.

Field Measurements.

Barometric haights were recorded and noted at expoures of the various ore zones visited. Dip and strike were recorded as follows:

1. North of Ingeborg Vannå where the structure is fairly easy to see, measurements were made at approximate 200 metre intervals along the geophysiets grid.

2. On both sides of the river between Ingeborg Vann and Botnvann meaurements were made at each individual outcrop. This was because of imperfect exposures in the thickly wooded ground, and because it was thought that the distribution of ore might be structurally controlled.

In one or two cases the writer was in doubt as to whether certain exposures were in situ, these are indicated in the field notes. In spite of the number of measurements made south of the river, some areas are better represented than others since exposures are not good on some of the lower ground in the woods.
The measurements of dip and strike are considered to be accurate to $\pm 5^{\circ}$, in view of the fact that many of the surfaces used are rather uneven.

Origin of the amphibolites.

With one or two possible exceptions, the writer found no evidence in the field for an igneous origin, as proposed by Raith and Thalenhorst in Report no. 103. They occur as isolated bands up to 10 metres broad, and there are no traces of either chilled margins or hornfelsing of the host rock, though if these features did originally exist, they may have been obliterated by effects of later regional metamorphism. In view of their limited thickness they are unlikely to be lavas, but since they are concordant they may be thin sills. Favouring a sedimentary origin are the varability of grain size and modal mineral content, which points to a considerable range of chemical composition, where as one might except a fairly uniform chemical composition if these rocks were magmatic.
At 2 920 N/1 190 V there is an exposure which shows a 2 metre thick body of amphibolite thinning rapidly westwards and with some interfingering against the enclosing calc-mica-schists at the lower contact. Further examination of this and other exposures, possibly with thin-section microscopy, might rësolve this problem.

Conclusions.

1. The structure of the area is essentially simple, with near-vertical strata striking approximately NE-SW, and very gently flexured.

2. The distribution of the ore horizons is related of that of amphibolite bands and is not controlled on a small scale by structures.

3. The ore always occurs in amphibolite bands, or at the same stratigraphic horizon as nearby amphibolites, in the latter case there is very little ore present.

4. The sulphide ore deposits are possibly due to replacement of the amphibole by sulphur-bearing hydrothermal solutions, which carry away Mg, Fe and other elements and convert the rock to an ore-bearing quartzite (see F.J. Turner and J. Verhoogen: "Igneous and Metamorphic Petrology" p. 577 McGraw-Hill 1960). However, no ferm conclusions can be drawn with regard to the mode of origin of these sulphide ores without detailed petrographic and chemical work.

5. In view of the field relations of the ore it is considered by the writer that the thicker amphibolites are more likely to be rich in ore than thinner bands.

6. The results of this investigation, taken in conjuction with the geophysical survey, indicate that the only ore horizon in the area likely to contain economic quantities of copper (except possibly at depths beyond investigation limits of an electrical conductivity survey) is zone 1, in the area between the river at the west end of Ingeborg Vann and grid line 5 400 N.

7. Possible further lines of study:

   i) Detailed mapping further east towards Storforsdalselven in order to determine the lateral extent of these ore zones.

   ii) Systematic collectionof selected rock samples from the ore zone for thin-section study and chemical anlyses, in order to determine the mode of emplacement and copper content. These lines of investigation may already have been undertaken but the author is not aware of this.

   iii) Diamond drilling of zones 1, 2 and 4 would indecate the existence or otherwise of copper deposits at depth in these zones.

INGEBORG · VANN

KEY TO THE MAP AND CROSS-SECTIONS

	54	direction and magnitude of dip
		old mine ; recent excavation
		ore zone
101/6		calc-mica schists ; carbonate-free mica schists ; quartzofelspathic schists
999/20		Furulund Gneiss
999/30		calc-mica-schists
101/9		amphibolite and biotite-amphibolite
101/9		garnet-amphibolite
		Upper-Lower Furulund Boundary

} Upper Furulund

— Lower Furulund

	Målestokk	Tegn.
		Trac.
		Kfr.
	Erstatning for:	
R. Elsdon		
	Erstattet av:	

MAGNETIC

1500 V

1000 V

500 V

INGEBORG VANN

2500 N

3000 N

3500 N

4000 N

4500 N

5000 N

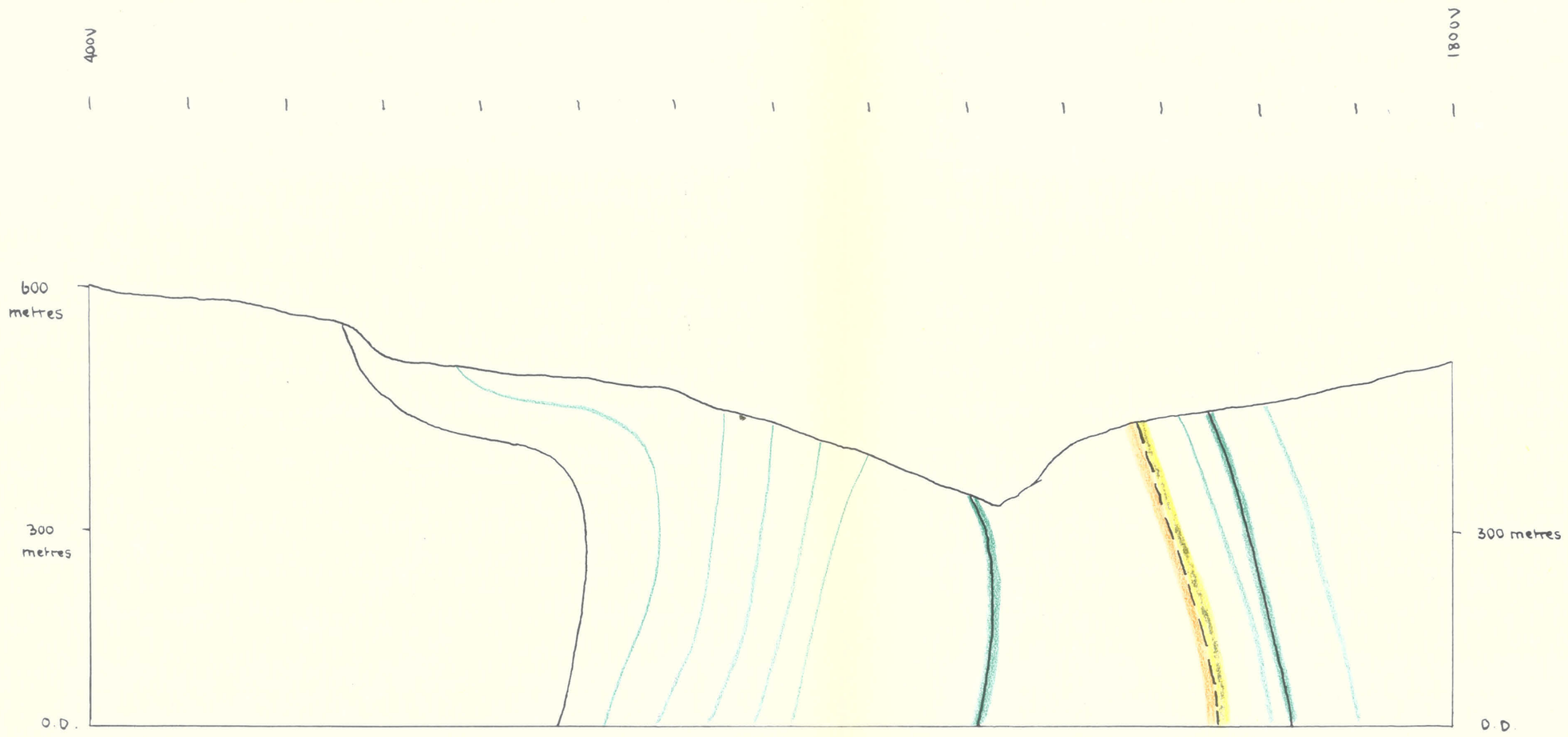
5500 N

	Målestokk 1:10,000	Tegn. / Trac. / Kfr.
Ingeborg - vann.	Erstatning for:	
R. Elsdon		
	Erstattet av:	

INGEBORG - VANN

PROFILE

2900 N. · 400 V. - 800 V.



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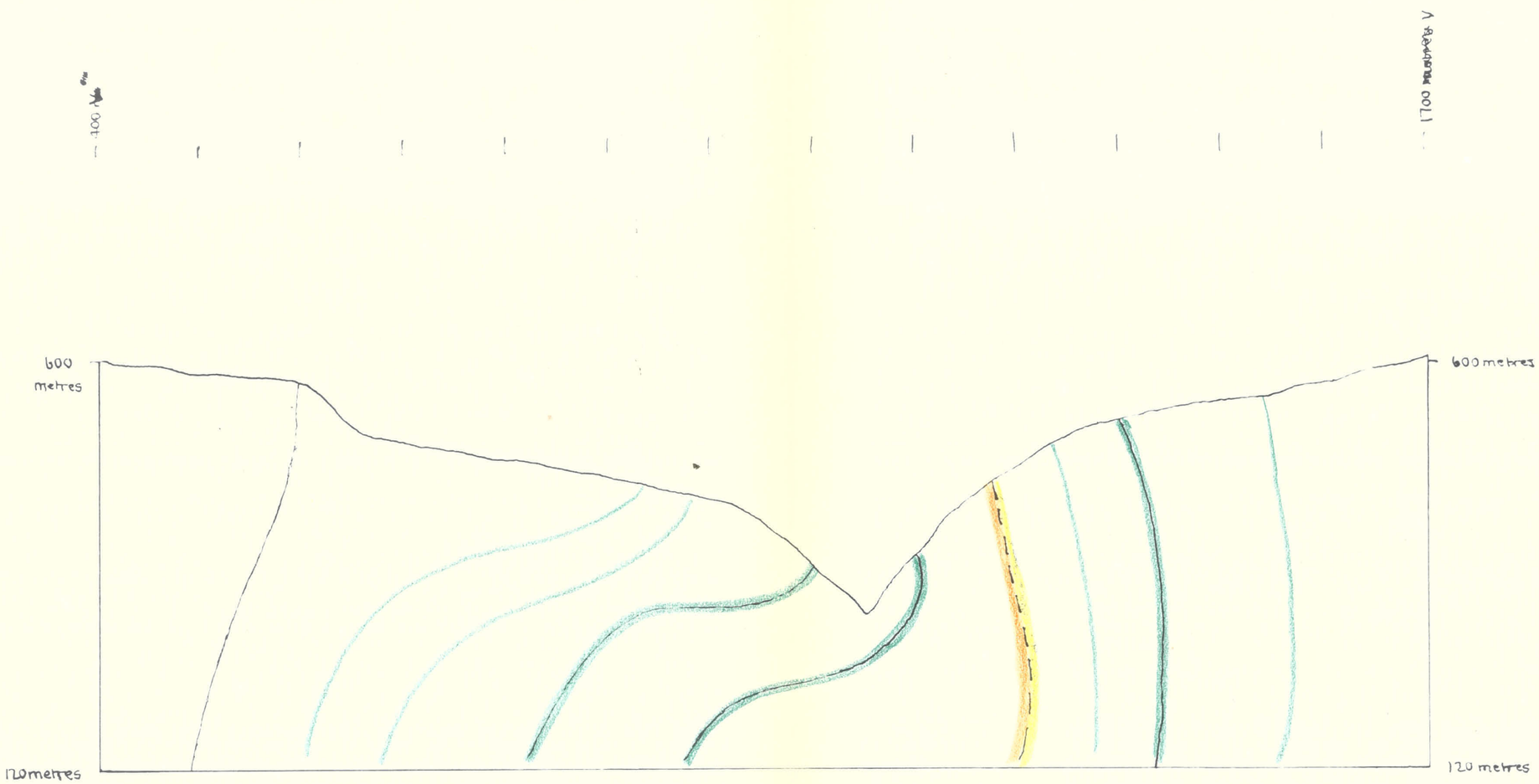
R. Elsdon		
	Erstattet av:	

3100N: 400V - 1700V

ANLEGG 1

INGEBORG - VANN

PROFILE



	Målestokk	Tegn.
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		Kfr.
	Erstatning for:	
R. Elsdon		
	Erstattet av:	

3100N : 400V - 1700V

ANLEGG II

INGEBORG - VANN

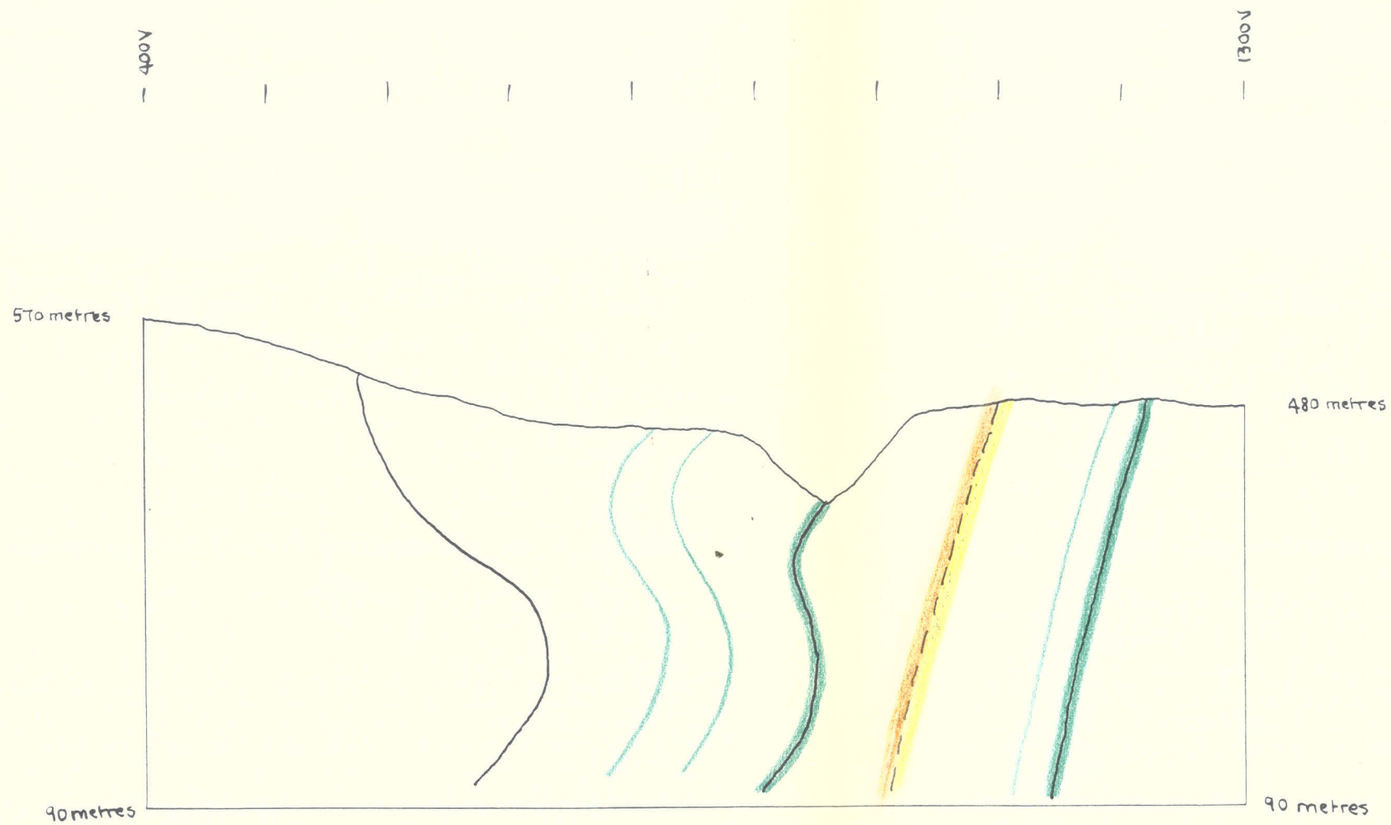
PROFILE

	Målestokk	Tegn.
		Trac.
		Kfr.
	Erstatning for:	
R. Elsdon		
	Erstattet av:	

INGEBORG - VANN

PROFILE

3350N : 400V - 1300V



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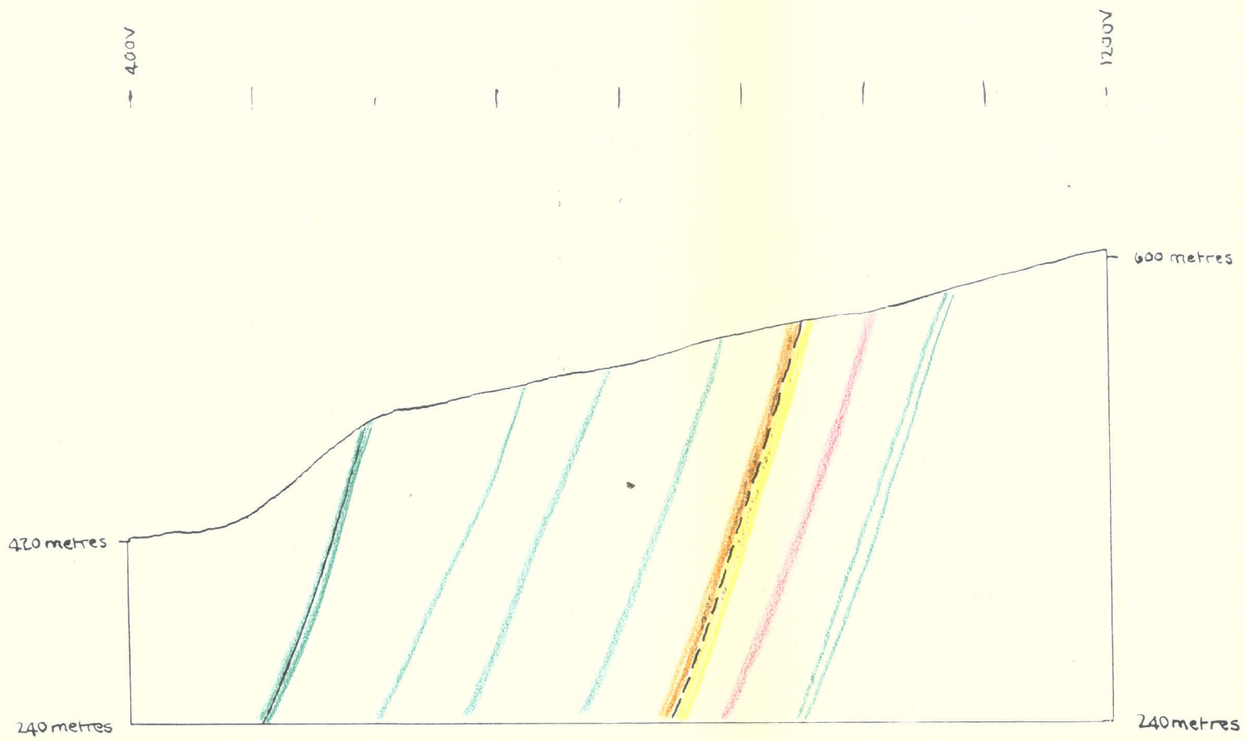
	Erstatning for:	
R. Elsdon		
	Erstattet av:	

4000N : 400V - 1200V

INGEBORG - VANN

PROFILE



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		Kfr.
	Erstatning for:	
R. Elsdon		
	Erstattet av:	

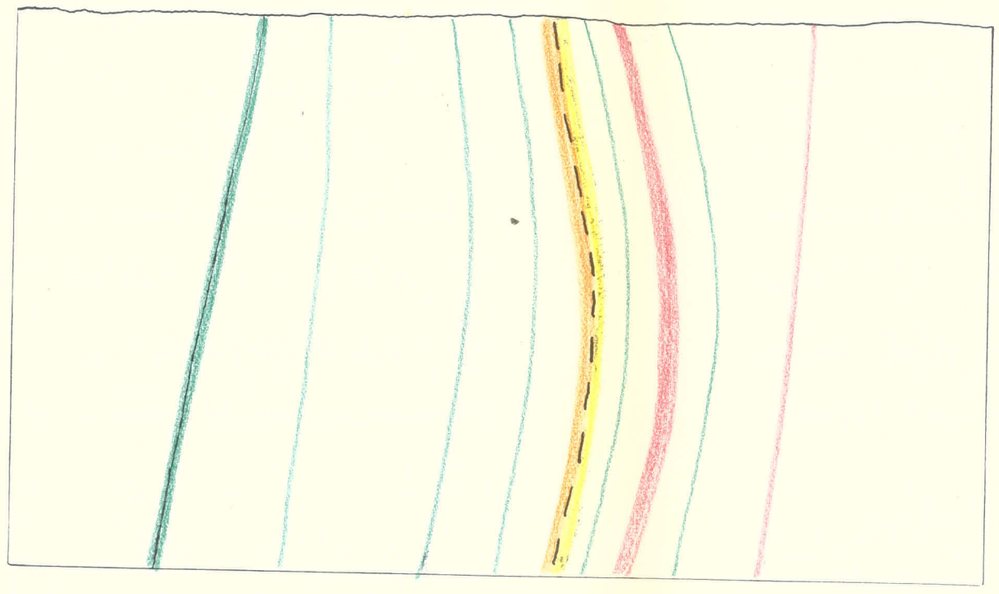
5000N : 400V – 1200V

INGEBORG - VANN

PROFILE

– 400V

1200V



700 metres

160 metres

	Målestokk	Tegn.
		Trac.
		Kfr.
	Erstatning for :	
R. Elson		

Report on the geology of the ore-bearing area around Ingelvig-Vann
Summer 1967

022.009

by R. Blecken

INTRODUCTION

This report forms part of a study which was aimed towards determining the extent of copper-bearing deposits in the Sulitjelma area.

Copper minerals have been mined north of Ingelvig Vann in previous times. Two mines can be seen but both are abandoned. In 1965 N. Rautaruvaara & H. Thalenhorst mapped the area on a scale 1:50,000 as part of a more extensive study of the geology of the Saltdal-Sulitjelma-Balvatn area (report number 103). In the early summer of 1967 an electrical conductivity survey was carried out on the rocks around Ingelvig-Vann, Skaurdalen and extending towards Botnavann, and the results gave an indication of the distribution of metalliferous ore deposits. The present study was performed in the early part of September 1967, with mapping on a scale 1:2000; the accuracy of the mapping was facilitated by the presence of posts in the ground marking a 100-metre grid, with posts at 100, 50 or 25 metre intervals, set by the geophysics team. It is hoped that the results will provide detailed information for future diamond-drilling on the ore-bearing areas.

The author wishes to thank A/S Sulitjelma Gruber for the opportunity to study the rocks around Ingelvig-Vann, and for providing first-class facilities. He also wishes to thank Mother Nature for the weather, which was normally very good.

STRATIGRAPHY

All the rocks studied lie within the Furulund Schist formation. Rautaruvaara & Thalenhorst have divided the Furulund into upper and lower parts; the bottom of the Upper Furulund is taken as the first carbonate-free biotite-rich schist, and the Lower Furulund contains none of these carbonate-free schists. North of Ingelvig-Vann, where exposures are good, this boundary can be traced quite easily, but to the west, on thickly wooded country, it is impossible to follow it

with any degree of certainty, but the author feels that it does not cross the river between Ingeborg-Vorn and Bohrmann.

Lower Furuland

The dominant rock type is a talc-muscovite-biotite-schist (calcium-metasiltstone), grey and medium-grained, pale grey in colour on fresh surfaces but weathering a faint rusty brown colour. Granulitic varieties were not found.

Interbedded within this rock, one may find:—

1. biotite-rich schists, sometimes finely laminated. These are more finely cleaved than the talc mica-schists, and may contain garnet. They also sometimes contain coarse biotite aggregates in small lenses 1-2 cm in diameter.
2. amphibolites — thin but unusually continuous bands a few cms to 5 metres thick. Generally they are finely coarse-grained, but the grain size can be very variable even within the volume of a hand specimen; also, the modal mineral content is not constant, so feldspar-rich and feldspar-poor varieties are encountered. Biotite- and garnet-bearing amphibolites are present. In hand-section, garnet may be present in certain parts of a given amphibolite but absent from others. There is no consistent pattern to this variation and it is possible that the appearance of garnet may be controlled by the chemical composition rather than metamorphic grade. This also applies to the biotite-rich schists which, however, contain garnet more often than do the amphibolites.

Upper Furuland

1. talc-mica-schists — common in the lower part, similar to that in the Lower Furuland.
2. biotite-rich schists — with or without carbonate, more common than in the Lower Furuland. These may contain garnet, often up to 1 cm in diameter, and are very finely cleaved.
3. psammitic schists — light-coloured quartz-feldspar-mica schists, and quartzites, which are quite common above the horizon of the Furuland Gneiss.
4. Furuland Gneiss — coarse grained quartz-orthoclase-mica gneiss, often

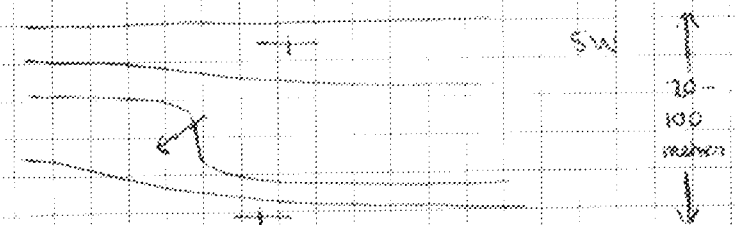
with large kryptoclastic feldspars, which stand out as white lens on weathered surfaces, a criterion which renders the gneiss to be easily identified in the field. There are two bands of gneiss in the mapped area, both apparently concordant. The southern band is 10 metres thick at 5400N|990V but thins gradually westwards and is only 5 metres thick at 3900N|1000V, at 3890N|1000V this band suddenly disappears. An isolated exposure of a gneissic-looking rock 2 metres thick was found at 3400N|1150V but could not be traced in either direction; and it is a matter of conjecture whether it is physically connected at any level with the main gneiss band. The northern gneiss band is thinner — 5 metres at 5400N|820V and at 4800N|1125V though up to 10 metres thick in between. At the latter point it apparently disappears at the present level; it should be noted, however, that little attempt was made to locate it further west since it is rather remote from the ore horizons.

5. Amphibolites — some have the characteristics already enumerated for the amphibolites of the Lower Furulund. Others are very fine grained and dense; these "amphibolites" are usually very thin (a few cms thick), and some may be fine-grained chloritic rocks.

Quartz veins, generally elongated parallel to the schistosity, occur irregularly throughout. The ore horizons will be considered in a later section.

STRUCTURE

According to Swan & Thalenhorst, the mapped area forms part of the western limb of the Ingelvog Anticline. In general the rocks are approximately vertical, and may be overturned, especially north of Ingelvog-Vann, but the dips vary to some extent from down-dip and down-strike. Throughout the area are small scale normal faults. North of Ingelvog-Vann these are well exposed and generally result in a SE → NW strike on the beds affected:—



zunaked — For most of its length it was 10 metres thick, but tapers rapidly as the river, the section and was not studied in detail beyond 5400N grid line. It was set in dense, schistose, coarse-grained amphibolite, which sometimes contains garnet, interbedded with coarse-grained biotite-garnet-schists. In the middle of this band is set a brown-weathering zone, about 2 metres wide, of biotite-quartz-muscovite-schist and sometimes a massive, very coarse-grained quartz-muscovite rock. On the surface it shows signs of brown ferruginated limonitic material, and occasionally bright-green chromium-bearing mineral, and occasionally bright-green chromium-bearing mineral, known as "emerald". Where excavations have been made, and on the waste-heaps outside the two mines, are blocks of massive, fine-grained quartz-rich rock containing varying amounts of chalcopyrite, pyrite and hypersthene (orthorhombic), with a distinctive deep purplish brown weathered surface. The amount of ore in this rock is variable, but sometimes very-ore rich, although not all the ore is chalcopyrite.

West of the river there is no sign of the amphibolite, but the ore horizon persists to 2650N, although in places e.g. 3600N — 3000N it is very difficult to follow. It is set in a medium-grained quartzite, which is weathered on the surface to a pale brown colour. Two excavations on the hillside at 2880N|675W and 2890N|675W show chalcopyrite and hypersthene concentrated in bands in the quartzite. The bands are thin and the copper content of the rock cannot be very high.

2 the ore zone on the Ingelvog River at 3420N|910W. This zone extends across the river for a distance of about 15 metres but cannot be followed up the hillside in either direction. It is 10 metres wide and is set in coarse amphibolite without garnet. There is no gossan to be seen here and the ore rock is a coarse quartz rock with much finely disseminated brown dimensitic material. The amphibolite, however, contains a little garnet.

3 the ore zone on the hillside north of the Ingelvog River at 3200N|1120W. This band is only 2-3 metres thick and cannot be traced far in either direction. It contains only a little chalcopyrite and pyrite ore, which is disseminated throughout the host-rock

Thus it can be seen that, at the centre of these folds, the dips are towards the east and north-east, and the beds are completely overturned.

South of the river between Ingeleng-Vann and Bchwann none of these folds can be seen as clearly but some isolated dip measurements showing north reversed dips may represent these folds, but there is uncertainty in view of unpeg back expected. Also south of the river there are some simple monoclinal folds of similar magnitudes, with axial planes vertical and parallel to the strike.

Within the estimated accuracy of measurement, the strike directions are roughly uniform and show that there is a broad, gentle folding structure which has now been tilted into a vertical position. Average strike values -

1. N of lake 140°
2. N of lake 125°
3. NE of lake 135°
4. W end of lake 125°
5. S of lake 140°

Some smaller-scale structures are also seen at times -

1. very fine translation of biotite schists in the Lower Feruland.
2. small tight folding of quartz veins and lenses.
3. an unusual well-developed schistosity, apparently parallel to the bedding.

ORE-HORIZONS

Magnetic ores, or signs of them, were found at 9 different horizons within the Feruland. All occur within amphibolite bands or at stratigraphic horizons where amphibolites occur nearby along the strike. Each horizon, beginning at the one which is stratigraphically lowest, will now be described, and conclusions will then be attempted regarding the occurrence of ore.

1. the zone extending from 5400N|5800 westwards to 2650N|1750. This zone can conveniently be divided into two parts, extending from 5400N|5800 to the point where it crosses the river at the west end of Ingeleng-Vann, and from thence westwards to 2650N|750

The first part of the zone, on which both the aforementioned abandoned mines are

which is a coarse ground dark green amphibolite. This rock has a purplish brown weathered surface.

The zone running from 3850N|1585V to 3600N|1090V. For the majority of its length it consists of a 5-7 metre wide coarse amphibolite, sometimes containing biotite, in which is set pockets of coarse quartz rock containing brown disseminated pyrrhotite mineral. At 3600N|1090V, however, the pyrrhotite mineral is disseminated through a light-coloured quartz-feldspar-biotite schist. Further east there is another fine-grained amphibolite at the same stratigraphic horizon.

A similar exposure of disseminated pyrite in a dark, fine-grained amphibolite at 4800N|950V.

It is interesting to compare the observed distribution with the results of the geophysical survey.

1st zone — a large anomaly exists east of the Ingleby River as far as 5500N, in a position corresponding to the surface distribution of the ore zone. West of the river the anomaly disappears at 3550N, but is present weakly between 3000N and 2100N. However a strong anomaly at depth persists in a south-westerly direction

2nd zone — a large anomaly is present across the river at 3400N|980V but does not extend very far south west or north east. A strong anomaly extends south-westward as far as 3000N|950V.

3rd zone — there is no geophysical anomaly apparent corresponding to this ore zone

4th zone — a weak anomaly exists between 3300N|1180V and 3600N|1080V.

5th zone — no apparent anomaly.

There is some case geophysical work agrees well with the detailed grid work, but where the ore is badly weathered or present in small (though still discernible in hand specimen with the naked eye) quantities the electrical conductivity survey fails to reveal its presence. Finally it should be noted that many very small anomalies present on the conductivity survey diagrams correspond with outcrops of amphibolite on which no ore can be seen.

FIELD MEASUREMENTS

Barometric heights were recorded and noted at exposures of the various ore zones visited.

Dip and strike were recorded as follows:-

1. north of Ingelsorg-Vann, where the structure was fairly easy to see, measurements were made at approximately 200 metre intervals along the geophysicists' grid.
2. on both sides of the river between Ingelsorg-Vann and Bolvikvann measurements were made at each individual outcrop. This was because of irregular exposure in the rather wooded ground, and because it was thought that the distribution of ore might be structurally controlled.

In one or two cases the writer was in doubt as to whether certain exposures were in situ; these are indicated in the field notes. In spite of the number of measurements made south of the river, some areas are better represented than others since exposures are not good on some of the lower ground in the woods.

The measurements of dip and strike are considered to be accurate to $\pm 5°$, in view of the fact that many of the surfaces used are rather uneven.

ORIGIN OF THE AMPHIBOLITES

With one or two possible exceptions, the writer found no evidence in the field for an igneous origin, as proposed by Raven & Thaarnaar in Report No 103. They occur as isolated bands up to 10 metres thick, and there are no traces of rather chilled margins or thickening of the host rock, though if these features did originally exist, they may have been obliterated by effects of later regional metamorphism. In view of their limited thickness they are unlikely to be lavas, but since they are concordant they may be thin sills. Favouring a sedimentary origin are the variability of grain size and modal mineral content, which tends to a considerable range of chemical composition, whereas one might expect a fairly uniform chemical composition if these rocks were magmatic.

At 2920N/1190V there is an exposure which shows a 2 metre thick body of amphibolite thinning rapidly westwards and which seems interfingering against the enclosing calc mica schists at the lower contact. Further examination of this and other exposures, possibly with thin section microscopy, might resolve this problem.

CONCLUSIONS

1. The structure of the area is essentially simple, with near-vertical strata striking approximately NE - SW, and very gently flexured.

2. The distribution of the ore horizons is related to that of amphibolite bands and is not controlled on a small-scale by structures.

3. The ore always occurs in amphibolite bands, or at the same stratigraphic horizon as nearby amphibolites; in the latter case there is very little ore present.

4. The sulphide ore deposits are formed due to replacement of the amphibole by sulphur-bearing hydrothermal solutions, which carry away Mg, Fe and other elements and convert the rock to an ore-bearing quartzite (see F.J. Turner & J. Verhoogen, "Igneous & Metamorphic Petrology" p 577 McGraw-Hill 1960). However, no firm conclusions can be drawn with regard to the mode of origin of these sulphide ores without detailed petrographic and thermal work.

5. In view of the field relations of the ore it is considered by the writer that the thicker amphibolites are more likely to be rich in ore than thinner bands.

6. The results of this investigation, taken in conjunction with the geophysical survey, indicate that the only ore horizon in the area likely to contain economic quantities of copper (except possibly at depths beyond investigation limits of an electrical conductivity survey) is zone 1, in the area between the mouth of the west end of Ingelvig-Vann road grid line 5400N.

7. Possible further lines of study :—

   i) detailed mapping further east towards Steyerstadvatnet in order to determine the lateral extent of these zones.

   ii) systematic collection of selected rock samples from the ore zones for thin-section study and thermal analyses, in order to determine the mode of emplacement and copper content. These lines of investigation may already have been undertaken but the writer is not aware of this.

   iii) diamond drilling of zones 1, 2 and 4 would indicate the existence or otherwise of copper deposits at depth in these zones.

MAGNETIC

2000V

1500V

1000V

500V

INGEBORG VANN

7500N 8000N 8500N 9000N 9500N 10000N

INGEBORG – VANN

1 : 10,000

R. Elsdon

Målestokk	Tegn.	
	Trac.	
	Kfr.	
Erstatning for:		
Erstattet av:		

MAGNETIC

1500V

1000V

500V

INGEBORG
VANN

2500 N

3000 N

3500 N

4000 N

4500 N

5000 N

5500 N

	Målestokk	Tegn.
		Trac.
	1:10,000	Kfr.
Ingeborg - vann.		Erstatning for:
R. Elsdon		
		Erstattet av:

INGEBORG - VANN

KEY TO THE MAP AND CROSS-SECTIONS

direction and magnitude of dip

old mine ; recent excavation

ore zone

calc-mica-schists ; carbonate-free mica schists ; quartzofelspathic schists } Upper Furulund

Furulund Gneiss

calc-mica-schists

amphibolite and biotite-amphibolite

garnet-amphibolite

Upper-Lower Furulund Boundary

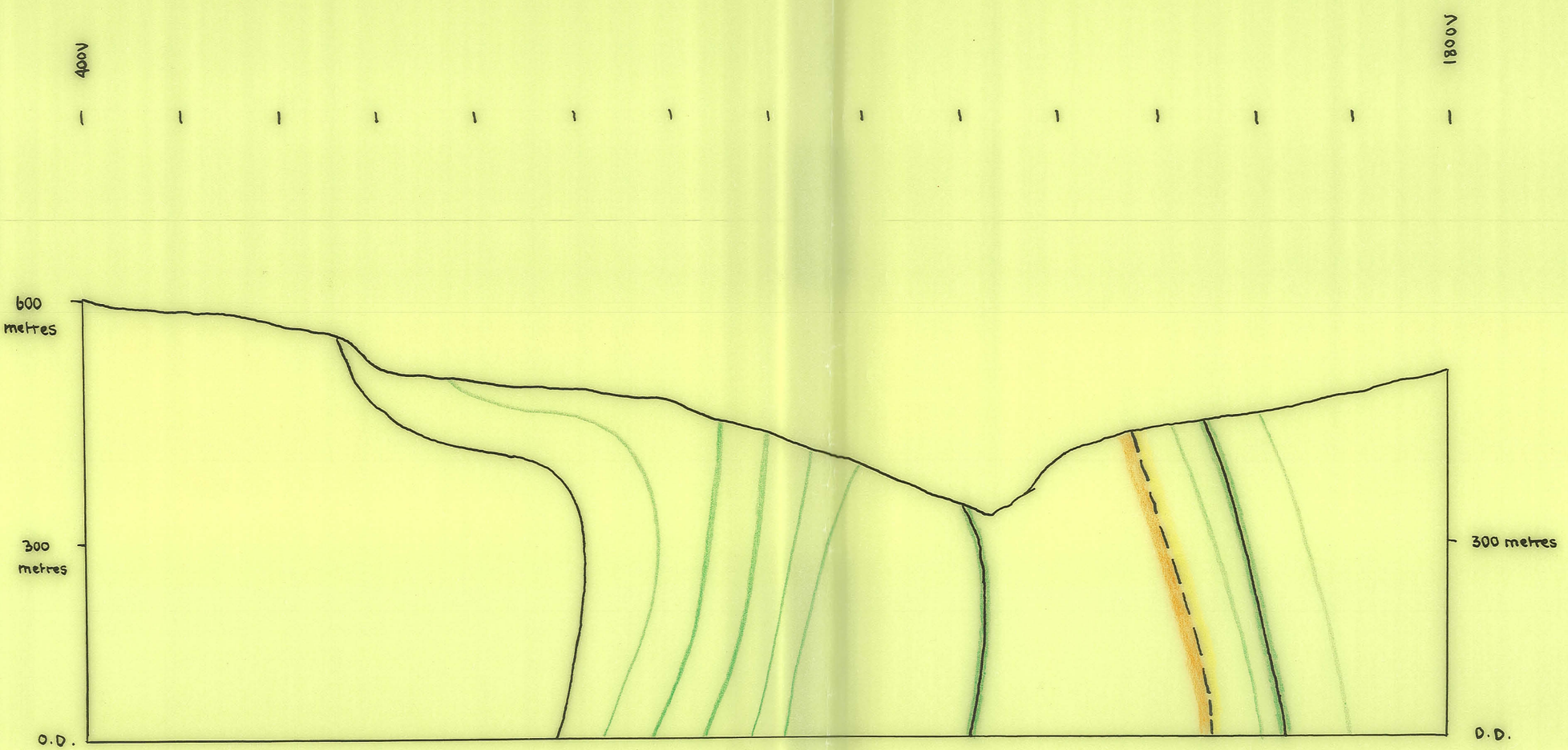
— Lower Furulund

	Målestokk	Tegn.	
		Trac.	
		Kfr.	
	Erstatning for:		
R. Elsdon			
	Erstattet av:		

INGEBORG - VANN

PROFILE

2900 H.: 400.V.- 800 V.



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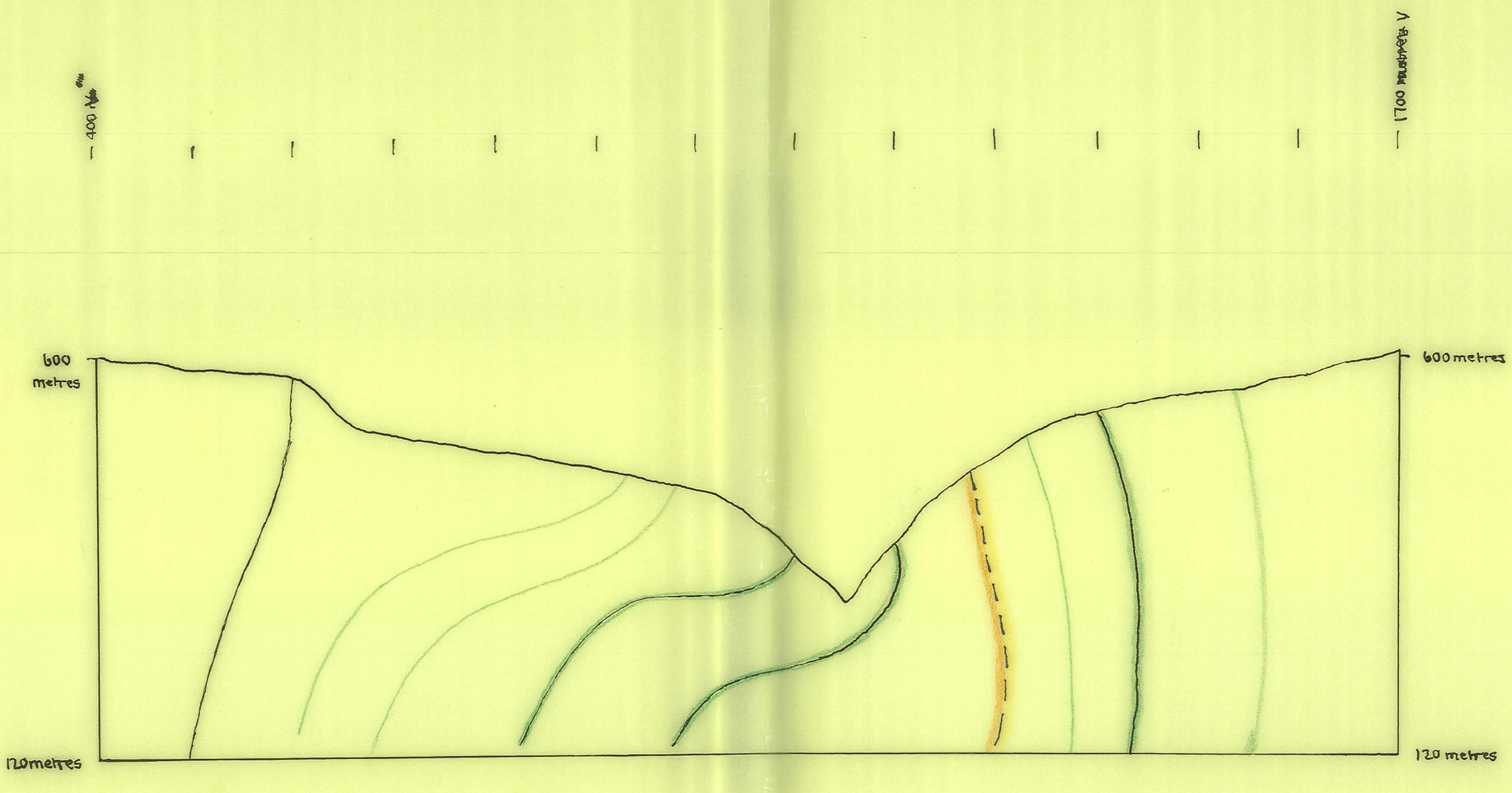
		Trac.	
		Kfr.	
	Erstatning for:		
R. Elsdon			
	Erstattet av:		

3100N: 400V - 1700V

ANLEGG 1

INGEBORG - VANN

PROFILE



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		Kfr.	
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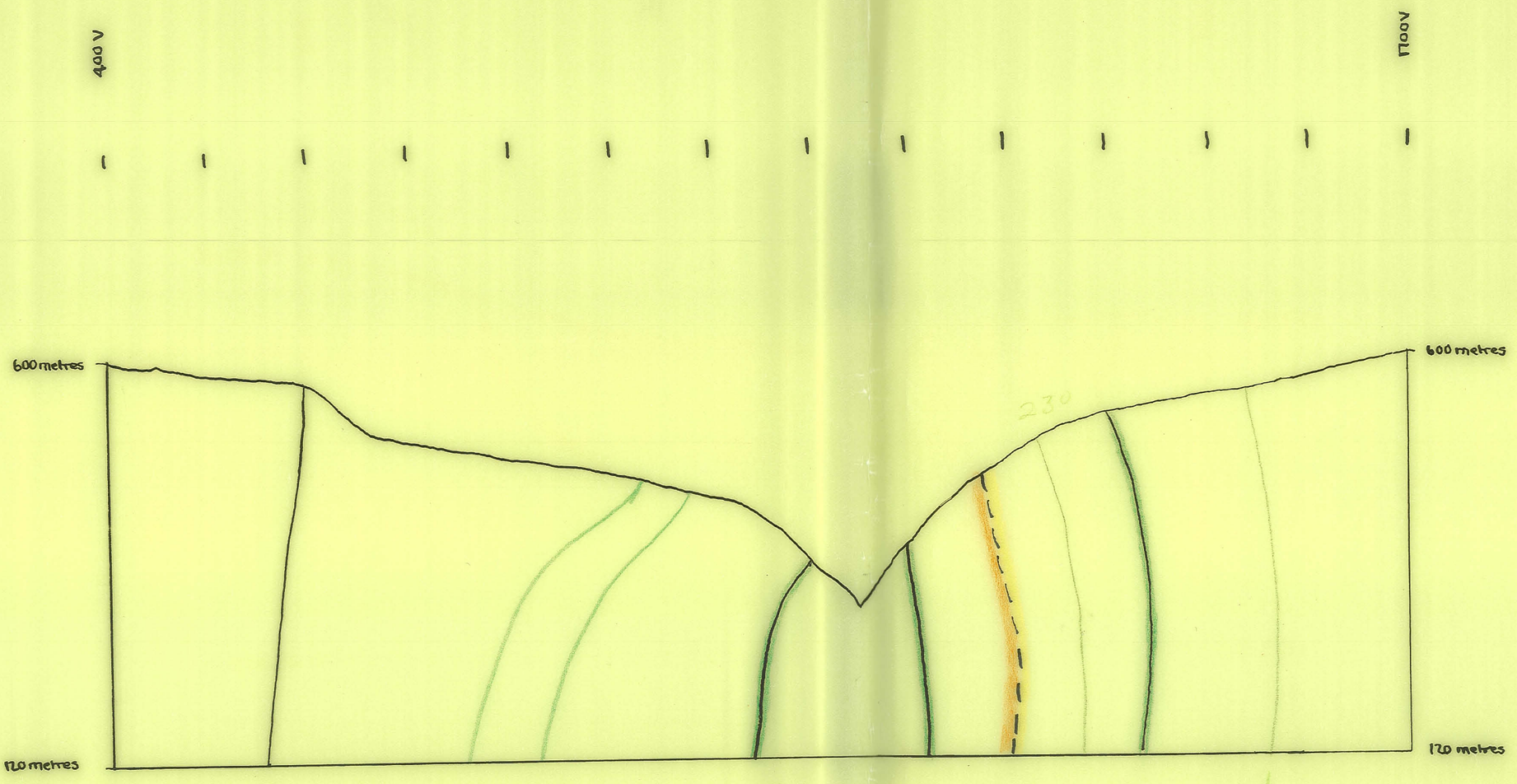
R. Elsdon			
	Erstattet av:		

3100N : 400V - 1700V

ANLEGG II

INGEBORG - VANN

PROFILE



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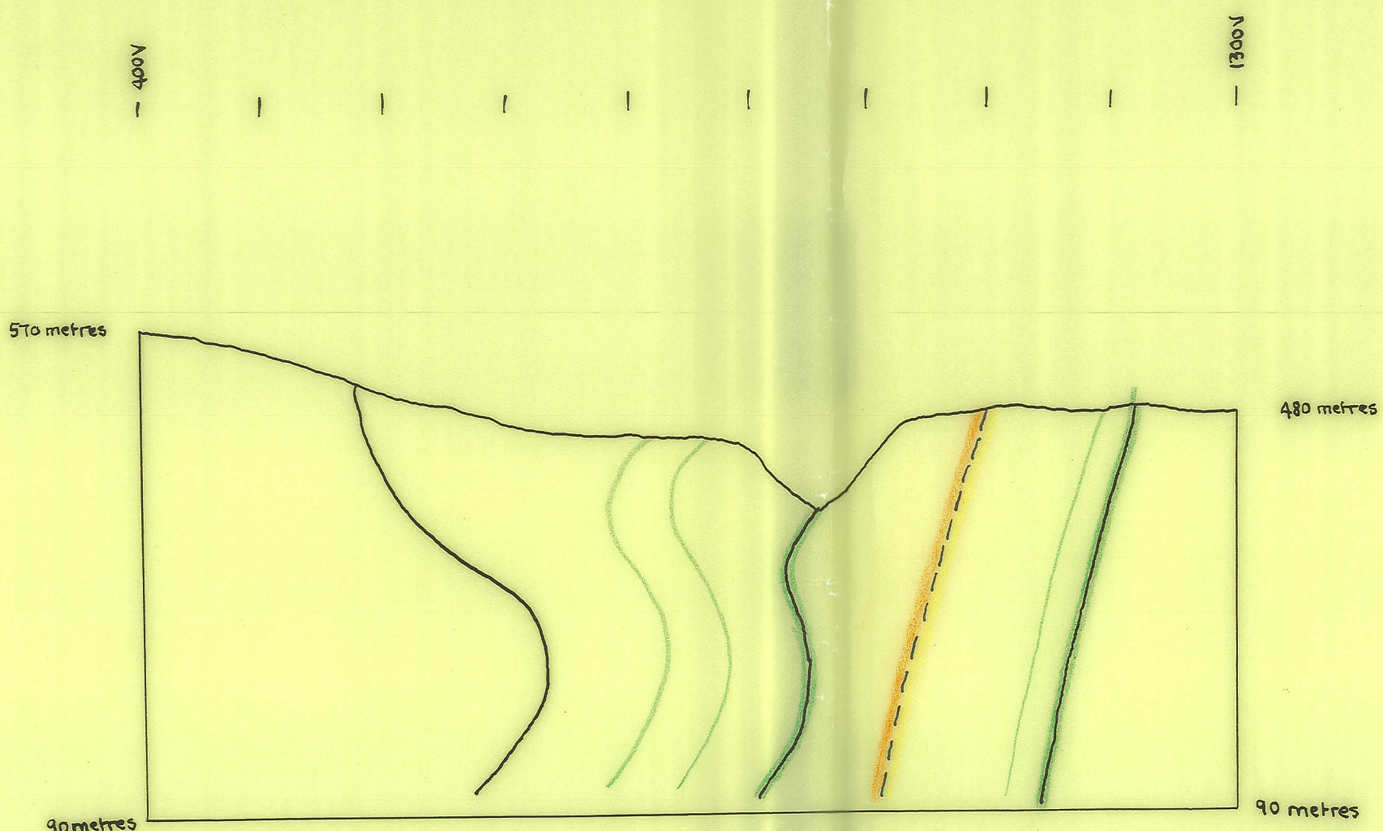
		Trac.	
		Kfr.	
	Erstatning for:		
R. Elsdon			
	Erstattet av:		

INGEBORG - VANN

PROFILE

3350N : 400V - 1300V



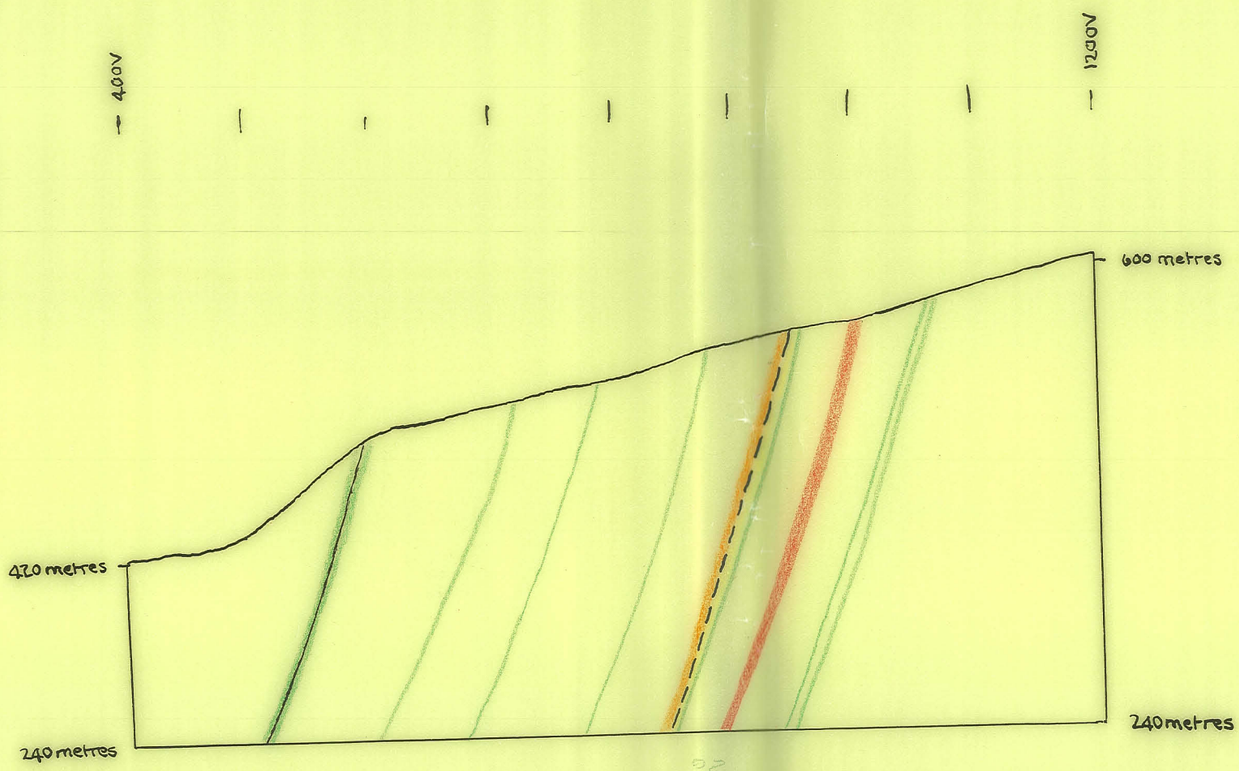
	Målestokk	Tegn.	
		Trac.	
		Kfr.	
	Erstatning for:		
R. Elsdon			
	Erstattet av:		

Format A3

4000N : 400V - 1200V

INGEBORG - VANN

PROFILE



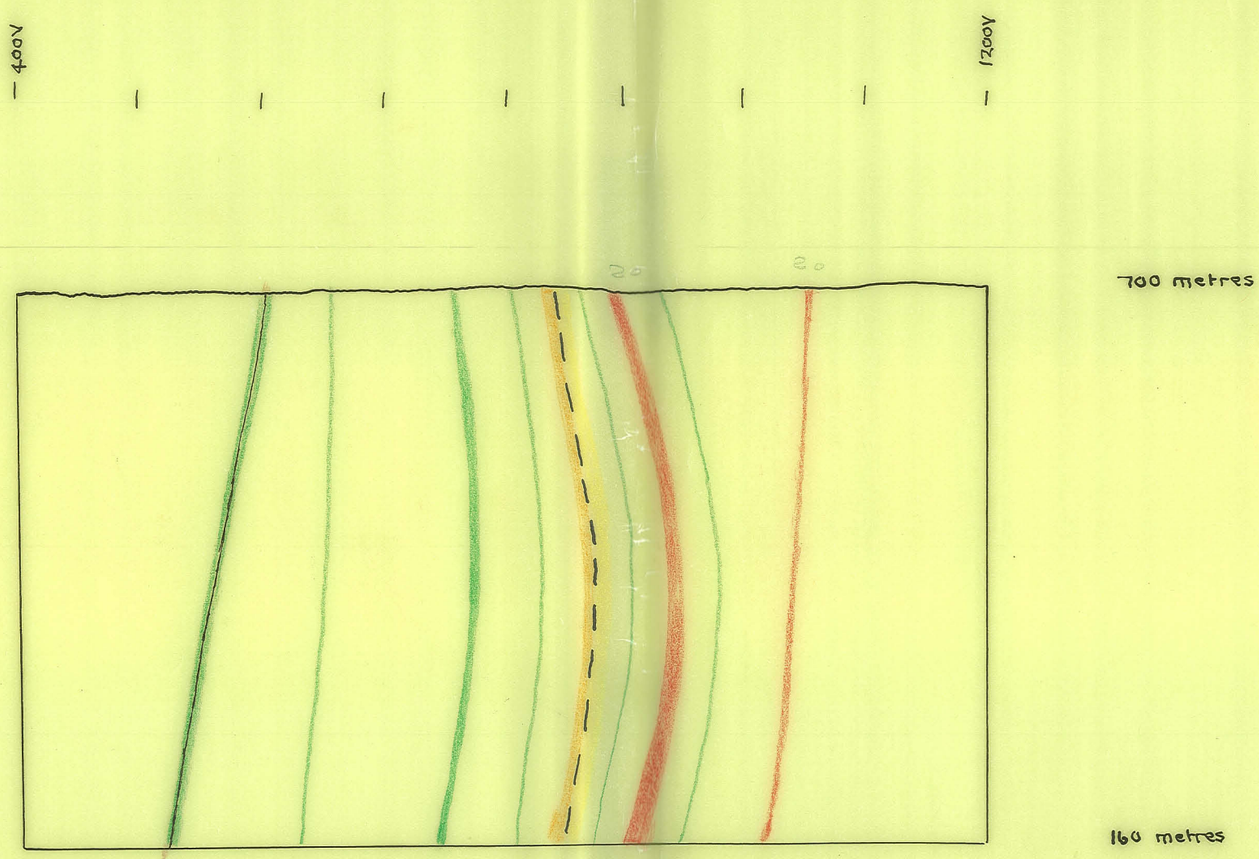
	Målestokk	Tegn.	
		Trac.	
		Kfr.	
	Erstatning for:		
R. Elsdon			
	Erstattet av:		

Format A3

INGEBORG - VANN

PROFILE

5000N : 400V - 1200V



	Målestokk	Tegn.	
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	Erstatning for:		
R. Elsdon			
	Erstattet av:		

Format A3