

# Bergvesenet Postboks 3021, 7002 Trondheim

## Rapportarkivet

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Kommer fraarkiv Sulitjelma Bergverk A/S	Ekstern rapport no "522145003"	overse	endt fra	Fortrolig pga	Fortrolig fra dato:
Tittel Report on the geo	ology of the ore-	-bearing are	a aroun	d Ingeborg vann.	
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ELSDON R.			1967	Sulitjelma Gruber A/S	
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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 conductivety survey was carried out on the rocks around Ingeborgvann, Staurdalen and extending towards Bothvann, 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 - gearing 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 certainly, but the author feels that it does not cross the river between Ingeborgvann and Botnvann.

#### Lower Furulund.

The dominant rock type is a <u>calc-muscovite-biotite-schist (calcglimmerschiefer)</u>, 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. <u>Biotite-rich schists</u>, 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.
- 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. <u>Calc-mica-schists</u> common in the lower part, simular to that in the lower Furulund.
- 2. <u>Biotite-rich schists</u> 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. <u>Psammitic schists</u> 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

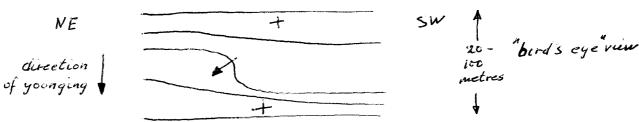
thick at 3900 N/1 000 V, at 3 890 N/1 000 V this band suddenly disappears. An isolated exposure of a gneissic-looking rock 2 metres thick was found at 3 400 N/1 150 V but could not be traced in either direction, and it is a matter of conjecture whether it is physically connected at any level with the 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 mendinal folds. North of Ingeborgvann these are well exposed and generally result in as 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 Bothvann 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-germet-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 minws, are blocks of massive, fine-grained quartz-rich rock containing varying arounts of chalcopyrite, purite and pyrrhotite (or mine-blende), with a distinctive deep purflish 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 liminitic material. The amphibolite, however, contains a little "resh 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 hist-rock which is a correspressed-dark-garmet-amphibelite. This rock has a purplish brown weathered surface.
- 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 screttigraphic 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 notth east. A strong anomaly extends south-westwards underground as far as 3 000 N/950 V.

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

4th zone  $\rightarrow$  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 Bothvann 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  $\frac{1}{2}$  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 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 collection of 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.

## KEY TO THE MAP AND CROSS - SECTIONS

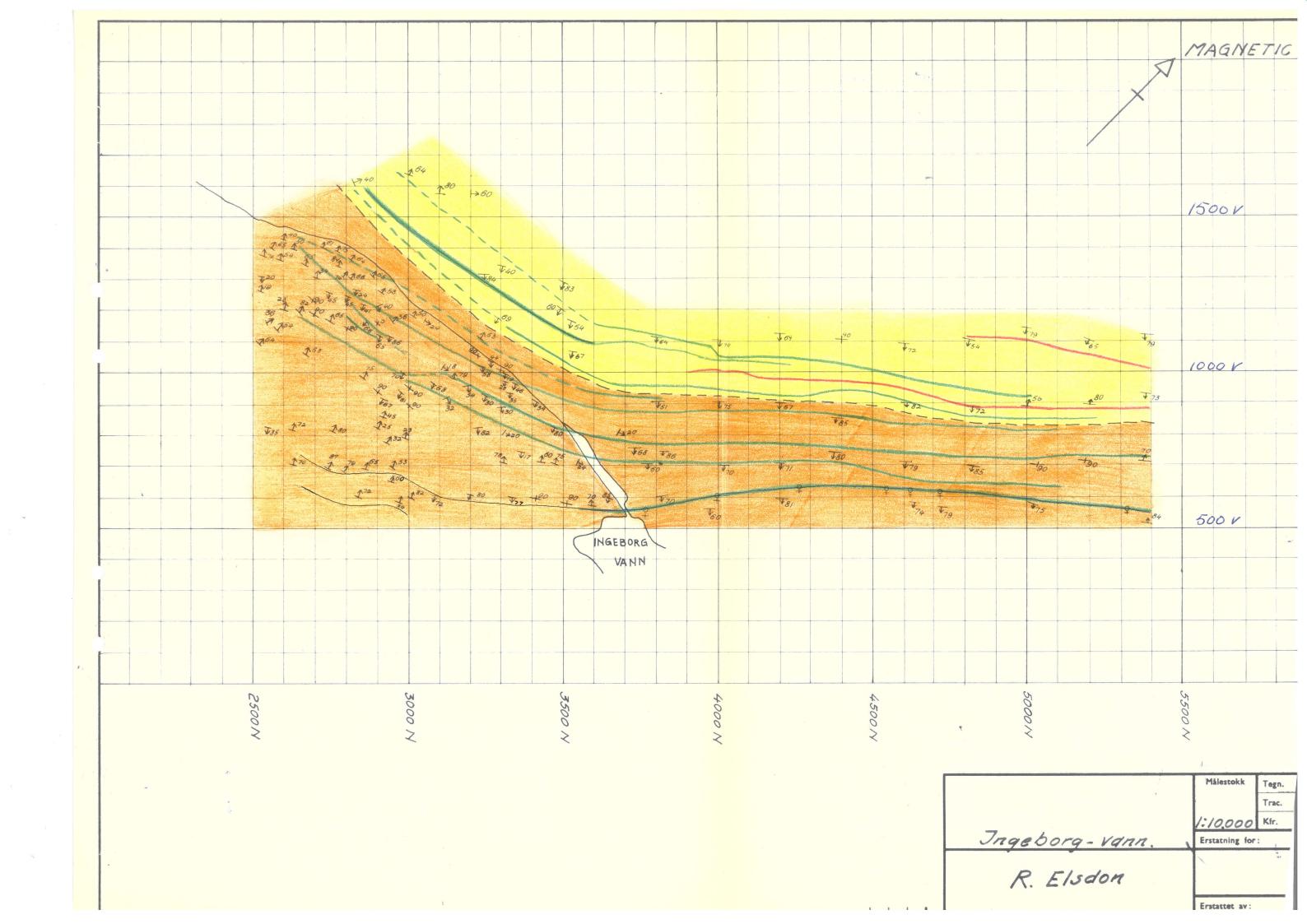
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R. Elsdon

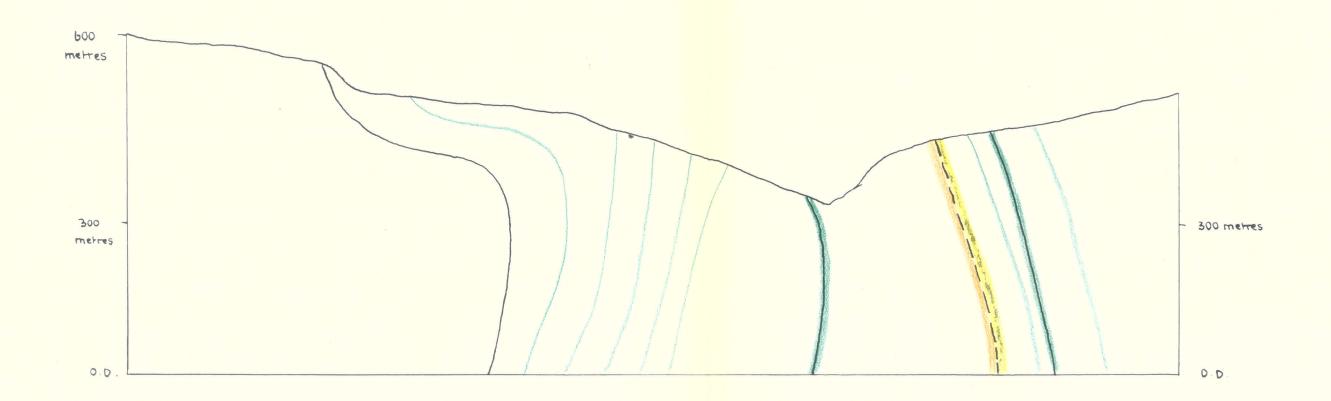
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INGEBORG - VANN

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PROFILE

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400

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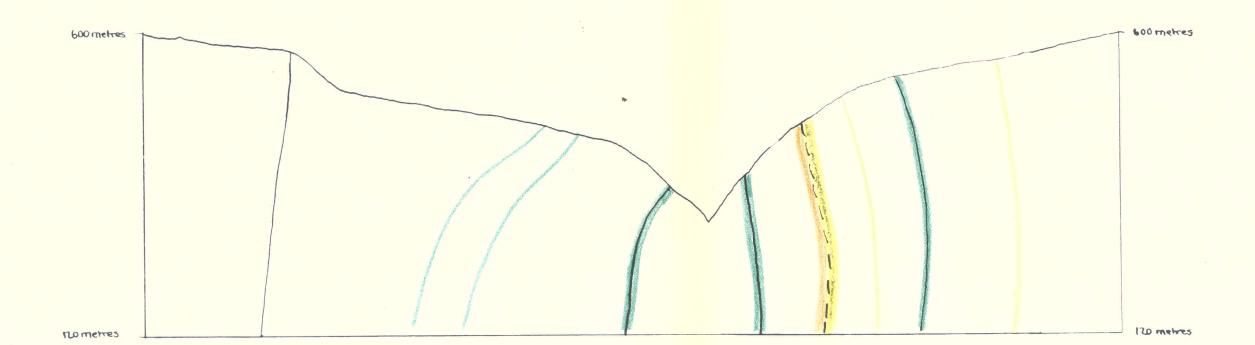
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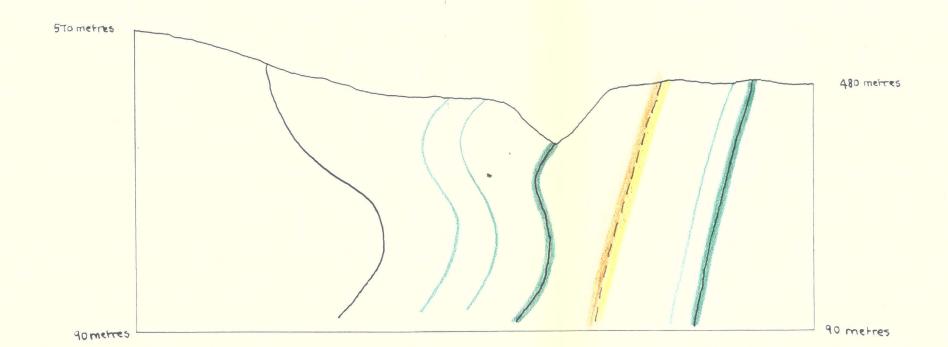
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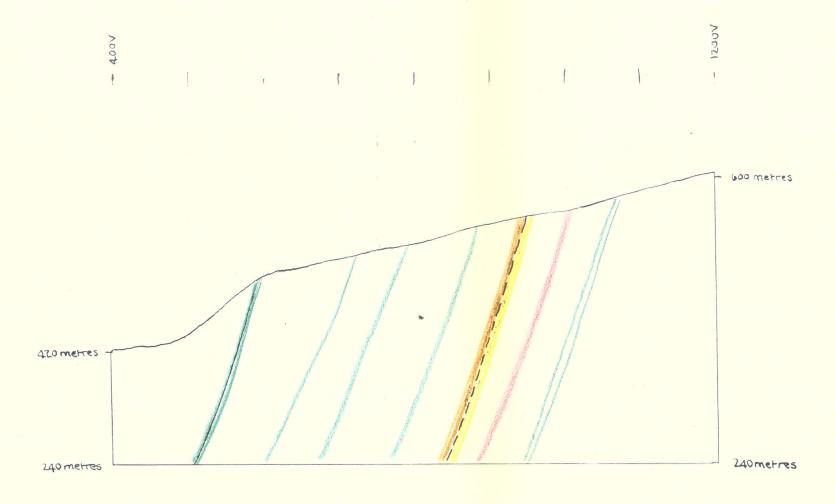
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### INGEBORG-VANN

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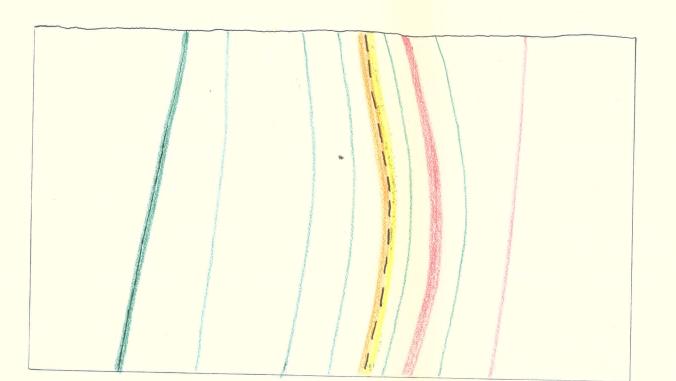
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5000N : 400Y - 1200Y

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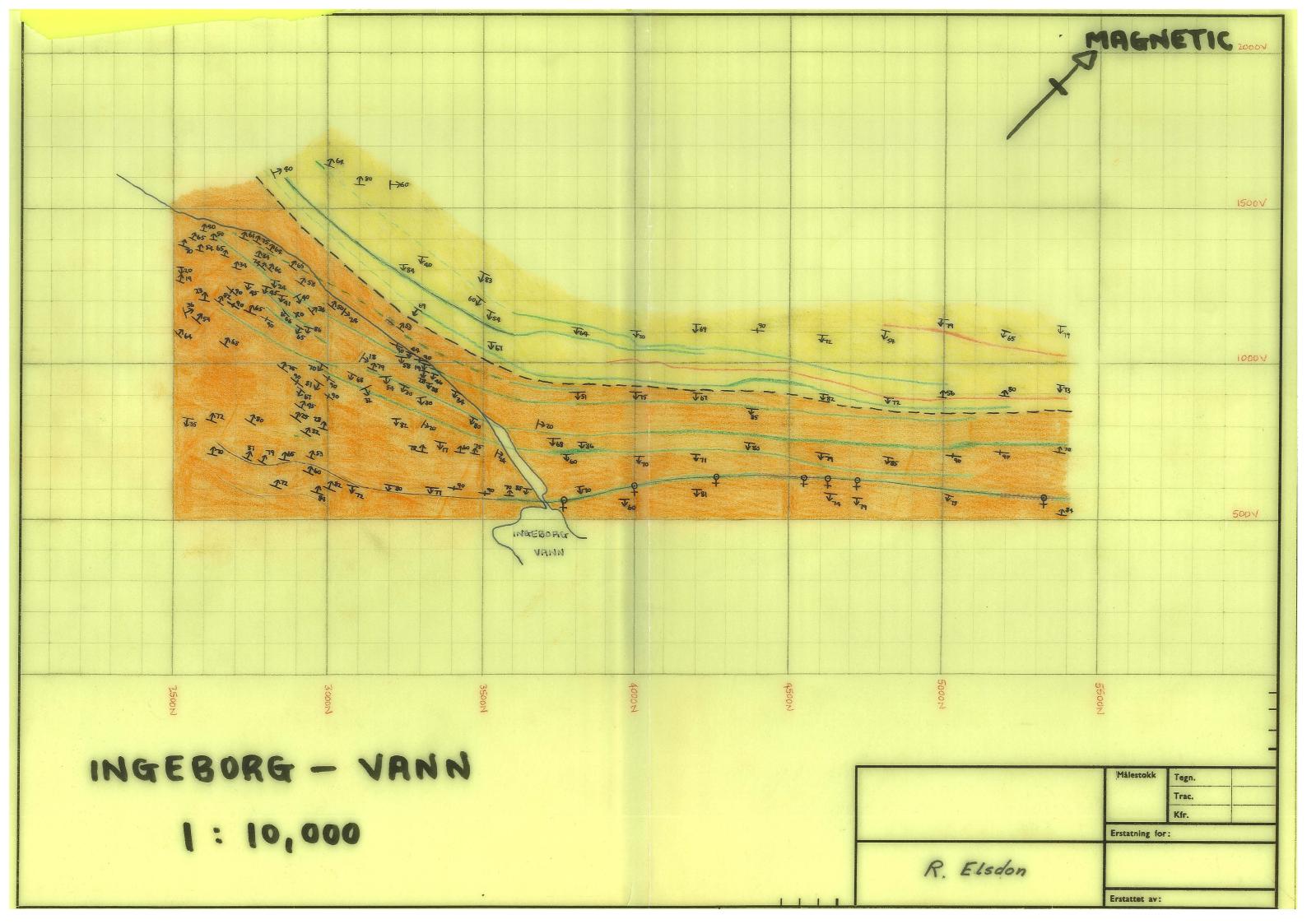
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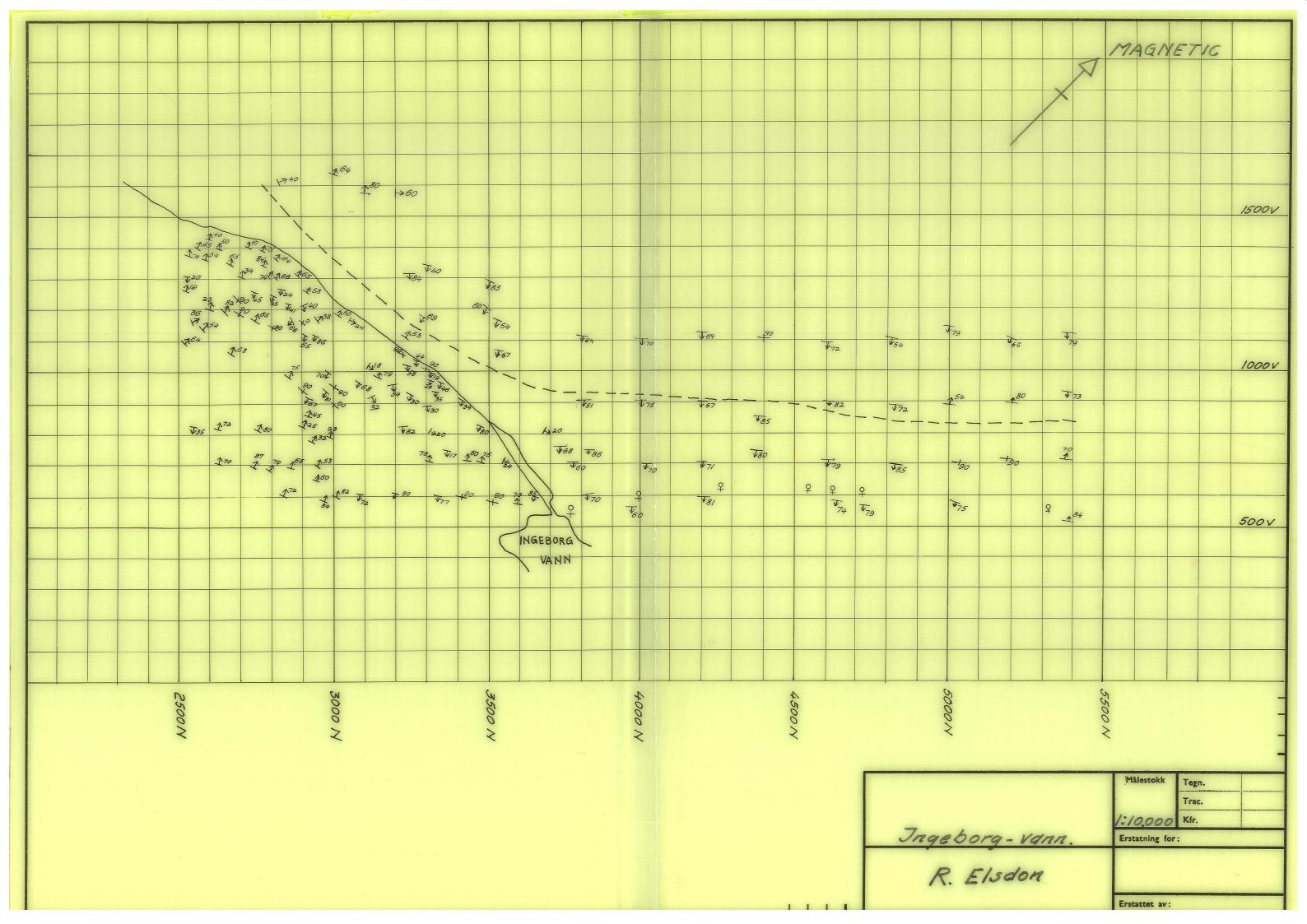
Thus it can be seen that at the center of these fields, the depo are towards the east and rush tour, and the been are temperally evertwined South of the rove behaven Ingelong-Vivan and Bethanism home of these Joldes Can the secretary we knowledge but some victoried dup transmirration showing receive environment they may represent these selds. In this is inserted in it wise of inspect experies Was south of the rese there was come sumple monochinal tolds of summer magnitudes, was orial thores myster and tenalled to the stake William the commonly accounty of measurement, the strike elisections are I very uniform and show that there is a broad general felding structure which has now been taked our a vertical frommer. assessed strokes values 140 Nul lux 1250 2 N Of Lane **13**5 ME of lake Wendelland 125° S by name 140 Some smaller - scale structures are absorber at themes very fire translation of brothe sensats in the Loves Fireland small higher foldling of quarter veins over Lenses a universal well developed series only . Offerentry pointful to the bedding ORE+ HORIZONS meanifering our, or 549420 Micro, win Journ at 5 different housers within the Forward All occur within amprilouse bonds of at strategraphic horizons where prophelostics occur heavily along the stocke Each hanger, bus, roung of the one which is strategraphically lowest, will now be described, and conclusions which he observed regarding the occurrence of one 1. The zone entering years specialston we have us to 24501/1501. Thus zone con be devided with the parts , extending from \$4000 5000 to the point where it oxides the next cot the west end of Ingeling Vann, and Jim thence westerness to 2650N 156 The first food of the zone, on which with the efficience thround absorbered minies

which us to know ground those gover amphibility. This rists has a purplish brown was the said the year. the zero running from 1850x 1585V to 3600x 1030V For the majority of the length ut consulting a 5-7 meter while course comprehence, sometimes continuously brothe my which is set feethers of ecoust amount were containing promise ensuranced Of 30004/1090 V. however, the luminitie masterial us umendie modudi diversionly trough to light coloured quarte Johnson builds school Further early there is an one free complete out the scene strategraphic strategrap a school exercise of appearanced pinks in a dark, first grained amphibolite al 4800N 1950V. It is interesting to compare the observed this tribution with the Houses of the Jeephysmas word 151 zone - a ronge anorrowy exists east of the Tragelong Runes wo for as 55000, win to former corresponding to the subject distribution of the out actual west of the was the circumply throughour at 3550H, but to present meaking between 3000H and 2100H Univers a Shorty anomaly at digith powers in a sculb - winderly distriction 2nd zone - a varge arranged to present across the river at 340011/9404 but does not extend very far south what or north east a strong animally extends south wisheards water VOTP/ HOODE to Jan to January 3rd zone - there is no gerthyway animaly afterest severationing to this are some house 4th zone - to webs arimally tribiblewood Front 1804 and 3600H/0804 5th ione - he observed anomaly Thus in some cases geothysical work agrees were with the delated field work, but where the se in body weathered to beside it straigh through out discovable in band specimen worther resident eyel operation the electrical conductivity survey forthe to KUKOLIE PROBLETCE Fundling at should be raded that many very similar morners present on the conductionisty survey diagrams correspond with outereps of properuption in one can be seen FIELD MEASUREMENTS Bournetur heights were recorded and noted at exposures of the various or lines

By and showe were becorded to fillions nown of Ingelong - Vann, where the structure is fairly easy to see, measurements wit make at appressioned 200 make intervals along the geophysicisms' and ron both suter of the never behalver Ingolong-Vann and Between measurements were made to each individual outsies. This was become of improject exposures in the Husby wooded ground, and because it was thought that the distribution of our might his musucally rentified In one to have taken the write, which is doubt aster whether terrain experiences were join; there are inducated in the just notes. In other of the number of mensurants made south of the river, some creas the total represented than others surce exposures are not good on some of the lower ground in the words The measurements of appared strike are considered to be becaused to ±5° where of the fact these many of the surfaces wild and rather underson. ORIGINA OF THE AMPHIBOLITES with one or two formula exceptions, the writer found no evidence in the field Jos for igneous rugins, no proposed by Raids o Thabahast in Report No 103. They occur as victared bands up to 10 meters thank , and there are no traces of entres chilled mangers or handernoted the had rock, though if their leatures dutingmenty exist, they may have been there exist by exects of war ugunal metanosphism. In view of their demoted the charges they are mentalized to be loves, that since they are concerdant they may be then sells. For the unity is redunentary origin one the various letter of grain size and made musical centered, which to use to a considerable range of there as composition, wherever one might except a family wrigher chamical composition of their resist were magnitude Or 2920H 11904 there is an expersua which shows to Zmero thick body of complimate themses repetly becaused and with some interfunctions against the enciping sale much servors at the bower contact Forther examination of this and other exposures, tossibly with their section mercacopy, might weather their problem

CONC	
	The structure of the own in essenticity smaple with near vertical strates stratus
•	affromatily NE-SW, and very gently Plexwed
2 .	The diversity or and the out how your so reserved to that of transplacions during the
ν.	nel comend en la small-scale loy structures
3.	The our thirty occurs in amphibolic bench, or the some straing cipies housen as ready enopologics; in the later take their is very water or present
ě.	The augenite on deposit one franchy the to replace only the composited by
	sulpur bearing hydrothernal selections, which carry away Mg, le and cour
	elements each convert the 12 to the trace to the sachuring typical side & see F. I work "
	I Vernongen, "Tyrevus - Metarnosphie Tehrology" p 577 Malaras Hull 19601.
	However, no Juan conclusions can be drawn with regard to the mode of origin of these
ew.	Julyhode crus windsond defended petrographic and tremical durate.  In ourse of the field reletions of the crest is accordanced by the winter than the
3	More than the second control to the second c
<b>b</b> .	The require of their in managation, taken in conjunction with the geophysical survey,
	induced that the coly on howyon with a cirea leading to contain decorrons
	quantaies of copies (except possibly as earths beyond investigation limites of an
	electrical comeductivity survey) we some I wo the screen victories the over est.  The west eventy Ingelially Vann tand great line 5400N
~}	
	II astrolica masparo Justino eras terrando Sterjervadosabren ún trolo to
	ach with the store with a stant of the same stants
	is a second to the form of several and second to form the one series for
	this section showy and entruced executates who exited to little visite the
	Though already have been unclestables and the authorizing of aware of this.
	ii) quanting the versions of 2014 of 1,2 and 4 would inducate the versions in
	tothe course of collections and depths in there some?





## INGEBORG - VANN

## KEY TO THE MAP AND CROSS - SECTIONS

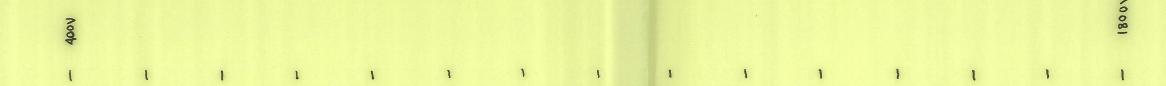
V 54	direction and magnitude of dip
7	old mine; recent excavation
	are some
	calc-mica-schists; carbonale-free mica schists; quart-cofelspathic schists  Upper Furulund
	Furulund Greiss
	cale-mica - schists
	amphibalite and biotite-amphibalite
occes.	garnet - amphibolite
	Upper-Lower Furuland Boundary

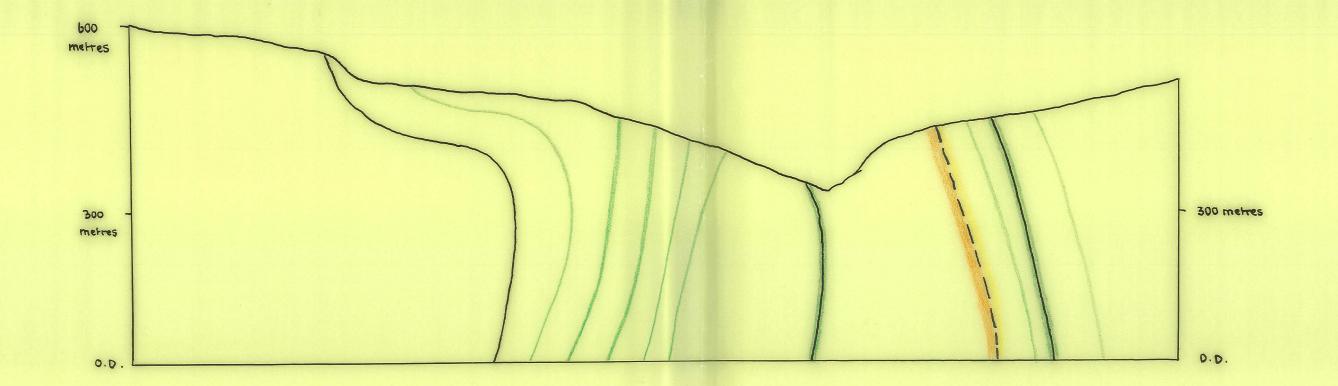
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	Erstatning for	<u> </u>	
R. Elsdon			
	Erstattet av:		

INGEBORG - VANN

2900 M: 400.V. - 800 V.

PROFILE





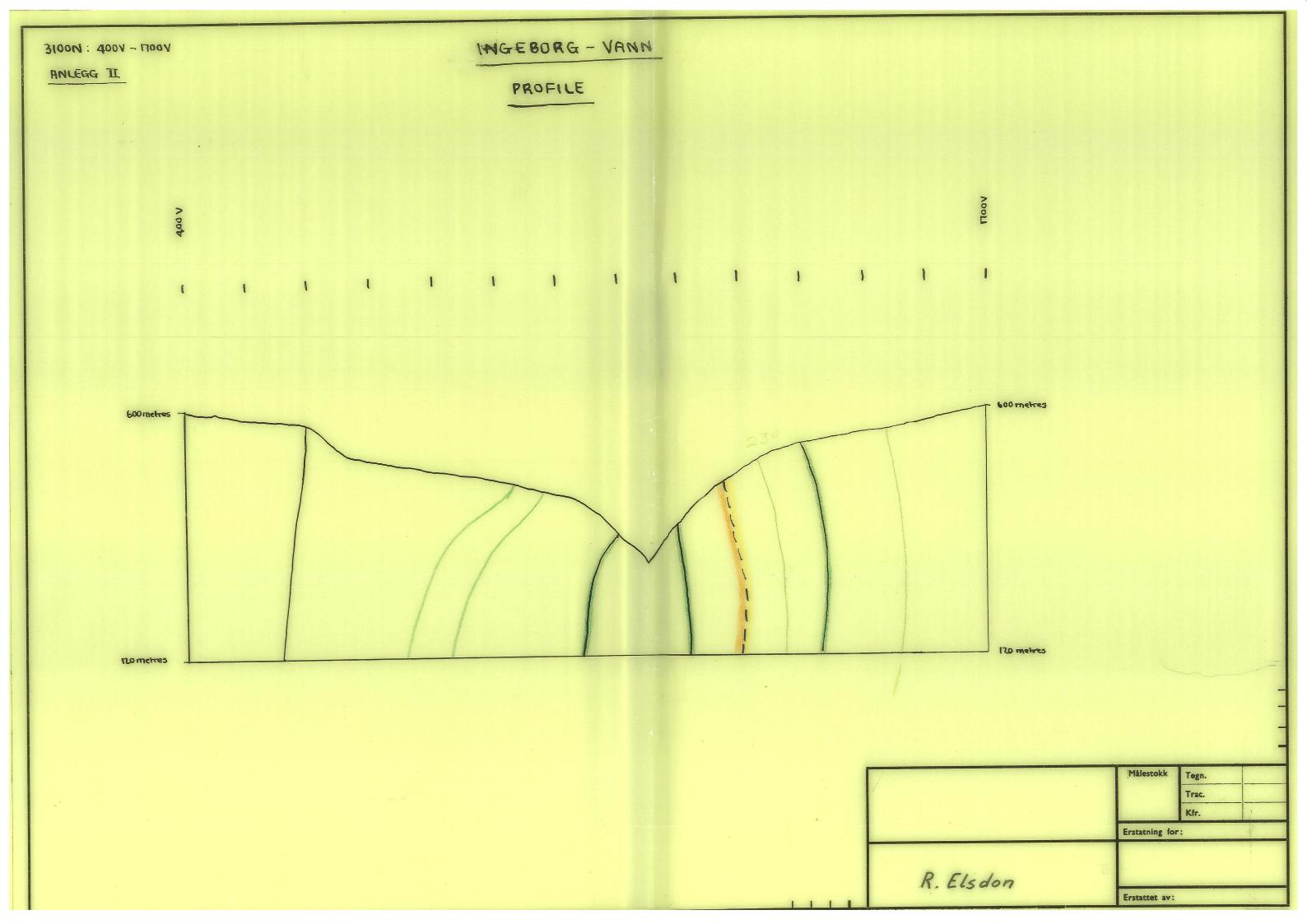
Målestokk
Tegn.
Trac.
Kfr.

Erstatning for:

R. Elsdon

Erstattet av:

INGEBORG - VANN 3100N: 400V - 1700V ANLEGG 1 PROFILE 600 metres metres Dometres Tegn. Trac. Kfr. Erstatning for: R. Elsdon Erstattet av:



INGEBORG-VANN
PROFILE

3350N: 400V - 1300V

90 metres

480 metres

40 metres

Målestokk
Tegn.
Trac.
Kfr.

Erstatning for:

INGEBORG-VANN 4000N: 400V-1200V PROFILE 600 metres 420 metres 240metres 240 metres Erstatning for: R. Elsdon

Format A3

Erstattet av:

INGEBORG - VANN 5000N: 400Y - 1200Y PROFILE 700 metres 160 metres Tegn. Trac. Erstatning for: R. Elsdon Erstattet av: