Bergvesenet
Postboks 3021, N-7441 Trondheim

Rapportarkivet

Bergvesenet rapport nr	Intern Journal nr	Internt arkiv nr	Rapport lokalisering	Gradering
5378				

Kommer fra ..arkiv	Ekstern rapport nr	Oversendt fra	Fortrolig pga	Fortrolig fra dato:
Sulfidmalm	Sul 905-15	Sulfidmalm a.s.		

Tittel
SUMMARY OF FIELD WORK IN THE ESPEDALEN AREA

Forfatter	Dato	År	Bedrift (oppdragsgiver og/eller oppdragstaker)
Wilson, B.H.	18.08	1972	Falconbridge Nikkelverk AS

Kommune	Fylke	Bergdistrikt	1: 50 000 kartblad	1: 250 000 kartblad
Sør-Fron	Oppland	Østlandske	17174	Lillehammer

Fagområde	Dokument type	Forekomster (forekomst, gruvefelt, undersøkelsesfelt)
Geologi Geofysikk Boring Analyser		The Evans mine Statsråd Stangs mine The Andreasberg mine and surrounding area Jørstad area

Råstoffgruppe	Råstofftype
Malm/metall	Ni Cu S

Sammendrag, innholdsfortegnelse eller innholdsbeskrivelse

Rapporten er et sammendrag av de arbeidene som er utført de siste 10 årene basert på informasjon fra deltakerne i Norsk Hydro joint-venture.

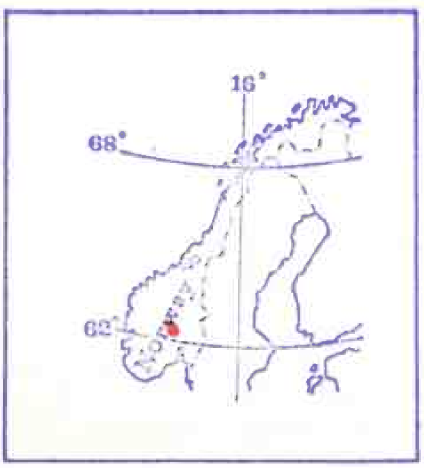
FOR FALCONBRIDGE NIKKELVERK A/S

A/S SULFIDMALM

PROJECT 905-15

SUMMARY OF FIELD WORK IN THE ESPEDALEN AREA, OPPLAND, NORWAY. AUGUST, 1972.

B.H. WILSON



INTRODUCTION

Nickel-bearing sulphides have been known to occur in the Espedalen area since the 17th century. Mining of the sulfids on a large scale took place in the mid 18th century, specifically between 1846-57 and 1874-78. The principal producing mines were the Statsråd Stang and Evans Mine.

Interest in the Espedalen area by A/S Sulfidmalm developed in 1962 with the aquisition of the old showings. Investigations were carried out and many of the claims were dropped. In 1971 a joint-venture with Norsk Hydro was signed and a pooling of mutual information has resulted in a renewed interest in the region.

This report is a summary of the work that has occurred in the past 10 years and is based on the information of the joint-venture participants.

THE EVANS MINE

A summary of the geology of the Evans mine has been completed by Overwien (1965), and Vokes-Vrålstad (1969). Essentially, they state; the sulfide zone is flat lying on the underside of an ultrabasic body cut off on both ends by faults. The down dip extension was then unknown. But, in 1971 a mise-á-la-masse survey reported by A. Sindre (1971) shows that any sulfides remaining would be of a small quantity.

Vokes-Vrålstad had assays of tip material that gave .5% Ni to 3.4% Ni.

Based on the mise-á-la-masse survey no further work has been conducted at the Evans mine.

STATSRÅD STANG'S MINE

Overwien (1965) states that the strike length of the Stang mine is 115 m long, with an east-west direction. The dip varies between 40 - 60° to the north with an average of 50°. The workings have a depth of 30 m down dip. Some assays quoted in this report are:

.28 - 1.3 % Cu
.65 - 1.2 % Ni

It appears that Vokes-Vrålstad (1969) have relied heavily on a report by Vogt (1917) and gave a general idea on the geometry of the ore zone and the host rock geology, that is the ore zone appears to be lensoidal in shape, pinching out at both ends. The geology of the host rock is anorthosite in the hanging wall and a norite or mafic norite in the footwall.

In 1972 mapping of a region occupied by Statsråd Stang and the Nicoline mines, and the geophysical anomalies in the vicinity, was carried out by Ryan (mapping and subsequent report still in progress). A surface sketch map of the two old mines was done by the author.

Geophysics at and near the Stang Mine has turned up an interesting anomaly in 1964. The anomaly lies north of the Stang mine between it and the Nicoline. In a letter to Mr. S.N. Charteris (1965) Overwien attributes this anomaly to small amounts of pyrrhotite, and based on observations at the Stang mine goes on to say; " In the area north of the Stange mine there is a tendency toward schistosity in the rock and sulfides seem to occur both as dissseminations and as a film on the schistosity planes. The latter fact should increse the conductive power of the rock. I therefore doubt that these anomalies are caused by massive sulfides." This may explain why drilling of this anomaly has been held back. Overwien (1965) goes on to statethat rtrenching on this anomaly turned up a "fine grained altered basic norite". Macroscopically one can see very small disseminated sulfide grains or very thin sulfide stringers along the schistosity planes. The rock does not contain more than 1% sulfides (approx.).

In 1971 geochemical investigations were carried out by R.Band and in his report he gives the following comment on the area immediately north of the Stang mine, known as the Sulfidmalm anomaly, or S. anomaly. It should be noted that he compares the Stang mine area to that of Jørstad and Andreasberg, which will be dealt with later in this report.

"The Statsråd Stang mineralization is characterised by a restricted, low-order Ni and Cu anomaly. There is a very low anomaly to background contrast and the majority of Ni and Cu values are in the "possible" or "probable" anomaly range. Rock analyses indicate low Ni and Cu contents in bedrock north of the Statsråd Stang deposit. The target at Stang is much more restricted in areal extent than at either Andreasberg or Jørstad, and this may account for the differences in geochemical expression".

"ANOMALY 'S' (map 15-71-7): The geophysical anomaly is situated approximately 175 m north of the Statsråd Stang mine workings. A/S Sulfidmalm located the anomaly during a ground survey in 1964 and reported finding disseminated mineralization in a trench dug across its axis. Norsk Hydro's interpretation of their geophysical data suggests a "non-mineralization" cause. Till cover in the vicinity of anomaly 'S' reaches a maximum thickness of 2.0 m.

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Pit profiles (map 15-71-7) show highly anomalous Ni and Cu values (maximum 410 ppm Ni, 302 ppm Cu) over the geophysical anomaly. Co, Zn, and Cr values are high, with maxima of 50 ppm Co, 88 ppm Zn and 280 ppm Cr. Ni/Zn ratios are also uniformlyhigh. The high Cr values at anomaly 'S' are considered particularly significant.

During the course of rock sampling in the Statsråd Stang area, a zone of ultramafics was noted trending northwestwards from east of pit RF-18 to anomaly 'S'. This is apparent on map 15-71-7 as a zone of rock-nickel contents greater than 500 ppm Ni (aqua regia) compared with a maximum of 200 ppm Ni for other samples.

Anomaly 'S' is partially coincident with the 500 ppm Ni contour on map 15-71-7, which is interpreted as approximating the ultramafic/anorthosite-norite contact".

"Conclusions

The geochemical anomaly over anomaly 'S' at Statsråd Stang resembles mineralization-related anomalies at Jørstad and Andreasberg. The geological situation is favourable and this anomaly warrants further work".

THE ANDREASBERG MINE AND SURROUNDING AREA

The Andreasberg area in general appears to be a point of disagreement between Overwien (1965), (1971) and Vokes- Vrålstad (1969), even though there has been a good deal of geophysics and a reasonable amount of geological mapping.

Both Norsk Hydro and Sulfidmalm have done geophysics and both companies have shown electrical conductors southwest of the Andreasberg. The point of conflict appears in regard to the geology and the quality of mineralization. Overwien considered the area southwest of Andreasberg, where the conductors are located, as part of the Andrthosite complex, whereas Vokes- Vrålstad consider this part of a metasedimentary sequence. It should be pointed out, that with the exception of the ridge which the Andreasberg mine is located on, outcrops of bed rock are very limited. Only through systematic outcrop mapping will the situation be partially solved, bearing any structural complexities.

A second point of disagreement is that on the quality of mineralization. Vokes-Vrålstad (1969) play down the significance of the area with the reservation that it is still interesting. They quote assays from Vogt of 3, 4.5 and 6% Ni. Also, from their sampling of wall rock impregnation at Andreasberg they they got .42 % Ni, .15% Cu and 1.9% S. They go on to say "omregnet gir dette ca. 8% Ni i ren kis".

Southwest of Andreasberg where there is situated a number of old showings and co-incidental geophysical anomalies. Vokes-Vrålstad have mentioned that the geology is somewhat similar to that of Statsråd Stang, and that the formation below the old mine is possibly sediments or graphite schists, and though they are sulfide rich they are Ni-poor.

Overwien (1971) states further that the area south - southeast - southwest of Andreasberg, though not lacking Ni, is Ni-poor with 1.7% Ni in the sulfide phase with a high Ni:Cu ratio.

As Band's 1971 survey was only an orientation survey, little can be drawn from his results at this time, other than interest is still maintained.

JØRSTAD AREA

All reports on the Jørstad give favourable comments. Vokes-Vrålstad (1969) have dealt more extensively with this area than Overwien and thusly a condensation of their findings are contained here within.

The Jørstad zone is 100 m wide, 40° dip and a strike direction east - west. These directions are all approximate. The approximated true width is 30-40 m. From the limited number of showings it was possible to see that the zone was pinching out to the west and northwest. In the east it was impossible to determine what was happening because of overburden.

From their report one gets the impression that they consider the zone to be 300-400 m long, 30-40 m wide and lensoidal in shape. However, there is a note of overemphasis in the tone of their report.

Geophysical anomalies do not compliment the geology, because there is a series of small, weak anomalies to the south of the showing zone. A calculation of 10,000 m^2 area of anomalous conductor is given.

Also, they claim that the Jørstad geology is different from that of other known mineralized areas. That is, though tectonism is present, half of the ore zone may be composed of mineralized impregnated hanging wall. Evidence of drag folding can be seen in the footwall, which can be followed to the northwest. This is different from the Stang and Evans mines because there we have sulfides occurring near the footwall and dissipating toward the hanging wall.

Overwien (1965) noted that the mineralization was very weak. Vokes-Vrålstad (1969) were able to sample the zone and give the following assays:

1) .15 - .22 % Ni, .10 - .09 % Cu, 1.0% S, S:Ni = 5
2) .65 - .66 % Ni, .34 - .38 % Cu, 8.0% S, S:Ni = 14

In spite of the lack of showings, they suggested drilling before trenching with a bulldozer because of costs etc.

In 1970 the drilling was conducted and according to Vrålstad (1971) the following results were obtained:

DBH	No.	1	-	4,5 m	=	.34% Ni,	.13% Cu	
"	"	2	-	14 m	=	.30% Ni,	.10% Cu	
"	"	3	-	9.5 m	=	.23% Ni,	.06% Cu	
"	"	4	-	18.8 m	=	.35% Ni,	.09% Cu	
				(which was included in the section)				
				24.4 m	=	.30% Ni,	.08% Cu.	

A copy of Ni:S ratios and analyses is included in this report for the readers reference.

After the 1970 drilling a mise-á-la-masse survey was carried out. The results are summarised by J.B. Gammon in an inter-office memo. He states, " Indications are that a conducting area of 600 x 200 m is present. Thickness estimates of 50-100 m given, but a 30 m thickness would be more in order. This leads to a potential of 10 million tons of indicated mineralization". Overwien (1971) calculated a potential tonnage based on Norsk Hydro geophysics and drill results of 2.4 million tons of .3% Ni, which would yield 7,200 tons of Ni.

Detailed outcrop mapping was conducted in 1972 by Ryan (still in progress), and possibly his results will further enlighten the situation there.

This then is a summary of the knowledge of the known mineralized areas.

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INVESTIGATION OF THE TERRATEST ANOMALIES

In spite of the preliminary investigations by Vokes-Vrålstad (1970) of the Terratest preliminary results, a second investigation was undertaken by Ryan and Wilson in the summer of 1972. Ryan's report is still pending. The following is a brief breakdown of Terratest's opinions on the causes of these anomalies and observations made by the author while accompanying Ryan in our investigations. The prime purpose of this re-investigation was to examine some anomalies in light of new geological information supplied by The Robertson Research (1971) Photo-Geology Report.

The anomalies will be discussed in numerical order as plotted on the Terratest imaginary component map.

Anomaly No. 1: Terratest attributed this anomaly to graphite schists. However, upon ground investigations it was thought that the anomaly may be located along a thrust fault contact. Moving west from the road, one crosses over this zone, moving from anorthosite with highly altered gabbro into highly phyllitic schists. A geochemical traverse was placed south of this anomaly, and the reader is referred to a report by T.H. Tan (in progress) for the results.

Anomaly area No. 2: The Terratest opinion on this group of anomalies was that they are caused by graphitic schists, and investigations have shown this to be partially true. However, the situation here appears to be very complicated. Of the four anomalies in this area, the smallest was not investigated. The western half of the northeastern one appears to be in sparagmite while the easternly half is in the anorthosite.complex. The area is heavily drift covered. The middle anomaly is in sparagmite and is considered uninteresting. The largest anomaly however, presents a complicated picture. In swampy areas graphitic schist blocks are present. Along ridges of outcrop, in this flat, somewhat swampy area, a fine grained olive green rock with pyroxene or hornblenditic phenocrysts is present. Petrographic studies of this rock type will accompany Ryan's report. Between the northwest end of this anomaly and the Espedalen Turistheim many blocks of basic rocks were seen. Some of these blocks were slightly mineralized, and ranged in alteration from highly serpentinized to unaltered.

Anomaly No. 3: Terratest states that this anomaly has good definition, but is of low amplitude and an associated mag. high accompanies it. They further add that it may be a result of human activity. Investigation of outcrop located in front of the Dalseter Hotel on the east side of the road revealed disseminated sulfides in a basic norite or mafic norite.

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Anomaly No. 4: The area is mostly drift covered, but it was possible to see outcropping of anorthosite and basic norite in a few places. The basic rocks seen were slightly mineralized. A geochemical profile was placed south of this anomaly and the reader is referred to a pending report by T.H. Tan .

Anomaly No. 6: The Terratest report states that this anomaly may be caused by meta-sediments in the anorthosite complex. Investigations show that this area is more than 90% drift covered, but the few outcroppings seen proved to be meta-sediments as expected.

Anomaly No. 7: Terratest was not sure of the exact location of this anomaly because of a map error and go further to suggest that the anomaly may be due to a conductor that is masked by magnetite (?). Ground investigations did not turn up anything of significance, nevertheless a geochemical traverse was put in. The results, of which, will be reported by T.H. Tan.

Anomaly group No. 8: Again Terratest questioned the exact location of the anomaly group because the Stang mine failed to show up. However, if the plotting of the anomalies is accurate, then the anomaly below the Stang mine is due to a schist zone, known to occur there. This area will be covered in some detail by Ryan on completion of his field work, and the reader is suggested to refer to his pending report.

Anomaly group No. 9: Terratest gives no explanation for this anomaly group. Investigations were limited to two zones of this group, they are the most northernly and the strongest ones. The whole series of anomalies is strung out along the top of the valley ridge and access was rather restricted due to near vertical relief in places. The northernmost anomaly was attributed to metasediments and mica schists etc. A road leading up to the Stang mine cuts through the largest anomaly, and in the road cuts there can be seen gabbro and mafic norites with very minor disseminated sulfides.

Anomaly No. 11: This is one of the largest anomalies turned up by Terratest. Their explanation for it was that it could have been caused by a graphitic schist zone. Associated with this anomaly is a complicated magnetic disturbance. The area is mostly drift covered and the best exposures occur along ridges. Norsk Hydro investigated this anomaly in 1972 with mag. and EM and showed that 3 anomalous zones existed. On the basis of this new information, two geochemical profiles were put in by T.H. Tan, the results of which are pending. Further geological investigations by Ryan and Wilson of this area revealed an ultramafic body with chalcopyrite

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and pyrrhotite. From the ground geophysical map this zone is about 120 m long and 40 m wide. Assays of the samples are pending. This is the most encouraging anomaly investigated in the Espedalen area, and the mineralization has not been known to the joint venture participants before this investigation. It has been named the Rywil anomaly.

Anomaly No. 13: Terratest attributes this anomaly to Ni-free unmagnetic pyrrhotite. It is felt that this is a rather unsafe assumption. This anomaly area will also be dealt with by Ryan in his mapping and subsequent report.

Anomaly No. 14: Terratest's explanation for this anomaly is that it is caused by magnetite content. Field observations were restricted by heavy drift cover near the bottom of the valley. However, one outcropping was found to contain scattered disseminations.of sulfides. One geochemical profile was put in, and the results will be reported on by T.H. Tan.

Anomaly No. 16: This is the Jørstad area and has previously been dealt with.

Anomaly Nos. 17 and 18 are in a drift covered area and no explanation has been found for its occurrance. More detailed information will be given by Ryan.

Anomaly No. 19: This anomaly is the Andreasberg area and has been previously dealt with.

Anomaly No. 20: The Vesle mine. Terratest reports that because of the low amplitude and size of the anomaly, little mineralization could be expected to remain. Sulfidmalm has investigated this old showing previous to Terratest,and EM geophysics have given the same conclusion.

Anomaly No. 21: Terratest suggests that this anomaly has been caused by human activity. Ground investigations were restricted because of drift, cover, but a number of large blocks of ultrabasics were seen, containing sparsely disseminated sulfides.

Anomaly No. 22: No mine was found at Dritua as indicated on the Terratest map, but a mineralized showing was found on a ridge running between two swamps. Norsk Hydro has done some ground geophysics over this showing and has picked up two anomalies between 640 S and 1000 S.

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RECOMMENDATIONS AND CONCLUSIONS

Since 1962, when interest first developed in the Espedalen nickel province, much work has been done to eliminate areas that are uninteresting from those that are. Showings at Statsråd Stang, Nicoline, Jørstad, Andreasberg, Dritua and Rywil to date are areas that warrent further investigation.After all the work done so far there are still many unanswered questions. For example, the lack of good outcropping of the mineralized zone at Jørstad coupled with a complex EM anomaly does not, in my opinion, give good grounds for a drilling program.

It is hoped that situations will soon exist where both concerns in the joint venture will be able to conduct a program based on the following recommendations, or a variation of them and eliminate these interesting areas, or go further with a comprehensive program of drilling.

1) The Evans mine does not warrant further work. However, in the event production should start onee more, the Evans mine tip could prove useful mill start up material.

2) The Statsråd Stang area is one area that requires more investigations. A re-examination of the Stang ore body with the mise-á-la-masse method, using a variation in electrode patterns to eliminate the effect of conductors, may yield a more definite evaluation. Also the test area could be expanded to include the "S" anomaly and the Nicoline mine. However, if this method proves unuseful, then consultation should be sought to select a method that would settle questions on size, shape, and location of potential metalliferous areas.

   As access to this are is relatively good, it is felt that the anomaly "S" area could be further investigated by trenching. A tractor mounted back hoe can dig a trench 14 ft. deep 25 ft. long in one hour. On this basis it is possible that a trench some 200 ft. long, 3 ft. wide and 3 ft. deep could be dug in 1 hour. This would be quite sufficient to cut the "S" anomaly axis. Also a trench in the correct location could enlighten the geological situation between the Stang and Nicoline mines, where there is an uncommitted feeling that there exist a complex structure. (This may be revealed by Ryan's mapping). Trenching of this nature would settle any questions concerning geology, structure, geochemistry and surface expressions of mineralized horizons.

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3) Although there at the time of writing is no clear cut picture of the geological situation at Andreasberg, one may come out of the mapping by Ryan. However, there still remains a problem of the quantity of nickel, and copper in surface mineralization. It may be of interest to see what the mise-á-la-masse method would turn up with respect to remaining ore in the Andreasberg mine. It seems though that this area also wants investigation via a reliable geophysical method whose results give the least amount of ambiguity. In the event that this is unobtainable, then, as suggested for the Stang area, a series of trenches would appear to be the only way to solve these questions short of drilling. As, at Stang, trenching of this kind would facilitate mapping of a cross-sectional nature, and sampling of any encountered mineralized horizons.

4) The Jørstad mise-á-la-masse has shown that there exists 120,000 m^2 surface area of conductor present. Drilling has shown that there exists .3% Ni, with good Ni+S ratioes. There remains a question of whether there exists a massive sulfide zone. To date the geological situation appears to be more complex than shown by Vokes-Vrålstad. Perhaps these complexities will be enlightened by Ryan. However, in the event they are not, then it is doubtful that trenching, as previously mentioned, would prove as useful. Rather, it is felt, what is needed is another geophysical survey that will give better definition of the anomalies, and pinpoint where any massive horizon may exist, or define zones where disseminated sulfides may exist to the extent of potential area for an open cast mine.

5) Anomaly area 11 - the Rywil anomaly. As this anomaly has been checked out on the ground by Mag./EM no further geophysics is recommended at this time. Geochemistry in the form of rock and soil may give a better indication of the grade of nickel and copper that exists there. As the ground geophysics gave a good indication of the surface area of this anomaly, (4800 m^2) it would be of interest to know what the down dip extension of this zone is. (IP?)

6) No additional work should be conducted in other anomalies unless significant geochemical results are reported by T.H. Tan.

7) Should any drilling be conducted in Espedalen, it may be of interest to check out some of the Dritua anomaly.

Acknowledgement.

Many thanks go to Mrs. Eva Lie-Nielsen who was kind enough to verbally translate reports by Vokes- Vrålstad and Terratest.

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Reports pending by
M.J. Ryan
T.H. Tan.

Respectfully
submitted,

Bryan H. Wilson

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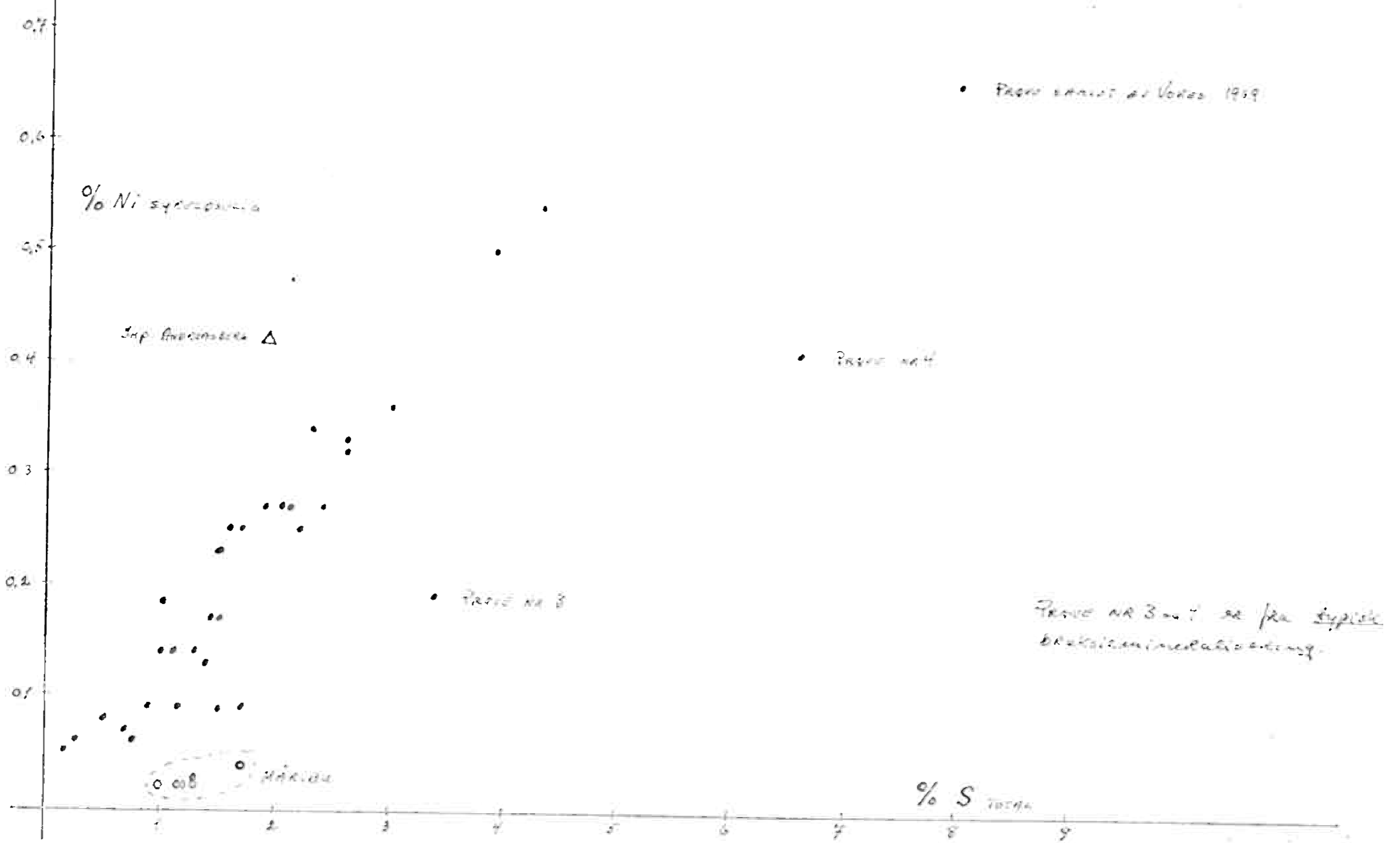
Bryan H. Wilson

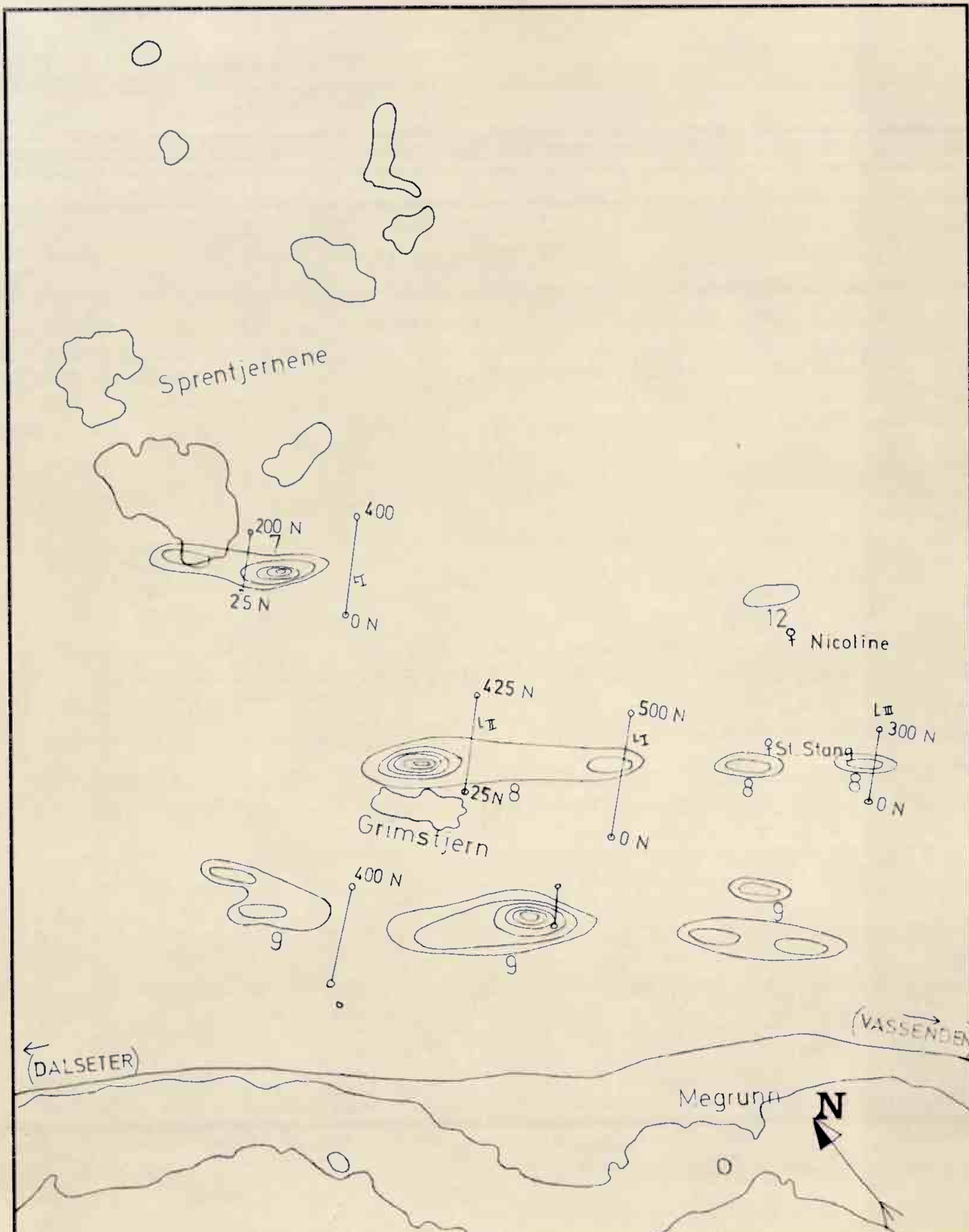
Oslo, August 18th, 1972.

T&F/Prosp.
Vrå:JAa
30.4.1971
trsp.

Prøve nr.	Hull nr.	Fra - Til	Lengde	Resultat Ni	Cu	S
1	1	16.65 - 18.06	1,41	0,12	0,03	1,4
29	1	18.06 - 20.50	2.44	0,06	0,02	0,2
30	1	20.50 - 23.00	2.50	0.05	0.02	0.1
2	1	23.00 - 24.44	1.44	0.09	0.05	1.5
31	1	24.44 - 27.00	2.54	0.17	0.09	1.4
32	1	27.00 - 29.40	2.40	0.09	0.05	1.1
3	1	29.40 - 30.75	1.35	0.19	0.08	3.4
4	1	30.75 - 33.95	3.20	0.41	0.16	6.6
33	1	33.95 - 38.80	4.85	0.06	0.05	0.7
34	1	38.80 - 41.20	2.40	0.27	0.12	2.0
5	2	8.00 - 11.00	3.00	0.36	0.12	3.0
6	2	11.00 - 14.00	3.00	0.32	0.14	2.6
7	2	14.00 - 17.00	3.00	0.33	0.11	2.6
8	2	17.00 - 20.00	3.00	0.27	0.07	2.4
9	2	20.00 - 22.00	2.00	0.27	0.07	1.9
10	3	21,60 - 24.60	3.00	0.09	0.06	0.9
11	3	24.60 - 27.60	3.00	0.14	0.07	1.3
12	3	27.60 - 30.60	3.00	0.17	0.06	1.5
13	3	30.60 - 33.60	3.00	0.14	0.05	1.0
14	3	33.60 - 36.60	3.00	0.14	0.06	1.1
15	3	36.60 - 39.40	2.80	0.23	0.08	1.5
16	3	39.40 - 40.50	1.10	0.07	0.03	0.7
17	3	40.50 - 43.50	3.00	0.27	0.05	2.1
18	3	43.50 - 46.10	2.60	0.25	0.06	1.7
19	4	7.40 - 10.60	3.20	0.09	0.07	1.7
20	4	10.60 - 11.40	0.80	0.44	0.11	6.80
21	4	11.40 - 13.40	2.00	0.13	0.05	1.4
22	4	13.40 - 16.50	3.10	0.26	0.08	3.4
23	4	16.50 - 20.00	3.50	0.25	0.07	2.2
24	4	20.00 - 23.00	3.00	0.54	0.10	4.3
25	4	23.00 - 26.00	3.00	0.50	0.15	3.9
26	4	26.00 - 29.40	3.40	0.34	0.07	2.3
27	4	29.40 - 32.70	3.30	0.08	0.04	0.5
28	4	32.70 - 37.00	4.30	0.25	0.09	1.5

Forholdet syreoppløselig Ni/S i analyser fra [illegible], Hårisu og Andreasberg.





A/S SULFIDMALM FIG.4	
SULFIDMALM-NORSK HYDRO JOINT VENTURE	
ESPEDALEN	
HEM anomalies and till sampling lines	
SCALE 1:21000	DRAWN
DATE	TRACED BL 9-72