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Tittel

Till geochemistry investigations in the Njullas area, Finnmark, Norway, 1971-72

Forfatter	Dato	Bedrift
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Sammendrag

Kristiansand.

FOR FALCONBRIDGE NIKKELVERK A/S

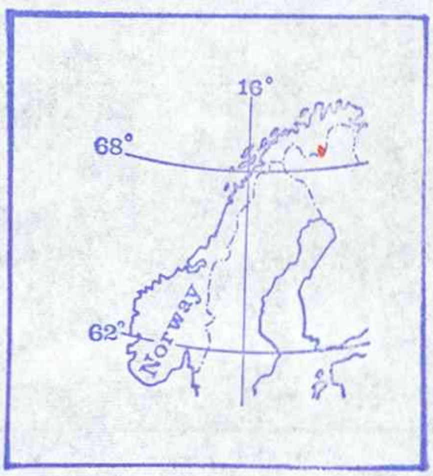
A/S SULFIDMALM

PROJECT 905-01

TILL GEOCHEMISTRY INVESTIGATIONS IN THE NJULLAS AREA, FINNMARK, NORWAY, 1971-72.

by

R. B. Band



198-72-1

1. INTRODUCTION:

In June 1971 the southernmost part of the Njullas area was covered by a helicopter-borne mag.-EM survey, flown by Terratest A/B. The till geochemistry investigations described in this report were a follow-up to the Terratest survey. They were designed to provide data for screening airborne geophysical anomalies and to facilitate the selection of drill targets from the geophysical results. The extent of the area covered by the geophysical and till geochemistry surveys is shown in fig. 1.

2. Method:

Till samples were collected at intervals of 50 m along profiles sited to test specific geophysical indications. These profiles were laid out perpendicular to the strike direction, as indicated by the geophysical data, and were sited north (or "down-ice") of the target to be evaluated. A total of 40 profiles were sampled, ranging from 1.6 km to 2.5 km in length.

In the initial phase of the sampling program (August-September 1971) samples were collected by hand-pitting to depths of between 0.5 m and 2.0 m. The till horizon underlying surficial swamp or fluvio-glacial material was sampled. Profiles 1, 2, 3, 4, 5 and 8 were sampled in this manner.

In the second phase of the program (November - December 1972) the sampling was contracted out to the Finnish company Geotek Oy. A conventional percussion drill was used to sample both till and the underlying bedrock. As a routine procedure the sample was blown to the surface by compressed air and collected on a plastic sheet. After each 1.0 m run the material on the sheet was sampled and the plastic cleared for the next sampling run. In this way serial samples were obtained through the till profile and into bedrock. As the holes were not cased individual 1.0 m samples almost certainly include material derived from higher up the hole than the section penetrated during that sampling run. Where the drill hole intersected appreciable ground-water flow the compressed-air sampling system could not be used and samples were collected using a coring tube. It was not possible to penetrate bedrock with this coring tube.

Samples were classified as "till", "basal till" or "bedrock" on the basis of the drillers logs. The maximum depth drilled was 11.5 m and the maximum bedrock penetration was 7.0 m.

Due to unexpected operating difficulties and consequent cost escalation only four profiles were completed (profiles 1, 1b, 2 and 3) before sampling with the Geotek equipment was abandoned in late December 1971. The hand-pitted localities on profiles 1, 2 and 3 were re-sampled with the percussion drill, and the original profiles extended.

In the third phase of the program (March-April 1972) the remaining 34 profiles were sampled by hand-pitting. As this sampling was carried out under winter conditions, it was necessary to use a Cobra drill to break up the frozen upper 20 cm of the soil profile. The pits were then dug down through loose weathered material and the sample collected from the underlying compact C horizon. This was generally found at a depth of 0.4 m to 0.7 m. In areas with shallow swamp cover the pits were sunk to a maximum depth of 1.5 m.

The till samples were siered to - 80 mesh in Kristiansand or, later, in Kautokeino, and were sent to the Falconbridge geochemical laboratory, Vancouver for analysis. The 1971 hand-pitted samples were analysed for Ni, Cu, Co and Cr. Subsequent samples were analysed for Ni, Cu and Co. Ni, Cu and Co were determined by atomic absorption analysis after digestion of the sample for 1 hour with boiling 10% nitric acid. Cr was determined by atomic absorption following a fusion attack.

3. 1971 Hand-pitting Results.

The results of the 1971 hand-pitting program have been presented and discussed in a previous report (J. Jacobsen:- "Report on preliminary till geochemistry, Våkdalsvann, Njullas area, Norway, 1971"). This work revealed anomalous Ni, Cu and Co values on profiles 1, 2, 5 and 8 and background values on profiles 3 and 4. Since these profiles were duplicated during the Geotek sampling program the results will not be discussed further. A comparison will however be made between the two sets of data.

4. Geotek overburden drilling results.

The results of the Geotek sampling program are presented in figs. 2 and 3. In the absence of detailed toptgraphic information, the data are plotted relative to constant ground surface. Data from the 1971 hand-pitting program are also plotted for comparison. Frequency distributions for Ni, Cu and Co in the till samples are shown in fig. 4. Based on these frequency distributions the following critical ranges were selected:

	Ni	Cu	Co
Background	< 50 ppm	<50 ppm	<20 ppm
Possibly anomalous	50-70 ppm	50-70 ppm	20-25 ppm
Probably anomalous	70-100 ppm	70-100 ppm	25-30 ppm
Anomalous	>100 ppm	>100 ppm	>30 ppm

The spatial distribution of the various anomaly classes is summarized in figs. 5, 6 and 7 for Ni, Cu and Co respectively.

On profiles 1 and 1 b the three metals have broadly similar anomaly patterns. In detail however Ni and Co show slightly more restricted anomalies than Cu. Ni and Co show a strong correlation, but the correlation between these two metals and Cu is not so well developed. For all metals the distribution of anomalous values along the profiles is erratic, with "background" holes interspersed through the anomaly. There is a tendency for higher metal values to occur at deep levels on Profile 1 b and at shallow levels on Profile 1, indicating that Profile 1 b is closer to the anomaly source.

The main Ni anomaly appears to culminate on Profile 2, with a maximum value of 1070 ppm Ni, and a maximum basal till value of 830 ppm. In contrast the maximum Ni value on Profile 3 on the anticipated "up-ice" extension of the anomaly fan is 76 ppm Ni. The Co anomaly distribution pattern is very similar to that of Ni, with maximum values of 116 ppm Co on line 2 and 35 ppm Co on the "up-ice" extension of the anomaly on line 3. Cu does not show such a strong anomaly on line 2, the maximum value being 106 ppm Cu. Ni, Cu and Co show evidence of a second anomaly on Pr. 3 centred on deep samples at 1050 W. Maximum values are 315 ppm Ni, 95 ppm Cu, 45 ppm Co.

Summarizing, the Geotek data points to two possible anomalous dispersion fans in the till. The strongest fan culminates between profiles 2 and 3. Data from profile 2 indicates that the peak of the anomaly is at 250W on that profile. Based on the Ni and Co data the axis of the second fan lies at 950W on Profile 3. The combined Ni-Cu-Co anomaly pattern on this profile is diffuse, possibly indicating that the source lies some distance to the south.

5. Comparison of hand-pitting and percussion drill results.

The results of the 1971 pit-sampling are plotted on figs. 2 and 3. In background areas Ni and Cu tend to show generally higher levels in the hand pitting samples than in Geotek samples collected from a similar depth. Co levels on the other hand, are similar in both data sets. In anomalous localities the hand-pitting results are in most cases markedly higher for all three metals.

If the critical ranges used in interpreting the Geotek data are applied, the anomalous sections of profiles 1 and 2 can be readily identified from the hand-pitting results. In fact the anomalous sections of both these profiles appear longer on the basis of the hand-pitting data. It is concluded that, while deeper overburden sampling provides additional information, pit-sampling is the more rapid method of locating till anomalies, at least in areas of relatively shallow overburden, to a maximum depth of about 4 m.

6. 1972 Hand-pitting results.

The results of the 1972 pit-sampling are presented in figs. 8, 9 and 10. For completeness data for the topmost sample at each Geotek sampling locality on profiles 1, 1 b, 2 and 3 are also plotted. Pit-sampling data for profiles 4, 5 and 8 are also included on fig. 8. Frequency distributions for the 1972 data are shown in fig. 11. Based on these distributions the following critical ranges were adopted in interpreting figs. 8, 9 and 10:-

	Ni	Cu	Co
Background	< 50 ppm	<45 ppm	< 15 ppm
Possibly anomalous	50-75 ppm	45-60 ppm	15-20 ppm
Probably anomalous	75-100 ppm	60-100 ppm	20-40 ppm
Anomalous	>100 ppm	>100 ppm	>40 ppm

The spatial distribution of the various anomaly classes is summarized in fig. 12.

7. Quaternary Geology.

Knowledge of the Quaternary geology of the southern Njullas area is very incomplete. The area lay to the north of the main ice-divide, and was effected by predominantly northward moving ice. However in the early stages of glaciation, prior to the development of the main ice sheet, a local ice-sheet is thought to have been present in the mountains of Finnish Lapland. Glacial striae related to this earlier glaciation and indicating a westward ice-movement have been found in Finland, south of the Njullas area.

Topographically the south Njullas area is characterised by approximately north-south trending, roughly elliptical, rounded ridges (e.g. Pandefjell, Njullasfjell, Burfjell) separated by broad valleys. These ridges appear to be bedrock features. On a detailed scale these were probably sufficient to cause local deflections from the general south to north direction of ice-movement. Indications of local glacial transport directions, based on photo-interpretation, are included in fig. 12.

The depth of glacial material is thought to increase southwards. Percussion drill sampling in the north of the area revealed on average depth of 2-3 metres. No data is available for the south of the area, but it is thought that the average depth in the south may be of the order of 10-15 metres.

Fluvio-glacial deposits are locally present, overlying glacial material. These include well-sorted sands, sandy-gravels, and boulder deposits. Extensive, relatively thick deposits of fluvio-glacial sand can be recognised on air-photographs (e.g. south of the western section of profile 3).

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Widespread reindeer-moss cover tends to mask the reflectance of well-sorted sands however, and photo-interpretation does not appear to be a reliable method of outlining areas with only a thin veneer of fluvio-glacial material. Fluvio-glacial material to a depth of 50-70 cms would be sufficient to invalidate hand-pitting as a till sampling method at that particular locality.

8. Interpretation.

The purpose of the till geochemistry survey was to screen airborne geophysical data and to aid in the selection of drill targets. Because of the variable depth of till likely to be encountered and the possibility of fluvio-glacial deposits masking till anomalies, the till geochemistry results must be regarded as positive indicators only. Till geochemistry anomalies must have a source, but the absence of a "till" geochemistry anomaly down-ice from a favourable geophysical indication does not necessarily mean that the geophysical target should be discounted.

The available geophysical, geochemical and glacial transport information are summarized in fig. 12. Geophysical targets which are probable sources for till geochemistry anomalies are also shown on fig. 12. The data relating till geochemistry anomalies and geophysical targets are summarized in table 1, where the probable sources of a number of geochemical anomalies are listed. These targets will be further evaluated during the 1972 ground geophysical program.

In addition to the above targets there are till geochemistry anomalies, which are not obviously derived from geophysical targets, using the photo-interpreted glacial transport directions and a probable anomaly length of 2 to 3 km. These last anomalies are listed in table 2. Additional till sampling should be carried out to idenitfy the source area of these anomalies.

9. Conclusions and Recommendations.

(a) The 1971-72 till geochemistry program revealed twelve anomalous disparision trains, which appear to be derived from geophysically indicated target areas. (Table 1). Further evaluation of these targets by ground magnetic and electromagnetic surveys is almost completed. Favourable targets will be tested by diamond drilling.

(b) The four till geochemistry anomalies for which an acceptable geophysically indicated source could not be found should be further evaluated by additional shallow till sampling. (Table 2).

(c) Shallow till sampling, at a depth of 0.5 to 0.7 m, appears to be the most effective method of obtaining till geochemistry data for the preliminary evaluation of a relatively large area. The data obtained in the present survey have been of considerable use in screening airborne geophysical anomalies. In view of the greatly increased sampling costs, deep till sampling is best reserved for more detailed investigations, where anomalous dispersion trains have already been partially outlined by surface sampling.

TABLE 1:

Summary of relation between geophysical targets and till geochemistry anomalies.

TILL GEOCHEMISTRY (values in ppm)				GEOPHYSICAL TARGET (PROBABLE SOURCE)
Profile	Ni Max *	Cu Max *	Co Max *	
1 1 b 2	520 220 1070	160 175 320	61 39 116	1
5	162	138	35	D - 2
7 7 B	81 72	35 53	9 13	2
8 35 6 ?	269 281 69	159 104 467	27 23 10	S
26 28 ?	68 85	48 35	18	1 - C
28 ? 33 ?	85 290	35 73	21 70	1 - E
33	116	66	21	1-I or 1-G
32 33	107 116	72 66	20 21	C
14 B	360	112	40	3 and Q
18	470	105	30	I and H
31	64	99	20	F - 2
11 12 13	115	190	18	M, N and O

* all data
TARGETS M,N AND O ARE THE "NJULLAS ZONE", 1969 DRILLING WAS CONCENTRATED ON THIS ZONE (5 HOLES).

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TABLE 2:

Summary of data for till geochemistry anomalies without a geophysically indicated source.

Profile	Ni Max (ppm)	Ni Width (m)	Cu Max (ppm)	Cu Width (m)	Co Max (ppm)	Co Width (m)
3 *	315	250	95	600	45	200
5 (OW)	55	50+	119	50	26	50
7 (1400E)	90	100	157	100	17	100
15	470	100	24	-	40	100
24	164	150	34	-	21	50

* Geotek deep till sampling data.

\+ 50 m width = 1 anomalous sample only.

Appendix I : Additional till sampling west of Vaakdalsvann.

The Geotek overburden sampling indicated strongly anomalous Ni, Cu and Co values on profiles 1, 16 and 2, west of Vaakdalsvann. The most probable source of this anomaly was considered to be a low-order magnetic anomaly lying between Profiles 2 and 3 and close to the projected "apex" of the anomaly. A subsequent drill-hole sited to test this magnetic anomaly intersected acid gneiss and amphibolite, the anomaly being due to the magnetite content of the amphibolite.

Following this an additional six till geochemistry profiles were laid out up-ice from Profile 2. The location of these profiles in relation to the "Geotek anomaly" is shown in fig. 13. The additional profiles were sited to more closely outline the till geochemistry anomaly and to test the possibility of connection between the eastern and western till anomalies (fig. 13). A total of 145 samples were collected using a hammer auger. The samples were collected in September 1972 and have not yet been analysed.

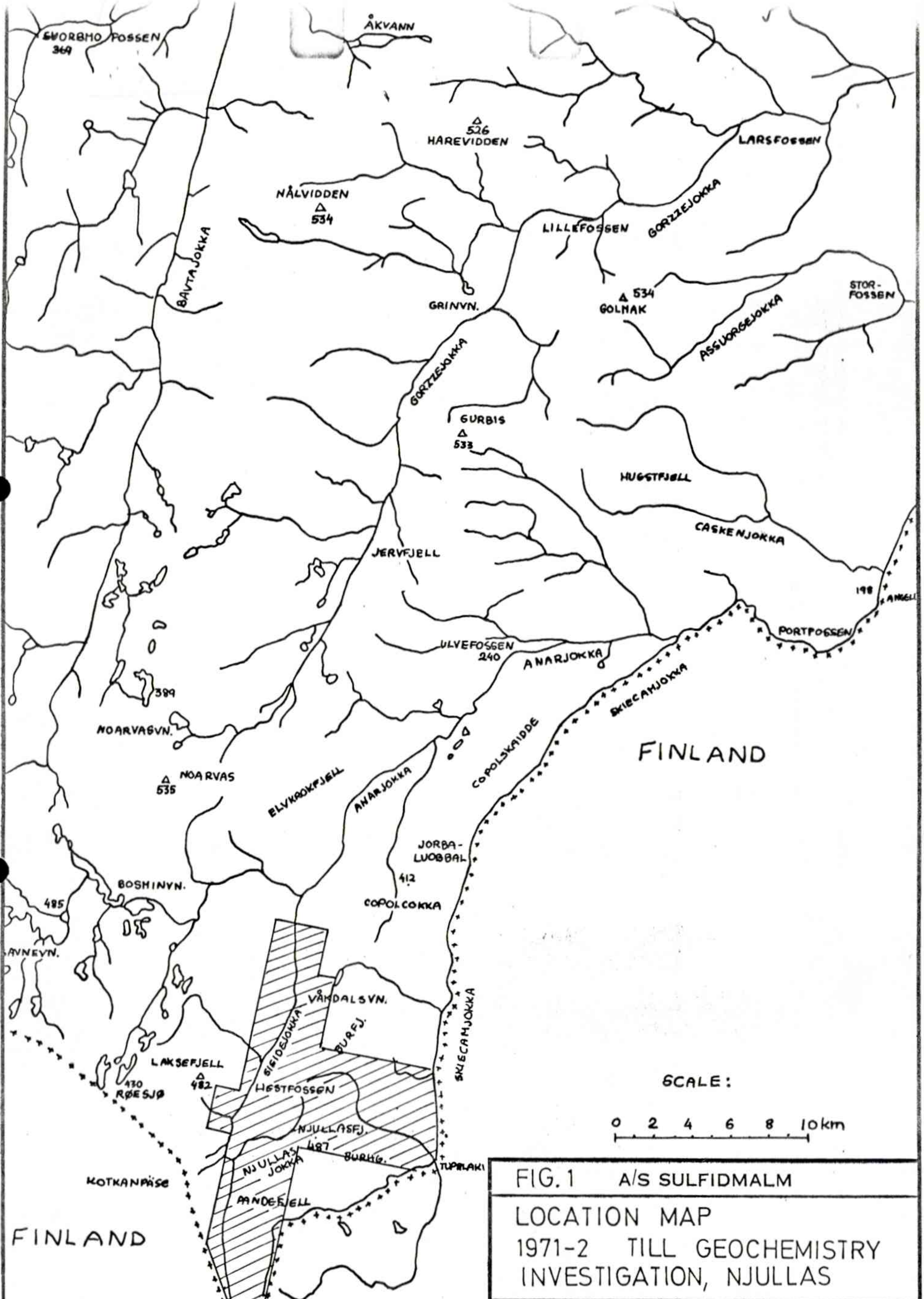


FIG. 1 A/S SULFIDMALM

LOCATION MAP
1971-2 TILL GEOCHEMISTRY
INVESTIGATION, NJULLAS

SCALE	1 : 250.000	DRAWN	RBB
DATE	10 - 72	TRACED	BL

A/S SULFIDMALM

INTER-OFFICE MEMORANDUM

12. 12. 72

BESV. | ARK.

FOLSKN.UTV.

SAKSBEARB. Nixon

SVARDATO

Date: 11th December, 1972

To: Falconbridge Nikkelverk A/S

cc: A. M. Clarke, D. R. Lochhead, R. B. Band

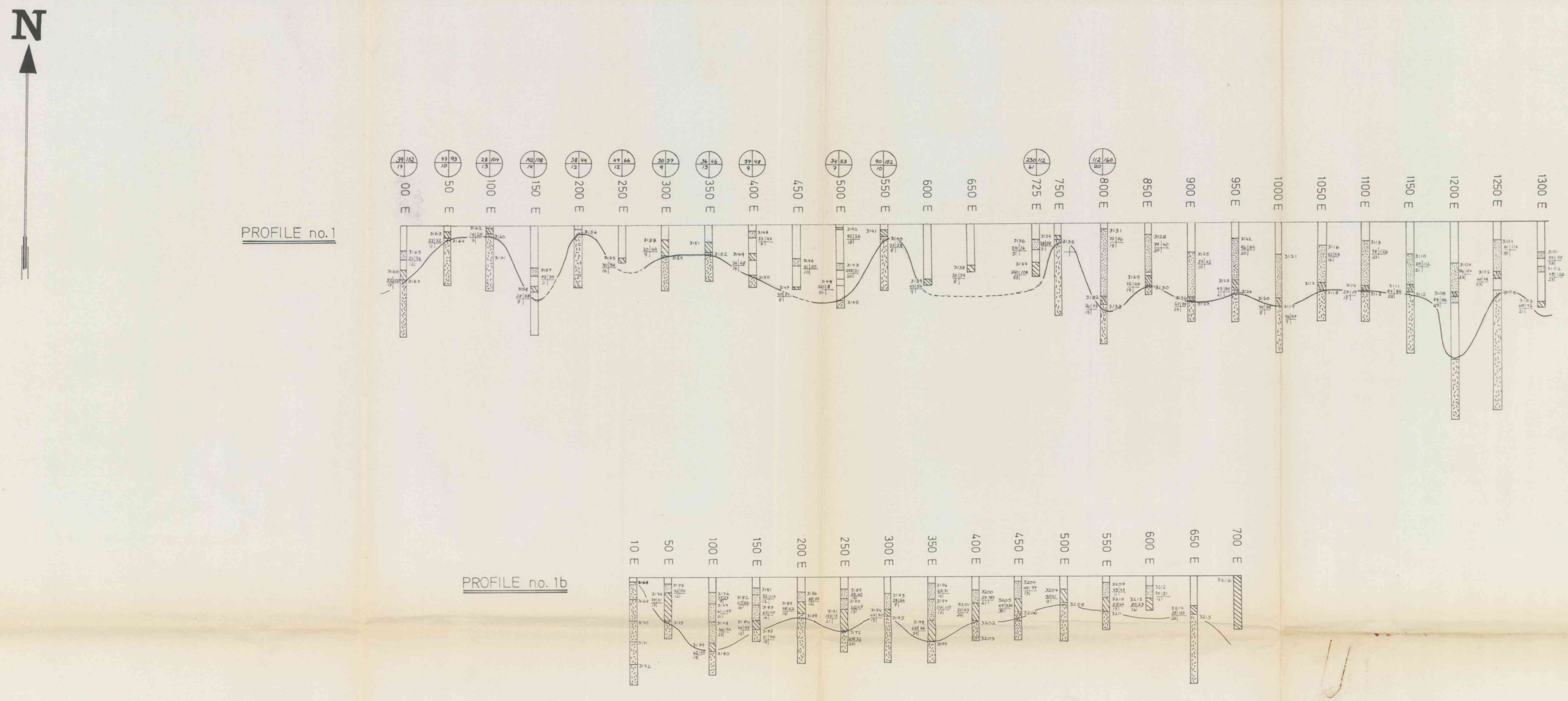
From: J. B. Gammon

Subject:

905-1, Till geochemistry, Njullas area. (Rept Nr. 198-72-1).

Please find attached Band's report on till geochemistry in the Njullas area. This till sampling approach was of considerable assistance in interpreting the helicopter geophysics results leading to 12 anomalous dispersion trains, which appear to be derived from geophysically indicated target areas.

J B Gammon



KEY

- Sample interval - till
- " " - basal till
- " " - bedrock
- 3380 - Sample number
- Ni|Cu / Co|
- Bedrock / till interface
- 1971 - Hand pitting data

Scale 1:2500

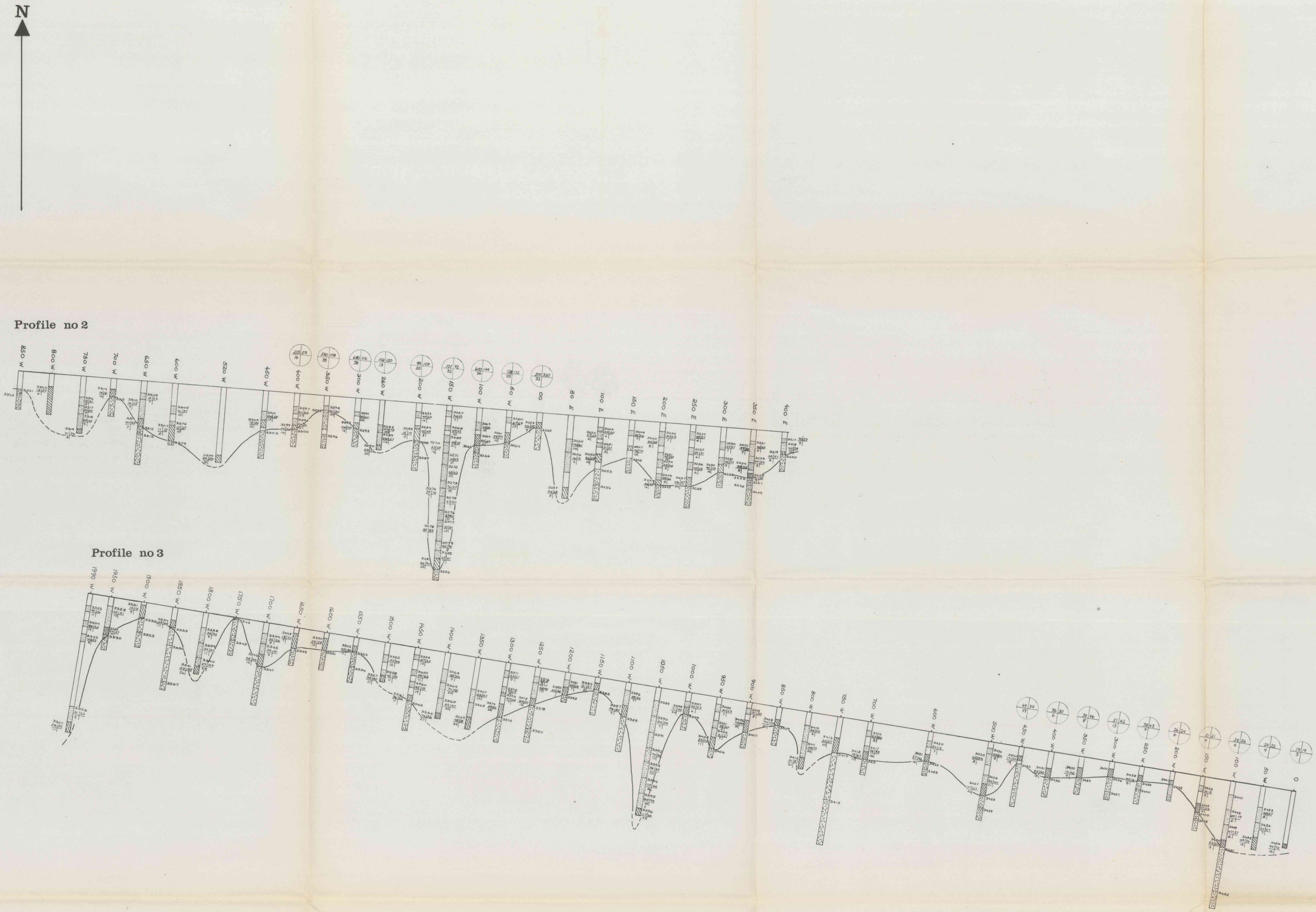
0 125 250

Down Hole Scale 1:100

0 5 10

TILL GEOCHEMISTRY (Overburden drilling) Våkdalsvann Area Kautokeino, Finnmark FIG. 2	SCALE 1:2500 1:100	OBS. OF; DRAW. UT 14-3-72; TRAC. BL 10-72; CHK. RBB 10-72
A/S SULFIDMALM		MAP NO. / MAP SHEET

A.s Terrkopi. 3020. A 1. E 9 gl. 10-71. Sentrum Trykkeri.



KEY

Sample interval – till

" " – basal till

" " – bedrock

3380 – Sample number

Ni | Cu
Co

Bedrock / till interface

Ni | Cu / Co — 1971 hand pitting data

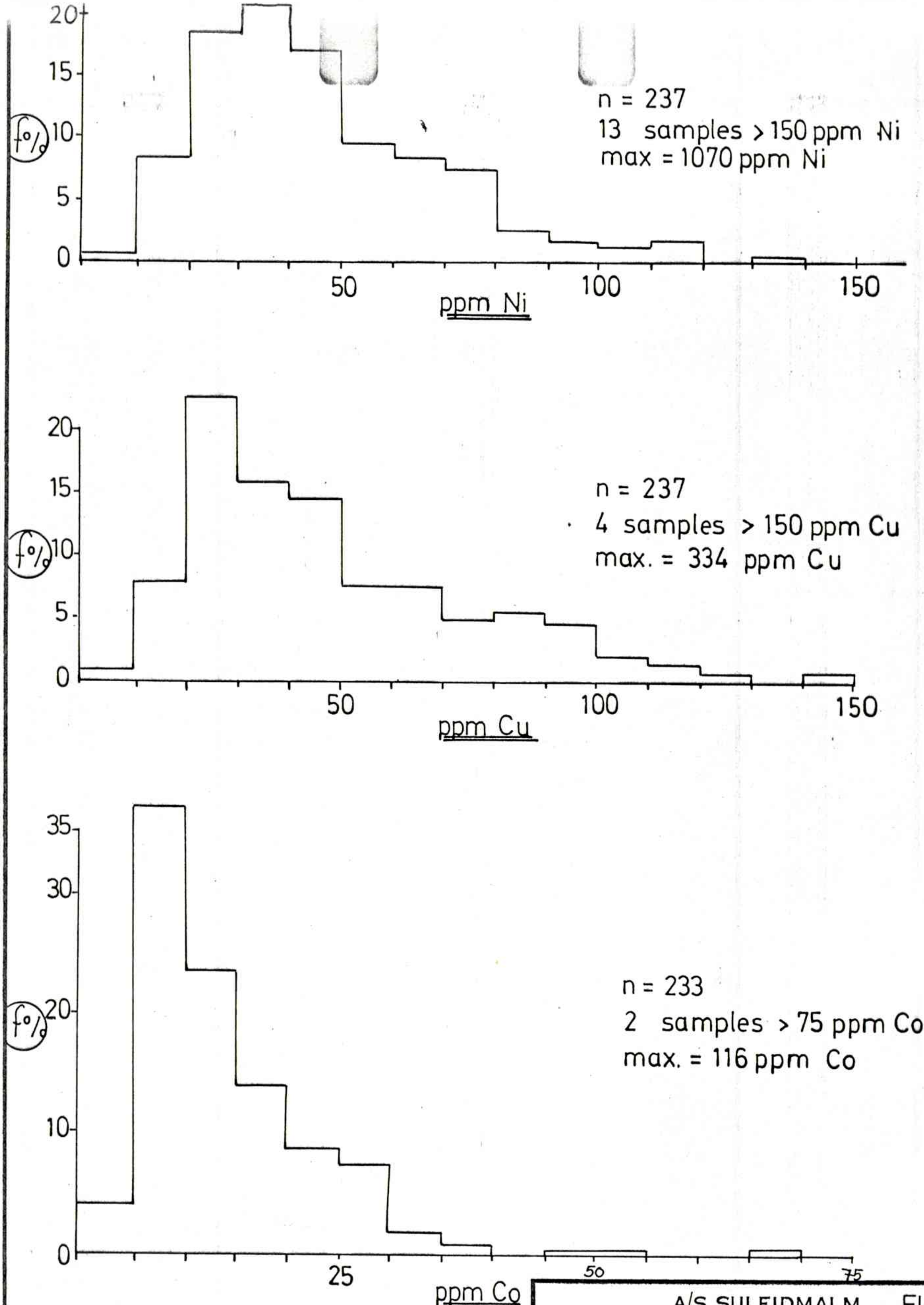
Scale 1:2500

0 125 250

Down Hole Scale 1:100

0 5 10

TILL GEOCHEMISTRY (Overburden drilling) Våkdalsvann Area Kautokeino, Finnmark — FIG. 3	Scale 1:2500 1:100	Obs. O.F.	
		Draw. U.T.	14-3-72
		Trac. U.T.	– " –
		Chk. J.G.	
	Map. no.		
A/s Sulfidmalm	Map. sheet		



A/S SULFIDMALM FIG. 4

Frequency distributions for Ni, Cu and Co in till for profiles 1, 1b, 2 and 3 NJULLAS ('GEOTEK' SAMPLES ONLY)

SCALE	DRAWN RBB
DATE 10-72	TRACED BL

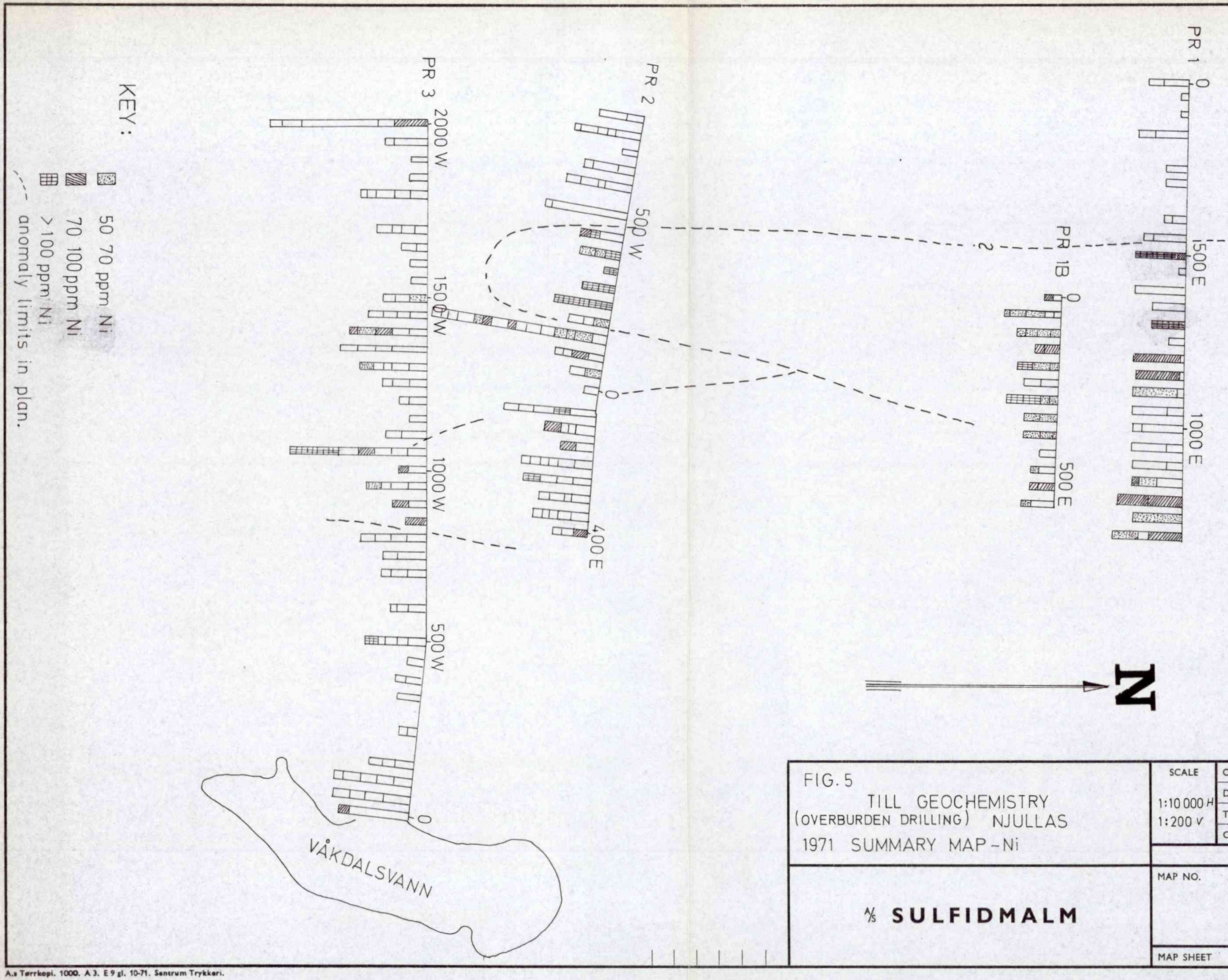


FIG. 5

TILL GEOCHEMISTRY
(OVERBURDEN DRILLING) NJULLAS
1971 SUMMARY MAP - Ni

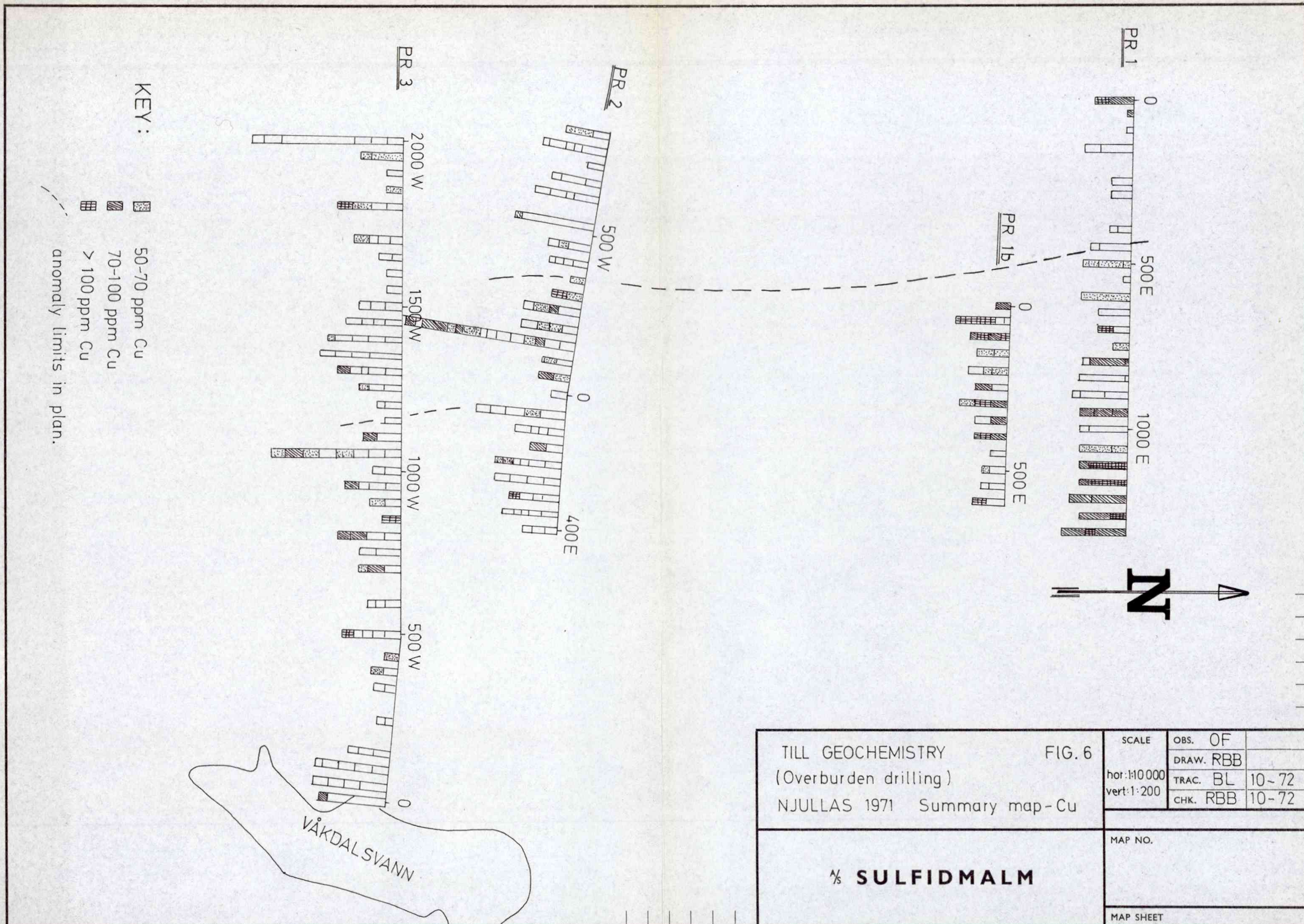
SCALE		
1:10 000 H 1:200 V	OBS. OF	
	DRAW. RB	10-72
	TRAC. BL	10-72
	CHK.	

MAP NO.

A/S **SULFIDMALM**

MAP SHEET

A.s Tørrkopi. 1000. A 3. E 9 gl. 10-71. Sentrum Trykkeri.



TILL GEOCHEMISTRY
(Overburden drilling)
NJULLAS 1971 Summary map - Cu

FIG. 6

SCALE			
hor: 1:10 000 vert: 1:200	OBS.	OF	
	DRAW.	RBB	
	TRAC.	BL	10-72
	CHK.	RBB	10-72

MAP NO.

A/S SULFIDMALM

MAP SHEET

A.s Tørrkopi. 1000. A 3. E 9 gl. 10-71. Sentrum Trykkeri.

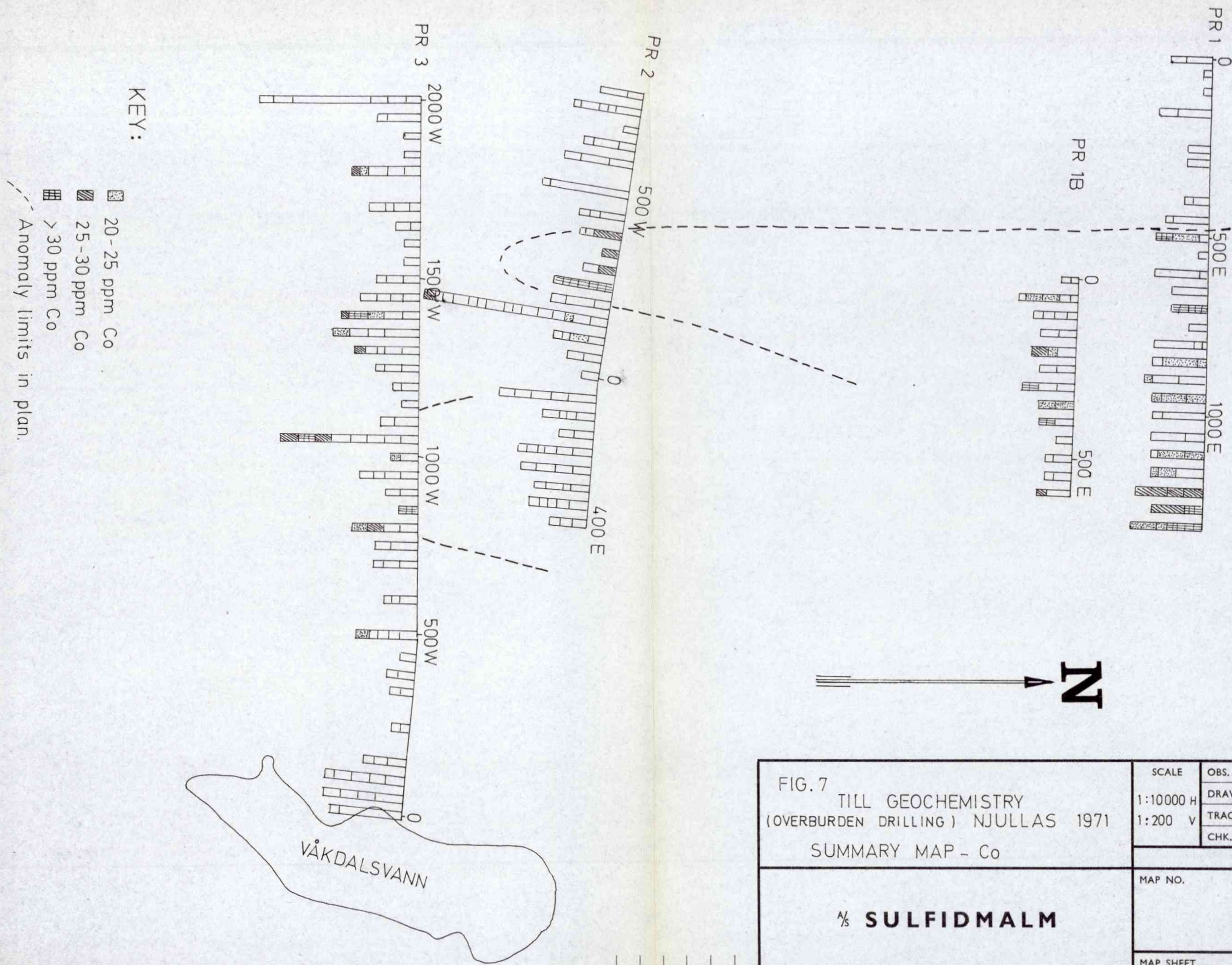


FIG. 7
TILL GEOCHEMISTRY
(OVERBURDEN DRILLING) NJULLAS 1971
SUMMARY MAP - Co

SCALE		
1:10000 H	OBS. OF	
1:200 V	DRAW. RB	
	TRAC. BL	10-72
	CHK.	

MAP NO.

A/S **SULFIDMALM**

MAP SHEET

A.s Tørrkopi. 1000. A 3. E 9 gl. 10-71. Sentrum Trykkeri.

Ni | Cu
Co | Cr

NJULLAS TILL GEOCHEMISTRY 1971 - 72 FIG. 8	Scale 1:10 000	Obs. OF 3/72 4/72; Draw. RBB 5/6/72; Trac. EW; Ck. RB 10-72
A/s Sulfidmalm		Map sheet 1

FIG. 9 NJULLAS TILL GEOCHEMISTRY 1972

Scale 1:10000 | Obs. OF 3/72 4/72 | Drawn RBB 5/6/72 | Trac. EW | Chk.

Map no.

A/S Sulfidmalm

2

Map sheet

PR 27
PR 28
N
PR 26
3
1
2
PR 33
PR 32
Ni Cu
Co
0
500
1000 metres
FIG. 10
NJULLAS TILL GEOCHEMISTRY
1972
SCALE
1:10000
OBS. OF 3/72 4/72
DRAW. RBB 6-72
TRAC. BL 10-72
CHK.
MAP NO.
3
MAP SHEET
A/S SULFIDMALM

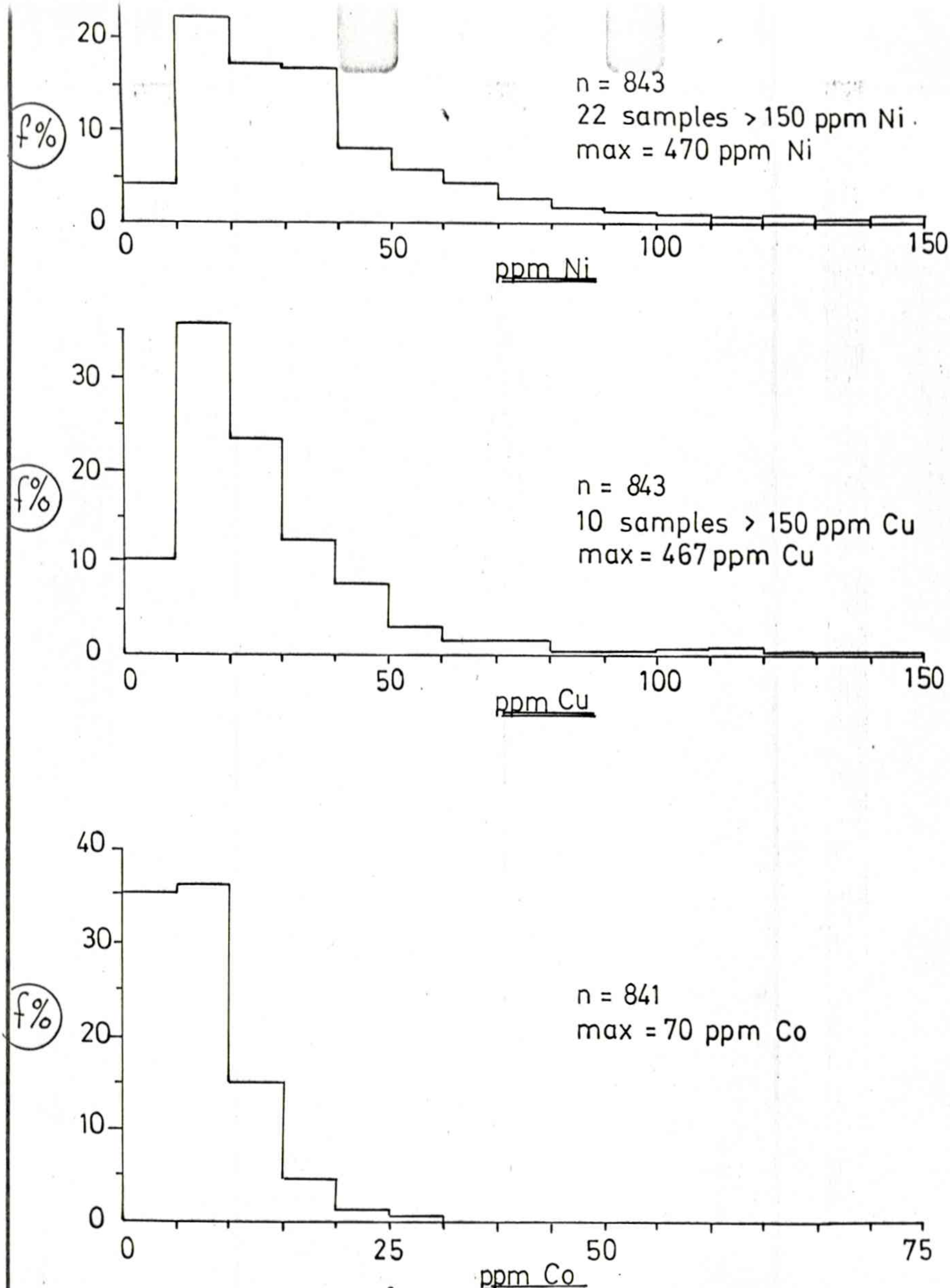


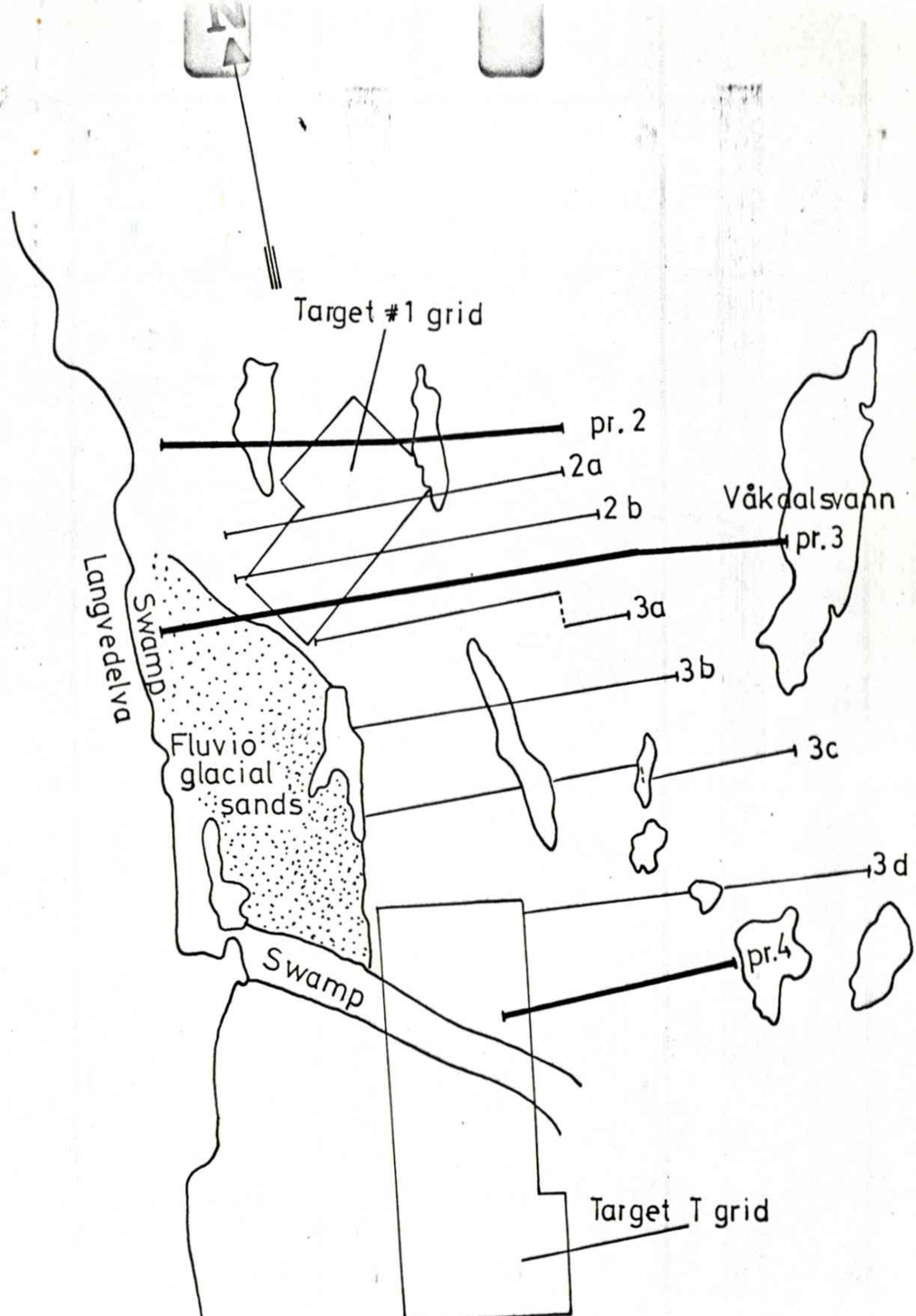
FIG. 11 A/S SULFIDMALM

Freq. distribution for Ni, Cu & Co in till, 1972 sampling

NJULLAS

SCALE	DRAWN RBB
DATE 10-72	TRACED BL

N
1-C
1-E
1-G
1-I
TARGET 1-I
M
N
O
C
D2
1
2
S
3
Q
I
H
F2
PANDEFJELL
LEGEND
GLACIAL TRANSPORT
a) Photo interpretation
Eskers, ridge features
Depressions
b) ← Ground observations
LEGEND
CONDUCTIVE ZONE
MAGNETIC ANOMALIES
PROBABLE SOURCE OF TILL GEOCHEM. ANOMALY.
Ni
Cu
Co
>100ppm
>100ppm
> 40ppm
75-100 ppm
60-100ppm
20-40ppm
50 75ppm
45 60ppm
15 20ppm
0
1000
2000 m
FIG.12 NJULLAS AREA
TILL GEOCHEMISTRY
SUMMARY MAP
A/S SULFIDMALM
Scale
1:20000
Obs. JJ-OF 9/71-5/72
Draw. RBB 6/72
Trac. BL
Chk. RB
Map. no. 1
Map. sheet



pr. 2
previously sampled profile

2a
additional profile

FIG. 13	A/S SULFIDMALM		
Additional till sampling profiles			
NJULLAS			
SCALE 1 : 20000		DRAWN RBB	
DATE SEPT-72		TRACED BL	