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Geohemical Orientation Study in Vakkerlien area, Kvikne.

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Sammendrag
To eksemplarer i Trondheim

A/S SULFIDMALM

INTER-OFFICE MEMORANDUM

Date: 7th July, 1977

To: Falconbridge Nikkelverk A/S

cc: W.D. Harrison, H.T. Berry, R. Jahnsen, R.B. Band
F. Nixon, R. Sivertsen

From: J. B. Gammon

Subject:

Report No. 424/76/20. Geochemical orientation at Vakkerlien.

Please find attached Band's report on a geochemical orientation survey at Vakkerlien. His main conclusion is that all weak, but continuous, Ni stream sediment anomalies should be followed up in the area, as this is the best expression that can be hoped for from Vakkerlien type mineralization.
Peat edge sampling is recomended as a more reliable tool for filtering geophysical anomalies than conventional till sampling in this area.

FOR FALCONBRIDGE NIKKELVERK A/S
A/S SULFIDMALM

Project 905-20

Geochemical Orientation study in Vakkerlien area, Kvikne
July 1976

By

R. B. Band

Report No. 424/76/20

1. Introduction

A geochemical orientation study was carried out around the Vakkerlien Ni deposit in July 1976. The purpose of the study was: a) to test the efficiency of the various geochemical sampling media in locating deposits of the Vakkerlien type; b) to determine optimum sampling conditions for each sampling medium; c) to provide control data to aid in interpreting wider-ranging surveys.

The following sampling media were examined:

a) active inorganic stream sediments;

b) organic sub aqueous stream bank samples (refered to subsequently as "organic stream sediments");

c) moraine;

d) peat.

Details of sampling methods used are given below in the relevant subsections. All samples were analysed at Institute for Atomenergi's lab., Oslo.

2. Stream Sediment Sampling

For convenience the two stream sediment sampling techniques are presented in one section. The drainage system from the Vakkerlien showing, down the main Stillbekken stream to the Oklar river was sampled to determine the length of the anomalous dispersion train in the two stream sediment types. The remainder of the upper Stillbekken drainage system (Tributaries B&C) was sampled to provide background data (fig. 1 & 2).

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Because of the extensive drilling programme carried out on the Vakkerlien zone in 1975 there is a real risk of contamination in the Vakkerlien drainage system, particularly from waste drill-water charged with finely-ground sulphide particles. Water in the main Stillbekken stream ca. 2 km down drainage from the drilling area was described as "undrinkable" during the actual drill programme because of suspended material. This must be borne in mind in evaluating the intensity and length of anomalous dispersion trains.

2.1. Inorganic Stream sediment samples.

These samples were collected in the routine fashion for this type of survey, using a wet-sieve to screen material at the sample site. Results are presented on fig. 1.

2.1.1. Threshold levels.

Threshold values are estimated on the basis of the variation shown by background streams, above the Vakkerlien confluence, rather than by using a statistical estimate. Threshold is taken as the upper limited of background variation and a "strong" anomaly as being double the median background value.

Levels for the various elements are:

	Threshold	Strong Anomaly	Maximum Value
Ni	30 ppm	>50 ppm	244 ppm
Cu*	30 ppm	>50 ppm	258 ppm
Co	15 ppm	>20 ppm	43 ppm
Zn	70 ppm	>100 ppm	182 ppm
Mn	700 ppm	>1000 ppm	3900 ppm
Cr	100 ppm	>150 ppm	114 ppm

<u>NB</u> a) High Cu values occuring in "background" stream C, above the Vakkerlien confluence, are regarded as significantly anomalous.

b) Zn is not associated with the Vakkerlien mineralization.

c) Cr data shows a similar range in background streams (40-100 ppm) to the Vakkerlien drainage (40-90 ppm). Mineralized samples also show very low Cr values and for this reason the Cr data has not been processed further.

2.1.2. <u>Dispersion lengths and Anomaly intensities</u>.

a) <u>Nickel</u> shows a strong anomaly, with max. 244 ppm Ni, in the small stream (A) draining the Vakkerlien showing. This is diluted to ca. 50 ppm Ni after the confluence with Stillbekken and "weakly anomalous" Ni values (ie. 30-40 ppm Ni) persist in the main stream for ca. 1.5 km, i.e. below the confluence with the next background tributary. Isolated values in this range also occur in background streams, so that the distinctive feature of this section of Stillbekken is the <u>continuous nature</u> of the weak anomaly, with a long section of the stream having weakly anomalous values.

b) <u>Copper</u> shows only <u>background</u> values in the Vakkerlien tributary (A). In contrast anomalous values (max. 110 ppm Cu) occur in the "background" stream C. Strongly anomalous Cu values also occur in Stillbekken down stream from the Vakkerlien confluence, with maximum values of 258 ppm Cu.

There is some evidence to suggest that Cu is much more mobile than Ni in the secondary environment at Vakkerlien (see later section on overburden sampling), but it is difficult to convincingly demonstrate any connection between these Cu anomalies and the Vakkerlien mineralization. It is possible that they are either a) associated with the same source as the Cu anomalies in stream "C"; or b) associated with a separate, but similar source nearer the anomalous sample site; or c) are due to contamination from the drilling programme, with the contaminant (sulphide grains?) collecting sporadically under favourable stream bed conditions. Comparison with 1974's results (section 2.1.4.) suggest the latter may be the case.

c) Cobalt shows strongly anomalous values (max. 43 ppm) in the upper portion of the Vakkerlien tributary and very low values elsewhere. The anomalous dispersion train is thus shorter than for Ni.

d) Manganese shows highly anomalous values in both Vakkerlien tributary A and background stream B. This reflects a local environmental feature common to both streams, leading to accumulation of Mn (and also Fe) in the stream sediment. This is normally thought to be due to a sharp oxidation potential change, from reducing conditions, where Mn and Fe are solubilised, to oxidising conditions where they are precipitated out as Mn-Fe hydrous oxides.

The classic situation is wet or water-saturated overburden, perhaps with high humus content, giving rise to reducing conditions and groundwater with high dissolved Mn and Fe content. Where this groundwater moves into an oxidising environment, i.e. groundwater, seepages either into a stream bed or at the ground surface, Mn and Fe are precipitated out as limonitic deposits. This is a very common feature in the beds of streams running through swamps (such as Vakkerlien stream A).

2.1.3. Effect of Mn Scavenging

It is very commonly observed that Fe-Mn hydrous oxide precipitates of the type described above show enhanced contents of various trace elements, in particular Ni, Co and Zn. Many authors recommend adjusting regional stream sediment Ni, Co or Zn values for the effect of "Manganese-scavenging" by using, for example, regression analysis to obtain "Mn-corrected" values.

Fig. 3 shows a plot of Mn vs Ni for the inorganic stream sediment samples. The data clearly groups into 4 main fields i.e.

I) The anomalous stream "A" below the Vakkerlien showing, where there is a clear positive correlation between Ni and Mn contents;

II) The background stream "B" south-east of Vakkerli where there is a complete absence of correlation between Ni and anomalous Mn values.

III) A group of samples with non-anomalous Mn values and a ca. 10:1 relationship between Mn and Ni (field I) which corresponds mainly to the portion of Stillbekken below the Vakkerlien confluence (ie. samples still affected by mineralization/contamination, but diluted gradually with increasing dispersion length.

IV) A final group with non-anomalous Mn values plotting in a field (II) showing an overall ca. 20:1 relationship between Mn and Ni.

An inspection of the Co data in fig. 1 suggest a similar relationship applies between Co and Mn for samples from the anomalous Vakkerlien stream (A) and background stream 3.

2.1.3. (II) Conclusions regarding Mn scavenging.

I) It is clear from comparing data from streams A and B that highly anomalous Mn values in a stream are not automatically accompanied by high Ni (or Co) values. There has to be a source of Ni and this Ni has to be available for scavenging.

II) In a highly anomalous stream effected by Mn scavenging (ie. stream A) the actual distribution of Ni values may be more dependent on the distribution of Mn precipitate material along the stream course than on proximity to the nickel source (see fig. 4).

III) Routinely correcting for Mn-scavenging may be a fairly hazardous procedure, giving the wide range of relationships evident in the sub-groups of fig. 3.

Mn data would certainly be very useful in qualitatively evaluating Ni stream sediment anomalies, e.g. a high Ni value without high Mn should be given more weight than a similar high Ni value associated with high Mn.

2.1.4. Comparison of results from 1974 and 1976.

Active Stream Sediment samples were also collected in the Vakkerlien area in 1974 as part of a regional sampling programme in the Kvikne area. Fig.5 compares Ni and Cu values for samples collected at approximately the same locations in 1974 and 1976. Comparison is complicated by the fact that the 1974 samples were analysed by a different laboratory (Falconbridge Vancouver) and a slight shift in levels could well occur between the two data sets.

Comparison of the two sets of results shows the following:

For Ni: a) Background stream B and C, where there is no possibility of contamination, show an average difference from 1974 to 1976 of +6 ppm Ni (12 samples). Differences range from +1 to +13 ppm.

b) The main Stillbekken stream shows an average difference of +9 ppm Ni, with a range of -1 to +16 ppm Ni (7 samples).

The orientation study results are therefore somewhat higher, an average by 7 ppm Ni, and this increase is about the same in both background streams and the weakly anomalous portion of Stillbekken. This suggests drill contamination is not a significant factor in the build up of the weak Ni anomaly downstream from the Vakkerlien confluence.

For Cu: Both background stream C and Stillbekken show sporadic very marked differences between 1974 and 1976 results. For background stream C one sample shows an increase of 106 ppm Cu, while for Stillbekken, below the Vakkerlien confluences, two samples show increases of 235 and 255 ppm Cu. Ignoring these 3 samples the differences for all streams are similar (average 7 ppm Cu). The evidence therefore points to contamination in lower Stillbekken, but because of the similar increase in one sample of stream C, this can not be conclusively demonstrated.

2.2. "Organic stream sediment samples"

This sample type has been proposed as an improvement on the traditional active inorganic stream sediment type (Brundin & Nairis, Journal of Expln. Geochem. v.1 Nr 1, p. 7-46, 1972). The advantages are claimed to be:

a) The sample is widely available, whereas in flat, slow moving streams it can be difficult to find adequate active sediment;

b) The effects of variations in sample type, particularly organic content, should be reduced by collecting an entirely organic sample;

c) Dispersion train lengths and anomaly contrast are frequently better than for active sediments.

Organic and inorganic samples were collected at the same sampling locality, by a single sampler, to ensure a valid comparison.

Approximately two handfulls of decomposed organic bank material were collected from below waterlevel of each site. The sample included humus, roots, leaves and some inorganic material. Samples were not ashed prior to analysis, and there is no data for the inorganic content of the samples.

2.2.1. Threshold levels

Again by inspection the following threshold levels have been selected:

	Threshold	Strong Anomaly	Max. values
Ni	30ppm	>50ppm	320ppm
Cu	15ppm	>50ppm	88ppm
Co	15ppm	25ppm	118ppm
Zn	70ppm	100ppm	120ppm
Cr	range: 36-98ppm Cr		
Mn	700ppm	1200ppm	3640ppm

2.2.2. Dispersion lengths and anomaly intensities.

a) Nickel: shows a strong anomaly (max. 320 ppm Ni) over the length of the Vakkerlien tributary and extending ca. 200 m into the main Stillbekken stream. A weak anomaly (30-50 ppm) persists in the main stream for 1.7 km, i.e. about the same dispersion length as for the active, inorganic sediment anomaly. A weak homogenous anomaly also appears over ca. 0.5 km length of background stream B. Background stream C has no values >30 ppm Ni.

b) Copper: Shows only 2 anomalous values (76 ppm & 88 ppm), both in the Vakkerlien tributary. The highly anomalous Cu values picked up by the inorganic active sediments in the main Stillbekken stream (ie. 258 ppm Cu, 238 ppm Cu) are not reflected in the inorganic samples (corresponding values < 10 ppm Cu). Similarly the active sediment Cu anomalies in stream C are not reflected in the organic sediment copper values.

c) Cobalt: Shows a strong anomaly confined to the Vakkerlien tributary. Maximum value is 118 ppm Co, and contrast is thus greater than for active sediment Co.

d) Manganese: Shows highly anomalous values in the Vakkerlien tributary and in stream B, but there is a shift in position of the anomaly, depending upon the sampling medium.

2.2.3. Effect of Mn scavenging

A quick scan of the organic sample data on fig.2 indicates the same type of relationship between high Mn and enhanced Ni and Co values that has been previously established for inorganic samples.

2.3. Comparison of Inorganic and Organic stream sediment sampling results.

I) Organic sample data shows a more intense Nickel anomaly (max. 320 ppm Ni) in the Vakkerlien tributary than inorganic samples (max. 244 ppm Ni).

"Strongly" anomalous Ni values also persist a short distance into the main Stillbekken drainage in the organic data, whereas the inorganic anomaly is immediately diluted down to the "weakly anomalous" class in the main drainage. Co data also shows a more intense anomaly in the organic phase.

II) Organic sampling detected a 2-point Cu anomaly in Vakkerlien tributary, which did not show up in the active sediment data. On the other hand the active sediment data picked up two strong Cu anomalies in Stillbekken and also Cu anomalies in stream C which are not evident in the organic sample data. This indicates a distinct weakness in the organic sampling technique as applied to Cu.

III) Mn-scavenging seems to be a significant factor in the build up of Ni and Co anomalies in both the organic and inorganic sediments. "Environmental factors" will thus be a problem in interpreting both types of data.

IV) In conclusion the Vakkerlien data suggest that organic sediments may offer slight advantages over active sediments in terms of slightly enhanced anomaly intensity and improved anomaly dispersion length. The fact that organic sampling picked up Cu anomalies in the Vakkerlien tributary, not detected in the active sediments, but did not detect the numerous active sediement Cu anomalies in the remainder of the study area is disturbing, if these latter anomalies are indeed significant. It suggests that the organic sampling method is unsuitable for multi-element reconnaissance programmes where copper mineralization is a primary object.

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3. Moraine sampling

Moraine samples were collected along a profile crossing the suboutcrop of the Vakkerlien mineralization (250S). This line was selected because the four diamond drill holes along the profile give good control over the position of the mineralization and indicate that mineralization suboutcrops below the moraine cover.

No studies have been carried out on the direction of ice transport at Vakkerlien. The generalized direction of ice transport in the Kvikne area is SE to NW. However as Kvikne lay close to the location of the central Norway ice-divide, there may well have been marked local divergences in transport direction.

3.1. Method

Sampling was carried out using the Partner overburden sampling-system. This consists of a light-weight percussion drill, a threaded rod string and a through-flow, Holman-type sampling-bit. A jack is used to retrieve the rod-string (Photos 1-4 show the system in operation). Samples were collected at 1 m intervals through the moraine, and at the moraine/bedrock interface. The greatest depth sampled in moraine was 3.2 m. Fluvio-glacial sands were sampled down to 4.0 m (the limit of the rod string then available). Sampling at 1 m intervals greatly increased the time involved, since collapsing of the hole-sides meant the complete hole has essentially to be re-drilled for each sample. In moraine a 3.0 m hole would thus take approximately 1 hour, sampling at each metre, vs. possibly 20 min. if only the basal moraine is sampled. Jacking up the rod-string for each sample is also a time consuming process, taking almost as long as the drilling stage.

3.2. Moraine sampling results

Ni,Cu,S,Cr,Zn and Co data are summarized in fig.6. This shows the relationship between moraine sample data, the position of sub-outcropping mineralization, based on drill hole data, and topography. The low-lying swamp area west of DDH 62 is underlain by fluviaglacial sands to a depth of at least 4 m, the maximum sampling depth possible with the Partner equipment at the time of the study(additional rods giving a 10 m depth capasity have now been acquired).

Due to the very limited data collected, threshold and anomaly levels were again set by inspection. The most striking feature is the very restricted nature of the moraine anomaly. Strong to moderately anomalous Ni or Cu values are confined to a (probably) 30 m wide zone (data indicates between 20 m and 40 m) displaced slightly west, ie. down slope in the bedrock topography) from the trace of the mineralization. Weakly anomalous Ni values (50-100ppm) extend out beyond this to the edges of the sampling profile. Anomalous Cu values are restricted to moraine samples immediately above mineralization. Samples at the bedrock-till interface immediately over mineralization show over 1000 ppm Ni, with up to 6480 ppm Ni in one sample. Cr shows little variation across the profile.

3.2.1. Ni/Cu relationship

A very interesting feature is the relation between Ni and Cu values in the moraine samples. Diamond drilling has shown that over the 3 metre thickness of the mineralized zone in profile 250S, average metal contents are 1.5% Ni and 0.33% Cu, i.e. a Ni:Cu ratio of 4.5:1.

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The two basal moraine samples from 162E on profile 250S both have ca. 0.65% Ni. One of these samples (509) contained weathered pyrrhotite fragments and has a Sulphur content of 4.36% S. It clearly represents partly weathered mineralization, either in a local loose block or at the uppermost bedrock surface. The Ni:Cu ratio of highly anomalous moraine samples (i.e. 505, 507, 509, 510) is ca. 3:1, 3:1, 11:1, 11:1, with moraine samples with the highest Ni content actually having the lowest Ni:Cu ratio. It appears that the copper is more mobile than nickel in the secondary environment at Vakkerlien and is being preferentially removed.

In a near-surface, oxidising environment pyrrhotite is very unstable. Sulphuric acid produced by the oxidation of pyrrhotite will attack other sulphides and render them unstable. Chalcopyrite could well be more readily attacked than pentlandite under these circumstances, which could explain the depletion of Cu in moraine samples above weathering mineralization.

However, the generally low S contents in moraine samples (under 0.1% S, except for samples containing visible weathered pyrrhotite fragments) indicate that nickelferous sulphides have also been completely decomposed in the moraine and the liberated Ni bound up again in some other, non-sulphide phase (with limonitic material, or absorbed on clay minerals?). Certainly peat samples on the continuation of profile 250S (fig.6 and section 4) show high Ni values (max. 980 ppm) indicating that Ni is being removed from the mineralization - moraine locale in ground water and is accumulating elsewhere under favourable circumstances.

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Peat samples do not indicate accumulation of Cu on profile 250S, even though other peat samples, clearly unaffected by the main Vakkerlien mineralization (Section 4) show very high Cu values. To answer the question of what has happened to this "removed Cu" would require a detailed examination of the secondary environment around Profile 250S, from the bedrock sub-outcrop through the moraine cover, the peat-swamp and into the stream bottom environment. As a guess I would suggest that groundwater draining from the oxidising mineralization may have such a low pH that it inhibits the normal adsorption processes by which copper is removed from in-flowing Cu-enriched groundwater and accumulated along swamp margins.

3.3. Conclusions

The trial moraine sampling profile was selected to give the best possible conditions for the development of a moraine geochemical anomaly. The target mineralization suboutcrops below the moraine for a total width of ca. 9 m. Moraine cover is shallow (2-3 m) and the upper portion of the mineralization is oxidising rapidly.

Highly anomalous Ni and Cu values (i.e. > 500 Ni, >400 ppm Cu) are confined essentially to the sub-outcrop of the mineralization. Moderately anomalous Ni values (100-500 ppm Ni) present a slightly broader target, extending over ca. 20 m width. Weakly anomalous Ni values (50-100 ppm Ni) extend over 90 m in the basal till, but such weak anomalies might be difficult to evaluate in a regular survey.

Profile 250S presents optimum conditions for moraine geochemistry, in that the target mineralization sub-outcrops.

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Drilling in the Vakkerlien zone has shown that, because of it's flat-lying, pencil-like form, only a very small proportion of the mineralized zone suboutcrops in this way. Most of the zone is capped by a variable thickness of barren mica-schist. Under these circumstances it is difficult to concieve that the blind mineralization could give rise to a moraine geochemical anomaly. Only a very shallow schist capping would be enough to prevent incorporation of material from the mineralization into the moraine. It would be very interesting to confirm this by additional moraine sampling down plunge of the Vakkerli zone, but at this stage the conclusion must be that moraine geochemistry would provide a very uncertain tool for evaluating geophysical indications in the Vakkerlien area.

4. Peat Sampling

4.1. Method

Peat samples were collected from a depth of ca. 50 cms along profiles crossing the extensive swamp system immediately west of the Vakkerlien zone. Fig.1 and 6 show the relation of the peat sampling profiles to the mineralized zone.

Profiles 100S to 300S are in the vicinity of the Vakkerlien showing and are alongside the sub-outcropping portion of the mineralization. The swamp is down slope from the mineralization . Drainage within the swamp is from north to south. Profiles 400S and 450S are in the same swamp, but overly a portion of the mineralized zone which is capped by barren mica schist.

Profile 650S crosses a separate swamp not connected hydrographically to the main Vakkerlien swamp. It also overlies blind mineralization.

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Profiles 50S and 00S were intended as background profiles. They cross a swamp lying to the north of the northernmost known mineralization and approximately 10 m topographically higher than the Vakkerlien swamp. There is therefore no drainage connection between this swamp and the Vakkerlien showing.

4.2. Results

Peat sampling results are shown in fig.7. The most obvious features are:

a) A strong Ni-Cu anomaly running along the east edge of the swamp from 200S to 400S. Maximum values are 1430 ppm Ni, 420 ppm Cu, 32 ppm Co. Anomalous Zn values also occur along the east edge of the swamp, with max. value 145 ppm Zn. Anomalous values extend only a short distance into the swamp from the swamp edge (generally less than 30 m). The anomaly is most probably heavily influenced by contamination from the Vakkerlien showing waste-dump. The anomaly's form probably reflects the flow pattern of contaminant water from the waste dump through the swamp.

b) On 450S and particularly on 650S, the affect of waste dump contamination has died out. The portions of the swamp overlying the mineralized zone on these lines have background Ni values, (in fact $<$ 25 ppm Ni), but do show Cu and Zn anomalies, with maximum of 205 ppm Cu and 164 ppm Zn.

It could well be a fortuitous coincidence that this Cu-Zn anomaly occurs in the swamp above the blind, but shallowly buried mineralized zone.

On the other hand the moraine sampling data has shown that copper is more mobile than nickel in the immediate environment of the oxidising ore, and is certainly depleted in the moraine immediately above the oxidising suboutcropping mineralization. It is interesting to speculate whether, if mineralization is more deeply buried, the same secondary partition process still occurs and could give rise to a hydromorphic copper anomaly in the nearby moraine or swamp. With deeper burial the degree of oxidation of the sulphides would be much lower, producing a less acid environment and allowing the "normal" adsorption processes to fix copper more readily in moraine or humus-rich swamps than was the case where mineralization outcrops. The coincident zinc anomalies on line 450S and 650S are not readily explained by this suggestion. There are however anomalous Zn values associated with the Cu-Ni peat anomalies related to the Vakkerlien showing.

c) Along the western edge of the main Vakkerlien swamp from 100S to 300S, and also of the higher level "background" swamp from 50S to 00S, there is a very strong Cu-Zn anomaly, without associated high Ni values. Maxima are 870 ppm Cu and 1308 ppm Zn. This portion of the swamp system is clearly unaffected by either contamination from the waste dump or from the main Vakkerlien mineralized zone. There is a VLF - EM anomaly running along the west edge of the swamp, which may represent a mineralization source for the peat geochemical anomaly. It will be interesting to see whether this is a Cu-Zn mineralization, of a type distinct from Vakkerlien, or a blind Ni-Cu mineralization as suggested by the parallel with paragraph b) above.

4.3. Conclusions regarding Peat sampling

I) The strong Ni-Cu anomaly in peat down drainage from the Vakkerlien showing certainly reflects contamination.

II) The weaker Cu-Zn anomaly at 650S could be representative of the type of anomaly developed in peat-swamps over or near blind Ni-Cu mineralization.

III) The very strong Cu-Zn anomaly along the west edge of the swamp system, from 0S to 300S, is a very significant feature which should be tested further.

IV) The strong western Cu-Zn anomaly is evidence that the swamp edge sampling technique will detect naturally occuring anomalies, not just features reflecting contamination. It certainly offers a cheaper, more rapid sampling medium than moraine and, as the swamps form a groundwater sink for a much larger catchment, swamp edge samples should have a greater areal representivity than basal moraine samples. Peat sampling would be an effective technique for preliminary follow-up work on stream sediment anomalies, or as a rapid geochemical technique to complement geophysical surveys.

Based on the orientation data from the west margin of the Vakkerlien swamp system the recommended technique is:

a) Sample both sides of all swamps, at an interval of 50 m;

b) At each 50 m location collect 3 peat samples, one at the swamp edge, one 10 m into the swamp, and one 20 m into the swamp;

c) The sample should be taken from below the living swamp plants, and consist dominantly of decomposed humus. A depth of 50-70 cms is adequate; A normal till sampling spade ("Kreivi-auger") can be used.

5. Other possibilities not investigated

5.1. Humus sampling

Outokumpu have developed a technique for humus sampling which they claim is very effective in areas of deep overburden cover . It is supposed to give very well-defined anomalies, much sharper than anomalies in moraine, and which, in general, occur directly over the mineralization source.

This technique will be tried in Pasvik in March 1977. It would be possible to test it over the Vakkerlien zone in April 1977.

5.2. Bedrock geochemistry

It was originally intended to include a bedrock geochemistry study in the Vakkerlien orientation programme. A collection of drill-core samples has been made for such a study, but no analyses have been carried out. The samples were collected specifically for this purpose by J. Thomson, at the time he was examining the core for a petrographic study. The samples are stored in Oslo.

6. Conclusions and Recommendations

6.1. Stream sediment surveys

a) It appears that there is little advantage to be gained by changing to a "organic" sediment sampling system in the Kvikne area, particularly as this techique may miss copper anomalies detectable by an active sediment survey.

b) The Vakkerlien mineralization gives a strong Ni anomaly in the small tributary draining the showing. The intensity of this anomaly is probably due to contamination. It is rapidly diluted to weakly anomalous levels (<50 ppm Ni) in the main drainage system. The distinctive feature of this weak anomaly is its continuity over the ca. 1.5 km dispersion length. There is no copper anomaly associated with Vakkerlien.

c) Mn-scavenging can have an important effect on Ni-levels within an anomaly. Mn data will be useful in evaluating Ni stream sediment anomalies and priortising them for follow-up.

d) Vakkerlien is favourably sited to give a stream sediment geochemistry expression. Despite this the Ni anomaly developed in the main Stillbekken stream is weak. It does not have associated anomalous Cu values and could easily be interpreted as due to a basic or ultrabasic feature.

It would appear that all weak, but continuous, Ni steam sediment anomalies in the Kvikne are should be followed up, if we wish to make optimum use of the large volume of regional stream sediment data already collected.

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6.2. Moraine sampling

a) The moraine sampling study showed that under favourable conditions, with suboutcropping mineralization, an intense but narrow Ni anomaly is developed in the moraine immediately overlying mineralization. Anomalous Cu values are of even more restricted extent.

b) To be successful moraine sampling requires that the target is exposed at the bedrock/moraine interface, in order that eroded mineralised fragments can be incorporated in the moraine, or that the mineralization is close enough to the bedrock surface that a hydromorphic geochemical anomaly can develop in the moraine. Since the form of the targets in the Vakkerlien area is that of a gently-plunging pencil it is most probable that, as for the main Vakkerlien zone, the majority of targets will be capped by barren mica-schist for most of their length although they may lie near enough to the surface to give strong geophysical anomalies.

It is concluded that under these conditions moraine geochemistry would offer an extremely unreliable method for screening geophysical anomalies and that this technique can not be recommended for use at Vakkerlien.

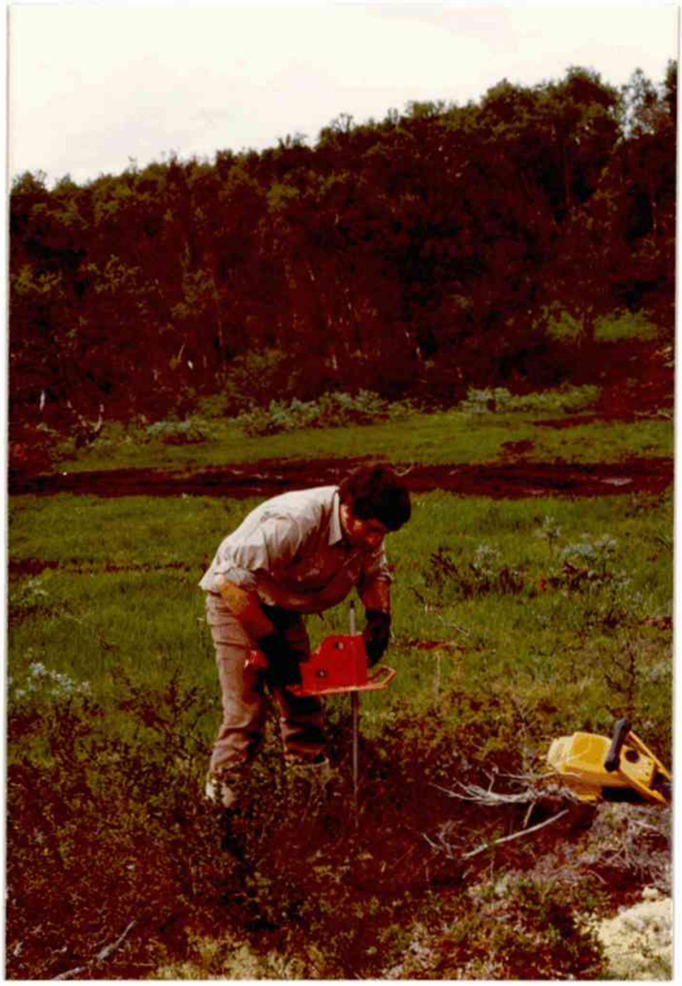
6.3. Peat Sampling

a) Swamp-edge peat sampling offers a very useful technique for following-up stream sediement anomalies and as a complement to geophysical surveys, such as the large Vakkerlien grid.

It can not strictly be used as a screening technique for geophysical anomalies, but would appear at Vakkerlien to be a better alternative than moraine sampling for this purpose.

1) <u>The drill in action</u>

N.B. there is no rotary action just straight percussion.
Penetration rate depends on moraine type:
in a test 0-1 m depth drilled in 3 mins
1-2 m depth drilled in 10 mins,
the moraine being more compact in depth.



2) <u>The Jack</u>

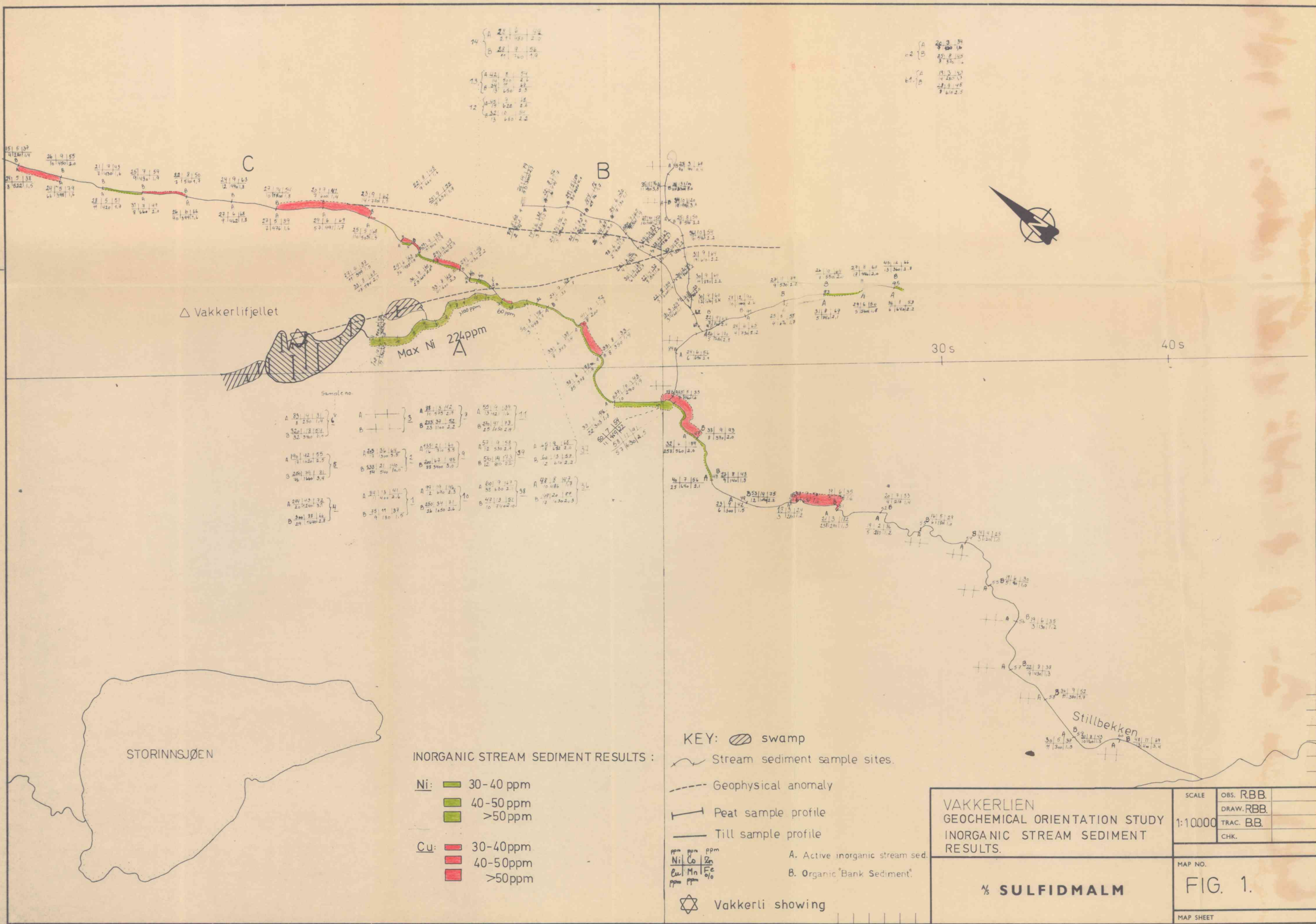
is used to remove rods and sampler from the hole. The drill and hexagonal coupling must be removed and the jack lowered down over the rod.

3) <u>Jacking</u>

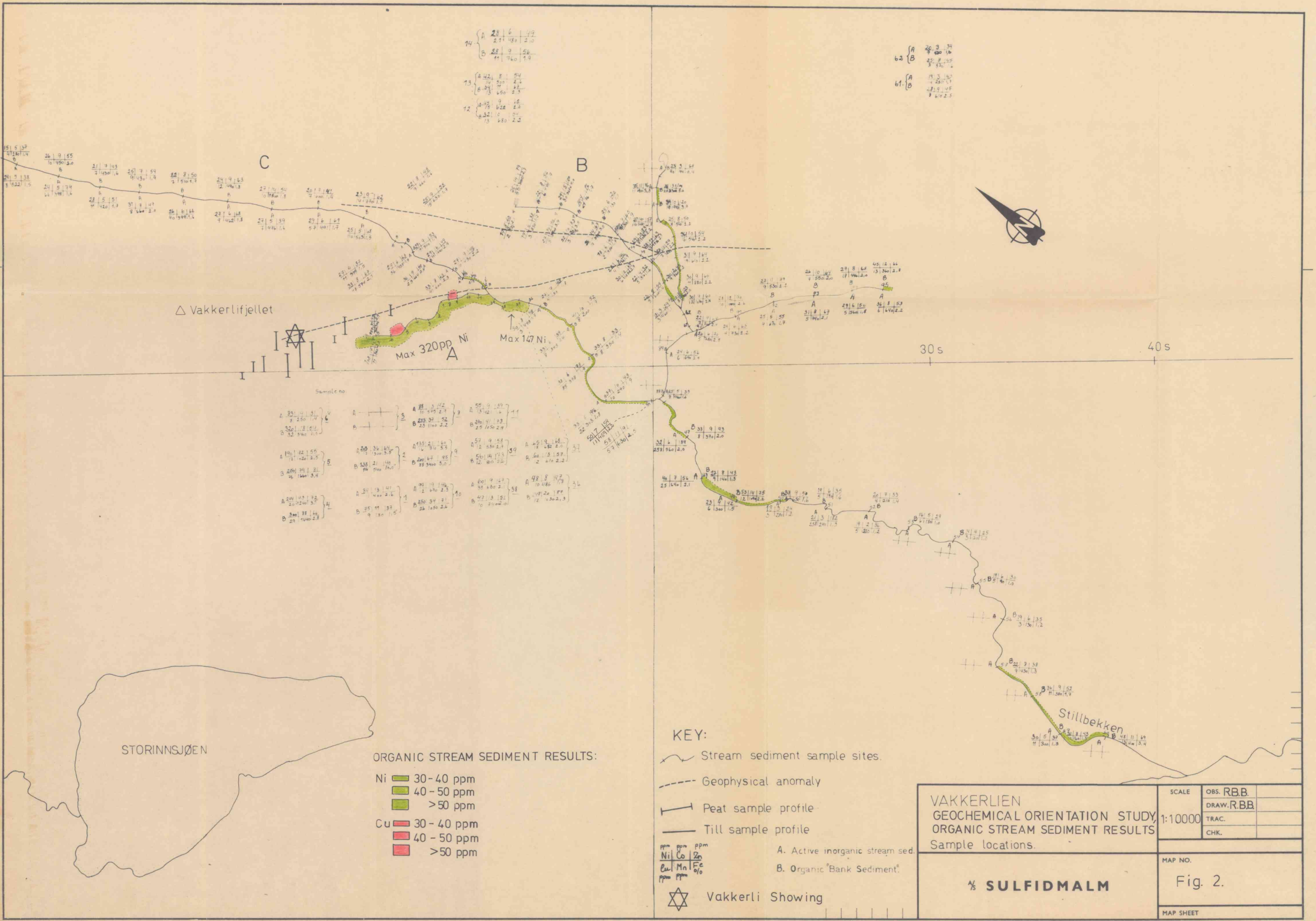
up rods and sampler: This can take almost as long as drilling down.

4) <u>Sampler</u>:

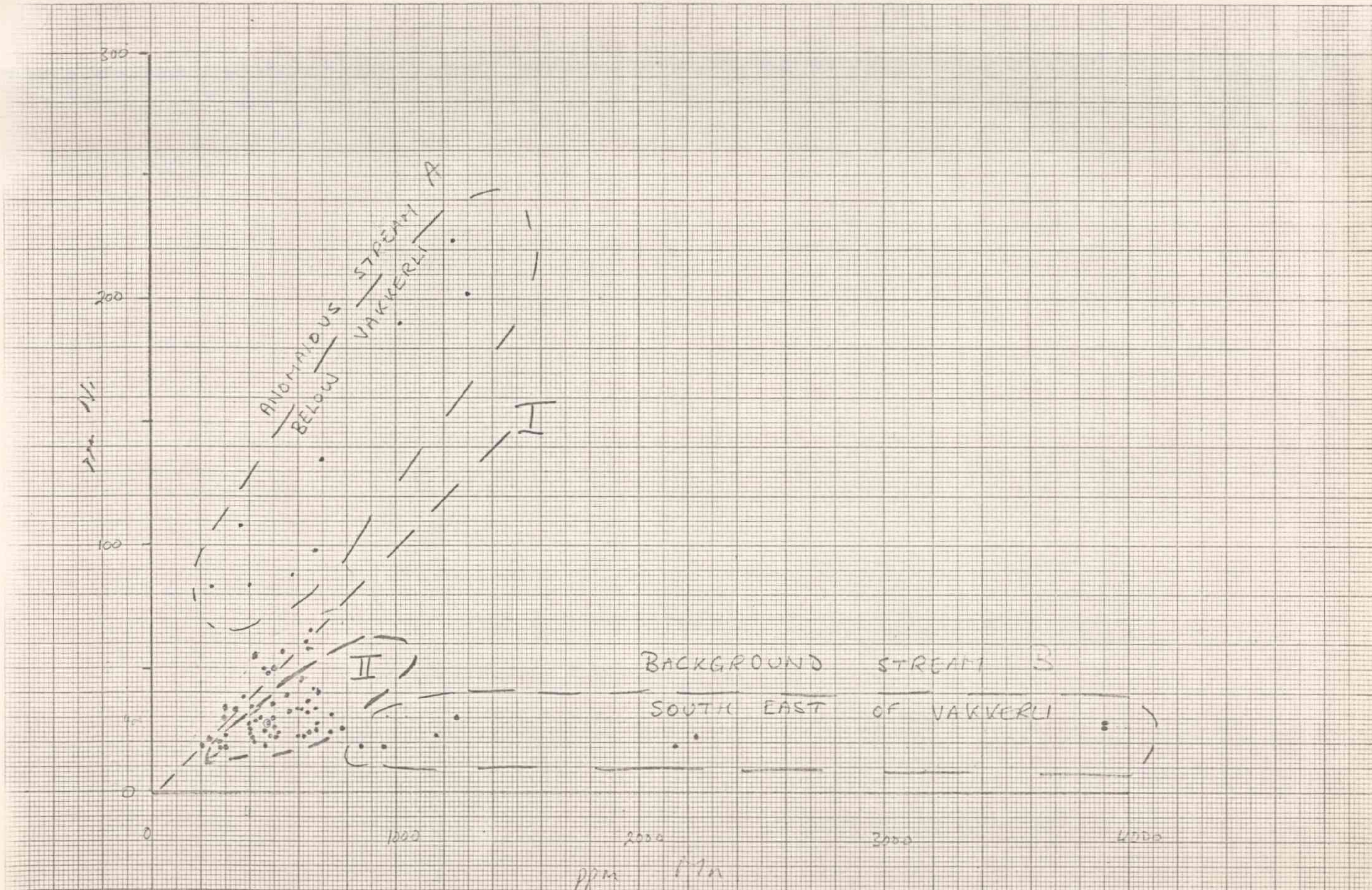
The till sample is packed solidly in the through flow sampler.



A.s Terrkopi. 2000. A 2. E 9 gl. 10-71. Sentrum Trykkeri.



A.s Terrkopi. 2000 A 2. E 9 gl. 10-71. Sentrum Trykkeri.



3: Ni vs Mn, inorganic stream sediment samples, Vakkerli orientation study

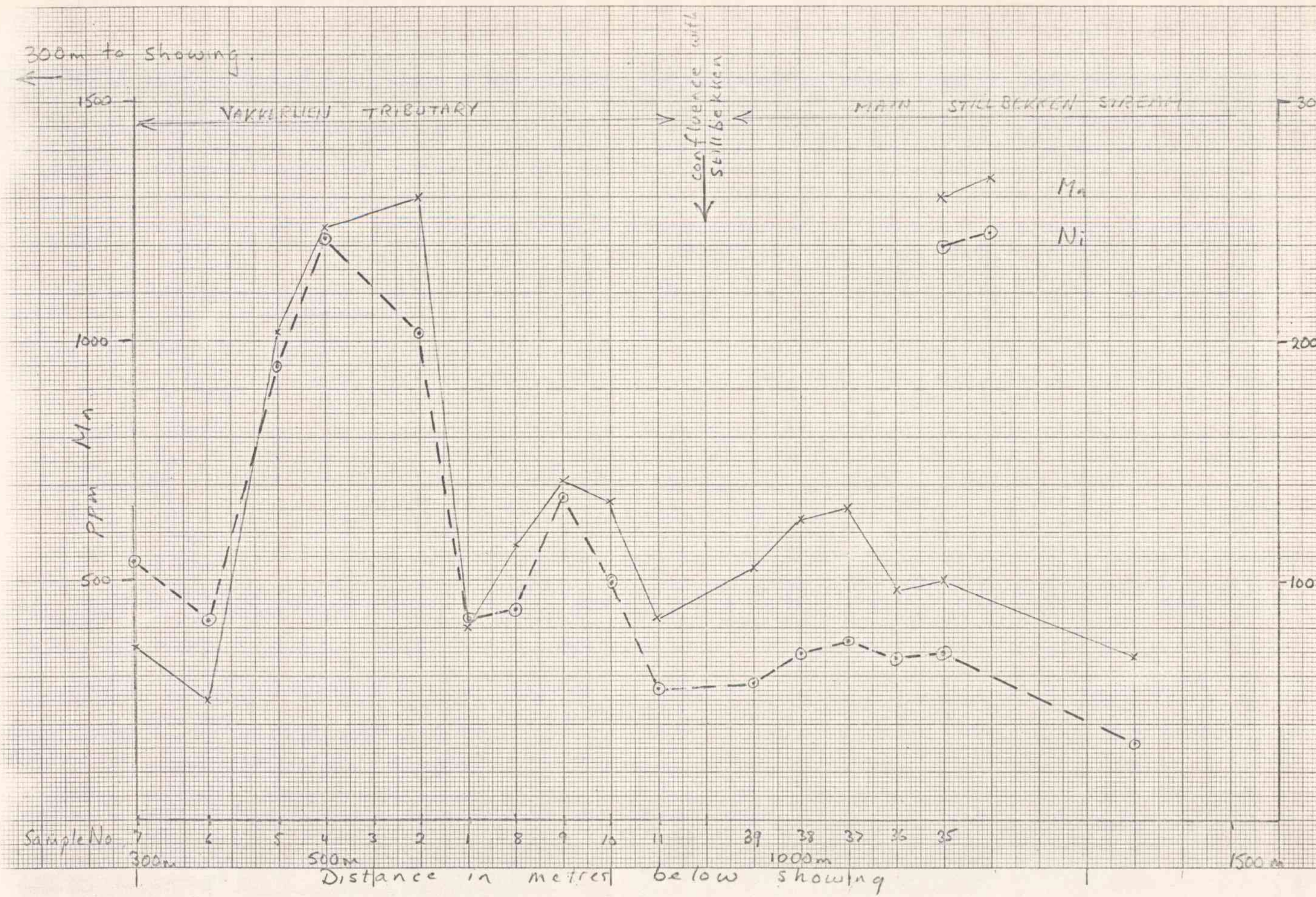
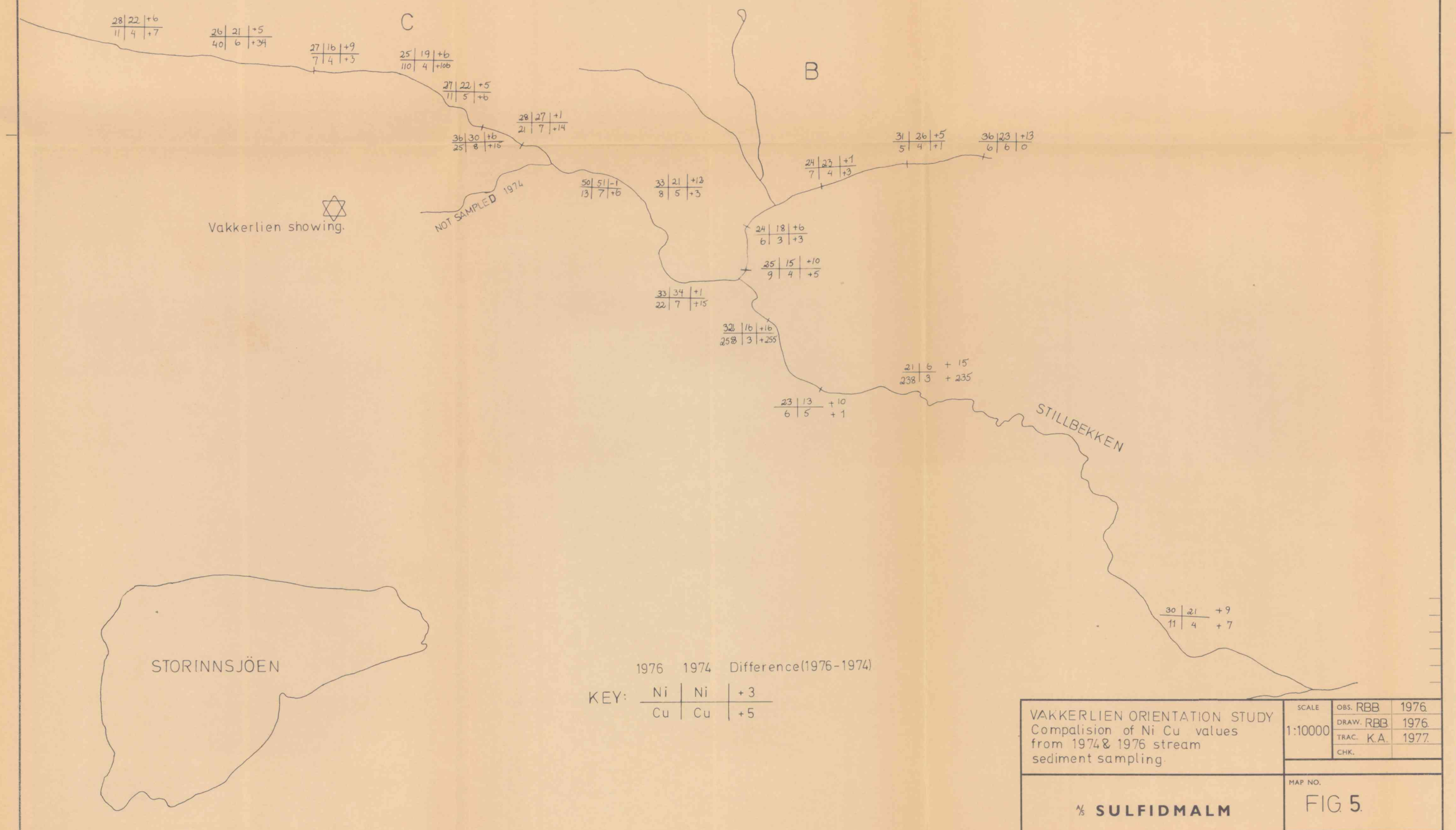


Fig. 4 RELATION BETWEEN Ni & Mn IN ACTIVE STREAM SEDIMENT, VAKKERLIEN ANOMALY



VAKKERLIEN ORIENTATION STUDY
Compalision of Ni Cu values
from 1974 & 1976 stream
sediment sampling.

SCALE		
1:10000	OBS. RBB	1976
	DRAW. RBB	1976
	TRAC. K.A.	1977
	CHK.	

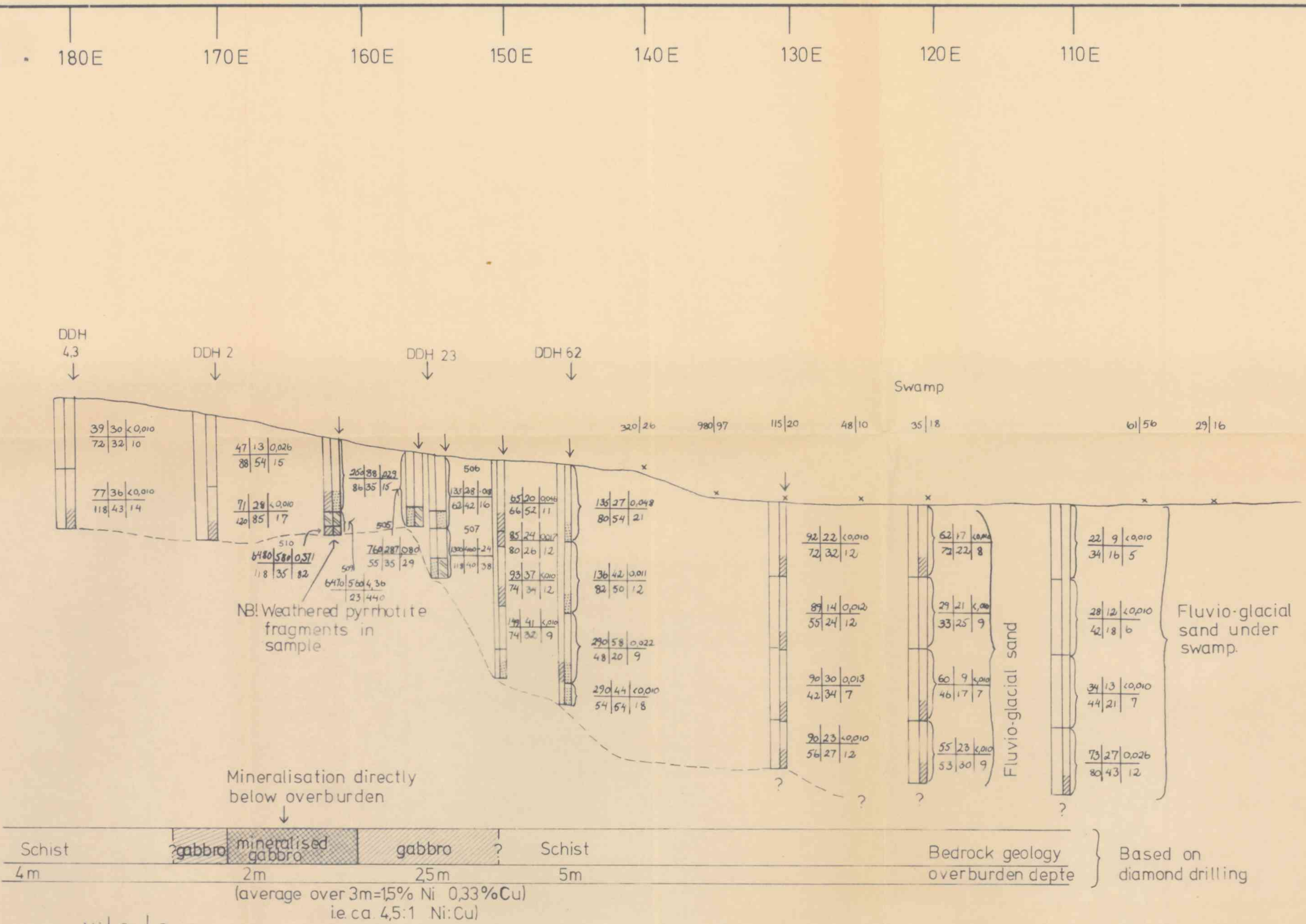
A/S SULFIDMALM

MAP NO. FIG 5.

MAP SHEET

A.s Torrkopi. 2000. A 2. E 9 gl. 10-71. Sentrum Trykkeri.

PROFILE 250 S



Key:

Ni	Cu	S
Cr	Zn	Co

Scales:

10 m Scale horizontal

1m (sample depth)

Topography 2m

Background Ni or Cu (<50 ppm)

Weakly anomalous Ni or Cu (50-100 ppm)

Moderately anomalous Ni or Cu (100-500 ppm) Ni (100-400 ppm) Cu

Strongly anomalous Ni or Cu (500 ppm) Ni (400 ppm) Cu

CuNi

980 97 × peat sample locatiion, Ni/Cu value.

VAKKERLI ORIENTATION GEOCHEMICAL SURVEY.
Deep till sampling results
('Partner' sampling system)

SCALE 1:250

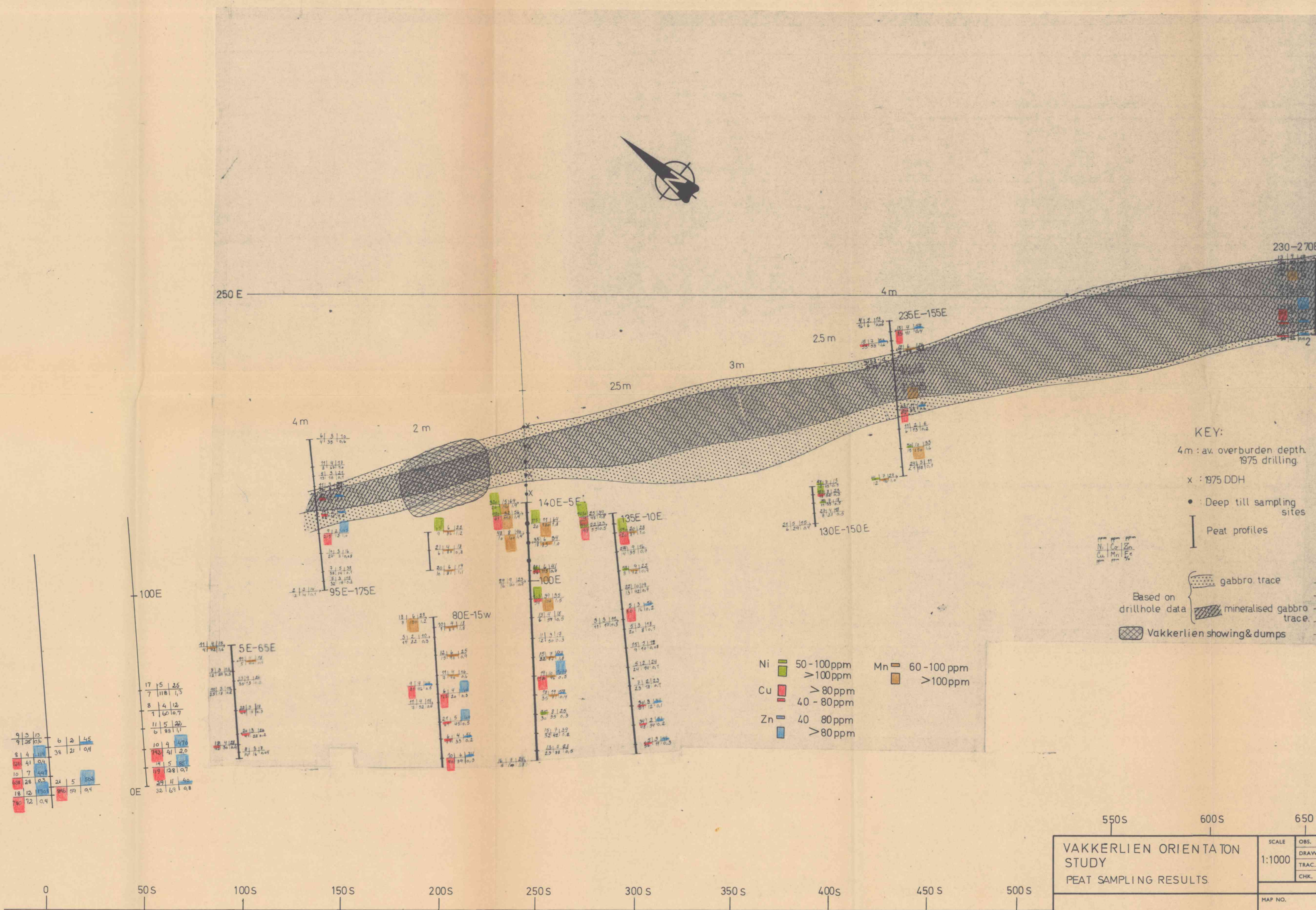
OBS. RBB
DRAW. RBB
TRAC. KA 3-77
CHK.

A/S SULFIDMALM

MAP NO. FIG. 6

MAP SHEET

A.s Tørrkopi. 2000. A 2. E 9 gl. 10-71. Sentrum Trykkeri.



VAKKERLIEN ORIENTATON STUDY PEAT SAMPLING RESULTS	SCALE 1:1000	OBS. RBB	7 – 76
		DRAW. RBB	7 – 76
		TRAC. BB	10 – 76
		CHK.	
A/S SULFIDMALM	MAP NO. FIG 7.		
	MAP SHEET		

A.s Terrkopi. 3000. A 1. 5 9 gl. 10-71. Sentrum Trykkeri.