



Bergvesenet

Postboks 3021, N-7441 Trondheim

Rapportarkivet

Bergvesenet rapport nr 7333	Intern Journal nr	Internt arkiv nr	Rapport lokalisering	Gradering
Kommer fra ..arkiv	Ekstern rapport nr	Oversendt fra F.M. Vokes	Fortrolig pga	Fortrolig fra dato:
Tittel Nickel prospecting in Sørlandet. Proposals for fieldwork, summer 1970				
Forfatter Vokes, Frank M.		Dato År 05.04 1970	Bedrift (Oppdragsgiver og/eller oppdragstaker) Norsk Hydro A/S	
Kommune Arendal	Fylke Aust-Agder	Bergdistrikt	1: 50 000 kartblad 16114	1: 250 000 kartblad Arendal
Fagområde Geologi Malmgeologi	Dokument type	Forekomster (forekomst, gruvefelt, undersøkelsesfelt) Messelheia Brattåsen Toskedal Bamble Høgåsen Hullvann		
Råstoffgruppe Malm/metall	Råstofftype Cu, Ni, Co			

Sammendrag, innholdsfortegnelse eller innholdsbeskrivelse

Med utgangspunkt i tidligere utførte geologiske, geokjemiske prøveinnsamlinger og flyborne geofysiske undersøkelser blir det foreslått geofysiske helikoptermålinger i utvalgte områder, dertil blir det foreslått geologisk kartlegging og prospektering i Bamble

Nickel prospecting in Sørlandet.

Proposals for field work, summer 1970.

The following is a proposal for a prospecting campaign for the field season 1970, as a follow-up of the previous season's mainly geochemical reconnaissance work carried out by NGU's personnel following the agreement with Norsk Hydro A/S on cooperation of 2.6.1969.

The proposals are based on NGU's report nr. 885, volume I, received via overingeniør N.-A. Nielsen. As background material use has been made of geological maps by J.Touret, M.J.Ryan, R.D.Morton and H.Batey, I.Starmer and collaborators, and others; the airborne geophysical maps on a scale of 1:250.000 and 1:100.000 published by NGU, as well as the writer's own limited observations from the summer of 1968.

The conclusions reached in this report are thus not based on the most detailed information available. In particular, reference will have to be made to the other eight volumes of NGU's report 885 and to the more detailed geological maps which it is hoped Drs' Starmer and Ryan will be able to provide if they agree to the proposed programme of cooperation. (cf. director Kielland's letters of 6th March to Ryan & Starmer).

Background information.

I will not consider here the information on the geology of Sørlandet (here taken to mean the former Kongsberg-Bamble formation between Grimstad and Breivik) and on the geology of the nickel deposits published prior to Hydro's present operation (see summary in NGU report 885). These operations may be said to have commenced in the summer of 1968 with a geological-geochemical-geophysical study of the Skogen area by R.Sinding-Larsen, geological reconnaissance in Messelfelt and Bamble by F.M.Vokes and geophysical surveying in the Messelfelt and Bamble areas by the team from Kjørholt. The main activity in the summer of 1969 was the above-mentioned geochemical reconnaissance of more or less the whole area of interest by the NGU team under the leadership of Sinding-Larsen. At the same time geophysical

surveying (EM) of areas of interest in the Skogen area were carried out by the team from Kjørholt. Late in the season two diamond drill holes were put down to test part of the Brattåsen mineralization in Messelfeltet.

The above work has lead to certain areas of interest being defined in this rather large geological subprovince. These are defined partly on the geology of the area, supplemented by the airborne (AM) geophysical results, and partly on the geochemical results. Previous to the geochemical survey, guides to nickel ore in the area were in the main the presence of supposedly favourable igneous lithology (ultramafites, mafites), and the actual occurrence of Ni-Cu sulphides in the form of old mines, mineral prospects and other visible surficial showings. In several cases coincidence of favourable lithology and sulphide showings occurred and these areas were considered as rather more favourable at the regional scale, though of course no obvious leads to the presence of economic bodies of sulphide were apparent. Perhaps the only exception to this was in the Messel area, where the weathered outcrops of mineralized norite at Brattåsen and Ramsefotfjell were obvious targets for an investigation at the follow-up stage already in 1968. The rather disappointing results (reported verbally) from the drilling at Brattåsen should not, in my opinion, lead to the premature abandonment of the area. The Messel area should be one of the areas given priority in this summer's programme (See below).

Sinding-Larsen's work in the Skogen area in 1968 showed that geochemical methods using both humus and stream sediments as sample material were well adapted to investigating the presence of mafic rock and associated sulphide mineralization.

The agreement entered into between NGU and Norsk Hydro called for a geochemical reconnaissance of the whole area defined above to extend the Skogen study to other areas of potential interest. One had no good grounds for supposing that the Skogen area was necessarily the area of greatest interest for nickel deposits and the geochemical reconnaissance technique offered a relatively rapid method of delimiting other areas of promise.

The results of this survey have now been presented in NGU report 885 and an assessment is made therein of the relative order of interest of the geochemically anomalous areas defined during the survey.

I have made an independent assessment of the anomaly areas defined by NGU. It does not however necessarily imply agreement that the limits placed on the areas on geochemical grounds by NGU are necessarily the same as the limits of areas of potential ore interest. The following-up programme will in more than one case take in several areas of geochemical anomaly.

Results of 1969 field season.

The geochemical results from the 1969 field season have resulted in the definition of a series of anomalous areas based on both humus and stream sediment anomalies. In some cases there is coincidence between the anomalies based on the two different sample materials, but in the majority of cases, such coincidence is not observed. There seems to be little basis for assessing the relative effectivity of humus versus stream sediment sampling for defining areas of interest in the present connection. However, I have tended to place greater weight on areas where there is a coincidence of anomalies from both types of sample material. (This may of course be open to question?).

The geochemical reconnaissance has served to define a series of targets where metal concentrations in surface materials are greater than in the surrounding areas. In this respect the programme can be said to have fulfilled its main purpose. The purpose of all types of prospecting at the regional level is the definition of "targets" in the form of anomalous areas to which attention can be directed at the next, follow-up level. This has happened as far as the geochemistry is concerned.

Of course we have other indications of "targets" besides these geochemical ones. These are both geological, ore geological (prospecting) and geophysical. Coincidence of two, or more of the available indications are considered as increasing a particular target's favourability. Many of the geochemical anomalies coincide with the reinforce, other types of indications, such as favourable lithology, presence of "showings", etc. In other case a geochemical anomaly occurs in the areas where other indication

were not known in advance. In such cases further work must be directed to investigate the other parameters in these areas. In yet other cases, the geochemical results have drawn our attention to areas, not originally considered as targets, which on closer inspection are seen to possess other favourable indications. A particularly good example of this is seen in the Toskedal area.

Many of the geochemical anomalies are located over, or near, known bodies of mafic-ultramafic rocks, which in themselves have been regarded as favourable targets for Ni-Cu ores. One has been aware, however, that not all bodies of this type have the same potential for ore occurrence. NGU have attempted, both on the basis of the secondary geochemical dispersion from such bodies and on the actual geochemistry of the rocks themselves, to classify their "ore potential". This work is still in its infancy here in Norway and it is to be hoped that NGU will find time and manpower to develop their studies. In the meantime, the criteria so far arrived at have been used in the following assessment of priorities.

Proposals for field work 1970.

The methods used in following-up the results of the previous season's work will vary in detail from area to area depending on the type of information already available. One can envisage the use of geological mapping, both detailed and reconnaissance; mineral prospecting, i.e. the finding and delineation of surface expressions of sulphide mineralization; further detailed geochemical work to substantiate and refine the anomalies already found, as well as geophysical surveys both ground-based and airborne. It is suggested that geological and prospecting work will constitute the main part of the operations in Sørlandet as a whole, though it will probably be necessary to take supplementary geochemical samples. As regards geophysical techniques, the time does not yet seem ripe for widespread application of these, though selected areas can even now be recommended for measuring as a form of case history on which to base future work. Even so these measurements must be supplemented by the application of other methods in order to complete the case histories.

Airborne geophysics (helicopter).

In a memorandum dated 11.3.70 Director Kielland mentions that it has been decided to allot funds for about 50-60 square kms of geophysical coverage by helicopter (Terratest AB) within the area considered here, preferably spread over not more than two areas. I am given the task of selecting the area(s) to be flown. My proposals are set out below and it must be again emphasized that they are based on case history considerations and not in the hope that one will find ore straight away.

One of the requirements for a good case history in mineral exploration is that it encompasses mineral-bearing ground of known quality, where the geology is known in good detail. The only area we seem to have in Sørlandet where these conditions can be said to even be approximately fulfilled is the Messelfell area.

This area, in my opinion, stands out on several grounds. The favourable combination, mafic rocks with sulphide mineralization, occurs; one has a certain idea of the grades involved from last year's drill results; the mineralized zones have given

marked, unequivocal EM anomalies on the ground; the area is the locus of both a small marked humus geochemical anomaly and a larger stream sediment anomaly; the AM map shows that the rock types in the Messelfelt most probably continue to south for at least 5 kms while there are indications of similar rocks to the north.

The only condition not fulfilled is a sufficient knowledge of the geology of the area and thus the area must be mapped this summer, probably by Dr. Starmer and his coworkers. (See below).

The Messelfelt area and surroundings is given No 5 ranking on geochemical grounds by NGU, but I feel that ore geological considerations justify it being given the highest priority and forming part of the case history area for helicopter borne geophysical measurements.

This is especially so as it seems it may very well be combined with another area nearby where conditions are extremely favourable for the occurrence of interesting mineralization. This is part of the area given No 2 ranking in the NGU report and may be referred to as the Toskedal area.

The favourable indications in this area are; firstly the occurrence of numerous sulphide prospects, as indicated on NGU map No. 32-5, the presence of interesting humus and stream sediment geochemical anomalies, a very interesting AM anomaly in the form of a low magnetic "tongue" stretching northwards from the generally high magnetic topography of the Herefoss granite, and finally, as far as can be judged from the published maps of the area, favourable lithology (basic, "amphibolitic" gneisses) coinciding with the prospects and the geochemical and geophysical anomalies. The coincidence of these favourable features makes the Toskedal area rank second only to the Messelfelt area as an obvious place to test the helicopter techniques. Again, as at Messelfelt, fairly detailed mapping is required to determine the geological control for the other parameters.

Between Messelfelt and the Toskedal area are other sulphide prospects, probably not all of the Ni-Cu type, but of sufficient interest to justify a determination of their geophysical-geological characteristics. Among these are probably deposits of the "fahlband" type (Bøilestad type).

I will thus propose that the Messelfelt and Toskedal areas be combined to form one "case history" area with helicopter-borne geophysical measurements and geological mapping in fair detail. The area in question is shown in the accompanying figure based on parts of NGU's 1:100.000 AM map sheets 1611, 1511, 1612, 1512. The area proposed flown is 15 km long E-W and 4 km broad NS. The total flight distance, taking 8 profiles per km along a 15 km central line, will be 480 line-km.

Roughly the same area, with extensions, where necessary to elucidate rock units, structures, etc, will form the main mapping project for Dr. Starmer and his coworkers. Dr. Starmer will be contacted regarding this.

Other work.

Although the Messelfelt and Toskedal areas are selected as being the most rewarding from a case history point of view, it is clear that the region under consideration abounds with areas of the highest interest from an ore prospecting point of view. With the resources of man power and time at our disposal it is also clear that only a relative few of these areas can be investigated in the coming field season.

Thus the list of areas of interest below is by no means exhaustive and it is not certain whether we shall be able to cover all, or even the majority.

The man power available for geological mapping and prospecting work in Bamble this year is:

Dr. M.J.Ryan with field assistant (NTH. stud.techn) for 3 months, part of which will have to be devoted to Ringerike.

Dr. I.Starmer, possibly with two colleagues, for about 1 month each. (See, however, Dr. Starmer's letter of 24.3.1970).

The writer of this report; of the order of some days mostly devoted to coordination and to guidance of the others.

The main effort of Dr. Starmer and colleagues will be the mapping on aerial photos at 1 : 15.000 of the area flown by Terratest AB (see above). Any time remaining at their disposition would be best employed in extending the mapping on a more reconnaissance scale to cover the remaining parts of NGU's "interesseområder" No's 2 and 5, i.e., to try to assess possible cause for the geochemical anomalies in these areas. With this latter work could also be included reconnaissance in the vicinity of

humus anomaly 2009 (area 12) and visits to the sulphide prospects marked on NGU's map 32-5 to the east of the Herefoss granite.

Dr. Ryan and assistant (on the basis of say 1½ months in Sørlandet and 1½ months in Ringerike), would be available to undertake the rest of the work. They will obviously not be able to cover all the areas of interest listed below.

Areas of interest.

1. The Høgåsen-Laget area (NGU's area 1).

This area comprises stream sediment anomalies 92 and 189 and humus anomalies 3349, 2963, 2774, 3699, 2810 and 2783, i.e. it is a dominantly humus type anomaly area. There are direct coincidences between SS 189 and parts of H 3349 and H 2963, but these are in the northern part of the area away from the known mineralization of the Høgåsen area.

Geology: the area is covered by Starmer's group on the scale of 1:15.000 and probably needs no further mapping. Starmer will be able to provide the geological coverage. From information available at the moment, H 3349 and probably SS 189 seemingly coincide with the large mafic-ultramafic massiv between Songevann and Sandnesfjord (Laget massif). Sinding-Larsen classifies the Laget massif as No 1 on his copper criterium, No 2 on his cobalt criterium and No 4 on his nickel criterium. However no megascopically visible sulphides seem to have been found in connection with this massif. H 2963, southwest of Laget (Bjørnåstårnet) seems to coincide with amphibolites plus sediments. No direct geochemical anomaly appears to be related to the Høgås deposits.

Geophysics: the AM picture is characterised by rather subdued relief, with large, shallow, negative anomalies, one of which coincides with the Laget massif. The Høgåsen deposits lie in a similar magnetic "low" or negative anomaly, but there is a steep gradient immediately to the west to a NE trending ridge of magnetic highs.

Conclusion: the area is of decided interest and should be assessed on the ground this summer. On the basis of Starmer's 1:15.000 map the area should be prospected with a view to ascertaining the cause of the geochemical anomalies, particular care being taken to detect possible non geological causes. References should be made to the original geochemical data sheets with a view to eventually supplementing the sampling.

2. The area north of Nes Jernverket. (NGU's area 3).

This eggshaped area, about 6 km long NS and 3-4 km wide EW, is dominated geochemically by anomaly SS 387 which runs NS almost the whole length of the area and has a width of 1 km. A humus anomaly 3716 occurs on the extreme east of the area and apparently not connected to 387. SS 387 seems to be related to a certain stream and its small tributaries, draining south into Storelva east of Nes Jernverk. This drainage system cuts almost at right angles to the regional strike.

Geology: included in the area covered by Starmer's 1 : 15000 mapping. Also lies in Touret's area and he shows a NE-striking belt of "amphibolites" with large lenses of "orthoamphibolites" (amphibolites of magmatic derivation), of which the one near Skjerkholt and the one to the NE of this, may be of significance regarding the anomaly.

No sulphide showings reported in the area.

Geophysics: The amphibolite belt is well defined by a NE trending belt of magnetic highs with a maximum relief of about 700 γ over the adjacent areas. Geochemical anomaly H 3716 coincides with an interesting local geophysical high-low juxtaposition with a sharp relief of 600 γ .

Conclusion: as for area 1: reconnaissance and prospecting using Starmer's 1 : 15000 maps as basis.

3. The Hullvann area. This forms part of NGU's area No 6, which probably should be investigated as a whole. The geochemical anomalies in the area are wholly of the humus type, nos. 3154, 3186, 3521, 3591 and 3434.

NGU report that these anomalies show medium to high metal values which in the main must be due to the weathering of the underlying mafic and ultramafic rocks. No sulphide showings are reported from this area.

Geology: The area lies outside the areas covered by Starmer and Touret, but is partly covered by a 1 : 15000 detail map by Dr. Ryan. Ryan has promised to send information regarding map coverage in general in the area from Risør and northeastwards. We have every hope that the area is already wholly covered in sufficient detail for our purposes.

What I know already of the geology seems to be very encouraging from the point of view of Ni-Cu sulphides, in spite of the lack of reported occurrences.

Anomaly H 3154, which is given priority by NGU, covers the large mafic-ultramafic massif between Hullvann and Grummestadvann shown on Ryan's available map. This is a priori a very promising Ni-Cu situation. NGU's investigations of hard-rock geochemistry place the Hullvann massif No 1 on both the Co and Ni criteria.

Geophysics: Hullvann marks the extreme SW limit of a belt of marked magnetic topography, with highs up to 50 000 γ and lows down to 48200 γ in close juxtaposition, which runs SW through the Bamble area and covers the former mining areas of Nystein, Vissestad and Meikjær. Thus geochemical anomaly H 3154 is the only one which appears show relation to this magnetic belt. Probably the belt NE from Hullvann should be regarded as an entity and subjected to an integral prospecting operation. It probably ranks second after the area already proposed as a site for helicopter-borne geophysical measurements. The field work in 1970 should be directed towards completing the geological-prospecting - geochemical background in this area with a view to providing a good basis for an actual helicopter follow-up at a later date.

Conclusion: completion of geological coverage and prospecting of the type already proposed for areas 1 and 2.

The areas outlined above seem, to me, to be the ones requiring immediate attention this summer to complete the geological prospecting, and possibly, - geochemical backgrounds prior to any eventual geophysical follow-up. There remains, of course, a large number of interesting situations which will require attention as and when the manpower and time become available. These are listed below, with an assessment of each. The ranking in the list does not necessarily imply anything regarding their relative priorities for attention.

4. NGU's area 13.

An oval shaped area 6 km long NE-SW and $2\frac{1}{2}$ km wide NW-SE. SS anomaly 350 in extreme NE end.

H anomalies 2795 and 2753 as small circles at either end. SS350 and H 2795 nearly coincide. Relatively small anomaly areas here.

Geology: Lies outside Starmer's mapped area, but on the area of Touret's map. This shows that the area is cut centrally, lengthwise, by a NE striking belt of "amphibolite" and "orthoamphibolite" up to 3 km wide, part of a much longer belt which runs almost the whole length of Touret's map, from Kroken, through Vegårshei, Espelands myr and further SW. Complicating factor is the presence of the Etterdalen sulphide deposit (Pb-Zn-? Cu) which as Sinding-Larsen remarks, could give rise to at least the SS anomaly. However the two humus anomalies seem to be connected to the SE border of the amphibolite zone and may be of interest to us.

Suggest: Area has a certain interest and a prospecting-type reconnaissance mapping of the amphibolite belt in this area would be of interest - followed up by supplementary geochemical work to define the humus anomalies rather better. Fairly low priority

5. NGU's area no. 15.

A roughly rounded rectangle, 5 km long, NE-SW, 3 km wide SE-NW. Lies SW along strike from NGU area 3. Contains two SS anomalies 601, 609 at either end (NE and SW) of the area and H anomaly 3782 rather centrally placed between them, but nearer to 609. Small anomaly areas. Sinding-Larsen gives them low priority.

Geology: Lies on the border of Starmer's mapped area, but mostly inside it, should be adequately covered.

Lies in Touret's area. According to him it covers an area of quite monotonous geology - wholly consisting of his "undifferentiated Bamble banded migmatites".

Very difficult to see a geological reason for the geochemical anomalies in this area. Suggest it deserves a low priority - unless Starmer's maps show something of interest.

No further field work proposed if Starmer confirms Touret's picture.

6. NGU's area 12, anomaly H 2009.

NGU mention high Cu and low Co, Ni indicating Cu mineralisation connected with quartz veins, but also mention po showing possibly connected with amphibolites.

No geological control. Lies within 3 km of border of Herefoss granite.

Very low priority - but may be worth a visit if personnel and time allow. (See remarks above regarding the Starmer group's programme).

7. NGU's area 17, anomaly H 2726.

NGU indicate low metal values, sample is probably taken over amphibolite. Touret's map confirms this. A belt of "amphibolite" with "orthoamphibolite" "core" $\frac{1}{2}$ -1 km wide, runs for ca 6 km from Heståsen to the SSW, with the core ca $2\frac{1}{2}$ km NW of Froland, coinciding with the anomaly.

Could be prospected for further signs of mineralization. Must be given a low priority.

8. NGU's area 14. Anomalies H 2502 and H 2175.

NGU give priority to H 2175, but it is difficult to see reason for this on geological grounds. Both anomalies appear to be related to the belt of "amphibolite" and "orthoamphibolite" shown on Touret's map running from NE to SW from Kroken to Bleggstadvatn, a distance of some 55 km. It is the same belt to which anomaly area 13 is related (see above). It would be interesting to plot all samples falling on or near this belt to see if it has a general anomalous character or not. Experience is that such "concordant" amphibolite zones are not the best places to look for nickel ores - cf Ringerike report from last summer.

Area 14 could be included with 13 as far as recommendations for further work go, i.e. a prospecting type reconnaissance with possible supplementary geochemistry. Fairly low priority.

9. NGU's area 16, anomaly H 3086.

NGU do not give this any high priority; the anomaly is Cu-high.

According to Touret it lies in an area of granitic gneiss forming the core of a regional fold outlined by a thin belt of amphibolite outcropping some $\frac{1}{2}$ -1 km to the west. The anomaly does not seem to be related to this amphibolite.

One cannot give this any priority.

10. NGU's area 10, anomalies H 2947, H 3128.

NGU consider these anomalies, with medium-high values in Ni, Co and Cu, to be due mainly to the weathering of mafic rocks

The area lies within Starmer's area and we should be able to get good geological coverage. Touret has also covered it. His maps shows rather interesting geological features. It is obviously an area of great complexity, both of structure and of lithology.

H 3947, the southerly of the two anomalies appears to coincide with an area of mafic rocks at Indre Søndeled. The northerly anomaly H 2128 is not so obviously related but there are smaller areas of mafics within it.

The area thus appears to be not without possibilities for the occurrence of Ni-Cu sulphides and ought to be further investigated. This would probably be best carried out in conjunction with the investigation of parts of area 1 and the Barmen area. These areas logically hang together and ought to be investigated as one project. (See below).

11. NGU's area 4: anomalies SS 153 and SS 340, of which no. 340, mainly to the east of Nidelva, is by far the bigger, covering an area roughly 10 km NS by 2-3 km EW. No. 153 is a small, circular (single point ?) anomaly west of Nidelva. NGU characterise the area as containing "many, often very high, Ni and Cu-values indicating that nickel and copper sulphides are concentrated in the area".

Geology: To the west of the area covered by Starmer's group. Covered by Touret's map, which indicates the area is underlain mostly by banded migmatites, with a rather narrow NE-SW belt of amphibolite ca. 5 km long. No prospects known within the anomaly areas, but one is marked on the NGU map due west of the Nidelv on the edge of 340.

Not too easy to assess this at present level of geological knowledge. Needs mapping and prospecting on ground before further work can be recommended.

12. NGU's area 9: Anomaly SS 692, an oval-shaped anomaly area 5 km long ENE and up to 2 km wide. Characterized by NGU as showing, in part, very high Ni, Co and Cu values which should indicate the weathering of sulphides.

Geology: Outside the area mapped by Starmer's group. Touret's map indicates two NNE-striking "amphibolite-orthoamphibolite" bands, each about $\frac{1}{2}$ km wide, crossing the anomaly area. The anomaly is obviously related to a drainage system crossing the strike of these bands, and may be due to sulphide mineralization associated with them. However, a number of zones of graphitic schists are also indicated as crossing the upper part of the stream system and may possibly have contributed to the anomalous metals in the stream.

Such an anomaly must be carefully followed up on the ground in order to check the possible sources of the metals.

13. NGU's area 11. Anomalies SS 375 and SS 378. Two small (single point ?) anomalies about 5 km apart along the NE-SW strike of the rocks of the area. NGU say: "comparatively high nickel values indicate the possibility that there may be nickel sulphides connected to basic layers". However, Touret's map indicates a number of zones of graphitic schists in this area and the anomalous metal values could be related to these.

These two anomalies would not appear to be very promising as far as presence of sulphide deposits related to mafic bodies is concerned. One should however note the presence of a nickel prospect 2 km east of 378. Should be checked on ground on a prospecting basis.

14. NGU's area 8: anomaly SS 413, a roughly circular anomaly area ca. 3 x 2 km, just east of Gjerstad.

From Touret's map it can be seen that this anomaly straddles the NE striking zone of amphibolite-orthoamphibolite, which runs from Kroken to Bleggstadvann and which has already been mentioned in connection with NGU areas 13 and 14. This zone, which is some thing over 1 km wide at this point is cut at right angles by a prominent drainage system to which the anomaly area is also related. NGU say, "Nickel sulphide prospects are known in the area and are responsible for at least one of the anomalous points in anomaly 413. It is probable that the sulphides follow the

NE-striking amphibolite without being able to say anything regarding the form or quantity of the sulphide concentrations".

The juxtaposition of SS anomaly, the right type of lithology and actual sulphide prospects, is interesting and would indicate the necessity of looking more closely at the area on a prospecting basis. The area also needs to be mapped geologically.

15. NGU's area 7: anomaly SS 450, a bow shaped anomaly area with its concavity facing east and with about 5 km between the "horns" of the bow. NGU reports that the area is especially characterized by high nickel-cobalt values and medium to low copper values. This anomaly possibly represents merely the weathering of somewhat sulphidic basic rocks".

Geology is completely unknown to me at the moment, but may be covered by Ryan's mapping. If not it requires reconnaissance mapping and, in any case prospecting for signs of mineralization.

Summary of proposals.

The work proposed for the Messel-Toskedal area, in conjunction with the airborne geophysical work is given the highest priority in the summer's work.

The following work is also regarded as essential this year (See "Other work" above pp 7-10).

Area 1. (Høgåsen-Laget). Maps to be provided by Starmer's group as basis for prospecting by Ryan.

Area 2. (NGU's area 3). Maps to be provided by Starmer's group as basis for prospecting by Ryan.

Area 3. (Hullvann area - NGU's area 6). Maps to be provided by Ryan as basis for own prospecting.

The following areas should be given attention if and when the above work is completed. (See text of report for details.

Area 11. (NGU's area 4) Needs mapping geologically.

Area 15. (" " 7). Ascertain if mapped. If so prospecting operations.

Area 14. (" " 8) Needs mapping geologically.

Area 12. (" " 9) " " "

Area 10. (" " 10) Covered by maps. Could be prospected together with area 1.

It is not considered realistic to list any more areas for attention this coming summer even though it is obvious that these exist.

Without wanting to present too rigid a programme, the following proposals are made for the disposition of the man power available for the work in Sørlandet this summer.

Dr. I. Starmer, with two colleagues (?).

About 1 month each, i.e. total of 3 man months in field.
To provide: geological maps at 1:15 000 of the area already mapped by them (cf. Starmer's letter to FMV, dated 29.1.70) from lat. $58^{\circ}35'N$ to $58^{\circ}55'N$ (i.e. from ca. 5 km south of Tvedestrand to about Gjerstad).

To map and prospect: 1) the areas proposed for helicopter -borne geophysics, together with the extensions suggested above.

2) Area no. 11 above, (NGU4) on a reconnaissance scale with special attention to possible causes of the geochemical anomalies.

3) if time still allows prospecting and reconnaissance of NGU's areas 13 and 14.

Dr.M.J.Ryan with assistant: 3 months, of which about $1\frac{1}{2}$ to 2 in Sørlandet (?).

To provide: detailed maps of the relevant areas north of Starmer's mapping, especially those covering area 3 above (NGU 6) and NGU 7 and 8, if these are available.

To prospect and if necessary to complete mapping on a reconnaissance scale, the following areas:

Høgåsen-Laget; area No 2 above (NGU 3), Hullvann area and rest of area 3 above (NGU 6); area 14 (NGU 8) area 15(NGU 7) area 12 above (NGU 9 and area 13 above (NGU 11).

The above suggestions are probably maximum programmes and are subject to adjustment.

Trondheim, 5.4.1970.

F.M. Vokes.
F.M.Vokes.