Bergvesenet rapport nr	Intern Journal nr	Internt arkiv nr	Rapport lokalisering	Gradering
BV 474			Trondheim	**Åpen**
Kommer fra ..arkiv	**Ekstern rapport nr**	**Oversendt fra**	**Fortrolig pga**	**Fortrolig fra dato:**
Falconbridge	Sul 229-72-15	Sulfidmalm A/S		

Tittel

Field work in Espedalen, summer 1972.

Forfatter	Dato	Bedrift
M J Ryan	1972	Sulfidmalm A/S

Kommune	Fylke	Bergdistrikt	1: 50 000 kartblad	1: 250 000 kartblad
Sør-Fron Gausdal	Oppland	Østlandske	17171 17174	Lillehammer

Fagområde	Dokument type	Forekomster
Geologi	Rapport	Statsråd Stang Nicoline Andreasberg
Råstofftype	**Emneord**	
Malm/metall	Cu Ni	

Sammendrag

Geologisk undersøkelser av helikopteranomalier.

Vi har duplikat av tekstdelen

Oslo Univ
NGU IBG.

FOR FALCONBRIDGE NIKKELVERK A/S

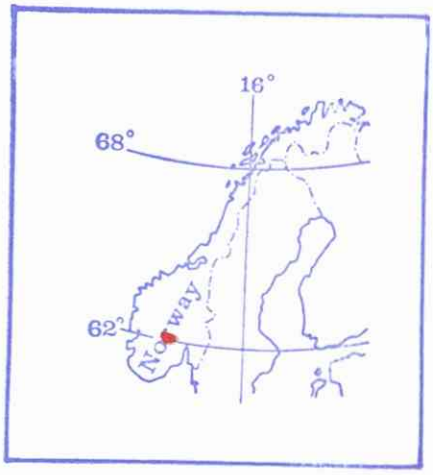
A/S SULFIDMALM

PROJECT 905-15

FIELD WORK IN ESPEDALEN, SUMMER 1972.

by

M. J. RYAN



22/12/15

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FIELD-WORK IN ESPEDALEN

Summer 1972

Order No. T.67039/K
Field-work in Norway, 1972
(Project 955)

M. J. Ryan

C O N T E N T S

1. INTRODUCTION

Five weeks from July 16th - August 19th, 1972 were spent in the field in Espedalen.

After meeting Professor Vokes in London and Dr. Gammon at the a/s Sulfidmalm office in Oslo, it was decided that the time to be spent in Espedalen should be divided approximately equally between:

a) further geological reconnaissance over airborne geophysical anomalies

b) detailed geological mapping around the known showings - especially around Statsrad Stang-Nicoline Andreasberg and Jorstad.

It was agreed that Ryan and student geologist Wilson would work together on the geological reconnaissance, co-ordinating with the geochemical sampling group led by T. Hong Tan of a/s Sulfidmalm. For the geology of Known Showings, it was decided that Wilson would map, measure up, sample etc. the workings and Ryan cover the areas around the old mines.

Since general geology etc. has been dealt with previously by Vokes-Vralstad (1969) and Lucarelli (1972) no description of the regional geology need be given here.

Fig.1 Airborne EM-anomalies: location and nomenclature

Fig.1 Airborne EM-anomalies: location and nomenclature

2. GEOLOGICAL RECONNAISSANCE OF KNOWN ANOMALIES

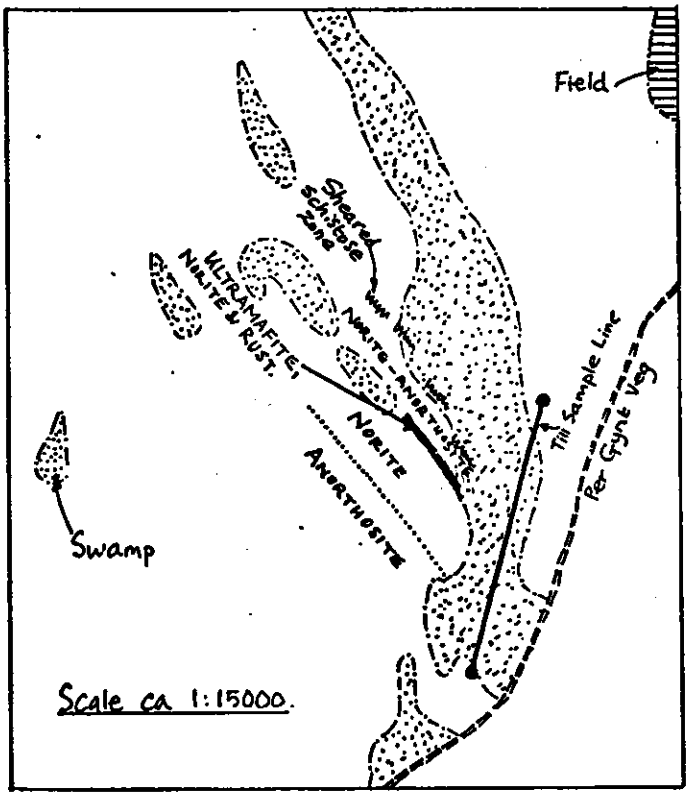
Figure (1) shows the location of the Electromagnetic Anomaly Areas flown by Terratest a/s in 1970. Each anomaly area or group of areas has been named and - where relevant - lettered. In addition, the Terratest anomaly numbers and the numbers from the report of Vralstad (November, 1970) are given in brackets.

(i) PER GYNT VEG ANOMALIES (Terratest 4, Vralstad 3)

Per Gynt Veg (a). This area is made up of massive white anorthosite overlying mixed norite/noritic anorthosite in turn overlying a 'belt' of fine-grained, greenish, sheared schistose anorthosite and ultramafite in which runs a thin rust zone consisting of sulphide-bearing norite/ultramafite - see figure (2).

The general trend of the foliation is 140-150°, dipping gently towards southwest. The extent of the rust zone is masked by poor exposure but it appears to be no more than 3-4 metres wide and discontinuous along the strike consisting of weathered mafic/ultramafic rock with small patches of weak mineralisation - pyrrhotite, chalcopyrite and bornite - running along the northern margin of the anomaly area. The rest of the area contains only accessory amounts of sulphides, chiefly in norite, mafic norite etc.

Per Gynt Veg (b). This area is completely unexposed and consists mainly of dried-up swamp.


Field
Sheared Schistose Zone
Ultramafite, Norite & Rust.
Norite - Anorthosite
Norite
Anorthosite
Till Sample Line per Gyrit Veg
Swamp
Scale ca 1:15000.

(ii) RYTA ANOMALY (Terratest 6)

According to Lucarelli, this area straddles the boundary between SD2 (Anorthositic Rocks) and PDS (Valdres Sparagmite). The western end of the anomaly, which should be on SD2, is completely covered but the eastern end shows banded metasediments, strike 130 dip 25NE.

This anomaly is probably of little significance; no sulphides were observed in the metasediments.

(iii) DALSETER ANOMALIES (Terratest 3)

Dalseter (a) is poorly exposed but just south of the area at the road junction occurs fine/medium grained norite with (weak) disseminated pyrrhotite and chalcopyrite. Zones of foliated, sheared norite with slickensided, serpentinised shear planes also occur. Further north, in the anomaly area schistose meta-norites with pyrite cubes were seen and at the stream above the fields blocks of 'greenschist', some containing asbestiform amphibole occur.

Dalseter (b) is unexposed, covered by swamp and fields. Thus the Dalseter (a) anomaly is probably due to a weak sulphide mineralisation in norite/mafic norite. No ultramafic rocks were seen, except secondary serpentinised, sheared zones.

(iv) RUTEN ANOMALY (Terratest 1)

According to Lucarelli this area lies on or just north of the thrust junction between OP (Ordovician Phyllite) and SD2 (Anorthositic Rocks) - with the anomaly on SD2.

Again the area is very badly exposed with either field or forest cover. Loose, angular blocks of phyllite occur below - i.e. south of - the Lucarelli Thrust mentioned above and at the thrust is a complicated

mixture of sheared anorthosite, ? quartz-bearing anorthosite and a dense, fine-grained greenish coloured rock with minor sulphides.

There is no clear evidence of any ultramafic rock. The anomlay could be due in part to a weak mineralisation connected with thrusting or the peculiar greenish coloured rock which may be sheared, mylonitised ultramafic, poor in sulphides.

(v) BREISJOEN ANOMALIES (Terratest 2, Vralstad 2)

Breisjoen (a) and (b) are on OP according to Lucarelli and this was confirmed by the two traverses across phyllitic metasediments containing chlorite, graphite etc.

Breisjoen (c) is porrly exposed and should be composed of PDS (Valdres Sparagmite) according to Lucarelli. The area is poorly exposed but contains a few exposures of a green schistose ? meta-volcanic rock composed essentially of green actinolitic hornblende and greenish feldspar with disseminated pyrrhotite. At the swampy area which covers much of the anomaly, ridges of metasediments, possibly graphitic, occur.

(vi) SLETTESETER ANOMALY (Vralstad 4)

According to Lucarelli, the area should be close to the PDS/SD1/SD2 junction (SD1 - Greenstone and saussuritised gabbro). Although the anomaly area is badly exposed, scattered small outcrops show metanorite and feldspathic ultramafite with minor sulphides. There is no marked rusting exposed.

(vii) SPRENTJERN (Terratest 7, Vralstad 5)

According to Lucarelli the area contains the PDS/SD2 junction (covered ground). The area is probably

underlain by SD2 with the contact approximately 100m west of the southwest corner of Sondre Sprentjern. Although the anomaly area is totally covered, outcrops above the eastern end of the anomaly consist of sheared contorted anorthosite.

(viii) GRIMSTJERN-STATSRAD ANOMALIES (Terratest 8)

(a) Poorly exposed with norite plus accessory pyrrhotite at the western end of the anomaly just north of the lake. No ultramafite was seen within the anomaly area, only mafic norite, norite and noritic anorthosite with minor sulphides.

(b) This is the anomaly south of Statsrad Stang Mine and contains rusty sulphide-bearing metasediments (see later) while

(c) the easternmost of these three anomalies consists of rusty ultramafite and mafic norite with weak sulphides.

(ix) MEGRUND ANOMALIES (Terratest 9, Vralstad 6)

(a) This area covers a contact between anorthosite complex and Valdres Sparagmite. The eastern quarter of the area is made up of norite with accessory sulphides and the rest consists of sediments - micaceous, quaztzo-feldspathic, graphitic etc with biotite graphite schist at the top of the cliffs overlooking Espedalen.

(b) Consists of sheared metagabbro and anorthosite with strongly lineated, sheared ultramafite plus accessory sulphides along the northern margin of the anomaly. At the northeastern 'corner' of this area occurs small-folded chlorite-actinolite schists and metagabbro with 1m ultramafic lenses containing minor sulphides.

(c) and (d) Weak rusting can be seen from the main road in the cliffs above Megrund. The northern part of (c) contains norite/mafic norite and where the gully east of (d) intersects the main cliff overlooking Espedalen is exposed a 40-50m section through sheared, folded anorthosite and norite/anorthosite with streaked out lenses of mafic norite and brown-weathering ultramafite. If this section is at all typical of the poorly-exposed Anorthosite Complex in the Megrund-Statsrad area, then the likelihood of extensive, undisturbed ore zones is not great. The small anomaly area (d) consists of metanorite and folded and sheared schistose chlorite-actinolite metanorite.

Thus the ground below Grimstjern containing these Megrund (a) (b) (c) (d) anomalies is made up of thoroughly sheared, foliated etc. Anorthosite Complex and the anomalies are probably due to disseminated sulphides (probably pyrite and graphite in metasediments in the case of (a)) in mafic metanorite and streaked out ultramafite lenses.

(x) MEGRUNDTJERN ANOMALY (Terratest 11, Vralstad 7)

Most of the western half of the area is covered but the exposed part of the eastern half contains norite and noritic anorthosite with no noticeable sulphides. Just southwest of the anomaly area is an 80m long ultramafic lens containing abundant disseminated pyrrhotite and chalcopyrite (claims RF 1, 2 and 3). Further south, along the southwest margin of the area - but just off it - are other lenses of ultramafics, apparently with no sulphides, and also metasediments - quartzite and pelite. An attempt was made to try and locate two other claims, one near the 1281m top and the other near the 1174m top, but this was unsuccessful.

Ultramafic lenses, without conspicuous sulphide, were seen about 400-450m south west of Nordgaard Setere and the cliffs forming the north east boundary of the Megrundtjern anomaly area appear to show minor rusting - but this was inaccessible.

Northwest along the strike is Terratest anomaly 10 and 'scherp' - the Grasgarli anomaly of this report fig. 1. There was not enough time to visit Grasgarli nor to reconnoitre the ground between it and Megrundtjern - but from below and from the other side of Espedalsvatn it appears that there may be poisoned-vegetation streaks and, possibly, outcrops of ultramafic. (Note that the Terratest Survey does not show anything of interest between the two anomaly areas - but the sulphide-rich ultramafic of RF 1, 2, 3 also did not show on the Terratest Survey). If more work is to be done in Espedalen this area would seem to merit some reconnaissance.

(xi) NICOLINE (Terratest 12)

This area contains quartz-bearing metasediments above and east of the Nicoline mines and two small 'scherps' above Nicoline show mafic norite - minor ultramafic with disseminated pyrrhotite and minor chalcopyrite.

(xii) GRAHOEN (Terratest 13)

In this district two groups of outcrops on the north-western and south-eastern ends of the area show metanorite and very coarse grained/pegmatitic meta-norite with very weak accessory sulphides.

(xiii) JORSTADGROUP (Terratest 16 and 17)

Jorstad (a) (Terratest 16) was covered by the detailed mapping - see later.

Jorstad (b) (Terratest 17) is for the most part badly

exposed - on the southern side of the anomaly area is brown-weathering mafic norite/ultramafic with weak disseminated sulphides. The area also contains garnetiferous meta-leuconorite.

Jorstad (c) and (d) (Terratest 17 and No Number) occupy flat, swampy unexposed ground with poor reddish brown vegetation - possibly due to poisoning - and area (d) contains a small 'scherp' in rotten, rusty ? ultramafite with sulphides. If these two areas prove to have interesting till geochemistry then further exploration would be merited.

(xiv) STUBBERUD (Terratest 14)

Is badly exposed in the steep, thickly forested valley side above the main road. The area contains ultramafic with pyrrhotite and chalcopyrite of unknown extent; it is probably the same structural level as Megrund (b) and (c) but difficult to assess on account of the cover.

(xv) ESPEDALEN (Terratest 18)

Is completely unexposed, consisting largely of swamp. Loose angular boulders of ultramafic without sulphides occur.

(xvi) ANDREASBERG GROUP (Terratest 19)

(a) is due to the ultramafic etc. which contains the Andreasberg mine (see later),

(b) is mainly unexposed (see later) but east of it along the strike occurs norite and ultramafic with minor sulphides,

(c) is chiefly swamp with outcrops of norite on the northeast and southwest sides,

(d) appears to be mainly norite, possibly containing rafts of sulphide-bearing metasediments.

(xvii) DRITYA ANOMALIES (Terratest 22)

A very small, insignificant scherp lies in a sheared zone in rusty norite between areas (a) and (b). Area (a) is mainly swamp covered but contains contorted, sheared norite/anorthosite with accessory sulphides. Area (b) is also mainly swamp with rusty sulphidic norite to the north of the eastern end of the swamp.

(xviii) VIKEN (Terratest 21)

Contains very little outcrop in thick forest. Mafic norite and ultramafite, both with accessory sulphides, occur along the lake shore - either in situ or as large blocks. 250m southeast along the strike occur ultramafics with blebs and microveinlets of pyrrhotite/chalcopyrite and sheared dark greenish-grey ultramafic with minor pyrite.

(xix) VESLE (Terratest 21)

There is no exposure except immediately around the mine where an ultramafic lens in contact with anorthosite has sulphides concentrated at the contact and disseminated through the lens (see also Vokes-Vralstad). The area contains claim AK XXXXIV.

3. GEOLOGY OF THE AREAS AROUND JORSTAD, STATSRAD AND ANDREASBERG

INTRODUCTION:

After examining the various EM - anomaly areas it was decided to try and map the stratigraphy of the Anorthosite Complex in division of

Ultramafic rock (very little or no feldspar)
Mafic norite (less than $\frac{1}{3}$ feldspar)
Norite (between $\frac{1}{3}$ - $\frac{2}{3}$ feldspar)
Norite-anorthosite (more than $\frac{2}{3}$ feldspar)
Anorthosite (at least 5/6 feldspar)

However, rapid variations in lithology - both original and due to later metamorphism - combined with generally poor exposre made it difficult to correlate between widely spaced outcrops. The metasediments which occur in all three areas were grouped as either psammitic or pelitic.

Field-mapping was done using enlargements of the 'Nor-Fly' aerial photographs (Oppgave Nr 616) at a scale of 1:4,000 and the final maps constructed by enlarging optically to 1:2,000 - thus there were two sources of possible distortion.

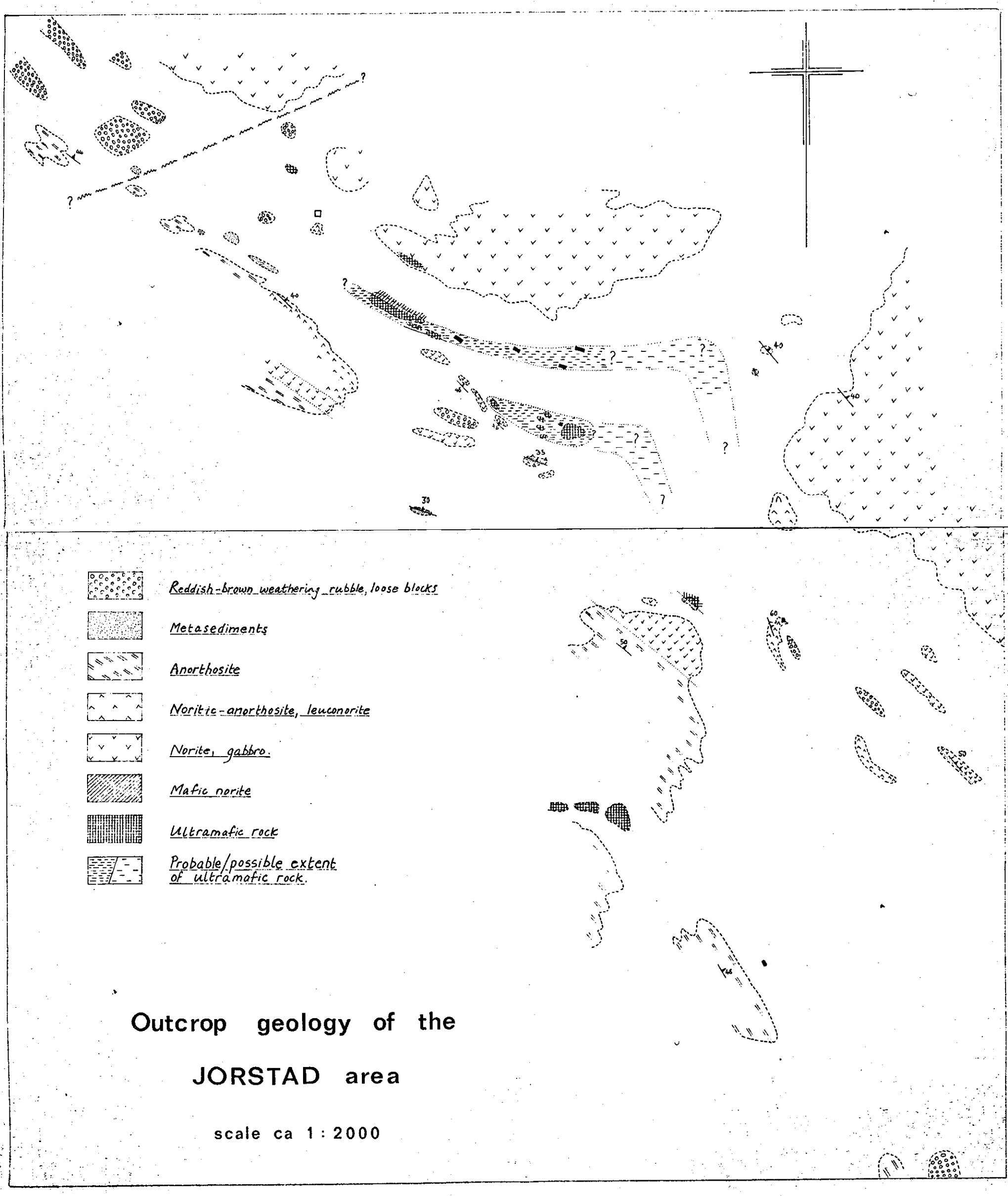
3. NOTES ON THE GEOLOGY OF THE JORSTAD AREA

The NW-SE trending sulphide-bearing zone, dipping about 40° to NE overlies norite and anorthosite with medium-coarse grained, light grey olivine norite above it. North of RR7 - RF8 small lenses of ultramafic rock occur in the basal part the hanging wall rock mass.

The rust zone, with its marked EM-anomaly, consists of thin lenses of ultramafics and interbanded mafic norite, coarse grained norite, norite and norite-anorthosite. Along the southwestern margin of this poorly exposed zone runs a discontinuous series of metasedimentary lenses - pale blueish-grey rusty quartzite, garnetiferous semipelites, pink and grey sheared, mylonitized quartzite without sulphides etc. The occurrence of these metasediments ± sulphides probably exaggerates the width of any potential sulphide ore zone. Also the fact that the mafic norite - norite - norite/anorthosite parts of the sulphide zone contain little or no sulphides makes one suspicious of the extent of the zone of possible workable sulphides. The rocks of RF8, RF7 and RF6 are difficult to identify with absolute certainty on account of their rotten, rusty nature - but they all appear to be sulphidic ultramafics. From the outcrop mapping it is not possible to decide whether the various 'scherps' lie on one large mineralised ultramafic lens or whether the mineralised zone contains a number of smaller lenses lying en echelon.

At first sight the rusty, brownish-red coloured rubble 'outcrops' that occur throughout the sulphide-bearing zone - especially to the northwest and to a lesser extent the southeast - give the impression of being composed of rusty ultramafic rock. This is not always so - several contain a mixture of ultramafic and norite - but none contain any more than merely accessory amounts of sulphides.

Thus from the outcrop geology only the lens or



Outcrop geology of the JORSTAD area

scale ca 1 : 2000

lenses with which RF8 and RF7 (and possibly RF6) are connected appear to be of (minor) interest. What lies between RF6 and RF5 is impossible to say - the EM geophysics (see Vokes-Vralstad 1969) is not encouraging.

NOTES ON THE GEOLOGY OF THE AREA AROUND STATSRAD-NICOLINE

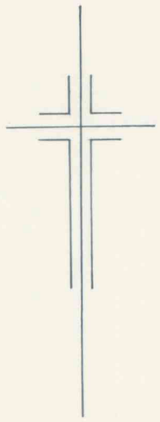
Of the three areas mapped, this one is structurally the most complex. The generally constant NW-SE structural trend of the anorthosite-norite complex has been affected by (presumably later) NNE-SSW or NE-SW structures. This probably accounts for the trend of the Statsrad and Nicoline mines.

The ground south and southwest of Statsrad contains much quartzose metasediment and schistose amphibolite, "greenschist" etc. The amphibolite is unlike the more massive metanorite seen elsewhere and may well be metavolvanic, unrelated to the anorthosite-norite complex.

The mineralised zone at Statsrad consists of mafic norite, feldspathic ultramafic and ultramafic rock, with medium-grained norite in the footwall and norite and mafic norite and anorthosite in the hanging wall. In the eastern most hole only 30cm of sheared rusty ? ultramafic rock is present; an outcrop of gneissic, banded metanorite between holes 3 and 4 (see sketch below) shows that the ultramafic has a pinch and swell structure.

North of and above the Statsrad holes is a NW-SE ridge containing a layer of ultramafic rock strike 130/dip 45 NE and north of this ridge is a solitary 2 m^2 outcrop of ultramafic. ENE of the Statsrad holes there is also a small outcrop of ultramafic. None of these outcrops contain more than normal accessory amounts of sulphides. It is probable that the "Sulfidmalm Ground Geophysics Anomaly" - this area was visited by Dr. Gammon and Herr Hegna on 7/8/72 - is underlain by ultramafic. Also on the Statsrad-Nicoline map of Vokes-Vralstad the circular shaped EM-anomaly NE of the Statsrad mine has the small outcrop of ultramafic, mentioned above.

At Nicoline, several scattered outcrops of metasediments occur south and east of the line of scherps. No encouraging signs of ultramafics were seen.



Area with ultramafic rock at shallow depth

? in situ

Steep slope

Interbanded norite, mafic norite and anorthosite

Ore in thin ultramafic lens with pinch and swell

Zone of amphibolitic ? metavolcanics in norite/metanorite

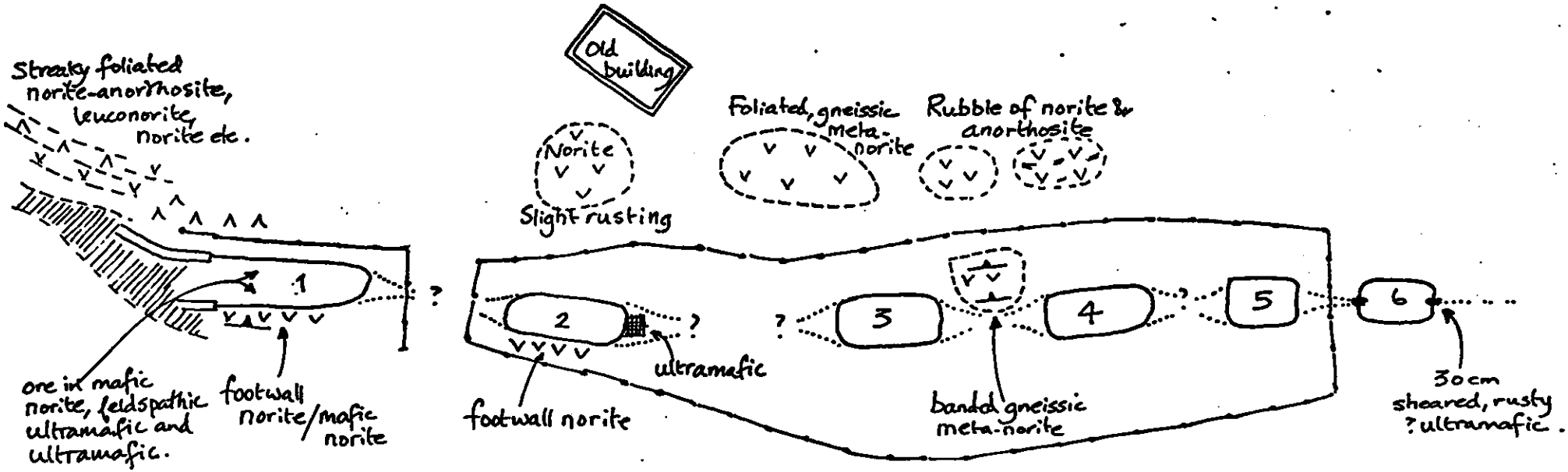
Zone of quartzose metasediments in anorthosite

ultramafic/mafic norite

Outcrop geology of the STATSRAD STANG - NICOLINE area

scale ca 1:2000

- Schistose, small-folded amphibolites.
- Metasediment
- Anorthosite
- Noritic anorthosite, leuconorite
- Norite, gabbro.
- Mafic norite
- Ultramafic rock.



Sketch of Statsråd-Stang Mines.

NOTES ON THE GEOLOGY OF THE ANDREASBERG AREA

This area appears to be the least complex of the three areas mapped in detail. The Andreasberg mine lies on the lower contact of a large ultrabasic lens which contains weak rusting sporadically over much of its length.

An extensive zone of sulphide-bearing quartzose metasedimentary rocks lies to the southwest. Except around the mines, the area of interest is poorle exposed. Northwest of Andreasberg, close to the track from Espedalen, sulphide-bearing ultramafics occur - see also Vokes-Vralstad - and the EM - anomaly there is probably an extension of the ultramafic ? lens.

Outcrop geology of the ANDREASBERG area

scale ca 1 : 2000

? loose blocks of ultramafics.

loose blocks & rubble of ultramafic rock

Metasediment

Anorthosite

Noritic anorthosite / leuconorite

Norite, gabbro.

Mafic norite

Ultramafic Rock.

Fault

CONCLUSIONS

Of the three areas mapped in detail the area north of Statsrad - with the Sulfidmalm and Norsk Hydro ground geophysical anomalies and probable ultramafic occurrences - would seem to be the most interesting.

There is little to add to the Vokes-Vralstad report of Jorstad except that the present writer feels there is enough evidence to restrict the areas of economic mineralisation to a few ultramafic lenses (of unknown extent) within the wider area suggested earlier.

Regarding the occurrence of the sulphides in the anorthosite complex: the whole Espedalen area contains many lenses of ultramafic rocks of which a small number contained economic mineralisation before mining. It seems a curious coincidence that at Statrad, Nicoline, Jorstad and Andreasberg sulphide-bearing metasedimentary rocks lie close to - and structurally beneath - the deposits. Is it more than coincidence?

The Megrundtjern area south of Espedalsvatn is of some interest because of the outcrop of a lens of sulphide-bearing ultramafite WSW of the helicopter-borne geophysical area. The ultramafic lens has claims RF1, RF2 and RF3 at co-ordinates (from the ground geophysical survey) 120S/440V, 105S/390V and 80S/330V respectively. There is a good correlation between EM-real, EM-imaginary and Magnetic over the lens above. About 200 metres NE of the outcropping ultramafic in unexposed ground is an area with strong EM-real, moderately weak EM-imaginary and moderately weak Magnetic anomaly (maximum 1500γ compared with 2000γ overall and maximum of 7000γ for the exposed ultramafic lens). One can see from the hand-specimens collected from RF1 and RF2 that the mineralisation is sub-economic at the surface but the whole area would be worth further consideration if more exploration is to be carried out in Espedalen - see the description of the Megrundtjern Anomaly Area earlier. If any ore bodies are found, their size is not likely to exceed that of Statsrad Stang - judging from the nature of exposed ultramafics and mineralisation and the tectonised style of

the Anorthosite Complex.

Thus the priorities in Espedalen ought to be

1. Further investigation of the geophysical anomaly areas in the Statsrad Stang area - but it must be remembered that the exposed ultramafics show only small, accessory amounts of sulphides.
2. (Low priority) Further investigation of the mineralised zone at Jorstad.
3. (Low priority) Reconnaissance on the south side of Espedalsvatn between the Megrundtjern Anomaly area and Grasgarli (the area does NOT appear interesting from the helicopter survey - hence the low priority) and possibly further investigation of the Megrundtjern area itself.

A/S SULFIDMALM

INTER-OFFICE MEMORANDUM

Date: 27th March, 1973

To: Falconbridge Nikkelverk A/S

cc: A. M. Clarke, M. T. Berry, T. H. Tam, K. Hovland

From: J. B. Gammon

Subject:

905-15, Espedalen, (Norsk Hydro Joint Venture) Report No. 221/72/15.

Please find attached Ryan's account of field work in Espedalen in 1972. His assignment was to carry out detailed mapping around the main known deposits in the area and to do reconnaissance work over the various HEM anomalies resulting from the Terratest survey. Tam carried out till geochemistry in parallel with the latter programme.

Ryan's work indicates that the "Sulfidmalm EM anomaly" at Statsrid Stang's mine is the only target worth testing in the vicinity of known mineralisation. His reconnaissance work indicates fairly encouraging results over the Nygrundtjern - Graagarli area (pp 5-7), Jørstad anomalies (c) and (d), the Stubberud anomaly and the Viken anomaly.

Planning of further work will await the results of Tams' till geochemical investigation.

J. B. Gammon