A/S Sulfidmalm
Kristiansand S, Norway.

Report from a geological and geophysical survey in Espedalen, Oppland, Norway.

June 29th - August 22nd 1964.

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SUMMARY.

Nickel-bearing sulphides in Espedalen are mainly associated to ultrabasic bodies within an anorthosite-norite thrust nappe belonging to the Jotunheimen massive of the Caledonian chain. Foliation is usually well developed within the nappe in a NW-SE direction which coinsides with the direction of movement (from NW).

Mining of copper started in the 17th century, and based on nickel mining took place in the years 1846-57 and 1874-78. The ore being mined is said to have contained 1 % of Ni and ore of some very good quality to contain from 4 - 6 % Ni in sulphides.

It is supposed that the two main mines produced approximately 50.000 t of ore.

The disseminated sulphide deposits with very limited extension appear along the contacts of small ultrabasites. The whole thrust nappe seems to be too intensely tectonized to give favourable conditions for accumulations of nickel-bearing sulphides of such a size that they can be regarded as economically intersting.

E.M. survey near some of the known deposits detected an unknown conductor immediately to the north of Statsråd Stang's mine. Some limited trenching in the morraine were carried out, and the exposed rock consisted of an altered basic norite with locally developed schistosity striking NW-SE. Small amounts of sulphides, approximately a few %, occur as fine disseminations, or as very thin sulphide stringers along the schistose planes.

Since this does not give any satisfactory explanation of the relative high anomalies, it is recommended to try to expose the conductor better before carrying out eventually diamond drilling. Nickel investigations in other parts of the Espedalen area are not warrented.

INTRODUCTION.

In 1962 A/S Sulfidmalm claimed some old mines in Espedalen. In the spring, two years later, it was decided to do a survey within the anorthosite thrust sheet, where all known nickel deposits in this area occur and a special examination of the deposits owned by A/S Sulfidmalm.

A photomosaic, based on AMS air photographs in scale

1:50.000 was made at the Geological Survey of Norway. Unfortunately, the quality of the air photographs of the interesting area was not so good, and consequently the benefit of the mosaic was limited.

The survey was carried out during extremely bad weather conditions by Overwien (29/6 - 25/7, 10/8 - 22/8) and the assistants Erik Brenna (29/6 - 25/7), Jan U. Jahnsen (29/6 - 12/8) and Sveinung Christensen (22/7 - 22/8).

Espedalen is situated in the county of Oppland, about 60 km NW of the town Lillehammer. There is a good road connection with this town, and also with Vinstra, which is situated about 45 km NE of Espedalen at the railway between Oslo and Trondheim.

The altitude of Espedalsvannet is 722 m.a.s.l., and from this lake the country raised very steeply up to the nearest mountains, more than 1400 m.a.s.l., on both sides of the valley. The downpour in this part of Norway is supposed to be very modest, so the summer 1964 mus have been an exception.

The maps covering the area are the 1:50.000 AMS ones nr. 1717 I and 1717 IV and the German war map F 30 V. As mentioned above, the area is also covered by aerial photographs (AMS) of the same scale.

HISTORY AND FORMER WORK.

In the 17th century mining on copper started in Espedalen, but regarded as copper-ore, it was very lowgrade.

Professor Scheerer from the University in Christiania (Oslo) described in 1843 a new nickel mineral (Lillehammerite) found in Espedalen, The mineral was later called pentlandite.

Two English brothers called Evans, in 1846 started mining based on nickel on the two main deposits (Evans Mine and Stang's Mine). A smelter was erected, and the company employed 500 men at the most, before all production stopped in 1857.

Evans Mine was put in production again in 1874. A new smelter was erected, and in 1878, the last year the company was in operation in Espedalen, the production was 450 t raw matte, with a little more than 5% Ni.

The first reconnaissance geological survey in this central

part of the Norwegian Caledonian mountain chain was carried out by K.O.Bjørlykke about 70 years ago. Several geological surveys followed, but the NGU publication 163 ("Geologiske undersøkelser i Espedalen") from 1945 by Brynjulf Dietrichson is the one which mostly dwells with Espedalen. The map accompanying this report is mainly based on Dietrichson's map.

Special mine reports from Espedalen are available in the files of NGU, Trondheim:

No. 2108.	H. Strøm,	1822.
No. 284.	G. Fougner	1907.
No. 285		
No. 1420.	A. Petersen (analyses)	1915.
No. 1419.	J.H.L. Vogt	1917.
No. 836.	I. Braastad, A. Gurholt, E. Kiil	1936.
No. 61.	B. Dietrichson	1937.
No. 297.	Arth. O. Poulsen	1941.
No. 837.	Pollack	1941.
No. 1582.		1941.
No. 1583.		
No. 1159.	Horvath	1946.
No. 3152.	Arth. O. Poulsen	1961.

GEOLOGICAL SYNOPSIS.

This chapter is mainly based on B. Dietrichson's thesis.

As mentioned above, the mountains around Espedalen belong to the central part of the Caledonian chain, and they must be regarded as the fore-land of the Jotunheimen massive. The mountains are built up of thrust massives, that as nappes have been thrust forward from NW towards SE of the southern side of the Jotunheimen syncline.

The direction of the foliation, which coincides with the direction of movement NW-SE, makes itself evident in the drainage system of Espedalen (dal = valley), and the chief direction of the mountain ridges. The cross direction NE-SW is marked by the course of tributary rivers, passes, and cross valleys.

The geological units of the present area are as follows:

I. Basal sediments of Cambro-Ordovician age.

II. Thrust masses of igneous rocks of the Bergen - Jotun-series with their accompaniment of crystalline schist.

III. The Valdres sparagmite, which is a synorogene or interorogene flysch formation, that has been subjected to thrusting and recrystallization.

I. Basal sediments.

Mylonitization occurs in the neighbourhood of the thrust planes, and the phyllite division usually forms the base of the thrust masses.

II. Thrust nappes.

A. Greenstones and saussurite gabbros.

Undermost is a sheet of greenstone accompanied by saussurite gabbros, which petrographically is closer related to the rocks of the Bergen - Jotun-series than to the anorthosite rock types in the next higher sheet.

B. Anorthosite and Jotun granite.

The anorthosite rocks in Espedalen including the associated ultrabasites to which most of the nickel deposits are related, form a thrust sheet that tectonically overlies the greenstones. They also overlay the Valdres sparagmite SW of the Espedalsvann. The rocks, which will be described in a special chapter, are again overlain by a few sheets of Jotun granites with their characteristic microcline perthites. The granites are found associated with minor thrust planes in the anorthosites.

The anorthositic rocks of Espedalsgraahøene are supposed to form part of a larger sheet that may have been connected with the extensive anorthosite areas in Sogn.

C. Sheet of gneiss.

These rocks, which are situated NE of Espedalsgraahøene are petrographically rather heterogeneous and consist of amphibolites alternating with quartzites and granitic dykes. They probably are pushed from NW where similar rocks occur.

III. Valdres sparagmite.

As mentioned above, the sparagmite SW of Espedalsvann is tectonically overlain by the anorthosite layer. The sparagmite layer at Ruten, however, has been thrust on top of the anorthosite layer, which also is outcropping further NW around Breisjøen.

ANORTHOSITE SHEET WITH ITS BASIC DERIVATES.

The rocks belonging to the anorthosite thrust sheet can be divided into 4 types with gradual transitions from light to more basic types:

1. White labradorite anorthosite.
2. Coarsegrained anorthosite with large phenocrysts of deformed pyroxenes.
3. Finegrained dark norite.
4. Ultrabasic rocks.

At the accompanying map only the ultrabasites are plotted as a separate rock as it is impossible to do this with the others, especially group 1 and 2, because of all transition types of these.

1) and 2). Pure mediumgrained labrador is rather seldom and mostly occurs near the Espedalsvann. Usually there is more or less a certain content of dark minerals, and especially in the highest Gråhø, there are situated coarsegrained varieties that contain pyroxene, which is squeezed out to dm long schlieren in a more mylonitic labrador mass.

3) The finegrained dark norites are mostly situated along the NE part of the sheet, and sometimes appear more like dykes striking parallel to the foliation. According to Dietrichson inclusions of coarsegrained anorthosite containing large pyroxene crystals are found in these finegrained norites, and in some pillars at Evans mine there are inclusions of light anorthosite. The finegrained norites therefore seem to have crystallized after the more coarsegrained anorthosite types.

A thin section from the norite hanging wall of the Stang's Mine shows approximately 50 % enstatite, equal amounts of a light brown amphibole, which is faintly chloritized and strongly sericitized plagioclase and 1 % ilmenite and magnetite. Sulphides sometimes appear as accessoric

minerals, and several of the nickel deposits occur in noritic rocks.

4) The ultrabasic rocks form concordant schlieren among the other rocks in the thrust sheet. Their length axis usually strike NW-SE, and the length is usually less than 2-300 m. The one at Andreasberg Mine is an exception with a length of nearly 1000 m.

Macroscopically the ultrabasites appear fine - medium-grained and homogenously. They are usually faintly serpentinized and reported to contain both monocline- and rhombic pyroxene. A few thin sections shows 70 - 80 % enstatite, up to 15 % olivine and 15 % serpentine, very little amphibole and biotite, a few % of opaque grains and brown spinel as accessoric mineral. Among the opaque grains ilmenite and magnetite are the most common, but sulphides are also present, especially near the contacts where concentrations have given rise to mining.

The 5 small ultrabasic bodies situated near the Jørstad Mine mainly consist of a rhombic pyroxene, and the surface is covered by an intense redbrown colour. They seem to contain less sulphides than the others.

The contacts towards the rocks 1, 2 and 3 are sometimes very sharp, but often there is a continuous transition towards the finegrained norite. Movements have often taken place along shears or thrust planes following the contact, probably because of variations in solidity between the ultrabasites and the other rocks. Some of the bodies are schistose or sheared, as are all rocks within this thrust sheet.

The foliation within the anorthosite sheet dips towards NE. In the south-western part the dip is modest, and it increases towards the north-eastern contact where it locally is nearly vertical.

ORE DEPOSITS.

The structural control of the main nickel deposits in Espedalen is the contact of the ultrabasites. Mineralization has also taken place in norites and more anorthositic rocks as discontinuous schlieren and lenses parallel to the foliation.

The ore usutally occurs as sulphide disseminations, and massive types are rare. Sulphides also occur as small stringers in the host-rock, and is probably a secondary feature caused by the strong tectonic forces

that once acted in this area. The degree of metamorphism must have been very high as Dietrichson reports large brecciated pyroxenite fragments in norite and the latter contains small veins of pseudo-tachylite.

Most common ore minerals are pyrrhotite, chalcopyrite and pentlandite, but pyrite, ilmenite and magnetite are also present.

Pyrrhotite normally composes more than 75 % of the sulphides, and pentlandite appears as distinct interstitial grains, which lie between the former. Pentlandite grains often seems to concentrate, as also does the chalcophyrite. Only a very few grains of flamelike pentlandite were observed in polished sections from the Espedalen ores.

Old reports says the average nickel content of the mined ore from the deposits in Espedalen is 1 %. There are more pentlandite among sulphide minerals in the disseminated ore types than in the more massive types.

Evans Mine, (owned by INCO) 1200 m.a.s.l.

The largest nickel deposit in Espedalen, which can be followed 150 m along the strike direction (NW-SE), is associated to parts of the footwall of a more than 300 m long and a 30 m broad ultrabasite (see sketch). The latter again is surrounded by anorthosite with norite schlieren, and where exposed, the contact is sheared, especially along the hanging wall.

The sheet shaped orebody is about 3 m wide and dips 25^{g} towards NE. It is said that the ore is followed 50 m along the dip, and that the deepest parts of the mine was rather poor.

The ore consists of disseminated sulphides in the ultrabasic rock, but a few massive specimens with inclusions of a dark green pyroxene were also observed on the dumps. Two average specimens from the dumps are analysed by Vogt:

	Weight in kg	% Ni	% Cu	Calculated % sulphides	Calculated % Ni in sulphides
Sulphiderich ore	1,0	2,08	1,28	43,8	4,75
Disseminated ore	2,3	1,64	0,74	32,2	5,1

16 samples, collected by ing. Thorkildsen, contained from 0,5 % - 3,4 % Ni.

Two joints seem to follow the footwall and hanging wall of the orebody, and the latter is also intersected by lots of N-S striking gauge-filled slips, which has caused minor faulting.

Statsråde Stang's Mine, (owned by INCO) 1160 m. a. s. l.

The mineralization is associated to a limited basic part of a nearly homogeneous and finegrained norite body (see map).

The ore, which can be followed 115 m along the strike direction (approximately E-W) is like a sheet 1 - 2 m wide and dips 50^g towards north. The orebody is said to be followed 25-30 m along the dip, which decreases in the deepest parts of the mine. Towards east the mineralization fades out before the overburden starts.

In the hanging wall just above the ore, there are mm-thin plagioclaserich bands in the norite, which runs parallel to the orebody and could indicate a primary banding. The footwall seems to follow a clean joint. Gaugefilled faults with positions nearly parallel to the orebody also intersects it, and some very steep ones striking N-S seem to have caused smaller displacements in it. The contact between norite and anorthosite further west is strongly sheared.

The sulphides mostly occur as disseminations in a dark green rock, which is chloritized to a certain extent. The rock often seems to have been sheared or kneaded, and here the sulphides (mostly chalcopyrite) occur as more or less parallel stringers. On the oredumps, there also are more finegrained sulphiderich specimens, which are spottet with small, dark green gangue minerals. A variety of the latter contains up to an inch large inclusions of norite or anorthosite, which are well rounded. Around these inclusions there often is a very thin rim of a dark green mineral, and around this usually a thin rim of chalcopyrite. The sulphiderich part, which is rich in pentlandite, contains approximately 30 % dark gangue minerals, and the inclusions contain a very litte amount of finedispersed pyrrhotite and rarely chalcopyrite.

Specimens from ore dumps, collected by Vogt, containing approximately 35 % sulphides, showed 1,3 % Ni and 0,28 % Cu.

6 specimens collected by ing. Thorkildsen contained from 0,65 % - 1,2 % Ni.

It is supposed that Evans Mine and Statsråd Stang's Mine have produced around 50.000 t of ore.

About 350 m NE of the Stang's Mine there is situated a very small mine called Nicoline. The surrounding norite with varying content of plagioclase is foliated after the direction N 30^g E, which also is the strike of the deposit. The dip is 50^g towards NW. About 50 m towards east and a little more towards west the rock has the normal NW-SE foliation.

The orebody, which is 45 m long and approximately 1 m broad does not seem to be as rich in sulphides as the Stang ore. The ore minerals occur in the same way.

EM Survey.

Statsgeolog Færden brought the EM GUN to Espedalen, and for the first test there was run a profile across the Stang deposit and further towards north, where there was situated an ultrabasic body. The expected anomalies were obtained over the known orebody, but as much higher anomalies were detected between the ultrabasite and foliated norite further north, it was decided to carry out a more detailed survey.

A base line was lain parallel to the ultrabasite, and traverses were made by 60 m or 30 m intervals. The instrument in the beginning worked only on the 1760 c/s frequency, but after a technician from ABEM in Stockholm had been called to Espedalen, it was possible also to do observations on the 440 c/s frequency. Two profiles were therefore run once more to compare the anomalies on the two frequencies. The out of phase components of the two frequencies were nearly the same, but the value of the in phase component of the lower frequency was less than half the corresponding value of the higher frequency.

The profiles were run by means of a compass, and the feeding cable between the transmitter and receiver was used as a tape. Due to a very high magnetite content in parts of the ultrabasic rock profiles started to cross each other, but after this was discovered, there was no trouble in managing running parallel profiles. A Paulin barometer was used to measure the difference in altitude between receiver and transmitter staff for calculating the terrain correction for observed real component of the vertical field vector.

The conducter was found to extend from 60 E to 180 W. After a detailed measuring to determine the outcropping of the footwall of the conductor trenching was carried out in some profiles. The exposed rock is a finegrained and altered basic norite, which seems to contain less than 10 % plagioclase. The enstatite and plagioclase minerals are intersected by cracks, which are filled with a very finegrained mass of new-crystallized minerals (also opaque minerals) as also are the intermediate space between the larger minerals. The rock also shows schistosity striking NW-SE with a dip of nearly 50^{g} towards NE.

Macroscopically one see very small disseminated sulphide grains or very thin sulphide stringers along the schistose planes. The rock

does not seem to contain more than approximately 1 % of sulphides.

Polished sections show that more than 90 % of the less than 0,2 mm large sulphidegrains consists of pyrrhotite. The rest is chalcopyrite and pentlandite in nearly equal amounts. Pentlandite occurs as indepandant grains among pyrrhotite, but tendencies towards flamy tectures are noted in a few cases. Other minor ore minerals are ilmenite and also some magnetite.

Vesle Mine (owned by INCO) 870 m.a.s.l.

Disseminated sulphides are associated more ore less to the whole part of an ultrabasic body, which is exposed in a length of 30 m and width of 20 m. 3 adits back into the 8 m high ultrabasite, where more than 500 m^3 of ore is mined out. The ore is said to contain 1,07 % Ni and 0,5 % Cu.

Vogt has collected several specimens, which gave following results:

	Weight in kg	% Ni	% Cu	Calculated % sulphides	Calculated % Ni in sulphides
Sulphiderich ore very common	1,9	1,92	0,56	45,2	4,25
Very common dissemination	2,7	1,58	1,02	40,0	3,95
Poor dissemination.	2,6	1,36	1,08	46,2 (?)	2,95

In the southwestern part of the deposit, the footwall of the ultrabasite is separated from anorthosite by a strong shear dipping 25-40^g

towards NE showing movements have taken place along the contact. Several nearly vertical NE-SW gauge filled faults intersects the deposit.

The environments of the deposit are heavily covered by overburden, and as no developement work has been carried out outside the exposed orebody, a few profiles were run with the EM GUN. A few anomalies occur S and SE of the mine in profile 120 S, but as they appear so near the INCO mine, they are of no interest for other companies. In profile 240 S the in phase component was diffecult to zero, because of some damage in the circuit.

Gammelseter mine. 860 m.a.s.l.

Gammelseter deposit is a classic example of J.H.L. Vogt's liquide segragation nickel ore. Sulphides are concentrated at the footwall of a peridotite, and the up to 2 m wide deposit striking N 50^g W and dipping 35^g towards NE can be followed about 75 m along the strike (see sketch). Towards east mineralization seems to decrease before overburden covers the rocks. The western part of the ore is mined in a length of 20-30 m and followed approximately 20 m along the dip, which seems to decrease to 20^g in the deepest parts of the mine.

The footwall contact is extremely sharp and no movements have taken place along it. Above the anorthosite there is a 25 cm broad layer of nearly massive ore, which again passes into the usual disseminated type, which is much like the similar ore types from the other deposits.

No foliation is developed in the surrounding rocks, but the deposit is intersected by numerous joints running parallel to the contacts.

There is a continuous transition zone from peridotite to norite towards west, but overburden covers the northern and eastern contacts. Most probably, one is concerned with a small peridotitic lense.

Jørstad mine. 1260 m.a.s.l.

In a medium- to coarsegrained anorthosite containing about 30 % large phenocrysts of deformed pyroxenes there runs a 80 m long and maximum 2 m wide rusty zone along the foliation, which is nearly vertical and strikes N 70^g W. The mineralization is very weak, and pyrrhotite and chalcopyrite occurs as disseminations or small stringers in the host rock, which near the rusty zone is schistose.

3 up to 6 m deep shafts are sunk in the zone, and speci-

mens from the dump hardly shows sulphides. A few, however, contained up to 30 - 40 % sulphides with dark green gangue minerals, so most probably the sulphides originate from a small basic lense. Later tectonical movements with mobilization of sulphides may have caused a stretching of the original deposit along the foliation.

Kong Knut's Mine. 1200 m.a.s.l.

The southwestern contact of a 150 m long ultrabasite with length axis trending NNW is mineralized and is cut by a 8 m long, 4 m wide and 1,5 m deep trench. A few specimens from the dumps shows up to 40 % of desseminated sulphides, but the mineralization decreases rapidly towards NW.

Rødhaugen Mine. 1150 m.a.s.l.

The mine consists of a 10 m long and 4 m wide trench in a limited and faintly mineralized part of a 100 m long and 40 m wide, strongly sheared ultrabasite with length axis striking N 30^{g} W. The whole body contains traces of sulphides.

The Andreasberg area.

Except from an ultrabasic ridge, this area is heavily covered with morains, and few outcrops are to be seen. There are all transitions from norite types to more anorthositic ones. A finegrained norite and an ultrabasite contains inclusions of the more plagioclaserich rocks. The latter are often very foliated and even banding NW-SE is developed. Also an up to 1 km long ultrabasite is sheared, and Andreasberg deposit is associated to this rock.

S and SE of this mine there are situated several mineralized zones, often in an echelon pattern, and some exploration work has been carried out in some of them. To determine whether these exposed mineralized zones could be part of a larger mineralization covered by overburden, and to figure out if the Andreasberg ultrabasite could have an extension, eventually with mineralization, SE of Lillefjellstjern, a survey with the EM GUN was carried out. Unfortunately the EM instrument failed several times, and the survey therefore got delayed.

A. Andreasberg Mine. (Claimed by Sulfidmalm 1962), 990 m.a.s.l.

The deposit is associated to the south eastern part of a 1 km long and approximately 30 m wide NW-SE striking ultrabasic body. The whole ultrabasite contains sulphides as accessoric minerals, but SE of a lineament striking N 10^g E (probably a fault), where the width of the ultrabasic body has increased to 50 m, pyrrhotite and chalcopyrite are concentrated in the foot wall dipping 80^g towards NE.

Sulphides occur as disseminations and very fine stringers (especially chalcopyrite), and at the southernmost shafts the deposit is 1,5 - 2 m wide. An adit at any rate connects the 2 southernmost shafts, probably being 10 m deep, and at the entrance one only notice a weak $\frac{1}{2}$ m wide rusty zone. NW of the northernmost shaft the deposit decreases to a 1 m broad rusty zone with a few % of sulphides, but some enriched schlieren contains up to 10 - 20 % of sulphides.

Pentlandite mostly occurs as distinct interstitial grains together with pyrrhotite, but a few flamy lenses within pyrrhotite grains are also observed. 2 representative specimens from the ore dumps were analysed by Falconbridge Nikkelverk A/S.

	% Ni	% Co	% Cu	% Fe	% S	Calc. % sulph.	Calc. % Ni in sulph.	Calc. % Ni in Ni-bearing sulphides
Sulphiderich ore	2,34	0,13	0,19	29,5	14,9	39,0	6,0	6,07
Normal disseminated ore	0,69	0,028	0,18	11,8	3,9	10,30	6,7	7,05

Local concentrations of up to 25 % of sulphides are seen at the ultrabasite contact NE and SW of the mine.

Only 2 profiles near the mine give anomalies across the ultrabasic body, so its associated concentration of sulphides seems to be very limited.

B. Scheerer Mines.

In a valley just S of Andreasberg deposit, there are situated several shafts along a line following the direction of the valley. These are called the Scheerer Mines, where several, probably up to 6 - 7 m deep shafts are sunk in the sulphiderichest parts of a long and discontinuous

mineralized zone running N 40^{g} W, which is the strike of the usual surrounding and foliated norite to anorthosite rocks. The width is normally 1 - 2 m, but locally the rustzone exceeds 4 m.

Outcrops in the valley are scarce, but it is obvious that the richest mineralization is to be found between the profiles 60 N and 180 S. Faint anomalies are detected to profile 330 S. Towards N exposures are frequent, and the zone splits into several parallel rust zones, which also is implied by the anomalies. In profile 300 N the anomaly is still present, so the mineralized zone is about 600 m long.

Sulphides seem to be associated to noritic schlieren and seldom to more plagioclaserich rocktypes. They occur as disseminations and fine stringers, and a polished section of a sample from shaft 145 S shows that approximately 90 % of the oreminerals consists of pyrrhotite. Chalcopyrite and pyrite often appear together in equal amounts, and magnetite is accessoric mineral. Some specimens were collected and analysed by Falconbridge Nikkelverk A/S.

	Co-ordinates	% Ni	% Co	% Cu	% Fe	% S	Calc. % sulph.	Calc. % Ni in sulphides
Finegrained rich ore	25W - 145 S	0,32	0,039	0,17	39,9	21,3	54,56	0,59
Disseminated ore	25W - 145 S	0,15	0,031	0,11	28,0	16,2	41,39	0,36
Poor disseminated ore.	22W - 318 N	0,29	0,031	0,14	17,8	6,6	16,99	1,7

The two calculations are based on assumptions that Ni intrudes pentlandite and that the ore is not pyritebearing. Therefore they will not be quite correct.

The conclucion is, however, that the ore at the Sheerer Mines, regarded as Ni-Cu ore, is very lowgrade compared with the deposits associated to ultrabasites. The concentration of Ni among sulphides are much less than in the latter deposits.

C. Anomalies 120 W/540 S - 60 E/780 S.

The anomalies are weaker than across Scheeres Mines and must be owing to a NW-SE striking mineralized zone along which some limited prospecting work has been carried out during last century.

The mineralization is associated to noritic bands and in profile 720 S and 480 S to smaller pyroxenitic schlieren, which is strongly foliated. The rusty zone is up to 2,5 - 3 m wide, and sulphides appear as fine disseminations and stringers. A mineralized specimen from profile 480 S shows pyrrhotite, chalcopyrite and pentlandite as small fracturfillings, and the sulphides also fill small cracks in the altered pyroxene crystals. One of the richest specimens found at the 5 m deep shaft near profile 720 S was assayed by Falconbridge Nikkelverk A/S.

	% Ni	% Co	% Cu	% Fe	% S	Calculated % sulphides	Calc. % Ni in sulphides
Disseminated ore	0,31	0,045	0,15	23,6	10,0	25,67	1,2

North of profile 480 S no rust staining can be seen at the surface. The faint anomaly at 100 W/360 S is probably caused by an exposed 2 m wide and 10 m long rusty zone, where up to 20 % of sulphides, mainly pyrite, are associated to a very small basic pod.

D. Anomaly in profile 120 S.

Just NW of the anomaly in this profile there is situated an at least 5 m deep shaft in a minimum 2 m wide ruststained outcrop. Some specimens contains up to 30 - 40 % disseminated sulphides in a noritic rock. According to the EM survey it is a very limited mineralized zone.

E. Anomaly 150 E / 660 S.

A 2 - 3 m wide ruststained zone striking NW-SE was exposed. A plagioclaserich norite contains up to 10 % of disseminated pyrrhotite.

F. Anomalies 150 E/360 S - 180 E/480 S.

After detailed measuring of the outcropping of conductors detected by these anomalies, a 1,3 m wide rusty zone was exposed in profile 420 S and 480 S. Less than 10 % of sulphides occur as very fine disseminated grains and stringers in a finegrained plagioclaserich rock. The measured outcropping of a second conductor in profile 420 S fits well with the westernmost anomaly in profile 360 S where there also seems to be a second conductor. None of these were exposed.

G. 2 shafts at 45 E near profile 240 S.

A less than 1 m wide mineralized zone consisting of up to 20 % of disseminated sulphides in a noritic rock, apparantly has a very limited extension.

H. Area E of Andreasberg Mine.

Some faint anomalies in this area being rich in moraine and swamps were not found worth to be followed up.

Victoria and Elisabeth Mines, which were claimed by Sulfidmalm in 1962, has to be one of the shafts plotted at the map, but older descriptions are so vague, that it is impossible to say which ones.

CONCLUSION.

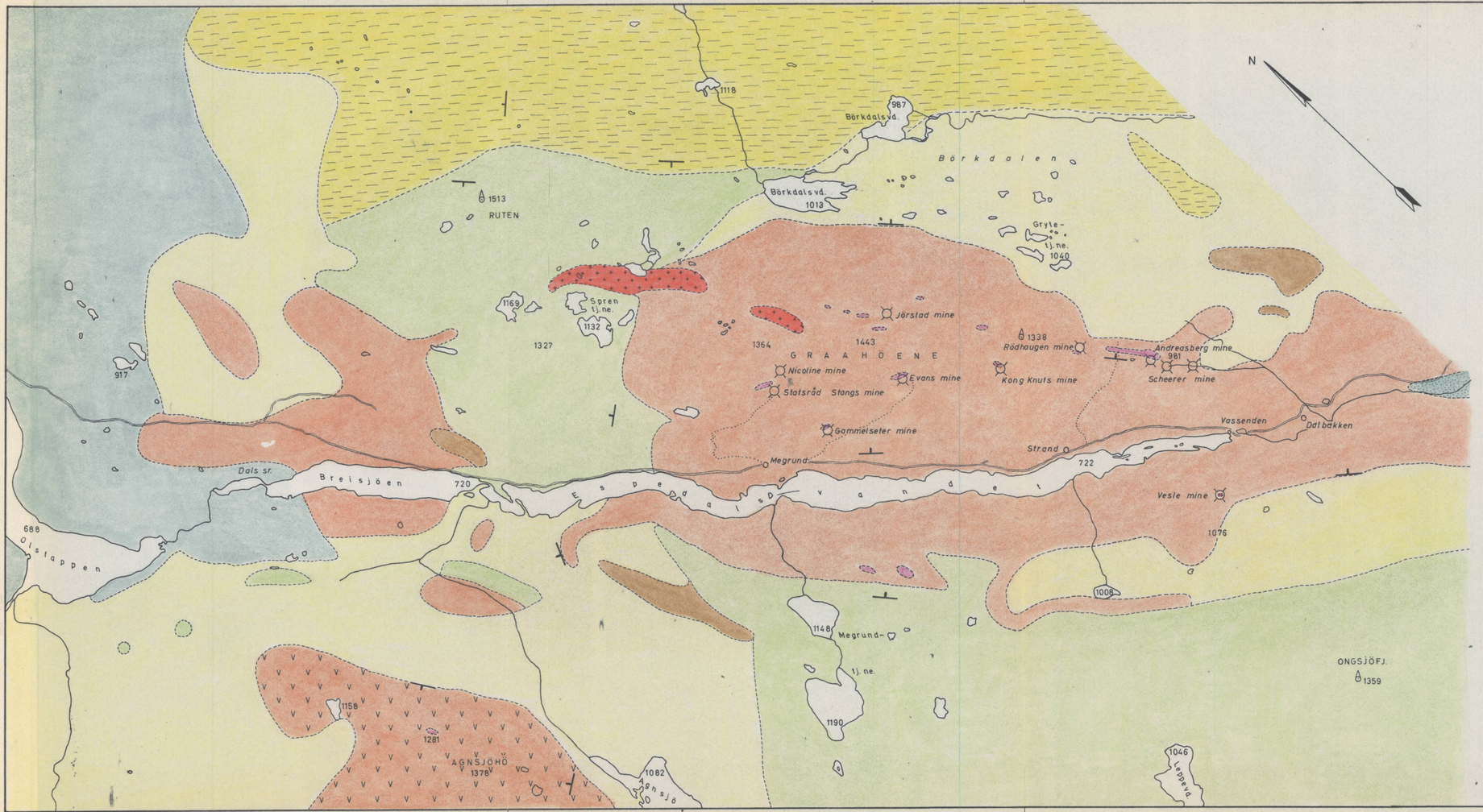
The nickel deposits in Espedalen, of which nearly all, and in any case all with the highest nickel content, are associated to comparatively small ultrabasic bodies within the anorthosite-norite thrust nappe. This thrust nappe seems to be too intensively tectonized to give favourable conditions for accumulations of nickel-bearing sulphides of such a size that they will be of economical interest.

Except from some E.M. anomalies north of Statsråd Stang's Mine, the E.M. survey was rather negative. No satisfactory explanation for the reason why anomalies should appear immediately to the north of this mine is found, and it is therefore recommended to continue the exploration in this area.

Since the pyrrhotite in the Espedalen deposits is nearly unmagnetic, a magnetic survey will hardly detect consentrations of sulphides, but can give some information about the extension of the ultrabasite south of the anomalies. If a tractor, in spite of very rugged terrain can reach the area, it could be of great help in removing the overburden covering the conductor. This should be done before doing any diamond drilling.

Trondheim, March 17th 1965

Einar Overwien
geologist



A/S SULFIDMALM

GEOLOGICAL MAP FROM ESPEDALEN AREA, NORWAY.

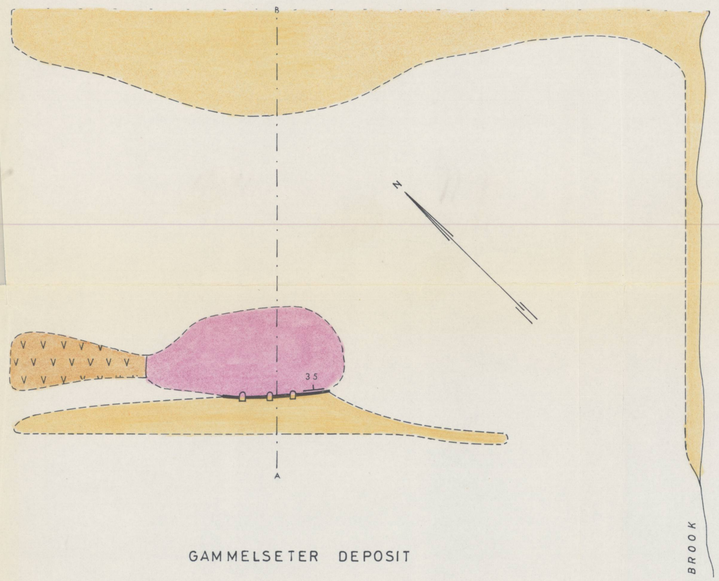
MÅLESTOKK 1:50 000	OBS. BD.		1964
	TEGN. E.O.		1964
	TRAC. B.H.		17.11.1964
	KFR.		

NORGES GEOLOGISKE UNDERSÖKELSE
TRONDHEIM

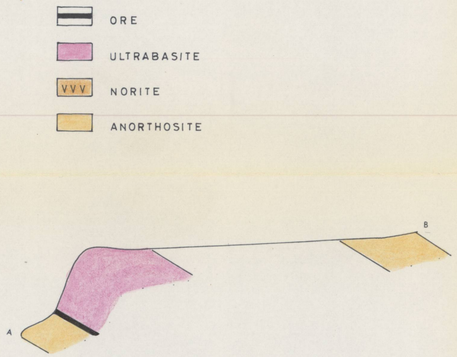
TEGNING NR.

KARTBL. F 30 V

Ⓐ



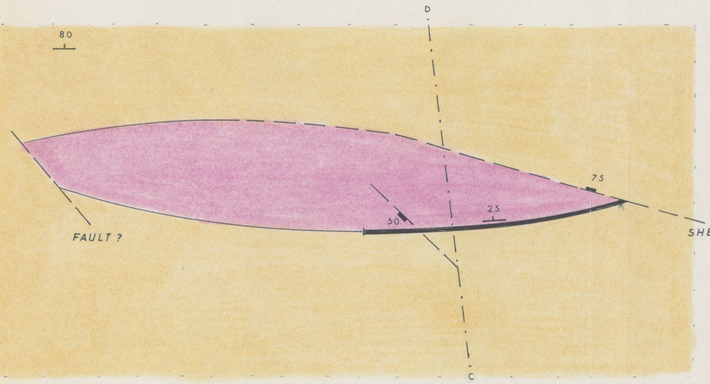
GAMMELSETER DEPOSIT



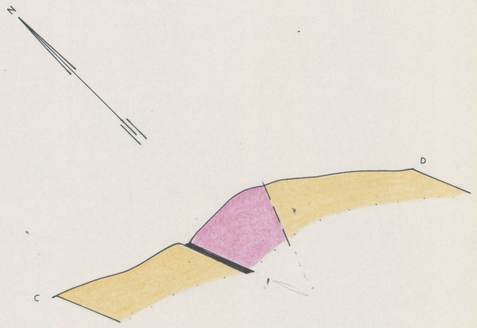
SECTION A — B

0 50 100 m.

Ⓑ



EVANS DEPOSIT



SECTION C — D

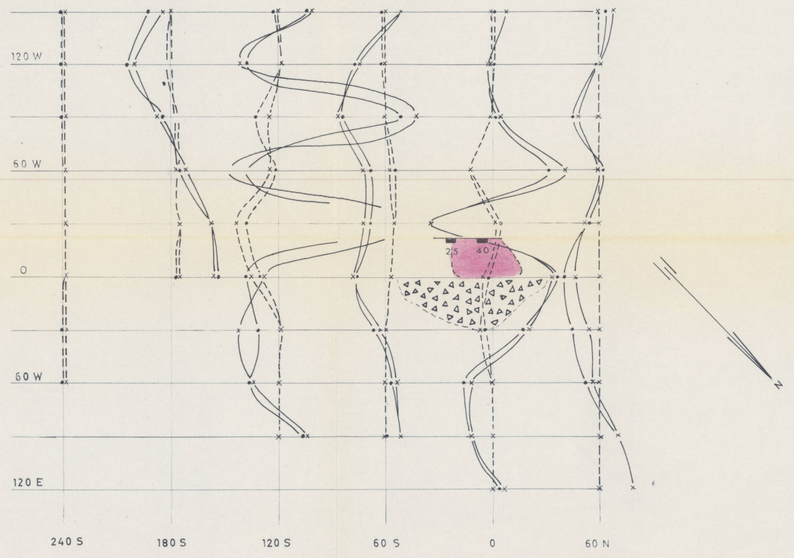
ORE

ULTRABASITE

ANORTHOSITE WITH NORITE SCHLIEREN

0 50 100 m.

Ⓒ



VESLE MINE

MINERALIZED ULTRABASITE

OVERBURDEN

ORE DUMPS

0 50 100 m.

EM. ANOMALIES

OUT OF PHASE ÷ + x 1760 c/s

IN PHASE >100% <100% • 440 c/s

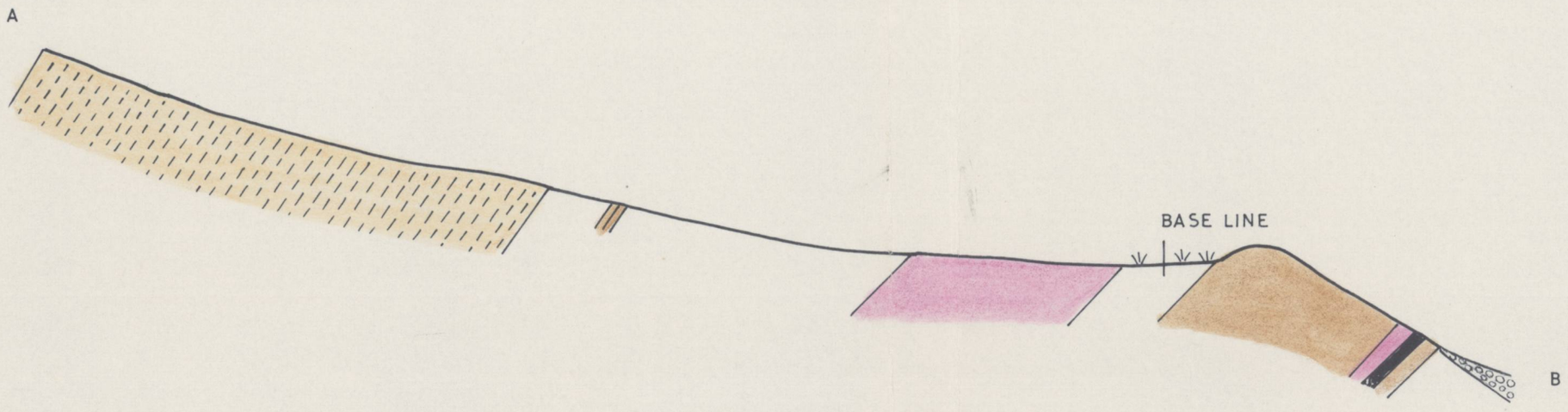
1 m.m. = 1 %

A/S SULFIDMALM

GEOLOGICAL SKETCHES FROM EVANS-AND GAMMELSETER DEPOSIT. E.M. SURVEY AT VESLE MINE ESPEDALEN IN OPPLAND NORWAY

NORGES GEOLOGISKE UNDERSØKELSE
TRONDHEIM

MÅLESTOKK 1:2 000	OBS. E.O		
	TEGN E.O.	7-2-65	
	TRAC. R.W.	9-2-"	
	KFR.		
TEGN. NR.		KARTBL. 1717 I – IV	



ORE

ULTRABASITE

NORITE (MAINLY HOMOGENEOUS)

NORITE WITH BANDS OF ANORTHOSITE

ANORTHOSITE (SHEARED)

MAINLY OVERBURDEN

SHAFT

OUTCROPPING OF CONDUCTOR

ORE DUMPS

EM ANOMALIES

OUT OF PHASE ÷ + × 1760 c/s

IN PHASE < 100% > 100% ° 440 c/s

1 mm = 2 %

A/S SULFIDMALM

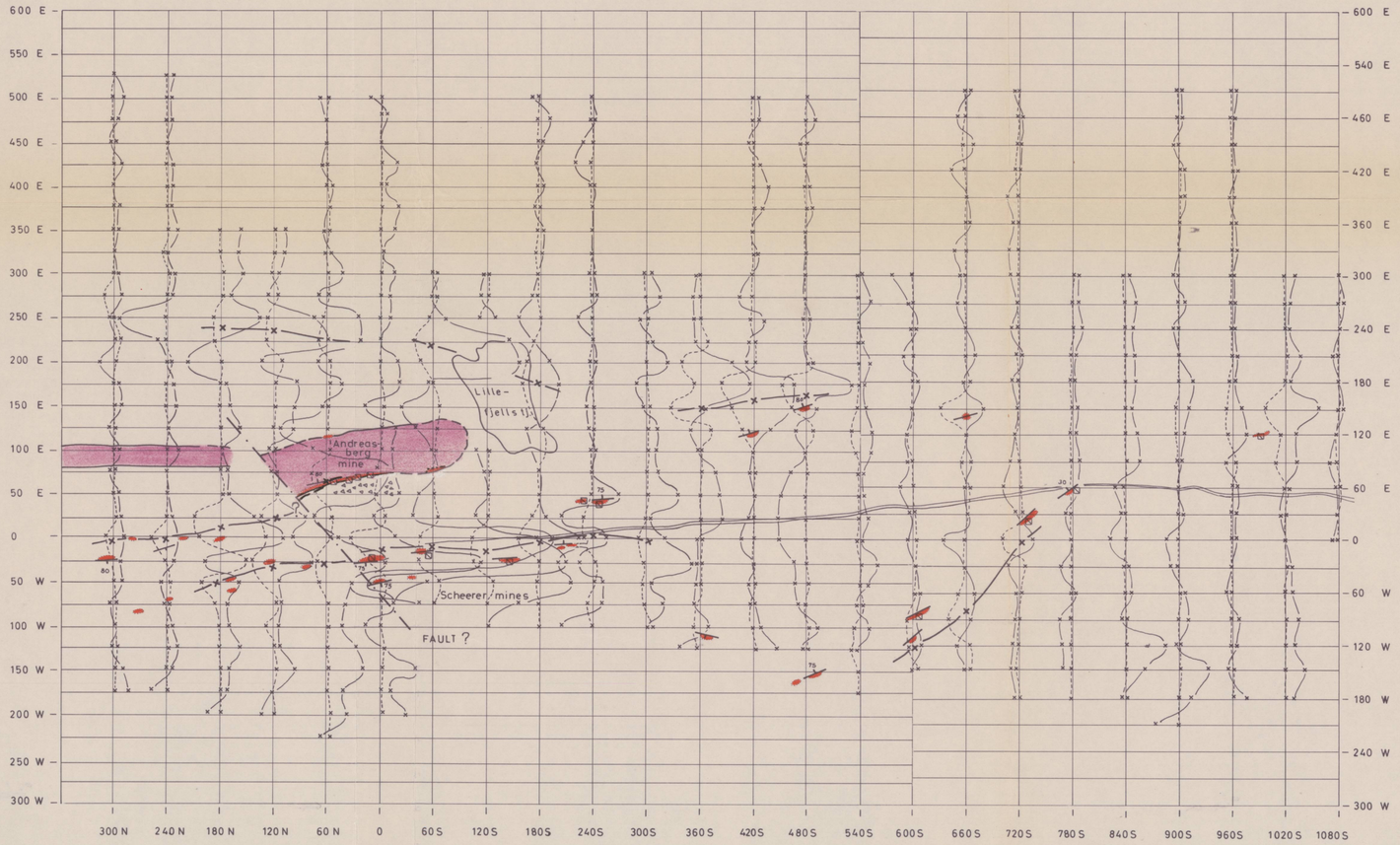
E.M. SURVEY NEAR
STATSRÅD STANGS MINE
E.M. GUN
ESPEDALEN IN OPPLAND NORWAY

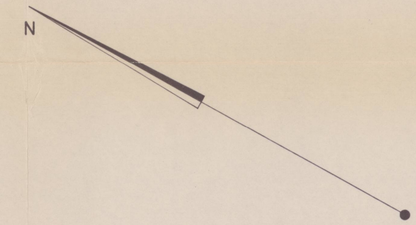
MÅLESTOKK: 1:2000	OBS J.J. E.O.	
	TEGN. E.O.	
	TRAC. R.W.	3-2 -65
	KFR.	

NORGES GEOLOGISKE UNDERSØKELSE
TRONDHEIM

TEGN. NR.

KARTBL. 17 17 IV





ULTRABASIC ROCK

MAINLY OVERBURDEN FOLIATED ANORTHOSTE-NORITE

MINERALIZED EXSPOSURES

CONTACT

SUPPOSED CONTACT

SHAFT

ADIT TRENCH

EM ANOMALIES

OUT OF PHASE ×1760 c/s

1mm = 2 %

IN PHASE <100 % ×1760 c/s

>100 %

CENTER OF ANOMALY

A/S SULFIDMALM
E.M. SURVEY IN
THE ANDREASBERG AREA
ESPEDALEN IN OPPLAND NORWAY

NORGES GEOLOGISKE UNDERSÖKELSE
TRONDHEIM

MÅLESTOKK 1: 4000	OBS: J.J.		
	TEGN: E.O.		
	TRAC. B.H	23.3.1965	
	KFR		

TEGN. NR.

KARTBL. 1717 I – IV