Bergvesenet

Postboks 3021, 7002 Trondheim

Rapportarkivet

Bergvesenet rapport nr	Intern Journal nr	Internt arkiv nr	Rapport lokalisering	Gradering
BV 1153	116/72 VB		Trondheim	**Åpen**
Kommer fra ..arkiv USB	Ekstern rapport nr Elkem 155/72	Oversendt fra	Fortrolig pga	Fortrolig fra dato:

Tittel

Nikkelundersøkelser, Hosanger, Osterøy i Hordaland

Forfatter	Dato	Bedrift
Roar Jensen R.F. Mead	09.02 1972	ELKEM A/S

Kommune	Fylke	Bergdistrikt	1: 50 000 kartblad	1: 250 000 kartblad
Osterøy	Hordaland	Vestlandske	12163	

Fagområde	Dokument type	Forekomster
Geologi Geofysikk		Hosanger gruber
Råstofftype	**Emneord**	
Malm/metall	Ni	

Sammendrag

Rapporten inneholder et sammendrag av R. Jensen og en geologisk rapport av R.F. Mead.

Det er i 1970 - 71 utført et undersøkelsesprosjekt etter nikkelmalm i områdene rundt de gamle nikkelgrubene i Hosanger, Hordaland.

ELKEM har håndgitt 30 anvisninger fra Staten etter en avtale.

Feltets geologi er kartlagt uten at utgående av større disseminated mineralisering er funnet.

Helikopter bårne geofysiske målinger har vært til god hjelp i dette arbeidet, uten at man ved kontroll av de fremkomne anomalier har kunnet påvise malmer.

Ved Indusert Polarisasjon (bakkegeofysikk) har man kunnet påvise mineraliseringer også mot dypet, men målingene har ikke indikert de tonnasjer man av økonomiske grunner må sette som minimum for denne type forekomster.

De mineraliseringer man har funnet i dagen, har ikke så høye Ni-Cu-gehalter at vi vil gå inn for en videre undersøkelse av feltet. Vi anbefaler derfor å si opp avtalen med Staten med virkning fra 31.3.1973.

Statsforvaltningen

Oversendelse

Avsender

Vestlandske Bergmesterembete, Oslo 2.

Mottaker

Industridept., Bergverkskontoret, Oslo.

Deres ref. og dato	Vår ref. og dato	Svar eller retur innen (dato)
	116/72.V.B. 28/3.72.	

☐ Til uttalelse ☐ Til behandling ☐ Til orientering ☐ Til utlån ☐ Retur av dokumenter

A/S Elkem's rapport av 9.2.1972,
nr. 155/72 - Hosangerfeltet, Osterøy.

Til orientering, under henvisning avtale av 31.3.7o, Id. 2922/7o A AP/AGM.

Oslo, den 28.3.1972.

Rolf Myhra.

Fellesblankett nr. 5. — Rekvireres fra Statens trykksakekspedisjon.

Baksiden er tilpasset vinduskonvolutt.

Statsforvaltningen

Oversendelse

Mottaker: Geolog Sv. Svinndal, Undersøkelser av Statens Bergrettigheter,
Postboks 3006, 7001 Trondheim.

Avsender: VESTLANDSKE BERGMESTEREMBEDE
MUNKEDAMSVEIEN 62
POSTBOKS 7581 SKILLEBEKK
OSLO 2

Deres ref. og dato	Vår ref. og dato	Svar eller retur innen (dato)
	31/76.VB. 20/1.76.	

Til uttalelse	Til behandling	Til orientering	Til utlån	Retur av dokumenter
			x	

Hosangerfeltet Osterøy./Elkems rapp. 9.2.1972.

Til utlån og retur etter bruk (evt. kopiering) i henhold til avtale med konsulent Bruusgaard, Industridept,s Bergverkskontor, den 20.1.76.
Med hilsen.

Vestlandske bergmesterembete, O
20.januar 1976.

Rolf Myhra.

X-005. — Rekvireres fra Statens trykksakekspedisjon.

Baksiden er tilpasset vinduskonvolutt.

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Majorstua Oslo 3

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Telegram: Elkem Oslo
Telex 18 229 Elkem N

1153

ELKEM AS

Hovedkontoret

Bergmesteren i Østlandske
Bergdistrikt

Munkedamsvn. 62
Oslo 1

Inst. 116/72. V.B.

Deres ref.

Vår ref.
Grubediv.
RJ/AG

Oslo,
27. mars 1972

HOSANGERFELTET OSTERØY, HORDALAND

Vi viser til avtale av 31.3.70 med Staten v/ Industridepartementet om håndgivelse på Statens bergrettigheter i Hosangerfeltet.

.//. Vedlagt følger i 2 eksemplarer vår rapport fra de utførte undersøkelser i feltet.

ELKEM A/S kommer ikke til å utføre malmletingsarbeider i Hosangerfeltet i 1972.

Med hilsen
pr. ELKEM A/S

Fredrik Qvale

R. Jensen.
R. Jensen

VEDLEGG

Kopi m/bilag: Industridepartementet.

2/72

ELKEM AS

Intern rapport

Jnr. 116/72. V. B.

Forfatter	Avd.	Dato	Rapport nr.
R. Jensen	G. D	9.2.1972	155 /72

Sak

Nikkelundersøkelser, HOSANGER, Osterøy, Hordaland

Ant. sider 5 | Ant. bilag

Arkiv nr.

Indekseringstermer

Forfatterens [ ] Resyme [x] Konklusjon [ ] Evtl. forslag til behandling

Behl. av avd.

Konklusjon:

Det er i 1970-71 utført et undersøkelsesprosjekt etter nikkelmalm i områdene rundt de gamle nikkelgrubene i Hosanger, Hordaland.
ELKEM har håndgitt 30 anvisninger fra Staten etter en avtale.

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Sirkulasjon:

- [ ] Hagerup-Larssen
- [ ] Lorck
- [ ] Lie
- [ ] Brodtkorb
- [ ] Collin
- [ ] Heggstad
- [ ] Kielland, K. K.
- [ ] Nyløkken
- [ ] Qvale
- [ ] Schanche
- [ ] Schartum
- [ ] Sejersted
- [ ] Stine
- [ ] Tandberg, E. G.

- [ ] Forskning
- [ ] Juridisk
- [ ] Kontor
- [ ] Dir.sekretær/P.R.
- [ ] Personal
- [ ] Patent
- [ ] Spesielle prosjekter
- [ ] Utbygning
- [ ] Økonomi

- [ ] Innkjøp
- [ ] Konstruksjon
- [ ] Metallurgisk
- [ ] Salg

- [ ] Elkem-Rockwool, Oslo
- [ ] Elkem Trading
- [ ] Fiskaa Verk (2)
- [ ] Forskn. div. Fiskaa V (2)
- [ ] Lista Al.verk
- [ ] Mosal Al., Oslo
- [ ] Mosjøen Aluminiumv. (2)
- [ ] New York (2)
- [ ] Ellefsen Syd-Afrika (1)
- [ ] PEA (2)
- [ ] Salten Verk (2)
- [ ] Skorovas Gruber (2)
- [ ] Sulitjelma Gruber, Oslo

- [ ] Arkiv

Uttalelser

Andre avd./Personer

- [ ]
- [ ]
- [ ]
- [ ]
- [ ] Forfatter

1. Det benyttes rapportnr. som oppgis av arkivet.
2. På original- (transparent) eksemplaret understrekes hvilke personer eller avd. som skal ha kopi. (Bruk blyant, sort kulepenn e.l. som egner seg for lyskopiering.)
3. På de respektive kopier settes x foran mottagernavnet. Fordeling skal godkjennes av nærmeste overordnede i avd.
4. Originalen og en kopi (mappekopi) sendes direkte fra lyskopiering til arkivet som skaffer ekstrakopier ved behov.
5. Hvis det under sirkulasjon avgis uttalelser sendes kopien i retur til forfatteren til orientering og evtl. behandling.
6. Arkivet fører alle uttalelser fra sirkulasjonskopiene over på mappekopien.
7. I rubrikk merket «Indekseringstermer» påføres fagtermer som er karakteristiske og dekkende for rapportens innhold.

9-70 Cicero a.s 1500
1220

ELKEM AS

Intern rapport

Dato	Rapport nr.
9. 2. 1972	155/72
	Side (1) / Ant. bilag
	Arkivnr.

NIKKELUNDERSØKELSER, HOSANGER, OSTERØY, HORDALAND

1. KONKLUSJON

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2. TID

Avtalen med Staten ble inngått 31. 3. 1970. Undersøkelsene ble startet våren 1970 og avsluttet i felt høsten 1971. De siste analysedata forelå i februar 1972 og den endelige rapport fra NGU i mars 1972.

3. MÅLSETTING

Målsettingen ved prosjektet var

- å undersøke eventuell fortsettelse av gangforekomstene man tidligere har drevet grubedrift på
- å undersøke om det eksisterer impregnasjonsmalmer med større mektigheter i gabbro-områdene rundt grubefeltet.

Impregnasjoner med 0,5% Ni var kjent fra diamantboringer. Slike "disseminated ores" kan, dersom de har utgående i dagen, tas som dagbrudd, og Ni-gehaltene kan være relativt lave. (0,2 - 0,4%). På større dyp er denne malmtype vanskelig å påvise, men med en jevn gehalt og relativt stor tonnasje, er malmtypen av meget stor interesse også for grubedrift.

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4. TIDLIGERE UNDERSØKELSER

I feltet er det drevet på 3 forskjellige forekomster, nemlig Nonås, Litland og Lien. Grubene ble drevet av Raffineringsverket A/S i 3 perioder 1883 - 91, 1915 - 20 og 1933 - 45. Tilsammen er det produsert ca. 500.000 t malm med 0,87% Ni og 0,34% Cu. Den utdrevne malm er hovedsakelig fra gangforekomster med relativt liten mektighet, men med en feltlengde på 1250 m.

Driften ble nedlagt i 1945/46 på grunn av mangel på drivverdig malm, men det skal bemerkes at Raffineringsverkets kontrakt med Falconbridge også utløp på det tidspunkt.

Spesielt i den siste del av tiden (1934-45) ble feltet inngående undersøkt for å finne ny malm. Omfattelde diamantboringer og elektromagnetiske bakke-målinger ble foretatt, men de nye malmer som ble påvist var for fattige eller for små til å være drivverdige.

Vi foretok først en gjennomgåelse av rapporter, beskrivelser, kart og analyser fra denne perioden.

Analyser fra de forskjellige felt viser følgende:

Flatås:	3,35 m	mektig	malmsone	med	0,34% Ni,	0,33% Cu
Litland	4,15 m	"	"	"	0,57% Ni	0,14% Cu
Nordås	6,30 m	"	"	"	0,36% Ni	0,20% Cu
Heldal:	17,40 m	"		"	0,16% Ni	0,06% Cu
"	33,70 m	"	"	"	0,16% Ni	0,04% Cu

Disse analyser bekrefter at man har en nikkelmineralisering av impregnasjons-type, men at de gjennomborete partier har for svak malmføring.

Spesielt området ved Heldal er interessant.

Sammenholdt med det øvrige materiale ga dette grunnlag for en prospekter-ingsplan for feltet.

5. UNDERSØKELSESMETODIKK

Etter forberedende geologisk feltarbeide (rekognosering) ble det klart at en eventuell fornuftig diamantboring måtte baseres på omfattende geofysiske målinger. Det ble derfor utført testmålinger av NGU ved IP-målinger på bakken. Feltet ble dekket av helikopterbårne elektromagnetiske- og magnetiske målinger.

Senere ble feltet geologisk kartlagt hvor det ble lagt spesiell vekt på de geo-fysisk anomale områder. Man utførte prøvetaking på de mest positive soner, og NGU utførte IP-målinger i et spesielt prioritert område.

6. RESULTATER FRA UNDERSØKELSENE

A: Geologisk kartlegging.

Som grunnlag hadde man H. Bjørlykkes kart og publikasjon NGU nr. 172. På kartblad M = 1:5000 (økonomisk kartverk) har vi fremstilt geologisk kart over hele det aktuelle område. Spesielt området i N. er detaljert kartlagt, da dette var et relativt ukjent område.

Av den detaljerte geologiske rapport tas her følgende konklusjon med:

Svovelkis og andre sulfidmineraler opptrer i dagen eller dagnær som impregnasjoner på en rekke steder rundt i hele feltet. I 90% av tilfellene er den knyttet til en mørk grønn gabbrovariant eller til mørk gneis og er oftest av meget lokal utbredelse. Mens kompakt malm fra Litland Grube kan holde 2,65% Ni, er de mineraliseringer som er prøvetatt så lave som 0,01 - 0,08 % i nikkelinnhold.

Området er middels overdekket med skogbunn, og overflaten ble godt dekket ved tette profiler og tråling til fots. Det anses derfor lite sannsynlig at det opptrer sulfidmineralisering av økonomisk interesse i dagoverflaten.

De forekomster som er kjent fra tidligere drift, er alle knyttet til gabbro eller til kontakten gneis/gabbro. Det er derfor ved kartleggingen lagt stor vekt på å forsøke å dele gabbroen inn i undergrupper og å kartlegge gabbroens grensesoner.

B: Helikoptermålinger.

Feltet ble dekket med. 198 profiler med 50 m profilavstand og 10 - 20 m høyde over bakken for instrumentbeholderen.

Det ble registrert magnetisk totalfelt, elektromagnetisk reellkomponent og imaginær komponent.

Ved målingen fikk man en rekke EM-anomalier. Selve grubefeltet kom ikke frem. EM-imaginær har en nedre indikasjonsgrense ca. 10% kis. Man har ikke fått EM-imaginær-anomali som man ikke har kunnet forklare ved et kunstig ledende legeme, f. eks. kraft- eller telefonkabler.

Vi har imidlertid ikke funnet en fysisk forklaring på alle anomalier, til tross for at disse er kontrollert meget detaljert på bakken. I et par profiler har man kunnet kontrollere anomaliene med IP-målinger uten at man får sammenfallende konklusjoner.

Ved måle-operasjonen ble strømmen slått av på kraftnettet, men på reellkartet er ledningssystemet likevel kommet meget godt frem.

Større telekabler har også i en del av feltet gitt en markert anomali.

Vi må bemerke den positive erfaring vi har fra kontakt med Terratest under bearbeidelsen av anomalikartene. Kontakt felt-geolog/geofysiker synes å være av stor verdi ved slike prosjekt.

De magnetiske anomalier har alle en tilknytning til mørk hornblendeførende gneis, spesielt når denne opptrer i forbindelse med en mørk grønn gabbro, der en eller begge typer fører en disseminated magnetitt- eller sulfidmineralisering.

Strukturelt er derfor de magnetiske målinger til stor hjelp i feltarbeidet, men synes også å ha en tilknytning til mineralisering.

C: IP-Målinger.

EM-Turammålinger ble utført av Geofysisk Malmleting i 1937. Dette viste seg å være en vellykket metode for å påvise kompakte malmsoner. Impregnasjoner er imidlertid ikke påvisbare med den metoden.

For å prøve andre geofysiske metoder utførte NGU prøvemålinger med Indusert polarisasjon (IP), tilsynelatende ledningsevne (σ_a) og selvpotensiall (SP).

Da kompaktmalmene delvis er utdrevet, og dypet ned til dem er stort, har man ikke kunnet påvise fortsettelse av de kjente kompaktmalmer med denne metode. Man har imidlertid fått frem en rekke impregnerte soner på et mindre dyp.

En eventuell sammenheng fra profil til profil kunne ikke avgjøres ved det valgte profilopplegg.

Som supplement til disse test-målinger utførte NGU målinger som skulle kunne påvise større impregnasjonsmineraliseringer på et noe større dyp. I de 6 målte profiler ble det bare ett sted påvist vesentlige effekter fra større dyp og denne hadde liten utstrekning i felt. Konklusjonen er at det i det målte område er lite sannsynlig at det finnes mineraliseringer av økonomisk interesse.

D: Prøvetaking

De sterkest mineraliserte områder i dagoverflaten ble prøvetatt. På det geologiske kart M= 1:5000 er prøvepunktene avmerket. På noen steder var det tidligere sprengt (vegskjæring, brønn o.l.), slik at man hadde friske prøver til den kjemiske analysen. På de øvrige stedene ble det tatt dagprøver. Det var bare i Nonåsfeltet at man kunne se jernhattforvitring av noen størrelse.

E: Kjemiske analyser.

Prøvested:	%Ni	%Cu	%S	%Fe
Litland grube, typeprøve	2,65	1,26	21,o	29,7
Fjellskålnes, mutingsstuff	0,08	0,06	0,58	8,5
Pr. 26	0,01	0,00	0,19	14,4
28	0,01	0,01	0,26	15,7
29	0,01	0,01	0,25	14,2
32A	0,07	0,03	0,32	7,9
34	0,01	0,03	0,35	15,6
35	0,01	0,03	0,21	16,9
42	0,05	0,00	0,13	7,3
43	0,01	0,01	0,23	16,o

7. SIKRING AV GRUBESTOLLEN

I punkt 7 i avtalen med Staten er det pålagt oss for Statens regning å besørge sikring av de grubeåpninger som berøres av avtalen.

Dette er utført og godkjent pr. 2.1.1971. Vi har ikke utført nye sprengningsarbeider eller arbeider av noen art som har ført til farlige grubeåpninger. Grubeåpningene anses derfor å være forsvarlig sikret.

8. REGNSKAP

Helikoptermålinger:	54,000 kr.
Geofysiske bakkemålinger (NGU)	44.000 "
Avgifter	3.100 "
Geol. kartlegging, prøvetaking og befaringer	27.480 "
Totalt:	128.580 kr.

RJ/AG
9.2.72

9-70 Cicero a.s 5000
1221

TO: Bergingeniør R. Jensen, Grubedivisjonen, ELKEM A/S.

REPORT OF FIELD WORK IN THE HOSANGER AREA, OSTERØY, HORDALAND

June 16th - July 28th, 1971.

By R.F. MEAD.

CONTENTS

1. Aims of the Hosanger Field Project.

In connection with further prospection for nickel or other minerals, after the recent geophysical surveys x), the following aims emerged: -

(1) To explain the geophysical anomalies, E/M real and imaginary, I/P and magnetic in terms of geology or other phenomena.

(2) To look for surface disseminated mineralisation in the anomaly areas, and other, and sample.

(3) To produce a geological map of the northern half of the area showing rock types and structure using hand specimens only in the first instance. Then produce a composite map of present work and areas mapped earlier.

(4) To comment on the usefulness of the various geophysical methods employed.

(5) To report on geological phenomena in the area from field observations.

x) N. G. U. June 70 & May 71 Induced Polarisation Methods
Terratest September (?) 70 Airborne Electromagnetic and Magnetic Measurements from a low flying Helicopter.

2. Sampling Results and General Conclusions.

Surface and very near surface disseminated mineralisation of visible pyrite and associated minerals occurs in numerous localities scattered throughout the area. In C. 90% of the cases this is restricted to the dark green gabbro var. and the "dark gneiss" and is often of local extent.

Chemical analysis of samples from near Litlands Grube in the main gabbro showed at best a very low nickel content 2.65%. Fjellskålnes assayed at 0.08% Ni. and the remainder with little exception no greater than 0.01% (localities 26 - 43).

A large amount of the area outlined was covered by foot in the field session and no better visible concentrations of surface disseminated mineralisation have been noted. Therefore it is unlikely that mineralisation of this type could be of any economic importance from on-surface localities.

Further Conclusions.

The airborne E/M methods have shown so far to be worthless after consultation with associated data at present available.

The airborne magnetic method is useful as an indicator of possible sites of disseminated mineralisation on-surface if it is contained in a sufficiently high magnetic milieu i. e. a compact dark pyroxenous gneiss or some gabbros.

The I/P method is useful for picking out suitable targets for sub-surface sampling in small areas of known likelihood i. e. across a large gabbro. Proving drilling in certain of the zones would conclude this.

In connection with outstanding anomaly areas related to a "likely" geologic environment two areas could be diamond drilled:

(1) Area W. of Røslandsvann.
(2) S. Nonås.

3. The Geology of the Area.

I Introduction. - The Hosanger area situated 20 km NW of Bergen within the outermost arch of the Bergen arch system lies at a point where the general strike of the constituent Cambro-Silurian gneisses and gabbros tracks N-S. Nickel production from a sub-surface mineralised orebody in the base and smaller ones in the margins, of the largest gabbro ceased more than 20 years ago.

Present studies are directed towards the location of further sub-surface orebodies (if any) of intense mineralised nature and the validity of disseminated mineralisation on or near surface as an economic prospect.

II Discussion of Lithologies mapped. - Two rock types were distinguished during earlier mapping of the area by H. Bjørrlykke - gneisses and gabbros. No detailed mapping of the area N and W of Røslandstjønna has been recorded to date, but after some field time had been spent during the late session it was decided to attempt to subdivide the two major groups further, even if the sub-lithologies were only of local extent.

The gneisses range from pale pink or white felsic types with biotite to more mafic dark greys and blacks, so the following range can be identified in the field:

1. Quartz Feldspars Biotite
2. Quartz Feldspars Biotite Pyroxenes
3. Quartz Feldspars Pyroxene Biotite $\pm$ garnet
4. Pyroxene Quartz Feldspars $\pm$ garnet
5. Pyroxene - hard, black, compact and part of the gneiss formation occurring as pods or lenses with disseminated mineralisation and occasionally containing small inclusions of dark green gabbro.

An attempt has been made to map 1-3 as the Pale Gneiss (GN) and 4-5 as Dark Gneisses (DGN). It is noteworthy that in the S. of the area DGN occurring over a considerable extent was earlier included as "gabbro". Here the material tends to be more closely delimited by a gabbro environment, so naming of the darker rock types has often depended on the immediate tectonic environment for inclusion as gabbro or gneiss.

Augen gneiss material is present in small outcrops forming part or edges of the larger gabbros, but in this case a distinct boundary is qestionable.

The gabbros range considerably in their appearance in the hand specimen. They occur as hard, compact coarse-grained essentially pyroxene rocks to streaky feldspathic types essentially green in colour. These are mapped as the "dark green gabbros".

Mottled pale green and brown or grey gabbros with feldspar dominant occur without tectonic discordance to the surrounding gneiss (maybe uralitised). These are mapped as the "pale green gabbros".

Dioritic rock types also occur. These are black and white, streaky and massive, usually in close association to the gabbros and of limited extent.

Aplites and pegmatites are scattered throughout the area, the latter often occurring as a gneiss facies rather than in dyke form.

IV Description of some Field Localities. -

1. Thick aplite or pegmatite band conformable with gneiss, demonstrating that the mobile aplitic material followed the layering of the original gneiss material.

2. Banded gneiss with slight folding perpendicular to the general strike. A cross-cutting pegmatite band shows "boudinage" structure probably due to this folding. A further aplite band is more or less conformable with the gneiss.

   The dykes therefore pre-date the final folding of the gneiss.

3. A pair of fold noses in the gneiss with similar plunge.

4. Gneiss showing isoclinal folding and localised ptygmatic folding. The isoclinal is cut by an aplite band.

5. A further example of cross-cutting aplite dykes.

Short Summary:

Time. ↑ Period of gentle folding causing "boudinage" of dykes.
Period of aplite and pegmatite dyke intrusion.
Tight folds introduced.

6. Dark rotten gabbro with much biotite situated between massive gneiss with a thick, dominantly quartz-aplite band.

6A. Massive pale gneiss between dark green somewhat nodular weathered gabbro. An upwarped contact is evident. These are probably detached gabbro fragments buoyed up into the gneiss from the adjacent "Heldal Gabbro". The gabbro contains much biotite in crenulated bands with some disseminated pyrite and chalcopyrite.

7. Aplite dykes at the contact of gneiss and gabbro.

8. A well defined lithological contact in the gneiss without visible tectonic change. This may be a dolerite dyke. Quartz blebs in the "dolerite" are mineralised with pyrite and associated quartz veining cuts the contact (Post-dates contact).

9, 9B. Further examples of aplite dyke forms in the gneiss.

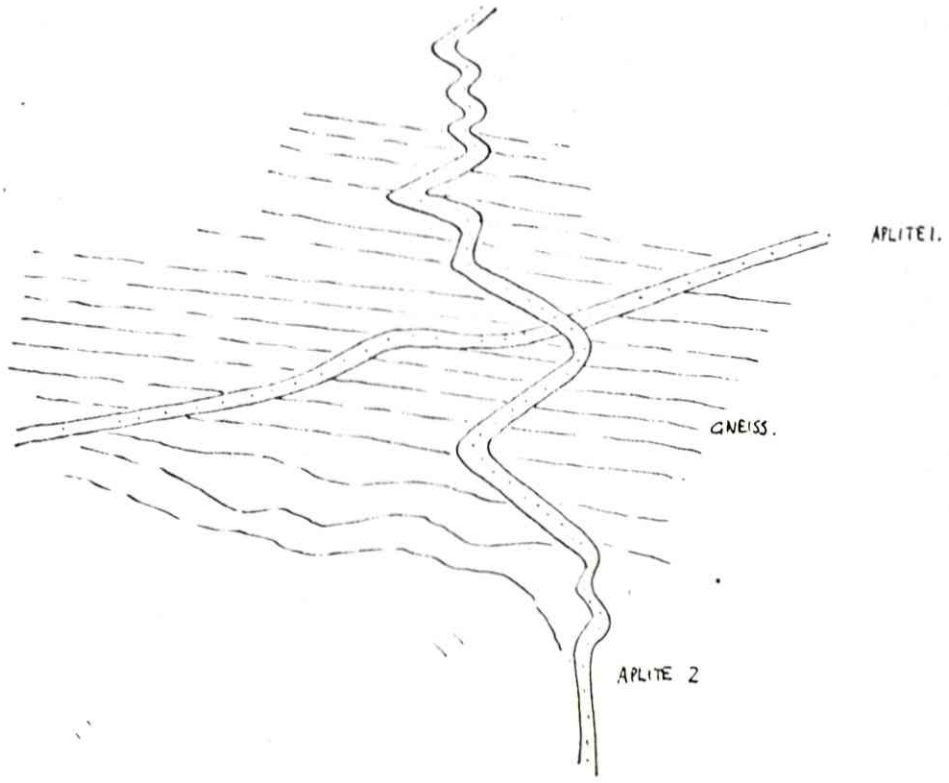
10. The gabbro/gneiss contact (Heldal Gabbro). The gabbro which is nodular and brown weathered is apparently finer grained closer to the contact suggesting that the contact is tectonic and not original. Biotite is more abundant in the medium and finer gabbro i. e. upwards towards the contact zone.

11. Along the southern contact of the Heldal gabbro in base of the exposed face of the gneiss a zone of up to 10m in thickness of "gneiss with included gabbro" can be traced. The gabbro takes the form of irregular lenses and the gneiss is clearly seen to be wrapped around the included chunks. In some places it is much chloritised where biotite is concentrated.

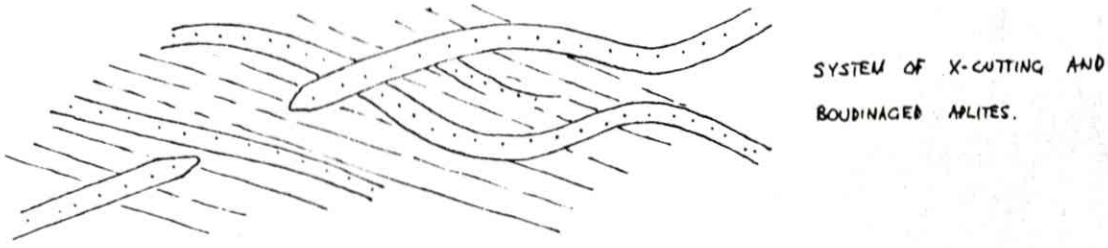
The surrounding gneiss is finely laminated in bands of not greater than 3 - 4 cm. and in places is very dark in colour owing to high biotite content.

12. Very soft and highly crenulated "biotite schists" not seen again at other localities.

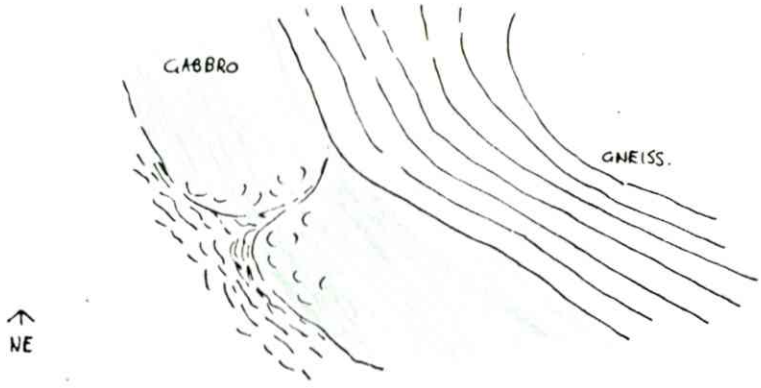
9


APLITE 1.
GNEISS.
APLITE 2

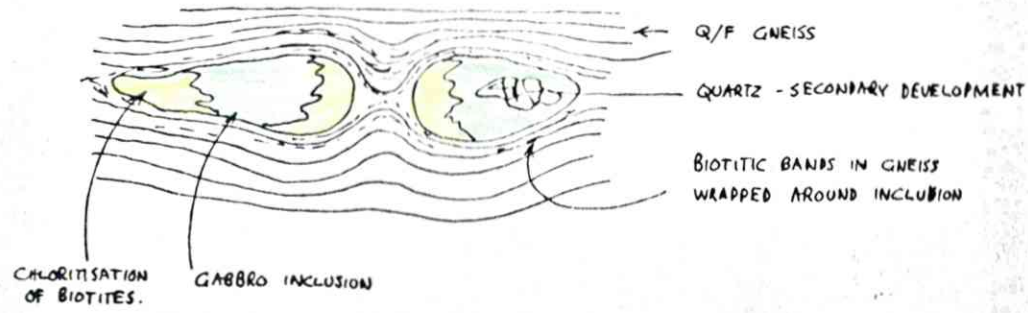
9b.


SYSTEM OF X-CUTTING AND
BOUDINAGED APLITES.

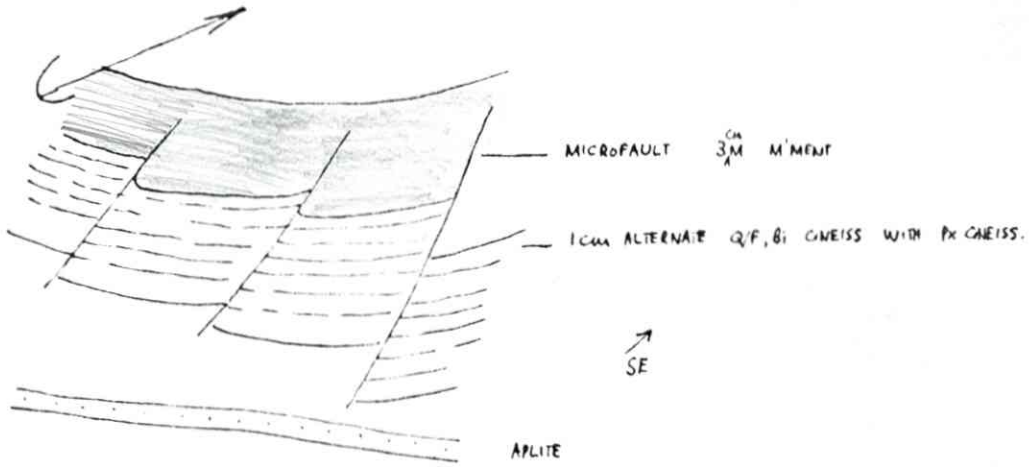
10.


GABBRO
GNEISS.
NE

11.


Q/F GNEISS
QUARTZ - SECONDARY DEVELOPMENT
BIOTITIC BANDS IN GNEISS
WRAPPED AROUND INCLUSION
CHLORITISATION
OF BIOTITES.
GABBRO INCLUSION

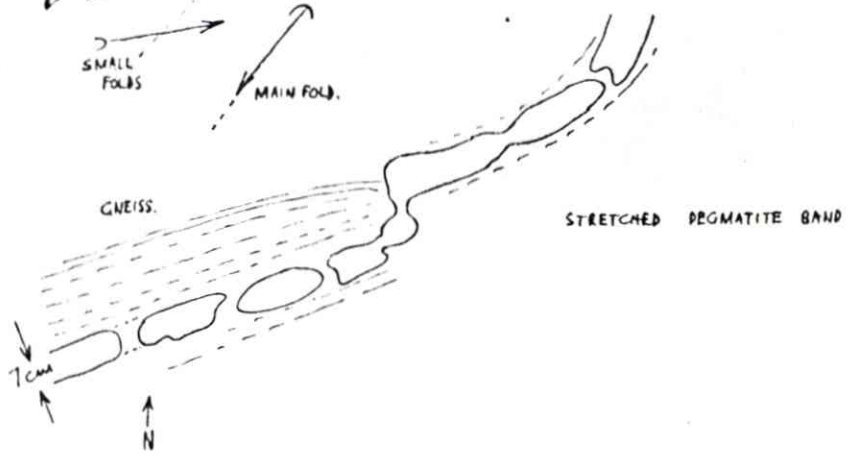
13.


MICROFAULT
3cm M'MENT
1cm ALTERNATE Q/F, Bi GNEISS WITH Px GNEISS.
SE
APLITE

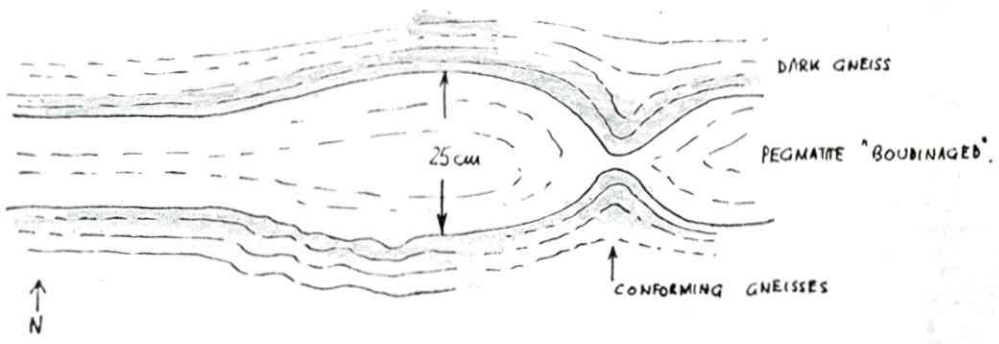
14.


SE
SMALL FOLDS
MAIN FOLD.

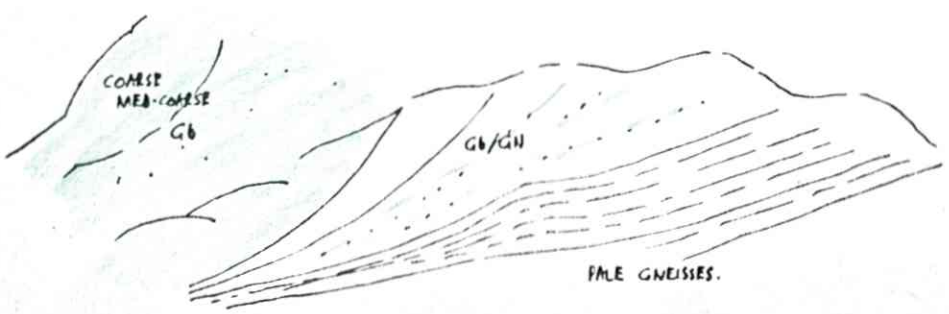
17


GNEISS.
STRETCHED PEGMATITE BAND
7cm
N

21.


DARK GNEISS
25cm
PEGMATITE "BOUDINAGED".
CONFORMING GNEISSES
N

22


COARSE
MED-COARSE
Gb
Gb/GN
PALE GNEISSES.

13. Here the gneiss shows laminated quartzo-feldspathic and biotite (c. 1cm alternations) at the contact with a dark gneiss band which is homogenous and probably highly pyroxenous. It is this latter material which has been mapped where its extremity and isolation warrants it.

Small faults can be detected at this locality with a post-dating aplite dyke.

Small red garnets are developed in both the "pale" and "dark gneisses".

In this area plagioclase was noted to be sparser away from the contact zones. Biotite was more evident towards the gneiss contact. Chloritisation also increased in the same sense.

14. Two fold systems in the gneiss approximately perpendicular.

15. Many contorted, discontinuous and broken aplite bands - some vertical and slightly faulted.

16. Chloritised bands. Thin, crumpled with some gabbro inclusions. This may represent a contact margin zone overlying the main gabbro.

17. Stretched pegmatite band in gneiss.

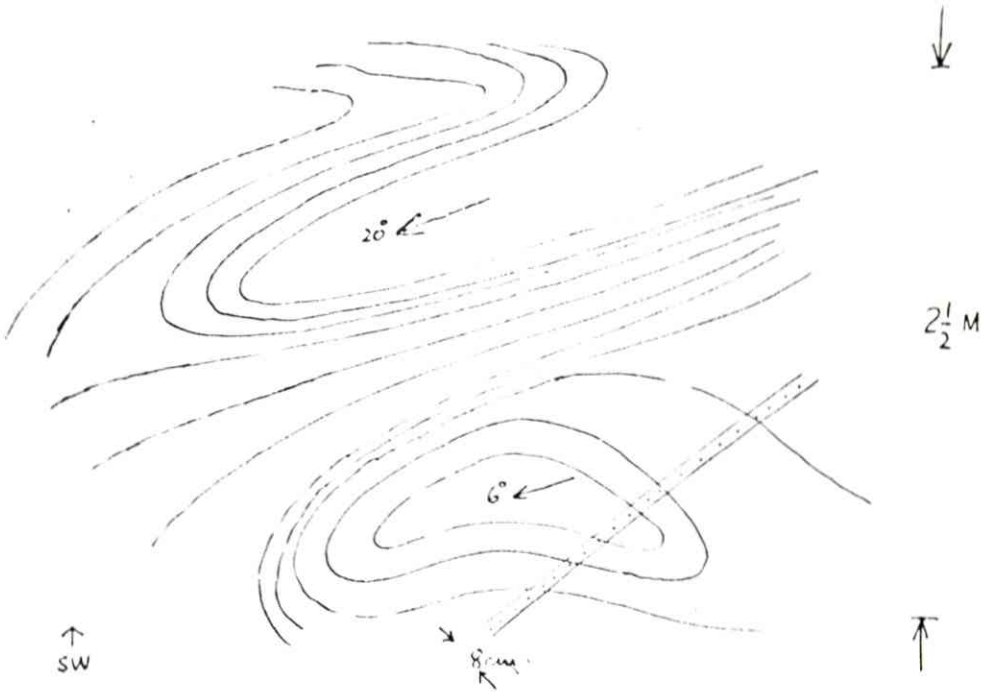
19. Gabbro ? The gneiss to the N is highly banded, but regular in lithology becoming garnetiferous and progressively assuming a different strike from the N-bounding hill. This shows a gradation into coarse mottled gabbro with much plagioclase and a further tendency to anorthosite type.

21. Pinched pegmatite band.
As is the case with most pegmatite bands observed "boudinage" form is evident.

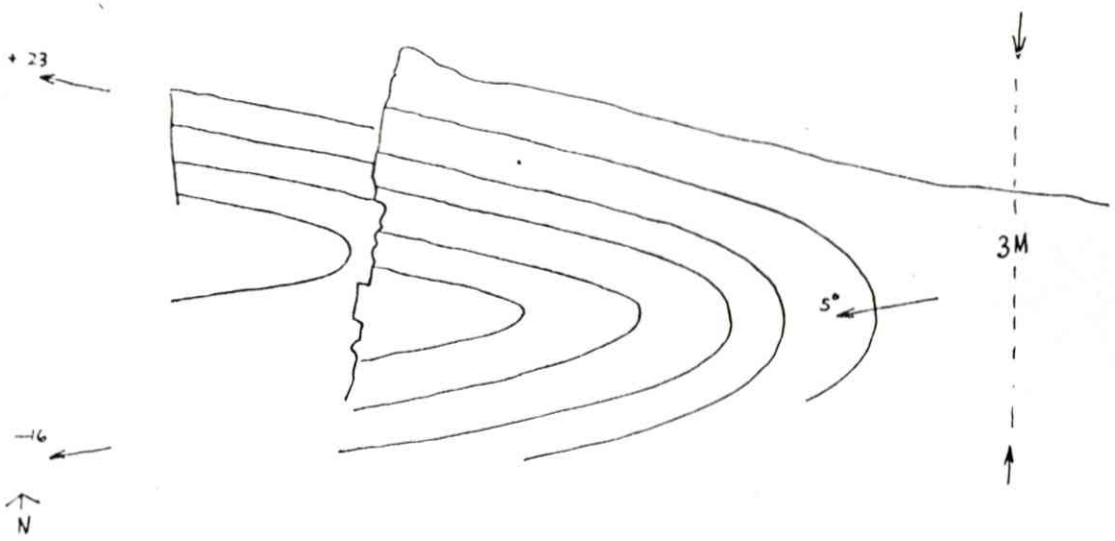
22. Gabbro/gneiss contact looking N.
Some visible plagioclase in the N-most exposure, but with a fine grained green matrix.

23. The gabbro shows a planar surface and orientation of biotite. Some facies with similar orientation are almost gneiss. The overall texture is coarse, but the sub-texture of the green matrix remains fine and medium fine.

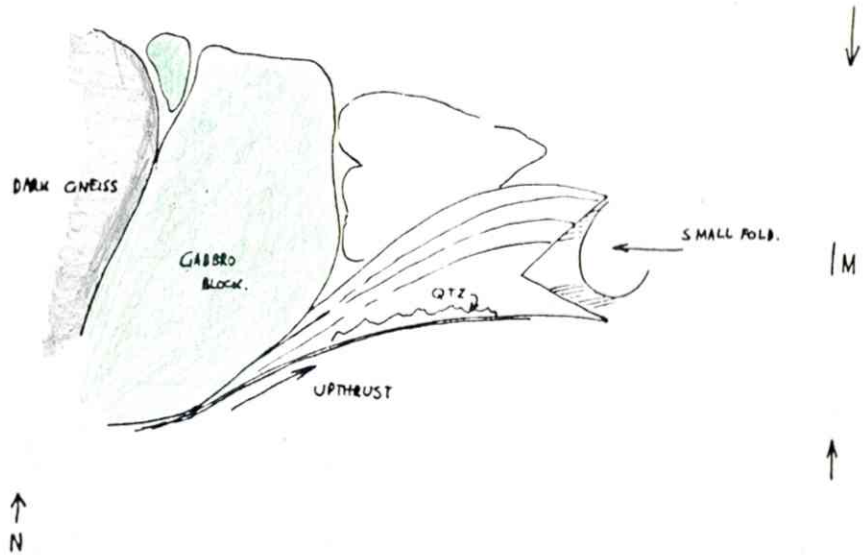
24.


20°
6°
SW
2½ M

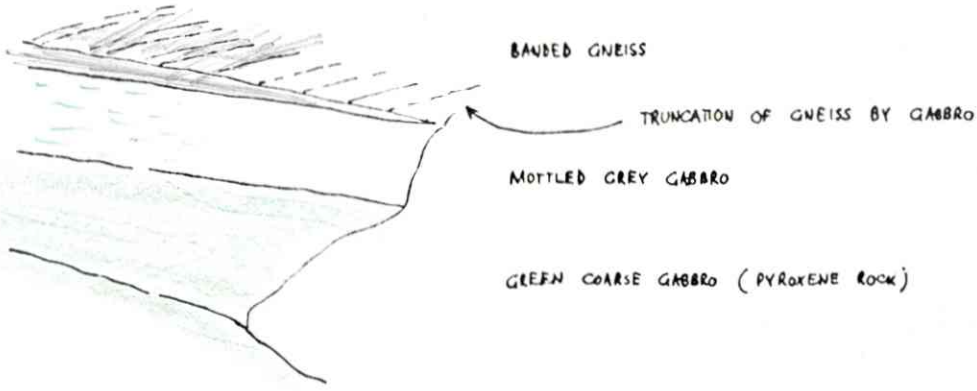
33.


+ 23
5°
3M
-16
N

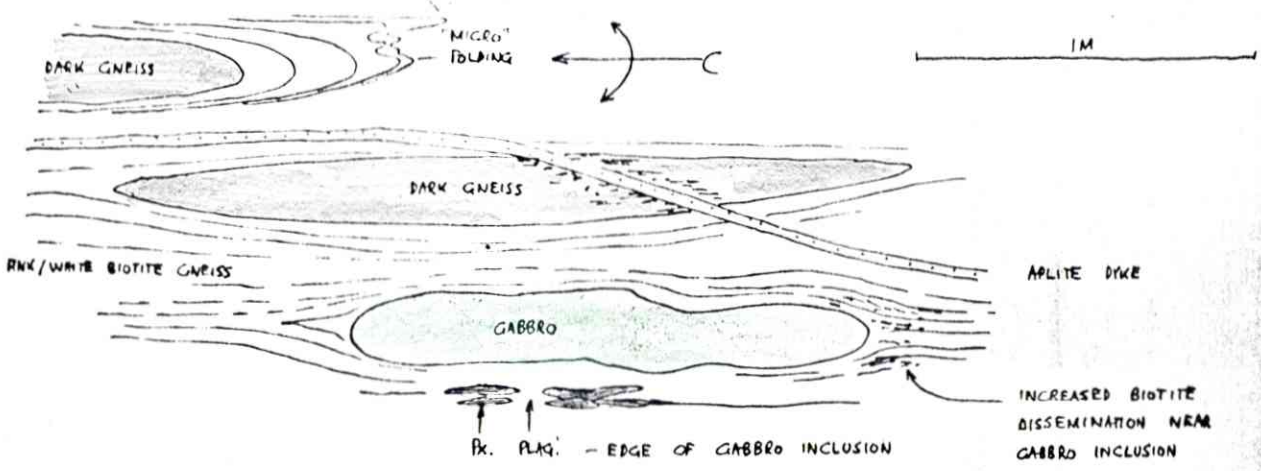
34.


DARK GNEISS
GABBRO BLOCK.
QTZ
SMALL FOLD.
UPTHRUST
1M
N

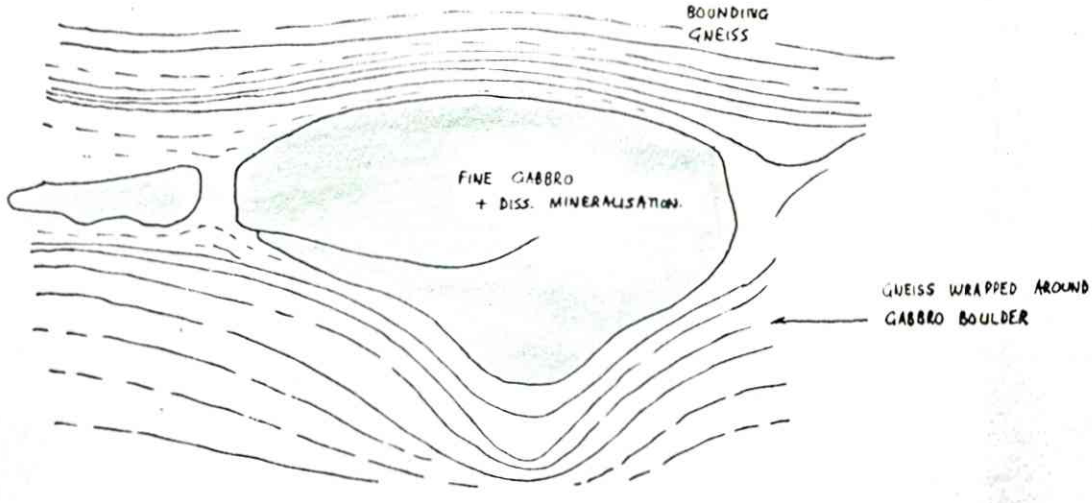
36.

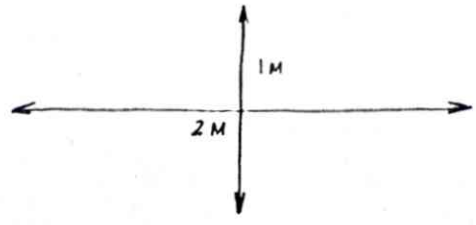

BANDED GNEISS
TRUNCATION OF GNEISS BY GABBRO
MOTTLED GREY GABBRO
GREEN COARSE GABBRO (PYROXENE ROCK)

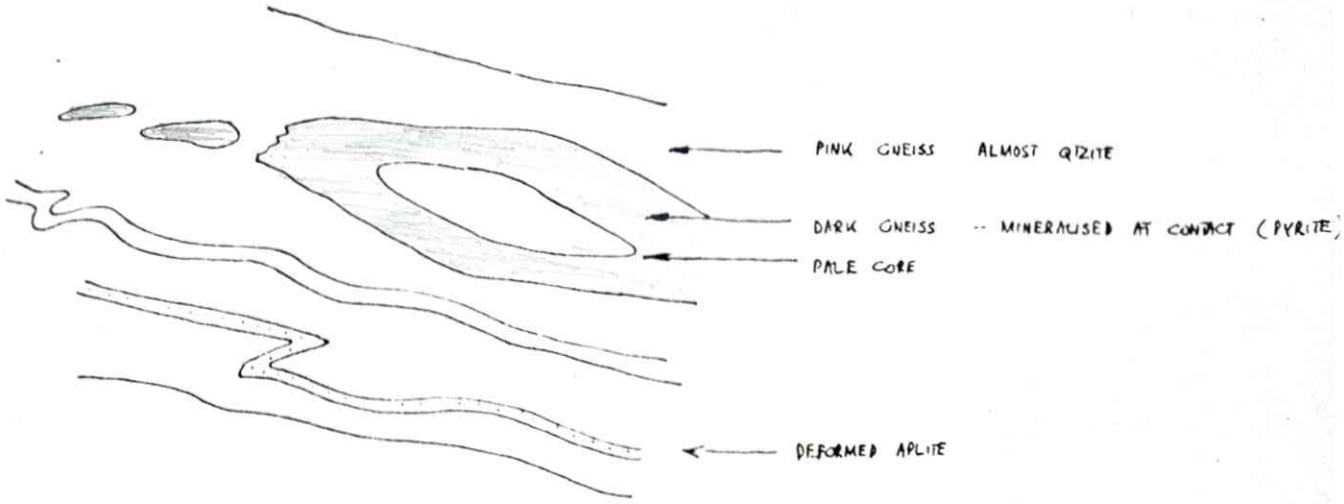
38.


"MICRO" FOLDING
1M
DARK GNEISS
DARK GNEISS
PINK/WHITE BIOTITE GNEISS
APLITE DYKE
GABBRO
INCREASED BIOTITE DISSEMINATION NEAR GABBRO INCLUSION
Px. PLAG. - EDGE OF GABBRO INCLUSION

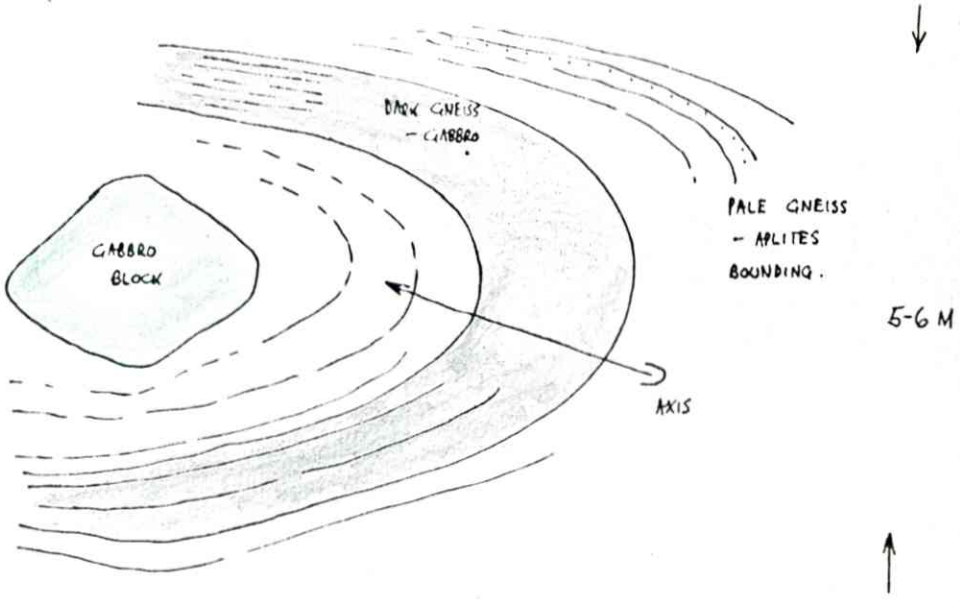
41.


BOUNDING GNEISS
FINE GABBRO
+ DISS. MINERALISATION.
GNEISS WRAPPED AROUND GABBRO BOULDER


1M
2M


PINK GNEISS ALMOST QTZITE
DARK GNEISS -- MINERALISED AT CONTACT (PYRITE)
PALE CORE
DEFORMED APLITE

30A.


DARK GNEISS
- GABBRO
PALE GNEISS
- APLITES
BOUNDING.
GABBRO
BLOCK
AXIS
5-6 M

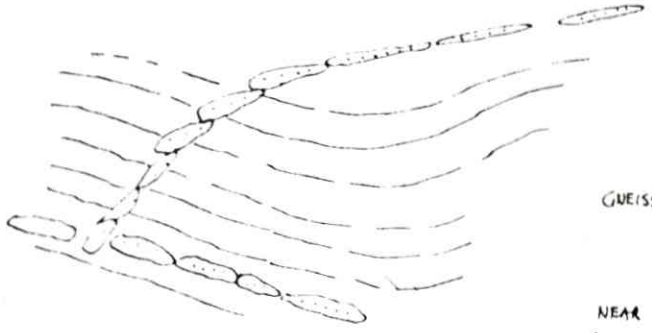
1.

GNEISS

CONFORMING APLITE

GNEISS

2.

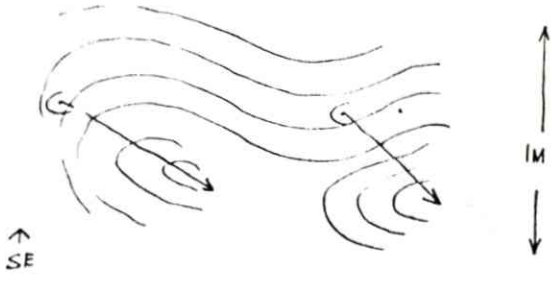


BOODINAGED & SHEARED APLITE

GNEISS

NEAR CONFORMABLE APLITE
(SLIGHTLY BOUDINAGED).

3.



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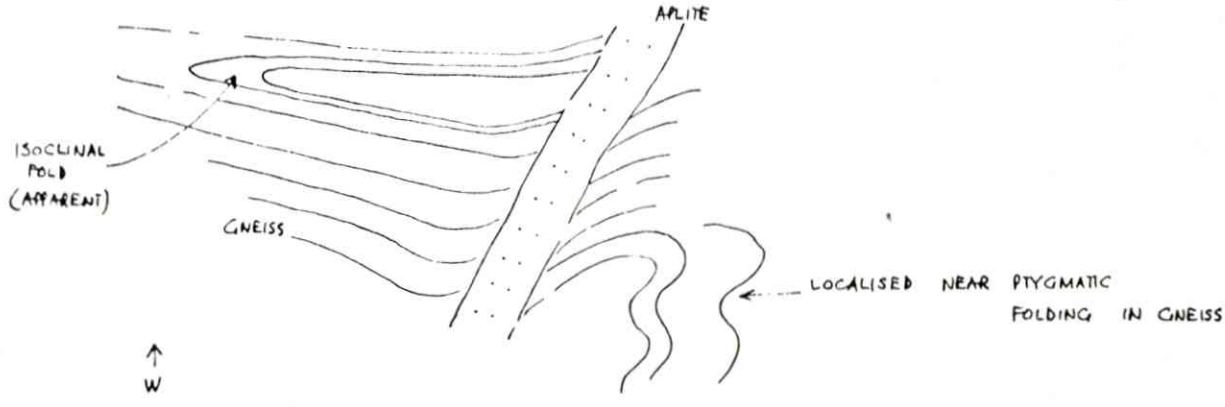

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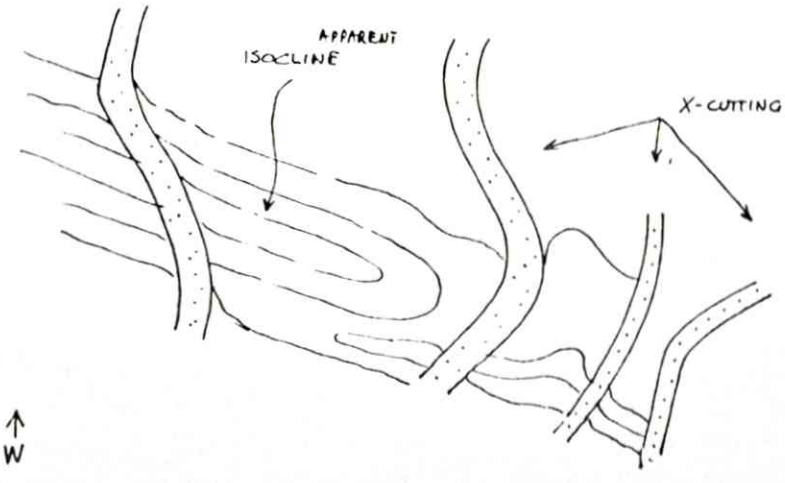
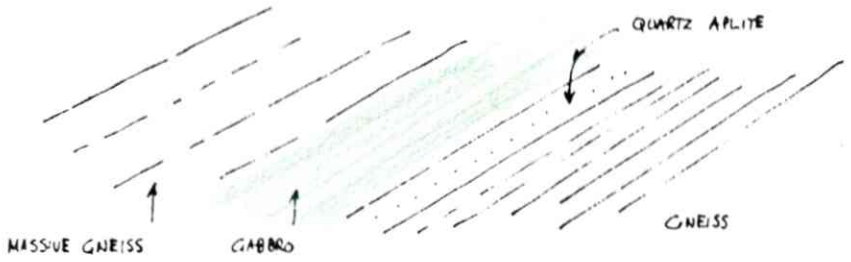
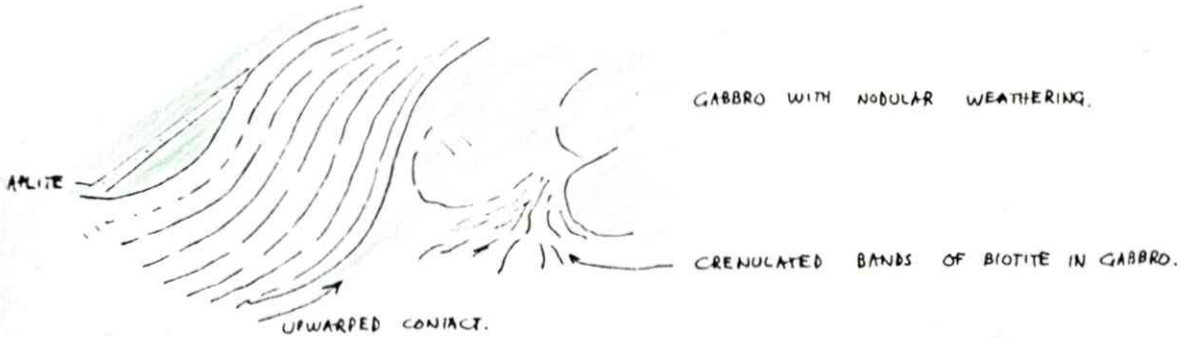


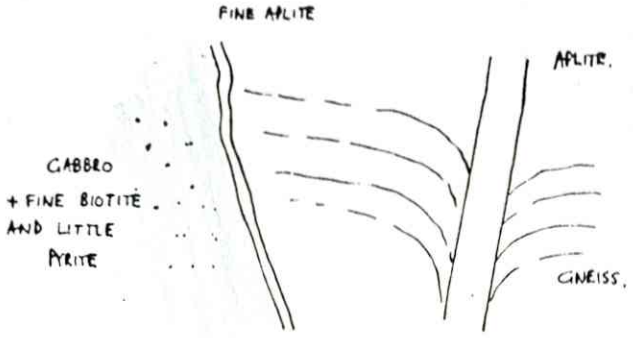
6.


QUARTZ APLITE
MASSIVE GNEISS
GABBRO
GNEISS

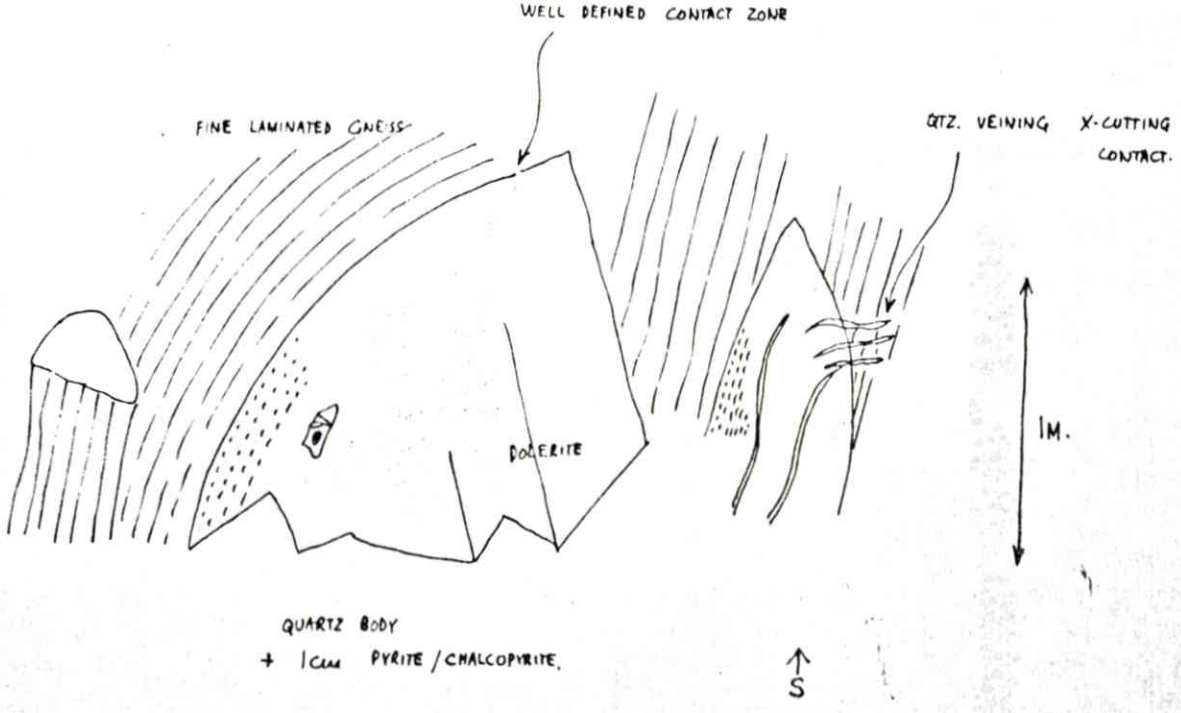
6A.


GABBRO WITH NODULAR WEATHERING.
APLITE
CRENULATED BANDS OF BIOTITE IN GABBRO.
UPWARPED CONTACT.

7.


FINE APLITE
APLITE.
GABBRO
+ FINE BIOTITE
AND LITTLE
PYRITE
GNEISS.

8.


WELL DEFINED CONTACT ZONE
FINE LAMINATED GNEISS
QTZ. VEINING X-CUTTING CONTACT.
DOLERITE
1M.
QUARTZ BODY
+ 1cm PYRITE / CHALCOPYRITE.
S

24. A well exposed fold system in the gneiss.

25, 26, etc. and top of Langtjønna. ("Langtødna")
The gneisses are generally dark with considerable amounts of pyroxene. The zones of high pyroxene conform with the planar surfaces of the mass. Some occur as bands and grade to pyroxene rock (pyroxenite). An overall coarse texture shows particularly well on weathered surfaces.

27. Dark gneiss or fine gabbro ?

33. A well exposed fold in the gneiss.

34. A gabbro block apparently upthrust into the surrounding black gneisses. Small folds in the vicinity show a number of almost contradictory fold axes.

36. An example of truncation of gneiss by gabbro.

38. Thin laminated pink-white biotite gneiss with some more or less conformable streaks of dark (high Bi and Px) material. Some material lensed. Some small lenses not greater than 1/2 m are gabbroic and are dark green-grey with little or no visible plagioclase. Tight in-strike folding occurs within a simple but more massive general dip trend. Thin pegmatites also seen both conforming with and truncating the gneiss.

38-2. Mineralised fine dark green streaky gabbro. Matrix material mottled.

41. A large gabbro block with associated smaller blocks included in the gneiss formation.

44. Pink gneisses almost without biotite. Some material is almost quartzite.

47. Gabbro. Very heavy sample showing little disseminated sulphur-mineralisation, but probably contains much magnetite.

50A. A number of rock types in the same locality (Nonås). A large gabbro block is contained within the fold nose of gneisseous material with a dark gneiss-gabbro formation forming one of the marker bands of the fold . Pale gneisses with more or less conformable aplites form the margins.

55. Feint bands of mineralised material cross-cutting the pegmatite structure. The mineralisation also occurs as blebs and irregular patches within this pink-orange host rock. This is quite extensive and may be associated in part with the strong magnetic anomaly in the area.

V Modes of Gabbro Occurrence and Types. - During the period of mining operations in theHosanger district it was noted by H. Bjørlykke and others that mineralisation was not entirely restricted to within the boundaries of the gabbros. However, it was considered that the ores were principally of primary magnetic origin evolved from the gabbroic material. Therefore, considering the area as a whole it is of interest to discuss the modes of occurrence of gabbro and gabbro affiliated material and attempt to subdivide the various types encountered.

Gabbro occurring as a dark green rock with little or no visible plagioclase and traceable in outcrops through a considerable area invariably shows itself to be plutonic in origin. This accounts for the main N-S oriented gabbro body south of Litlandsvann, the Heldal gabbro and Fjellskånes. Some discordance between the gabbroic material and the bounding gneisses can be seen along the margins of these three gabbros and rather indicates a "plastic" intrusion environment than one in which the contact zones were completely mobile (A). The contacts with the gneiss are generally well marked, the gneiss often showing upwarping and considerable changes in strike in the vicinity.

Gabbro of similar material (B), but usually of finer texture also occurs at many localities throughout the area included within the gneiss formations in the form of lenses (c 1 - 2 m long), small bebs (several cm in length) and larger irregular fragments or boulders measuring several meters. Irrespective of the shape or size of the gabbro material in these instances the bounding gneiss is wrapped around this material as the shape and alignment of the material permits (eg 41, 50A). Some times this material occurs in the gneiss immediately overlying a large visible gabbro of the first type e. g. above the Heldal gabbro in the S-end head wall, while in other instances they occur in somewhat isolated form in gneiss terrain. In the second instance this could be an indicator of gabbro beneath and by analogy could be mineralised. While this material clearly shows a direct simularity to the material seen within the major pluton zones the precise mechanics of how it was positioned, in bands, not discordant but only disturbing the planar surfaces of the gneiss, is unclear.

In connection with the occurence of gabbro in this form it should also be pointed out that dark gneiss material may often be associated, but is restricted to lens form.

The third and most complex forms of the gabbro is the occurrence of the "mottled" type best exposed in the N and W of the area. This material has a closer affinity with a "standard gabbro" and visible plagioclase is clearly seen in the hand specimen. In some instances it is barely distinguishable from some gneiss formations with which it is associated. Where it covers a considerable area it often contains zones of dark green (pyroxenite type) gabbro.

Tectonically no discordance is seen between this type of gabbro and the surrounding gneiss, so the precise relationship which this has with the plutonic type gabbro is unclear. The N part of the Heldal gabbro is continued northwards as a narrow band and is composed of (C)-type gabbro and so could be a marginal facies of plutonic gabbro or a contamination product produced in the gneiss by an emination process. Further explanation without thin section study and more detailed mapping is beyond the scope of this report.

VI The Geological Map. - This is a composite geological map. The N half of thearea (N of Røslandstjønna) had not previously been mapped and most attention was paid to this area during the field session.

The remainder of the area is based on earlier work by H. Bjørlykke and his principal divisions and boundaries are included, omitting details of the sub-surface mineralised phacolith in the largest N-S oriented gabbro. Further details for the composite have been obtained from maps drawn up by J. Færden covering the more important areas of the central southern portion.

Some time was, however, spent investigating the anomaly zones in the Nonås-Nordås area and some further detailed mapping attempted which is here recorded. This was considered necessary to draw the profile P. I. and lead to a better understanding of the gabbro form in this area.

EXPLANATION OF SYMBOLS

GABBRO - DARK GREEN PYROXENITE TYPE NEARLY HOMOGENOUS.
"DARK GREEN GABBRO"

GABBRO - MOTTLED GREEN AND WHITE

GNEISS WITH INCLUDED GABBRO FRAGMENTS

GNEISS QUARTZO FELSPATHIC WITH BIOTITE

GNEISS QUARTZO FELSPATHIC WITH PYROXENES
"DARK GNEISS"

PEGMATITES / APLITES.

C, M, F — COARSE, MEDIUM, FINE — W. REF. TO GABBRO GRAIN SIZE.

STRIKE TREND

DIP AND DIRECTION OF MINERAL BANDING (GABBROS).

LEVEL STRIKE OF MINERAL BANDING

DIRECTION OF MINERAL ORIENTATION (MAINLY MICAS)

VERTICAL DIP

DIP / STRIKE

HORIZONTAL

FAULT

FOLD - PLUNGE DIRECTION + AMOUNT

FOLD WITH ORIENTATION OF LIMBS AND ANGLES

INFERRED FOLD.

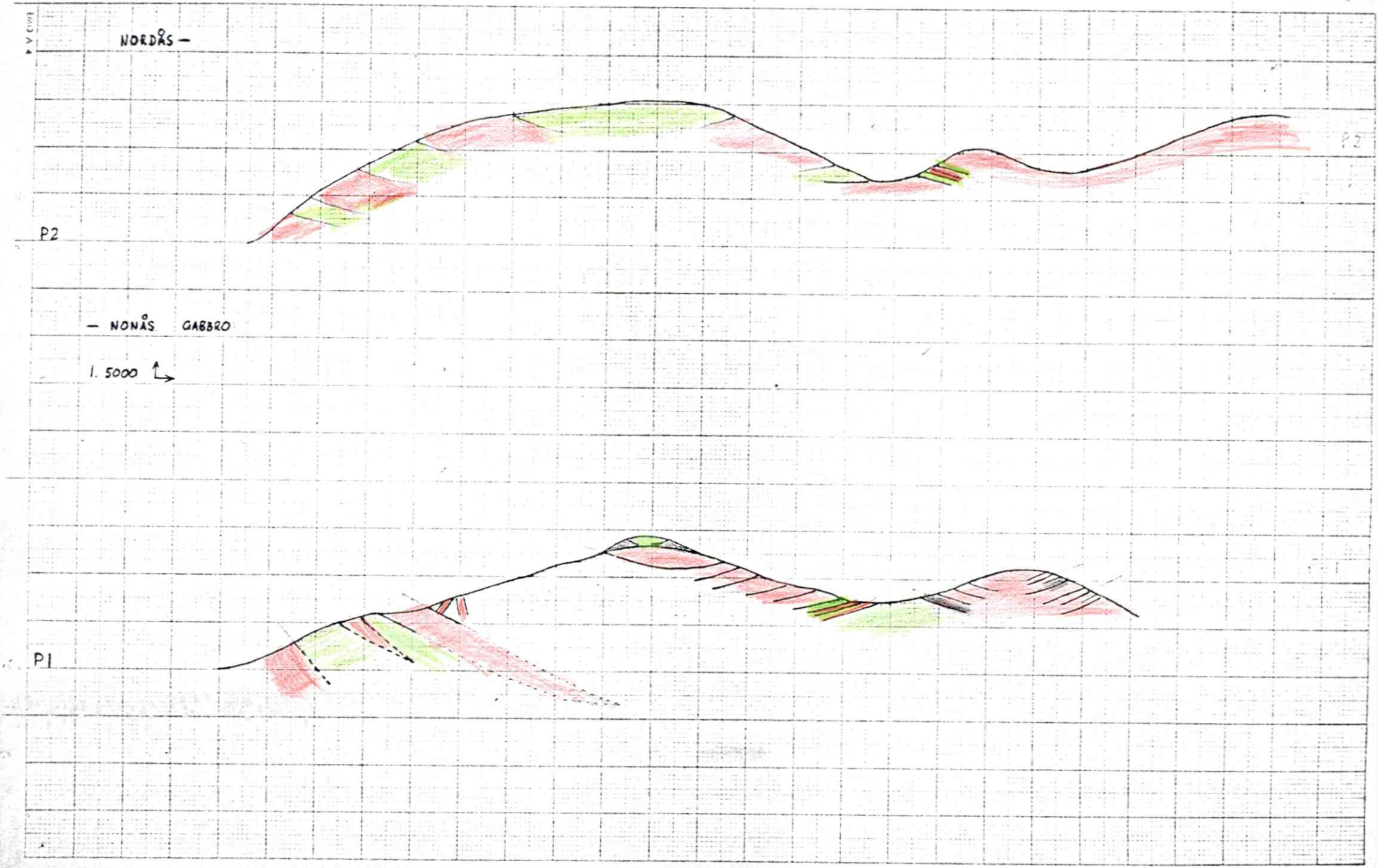
GENTLE FOLD - GENTLE DISTURBANCE OF MAIN STRIKE ONLY.

MINS. DISSEMINATED MINERALISATION. (PY, Cp, Pent, Pyr etc.)

(46), (27A) LOCALITY (TEXT) AND SPECIMEN NUMBERS., CHEMICAL ANALYSIS

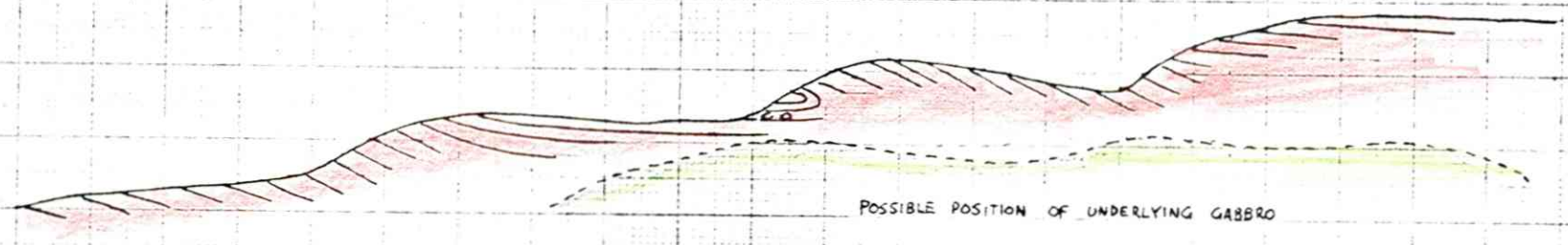
Sections

VII SECTIONS ALONG I/P TRAVERSES

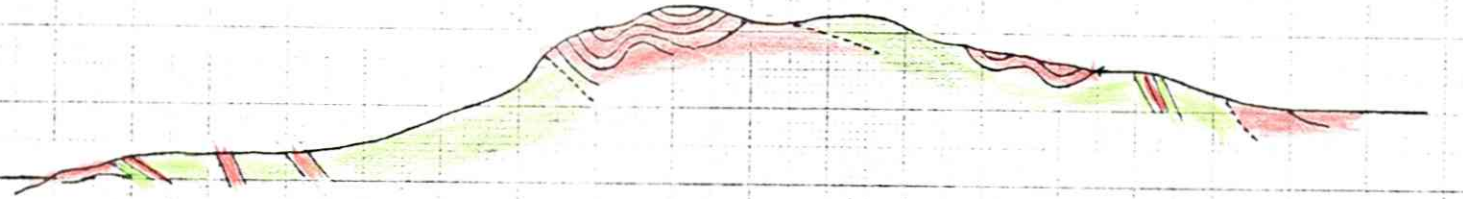


GNEISS W. OF RØSLANDSVANN

1. 5000



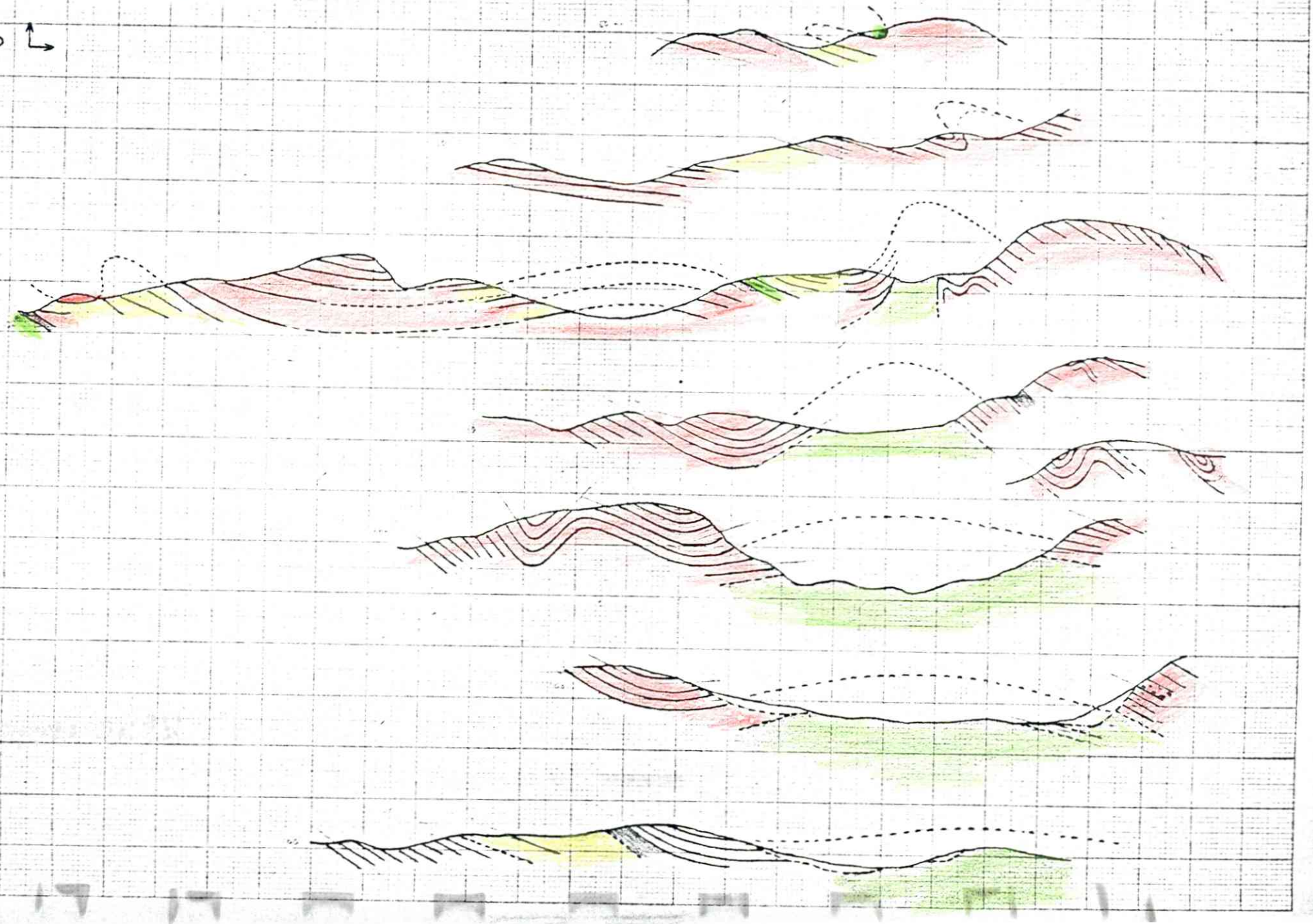
BYSHEIM GABBRO



VII SECTIONS ALONG I/P TRAVERSES

HELDAL GABBRO AND BOUNDING GNEISSES

1 : 5000



VIII Tectonics. - The general tectonics are indicated from the comments on the gabbro.

A general N-S strike trend is apparent with an average dip of 30° - 35° to E easily traceable in the gneisses of high topography along the E and W boundaries of the area. In the intermediate zone the strike is considerably disturbed from the general trend particularly in the vicinity of the gabbros.

Minor folds are seen at many localities and fall more or less into two classes:

a) Tight in-strike folding, usually recumbent and some times approaching an isoclinal condition. It is likely that in the latter condition they reverse locally without altering the general trend of the gneiss. They lie within an "axis sector" between 30° E and W of N-S. and often plunge deeply towards N or S.

b) Gentle undulating folds within an "axis sector" from 40° N and S of E-W. These are seen throughout the area particularly in the central gneiss terrain and have negligible effect on the general strike.

Gabbro lineations dip 40° towards N in the Nordås area suggesting the main gabbro body emerges in this area and is not present further south. Passing N the gabbro plunges progressively deeper in the gneiss. The Heldal gabbro being exposed owing to erosion of overburden gneiss. Further N again only the gneiss is seen.

4. Relation of Geology and Geophysics.

Summary.

The explanations of the geophysical anomalies remain inconclusive, but some generalisations can be made.

It is very likely the EM/I anomalies were caused by the overhead cable network. Part of the EM/R pattern probably has the same cause.

The magnetic anomalies have a relationship with the dark, highly pyroxenous gneisses especially when in association with the dark green gabbros and a most consistent relationship when one or other or both contains disseminated mineralisation.

Sufficiently high magnetic contrast is probably the cause.

The I/P anomalies show "highs" over the dark gabbros at shallow depths. The contrasts becoming considerably lessened with increasing effective penetration depth. Further proving could be done by drilling.

Explanation of Anomalies.

While attempting a tentative explanation of the geophysical anomalies the following points have been considered: -

The validity of subsurface geologic structure inferred by section drawing.

The validity of subsurface geology below an arbitrary anomaly zone devoid of geologic data inferred from the closest points nearby with available data.

The resultant penetration depth of the methods employed. Can the anomalies be explained by the nature of surface outcrops only, in some instances ?

The majority of anomaly zones are subcircular or elongate in form with long axis normally sub-parallel to the general geologic strike.

Electric power was cut off from the area while the airborne geophysical survey was in progress.

I Magnetic Anomalies - Little or no immediate similarities can be seen by comparing the magnetic anomaly data with the boundaries of the two basic geologic divisions of gabbro and gneiss. However, the significance of the dark gneiss outcrops somewhat changes this picture, and it is in this connection that they have been assumed to contain a higher magnetic content than other rock types present. Magnetite has been shown to be present in appropriate hand specimens by applying a magnet to the crushed material.

In the N part of the area anomalies with a N-S oriented long axis occur over three distinct outcrops of dark gneiss. In all cases the anomalies are of high magnitude and on the ground correspond with dark gneiss disseminated mineralisation. In two of these cases small zones of green gabbro are also found surrounded by the dark gneiss material.

The strong anomaly (1400^{g}) immediately N of Røslandsvann overlies the subsurface gabbro which plunges under the gneisses from outcrop N of the lake to occur as the Heldal gabbro further to the N. Unfortunately, shallow drift cover obscures the surface, but marginal zones to the W show dark gneiss.

By inference from the three earlier examples and the immediate geological environment it is not unreasonable to suggest that this anomaly is associated with high magnetite content and other disseminated minerals at or close to the surface.

In the SE of the area strong "magnetic highs" occur. Dark gneiss is associated with the majority of cases although the immediate geologic environment in these cases is variable. Visible disseminated mineralisation (pyrite, chalcopyrite, pentlandite, etc.) is barely apparent. However, the magnetite content may still be high enough to cause contrast. Magnetic anomalies here are centred coincident with rapidly falling topography.

II Electromagnetic - Imaginary Anomalies - Plotting of the above surface conductors (LT and HT power cables and telephone lines) produces accurate co-incidence with the long axes of the major anomalies and gives a readily available explanation for these anomalies quite independent of gelogical considerations.

Junction areas within the network, especially where a transformer is present, produce strong anomalies, where an anomaly is recorded. The strongest anomalies are elongate around the H/T cable traces, but are not everywhere present.

Several outlying EM/I anomalies with an E-W orientation cannot be accounted for by the cable network. However, these are of low order by contrast and could be disregarded.

III Electromagnetic - Real Anomalies. - The total pattern consists of both positive and negative components. Some similarities with the EM/I picture can be noted, but the stronger anomalies are more localised in extent. No immediate similarities between the major boundaries of the surface geology and the total (+ and -ve) anomaly pattern can be recognised, although the negative EM/R part is magnetic in nature and follows the magnetic anomalies with a considerable degree of accuracy.

However, outcrops of dark gneiss are everywhere represented by an anomaly zone of similar shape. In the S subsircular outcrops with variable strike patterns correspond with circular anomaly zones. In the N and W constant strike and elongate outcrops correspond with elongate anomaly zones.

IV Induced Polarisation Anomalies (latest survey). - Comparison between the I/P sections incorporating different x values (meters) and % I/P with the geological sections shows:

a) Lowest x values produce the high maxima not greater than 3% IP over the gabbro outcrops (dark green type). The highest value of 4% - 5,5% is recorded over the N end of the Heldal gabbro.

b) In some places these are high over only part of the outcrop, but generally "highs" follow the outcrop.

c) Higher x values give smoother curves with progressively flatter maxima which are not restricted to the gabbro outcrops i.e. increasing penetration depth produces increasingly flatter curves.

Profile I. - A high I/P value (3.25 %) over the Nonås mine is produced as should be expected. Secondary highs are produced on the opposite side of the hill for low x values.

Therefore, in this area values of % IP not greater than 3% are clearly of interest. (This is the value for an abandoned mine near surface).

Profile 2. - The % IP is low near surface rising to 2% - 5% IP for values of x = 200, 300 at a probable depth of 100, 150 meters and therefore shows little of interest.

Profile 3. - The values of near-surface I/P rises to 3.25% in the Bysheim gabbro in the coast zone. This is of interest.

Profile 4. - A 3,5% I/P maxima for x = 50 m occurs over the gneisses W of Røslandsvann. This is an important area of interest as the gneiss is likely to be thin covering a near surface gabbro.

Profile 5. - 3.25% IP is produced for lowest x values over the centre of the exposed Heldal gabbro.

Profile 6. - 4% IP is produced for x = 50 m over the N extremity of the Heldal gabbro outcrop increasing to 4.25% IP for x = 100 m (depth 50 m ?)

5. Suggested Areas for further Studies.

The Area immediately W of Røslandsvann.

This area is of considerable interest owing to the following observations:

a) Three types of geophysical anomaly are represented in the area. The EM/I, R patterns are less likely to be entirely the result of overhead cables owing to shapes. A strong magnetic anomaly is recorded. The I/P ($x = 50$ m) curve produces a high I/P effect (3.5%) in this area as a notable peak.

b) The gneisses which cover the area show considerable changes in strike over short distances indicating a dome structure. Included gabbro blocks are seen in the gneisses at the road side. The gneisses may therefore form a thin cover over a dark green gabbro.

c) On the W margin of Røslandsvann dark pyroxenous gneiss marks the steeply dipping somewhat discordant gabbro/gneiss boundary. Fine disseminated mineralisation occurs in both the gneiss and gabbro.

These facts indicate a shallow subsurface continuation of the main N-S gabbro with probable mineralisation of a more interesting order.

The S Nonås Area.

This area remains of interest owing to

a) Earlier mining in the area immediately to the N.

b) High magnetic and "unexplained" EM/R anomalies.

c) A dark gneiss and dark green gabbro in the edge zones of a large gabbro.