NGU Report 93.100

Ground magnetic survey at the Saurdal eclogite, Fjaler, Sogn og Fjordane

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REPORT

Report no. 93.100	ISSN 0800-3416	Grading: Confidential to 1999

Title:
Ground magnetic survey at the Saurdal eclogite, Fjaler, Sogn og Fjordane.

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Map-sheet name (M=1:250.000) Florø	**Map-sheet no. and name (M=1:50.000)** 1117 I Dale
Deposit name and grid-reference: Saurdal 2971 68018	**Number of pages:** 12 **Price:** **Map enclosures:** 4

Fieldwork carried out:	Date of report:	Project no.:	Person responsible:
15.-22.06.93	02.02.94	67.1900.05	[signature]

Summary:

This report presents results from a ground magnetic survey at the Saurdal eclogite at Saurdalsvatnet, Gjølangen, Fjaler in Sogn og Fjordane. The report also presents results from magnetic susceptibility measurements on drill-dust samples from the outcropping parts of the eclogite. The measurements aid in mapping the eclogite's westward extension.

The Saurdalhaugen area appears with great variation in magnetic levels. One locality of similar magnetic signature is detected further west. The magnetic susceptibility measurements indicate a weak positive correlation between content of TiO_2(total) and magnetic susceptibility. However, magnetic highs are no guarantee to great content of TiO_2(total). Furthermore, analyses indicates that no magnetic level has great TiO_2(rutile) content (i.e. > 3 %). In magnetic highs, however, the majority of samples (63 %) have a content of TiO_2(rutile) between 1.5-3 %. Hence, it seems clear that magnetic highs can be of interest concerning high TiO_2(rutile) content. The relative content of TiO_2(rutile) (i.e. % TiO_2(rutile)/TiO_2(total)) seems to be greatest in low magnetic areas, which might be explained by alteration from medium magnetic ilmenite to low magnetic rutile.

Keywords: Geophysics, Mineral deposit, Ground survey, Petrophysics, Magnetometry

Keywords: Geofysikk	Mineralforekomst	Bakkemålinger
Petrofysikk	Magnetometri	
		Fagrapport

TABLE OF CONTENTS

TABLES

FIGURES

MAPS

1 INTRODUCTION

In connection with mapping of the Saurdal eclogite at Fjaler in Sogn og Fjordane, a ground magnetic survey was carried out along some chosen profiles. In addition, magnetic susceptibility was measured on 97 drill-dust samples from the area.

The Saurdal eclogite is a gabbroid intrusion with layers of magnetite (Fe_3O_4) and ilmenite ($FeTiO_3$) (Korneliussen 1994). It has been exposed to tectonic and metamorphic processes in the form of eclogitization and subsequent retrogression. In the eclogitization process ilmenite was altered to rutile (TiO_2) and iron from the ilmenite went into garnet. The subsequent retrogression of eclogite consists of 2 phases. During the first retrograde phase eclogite is partly altered to amfibolite, while rutile is variably altered to ilmenite. In the second phase, which is a chloritization of eclogite/amfibolite, one can get a 100 % conversion of rutile into ilmenite, and also some growth of magnetite within clorite. After these processes there might be some remainders of original magnetite- and ilmenite layers preserved (cf. Korneliussen (1994) for a more detailed description).

Magnetic susceptibility for the mineral ilmenite varies from 0.3 to 4, with a mean of 2 SI-units (Telford et al. 1978). Alteration into rutile would give lower susceptibility. Areas with high TiO_2(total)-content and low susceptibility should, on this theory, be of special interest. Small quantities of magnetite, which has a susceptibility from 1 to 20 SI-units, would interfere with this idea. The magnetic picture is consequently dependent on to what extent the rock has been altered, and also depend on the content of original magnetite and ilmenite. The purpose of this geophysical survey was primarily to see what magnetic response the known part of the eclogite would give, and thereby mapping the eclogite's extension towards the west, where bedrock is unexposed.

2 MEASUREMENTS

2.1 Laboratory measurements.

The drill-dust samples were collected and their rock-type identified by Are Korneliussen and Leif Furuhaug (NGU). Magnetic susceptibility measurements on the samples was carried out at the petrophysical laboratories at NGU. The drill-dust is put into 100 ml plastic sylinders. Because these are dust samples, the volume (100 ml) is greater than the volume of a natural sample with equal weight. Increasing the volume in the formula of apparent magnetic susceptibility will give lower susceptibility. Hence, the susceptibility of the drill-dust samples, presented in this report, are too low relatively to the susceptibility of natural samples. Still, the relative difference between the susceptibility values is correct. The results from chemical analyses are taken from Korneliussen 1994.

2.2 Field measurements.

The profiles were marked out using compass and measuring tape. The lines were marked every 25 m with sticks with a coordinate inscription. The distance between measuring points were 12.5 m and 6.25 m. The magnetic survey was carried out using two Scintrex

MP-3 proton magnetometers with an accuracy of ± 0.1 nT. One of the magnetometers served as base station for correction of diurnal variations. The magnetic conditions were very stabile during the days of surveying. When measuring, the probe was placed c. 2 m above the ground.

3 RESULTS AND COMMENTS

3.1 Laboratory measurements

The results from susceptibility measurements and chemical analyses are presented in figures 1-5. The locations of drill-dust samples are shown in map no. 93.100-04.
Figure 1 shows content of Fe_2O_3 in magnetite and ilmenite versus magnetic susceptibility. The figures 2-4 show content of TiO_2(total), TiO_2(rutile) and TiO_2(ilmenite) respectively plotted versus magnetic susceptibility. In figure 5 content of TiO_2(rutile) on TiO_2(total) is plotted versus magnetic susceptibility.

Looking at the correlations, one has to take into consideration a variable contribution from magnetite. Figure 1 shows a nearly linear positive correlation between content of Fe_2O_3 (in magnetite and ilmenite) and magnetic susceptibility. Fig. 2 indicates a positive correlation between TiO_2(total) and magnetic susceptibility. Hence, the laboratory measurements indicate that magnetometry is a method that can be of some help in finding areas with high content of TiO_2(total). Fig. 4 shows a certain positive correlation between TiO_2(ilmenite) and magnetic susceptibility. Because of the content of ilmenite ($FeTiO_3$), rutile ores should give increased magnetic field relatively to the surrounding rocks. The measurements on drill-dust samples from the location show no correlation between content of TiO_2(rutile) and magnetic susceptibility (Fig. 3). In this case it can be concluded that areas with high content of TiO_2(rutile), will probably not appear as magnetic lows, as expected. One condition, for this to happen, is that the initial material is homogeneous and also that no other magnetic minerals are involved. Figure 5 indicates a negative correlation between content of TiO_2(rutile) on content of TiO_2(total) and magnetic susceptibility. This might be explained by alteration of medium magnetic ilmenite to low magnetic rutile.

3.2 Field measurements

Results from total magnetic field surveying are shown in maps no. 93.100-02 and -03. Based on these maps a magnetic interpretation map was made (map no. 93.100-04). This map shows the investigated area devided into low (< 49800 nT), medium (49800 nT-51200 nT) and high (> 51200 nT) magnetic levels. The map shows that Sørdalshaugen appears with great variation in magnetic level. Both in the southern part and northern part of Sørdalshaugen the survey was impeded by very rough terrain. The profiles 4600 X, 4700 X and 4800 X should be extended northwards, but this was not possible. Nevertheless, the present results indicate that the magnetic high south of the Sørdalshaugen make a turn on its western side, and continues north of the Sørdalshaugen. A similar complex magnetic pattern with magnetic highs (> 51200 nT) and lows (< 49800 nT) is seen west of Saurdal between the profiles 3300 X and 4100 X. The anomalies are delimited by the line 4900 Y in the south and the line 5600 Y in the north. These anomalies probably indicate an eclogite of Saurdal type. Apart from these two strictly delimited anomaly areas, the magnetic values lie around 50500 nT. Any eclogite of Saurdal type may probably be found by studying areas with this kind of regional anomaly pattern.

The drill-dust samples, taken along the profiles crossing the location, are, as mentioned, analysed on the content of TiO_2(total), TiO_2(rutile) and TiO_2(ilmenite). Based on the location of the samples within the investigated area, one has tried to give a detailed picture in the figures 2-4. The tables 1-3 show a general view of how analyses (values) are distributed on magnetic levels. Dealing with these values, one has to be aware of that the analyses represents values from the upper 20 cm of the rock, while magnetic values are influenced by a much greater volum of the rock. One must also take into consideration some uncertainty when drawing the locations of the samples on the map. Hence, the tables must be regarded as a broad general view.

Table 1. TiO_2(total)-analyses on drill-dust samples distributed on magnetic levels.

Magnetic level	*TiO_2 (total)*			Σ
	< 3%	3 - 5%	> 5%	
High **(> 51200 nT)**	34.4 % 11	31.2 % 10	34.4 % 11	100 % 32
Intermediate **(49800-51200 nT)**	40 % 20	40 % 20	20 % 10	100 % 50
Low **(< 49800 nT)**	60 % 9	33.5 % 5	6.7 % 1	100 % 15

As can be seen from table 1, the samples are not evenly distributed within the three magnetic levels. There are only 15 samples within the magnetic lows (< 49800 nT). Looking at all samples, the susceptibility measurements indicate that there is a weak positive correlation between content of TiO_2(total) and magnetic susceptibility (Fig.2). Table 1 shows the same trend, but it also shows that magnetic highs are no guarantee to great content of TiO_2(total). Samples collected within the magnetic highs are evenly distributed on the three groups of TiO_2(total). In areas with intermediate total magnetic field, there are a majority of samples (40 %) with a content of 3-5 % TiO_2(total) and samples containing less than 3 % TiO_2(total) (also 40 %). Within magnetic low areas, there are a majority of samples (60 %) containing less than 3 % TiO_2(total).

Generally speaking, susceptibility measurements indicated no correlation between content of TiO_2(rutile) and magnetic susceptibility (Fig.3). Hence, it is not possible to say for sure that rutile-rich zones will appear as magnetic lows on the interpretation map. Table 2 confirms this statement. The majority (67 %) of the samples within magnetic lows contain less than 1.5 % TiO_2(rutile). Within intermediate magnetic areas, 58 % of the samples contain less than 1.5 % TiO_2(rutile), while 63 % of the samples within magnetic highs have a TiO_2(rutile) content between 1.5 % and 3 %. This shows that most samples within low and intermediate magnetic levels, have low TiO_2(rutile) content, while most samples within magnetic highs have intermediate TiO_2(rutile) content. Even though the relative growth of rutile (% TiO_2(rutile) / % TiO_2(total)) was greatest within magnetic lows, it looks like the content of TiO_2(rutile) is positive correlated with magnetic highs. This has to be associated with a low starting content of TiO_2(total) (cf. table 1). No magnetic level suggests itself as rich on TiO_2(rutile) (i.e. > 3 %), but most samples within magnetic highs have a content of TiO_2(rutile) between 1.5 % and 3 %.

Table 2. **TiO_2(rutile)-analyses on drill-dust samples distributed on magnetic levels.**

Magnetic level	*TiO_2 in Rutile*			Σ
	< 1.5%	1.5-3%	> 3%	
High (> 51200 nT)	28.1 % 9	62.5 % 20	9.4 % 3	100 % 32
Intermediate (49800-51200 nT)	58 % 29	28 % 14	14 % 7	100 % 50
Low (< 49800 nT)	66.6 % 10	26.7 % 4	6.7 % 1	100 % 15

Table 3. **TiO_2(Ilmenite)-analyses on drill-dust samples distributed on magnetic levels.**

Magnetic level	*TiO_2 in Ilmenite*			Σ
	< 3 %	3-5%	> 5 %	
High (> 51200 nT)	50 % 16	34.4 % 11	15.6 % 5	100 % 32
Intermediate (49800-51200 nT)	68 % 34	18 % 9	14 % 7	100 % 50
Low (< 49800 nT)	86.6 % 13	6.7 % 1	6.7 % 1	100 % 15

Table 3 indicates a positive correlation between TiO_2(ilmenite) and magnetic level.

CONCLUSION

The magnetic survey shows that Sørdalshaugen is characterized by a complex magnetic pattern of alternating magnetic highs and lows. An area with similar variations between magnetic highs and lows, is detected to the west of Saurdal. This anomaly may indicate an eclogite of Saurdal type. Other eclogites of Saurdal type can probably be found by studying areas with this kind of anomaly pattern.

Laboratory measurements on drill-dust samples from the eclogite, show weak positive correlation between content of TiO_2(total) and magnetic susceptibility. The same effect can be seen when plotting TiO_2(total) as a function of measured magnetic level. However, magnetic highs are no guarantee to great content of TiO_2(total).

The ratio of % TiO_2(rutile) to % TiO_2(total)) is greatest within magnetic lows, which might be explained by alteration from medium magnetic ilmenite to low magnetic rutile. Still, content of TiO_2(rutile) is poor within magnetic lows because content of TiO_2(total) is low.

Laboratory analyses indicate poor correlation between content of TiO_2(rutile) and magnetic susceptibility. However, plotting TiO_2(rutile) versus measured magnetic levels shows that greatest content of TiO_2(rutile) is connected to magnetic highs. This has to be assosiated with high content of TiO_2(total).

Hence, it seems clear that magnetic highs can be of interest concerning high TiO_2(rutile) content. The ratio of TiO_2(rutile) to TiO_2(total)) being greatest within magnetic lows, indicates that any magnetic low that may have high TiO_2(total) content, could be of interest as well.

5. REFERENCES

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Lauritsen T., og Rønning J. S. 1990: Petrofysiske og geologiske undersøkelser på rutilførende eklogitter ved Husebø, Meland kommune, Hordaland. NGU Report 90.004.

Korneliussen A. 1994: Rutile-bearing eclogites in western Norway. Summary of available information, DuPont/NGU - collaboration project 1993. NGU Report 94.013.

Figure 1. Drill-dust samples, Saurdal
% Fe2O3(magnetite+ilmenite) vs. Magnetic susceptibility

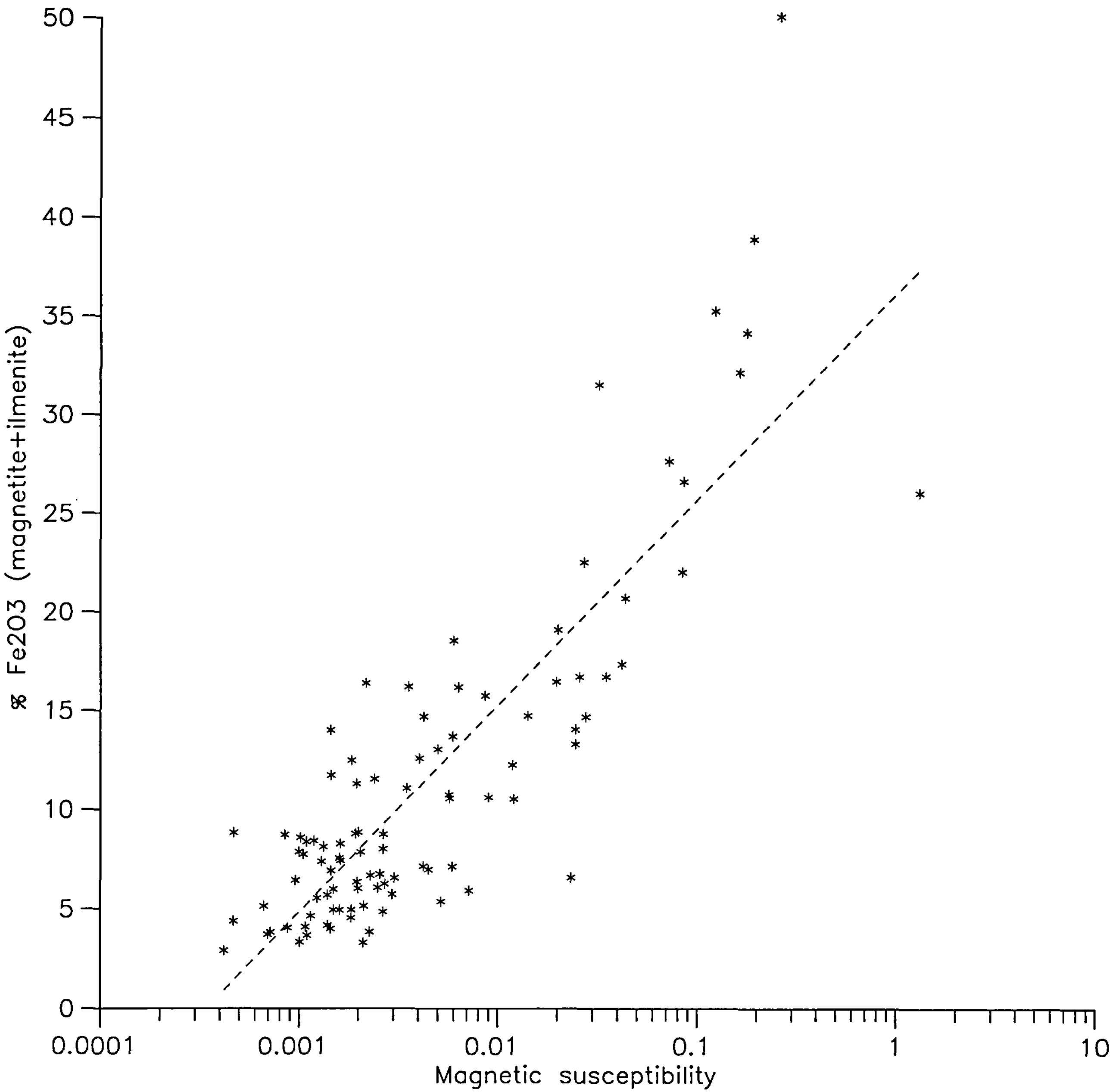


Figure 2. Drill-dust samples, Saurdal
% TiO2(total) vs. Magnetic susceptibility

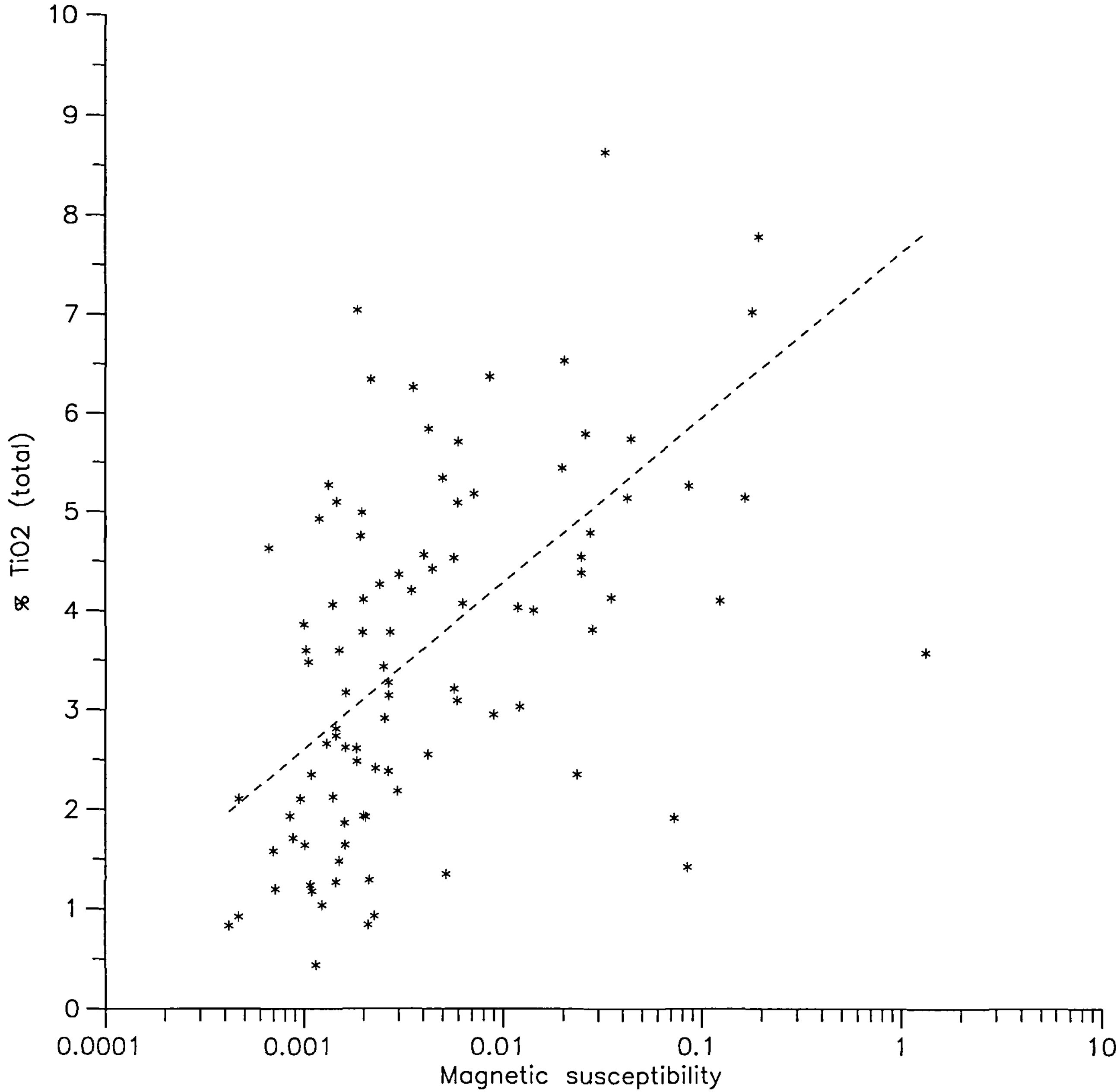


Figure 3. Drill-dust samples, Saurdal
% Rutile vs. Magnetic susceptibility

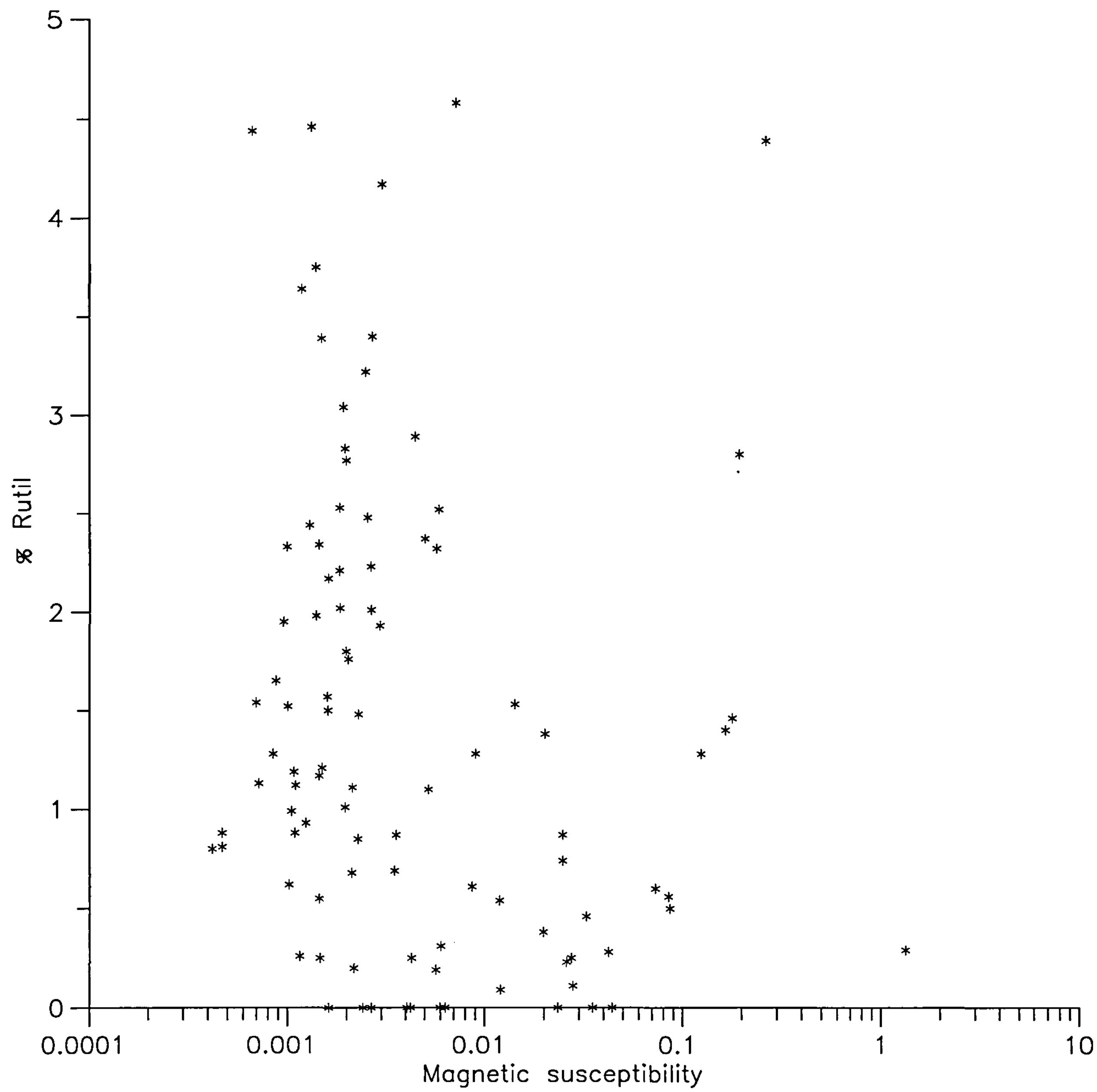


Figure 4. Drill-dust samples, Saurdal
% TiO2(Ilmenite) vs. Magnetic susceptibility

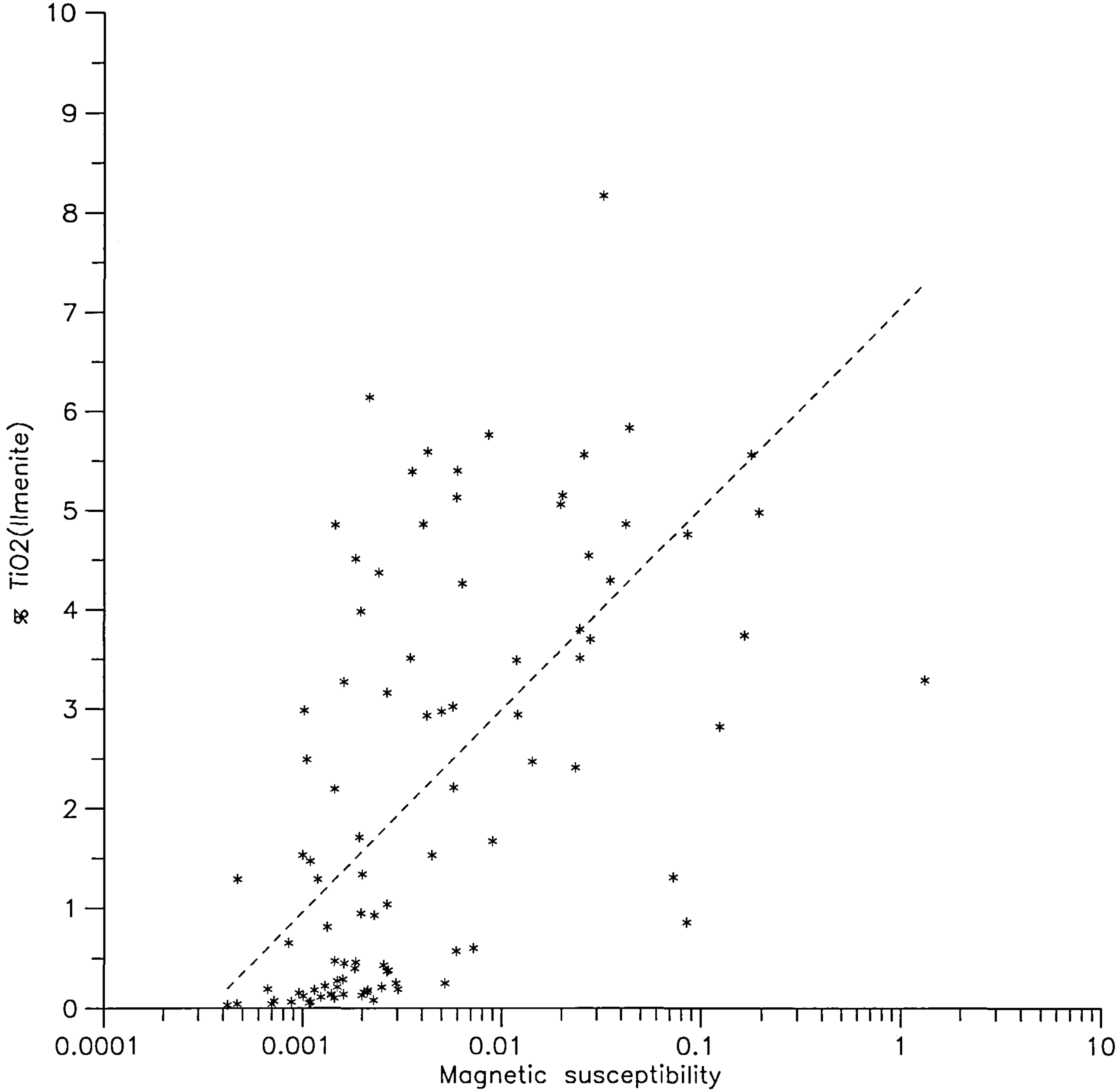
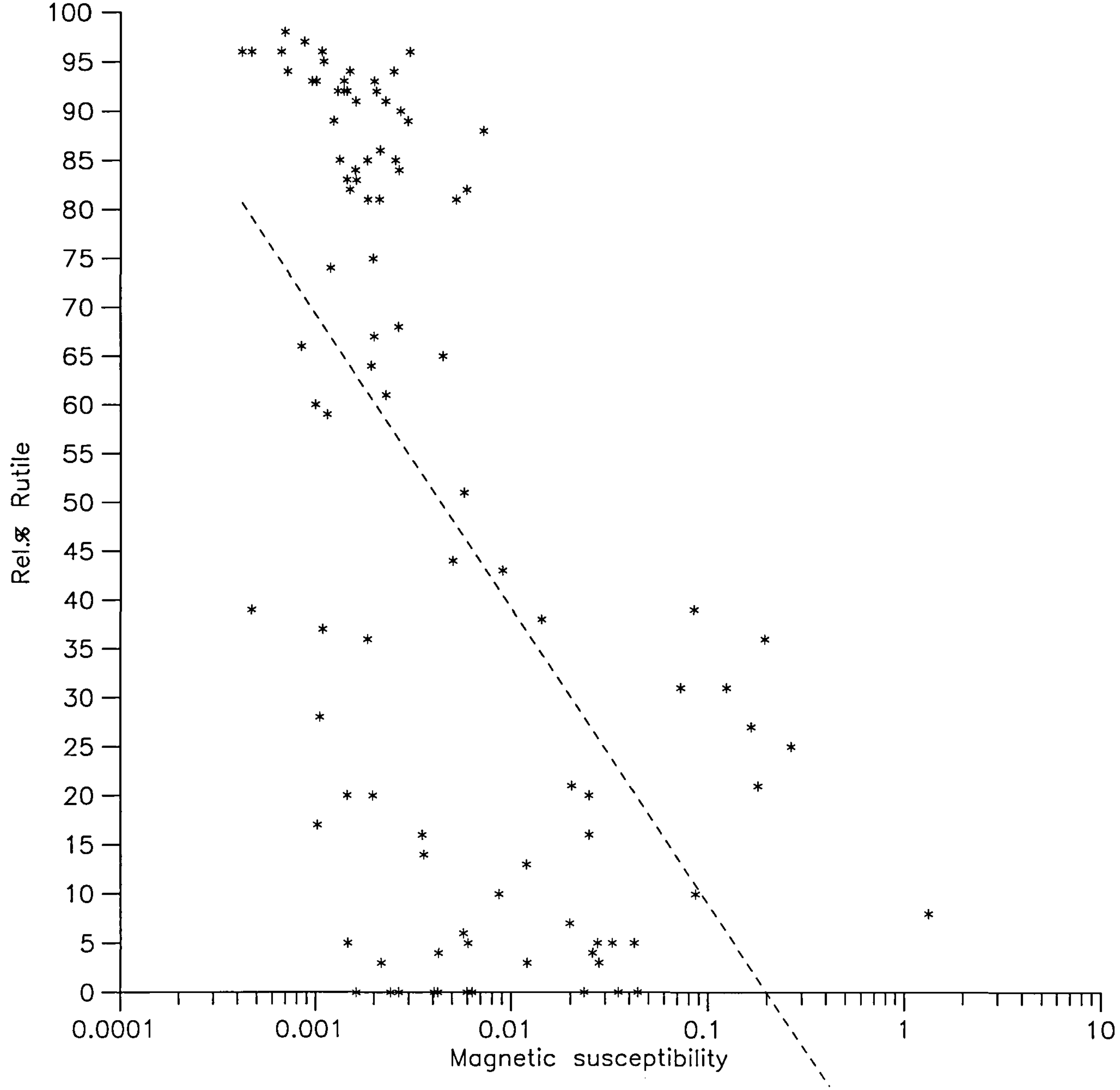
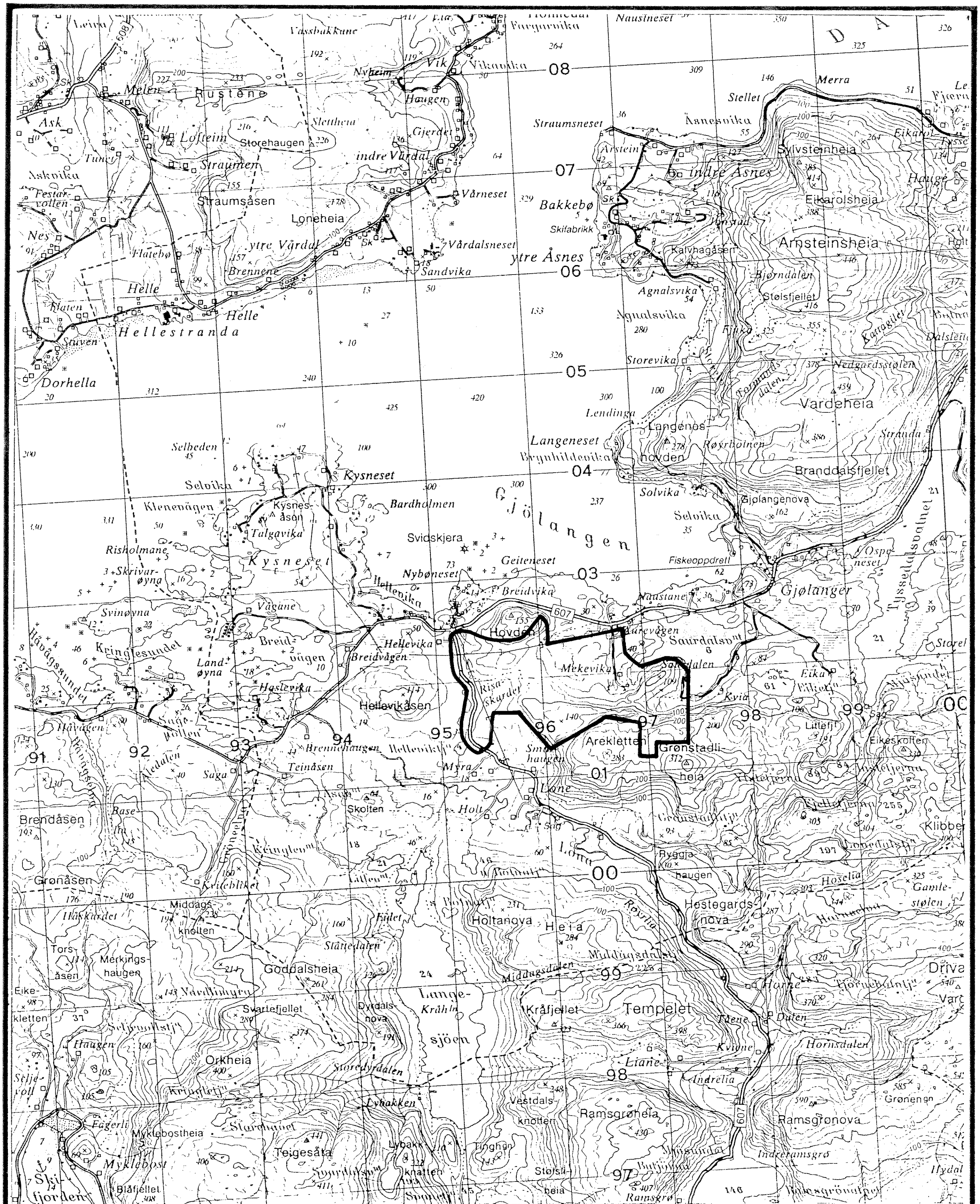


Figure 5. Drill–dust samples, Saurdal
Rel.% Rutile (% TiO2(rutile)/% TiO2(total)) vs. Magnetic susceptibility





NGU MAGNETIC GROUND SURVEY SAURDAL FJALER, SOGN OG FJORDANE	MÅLESTOKK 1:5000	MÅLT T.L	JUNI-93
		TEGN	
		TRAC	
		KFR.	
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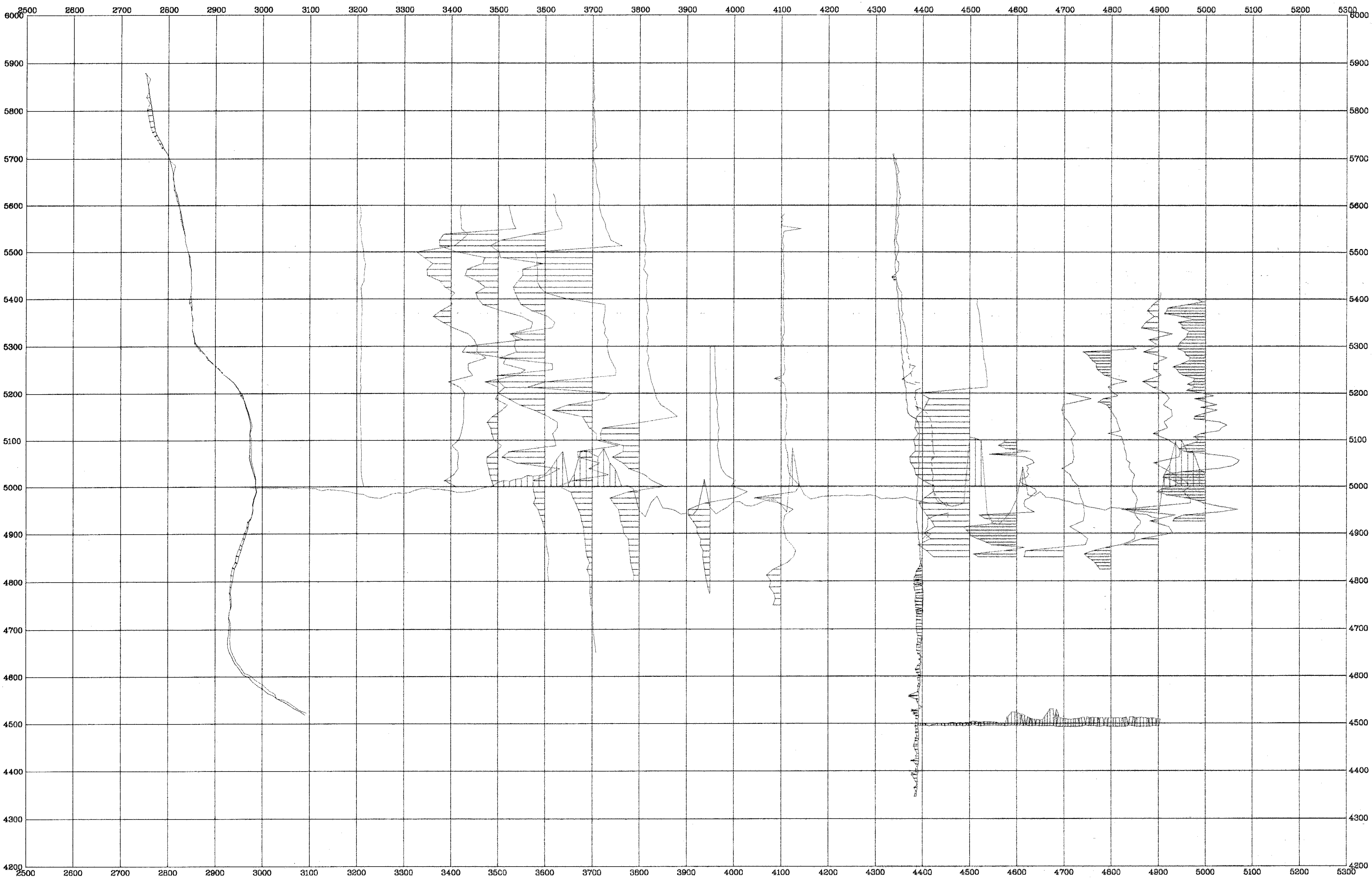


MAGNETIC TOTAL FIELD

Ground survey

SAURDAL

Fjaler

Sogn og Fjordane

MAP No. 93.100-02

PSEUDOLOGARITHMIC SCALE (nT)

10.000
5.000
2.000
1.000
500
0

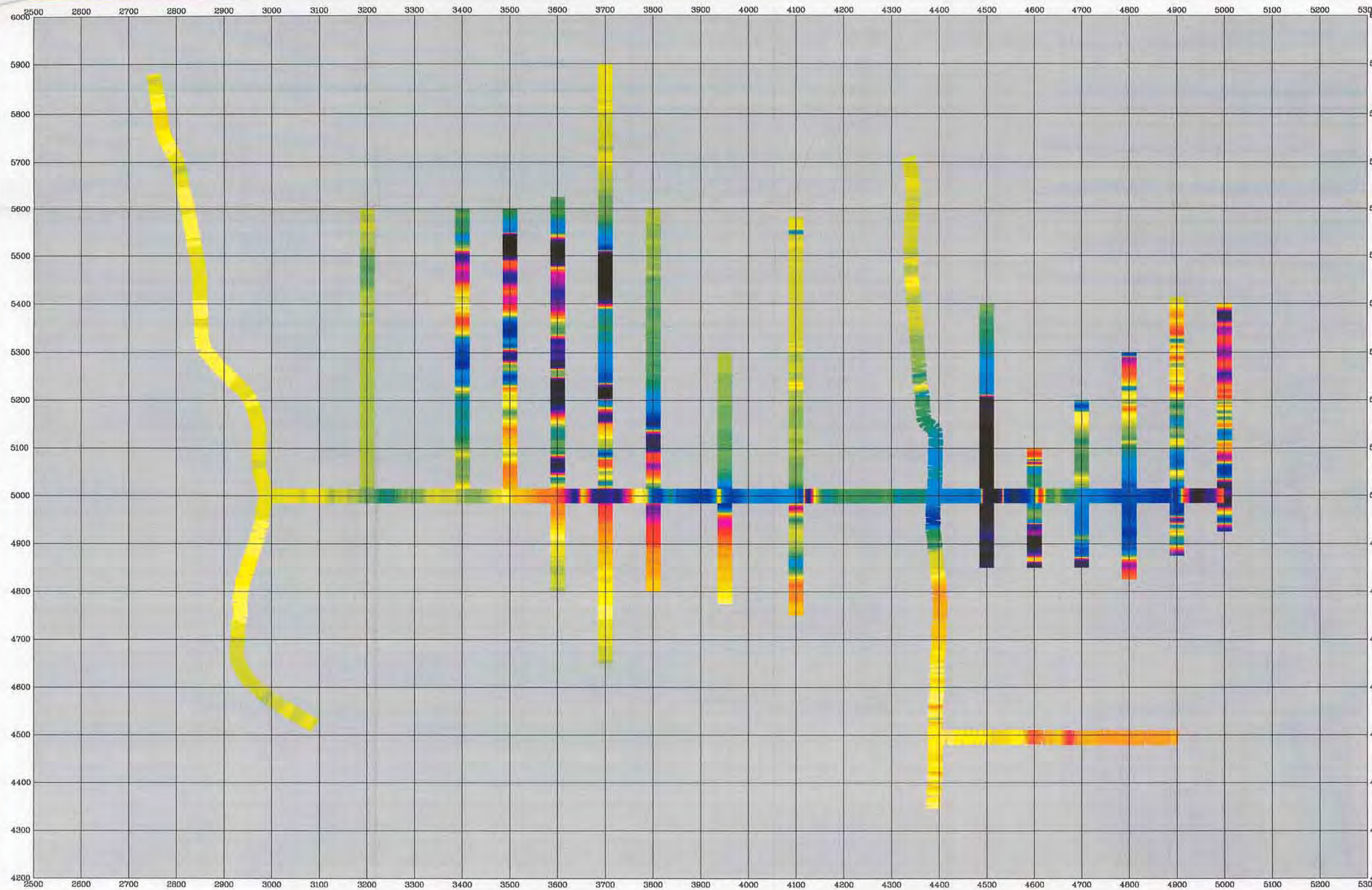
M 1: 5000

km

0,0 0,1 0,2 0,3

NGU 1993

GEOLOGICAL SURVEY OF NORWAY



MAGNETIC TOTAL FIELD

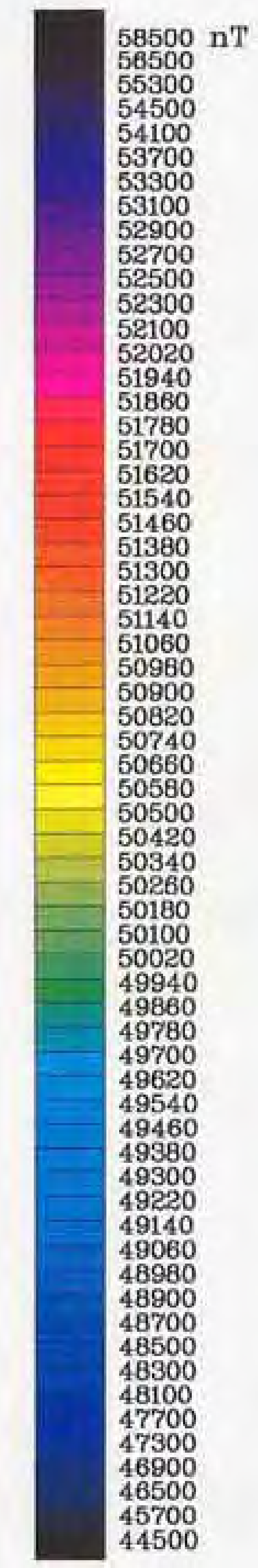
GROUND SURVEY

SAURDAL

Fjaler

Sogn og Fjordane

MAP No.:
93.100–03



M 1 : 5000

km
0.0 0.1 0.2 0.3

NGU 1993
GEOLOGICAL SURVEY OF NORWAY


N
LEGEND
MAGNETIC LEVELS
≥ 51200 nT
49800 - 51200 nT
≤ 49800 nT
QUARRY
MAGNETIC PROFILE
DRILL-DUST SAMPLES
NGU
MAGNETIC INTERPRETATION MAP
SAURDAL
FJALER, SOGN OG FJORDANE
MÅLESTOKK
1 : 5000
MÅLT T.L
JUNE-93
TEGN
TRAC
KFR
NORGES GEOLOGISKE UNDERSØKELSE
TRONDHEIM
TEGNING NR.
93.100-04
KARTBLAD NR.
1117 I
5600 Y
5400 Y
5200 Y
5000 Y
4800 Y
4600 Y
4450 Y
4500 Y
3200 X
3400 X
3600 X
3800 X
4000 X
4200 X
4400 X
4600 X
4800 X
5000 X
Hovden
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Leite
Oyisteholmen