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Helicopter measurements over the Gjølanger area

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REPORT

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Title:

Helicopter measurements over the Gjølanger area.

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County: Sogn og Fjordane	Commune: Fjaler
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Fieldwork carried out:	Date of report:	Project no.:	Person responsible:
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Summary:

A helicopterborne geophysical survey was undertaken by the Geological Survey of Norway (NGU) over the Gjølanger area in Sogn og Fjordane county. The primary geophysical target was rutile bearing eclogite bodies, and to investigate if helicopterborne geophysical surveying is suitable for prospecting of this type. The survey consisted nominally of 1065 line kilometres with a line spacing of 100 metres. The instrument package included magnetometer, VLF-EM and gammaray spectrometer.

This report describes equipment used for data acquisition. It also presents the processing sequence, and the results as colour maps in reduced scale. Maps in scale 1:20000 may be ordered from NGU.

Keywords: Geofysikk	Magnetometri	Radiometri
Elektomagnetisk måling		
		Fagrapport

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Coloured maps produced and included in this report (scale appr. 1:100 000, except figure 1) :

1. Introduction

A helicopterborne geophysical survey was undertaken by the Geological Survey of Norway over the Gjølanger area in Sogn og Fjordane County, Norway. The area is located in Norwegian M711-mapsheet 1117-I (Dale), illustrated in figure1. The survey was executed during mid October, 1994, and consisted nominally of a total of 1065 line kilometres. Line spacing was nominally 100 meters at a flight elevation of 60 meters. Equipment included magnetometer, a VLF(Very Low Frequency)-EM system and gamma ray spectrometer. Geophysical targets for this survey was rutile-bearing eclogite bodies in the Gjølanger area, and the survey was carried out to investigate if helicopterborne geophysical surveying is suitable for prospecting of this type. The survey was carried out in co-operation with DuPont, USA.

2. Operation conditions

Environmental variables: Weather conditions affects the results of geophysical mapping from helicopter. Rain and heavy wind leads to increased noiselevel and reduce the quality of the collected data. Rain affects the results of natural radioelement mapping surveying because waterlogged soil attenuates radiation from the ground. Areas of recent heavy rain should therefore be avoided during surveying. One of the daughter radionuclides in the U decay series of the radioactive gas, radon (^{222}Rn) can diffuse from the ground into the atmosphere. The rate of diffusions depends on such factors as air pressure, soil moisture, ground cover, wind and temperature. In general, radon concentrations near the ground are higher in still conditions in the early morning than in the afternoon. One of the decay products of radon is ^{214}Bi, which is the nuclide used to measure the U content of the ground. Under certain climatic conditions, and in some geographic areas, the effect of radon and its gamma ray emitting decay products can be significant and cause serious errors in the measurement of ground concentrations of uranium.

Operational variables: Flying height is an important operational variable. Gamma rays are attenuated by air in an exponential fashion. For an infinite slab source, the amplitude decreases by approximately one half for every 100 m of height. The amplitude at 120 m is therefore only about 35 % of the ground level amplitude. For a point source the fall-off is much greater. The measured total magnetic field will also vary due to variation in ground clearance. Normal acceptable variation in flying height is ±20% of the nominal height (60 meters) In hilly and mountainous terrain, it may be difficult to remain within these limits and keep constant flying speed. Safety considerations override the specifications of flying height and speed. Diurnal changes in the magnetic field affects the quality of the magnetic data. In periods with high diurnal changes (magnetic storm) flying is cancelled.

3. Aircraft and Equipment

Aircraft: The survey was flown using an Aerospatiale Ecureuil B-2 provided by Airlift A/S, based in Førde. Geophysical and ancillary equipment were installed in Trondheim at the Geological Survey of Norway.

Magnetometer: Magnetic measurements were made with a Scintrex, MEP 410 cesium magnetometer, which has a resolution of 0.01 nT. Magnetic data are recorded 10 times per second and the sensor is located approximately 15 meters below the helicopter.

Magnetic base station: Diurnal variations in the magnetic field were recorded with a Scintrex MP-3 magnetometer located at the base of helicopter operations. Data were recorded digitally on a personal computer and in analogue form on a thermal chart recorder. Clocks in the base station and the data acquisition system were synchronised prior to each flight to ensure diurnal effects could be accurately removed from the magnetic profile data.

Radiometrics: Radiometrics were recorded with a 1024 cubic inch crystal volume detector which was coupled to a Exploranium GR820 gamma-ray spectrometer system. The crystal is mounted under the helicopter.

VLF-EM system: VLF-EM measurements were made with a Herz Totem-2A VLF system. The system measures the field strength radiated from transmitters in the 15 to 30 kHz range which are operated by various national governments. The system provides total field and vertical quadrature measurements of the field from two such stations. The sensor was towed in a bird located approximately 10 meters below the helicopter.

Data Acquisition system: Data were acquired by a DAS-8 data acquisition system manufactured by RMS Instruments Ltd. Data were recorded both digitally and in real time with a thermal graphic printer. Digital data were subsequently transferred to a VAX at NGU for processing and map production. An integrated part of the data acquisition system is the analogue recorder, which allows output of the system to be monitored in real time.

Navigation: The survey was flown with satellite navigation, differentially uncorrected GPS navigation during flight. Differentially corrections were applied to the navigation data during processing giving an accuracy of ±15 m in the positioning.

Radar altimeter: A King KRA-10A radar altimeter was mounted in the helicopter to provide ground clearance information to an accuracy of 5% of flying height. The primary use of the radar altimeter data is an aid for maintaining constant ground clearance, but the data are also used in the processing of the measured radiometric data.

4 Field operations

Survey information: The location of the survey is the Gjølanger area, Sogn og Fjordane County, Norway (mapsheet 1117 I Dale), illustrated in figure 1. The survey consisted of 5 flights and nominally of a total of 1065 line kilometres. Line spacing was nominally 100 meters at a flight elevation of 60 meters. Aircraft ground speed was approximately 60 knots (100 km/h) or about 30 meters/second. The survey area is approximately 100 km^2 and consists of 144 north - south lines. The survey was carried out in the period 23.10-26.10.94. Field work was completed by Oddvar Blokkum and John Mogaard from NGU.

Survey conditions: The survey was flown in good weather conditions (during flights), but due to the season (late autumn) some areas of recent rain were flown. No levelling problems during processing of the radiometric data indicates that this had no effect on the quality of the collected radiometric data. The survey was flown in periods with small diurnal variations in the magnetic field (inside the specifications of a helicopterborne geophysical survey). Due to mountainous and hilly terrain it was impossible to keep constant flying height and speed.

Navigation: The survey was flown with a combination of GPS (differentially uncorrected during flight) and visual navigation. Flight path was then reconstructed by applying differential corrections to the digitally recorded GPS data, after each flight. The GPS basestation was located in Trondheim, operated by Seatex A/S.

Magnetic basestation: A magnetic basestation was operated so diurnal changes in the magnetic field could be removed from magnetic profile data. The basestation was located at Bringeland airport, Førde. The diurnal field was sampled every 4 seconds and was recorded both digitally for later processing and in analog format to assist in quality control.

Spectrometer background lines: Background lines were flown before and after every flight for a duration of approximately one minute. These lines were recorded digitally, and used for background correction during processing of the radiometric data.

VLF stations: Station NAA was used as the orthogonal channel whilst GBR was used for the inline chanel. Further pertinent information is:

Abbreviation	Location	Frequency
GBR	Rugby, England	16.0 kHz.
NAA	Cutler, Maine	24.0 kHz

5 Processing

Processing system: Data were processed on a microVax 3100 using software acquired from Aerodat Ltd, Canada. Colour maps were produced on a Calcomp 58000 plotter at NGU. Map illustrations included in this report were produced using software from Geosoft Inc, Canada, and plotted on a HP paintjet XL300.

Processing philosophy: Processed products were generated using minimal filtering, interpolation, blending of data between lines while gridding, and with minimal pruning of the data. Grids were filtered only to reduce raggedness of the contoured product, and not to blend data between lines. Any manual intervention in the levelling of the data is explained in the sections below. Thus the maps produced reflect the quality of the data used to generate them, and not that of an idealised geophysical dataset.

Gridding: Contour and colour presentations were prepared from gridded profile data at a 25 meter grid cell spacing. Profiles were gridded by interpolating in a east-west direction. The routine used for gridding was Akima Spline interpolation (Akima 1970).

Total field magnetics: Spikes were removed from the magnetic profile data. The diurnal variation was then subtracted form the profile data, assuming a base field of 50420 nT. The data was then filtered with a 5 point (0.5 second) Hanning filter. Data were then gridded at 25 meters and contoured, with a 5 by 5 point Hanning filter applied to the grid before contouring.

Total magnetic field gradient: The magnetic field vertical gradient map were prepared from the Hanning filtered total magnetic field using a 17 by 17 point vertical gradient filter. The resulting grid was then smoothed with a 5 by 5 point Hanning filter before contouring.

VLF: VLF in line and orthogonal total field channels were processed using a spike rejection algorithm, and then Hanning filtered using a 9 point (1.8 sec) filter. The VLF were then contoured and manually pruned to eliminate anomalies along profiles which could obviously have no geological origin. The data were re-gridded and filtered with a 5 by 5 point Hanning filter before contouring.

Radiometric data: The radiometric data were processed using software originally developed by Geometrics, USA. This software use the same procedure as recommended by IAEA (1991). Data are corrected for deadtime (spectrometer delay in the A/D converters) and normalised to cps (counts per second). Corrections for cosmic and aircraft backgrounds were made by using data from the spectrometer background lines. All radiometric data were normalised to a height of 250 feet using data from the radar altimeter. Stripping was carried out to remove effects of spectral overlap. The values of the stripping ratios were provided by the instrument producer. The date were gridded and filtered with a 7 by 7 Hanning filter before contouring. Due to low counts in the radiometric channels no ratio (K/U, K/Th and U/Th) maps were produced.

6 Products

The following is a list of maps produced for this job and available from NGU(scale 1:20 000) :

95.053-01	Total field magnetics
95.053-02	Calculated vertical magnetic gradient
95.053-03	VLF-line
95.053-04	VLF-ortho
95.053-05	Radiometric, total radiation
95.053-06	Radiometric, potassium radiation
95.053-07	Radiometric, uranium radiation
95.053-08	Radiometric, thorium radiation

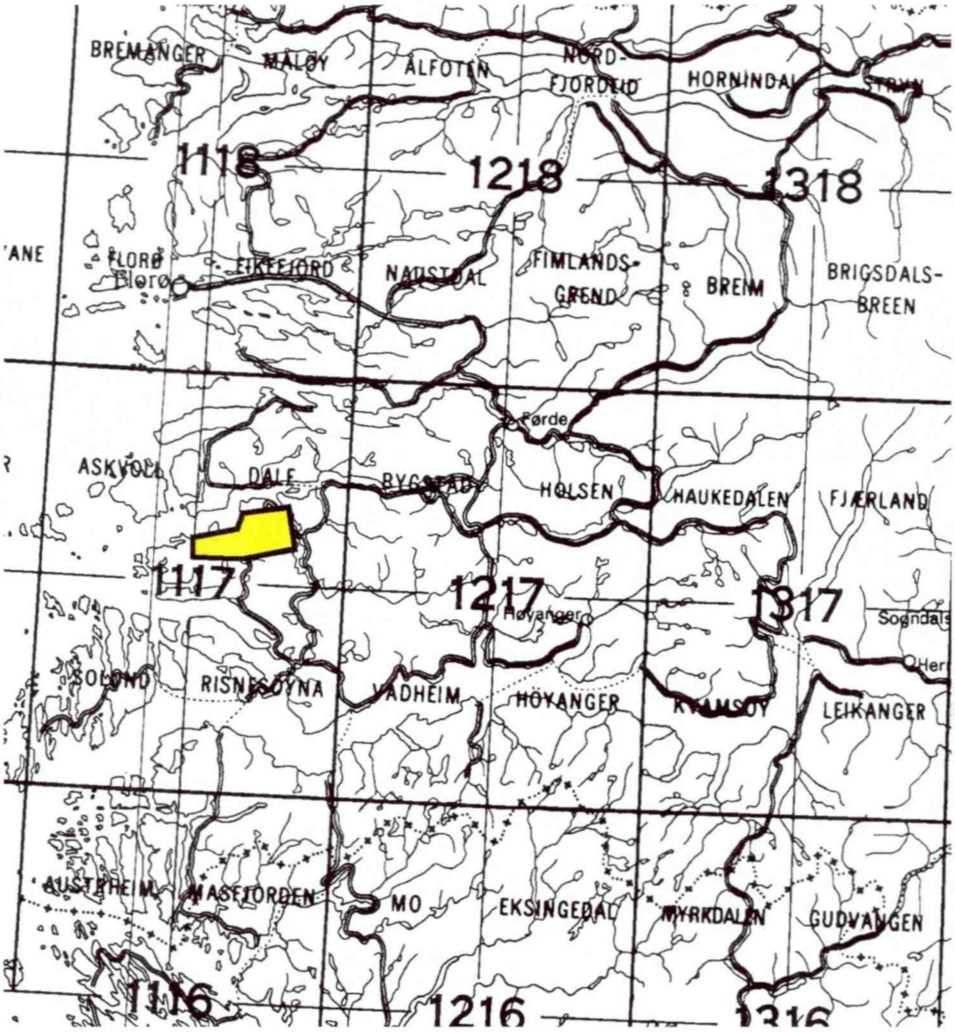
As an illustration, the following maps have been produced in approximately 1: 100 000 scale for this report (except figure 1) :

Figure 1:	Surveyed area (location)
Figure 2:	Total field magnetics
Figure 3:	Radiometric, total radiation
Figure 4:	Radiometric, potassium radiation
Figure 5:	VLF-line
Figure 6:	VLF-ortho

7 References

Akima, H 1970: A new method of interpolation and smooth curve fittings based on local procedures. Jour. of Ass. for computing Machinery 17, 589-602

International Atomic Energy Agency, Vienna 1991: Airborne gamma ray spectrometer surveying, technical reports series No 323, ISBN 92-0-125291-9



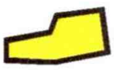
 **Surveyed area**

Figure 1 **Surveyed area (location)** **Gjølanger area** **Sogn og Fjordane Fylke**	**Meas. JOM/OB**	**OCT. 94**
	Draw SR	**20.03.95**
	Kommune Fjaler	
Geological Survey of Norway **Trondheim**	**Mapsheet 1117 I**	

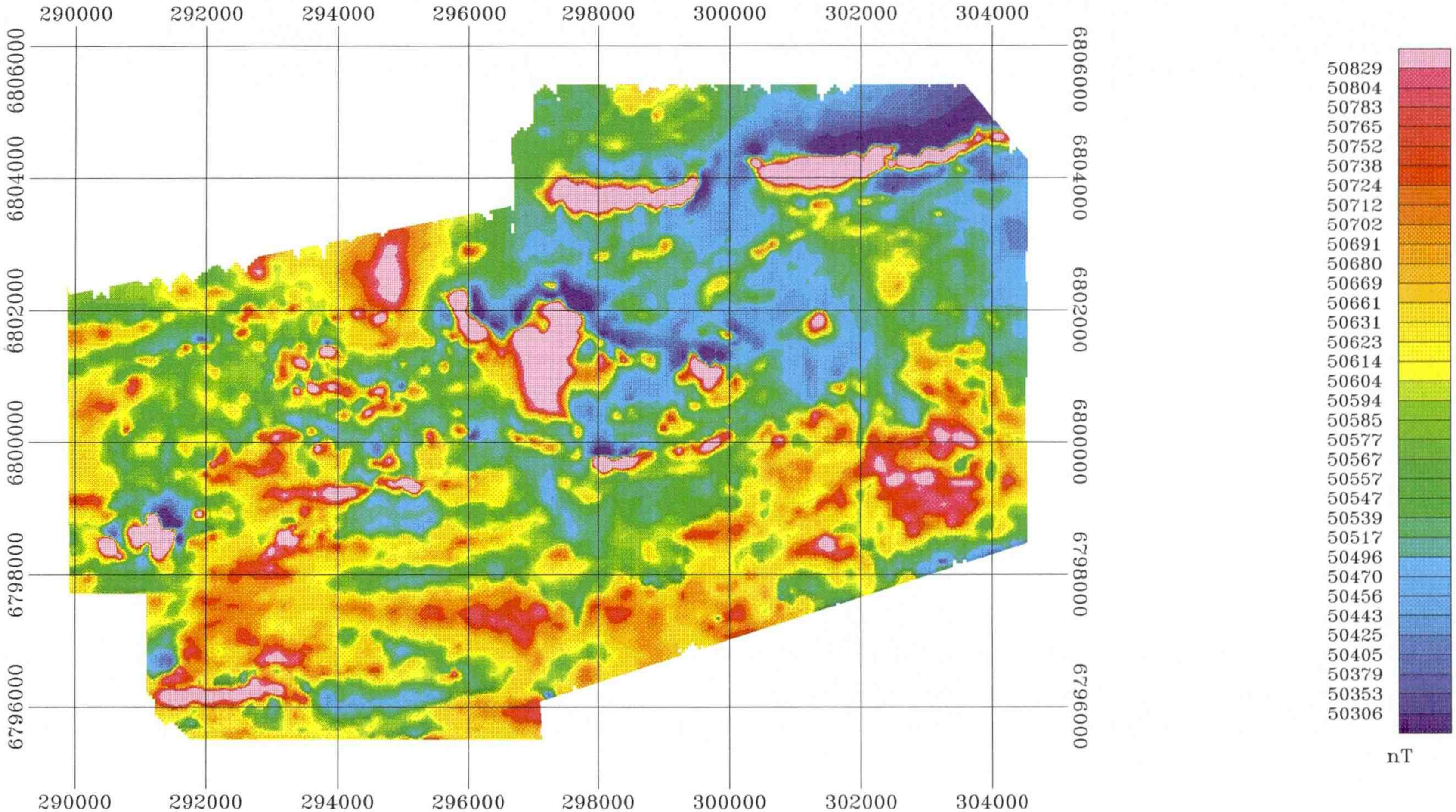


Figure 2 Total field magnetics Gjølanger area Sogn og Fjordane Fylke	Meas. JOM/OB 1994 Draw SR 07 03 95 Kommune Fjaler
Geological Survey of Norway Trondheim	Mapsheet 1117 I

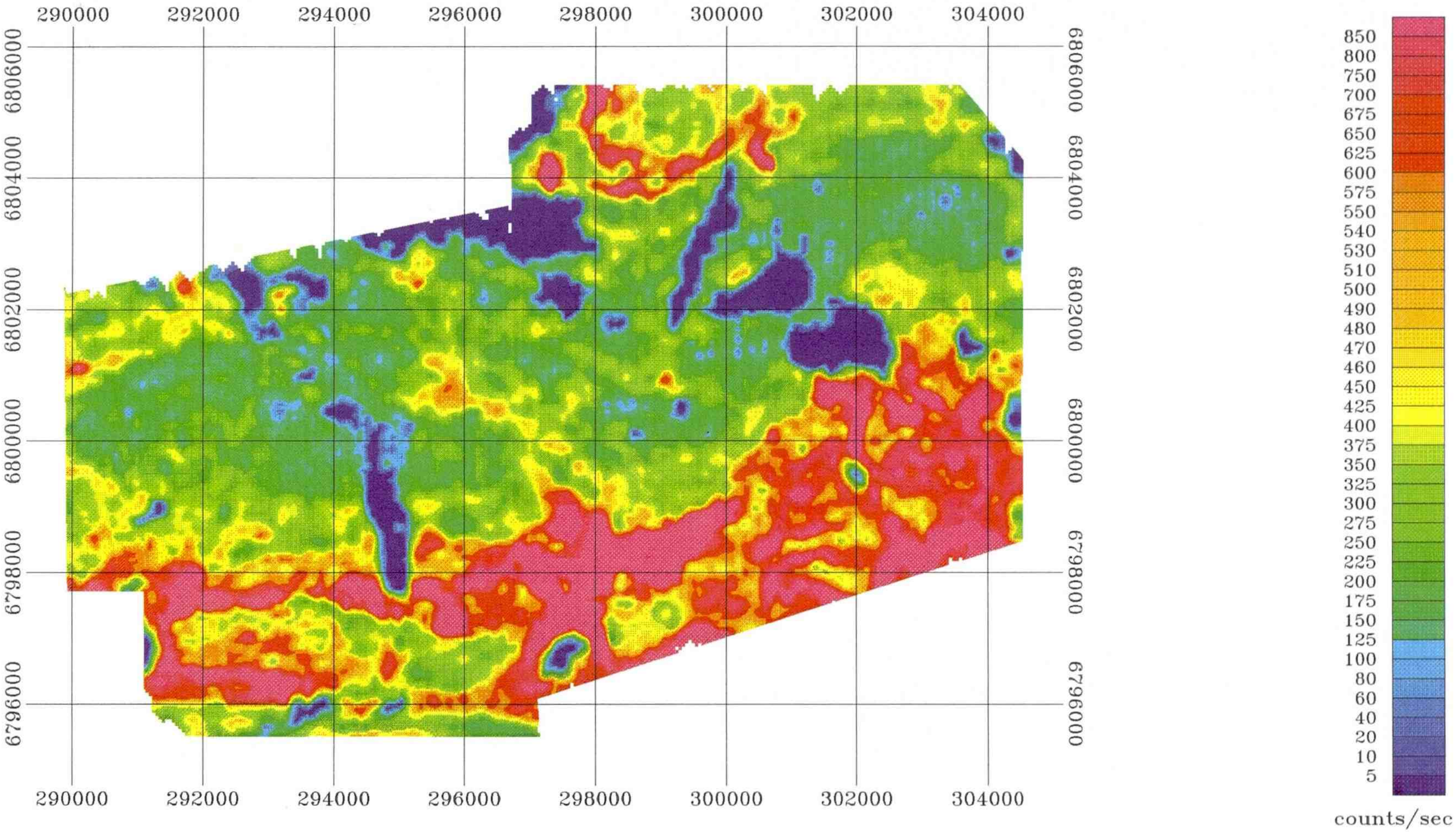


Figure 3 Total radiation
Gjølanger area
Sogn og Fjordane Fylke

Meas. JOM/OB 1994
Draw SR 07 03 95
Kommune Fjaler

Geological Survey of Norway
Trondheim

Mapsheet 1117 I

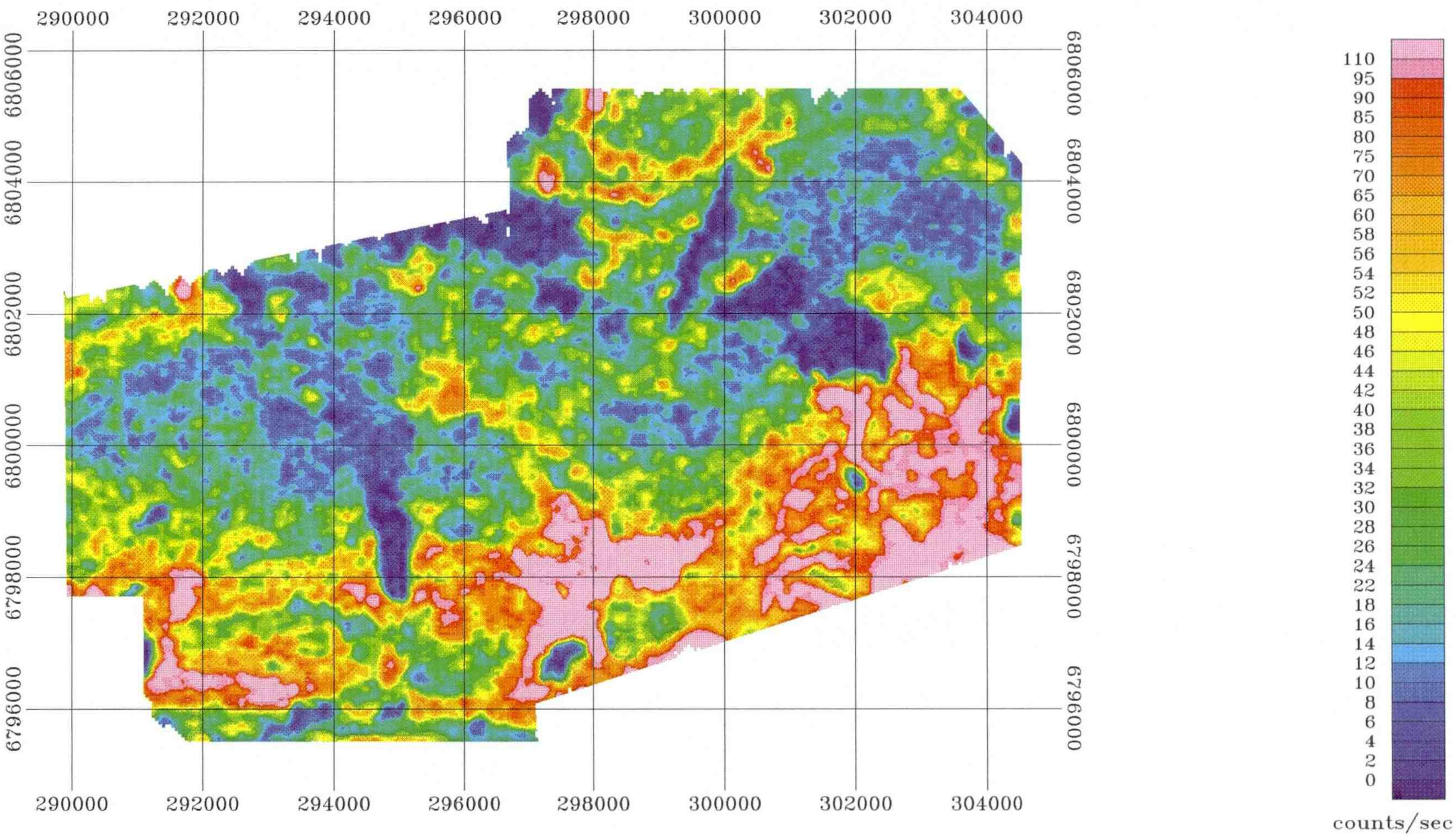


Figure 4 Potassium radiation Gjølanger area Sogn og Fjordane Fylke	Meas. JOM/OB 1994 Draw SR 07 03 95 Kommune Fjaler
Geological Survey of Norway Trondheim	Mapsheet 1117 I

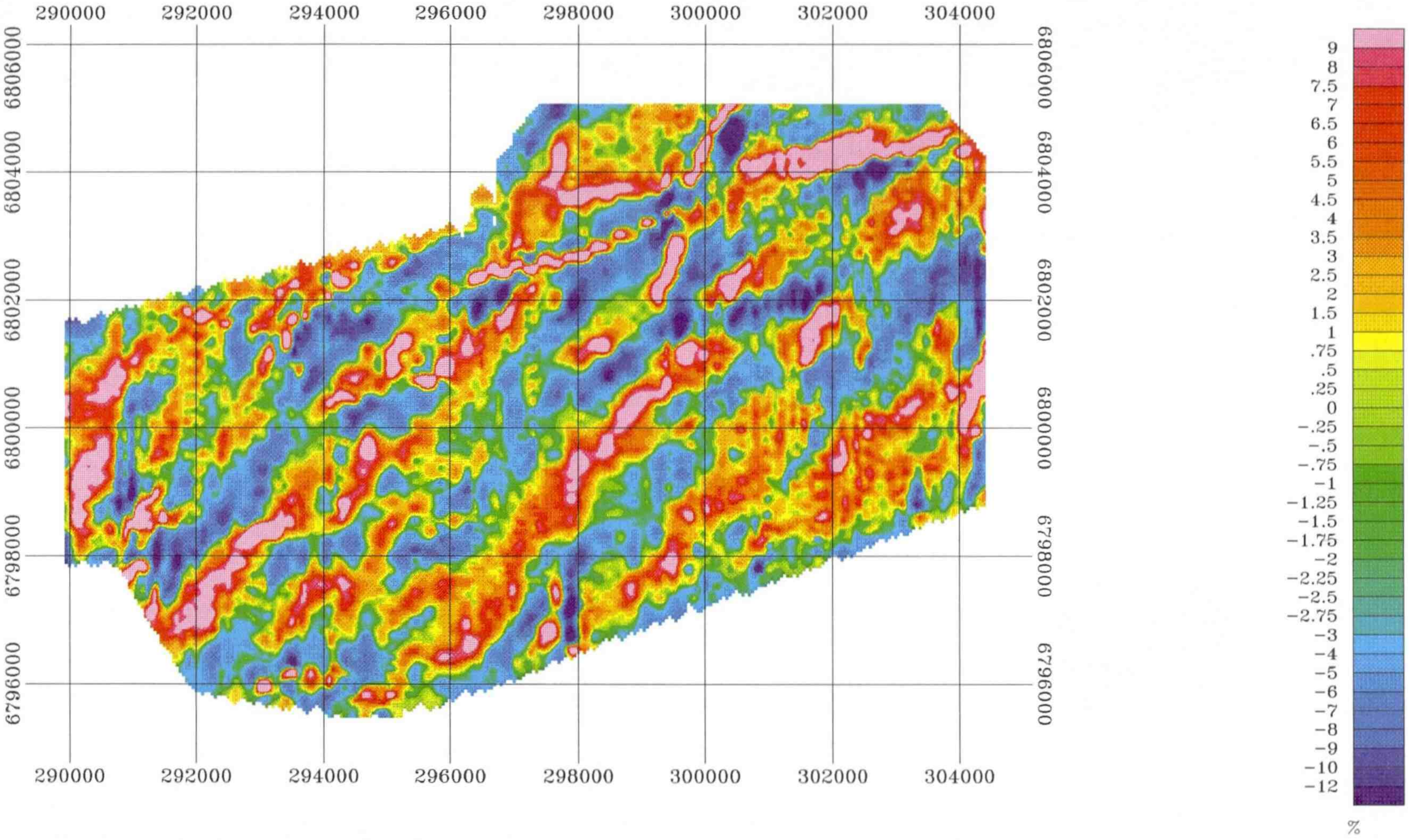


Figure 5 VLF–EM line Gjølanger area Sogn og Fjordane Fylke	Meas. JOM/OB 1994 Draw SR 07 03 95 Kommune Fjaler
Geological Survey of Norway Trondheim	Mapsheet 1117 I

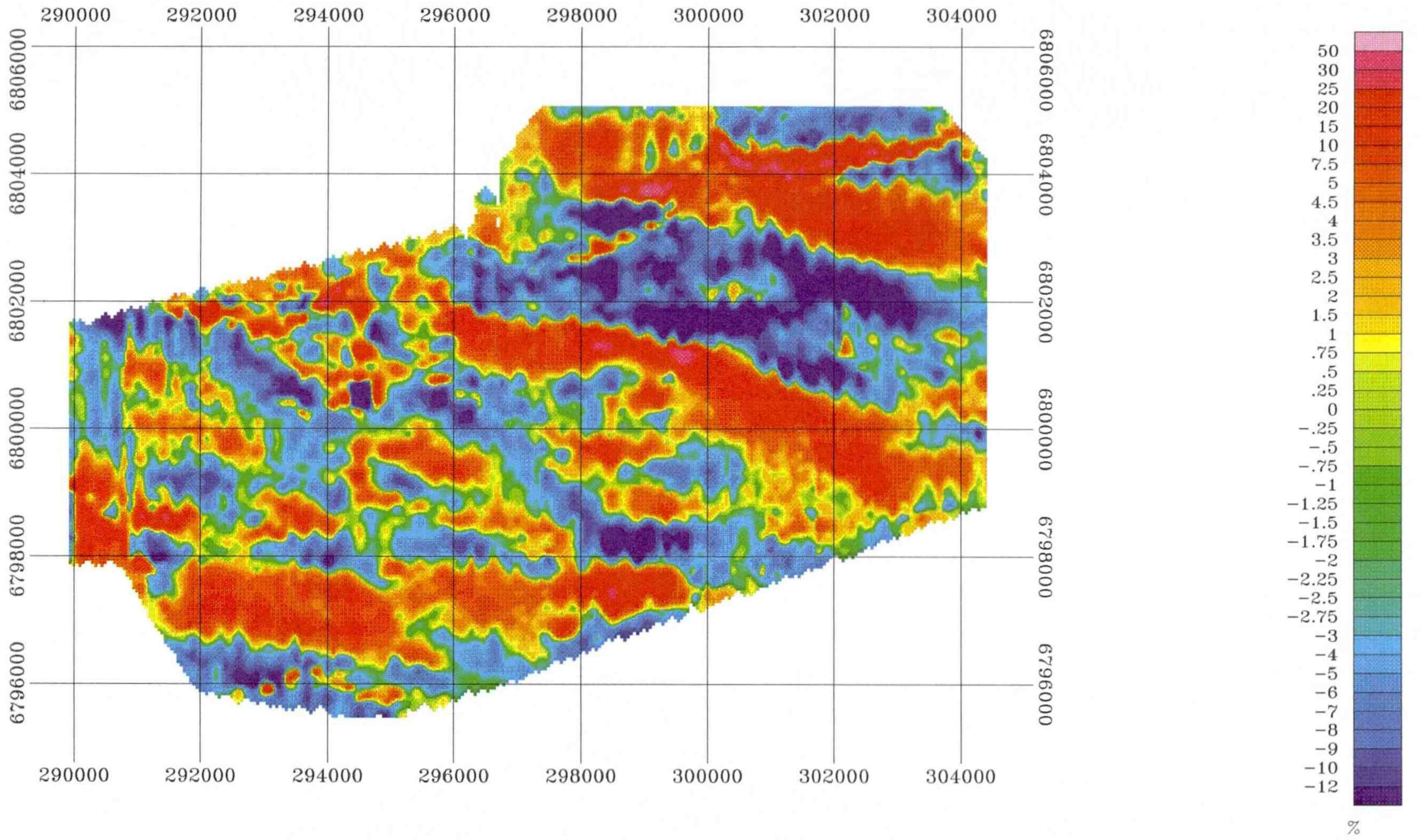


Figure 6 VLF−EM ortho Gjølanger area Sogn og Fjordane Fylke	Meas. JOM/OB 1994 Draw SR 07 03 95 Kommune Fjaler
Geological Survey of Norway Trondheim	Mapsheet 1117 I