NGU Report 2002.099

Data Acquisition and Processing - Helicopter Geophysical Survey, Ringvassøy

NGU
Norges geologiske undersøkelse
Geological Survey of Norway

Geological Survey of Norway
Leiv Eirikssons vei 39
N-7491 Trondheim, Norway
Tel.: 47 73 90 40 11
Telefax 47 73 92 16 20

REPORT

Report no.: 2002.099	ISSN 0800-3416	Grading: ~~Confidential until 10.01.2004~~ Åpen

Title: Data Acquisition and Processing - Helicopter Geophysical Survey, Ringvassøy	
Authors: John Olav Mogaard & Eirik Mauring	Client: Crew Development Corporation
County: Troms	Commune:
Map-sheet name (M=1:250.000) Helgøy, Tromsø	Map-sheet no. and -name (M=1:50.000) 1535 III Rebbenesøya, 1535 II Helgeøya, 1534 IV Ringvassøya, 1534 I Reinøya
Deposit name and grid-reference: Tverrfjellet 430000 - 7767000	Number of pages: 9 Price (NOK): Kr. 1156,- Map enclosures:

Fieldwork carried out:	Date of report:	Project no.:	Person responsible:
July 2002	19.12.2002	2990.01	Jan S. Rønning (signature)

Summary:

In July 2002, a helicopter geophysical survey was carried out over Ringvassøy, Troms county. The purpose of the surveys was to provide geophysical information for mineral exploration. The data were collected and processed by Geological Survey of Norway (NGU). A total of about 1589 line-km of electromagnetic (EM), very low frequency EM (VLF), radiometric, and magnetic data were acquired using a nominal 200-m line spacing. The nominal flying height was 60 m above ground level (AGL), and lines were flown in alternating directions at headings of South and North. Noise levels were within survey specifications.

All initial processing was carried out on a flight-by-flight basis. Magnetic data, consisting of total field measurements collected by a cesium vapor magnetometer, were corrected by removing diurnal variations as recorded at a magnetic base station at Hansnes, Ringvassøy. Radiometric data were reduced using three-channel processing according to procedures recommended by the International Atomic Energy Association. VLF data were reduced by removing a first-order trend along each line. EM data were leveled using data from frequent high altitude excursions above 300-m AGL. All final processed data were gridded using 50-m square cells. Geophysical maps were produced at a scale of 1:50 000 and are considered as standalone products

This report covers aspects of data acquisition and processing.

Keywords: Geofysikk (Geophysics)	Radiometri (Radiometrics)	Magnetometri (Magnetometry)
Elektromagnetisk måling (Electromagnetic measurements)	Databehandling (Data processing)	Fagrapport (Technical report)

CONTENTS

Maps available for order from NGU

Scale: 1:50 000

Map 2002.099-01:	Flight path.
Map 2002.099-02:	Total magnetic field.
Map 2002.099-03:	First vertical derivative of magnetic total field.
Map 2002.099-04:	EM stacked profiles 880 Hz coplanar.
Map 2002.099-05:	EM stacked profiles 980 Hz coaxial.
Map 2002.099-06:	EM stacked profiles 6606 Hz coplanar.
Map 2002.099-07:	EM stacked profiles 7001 Hz coaxial.
Map 2002.099-08:	EM stacked profiles 34133 Hz coplanar.
Map 2002.099-09:	EM apparent conductivity 6606 Hz coplanar.
Map 2002.099-10:	EM apparent conductivity 7001 Hz coaxial.
Map 2002.099-11.	Radiometric total count.
Map 2002.099-12.	Radiometric Potassium, ground concentration (%)
Map 2002.099-13.	Radiometric Uranium, ground concentration (ppm)
Map 2002.099-14.	Radiometric Thorium, ground concentration (ppm)
Map 2002.099-15.	VLF-EM total in-line.
Map 2002.099-16.	VLF-EM total orthogonal.

1 INTRODUCTION

In July, 2002, a helicopter geophysical survey was carried out over Ringvassøy, Troms county. The total area covered is 522 km^2, and the total distance flown was 1589 line-km (see Fig. 1). Magnetic, electromagnetic (EM), radiometric and very low frequency electromagnetic (VLF) data were collected. The primary objective of the survey was to provide geophysical information for mineral prospecting in the area.

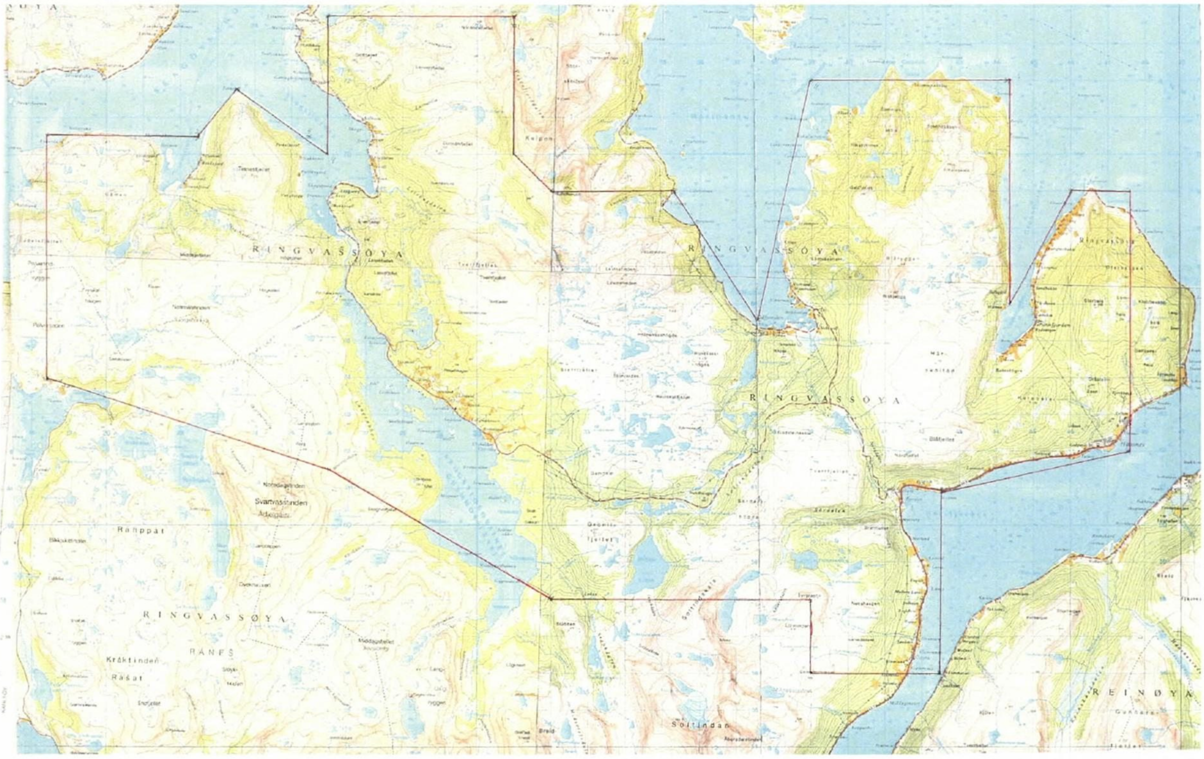

Fig. 1: Outline of the surveyed area

2 SURVEY VARIABLES AND CONDITIONS

Strong wind can increase the noise level of airborne geophysical data. High winds were not frequent during the survey, but were encountered occasionally.

2.1 Magnetic data

Diurnal changes in the earth's magnetic field affect magnetic data. The base station magnetic field never indicated strong magnetic storm conditions during the surveys. Magnetic data quality is excellent on all lines.

2.2 EM data

Strong vertical temperature gradients can affect EM leveling because the temperature at the 300-m nulling altitude is different from the temperature when the EM sensors are only 30 m above ground level. In addition to this, measuring at different altitudes may cause drift effects along profiles. Drift effects between nulling are corrected using standard linear interpolation, and the quality of data can ce characterized as good.

2.3 Radiometric data

Radiometric data can be negatively affected by atmospheric radon. However, in this survey radon contamination did not appear to be significant. The quality of the radiometric data is good.

2.4 VLF-EM data

VLF transmitters are controlled by naval defense authorities for communication with submarines, and their power output cannot be predicted or controlled during a survey. VLF data quality is generally good.

The resolution of geophysical sensors decrease exponentially with flying height. To achieve the greatest possible resolution, the aircraft should be flown as low as is safely possible. The target flying height was 60 meters above ground level, and this height was achieved over level terrain.

3 DATA ACQUISITION

The survey aircraft was an Areospatiale Ecureuil SA 350 B-3. Flying speed was approximately 100 km per hour (28 meters per second). Flight lines over survey area were in directions North and South with a flight line spacing of 200 m. The radiometric sensors were mounted immediately beneath the helicopter. VLF sensors were suspended on a cable 10 m beneath the helicopter. The 5-frequency EM system and the magnetometer were enclosed in a 6-m long 'bird' suspended by cable 30 m beneath the helicopter.

NGU personnel responsible for data acquisition were John Mogaard and Janusz Koziel.

3.1 Magnetic measurements

A Scintrex CS-2 cesium vapor magnetometer was used. The magnetometer resolution is 0.01 nT. Sampling rate was 10 measurements per second (approximately 3 meter spacing).

A Scintrex MP-3 proton precession magnetometer was located at Hansnes, Ringvassøy, and was used for base station measurements. The base station magnetometer was synchronized with the helicopter-borne magnetometer to ensure proper removal of diurnal magnetic changes from the helicopter magnetic measurements. The magnetic total field at the base station was digitally recorded during flights at a rate of 15 measurements per minute.

3.2 Electromagnetic system

The EM system used was the 5-frequency Hummingbird system made in Canada by Geotech, Ltd. The Hummingbird records data at a sampling rate of 40 measurements per second. It has two coil orientations—vertical coaxial (VCA) and horizontal coplanar (HCP). The VCA coils operate at 980 Hz and 7001 Hz. The HCP coils operate at 880 Hz, 6606 Hz, and 34133 Hz. The transmitter-receiver separation is 6 m for lower frequencies and 4.2 m for 34133 Hz. The manufacturer specified noise level for each frequency is 1-2 ppm.

3.3 Radiometric measurements

The radiometric system, purchased from Exploranium, Ltd. of Canada, consists of four sodium iodide (NaI) crystals (model GPX-1024-256) having a total volume of 1024 cubic inches (16.78 liter). The NaI crystals are coupled to a 256 channel Exploranium GR820 gamma ray spectrometer. Registration rate is one per second. An upward looking crystal was used in this survey, and can if desired be used to correct for airborne radon contamination. The crystal package is mounted in a frame underneath the helicopter.

The spectrometer is an energy pulse height analyzer that sorts data into 256 channels according to energy magnitude. Every channel is 0.012 MeV wide. The full 256 channel spectrum was recorded. Windows constructed from selected groups of channels record the contributions of Potassium-40, Bismuth-214 (the daughter product of Uranium-238), and Thallium-208 (the daughter product of Thorium-232). These windows are labeled potassium, uranium, and thorium respectively. A fourth window—the total count window—measures gamma ray energy between 0.4 MeV and 3 MeV.

3.4 VLF-EM system

The VLF measurements were made with Totem-2A VLF receivers purchased from Hertz Industries, Ltd. of Canada. The three receivers are mounted orthogonally and measure fields in the direction of the flight line (in-line), normal to the flight direction (orthogonal), and vertical fields. The energy sources for VLF signals are powerful transmitters used by military organizations for communication with submarines. Their frequencies are in the range 15-30 kHz, depending on the individual transmitter. The VLF receivers are suspended 10 meters beneath the helicopter. Registration rate is five per second (sample spacing of approx. 6 m).

Good VLF targets are thin, shallow (a few tens of meters), near vertical conductors which are approximately on a line with one of the monitored VLF transmitters. For this survey, the primary VLF stations monitored were GBR (16 kHz, Rugby, England), used for in-line receiver measurements, and NAA (24 kHz, Cutler, Maine, USA), used for orthogonal receiver measurements. Other stations were used when either of these stations ceased transmission.

3.5 Navigation, altimetry, and data logging

The navigation system used was an Ashtech G12, 12 channel receiver. Position accuracy using this system is better than 5 m.

The navigation console was a PNAV 2001 manufactured by the Picodas Group, Ltd. of Canada. Profile line data are entered into the console and the helicopter pilot can view the traces. The pilot can see his position with respect to these predefined lines and adjust accordingly.

The helicopter is equipped with a King KRA-430 radar altimeter that measured height above ground level, and was recorded digitally and displayed before the pilot. The altimeter is accurate to 5 percent of the true flying height.

The data logging system is an integral part of the Hummingbird electromagnetic system, manufactured by Geotech, Ltd. of Canada. Data is recorded both digitally and analog.

4 PROCESSING

The data were processed at the Geological Survey of Norway in Trondheim using Geosoft processing software (Geosoft, 1996) designed for NT operating systems. All maps were constructed from grids using a 50-m grid cell. Obvious inaccuracies in navigation were manually removed from the data. The datum used was WGS84 and the projection was UTM zone 34.

Total field magnetic data: The data were inspected flight-by-flight and any cultural anomalies were identified and manually removed. A base station correction was applied to each flight using corrections based on the diurnal measurements from the base station magnetometer at Hansnes.

Radiometric data: The Geosoft radiometric processing package (Geosoft, 1995) follows the three channel processing procedure outlined in International Atomic Energy Agency Technical Report No. 323 (IAEA, 1991). A narrow nonlinear filter was applied to the radiometric data to remove spikes and a low pass filter was applied to smooth the data slightly prior to further processing. Background radiation levels were estimated by flying background calibration lines over water, usually two per flight, and by analyzing flight lines passing over lakes. After background reduction, the data were corrected for spectral overlap using experimentally determined stripping ratios. Atmospheric radon does not appear to have been a major source of data contamination in any of the flights. The processed data are presented as ground concentrations of the uranium, potassium, and thorium, and as ground level total counts.

VLF-EM data: Along each line of the raw VLF data channels - orthogonal and in-line receivers – a constant base level was estimated and removed, leaving lines containing residual anomalies. The data were micro-levelled using a differential median filter (Mauring & Kihle, 2000). The maps from the gridded data show VLF anomalies from a receiver orthogonal to the flight direction, and anomalies from the receiver in-line with the flight direction. In general, the maximum of the VLF anomaly should be centered over the conductive structure causing the anomaly.

EM data: EM data were processed on a flight-by-flight basis. Zero levels and drift control for each frequency were obtained by frequent excursions above 300m AGL, usually at the end of each flight line. A nonlinear filter was applied to all EM data to remove data spikes resulting from sferics. Before levelling, all data were mildly low passed using a 45 m filter. Noise levels for all frequencies were within an envelope of 2 ppm, and the four lower frequencies usually had a noise level of about 1 ppm. Noise levels over 2 ppm occurred near powerlines. Dikes or other structures having high magnetic susceptibility may produce negatively oriented in-phase anomalies. Apparent conductivity maps were computed for 6606 Hz coplanar and 7001 Hz coaxial using least squares inversion and a homogeneous half space model. In most cases the inversion was performed on the in phase and the quadrature data combined. In instances where the quadrature data was clearly superior to the in phase data, the inversion was performed on the quadrature component only.

5 MAPS PRODUCED

Maps were produced at a scale of 1:50 000, and presented with contours and in shaded-relief. EM data were produced using stacked plots. Shading was from the northeast at 45° sun inclination above the horizon. The grid cell size for all maps was 50 meters. Originally, it was planned to make resistivity maps from 980 Hz VCA and 7001 Hz VCA. Based on discussions with Crew's representative Bernt Røsholdt, it was decided to make conductivity maps instead of resistivity maps. Very low signal for 980 Hz VCA made it difficult to produce a continuous conductivity map, and in agreement with Bernt Røsholdt, 6606 Hz HCP was chosen for the second conductivity map.

A list of the 16 maps produced is shown on page 3 of this report. These maps can be ordered from NGU either in digital form or as hard-copies.

6 REFERENCES

Geosoft Inc., 1995: OASIS Airborne Radiometric Processing System Version 1.0 User's Guide, *Geosoft Incorporated, Toronto.*

Geosoft Inc., 1996: OASIS montaj Version 4.0 User Guide, *Geosoft Incorporated, Toronto.*

IAEA, 1991: Airborne Gamma Ray Spectrometer Surveying, Technical Report 323, *International Atomic Energy Agency, Vienna,* 97 pp.

Mauring, E. & Kihle, O. 2000: Micro-levelling of aeromagnetic data using a moving differential median filter. *NGU Report 2000.053.*