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Appendix to report No. 346/74/24

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(Translation of NGU report No. 1269)

Client: A/S Sulfidmalm

NGU report no. 1269

Helicopter-borne magnetic and electromagnetic survey over SKRATÅS STEINKJER, NORD-TRØNDELAG

17 - 29 June 1974

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INTRODUCTION

The geophysical department of NGU received a contract from A/S Sulfidmalm to carry out a geophysical survey by helicopter over an area (in this report called Skratås) northeast of Steinkjer, North-Trøndelag. The area, which covers about 100 sq. kms, is situated along the south-eastern side of Snåsavatnet and extends from Trondheimsfjord in the south , to Valøy in the north. NGU has previously carried out an aeromagnetic survey (by fixed wing aircraft) over the same area.

SURVEY CONDITIONS

Weather conditions should be reasonably good in order to get successful results. Such measurements cannot be carried out in strong winds, rain or fog. If the wind is too strong, the measuring probe would swing, resulting in a high noise level in the receiver. The noise also increases in rain, and moreover the visibility would be reduced so that the low flight altitude could be maintained. During the measurements over the Skratås area the weather conditions were good.

The speed of the helicopter is held to about 100 kph during the actual survey, and the height over the ground is kept constant at about 170 ft. The base map must be of good quality so that the navigator could give the correct course and height. This is especially important if one has few reference points on the ground to go by, like rivers, lakes, roads etc. A photomosaic of 1:15 000 scale was used during this programme. The quality of the mosaic was good, and there were few navigation problems.

During magnetic surveys, either from a fixed wing aircraft, from a helicopter or on the ground, one must guard oneself against the fact that variations of the magnetic field of the earth one measures are dependent on time. This is achieved by placing a magnetometer in the survey area which registers just such variations. On days with high magnetic activity the survey must be discontinued. We did not have any days with such high variations in the magnetic field.

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The electromagnetic readings are often interfered by radio transmitters in the vicinity of the survey area, even if they operate with frequencies which are quite different to the frequencies of our instruments. The survey over Skratås area was especially disturbed by an FM transmitter on Byafjellet near Steinkjer and by a military station at Rinnleiret, Verdal. The signals from the latter could be filtered away, thanks to its relatively large distance, but the FM transmitter on Byafjellet did make serious disturbances in the southern part of the survey area. In addition, a high voltage power line went through the southern part of the field. The radiation from this interfered with the electric readings in such a way that there remained an uncovered zone of 150-200 m on either side of this line.

SURVEY METHODS, INSTRUMENTS

During the survey of the Skratås area, two of the physical properties of the earth were measured, i.e. the total magnetic field of the earth, and the variations of the electrical conductivity on the ground under the helicopter.

The magnetic field was measured with a Sander proton magnetometer, type NPM 4. This instrument consists of a measuring probe and an amplifier, which are placed in a cigar-shaped instrument container, 65 ft below the helicopter. Due to the large distance between the probe and the helicopter, the magnetic field was measured with great accuracy. The proton magnetometer is a point-registering instrument. The time-interval between each measuring point should be as short as possible, but if this is too short, the accuracy of the instrument would suffer. During the measurements over the Skratås area this interval was 1 second. The speed of the helicopter being 100 kph, this would mean that one reading is made every 25 meters. One tries to keep the altitude of the helicopter at 170 ft, and the instrument container would then be 100 ft over the ground.

The instrument container also houses the mainpart of the electromagnetic instruments which are of the type Sander EM 3.

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The transmitting and receiving coils are placed at a distance of about 7 m distance from each other, at either end of the container. This is of the coaxial type, and the system is very little influenced by noise because of its special construction. The depth penetration is consequently relatively large, and is indicated by Sander Geophysics Ltd to be about 100 m under the ground surface in favourable conditions. The system measures both the real and imaginary components of the signals from the conductor under the measuring probe.

This "anomaly signal" is read in parts per million (ppm) of the signal that the transmitting coil induces in the receiver coil. The system is indicated to have a noise limit of 0.5 ppm for the imaginary component, and 1 ppm for the real component. These figures are naturally related to the most favourable cases with quiet weather and good topographic conditions.

The registration of the magnetic and electromagnetic data was doneiin the helicopter on a six-channeled oscillograph recorder of the type Century 444. Two channels were used for magnetic, and two for electromagnetic readings. The fith channel was used for the recording of the data from the radar altimeter of the type Bonzer TR 70. This measures the height of the helicopter over the ground with an accuracy within 10 ft. The sixth channel recorded the fiducial points from the Sander CM 3-12 camera. This photographs the ground every other second, and the film is numbered with the same code as used on the recording paper. To make the plotting of the registered anomalies easier, the navigator on the helicopter marks of the easily recognisable points along the traverses on the photo mosaics. Such points are also registered on the recording paper.

While the survey was being carried out, a magnetic ground station was established at the base in Steinkjer in order to register, and to be warned by, the diurnal changes in the earth's magnetic field. This station of an Elsec proton magnetometer and a recorder, and the field is measured and recorded with an accuracy of ± 1 gamma.

OPERATION

The limits of the area, the bearing of the profile-lines, and the distances between these lines, were determined after consultation with A/S Sulfidmalm. The bearing was 330°/150° and the profile interval was 200 meters. A total of 510 profile-kilometers was flown.

The aerial survey was carried out in the period of 17 - 25 June and a field by By farm was used as landing ground for the helicopter.

The helicopter was a Hughes 500, owned by A/S Helilift, Hamar, and the crew was:

Helge Siljeberg pilot

Finn Hegle mechanic

PROCESSING

The processing of the results is the plotting of the correct profile courses on the photo mosaic. On the average, one point was plotted for each flown kilometer. We have assumed that the helicopter had kept the same course and speed between these points. The transfer of the measured magnetic data to the plotted profiles on the mosaics was then carried out after the scale of the profile papers was adjusted to the scale of the mosaic. The magnetic data are then contoured with 100 gammas' interval. The electromagnetic readings were given corrections with the help of the radar altimeter's recording, to a special reference height of 170 ft. This is done to eliminate the variations in the amplitude of the anomalies due to the varying heights between the helicopter and the ground. The electromagnetic results are then plotted on the mosaic and contoured in the same fashion as the magnetic results. The contoured intervals we used were 0, 5, 10, 20......ppm.

RESULTS

The results of the survey over the Skratås area are presented on the following maps in a scale 1:15 000:

2 mags. contour maps,	with flight lines	Pl. 1269/1-2
2 electromagn. contour maps, real component	with flight lines	Pl. 1269/3-4
2 electromagn. contour maps, imiginary component	with flight lines	Pl. 1269/5-6
2 interpretation maps,	with flight lines	Pl. 1269/7-8

When making the interpretation of the electromagnetic anomalies, both the imaginary and real components should be used. If one assumes that the conductors in the area can be regarded as thin vertical sheets, with large extention in both strike directions and in the down-dip, (larger than 200 - 300 m length and 100 m depth), one can form some idea of the conductivity by comparing the real and the imaginary components. One usually operates with the product of the conductivity and the thickness of the conductor, (sigma.t).

When making the interpretation, one should be aware of the fact that Sanders system, and the majority of other helicopter systems, favourize vertically standing conductors, because of the vertical, coaxial symmetry of the transmitting and receiving coils. Thin, horizontally lying conductors will therefore be bad targets for such systems.

Strong magnetic anomalies can often be detected by the EM-system. These can give positive real components as opposed to the usual conductive objects which give negative real components.

The interpretation maps in this report are worked out from the response curves published by Sander Geophysics Ltd. The interpretation of the electromagnetic anomalies are based on the assumptions mentioned above, with regard to the geometry, and moreover on the assumption that the conductor has the same magnetic permeability as the surrounding rocks.

The numbers would then indicate the measure of the conductivity. One can see from the interpretation maps that the majority of the anomalies have (sigma.t) values lying between 0 and 20. If one uses the interpretation map with the anomaly maps of the real and imaginary components, one sees that many anomalies with low (sigma.t) values form long conductors and have strong real and imaginary values, while in contrast, high (sigma.t) values can often refer to small real and imaginary anomalies. It would seem that the anomalies in areas with low (sigma.t) values are caused by quarternary geological formations like marine clay. Only one of the electromagnetic anomalies have very good (sigma.t) value, (100). This lies near the FM-transmitter on Byafjellet and this seems to be the best choice in the Skratås area, if one wants to use the (sigma.t) values to make the priority list. As stated before, one can use the interpretation map to make such a priority list to follow up electromagnetic anomalies, but one should always be aware of the assumptions on which these interpretations are based, and the knowledge of the geology should also be taken into account when making these priorities.

Trondheim, December 16, 1974

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