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INTERPRETATION REPORT

AIRBORNE MAGNETOMETER SURVEY

COLVILLE LAKE, NORTHWEST TERRITORIES

FOR

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UNION OIL COMPANY OF CANADA LTD.

BY

GEOTERREX LTD.

Project 81-90

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I. INTRODUCTION

In accordance with the terms of a contract signed on June 15th, 1970, between Union Oil Company of Canada Limited and Geoterrex Limited, an exclusive high-sensitivity airborne magnetometer survey was flown by Geoterrex in the Colville Lake area of Northwest Territories.

The flights were carried out during the period from September 8 to September 16, 1970. The operational base was Norman Wells.

The total mileage flown and accepted amounted to 3,589 line-miles.

II. SPECIFICATIONS

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Flight Grid

The basic flight pattern consisted of east-west lines, one and a half miles apart, and north-south tie lines six miles apart.

Flight Altitude

The flight altitude was 2,500 feet above sea-level. On some profiles the aircraft had to be flown locally higher by one or two hundreds of feet to clear some narrow hills culminating above 2500 feet. This was the case for Line 13 over Lake Belot anticline.

Equipment

The total intensity of the earth's magnetic field was measured by a caesium-vapour magnetometer towed by a cable off the aircraft.

Both analog and digital records were used and measurements were made in units of 0.01 gammas at intervals of one second, controlled by crystal clock.

The flight path was recorded on 35 mm film by a tracking camera.

A Rosemount barometric altimeter was used to record the flight altitude on analog chart paper.

Diurnal Specifications

A high-sensitivity ground magnetometer was set up at Norman Wells to record diurnal variations of the earth's magnetic field during the survey. The specifications were that all possible data had to be obtained during quiet magnetic periods when the ground magnetometer trace showed departures of less than 2 gammas from any chord two minutes long, or during periods of moderate disturbance when the ground magnetometer trace did not show departures of more than 5 gammas from any chord two minutes long.

Some profiles flown during such periods of moderate disturbance were reflown. Since very few differences were observed between the original data and the "reflown" data, the reflights were limited to 330 line-miles.

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III. GEOLOGICAL BACKGROUND

The survey area lies within the highest part of Anderson plain, which is a plateau where Devonian, Silurian and ordovician rocks are exposed on surface. From top to bottom the sedimentary section may be summarized as follows:

Quaternary	glacial till, thick morainal deposits.	
vvvvv		
Lower Cretaceous	basal sandstone	100 feet?
vvvvv		
Middle Devonian		
Hare Indian Formation	Shales	250 feet?
Hume Formation	Fossiliferous Limestone	400 feet?
Bear Rock Formation	Dolomites, limestone +gypsum(?)	800 feet?
vvvvv		
Ordovician and Silurian		
Mount Kindle Formation	Dolomites	400 feet?
Ronning Group	Dolomites	700 feet?
Cambrian		
Saline River Formation	Shales, Gypsum, Salt, siltstones, dolomites.	?600feet?

The overall thickness of the sedimentary section could be approximately 5000 feet.

All formations were deformed during the compressional movements that gave rise to the structures of the Franklin mountains and Colville hills. Several narrow flexures in the ordovician and middle Devonian are present within the survey area; these may be Tectonic features or they may be due to joint enlargement and collapse attendant upon solution of underlying gypsum.

The above geological data are extracted mainly from the descriptive note of Geological Survey of Canada geologic map 6-1969-Lac Belot.

IV. DATA COMPILATION AND PROCESSING

Data compilation and processing included the following steps:

1. Flight path recovery on photomosaics and transferring points onto base maps.
2. Locating times of intersections of north-south and east-west lines by crossing 35 mm films.
3. Reading X-Y coordinates of intersections on maps, using a universal transverse Mercator grid.
4. Preparing IBM cards showing times and X-Y coordinates at every intersection.
5. Checking and correcting flight path by computing aircraft ground speed between every intersection.
6. Editing air magnetometer readings and correcting any recording errors.
7. Computing differerences of magnetic measurements from both lines and tie-lines at each intersection.
8. Adjustment of differences to level data together.
9. Computing final magnetic values, including regional correction, and X-Y coordinates at five second intervals.
10. Computing vertical gradient values.
11. Printing calcomp profiles of total intensity and vertical gradient data.
12. Computer contouring of field contour maps.

V. INTERPRETATION METHODS

The interpretation is based mainly on the analysis of the calcomp profiles.

In the first stage all the anomalies visible on the calcomps are transcribed onto the interpretation maps. Usually both magnetic high and low of an individual anomaly are transcribed. Since the inclination of the earth's magnetic field is very close to 90° in the survey area, the negative component of the anomalies is very small and only the magnetic highs have been transcribed. These magnetic highs are then correlated from profile to profile.

In the second stage the depths to the magnetic marker(s) are calculated. For this purpose the method used has been largely the inflection tangent intersections method (ITI) developed by Compagnie Generale de Geophysique (Naudy 1962). The principal parameters that are measured are illustrated in Figure 1. These are based on the three inflection tangents and the asymptote of the anomaly. The tangents at the maximum and minimum are also used. The analysis is made in two stages, using horizontal and vertical measurements on the profiles. Five horizontal measurements may be used, the horizontal projections of A1 A2, A2 A3 and A3 A4 together with the peak and inflection point widths T1 T2 and I1 I2. These lengths are plotted on Transparent logarithmic paper and compared with the calculated lengths of various theoretical models: two dimensional dykes extending to great depth, or "thin plates" the thickness of

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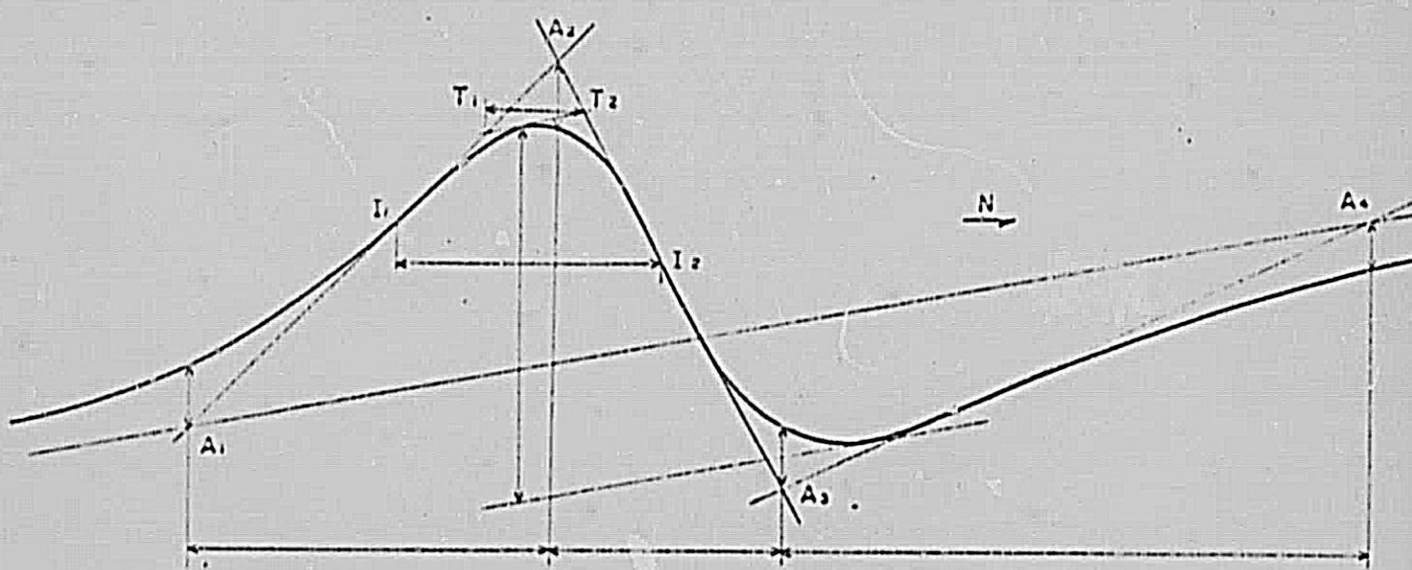

Fig: I

PARAMETERS OF INFLECTION TANGENT INTERSECTIONS which is small compared to their depth. The master curves for total intensity and vertical gradient include a wide range of width/depth ratios and angles of dip or inclination. The comparison of measured parameters and master curves shows which model gives the best fit and consequently the depth to the top of the body as well as its width.

A common difficulty in this process is choosing the proper zero level or asymptote. This is now checked by vertical measurements from the tangent intersections to the curve and the total relief of the anomaly as shown in Figure 1. Again a comparison with master curves shows the best fitting model and its magnetization contrast (if needed). The measurements and analysis are reviewed to ensure that the two models, from vertical and horizontal measurements, are consistent.

In the third stage of the interpretation the magnetic anomalies have to be explained in geological terms. The essential problem is deciding whether an individual anomaly originates from basement or from another magnetic markers. A reference to the regional geology is useful at this stage, as explained in the next chapter.

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VI. MAGNETIC MARKERS

Three different magnetic markers are visible on the profiles:

(a) Broad anomalies are frequent in the survey area and their interpretation generally yields depth estimates over 20,000 feet below sea level. These anomalies therefore cannot be related to the basement surface; they should have their source in some deep-seated magnetic contrasts within the basement. Such anomalies will be called "crustal anomalies" in this report. They account for most of the anomalies visible on the field contour maps.

(b) Narrow anomalies, of moderate amplitude (10 to 30 gammas, except in the southern area where the amplitudes of such anomalies may be greater than 200 gammas) yield depth estimates ranging from 2000 feet to 6000 feet below sea level. These anomalies may be related to the basement surface - since the basement is generally granitic in the area, the basement anomalies probably originate from dykes intruded into the basement. Magnetic trends of this type are close to north-south.

(c) Even narrower anomalies, of low amplitude (a few gammas) may be associated with superficial magnetic markers such as glacial drift. These anomalies frequently disturb the basement anomalies, thereby making their interpretation more difficult.

The occurrence of three different magnetic markers, of which only one is interesting, is a source of complications for the interpretation, since the interesting anomalies are either disturbed by the superficial marker or subdued by the stronger crustal anomalies. A common difficulty was choosing the proper zero level when interpreting the basement anomalies, since these anomalies are frequently sitting on broad regional slopes arising from the crustal marker. It is then necessary to draw a regional baseline and to calculate the residual anomaly. Several solutions are generally possible and considerable time had to be spent checking which hypothesis gives the most reliable and consistent result on a series of profiles.

In some cases the vertical gradient was useful for separating the basement anomalies from the crustal anomalies. In many other cases, however, the superficial anomalies are enhanced on the vertical gradient in such a way that basement anomalies become too much disturbed.

To conclude with the specific problems arising in this particular area, it is possible to say that the major difficulties are the following:

The basement anomalies are frequently disturbed by the shallower marker or obscured by the deeper marker.

The precambrian basement is benerally granitic and homogeneous. Magnetic anomalies therefore are sparse and their amplitude rather low.

VII. INTERPRETATION

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The basement depth estimates shown on the interpretation map have been classified in three groups ranging from poor through fair and good. For a "good" depth estimate the possible error is probably less than 5 or 10 percent, whereas a "poor" depth estimate could be off by 15 percent or more.

On the other hand, it is obvious that the depth contours could be drawn locally in several different ways since the contours have to be interpolated arbitrarily between the depth estimates.

1. Northeast Area

The shallowest depth estimates have been found in the northeast corner of the survey area. In this area the basement dips to the southwest; from 2000 ft. to 4000 ft. below sea level. The magnetic trends are either N 20° W, which is the most common strike in the survey area, or N 15° E which is more unusual.

2. Southeast Area

In the southeast corner the amplitude of the magnetic anomalies is generally higher. A broad magnetic high is visible from profile 5 to 43 approximately. Its amplitude ranges from 200 to 300 gammas. This magnetic high may be split into two (or locally three) individual anomalies interfering in such a way that calculation of depth estimates is difficult. Another magnetic high, right in the southeast corner of the survey area has a maximum amplitude close to 500 gammas. The depth calculations would locate the source of the anomaly between 3100 ft. and 3500 ft. b.s.l.

Near the eastern end of profiles 35 through 47, a north-south trending anomaly yields several good depth estimates ranging from 4000 to 4600 ft. b.s.l.

To conclude with the southeast corner, it seems that this area is relatively flat, with a possible basement 'nose' plunging to the northwest.

3. Southwest Area

A large amplitude magnetic anomaly occurs on profiles 1, 3 and 5, between tie lines 227 and 233. The interpretation of this anomaly yields excellent depth estimates (4000 - 4200 ft. b.s.l.). In between lines 7 and 9 the amplitude of the anomaly decreases abruptly and the anomaly axis is offset to the west. For these reasons a fault has been drawn between profiles 7 and 9.

All the anomalies are striking N 15° W or N 20° W. Their amplitudes are generally very small (10 - 20 gammas). Even then the calculated depths are fairly consistent from profile to profile. The basement in this area seems to be relatively flat, with depth ranging from 4000 to 5300 ft. b.s.l.

North of Colville Lake, the narrow flexure where the Mobil E-15 well has been drilled, does not coincide with any magnetic feature and it seems likely that this sort of flexure does not correspond to a basement high.

4. Northwest Area

Very few anomalies can be related to basement surface in this area. The basement depth estimates therefore are very sparse. This area, however, seems to be generally deeper than the other ones, since several depths are higher than 5000 feet.

VIII. CONCLUSION

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It is interesting to compare the basement map supplied by Union Oil with the basement map resutling from the airmag interpretation.

In the northeast quarter of the survey area, both maps coincide fairly well and show that the basement dips to the southwest.

In the southeast corner both maps show basement depths which are very similar (about 4000 ft. b.s.l.).

In the southwest corner, however, the airmag interpretation makes it possible to point out that the basement is shallower than expected and is no more dipping to the south-west.

Another point of interest is finding out whether the surface flexures have some magnetic extension or not. If it was impossible to detect any magnetic feature along the ENE flexure drilled by Mobil north of Colville Lake, some other flexures coincide very closely with magnetic highs. This is the case for the flexure north of Lac Maunoir: this flexure is bounded by a magnetic high along its western flank, and the magnetic trend is exactly parallel to the axis of the flexure. It seems, therefore, that the flexure could have some expression in the basement. A possible explanation would be the existence of a fault, with the downthrow side to the west, along the western edge of the flexure.

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