REPORT ON

THE INTERPRETATION OF AN AIRBORNE MAGNETOMETER SURVEY OF AN AREA NEAR YORK FACTORY, MANITOBA

for

SOGEPET LIMITED

by

HUNTING SURVEY CORPORATION LIMITED

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I INTRODUCTION

In February 1963 Hunting Survey Corporation was contracted by Sogepet Limited to carry out an airborne magnetometer survey over several areas along the south and west coasts of Hudson Bay, near York Factory Manitoba A total of approximately 1350 line miles was flown, including nine lines which extended approximately 20 miles out over Hudson Bay. The lines were flown in February and the data compilation and interpretation was completed in March 1963

The interpretation was carried out in order to obtain information with regard to the depth of the Precambrian basement It was also hoped that the study could reveal some significant features on the Precambrian surface, which in turn might have controlled the sedimentation processes in the area and in this way be of assistance in the preliminary stages of an oil and gas exploration program

1 Data

The basic data consists of a number of continuous airborne magnetometer profiles along the shoreline as well as the previously mentioned nine, which extend beyond the shoreline The data have been presented as contours of total magnetic intensity at 10 gamma intervals on maps at a scale of 2 miles to the inch On the single lines over Hudson Bay the data are shown as profiles of magnetic intensity at a scale of 500 gamma to the inch

In addition to the above-mentioned survey, data from two previously

conducted surveys were made available for the interpretation One of these is the G S C. aeromagnetic survey published in 1956 which extends from latitude 58°00' to just north of 58°45' and east of longitude 94°30' to Hudson Bay The other is an area surveyed by Hunting Survey Corporation for Kennco in 1960 and covers the land area approximately between latitudes 57°00'and 57°30' east of longitude 93°00' The total effect of the combined surveys gives magnetic coverage along the southwest coast of Hudson Bay from Churchill east to the Manitoba-Ontario border In the G.S C and Kennco areas only the contoured data were available for interpretation

The instrument used during the survey was a high-sensitivity Gulf Mark III magnetometer installed in a Lockheed 14 aircraft The quantity measured by this instrument is the total magnetic field intensity, i.e the magnetic field in the direction of the magnetic inclination, which in this area is about 83°N The profiles are accurate to ± 2 gamma

2 Preliminary Information

The geology of the area under consideration consists of Paleozoic sediments overlying a Precambrian basement Three exploratory holes have been drilled to the southwest of the area and are shown on the interpretation map with the corresponding depths to basement An earlier interpretation of magnetic information by Paterson (1) has provided depths at specific points around the area These are necessarily limited in reliability since they were made from single profile magnetic data and therefore the strike of the anomalies and the anomaly shapes were unknown

II ANALYSIS OF DATA

1. Basic Considerations

The purpose of the interpretation is to attempt to determine the form and nature of the Precambrian surface underlying the Paleozoic sediments in the area. This is achieved by determining the magnetic forms causing the anomalies and thereby deriving their depths below the level of observation. The basic assumptions made here are:

(1) That all the magnetic activity seen in the maps is caused by changes in magnetism in the Precambrian basement and that the overlying sediments are effectively non-magnetic,

(2) The majority of the anomalies are caused by large lithologic units having magnetic susceptibilities different from each other and from the surrounding rock and truncate at the erosional surface of the Precambrian.

On the basis of these assumptions, calculations are made of the depth to the top of these lithologic units and thus to the Precambrian surface.

2. Methods Used

a) Vacquier's Interface Analysis (V)

For bodies bounded by approximately plain vertical interfaces going to great depths, several criteria or indices from the total intensity and the second vertical derivative anomalies can be used to calculate the

depth to the top of the body This method is used mainly on contoured data and can therefore be applied only on the groups of lines that are contoured Vacquier (3) published charts and diagrams for making these depth calculations

b) The Dipping and Symmetrical Dike Methods (d d and s d)

The dipping dike method was developed at Hunting Survey Corporation Limited and utilizes various characteristics of an anomaly, such as distances between maxima, minima, and inflection points, to solve the general dike equation by graphical means It provides depth, width, dip and susceptibility of a dike to an accuracy of about 10%. It is applicable only to well shaped dike-like anomalies and is therefore often restricted in use

The symmetrical dike method is a simplification of the dipping dike method which is used when the anomaly is symmetrical in shape about the maximum

c) Half Slope Method (1/2 slope)

Peters (4) has empirically related the depth of a dike-like body to the distance between the tangent points of two lines which have one half slope of the anomaly at its inflection point The method may also be applied with modifications to the anomaly produced by a vertical contact

3 Grading of Depth Determinations

The depth determinations have been graded A, B, C or D, according to their reliability These grades are based on the following criteria size and shape of anomaly, number of lines on which the anomaly is seen, degree

of agreement between depths found from several lines, agreement between depths found from several methods, extent to which assumptions are valid, and degree of fit of any model

Grade A is given to an analysis in which the assumptions of the shape of a causative body appear to be correct. This is most often indicated by good agreement between the various measures that a particular method uses (e g the several indices applied by the Vacquier method) A good agreement amont the depths calculated from several lines over the same anomaly will also provide a grade A Anomalies covered by only two lines are not always considered eligible for an A grade even if the above conditions are true since their strike direction may still be open to question

Grade B, or fair, is given to those analyses which have a somewhat poorer agreement in depth, and in which some ambiguity in picking characteristic points is present, but in which the basic accumptions are believed valid

Grade C, or poor, is used to indicate that some extraneous factors have effected the anomaly and distrubed the position of the characteristic points Good anomalies on single line data are also eligible for this grade

Grade D is used to indicate an unreliable determination This type has been used on depths which are taken from very disturbed anomalies or some moderately disturbed anomalies on single line data

These grades do not apply to the accuracy of the depth determination which in all cases should be within ±15% if the assumptions are valid and the

anomaly properly defined The grade is a measure of the reliability of the determination, indicating the degree to which the anomaly answers the requirements necessary for its effective analysis For example, analyses of single-line data may be accurate within the ±15% limits, but there is a very high degree of ambiguity as a result of unknown strike and shape, which of necessity results in a low reliability grade

4 Maps

Included with this report are the following maps

1 Three sheets at a scale of two miles per inch, showing the total magnetic field and depth determinations beside the anomalies used for analysis

2 One composite of the G S C magnetic survey near Churchill at a scale of four miles to the inch, showing the depth determinations made in that area

3 One sheet of the entire area at a scale of eight miles to the inch, showing the interpreted depth contoured On this map the depths calculated by the recent survey are distinguished from the ones determined from the G S C profiles Since the former have the advantage of being calculated from contoured data they are weighted above the latter group in the depth contouring

III RESULTS AND INTERPRETATION

1 Depth Determinations

From a study of the anomalies a total of 33 fairly reliable depths have been calculated Some of these determinations have been made using several methods and the final depth in these cases was determined by a weighted average of the several values, the weighting factor of a particular depth being approximately proportional to the reliability of that determination The tops of the magnetic bodies were referred to sea level by subtracting the calculated depth from the aircraft altitude which was a constant 1,000 feet above mean sea level

Table I,summarizing the depth determinations, lists the anomaly number, final depths expressed in feet below sea level, the grade, the methods used and the susceptibility contrast where calculated

In the depth determinations on the single line data apparent depths vary from -1640 to -5800 feet (m s l.) It is believed that this wide variation is due chiefly to the strike effect It is to be noted that the anomaly located at 91°10'E and 57°54'N is discussed by Paterson (1) as being eligible for a strike correction, this would change the depth to -2800 below m s l and it would fit quite well into the general contour pattern A similar argument is valid for anomalies #10 (-4300 m s.l) and #4 (-3600 m s l).

Anomaly #1 needs some special discussion as it is in a rather crucial position This anomaly was interpreted as a contact between rock types

having dissimilar magnetic susceptibilities Depth analyses were performed on all seven lines which cross this anomaly and gave a rather wide scatter of depths averaging -2800 feet (m s l) with a mean difference of ±700 feet Its location is such that the depth can be neither confirmed nor rejected by adjacent anomalies. The significance of this is that if it errs on the shallow side then a greater thickness of sediments is indicated at this point and possibly a basin-like feature extending to the southeast is indicated If the reverse is true it causes the depths along the Kaskattama River to form a rather well defined synclinal structure

The best estimate that could be made mathematically favours a depth in the shallow part of the above depth range and consequently supports the second structural alternative

2 Magnetic Basement Surface

By combining the A and B grade depth determinations from the previous study with the present ones a magnetic basement has been defined and contoured. In regions where a high density of points exists the depths are often scattered owing to the inaccuracies previously mentioned In these areas the contouring has been biased toward the A and B grades of determinations

The contours indicate the regional basement surface to be dipping away to the north as would be generally expected Superimposed on this regional gradient is a series of synclines and anticlines with relief in the

order of 1,000 feet crossing the regional strike in a transverse direction This pattern appears to be reflected by the surface topography to a certain extent, in that Cape Tatnam coincides with the anticlinal nose and the Nelson - Hay River valley and Kaskattama - Kettle River valleys coincide with the synclines

3 Identification of Basement

It is important to consider the distinction between magnetic and Precambrian basements. It has been found from previous work that a magnetic surface may lie above the Precambrian surface due to the presence of basic rocks within the sedimentary layer Alternatively, a series of magnetic bodies terminating below the Precambrian surface may appear to define a sub-Precambrian magnetic surface Also, layers within the Precambrian, such as the boundary between Archean and Proterozoic can provide an effective magnetic "basement"

No drill holes to the Precambrian basement exist in the area of the most recent survey and identification of the magnetic basement can only be made on the basis of reasonableness of fit with an extrapolation of the known Precambrian surface and by assessment of the "magnetic character" of the total field An extrapolation of the Precambrian surface from where it disappears under the Paleozoics to the south and through the three diamond drill holes would bring the Precambrian surface somewhat above the interpreted magnetic basement level, especially in the synclinal parts. However it is felt that the relatively rapid decrease in elevation indicated by the magnetic basement contours is not unreasonable, and in itself is not

sufficient evidence against the two basements being one and the same As reported by Paterson (1) part of the difference in elevation may be explained by an unspecified thickness of non-magnetic weathered basement rock lying above the Precambrian basement

The general magnetic pattern or magnetic character in the area appears to be typically Precambrian In the contoured area (especially the group of seven lines) the character of the total field appears to change abruptly at several places These are interpreted as major changes in the lithology of the rocks causing the anomalies and classifications of basic, intermediate, and acid rocks have been assigned It is felt that the rocks interpreted as basic may represent either flat lying Proterozoic rocks containing magnetite or broad intrusive masses of Archean age It is probable that the latter case holds true for the dike-shaped anomaly, number 9 It is considered unlikely that any rocks of basic composition overlies the interpreted basement surface

We therefore conclude that the interpreted basement surface either

(1) lies very close to and represents the Archean surface, in which case it is overlain by essentially non-magnetic rocks of either Paleozoic or Proterozoic age (or both),

or (2) represents a basic member of the Proterozoic sequence,

or (3) is a combination of (1) and (2)

TABLE I

Summary of Depth Calculations

No	Depth Feet (m s l)	Grade	Methods Used	Susceptibility c g s units
1	-2800 ± 600	C	V , 1/2 slope	
2	-1600	D	1/2 slope	
3	-3400	C	1/2 slope	
4	-3600	D	1/2 slope	
5	-2300	A	1/2 slope, d d	0 0028
6	-2250	B	s d., 1/2 slope	0 0023
7	-2800	A	d d , 1/2 slope	0 0028
8	-2250	B	s d., 1/2 slope	0 0011
9	-2600	A	1/2 slope, s d	
10	-4300	D	1/2 slope	
11	-2700	D	1/2 slope	
12	-1850	D	1/2 slope	
13	-2300	B	1/2 slope, V	
14	-1200	B	1/2 slope, V	
15	-1200	C	d d	
16	-2120	C	V	
17	-2100	C	s d	
18	-1400	C	1/2 slope	
19	-1800	A	1/2 slope	
20	-2650	C	V	
21	-1700	B	V	

Table I (continued)

No	Depth Feet (m s l.)	Grade	Methods Used	Susceptibility c g s units
22	-1400	D	1/2 slope	
23	-1500	A	d d , 1/2 slope	
24	-1400	A	1/2 slope	
25	-1200	A	1/2 slope	
26	-1850	B	1/2 slope	
27	-950	C	1/2 slope	
28	-1500	B	1/2 slope	
29	-1350	A	1/2 slope	

IV SUMMARY AND CONCLUSIONS

1. A study has been made of approximately 1350 line miles of magnetic profile along the southwest coast of Hudson Bay Also a short study was made of major anomalies in an area surveyed by the G S C southeast of Churchill and in another surveyed by Hunting Survey Corporation Limited for Kennco north of Fort Nelson.

2 Determinations of depth of magnetic basement have been made in thirty-three places and have been graded according to reliability

3 Contours of elevation of the magnetic basement have been interpreted and drawn on the accompanying interpretation map These contours are drawn by a process of selection and averaging, plus a certain amount of intuitive reasoning It is believed that the magnetic surface and the Precambrian surface are one and the same within certain limits already described Because of the limitations of the depth determinations it is more appropriate to consider the contoured surface as being representative of a qualitative trend of the basement rather than an actual absolute elevation surface

4 The most prominent feature is a large arch flanked by deep synclines plunging approximately northeast beneath Cape Tatnam This is reflected to a certain extent by the surface topography .

5 The magnetic intensity seen in the group of seven flight lines has been interpreted to show three major rock types (i.e basic, intermediate and acid) It is possible that the basic rocks are either Proterozoic basic flows

or basic intrusions of Archean age

6 Analyses of the magnetic field can be a useful tool in this area in estimating the depth, shape, and composition of the Precambrian surface Should any further work of this sort be contemplated it is recommended that single profile measurements be dispensed with in favour of groups of lines (a minimum of five lines in a group) Such an arrangement would provide better definition of anomalies as well as strike direction, thus enabling a more accurate analysis and a better geological interpretation

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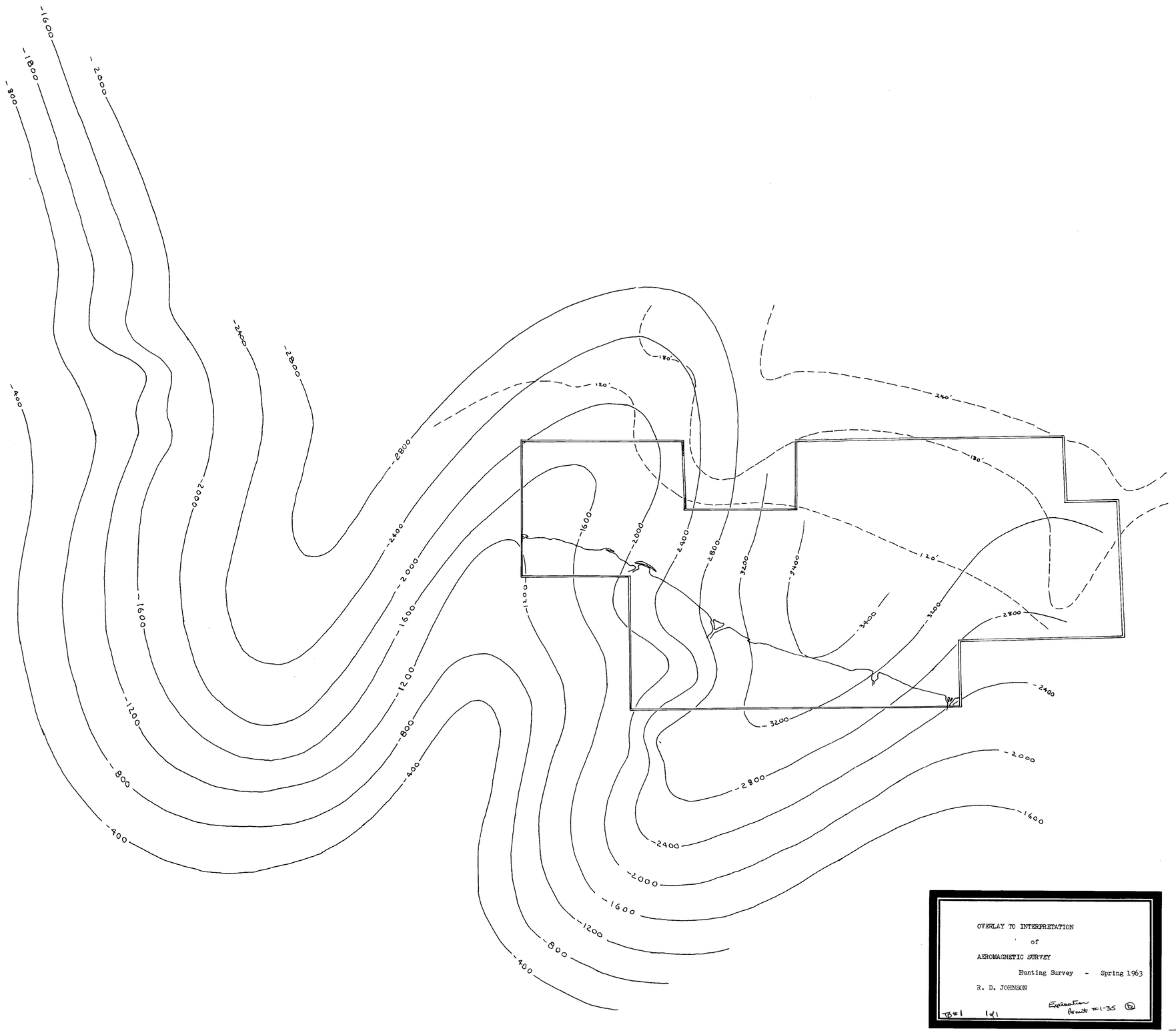

OVERLAY TO INTERPRETATION
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