COMPAGNIE GÉNÉRALE DE GÉOPHYSIQUE

MERCURE INTERNATIONAL PETROLEUM PTY. LTD.

DUNMARA

AEROMAGNETIC SURVEY

NOVEMBER 1965

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INTRODUCTION

This is the final report of an aeromagnetic survey carried out during the month of November 1965 by the COMPAGNIE GENERALE DE GEOPHYSIQUE on behalf of MERCURE INTERNATIONAL PETROLEUM PTY. LTD.

The surveyed area is the Oil Permit 64/3 Northern Territory. For this work a CSF digital caesium vapor magnetometer was used and the navigation was made with the mosaics.

3078 kilometers were flown over the permit and 453 kilometers of supplementary profiles up to the proterozoic outcrops: the total mileage is 2195 miles (3531 kilometers).

CHAPTER I

TECHNICAL SPECIFICATIONS.

I-1 Location of the survey Flight grid

The surveyed area is located between the meridians 132° 30' and 134° E. (approximately) and the parallels 16° 15' and 16° 50' south.

The flight program consisted of :

- three bands of five lines East-West. The spacing was one mile between two lines and twelve miles between two bands.
- seven tie lines North-South, 18 miles apart.
- two lines N.S., from the N.E. corner of the permit to the basement outcrops.
- two lines E.W. from the N.W. corner of the permit to the VICTORIA RIVER BASIN.

The flight altitude was 2000 feet above sea level.

I-2 Staff and equipment

Aircraft :

The aircraft was a twin engined HUDSON provided by ADASTRA AERIAL SURVEYS.

Adastra crew :

- one pilot
- one engineer
- one navigator

C.G.G. staff :

- one geophysicist, party chief
- two datamen .
- one flying magnetometer operator
- one ground magnetometer operator.

Geophysical equipment :

- one CSF optically pumped caesium vapor magnetometer giving an accuracy of 0,1 gamma.
- one TEXAS recorder.
- one COTELEC magnetic recorder.
- one AEROPATH strip camera, 35 m/m
- one statoscope, IGN type, recording the altitude.

Ground equipment :

- one GULF flux gate magnetometer (supplied by ADASTRA) recording the diurnal variations of the magnetic earth field.

CHAPTER II

METHODS OF INTERPRETATION

II-1 QUALITATIVE INTERPRETATION

The qualitative interpretation of the aeromagnetic data is made by studying not only the magnetic maps but also the recorded profiles since most of the interesting anomalies of slight amplitude cannot be taken into consideration when inspecting the magnetic contours.

II-2 ANALYSIS OF THE MAP OF THE TOTAL INTENSITY

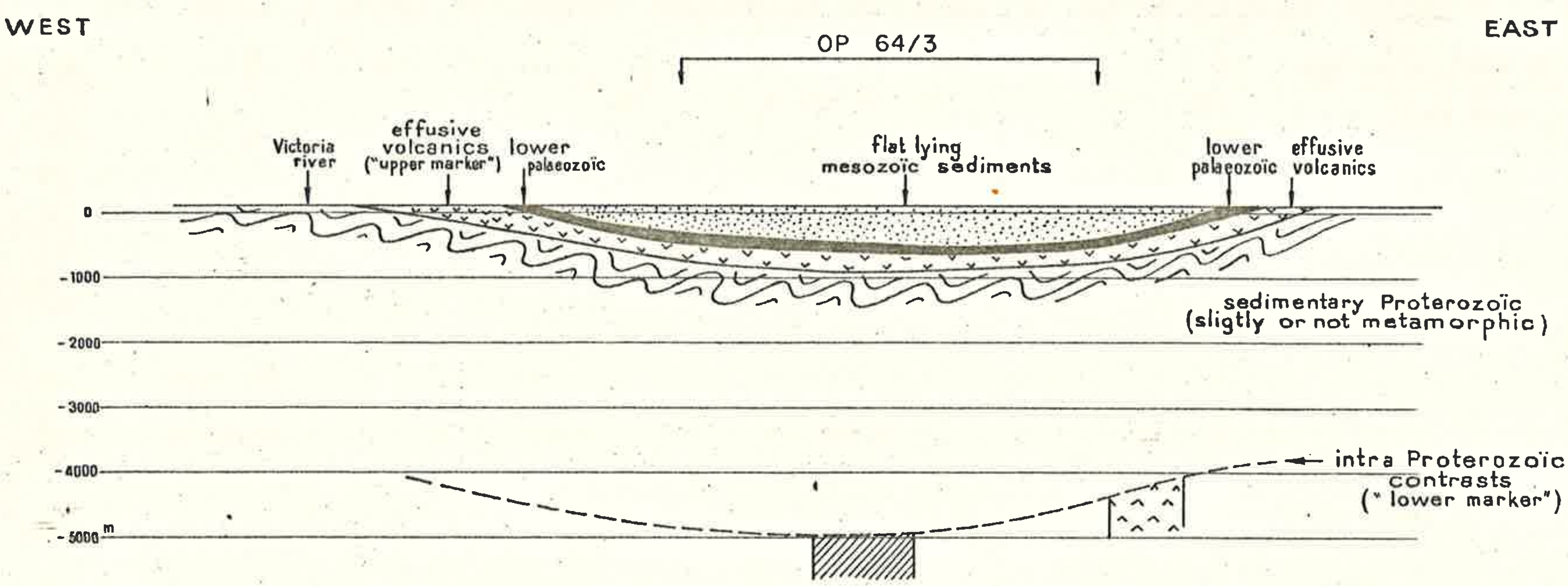
The main structural trends can be defined by analysing the map of total intensity. Three kinds of magnetic features are:

- The gradient observed along a considerable distance.
- The alignment of lateral shifts which offset the main anomalies.
- The alignment of closed anomalies of contour inflections.

The significance of such magnetic features is to be well defined. In fact, the total amplitude of an anomaly is almost completely caused by magnetic contrasts, whereas the effect of the vertical throw H-h, accompanying sometimes such magnetic contrasts has generally a very small influence upon the total amplitude of the resulting anomaly.

However, from experience, the Tectonic disturbances are often located at magnetically differentiated contacts, thus it is reasonable to consider the above mentioned magnetic features as possible structural features.

It is only when examining the depth estimates that the interpretor may concede some probability to the existence of such structural features and indicate the eventual down throw side and the range of this displacement.



INTERPRETATIVE CROSS SECTION

Horizontal scale : 1/2.534.400
Vertical scale : 1/100.000

FIG. 1

II-3 ANALYSIS OF THE MAGNETIC PROFILES

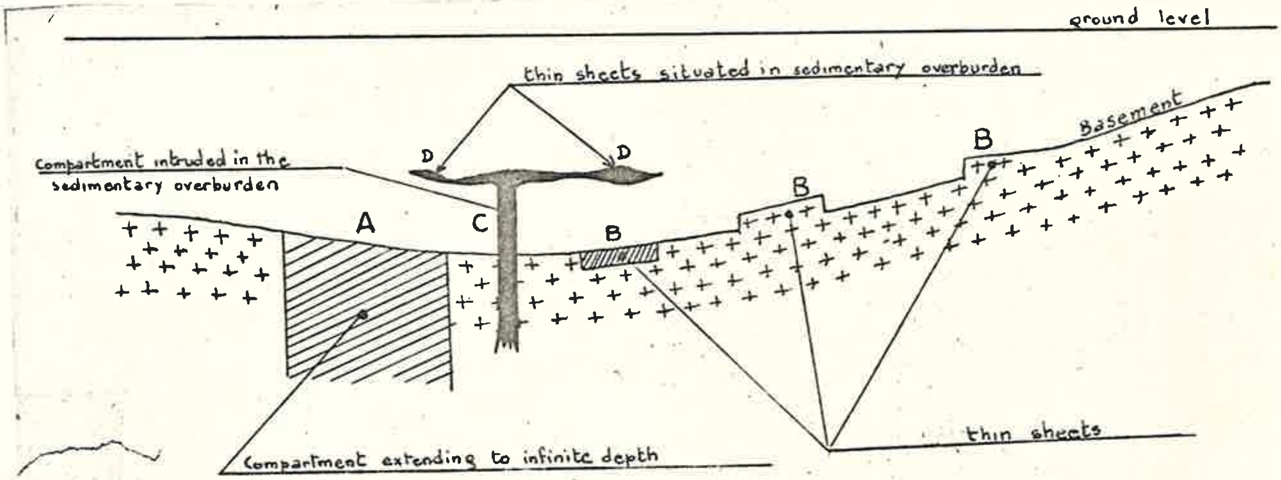
The various characteristics of the anomalies observed on the recorded magnetic profiles are often rather different. Most of the anomalies, however, can be classified in four categories:

- A wide anomaly of high intensity (Fig. 3)
- B wide anomaly of low intensity (Fig. 3)
- C narrow anomaly of high intensity (Fig. 4)
- D narrow anomaly of low intensity (Fig. 4)

It is not advisable at this stage to consider that each category of anomaly may correspond to a particular horizon though a particular method of interpretation is used for each category.

II-4 QUANTITATIVE INTERPRETATION

Most of the methods of quantitative interpretation are based upon graphic determination of parameters related to the depth of the magnetized bodies. In a first step simple geometrical bodies or structures are assumed to present forms similar to those encountered in nature. They are generally parallepipeds with a plane upper surface and walls extending to an infinite depth representing basement compartments or dykes - or "thin sheets" used for representing volcanic flows or irregularities of the basement upper surface (see figure 5).



Différent types of magnétic contrasts Fig.5

The magnetic anomalies created by such uniformity magnetized geometrical bodies are mathematically calculated.

On the theoretical anomalies, several characteristic graphic parameters proportional to the depth are defined. For interpreting a real anomaly, the most approaching theoretical anomaly is selected first: graphic parameters are determined on the real anomaly by repeating the same process used previously on the theoretical model. Since the depth to the theoretical body is known, the depth to the real magnetized body is deduced by proportionality.

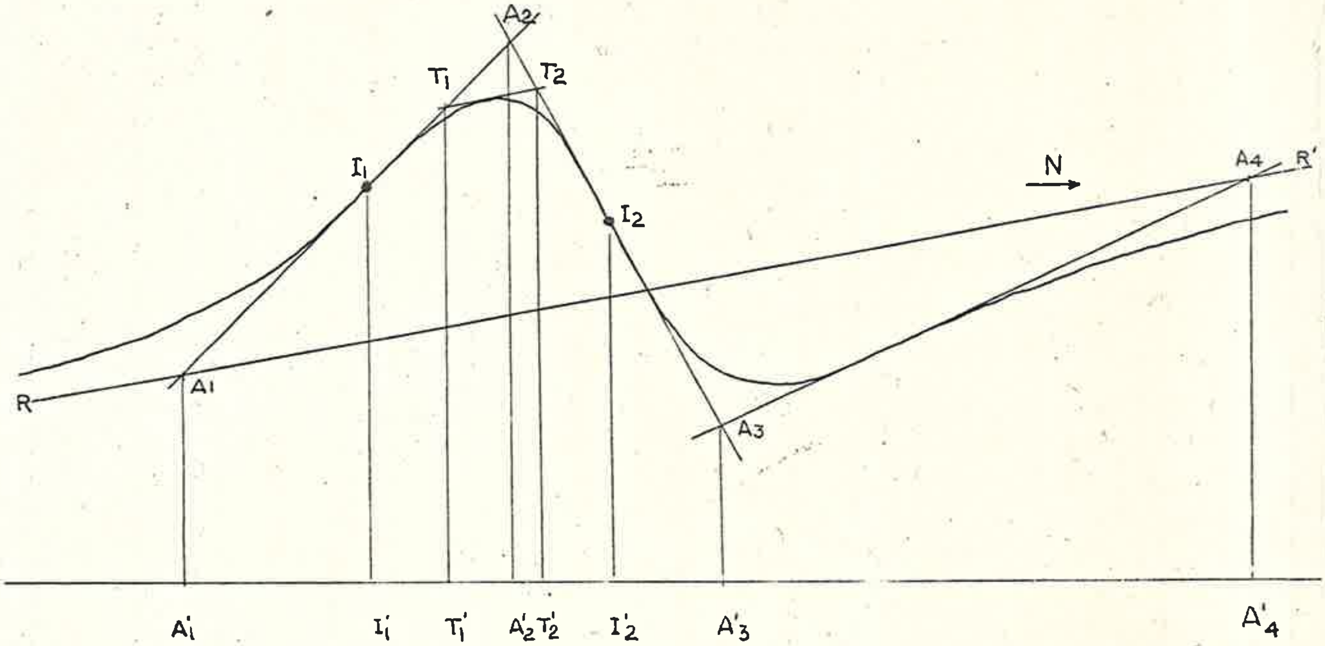
II-5 METHOD OF INFLECTION TANGENT INTERSECTION (I.T.I.)

II-5-1 Principle of construction (Fig. 6)

The asymptote of the anomaly and three inflection tangents are considered (five tangents in the case of very wide compartments). A_1, A_2, A_3, A_4, being the intersections of the tangents to the inflection points, the parameters to be measured are the segments A'_1, A'_2, A'_2, A'_3, A'_3, A'_4, which are the horizontal projection of the segments A_1, A_2, A_2, A_3, A_3, A_4.

In addition, two other parameters are considered : the parameter T'_1, T'_2 and T_1, T_2 are the horizontal projection of the segments T_1 T_2 and I_1 I_2. The points T_1 and T_2 are the intersection tangents A_1 A_2, A_2 A_3 and the tangent to the maximum in parallel direction to the regional field RR'. The points I_1 and I_2 are the inflection points of the curves which constitute the flanks of the positive anomaly.

Fig. 6



Parameters of inflection tangent intersections

In the example of figure 6 the theoretical anomaly for an inclination of 51° corresponds to a body having an East West infinite strike length and vertical walls extending to infinite depth. The direction of intersecting profile is North South.

II-5-2 Depth determination

Several sets of monologarithmic master curves have been established for various types of two dimensional compartments, square base compartments and faults extending to infinite depth and for magnetized "thin sheets". Master curves are available for a large range of the ratios a/h ("a" being half of the width of the geometrical body and "h" the depth of its upper surface) and H/h (the difference H/h being the fault throw, and H the depth to the downthrown compartment.

The anomaly to be interpreted is defined by 5 parameters. They are plotted on logarithmic transparent paper. The ratio a/h or H/h and the depth h are determined by matching the plotted parameters with the master curves.

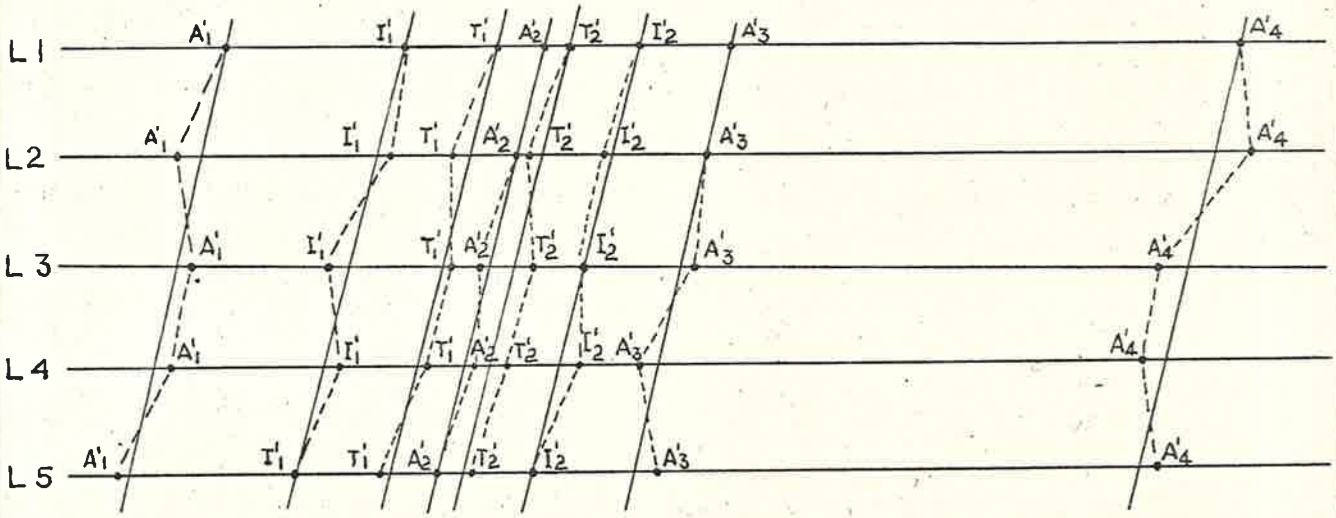
It is not frequent to encounter a well isolated anomaly on which the five parameters can be measured. The causes of the magnetic contrasts are generally rather closely spaced and the resulting anomalies interfere. The main difficulty lies in avoiding the interferences that cause erroneous depth estimates.

II-5-3 Intersection point mapping (Fig. 7)

In order to eliminate as far as possible these causes of error, the intersection points A'_1, A'_2, A'_3, A'_4 are plotted on a map, before the segments lengths are measured directly on the recorded profiles.

The correlations of the points A'_1, A'_2 .... from traverse to traverse enables the angle between the profile and the positive axis of the anomaly to be measured and quality of the estimate to be discussed. Only the correlations visible on several traverses are taken into consideration. As a matter of fact, a ficitious anomaly caused by two or more interfering anomalies is not likely to proceed through more than three traverses. Besides, this method is well suited for eliminating the irregularities of the broken lines joining the points A'_1 .... the point A'_2 .... related to the same anomaly. The distance to be measured is taken perpendicularly to the successive smoothed mean lines.

Fig. 7 Plotting of the intersections



II-5-4 <u>Advantages of the method</u>

The determination of the parameters is almost independent of the operator and remains possible even for anomalies of very small intensity : the parameters are generally sufficient in number to provide an univocal determination of the depth h and the ratio a/h.

II-5-5 <u>Parameters ITI γ</u>

In the same concept another kind of parameters has been studied. The parameters ITI γ are the vertical differences between the inflection tangent intersections and the curve itself. They are useful to confirm the determination of the ratio a/h and to calculate the apparent magnetization contrast J' (J' is equal to the actual magnetization contrast in the case of two dimentional structure striking East-West magnetically).

II-6 METHOD OF BILOGARITHMIC TOTAL MASTER CURVES

Instead of using selected graphic parameters, it is preferable to match the entire anomaly curve with a theoretical model by means of several sets of bilogarithmic total master curves. The method yields more reliable results for anomalies of noticeable width and intensity.

Bilogarithmic total master curves have been calculated for several types of theoretical models and varying inclinations of the earth's magnetic field.

The transcription in bilogarithmic co-ordinates is made either from the recorded profiles or from cross-sections taken on the map of total intensity. The depth "h", half-width "a" and apparent magnetization contrast "J" are obtained by direct reading.

II-7 CHOICE OF THE MASTER CURVES

The master curves of the parameters ITI and ITI γ and the bilogarithmic total master curves can be split into two classes depending whether or not the magnetized body is extending to infinite depth.

As far as the interpretation of the bodies extending to limited depth or "thin sheets" is concerned, bilogarithmic total master curves have been calculated for a varying range of the ratio H/h (where H is the depth to the base and h to the upper surface of the body, whereas the parameters ITI and ITI γ deal only with "thin sheets" the thickness of which is assumed to be very small compared to the depth. If the depth "h" and half-width "a" can be determined for a given ratio H/h, reciprocally the master curves cannot generally yield any information on the ratio H/h. The choice between bodies extending to infinite depth and bodies extending to limited depth is left to the experience of the interpretor.

Nevertheless, the intensity of the anomalies caused by magnetized "thin sheets" does not exceed a few tens of gammas, whereas the compartment of the basement extending to infinite depth may produce anomalies of several hundred of gammas.

II-8 APPROACH OF THE INTERPRETATION

II-8-1 General considerations

The intensity of the anomaly is a function of :

- the depth to the body below the aircraft level
- the direction of the structural axis compared to the magnetic North,
- the intra-basement and sedimentary-basement magnetic contrasts.

Besides, it is obvious that interpreting systematically all anomalies of low intensity as "thin sheets" would be arbitrary. For all these reasons the interpretation is split into successive stages.

II-8-2 Actual Intensity of the Anomalies

When the direction of the axis is not magnetic East-West, the actual intensity of the anomaly is calculated. With "α" being the angle of the magnetic meridian with the plane normal to the axis of the anomaly, "i" the inclination of the earth's magnetic field, the apparent inclination "i'" of the body is given by the following relationship :

$$tg\,i' = \frac{tg\,i}{\cos\alpha}$$

To obtain the actual magnetization "J", the apparent magnetization "J" is to be multiplied by :

$$\left(\frac{\sin i'}{\sin i}\right)^2$$

II-8-3 Wide Anomalies of high intensity "A type" (Fig. 3)

Hypothesis : "compartment extending to infinite depth, the upper surface constitutes the magnetic horizon of the basement."

First of all, the study concerns the anomalies correlating on several traverses and sufficiently clear of the adjoining anomalies to avoid the interference phenomena which alter the results. Such fair estimates are used as references for studying other "A type" interfered anomalies by decomposing the resultant anomaly in two or more anomalies, the results become the more doubtful as the apparent inclination is closer to 45°.

II-8-4 Wide anomalies of low intensity "B type" (Fig. 3)

Three cases are to be considered :

- The hypothesis : "compartment extending to infinite depth" gives rise to a depth estimate similar to the mean of the adjoining fair estimates. It is reasonable to adopt it.

- The hypothesis : "thin sheet at the upper surface of the basement" gives rise to a depth estimate similar to the mean of the adjoining fair estimates. It is reasonable to adopt it.

- The hypothesis : "thin sheet at the upper surface of the basement" gives rise to a depth estimate considerably smaller than the mean of the adjoining fair estimates. Then the existence of a magnetic contrast in the sedimentary overburden becomes probable, since the hypothesis "thin sheet" always provide depth estimates higher than those obtainable from the hypothesis "compartment extending to infinite depth".

II-8-5 Narrow anomalies of high intensity "C type" (Fig. 4)

Hypothesis : "intrusion to infinite depth : the upper surface of which is situated in the sedimentary overburden".

II-8-6 Narrow anomalies of low intensity "D type" (Fig. 4)

Hypothesis : "thin sheet the upper surface of which is situated in the sedimentary overburden".

II-8-7 Remarks

- Available bore logs or refraction seismic data can be used for calibrating the anomalies located in the immediate proximity and can indicate the most probable hypothesis to be applied to the different categories of anomalies.

- The "A type" anomalies are assumed to be related to compartments the upper surface of which constitutes the magnetic horizon of the basement. Nevertheless the fact is not excluded that some of them are situated deeper in the basement giving erroneous estimates, in excess.

- When a narrow anomaly presents a rather low intensity, it is often difficult to choose whether it corresponds to a "dyke extending to infinite depth", or to a "thin sheet". Therefore, the depth estimates in the sedimentary overburden can only represent a rough estimate.

- It is worth specifying the geological significance of the term "thin sheet" : a "thin sheet" structure can designate either a volcanic flow, sill, or a horst, or a fault. Thus it is very important to emphasize the axis of anomalies interpreted as "thin sheet" on the interpretation map.

II-9 ISOBATH CONTOURS OF THE BASEMENT

The depth estimates retained by the interpretor to be plotted on the map are those given by the quantitative study of A and B type anomalies related to magnetic contrasts of the basement. The isobath contours are founded on probable estimates only, to the exclusion of the interrogative marked estimates. Besides, the directions observed on the magnetic map of total intensity are used as a guide for the drawing of the isobath contours.

CHAPTER III

INTERPRETATION

III-1 Magnetic Markers and Geology

The records display many anomalies, the intensity of which ranges from 5 to 40 gammas. All these anomalies are assumed to be related to one same magnetic marker called in this report "upper marker".

By smoothing the curves in order to eliminate these comparatively small anomalies, some big anomalies appear certainly relating to another magnetic marker called "lower marker".

As far as the profiles flown from the Western limit of the permit to VICTORIA RIVER are concerned, the magnetic style is always the same, except in the last twenty kilometers, where sharp anomalies disappear, in this Western area the geological map shows outcrops of upper Proterozoic.

These data enable to make the following conclusions :

- the upper marker can be related to the volcanics of Lower Palaeozoic (Pzl on the geological map).

- the upper Proterozoic outcropping in the VICTORIA RIVER BASIN is slightly or not metamorphic.

- the lower magnetic marker must be related to some intra-Proterozoic contrast.

The interpretative cross section (Fig.1) summarizes these geological and magnetic data.

Remark: A supplementary profile had been requested by MERCURE during the survey, from the N.E. corner of the permit to BAUHINIA DOWNS. We could not fly this profile because ADASTRA'S plane had to go back to SYDNEY urgently.

III-2 Qualitative interpretation

Both markers pointed out before are visible on the isogams contour maps.

Few correlations of the upper marker anomalies are asserted : some N.W.-S.E. trends are still ensured.

The main trend of the lower marker anomalies could be approximately North-South.

III-3 Quantitative interpretation

III-3-a - Local magnetic features

In the surveyed area the average magnetic dip is 44° south. With such an inclination, a magnetic body extending east-west gives a symmetrical anomaly (the positive part and the negative part are equal), and the negative part is located at the south of the positive one.

III-3-b - Interpretation of the "upper marker" anomalies

More than ninety per cent of the anomalies are to be related to this upper marker. The relevant anomalies are narrow and contiguous. All of them have been interpretated as "thin plates".

On the calcomps of lines 1 to 15 and tie lines 101 to 108 and 109, depth estimations have been computed giving an average depth value equal to - 0,5 kilometre, with extreme values equal to - 0,3 and - 0,9 km. (below sea level).

The anomalies being very numerous and similar, the correlations between two contiguous lines are often impossible to ascertain. For this reason the angle of the anomalies trends with the flight lines have not always been taken into account, the consequence that some depth values may be over-estimated.

Anyhow, it can be asserted that the magnetic basement is very shallow and flat. The thickness of the so called Mesozoic sediments (on the geological map) is certainly very thin.

As for the thickness of the volcanics, it could be a few hundred metres.

III-3-c - Interpretation of the "lower marker" anomalies

Figure number 2 shows an example of profile with two distinct types of anomalies. On this part of the profile two depth values of the deep marker ("lower marker") have been computed. It is obvious that the depth estimation of the big anomaly is very unprecise, because the tangents can be drawn otherwise. In that case, the accuracy is not better than thirty per cent. In fact the anomalies of the upper marker disturb the anomalies of the lower marker too much to allow a correct study of the latter.

The depth values computed on the big anomalies range from 3900 metres to 6600 metres below sea-level.

As said before the magnetic contrasts responsible for these anomalies are certainly intra-Proterozoic (possibly the contrast between the unmetamorphic upper Proterozoic and the metamorphic lower Proterozoic, or the contrast between the lower Proterozoic and the archean?)

CONCLUSION

The airborne magnetic survey of OP 64/3 allowed to clear up very quickly the main geological and morphological features of this area.

These main features are the following:

a - The thickness of "Mesozoic" and Palaeozoic sediments is very thin, everywhere less than 1000 metres and generally about 500 metres.

b - A magnetic marker giving many anomalies may be related to the effusive volcanics of Lower Palaeozoic. The anomalies express the variations of thickness or of depth of the volcanic layers. The weak variations of depth did not enable us to outline the isobaths.

c - Another magnetic marker may be seen and its depth ranges from 3900 to 6600 metres. This marker is certainly intra-Proterozoic.

As a conclusion the weak thickness of deposits overlying the upper marker does not seem favourable for the oil research. However the thickness of unmetamorphic Proterozoic may rise to three or five thousand metres, which could be more interesting.

27th April, 1966

J. LERIDON.

PE65/19 B

DUNMARRA AEROMAGNETIC SURVEY

Navigation and Plotting of Flight Path :

The following maps and mosaics were available at the time of the survey:

- Aeronautical charts scale 1:1,000,000 "Halls Creek" and "Newcastle Waters".

- Photomaps scale 1:100,000 covering permit area only, (prepared by SNPA, France, from airphotos).

- Photomaps scale 1:250,000 compiled by the Division of National Mapping: E 52,4 Victoria River Downs, E 53/1 Daly Waters, E 53/2 Tanumbirini, D 53/4 Hodgson Downs.

- Photomaps scale 1" to 1 mile, covering western portion of permit area only (for the two N-S Lines, from the N.E. corner of the permit area to the basement outcrops, mosaics were specially compiled by C.G.G.)

- Vertical aerial photographs scale approx, 1:48,000

Navigation was made with the photomaps, mosaics and 35mm strip films. The position of the aircraft over the ground recorded on 35mm films, was initially identified and plotted by reference to topographical detail depicted on the 1:100,000 scale semi-controlled photomaps. (For the extended lines to the West and North, reference was made to the 1" to 1 mile semi-controlled mosaics). These positions were then transferred directly onto detail overlays at scale 1:100,000 and used as a base for plotting the corresponding values from the aeromagnetic profiles.

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