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COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD No. 1965/130

GAMBIER - OTWAY AEROMAGNETIC INTERPRETATION, SOUTH AUSTRALIA

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by

COMPAGNIE GENERALE DE GEOPHYSIQUE

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AEROMAGNETIC INTERPRETATION,

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INTRODUCTION

In accordance with the contract acceptance of October 26 th, 1964 No C.506831 , COMPAGNIE GENERALE de GEOPHYSIQUE (C.G.G.) was charged by the DEPARTMENT of SUPPLY, COMMONWEALTH of AUSTRALIA , with the interpretation of aeromagnetic data concerning the GAMBIER-OTWAY BASIN (South Australia) for the DEPARTMENT of NATIONAL DEVELOPMENT.

The survey consists of about 4,000 line miles flown in 1955 by ADASTRA HUNTING GEOPHYSICS LTD at 500 feet above ground level.

The GAMBIER-OTWAY BASIN covers the southern part of the MURRAY BASIN lying in South Australia bounded on the north by the parallel $36^{o}45'$, on the east by the Victorian State boundary . The area covers approximately 5,000 sq. miles .

CHAPTER I

GENERAL DATA

I-1 . OBJECTIVES OF THE INTERPRETATION

As required in the Special Conditions and Specifications of the Contract, the main objectives of the interpretation of the aeromagnetic data are :

- A description of the relevant geological and geophysical background information of the surveyed and adjacent areas .
- A description of basement zones and intermediate magnetic horizons in terms of possible age and composition of rocks,
- A description of the isobath contours based upon estimated depths to magnetic basement and to intermediate horizons,
- A description of the interpreted structures,
- A description of the probable distribution of sediments within the basin and an assessment of the oil projects .

I-2. AVAILABLE DOCUMENTS

The following documents have been supplied to C.G.G. for interpretation :

- flight line plotting sheets (14) at 1/63,360 approximately
- total magnetic intensity contour maps (14) at 1/63,360 scale
- total magnetic intensity contour map at 1/253,440 scale
- geological map at 1/253,440 scale,
- magnetometer records (13)
- radio-altimeter records (10)

- flight-logs (9)
- geological reports (3) by Messrs N. LUDBROOK & E. O'DRISCOLL.

I-3. GEOLOGICAL DATA

I-3.1 - Physiography

The area consists essentially of a broad peneplain. The natural surface broken by series of dune chains and a few volcanic cones, gently rises up towards the north-west, and hardly exceeds 300 feet. In most places the elevation is below 150 feet.

I-3.2- Stratigraphy

Proterozoic & Paleozoic

The bedrock consisting mainly of granite occurs at varying but generally shallow depths in the Padthaway Ridge separating the GAMBIER-OTWAY BASIN from the MURRAY BASIN proper. Bedrock of the Paleozoic or earlier age has been intersected at R.L- 752 feet in the Kingston bore situated immediately south of the Lucindale fault which marks the southern edge of the Padthaway Ridge . Further south no bore so far has reached the Paleozoic bedrock .

Permian

The extent of the Permian glaciation of the basin is unknown.

Mesozoic and Tertiary sedimentation

The basin is an area of Mesozoic and Tertiary sedimentation. More than 4,000 feet of Mesozoic sediments (siltstones, mudstones and arkosic sandstones) mainly of lower Cretaceous age have been encountered in the Robe bore which bottoms at R.L -4504 feet .

Mesozoic sediments are unconformably overlaid by a Tertiary sequence, the oldest strata belong to the Knight Group of Eocene age . The thickness of the Tertiary sediments is known to exceed 4,000 feet in the Nelson bore .

Apart from exposures occuring in the southern and north-eastern parts of the area, the Tertiary sediments are overlaid everywhere else with Pleistocene and recent deposits.

I-3.3- Stucture

An attempt has been made to contour the Knight Group upper surface by using correlations between available deep bores . The location and type of two main structures are suggested . It appears as an anticline the axis of which is elongated in a northeast- southwest direction possibly swinging southward after crossing the KALANGADOO-Mt GAMBIER line. The southern end of the upward axis is intersected and downthrown by series of faults, whereas the northwestern flank gently sweeps down to become part of a complementary but much broader syncline on which Robe bore appears to be situated .

Volcanic rocks occuring in the vicinity of Mt GAMBIER and Mt BURR are believed to be associated with fault zones passing through the area in a general northwest-southeast direction.

I-4. GEOPHYSICAL DATA

I-4-1. Magnetics

Aeromagnetic data are available on adjacent areas .

In the northern part of the MURRAY BASIN, the magnetic contours indicate the continuation of the same prevailing north-south to north-west -south east trend intersected at places by a secondary northeast southwest direction .

Further west in the EYRE's Peninsula prominent anomalies elongated in a north-south direction are related to highly magnetic quartzites of Archean age including magnetite and hematite ore deposits, whereas other significant north-south anomalies are caused by igneous rocks intrusive into the basement formation .

I-4.2- Gravity

A BOUGUER anomaly map of the GAMBIER-OTWAY BASIN is available with a contour interval of 40 milligals. The contour zero passing near PENOLA, LUCINDALE and Mt BENSON appears to split the area into two zones of different character. East-west and northwest- south east directions occur in the southern zone, whereas a north-south trend is visible in the northern zone. A noticeable semicircular positive anomaly centered near BEACHPORT , where no deep drilling information is available , is believed to be caused by buried volcanic rocks perhaps associated with faulting rather than by a sudden heightening of the basement .

I-5. POSSIBLE MAGNETIC MARKERS

I-5.1. Ascertained magnetic markers

From a comparison between the geological map and the total intensity contours, it is obvious that most of the narrow and sharp magnetic anomalies are created by superficial volcanic rocks which at places have a remanent magnetization revealed by a few negative anomalies .

I-5.2. Probable magnetic markers of the overburden

Probable intermediate magnetic markers can be created by volcanic material buried at any level of the sedimentary overburden as mentioned above .

I-5.3. Probable magnetic markers of the basement

A good magnetization contrast can be anticipated for some of the basement rocks. Among the possible magnetic markers, magnetite quartzites of Archean age and basic intrusions are to be mentioned , whereas a less important contrast is expected for the granites .

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

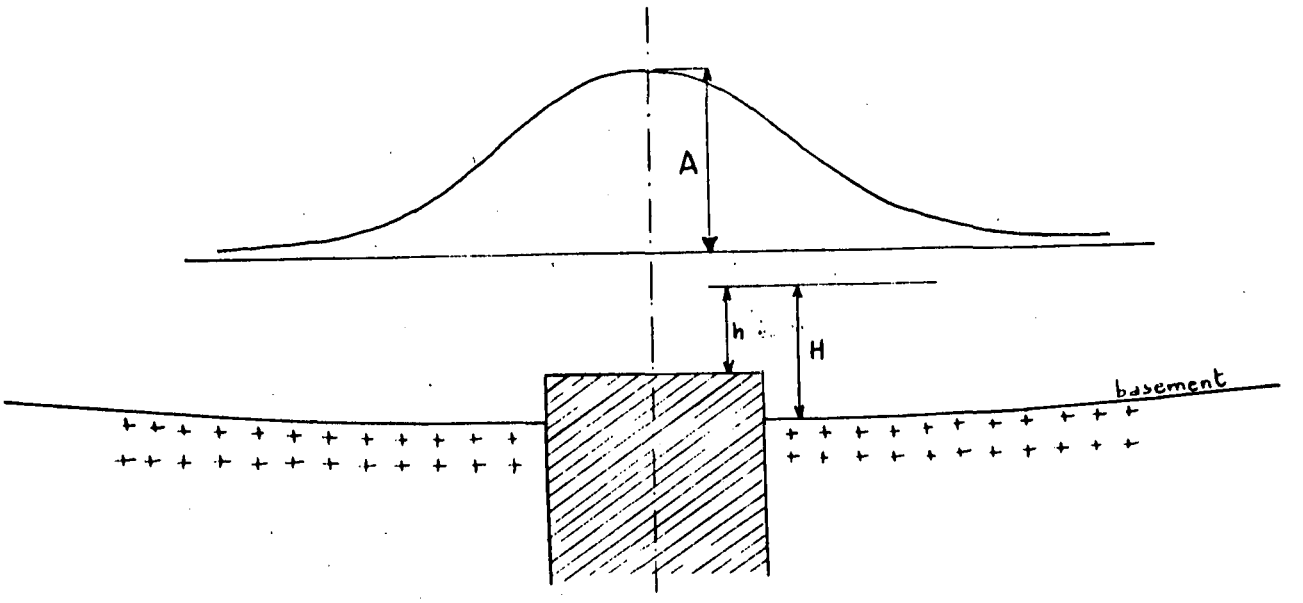
The main structural trends can be defined by analysing the map of total intensity .Three kinds of magnetic features are :

- 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 downthrow side and the range of this displacement .



The effect of the throw H-h has a very small influence upon total amplitude A

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 1.)
- B wide anomaly of low intensity (Fig 1)
- C narrow anomaly of high intensity (Fig 2)
- D narrow anomaly of low intensity (Fig 2)

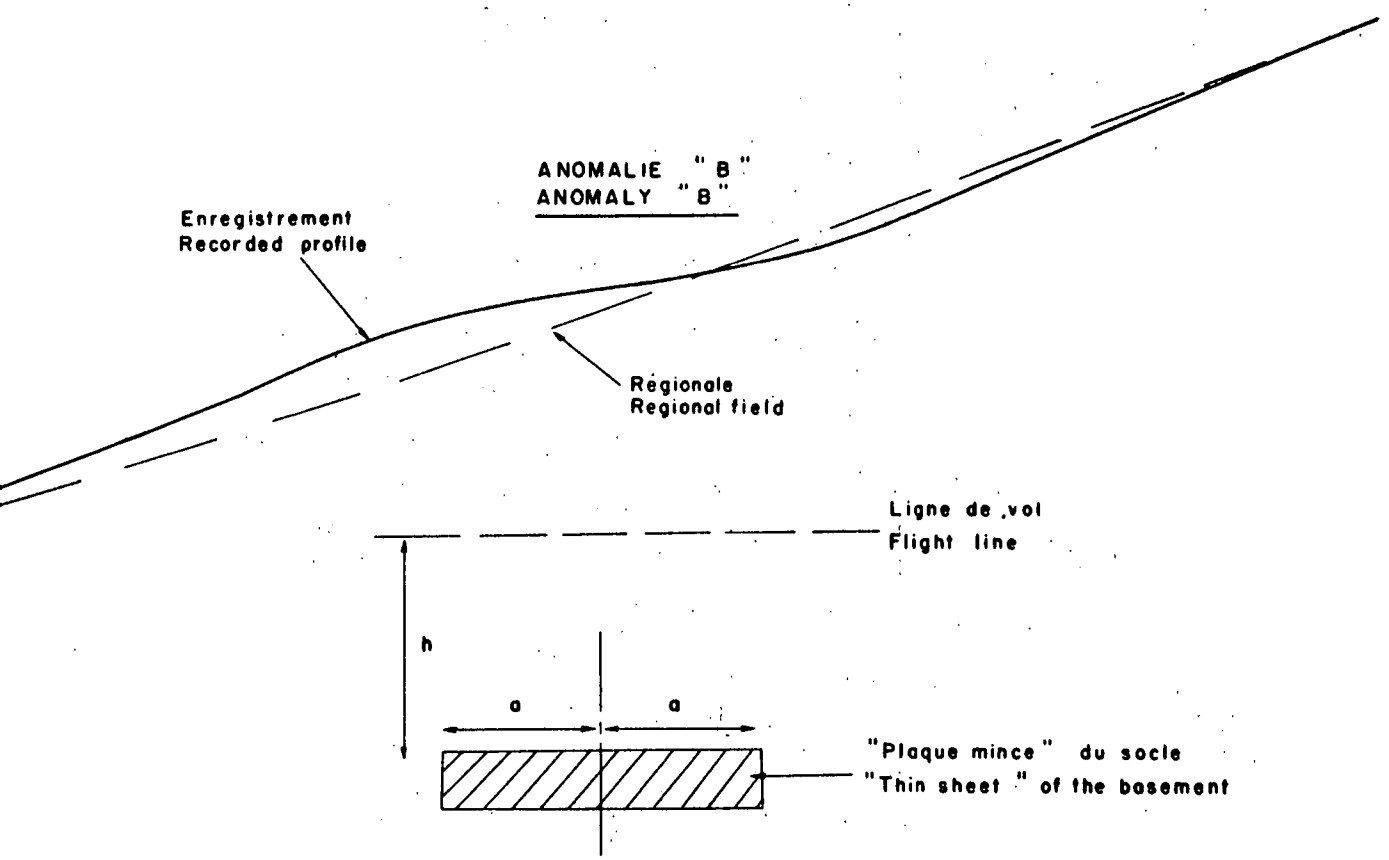
It is not advisable at this stage to consider that each category of anomaly may correspond to a particular horizon though a particular method of interpretation is used for each category .

II-4. QUANTITATIVE INTERPRETATION

Most of the methods of quantitative interpretation are based upon graphic determination of parameters related to the depth of the

Fig. 1 BROAD ANOMALIES

OF TYPE "B"



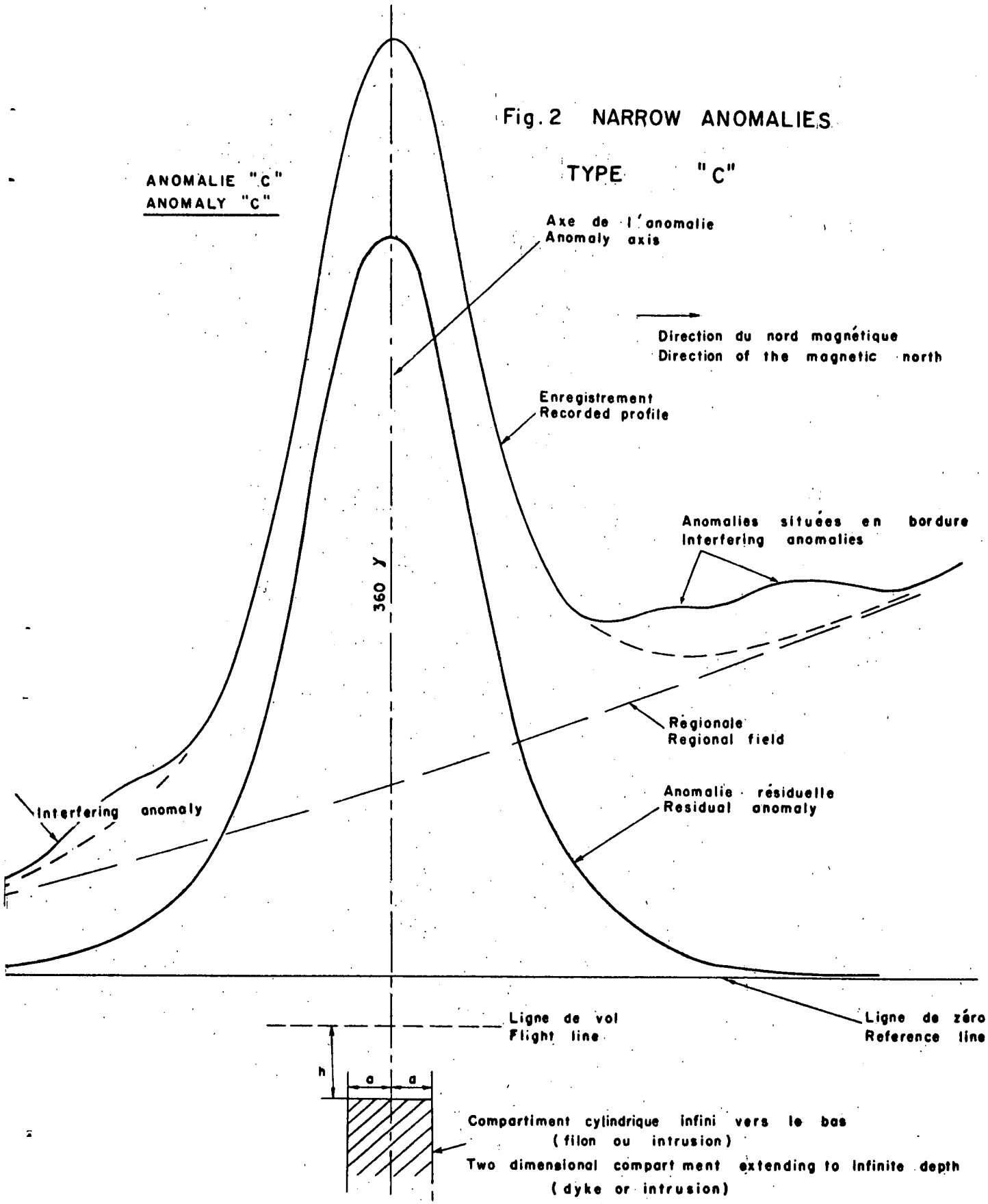
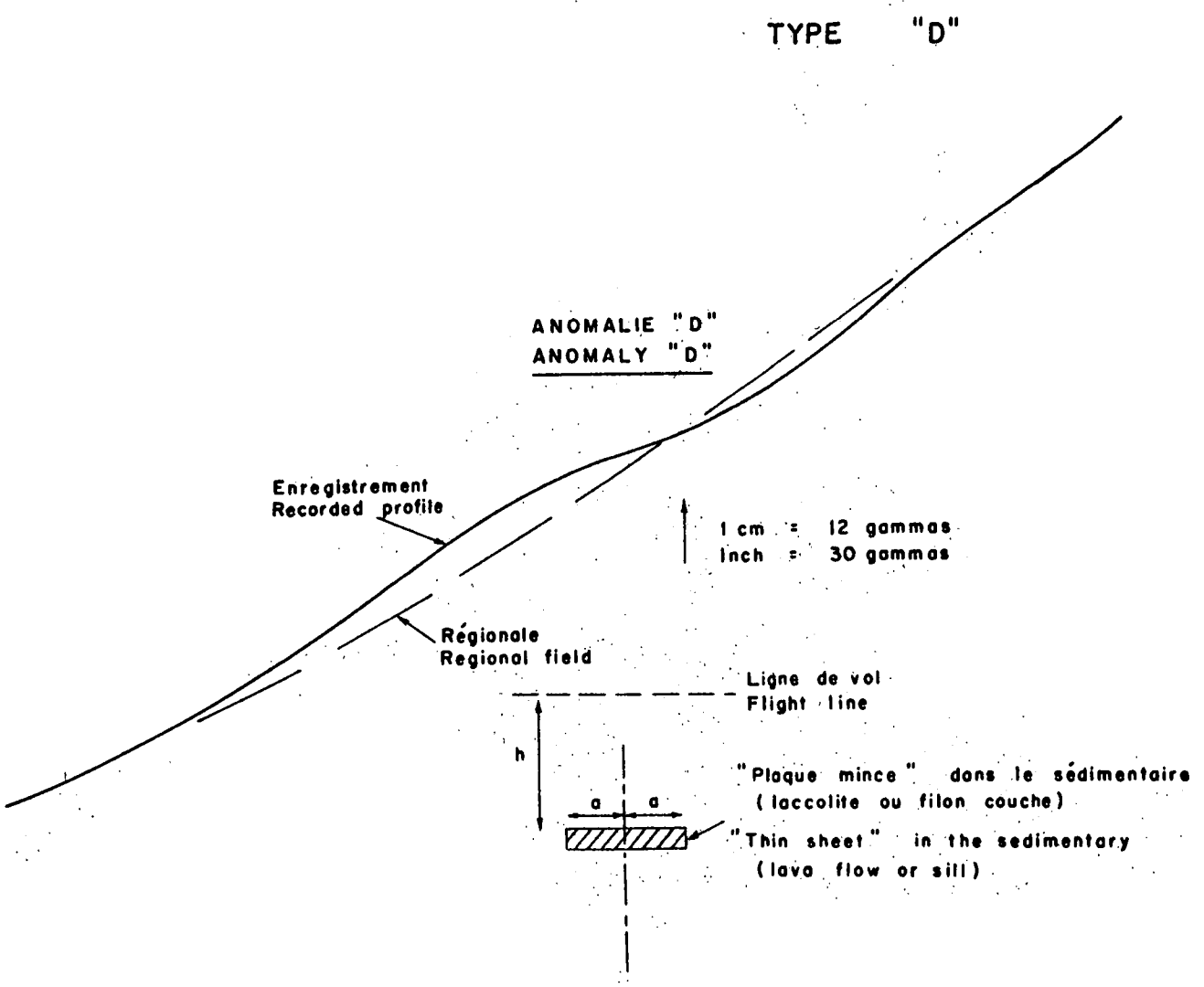


Fig. 2 NARROW ANOMALIES
TYPE "C"
ANOMALIE "C"
ANOMALY "C"
Axe de l'anomalie
Anomaly axis
Direction du nord magnétique
Direction of the magnetic north
Enregistrement
Recorded profile
Anomalies situées en bordure
Interfering anomalies
360 γ
Régionale
Regional field
Interfering anomaly
Anomalie résiduelle
Residual anomaly
Ligne de vol
Flight line
Ligne de zéro
Reference line
h
a
a
Compartiment cylindrique infini vers le bas
(filon ou intrusion)
Two dimensional compartment extending to infinite depth
(dyke or intrusion)

Fig. 2 NARROW ANOMALIES



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 3)

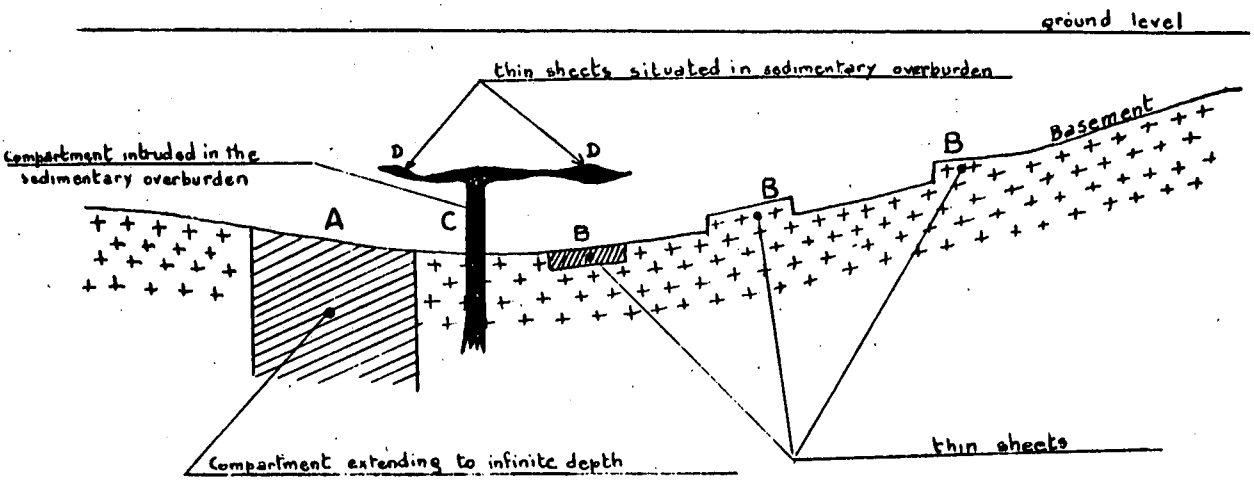


Fig. 3 Different types of magnetic contrasts

The magnetic anomalies created by such uniformly 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 4)

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 $I'_1\ I'_2$ 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 intersections between the inflection 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 .

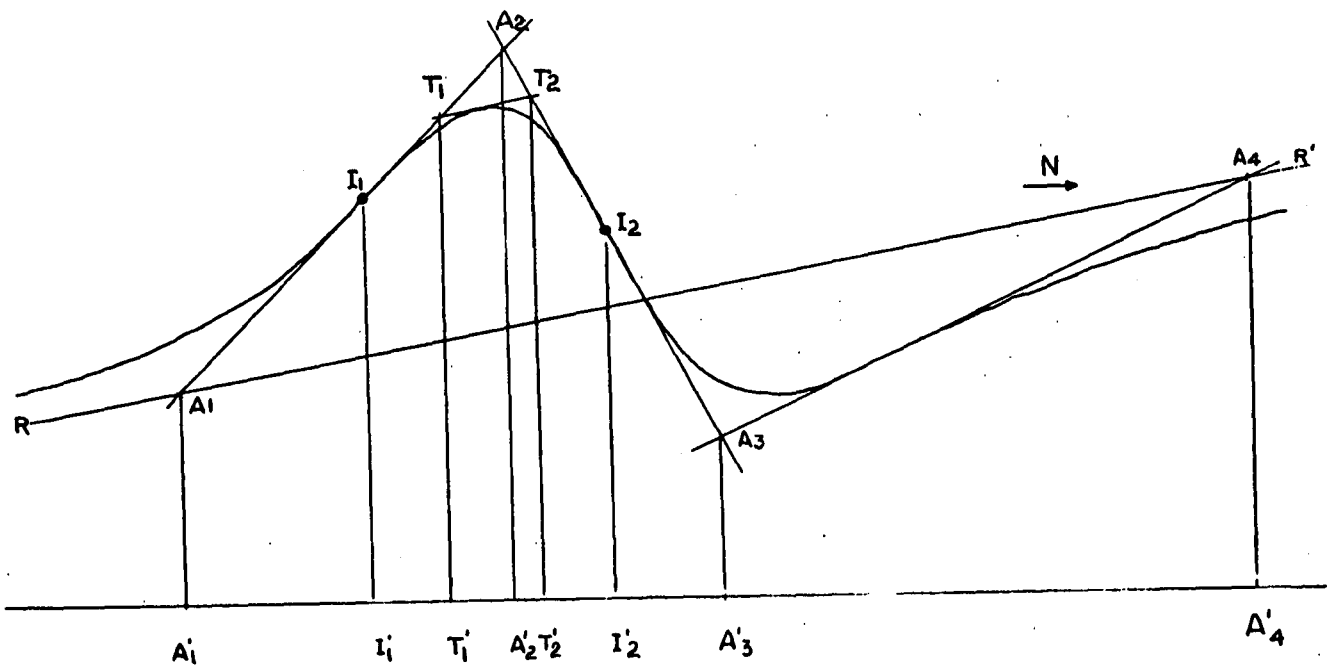


Fig. 4 Parameters of inflection tangent intersections

In the example of figure 4 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 to 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 .

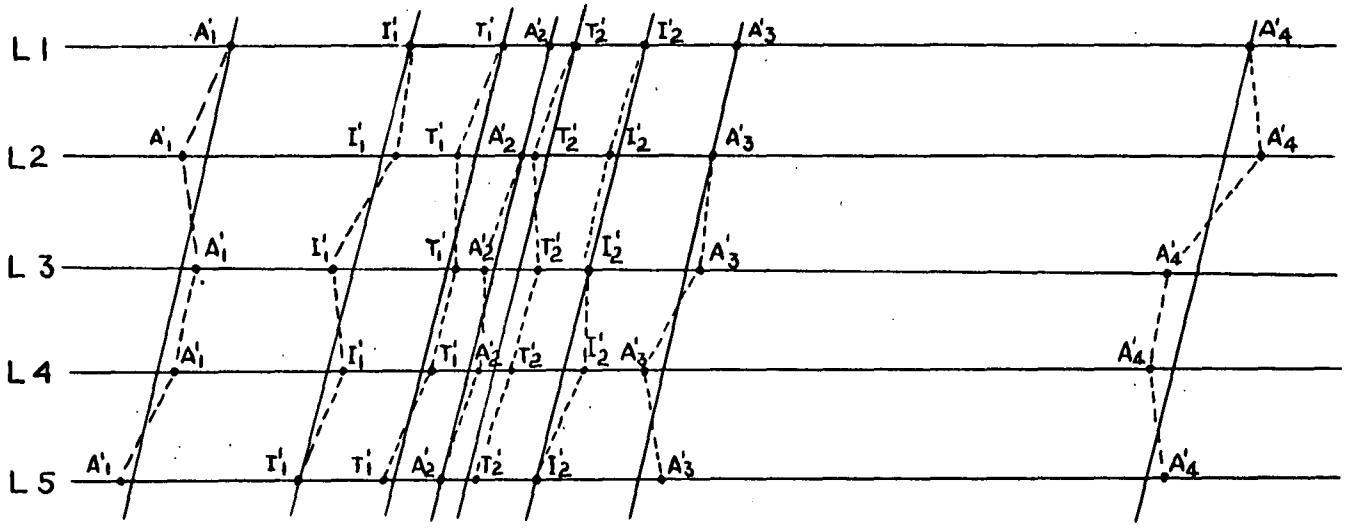
II-5.3. Intersection point mapping (Fig 5)

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 $A'_1, A'_2 \ldots$ from traverse to traverse enable the angle between the profile and the positive axis of the anomaly to be measured and the quality of the estimate to be discussed.

Only the correlations visible on several traverses are taken into consideration. As a matter of fact a fictitious 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 are taken perpendicularly to the successive smoothed mean lines.

Fig. 5 Plotting of the intersections



II-5.4. Advantages of the method

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. Parameters ITI δ

In the same comcept another kind of parameters has been studied. The parameters ITI δ are the vertical differences between the inflection tangent intersections and the curve itself . They are useful to confirm the determination of the ration 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 type 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 δ 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 δ 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 gamms, whereas the compartment of the basement extending to infinite depth may produce anomalies of several hundreds of gammas .

II-8. APPROACH OF THE INTERPRETATION

II-8.1. General considerations

The intensity of an 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 sheet" 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 :

$$tgi' = \frac{tgi}{\cos \alpha}$$

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 "(Fig1)

Hypothesis :"compartment extending to infinite depth,the upper surface constitues 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^{o}.

II-8.4. Wide anomalies of low intensity "B type"(Fig 1)

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 2)

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

II-8-6. Narrow anomalies of low intensity "D type"(fig2)

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 constitute 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 interpreter to be plotted on the map (scale of 1/500,000 or 1/200,000) 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

QUALITATIVE RESULTS

III-1 .ANALYSIS OF THE RECORDED PROFILES

The quality of the available magnetometer records is not as good as that which can be obtained now: this survey has been flown in 1955, probably with a GULF MARK II. The instrument noise can sometimes exceeds a level of 5 gammas. The drawing of the inflection tangents frequently necessitates a previous rectification of the curve, so that the quantitative interpretation of the anomalies of low intensity is less accurate

The four categories of anomalies described in the paragraph II,2-3 are represented on the recorded profiles . The hypothesis adopted for the interpretation of each category are indicated in the following tabulation:

Zone	Category	Hypothesis adopted for interpretation
North	A	narrow compartment of the magnetic basement, extending to infinite depth
South	A	compartment of the magnetic basement extending to infinite depth
	B	"thin sheet" situated at the upper surface of magnetic basement
	C	compartment extending to infinite depth situated in the sedimentary overburden
	D	"thin sheet" situated in the sedimentary overburden .

The boundary MN between northern and southern zones is defined hereunder, paragraph III-2.1.

III-2. ANALYSIS OF THE MAGNETIC MAP OF TOTAL INTENSITY (Pl1)

III-2.1. The anomalies

The analysis of the magnetic contours indicates numerous anomalies distinct by their shape, their intensity and their direction.

The northwestern part of the area is characterized by several north-south axes of narrow anomalies the intensity of which often exceeds 500 gammas. Step by step, the anomalies become wider towards the south .

In the northeastern part of the area, narrow anomalies elongated in a north-south to northwest-southeast directions occur to the south and the southeast of NARACOORTE , whereas to the north of this locality elliptic anomalies of intensity less than 100 gammas appear in a zone of lower magnetic intensity .

To the south of a boundary MN passing approximately 15 miles to the north of ROBE and 10 miles to the north of PENOLA , the style of the magnetic map changes almost completely and becomes less contrasted . The anomalies are wider and present elongated or elliptic shapes . The direction of axis is north-south in the western zone whereas northwest-southeast or northeast-southwest trends prevail in the central and eastern zone.

Between the localities of MILLICENT , KALANGADOO and Mt GAMBIER, the wide positive anomalies are perturbed by several sharp and generally negative anomalies .

Besides, the magnetic map indicates three zones of low magnetic intensity where the isogammic contours present only infrequent inflections. They are situated :

- to the east of the locality of ROBE
-between the localities of KALANGADOO and PENOLA
-to the southwest of a line passing from the localities of MILLICENT and Mt GAMBIER.

III-2.2 The Directions (Plates 1.2 and 3)

The magnetic features as defined in paragraph II.2 display two prominent directions varying from NNW-SSE to NNE-SSW and from NW-SE to WNW-ESE and a secondary NE-SW direction underlined by a structural contact passing by the locality of PENOLA .

Between the localities of MILLICENT and KALANGADOO, the NW-SE direction appears on two magnetic features which are marked by the alignment of several sharp anomalies perturbing a broader anomaly as well as by a closing up of the isogammic contours .

III-3. ZONES OF THE BASEMENT

From the qualitative analysis of the recorded profiles and magnetic map of total intensity a sudden deepening of the magnetic basement can be expected to the south of the boundary MN which appears to represent the practical limit of the sedimentary basin .

CHAPTER IV

QUANTITATIVE RESULTS

IV-1. MAGNETIZED BODIES (Plate 2)

IV-1.1. Presentation of the map of magnetized bodies

Only the well defined magnetized bodies are represented on the map of Plate 2 by their location and extent. The magnetic susceptibility "K" and the magnetic capacity which is the product "Ka" ("a" being half of the width of the body) have been calculated on well defined anomalies in an attempt to display an eventual difference in the nature of the magnetized bodies .

IV-1.2. Compartments of the basement extending to infinite depth ("A type")

- northern area

Calculations made on the very elongated anomaly axes of the KINGSTON area give a varying range for the magnetic susceptibility from 250×10^{-5} to $1,800 \times 10^{-5}$ CGS units, whereas the magnetic capacity remains almost constant . On the north-south axis passing 10 miles to the east of the locality of KINGSTON "Ka" ranges from 6.3 to 8.0.

To the north and east of the locality of NARACOORTE, calculations made on small elliptic anomalies situated in an area of low intensity level give magnetic susceptibilities lower than 200.10^{-5} CGS units.

Such a difference in the range of the magnetic susceptibility suggests a possible difference in the nature of the magnetized bodies of the basement. Highly magnetic material such as ultrabasic rocks or magnetite quartzites seem to be interbedded in parallel strips in the KINGSTON area,

less magnetic material such as less basic rocks seem to be intruded in an acid basement to the north and est of NARACOORTE .

-southern area

To the south of the boundary MN defined in the paragraph III,2.1. the magnetic susceptibility ranges from 45 x 10^{-5} CGS units .

The magnetic susceptibilities lower than 100 x 10^{-5} CGS units correspond to anomalies of lower intensity and approximately east-west direction .Such anomalies are often validly intersected on one traverse only so that the determination of "K" and "a" cannot be ascertained. The nature of the magnetized bodies corresponding to these anomalies seems to be in no case comparable to that of the KINGSTON area .

The magnetic susceptibilities higher than 100 x 10^{-5} CGS units correspond to prominent anomalies and their magnetic capacities ranging from 18.5 to 42.0 exceed those of any of the highly magnetized bodies existing in the KNIGSTON area. Taking into account the deepening of the basement after the crossing of boundary MN towards the south,it is reasonable to consider the wider southern anomalies as if they represent the integration of the individual effects of several parallel strips of highly magnetized bodies which are situated at shallower depth in the northern zone .See Fig 6.

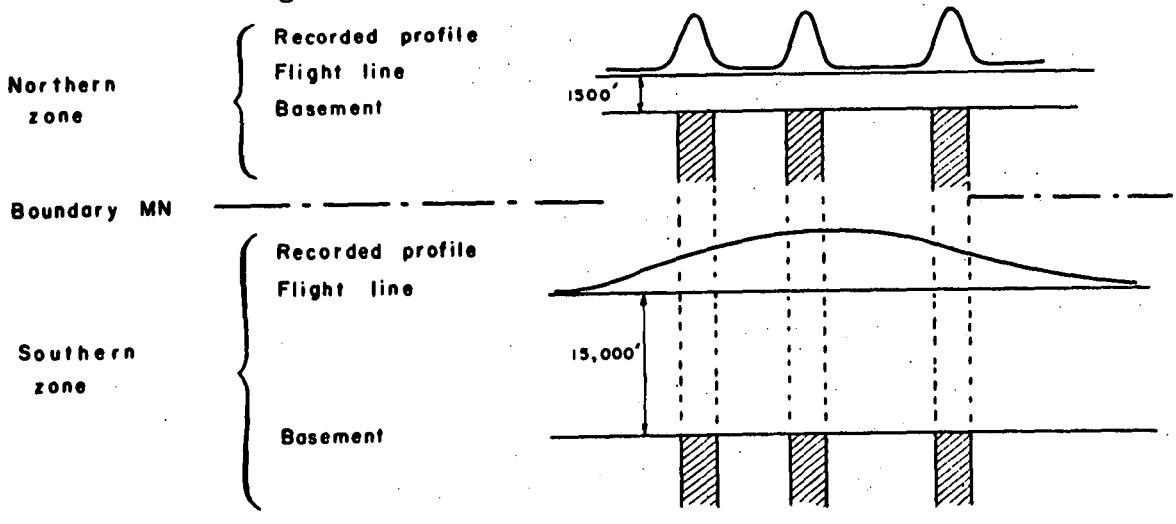


Fig. 6 Depth influence

The latter remarks and the fact of the continuation of the same north-south direction give support to the idea of the same nature for the material of the magnetic basement in the elongated area starting near the locality of KINGSTON and passing between the localities of BEACHPORT and MILLICENT . By analogy, the same nature is also anticipated for other prominent anomalies of the southern zones though their directions are different .

As far as the interpretation of the wide anomaly situated just to the east of the locality of MILLICENT is concerned, it is worth noting an excellent agreement between both qualitative and quantitative approaches. The two northwest-southeast structural contacts of the magnetic features, match exactly with the magnetic body's boundaries deriving from the determination of the width 2 a by the method of the inflection tangent intersections. Such correlation may suggest the idea of two fault zones limiting a large magnetic compartment of the basement.

IV-1.3 "thin sheet" situated at the basement upper surface (" B type")

The magnetic susceptibility has been calculated on several profiles. Their range is similar to that of the prominent anomalies.

IV-1.4. Compartments situated in the sedimentary overburden ("C type")

The sharp anomalies situated in the vicinity of MILLICENT and Mt GAMBIER are rather disturbed: so that no accurate determination of the magnetic susceptibility is possible . They correspond to volcanic material .

A prominent anomaly situated immediately north of the locality of BEACHPORT presents a magnetic susceptibility of 160.10^{-5} CGS units . Its magnetic capacity of 11.5 is lower than the mean capacity of the surrounding compartments of the basement. The reasons for attributing this anomaly to an intermediate horizon, will be presented hereunder.

IV-1.5." Thin sheets" situated in the sedimentary overburden (" D type ")

Such magnetic bodies are not represented on the map of plate 2 since the anomalies are not correlating on a sufficient number of profiles .

IV-2 . ISOBATH OF MAGNETIC BASEMENT AND INTERMEDIATE HORIZON (Plate 3)

IV-2.1 Contour Interval

Isobath from 500 to 18,000 feet below the sea level have been contoured .They are based upon few fair and numerous probable depth estimates,whereas the interrogative marked estimates have been neglected each time they are not consistent with surrounding depth determinations.

The contour interval has been chosen to give a fair idea of the precision of the depth estimates. From statistical calculations made on aeromagnetic results of previous surveys the mean quadratic relative error to be anticipated for a group of depth estimates is about 10%. The mean quadratic absolute error is about $\pm$ 350 feet in the northern zone where the average depth to the basement is about 3,500 feet below the flight line. Thus, a contour interval of 1,000 feet in the northern part of the area is admissible.

To the south of the boundary MN where the average depth to the basement ranges about 13,000 feet,the mean absolute quadratic error is $\pm$ 1,300 feet. To underline the main features of the basin, a contour interval of 2,000 feet has been chosen even if it is not theoretically acceptable.

IV-2.2. Northern Area (bounded to the south by the line MN)

To the north of the line passing near the localities of KINGSTON and NARACOORTE,the magnetic basement consists essentially of a table-land at 500 feet below the sea level. Several north-south or northwest-southeast structural contacts displayed by the qualitative analysis of the isogammic contours,cannot be studied quantitatively in terms of eventual displacement.

To the south and southwest of the locality of KINGSTON, the isobath contours indicate a deepening of the basement exceeding 6,000 feet. A structural contact of an approximate WNW-ESE direction, passes 3 miles to the south of the locality of KINGSTON. Depth estimates made on both sides of the contact suggest the idea of a fault which downthrows the southern compartment of the basement. Its variable throw is increasing from about250 feet near the coast to 1,200 and 4,500 (?) feet towards the east. Such figures are only rough estimates. This fault disappears against a crossing fault but is continued towards the east by several northwest-southeast faults intersected by transverse faults .

IV-2.3. Southern Zone (bounded to the north by the line MN)

In order to facilitate the description of the isobath contours, the letters A,B,C.... are used to designate the zones which require special attention .

ZONE A.

The "thin sheet" hypothesis adopted for an anomaly of low intensity indicates the beginning of an heightening of the basement in the vicinity of the locality of ROBE. However, the depth estimates ranging from 10,700 to 12,500 feet are not certain since the western flank of the anomaly extending beyond the coast has not been entirely recorded .

ZONE B.

Two basement upwards are situated just to the south and almost in the middle of line NM.

- The western high which represents only a reduced area culminates at about 7,000 to 8,000 feet. Its southern end is intersected by a fault of WNW-ESE direction.

- The eastern high appears as an anticline the axis of which presents a northwest-southeast direction . Its southwestern flank is affected by a downthrowing fault ranging about 3,000 feet .

The eastern and western ends are affected by two other downthrowing faults of NNW-SSE direction, but the amplitude of their throw cannot be determined .

Besides, the existence of an intermediate magnetic horizon is suggested by the quantitative interpretation of three small anomalies of low intensity situated in zone B in the immediate proximity of above mentioned faults . The " thin sheet" hypothesis gives depth estimates ranging from 4,400 to 5,700 feet which indicate a level situated about 2,000 feet above the basement. These anomalies are probably created by buried volcanic bodies associated with faulting zones .

ZONE C.

Zone C corresponds to a very elongated upwarp the axis of which presents a direction N. 15° W. The delineation of the contours is based upon the quantitative interpretation of two anomalies related to the basement Since a part only of the western flanks of these anomalies is recorded on the profiles , the method of the total bilogarithmic master curves has been used to confirm the results obtained by the method of the inflection tangent intersections . The average of the depth estimates determined by both methods indicates clearly the existence of the upwarp to the southwest of the locality of MILLICENT, whereas its western flank sweeping down towards BEACHPORT is not well established .

ZONE D.

The existence of a broad northwest-southeast upwarp to the northwest of the locality of KALAGADOO is based upon the interpretation of four anomalies corresponding to " thin sheets" situated at the upper surface of the basement, their geological significance : sills of basic material or horsts, cannot be disclosed .

Zone D is intersected by several fault zones. Two of them present a secondary southwest-northeast direction normal to the general trend of the basin. The fault which intersects the southeastern end of the upwarp can be continued beyond the locality of PENOLA and the determination of its downthrow side is deduced only from the analysis of the map of total intensity . as a matter of fact the existence of a deep compartment between the localities of KALANGADOO and PENOLA is suggested by a very calm and low magnetic level observed in this area though no depth estimate is available . However, such a calm magnetic area could also result from a basement without magnetic differenciation at any depth .

On the southwestern flank of the upwarp several sharp anomalies correspond to intrusions in the sedimentary overburden culminating at a depth of 100 to 300 feet below the natural surface of the cones of volcanic material which appears to be affected by a rather deep weathering .

ZONE E.

A culmination at 11,500 feet below sea level is found by applying both methods of inflection tangent intersections and total bilogarithmic master curves for a single anomaly of 40 gammas situated 6 miles to the southeast of the locality of KALANGADOO and validly intersected by the tie line 6 only. Such compartment of the basement appears to be limited towards the south by an east-west structural contact . Other limits of this upwarp are not delineated with precision except by three " thin sheet " anomalies which indicate the continuation towards the north of the - 12,000 contour and of an intermediate- 13,000 contour. However the depth estimates is rather inaccurate since the amplitude of these anomalies does not reach 15 gammas .

MILLICENT -Mt GAMBIER ZONE

To the south of zones D and E the isobath contours indicate as a broad syncline the axis of which presents a northwest-southeast direction swinging towards the east of the vicinity of Mt GAMBIER.

The sharp anomalies observed in the Mt GAMBIER area correspond to highly magnetic material intruded in the sedimentary overburden and culminating at various levels ranging from 50 to 1,500 feet below the natural surface of exposed volcanic rocks. Since it is impossible for a weathered zone to extend to a depth of 1,500 feet, it is more reasonable to suggest either the occurence of distinct phases of volcanism, or merely erroneous determinations caused by the fact that some very narrow anomalies have been intersected on their fringe by the flight lines.

ZONE V.

The quantitative interpretation of a prominent anomaly situated immediately to the north of the locality of BEACHPORT indicates the occurence of a magnetic contrast at a depth of about 5,000 feet. Since the average of the surrounding depth estimates ranges about 13,500 feet, the hypothesis of a magnetic horizon intercalated in the sedimentary overburden has been adopted . This hypothesis is confirmed by the interpretation of several anomalies of lower intensity interfering with much broader anomalies related to the basement .

An attempt has been made to contour the upper surface of this intermediate horizon, the depth is shown to be between 3,500 and 8,000 feet below sea level . The isobath contours delineate a sort of north-south ridge the axis of which passes 4 miles to the east of the locality of BEACHPORT.

Two north-south magnetic contacts have been located on the alignments of anomalies .

As far as the geological significance of these anomalies is concerned the prominent magnetic anomaly of BEACHPORT seems to be caused by the buried core of a volcanic system and other anomalies of lower intensity by buried volcanic flows of variable thickness, subsequently affected by faulting.

CHAPTER V

SYNTHESIS OF THE RESULTS

V-1. COMPARISON WITH GRAVITY DATA

The agreement between the main features of the gravity map and the prevailing directions of the magnetic map of total intensity, already mentioned in Chapter 1 is renforced by the comparison of some characteristic contours of Bouguer anomaly with the isobath contours of the magnetic basement and intermediate horizon :

-The-40 milligal contour separating the gravity map in two distinct northern and southern areas coincides approximately to the isobath contour -4,000 feet which marks the practical limit of the basin towards the north .

- the - 120 milligal contour defining two broad negative Bouguer anomalies seems to confirm the occurence of deep zones of the magnetic basement located to the east of zone A and between zones B and D.

- The generally accepted idea of a gravity contrast in the overburden in the vicinity of the locality of BEACHPORT is in good agreement with the proposed hypothesis of an intermediate magnetic horizon . Although no certitude can be obtained without a quantitative interpretation of the gravity data, the positive gravity anomaly of BEACHPORT could correspond, by its amplitude (higher than 200 milligals) and its particular semicircular shape, to the hypothesis of a gravity contrast shallower than those creating much broader surrounding anomalies.

As a result the " gravity basin" seems to correspond more or less to the " magnetic basin" defined by the isobath contours. Some of the gravity contrasts existing in the upper part of the basement and in the

sedimentary overburden might be closely related to some magnetized bodies of a density higher than that of the surrounding material.

V-2. NATURE OF THE MAGNETIC CONTRASTS

There is no doubt that the magnetized bodies constituting the magnetic compartments and "thin sheets" in the sedimentary overburden correspond to basalts or similar rocks .

It is logical to anticipate the occurence of basic or and ultra-basic dykes and sills in association with the volcanism and to relate them to some of the magnetic compartments, whereas other "thin sheets" are related to the morphology of the upper surface of the basement such as horsts, downthrowing faults .....

The area of lower magnetic level probably related to a granitic bedrock or other acid rocks suggest the extension of the PADTHAWAY RIDGE towards LUCINDALE and NARACOORTE.

Considereing the western part of the basin, it is worth noting that the anomalies are continuous and their north-south direction very constant in spite of the deepening and faulting of the basement, besides, the increase of the apparent magnetic capacity towards the south has been interpreted in Chapter III as resulting from the integration of the effects of several parallel upturn strips of highly magnetized material of rather constant magnetic susceptibility. Such conditions are so similar to those existing in the eastern part of the EYRE's peninsula, that it does not seem illogical from the geophysicist's point of view to correlate some of the magnetic markers of the western area with the magnetic quartzites of the MIDDLEBACK Group of Pre-Cambrian age, as suggested in Chapter I.

V-3. CHARACTERISTICS OF THE SEDIMENTARY BASIN

V-3.1. Distribution of the sediments

A considerable thickness of sediments characterizes the southern part of the basin, the maximum estimate is in excess of 18,000 ft. However, it must be stressed that in addition to the absolute quadratic error in the depth determination, there does exist an unforeseable cause of error related to the magnetized body itself since its upper surface can even -tually be deeper than that of the geological basement proper. The latter error always in excess .

The intermediate magnetic horizon mapped in a rather broad area to the east of BEACHPORT (Zone V) and mentioned to the southeast of LUCINDALE (Zone B) may perhaps constitute a reference stratigraphic horizon valid for the medium part of the basin if the volcanism is related to a known tectonic phase.

V-3.2 Structures

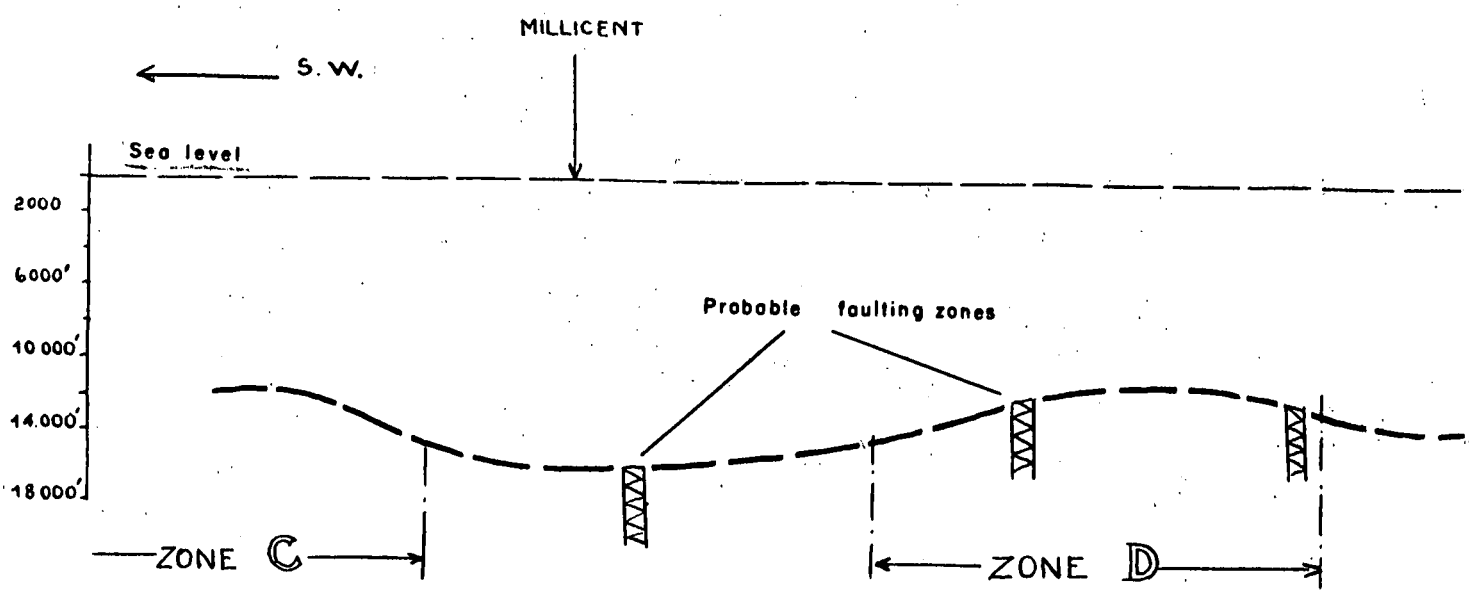
Apart from the faults of approximate northwest-southeast direction which affect the Tertiary strata, other faults of northeast- southwest, north-south and east-west directions often marks the limits of the upwarp structures of the basement .

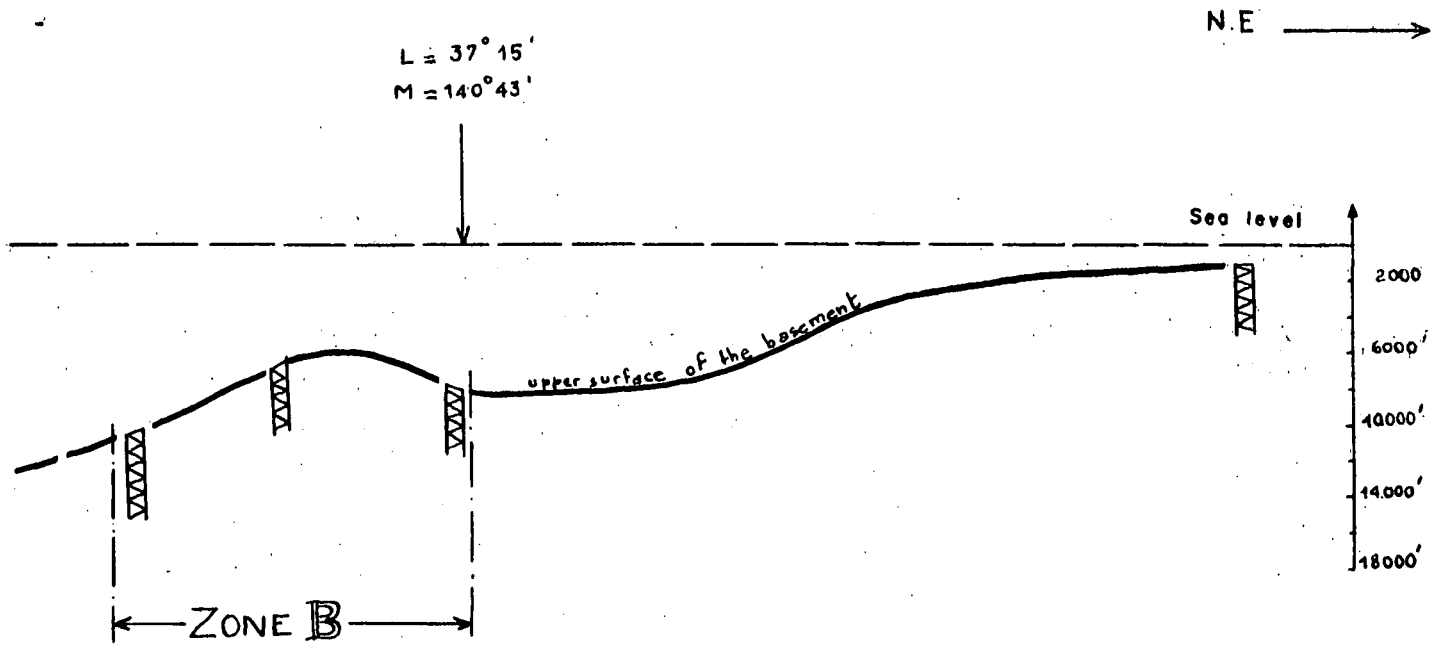
Frequently the axes of the upwarp structures are better determined than their flanks and associated synclines, which are subject to the error mentioned in the above paragraph V, 3-1.

Among the features presenting some interest from a structural point of view, are three located in zones A and B situated in the vicinity of the main faults that limit the basin towards the north, and three in zone C, D and E situated in a deeper part of the basin .

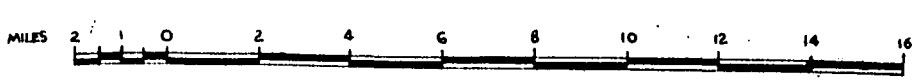
Zones B, C and D are represented on a cross-section of northeast southwest direction passing by the locality of MILLICENT (see Fig 7.)

Fig. 7 STRUCTURAL CROSS-SECTION





SCALE



CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

VI-1. CONCLUSIONS

The interpretation of the aeromagnetic data confirm that the GAMBIER-OTWAY BASIN is a very deep basin largely open towards the Southern Ocean and completely isolated from the MURRAY BASIN proper.

The depth to the magnetic basement exceeds 18,000 feet in the deepest part of the area situated between the localities of MILLICENT and Mt GAMBIER, whereas less than 1,000 feet of the sediments overlay the northern table land in the area of KINGSTON, LUCINDALE and NARACOORTE. The transition between both areas is marked by a steep deepening of the basement associated with faulting zones and presenting a general WNW-ESE direction .

The isobath contours of the basement suggest the occurence of six upwarps generally affected by faulting and located near the northern limit and in the deeper part of the basin. They may constitute interesting objectives for further research.

Considering the nature of the magnetic markers, the shallow magnetic contrasts are related without doubt to volcanic material generally associated with faulting zones . An intermediate magnetic horizon located in the BEACHPORT area and to the southwest of LUCINDALE is attributed to buried volcanic outflows corresponding to a former period of volcanism.

As far as the nature of the magnetic basement is concerned, the similarity in the relatively high magnetic susceptibility of several compartments of the northwestern parts of the area leads to the concept of a same magnetic marker which in turn could be related by analogy to Pre-Cambrian formations of the EYRE Peninsula .

VI-2. RECOMMENDATIONS

Since most of the broad coastal anomalies are not entirely recorded it would be advisable to extend most of the traverses towards the west to escertain the depth estimates . In addition the reliability of the main structural results could be estimated by means of a northeast-southwest refraction seismic traverse passing by the locality of MILLICENT in order to intersect three of the supposed basement upwarps and associated structures reflected in the sedimentary strata.

BRISBANE the 26 th of April 1965

For COMPAGNIE GENERALE de GEOPHYSIQUE

Mr. M. JACQUEMIN
Airborne Surveys Project Manager

PL:1

COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

AEROMAGNETIC MAP OF TOTAL INTENSITY
GAMBIER-OTWAY BASIN, SA

SCALE

miles 5 0 5 10 15 miles

Kilometres 5 0 5 10 15 20 Kilometres

MAGNETIC CONTOUR INTERVAL 20 GAMMAS.

LOCATION DIAGRAM

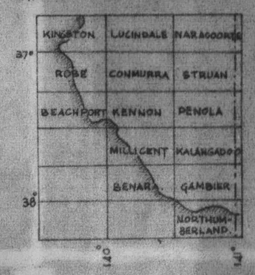
LEGEND

- Magnetic contours (Values in gammas)
- Flight line (showing photo positions)
- Magnetic low
- Main, secondary roads
- Track
- Railway
- Swamp
- Boundary between northern and southern areas MN.
- Possible structural contact
- Indication of possible downthrown side

NOTES : This map is compiled from an airborne magnetometer survey conducted by Adastra Hunting Geophysics Ltd. on behalf of the S.A Department of Mines. The total magnetic intensity at 500 feet above ground level was recorded continuously. Uncontrolled photomosaic assemblies were used to navigate flight-lines at a spacing of one mile and semi-controlled base maps indicate the aircrafts actual flight course as recorded on over-lapping photographs taken with a 35 mm Vinten camera during flight.

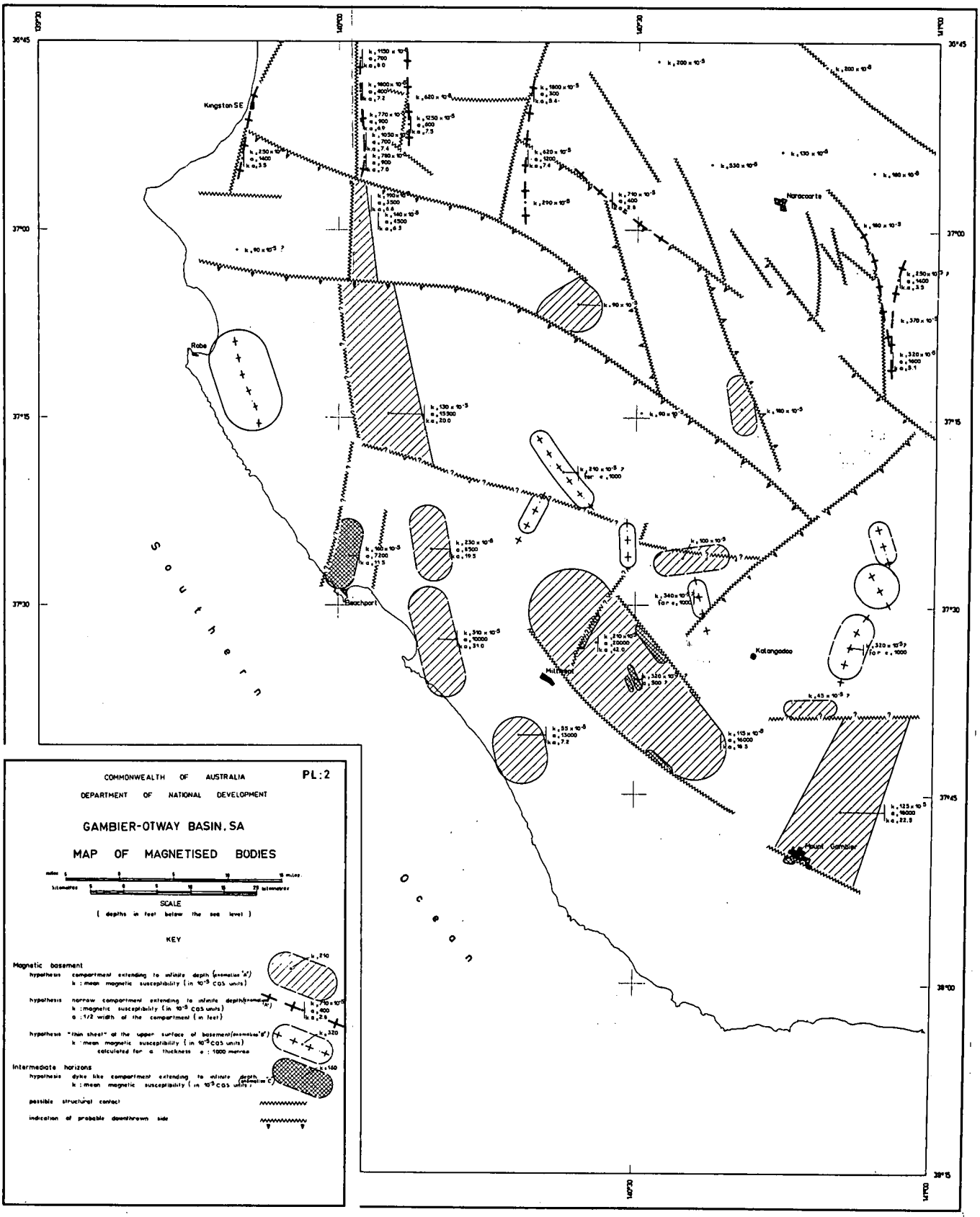
Results reduced by Geophysical Section, S.A. Department of Mines. The contours are corrected for normal regional gradient.

REFERENCE TO 1-MILE AUSTRALIAN NATIONAL MAP SERIES.



COMPAGNIE GÉNÉRALE DE GÉOPHYSIQUE

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics J54/BI-5



COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

PL:2

GAMBIER-OTWAY BASIN, SA

MAP OF MAGNETISED BODIES

SCALE

(depths in feet below the sea level)

KEY

Magnetic basement

hypothesis compartment extending to infinite depth (anomalies 'A')
k : mean magnetic susceptibility (in 10^{-6} CGS units)

hypothesis narrow compartment extending to infinite depth (anomalies 'A')
k : magnetic susceptibility (in 10^{-6} CGS units)
a : 1/2 width of the compartment (in feet)

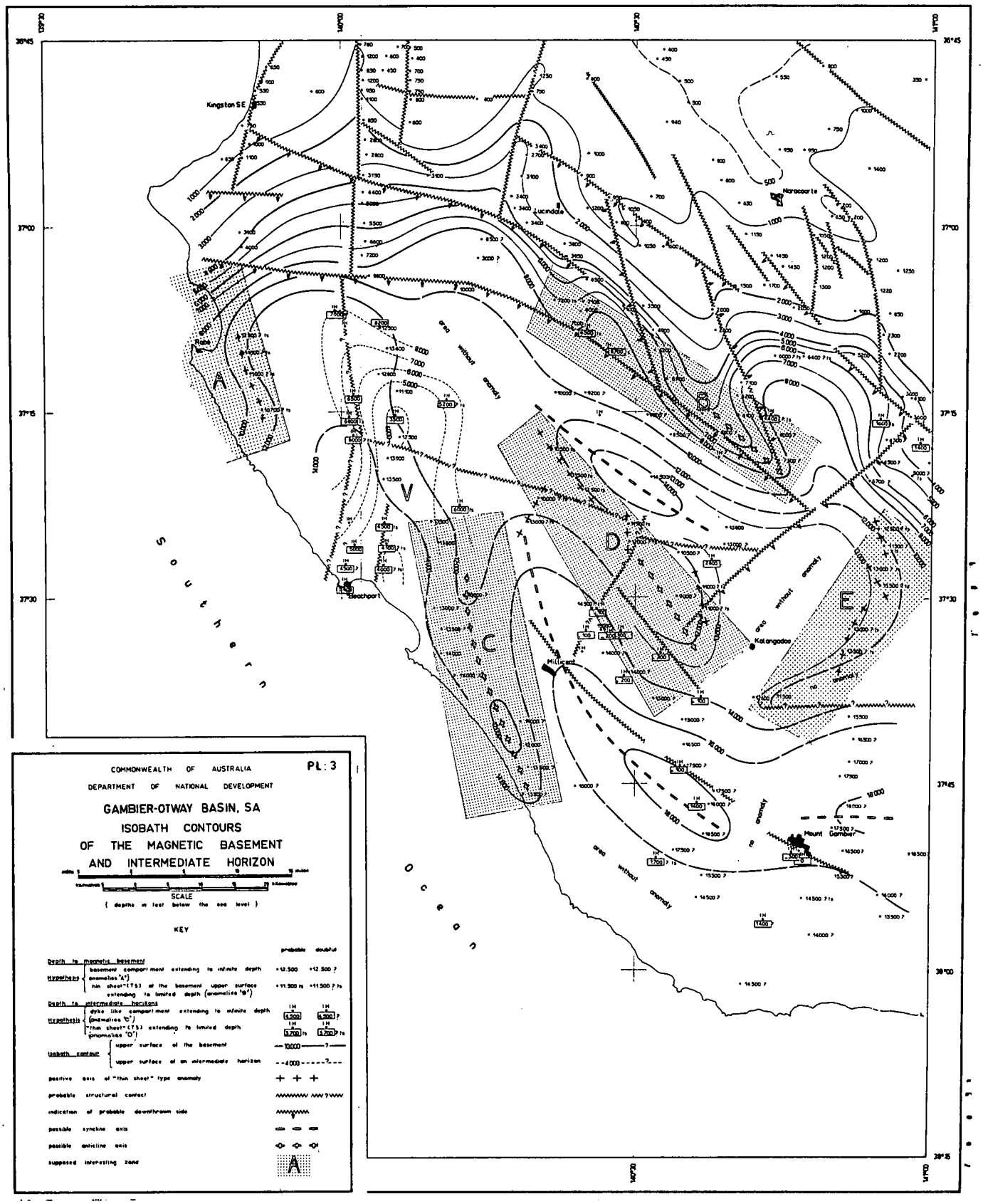
hypothesis "thin sheet" of the upper surface of basement (anomalies 'B')
k : mean magnetic susceptibility (in 10^{-6} CGS units)
calculated for a thickness e : 1000 metres

Intermediate horizons

hypothesis dyke like compartment extending to infinite depth (anomalies 'C')
k : mean magnetic susceptibility (in 10^{-6} CGS units)

possible structural contact

indication of probable downthrown side



COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

PL: 3

GAMBIER-OTWAY BASIN, SA

ISOBATH CONTOURS OF THE MAGNETIC BASEMENT AND INTERMEDIATE HORIZON

SCALE

(depths in feet below the sea level)

KEY

		probable	doubtful
Depth to magnetic basement			
Hypothesis	basement compartment extending to infinite depth (anomalies 'A')	+12.500	+12.500 ?
	thin sheet" (TS) of the basement upper surface extending to limited depth (anomalies 'B')	+11.500 ts	+11.500 ? ts
Depth to intermediate horizon			
Hypothesis	dyke like compartment extending to infinite depth (anomalies 'C')	IH 4.500	IH 4.500 ?
	"thin sheet" (TS) extending to limited depth (anomalies 'D')	IH 4.700 ts	IH 4.700 ? ts
Isobath contour	upper surface of the basement	—10.000—	—?—
	upper surface of an intermediate horizon	--4.000--	--?--
positive axis of "thin sheet" type anomaly		+ + +	
probable structural contact			
indication of probable downthrown side			
possible synclne axis			
possible anticline axis			
supposed interesting zone		A	