1969/58
c.4

COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record No. 1969 / 58

Papuan Basin and Basic Belt Aeromagnetic Survey,

Territory of Papua & New Guinea 1967

by

Compagnie Generale de Geophysique

TEXT

BUREAU OF MINERAL RESOURCES

AEROMAGNETIC SURVEY OF THE PAPUAN BASIN AND BASIC BELT

(June - November 1967)

COMPAGNIE GENERALE DE GEOPHYSIQUE

TABLE OF CONTENTS

Page

LIST OF FIGURES

LIST OF PLATES

		Scale
Plate 10	MAER ISLAND - Field Contours (4,000')	1/250,000
Plate 11	AROA - Field Contours (4,000')	1/250,000
Plate 12	Total Magnetic Field Contours (4,000' and 15,000')	1/500,000
Plate 13	SALAMAUA- Magnetic profiles and Planimetric Map	1/250,000
Plate 14	Interpretation Map of the Papuan Basin and Basic Belt	1/500,000
Plate 15	Geological Map	1/500,000
Plate 16	LAE	1/250,000
Plate 17	Locality Map	1/1,000,000

FOREWORD BY BUREAU OF MINERAL RESOURCES

The objectives of the survey were:

(1) To delineate basement depth and topography, the extent of volcanic sequences, and structures significant for petroleum exploration in the Papuan Basin.

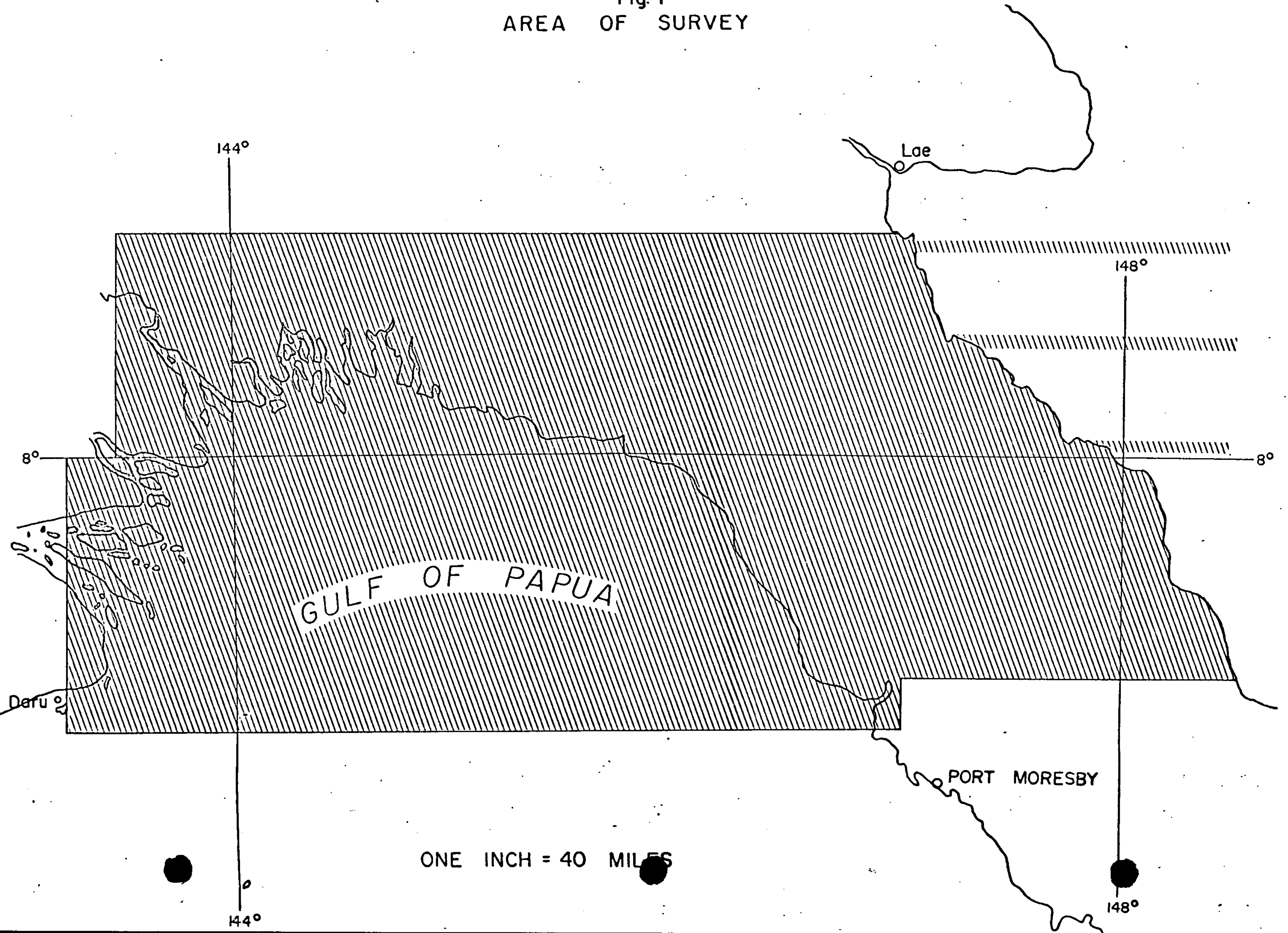
(2) To outline the subsurface extent and disposition of the Basic Belt and provide information on its possible origin as an upfaulted segment of oceanic mantle.

The contract for the survey was awarded to Compagnie Générale de Géophysique in April 1967. Survey operations took place between July and November 1967. Preliminary reports of the survey results were available in February 1968. Owing to unexpected delays, the final report was not received until June 1969.

The survey operations and subsequent data processing, presentation, and interpretation were supervised by a number of officers of the Airborne and Drafting Sections of the Geophysical Branch of BMR.

The survey has provided a considerable amount of information on regional and detailed structures in the Papuan Basin, and has stimulated further exploration in the region. The interpreted structure of the Basic Belt is a solution, though not a unique one, which requires further geophysical and geological study to test its accuracy.

Fig. I
AREA OF SURVEY



INTRODUCTION

By terms of a contract dated April 20th. 1967, No. C 500551, the COMPAGNIE GENERALE DE GEOPHYSIQUE, Head Office at 50 rue Fabert, Paris 7^{o}, France, undertook to carry out, compile and interpret an airborne magnetometer survey in the Territory of Papua and New Guinea for the Australian BUREAU OF MINERAL RESOURCES.

The surveyed region covers some 45,000 square miles in an area bounded approximately by latitudes 7^{o} South and 9^{o}15' South and longitudes 143^{o}15 East and 148^{o}30' East (see Fig. 1).

A total of 20,802 linear miles were flown in carrying out this programme, which once the reflights and various contractual obligations were subtracted, amounted to 19,123 miles.

The compilation and the final interpretation of the data was made by CGG's Airborne Geophysics Department under the supervision of Mr. J. LERIDON, who had overseen the field operations and prepared the in-the-field interpretation report.

CHAPTER I

SPECIFICATIONS AND OPERATIONS

1. EQUIPMENT

1.1 AIRCRAFT

The aircraft used was a four engine B17 registered to, and operated by, the INSTITUT GEOGRAPHIQUE NATIONALE of France.

The use of such a large long range aircraft proved to be very suitable for operations in this area of extreme topographic relief (mountains to 14,000 feet) where very bad meterological conditions (rain and heavy clouds) are common. Indeed, the speed and long range of the B17 resulted in the rapid completion of flight lines during the favourable weather periods (particularly over the Gulf of Papua where the radio navigation chain was used) and the flying at 15,000 feet (with oxygen) over the mountains with safety and stability (thus ensuring the best measurement conditions).

1.2 GEOPHYSICAL EQUIPMENT

Mounted in the aircraft were:

- one CSF optical pumping Cesium Vapor magnetometer towed some 150 feet below and behind the aircraft.
- one ROCHAR frequency meter.
- one COTELEC digital magnetic type recorder.

- one SFIM digital magnetic tape recorder.
- one TEXAS INSTRUMENTS analog recorder.
- one ROSEMOUNT barometric altimeter.
- one MOSELY analog recorder.
- one RADIO altimeter, giving the altitude above terrain.
- one AEROPATH strip-camera.
- one CAMEMATIC single-frame camera.
- one BENDIX Doppler navigator system.
- one TORAN receiver system, with two sets of phasemeters for over water navigation.

All the recorders were synchronised by fiducial markers delivered every 20 seconds by the Quartz Timebase of the frequency meter.

A ground station magnetometer was set up at the BMR Geophysical Observatory a few miles north of PORT MORESBY. This magnetometer was a SUD AVIATION proton precession instrument; on September 9th. 1967 it was destroyed by a bush fire and subsequently replaced by an ELSEC-LITTLEMORE nuclear magnetometer rented from the UNIVERSITY OF TASMANIA. In the interim a few flights were carried out without a ground magnetometer but the magnetic storm activity was controlled by checking the records of the observatory.

2. PERSONNEL

2.1 The IGN crew was composed of :

Fig. 2

TORAN STATION LOCATIONS

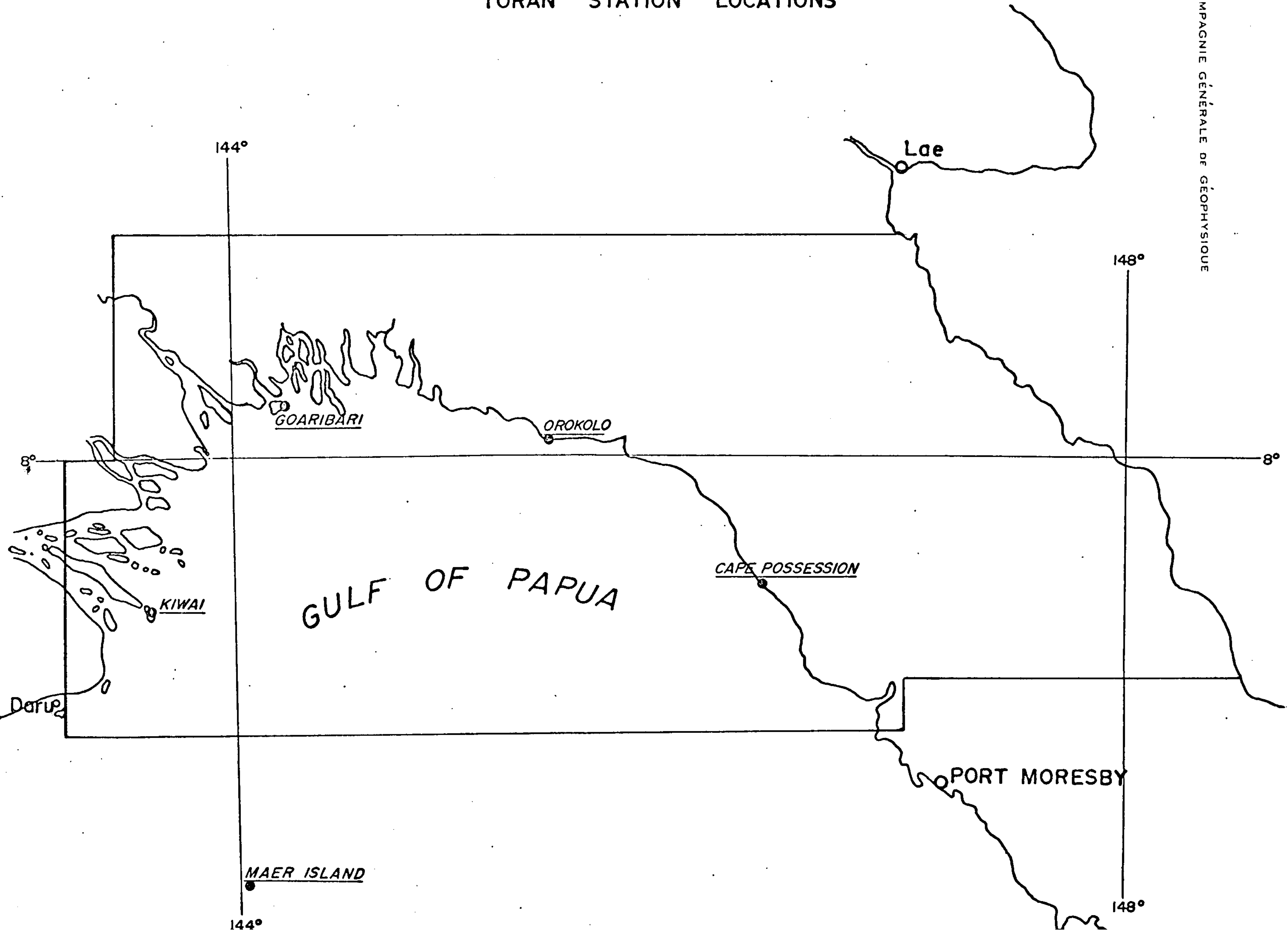


Fig.3

COMPAGNIE GEN...

GEOGRAPHICAL COORDINATES OF THE TORAN STATIONS

	LONGITUDE	LATITUDE
MAER ISLAND	144° 03' 44"00	09°54'44"00
KIWAI ISLAND	143° 38' 42"23	08° 39' 47"41
GOARIBARI ISLAND	144° 16' 22"15	07°46' 33"41
CAPE POSSESSION	146° 22' 07"53	08° 34' 34"69
OROKOLO	145° 19' 29"66	07°51' 35"82

- 2 Pilots
- 1 Navigator
- 1 Radio operator
- 1 Flight engineer
- 1 Ground engineer

2.2 The C.G.G. team consisted of :

- 1 Geophysicist, charged with the preliminary interpretation
- 1 Party chief
- 1 Senior computer
- 1 Assistant computer
- 2 Magnetometer operators
- 1 Airborne TORAN operator
- 5 TORAN electronic technicians for operating the TORAN transmitters set up along the coast.
- 1 TORAN party chief.

3. FLIGHT GRID (Plate 17)

3.1 THE WESTERN AREA (west of the OWEN STANLEY mountains) was flown at 4,000' above sea level.

West of 145°, and in the coastal area between latitudes 8° and 9° S, the flight grid was composed of :

East-West profiles spaced 3 miles apart
North-South profiles spaced 6 miles apart.

In the remainder of the western area the flight grid was the following:

East-West profiles spaced 6 miles apart,
North-South profiles spaced 12 miles apart.

3.2 THE EASTERN AREA was flown at 15,000' above sea level. Line spacings were 3 miles East-West x 6 miles North-South in the most eastern zone, and 6 miles East-West x 12 miles North-South in the intermediate zone between the previous one and the western area.

4. FLIGHT PROGRESS

The first flight took place on June 20th. and the last one on November 10th. 1967. During these five months 20,802 miles of profiles were flown and recorded, including approximately 1,580 miles in the ASTROLABE area which is the object of a separate report.

The following factors had an influence upon the completion of the survey:

- The B17 was unserviceable during more than three weeks in August, due to a petrol tank failure.
- The TORAN stations were difficult to set up, because the barge used proved to be unreliable and had to be replaced by plane and helicopter.
- Meteorological conditions were very poor, except from 23rd. October to 10th. November, when the north western area was exceptionally clear.

CHAPTER II

GEOLOGICAL BACKGROUND

The following geological data are based principally upon A. P. C. (1961), Davies (1967) and Pitt (1966).

1. EASTERN PAPUA AND NEW GUINEA

Upon the enclosed geological map (Pl. 15) a major geological feature can be seen: the OWEN STANLEY FAULT, which runs from SALAMAUA to GARAINA, KOKODA and further southeast beyond the southern boundary of the survey area. This fault separates the metamorphics of the Owen Stanley Range (western side) from the Ultramafic Belt (eastern side). From west to east, the succession is as follows:

- Owen Stanley Metamorphics

These rocks range from medium-grade metamorphics (biotite zone) in the east to low-grade metamorphics in the west. They include quartz-biotite schists, calcareous schists, marbles, greywackes, sericite schists whose ages range from Cretaceous to Lower Mesozoic or possibly older. Near BULOLO, WAU and SALAMAUA, large batholiths were intruded some time in the Tertiary ("MOROBE granodiorite").

- Papuan Ultramafic Belt

This belt, 250 miles long and up to 25 miles wide, is composed of mafic and ultramafic rocks in approximately equal proportions; mafic rocks are gabbro and norite, ultramafic are peridotite, dunite and pyroxenite.

The Papuan Ultramafic Belt and overlying basalts are generally regarded as a slab of oceanic mantle and crust which moved westward during Cretaceous or Eocene times and was forced upwards by collision with the sialic core of Papua New Guinea. This "slab" consists (from top to bottom and east to west) of:

- Cretaceous basalt (upper oceanic crust)
- gabbro and norite (lower oceanic crust)
- peridotite (mantle)

- <u>Basaltic Volcanics (Cretaceous)</u>

They are best preserved in the BOWUTU mountains ($7^{o}30'$ to 8^{o}S) where they comprise massive lavas and pillow lavas, with a total exposed thickness of about 5000 feet. They are overlaid by 2000 feet or more of folded agglomerate and tuff.

- <u>Miocene Sediments</u>

Miocene grit and volcanics unconformably overlie the Cretaceous volcanics at $8^{o}10'$5. The Miocene strata near the contact dip at 15-20^{o} to northeast.

- <u>Cainozoic Sediments and Volcanics</u>

The area between the Ultramafic belt and the eastern coast of Papua is mainly covered by Quaternary alluvium. Pliocene, Pleistocene and Recent volcanics cover parts of the area south of POPONDETTA. Mount LAMINGTON, an andesitic cone, last erupted in 1958.

2. WESTERN PAPUA

- South Western Region

North of DARU, previous geophysical investigation showed a northward plunging extension of the Australian continent (the subsurface ORIOMO Spur) with northsouth trends parallel to those of the Cape YORK peninsular. The total sedimentary section above known crystalline basement is generally less than 10,000 feet with Miocene, Pliocene and Quaternary beds cropping out. The small granitic outcrops known at MABADUAN are outside of the limits of the survey area.

Along the GUAVI River, an important subsurface fault is known (KOMEWU fault) with downthrow to the northeast. This pre-Miocene fault has a downthrow of approximately 4,000 feet; granitic basement deepening from 6,000 to 10,000 feet.

- Delta Region and Gulf Area

The "Delta Region", south of Central Foothills, is well known from geological mapping, seismic surveys and drilling carried out for oil exploration. The thickness of Tertiary and Mesozoic sedimentary cover is much greater than in the south western region of the Papuan Basin.

Practically no Palaeogene outcrop is known in the area. The main Tertiary marine transgression occurred in early Miocene; algal and bryozoal reefs flourished in the sea and thick reefs were built up. Deposition of reef sediments and terrestrial material (derived from the north and east) occurred periodically from the Miocene to the present time.

Seismic surveys carried out in the Gulf of Papua along the coast (permit 39) showed that the thickness of the sedimentary section (Tertiary and Mesozoic) may be as great as 35,000 to 40,000 feet.

A very large reef - more than 80 miles in length - has been mapped between meridians 144^o and 144^{o}30', with a submeridian trend (Phillips Australian Oil Co. 1965, 1968, In Press)

Along the eastern coast, the thickness of sediments is assumed to be very big, with possible igneous extrusions and intrusions, and diapirs.

> Note: Many bores have been drilled in this part of the survey area but none reached crystalline basement.

3. VOLCANICS

A special chapter must be devoted to volcanic rocks due to their importance in the interpretation of the magnetic data.

3.1 VOLCANICS ASSOCIATED WITH THE ULTRAMAFIC BELT

(a) As mentioned above, basalts and pillow-lavas are associated with the Ultramafic belt throughout its length. These lavas are thought to be mainly Cretaceous, in part the remnants of the upper oceanic crust which existed before fault movement began. The total thickness of these volcanics is at least 5,000 feet.

(b) Miocene volcanics unconformably overlie the Cretaceous at $8^{o}10'S$, $148^{o}00'E$.

(c) Quaternary volcanics of the Mt. Lamington complex cover parts of the Ultramafic belt south of $8^{o}30'S$. These range in composition from basalt to andesite, dacite and rhyodacite.

3.2 VOLCANICS IN THE PAPUAN BASIN

Massive volcanics are associated with the Tertiary and Pleistocene deposits in many places, mainly along the eastern flank of the Papuan Basin.

(a) Miocene and Pliocene Volcanics. In the KURAI Range (southeast of LAKEKAMU River) a sequence of marine Miocene sediments exposed on an anticline is both overlain and underlain by volcanic rocks. The lower of these volcanic units is regarded as Lower Miocene; it is made up of basic extrusive rocks interbedded with conglomerates and intruded in places by dykes. This thick sequence of volcanic beds can be correlated further southeast to the ANGABUNGA River where some 10,000 feet of volcanics are exposed. The upper volcanic unit is thought to be mainly Pliocene in age.

These volcanics cover a large area approximately parallel to the coast and extending from $8^{o}S$ to $9^{o}S$. It is not certain whether these volcanics extend to the coast (overlain by recent alluvium).

(b) Pleistocene Volcanics. In the north western zone of the survey area, the volcanic activity was very intense during the Pleistocene.

Thirteen major centres of eruption are known; only a few of these are in the survey area:

Mounts DUAU and FAVENC are twin cones whose heights reach about 6, 000 feet. The extruded material is mainly andesitic and rests upon a deeply eroded surface of Pliocene strata which had been folded and faulted before dissection.

AIRD HILLS are a group of small volcanic hills which rise abruptly from the delta of the KIKORI River; volcanic rocks include tuff, agglomerate and andesite.

BRAMBLE CAY is a small islet east of Daru, where loose blocks of volcanics have been reported.

4. CONCLUSION

The above description of the regional geology makes it clear that the eastern block (flown at 15, 000') and the western block (flown at 4, 000') are completely different:

- The eastern block includes metamorphics, igneous basement and volcanics.
- The western block is an asymmetrical sedimentary basin.

The consequence of this is very important for the interpretation:

- As far as the eastern block is concerned, attention must be drawn mainly upon the qualitative interpretation, that is: the trends of the anomalies, the faults, the description of basement zones with their boundaries, the intensity of the main anomalies, as for a mining survey. The aspect of the total Field Maps is therefore more important and more instructive than the computation of depth-estimates, since the elevation of the magnetic marker is generally the same as the ground-elevation.

- On the contrary, the western block must be interpreted in quantitative terms of basement-depth calculations, as for an oil survey, leading to drawing the depth-contours of the basement and to defining some assessments of the oil prospects.

CHAPTER III

INTERPRETATION OF THE EASTERN AREA (15,000')

1. SHEET BUNA (Pl. 8)

All the geological units defined in Chapter II - 1 may be identified upon the field contour maps (see Sheet BUNA, 1/250,000).

Owen Stanley Metamorphics

The low-grade metamorphics themselves constitute an area of very quiet magnetic style in which the magnetic field increases gently to the southwest, without any noticeable anomaly.

Further to the southwest, however, several intense anomalies may be seen, the intensities of which range from 200 to 400 gammas. Considering both the intensity and the shape of the anomalies, these are obviously caused by basic igneous rocks, most probably basic volcanics. The depth-calculations indicate a nearly outcropping marker with computed depths between -4,000 and -5,400 feet (i.e. +4,000 a.s.l., etc.). Three major volcanic areas have been mapped (V1, V2 and V3 upon the interpretation map).

The magnetic data in this area clearly indicate the presence of volcanic rocks, e.g. Mt. Victoria locality.

Ultramafic Belt and Associated Volcanics

The magnetic style in this area is still characterized by a magnetic gradient which increases to the southwest; however, it differs from the previous area in that anomalies are more numerous. These anomalies are of weak amplitude (under 20 gammas) and trend northwest or north-northwest. Some transverse anomalies trend approximately west-east.

The low amplitude of the anomalies supports the assumption that the ultramafic rocks were not intruded in situ, but are only the most western part of a slab of oceanic basement which overlies the metamorphics.

The most interesting magnetic feature in the area is an elongated negative anomaly which has a very constant trend (N55°West). This anomaly coincides exactly with the Owen Stanley fault in the north whereas more to the southeast it is parallel to an extension of the TIMENO fault. In the area where the Timeno fault diverges from the Owen Stanley fault, the former appears to be of major structural importance, whereas the Owen Stanley fault delineates the western limit reached by the basic rocks.

Cainozoic Sediments and Volcanics

The area east of the Timeno fault is generally characterized by a gentle magnetic gradient which increases to the northeast. Many depth calculations are doubtful due to the uncertainty regarding the trends of the anomalies, and therefore, no depth contour was drawn. The thickness of sedimentary cover including recent alluvium is generally less than 5,000 feet.

In the southeast corner a negative anomaly trends approximately eastwest and has an amplitude of 300 gammas. This anomaly may be regarded as related to a volcanic area, elongated east-west, the axis of which runs through Mount Lamington, where effusive andesitic volcanics are known.

Interpretation of the negative anomaly upon profile 58S gives the following results:

Magnetic susceptibility	K = 0.0019 CGS e.m.unit
Width of magnetic block	l = 37,000 feet
Depth	h = 3,400 feet below sea level.

2. SHEET SALAMAUA (Pl. 4)

Most of this sheet is the domain of the mafic-ultramafic rocks and basic volcanics.

In the south western corner, the Owen Stanley fault may be drawn easily as it is delineated by the extension of a negative anomaly referred to above (III - 1).

The other anomalies fall into two classes:

(a) In the BOWUTU Mountains, which are the domain of ultramafic rocks, most magnetic trends are parallel to the Owen Stanley fault: northwest - southeast to the south and nearly north-south to the north. The amplitude of these anomalies is generally moderate (under a few tens of gammas).

(b) Another magnetic trend is oblique to the previous one (east northeast - west southwest). Several important anomalies, with amplitudes of approximately 100 gammas, fall into this group. An example of these, is the anomaly located at the intersection of profiles T231 and L48 (Plate 17), which approximately coincides with a mapped diorite outcrop (Davies, 1967).

Note: Similar to this is the negative anomaly located on Sheet BUNA, near the intersection of profile L52 and T227; this anomaly could be related to a diorite body, more or less concealed by basaltic flows.

To the east, where the volcanics and ultramafic rocks are overlain by recent alluvium, no depth estimate was found to be greater than 2,200 feet below sea level.

3. SHEET YULE (Pl. 7B)

Over most of this sheet, the metamorphics and the sediments are concealed by intrusive and/or effusive volcanics. The whole volcanic area has a high residual magnetic field, the most important anomaly being located near Mount Yule. This anomaly has an amplitude of 450 gammas and its shape suggests its source to be an intrusive magnetic body, such as a volcanic plug, rather than a volcanic flow. Like V1, V2 and V3 on Sheet BUNA this body could be a major volcanic centre from which the lavas overlying the metamorphics were extruded.

Magnetic susceptibility of the Mount Yule anomaly, computed on profile L41, is of the order of 0.014 CGS e.m.u. which corresponds to the susceptibility of a highly basic lava (andesite or basalt).

The volcanics extend throughout a northwest - southeast belt approximately 20 miles in width and more than 60 miles in length. These volcanics are partly Miocene and partly Pliocene in age.

4. SHEET WAU (Pl. 3B)

The magnetic field contours are very different in this area as compared to those mentioned above. The Owen Stanley fault runs approximately along the eastern boundary of the sheet; this area, therefore, is mostly composed of metamorphics. The most prominent features of the magnetic contours are due to the granodiorite intrusives which crop out in the EKUTI Dividing Range and KUPER Range. The main purpose of the interpretation in this locality therefore, is to map these intrusives.

Further southwest, the magnetic style is much more quiet over the sedimentary area which is devoid of intrusives but may include volcanic flows.

The boundary between these two areas roughly coincides with the boundary between Papua and New Guinea.

(a) North Eastern Area

This is an area of highly contrasted magnetic style with many intense anomalies; the main magnetic trend is southwest - northeast. The geological maps indicate two granodiorite intrusives, one of them to the northeast of BULOLO, the second southwest of WAU. From the magnetic contours, three intrusives may be inferred:

- GD 1 coincides approximately with the largest granodiorite intrusive; this area is featured magnetically by a large negative anomaly fringed by a positive anomaly to the north; the granodiorite extends partly over the negative and partly over the positive anomaly, conforming in this respect to the theoretical shape of the anomaly for such a magnetic dip (30^o South).

- GD 2 and GD 3 are two similar areas, which can be assigned to granodiorite intrusives. GD 2 is located west of WAU, GD 3 southwest of WAU. These two batholiths appear to be without any connections between one another; the geological mapping in this area is quite different, with only one bulk of granodiorite, trending northwest - southeast, which is unlikely if compared to the magnetic contours and their interpretation.

Magnetic susceptibility contrast between the granodiorite and the metamorphics was found to be k = 0.006 CGS, upon profile 38 (GD2) - Owen Stanley fault: the Owen Stanley fault may be positioned along the line where the northwest - southeast anomalies (see Sheet SALAMAUA) disappear; if then compared to the geological map the coincidence is good.

(b) South Western Area.

Its magnetic style is generally much more quiet, if compared to the northeast area.

In the sedimentary area the anomalies are generally weak (under 30 gammas) with northwest - southeast trends; the computed depth estimates range from 400' to 4,700' below sea level; these probably correspond to the top of Miocene volcanics which are known in the KURAI HILLS. The basement itself is probably much deeper and no anomaly can be related to it.

In the CHAPMAN Range, a large positive anomaly may be assigned to Mio-Pliocene volcanic flows overlying the metamorphics (extension of the Mount Yule volcanics). Further east, alongside the middle ONO River a small positive anomaly coincides with an andesite porphyry intrusive known from geological mapping.

Near Mount Lawson, another large anomaly is more difficult to explain, since it could as well be produced either by a granodiorite intrusive or by volcanics: the anomaly is very intense (370 gammas) and similar to those created by the granodiorite or by some intrusive volcanics such as the ones found on Sheets YULE and BUNA. The magnetic susceptibility is K = 0.004 CGS.

In the northwest corner, other positive anomalies could be related to quaternary volcanics since one of them coincides with such volcanics (Mount YELIA). (Pitt, 1966)

Another peculiar feature is the large circular anomaly located between the previous one and the granodiorite GD2; this positive anomaly is rimmed by a narrow negative anomaly; this suggests a batholithic intrusion (granite?) but this batholith is probably concealed under Miocene deposits.

Finally, the abundance of intrusives and volcanics of all ages, from Miocene to Quaternary, prevents mapping accurately the magnetic trends within the sedimentary area, and computing the depth-estimates of the basement, since the anomalies of volcanics or intrusives are more intense than the anomalies of the basement.

5. SHEET KIKORI (Pl. 2B)

Only a small part of this sheet was flown at 15,000'. Both qualitative and quantitative interpretation make it clear that some magnetic features are due to an intermediate magnetic marker (shallow volcanics), and others to a deeper marker which is the real magnetic basement.

- Intermediate marker: The most interesting anomaly of this type is a submeridian anomaly (amplitude: 10 gammas) that may be regarded as a fault with downthrown side to the west; the axis of this anomaly coincides with the AURE Scarp.

- Deeper marker: Two depth estimates of the basement have been calculated; these depth estimates (21,000' and 24,000') are consistent with those found in the same area on the profiles flown at altitude 4,000 feet.

6. INTERPRETATION OF THE THREE PAIRS OF PROFILES OVER THE SOLOMON SEA. (Pl. 13)

The interpretation of these profiles indicates that the basement dips steeply to the northeast. Two depth-contours (5,000' and 10,000' below sea level) have been drawn. Comparison with some bathymetric contours of the oceanic ground floor suggests that the sedimentary cover is practically nil.

7. INTERPRETATION OF THE SUPPLEMENTARY AREA (Between LAE and SALAMAUA) (Pl. 16)

This area is too much confined for bringing out reliable information. A large positive anomaly is the continuation of the one mentioned in III - 4 (northern boundary of granodiorite GD1); the axis of this anomaly is shifted to the north between profiles L743 and L744.

The general magnetic style of the area points out that the continuation of the Owen Stanley fault probably runs more easterly, since this magnetic style suggests an extension of the granodiorites rather than the continuation of the ultramafic belt.

8. CONCLUSION

The contribution of airborne magnetics in the area may be considered from different points of view :

- If compared to detailed geological mapping, the magnetic data is necessarily less accurate, due to the great altitude of flight. For instance, the boundaries of minor intrusives cannot be mapped accurately.

- The altitude of flight, however, is favourable to the interpretation of the broad regional anomalies; in that respect the most important point is the problem of the origin of ultramafic belt. In order to check the hypothesis made by Davies (1967) the following process was tried:

(1) Firstly, one calculates, with a computer programme, what would be the anomaly created at altitude 15,000' by a fault plane dipping at 20^{o} - 30^{o} to the east, and separating metamorphics and sialic rocks from ultramafic rocks; the contact is assumed to be horizontal below the depth - 6 miles (Mohorovicic discontinuity).

(2) The computed anomaly is then compared to the recorded data, more exactly to a cross-section of the magnetic field contours (the field contours are first regularized in order to remove the superficial anomalies).

(3) The two anomalies are then matched, to see how closely they coincide.

Fig. 4 represents the calculated anomaly, assuming the following hypothesis:

FIG.4

CALCULATED ANOMALY

SCALE : 1/500000

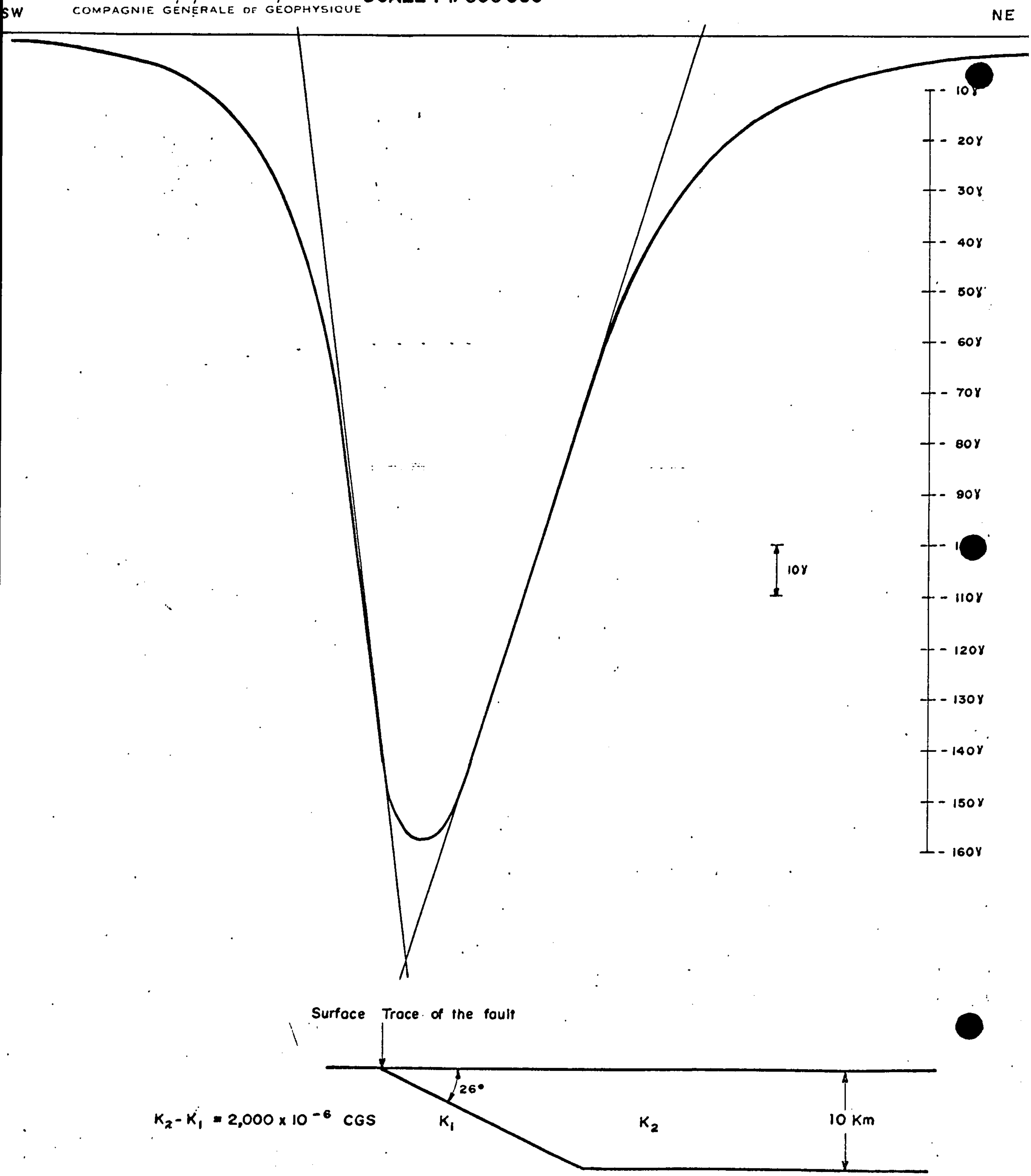


FIG. 5

CROSS - SECTION OF FIELD CONTOURS (AA')

COMPAGNIE GÉNÉRALE OF GÉOPHYSIQUE

SCALE : 1/500 000

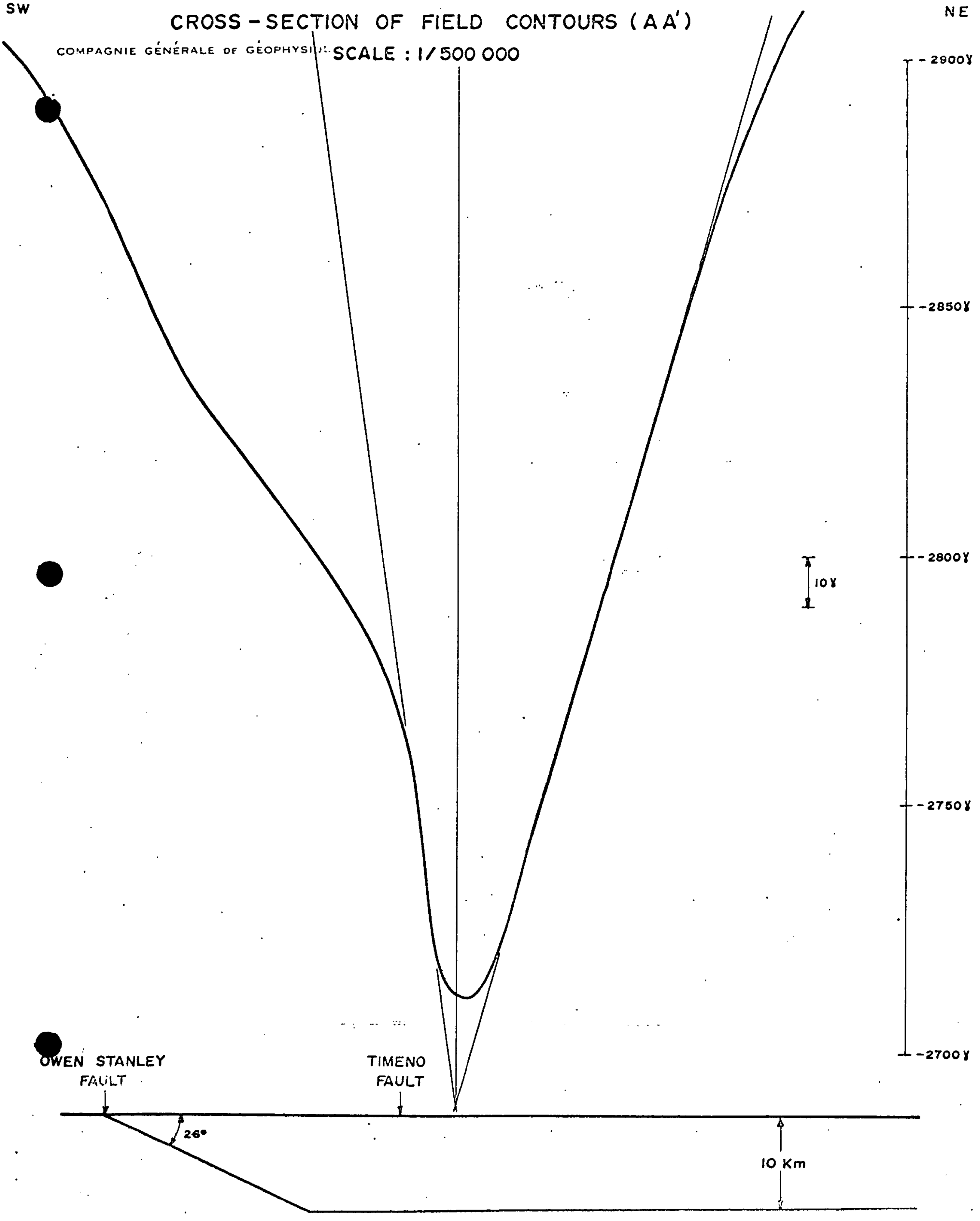
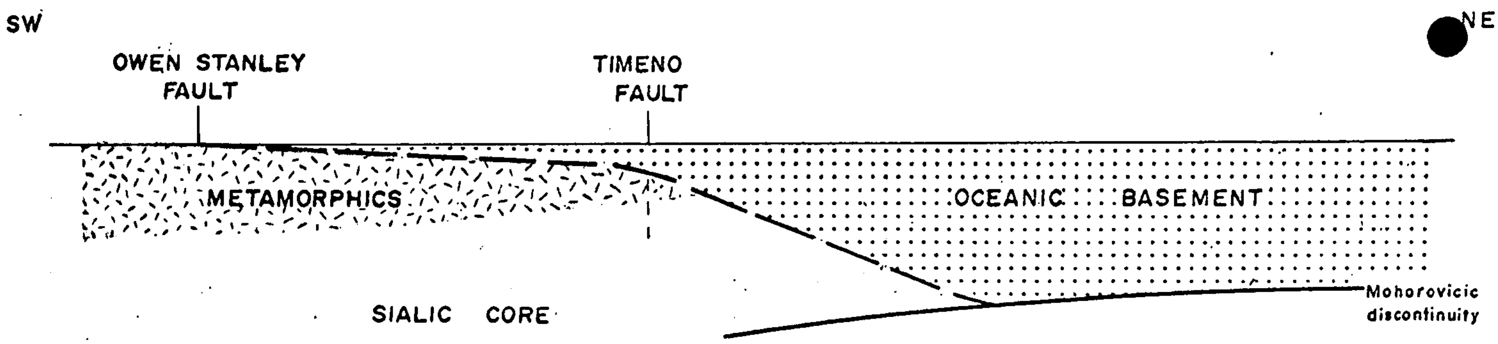


FIG. 6

POSSIBLE GEOLOGICAL CROSS - SECTION

COMPAGNIE GÉNÉRALE DE GÉOPHYSIQUE

SCALE : 1 /500000



- dip of the fault plane: 26^{o}
- magnetic susceptibility contrast: $2,000 \times 10^{-6}$ CGS
- flight altitude: 15,000 feet above sea level.

The anomaly is negative, with a steep flank to the south-west; its intensity is approximately 160 gammas.

Fig. 5 is a cross-section of field contours (see location of this cross-section AA' upon the interpretation map); this regional anomaly is a negative one, its amplitude is over 200 gammas.

Fig. 4 allows one to conclude that the minimum of the anomaly should be located approximately 1.5 miles northeast of the surface trace of the fault. But Fig. 5 points out that this minimum is much further away from the Owen Stanley fault. Finally, the diagram which best fits the magnetic data could be the cross-section shown on Fig. 6 and the following conclusions may be expressed.

(4) The fault thrust plane dips at a very low angle between the Owen Stanley and Timeno faults (GIRA fault); further east, the fault dip could be 20^{o} - 30^{o} as suggested by Davies. The outcrops of Ultramafic belt only represent a very thin cover of basic rocks overlying the metamorphics, and the thickening of these basic rocks takes place further beyond the Timeno fault.

CHAPTER IV

INTERPRETATION OF THE WESTERN AREA (4,000')

1. SHEETS WAU-YULE-AROA (Pls. 3A, 7A, 11)

1.1 RESIDUAL FIELD

Two distinct zones may be considered in this eastern part of the area flown at 4,000 feet.

(a) Northeast of a line roughly parallel to the coast and running approximately 30 miles from the shore, the magnetic field contours are most intricate. The anomalies are abundant and the magnetic trends range from N20°W to N40°W; the anomalies are generally narrow, well elongated and occasionally shifted by transverse anomalies.

(b) Southwest of this line, the anomalies are scarce and very broad; their trend is nearly east-west.

1.2 INTERPRETATION

The above description makes it clear that two distinct areas are to be considered:

(a) To the north and northeast, i.e. along the coastal area of the Gulf of Papua between KEREMA and OROI, and in the neighbouring mainland, it is well known that the detrital sediments are mainly derived from the erosion of volcanic rocks; in many places, conglomerates including boulders of igneous rocks volcanic conglomerates, basic lapillitic tuffs, agglomerates and basaltic lavas are reported. Most of the anomalies therefore have certainly their source in the volcanic markers. Other reasons may be advanced for supporting this point of view :

- In the Yule Island - Oroi area, the geological data assign a thickness more than 5,000 feet to the Lower Miocene only. Since many depth-estimates in this area are less than 5,000 feet, the magnetic marker cannot correspond to the basement.

- The trends of the anomalies along the shore exactly coincide with the geological trends, which is normal if we assume that the anomalies are caused by volcanics interbedded within the Tertiary deposits. The coincidence would be more surprising if the anomalies had their source in the basement (in fact we shall see further that the trends of the basement are predominantly east - west).

- Thick volcanic units are exposed in the mainland, and their thickness may be as great as 10,000 feet.

Finally, we consider that, east of a line drawn on the interpretation map ("Westermost limit of massive volcanic markers") all the anomalies are related to volcanic markers. The depth of the basement in this area cannot be estimated; some attempts were made for filtering the anomalies of the volcanic markers, but they were unsuccessful because of the comparatively high intensity of the anomalies.

The depth contours of "volcanic" marker(s) were not drawn since there are probably several markers of this type; their depth ranges from -1,000 feet (outcrops) to 8,000 feet below sea level.

North of Kerema the marker is especially shallow; a few miles southeast of Kerema a fault can be inferred from the aspect of the field contours, with the downthrow side to the southeast. Other faults are drawn on the interpretation map, but the side of the downthrow is not always clear.

Some anomalies have a remarkable extension, over more than forty miles, and may be regarded as major geophysical features (possibly faults intruded by igneous rocks).

(b) To the west, the "volcanic" anomalies practically disappear and the broad anomalies are certainly caused by contrasts of magnetization in the basement. Only a few depth estimates can be computed, they range from 15,000 feet to 28,000 feet below sea level. The three depth estimates located along the boundary of the volcanic area (Sheet AROA 8,000', 9,300', 12,000') may be assigned either to a volcanic marker or to the basement.

2. SHEETS SC 55-1 and MAER ISLAND (Pl. 6 and 10)

This area is one of the most important of the survey, since it covers the whole central part of the Gulf of Papua where very few geophysical investigations had been carried out prior to this survey.

2.1 FIELD CONTOURS

Two types of anomalies can be seen :

- Broad anomalies, of various amplitudes, sometimes very intense such as the big negative anomaly located in the north eastern part of Sheet SC 55-1 (approximately 100 gammas). The main magnetic trends are either nearly east-west, or nearly north-south in the southern area. These anomalies have unquestionably their source in the crystalline basement.

- Another type is featured by narrow anomalies, responsible for the most intricate aspect of the field contours in some areas (for instance between profiles L11 and L14). These anomalies should be related to intrasedimentary magnetic contrasts, either due to shallow volcanics, or possibly to reefs as discussed further. In the north eastern corner of Sheet SC 55-1, two narrow anomalies can be ranged in the same group of "volcanic" anomalies as the ones described in Chapter IV - 1.

2.2 INTERPRETATION

Syncline S1: To the north (N of 8°30'S), a large synclinal area was mapped; the sedimentary cover is approximately 30,000 feet thick in the centre of the syncline (maximum computed depth is 29,500 feet). An important fault (F1) is suggested by the aspect of the field contours and the lateral displacement of the trends of anomalies. The downthrown side appears to be to the south.

Syncline S2: The anomalies, and consequently the depth estimates, are very scarce in this area. However, the general aspect of the field contours and of the reconstituted digital records (calcomps) suggests a basement depression which trends north-south in the north and north northeast-south southwest to the south.

In the areas S1 and S2 the field contours are most intricate due to shallow magnetic markers which create weak anomalies (generally 1, 2 or 3 gammas); these anomalies are difficult to correlate from one profile to another; their trends are frequently west southwest-east northeast.

In the preliminary report, it had been suggested that some weak anomalies could represent the effect of a reef; it is well known that reefs theoretically cause negative anomalies, since calcareous reefs are less magnetic than surrounding shales. In practice the contouring of the reefs by means of the magnetic data is very difficult due to the large spacing of the profiles and two other reasons.

- The location of the main reef, as defined by seismic data, coincides with an area of low magnetic intensity, and it would be very subtle to say which is the contribution of the reef to this regional magnetic "low".

- Furthermore, most of the narrow anomalies could be created by shallow volcanic markers, which makes the identification of the reefs all more difficult.

<u>Anticline A3</u>: This anticlinal area is located between the syncline S2 and fault F2. It could include one branch heading to the northwest and one branch

heading to the southwest. Depth of basement at the top of the structure is approximately 17, 000 feet.

Anticline A4: This is the most important structure of the area, and probably of the whole survey. It roughly coincides with a positive anomaly, trending N10^{o} East. Maximum intensity of the anomaly is 75 gammas, and the anomaly was interpreted as an intrabasement magnetic body (large vertical extent downwards) because the uplift of the basement cannot explain the total amount of the anomaly.

Depth of the basement at the top of the structure is 12, 000 feet below sea level. The closure of the structure is well ascertained and could be as great as 3, 000 feet at the top of crystalline basement. The aspect of field contours suggests that the anticline is limited to the south by a fault (fault F4).

Anticline A5: This area is probably a basement high, but if an anticline exists, its shape cannot be delineated due to the lack of information to the south.

Anticline A6: is a "nose" plunging to the north, and which may be on the same structural trend as anticline A3.

On both areas A5 and A6 the top of the basement is approximately 14, 000 feet deep.

Finally the whole area including A3, A4, A5 and A6 appears to be much higher than the remainder of the central Gulf area and could correspond to a shield of the basement. In this area the basement lies at depths ranging from 12, 000 to 18, 000 feet whereas it lies at more than 20, 000 feet to the east, to the north and to the west.

Faults : The qualitative interpretation of the magnetic field contours allowed seven faults to be drawn. The downthrown side of the faults was shown when possible. In some cases difficulties were experienced to find out which side of the fault is downthrown. But it is to be underlined that some faults may be featured by lateral displacement only (transcurrent faults) without any noticeable vertical throw.

Intrasedimentary markers : The abundance of small anomalies caused by intrasedimentary magnetic markers is remarkable. Upon some records, their number is so great that they make the broader anomalies of the basement impossible to interpret properly. The interpretation of the narrow anomalies generally leads to depths ranging from 2, 000 to 5, 000 feet. This magnetic marker could be tentatively identified as thin volcanic flows, or conglomerates including volcanic or igneous boulders.

It is remarkable that the anomaly located in area A4 is undisturbed, i. e. devoid of any intrasedimentary magnetic marker, whereas in the vicinity all records are disturbed by minor anomalies. This could be explained by assuming that, on this uplifted zone, the layers including intrasedimentary magnetic markers were either eroded or never existed.

3. SHEET KIKORI (Pl. 2A)

3.1 FIELD CONTOURS

On this sheet also the aspect of the field contours makes it obvious that several magnetic markers are present; since very small and narrow anomalies occur in the vicinity of larger and generally more intense anomalies. Practically no area is devoid of intrasedimentary magnetic horizon, but it is possible to define some areas where the narrow anomalies are more abundant:

- East of 145°15' narrow anomalies are locally intense (more than 50 gammas) and have generally a great extension; magnetic trends are north-south or north northwest-south southeast. This is the continuation of the volcanic markers' area recorded in Chapter IV - 1 (YULE-WAU) and which corresponds to the imbricate fold zone (A. P. C., 1961).

- To the north of the survey area, between longitudes 144°25' and 144°45', narrow anomalies trending northwest-southeast may be related to the volcanic mantle cropping out between KURU and BWATA (two volcanic cones, Mounts DUAU and FAVENC, are known more northerly, and the extruded material is predominantly andestic).

- In the Gulf of Papua itself, the small narrow anomalies are still comparatively abundant and may be also tentatively related to volcanics. At the exact location of AIRD Hills, a group of volcanic hills, a positive anomaly of 50 gammas was recorded. Elsewhere the narrow anomalies are much less intense (only a few gammas).

The magnetic anomalies related to the deeper marker have generally a nearly west-east trend. The most important anomaly of the basement is the negative anomaly which runs approximately a little to the north of latitude 7°30'; the extension of this anomaly is more than fifty miles, its intensity reaches 75 gammas from maximum to minimum on profile L13.

Another big anomaly, also trending east-west, is the positive anomaly located north of 8^{o} on both sides of meridian 145^{o}.

Most of the other anomalies of the basement are severely disturbed by the small ones (intermediate anomalies).

3.2 INTERPRETATION

Two anticlinal areas, more or less connected together appear from the drawing of the depth contours.

- Anticline area A1

  In the north western corner of the Sheet, an anomaly trending north-south was interpreted on profiles T48 - 49 - 50 as a thin plate at the top of the basement, leading to depth estimates ranging from 14,000 feet to 15,000 feet, which are much higher than the surrounding depth values. The existence of an anticline may be regarded as reliable, but it is doubtful whether a closed structure would exist, due to the lack of information to the north-west.

- Anticlinal area A2

  This somewhat contorted uplifted area is centred near $144^{o}30'$E $7^{o}30'$S. Its connection with the previous area A1 is probable, since a depth of only 16,000 feet was found between A1 and A2, near Aird Hills.

The top of the basement is nearly 17,000 feet deep in the area A2.

South of A1 and A2, the basement deepens steeply to the south, with a dip ranging between 5° and 10°; offshore the basement depth is practically everywhere greater than 20,000 feet. Maximum depth was found to be 29,000 feet but, as the depth increases the depth estimates are all the more scarce, so that the basement depth could be locally greater than 30,000 feet.

East of 145°, it is not clear whether the basement deepens or rises; the sedimentary section is still very thick (more than 20,000 feet along longitude 145°), but further east the anomalies of the basement are concealed by the volcanic markers, which makes the computation of basement depth impossible.

Interpretation of the "intermediate horizon" (intermediate magnetic marker).

The intermediate horizon is shallow everywhere; it is cropping out at Aird Hills and in the KURU-BWATA area; in this area it is sure, by geological evidence, that this intermediate horizon may be identified with volcanic material; elsewhere, and more especially in the KARIAVA area, the intermediate marker is still shallow (less than 2,000 feet deep); this marker was related to volcanics in this report, but in some places it could be related to conglomerates containing igneous boulders: such conglomerates are reported in the Kariava area, occuring at various horizons within the Miocene sequence.

4. SHEET AWORRA RIVER (Pl. 1)

4.1 FIELD CONTOURS

The field contours outline some big anomalies; their trends are generally east-west, sometimes northwest-southeast. The magnetic field is highly contrasted, with anomalies in the range of 50 gammas. Anomalies assigned to an intermediate horizon appear on the field contour map; smaller ones only appear on the profiles, still making necessary the "smoothing" of the profiles, in order to separate the effect of the different magnetic markers.

4.2 INTERPRETATION

Between latitudes $7^{o}30'$ and 8^{o} the basement rises to the west from 22,000 to 16,000 feet. The big positive anomaly along latitude $7^{o}30'$ is truncated by southwest-northeast faults; the basement possibly rises to the west by steps corresponding to these faults.

North of $7^{o}30'$ another fault (F13) may be inferred from the aspect of the field contours; the downthrow side would be to the east. East of this fault the depth estimates range between 17,000 and 18,000 feet. There are interferences between anomalies of various trends, which makes the accuracy of the depth-computations rather poor, since the heading of the anomalous axes cannot be defined exactly (one must recall here that the depth found by the calculation is to be multiplied by the cosine of the angle defined by the direction of the profile and the perpendicular to the axis of the anomaly). However, there is a strong probability that the zone between F13 and meridian

144° would be a synclinal area; this syncline S3 would have a northwest - southeast trend and may be followed to the south where it joins the syncline S1.

5. SHEETS KIWAI and DARU (Pl. 5 and 9)

5.1 FIELD CONTOURS

With the exception of a north-south anomaly to the west, most of the anomalies assigned to the basement have a nearly east-west trend. Two negative anomalies appear to be interesting: one is located north of Kiwai, the second is on the northern side of the Fly River estuary. These anomalies could correspond to faults, as discussed further below.

More to the south, the aspect of the field contours becomes most intricate and it is sometimes difficult to make the distinction between the anomalies of the basement and the anomalies of the intermediate horizon(s). Near BRAMBLE CAY, the intermediate horizon may be related to volcanics, since volcanic boulders are reported on this islet. East of Daru, several anomalies may be also related to volcanics.

5.2 INTERPRETATION

The Fly River estuary appears to be a depressed zone of the basement; the above mentioned negative magnetic trends suggest the existence of two faults; in this case the area between Kiwai Island and the northern bank of the Fly River estuary could be regarded as a graben of the basement, where the sediments are 12,000' to 15,000' thick (syncline S4).

South-east of this syncline, a shift of the magnetic trends outlines a fault which is the extension of fault F1 mentioned in Chapter IV - 2 (Sheet SC 55-1).

More to the south an anticlinal trend (A7), heading southwest - northeast may be seen; south of parallel 9° the anomalies assigned to volcanic markers become more abundant than the anomalies due to the basement. The depth of the volcanic marker ranges between 1,000' and 7,000'. Since the basement itself could be shallow in some areas near the coast, it is not always possible to determine the source of the volcanic anomalies (basement or intermediate volcanic marker?); for this reason the basement depth contours were not drawn south of 9° and west of $143^{\circ}30'$. Anyway it is well known that the basement rises to the south-west and finally outcrops at MABADUAN.

Remark : If compared to the preliminary interpretation map ("Fly River area") the final map offered many differences: this is due to the fact that some anomalies which were assigned to basement in the preliminary report were assigned to intermediate volcanics in the present final report. The final interpretation itself is not quite satisfactory in this western area which would deserve a more detailed survey.

6. CONCLUSION

The Papua Basin was clearly outlined by the airborne survey, with the exception of its eastern boundary which still remains unknown. The intermediate anomalies due to the complex tectonics and volcanics conceal the basement anomalies in this eastern zone, preventing from finding out whether the basement rises to the east up to the Owen Stanley range or if it still deepens.

With the exception of this eastern zone, the Basin appears to be nearly symmetrical, with the maximum depth a little to the south of the point of coordinate 144°30' East - 8° South. From this point the basement rises sharply to the north, up to the latitude 7°30', and then slightly deepens further north.

Westward and southward the basement rises in a similar manner. To the south the basement up rises from depth 25,000 - 30,000 feet to the depth 14,000 feet on latitude 9°15'. This southern area is the most interesting since it is the only one where a closed structure (A4) and a possible other one (A3) could be mapped.

Oil Prospects

Preliminary remark: The interpretation of magnetic data defines the relief of the basement whereas the main reservoirs for the hydrocarbons appear to be within the Tertiary deposits (Eocene-Miocene). It is most probable that in the strongly folded areas (imbricate fold zone) an important structural discordance should exist between the basement and the Cainozoic structures. In this zone (that is to the north and the northeast) the interpretation of the basement structure therefore is less directly useful than in the more quiet areas (gently folded zone).

The southern part of the survey may be regarded as a part of the gently folded zone. The mapped structures of the basement therefore are especially interesting for the oil research, and more especially the structure A4, the features of which may be recalled hereunder:

- Centre of the structure (top): X = 144°45' Y = 8°55'S
- Depth of basement at the top: 12,000 feet
- Possible closure : 3,000 feet
- Heading of the anticline : N10° - N20°E.

Other possible prospects could be investigated along the anticlinal axis which runs from A6 to A3; this axis being well defined by the aspect of field contours.

To the north of the surveyed area, favourable prospects for oil could be considered in the area A1 - A2, yet with the above mentioned restrictions (possible unconformity between the basement and the Tertiary deposits).

Anticline A1 could be north northwest - south southeast, although the anomaly which defines the structure (thin plate) is trending north - south.

To the south, the axis of the anticline trends to the south-east and finally to the east; one can remark that this axis A1-A2 presents a real similarity with the geological trends known by surface mapping.

CONCLUSION

The purpose of the airborne survey was double :

- Firstly, the realization of the Magnetic Field Map.
- Secondly, the research for the oil prospects.

The first purpose was fully achieved, in spite of the notorious unfavourable meteorological conditions in the area.

The second purpose was achieved only in the area comprised between longitudes 144° and 145°; elsewhere the recorded information and interpretation are not so complete due to the following reasons:

- Too large spacing of profiles (east of 145°)
- Predominance of volcanic markers (eastern zone)
- Ambiguity in the significance of the markers (west of 144°)
- Difficulties inherent to the interpretation itself (anomalies of various trends interfering between themselves).

Respectfully submitted

Interpreted by:
J. LERIDON

J-M. CUNIN
Australian Branch Manager.

BRISBANE, August 5th.1968.

REFERENCES

Australian Petroleum Company (A. P. C.)	1961	Geological results of petroleum exploration in Western Papua <u>Journal Geol. Soc. Aust.</u> 8(1)
Davies, H. L.	1967	Papuan Ultramafic Belt <u>Bur. Min. Resour. Aust.</u> Rec. 1967/107
Phillips Australian Oil Company	1965	Marine Seismic reconnaissance survey Gulf of Papua <u>Bur. Min. Resour. Aust. Petrol. Search Subs. Act Report (unpubl.)</u>
Phillips Australian Oil Company	1968	Permit 42 R-1 marine seismic survey. Gulf of Papua. <u>Bur. Min. Resour. Aust. Petrol. Search Subs Act Report (unpubl.)</u>
Phillips Australian Oil Company	In Press	Permit 39, marine seismic survey <u>Bur. Min. Resour. Aust. Petrol. Search Subs. Act.</u> Pub. 84
Pitt, R. P. B.	1966	Tectonics in Central Papua and the adjoining part of New Guinea. Unpublished Ph.D Thesis, University of Tasmania.

APPENDIX I

PRINCIPLES OF TORAN

The TORAN is a hyperbolic system based on the principle of the measurement of the phase of a low frequency beat signal derived from two high frequency signals which are radiated from two fixed transmitter stations.

1. Generation of a Hyperbolic Network

Two fixed transmitters A and B radiate an unmodulated continuous wave. These transmitters are simple free-running oscillators, they are neither synchronised nor phase or frequency locked. Frequencies Fa and Fb, of the order of 2 mc/s, are chosen very close to each other, so that their difference is a low frequency f of about 100 cycles.

$$Fa - Fb = f$$

The receiver of a mobile station M is tuned to the intermediate frequency of Fa and Fb. Waves Fa and Fb leave their antennae with respective phases a and b which are constantly variable. They arrive at the receiver M with phase :

$$\varphi a + Fa \frac{MA}{V}$$

$$\text{and} \qquad \varphi b + Fb \frac{MB}{V}$$

V being the wage propagation velocity.

The low frequency beat signal is selected by appropriate filtering. Its phase m is equal to the difference in phase of the component signals :

$$\varphi m = \varphi a - \varphi b + Fa \frac{MA}{V} - Fb \frac{MB}{V} + km$$

km is a constant phase shift introduced by the receiver and tied to φm.

Taking into account the relation $f = Fa - Fb$

$$\varphi m + \varphi a - \varphi b + \frac{Fa}{V} (MA - MB) + \frac{f}{V} MB + km$$

This expression of φm cannot be used as it is, due to unknown terms φa and φb. In addition, a time of phase reference would be necessary at M for determining the φm value. These two problems are solved as follows.

2. Reference and Compensation

Another receiver located at a fixed point N produces the low frequency signal f with a phase φn.

$$\varphi n = \varphi a - \varphi b + \frac{Fa}{V} (NA - NB) + f \frac{NB}{V} + kn$$

kn is a coefficient similar to km.

A transmitter placed very close to N radiates a frequency Fn different from Fa and Fb and modulated by the signal f produced by receiver N.

The mobile receiver M is equipped with a second reception channel tuned to Fn. The phase φnm received in M is :

$$\varphi nm = \varphi a - \varphi b + \frac{Fa}{V}(NA - NB) + f\frac{NB}{V} + f\frac{MN}{V} + knm + kn$$

where knm is a coefficient similar to kn and km.

A phasemeter connected to the outputs of both channels of the receiver M indicates the phase difference

$$\varphi = \varphi m - \varphi nm$$

$$\varphi = \frac{Fa}{V}(MA - MB) - \frac{Fa}{V}(NA - NB) + \frac{f}{V}(MB - MN) - \frac{f}{V}NB + km + kn + knm$$

In this equation :

$\frac{Fa}{V}(MA - MB)$ is a hyperbolic term of focuses A and B.

$\frac{Fa}{V}(NA - NB)$, $\frac{f}{V}NB$, km, kn, kmn are constant terms which are eliminated when calibrating the system.

$\frac{f}{V}(MB - MN)$ is practically negligible since the ratio $\frac{f}{Fa}$ # 1/20,000. When necessary this term is taken into account as a correction term in the computation of the hyperbolic network.

The double function of station N is indicated by the terms "Compensation Receiver" and "Reference Transmitter" given to the two parts of this station.

Finally, after elimination of the constant terms the indication of the phasemeter

M represents the phase

$$\varphi = \frac{Fa}{V} (MA - MB)$$

which defines one hyperbolic coordinate.

3. Toran Couples and Chains

Focus transmitters A and B and the compensation-reference station N constitute a TORAN couple, and define one coordinate.

The second coordinate is supplied by a second couple.

A third pair may be used to supply an additional coordinate, either to make up a "triangle of error" or to secure a better coverage of a wide area or an area of complicated configuration.

4. Lane Identification System

The principle is to realise a fictitious network with lanes 10 and 100 times wider than those of the basic working network.

For one couple A - A' using the frequency F1, the lane identification frequencies are :

$$F2 = \frac{90}{100} F1$$

and

$$F3 = \frac{99}{100} F1$$

The corresponding readings on the phasementer M are :

$$1 = \frac{F1}{V} (MA - MA')$$

$$2 = \frac{F2}{V} (MA - MA') = \frac{90}{100} \frac{F1}{V} (MA - MA')$$

$$3 = \frac{F3}{V} (MA - MA') = \frac{99}{100} \frac{F1}{V} (MA - MA')$$

The computations of the differences :

$$1 - 2 = \frac{1}{10} \cdot \frac{F1}{V} (MA - MA')$$

$$1 - 3 = \frac{1}{100} \cdot \frac{F1}{V} (MA - MA')$$

give the values of the phases in a fictitious network of focuses A and A' with frequencies $\frac{F1}{10}$ and $\frac{F1}{100}$ (lanes 10 and 100 times wider than those of the basic network using the frequency F1).

Therefore the difference $\varphi_1 - \varphi_2$ enables to determine the units figure of the hyperbola number and the difference $\varphi_1 - \varphi_3$ the tens figure.

APPENDIX II

METHOD OF INTERPRETATION

INTRODUCTION

The basic data involved in the interpretation of this aeromagnetic survey are the digital records, from which are obtained:

- The isogam contour map, with an interval of 5. 0 gamma between contour lines.

- The profiles restituted by the IBM 1620 II and the CALCOMP computing machines.

The restitution scale chosen is a function of the anomaly intensity for a given profile (generally 1 cm = 2 gammas), thus the quantitative interpretation of anomalies as weak as one gamma is possible, using the techniques now to be described.

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 account when examining the isogam contours.

1-1 Analysis of Isogam Contour Maps

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

- 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.

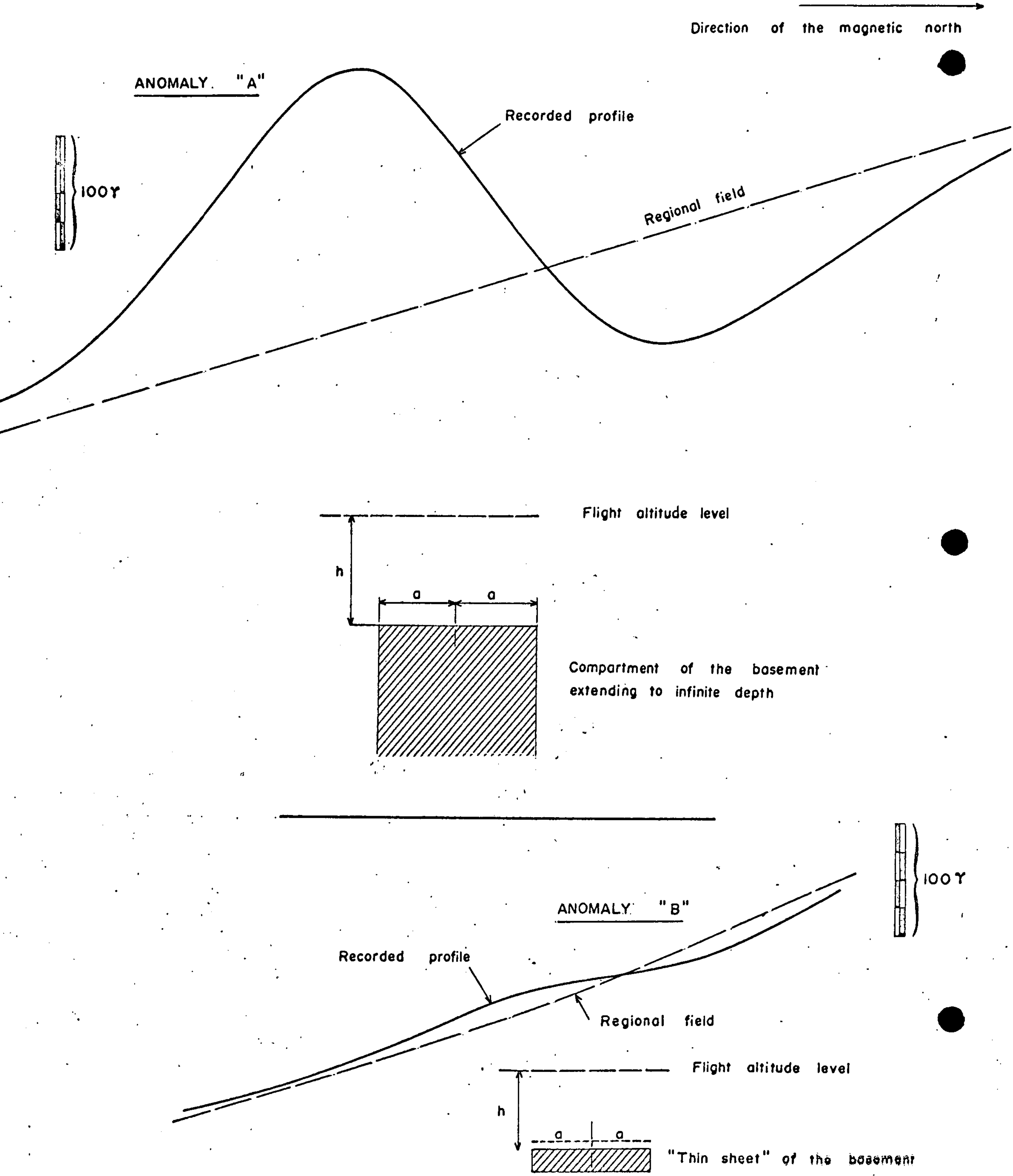
The significance of such magnetic features is to be well defined. In fact, the total amplitude of an anomaly is almost completely caused by susceptibility contrasts, whereas the effect of the vertical throw H-h, that sometimes accompanies such magnetic contrasts generally has a very small influence upon 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 interpreter may concede some probability to the existence of such structural features and indicate the eventual down-throw side and the range of this displacement.

Fig: 1

BROAD ANOMALIES OF TYPES "A" & "B"



1-2 Analysis of Calcomps

The anomalies observed on the CALCOMPS have various features, which in most cases makes it possible to separate them into four clases :

- Class A : Broad and intense anomalies (see fig. 1)
- Class B : Broad and weak anomalies (see fig. 1)
- Class C : Narrow and intense anomalies (see fig. 2)
- Class D : Narrow and weak anomalies (see fig. 2)

It would be untimely to assert that those four classes are to be related to four distinct markers. But their aspect on the isogam contour map and on the calcomps leads to the adoption of different types of interpretation methods for each class.

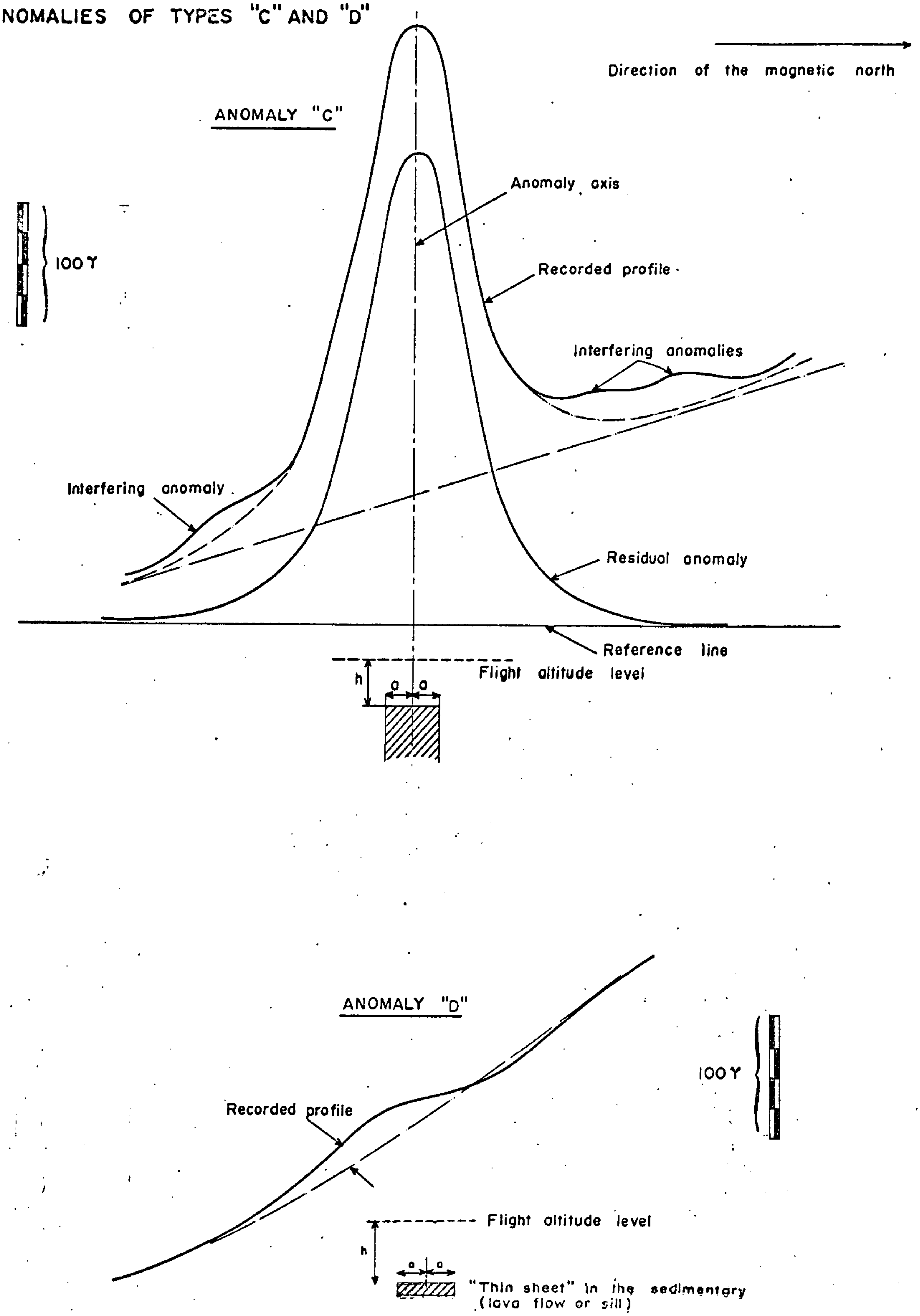
2. QUANTITATIVE INTERPRETATION

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 parallelepipeds with a plane upper surface and walls extending to an infinite depth, representing basement compartments or dykes, or "thin plates" used for representing volcanic flows or irregularities of the basement's upper surface (see fig. 3).

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

Fig: 2

NARROW ANOMALIES OF TYPES "C" AND "D"



On the theoretical anomalies, several characteristic graphic parameters proportional to the depth are defined. For interpreting a real anomaly, the most nearly 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.

2-1 Method of Inflection Tangents Intersections (ITI)

2-1-1 Principles of Construction (fig. 4)

The asymptote of the anomaly and three inflection tangents are considered (five tangents in the case of very wide compartments). A1, A2, A3, A4 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 A1 - A2, A2 - A3, A3 - A4.

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 T1 - T2 and I1 - I2. The points T1 and T2 are the intersection of the tangents A1 - A2 and A2 - A3 with the tangent to the maximum in a direction parallel to the regional field RR'. The points I1 and I2 are the inflection points of the curves which constitute the flanks of the positive anomaly.

In the example of figure 4 the theoretical anomaly for an inclination of 51° corresponds to a body trending East-West, with vertical walls extending to infinite depth. The direction of the intersecting profile is North South.

2-1-2 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) or 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.

2-1-3 Intersection Point Plotting (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 segment 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 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 profiles. Besides, this method is well suited for eliminating the irregularities of the broken lines joining the points A'1 ......, the points A'2 ...... related to the same anomaly. The distance to be measured is taken perpendicularly to the successive smoothed mean lines.

2-1-4 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 uniquivocal determination of the depth h and the ratio a/h.

2-2 "ITI Gamma" Method

For improving the ITI method, another kind of parameters has been studied: these parameters - called ITI Gamma - are the vertical distances between the inflection tangent intersections and the curve itself. They are useful for confirming the determination of the ratio a/h and for computing the apparent magnetization contrast J' (J' is equal to the actual magnetization contrast J if the structure is trending East-West).

2-3 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 cuves. 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 for 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", the half-width "a" and the apparent magnetization contrast "J" are obtained by direct reading.

2-4 Example of Interpretation

Figure 6 illustrates a selected example of interpretation. The upper record was performed with a GULF MARK III magnetometer.

The lower record shows the same anomaly recorded by a CSF caesium vapor magnetometer; it corresponds to the CALCOMP restitution of the digital data of magnetic tape.

Both records were performed at the same flight altitude of 900 metres above seal-level.

On the upper record, only the main horizontal parameters may be measured with some accuracy.

On the lower record, all horizontal and vertical parameters may be measured accurately. Both the ITI and ITI Gamma methods may be used, enabling one to confirm the value of the a/h ratio and accordingly the value of h.

It is obvious, moreover, that the anomaly on the lower record may be interpreted by the bilogarithmic master curve method.

2-5 The Charts

The charts of the parameters ITI and ITI Gamma, and the bilogarithmic master curves may be split into two classes, depending upon whether or not the magnetized body extends to an infinite depth.

As far as the interpretation of bodies extending to a limited depth is concerned, (i. e. "thin plates") bilogarithmic master curves have been computed for a varying range of H/h ratio (H being the depth to the lower surface and h the depth to the upper surface of the plate), whereas for the ITI and ITI Gamma parameters that deal with thin plates, the thickness 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 charts or master curves cannot generally yield any information about this ratio. The choice between bodies extending to infinite depth and thin plates is left to the experience of interpreters.

Nevertheless the intensity of the anomalies caused by "thin plates" does not exceed a few tens of gammas, whereas a block extending to infinite depth may produce anomalies of several hundreds of gammas.

2-6 Performing the Interpretation

2-6-1 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.

2-6-2 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 " ψ " 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 :

$$\tan i' = \frac{\tan i}{\cos \psi}$$

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

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

2-6-3 Wide Anomalies of High Intensity (Class A)

Hypothesis: "Compartment extending to an infinite depth and whose 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" interfering anomalies by decomposing the resultant anomaly into two or more anomalies. The results become more doubtful as the apparent inclination approaches 45°.

2-6-4 Wide Anomalies of Low Intensity (Class B)

Three cases are to be considered :

- The hypothesis : "Compartment extending to an 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 plate 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 plate 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 plate" always provide depth estimates higher than those obtainable from the hypothesis "compartment extending to infinite depth".

2-6-5 Narrow Anomalies of High Intensity (Class C)

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

2-6-6 Narrow Anomalies of Low Intensity (Class D)

Hypothesis : "Thin plate the upper surface of which is situated in the sedimentary overburden".

2-6-7 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 erroneously excessive estimates.

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 plate". 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 plate": a "thin plate" 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 plate" on the interpretation map.

2-7 Drawing the Isobath Contours of Basement

The depth estimates computed by the interpreter and related to the basement (A and B class anomalies) are plotted on a small scale map (1/500, 000 or 1/200, 000). The drawing of isobath contours proceeds from the relevant depth spots; the doubtful values (with interrogration marks) are not taken into account. Finally, the assumed faults or magnetic accidents observed on the isogam contour map are used to support the outline of the isobaths.

APPENDIX III

TORAN NETWORK CALIBRATION

It was not possible during the course of the flight operations to carry out complete passages of the aircraft behind each of the TORAN couple's shadow lines due to erratic or even non-existant reception. Consequently, the network was calibrated by over-flying a readily identifiable point on YULE Island and recording the several TORAN values derived from the different couples.

Most particularly it was found that the ϕ differences observed at YULE using couples MAER ISLAND - GOARIBARI and KIWAI - CAPE POSSESION were very nearly one hyperbola greater, in each couple, than the theoretical values if OROKOLO is held fixed, (OROKOLO is approximately midway between KIWAI and CAPE POSSESSION), i. e.

$$\phi_{A,B}\ \text{YULE} = \phi\ \text{OROKOLO}_{A,B} + \Delta\ \text{OBSERVED}_{A,B}\ \text{YULE - OROKOLO}$$

		A	B
OROKOLO		4004.98	4594.61
Δ	+	4829.00	3203.75
	-	3974.68	4556.90
		4859.30	3241.46

whereas $\phi_{A,B}$ YULE Goaribari, Cape Possession, etc.

	A	B
	4860.66	3242.38

A similar excess was noted over the point URUTAI and consequently it was decided to insert an overall correction of -1 hyperbola in the couples A and B guaranteeing in effect, a closure error of less than one hyperbola even at the extremities of the surveyed area.

This was the only phase correction, as such, applied to the network.

COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record No. 1969 / 58

Papuan Basin and Basic Belt Aeromagnetic Survey,

Territory of Papua & New Guinea 1967

by

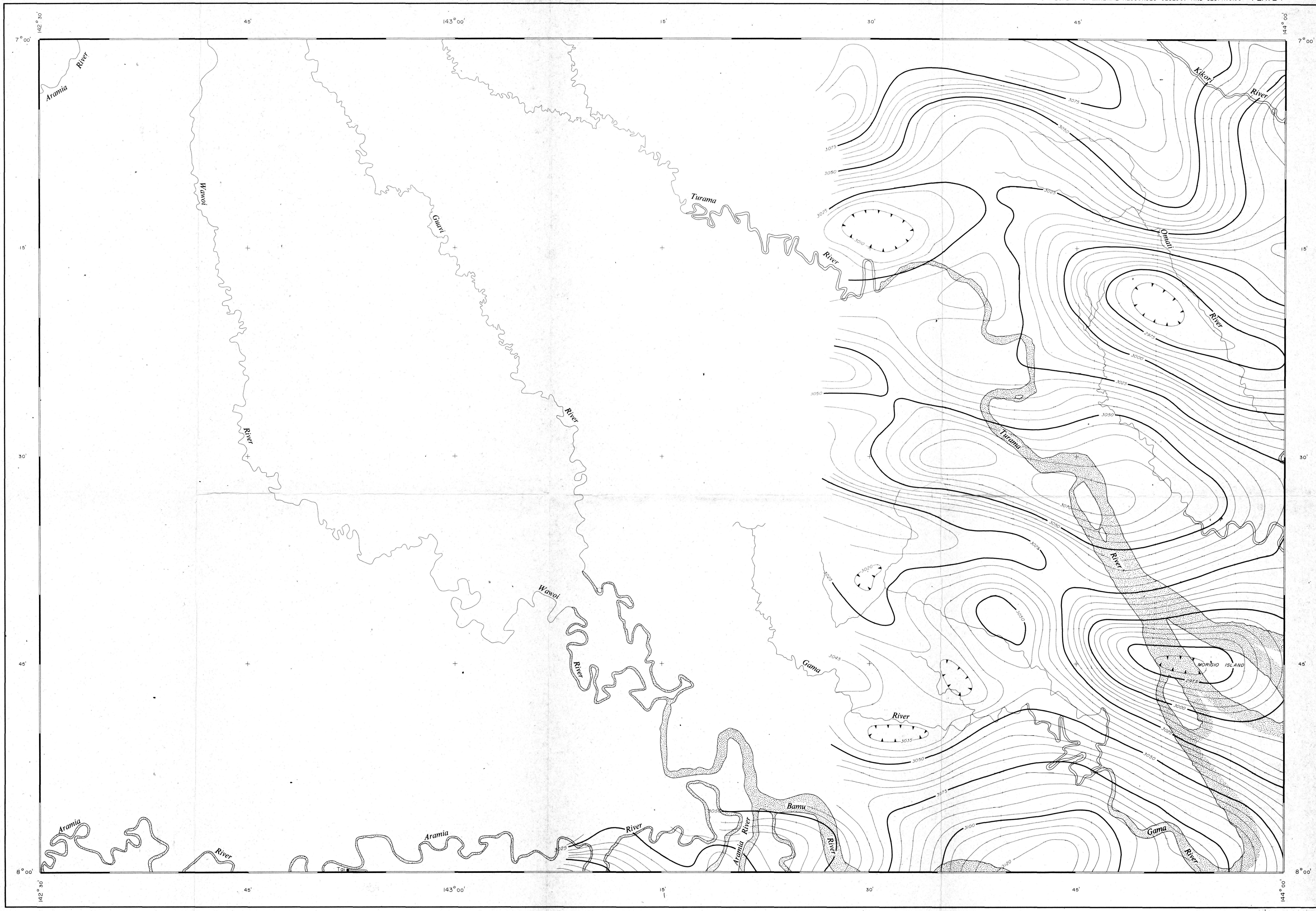
Compagnie Generale de Geophysique

Plates 1 to 11

NEW GUINEA 1:250,000

AWORRA RIVER

BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS PLATE I



COMPAGNIE GENERALE DE GEOPHYSIQUE

TOTAL MAGNETIC INTENSITY

(4,000' ALTITUDE)

CONTOUR INTERVAL 5 GAMMAS

COMPAGNIE GENERALE DE GEOPHYSIQUE

TOTAL MAGNETIC INTENSITY

(4,000' ALTITUDE)

CONTOUR INTERVAL 5 GAMMAS

KIKORI

COMPAGNIE GENERALE DE GEOPHYSIQUE

TOTAL MAGNETIC INTENSITY

(15,000' ALTITUDE)

CONTOUR INTERVAL 5 GAMMAS

TOTAL MAGNETIC INTENSITY

(4,000' ALTITUDE)

CONTOUR INTERVAL 5 GAMMAS

COMPAGNIE GENERALE DE GEOPHYSIQUE

COMPAGNIE GENERALE DE GEOPHYSIQUE

TOTAL MAGNETIC INTENSITY

(15,000' ALTITUDE)

CONTOUR INTERVAL 5 GAMMAS

COMPAGNIE GENERALE DE GEOPHYSIQUE

TOTAL MAGNETIC INTENSITY

(15,000' ALTITUDE)

CONTOUR INTERVAL 5 GAMMAS

COMPAGNIE GENERALE DE GEOPHYSIQUE

TOTAL MAGNETIC INTENSITY

(4,000' ALTITUDE)

CONTOUR INTERVAL 5 GAMMAS

NEW GUINEA 1:250,000

SC 55-1

BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS PLATE 6

COMPAGNIE GENERALE DE GEOPHYSIQUE

TOTAL MAGNETIC INTENSITY

(4,000' ALTITUDE)

CONTOUR INTERVAL 5 GAMMAS

NEW GUINEA 1:250,000

YULE

BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS PLATE 7A

COMPAGNIE GENERALE DE GEOPHYSIQUE

TOTAL MAGNETIC INTENSITY

(4,000' ALTITUDE)

CONTOUR INTERVAL 5 GAMMAS

NEW GUINEA 1:250,000

YULE

BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS PLATE 7B

TOTAL MAGNETIC INTENSITY

(15,000' ALTITUDE)

CONTOUR INTERVAL 5 GAMMAS

COMPAGNIE GENERALE DE GEOPHYSIQUE

COMPAGNIE GENERALE DE GEOPHYSIQUE

TOTAL MAGNETIC INTENSITY

(15,000 ALTITUDE)

CONTOUR INTERVAL 5 GAMMAS

DARU

TOTAL MAGNETIC INTENSITY

(4,000' ALTITUDE)

CONTOUR INTERVAL 5 GAMMAS

COMPAGNIE GENERALE DE GEOPHYSIQUE

MAER ISLAND

COMPAGNIE GENERALE DE GEOPHYSIQUE

TOTAL MAGNETIC INTENSITY

(4,000' ALTITUDE)

CONTOUR INTERVAL 5 GAMMAS

AROA

COMPAGNIE GENERALE DE GEOPHYSIQUE

TOTAL MAGNETIC INTENSITY

(4,000' ALTITUDE)

CONTOUR INTERVAL 5 GAMMAS

COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record No. 1969 / 58

Papuan Basin and Basic Belt Aeromagnetic Survey,

Territory of Papua & New Guinea 1967

by

Compagnie Generale de Geophysique

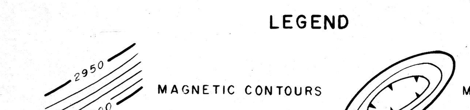
Plates 12 to 17

AIRBORNE MAGNETOMETER SURVEY
PAPUAN BASIN AND BASIC BELT
TOTAL MAGNETIC INTENSITY.

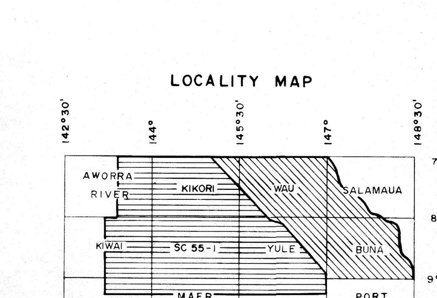
SCALE : 1/500,000

CONTOUR INTERVAL : 10 GAMMAS

LEGEND

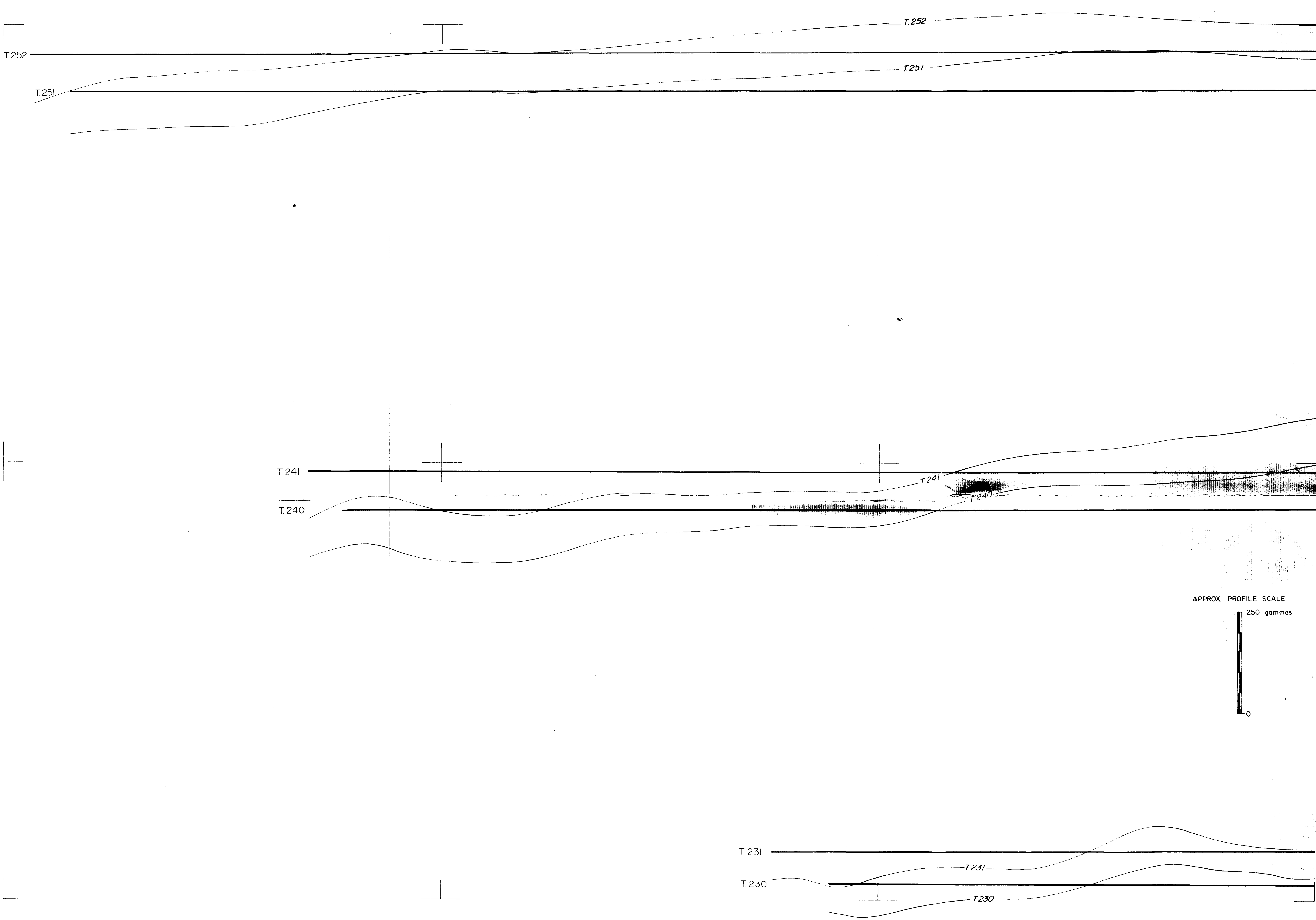


LOCALITY MAP



COMPAGNIE GENERALE DE GEOPHYSIQUE

SALAMAUA



KIKORI SB.55.13	WAU SB.55.14	SALAMAUA SB.55.15
	YULE SC.55.2	BUNA SC.55.3

MAGNETIC PROFILES

SCALE = 1/250000

PAPUAN BASIN AND BASIC BELT

[illegible] MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS — PLATE: 14

AIRBORNE MAGNETOMETER SURVEY
PAPUAN BASIN AND BASIC BELT

INTERPRETATION MAP

SCALE : 1/500,000

LEGEND

- MAJOR BASEMENT ZONE BOUNDARY
- MINOR BASEMENT ZONE BOUNDARY OR INTERMEDIATE HORIZON BOUNDARY
- MAGNETIC BASEMENT FEATURES — A2, S3, F5, GD1, V2
- MAGNETIC BASEMENT DEPTH ESTIMATE (BELOW SEA LEVEL) — 2,000'
- INTERMEDIATE HORIZON DEPTH ESTIMATE (BELOW SEA LEVEL) — 3,000'
- BASEMENT DEPTH CONTOURS — 20,000'
- CHANGE IN LEVEL OF MAGNETIC INTENSITY
- MAGNETIC TREND (Positive)
- MAGNETIC TREND (Negative)
- FAULT (Movement Unknown)
- FAULT VERTICAL MOVEMENT (Barb Points to Downthrow)
- ANTICLINE
- SYNCLINE

COMPAGNIE GENERALE DE GEOPHYSIQUE

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

PLATE 15.

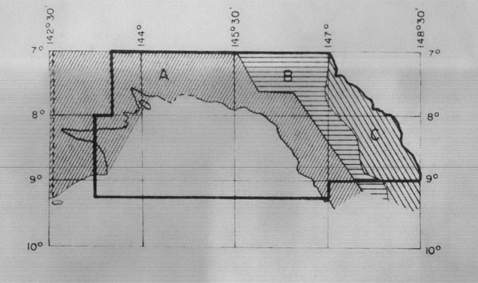
AIRBORNE MAGNETOMETER SURVEY
PAPUAN BASIN AND BASIC BELT
GEOLOGICAL PLATE

SCALE : 1/500,000

LEGEND

- QUATERNARY ALLUVIUM — QA
- QUATERNARY VOLCANICS — QV
- PLEISTOCENE SEDIMENTS & VOLCANICS — QP
- PLIOCENE SEDIMENTS & VOLCANICS — TP
- UPPER MIOCENE SEDIMENTS
- MIDDLE & LOWER MIOCENE SEDIMENTS & VOLCANICS — TML
- LOWER TERTIARY, MAINLY EOCENE — TE
- TERTIARY &/OR CRETACEOUS SEDIMENTS & VOLCANICS — TK
- TERTIARY MOROBE GRANODIORITE
- ?CRETACEOUS BASE VOLCANICS
- ROCK OF PAPUAN ULTRAMAFIC BELT
- CRETACEOUS & OLDER OWEN STANLEY METAMORPHICS
- ?PALAEOZOIC GRANITE
- FAULT
- ANTICLINE

GEOLOGICAL REFERENCE



A. GEOLOGY AFTER AUSTRALASIAN PETROLEUM COMPANY PROPRIETARY LIMITED (A.P.C.) 1961. JOURNAL OF THE GEOLOGICAL SOCIETY OF AUSTRALIA VOLUME 8, PART 1, 1961.

B. GEOLOGY AFTER R.P.B. PITT 1966. UNPUBLISHED PH D. THESIS, UNIVERSITY OF TASMANIA.

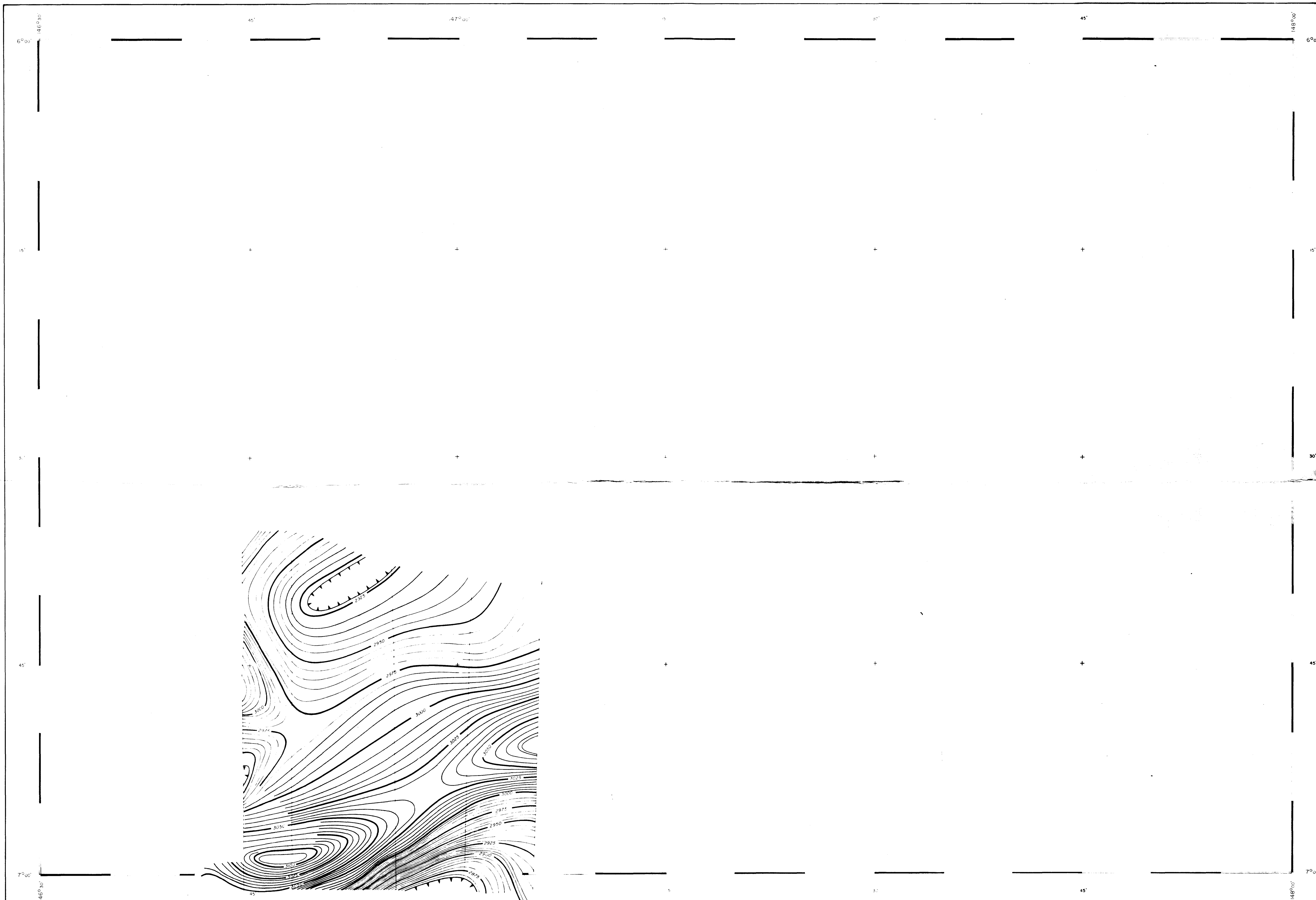
C. GEOLOGY AFTER H.L. DAVIES 1967. BUREAU OF MINERAL RESOURCES, AUSTRALIA RECORD 1967/107.

COMPAGNIE GENERALE DE GEOPHYSIQUE

Airborne Gp Copy

LAE

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS.



	MARKHAM SC 55-10	HUON SC 55-11
KIKORI	WAU	SALAMAUA
	YULE	BUNA

TOTAL MAGNETIC INTENSITY

(15,000' ALTITUDE)
CONTOUR INTERVAL 5 GAMMAS

COMPAGNIE GENERALE DE GEOPHYSIQUE

LAE

PLATE 17.
SURVEY ALTITUDE 15,000 FEET A.S.L.
SURVEY ALTITUDE 4,000 FEET A.S.L.
PORT MORESBY
BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS
LOCALITY MAP
AEROMAGNETIC SURVEY
PAPUAN BASIN AND BASIC BELT
SCALE 1 : 1,000,000
MILES
KILOMETRES
LOCATION DIAGRAM
INDEX TO 1:250,000 MAP SERIES
LAKE KUTUBU
KARIMUI
MARKHAM
HUON (LAE)
AWORRA RIVER
KIKORI
WAU
SALAMAUA
KIWAI
SC 55
YULE
BUNA
CAPE NELSON
DARU
MAER ISLAND
AROA
PORT MORESBY
TUFI
COMPAGNIE GENERALE DE GEOPHYSIQUE