Volume 1

Record No. 1971/67

Eastern Papua Aeromagnetic Survey. Part 1: Northeastern portion (mainly offshore) flown in 1969

by

COPY 4

Compagnie Generale de Geophysique

Record 1971/67

EASTERN PAPUA AEROMAGNETIC SURVEY

Part 1: Northeastern portion (mainly offshore) flown in 1969

by

Compagnie Generale de Geophysique

BUREAU OF MINERAL RESOURCES

AEROMAGNETIC SURVEY OF EASTERN PAPUA

(November - December 1969)

COMPAGNIE GENERALE DE GEOPHYSIQUE

SUMMARY

The East Papuan aeromagnetic survey conducted in 1969-71 by Compagnie Generale de Geophysique under contract to the Bureau of Mineral Resources was divided into two areas.

This report describes the operation, compilation, and interpretation of the survey area designated panel 1B, flown at a barometric altitude of 8000 feet (2440 m), which covered the CAPE NELSON, TROBRIAND ISLANDS, and FERGUSSON ISLAND 1:250,000 Sheet areas and part of the BUNA, TUFI, ABAU, and SAMARAI Sheet areas.

The survey delineated two main elongate, east-west oriented basement troughs. One extends eastward from Cape Nelson along latitude 9°00'S. The other, partly connected with the former, extends eastward from longitude 150°00'E along latitude 8°45'S.

Two smaller troughs were delineated, one northeast and east of the Trobriand Islands and the other centred at longitude 9°12'S and latitude 151°30'E. These troughs are located in regions of deepening sea floor.

A subsequent report will describe the survey in the adjacent area designated panel 1A, which was flown at a barometric altitude of 15,000 feet (4600 m) and covered the mainland of east Papua.

TABLE OF CONTENTS

LIST OF PLATES

(NOTE : Plates 4 and 7 will be included in a subsequent report dealing with Panel 1-A)

LIST OF FIGURES

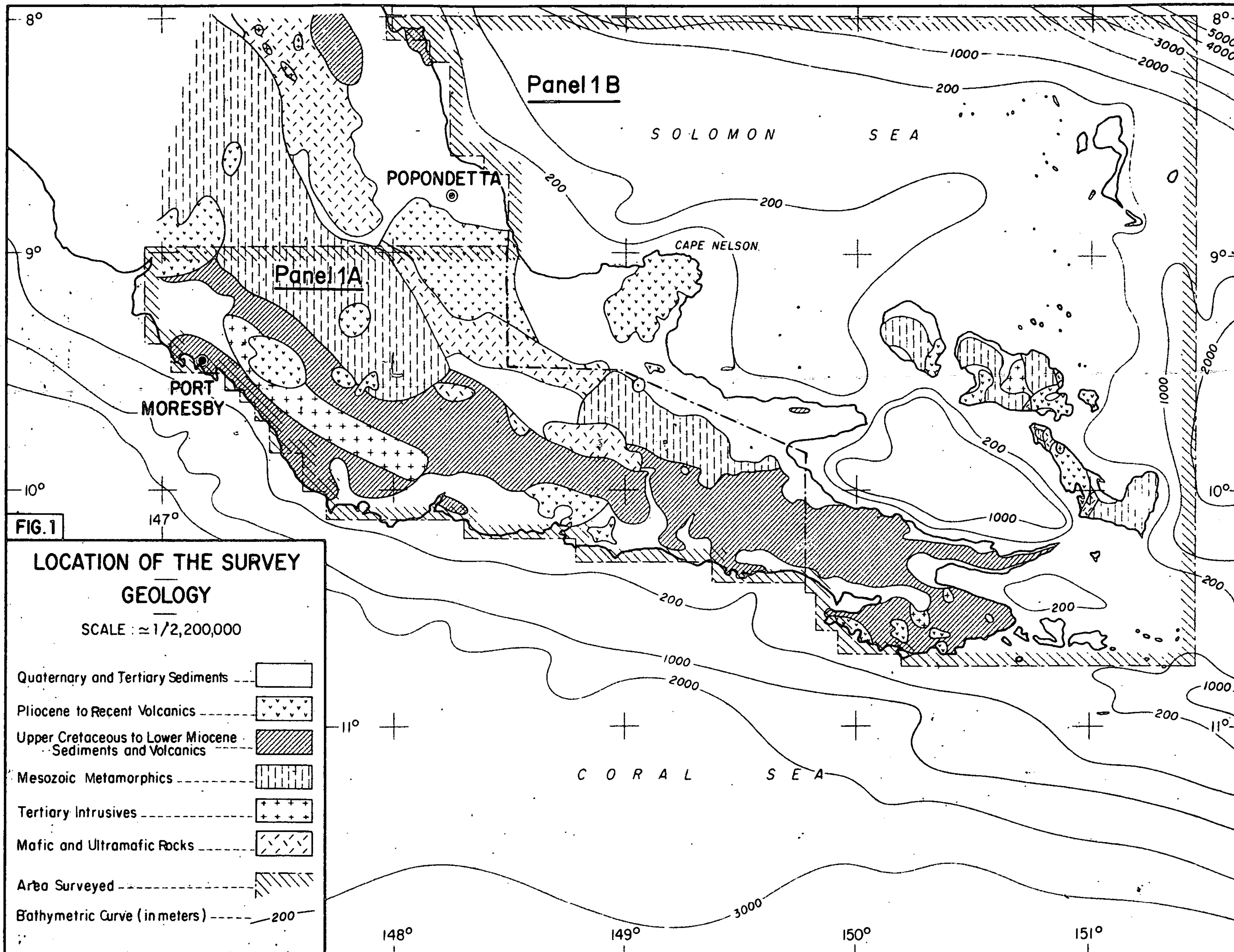


FIG. 1
LOCATION OF THE SURVEY
GEOLOGY
SCALE : ≃ 1/2,200,000
Quaternary and Tertiary Sediments
Pliocene to Recent Volcanics
Upper Cretaceous to Lower Miocene Sediments and Volcanics
Mesozoic Metamorphics
Tertiary Intrusives
Mafic and Ultramafic Rocks
Area Surveyed
Bathymetric Curve (in meters)
200
Panel 1B
Panel 1A
SOLOMON SEA
CORAL SEA
POPONDETTA
PORT MORESBY
CAPE NELSON
8°
9°
10°
11°
147°
148°
149°
150°
151°
200
1000
2000
3000
4000
5000

INTRODUCTION

By terms of a contract dated August 8th 1969, No. Q 560447, 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 the whole of the CAPE NELSON, TROBRIAND ISLANDS, TUFI and FERGUSSON ISLAND 1/250,000 scale map areas, and part of the BUNA, PORT MORESBY, KALO, ABAU and SAMARAI 1/250,000 scale map areas (see Figure 1).

The survey, which represents approximately 17,000 line miles, was divided into two panels, each to be flown at a barometric altitude defined by the terrain elevations of the areas :

- A panel 1-B flown at 8,000 ft. barometric altitude covering the whole of the CAPE NELSON, TROBRIAND ISLANDS, and FERGUSSON ISLAND maps and part of the BUNA, TUFI, ABAU, and SAMARAI maps.

- A panel 1-A flown at 15,000 ft. barometric altitude which covers the land areas of the PORT MORESBY and KALO maps, and parts of the land areas of the TUFI and ABAU maps.

Due to very bad meteorological conditions, the panel at 15,000 feet elevation could not be flown by the anticipated completion date. Therefore, this report concerns only that part of the survey flown at

8,000 feet which represents about 11,400 line miles of profiles. The flying in this panel commenced on November 12th 1969 and was completed on December 21st 1969.

This report presents and analyses the magnetic data and describes the compilation and interpretation procedures including :

- the plotting of all anomalies, even very weak ones, on Calcomp profiles and their transfer onto the Interpretation Map;
- the quantitative interpretation, using the method of the intersection of the tangents of inflection on all the anomalies whose widths and intensities allowed the tangents to be drawn accurately;
- the drawing of an Isobath Contour Map for the magnetic basement, this being a synthesis of the qualitative and quantitative interpretations.

CHAPTER I

SPECIFICATIONS AND OPERATIONS

1. EQUIPMENT

1.1 Aircraft

The aircraft used was a twin engine DC-3, Australian Registry VHP-WM, owned and operated by EAST WEST AIRLINES, of TAMWORTH, N.S.W. This aircraft was completely equipped by C.G.G. for aeromagnetic surveying.

For this particular project, a low pressure Demand-Oxygen system permitting up to eight hours of flight at 15,000 feet was installed. It was also modified to include an inboard fuel reservoir providing eleven hours of endurance with reserves.

1.2 Geophysical Equipment

Mounted in the aircraft were :

- one CSF optical pumping Cesium Vapor magnetometer, giving an accuracy of 0.1 gamma, and towed some 150 feet below and behind the aircraft
- one ROCHAR frequency-meter
- one COTELEC digital magnetic tape recorder
- one SFIM digital magnetic tape recorder

- one TEXAS INSTRUMENTS analog recorder (chart width = 348 mm) with a longitudinal scale of approximately 1/60,000, chart speed of 7.5 cm per minute, and a vertical scale 0.5 gamma per millimetre
- one ROSEMOUNT barometric altimeter, which enables the atmospheric pressure to be determined with great accuracy and thereby gives the altitude of the plane with a sensitivity of ± 5 feet
- one APN 1 radar altimeter for ground clearance information
- one MOSELEY/HEWLETT PACKARD analog recorder, for recording the instantaneous departures from the pre-selected flight level. The recording was at a vertical scale of 1 mm = 1 metre.
- one AEROPATH 35 mm continuous-strip camera for recording the actual passage of the aircraft over the ground
- one CAMEMATIC 35 mm frame-by-frame camera for recording the position of the aircraft at the instant of the fiducial trigger
- one CAMEMATIC 35 mm frame-by-frame camera for recording the Doppler information
- one DIGITORAN receiver, with two sets of phasemeters for over water navigation
- one HEWLETT PACKARD line printer for recording the TORAN information.

All the recorders, digital and analog, and all the cameras were synchronized by the precisely timed fiducial triggers generated by the frequency-meter.

A ground station magnetometer worked continuously on the ground during the survey in order to record the diurnal magnetic variations and the magnetic storms. This magnetometer was a SUD AVIATION proton precession instrument. It was installed at GURNEY (Milne Bay airstrip) from the 1st of November to the 27th of November, and at GIRUA (popondetta airstrip) from the 28th of November through to the 21st of December.

2. PERSONNEL

2.1 Originally, the E.W.A. crew was composed of :

- 2 Pilots
- 1 Ground Engineer

Due to the limitation on pilot's flight times imposed by the Department of Civil Aviation, a third pilot was dispatched to the survey area shortly after the actual start date. A rolling crew was formed and production flights in excess of 41 hours per week were obtained.

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

- 1 Party Chief
- 1 Data man
- 1 Magnetometer Operator
- 1 Ground Magnetometer Operator
- 1 Navigator
- 1 Airborne TORAN Operator
- 4 TORAN Electronic Technicians for operating

the TORAN transmitters set up along the coast.

3. FLIGHT GRID

3.1 PANEL 1-B consisted of 59 flight lines, oriented north-south, separated either by 4 or 8 statute miles, and 26 tie-lines,oriented east-west, separated each from the other by 8 statute miles. This panel was flown at a constant barometric altitude of eight thousand feet a.s.l.

Due to the rainy season, the survey was stopped after the execution of the Panel 1-B.

3.2 PANEL 1-A consists of 65 flight lines, oriented north-south, separated, with one exception, each from the other by 3 statute miles, and 18 tie-lines, oriented east-west, separated, with one exception, each from the other by 6 statute miles.

This panel will be flown at a constant barometric altitude of thirteen thousand five hundred feet a.s.l. when the meteorological conditions will be more favourable.

4. NAVIGATION

For the flights carried out in Panel 1-B, contact navigation techniques, using the Bureau of Mineral Resources supplied photo-assemblies and maps, supplemented by the Marconi AD-560 Doppler, were used for those portions of flight lines that took place over land.

FIG. 2 Location of TORAN NETWORK

PAPUA NETWORK "A-B"

TORAN 2 COUPLES — MISSION 501 · 31 · 17 NO IBM — CLIENT B.M.R.

ELLIPSOID HAYFORD — A = 6378.3880 — E2 = 0.0067226700223

PROJECTION UTM CLAS — KO 0.9996 — CTEX 500.000 — CTEY 10000.000 — MO = 150° 00 00. — LO = 00° 00 00.

UNIT OF X Y = 1.0 KM

	STATION	LONGITUDE (DEG.)	LATITUDE DEGRES	ALTI KM	X = (EAST)	Y = (NORTH)	FREQUENCY KC	VELOCITY KM	LAMBDA METRES	BASE EXTENSION PHASE
A	GUMBORO	148 11 55.78	-8 18 59.86	0.020	301.6291	9080.2368	1992.000	299759.8	150.482	3438.93
A'	GOODENOUGH	150 06 44.94	-9 15 30.82	0.020	512.3551	8976.5484	1992.080			6561.07
AR	CAPE NELSON	149 15	-9 02				1807.000	BASE LINE		234.9129 KM
B	KIRIWINA	151 01 19.82	-8 26 56.87	0.020	612.5260	9065.8916	1851.000	299629.0	161.874	4167.87
B'	GOODENOUGH	150 06 36.82	-9 15 42.93	0.020	512.1072	8976.1765	1851.080			5832.13
BR	CAPE NELSON	149 15	-9 02				1736.000	BASE LINE		134.7039 KM
C		.	.	.	.	.	.			.
C'		.	.	.	.	.	.	.	.	.
CR							.			. KM

CALIBRATION POINTS

	NAME	LONGITUDE (DEG.)	LATITUDE	ALTI	X	Y	PHASE A	PHASE B	PHASE C
	NOEL	150 16 24.20	-8 33 57.09	0.020	530.0855	9053.1235	6006.664	5027.168	.
1	MUKAWA	149 58 36.93	-9 37 50.50	0.080	497.4682	8935.4067	6328.129	5807.348	.
2	PG AA 26	149 52 30.59	-10 01 32.66	0.050	486.3190	8891.7266	6164.266	5783.473	.
3	PG AA 25	150 10 03.58	-10 06 15.97	0.670	518.3698	8883.0233	6324.746	5694.059	.
4	PG AA 23	150 51 43.52	-10 13 49.24	0.100	594.4209	8868.9807	6500.504	5386.648	.
5	PG AA 29	149 46 49.00	-9 39 01.29	0.340	475.8931	8933.2250	6138.953	5829.699	.

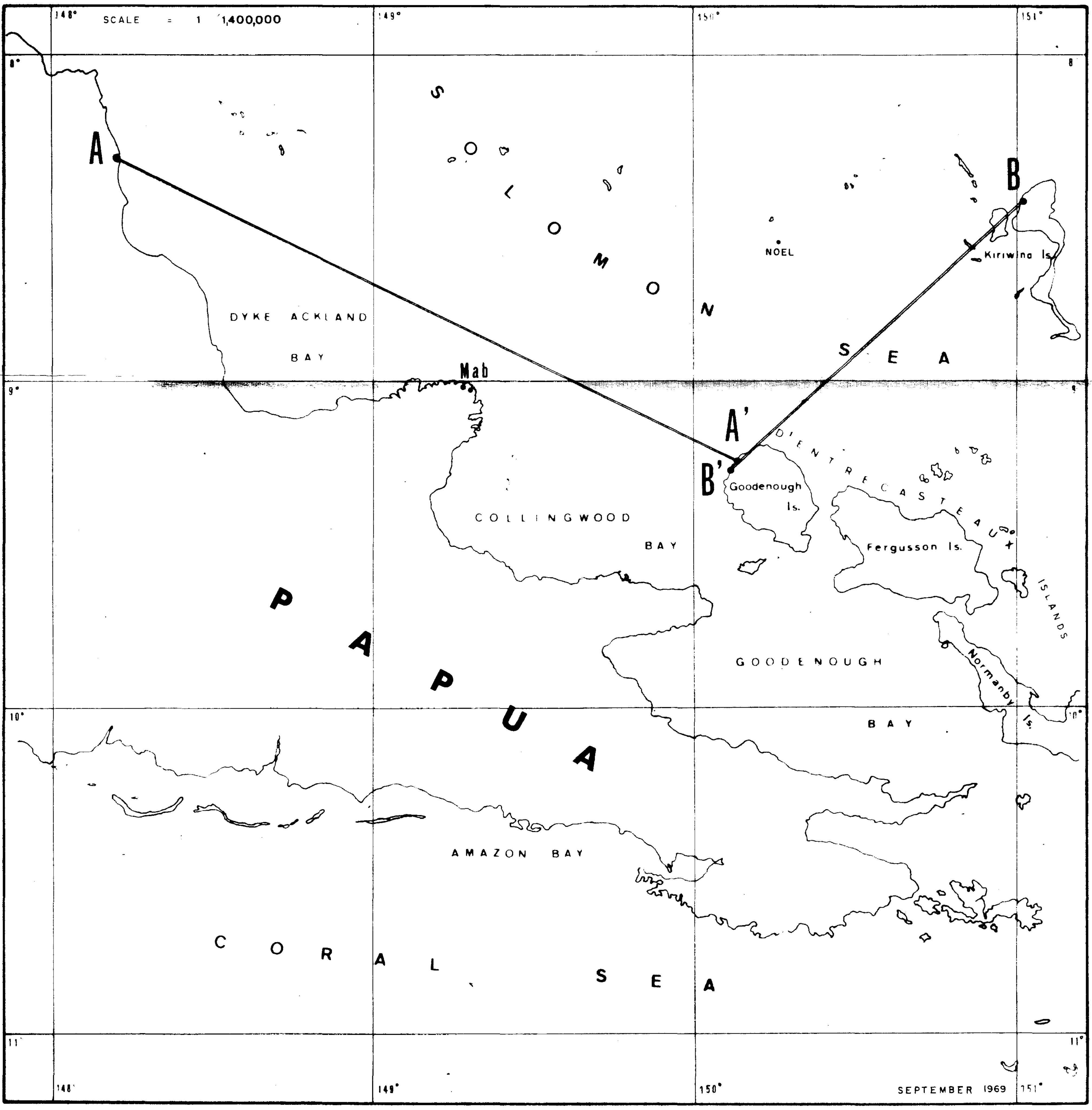


FIG. 2bis Location of TORAN NETWORK

PAPUA NETWORK "C-D"

TORAN 2 COUPLES MISSION 501-31-17 NO IBM CLIENT B.M.R.

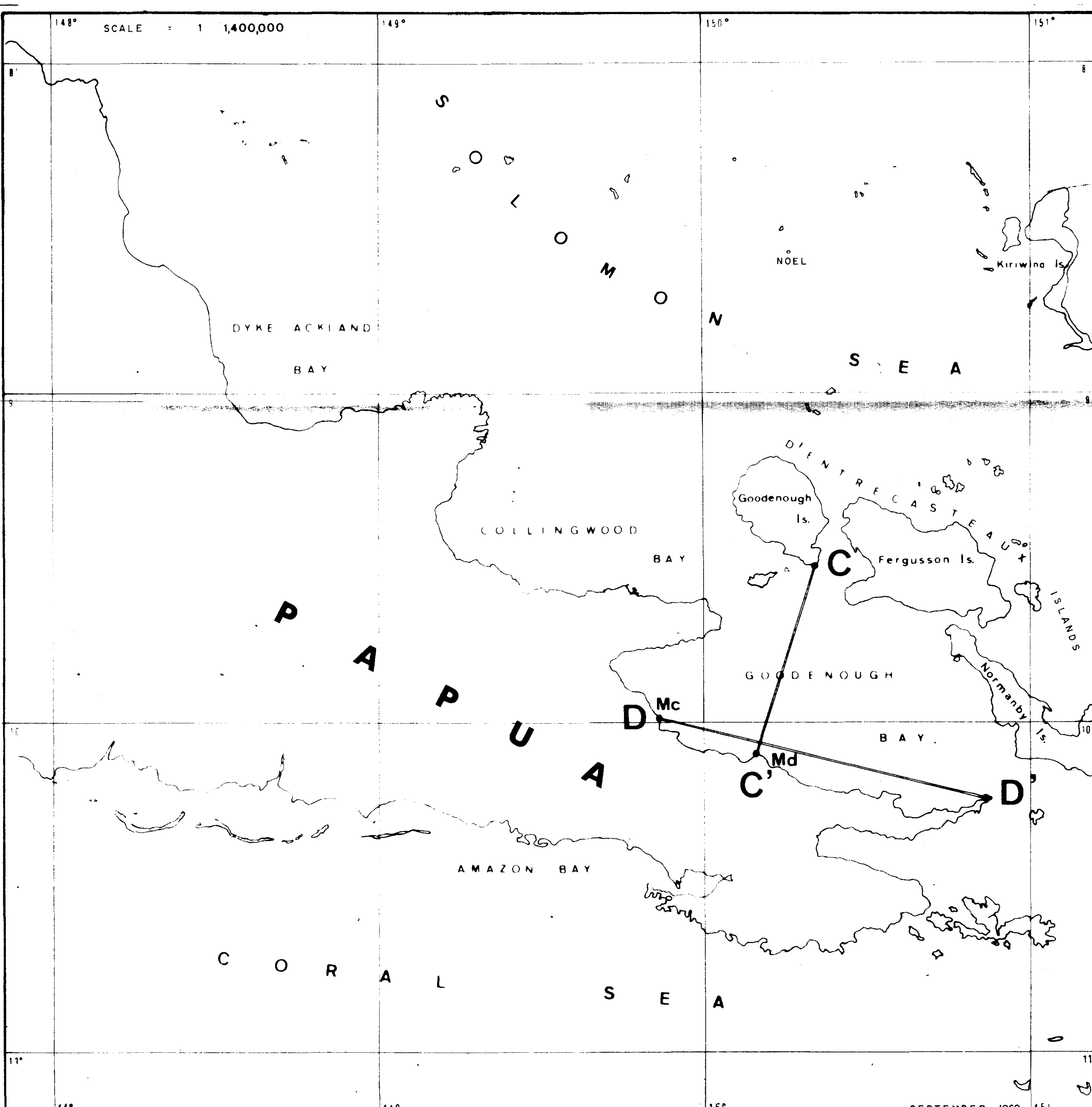
ELLIPSOID HAYFORD A = 6378.388 E2 = 0.0067226700223

PROJECTION UTM CLAS KO 0.9996 CTEX 500.000 CTEY 10000.000 MO = 150° 00' 00".0 LO = 00° 00' 00".0
UNIT OF X Y = KM = 1.000 KM

STATION		LONGITUDE (DEG.) DEGRES	LATITUDE	ALTI KM	X = (EAST) KM	Y = (NORTH)	FREQUENCY KC	VELOCITY KM	LAMBDA METRES	BASE EXTENSION PHASE
C	CAPE WATTS	150 20 00.52	-9 31 20.33	0.005	536.6014	8947.3720	1992.000	299650.0	150.427	4563.26
C'	CAPE FRERE	150 09 47.34	-10 05 30.32	0.015	517.8762	8884.4256	1992.080			5436.74
CR	MUSARA PT.	149 51	-9 59				1807.000	BASE LINE		65.6982 KM
D	MUSARA PT.	149 51 00.42	-9 59 07.34	0.005	483.5721	8896.1886	1851.000	299769.0	161.950	4289.42
D'	EAST CAPE	150 52 18.71	-10 13 28.94	0.015	595.4933	8869.6013	1851.080			5710.58
DR	CAPE FRERE	150 10	-10 05				1736.000	BASE LINE		115.0782 KM
										KM

CALIBRATION POINTS

	NAME	LONGITUDE (DEG.)	LATITUDE	ALTI.	X KM	Y	PHASE A	PHASE B	PHASE C
1	MUKAWA	149 58 36.93	-9 37 50.50	0.080	497.4682	8935.4067	4906.941	4527.746	
2	PG AA 26	149 52 30.59	-10 01 32.66	0.050	486.3190	8891.7266	5283.355	4344.305	
3	PG AA 25	150 10 03.58	-10 06 15.97	0.670	518.3698	8883.0233	5434.012	4746.301	
4	PG AA 23	150 51 43.52	-10 13 49.24	0.100	594.4209	8868.9807	5128.461	5697.348	
5	PG AA 29	149 46 49.00	-9 39 01.29	0.340	475.8931	8933.2250	4986.441	4396.855	



For those flight lines wholly or partly over water, the C.G.G. developed TORAN hyperbolic system was used.

Two separate two-couple networks were established :

- one northern network "A-B"
- one southern network "C-D"

The following tables (figure 2 and 2bis) give for each TORAN installation, in International Spheroid geographic and UTM coordinates, the values employed in the compilation and the compensation.

5. FLIGHT PROGRESS

5.1 Panel 1-B

First magnetic measure	:	November 12, 1969
Last magnetic measure	:	December 21, 1969
Flying time	:	164.56 hours
Mileage of profiles flown and recorded	:	11,350
Average production per hour	:	69 miles

The meteorological conditions were too bad to permit flying at 15,000 feet after December 21, 1969.

5.2 Panel 1-A

This panel was partly flown after the rainy season, in June and July and August, 1970. However, abnormally rainy weather (up to 5 inches per day) during this "dry" season limited the actual production to approximately 3,500 miles.

The remainder will be attempted again in 1971.

CHAPTER II

COMPILATION OF THE DATA

1. DOCUMENTS OBTAINED DURING EACH FLIGHT

The following documents were obtained during each flight :

- a 35 mm AEROPATH film strip for flight path recovery when above land or islands;
- a 35 mm CAMEMATIC frame-by-frame film, also for flight path recovery when above land or islands; this camera served as a backup to the first;
- a 35 mm CAMEMATIC frame-by-frame film for recording the "Doppler" information;
- a listing of the TORAN data obtained with a Hewlett-Packard digital printer, giving all TORAN information every second;
- a digital magnetic tape recording of the magnetic field intensity (one value every second);
- an analog chart recording of the same magnetic field intensity (one value every second);
- an analog recording of the altimeter data.

During the flights, the ground station provided an analog recording of the ground variations of the magnetic field (one value every second).

2. FLIGHT PROGRAMME

The profiles in the 8,000 foot panel being mostly off-shore, a radio navigation system was essential for this survey. It was necessary to implant two networks of TORAN couples. The first, with A-A' and B-B', as foci was used for the northern and northwestern parts of the survey, the second with C-C' and D'D' as foci, was used for the southeastern part of the survey.

The geographical locations of each set of foci in UTM coordinates (HAYFORD ellipsoid), with the meridian Mo = 150° East Greenwich as origin, are given in figure 2 and 2bis.

Maps of the different hyperbolic networks were drafted by an IBM computer coupled to a Calcomp plotter, and the theoretical flight-grid was located on these maps with the help of precalculated check points.

Two copies of these maps were then assembled to establish the flight strips, one for the lines, the other for the tie-lines.

3. DETAIL MATCHING AND RESTITUTION OF TORAN DATA

Establishing the points of coastal passage (at the departure and arrivals of the profiles) was made with the help of Aeropath films by comparing visible details on the strip films and the photomosaics and topographical maps supplied by the Bureau of Mineral Resources. Common points were pricked on the films and the photo documents.

A transfer of this "pricking" was then done onto the 1/250,000 scale topographic maps.

The information concerning the fiducial points of all the profiles which were recorded on the listing delivered by the printer installed on board the plane, were punched on IBM cards and then transformed into rectangular X and Y coordinates by the IBM computer. These X and Y coordinates were then used to restitute the profiles with the help of a Calcomp plotter.

4. ESTABLISHING THE LOCATION MAP

The restitution of the fiducial points was transferred by transparency onto the 1/250,000 scale graticules.

An assembly of all the graticules with fiducial points was then superimposed over an assembly of the 1/250,000 scale topographical maps.

We noticed that there was a small shift in the north-south and east-west directions between the points restituted with the TORAN system and the pricked points on the topographical maps. But, as this shift was practically constant over the whole surveyed area, we decided to displace slightly the geographical coordinates marked on the topographical maps so that they would correspond to the coordinates of the TORAN restitution. Therefore, all the parallels were affected by a shift of 2 millimeters towards the north and all meridians by a shift of 3 millimeters towards the east.

These displacements completed, we transferred the points pricked on the topographical maps onto the graticules. Then, we completed the location map by interpolation or extrapolation of "Doppler" data on the profiles where TORAN information was lacking, i.e. in the shadow zones located behind the foci.

This work being done, we proceeded to an enlargement at 1/100,000 scale of all the 1/250,000 scale graticules (six sheets for one 1/250,000 sheet); then we transferred the fiducial points onto these new 1/100,000 scale graticules, taking into consideration the contractual standard.

The intersections of lines and tie-lines located on land were directly picked up on the aeropath films. Those located off-shore were placed on the graticules at 1/100,000 scale. All these intersections are defined for the ensuing operations by the following three parameters : X and Y coordinates and the time of their occurrence (the temporal coordinate).

5. DATA PROCESSING OF THE DIGITAL "AIR" RECORDINGS

The frequencies given by the magnetometer (directly proportional to the magnetic field) are recorded in IBM code on the "Air" magnetic tapes. All this information is transferred onto a disk to make the further processing easier.

The parameters of the intersections which define the location map are punched on IBM cards; these are checked by a velocity programme.

A second processing in the IBM computer, entering on one hand the data related to the intersections and on the other, the "Air" magnetic data, allows the first stage in the programme of final value calculation to be carried out. This stage consists of defining the differences existing at the intersections between the magnetic values of lines and tie-lines and establishing a figure of these differences "L - T" with a Calcomp plotter.

6. ANALYSIS AND DEFINITIVE LOCATION OF THE INTERSECTIONS

The final adjustment is done manually by the compilation staff and combines translations of lines and tie-lines. It consists :

- of detecting the abnormal closures due to inaccurate plotting of the intersections or to poor identification of the parameters, and correcting for this by returning to the basic data and re-identifying and replotting,
- of reducing the too large or non-linear closures by moving the intersection position in a time range of ± 1 second, a displacement which is considered as normally admissible because of the possible swinging of the plane,
- of calculating the definitive corrections to be applied to each of the intersections in order to obtain a similar field intensity on both the line and the tie-line profiles.

7. CALCULATION OF THE RESIDUAL VALUES

The definitive corrections having been applied means that we will obtain equal values of the magnetic field at each intersection. The next and final stage is the calculation of the residual values of the total field. This consists of :

- feeding the computer with the digitised "Air" data,
- providing the computer with final intersection parameters (X, Y, and time) along each profile and with the final corrected values of the total magnetic field,
- producing the residual field after a linear distribution of the corrections between the intersections and after the subtraction of a regional field. In this survey, the regional field corresponds to a gradient of :

  -6.196 gamma per km in the south-north direction
  -0.729 gamma per km in the west-east direction

- listing the final residual values every 5 seconds and transferring them onto a new magnetic tape.

8. CONTOURING THE ISOGAM CONTOUR MAP

The final residual values are transferred every 5 seconds onto the 1/100,000 scale graticules with indications of the maximum and minimum values encountered on the profiles.

Transparencies with rectangular coordinates at the corners are then superimposed over the graticules and the isogam contours are drawn with a pencil every 5 gamma (or more for the intense anomaly contours). The maps obtained are at 1/100,000 scale, and represent for the part of the survey flown at 8,000 feet, a total of 33 sheets, but they were not ink printed for the final report. They were supplied to B.M.R. for acceptance and only reductions at 1/250,000 scale of these 33 sheets figure in the report. They represent 7 plates (BUNA, CAPE NELSON, TROBRIAND ISLANDS, TUFI, FERGUSSON ISLAND, ABAU and SAMARAI).

CHAPTER III

GEOLOGICAL BACKGROUND

1. GENERALITIES

Physiographically, eastern Papua and New Guinea are dominated by a continuous mountain system, the eastern cordillera, the southeast trending morphological continuation of the main cordillera of New Guinea. In eastern Papua and New Guinea, the ranges swing to a northwest-southeast trend and further east, become narrower, discontinuous and lower in elevation before passing out into the CORAL SEA as a chain of islands, the LOUISIADE ARCHIPELAGO. The main mountains of eastern Papua are known as the OWEN STANLEY RANGE. In the north, flanking the range, extends the coastal plain of POPONDETTA, drained by the MAMBARE and KUMUSI Rivers. In the south, the flank of the eastern cordillera is made up of small and narrow discontinuous coastal basins.

The major geological features of eastern Papua are shown in Plate 11.

2. BASEMENT AND METAMORPHIC ROCKS

The Owen Stanley fault runs from SALAMAUA to GABAINA, KOKODA. This fault separates the metamorphics of the OWEN STANLEY RANGE from the ultramafic belt.

2.1 Owen Stanley Metamorphics

These rocks range from medium-grade metamorphics to low grade metamorphics. They include quartz-biotite schists, calcareous schists, marbles, greywackes, sericite schists. Locally, large batholitic intrusions took place during the Pliocene and more recent times, and so did some andesitic porphyry intrusives.

2.2 The Papuan Ultramafic Belt

This belt, 400 kilometers long and up to 40 kilometers wide, is composed of mafic and ultramafic rocks in approximately equal proportions :

- mafic rocks are gabbros and norites,
- ultramafic are peridotites, dunites and pyroxenites.

The Papuan Ultramafic Belt and overlying basalts are generally regarded as a plate of oceanic mantle and crust which was thrust over the sialic core of Papua New Guinea during Cretaceous and Eocene times. This thrust plate consists of :

- Cretaceous basalt (upper oceanic crust)
- Gabbro and norite (lower oceanic crust)
- Peridotite (mantle).

3. SEDIMENTARY FORMATIONS

The known ages of sediments of eastern Papua and New Guinea range from the early Mesozoic through to the Quaternary.

3.1 Upper Cretaceous to Lower Tertiary Sediments

Uplifted remnants of Tertiary and Cretaceous deep-water marine sediments occur to the southwest. They are part of a series of sedimentary belts of Cretaceous, Miocene and Pleistocene ages which paralleled the northeast-southwest fault system affecting New Guinea and Papua.

3.2 Tertiary Intrusives

Tertiary intrusives consist of sills, dykes and stocks of granodiorite, diorite and gabbro. They outcrop widely to the east and southeast of PORT MORESBY.

3.3 Upper Cretaceous and Lower Tertiary (Eocene) Volcanics

Most basalts of the southeast Papuan mainland are Cretaceous or Eocene, according to recent investigations.

3.4 Pliocene and Recent Sediments and Volcanics

Pliocene and Recent volcanic occurrences appear on the northeast flank of the eastern cordillera. Pliocene is represented by thinly developed and isolated outcrops of sandstones and mudstones in the lower MAMBARE river area. Pliocene deposits which appear to the south of POPONDETTA, very likely extend beneath the coastal alluvium. In the PORT MORESBY sector, deposits of the same age consist of pyroclastic accumulations (volcanic breccias, tuffs, reworked volcanic conglomerates, sandstones, etc. ...).

3.5 Quaternary Limestone and Alluvium

Quaternary terrestrial sediments occur along the coasts and in the depressions. These include fluvial and swamp deposits with possibly some deltaic beds in the coastal regions. The youthful nature of the rivers draining from the cordillera into the basin means an abundant detritus supply.

4. VOLCANICS

Papua and New Guinea has been the field of an intense volcanic activity and the consequences upon the interpretation of the magnetic data may be of importance.

Some volcanics are associated with the Ultramafic Belt. They consist of altered basalts and pillow-lavas which are partly Cretaceous and are thought to be the remnants of the Oceanic crust which existed over the Ultramafic Belt before fault movement began. Some are Eocene basalts, Oligocene and Miocene tuffs. and in general overlie the Cretaceous unconformably.

Cainozoic volcanics cover parts of the Ultramafic Belt. They range in composition from basalt to andesite, dacite and rhyodacite.

5. POSSIBLE MAGNETIC MARKERS

Considering the above mentioned geological series, it can be supposed, a priori, that we will encounter several magnetic markers in this survey, i.e. :

(1) certainly, the mafic and ultramafic rocks, the Mesozoic metamorphics and the Tertiary intrusives, all three of which may be considered as representing the basement

(2) very probably, the Pliocene to Recent volcanics and the Cretaceous and Eocene volcanics and sediments.

We will see further, looking at the total field map, that all these series, including the "Cretaceous and Eocene Volcanics and Sediments", seem to act as good magnetic markers where they outcrop, and are practically impossible to separate from one another. As the corresponding depth-estimates locate the markers very near the surface, even where the "Pliocene to Recent Volcanics" or "Cretaceous and Eocene Volcanics and Sediments" series are outcropping, we must conclude that :

(1) either these series are very thin in places, and the real basement (mafic and ultramafic rocks, Mesozoic metamorphics or Tertiary intrusives) must be very near the surface level

(2) or, and this is probably more frequently the case, the composition of the material constituting these series is such that their magnetic response is nearly the same as that of the basement where this outcrops,

therefore they may be considered as corresponding locally to the magnetic basement.

6. CONCLUSION

Although the geological information regarding eastern Papua New Guinea is somewhat scarce, the existing bibliography has led us to make some deductions in an attempt to define the region's main features :

- The mountain system is represented by the OWEN STANLEY RANGE.
- These mountains are mainly formed by metamorphic and basic rocks (Ultramafic Belt).
- The known sediments range from the early Mesozoic through to the Quaternary.
- The Tectonic trends are mostly northwest.
- Volcanism continued throughout the Cainozoic in different parts of the area.

FIG-3

EXAMPLE OF TYPICAL ANOMALIES

PROFILE L10 – SCALE: 1/100.000

FIG. 3bis

EXAMPLE OF TYPICAL ANOMALIES

PROFILE L 10 – SCALE 1/104 000

CHAPTER IV

QUALITATIVE AND QUANTITATIVE INTERPRETATION

1. QUALITATIVE INTERPRETATION

1.1 The Calcomp Records

The Calcomps are presented at a horizontal scale of approximately 1/100,000. On each Calcomp, there are three curves. Two represent the variations of the total magnetic field at different scales, either 1cm = 10 gamma and 1cm = 50 gamma for the majority of the lines, and 1cm = 5 gamma and 1cm = 20 gamma for the majority of the tie-lines, and a few with 1cm = 2 gamma and 1cm = 10 gamma. The third (the one at the top) represents the variations of the computed vertical gradient along the measured profile.

The study of these Calcomps shows that the recorded anomalies may be classified in four categories (see figures 3 and 3bis) :

- category "A" : large (more than 45 and often more than 100 gammas) but narrow anomalies, which we have related to the outcropping or suboutcropping magnetic basement;
- category "B" : small and narrow anomalies (less than 45 and sometimes less than 20 gammas) that we have treated as thick plates or thin plates. They give depth-estimates very close to those obtained from nearby category "A" anomalies, and we have admitted that they were also related to the suboutcropping magnetic basement;

- category "C" : relatively wide and large anomalies (more than 45 and sometimes more than 100 gammas) that give relatively deep depth-estimates. We have related these to the magnetic basement below a certain thickness of sediments;
- category "D" : small (less than 45 and often less than 20 gammas) but relatively wide anomalies, which give depth-estimates very close to those obtained from nearby category "C" anomalies. We have also related these to the magnetic basement.

In conclusion, we have plotted these different types of anomalies depending upon their respective intensities; but, inasmuch as the corresponding depth-estimates in a given area are roughly in the same range, we have admitted that they were caused by the same magnetic marker, i.e. the magnetic basement.

1.2 Total Field Contour Map (see plate 10)

The residual total field contour maps have been drawn at 1/250,000 scale (pl. 1, 2, 3, 5, 6, 8 and 9). However, because of the large size of the surveyed area, it is necessary to look at the corresponding reduced map at 1/500,000 scale (pl. 10) to have a general view of this area.

This 1/500,000 scale total field contour map will be discussed and analysed in the "interpretation map" chapter.

1.3 Magnetic Lineations and their Direction

Two types of magnetic lineations generally may be recognized from aeromagnetic data :

- longitudinal lineations, which are nearly parallel to the anomaly axes, and which are indicated by sharp gradients in the contours of the total field;

- transverse lineations, which are at a large angle to the anomaly axes, and which are indicated by shifts in the alignment of anomaly maxima and minima.

These lineations are generally considered to be unfaulted contacts. Sometimes, they are considered as faults when a throw between the two magnetic compartments can be computed from the quantitative interpretation in the neighbouring area.

From the total field intensity contour map of this survey, we were able to draw many magnetic lineations :

- Those of the first type are relatively few and are generally oriented west-northwest/east-southeast. Only one (F 14) is oriented east-northeast/west-southwest. It was possible to indicate the downthrow side for F 6, F 14, F 27 and F 29, but not for F 26-F'26 and F 28-F'28.

- Those of the second type are the more numerous. They are most often oriented north-northeast/south-southwest, but some are oriented north-south and even north-northwest/south-southeast. Except for two in the southern part of the survey, F 20 and F 31, where a downthrow side could be estimated and which probably correspond to faults, the others may be considered as unfaulted contacts.

2. QUANTITATIVE INTERPRETATION

2.1 Magnetic Characteristics of the Survey Area

In the surveyed area, the magnetic inclination ranges from 30^{o} to 34^{o} S, this being the real inclination for an anomaly trending east-west. If the trend of the anomaly is not east-west, the "apparent inclination" is defined by :

$$\tan I' = \frac{\tan I}{\cos \phi}$$

with : I = magnetic inclination in the surveyed area

I' = "apparent" magnetic inclination of the anomaly

ϕ = angle of the anomaly axis with the east-west direction

In this survey, the trends of the main anomalies are generally almost east-west, so that the apparent magnetic inclination seldom differs greatly from 32^{o} S. This means that, theoretically, a magnetic body will generate an anomaly with a prominent negative to the south and a weak positive to the north.

Nevertheless, if the majority of the anomalies are effectively mainly negative, we should mention that some of them are indisputably positive. This is probably due to the influence of remanent magnetization. These have been plotted as if the magnetic inclination were between 45^{o} and 90^{o} S.

2.2 Depth-Estimates of the Magnetic Contrasts

All the interpreted anomalies have been plotted with the help of

CGG "ITI" and "ITI gamma" master charts, but it has been necessary to select an appropriate criterion for differentiating the "intrabasement bodies" and the "thick" or "thin plates". After several test-cases, it was decided that any anomaly whose apparent amplitude was greater than 45 gammas would be interpreted using the hypothesis of a magnetic block of infinite depth, whereas those with apparent amplitudes lower than 20 gammas would be interpreted as "thin plates".

Anomalies with amplitudes between these two values have generally been interpreted as "thick plates" (ratio $\frac{H}{h} = 2$), except where the two flanks were too assymetrical to fit in with this hypothesis; in such a case, the hypothesis of a magnetic block of infinite depth was employed.

It must be mentioned that the computed vertical gradient has been a great help in plotting the anomalies. Very often there is mutual interference between the anomalies on the total field, and in this case it is easier and certainly more accurate to plot them on the computed vertical gradient curve using special sets of master charts developed by CGG. We must underline the fact that even when not interfering, the anomalies were also plotted on the computed vertical gradient and that the depth-estimates obtained were always very near (differences less than 10% and very often less than 5%) to those obtained by plotting the same anomalies on the total field (as indicated by the example on figures 3 and 3bis). This furnishes a good reason to trust the values found by treating anomalies only on the computed vertical gradient where anomalies interfered too much with one another on the total field.

2.3 Transfer of the Depth-Estimates

The maxima and minima of the anomalies were transferred to the location map. The calculated depths were multiplied, where necessary, by the cosine of the angle between the flight line and the perpendicular to the plotted anomaly axis.

The exact location of the depth-estimate depends on the "apparent inclination". For a magnetic inclination of about 32° S, corresponding to a negative anomaly, the depth-estimate is plotted between the minimum and the maximum, to the north and close to the minimum (about one fourth of the distance between the minimum and the maximum).

Where the anomaly is a positive one, the depth-estimate is plotted to the south of the maximum and generally near this (about one fourth of the distance between the maximum and the minimum).

CHAPTER V

INTERPRETATION MAP

1. ACCURACY

From several statistics made on different detailed surveys where comparison has been possible between depth-estimates and data provided by drilling, it appears that, generally, the mean quadratic error to be expected from a group of depth-estimates corresponding to the interpretation of a well determined anomaly axis, is around 10 per cent.

For this survey where isobath contours are mainly included between 3,000 feet above and 8,000 feet below sea level (i.e. between 5,000 and 16,000 feet below the flight elevation), this means that the mean quadratic error would be between 500 feet and 1,600 feet. That is the reason why our isobath contours are drawn at intervals of 1,000 feet between successive contours up to 10,000 feet below sea level and only at 2,000 foot intervals from 10,000 feet onwards.

2. DESCRIPTION OF THE BASEMENT ISOBATH CONTOURS (see plate 12)

The isobaths of the magnetic basement have been contoured at 1/500,000 scale, i.e. the same scale as the geological map, so that a direct comparison between geology and isobaths is possible in the on-shore areas.

2.1 Sheets TUFI-ABAU and Part of SAMARAI (pl. 5, 8, 9)

These sheets completely cover the part of the on-shore area flown at 8,000 feet elevation. Part of the TUFI sheet covers a small zone in the off-shore area flown at the same elevation, east of CAPE NELSON and north of the CAPE VOGEL peninsula.

(a) Field Contours. Except in the northeastern part of the TUFI sheet (pl. 5) where the magnetic style is quite calm and where the anomalies are relatively wide, the total field in the on-shore area is very complicated and the anomalies are obviously much narrower and less elongated than in the off-shore area.

Superposing the 1/500,000 scale total field map on the geological plate at the same scale shows that practically the entire on-shore area corresponds, generally, to quite intense and narrow anomalies. It is impossible to separate these anomalies as corresponding to several well defined magnetic markers.

More particularly, in the SAMARAI sheet where, in addition to the outcrops of Quaternary and Miocene to Pleistocene sediments, there are several types of outcrops that may be possible magnetic markers, i.e. Tertiary intrusives, Lower Miocene volcanics and sediments, and Pliocene to Recent volcanics. Considering the anomalies recorded over these outcrops, it appears that it is quite impossible to differentiate those related to the three different formations from one another by shapes and intensities: all the corresponding anomalies are narrow and generally quite intense, and the depth-estimates obtained correspond more or less to the outcrops. As practically everywhere in the on-shore areas where these three types of outcrops exist, the anomalies are quite intense and narrow and, it being impossible to find a deeper magnetic marker, we have assumed that the recorded magnetic marker represents the magnetic basement. In places this may actually be the "envelope" of these three magnetic markers.

If this magnetic basement does not correspond everywhere to the geological basement, it still must not be far from the latter and we may assume that very probably it corresponds to the petroleum basement.

(b) Interpretation.

i. Sheet ABAU and part of sheet SAMARAI (plates 8 and 9)

- High Zone A 8:

It corresponds to the peninsula situated between MILNE BAY at the south and GOODENOUGH BAY at the north.

This peninsula is mainly composed at the surface of Eocene basalt and gabbro. This series must be relatively thin or else acts here, from a magnetic point of view, as if it were the magnetic basement. Effectively, the isobaths here are above sea level, between 0 and 2,000 feet a.s.l., and this elevation is very near to the topographical surface.

Three magnetic discontinuities were pointed out in this zone :

- F 25, north-northeast/south-southwest in orientation, crosses the peninsula perpendicularly;
- F 20, practically north-south, which separates the peninsula from NUAKATA ISLAND and marks the eastern border of the high zone (it was possible to indicate the downthrow side here);
- F'29, east-west in direction, which follows the peninsula axis in its middle.

- <u>High Zones A 9 - A'9 - A"9</u>

This group of high zones corresponds, practically, to the whole on-shore area covering the remaining part of the ABAU and SAMARAI sheets.

Except in the central part of the northern peninsula where they are only between 0 and 600 feet, the depth-estimates are everywhere above sea level and generally very near the surface level.

As previously mentioned, it is practically impossible to differentiate between magnetic markers in this area, except perhaps the Tertiary intrusives visible at the surface south of the SAGARAI River. These stand out on the total field map as two narrow but well individualized and above all very intense anomalies (750 gamma and 275 gamma). The depth-estimates for these are 1000 and 3300 feet a.s.l. on lines L 22 and L 23, just south of the parallel $10^{o}30'$ S. Everywhere else, the anomalies while relatively narrow are generally less individualized; some are quite intense, some are less intense, but they all give shallow depth-estimates, and they do not appear as if they were superimposed on wider anomalies which could give a deeper magnetic marker. Therefore, we assumed that all these anomalies were related to the same marker, the magnetic basement, which, if not always corresponding unquestionably to the real geological basement, very likely represents the petroleum basement.

Three main structural axes may be pointed out :

- A 9, more or less west-east in direction, corresponding to the centre of the peninsula, north and northeast of ORANGERIE BAY, and culminating at about 4,000 to 5,000 feet;
- A'9, extending north-south between meridians $150^{o}05'$ and $150^{o}15'$ and culminating at about 3,000 to 4,000 feet a.s.l. some 15 kilometers north of the southern coast;

- A"9, corresponding to the central part of the southern peninsula, having an east-west trend, and culminating at about 2,000 feet a.s.l. just south of the western part of MILNE BAY.

Several magnetic discontinuities may be pointed out, some of them probably corresponding to faults (F 29 and F 31) :

- three, F 30, F 31 and F 32, are north-south or north-northwest/south-southeast in orientation. For F 31 the downthrow side may be recognized;
- F 33, is north-northeast/south-southwest;
- F 29, is the most elongated, and it extends with a west-northwest/east-southeast trend all along the northern coast of the northern peninsula (for this, it was also possible to detect a downthrow on the north side.)

Inside this group of high zones, we must note to the west of A'9 the existence of a small low zone where our isobaths are just below sea level (between 0 and 1,000 feet). This corresponds to the ORANGERIE BAY and to the surrounding Quaternary deposits.

11. Sheet TUFI (plate 5)

Off-shore part of this sheet (northeastern corner of the plate). In this area, there are two main structural features in the basement isobath contours :

- Low Zones S 11 - S'11 - S"11

These three low zones appear as troughs more or less north-south in orientation, separated from each other by higher points and converging at the north of the sheet in the S1 low zone which will be studied further.

These three troughs may be considered as extensions towards the south of the wide S 1 low zone, between the CAPE NELSON at the west, a northwest prolongation of the A 4 high zone (GOODENOUGH ISLAND) to the east, and the CAPE VOGEL peninsula at the south. S 11 is the deepest, more than 6,000 feet below sea level in its centre but it is not very extended. S'11 and S"11 form a relatively more extended low zone, but one only 4,000 to 5,000 feet deep (i.e. between 1.2 and 1.6 km below sea level). S'11 extends a little to the south (contour 2,000 and even 4,000 feet) over part of the on-shore area, where there are Miocene to Quaternary sediments at the surface.

A magnetic discontinuity F 37, with a N. 10° W. direction, crosses the low axis S 11.

- High Zone A11

Located south-west of S"11 and west of S'11, this high zone, which is suboutcropping just below sea level (the O' contour), corresponds to COLLINGWOOD BAY. Two magnetic discontinuities F 39 and F 40 cross this high zone :

- F 39 with a north-south direction;
- F 40, more elongated, with a north-northeast/ south-southwest trend.

On-Shore part of the sheet. Several main features of the basement isobaths can be pointed out :

- High Zone A 10 - A'10 - A"10

Situated south of S 11 and west-northwest of S'10, this high zone corresponds to the eastern and southern parts of the CAPE VOGEL peninsula.

Except in a very small area at the southwest where basement depths would be around 1,000 feet below sea level, the isobaths are everywhere above sea level. The culminating points are located south of A 10 at 5,000 feet, north of A 10 along the coast at 2,000 feet a.s.l. and in the middle of A'10 (south of the coast) at 3,000 feet a.s.l. A"10 which culminates at around 3,000 feet a.s.l. corresponds apparently to the MOUNT GWOIRA indicated on the geological plate.

Except to the south of A 10 which corresponds to outcrops of Lower Miocene and younger sediments and the central part of A'10 which corresponds to outcrops of Upper Oligocene lavas and younger sediments, most of this high zone covers an area where there are only outcrops of Miocene to Pleistocene sediments. We must conclude that these series are probably very thin here and that the basement is suboutcropping.

As may be seen to the north of A 10, if there is not a complete junction between the north of the high axis A 10 (0 contour) and the west of the high zone A 4 (GOODENOUGH ISLAND), there is nevertheless a connection between the two. Considering the 1,000 foot contour (and not the 0 contour), we state that, except for two questionable values (1,000 and 1,300 feet), the entire area included between CAPE VOGEL and GOODENOUGH ISLAND, i.e. the WARD HUNT STRAIT, is located inside this 1,000 foot contour.

This means that a high zone in the magnetic basement connects GOODENOUGH ISLAND and the CAPE VOGEL peninsula.

It may now be asserted that there are practically no sediments in the large area included between the two 1,000 foot curves which delineates a high platform of the basement between the S 10 - S'10 low zone to the south-east (where there is no or very little thickness of sediments) and the low zone S 11 at the northwest which is the entry to the large sedimentary basin which develops northward.

Two magnetic discontinuities were pointed out in this large high zone, both with a north-northeast/ south-southwest trend :

- F 38, at the southwest along A"10;
- F 36, which crosses the WARD HUNT STRAIT from the eastern part of CAPE VOGEL to the western border of GOODENOUGH ISLAND.

- High Zone A 12 - A'12

Located southwest of CAPE NELSON, this high zone covers a large part of the CAPE NELSON peninsula.

The highest point is MOUNT VICTORY and practically corresponds to the top of this volcano. It could therefore be supposed that the magnetic marker being followed corresponds to volcanic material, and not to the basement; but this volcanic material has certainly its root in the basement, and it is very interesting to note that the O' contour does not correspond to the boundary of the area covered by the Pliocene to Recent volcanics series constituting the MOUNT VICTORY area. Particularly, north of MOUNT VICTORY there is an east-west anomaly, inside the coast, which gives, when plotted as an infinite extended downwards compartment depth-estimates of 1,000, 3,900 and 2,000 feet. This means that, very probably, we effectively follow there the real basement and not the lava flows which are outcropping at the position of this anomaly.

A magnetic discontinuity, F 41, with a north-south trend, crosses this high zone just east of MOUNT VICTORY.

- Low Zone S 12

Pinched between the A 12 - A'12 and the A 11 high zones, there is a low and very narrow synclinal axis S 12 located just along the southeastern boundary of the Pliocene to Recent volcanics series which covers the CAPE NELSON peninsula.

Although very narrow, this synclinal zone is based upon the interpretation of parts of three anomaly axes and therefore seems to be well established. Nevertheless, it is probably of too small an extent to be of great interest for petroleum search.

- High Zone A 13 - A'13 - A"13

This high zone, located in the southwestern corner of the part of the survey flown at 8,000 feet elevation, corresponds at the surface to outcrops of mafic and ultramafic rocks, to outcrops of Pliocene to Recent volcanics and also to a part of the on-shore area where, south of DYKE ACKLAND BAY, there are Quaternary sediments.

Three main high axes may be noted :

- A 13, approximately east-west in orientation, which culminates at about 3,000 feet a.s.l. to the west and at about 1,000 feet a.s.l. to the east;
- A'13 and A"13, which, north-south in trend, may be considered as extensions of A 13 to the north.

Two remarks must be made concerning this high zone :

1. As could be expected, the mafic and ultramafic rocks which represent the geological basement correspond to a good magnetic marker. The basement depth-estimates given by the plotting of the corresponding anomalies mainly agree with the surface topography and the basement is thus shown to be at shallow depth beneath much of the MUSA swamps.

2. The zones S 13 and S'13 are exceptions to this and are discussed below.

A magnetic discontinuity, F 43, trending north-south, apparently crosses the A 13 high in its western part and extends north along A"13.

- <u>S 13 - S'13 Low Zones</u>

These two low zones, oriented north-south and located on either side of the A'13 high axis may be considered as north-south extensions of the low zone S 1 to the north, in which they converge.

The southern parts of these two low axes are inside the on-shore part of the survey, where south of DYKE ACKLAND BAY there are Quaternary sediments at the surface. At the coastline, the basement would be 4,000 feet deep, i.e. about 1,300 meters below sea level.

2.2 Off-Shore Area i.e. Sheets BUNA - CAPE NELSON - TROBRIAND ISLANDS - FERGUSSON ISLAND and Part of SAMARAI

(Pl. 1, 2, 3, 6, 9)

This area is the most important of the survey, since it covers the biggest part of the off-shore zone where very few geophysical investigations had been carried out prior to this survey.

(a) Field Contours. The aspect of the total field is relatively complicated, although there is generally a trend which is dominating all over this zone, namely an east-west direction. This is the reason why most of the depth-estimates encountered on the interpretation map are provided by the lines oriented north-south and which, therefore, cross the main anomalies perpendicularly to their axes or at a large angle included between 60° and 90°. Very few depth-estimates are provided by the tie-lines which are generally more or less parallel to the anomaly axes and consequently do not cross these anomalies correctly, so that they cannot be accurately plotted.

In this large area some zones are quite calm. These generally correspond to relatively wide anomalies and thus to deep zones. Some are more complicated, and correspond generally to narrower anomalies and therefore to less deep zones; be that as it may, it is practically impossible to relate these several types of anomalies to different magnetic markers. As for the on-shore area, we have assumed that there was only one magnetic marker, which even if not corresponding everywhere to the real geological basement (it may perhaps locally correspond to a volcanic marker or to a mixture of the two), represents very likely the petroleum basement.

(b) Interpretation

- Low Zone S 1 - S'1 - S"1

To the north and all along the parallel 9^{o}S, a large trough S 1 was mapped between meridians $148^{o}31'$ and 150^{o}. This trough is one of the most important features of this survey, since it clearly indicates a thick sedimentary section. The section varies from 6,000 to 10,000 feet at the axis. Although this zone is not very wide, between 30 and 40 km on the average, such a thickness of sediments may certainly be of interest in petroleum search.

A magnetic discontinuity, F 42, seems to correspond to a relatively high zone crossing the synclinal area and dividing it into two units :

- one to the west where the maximum depth (10,000 feet) is at the coastline east of POPONDETTA:

- the second to the east of F 42 where the maximum depth (9,000 feet) is located about 20 km east of CAPE NELSON along the $9^{o}S$ parallel.

Other discontinuities have been drawn in this low zone, F1, F'1, F4 and F5, all with practically south-north trends.

S'1 - S"1 is a branch of S 1 extending to the northwest along the Papuan coast, but sediments are thinner there, between 4,000 and 5,000 feet.

- Low Zone S 2

East of meridian 150^{o} along parallel $8^{o}45'S$, another large trough area has been mapped. This second zone S 2 is also an important feature of the survey for the same reason as S 1 - S'1. It is a little wider (40 to 50 km) than S 1 - S'1, and also a little deeper, the deepest area being around 10,000 feet at the intersections of meridian $150^{o}40'$ and parallel $8^{o}45'S$.

The main support for this low zone consists of two elongated anomalies, one to the north which trends W - $10^{o}N$ and gives consistently large depth-estimates, the second to the south which gives smaller estimates (between 5,000 and 7,000 feet). This zone is therefore well defined and there is no doubt that it contains an important thickness of sediments.

Several magnetic discontinuities have been pointed out in this low zone :

- F'7 with a north-northwest/south-southeast direction;
- F 11, F 13 and F 16, with north-south or north-northeast/south-southwest trends.

Comparing our isobaths to the geological plate one important point may be noted : this low zone includes some small islands south of the TROBRIAND ISLANDS, such as WADANA and GIWAGIWA ISLANDS, which do not affect at all the total field contours, nor do the more extended island of VAKUTA and the line of reefs which extends southward from this island.

- High Zone A 1 - A'1 - A"1

This high zone, located to the north of S 1 - S'1, corresponds on the total field to intense anomalies less wide than on S 1, and this aspect alone of the total field map gives qualitatively the probability of a high zone there, especially just west of meridian 149^{o} and north of parallel 8^{o}30' S. The anomalies could possibly mark former volcanoes.

This high zone, which culminates just at sea level, is relatively wide (between 20 and 35 km for the 3,000 feet contour) and does not apparently correspond to any island or visible reef at the sea surface. However, it corresponds to a series of very shallow banks indicated on the marine map printed by the hydrographic service (from KEPPEL POINT to HERCULES BAY).

Three magnetic discontinuities, F 2, F'2, F3, were pointed out in this high zone; they all have north-northwest/south-southeast directions.

- High Zones A 2 - A'2 - A"2 - A"'2

East of zone A1, there is another high zone, A2, mapped by our isobaths between the 149°40' and 150°45' meridians, along the parallel 8°20'S.

The interpretation of this high zone is based on several relatively narrow anomaly axes. It corresponds on the geological map to the LUSANCAY Islands and reefs (some of which have volcanic outcrops) which appear to coincide at their western end with a dome in the magnetic basement. The basement here would be between 0 and 2,000 feet below the sea level.

A'2 and A"2 are small lateral extensions of A 2, the first towards the southeast, the second towards the southwest, but they do not cover very large areas. A"'2 is another extension of A 2 towards the northwest, along and south of F 6.

Five magnetic discontinuities were drawn in connection with this high zone :

- F 6 and F 7 with northwest-southeast trends;

- F 8, F 9 and F 10 with north-northeast/ south-southwest directions.

For F 6, it was possible to detect two different levels, and we believe that F 6 probably corresponds to a fault.

- High Zone A 3 - A'3 - A"3

The high zone A 3 - A'3 is centred on the two most important of the TROBRIAND ISLANDS, KAILEUNA and KIRIWINA, where the magnetic basement would be sub-outcropping. An important magnetic discontinuity, F'14, with an east-northeast trend, and for which a downthrow-side could be recognized, marks the southeastern boundary of A 3.

A'3 extends towards the southeast and passes over KITAVA Island where the basement would be about 3,000 feet below sea-level. The basement rises again in the southeast and approaches sea level at the convergence of A'3 and A"3 at 8°48'S and 151°30E.

- Low Zone S 3 - S'3 and its Extention to the West

Located east and northeast of the northern part of the TROBRIAND ISLANDS, this low zone seems to indicate the existence of a relatively thick sedimentary basin, since depth-estimates are included between 8,000 and 14,000 feet in its deepest point. In fact, however, the sea bottom already deepens quite quickly there and the real thickness of the sedimentary section is probably less important than indicated on our map.

Moreover, it must be noted that along the northern limit of the present survey, i.e. along the $8^{o}S$ parallel, and to the north of the A 2 and A 1 high zones, there is a rapid deepening of the magnetic basement to between 8,000 and 12,000 feet below sea level. As for S 3 - S'3, this deepening does not necessarily indicate the existence of an important sedimentary basin. The sea bottom itself is known to deepen rapidly in this area. Hence the deepening of our isobaths is perhaps only an indication of the plunging sea bottom, which a little to the north of parallel $8^{o}S$ is known to be between 3,600 and 5,000 meters (i.e. between 11,500 and 16,500 feet) below sea level.

A magnetic discontinuity, F 15, north-south in trend, seems to mark the western border of this low zone.

- Relatively Low Zones S 4 - S'4

Located between A'2 in the west and A 3 in the east, these two low zones cannot be considered as real sedimentary basins but only as narrow "grabens" which correspond to the northwestern part of the TROBRIAND ISLANDS (TUMA, KADAI, SILINIAKA and LULIMA ISLANDS). The maximum depth of the basement for the two zones is about 5,000 feet, i.e. about 1,500 metres, below sea level. They are separated by a north-south ridge which is only 2,500 feet deep and which is associated with a magnetic discontinuity, F 12.

- Low Zone S 5

A very small low zone S 5 is interpreted between the A 2 and A"2 high zones. Oriented east-northeast/west-southwest, it is quite narrow and may be considered as a pinched "graben".

- High Zones A 4 - A'4 - A"4 - A"'4

The high zones A 4 and A'4 cover almost completely the two biggest northern islands of the D'ENTRECASTEAUX GROUP, i.e. GOODENOUGH and FERGUSSON islands. Two extensions of these high zones must be noted, one to the east, A"4, the second to the northeast, A"'4.

As may be seen on the geological map (Plate 11), these two islands are mainly composed of Mesozoic metamorphics, Tertiary intrusives and Pliocene to Recent volcanics. It may be noted that while there is a sufficiently reasonable agreement between the depth-estimates and the Mesozoic metamorphics in GOODENOUGH ISLAND and the eastern part of FERGUSSON ISLAND for us to assign the magnetic basement to these metamorphics, elsewhere the estimated depth to magnetic basement is a little greater (1,000 feet at the south and even 2,000 feet in the north of FERGUSSON ISLAND); consequently we have reason to believe that we have followed the real magnetic basement in this entire zone and not simply unilaterally the metamorphics or the outcropping volcanics with which, locally, the basement contours are in fair agreement.

Several magnetic discontinuities have been pointed out in this large high zone :

- F 19, F 22, F 23, F 34 and F 35 have north-northeast/south-southwest directions;
- F 26, F'26, F"26 and F 27 have northwest-southeast trend;
- F 35 marks the contact between Mesozoic metamorphics and Pliocene to Recent volcanics;
- F 22 marks the boundary of the high zone A'4;
- F 27, whose downthrow-side can be indicated, underlines the southwestern limit of A 4.
- Low Zone S 6 - S'6 - S"6

This group of low zones covers a relatively extended area to the east and northeast of the high zone A'4. The centre, located at the intersection of parallel $9^{o}12'S$ and meridian $151^{o}30'$, is more than 14,000 feet below sea level.

This entire low zone may be considered as a southeastern extension of the low zone S 2, after a narrow high, about 6,000 feet in depth. In this part of the survey, the bathymetric contours are not very well known, but some values reported on the hydrographic map seem to indicate an average depth of 1500 to 2,000 metres below sea level for the sea bottom. Therefore, this low zone may be considered as the beginning of a probably important sedimentary basin which develops more to the east.

- <u>High Zone A 5 - A'5 - A"5</u>

Located southeast of the high zone A'4, this high zone is located in the northern and central part of the most southerly large island of the D'ENTRECASTEAUX GROUP, NORMANBY ISLAND.

It should be noted that in the north of NORMANBY ISLAND, the basement contours coincide with the Mesozoic metamorphic outcrops whereas in the southeast of the island the magnetic basement lies between 1,000 and 3,000 feet below sea level. A magnetic discontinuity, F 21, crosses the central part of the island with a north-northeast trend.

- <u>Low Zone S 7</u>

Situated east of the A 5 high zone, this low zone extends north-south along the meridian 151°30' each side of the parallel 10°S. In this area, the depth of the sea bottom, although not perfectly known, seems to be between 1,400 and 2,000 metres according to the detailed hydrographic map in our possession (from ORANGERIE BAY to CAPE VOGEL). As the mean basement depth here is between 5,000 and 7,000 feet below sea level (i.e. 1,500 to 2,100 metres), it appears that this apparent low zone of the magnetic basement probably corresponds simply to a sea bottom depression where there would be little or no thickness of sediments.

Two magnetic discontinuities, F 17 and F 18, approximately north-south, mark the eastern and southwestern boundaries of this depression.

- High Zone A 6

This high zone, located south of low zone S 7, corresponds approximately to the eastern part of the ENGINEER GROUP coral islands where the magnetic basement would be practically outcropping at HUMMOCK and HASZARD islands.

- Low Zone S 8

Located south of NORMANBY ISLAND, this low zone extends in the north-south direction between the A 8 and A 5 high zones.

The maximum basement depth is only 5,000 feet, just southeast of NUAKATA ISLAND, and it should be noted that the hydrographic marine map indicates some depths here of 300, 500 and even 960 metres for the sea bottom. Therefore, except just at the reef extending out from NUAKATA ISLAND, the sedimentary section must be very thin and this zone is not considered to be an interesting sedimentary area.

- High Zone A 7

Located west of the southern branch of S 8, this high zone corresponds to the western part of BASILAKI ISLAND and the eastern part of SIDEIA ISLAND where the magnetic basement is suboutcropping. Volcanics are exposed on these islands.

- Low Zone S 9 - S'9

This zone is not very low and does not contain a significant thickness of sediments. The lowest area in S'9 between A 7 and A"9 is only 3,000 feet deep below SARIBA ISLAND (near SAMARAI), and the 2,000 foot contour corresponds to the major part of MILNE BAY, where, according to the detailed marine map (from ORANGERIE BAY to CAPE VOGEL), the sea bottom is between 400 and 550 metres deep.

- Low Zone S 10 - S'10 - S"10

This extended low zone covers practically all the off-shore area between the D'ENTRECASTEAUX ISLANDS and the Papuan mainland.

Although this low zone, where the deepest point is about 6,000 feet below sea level, may appear as an important sedimentary basin, comparison with the bathymetric contours on the geological map shows that the sea bottom here is more than 1,000 metres deep (i.e. 3,300 feet). This is confirmed by the detailed marine map mentioned above which indicates depths between 1,200 metres and 1,450 metres in the centre of this area (i.e. between 3,600 feet and 4,800 feet). It is probable then that the basement is near the sea bottom in the entire low zone and that the sedimentary section is very thin, certainly less than 2,000 feet, and is of little or no interest for petroleum search.

Two magnetic discontinuities have been pointed out in this zone :

- F 28, northwest-southeast in direction, which is indicated on the total field by a sharp and elongated gradient. F'28 appears to be an offset continuation of F 28.

- F 24, trending north-south, which marks the southeastern limit of the low zone.

2.3 Relationship with the Geological Background

Three main purposes were assigned to the aeromagnetic survey in order to contribute to the geological knowledge of the surveyed area :

i. to provide information about the continuation of the Ultramafic Belt to the south of latitude 9^{o}

ii. to discover the relationship, if any, between the D'ENTRECASTEAUX ISLANDS and the mainland structures;

iii. to define the form and extent of any sedimentary basin in the TROBRIAND ISLANDS shelf area and its eventual relation to the Tertiary sediments in the CAPE VOGEL area.

Concerning the first point, it is impossible at the writing of this report to be definite since the part of the survey to be flown at 15,000 feet has not yet been recorded. Nevertheless, from those overland portions flown at 8,000 feet, there are no depth-estimates or interpretation trends inconsistent with the hypothesis that the Ultramafic Belt extends towards the southeast, east of MOUNT SUCKLING, below a probably thin cover of Lower Miocene volcanics and sediments until the two extremities of Eastern Papua, north and south of MILNE BAY.

Concerning the relationship of the D'ENTRECASTEAUX ISLANDS to the mainland structures, it seems now very clear that there is a real connection between the on-shore basement high "structure" A 10, which corresponds to the eastern extremity of the CAPE VOGEL peninsula, and the GOODENOUGH ISLAND "structure" (high zone A 4) where basement is also very high, as well as in the FERGUSSON ISLAND and in the western part of NORMANBY ISLAND. As a matter of fact, these three islands, which develop as a belt between CAPE VOGEL and the EAST CAPE, may be considered as part of the Papuan shelf from which they are only separated by the low zone S 10 - S'10 - S"10. This zone probably does not contain an appreciable thickness of sediments but represents primarily a depression of the sea bottom between F 27 and F 29.

Concerning the form and extent of any Tertiary sedimentary basin in the TROBRIAND ISLANDS shelf area, it appears that a large sedimentary basin S 1 - S2 exists which develops between the TROBRIAND ISLANDS, the LUSANCAY ISLANDS and Reefs and their western extension at the north, and the Papuan coast and the D'ENTRECASTEAUX ISLANDS at the south. As expected by the B.M.R., it is now obvious that there is a continuity in the isobath contours between this large basin and the Tertiary sediments which appear to be relatively thick (2,000 to 4,000 feet) west of the CAPE VOGEL peninsula. Assuming the depth of the sea bottom is about 200 metres as shown by the geological map, this large basin appears to have considerable thickness of sediments, between 5,000 and 8,000 feet. Such thickness of Tertiary sediments may probably be of interest for petroleum search.

CONCLUSION

During this aeromagnetic survey over the SOLOMON SEA, the TROBRIAND and D'ENTRECASTEAUX ISLANDS, and the most eastern extremity of eastern PAPUA, 11,408 statute miles of profiles were flown at 8,000 feet a.s.l., covering an area of about 80,000 km^2, mainly off-shore.

The purpose of this survey was mainly to give a general idea concerning the thickness of the possible sedimentary section east and north-east of eastern PAPUA in order to evaluate the oil potential of this area, and we think that this goal has been attained.

The qualitative and quantitative study of the recorded anomalies allowed us to draw an isobath contour map of the magnetic basement over the whole of the surveyed area.

This isobath contour map (Plate 12) mainly brings out the existence of several low zones, some of which may be considered as basins with sedimentary thicknesses of more than 5,000 feet, separated from one another by several magnetic basement high zones where the sediments are very thin, (between 0 and 2,000 feet).

1. Practically the entire on-shore areas are high zones with the exception of two small extensions of the low zone S 1, S13 and S'13, south of DYKE ACKLAND BAY. Therefore, it is concluded from this aeromagnetic survey that eastern Papua itself is not a favourable area for oil search.

In addition, several areas of the off-shore part of the survey do not present any petroleum interest. They are :

- A 1 - A'1, an elongated and relatively wide high zone, located just north of S 1;
- A 2 - A'2 - A"2 - A"'2, which constitutes a part of the LUSANCAY ISLANDS and Reefs, north of S 2;
- A 3 - A'3 - A"3, which correspond to the northeastern part of the TROBRIAND ISLANDS and extends to the southeast;
- A 4 and A 5 high zones which cover a large area south of S 2 and include practically all the D'ENTRECASTEAUX and AMPHLETT Group islands;
- A 6, at the southeastern extremity of the survey, which partly corresponds to the ENGINEER GROUP islands;
- A 7, which corresponds to parts of the SIDEIA and BASILAKI islands.

2. In the low zones delineated by this survey, some are very narrow or little extended, so that they probably present little or no interest. On the contrary, some of them are quite wide and relatively extended, so that they may be of interest for petroleum search. They are :

- the S 1 low zone, corresponds to a large part of the SOLOMON SEA without islands or reefs, and is located immediately north and northeast of CAPE NELSON peninsula. The sediment thickness is included between 6,000 and 9,000 feet, i.e. between 1,800 and 2,700 metres.

- the S 2 low zone, (the eastern extension of S 1), covers a big part of the off-shore area included between the LUSANCAY ISLANDS and REEFS at the north, the northern TROBRIAND ISLANDS at the northeast and the D'ENTRECASTEAUX ISLANDS at the south. In this zone, the thickness of sediment is between 7,000 and 10,000 feet, i.e. between 2,100 and 3,000 metres.

- the S 3 - S'3 low zone, is located east and northeast of the TROBRIAND ISLANDS. This low zone corresponds to a deepening of the sea bottom towards the east, so that the sedimentary thickness is at least 3,000 feet less than the basement depth indicated by the interpretation map (between 8,000 and 14,000 feet).

- the S 6 - S'6 - S''6 low zone, is an extension to the east and southeast of the low zone S 2. As a consequence of the sea bottom deepening, the thickness of sediments is probably at least 3,000 feet less than the basement depth indicated by our map (between 7,000 and 14,000 feet).

Such results are particularly significant; they allow one :

i. to eliminate numerous areas inside the perimeter of the survey which certainly do not present any petroleum possibilities (the high zones mentioned above);

ii. to show clearly the existence of several sedimentary basins where thickness of sediments is important enough to be of some interest for petroleum search and which, in our opinion, merit therefore more detailed geophysical investigation, the two most attractive being the S 1 and S 2 low zones.

Interpreted by :

J. DEGUEN

PARIS, December 23, 1970.

REFERENCES

- "Eastern Papua Geological Reconnaissance", by H.L. DAVIES, I.E. SMITH, G. CIFALI and D.J. BELFORD (Record No. 1968/66, BMR)

- "Papuan Ultramafic Belt" by H.L. DAVIES (Record No. 1967/107, BMR)

- "The Geology of FERGUSSON and GOODENOUGH Islands (Papua)" by H.L. DAVIES and D.J. IVES (Report No. 82, BMR, 1965)

- "NORMANBY Island, T.P.N.G. - Reconnaissance Geology" by H.L. DAVIES (Record No. 1967/50, BMR)

- "The Geology of the BOWUTU Mountains, New Guinea" by D.B. DOW and H.L. DAVIES (Report No. 75, BMR, 1964)

- "Notes on the Volcanoes Mount BAGANA and Mount VICTORY, Territory of Papua and New Guinea" by I.E. SMITH (Records 1969/12, BMR)

- "The East Indian Archipelago" by E.A. KISSLING (formerly of N.V. de Bataafsche Petroleum Maatschappij)

- "Australian New Guinea" by K. WASHINGTON GRAY (Anglo-Iranian Oil Company Ltd.)

- "De la Pointe Keppel a la Baie Hercule" (Iles d'Entrecasteaux et Archipel de la Louisade) Marine Map No. 4977 (scale 1/783,200) printed by the Hydrographical Service of the French Navy.

- "De la Baie Orangerie au Cap Vogel" (Iles d'Entrecasteaux) Marine Map No. 6301 (scale 1/332,200) printed by the Hydrographical Service of the French Navy (from the Marine Maps published in 1957 by the English Admiralty).

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 MHz, are chosen very close to one another, so that their difference is a low frequency f of about 100 Hertz.

$$Fa - Fb = f$$

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 phases :

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

and $$b + Fb \frac{MB}{V}$$

V being the wave 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 :

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

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

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

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

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 determing 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 .

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

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 .

Fig. 1

BROAD ANOMALIES OF TYPES "A" & "B"

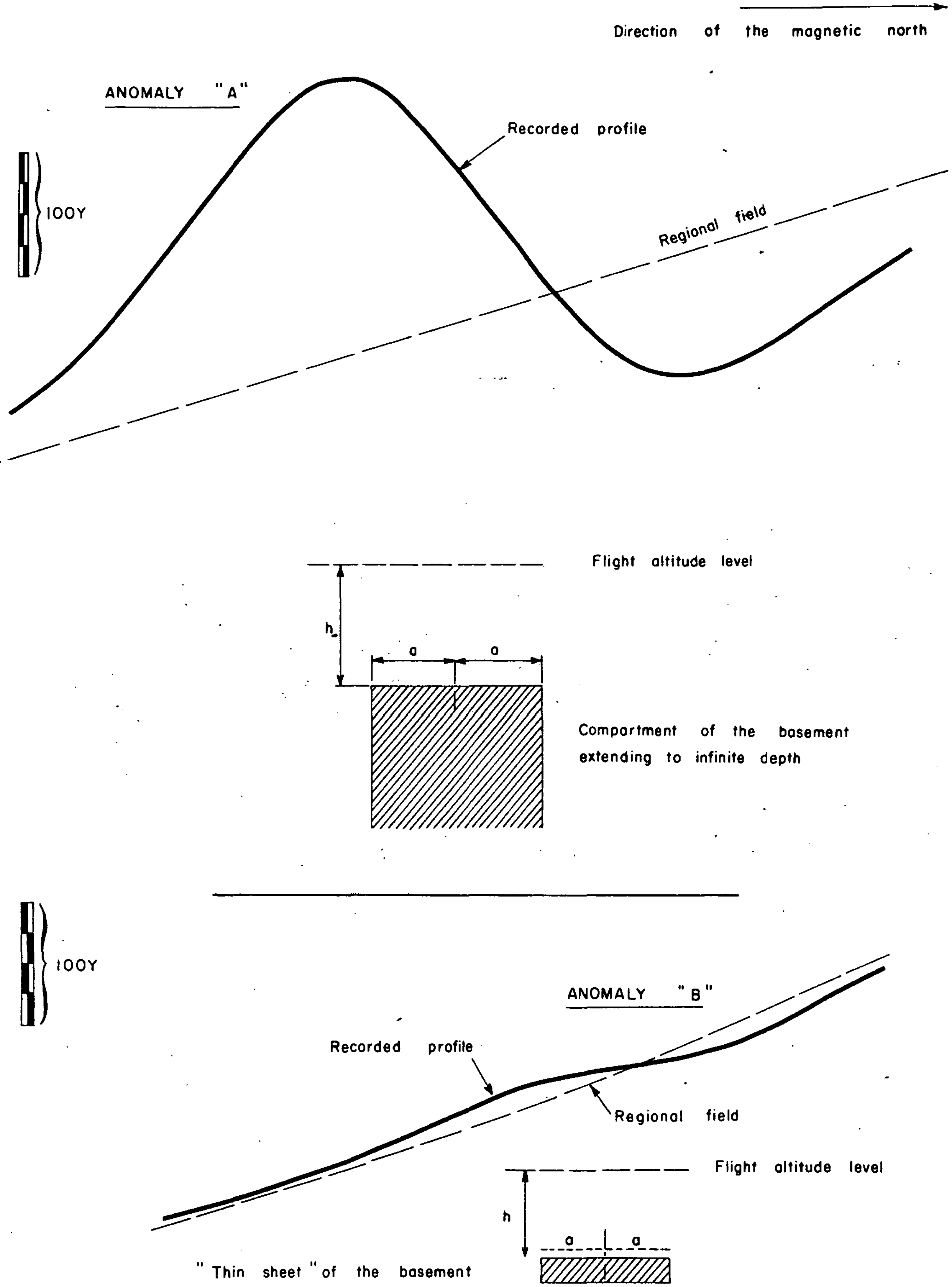
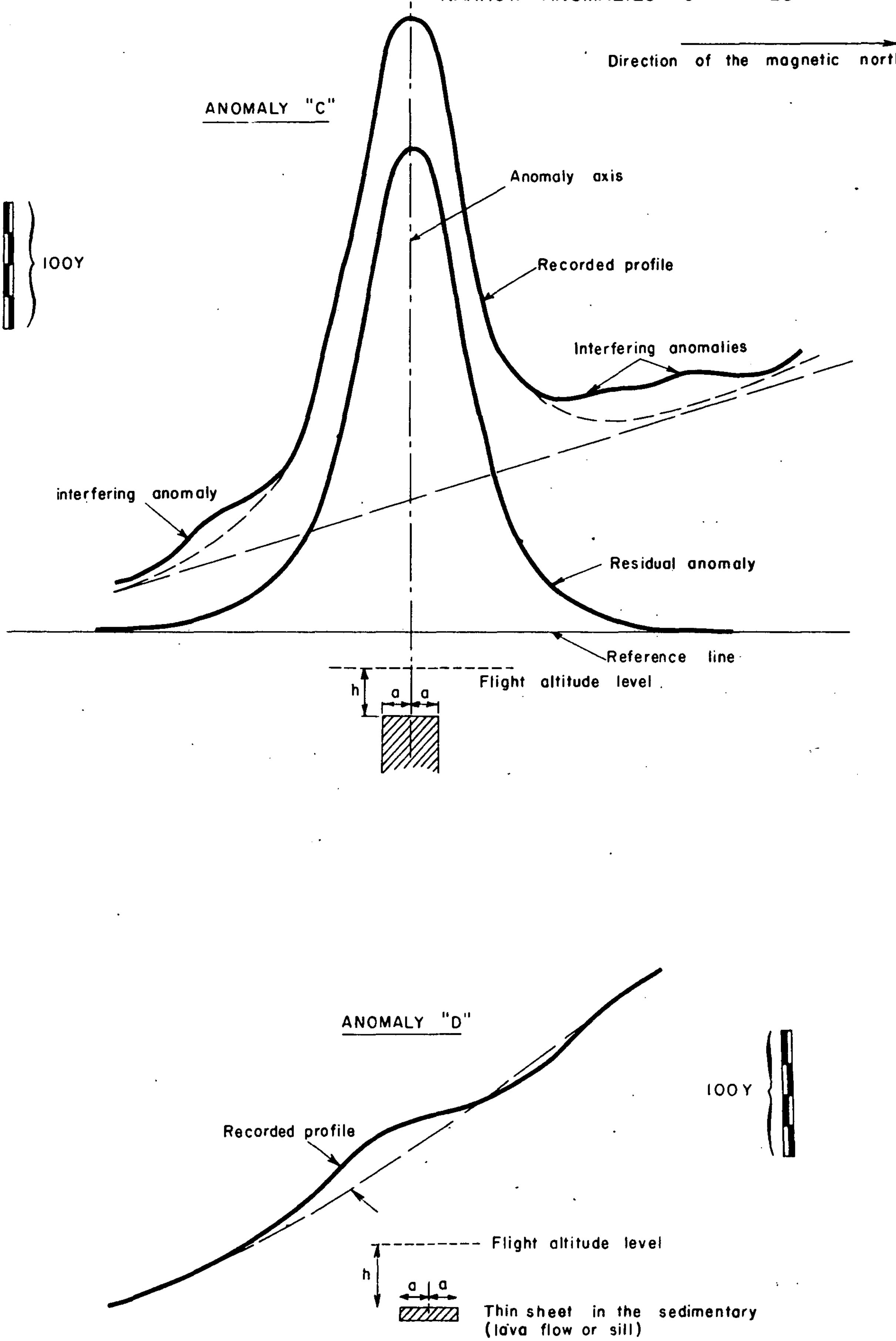


Fig: 2

NARROW ANOMALIES OF TYPES "C" & "D"



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

$$\phi nm = \phi a - \phi b + \frac{Fa}{V}(NA - NB) + f\frac{NB}{V} + \ldots$$

$$\ldots + f\frac{MN}{V} + knm + kn$$

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

$$\Phi = \phi m - \phi nm$$

$$\Phi = \frac{Fa}{V}(MA - MB) - \frac{Fa}{V}(NA - NB) + \frac{f}{V}(MB - MN) - \ldots$$

$$\ldots - \frac{f}{V}NB + km + kn + knm$$

In this equation :

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

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

$\frac{f}{V}(MB - MN)$ is practically negligible since the ratio

$\frac{f}{Fa} \approx 1/20,000$.

When necessary this term is taken into account as a correction term in the computation of the hyperbolic network.

Fig: 3 DIFFERENT TYPES OF MAGNETIC CONTRASTS

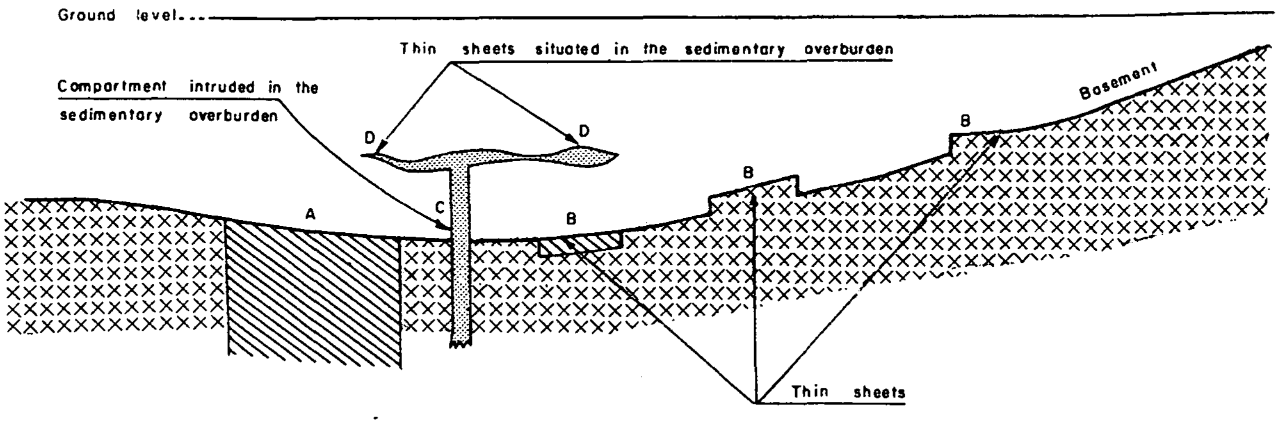


Fig: 4 PARAMETERS OF INFLECTION TANGENT INTERSECTIONS

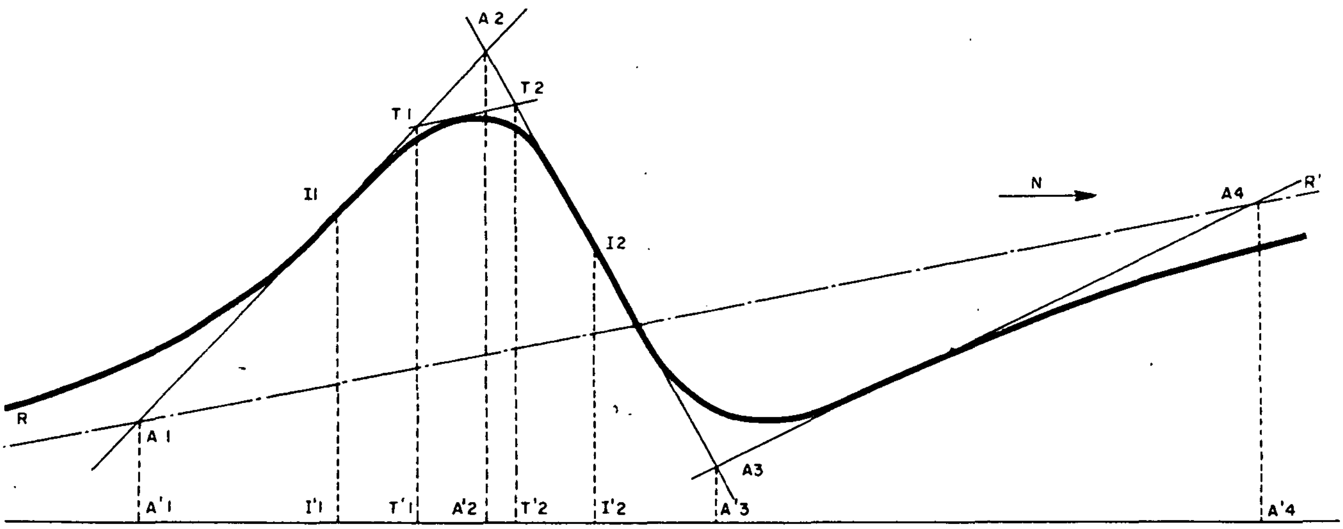
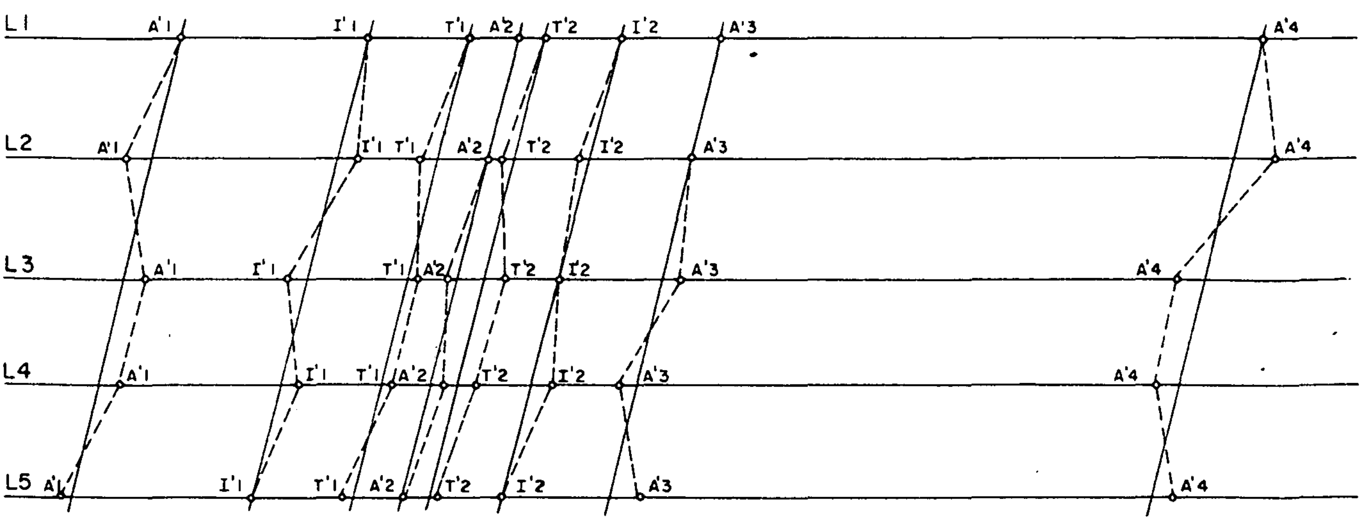


Fig:5 PROFILE TO PROFILE CORRELATION OF INTERSECTION POINTS



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

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

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.

Note : 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 :

$$F_2 = \frac{90}{100} F_1$$

and $$F_3 = \frac{99}{100} F_1$$

The corresponding readings on the phasemeter M are :

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

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

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

The computation of the differences :

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

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

gives the values of the phases in a fictitious network of foci 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 F_1).

Therefore the difference $\Phi 1 - \Phi 2$ enables one to determine the units figure of the hyperbola number and the difference $\Phi 1 - \Phi 3$ the tens figure.

APPENDIX II

METHOD OF INTERPRETATION

INTRODUCTION

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

- The isogam contour map, with an interval of 5 or 1 gamma (or sometimes 0.5 gamma) between contour lines.
- The profiles restituted by the IBM 360 and the CALCOMP computing machines.

The restitution scale chosen is a function of the anomaly intensity for a given profile, generally 1cm = 10 or 5 gammas (and sometimes 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 trneds 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 or contour inflections.

The significance of such magnetic features is well defined. In actual fact, the total amplitude of an anomaly is almost completely caused by magnetic 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 downthrow side and the range of this displacement.

1.2 Analysis of Calcomps

The anomalies observed on the CALCOMPS have various features, which in most cases make possible their separation into four classes :

- 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 graphical 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.

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 Tangent Intersections (ITI)

(a) 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). 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 projections of the segments A 1 - A 2, A 2 - A 3, A 3 - A 4.

In addition, two other parameters are considered : the parameters T'1 - T'2 and I'1 - I'2 are the horizontal projections of the segments T 1 - T 2 and I 1 - I 2. The points T 1 and T 2 are the intersections of the tangents A 1 - A 2 and A 2 - A 3 with the tangent to the anomaly's maximum in a direction parallel 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.

In the example of figure 4, the theoretical anomaly for an inclination of 51^{o} corresponds to a body trending east-west, with vertical walls extending to infinite depth. The direction of the intersecting profile is north-south.

(b) Depth Determination

Several sets of monologarithmic master curves have been established for various types of two dimensional and square base compartments extending to infinite depth for faults or magnetic contacts, and for magnetized "thin" or "thick" 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) 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.

A similar set of master curves has been prepared based upon the variations of the vertical gradient of the total field. Where the anomalies are well separated, the two approaches give identical results, as would be expected. However, in some instances, the interference between anomalies is such that more realistic depth-estimates will be obtained from the vertical gradient master curves.

(c) 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 correlation 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.

(d) 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 type 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 possible to match the entire anomaly curve with a theoretical model by means of several sets of bilogarithmic total master curves. The method yields more reliable results for anomalies of noticeable width and intensity.

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

The transcription in bilogarithmic coordinates is made either from the recorded profiles or from cross-sections taken from 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 cesium vapor magnetometer; it corresponds to the CALCOMP restitution of the digital data from the magnetic tape.

Both records were performed at the same flight altitude of 900 metres above sea 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" or "thick" 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 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 , 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 amplitude 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

(a) 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 magnetic north,
- the intra-basement and sedimentary-basement magnetic contrasts.

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

(b) 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 :

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

(c) 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 that correlate on several traverses and that are sufficiently clear of the adjoining anomalies so as to be free from 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°.

(d) 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".

(e) Narrow Anomalies of High Amplitude (Class C)

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

(f) Narrow Anomalies of Low Amplitude (Class D)

Hypothesis : "Thin plates, whose upper surface is situated in the sedimentary overburden".

(g) 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 whose upper surfaces constitute the magnetic horizon of the basement. Nevertheless the fact is not excluded that some are situated deeper in the basement, giving rise to erroneously excessive depth-estimates.

When a narrow anomaly presents a rather low amplitude it is often difficult to choose as to 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, a horst, or a fault. Thus it is very important to emphasize the axis of the anomalies interpreted as "thin plate" on the interpretation map.

2.7 Drawing the Isobath Contours of the 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 the isobath contours proceeds from the relevant depth spots; the doubtful values (with interrogation marks) are not taken into account. Finally, the assumed faults or magnetic discontinuities observed on the isogam contour map are used to support the outline of the isobaths.

BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS

RECORD

EASTERN PAPUA

AEROMAGNETIC SURVEY PART 1

I Total Field Contour and Interpretation Sheets

Plates 1 through 12

1969 1970

1971/67

1971/67

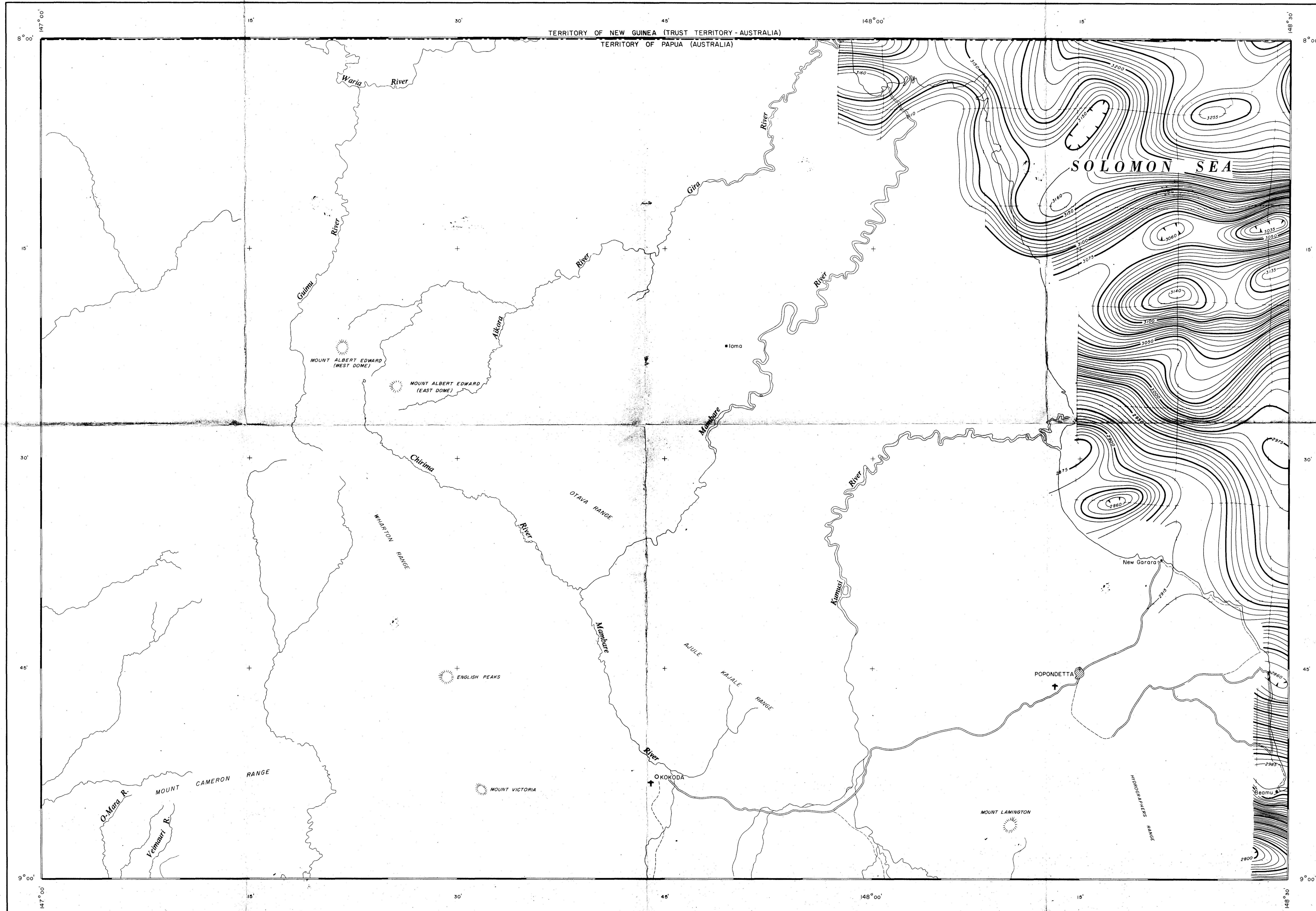
Vol. 2

COMPAGNIE GENERALE DE GEOPHYSIQUE

NEW GUINEA 1:250,000

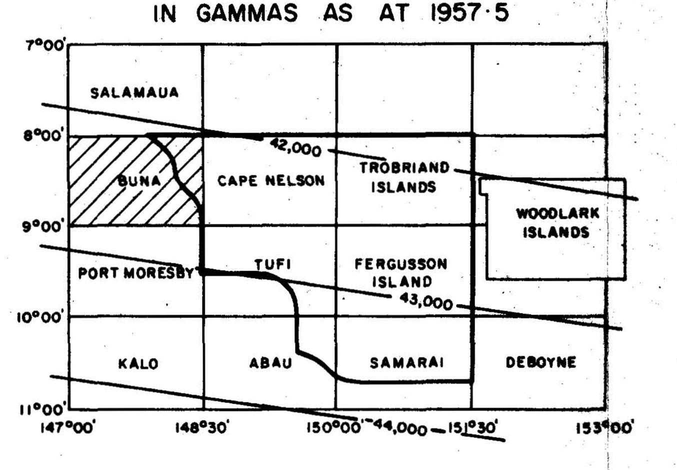
BUNA

BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS PLATE I



COMPAGNIE GENERALE DE GEOPHYSIQUE

REFERENCE TO 1:250,000 MAP SERIES
SHOWING REGIONAL TOTAL MAGNETIC INTENSITY
IN GAMMAS AS AT 1957·5



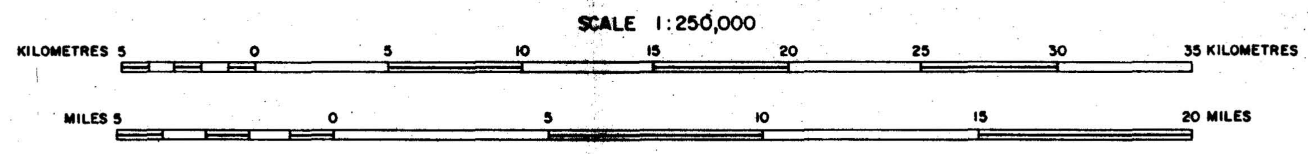
Regional Gradient as shown on the map diagram has been removed.

TOTAL MAGNETIC INTENSITY

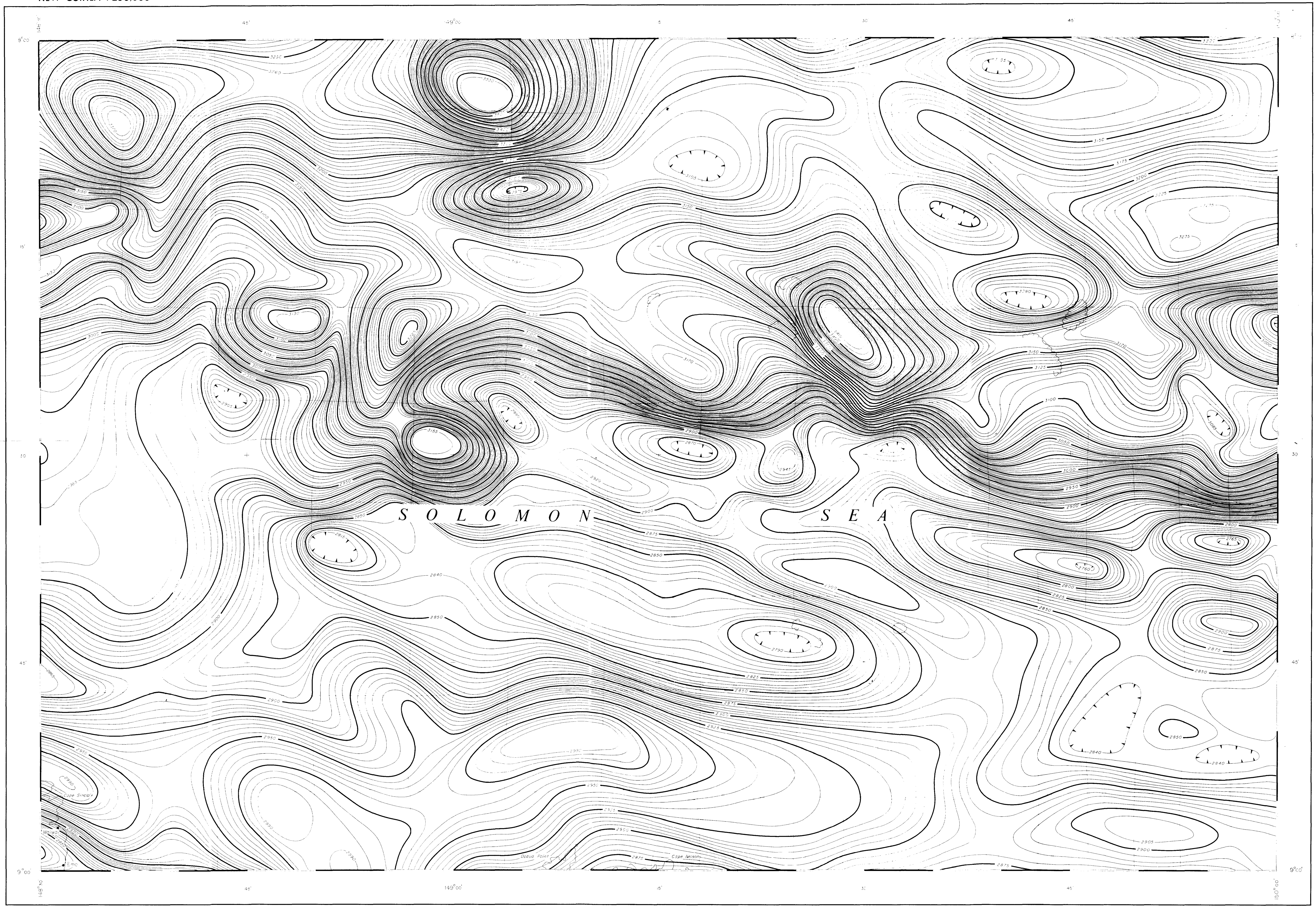
CONTOUR INTERVAL 5 GAMMAS

ALTITUDE 8000 FEET

SCALE 1:250,000

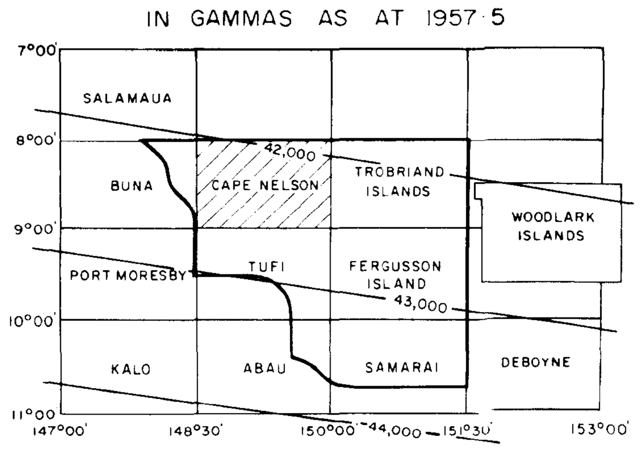


CAPE NELSON



COMPAGNIE GENERALE DE GEOPHYSIQUE

REFERENCE TO 1:250,000 MAP SERIES
SHOWING REGIONAL TOTAL MAGNETIC INTENSITY
IN GAMMAS AS AT 1957·5



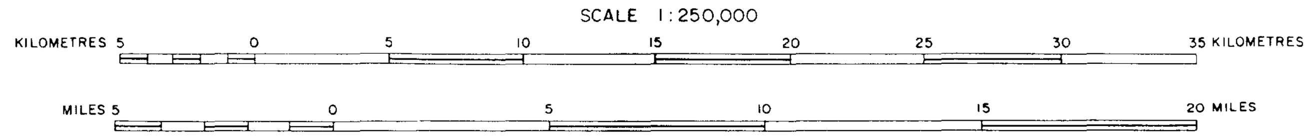
Regional Gradient as shown on the map diagram has been removed.

TOTAL MAGNETIC INTENSITY

CONTOUR INTERVAL 5 GAMMAS

ALTITUDE 8000 FEET

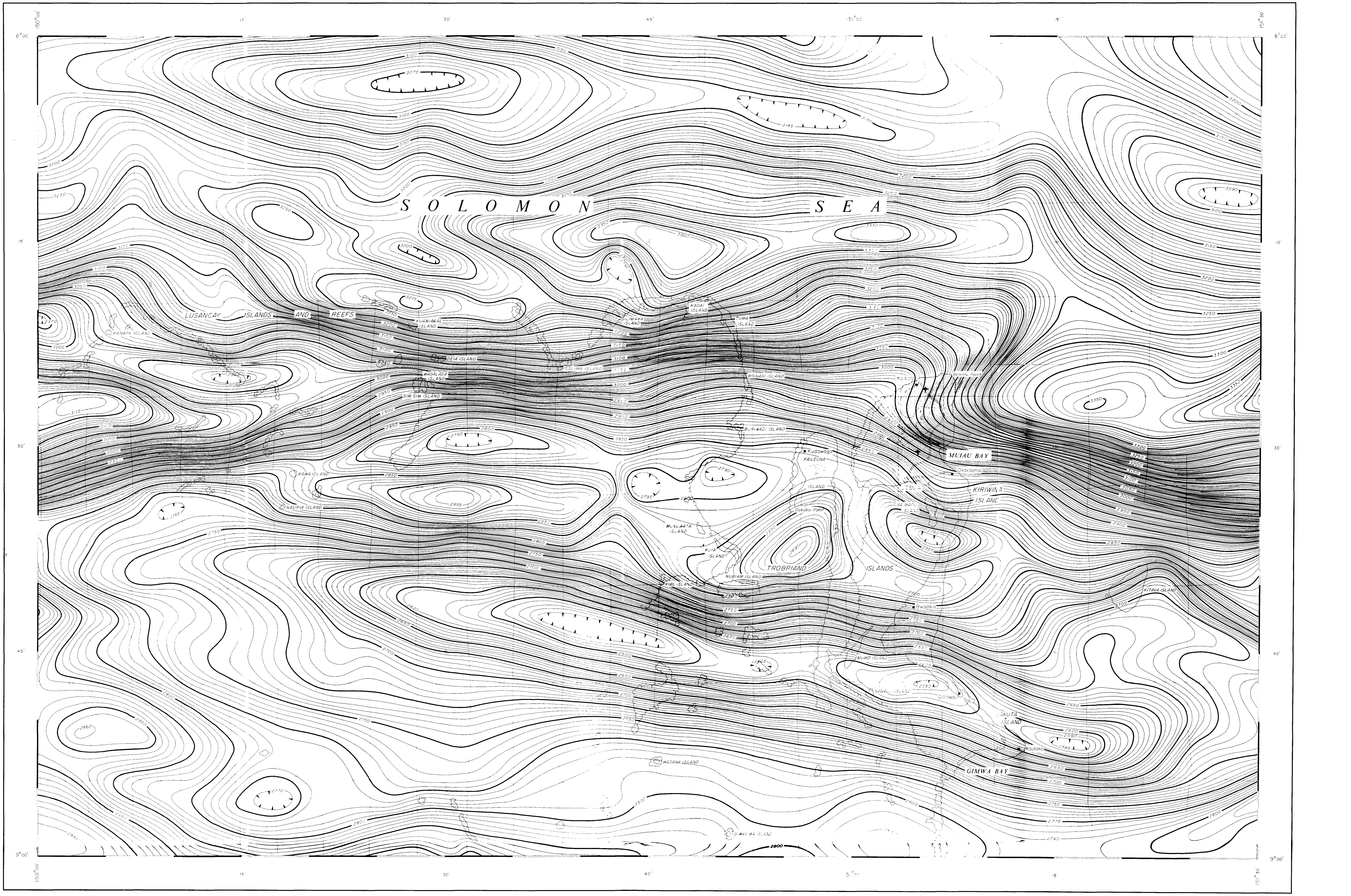
SCALE 1:250,000



NEW GUINEA 1:250,000

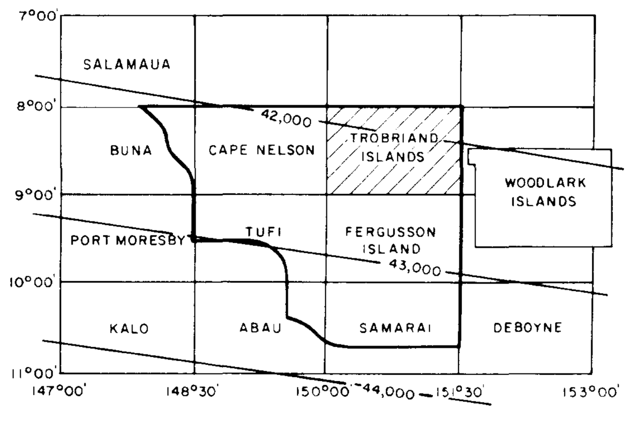
TROBRIAND ISLANDS

BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS PLATE 3 LITHO



COMPAGNIE GENERALE DE GEOPHYSIQUE

REFERENCE TO 1:250,000 MAP SERIES SHOWING REGIONAL TOTAL MAGNETIC INTENSITY IN GAMMAS AS AT 1957·5



Regional Gradient as shown on the map diagram has been removed.

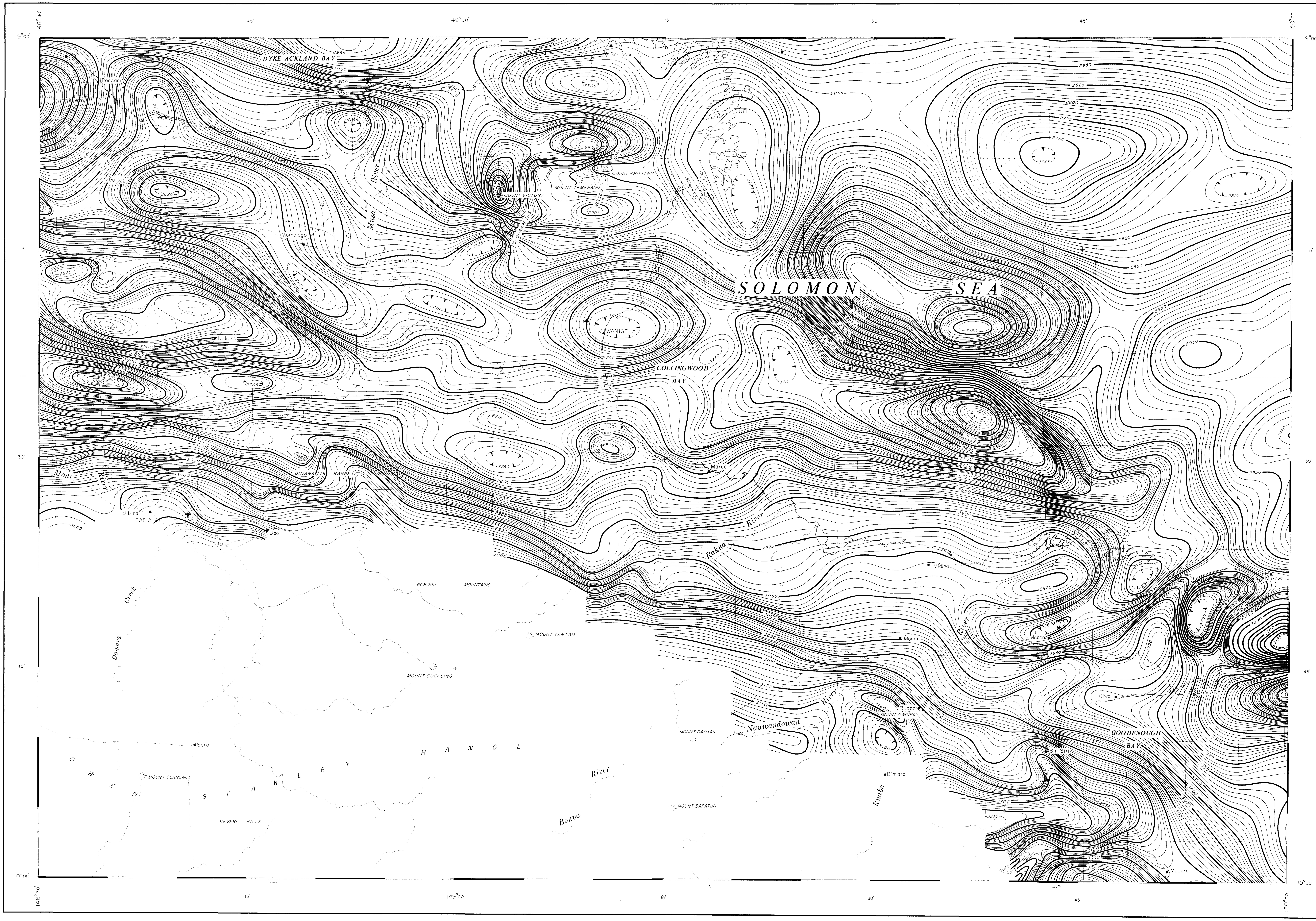
TOTAL MAGNETIC INTENSITY

CONTOUR INTERVAL 5 GAMMAS

ALTITUDE 8000 FEET

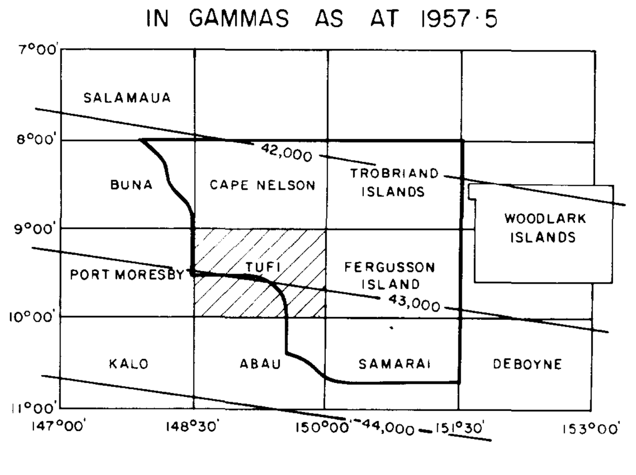
SCALE 1:250,000

TUFI



COMPAGNIE GENERALE DE GEOPHYSIQUE

REFERENCE TO 1:250,000 MAP SERIES SHOWING REGIONAL TOTAL MAGNETIC INTENSITY IN GAMMAS AS AT 1957·5



Regional Gradient as shown on the map diagram has been removed.

TOTAL MAGNETIC INTENSITY

CONTOUR INTERVAL 5 GAMMAS

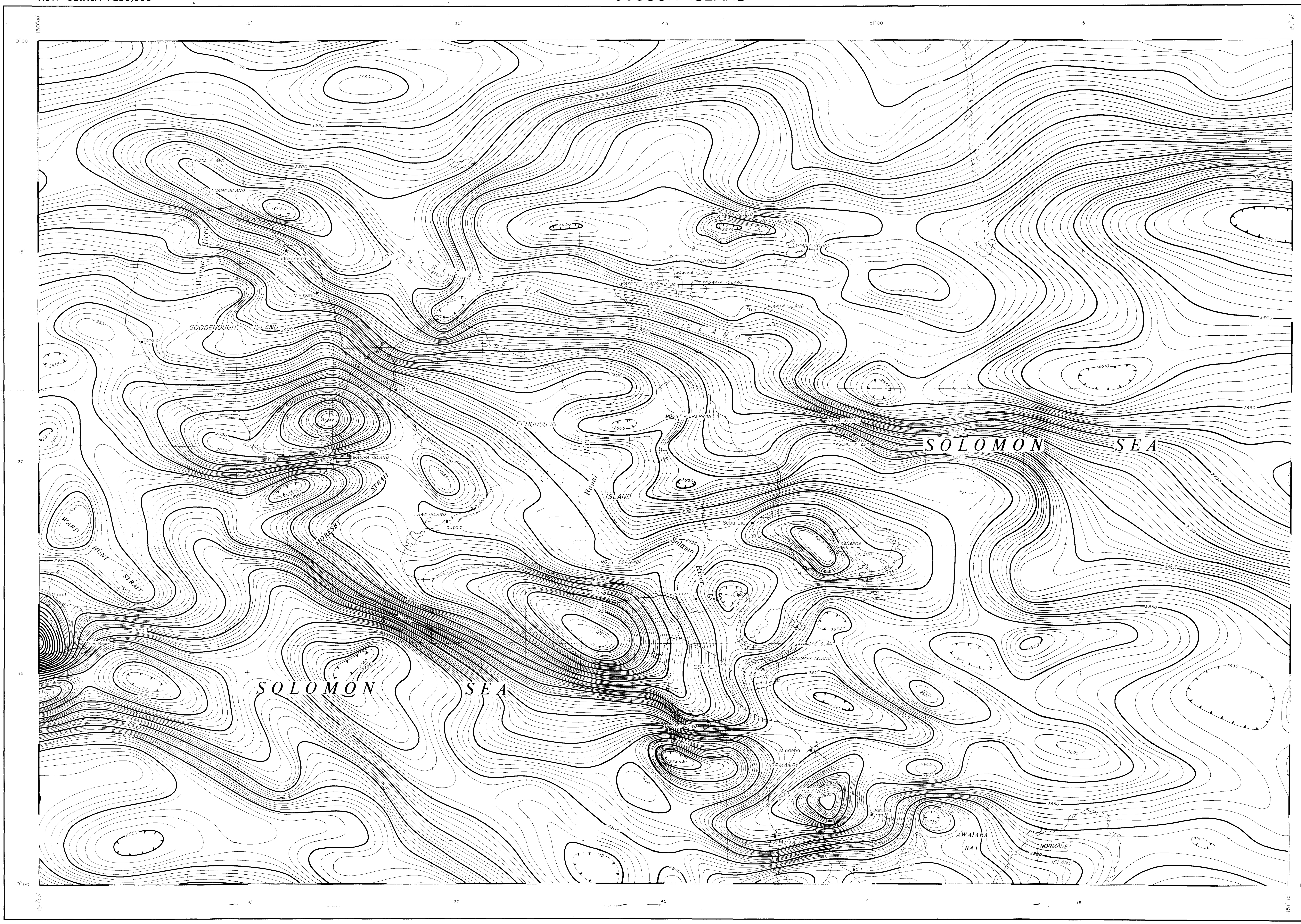
ALTITUDE 8000 FEET

SCALE 1:250,000

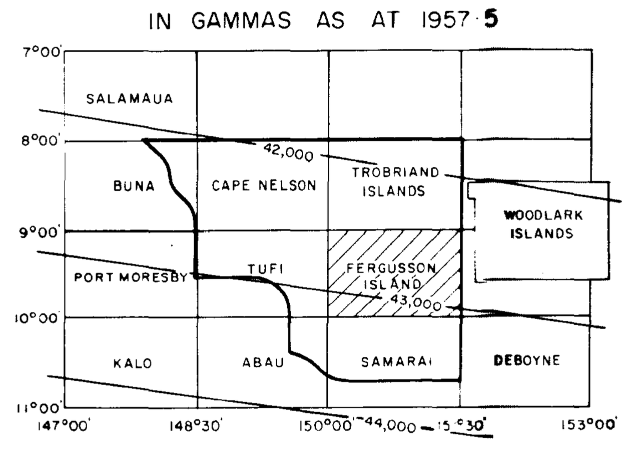
KILOMETRES 5 0 5 10 15 20 25 30 35 KILOMETRES

MILES 5 0 5 10 15 20 MILES

FERGUSSON ISLAND



REFERENCE TO 1:250,000 MAP SERIES
SHOWING REGIONAL TOTAL MAGNETIC INTENSITY
IN GAMMAS AS AT 1957·5



Regional Gradient as shown on the map diagram has been removed.

TOTAL MAGNETIC INTENSITY

CONTOUR INTERVAL 5 GAMMAS

ALTITUDE 8000 FEET

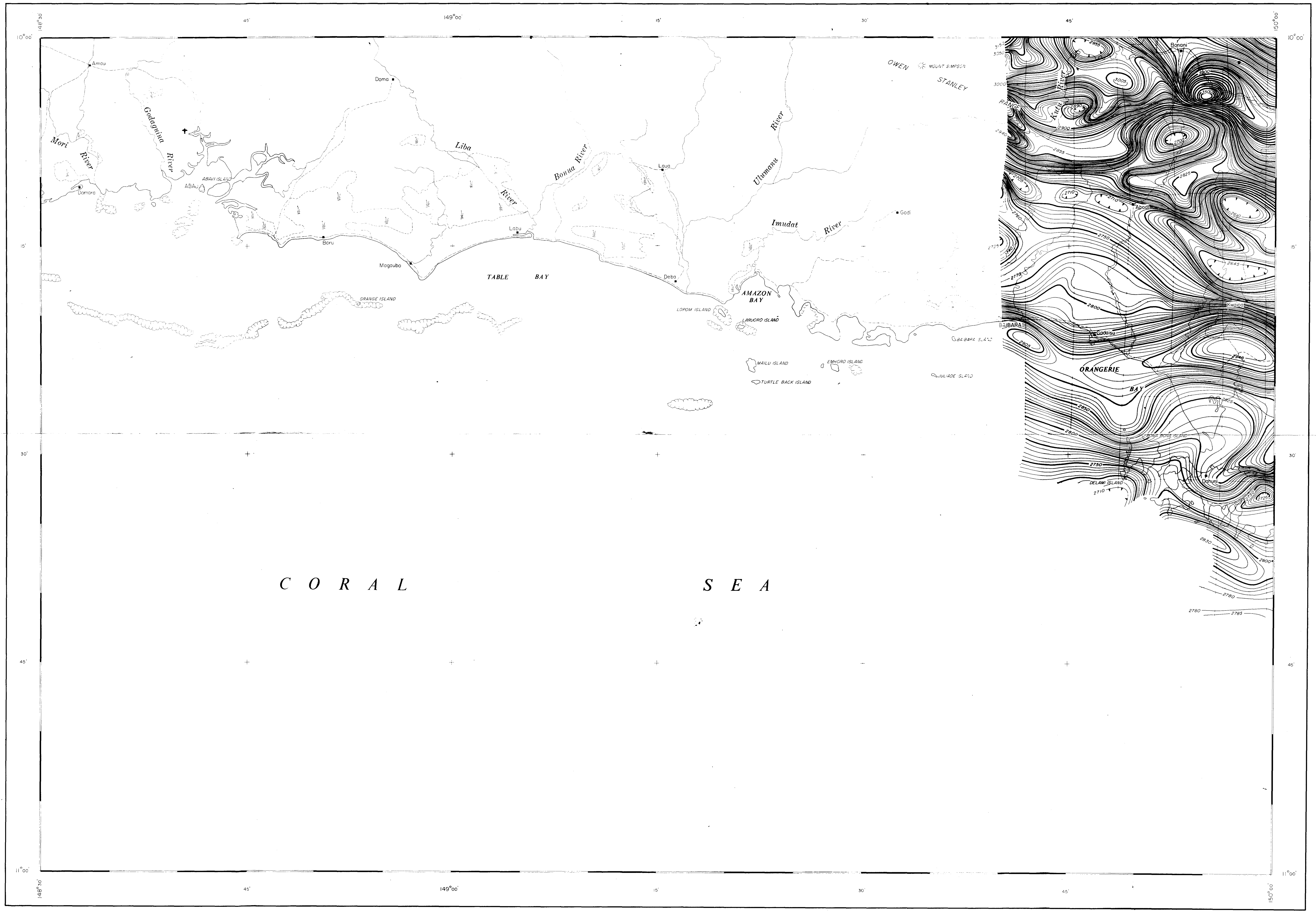
SCALE 1:250,000

KILOMETRES 5 0 5 10 15 20 25 30 35 KILOMETRES

MILES 5 0 5 10 15 20 MILES

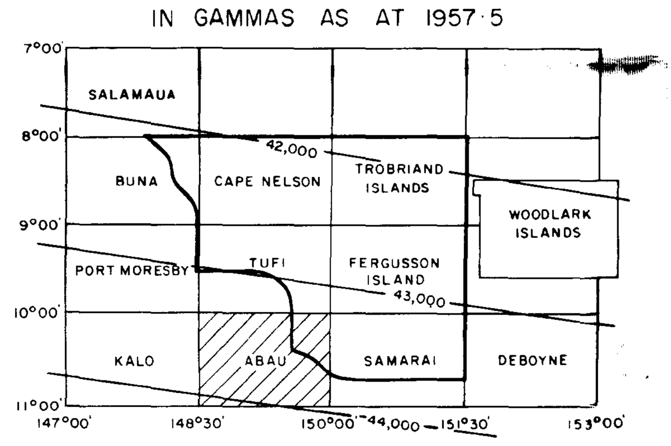
ABAU

BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS PLATE 8 LITHO (G55/B1-52)



COMPAGNIE GENERALE DE GEOPHYSIQUE

REFERENCE TO 1:250,000 MAP SERIES SHOWING REGIONAL TOTAL MAGNETIC INTENSITY IN GAMMAS AS AT 1957·5



Regional Gradient as shown on the map diagram has been removed.

TOTAL MAGNETIC INTENSITY

CONTOUR INTERVAL 5 GAMMAS

ALTITUDE 8000 FEET

SCALE 1:250,000

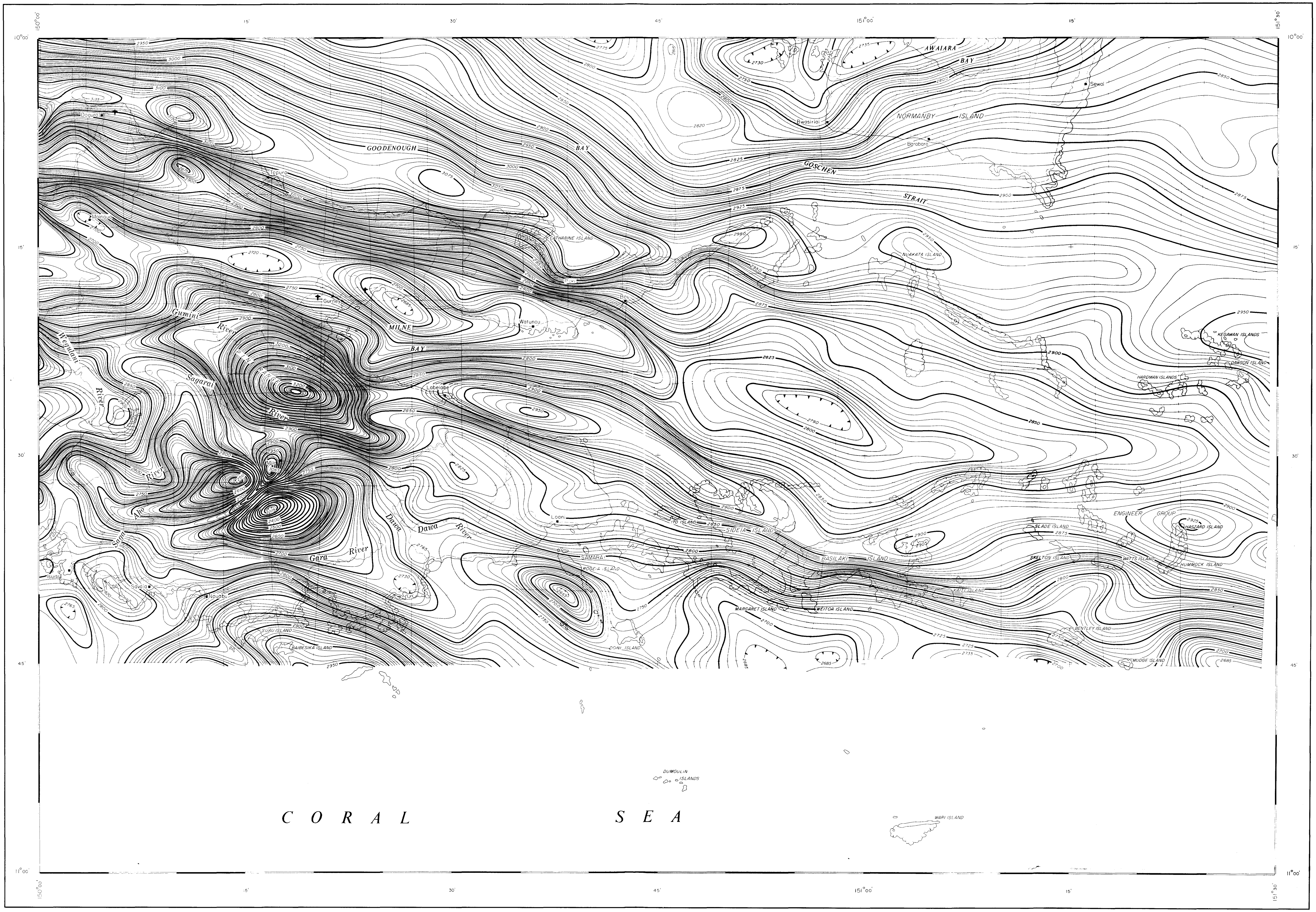
KILOMETRES 5 0 5 10 15 20 25 30 35 KILOMETRES

MILES 5 0 5 10 15 20 MILES

NEW GUINEA 1:250,000

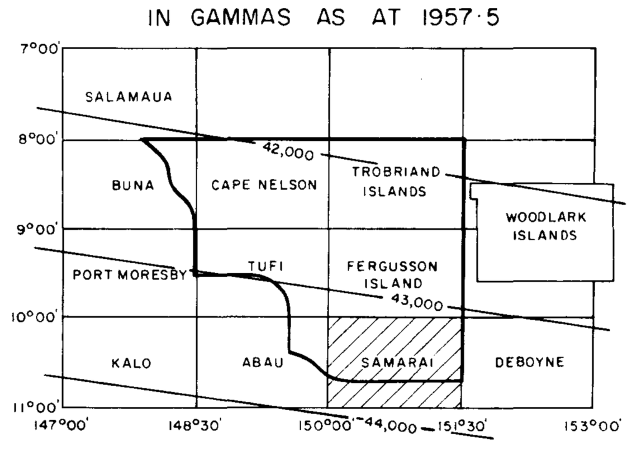
SAMARAI

BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS PLATE 9 LITHO



COMPAGNIE GENERALE DE GEOPHYSIQUE

REFERENCE TO 1:250,000 MAP SERIES
SHOWING REGIONAL TOTAL MAGNETIC INTENSITY
IN GAMMAS AS AT 1957·5



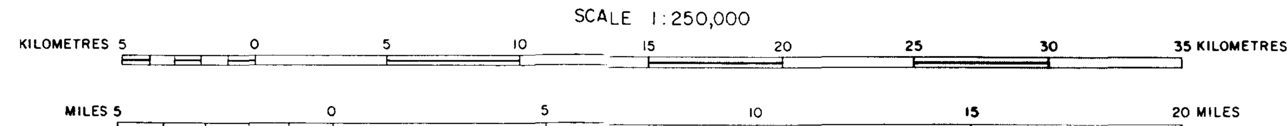
Regional Gradient as shown on the map diagram has been removed.

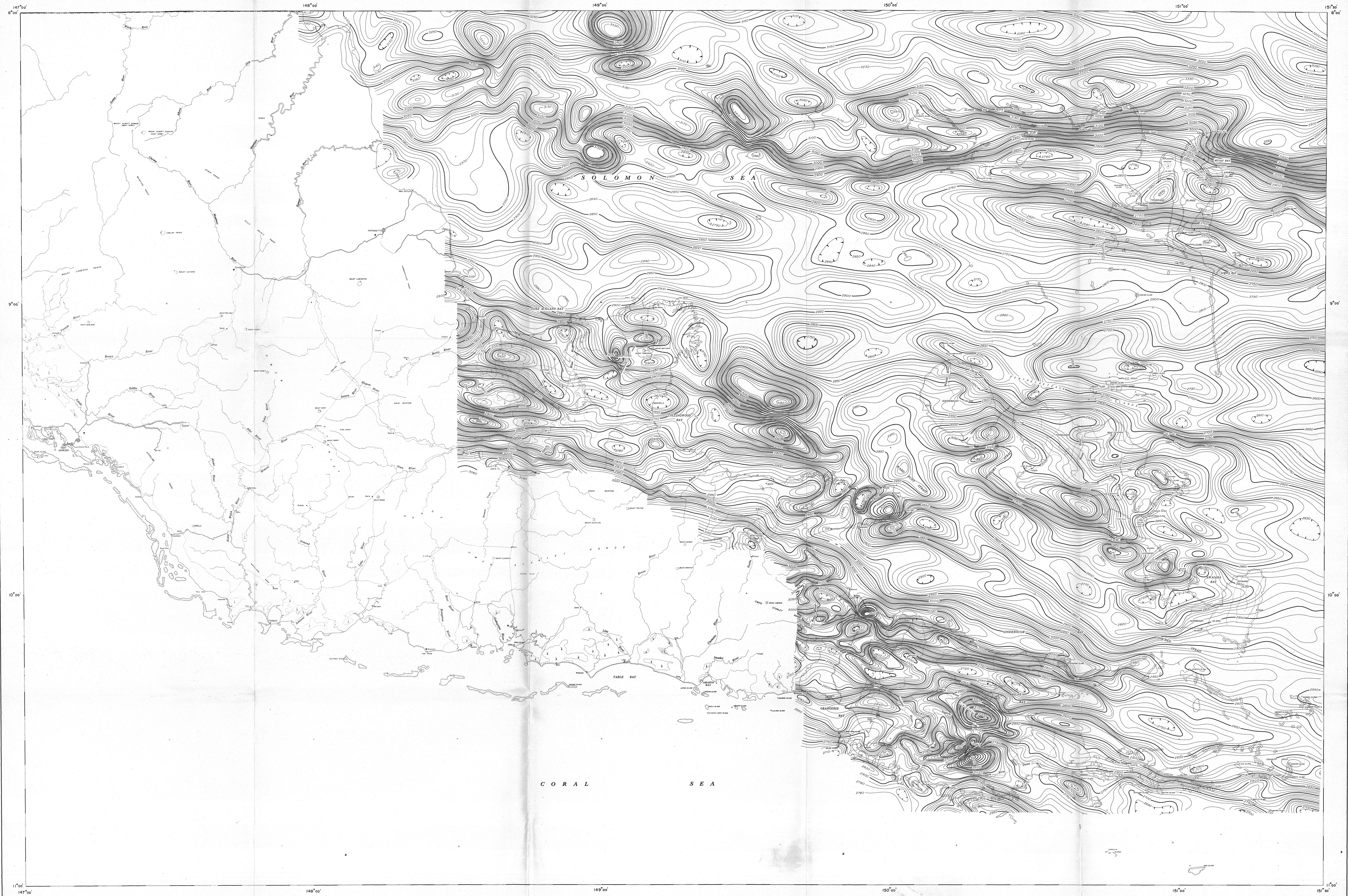
TOTAL MAGNETIC INTENSITY

CONTOUR INTERVAL 5 GAMMAS

ALTITUDE 8000 FEET

SCALE 1:250,000





BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

PLATE : 10

AIRBORNE MAGNETOMETER SURVEY

EASTERN PAPUA

TOTAL MAGNETIC FIELD CONTOURS

SCALE : 1/500,000

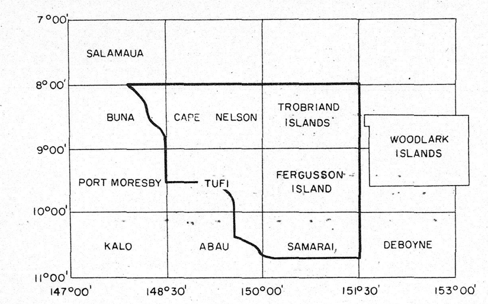
LEGEND

TOTAL MAGNETIC INTENSITY CONTOURS — 3000 / 2950

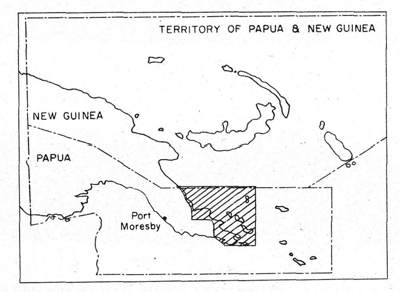
5 0 5 10 15 20 25 30 35 40 KILOMETRES
5 0 5 10 15 20 MILES

COMPAGNIE GENERALE DE GEOPHYSIQUE

REFERENCE TO 1:250,000 MAP SERIES



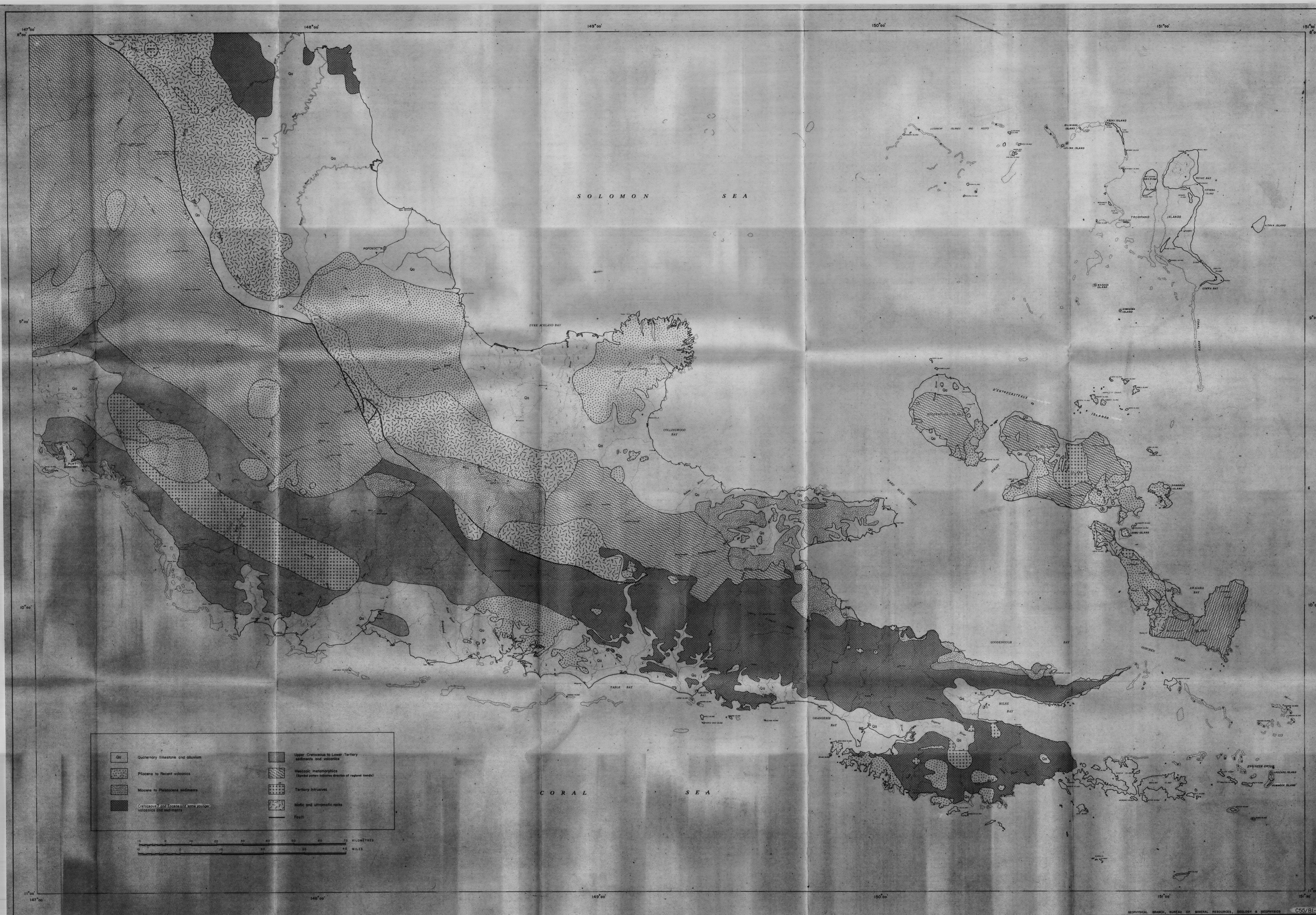
LOCATION DIAGRAM



BASED ON C55/B0-46.

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

C55/B1-48



BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS — PLATE : 11

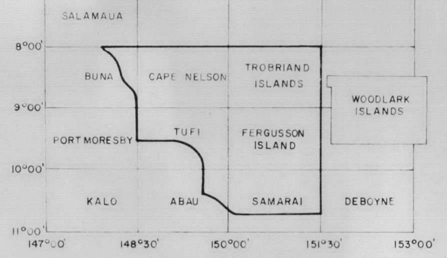
AIRBORNE MAGNETOMETER SURVEY

EASTERN PAPUA

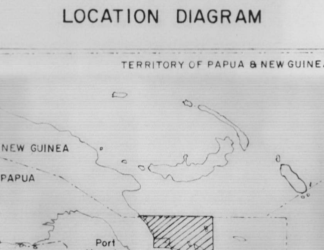
GEOLOGICAL MAP

SCALE: 1/500,000

REFERENCE TO 1:250,000 MAP SERIES



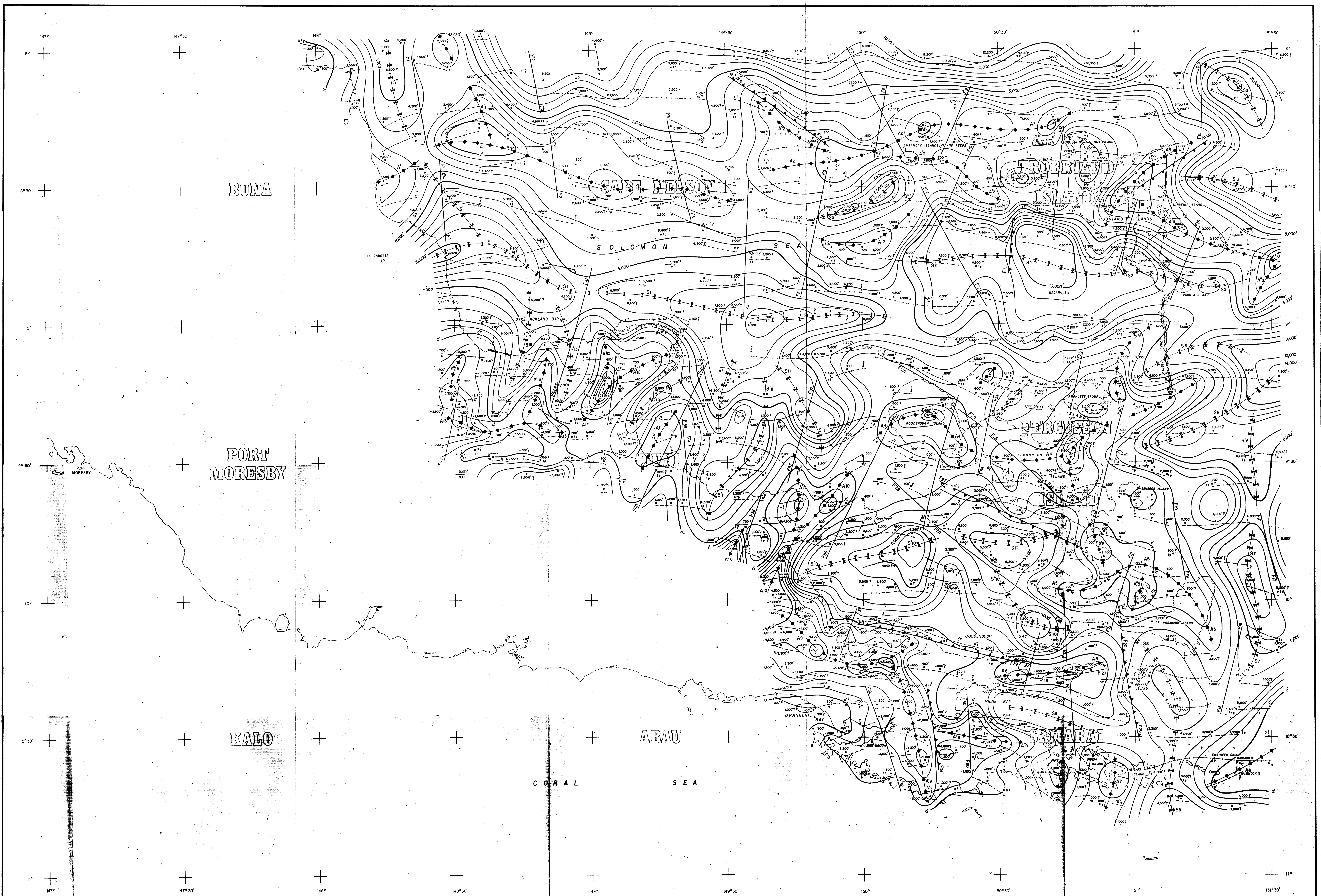
LOCATION DIAGRAM



5 0 5 10 15 20 25 30 35 40 KILOMETRES

5 0 5 10 15 20 MILES

COMPAGNIE GENERALE DE GEOPHYSIQUE



BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS — PLATE : 12

AIRBORNE MAGNETOMETER SURVEY

EASTERN PAPUA

INTERPRETATION MAP

SCALE : 1/500,000

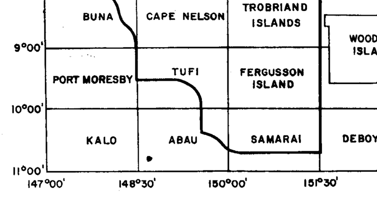
LEGEND

MAGNETIC BASEMENT FEATURES	A2 S2 F5
MAGNETIC BASEMENT DEPTH ESTIMATE (BELOW SEA LEVEL)	• 2,000'
THIN PLATE INTERPRETATION HYPOTHESIS	tp
BASEMENT DEPTH CONTOURS	5,000' 10,000'
MAGNETIC TREND (Positive)	
MAGNETIC TREND (Negative)	
FAULT (Movement Unknown)	
FAULT VERTICAL MOVEMENT (Barb Points to Downthrow)	
ANTICLINE	
SYNCLINE	

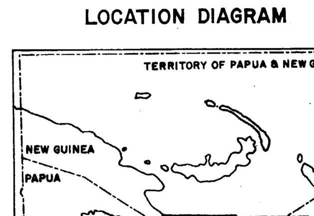
5 0 5 10 15 20 25 30 35 40 KILOMETRES
5 0 5 10 15 20 MILES

COMPAGNIE GENERALE DE GEOPHYSIQUE

REFERENCE TO 1:250,000 MAP SERIES



LOCATION DIAGRAM



C55/B1-46