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PORT MORESBY GEOPHYSICAL OBSERVATORY ANNUAL REPORT, 1965

by

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SUMMARY

The standard observatory programmes in geomagnetism, seismology, and ionospheric recording were continued throughout the year and all commitments to national and international organisations in the supply of data were fully met.

Seismic field stations at Popondetta and Tapini operated throughout the year in the crustal thickness project, and locations at Kerema and Daru were selected for future sites.

Earthquake statistics for 1960 and 1965 and provisional geomegnetic results for 1965 are presented.

1. INTRODUCTION

This report contains a description of the work carried out at Port Moresby Geophysical Observatory during 1965. Apart from routine observatory maintenance most of the time and efforts of the staff during the year were devoted to the crustal thickness project. This aims to determine the crustal structure of Papua & New Guinea by analysing the phase dispersion curves of Rayleigh waves. Preliminary results of this work are presented. Table 1 gives the co-ordinates of the observatory and its outstations.

In 1965, the observatory began contributing data to the International Seismological Research Centre (ISRC) at Edinburgh. The additional work of preparing revised bulletins as from January 1964 was undertaken, and these are being regularly distributed.

Normal geomagnetic recording was continued throughout the year but failure of a proton magnetometer made inter-comparisons impossible.

There were two changes in staff during the year. Mrs Byrne joined the section as a technical officer and J.A. Brooks, who had been in charge of the Observatory since April 1958, was replaced in November by the author. J.A. Brooks will continue crustal studies, using the records from the long-period field stations, at the University of Tasmania. Table 2 gives the staffing position throughout the year.

2. SEISMOLOGY

Instrumentation at Port Moresby

Routine seismological recording was maintained and regular performance and calibration tests were made on the World-wide Standard and Wood-Anderson seismographs. The characteristics of the different seismographs situated at Port Moresby during 1965 are listed in Table 3.

Further details of the instruments are given by Ripper (1966) and in the Operation and Maintenance Manuals issued by the Geotechnical Corporation (1962).

In May 1965 the free period of the long-period standard seismometers was reduced from 30 to 15 seconds. This was carried out at the request of the USCGS. The modification has resulted in greater stability of the long-period seismographs.

Throughout the year all the seismographs operated satisfactorily. The main problems encountered were with the timing system of the Standard Seismograph. Both the stroboscope motor and the frequency standard had to be replaced and the zero pulse and the 10-second relay gave trouble intermittently throughout the year.

Distribution of data

During the year, 4217 earthquakes were recorded and analysed. These were included in the preliminary bulletins which were distributed weekly. Information was supplied to USCGS through bi-weekly telegrams containing the larger shocks, and bi-weekly airmail letters containing all the recorded events.

The participation of the observatory in the ISRC scheme in effect necessitates the production of a final monthly bulletin. During 1965, events recorded at Port Moresby from January 1964 to February 1965 were re-analysed and the results sent to Edinburgh. For earthquakes recorded up to August 1964, mark sense cards were forwarded directly to ISRC but from that date onwards the results were entered on data sheets to be punched in Canberra and forwarded to Edinburgh. Punch cards are more reliable than mark sense cards.

The procedure adopted is to supply ISRC with the events listed in the preliminary weekly bulletins plus additional phases identified from teleseisms as a result of re-analyses using the source data supplied by USCGS in their 'Preliminary Determination of Epicentre' cards.

Monthly bulletins are now issued containing the results of the re-analysed teleseisms and listing all the identified primary and supplementary phases.

Over forty requests were received during the year for seismological information. As in previous years most of the requests were for copies of seismograms, arrival times, and information on local seismicity. In all cases the requests were met.

Territory seismicity

Earthquake risk zones. As the Territory of Papua and New Guinea develops and more complicated civil engineering projects are undertaken, the need for a reliable source of earthquake statistics and a proper evaluation of local seismicity becomes more urgent.

The New Zealand Earthquake Engineering Congress 1965 (Brooks, 1966), which members of Commonwealth Departments and the Papua and New Guinea Administration attended, gave a much needed impetus to such problems. Discussions were held in Port Moresby to help prepare a Territory Code of Earthquake Resistant Building Regulations.

To this end a report was prepared by Brooks and MacGregor (1965) in which was presented a zone map to be used in compiling the Building Regulations. This is shown in Plate 1. In preparing the map, the subdivision of the Territory was kept as broad and simple as possible and 50 years was taken as the average length of time the buildings would be exposed to earthquake risk.

Two earthquake zones are recommended, Zone A and Zone B. Within Zone A past statistics imply that on average every point will, at least once in 50 years, be located within 40 miles of the epicentre of an earthquake having a magnitude of 6 or larger. The significance of this size earthquake is discussed by Brooks (1963) in his report on earthquake activity in the Territory.

In each of the two zones, areas of amplified risk are defined where incompetent geological section outcrops. These areas coincide with regions where the surface rocks are of Quaternary age and also where land has been reclaimed, irrespective of the nature and compaction of the fill.

Although the map does not precisely define the earthquake risk for each area it does provide a general picture for the whole territory, which is not likely to change greatly as earthquake statistics become more complete.

Distribution of Territory earthquakes 1960, 1964, 1965. In the 1964 annual report (Observatory Staff, 1967) a start was made in listing detailed statistics of Territory earthquakes. Data provided by USCGS were used to abstract the epicentres, focal depths, and where possible the magnitudes of Territory earthquakes. A table was prepared cataloguing the events for 1963 and 1964 and the corresponding epicentral maps were also presented.

In this report a detailed list of the 1960 events is given, addenda to the 1964 data are presented, and all the 1965 earthquakes published by USCGS are tabulated.

The 1960 data have been taken from the "Final Report on Evaluation of 1960 Seismicity" (Fisher et al, 1964). They were obtained before the Standard Seismographs were installed and the number of earthquakes plotted in Plate 2 is much less than would now be observed in an average year. However, it is estimated in the report (loc cit) that all shocks with a magnitude greater than 5.0 are listed, and in fact it was possible to determine the epicentres of all but three of these events.

A large number of events were recorded by either Rabaul or Port Moresby only and in these cases it was possible to estimate the magnitude only of the earthquake. Table 4 gives a complete breakdown of the published results and Plate 2 shows plots of the earthquakes for which latitudes and longitudes are available. Each magnitude given is the weighted mean of magnitudes determined by thirteen different methods, and the reader is referred to Fisher's report for complete details of the methods used.

The magnitudes of several of the 1964 Territory earthquakes were not listed in the 1964 Annual Report because USCGS did not have enough data to make a preliminary calculation of the size of the event. Using the Port Moresby Wood Anderson records it was possible to estimate the magnitude of most of the shocks. The error involved in each case is not likely to exceed 0.5. Table 5 lists these events and also a correction to the 1964 catalogue.

Table 6 lists the earthquakes catalogued for 1965, and Plate 3 indicates the positions of the epicentre determinations made by USCGS. Both maps show trends similar to those observed in earlier years. The region of New Britain near Pomio was the most active and as the map indicates a large number of relatively shallow events were recorded from that area.

USCGS were not able to determine the magnitude of all the earthquakes listed. In Table 6, the magnitudes asterisked were estimated from the Port Moresby Wood-Anderson records. Where no magnitude is indicated the size of the event is unknown but probably small (i.e. less than 5.0).

Fourteen earthquakes occurred with a magnitude of 6 or greater, the largest were the ones near Pomio in New Britain and near Kilinailan Island north of Bougainville. Both these events had a magnitude of 6.5. The earthquake of magnitude 6.4, which occurred near Lae in December, was widely felt throughout the Territory and is currently the subject of a special study to determine the fault plane solutions.

Crustal thickness project

The crustal thickness project (Brooks and Ripper, 1966) to determine the thickness and structure of the crust in Papua & New Guinea by analysing Rayleigh wave dispersion was begun at the end of 1964. Long-period vertical seismometers and appropriate recording instruments were installed at Tapini, Popondetta, and Port Moresby (Table 1). During 1965 considerable difficulties were encountered in keeping the stations at Popondetta and Tapini in operation, but the instruments situated at Port Moresby worked satisfactorily.

At each station the instrumental arrangement consisted of a long-period vertical Press Ewing seismometer, situated on a concrete block and surrounded by a fibre glass vaultlet for thermal insulation, and coupled to a U.E.D. ER230 pen recorder. The power and time marks were provided by the NCD2 units which were designed and built by the BMR. At most field stations the mains power supplies are irregular so at each site power was provided by Nife batteries and trickle chargers. Labtronix radio receivers were used to detect the radio time signals.

The difficulties associated with the seismometers at the start of the project were:

(1) Instability of seismometer at 30-second free period

(2) Boom drift due to temperature changes

(3) High background noise

In the course of the year all these problems were overcome by reducing the seismometer free period from 30 to 15 seconds, and by installing the seismometers in especially constructed huts.

Originally the seismometers were situated in the Court House at Tapini and in an old lecture room at the Popondetta Agricultural College. Both these buildings proved unsatisfactory. The lecture room because large temperature variations affected the seismometer and the Court House because daily temperature changes appeared to tilt the building - causing high background noise.

In the course of the year both seismometers were repositioned. At Popondetta a hut with thick grass walls was used. The seismometer was situated on a concrete block and surrounded by its own pressure case and fibre glass vaultlet. The thermal insulation of this arrangement proved to be very satisfactory, the boom drift was reduced and since the hut was further away from man-made noise the background noise level was significantly reduced.

At Tapini a hut was built of locally constructed bricks. This was situated away from man-made disturbances and has performed satisfactorily ever since.

Although the rehousing of the seismometers solved some of the problems the stations still proved difficult to keep running and it was not until December 1965, almost a year after installation, that sufficient data had been collected from Network 1 (Brooks & Ripper, 1966). The Popondetta instruments were then dismantled and moved to Kerema (Network 2 of the Project) and a site selected at Daru (Network 2A). Reasons for the breakdowns were numerous but the main failures were caused by pen blockages and power failures. Approximately 54 man-days were spent at outstations during the year and a considerable amount of time was required at Port Moresby modifying and testing various components. (With three stations now (1966) in the field this position has become worse and the times when all three stations are operating simultaneously are rare).

At the time of writing (October, 1966) the detailed analysis of the results is being performed by J.A. Brooks at the University of Tasmania. A preliminary investigation shows that the wave forms are very complicated, being subject to refraction and interference.

3. GEOMAGNETISM

Magnetographs

The characteristics of the continuous recording magnetographs in operation at the observatory are given in Table 7.

Record loss throughout the year was caused mainly by failure of the clock-work drives and in the case of the rapid-run instrument, failure of the lens carriage movement.

Excessive rain and a blocked drain caused flooding of the vault on 18th December, and the records were affected for several weeks by the excessive vault humidity, which also caused drift of the rapid-run components, especially D.

Four sets of combination scale-value/orientation Helmholtz coils were received and installed in September and October. They are fitted around the H and D variometers of both magnetographs. These coils are constructed so that the scale-value and orientation coils are accurately set at right angles. This enables them to be positioned parallel to a certain azimuth and thereafter by switching from one pair of coils to the other, scale-value and orientation tests can be simply executed. Because the orientation coils now remain in a fixed position, more reliable observations of the change in magnet orientation should be achieved.

New wiring for the coils was completed inside the vault and a new switchboard was designed to accommodate the new installation. Orientation tests were made on the normal-run H and D components in May and November (Table 7).

In October the Z bimetallic strip on the normal-run was reversed and lengthened to its maximum extent to minimise the Z temperature co-efficient. It will not be possible to evaluate fully this change for about a year.

Magnetometers

Weekly calibrations of baselines and scale values were carried out on the normal-run magnetograph. The instruments used to determine the baselines were the QHMs 187, 188, 189, the Askania declinometer 580339, and the BMZ 68.

A BMR proton magnetometer was received in September for inter-comparisons. The instrument failed to operate satisfactorily and was returned to Canberra to be repaired before despatch to Antarctica.

The Askania declinometer 580339 was tested for the effect of residual fibre torsion and gave the result that the maximum allowable residual torsion corresponds to a line of detorsion no more than 4.7 scale divisions either side of zero.

Mean values

The routine data recording, analysis, and distribution programme was continued during 1965. Provisional mean values of the three field components at epoch 1965.5 were:

H : 0.36334 gauss decreasing at about 0.00020 gauss annually

D : 06^{o} 08.4' E approximately stationary during 1965

Z : -0.22990 gauss becoming more negative at about 0.00030 gauss annually.

See Table 8 and Plate 4.

Analysis

Transient magnetic effects, including storms, pulsations, and K-indices were listed from the magnetograms and distributed monthly. Microfilm copies of magnetograms were sent monthly to the National Aeronautics and Space Administration, USA.

1965 was a quiet year for magnetic activity, the overall average K-index for a three-hourly period was 1.73 as compared with 1.85 in 1964, 1.92 in 1963, and 2.12 in 1962. Table 8 shows how the magnetic activity has declined since 1962.

The draft text of the first Port Moresby Geophysical Observatory Mean Hourly Value report 1958-1960 (Brooks and Wilkie, in preparation) was completed in September, and preparation of the 1960-1962 report was almost complete in December. The record 'Dynamic calibration of Port Moresby rapid-run Magnetograph' (Wilkie, 1966) was completed in July.

H baseline drift and temperature coefficients for several periods up to February 1964 were determined using an iterative polynominal fitting process with an IBM 1620 computer (D. E. Winch, private communication). The analysis of variance F test was used to determine the best model to choose. The drift polynominals were usually parabolic or cubic, although occasionally quintic terms were significant.

Special requests

The Commander, United States Naval Oceanographic Office, Project Magnet, Washington, D.C. - microfilm of normal-run magnetograms.

Contract Supervisor Emmanuel College, Physics Research Division, 400 The Fenway, Boston 15 - information pertaining to the equatorial electrojet.

CSIRO, Division of Physics, Chippendale, New South Wales - request for magnetograms.

Service Meteorologique, Republic Democratique du Congo, Leopoldville - mean hourly values.

Miscellaneous

A United States Naval Hydrographic office Project Magnet Constellation aircraft visited Port Moresby in April. As a courtesy gesture an offer was made for a 2-3 hours survey flight. This was accepted and 550 miles were flown over the Papuan ultrabasic belt. This included eight 30-mile NE-SW traverses at 7000 to 8000 feet. Total force profiles were plotted for the traverses flown and a superficial examination of these provisional results indicated some correlation with known geological structural features. A report on the flight and all available information was prepared.

4. IONOSPHERIC

Instrumentation

Extensive deterioration of the Port Moresby Ionosonde Type IIIC continued during the last few months of 1964. A technical officer from I.P.S. visited the station during June and July to modify the recorder and improve its performance.

In essence his work consisted of bringing the Port Moresby equipment up to the standard of the IIID type. This entailed installing the following new units:

New units installed	IIID designation
Transmitter	"A" unit
Transmitter pulser	"R" unit
Video amplifier	"E" unit
Frequency marker	"C" unit
Time delay and overload unit	"Y" unit
250-volt regulated power supplies	"JKLM" units
VHT power supplier	"X" unit
-600 volt power supply	"Q" unit

Other alterations included the rewiring of the h.t. and filament distribution; the addition of indicators for overload detection and interlocks; time delay; camera shutter; provision of new aerial terminating resistors and the installation of additional metering facilities. The hourly gain switching unit has yet to be installed.

Since the modifications were completed the ionosonde has been functioning satisfactorily with only minor maintenance being necessary.

Data distribution

The normal hourly soundings were scaled for the usual parameters. These were forwarded to I.P.S. at monthly intervals. Six-hourly f_oF_2 values were telegraphed to I.P.S. weekly and f-plots and profile height scalings were prepared for Regular World Days.

Requests for ionograms were received from the Ionospheric Structure Section, Aeronomy Division of the Environmental Sciences Services Administration, Colorado, USA and from Ionospheric Prediction Service, Sydney.

Scintillation project

Apart from minor faults the scintillation equipment operated satisfactorily until October 1965, when a fault developed in the receiver and the equipment had to be closed down. A replacement crystal has been received but the satellite was still inaudible. At the end of the year the equipment was in-operative.

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TABLE 1

Co-ordinates of observatory buildings and outstations

Station		Latitude (°S)	Longitude (°E)	Elevation (metres)
Port Moresby (PNG)	Seismograph vault	09°24'33"	147°09'14"	67
	Absolute house*	24'37"	09'17"	70
	Ionospheric house	24'26"	09'31"	40
Popondetta (POP)		08°44'04"	148°14'58"	100 (ca)
Daru (DNG)		09°05'18.6"	143°12'20.5"	03
Kerema (KRG)		07°57'35"	145°46'08"	14
Tapinci (TPN)		08°21'24.7"	146°59'01.4"	988

* Geomagnetic co-ordinates : GM latitude =-18.7°; GM longitude = 218.0°

TABLE 2

Observatory staff 1965

Name	Classification	Term of Appointment
Brooks, J.A.	Geophysicist Cl. 3 (O.I.C.)	Until November, 1965
Denham, D.	Geophysicist Cl. 3 (O.I.C.)	From November, 1965
Wilkie, J.R.	Geophysicist Cl. 2	Continuous
Ripper, I.D.	Geophysicist Cl. 1	Continuous
Jones, M.S.	Technical Officer Grade 2	Continuous
Ciszek, M.	Technical Officer Grade 1	Continuous
Byrne, W.M.J.	Technical Officer Grade 1 *	From May, 1965
Cook, B.G.	Geophysicist Cl. 3/Ag	January to February, 1965 (relieving O.I.C.)
Noah, C.E.	Geophysical Assistant	Continuous

* Held against vacant Geophysicist Cl. 1 position.

TABLE 3

Seismograph constants

System	Component	Free period (sec)		Magnification
		Seismometer	Galvanometer	
World Standard	SP: E, N, Z	1.00	0.775	50,000 at 1 sec
	LP: E, N, Z	30.0 (a)	100	3,000
		15.0 (b)	100	3,000
Sprengnether	E, N	15.0	15.0	700 at 4-8 sec
Wood-Anderson	E	0.8	-	1,600
	N	0.8	-	2,200
Wilson Lamison	Z	1.1	1.7	11,000 at 1.3 sec

TABLE 4

Earthquakes 1960

Date		Origin Time H	M	S	Location Lat. (°S)	Long. (°E)	Depth (km)	Mag.
January	1	21	04	11	6.5	147.5		4.41
	2	19	19	55	Local (PMG)			3.47
	2	21	22	51	5.0	152.5		5.66
	4	06	19	49	4.5	153.5		5.36
	4	20	23	30	Local (PMG)			3.04
	7	21	09	58	NE New Guinea			4.54
	10	08	56	37	NE New Guinea Coast			3.43
	10	17	17	25	E New Guinea			3.80
	11	01	39	50	Local (PMG)			4.16
	11	22	54	03	2.0	140.5		5.38
	12	13	00	00	New Britain			3.40
	12	19	55	36	5.0	154.0		6.00
	13	07	26	26	3.5	140.0		5.91
	14	06	23	00	2.5	145.0		4.02
	16	12	41	14	New Britain			4.44
	16	23	32	28	4.5	152.0		5.33
	17	11	09	25	Local (PMG)			4.08
	17	12	11	45	Local (PMG)			3.55
	20	19	56	14	4.5	153.5		5.11
	23	18	51	40	Local (PMG)			3.72
	23	21	57	08	5.5	152.0		5.09
	23	22	19	05	5.5	152.0		4.94
	23	23	21	35	Local (PMG)			3.40
	23	23	37	42	5.5	152.0		5.05
	24	01	01	55	Local (PMG)			3.22
	24	03	18	52	5.5	152.0		4.56
	24	12	16	23	4.5	143.5	100	4,80
	25	02	02	25	Local (PMG)			3.79
	25	04	26	26	Local (PMG)			3.54

Date		Origin Time H	M	S	Location Lat. (°S)	Long. (°E)	Depth (km)	Mag.
January	25	13	48	22	Local (PMG)			3.99
	26	08	49	48	New Britain			4.73
	29	08	10	18	4.0	142.5		5.76
	29	08	10	41	4.5	143.5	150	4.73
	30	11	12	28	Local (PMG)			3.51
	31	05	07	50	Local (PMG)			3.09
February	1	03	00	21	Local (PMG)			4.61
	2	21	42	22	Near Rabaul			4.25
	3	11	50	48	5.0	153.0		5.82
	3	13	28	29	7.0	154.5		5.32
	3	19	35	33	8.7	148.3		4.93
	3	20	27	00	Local (PMG)			3.62
	4	03	46	30	4.5	153.5	100	6.50
	4	09	27	23	5.0	154.0	100	5.62
	4	11	01	18	4.5	153.5		4.86
	4	15	24	00	New Britain			3.90
	5	05	39	46	4.5	153.5		5.45
	5	09	33	04	Local (RAB)			4.40
	5	19	55	18	5.0	154.0		3.83
	6	01	20	02	5.0	154.5		4.82
	6	11	35	42	5.0	155.0		4.80
	6	17	04	30	New Britain			3.41
	7	17	02	36	New Britain			4.55
	7	22	33	46	6.0	148.5		4.48
	8	04	05	30	5.5	155.0		5.15
	8	09	19	45	5.0	155.0	100	5.67
	8	14	57	58	New Guinea			4.16
	8	21	02	57	Local (PMG)			3.69
	9	02	59	42	5.0	155.0		5.17
	9	15	20	36	Local (PMG)			3.52
	9	16	34	45	6.0	147.0		5.57
	10	15	44	54	4.5	154.5		5.94

Date		Origin Time H	M	S	Location Lat. (°S)	Long. (°E)	Depth (km)	Mag.
February	10	21	50	45	3.5	151.5		5.53
	11	08	28	58	6.0	155.0	100	5.57
	11	10	35	42	4.5	152.5		4.87
	12	01	29	42	4.5	153.5		5.76
	12	11	52	14	S of New Britain			3.76
	12	14	10	54	New Britain			4.40
	14	18	50	27	5.5	155.5		4.58
	14	20	30	44	5.0	154.5		6.11
	16	10	35	22	6.5	154.5		5.36
	17	16	49	42	5.0	142.5		5.66
	18	07	04	54	5.0	153.0		4.52
	18	23	40	08	Local (PMG)			4.12
	19	20	09	00	4.0	154.0		4.93
	22	02	18	28	Local (PMG)			3.73
	22	18	36	30	Local (PMG)			3.52
	23	16	04	50	6.0	154.5		6.46
	24	08	55	50	Local (PMG)			4.01
	24	21	37	04	7.5	156.0		6.67
	25	06	49	48	New Britain			3.34
	25	20	56	05	7.0	154.0	300	4.28
	27	13	57	56	7.0	156.5	150	4.59
	27	14	23	29	7.0	156.0	150	5.29
	27	14	56	22	7.0	156.0		4.42
	28	23	05	39	3.0	142.0		5.85
	28	23	52	27	3.0	142.5		5.05
March	3	01	02	20	7.0	156.0		5.16
	4	17	12	16	New Britain			4.42
	9	01	05	42	5.5	148.5	150	5.05
	9	01	47	42	3.6	144.8		4.75
	9	19	43	53	7.0	156.5		5.34
	12	02	14	56	4.0	152.5	150	5.77

Date		Origin Time H	M	S	Location Lat. (°S)	Long. (°E)	Depth (km)	Mag.
March	12	20	30	39	6.0	152.0		6.61
	13	00	20	48	New Britain			4.38
	18	12	16	51	4.5	152.0	150	4.92
	21	16	37	46	4.5	154.0		5.55
	23	09	37	18	7.0	155.0		5.36
	24	20	54	01	6.5	156.0	200	5.27
	25	06	29	42	4.5	144.5		5.00
	26	01	53	10	Local (PMG)			4.05
	29	22	10	20	6.0	147.0		5.70
	30	01	27	00	6.0	147.0		5.21
	30	02	47	32	New Guinea Coast			5.39
	30	04	19	06	New Britain			3.20
	31	03	29	45	5.5	143.5		4.77
April	2	00	57	21	5.0	146.5		4.28
	2	14	14	42	6.0	152.0		5.22
	3	08	27	29	Local (RAB)			3.10
	3	09	52	05	6.0	148.5		5.13
	4	10	20	12	1.0	145.5		5.22
	4	12	45	25	5.0	152.0	100	5.52
	4	14	33	30	Local (RAB)			3.56
	8	08	35	37	6.0	147.0		5.59
	11	08	52	59	Local (RAB)			3.63
	12	11	32	09	New Ireland			4.36
	12	21	46	02	3.5	152.0		3.97
	14	07	22	11	Local (PMG)			4.25
	15	18	41	07	Local (PMG)			4.53
	20	21	36	41	2.5	140.0		5.21
	23	17	58	19	6.0	154.5		5.21
	27	16	56	42	New Britain			4.40
	27	17	11	30	3.5	146.5		5.30

Date		Origin Time H	M	S	Location Lat. (°S)	Long. (°E)	Depth (km)	Mag.
April	28	05	08	07	3.5	144.5		5.27
	29	15	35	08	New Britain			4.93
	29	15	35	20	Local (PMG)			4.37
	29	20	05	50	Local (PMG)			3.16
	30	14	17	04	9.0	157.0		5.61
May	4	22	00	01	5.5	146.0	150	4.71
	5	23	21	51	2.0	150.0		5.46
	9	08	59	25	7.0	155.0		5.45
	13	03	01	20	Local (PMG)			3.20
	13	18	53	53	5.5	141.5	100	3.74
	15	00	03	27	Local (PMG)			3.51
	15	02	57	50	3.0	140.0		4.58
	20	00	23	22	3.5	147.5		4.94
	20	19	37	41	4.5	150.5		4.78
	27	04	35	26	5.0	153.0	60	4.14
	27	20	10	00	5.5	153.0	150	5.07
	27	22	21	07	5.5	153.0	150	3.68
	28	07	11	36	4.2	151.6		4.10
	31	13	11	02	7.5	156.0		6.12
June	2	07	47	11	5.5	151.5		6.31
	2	23	20	00	6.2	149.8		4.91
	3	07	38	14	5.5	151.0		5.39
	4	07	54	49	Local (PMG)			4.45
	5	03	37	26	Local (RAB)			4.18
	7	20	42	01	Local (PMG)			3.95
	8	00	37	46	Local (PMG)			3.81
	8	08	35	37	6.0	147.0		5.09
	9	15	10	54	10.0	150.0		4.76
	11	15	14	07	9.0	152.5		6.70
	11	16	29	30	9.0	152.5		4.85

Date		Origin Time H	M	S	Location Lat. (°S)	Long. (°E)	Depth (km)	Mag.
June	11	16	37	40	9.0	152.5		6.44
	11	17	07	57	9.5	152.5		5.94
	11	20	55	13	10.0	152.0	150	5.34
	11	21	33	26	Local (RAB)			4.38
	11	21	48	48	9.5	152.0	200	4.73
	12	00	49	33	Local (RAB)			4.86
	12	07	21	05	Local (RAB)			4.65
	12	21	01	16	Local (RAB)			4.61
	13	06	58	36	New Britain			4.42
	13	08	41	44	Local (PMG)			4.64
	14	14	35	54	New Britain			4.72
	14	16	20	06	Local (RAB)			4.58
	14	23	38	13	9.0	152.5		5.91
	15	08	09	13	8.5	150.0		4.77
	15	12	00	12	5.0	152.0		4.58
	16	15	09	43	Local (PMG)			4.53
	17	03	19	04	9.5	151.5		5.75
	18	03	19	04	9.5	152.5		5.53
	19	14	30	30	New Britain			4.86
	22	04	18	54	5.0	150.5		5.32
	26	22	13	07	Local (PMG)			4.27
	29	16	58	00	6.5	148.5		5.40
July	2	07	57	06	6.0	147.5		4.73
	7	23	36	04	5.5	155.0		5.46
	8	11	16	45	Local (PMG)			4.12
	9	06	43	36	Local (PMG)			4.83
	9	14	12	00	5.5	153.0		4.62
	11	15	35	47	Local (RAB)			4.72
	13	17	03	39	Local (PMG)			4.48
	13	17	03	58	Local (RAB)			4.51
	14	17	39	08	Local (PMG)			4.35

Date		Origin Time H	M	S	Location Lat. (°S)	Long. (°E)	Depth (km)	Mag.
July	15	02	10	59	Local (RAB)			4.22
	15	10	52	22	Local (PMG)			4.20
	17	23	35	48	6.0	147.5		5.07
	18	01	43	29	4.5	151.0	200	6.05
	19	14	11	30	New Britain			4.82
	21	13	01	00	New Britain			5.10
	24	19	52	00	Local (RAB)			4.67
	25	21	36	46	3.0	148.0		5.41
	27	14	10	01	5.5	147.5	150	5.31
	28	16	34	34	5.0	152.5		4.33
	30	04	56	10	Local (PMG)			4.21
	31	02	55	51	6.0	150.0	100	6.63
	31	07	04	36	6.0	150.0	100	5.98
	31	09	06	40	Local (PMG)			4.51
	31	09	06	42	New Britain			4.69
	31	16	30	30	New Britain			4.95
	31	13	21	53	Local (PMG)			4.04
	31	18	46	12	3.0	147.0		5.41
	31	22	34	15	Local (PMG)			4.59
August	1	12	20	37	New Britain			4.20
	3	21	32	30	New Britain			4.20
	8	16	48	35	Local (PMG)			4.13
	14	00	24	45	Local (PMG)			4.09
	14	14	41	03	7.0	146.0	171	4.86
	16	08	13	38	6.4	147.6	68	4.61
	16	08	[illegible]	00	New Britain		33	4.73
	[illegible]	[illegible]	[illegible]	50	Local (PMG)			4.40
	[illegible]	[illegible]	37	11	9.3	152.1	178	4.91
	[illegible]	16	47	24	New Britain		33	4.45
	21	00	18	03	4.4	143.5	38	6.06
	21	00	59	24	5.5	149.4	137	5.69
	23	11	29	10	7.3	156.6		4.89

Date		Origin Time H	M	S	Location Lat. (°S)	Long. (°E)	Depth (km)	Mag.
August	24	04	26	54	6.2	150.4	38	4.94
	25	09	50	54	New Britain			3.76
	27	19	25	15	5.9	147.1	80	5.01
	28	03	14	12	6.0	147.0	33	5.10
Sept.	3	12	41	34	6.1	154.5	457	6.37
	6	04	33	35	Local (PMG)			3.11
	6	12	35	16	4.9	145.1	38	4.86
	14	15	59	01	6.5	155.1	100	5.06
	15	11	55	17	Local (PMG)			4.85
	16	03	08	09	Local (PMG)			3.55
	17	12	58	56	6.3	154.4	134	4.82
	17	15	54	38	6.3	148.8	79	5.12
	17	15	12	18	3.6	149.5	220	3.57
	18	15	39	49	Local (PMG)			4.10
	21	02	48	44	8.1	149.4	115	3.77
October	1	11	44	04	4.7	153.3	90	5.07
	3	17	10	56	8.1	152.8	100	5.09
	3	19	17	30	New Britain			4.63
	4	09	51	16	7.5	155.3	134	5.52
	6	11	20	24	Local (PMG)			3.20
	8	01	20	48	Local (PMG)			4.42
	12	09	56	08	2.1	140.5	19	4.70
	12	18	29	35	6.1	148.6	119	5.02
	13	18	40	30	3.8	152.4	213	5.14
	16	19	05	50	Local (PMG)			3.32
	17	22	17	32	Local (PMG)			4.50
	18	14	08	12	Local (PMG)			4.23
	18	16	08	12	7.5	156.0	33	5.58
	18	17	42	02	Local (PMG)			3.70
	21	11	58	36	New Britain			3.97

Date		Origin Time H	M	S	Location Lat. (°S)	Long. (°E)	Depth (km)	Mag.
October	21	20	13	43	New Britain			4.35
	22	22	22	20	4.6	144.3	170	4.57
	24	10	40	20	Local (PMG)			5.33
	24	10	54	39	Local (PMG)			3.49
	24	17	09	14	6.1	150.0	122	4.93
	24	19	43	54	Local (PMG)			3.87
	25	09	36	52	6.8	155.1	145	4.34
	27	12	22	24	New Britain			3.90
	27	19	42	59	6.4	154.7	118	4.57
	28	12	57	09	5.5	146.2	26	4.64
November	3	20	53	34	Local (PMG)			4.56
	5	22	33	09	Local (PMG)			4.49
	12	10	53	38	6.8	156.3	179	4.70
	14	12	07	44	4.2	142.9	70	4.41
	16	19	35	17	Local (PMG)			4.66
	16	21	55	05	Local (PMG)			4.06
	17	17	42	39	Local (RAB)			3.67
	20	11	18	18	7.0	152.0	33	4.88
	21	04	29	05	3.4	152.2	369	5.36
	23	01	24	30	5.0	153.3	79	4.57
	23	04	11	27	4.7	154.2	431	5.57
	23	04	50	16	4.6	153.0	87	5.89
	23	09	42	47	10.3	151.7	34	5.10
	24	04	50	16	4.6	153.0	87	6.29
	27	13	10	07	5.5	146.3	44	5.06
	27	22	35	17	Local (PMG)			4.72
December	1	10	11	46	5.7	146.0	57	5.52
	1	20	49	50	4.5	154.0	117	4.62
	2	04	37	26	6.7	152.8	33	5.69
	3	21	47	26	4.3	151.9	174	4.75
	4	13	28	05	5.6	148.8	217	4.95
	6	09	10	55	Local (RAB)			4.56

Date		Origin Time H	M	S	Location Lat. (°S)	Long. (°E)	Depth (km)	Mag.
December	10	11	49	57	Local (PMG)			4.08
	14	13	11	33	5.3	151.3	67	4.36
	18	20	54	34	5.4	152.7	62	5.37
	19	01	45	13	Local (RAB)			3.61
	19	14	26	48	New Britain		33	4.48
	20	13	14	34	Local (RAB)		33	3.69
	20	22	20	04	4.3	152.1	154	4.92
	21	08	47	11	Local (RAB)		33	3.60
	21	17	02	35	Local (RAB)		33	3.48
	22	21	02	41	6.9	155.3	469	6.27
	25	12	19	14	Local (RAB)			4.07
	27	00	15	43	Local (PMG)			4.23
	29	13	42	35	5.5	146.1	57	6.13
	31	21	06	04	5.3	151.2	158	4.99

Magnitude shown is weighted mean of magnitudes determined by 13 methods (see text)

TABLE 5

Addenda to 1964 Catalogue

Date 1964		Lat. (^{o}S)	Long. (^{o}E)	Depth (km)	Mag. PM Wood Anderson	PDE No.
January	24	5.9	154.0	85	5.4	9
	24	5.6	146.7	141	4.6	9
	25	6.3	145.6	134	4.5	9
February	13	5.7	149.1	148	4.3	16
	15	5.3	151.9	56	4.6	19
March	12	5.6	153.0	40	4.6	31
April	20	4.7	143.1	98	4.3	39
	21	4.8	142.8	62	4.7	36
June	20	8.7	148.2	119	3.4	54
July	10	8.5	147.9	127	3.7	56
	30	6.0	154.4	79	4.8	61
August	6	4.2	140.5	50	-	65
September	7	4.1	151.7	246	4.5	72
October	28	6.1	149.3	60	4.8	88
November	5	5.1	146.1	137	4.9	88
	7	6.8	148.4	44	4.1	90
	7	6.7	148.2	69	4.2	90
	10	6.1	147.2	80	4.5	92
	20	5.5	150.1	91	4.3	96
	27	6.0	150.4	37	4.6	98

TABLE 6

Earthquakes 1965

Date		Lat. (^{o}S)	Long. (^{o}E)	Depth (km)	Mag. C.G.S.	PDE No.
January	1	5.4	154.3	136	-	2
	5	6.3	154.3	10	5.1	1
	9	3.5	150.3	32	4.7	7
	10	5.6	154.5	126	5.0	5
	10	5.8	147.3	113	6.5	3
	10	3.2	146.7	64	5.1*	5
	10	3.4	146.2	39	5.1	7
	10	3.4	146.1	24	5.2	6
	11	3.6	146.1	33	5.2	6
	11	6.5	154.4	100	5.3	4
	13	3.3	150.4	33	4.7	7
	14	6.2	149.9	63	5.6	4
	16	5.7	151.3	60	5.7	5
	20	4.9	142.3	96	5.5	6
	27	6.6	153.9	118	4.8	10
	27	6.7	154.6	49	4.7	13
	28	6.1	154.4	45	4.9	8
February	1	5.8	147.4	80	5.0	8
	2	5.5	147.0	217	5.1	8
	2	5.7	152.0	42	4.8	8
	4	5.7	154.4	183	4.3	13
	7	5.8	148.6	125	4.3	13
	9	2.7	140.4	33	5.4	20
	11	3.5	145.4	33	4.7	24
	20	5.5	146.3	99	4.9	23
	21	6.0	149.5	33	4.8	23
	21	3.5	149.8	33	4.8	24
	25	5.4	152.2	38	5.4	23
	25	5.5	152.0	35	5.9	24
	25	5.5	152.3	31	5.7	23

Date		Lat. (°S)	Long. (°E)	Depth (km)	Mag. C.G.S.	PDE No.
February	25	5.5	151.2	137	5.0	26
	27	5.4	152.3	51	5.1	24
	27	5.2	152.0	60	4.8	25
	27	4.1	152.7	118	4.9	25
March	1	5.5	152.1	35	5.7	24
	1	5.1	151.7	63	5.9	26
	1	5.2	152.1	33	5.7	16
	1	5.4	152.0	29	5.6	24
	1	5.2	151.9	59	4.8	24
	1	5.1	151.9	63	5.1	24
	2	5.3	152.3	40	5.7	24
	2	5.4	152.2	48	5.2	27
	3	5.5	151.9	44	6.0	26
	3	5.4	151.8	55	5.2	26
	3	5.3	152.1	56	5.4	25
	4	5.4	147.0	191	6.4	24
	4	5.3	152.1	60	5.3	25
	5	5.4	151.7	62	5.3	24
	8	5.3	152.2	51	4.8	25
	9	5.0	145.3	53	5.2	26
	10	4.1	143.5	122	5.2	25
	15	6.5	153.2	38	5.4	26
	15	5.6	152.3	33	5.3	28
	16	5.1	146.9	25	4.9*	34
	17	4.8	153.8	108	5.5*	36
	25	7.4	153.9	96	5.6	32
	26	5.5	152.7	37	4.7	35
	30	6.6	148.1	56	4.8	38
	30	6.4	154.5	70	5.2	36
April	2	5.0	150.7	33	5.1	39
	4	5.5	152.3	37	4.3	39
	5	3.2	148.4	10	5.0	40

Date		Lat. (°S)	Long. (°E)	Depth (km)	Mag. C.G.S.	PDE No.
April	8	5.8	154.6	125	5.5	39
	8	6.8	147.0	77	5.6	39
	10	4.8	152.6	66	5.1	39
	14	4.2	153.1	107	5.2	39
	14	5.4	154.1	166	5.0	39
	15	5.2	152.9	105	5.0	46
	16	5.3	154.7	127	5.8	44
	18	4.7	151.7	142	5.2	42
	19	2.9	147.6	5	5.0	42
	25	5.4	151.8	49	5.4	43
	28	7.2	155.0	143	4.7	43
May	5	7.1	153.8	73	4.9	46
	6	6.1	149.1	74	6.0	45
	8	1.8	141.8	33	5.4	57
	9	6.4	148.0	63	4.5	46
	10	5.4	147.0	226	5.7	52
	17	5.8	151.7	45	4.9	50
	19	4.8	152.3	70	5.6	48
	19	6.8	154.7	73	5.0	50
June	1	9.1	150.3	37	5.3	51
	1	5.6	152.0	48	4.9	51
	1	5.7	151.8	49	4.9	55
	3	6.2	155.0	123	4.2	51
	5	6.2	151.2	40	4.6	53
	5	4.1	153.1	51	5.1	52
	14	6.0	151.6	27	5.7	55
	22	2.3	141.7	33	-	58
	27	2.2	152.6	7	-	62
	28	5.1	153.0	50	6.1	57
	30	5.9	146.7	87	4.3	64
July	2	3.1	147.3	61	4.7	63
	4	6.0	149.8	33	5.1*	58

Date		Lat. (°S)	Long. (°E)	Depth (km)	Mag. C.G.S.	PDE No.
July	6	4.5	155.1	510	6.5	58
	13	4.2	143.3	101	6.0	59
	16	4.7	152.4	91	5.3	61
	17	7.2	153.6	28	5.7	61
	19	6.9	147.4	62	5.7	61
	23	6.3	147.8	52	4.8*	64
	24	5.6	150.8	60	4.8	64
	26	7.4	155.9	48	4.9	66
	27	6.8	155.1	86	5.5	64
	29	6.2	148.8	50	4.6	65
	31	5.9	148.5	65	4.5	65
August	5	5.3	151.7	47	6.3	65
	9	5.7	148.5	130	5.1	66
	12	5.3	152.2	41	5.9	67
	12	5.2	152.3	49	5.0	68
	12	5.3	152.2	50	4.8	68
	13	5.6	151.6	60	5.0	70
	13	5.9	151.1	45	5.0	68
	13	6.4	148.5	51	5.2	66
	16	6.0	153.9	78	5.4	70
	17	5.2	152.6	47	5.8	70
	17	6.6	147.2	89	5.5	68
	17	5.2	152.0	75	4.9	72
	19	6.0	151.4	42	5.1	71
	21	5.2	152.3	33	5.3	70
	23	3.7	151.2	33	5.3	71
	24	6.5	152.3	87	4.7	70
	24	3.2	141.0	44	-	70
	24	3.7	151.3	33	5.4	74
	28	5.7	152.9	70	4.8	70
	29	4.2	140.2	33	5.4	71
	31	5.1	153.0	52	4.9	72

Date		Lat. (^{0}S)	Long. (^{0}E)	Depth (km)	Mag. C.G.S.	PDE No.
September	3	5.2	153.7	54	5.9	70
	5	6.3	152.1	25	3.4*	71
	6	6.2	151.2	41	4.9	73
	11	5.3	153.0	67	6.3	71
	11	5.4	153.2	21	4.9	79
	12	4.9	152.3	59	4.8*	75
	12	6.3	151.6	48	6.2	71
	12	6.2	151.5	31	5.7*	74
	12	6.4	151.7	37	5.0	71
	14	5.3	152.9	57	4.8	75
	15	5.1	153.6	33	5.3	75
	15	6.4	154.0	76	5.0	76
	15	4.6	153.7	54	4.7	76
	16	5.5	154.2	133	5.3	73
	17	6.3	151.9	23	5.4	76
	17	6.9	154.6	168	4.7	76
	18	6.9	147.5	116	5.3*	75
	19	5.5	154.4	116	5.6	76
	19	6.2	151.5	34	5.9	73
	22	6.3	151.9	33	4.7	76
	22	5.4	151.5	57	6.5	74
	25	9.9	148.4	57	4.7	76
	26	6.3	151.4	33	4.7	79
October	1	6.2	151.7	34	5.0	78
	4	6.4	147.4	75	5.8	77
	5	6.0	149.8	53	4.0*	79
	6	5.2	151.8	64	4.7	82
	8	7.1	154.9	85	5.1	80
	10	6.7	155.0	109	4.7	80
	11	6.3	153.5	75	5.0	83
	13	6.4	153.0	223	4.6	85
	13	6.1	149.9	54	4.4*	80

Date		Lat. (^{o}S)	Long. (^{o}E)	Depth (km)	Mag. C.G.S.	PDE No.
October	16	6.2	149.0	56	4.9	81
	16	6.9	154.6	84	4.9	80
	17	8.0	155.9	93	5.5	80
	17	5.0	151.1	175	5.0	80
	18	6.2	147.0	93	5.2	81
	19	6.9	154.3	131	4.8	85
	19	6.8	154.2	167	4.4	87
	29	6.2	148.9	59	4.7	84
	31	2.8	140.5	26	5.5	84
November	1	4.2	142.9	101	6.0	83
	2	5.1	151.7	82	5.6	83
	5	3.1	143.8	31	5.7	83
	11	5.6	152.2	48	4.4	92
	18	5.1	145.2	55	5.1	89
	20	3.3	143.0	34	5.6	90
	20	5.8	153.2	36	4.9	89
	20	5.9	153.3	60	4.7	88
	25	3.9	150.3	457	5.5	88
	27	6.1	148.5	56	5.8	88
	29	5.5	146.5	95	4.6	93
December	1	3.2	142.2	76	5.1	91
	1	4.0	152.1	83	4.7	90
	2	2.9	142.0	51	5.1	93
	4	5.3	153.5	55	4.7*	93
	5	5.6	153.1	90	4.4	91
	7	5.8	151.7	46	5.0	94
	7	6.4	146.3	109	6.4	90
	11	4.4	155.0	510	5.1	92
	24	6.9	148.1	52	5.1	96
	26	5.5	151.4	133	6.0	95
	29	3.3	143.1	23	5.4	97
	29	6.6	155.0	68	5.4	96
	31	4.5	143.8	50	4.9	99

* Magnitude determined from Wood Anderson Seismographs.

TABLE 7

Magnetograph data

Recorder	Component	Scale Value gammas/mm	or (min/mm)	Magnet orientation (N pole) Geographic		Magnetic (a)
Normal run	D	4.7	(0.44)	06.5°	(16 Nov)	N 0.4°E
Recorder (15mm/hr)	H	2.8 - 2.9		95.3°	(18 May)	E 0.8°N
W of Vario-meters			(b)	96.7°	(19 May)	E 0.6°S
				96.0°	(16 Nov)	E 0.1°N
	Z	3.2 - 3.3				N
Rapid run	D	0.3	(0.03)			S
Recorder (180 mm/hr)	H	1.2				E
E of vario-meters	Z	0.4				S

(a) Relative to mean magnetic meridian 1965.5 (06.1°E)

(b) After adjustment

TABLE 8

Preliminary monthly means, 1965

Month	H (gammas)	D (°E)		Z (gammas)
January	36,355	06°	08.4'	-22,981
February	36,348	06°	08.2'	-22,983
March	36,345	06°	08.2'	-22,981
April	36,342	06°	08.2'	-22,984
May	36,340	06°	08.5'	-22,984
June	36,329	06°	08.8'	-22,988
July	36,333	06°	08.5'	-22,991
August	36,332	06°	08.2'	-22,994
September	36,332	06°	08.2'	-22,996
October	36,332	06°	08.6'	-23,000
November	36,333	06°	08.3'	-23,006
December	36,329	06°	08.2'	-23,008

TABLE 9

Preliminary annual means, 1960-1965

Epoch	H (gammas)	D (°E)		Z (gammas)
1965.5	36,334	06°	08.4'	-22,990
1964.5	36,356	06°	07.4'	-22,967
1963.5	36,376	06°	06.3'	-22,942
1962.5	36,402	06°	04.6'	-22,891
1961.5	36,414	06°	02.6'	-22,858
1960.5	36,431	06°	00.8'	-22,826

TABLE 10

Mean monthly K-index 1962 - 1965 (K9 = 300 gammas)

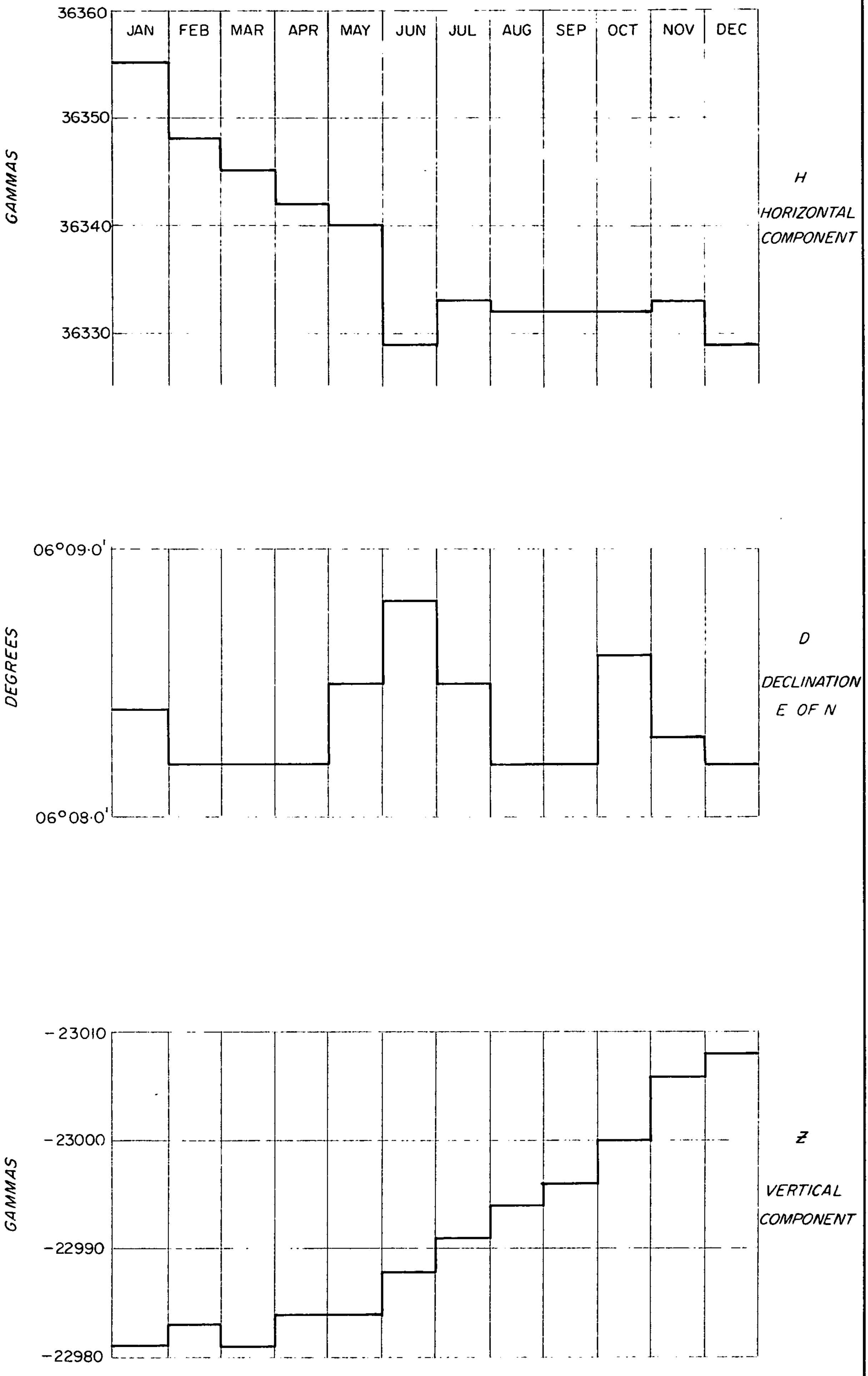
Month	1962	1963	1964	1965
Jan.	1.61	2.00	1.93	1.84
Feb.	2.21	1.62	1.72	2.04
March	1.91	1.55	1.99	1.64
April	2.25	1.79	2.25	1.63
May	1.62	1.97	2.00	1.40
June	1.92	1.80	1.82	1.78
July	1.88	1.87	1.80	1.65
August	2.37	1.83	1.83	1.98
Sept.	2.50	2.85	1.83	2.09
October	2.61	1.90	1.78	1.66
November	2.27	2.07	1.67	1.56
December	2.31	1.77	1.60	1.51
Mean	2.12 ± .09	1.92 ± .09	1.85 ± .05	1.73 ± .06

The limits given correspond to the standard error of the mean


PLATE I
PAPUA AND NEW GUINEA
MILES
50 0 50 100 150
LEGEND
International boundary
Territorial boundary
District boundary
Areas of amplified risk
A
B
Earthquake risk zones (see text)
141° 144° 147° 150° 153° 156° 159°
0° 3° 6° 9° 12°
MANUS
WEWAK
MADANG
LAE
KEREMA
PORT MORESBY
RABAUL
NEW GUINEA
PAPUA
NEW BRITAIN
NEW IRELAND
BOUGAINVILLE I
CHOISEUL I
YSABEL I
NEW GEORGIA
GUADALCANAL I
WEST NEW GUINEA
QUEENSLAND
TO ACCOMPANY RECORD No.1967/118
Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. G82/4-41

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. G82/4-39

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. G82/4-40



PRELIMINARY MONTHLY MAGNETIC MEANS FOR 1965

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS G82/4-45

TO ACCOMPANY RECORD No 1967/118