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DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD No. 1967/2

PORT MORESBY GEOPHYSICAL OBSERVATORY ANNUAL REPORT, 1964

by

OBSERVATORY STAFF

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CONTENTS

PLATES

SUMMARY

The activities of the Port Moresby Geophysical Observatory for 1964 are summarised.

The established programme of recording and distribution of geomagnetic, seismic, and ionospheric data was continued.

A programme of crustal structure investigation was commenced after special long-period seismographs had been received from overseas and had been tested in the observatory.

Earthquake statistics are given for 1963 and 1964.

1. INTRODUCTION

This is the third annual report of the activities of the Port Moresby Observatory. Basic information on observatory equipment and operations are given in reports for 1962 (Observatory Staff, 1965) and 1963 (Brooks & Cookson, 1965).

This report includes a description, and statistics, of seismicity for the years 1963 and 1964 in the Territory of Papua and New Guinea. This will be continued in future reports and it is intended that the annual report will thereby provide a source of annual earthquake statistics on which other studies can be based.

The proposed crustal structure investigation commenced late in 1964 but a description of operations and an assessment of the project is being left for the 1965 report.

During the year increasing use was made of a computer programme to establish variometer calibration data.

Signals from an artificial satellite were recorded on magnetic tape from October. The programme is expected to last for two years.

2. SEISMOLOGY

Routine seismological recording was maintained with instruments described in previous annual reports. Altogether 3408 earthquakes were listed in provisional bulletins.

Instrumentation

Regular performance and calibration checks were made on the World-Wide Standard and the Wood Anderson seismographs. The Sprengnether Series H and Wilson-Lamison vertical records were compared with the Standard Seismograph records to determine approximate magnification curves. In September the Series H seismometers were heavily overdamped to broaden the response and decrease the gain to about 500 to ensure more complete recording of large earthquakes. Calibration results have been summarised by Ripper (1966).

A USCGS modification team visited the observatory in August, made minor modifications to the standard system, and carried out an equipment performance check. Following their visit minor changes were made to routine test procedures.

Maintenance to the Standard Seismograph Control Console was required in February, March, June, and July.

Seismographs consisting of ER230 pen recorders and SV282 long-period vertical seismometers for the crustal structure field programme arrived in March. The recorders produced a much noisier trace than expected and extensive testing for most of the year by observatory technical staff was necessary. Modifications were made to the layout of recorder components to reduce induced noise. Otherwise faults were limited to wiring omissions and component failures.

A serious design fault in the seismometers was found in September when period instability with changing mass position was noted. The problem was referred to the manufacturers and had not been solved by the end of the year. Variations of up to 10 seconds were evident over the range of movement of the boom with a 30-second central position free period. This reduced to 1½ seconds at 15-seconds free period, where system gain was much lower, but corresponding phase mismatch was reduced to acceptable levels.

Power supplies for the field stations were received in October. These underwent brief testing in Port Moresby before being installed in the field. This equipment consisted of NCD2 timing and power units designed and built in the BMR workshops, batteries, and battery chargers.

Two systems were installed in the field: one at Tapini in November, and one at Popondetta in December.

A technical handbook and instruction manual for the NCD2 is being written. This cannot be completed until the instrument's performance under field operating conditions has been assessed, probably at the end of 1965. It will be produced as a BMR Record.

Distribution of data

Routine. Distribution of provisional seismic data was continued on the basis described in the annual report for 1963 (Brooks & Cookson, 1965).

Special requests. These were of a similar nature to those received in previous years and included several enquiries and discussions on earthquake engineering problems. Those held with officers of the Department of Works and the Snowy Mountains Hydro-electric Authority, concerning the means of estimating earthquake effects at sites of major hydro-electric installations, are particularly noteworthy and may lead to further examination of the desirability of installing a strong motion accelerometer network in the Territory of Papua and New Guinea.

Seismicity

The USCGS began routine computation of earthquake magnitudes for small earthquakes early in 1963. These data have made an annual assessment of seismicity feasible. Appendix 1 lists the earthquakes catalogued for years 1963 and 1964; corresponding epicentre maps are displayed in Plates 1 and 2.

The map for 1963 (Plate 1) contains magnitudes for only 11 months. Epicentres and focal depths conform closely with the active areas defined by Brooks (1963).

The 1964 map (Plate 2) also shows a typical epicentre distribution. Activity in the Northern District of Papua, represented by three epicentres, is characteristic.

Plate 3 illustrates the number of earthquakes and their energy release as a function of magnitude for both years. The data are inadequate to enable quantitative statistical conclusions to be drawn. The number of earthquakes falls off sharply below about magnitude $4\frac{3}{4}$ in both years, and this probably represents the threshold below which complete coverage is not possible with existing instrumentation. In reviewing these data two factors should be recognised:

(a) USCGS do not compute epicentres unless recordings of acceptable mutual consistency are available from at least five stations. This severely restricts data from the Territory of Papua and New Guinea.

(b) USCGS magnitudes appear to be generally much lower for the same event than those listed by the Pasadena Observatory. Magnitude data from the latter source were largely relied upon for statistics until 1962 (Brooks, 1963). The USCGS and Pasadena magnitudes have been compared since January 1963 in two magnitude ranges as listed by Pasadena, i.e. magnitude ranges 6 to $6\frac{1}{2}$ (44 earthquakes) and $6\frac{3}{4}$ to $7\frac{1}{4}$ (32 earthquakes) with the following results:

Pasadena magnitude (range 6 to $6\frac{1}{2}$) = USCGS magnitude + $(0.6 \pm .3)$

Pasadena magnitude (range $6\frac{3}{4}$ to $7\frac{1}{4}$) = USCGS magnitude + $(0.7 \pm .3)$

Computed energy release for six ranges of magnitude 0.5 unit wide are shown. The computations are based on

$$\log E = 11.4 + 1.5\,M$$

where M = USCGS magnitude

In Plate 4 earthquake frequencies for two depth ranges are compared for both years. Annual epicentre maps plotted on a 1° square grid will constitute a regular feature of future reports of observatory activities in order to accumulate statistical data on which to base an extreme value analysis of return periods for earthquakes of varying magnitude for small unit areas. Such an analysis should provide a means of defining earthquake probability per unit area statistically, with greater confidence than hitherto possible.

Isoseismal diagrams are presented in Plates 5 and 6 for two New Guinea mainland shocks, which were the subject of special study.

Earthquake of 26th February 1963 (Plate 5)

The solution for this earthquake was specially revised by USCGS:

H = 20 hr 14 min 08.7 s

h = 174 km

Lat = 7.5° S

Long = 146.1° E

USCGS Mag = 7.1

The isoseismal pattern was based on 196 written replies to questionnaires from 60 localities. It is noteworthy for its wide area of perceptibility, a feature consistent with the depth of focus. It is elongated parallel to the strike of the cordillera and compressed in the transverse direction. Increased intensities are noted around the Popondetta area, a feature consistent with unconsolidated surface sediments of the area.

The centre of the isoseismal pattern was displaced in a general north-easterly direction. It is premature to say whether this is usual or not. Similar features have been reported in New Zealand, e.g. New Zealand Seismological Report 1957, Bulletin E-138, map 5; and Report 1960, Bulletin E-141, map 4.

Earthquake of 24th April 1964 (Plate 6)

The published USCGS solution for this earthquake was:

H = 05 hr 56 min 10.1 s

h = 106 km

Lat = 5.1° S

Long = 144.2° E

USCGS Mag = 6.3 ± .3

This isoseismal map is based on 148 written replies to questionnaires. A wide area of perceptibility is again noticed although low intensities were not reported to the same extent as the previous case, probably because of the time of occurrence.

Elongation of the pattern parallel with the strike of the cordillera is again apparent, and the enhanced response of the unconsolidated surface sediments in the Sepik district is clearly shown by the widening of the isoseismal pattern north-west of the epicentre.

The questionnaires for these studies were as described by Richter (1958, p. 652). There is considerable evidence that they are unsuitable for describing earthquake effects in the Territory. European style architecture is common only in the towns and larger administration centres. A more suitable questionnaire could make greater reference to traditional local building types (which vary) and effects on trees and bushes, as well as surface effects to be expected on different types of ground, e.g. river banks, road cuttings, etc.

Crustal structure studies

Brooks and Ripper (1966) discussed the technique and instrumentation to be employed.

Outstations at Tapini and Popondetta were installed in November and December 1964. Operational problems which had emerged by the end of the year included:

(1) Siting of seismometer. Existing buildings may be unsuitable because of the influence of temperature variations on them and their poor insulating qualities.

(2) Timing. Despite the facilities for the simple determination of time corrections, unskilled people may continually experience difficulties in making reliable observations.

The insulated fibre glass seismometer vaultlets were initially designed with the object of burying the seismometer below ground level. While this would be possible it has been found that regular calibration and testing of the instruments would be so awkward as to make the proposal impracticable. These vaultlets are being successfully used as instrument covers.

Inadequate field experience had been obtained by the end of 1964 to permit a comprehensive review of operational and maintenance aspects of the programme. Detailed discussion of these will be incorporated in the annaul report for 1965.

The programme is being conducted with the co-operation of the Asministration of TPNG, who are permitting out-station facilities to be used and who are making staff available for routine duties.

3. GEOMAGNETISM

The routine data recording, analysis, and distribution programme was continued during 1964. Approximate mean values of the three field components at epoch 1964.5 were

H : 0.36356 gauss, decreasing by about 0.00020 gauss anually

D : 06° 07.4' E, increasing by about 1.5' annually

Z : -0.22967 gauss, decreasing numerically by about 0.00030 gauss annually.

The monthly mean values for 1964 are listed in Appendix 2. The secular variations of H, D, and Z from 1959 to 1964 are plotted in Plate 7.

Normal-run La Cour variometer (15 mm/hr)

Sensitivities.

Element	Scale value (per mm)
H	3.0 gammas until 20th February
	2.8 gammas from 21st February
D	4.7 gammas (0.44 minutes/mm)
Z	3.2 gammas

Operation. Routine weekly calibrations of the H, D, and Z normal-run variometers continued, using QHMs 187, 188, 189, Askania declinometer 580333, and BMZ68. The orientation of the H variometer magnet was measured and adjusted in February, and re-measured in June. The orientation of the D variometer magnet was also measured in June.

Rapid run La Cour variometer (180 mm/hr)

Sensitivities.

Element	Scale value (per mm)
H	1.2 gammas
D	0.3 gamma (0.03 minutes/mm)
Z	0.4 gamma

Operation. Considerable record was lost from time to time because of mechanical drive failure. The recorder was overhauled in September, and subsequent performance improved.

In July and August, a dynamic calibration test of the rapid-run system was carried out by means of a Hewlett-Packard low frequency oscillator. The variometers were found to be excessively underdamped and sensitivities too low to adequately record micro-pulsations with periods below about 30 seconds (Wilkie, 1966).

Instrument standardisation

In September, a series of simultaneous observations was made with Askania earth inductor 5111081, BMZ68, and QHM187 to determine a provisional correction to BMZ68. The accuracy of these observations was too low to warrant any change from the previous value of zero gammas.

In October, a series of intercomparison observations between the Port Moresby QHMs 187, 188, and 189 and the International QHMs 460, 461, and 462, was made to re-determine the corrections on the Port Moresby instruments to Toolangi Provisional Standard.

The following corrections were obtained:

QHM	Correction (gammas)	(Gammas/gauss)	Date	Place
187	-82	-224	October 1964	Port Moresby
188	-69	-189	"	" "
189	-26	- 72	"	" "

Baseline adoptions

During 1964, computations of baselines for the period 1959 to 1962 continued. The method has been described by Brooks and Cookson (1965) and Brooks and Wilkie (in prep.). H temperature coefficients and baseline drift rates were computed on an IBM 1620 by D. E. Winch of the University of Sydney. Baselines were adopted from these data for three separate intervals of the 1959 to 1962 period.

Data distribution

Routine. Transient magnetic effects, including storms, pulsations, and K Indices, were listed from the magnetograms and distributed monthly to ten recipients. Microfilms of magnetograms were sent regularly to BMR headquarters, Melbourne, for processing. Subsequently, one set of microfilm copies was forwarded regularly to National Aeronautics and Space Administration, USA.

Special requests. Requests for data were complied with. The main ones were:

Assistant Director (Petroleum Exploration) BMR Canberra - copies of magnetograms

Dr Veldkamp, Royal Netherlands Meteorological Institute, de Bilt - station particulars

Rev. Fr. A. Romañá, Observatorio del Ebro, Tortosa, Spain - check lists of rapid variations

J. S. Milsom, Party Leader, BMR, Aeromagnetic Party, Tennant Creek - copies of magnetograms

United States Army Electronics Laboratories, Fort Monmouth, New Jersey - copies of magnetograms

4. IONOSPHERIC

The IQSY ionospheric sounding programme was continued throughout the year with the standard fifteen-minute sounding schedule supplemented at times on special request.

Routine recording of NASA S66 satellite transmissions began in October.

Equipment

The ionospheric sounder was kept in normal operation throughout the year.

No major modifications were made to the sounder, but maintenance was required every month, except two, to keep the unit in a satisfactory condition. The majority of breakdowns occurred in the high tension power supplies and the power amplifier unit. In July, the silicon diodes were replaced by mercury vapour rectifiers, which had been in the rectifier circuits originally, to provide transmitter bias supplies and display unit high tension. This was necessary because so many failures of the silicon diodes had occurred.

Failure of the driver-stage transmitter amplifer tubes occurred frequently. These tubes were unable to sustain the required drive to the final stage, resulting in either tube failure if they were driven hard or inadequate drive to the final stage, resulting in low power transmission. The fault is inherent in the design and can only be eliminated by redesigning the unit. It is anticipated that a power amplifier from a type IIID recorder will be installed in 1965.

Other maintenance was relatively minor and involved mainly the variable frequency oscillator unit (mechanical parts), display unit, and frequency marker.

The scintillation recording system (Brooks & Cookson, 1965) required very little maintenance.

Distribution of data

Routine. The normal hourly soundings were scaled for the usual parameters, which were forwarded to IPS at monthly intervals. Six hourly foF2 values were telegraphed to IPS weekly, and f-plots and profile height scalings were drawn for Regular World Days.

Monthly median values of foF2 for 1964 at 00, 06, 12, and 18 hours 150° EMT are shown in Appendix 3.

Tape recordings of S66 transmissions were made for two orbits a day from 10th October, when the satellite was launced. Predicted times of transit are received each month from the Radio Research Board at Sydney University and tapes were forwarded every four days.

Special requests. Continuous soundings (one run per minute) were made at the time of launching of NASA satellite S66 on 10th October.

Continuous soundings were also made on Regular World Days (three per month) beginning in October. These were requested by the Symposium on Ionospheric Irregularities. Soundings commenced approximately half an hour before local sunrise and finished at 2200 hours local time. They will continue throughout the IQSY.

Prior to the initiation of routine scintillation recording in October, useful recordings were made of transmissions from Russian satellites "Cosmos 23", which failed early in January, and "Elektron I" from early February until the end of March.

Some known characteristics of equatorial and higher latitude Spread-F have been summarised by Briggs (1964) and Rangaswamy and Kapasi (1963 & 1964). In Plate 8 some F region characteristics at Port Moresby are compared with sunspot number for years of decreasing and low solar activity. These data do not represent a detailed study but, in keeping with the purpose of this record, indicate in a general way some features of the F region at Port Moresby. The known strong seasonal fluctuations in both foF2 and Spread-F are apparent, and at least in this portion of the sunspot cycle, the maximum incidence of Spread-F occurred in winter months. There is no obvious correlation with fluctuations in sunspot number.

In view of the facilities for observation at Port Moresby and known correlations between different features of the ionosphere, a pilot study of possible correlations between ionospheric and geomagnetic characteristics, using vertical incidence soundings, satellite scintillations, geomagnetic indices, and geomagnetic micropulsations, may indicate whether or not a detailed investigation of any particular aspect would be warranted, having regard to the observatory programme and facilities.

5. MISCELLANEOUS

New equipment

The observatory took delivery of the following new equipment during 1964:

Labtronics time signal receivers	(2)	January
Tektronix type 545 C.R.O.	(1)	February
ER230 U.E.D. seismic pen recorders	(3)	March
SV282 U.E.D. long-period vertical seismometers	(3)	March
Motor mower	(1)	March
NCD2 timing and power units	(3)	October
"Nife" batteries	(3)	October
Battery chargers	(3)	October

The following new units of equipment were constructed by observatory technical staff during 1964:

Darkroom timer	(1)	June
Seismograph calibration and battery monitor units	(3)	November

Miscellaneous maintenance

Maintenance was required to the following equipment, other than the principal recording units:

Synchronome master pendulum and slave clock timing system	January, September
Time signal receivers	June, October, November
"Advance" audio generator	July
Telequipment serviscope	April, May, August
Radio transceivers (for Commonwealth Department of Works)	July

Reports

The following draft reports were completed during the year:

"Seismicity of the Territory of Papua and New Guinea" by J. A. Brooks for presentation at Third World Conference on Earthquake Engineering in New Zealand 1965.

"A Proposed Investigation of Crustal Structure in TPNG" by J. A. Brooks and I. D. Ripper. BMR Record No. 1966/33. Presented at Seismology Symposium in Hobart, August 1964.

"Annual Report of Port Moresby Geophysical Observatory, 1963". BMR Record by J. A. Brooks and C. L. Cookson. BMR Record No. 1965/46.

Buildings

One additional residence was purchased for observatory staff during the year, making a total of five.

All assets were maintained to required standards by the Commonwealth Department of Works.

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APPENDIX 1

Earthquake catalogued for 1963 and 1964

	Date	Lat. °	Long. °	Depth(km)	USCGS Mag.	PDE No. *
1963						
January	1	6.8	155.9	165	-	1
	1	6.9	155.5	82	-	2
	2	5.8	150.0	33	-	1
	2	4.6	144.8	51	-	4
	3	5.3	151.5	74	-	3
	3	6.9	155.2	91	-	2
	3	5.9	155.0	99	-	2
	4	4.7	153.2	162	-	2
	4	4.7	154.0	69	-	2
	6	5.7	147.3	141	-	2
	6	4.9	153.8	131	-	3
	7	6.4	154.7	80	-	3
	13	6.5	149.3	29	-	8
	17	5.3	151.7	72	-	9
	21	5.5	149.0	173	-	8
	21	2.7	150.1	50	-	8
	21	4.3	152.5	110	-	9
	22	6.5	146.6	97	-	8
	25	4.6	147.4	33	-	13
	27	5.2	152.3	72	-	10
	28	2.6	149.9	33	-	10
	29	4.7	153.5	126	-	14
February	2	7.1	155.7	96	-	13
	4	6.3	149.1	36	-	11
	6	5.3	145.0	90	-	16
	6	3.5	146.0	33	-	14
	12	6.7	147.1	120	4.8	14
	14	5.0	144.6	80	6.0	16
	15	6.1	151.2	53	4.8	15
	16	0.6	147.5	33	5.0	15
	16	5.0	144.5	82	4.6	17
	17	4.8	144.2	35	5.7	17
	20	6.3	154.0	37	5.1	15
	26	7.5	146.2	171	7.1	16

	Date	Lat. °	Long. °	Depth(km)	USCGS Mag.	PDE No. *
February	27	6.0	149.4	52	5.2	19
	27	6.3	149.2	59	4.5	19
	27	4.6	152.9	100	5.0	18
	27	6.2	149.2	59	4.5	19
March	2	5.1	144.3	69	5.0	19
	2	1.8	143.6	129	5.3	18
	5	6.4	149.0	60	4.4	21
	5	6.3	149.1	19	4.1	21
	6	9.8	155.2	60	5.1	26
	7	6.0	148.6	59	4.2	21
	9	3.2	147.0	33	4.8	23
	9	3.2	147.1	33	4.9	21
	12	7.1	156.0	97	5.2	21
	14	5.9	144.6	33	4.3	22
	19	5.4	152.1	65	-	27
	21	5.5	152.2	33	4.8	29
	23	4.9	145.7	51	4.6	24
	23	6.5	147.9	33	-	27
	24	5.8	151.0	33	4.8	27
	24	3.2	146.8	33	5.0	24
	31	6.1	149.0	60	5.7	27
April	1	6.0	149.0	64	4.8	29
	2	6.1	149.1	65	-	27
	3	6.1	149.1	61	4.9	29
	6	5.1	145.5	57	4.8	30
	6	6.0	149.9	49	-	27
	8	4.2	152.2	158	4.8	30
	8	5.6	151.9	41	5.0	30
	9	4.0	151.0	33	-	31
	14	5.4	154.2	142	5.2	31
	21	3.2	146.9	33	6.0	34
	22	5.1	154.1	132	5.2	33
	23	5.1	146.1	134	-	35
	29	7.9	158.7	72	4.8	36
May	12	3.4	146.9	33	4.9	38
	13	5.5	154.6	386	5.1	42

	Date	Lat. °	Long. °	Depth(km)	USCGS Mag.	PDE No. *
May	13	6.0	150.1	94	-	40
	14	4.1	152.8	58	4.8	39
	15	3.4	146.8	33	5.7	39
	26	6.9	155.6	87	5.0	42
June	2	6.1	154.4	49	5.8	45
	5	3.6	149.6	33	5.1	46
	8	5.5	147.0	170	5.1	48
	10	4.6	152.0	174	5.2	49
	10	5.1	151.7	112	4.9	47
	10	4.5	152.8	69	5.2	47
	13	4.6	153.2	54	5.0	49
	16	4.5	153.0	72	5.7	49
	19	3.5	153.4	279	5.1	49
	22	6.1	154.4	64	4.9	50
	23	6.0	146.6	61	5.3	50
	25	7.2	154.8	207	4.8	54
	28	4.7	144.5	83	4.8	53
July	5	3.0	141.9	68	4.7	55
	12	5.5	153.3	56	5.0	57
	14	8.9	148.7	26	-	58
	22	6.1	148.9	59	5.1	58
	24	6.4	147.8	55	4.5	61
	24	9.7	154.4	16	5.2	60
	28	4.9	152.7	69	4.9	61
August	1	7.0	146.1	174	4.7	65
	3	7.6	156.8	402	5.1	62
	3	6.7	147.5	83	-	64
	4	5.2	145.9	59	4.9	63
	8	5.8	151.0	48	5.6	65
	9	3.0	152.3	143	5.3	64
	10	3.2	141.9	88	-	64
	11	4.7	145.4	86	5.5	67
	12	5.9	146.5	100	4.4	68
	14	4.9	152.3	62	5.8	65
	14	9.3	158.3	33	4.7	66
	20	5.5	145.8	90	-	68

	Date	Lat. °	Long. °	Depth(km)	USCGS Mag.	PDE No. *
August	21	5.5	147.7	164	4.4	70
	27	5.5	149.3	162	4.2	70
September	2	6.0	154.8	321	4.2	74
	4	0.9	145.7	33	5.5	73
	7	7.1	148.1	64	4.8	73
	9	4.4	152.7	34	5.6	70
	11	4.1	151.8	205	4.5	78
	15	5.9	146.7	89	1.4	77
	18	3.3	139.9	90	5.8	76
	22	5.2	150.6	45	5.2	81
	23	5.6	153.8	80	5.1	78
	26	5.6	148.0	156	4.9	79
	26	3.3	141.9	33	5.3	78
October	2	5.4	152.0	65	5.6	80
	7	1.0	147.5	68	5.0	82
	8	3.4	150.8	33	5.1	86
	10	5.6	145.6	102	4.7	83
	21	3.3	150.2	43	-	87
	23	6.9	148.4	29	-	89
	26	5.2	152.0	73	5.9	87
November	2	6.2	154.4	63	5.9	94
	18	3.6	143.4	33	5.2	100
	20	5.5	148.2	201	5.2	95
	22	6.1	154.3	78	4.7	97
	24	6.1	147.6	75	4.6	97
	26	9.5	155.5	33	4.6	102
	29	5.3	151.6	58	5.0	99
December	1	3.9	146.3	33	5.6	99
	1	4.6	154.8	479	4.6	97
	3	6.2	147.6	97	5.2	99
	6	5.8	150.3	61	5.3	102
	10	7.1	155.5	88	4.6	101
	13	3.5	140.1	44	5.8	107
	14	5.2	151.7	54	4.9	107
	14	2.8	140.8	33	-	102
	14	5.4	152.3	43	5.1	104

	Date	Lat. °	Long. °	Depth(km)	USCGS Mag.	PDE No. *
December	14	7.1	155.7	95	4.5	105
	17	6.5	146.8	33	4.8	103
	21	7.3	155.1	133	4.3	107
	22	6.1	146.9	102	5.4	104
	23	5.3	144.9	65	-	109
	24	5.0	155.1	197	4.5	106
	24	6.9	147.4	49	-	108
	24	6.6	146.8	53	-	106
	27	8.3	156.5	33	4.5	108
	28	5.1	153.5	70	5.5	105
	29	6.1	148.9	86	4.5	109
	29	4.1	151.9	119	4.9	110
<u>1964</u>						
January	2	8.4	157.1	33	5.5	1
	3	5.9	146.7	34	4.6	3
	4	3.4	149.2	33	4.3	5
	4	5.5	150.0	117	5.2	2
	8	5.0	144.3	72	5.1	3
	8	6.9	155.3	101	4.2	5
	12	5.4	146.8	229	5.6	6
	14	5.2	150.8	169	5.6	5
	15	7.1	154.8	55	4.9	12
	19	4.2	152.8	33	5.1	6
	24	4.2	154.2	416	4.3	9
	24	5.9	154.0	85	-	9
	24	5.6	146.7	141	-	9
	25	6.3	145.6	134	-	9
	25	5.2	153.1	64	4.6	9
	25	5.3	153.2	42	4.8	9
	28	6.3	148.7	33	5.1	8
February	5	3.8	141.3	110	4.5	12
	5	3.7	140.0	55	-	14
	7	5.8	154.0	77	4.6	13
	11	7.1	154.5	78	-	24
	12	3.5	146.6	33	5.4	15
	13	3.5	146.6	33	5.3	15

	Date	Lat. °	Long. °	Depth(km)	USCGS Mag.	PDE No. *
February	13	5.7	149.1	148	-	16
	14	5.1	151.7	55	6.0	15
	15	5.3	151.9	56	-	19
	15	4.8	152.4	71	5.5	15
	15	8.7	157.1	52	5.1	22
	16	5.6	152.0	49	5.6	15
	25	5.6	151.8	42	5.0	20
	27	4.5	143.4	37	5.2	20
March	1	7.1	155.4	100	4.8	17
	3	6.0	154.6	422	4.8	25
	6	6.1	154.4	74	5.8	20
	7	5.6	152.7	62	4.8	24
	8	4.7	152.7	83	4.4	21
	8	4.6	152.6	69	4.7	22
	8	5.1	151.3	156	4.7	20
	12	5.6	153.0	40	-	31
	13	7.0	155.5	95	4.5	25
	17	5.6	151.6	54	4.9	24
	20	6.1	150.4	34	4.9	26
	29	6.7	155.1	68	5.3	31
April	3	4.9	152.1	82	4.8	34
	6	5.1	154.0	116	4.8	34
	7	6.8	155.1	35	4.6	33
	16	7.0	155.7	78	5.4	35
	17	6.6	154.9	85	5.4	35
	20	4.7	143.1	98	-	39
	21	4.8	142.8	62	-	36
	23	6.7	155.0	72	5.0	36
	23	6.6	155.1	60	5.3	36
	24	5.1	144.2	106	6.3	39
	25	6.7	155.0	72	5.1	38
	27	8.6	148.1	110	4.5	39
	29	7.2	155.7	78	5.2	38
	30	4.6	153.2	78	5.2	42
May	5	9.0	156.6	33	5.1	40
	7	4.6	153.5	53	4.6	40
	9	9.2	156.7	26	5.4	46

	Date	Lat. °	Long. °	Depth(km)	USCGS Mag.	PDE No. *
May	10	4.6	153.2	77	4.6	42
	14	4.5	152.9	32	4.9	42
	14	7.6	155.9	33	4.8	42
	15	3.5	149.1	44	4.7	43
June	4	6.1	149.9	54	-	48
	7	5.5	152.4	58	4.9	50
	8	4.9	151.3	221	5.1	54
	8	6.1	153.6	59	4.5	54
	11	2.2	141.2	67	-	47
	11	1.9	141.0	40	5.3	47
	11	2.0	141.2	33	5.7	50
	11	2.0	140.8	18	-	47
	11	2.1	141.2	33	-	48
	12	2.1	141.1	33	5.5	49
	12	6.6	154.7	80	5.1	47
	13	1.9	141.2	33	5.9	48
	13	3.9	154.3	474	5.5	48
	16	2.0	141.1	13	5.9	51
	16	5.8	154.0	60	5.7	51
	20	8.7	148.2	119	-	54
	20	3.3	142.4	33	5.5	50
	24	7.1	155.6	123	5.0	54
	28	1.7	149.6	7	6.4	53
July	1	2.0	141.2	33	-	54
	6	6.3	154.7	49	6.4	57
	8	6.4	154.8	73	5.1	56
	9	1.8	141.6	33	-	57
	10	8.5	147.9	127	-	56
	11	7.3	148.0	58	5.1	56
	20	6.7	154.6	78	5.0	60
	21	4.6	153.3	60	4.9	60
	22	1.9	149.6	78	4.4	61
	24	6.6	154.8	62	5.6	59
	25	1.8	141.0	48	-	64
	26	5.0	142.1	17	4.9	60
	26	3.6	153.5	239	4.5	64

	Date	Lat. °	Long. °	Depth(km)	USCGS Mag.	PDE No. *
July	30	6.0	154.4	79	-	61
	30	1.4	149.2	90	4.7	61
	31	6.1	149.4	63	5.9	61
	31	4.3	152.8	63	4.5	61
August	6	4.2	140.5	50	-	61
	9	6.2	147.9	54	4.3	62
	10	6.4	154.2	166	4.7	67
	10	6.2	154.5	105	5.7	64
	11	5.8	154.1	425	5.3	64
	13	5.4	154.3	383	6.0	65
	16	5.9	151.4	54	5.4	66
	19	5.7	152.8	55	4.5	71
	20	4.0	151.6	192	4.3	67
	23	6.1	149.4	63	4.9	66
	25	5.4	147.1	203	5.0	68
	30	5.0	144.5	93	5.8	70
September	4	4.5	153.5	167	5.6	78
	5	5.8	154.0	69	6.4	69
	5	6.0	153.8	81	4.8	71
	5	5.9	153.7	106	4.6	72
	6	6.0	153.7	90	4.5	71
	6	4.7	144.8	76	5.7	70
	7	4.1	151.7	246	-	72
	12	4.4	144.0	120	6.3	72
	15	6.6	146.8	59	5.1	76
	16	5.9	152.0	29	6.2	76
	22	2.8	141.0	84	5.7	77
	24	5.6	151.8	35	5.3	78
	24	5.5	151.5	92	5.0	76
	26	4.9	153.5	34	5.5	76
	27	5.5	151.6	50	5.4	78
	28	5.2	150.5	224	5.5	79
	28	7.5	146.7	152	4.8	83
October	1	4.0	153.5	128	-	79
	7	6.8	155.2	70	5.5	79
	8	6.5	154.4	74	5.2	82

	Date	Lat. °	Long. °	Depth(km)	USCGS Mag.	PDE No. *
October	11	6.3	145.7	138	5.0	80
	12	4.5	144.5	77	5.2	82
	12	5.6	147.1	195	5.5	81
	13	3.3	149.9	59	5.1	80
	14	5.7	150.5	89	4.0	82
	15	6.6	154.8	62	5.1	82
	17	7.0	155.8	58	4.7	83
	19	4.6	152.9	70	4.9	85
	23	2.7	142.1	33	4.6	87
	24	4.5	152.9	49	5.8	87
	28	6.1	149.3	60	-	88
	28	6.4	154.7	90	4.9	88
	28	6.8	155.1	85	4.8	88
	29	6.9	143.6	33	4.7	86
November	3	1.7	149.8	35	5.8	88
	5	5.1	146.1	137	-	88
	5	5.5	147.2	197	4.9	88
	7	6.5	148.2	48	5.3	89
	7	6.8	148.4	44	-	90
	7	6.7	148.2	69	-	90
	8	5.5	147.0	170	4.7	88
	10	6.1	147.2	80	-	92
	14	5.3	146.8	228	4.3	91
	17	5.7	150.7	45	6.7	92
	17	3.5	150.1	33	5.0	94
	18	6.0	148.2	49	6.1	92
	19	3.4	150.1	38	5.7	92
	19	6.0	150.8	3	6.0	95
	19	6.9	149.9	33	5.6	96
	20	6.2	150.4	61	5.2	94
	20	5.5	150.1	91	-	96
	20	6.2	150.5	44	5.1	94
	20	4.9	145.4	152	5.8	98
	21	6.7	154.3	103	4.9	94
	21	6.2	150.5	43	4.9	92
	21	5.7	150.8	59	4.9	96
	22	6.2	150.4	39	4.7	95

	Date	Lat. °	Long. °	Depth(km)	USCGS Mag.	PDE No. *
November	22	6.2	150.4	47	5.4	92
	22	6.1	150.4	50	4.9	97
	22	6.4	150.6	48	5.1	94
	22	4.9	151.9	86	5.0	92
	23	6.5	150.7	63	4.9	93
	24	6.3	150.7	33	5.5	94
	27	6.0	150.4	37	-	98
	29	5.5	146.2	48	5.0	95
	30	6.4	150.9	37	4.4	99
December	3	6.1	150.6	35	4.7	98
	4	6.4	150.7	19	5.2	95
	4	5.5	151.2	101	5.2	100
	7	5.4	151.3	54	5.8	98
	7	5.1	153.3	57	4.4	101
	7	5.1	145.9	219	5.0	97
	12	6.9	150.6	33	5.9	101
	12	7.0	150.7	30	5.0	101
	12	5.8	147.1	68	5.0	99
	16	3.2	147.5	33	4.9	102
	16	3.2	147.3	33	4.8	102
	17	3.2	147.2	33	4.8	106
	21	5.9	154.3	40	4.8	102
	24	4.4	153.1	93	6.1	105
	29	6.2	155.5	50	5.2	107
	31	7.4	156.0	48	4.8	(105)
	31	4.6	153.0	77	5.1	(105)

* Preliminary Determination of Epicentre (U.S. Dept. of Commerce Earthquake Data Report)

APPENDIX 2

Approximate monthly mean values of geomagnetic elements, 1964

Month	Element		
	H (gammas)	D (° East)	Z (gammas)
January	36,361	06° 07.3'	-22,960
February	361	07.0	958
March	364	06.8	954
April	356	07.0	958
May	353	07.4	965
June	360	07.5	967
July	358	07.4	968
August	355	07.7	976
September	356	07.3	967
October	351	07.7	975
November	354	07.6	978
December	350	07.7	977

Approximate annual mean values

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

APPENDIX 3

Monthly median foF2 frequencies, 1964

Month	00h. E.S.T. (Mc/s)	06h. E.S.T. (Mc/s)	12h. E.S.T. (Mc/s)	18h. E.S.T. (Mc/s)
January	5.8	3.4	8.7	7.4
February	5.0	2.8	8.6	8.0
March	5.7	2.7	10.6	9.2
April	3.8	2.9	9.8	7.8
May	3.0	2.6	6.6	6.2
June	2.8	2.4	5.9	5.2
July	2.9	2.1	6.3	5.0
August	3.2	2.2	7.0	5.5
September	4.1	2.7	8.0	5.7
October	6.0	3.9	10.0	6.8
November	6.5	4.4	9.8	8.2
December	6.4	4.0	9.6	7.8

APPENDIX 4

Co-ordinates of the Observatory buildings

Seismograph vault	: Latitude	09°	24'	33"	S
	Longitude	147°	09'	14"	E
	Height above M.S.L.			220 ft	
Absolute magnetic building	: Latitude	09°	24'	37"	S
	Longitude	147°	09'	17"	E
	Height above M.S.L.			230 ft	
Ionospheric building	: Latitude	09°	24'	26"	S
	Longitude	147°	09'	31"	E
	Height above M.S.L.			130 ft	

Geomagnetic latitude : $-18^{\circ}.7$

Geomagnetic longitude : $218^{\circ}.0$

APPENDIX 5

List of geophysical staff, 1964

Name	Classification	Term of appointment
Brooks, J. A.	Geophysicist (O.I.C.)	Continuous
Ciszek, M.	Technical officer	Continuous
Cookson, C. L.	Geophysicist	Until December 1964
Jones, M. S.	Technical officer	Continuous
Noah, C. E.	Geophysical assistant	Continuous
Ripper, I. D.	Geophysicist	From April 1964
Wilkie, J. R.	Geophysicist	From May 1964
Van Erkelens, C. H.	Geophysicist	December 1963 - March 1964

PLATE 1

(BASED ON G20-7)

To accompany Record No. 1967/2

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. G82/4-30

PLATE 2

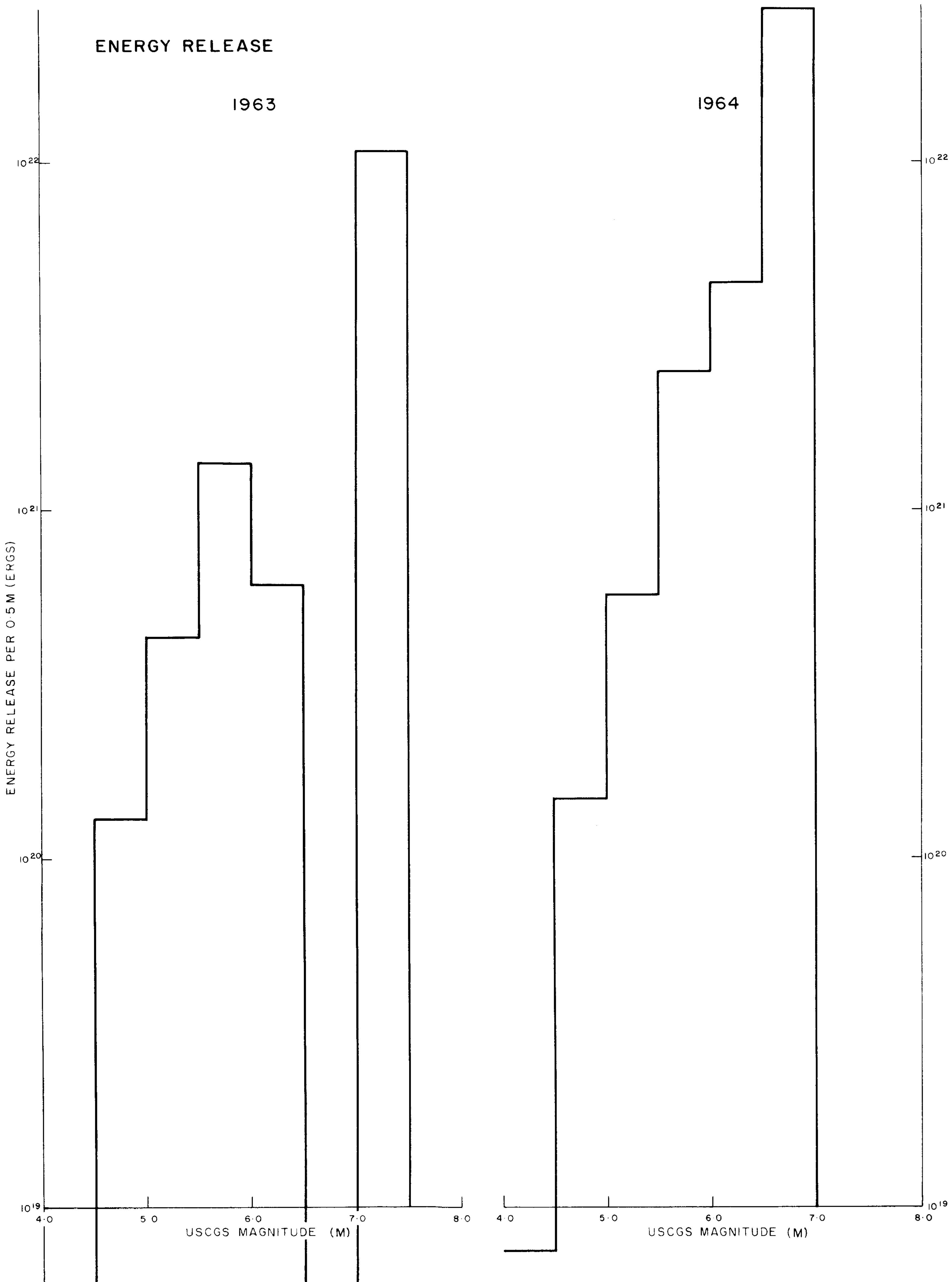
(BASED ON G20-7)

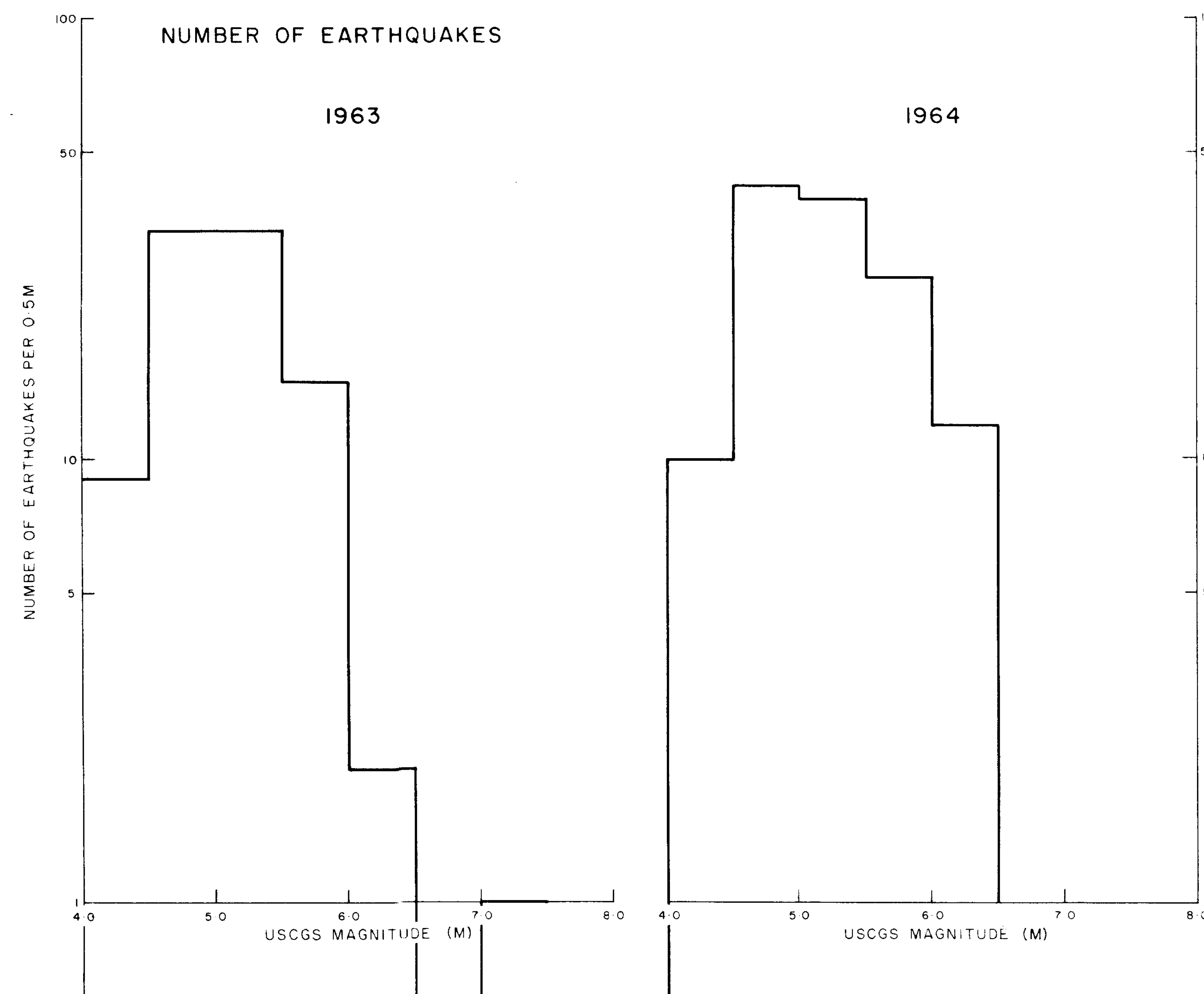
To accompany Record No. 1967/2

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics.

G82/4-31

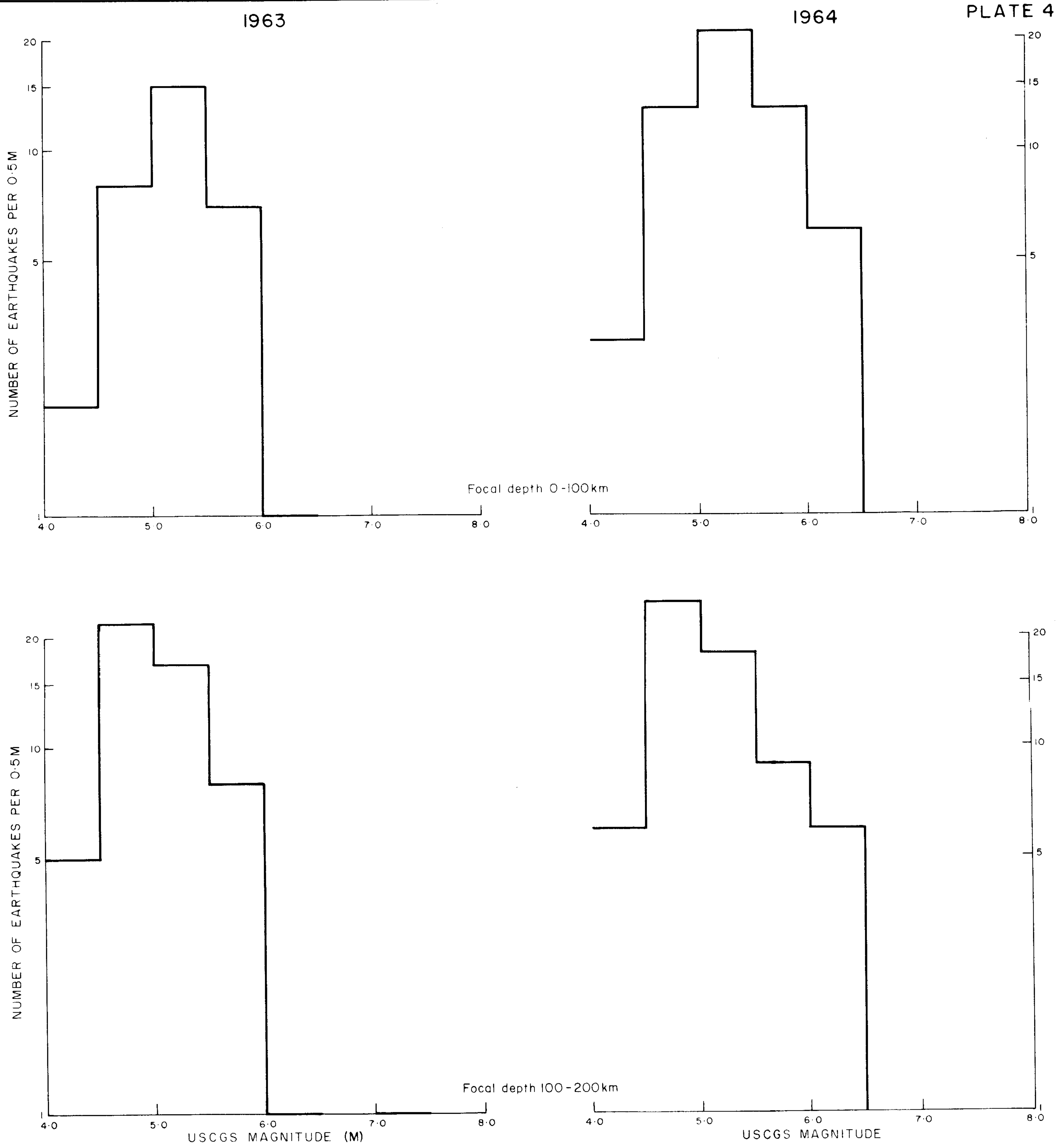
NUMBER OF EARTHQUAKES AND ENERGY RELEASE VERSUS MAGNITUDE FOR 1963 AND 1964





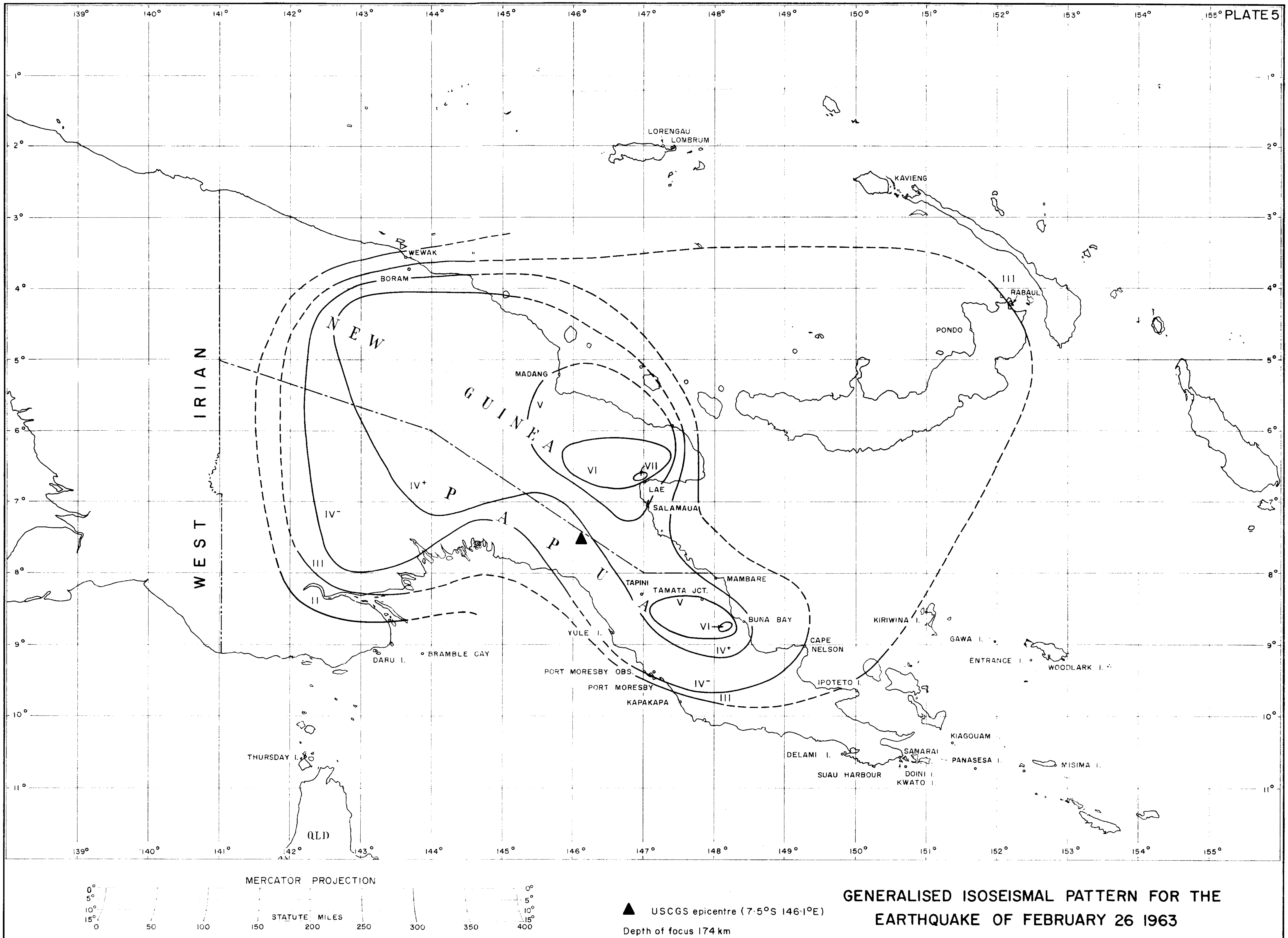
GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS G82/4-34

To accompany Record No 1967/2



NUMBER OF EARTHQUAKES VERSUS MAGNITUDE FOR 1963 AND 1964 FOR TWO FOCAL DEPTH RANGES

PLATE 5



GENERALISED ISOSEISMAL PATTERN FOR THE EARTHQUAKE OF FEBRUARY 26 1963

▲ USCGS epicentre (7·5°S 146·1°E)

Depth of focus 174 km

Magnitude 7·1

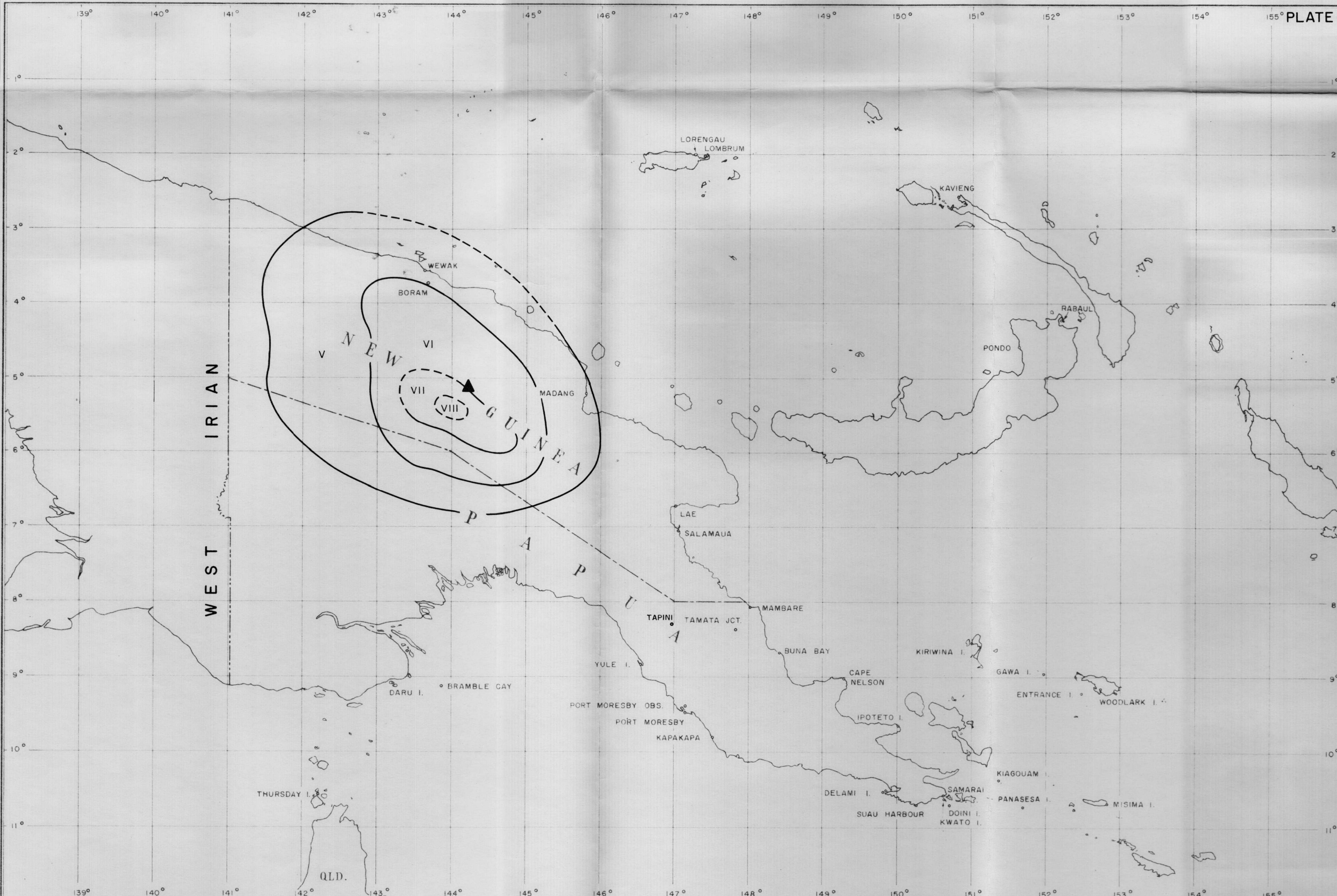
IV Felt Intensities, Modified-Mercalli Scale

(BASED ON G20-18)

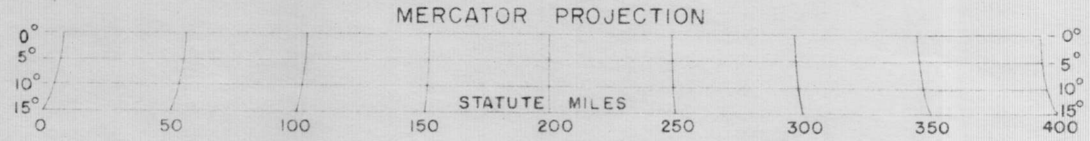
To accompany Record No. 1967/2

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. G82/4-32

PLATE 6



MERCATOR PROJECTION



▲ USCGS epicentre (5·1°S 144·2°E)

Depth of focus 106km

Magnitude 6·3±·3

VI Felt Intensities, Modified-Mercalli Scale

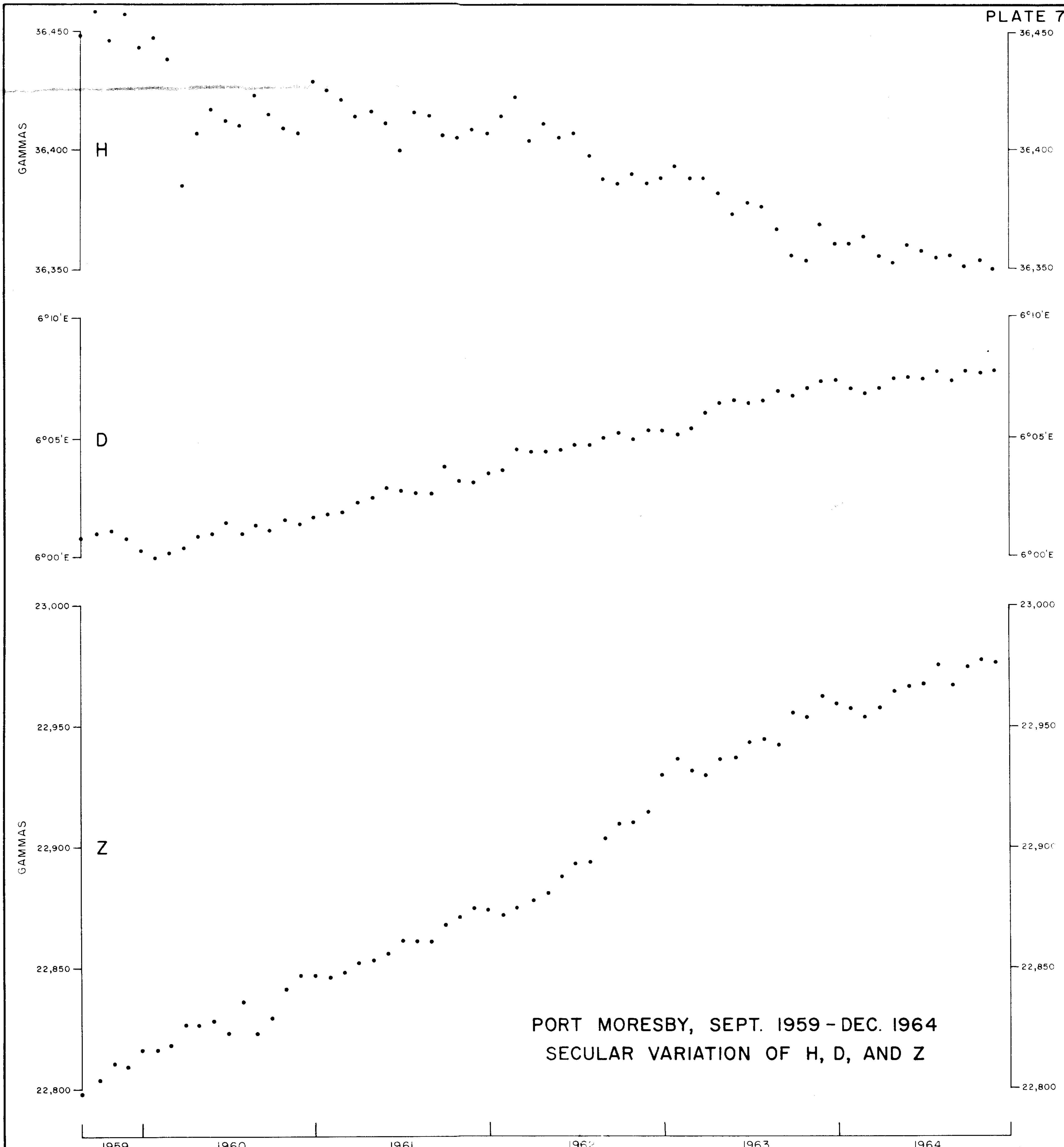
GENERALISED ISOSEISMAL PATTERN FOR THE EARTHQUAKE OF APRIL 24 1964

(BASED ON G20-18)

To accompany Record No. 1967/2

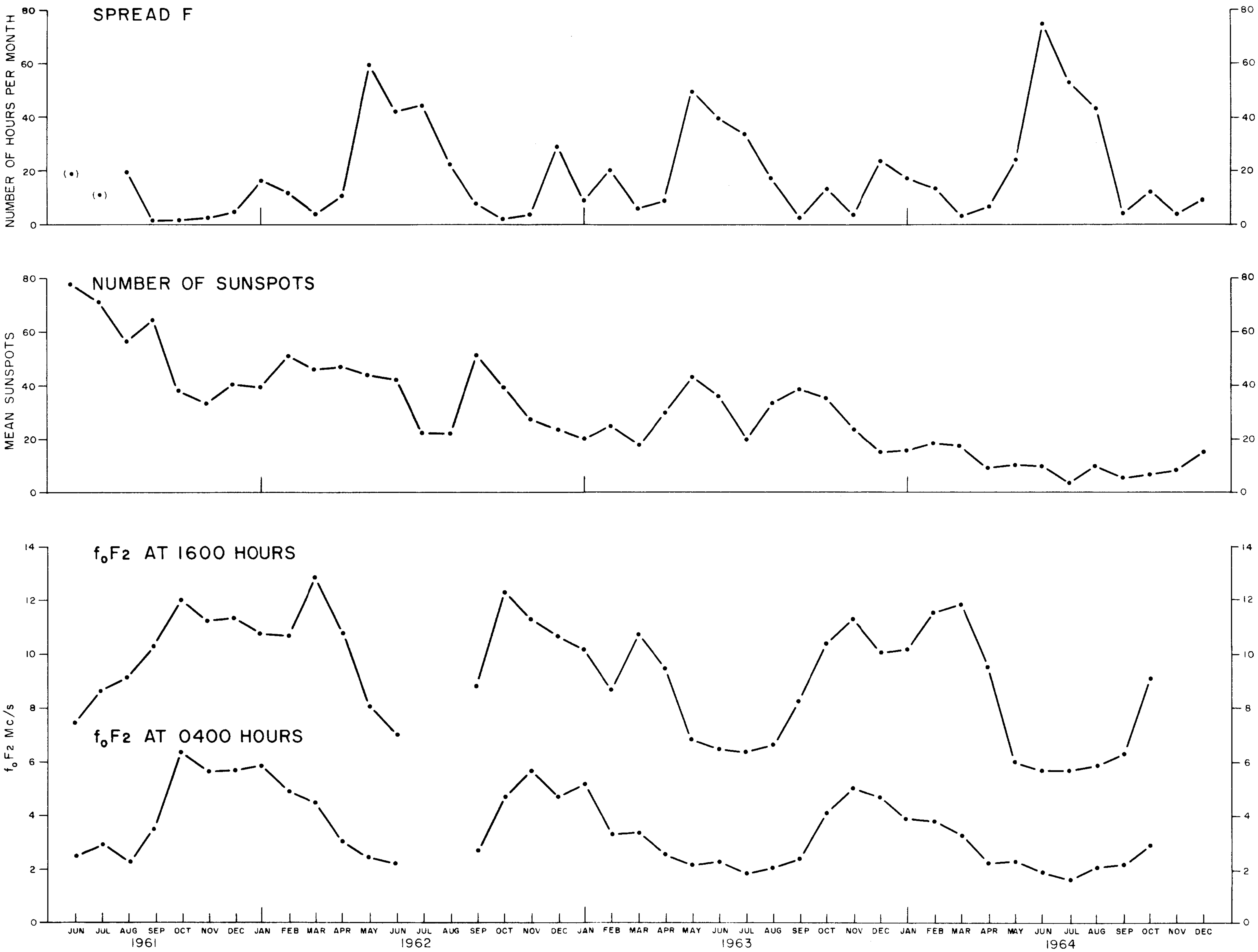
Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. G82/4-33

PLATE 7



To accompany Record No. 1967/2

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS G82/4-36



SEASONAL VARIATION OF MEDIAN f_oF2, SPREAD F AND NUMBER OF SUNSPOTS, 1961·5 - 1964