COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD NO. 1967/122

PORT MORESBY GEOPHYSICAL OBSERVATORY, ANNUAL REPORT 1966

by

OBSERVATORY STAFF

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ILLUSTRATIONS

SUMMARY

All commitments to national and international organisations in the supply of data were fully met during 1966.

Long-period field stations operated at Kerema and Tapini throughout the year. A station operated successfully at Daru and was transferred to Bubia near Lae in November.

The highlights of the year were the Carpentaria Region Upper Mantle Project and the introduction of a programme for systematically investigating felt reports of earthquakes throughout the Territory.

1. INTRODUCTION

This report contains a description of the work carried out at the Port Moresby Geophysical Observatory during 1966. The report is somewhat shorter than previous years because separate accounts will be published on the major activities of the observatory's work at a later date. In particular it has been decided to publish a full account of the 1966 earthquake activity in the Territory, together with an analysis of the seismicity and felt reports, as a separate record. This particular aspect of the Observatory work has become more important in recent months and is of practical interest to a large number of authorities in Papua and New Guinea.

The activities of the group during the Carpentaria Region Upper Mantle Project are also described elsewhere (Denham, in preparation).

In the geomagnetic discipline normal recording was continued throughout the year but failure of two proton magnetometers made inter-comparisons impossible. It is thought that interference from local radio transmitters caused malfunction of the magnetometers.

There were no changes of personnel at the observatory during the year and Table 1 gives the staffing position throughout the year.

2. SEISMOLOGY

Instrumentation at Port Moresby

Routine seismological recording was maintained and regular calibration checks were made on the Standard Seismographs and the Wood Andersons. The characteristics of the different seismographs situated at Port Moresby during 1966 are given in Table 2.

A USCGS inspection team visited the station in April to carry out modifications and routine calibration. Minor maintenance during the year was necessitated because of the general deterioration of component electrical parts due to the humid conditions; an air conditioning system was installed in the vault in December to counteract this. The N-S Benioff was moved on its pier in July to make room for a seismometer installed by the Department of Terrestrial Magnetism, Carnegie Institution of Washington (DTM).

The Wood Andersons and the Sprengnethers continued to operate normally throughout the year. The Wilson Lamison ceased operation in August and was replaced by the short-period medium-magnification channel of the DTM seismometer.

In addition, the long-period medium-magnification channel of the DTM was combined with a Kipp galvanometer to complete the long-period supplementary system. The Kipp has since been replaced by a Lehner and Griffiths galvanometer.

The Department of Terrestrial Magnetism installed their seismometer to investigate the possible existence of a 'plastic zone' situated at depths of from 300 to 800 km beneath South

America. This investigation involves the analysis of SKP at its focus (135°). Port Moresby is favourably located for recording SKP for most of the South American shocks above magnitude 5.5.

For their project DTM installed a vertical component seismometer which records over a wide range of frequency and amplitude. Three displacement and two velocity outputs are recorded on six-channel magnetic tape. The sixth channel contains the timing information, which is taken from the Standard Set and the Synchronome clock in the Ionospheric hut.

Operation has been satisfactory, although a little trouble has been experienced with the Synchronome timing slave circuits and with power failures.

<u>Distribution of data</u>

<u>Routine procedures</u>. During the year a total of 3677 earthquakes were recorded and analysed. These were included in the weekly bulletins which were distributed to 27 institutions. Information was supplied to USCGS by way of bi-weekly telegrams, containing large local events and teleseisms and bi-weekly airmail letters containing all the recorded events.

Re-analysis was carried out on a monthly basis and during 1966 the events from April 1965 to May 1966 were re-analysed. The results were distributed as a supplementary bulletin and the re-analyses were incorporated in the monthly earthquake summaries sent to Canberra for card punching and forwarding to the International Seismological Research Centre at Edinburgh, Scotland.

<u>Special requests</u>. A large number of special requests were received throughout the year, usually for copies of records, polarities of first arrivals, and times of arrivals. More important requests were received from Department of Public Works - felt effects at Lae; C.R.A. Explorations - seismic risk at Bougainville; Messrs Harrison and Crossfield - seismic risk and strong-motion measurements in Central New Britain; Commonwealth Department of Works - strong motion studies at Upper Ramu and earthquake risk at Lae.

All the requests were attended to.

<u>Seismicity</u>

<u>Advisory Committee on Seismology and Earthquake Engineering</u>. During the year His Honour the Administrator approved the formation of an Advisory Committee on Seismology and Earthquake Engineering with the following terms of reference:

(a) To advise Government Departments and non-Government bodies on seismic problems referred to it;

(b) To make recommendations to appropriate Government Departments and other official bodies on matters connected with earthquakes in the Territory.

The committee consisted of Administration officers representing the Department of Works, the Electricity Commission, the Geological Office of the Lands Department and Civil Defence, a representative of the Commonwealth Department of Works, and the Observer-in-Charge, Port Moresby Geophysical Observatory.

The most important aspects of the committee's work are that of evaluating the seismic risk in the Territory and the introduction of a building code which takes earthquake risk into account.

Territory felt intensity reports. During 1966, the Observatory began a regular programme of monitoring earthquakes felt effects throughout the Territory. Questionnaires have been printed and distributed to over 350 observers at all towns and government and mission outposts. Plate 1 shows a copy of the form. These are filled in and returned whenever an earthquake is felt. In addition, extra forms are sent out when a very large event occurs. The response to the forms has been good. Isoseismic maps have been drawn for several large earthquakes and these will be published at a later date.

Territory earthquake magnitude and distribution. The Wood Anderson seismographs are now being used to determine the magnitudes of all Territory earthquakes recorded on them. Epicentre determinations using the Port Moresby, Rabaul, and Charters Towers arrival times are being carried out, to give a more complete picture than that provided by USCGS epicentral determinations. The station Warramunga in Central Australia and the standard station at the South Pole were also found to be good recorders of Territory earthquakes. In some cases local earthquakes recorded at the South Pole and at Warramunga were too small to be recorded at Rabaul.

A report will be issued during 1967 covering the earthquake distribution and magnitudes within the Territory.

Territory short-period stations. Plans were initiated during 1966 for a network of short-period stations in the Territory. The need for such a network is illustrated by the facts that the epicentres of many earthquakes recorded at Port Moresby are unknown, and many earthquakes which are felt are not detected by either Port Moresby or Rabaul.

Some difficulty has been encountered in choosing locations for the short-period stations. The necessary requirements are a quiet, solid rock foundation, electric power, and a suitable institution that can make the daily record change. Most townships in the Territory are built on semi-consolidated river sediments in valleys, which are unsuitable foundations for an observatory. Many areas in the highlands where hard rock crops out are generally not populated, have no electric power, and there are no suitable institutions available. Possible sites that have been ruled out because of these requirements are Lae, Bulolo, Goroka, Mount Hagen, and Mendi. Tapini is an ideal site being on a rocky ridge, with 24-hour hydro-electric power, but it is too close to Port Moresby to be an effective station.

Station instrumentation will initially be a short-period vertical Willmore seismometer and a Willmore recorder. It is intended to install Wood Anderson seismographs when they become available.

Crustal structure investigations

Surface wave project. The network of 15-second period vertical Press Ewing seismographs continued to operate during 1966. Daru was installed in February and removed in October. Bubia (Lae) was installed in November. Port Moresby is included in the project by utilising the long-period Standard Set records.

Data were obtained from the triangles Port Moresby, Tapini, Kerema; Port Moresby, Daru, Kerema; and Port Moresby, Daru, Tapini.

Some record loss occurred owing to ER230 pen recorder failure. Generally, the recorder has not been satisfactory, and does not compare with the reliability of a photographic paper - galvanometer system.

The records were sent to J. A. Brooks at the University of Tasmania for analysis. No results from the project have yet been published.

Operation CRUMP

The Royal Australian Navy detonated three charges in Torres Strait in October 1966 as part of the Carpentaria Region Upper Mantle Project (Finlayson, in preparation). The Port Moresby Geophysical Observatory contributed to the project by installing temporary short-period stations at Tapini, Kerema, Daru, and Sogeri.

The ER230 pen recorders were converted to short-period recorders and the drum speed increased to 180 mm per minute. Willmore seismometers were used at Tapini, Kerema, and Sogeri and the Wilson Lamison seismometer was used at Daru. In addition, a refraction geophone spread was set up at Daru.

The results were plotted in the form of a travel time curve. The Tapini arrival from Shot 11 is 3.5 seconds early and the Kerema arrival 4 seconds late. These results are something of a surprise and can only be explained by an anomalous crustal structure in the Gulf of Papua, or by different transmission paths. The Port Moresby Geophysical Observatory contribution to CRUMP is discussed more fully by Denham (in preparation).

Port Moresby crustal thickness from P-Wave spectra. The layers of the earth's crust act as a filter with respect to seismic energy arriving at a given station. A method has been developed by Fernandez (1967) to use the frequency content of seismic P arrivals to determine the structure of the crust. To be of value the earthquakes must be fairly deep. This is so that reflections from either the surface of the earth or the core of the earth do not interfere with the first arrival.

Several large earthquakes recorded at Port Moresby and Rabaul have been digitised at half-second intervals and Fourier analysed.

Preliminary results indicate a mean crustal thickness at Port Moresby of about 30 km. At the time of writing the Rabaul results have yet to be computed.

Miscellaneous projects

Fiji earthquakes. A phase approximately 10 seconds after the P phase has been noticed on PMG seismograms of Fiji earthquakes. On 131 Fiji earthquakes examined, the phase was clear on 21 cases, and probably present on 56 cases. The existence of the phase appears to bear no relation to the depth of the earthquake or its azimuth. No explanation of the event has yet been proposed.

Focal mechanism survey. A programme is under way to examine the focal mechanism of a number of Territory earthquakes. This study has been made possible by the existence of the World-wide system of Standardised Seismographs.

Eleven earthquakes from 1963 to 1965 were chosen, having magnitudes greater than six. Questionnaires were sent to stations throughout the world, and copies of some records were requested from the USCGS.

The World-wide distribution of seismic stations is rather poor for studies of New Guinea earthquakes because the networks of Europe, America, and Russia are too far away, and they tend to duplicate readings. There are also few stations close to New Guinea, particularly to the north and north-east, in the Pacific Ocean.

At the end of 1966, a computer programme was being formulated to provide the epicentral distance measurements needed for the analysis.

3. GEOMAGNETISM

Mean values

The routine programme of data recording, analysis, and distribution was continued during 1966. Preliminary mean values of the three field components at epoch 1966.5 were:

H: 0.36311 gauss decreasing at about 0.00050 gauss annually

D: 06° 09.4'E increasing at about 1.6' annually

Z: -0.23024 gauss becoming more negative at about 0.00040 gauss annually.

Table 3 contains a breakdown of all the monthly values for the year, and the annual mean values since 1960.

Instrumentation and calibration

The characteristics of the continuous run magnetographs in operation at the observatory are given in Table 4.

No modification to the instrumental arrangements were made during the year. Most of the record loss occurred because of clockwork drive failure, both on the normal and rapid run.

The normal-run magnetograph was calibrated weekly using QHMs 187, 188, and 189, Askania declinometer 580339, and BMZ 68. It was noted early in 1966 that QHM 189 was giving low baseline values and an intercomparison was requested. The previous QHM intercomparison was made in October 1964 with QHMs 460, 461, and 462.

Both the BMR proton magnetometer MNZ1 and the Elsec proton magnetometer were transferred to Port Moresby but neither instrument could be made to work in the Absolute House. Interference from nearby radio transmitters is believed to have caused their malfunctioning because both magnetometers worked satisfactorily at sites further away from the transmitters near the observatory. No intercomparison was therefore possible during 1966.

Reduction of data

The mean hourly value report for 1961-62 was completed by J. R. Wilkie and forwarded to Canberra in February. The data are due to be published in 1970.

Z baselines for the period 13th October 1965 to 27th July 1966 were analysed by Mr. D. E. Winch of the University of Sydney on an IBM 1620 computer and the temperature coefficient was found to be zero. The temperature coefficient prior to 13th October 1965, when the bimetallic strip was adjusted, was -11 gammas/$^{\circ}$C.

K-indices and transient phenomena including storms and pulsations were listed from the magnetograms and distributed monthly to nine recipients. Microfilm of magnetograms were sent monthly to Melbourne for processing. Subsequently, one set of microfilm copies was forwarded regularly to National Aeronautics and Space Administration, USA.

1966 was a year of quiet magnetic activity. The overall average K-index for a three-hourly period was 1.79 as compared to 1.73 in 1965, but towards the end of the year the magnetic activity increased considerably and September 1966 was the most active month since September 1963. Table 5 shows the mean monthly K-index since 1962.

4. IONOSPHERIC

Instruments

In general the overall performance of the ionosonde throughout the year was good. Although record losses average 57 hours per month a substantial proportion of these were due to building repairs, mains power cuts, and programming faults.

The only major change to the equipment was the installation of a triple gain unit in August while recording was interrupted because of repairs to the building. The triple-gain unit enables ionograms to be recorded at low, medium, and high receiver gains each hour.

Six of the nine equipment faults recorded were in either the power amplifier or v.h.t. power supplies. In June a stand-off insulator on the power amplifier chassis, to which the +5000-volt v.h.t. was connected, broke down. The v.h.t. termination was re-arranged and no further difficulties were encountered with the v.h.t. supplies.

It was necessary to remove the Synchronome master clock while repairs were made to the wall behind the clock. When the clock was re-installed its daily rate was erratic. All moving parts were dismantled, cleaned and oiled. Its operation since then has been satisfactory.

During May the filament of one of the power amplifier output valves open circuited and it had to be replaced. In October the first drive stage valve was replaced because of low emission.

Mechanical faults of a minor nature on the cam-drive motor and slave clock contacts were the only other faults that caused record losses.

Data distribution

At the start of the year f-plot scaling ceased, and the number of parameters scaled was reduced to that before IQSY. The values determined throughout the year were f min, foE, foEs, Fo2, and M(3000)F2.

These values were forwarded to I.P.S. at monthly intervals and the six-hourly foF2 values were telegraphed weekly.

5. REFERENCES

DENHAM, D. — Results from Carpentaria Region Upper Mantle Project from the recordings made in Papua, October 1966. Bur. Min. Resour. Aust. Rec. (in preparation).

FINLAYSON, D. — Operational report of the Carpentaria Region Upper Mantle Project. Bur. Min. Resour. Aust. Rec. (in preparation).

FERNANDEZ, L. M. 1967 — Master curves for the response of layered systems to compressional seismic waves. Bull. Seism. Soc. America 57(3), 515 - 543.

TABLE 1

OBSERVATORY STAFF 1966

Name	Classification	Term of appointment
Denham, D.	Geophysicist Class 3 (O.I.C.)	Continuous
Wilkie, J. R.	Geophysicist Class 2	Continuous
Ripper, I. D.	Geophysicist Class 1	Continuous
Cooke, R. S. J.	Geophysicist Class 1	May to July
Jones, M. S.	Technical Officer Grade 2	Continuous
Ciszek, M.	Technical Officer Grade 1	Continuous
Byrne, W. M. J.	Technical Officer Grade 1 *	Continuous
Noah, C. G.	Geophysical Assistant	Continuous

* Held against Geophysicist Class 1 position.

TABLE 2

SEISMOGRAPH SPECIFICATIONS

Standard Seismographs

(a) Short-period instruments (Z, N-S, and E-W)
Ts = 1.0 sec. Tg = 0.775 sec.
Magnification 50,000 at 1 sec.

(b) Long-period instruments (Z, N-S, and E-W)
Tx = 15.0 sec. Tg = 100 sec.
Maximum magnification of 3000 at 15 sec.

Auxiliary seismographs

(a) Series H Sprengnethers (N-S and E-W)
Ts = 15.0 sec. Tg = 15.0 sec.
Maximum magnification about 700 at 4-8 sec.

(b) Wood-Anderson torsion seismograph (N-S and E-W)
Period of both seismographs = 0.8 sec.
N-S magnification about 2000
E-W magnification about 1700

(c) Wilson Lamison (Z) in operation until August
Ts = 1.1 sec. Tg = 1.7 sec.
Maximum magnification of about 11,000 at 1.3 sec.

(d) Department of Terrestrial Magnetism seismometer in operation since August 1966
Ts = 4.0 sec. Tg = 1.7 sec. (for short-period records)
Tg = 15 secs. (for long-period records)

TABLE 3

VALUES OF GEOMAGNETIC ELEMENTS

Preliminary monthly means 1966

	H (gammas)	D		Z (gammas)
January	36,329	06°	08.8'	-23,008
February	36,331	06	09.0	-23,012
March	36,322	06	09.0	-23,013
April	36,321	06	09.0	-23,018
May	36,322	06	09.3	-23,014
June	36,313	06	09.3	-23,020
July	36,306	06	09.5	-23,021
August	36,308	06	09.6	-23,029
September	36,289	06	10.3	-23,033
October	36,296	06	10.1	-23,037
November	36,298	06	10.3	-23,041
December	36,289	06	10.0	-23,044

Annual Mean Values 1960-1966

Epoch	H	D		Z
1966.5	36,311	06°	09.4'	-23,024
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 4

MAGNETOGRAPH CHARACTERISTICS 1966

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

Element	Scale value
H	2.8 gammas/mm
D	4.7 gammas/mm or 0.44'/mm
Z	3.3 gammas/mm

Rapid-run La Cour variometer (180 mm/hr)

Element	Scale value
H	1.2 gammas/mm
D	0.03'/mm or 0.3 gammas/mm
Z	0.4 gammas/mm

TABLE 5

MEAN MONTHLY K-INDEX 1962-1966

Month	YEAR				
	1962	1963	1964	1965	1966
January	1.61	2.00	1.93	1.84	1.85
February	2.21	1.62	1.72	2.04	1.79
March	1.91	1.55	1.99	1.64	1.72
April	2.25	1.79	2.25	1.63	1.58
May	1.62	1.97	2.00	1.40	1.58
June	1.92	1.80	1.82	1.78	1.56
July	1.88	1.87	1.80	1.65	1.62
August	2.37	1.83	1.83	1.98	1.92
September	2.50	2.85	1.83	2.09	2.41
October	2.61	1.90	1.78	1.66	1.54
November	2.27	2.07	1.67	1.56	1.86
December	2.31	1.77	1.60	1.51	2.00
Mean	2.12 ± .09	1.92 ± .09	1.85 ± .05	1.73 ± .06	1.79 ± .07

The limits given correspond to the standard error of the mean.

TABLE 6

CO-ORDINATES OF OBSERVATORY BUILDINGS AND OUTSTATIONS

Port Moresby (PMG)			
Seismograph vault		Latitude	09° 24' 33" S
		Longitude	147° 09' 14" E
	Elevation	67 metres above M.S.L.	
Absolute magnetic building		Latitude	09° 24' 37" S
		Longitude	147° 09' 17" E
	Elevation	70 metres above M.S.L.	
Ionospheric building		Latitude	09° 24' 26" S
		Longitude	147° 09' 31" E
	Elevation	40 metres above M.S.L.	
Geomagnetic Latitude =	-18.7°		
Geomagnetic Longitude =	218.0°		
Daru (DNG)		Latitude	09° 05' 18.6" S
		Longitude	143° 12' 20.5" E
	Elevation	03 metres above M.S.L.	
Kerema (KRG)		Latitude	07° 57' 35" S
		Longitude	145° 46' 08" E
	Elevation	14 metres above sea level	
Tapini (TPN)		Latitude	08° 21' 24.7" S
		Longitude	146° 59' 01.4" E
	Elevation	1000 metres above M.S.L. (approximately)	
Bubia Lae (LAE)		Latitude	06° 45' S
		Longitude	146° 52' E
	Elevation	about 50 metres above M.S.L.	

PLATE I

EARTHQUAKE QUESTIONNAIRE

To Accompany Record 1967/122

G82/4-35

Telephone : 4458

Telegrams :
"Buromin" Port Moresby.

Postal Address :
P.O. Box 323, Port Moresby.

COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT
BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

Port Moresby Geophysical Observatory,
Port Moresby, Papua,

We would be grateful if you would complete the questionnaire form below whenever you feel an earthquake. The results will assist studies being made into the risk of damage to constructions by earthquakes and the general nature of earthquake activity in the Territory. Wherever possible answer simply by underlining the words which are applicable or by adding more suitable words in the blank spaces. Any additional information will be appreciated. If necessary enclose an additional sheet.

Please refold this sheet and return in the envelope provided. Your co-operation would be appreciated.

Dr. D. Denham,
Observer-in-Charge

QUESTIONNAIRE

Name (block letters)..........

Address..........

District..........

Date of shock..........Time..........A.M..........P.M..........

Place where you were at time of shock..........

Motion rapid, slow..........Shook how long..........

Felt by me, several people, many, all..........

Direction of motion felt outdoors : not certain, N., NE., E., etc.

....

Nature of ground underneath locality ; rock, soil, loose, compact,

marshy, filled in..........

level, sloping, steep..........

Awakened me, no one, few, many, all (in my home)..........

(in community)..........

Frightened me, no one, few, many, all (in my home)..........

(in community)..........

Rattling of windows, doors, dishes..........

Creaking of walls, frame..........

Hanging objects, doors, etc., did, did not, swing, N., NE., etc.

....

Trees, bushes shaken slightly, moderately, strongly, fell down

....

Shifted small objects, furnishings..........

Overturned small objects, furniture..........

Cracked plaster, windows, walls, ground..........

Fall of, books, pictures, plaster, walls..........

Broke dishes, windows, furniture..........

Twisting, fall of columns, monuments, water tanks..........

....

Damage : none, slight, considerable, great, total, in building built

of Native Materials wood, brick, masonry, concrete..........

Pets : did the dog, cat get frightened ? Yes. No. Did not notice

....

Animals : what did the animals do ?..........

Noise : I did, did not hear anything..........

It sounded like a truck like thunder, like rolling a galvanized

iron tank..........

The sound seemed to come from over the hill, across the

flat, in the air, below my feet..........

from the N.S.E.W..........

The sound lasted for..........seconds.

Ground : Did people fall over, just stand, just walk, have no

trouble..........

were there landslides, water waves, ground waves, nothing

....

REMARKS.

Signature..........

Govt Print.—A2054/5.67.—1,000.