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DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD No. 1966/173

MELBOURNE OBSERVATORY GROUP ANNUAL REPORT, 1962

by

C.A. van der Waal

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ILLUSTRATIONS

SUMMARY

The Melbourne Observatory Group includes the observatories at Toolangi, Macquarie Island, Mawson, Wilkes, and Darwin and the Melbourne office, but separate reports are published for the Antarctic observatories.

The magnetic observatory at Toolangi operated continuously throughout 1962.

The seismological instruments operated at the Melbourne observatory in the Botanical Gardens until June 1962 when they were transferred to the new observatory at Blue Mount near Toolangi. They operated continuously at the new site for the remainder of the year.

At the Melbourne office, records were analysed and results published and distributed. Preparations for the future use of electronic computers for the analysis of magnetic data were continued and punching of data on paper tape was commenced.

1. INTRODUCTION

This is the first of a proposed series of annual reports on the activities of the Melbourne Observatory Group of the Bureau of Mineral Resources (BMR). The need to compile all activities of the group into one record has been felt for some time and it will provide a comprehensive reference of what happened during the year.

The Melbourne Observatory Group includes the magnetic and seismological observatories at Toolangi, Macquarie Island, Mawson, and Wilkes, the temporary seismological observatory at Darwin, and the Melbourne office. The group is part of the BMR Observatory Section, which also includes the separately operated geophysical observatories at Mundaring and Port Moresby.

The Toolangi Observatories are situated about 3 miles apart and about 36 miles north-east of Melbourne, or 50 miles by road (see Plate 1). The magnetic observatory has been operating at Toolangi since 1919 when it was transferred from the Melbourne Observatory (Dooley, 1959). The seismological observatory was transferred from Melbourne to Toolangi during 1962 (see Section 3). All analysis, reductions, distribution, and publishing of Toolangi results is done in the Melbourne office.

Preliminary data are extracted from the records at the Antarctic stations. These data are then sent to Melbourne for distribution. Final reductions and publishing are done in the Melbourne office.

Mundaring and Port Moresby do most of their own analysis, but the hourly scalings of magnetograms and tape preparation for electronic computing, as well as the publication of these results, is done in the Melbourne office.

2. GENERAL

Interrelation of observatories

Of the seven observatories within the Geophysical Branch of the BMR, four (Toolangi, Macquarie Island, Mawson, and Wilkes) are operated directly by the Melbourne office, while the temporary seismological observatory at Darwin is operated by the Darwin staff of the Metalliferous Group on behalf of the Melbourne Observatory Group.

Each of the three Antarctic observatories forms part of the respective ANARE base, and the geophysicist who operates the magnetic and seismological observatory is seconded to the ANARE during his tenure at the base. Separate reports are published on the work at the Antarctic observatories.

The Mundaring and Port Moresby observatories have independent workshop, library, and data copying facilities. However, the facilities of the Geophysical Branch are used by these observatories for the purchase of supplies, major instrument construction etc., and in such cases contact with the rest of the Branch is made through the headquarters group of the Observatory Section.

Toolangi Observatory, which was formerly operated by the Victorian State Government and later by the Commonwealth Solar Observatory, acts as headquarters observatory for the Observatory Section and provides the standard on

which the values of magnetic elements of all other observatories are based. The Toolangi preliminary standard for horizontal intensity is obtained by comparison with Rude Skov (Denmark); the declination standard is based on the Toolangi Ruska magnetometer; and the preliminary standard for vertical intensity, formerly based on the Schulze earthinductor No. 49, is now based on BMZ119.

The recently developed proton precession magnetometer provides a means of checking the preliminary standards for H and Z, and this will be done as soon as the BMR instrument is operating satisfactorily. The H and Z standards of the other observatories will then also be determined directly with this instrument.

3. TOOLANGI AND MELBOURNE OBSERVATORIES

Magnetic recording

The three elements of the geomagnetic field are recorded with a La Cour magnetograph. This instrument consists of three variometers sensitive to changes in declination (D), horizontal intensity (H), and vertical intensity (Z) and a recording drum rotating at a speed of 15 millimetres per hour. Recording is done by a reflected light beam on photographic paper, which is changed every morning at 1000 hr EST (00 hr GMT). The sensitivities of the variometers are: 1.16 minutes per millimetre for D, 4.6 gammas per millimetre for H, and 4.4 gammas per millimetre for Z. The instruments used for control observations are a Ruska magnetometer for D, three QHMs for H and a BMZ for Z. Continuous recording was maintained throughout the year and control observations were made every week.

Because of irregular scale-values of the Z variometer, the magnet in this instrument was removed in April and the knife edges and agate flats were cleaned. Some improvement in the consistency of the scale-values resulted.

The axle of the recording drum showed signs of wear, and the drum, axle, and supports were replaced in May. The new assembly incorporates ball bearings.

A proton free-precession magnetometer for observatory use was constructed in the geophysical workshop. The complete instrument consists of a detector head, electronic frequency-measuring equipment and power supply, and two vector coils. The instrument without the vector coils measures the total geomagnetic field (F). One coil is used for measuring H by backing off the vertical component and the other coil measures Z by backing off the horizontal component.

When the coils were tested a discrepancy of about 5 gammas was found between H measured with the vector coil and H computed from F and Z. Further investigations revealed that terminal lugs of the H coil were slightly magnetic and that something was wrong with the levelling of this coil. A number of observations at Toolangi showed a larger scatter than was expected from this type of instrument and further observations will have to be done. The instrument without coils was sent to Macquarie Island at the end of the year.

Tables to convert the output of the instrument (counts) to magnetic field values (gammas) were calculated. Also, tables of F as a function of H and Z were compiled covering the range of values at Toolangi, Mundaring, and Port Moresby.

Comparison observations to determine or check instrument corrections were carried out at Toolangi throughout the year as required. In an attempt to standardise the Toolangi instruments (QHMs 288, 289, 290 and BMZ 119) they were compared with the proton precession magnetometer. However, because of excessive scatter the observations will have to be repeated. The adopted Toolangi preliminary standards at 31st December 1962 were: for H, the mean of the values of QHM 288 - 9 gammas, QHM 289 - 10 gammas, and QHM 290 - 12 gammas; for D, Ruska declinometer - 0.3 minute; for Z, BMZ 119 + 38 gammas.

All instruments available in Melbourne were compared with the Toolangi preliminary standard during the year. The instruments used for comparison of the Antarctic station instruments were: HTM 154, QHM 172, BMZs 211 and 221, and declinometer 580339. QHM 174, BMZ 115, and declinometer 509320 were used for field work in Antarctica. HTMs 158 and 704, QHM 306, BMZs 115 and 211, and declinometer 509320 were used for field work in Australia. QHM 177 from Macquarie Island, QHM 189 from Port Moresby, and QHM 301 from Mawson were compared before returning them to their respective stations. Routine comparisons were made with QHMs 460, 461, 462, and 305.

The nuclear explosion at Johnston Island on 9th July caused a disturbance of the geomagnetic field, which was clearly discernible on the Toolangi magnetogram. A copy of this magnetogram is shown in Plate 5.

In November, Dr J. Mainstone of the Physics Department of the University of Queensland installed a micropulsation recorder at the Toolangi Seismological Observatory. The instrument consists of a coil, with a high-permeability core, feeding a slow speed magnetic tape recorder. A pen recorder was connected later to obtain a visual record of the micropulsations. This record was used to identify very small pulsations on the La Cour records from the magnetic observatory. There had been some doubt about what these pulsations were but it has now been confirmed that they are "pt" (pulsation trains). Since installation, the instrument has been operated by the observatory staff, and the magnetic tapes are forwarded to the University of Queensland about once every three weeks.

Advice was received that the electric power supply would be extended past the Observatory early in 1963. The Department of Works was requested to arrange for wiring of the observatory. It is proposed to install floor-heat type of heating in the absolute hut. Improved lighting is expected to ease the reading of instrument circles.

Magnetic analysis

All reductions of geomagnetic data are done in the Melbourne office.

Every week the control observations made at

Toolangi are worked out, and the values of the baselines computed.

At the end of each month the K-indices, which are a measure of geomagnetic activity, are measured from the magnetograms and tabulated. The beginning, end, and intensity of geomagnetic storms are extracted as well as geomagnetic phenomena such as sudden commencements, bays, and certain pulsations.

To obtain hourly mean values of the geomagnetic elements and associated daily and monthly mean values, all magnetograms have to be scaled for every hour of the day for all three components. At one time this was done by hand using a scaling glass, and later by semi-automatic means using a trace-reader, conversion equipment, and punched cards. As this equipment proved to be unsatisfactory, it is now intended to use the trace-reader for scaling, punch the data automatically on to paper tape, and do the conversions on an electronic computer.

A cross-hair on the trace-reader is mechanically attached to a coding disc, and the coding disc electronically connected to a tape punch. When the cross-hair of the reader is set on the mean hourly value of a magnetic trace, the value is punched on paper tape by pressing a foot switch.

The tapes with these data, together with a programme tape, are then forwarded to the University of Sydney to be processed on the Silliac electronic computer. The programme tape includes a programme to derive the Fourier coefficients of degree 1 to 4 for each day. In the Melbourne office the output tape is run through a tape reader, which operates an electric typewriter. The tables of hourly mean values are thus automatically typed in the correct form for photo-litho printing.

During the year the trace-reader was being converted to incorporate the coding disc and electronic equipment for direct punching of scalings on paper tape, but the conversion took longer than expected and no scaling was done during 1962. However, punching of previously scaled data on to paper tape commenced when a punch operator was appointed in August.

After the data are punched it is verified by punching it again on a verifier, which checks it at the same time against the first tape. The checking of the tapes is then completed by comparing the first and second tape again on the comparator. On this instrument the two tapes are run through simultaneously but stop when they disagree.

Although delivery of the tape verifier and comparator was expected about the middle of the year, they did not arrive until December and therefore none of the punched tape was verified and compared.

Hourly values from Gnangara for September to December 1959 were punched and computed on Silliac.

Hourly scalings for Macquarie Island 1955 and 1956 and Watheroo 1948 to 1954 inclusive were punched on paper tape in preparation for reduction on Silliac.

The magnetic tabulations of the IGY years (Toolangi and Watheroo 1957 and all observatories 1958), which had been computed on Silliac previously, were typed and checked, and copies were sent to World Data Centre A, Washington, in January.

An analysis of the correlation between departures from smoothed baseline curves for the three QHMs was carried out by Small (1965). There was a definite correlation, which indicated that fluctuations from the smooth curve are real changes in the baseline values (i.e. in the magnetograph). Therefore, the best instrument comparison results will be obtained with instantaneous observations, or by observing the instruments alternately in as short a time as possible, rather than relying on an average relation between the baseline value and the absolute instrument normally used (Small, 1965).

The magnetic data are distributed as listed in Appendix 2. Requests for about 1000 copies of magnetograms were answered from 13 institutions (mostly overseas). Mean hourly and annual values were sent, on request, to four other institutions.

Seismic recording

The first seismograph was installed at the Melbourne Observatory in 1902. It was a single-component Milne seismograph, which was later replaced by the more advanced Milne-Shaw seismograph. The present Benioff seismograph was installed at the Melbourne Observatory in 1956. From the first, the magnification had to be limited because of traffic noise and it became clear that the instruments would have to be transferred to a quieter site to obtain optimum performance.

For convenient operation it was desirable to have the seismic observatory not too far from the magnetic observatory. Therefore, the Toolangi area was searched for a suitable site, and one was found on Blue Mount, about two miles south of the magnetic observatory. Two buildings were constructed: an underground vault for the instruments and a building containing an office, darkroom, and store. The plans of these buildings are shown in Plate 2.

The installation of the instrumental and control wiring was commenced in February, and in June the first instruments were transferred from the Melbourne Observatory. The transfer was completed by the end of July, when all instruments except the Milne-Shaw were operating at Toolangi. During the next few months a number of adjustments were made and the instruments were calibrated with the Willmore bridge in November. The calibration curves are shown in Plate 4.

Plate 3 shows the calibration curves when the instruments were installed in the Melbourne Observatory before transfer to Toolangi. Comparison of Plates 3 and 4 shows that the instruments are operating at Toolangi at about 10 times the magnification used at Melbourne.

The seismological instruments consist of a set of three Benioff seismometers with a natural period of 1 second. Each seismometer has eight coils, four of which

are attached to a 0.25-second galvanometer and four to a 14-second galvanometer. The three short-period galvanometers record on to separate photographic traces on three drums moving at a speed of 60 millimetres per minute. The three long-period galvanometers record similarly with the drums moving at 30 millimetres per minute. An east-west component Milne-Shaw seismograph was also operated at the Melbourne Observatory most of the time. At the Melbourne Observatory the recording drums were rotated by synchronous motors, which operate from the mains power supply and thus are dependent on mains frequency. Time marks were recorded on the traces every minute, except on the hour, by the closing of electrical contacts on a slave clock, which was driven by a Synchronome master clock. At the beginning and end of the day's records, P.M.G. time marks were recorded manually by pressing a morse key synchronous with the telephone time pips.

Before they were moved to Toolangi the Benioff recorders were overhauled in the workshop.

To cope with any power failures an emergency power supply with automatic switch-over was installed at Toolangi. However, during the year it was found that the electric supply failures lasted longer than expected, and that the emergency power supply was not sufficient to take over completely. An increase in the capacity of the emergency power supply is therefore proposed.

At Toolangi the synchronous motors of the recorders are operated by a crystal controlled power supply. The rate of rotation of the recording drums is therefore much more regular than at the Melbourne Observatory.

The time marks are also operated by the crystal controlled supply. The P.M.G. time pips are directly put on near the beginning and end of the records so that human error is eliminated. A Synchronome master clock is operating continuously as a standby in case of failure of the crystal clock.

The crystal clock has been working well although its rate appears to be temperature dependent to some extent. This is being investigated.

The records are changed and processed by R. Biggs, a local resident of Toolangi, who also posts them to Melbourne daily, except on Sundays.

It is proposed to install a vertical seismograph at the Melbourne Observatory with remote visual recording in the office when the necessary equipment is available.

Seismic analysis

A preliminary analysis of all recorded earthquakes is carried out immediately after receipt of the records.

The main phases are forwarded by air letter to the USCGS, for epicentre determination, twice a week.

Once a week the preliminary readings are compiled into a bulletin, which is sent to the seismo-

logical observatories at Mundaring, Port Moresby, Darwin, Hobart, Canberra, Adelaide, Brisbane, Riverview, Rabaul, Wellington (NZ), Apia (Western Samoa), Pasadena (USA), and USCGS, Washington (USA).

In January a request was received from Dr P.L. Willmore of the Royal Observatory, Edinburgh, who was organising an automatic data processing system for the International Seismological Summary, asking some of our seismic stations to co-operate in an experiment with the use of mark sensing cards for the production of world bulletins using this system. It was agreed to co-operate, and a quantity of IBM cards and some special marking pencils were received in due course. The information is provided by Toolangi and Mawson observatories. The cards are filled in after the USCGS epicentre cards have been received, so that the original readings can be checked and amended if necessary.

During the year a nomogram for the determination of epicentral distances from longitude and latitude of the eipcentre was constructed for the Toolangi Seismological Observatory. This allows a much more accurate determination of the distance than by scaling from a globe.

Considerable difficulties are being experienced in searching for data required for earthquake studies, and, as the amount of collected data is rapidly increasing, it may soon become almost impossible to find the required data. It has therefore been proposed to list earthquakes together with the relevant epicentral and recording station data in a magnetic tape file. The data to be listed in such a file are already published by the USCGS and could be punched directly from their earthquake-data reports on to paper tape. It is proposed to list only earthquakes from Australasia and south-west Pacific regions recorded by stations in this area. It is estimated that this would include about 1500 earthquakes per year.

Requests for copies of seismograms for 21 earthquakes were received from six Australian and overseas institutions. A large number of telephone enquiries about local tremors were also answered.

4. ANTARCTIC OBSERVATORIES

The observers from Macquarie Island, Mawson, and Wilkes (J. Milne, R.J.S. Hollingsworth, and W. Burch, respectively) were at head office most of the year to analyse the observations made at those stations during 1961.

The seismograms were checked and re-analysed when necessary, and the results were published in an annual bulletin.

Magnetic phenomena, such as sudden commencements, bays, etc., were abstracted from the records and forwarded to the IUGG Committee on Rapid Magnetic Variations. A list of magnetic storms was sent to the Journal of Geophysical Research, Boulder, USA.

Control observations, standardisation observations, and sensitivity determinations were checked, and scale and baseline values were adopted. The data were prepared for punching on paper tape for further processing by Silliac.

5. DARWIN SEISMOLOGICAL OBSERVATORY

A temporary seismological observatory was set up in Darwin in 1961, using three Willmore seismometers and recorders. They continued to operate throughout the year. Large numbers of tremors, about 5° (550 km) from Darwin, are recorded. They appear to occur north to north-west of Darwin, but this can only be confirmed if another instrument is installed some distance from Darwin.

Mr. J.N. Jordan of the USCGS visited Melbourne to discuss (inter alia) the possibility of installing a set of standard-station seismographs in the Northern Territory. Mr. Jordan mentioned Tennant Creek as a possible location, but it is considered that it will be difficult to keep staff there to operate the observatory. Moreover, the continued existence of the town depends on the life of the mines, which may be limited. It was therefore decided that, if a suitable site could be located near Darwin, this would be preferable. Consequently investigations to find a suitable site were commenced during the year.

6. REFERENCES

DOOLEY, J.C. 1959 Preface to magnetic results from Toolangi Observatory, Victoria 1949-1951. Bur.Min.Resour. Aust.Rep. No. 44

SMALL, G.R. 1965 Fluctuations in the H-baseline value at Toolangi Observatory, Victoria. Bur.Min.Resour. Aust.Rec. 1965/235

APPENDIX 1

Staff movements and visitors

Staff for the whole year

C.A. van der Waal

B.G. Cook

C.H. van Erkelens

E. Gardonyi (Miss)

R. Biggs (Toolangi Observatories)

Commenced duty during the year on dates shown

Y. Rimington (Miss)	Geophysicist Grade 1	19th February
R.G. Toy	Geophisical Asst.	26th February (transferred from Darwin)
J.R. Wilkie	Geophysicist Grade 1	26th February
L. Kahwagi (Mrs.)	Computer	3rd April
I. Bodo (Mrs.)	Computer	28th May
I. Black	Geophysicist Grade 1	13th June
F. Wilson (Miss)	Computer	8th September
L. Stewart (Miss)	Computer	13th August
R. Whitworth	Geophysicist Grade 1	29th August
P.J. Gregson	Geophysicist Grade 1	17th October (transferred from Mundaring)
G.R. Small	Geophysicist Grade 1	27th November

Resigned on dates shown

H. Brown (Miss)	Computer	19th January
Y. Rimington (Miss)	Geophysicist Grade 1	23rd February
L. Kahwagi (Mrs.)	Computer	25th June
J. Milne	Geophysicist Grade 1	24th August
F. Wilson (Miss)	Computer	23rd November

Transferred to other groups

P. Mann, who had returned from a temporary transfer to Port Moresby on 18th November 1961, rejoined the Engineering Group on 7th March.

Antarctic staff movements

J. Branson left for Mawson on 4th January on the Nella Dan.

R.J.S. Hollingsworth returned from Mawson on the Nella Dan on the 18th March. He joined the Regional Magnetic Group on 30th August.

W. Burch transferred to the Regional Gravity Group in July.

I. Black was in Port Moresby for training from 3rd September to 28th October. He attended the ANARE indoctrination course from 29th October to 2nd November and a course to train as assistant to the medical officer at the Royal Melbourne Hospital from 11th to 24th December.

R. Whitworth was in Mundaring for training from 4th September to 28th October. From 29th October to 2nd November he attended the ANARE indoctrination course, and from 27th November to 10th December a course similar to that attended by I. Black at the Royal Melbourne Hospital. He left for Wilkes on the Thala Dan on 21st December.

P.J. Gregson arrived from Mundaring 17th October and attended the ANARE indoctrination course from 29th October to 2nd December. He departed for Macquarie Island on the Thala Dan on 30th November.

R.J.S. Cooke returned from Macquarie Island on 16th December.

Vacation students

G.R. Small, P. Dellimore, and J. Spender, who had joined the group in December 1961 as university vacation students, left again in February to resume their studies. D. Horne joined the group on 19th November, and left in February 1963.

Miscellaneous

B.G. Cook attended a symposium on the results of the IGY in Adelaide on 23rd and 24th February. Regular observatory staff meetings were held throughout the year.

Visitors

Mr. P. Gaffy of the University of Queensland Seismic Observatory visited the Melbourne office and observatory from 5th to 8th January.

Messrs. R. Finn and P.W. Morrison of Texas Instrument Corporation visited the Melbourne office during January and November respectively and copied a large number of seismograms.

A class from the Melbourne High School was shown over the Melbourne Observatory in March and the geophysics class of the Melbourne University in October.

Mr. J.N. Jordan of the USCGS visited the Observatory office to discuss the establishment of an additional standard seismic station in the Northern Territory.

Mr. I.B. Everingham (Geophysicist Class 2, Mundaring) visited the Melbourne office in September, and Messrs. J.A. Brooks and P.M. McGregor (Observers in Charge of Port Moresby and Mundaring Geophysical Observatories respectively) in November.

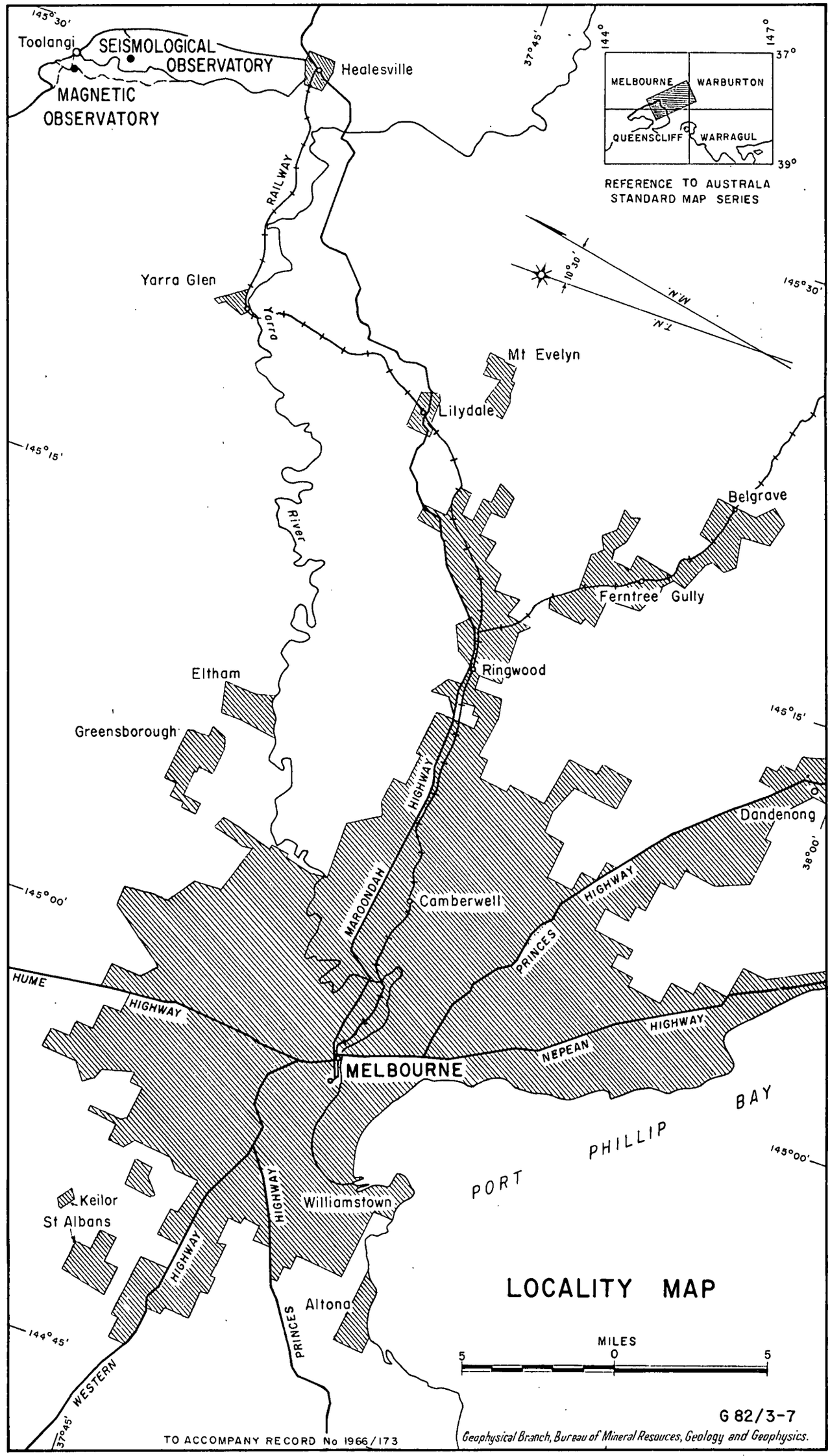
Dr. J. Mainstone of the University of Queensland visited Toolangi in November to install a micro-pulsation recorder.

APPENDIX 2

Distribution of magnetic data

Data	Distributed to
Monthly	
Toolangi K-indices and geomagnetic phenomena	The International Permanent Centre, De Bilt, Netherlands. World Data Centre A, Washington, USA. World Data Centre C1, Charlottenlund, Denmark. World Data Centre C2, Kyoto, Japan. Mr. H. Freeborn Johnston, Maryland, USA. Defence Signal Branch, Dept of Defence, Melbourne. Ionospheric Prediction Service, Sydney. University of Adelaide, Adelaide.
Macquarie Island, Mawson, and Wilkes K-indices	The International Permanent Centre, De Bilt, Netherlands. World Data Centre A, C1, and C2. Mr. H. Freeborn Johnston, Maryland, USA. Prof. J. Bartels, Gottingen, West Germany.
Macquarie Island K-indices	Invercargill IGY Station, N.Z. Dr. G. Allcock, Dominion Observatory, N.Z.
Maximum and minimum value of diurnal variation in D at Toolangi	National Standards Laboratory, Sydney.
Geophysical Observatory Report	To 190 interested persons and organisations throughout the world.
Quarterly	
Toolangi magnetic storms	Journal of Geophysical Research, Boulder, USA.
Annual	
Magnetic Storms from Macquarie Island, Mawson and Wilkes	Journal of Geophysical Research, Boulder, USA.
Annual mean values	World Data Centres A, C1, and C2. Mr. H. Freeborn, Johnston
Microfilm copies of magnetograms from Mawson, Macquarie I., and Wilkes.	World Data Centre A

PLATE 1

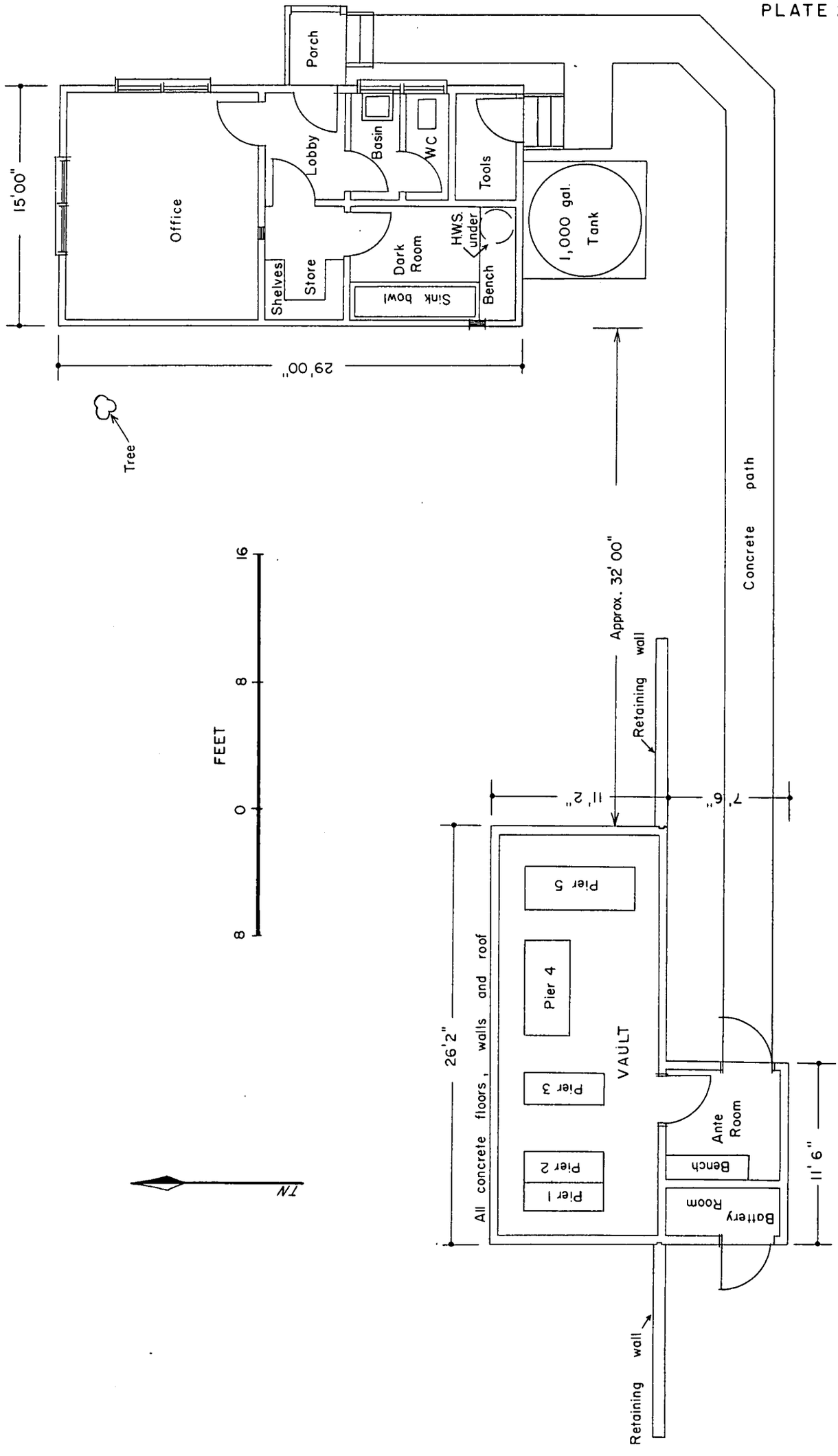


G 82/3-7

TO ACCOMPANY RECORD No 1966/173

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

PLATE 2



PLAN OF OBSERVATORY BUILDINGS

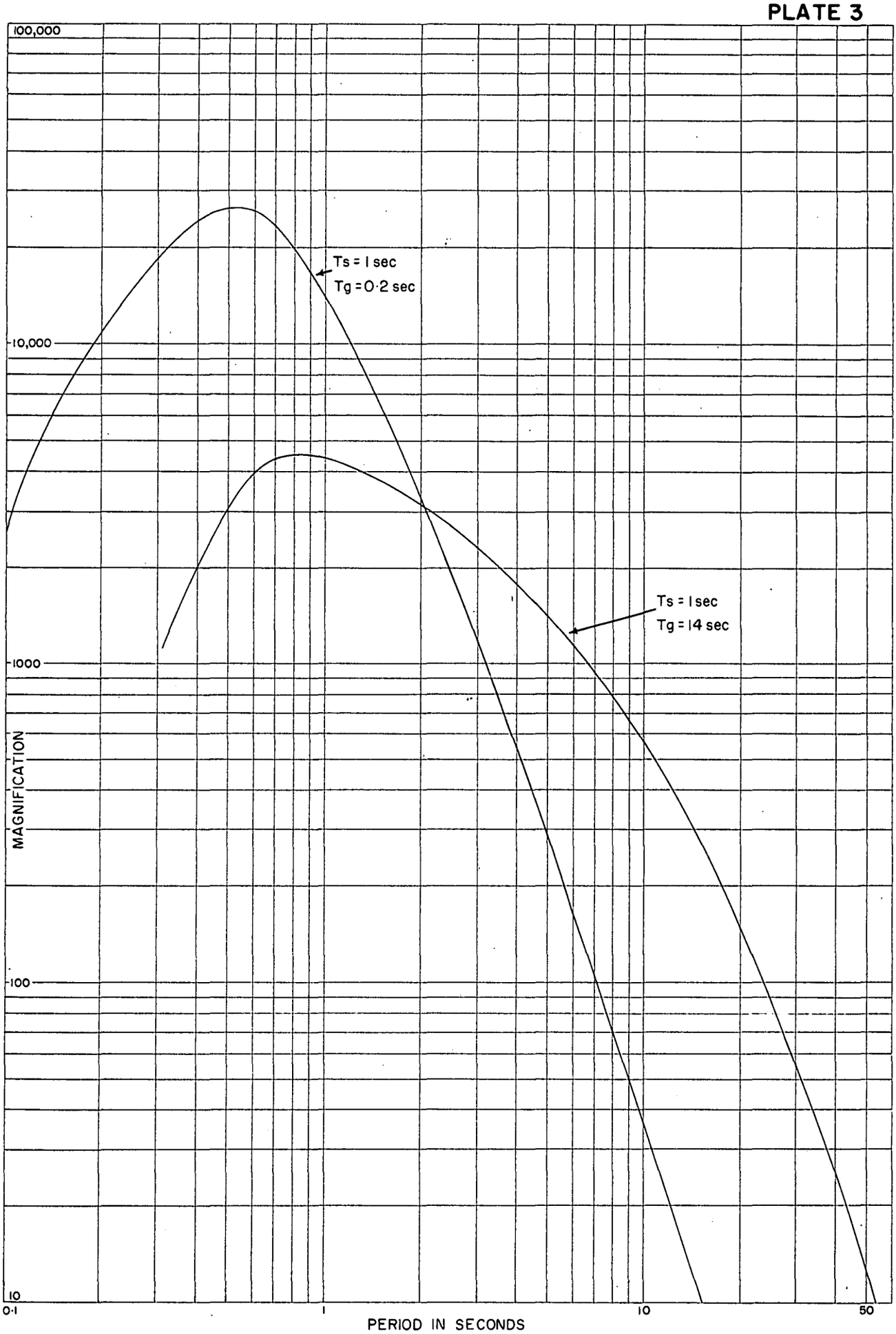
TOOLANGI, VICTORIA

TO ACCOMPANY RECORD No 1966/173

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

G 82-3-6

PLATE 3



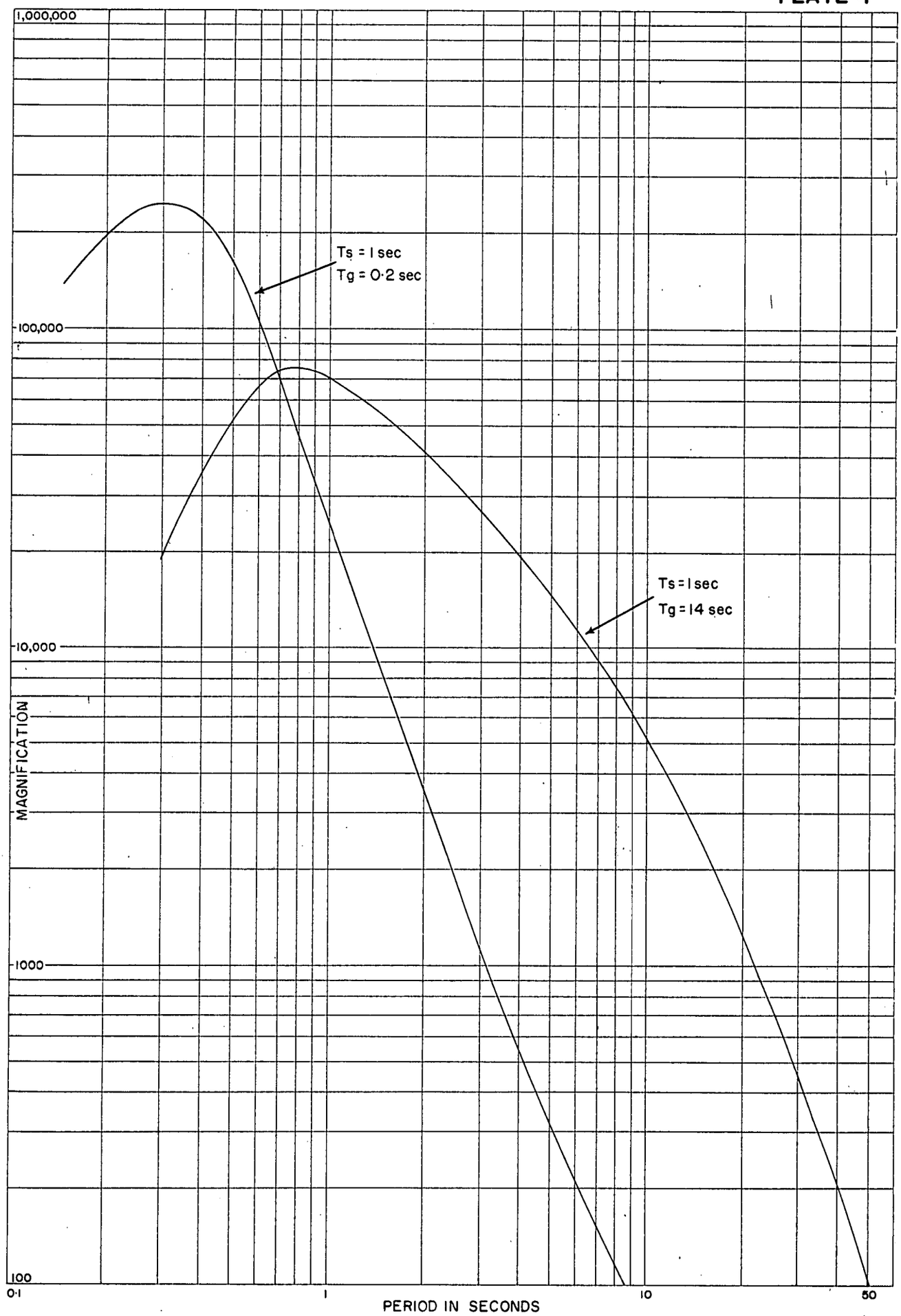
MELBOURNE
SEISMOLOGICAL OBSERVATORY

MAGNIFICATION CURVES FOR BENIOFF SEISMOGRAPH DETERMINED WITH THE WILLMORE CALIBRATION BRIDGE

(Based on G82/2-2) TO ACCOMPANY RECORD No 1966/173

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS **G82/3-8**

PLATE 4



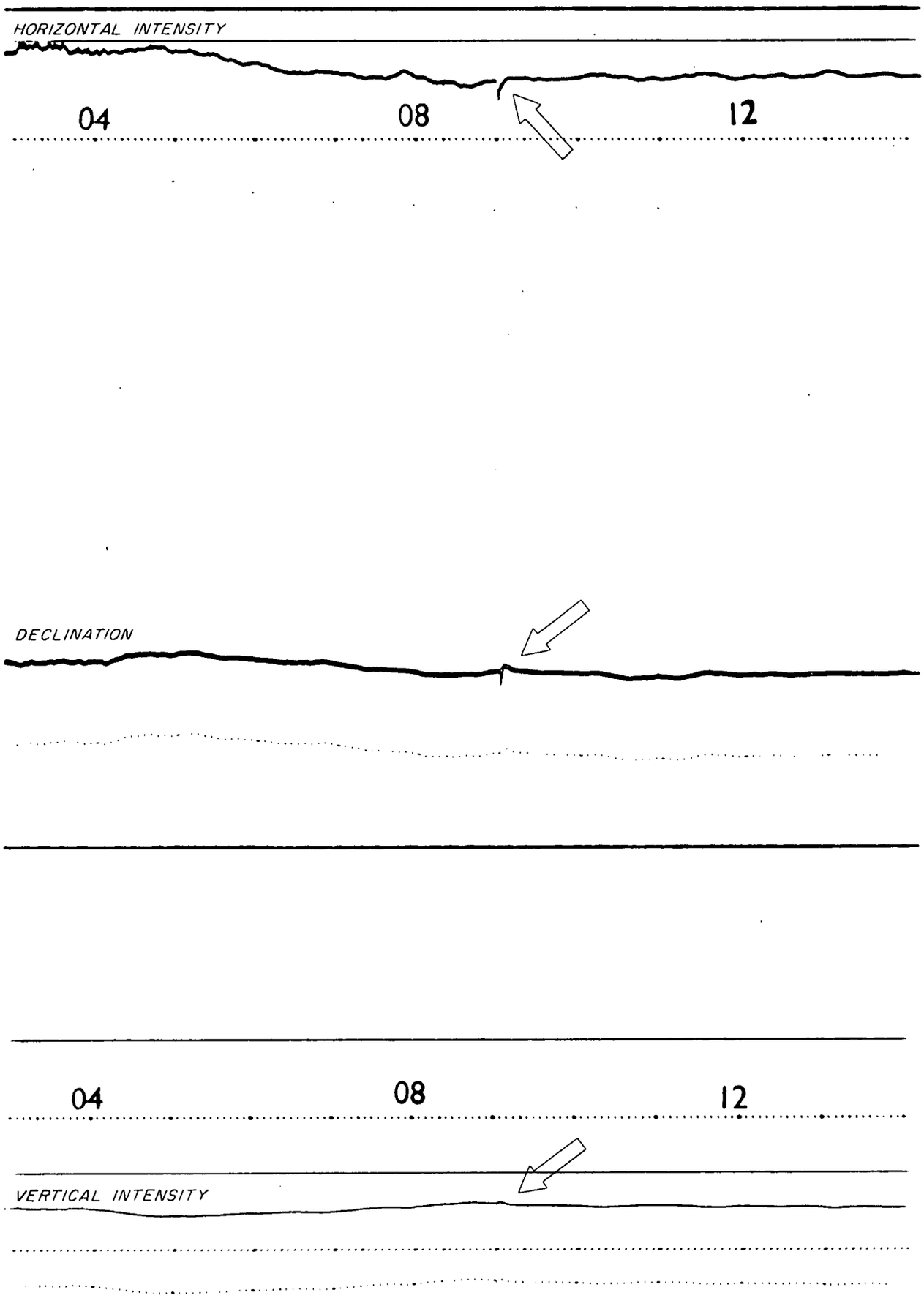
TOOLANGI
SEISMOLOGICAL OBSERVATORY

MAGNIFICATION CURVES FOR BENIOFF SEISMOGRAPH DETERMINED WITH THE WILLMORE CALIBRATION BRIDGE

(Based on G82/2-2) TO ACCOMPANY RECORD No 1966/173

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS **G82/3-9**

TOOLANGI MAGNETIC OBSERVATORY
9 JULY, 1962. GMT



EFFECT OF JOHNSTON ISLAND NUCLEAR EXPLOSION AT TOOLANGI MAGNETIC OBSERVATORY

TO ACCOMPANY RECORD No.1966/173
GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS G82/1-14