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Geophysical Branch Summary of Activities 1968

CONTENTS

1. OIL SEARCH

Gravity surveys	1
Seismic surveys	3
Seismic data processing centre	5
Well logging	6
Marine geophysical surveys	
Airborne surveys	7

2. METALS

Ground surveys	10
Darwin Uranium Group	11
Airborne surveys	13

3. ENGINEERING AND HYDROLOGY

Rabaul crustal investigation	17
Laboratory study of flow through porous media	
Adelaide River and Stapleton Creek dam site	
Christmas Island underground water	
ACT engineering surveys	
Miscellaneous	18

4. REGIONAL SURVEYS

Regional Gravity Group	19
Regional Magnetic Group	21

5. OBSERVATORIES 23

6. LABORATORIES 25

7. WORKSHOPS 28

8. MISCELLANEOUS INVESTIGATIONS

Palaeomagnetism	29
Computer programme for airborne reductions	
Aeromagnetic map of Australia	
Crustal study	30
AFMAG tests	
Turam model tests	
Magnetotelluric study	31
VLF investigations	32

ILLUSTRATIONS

Plate 1. Sedimentary gravity surveys, Australia

Plate 2. Sedimentary gravity surveys, New Guinea

Plate 3. NSW helicopter gravity survey, Bouguer anomalies

Plate 4. Ngalia Basin seismic survey

Plate 5. Deep seismic reflection survey, Mildura

Plate 6. Marine geophysical surveys, 1967 and 1968

Plate 7. Great Artesian Basin aeromagnetic survey 1965

Plate 8. Central Great Artesian Basin aeromagnetic survey 1968

Plate 9. Tennant Creek magnetic surveys, locality map

Plate 10. Queenstown geophysical surveys 1968

Plate 11. Rum Jungle area geophysical surveys 1968

Plate 12. SANDSTONE and YOUANMI airborne survey

Plate 13. Victoria River contract aeromagnetic survey

Plate 14. Western Victoria detailed aeromagnetic survey

Plate 15. Eastern Papua, preliminary Bouguer anomalies.

CONTENTS

1. OIL SEARCH

Gravity surveys 1
Seismic surveys 3
Seismic data processing centre 5
Well logging 6
Marine geophysical surveys
Airborne surveys 7

2. METALS

Ground surveys 10
Darwin Uranium Group 11
Airborne surveys 13

3. ENGINEERING AND HYDROLOGY

Rabaul crustal investigation 17
Laboratory study of flow through porous media
Adelaide River and Stapleton Creek dam site
Christmas Island underground water
ACT engineering surveys
Miscellaneous 18

4. REGIONAL SURVEYS

Regional Gravity Group 19
Regional Magnetic Group 21

5. OBSERVATORIES 23

6. LABORATORIES 25

7. WORKSHOPS 28

8. MISCELLANEOUS INVESTIGATIONS

Palaeomagnetism 29
Computer programme for airborne reductions
Aeromagnetic map of Australia
Crustal study 30
AFMAG tests
Turam model tests
Magnetotelluric study 31
VLF investigations 32

the development of the Tasman Geosyncline in central NSW. The outline of the Clarence-Moreton Basin can be correlated with an extensive residual Bouguer anomaly feature. An extensive Bouguer anomaly "low" can be correlated with the New England granite zone of uplift - the central complex of the Tasman Geosyncline. One of the most interesting features delineated by the survey was a north-trending Bouguer anomaly ridge extending from SURAT through TAMWORTH. The northern part of this Bouguer anomaly feature had been previously mapped and was correlated with the axis of the Bowen-Surat Basin; it was thought to represent density changes within the sedimentary section. Now that this feature has been mapped to the south the correlation does not hold and the feature is thought to represent some fundamental basement change. Future interpretation, involving stripping techniques, will assist in resolving this problem.

New Guinea helicopter gravity survey (Sepik River) (Plate 2). This survey, conducted by BMR personnel, commenced in August 1968. The party is still in the field and no results are available. The survey is planned in two stages:

a) A conventional helicopter survey with a station spacing of 4 miles. This stage has just been completed.

b) A remote-reading gravity meter is to be used from a hovering or floating helicopter in areas where it is impossible to obtain conventional gravity readings. The helicopter is at present being fitted out to commence this stage of the survey.

The survey should be completed in mid December.

Regional gravity traverses NSW. In July 1968 a ground survey commenced in central NSW. The survey was planned like a helicopter operation with a station interval of 7 miles and using a similar traversing procedure. The survey was used as training for two BMR personnel unfamiliar with gravity surveying. No results are available as the personnel involved in the survey are in New Guinea with a helicopter gravity party. During 1968, only the eastern thirds of NARROMINE and FORBES were completed, but it is hoped to continue this survey in future years to complete the gap between the 1966 helicopter training survey and the 1968 helicopter contract curvey.

Formation density project. Only a small amount of work was done on this project because the staff were committed to survey work.

Gravity map of Australia. Work continued in preparation for the issue of the 3rd edition in 1969. An accompanying report is almost complete. Preparations are in hand to commence the recomputation of all subsidised surveys, but this is being hampered by a shortage of available personnel.

Interpretational programmes. Several programmes were developed as aids to interpretation. These included two- and three-dimensional, iterative and non-iterative, basin and pluton fitting programmes. A full complement of programmes could not be established, owing to shortage of available manpower.

Seismic surveys

Ngalia Basin seismic survey NT. (Plate 4). An investigation of the Ngalia Basin commenced in 1967, as a joint project between the Geological and Geophysical Branches. Seismic Party No. 1 carried out two months' field work there in 1967 and returned in 1968 for a 7-month field programme.

A reflection traverse had been shot in 1968, 20 miles west of Vaughan Springs Homestead. This traverse has been extended both to the north and the south to cross the margins of the Basin. At the north end, very little further information was obtained as no significant reflections were recorded. It is obvious that the margin of the Basin occurs very close to the north end of the 1967 work, and is steeply dipping or faulted. At the southern end of this traverse, a suite of three reflections were followed to within about 6 miles of the surface expression at the southern margin. At this point there is still about 4000 feet of sedimentary section, and the beds are dipping steadily to the north at 10°. Refraction profiling was tried, but this has proved difficult to interpret, and it is suspected that the southern margin of the Basin at this point may be structurally complicated.

Further work was done near the northern margin in an attempt to tie the reflectors to geological formations. Along an east-west traverse 4 miles from the margin, reflection and refraction work was carried out and an expanded reflection spread was recorded. This work demonstrated that there were 3 main primary reflections at depths of 3000', 4600', and 7500', and that the middle reflector probably correlates with a refractor of velocity 18,700 ft/s. It was not possible to tie any of these reflectors to outcrop to the north because of the steepness of the margin at this point, and an attempt to profile on the 18,700 ft/s refractor to outcrop was also unsuccessful for the same reason. Reflection profiling was therefore carried out to the east towards an outcrop area where the dips shown on the surface were more gentle. The results were still inconclusive, but it appears that the middle reflector probably correlates with a dolomite below the Ordovician Djagamarra Formation, although it is not clear yet whether this dolomite is of Cambrian or Proterozoic age.

A reflection traverse was also shot across the Basin near Napperby Homestead, and some associated refraction work was done. The results in general were rather poor. A sedimentary section of at least 7000 feet was indicated. Another traverse was shot in the Waite Creek area and good reflection results were obtained. These reflections dip consistently to the north at about 10-15 degrees, to a point about one mile from the northern margin, where the depth of sediments is about 12,000 to 14,000 feet.

Roma Shelf seismic survey QLD. This survey commenced in June 1967 and continued until the end of April 1968. It is an attempt to use the seismic method to study stratigraphic problems associated with the accumulation and trapping of oil in this part of the Surat Basin. Initially three problems were being studies:

1) Porosity and permeability changes in the Precipice Sandstone.

2) Thickening of the Boxvale Sandstone west of the Roma Shelf.

3) The wedge-out of Permian sands on the eastern flank of the Shelf.

During the course of the survey a fourth problem was added:

4) Development of Permian sands in valleys on the Roma Shelf.

To study the Precipice Sandstone problem, a reflection traverse was shot from the Richmond Oil and Gas Field westwards to the Duarran Field, and a north-south traverse was shot from Ingle No. 1 through the Richmond Field to Blythewood No. 1. Some further detailed traverses were shot between the wells in the two fields.

Short traverses were shot at the Dirinda No. 1., Binya No.1 and Arbroath No. 1 wells, to study the effect of the development of the Boxvale Sandstone westwards from the Roma Shelf.

Another traverse was made from the Pickanjinnie Gas Field, through to the Wallumbilla South No. 1 gas well to the south-east, to the Bengalla No. 1 well. This traverse crossed the hingeline area of the Basin in the east side of the Roma Shelf, where the Permian sandstones wedge out against the Roma Shelf.

A valley of Permian sediments extends from the eastern side onto the Roma Shelf in a north-westerly direction between the Richmond and Bony Creek Fields and the Blyth Creek Field. A traverse was shot from the Blyth Creek Field across this valley to the Richmond Field in order to study the development of Permian sediments in this valley. A further traverse was shot along the valley to the south-east.

Interpretation of all this work is being done with the assistance of synthetic seismograms and also by having the field work processed digitally by GSI in Sydney. So far, the interpretation has not produced any significant solutions to the stratigraphic problems posed, but work is continuing using more refined synthetic seismograms and digital processing.

Deep reflection study, Murray Basin (Plate 5). BMR has undertaken to attempt a reflection traverse across the West Australian Precambrian Shield in order to study the structure of the Earth's crust at great depth, and if possible near the base of the crust. In order to determine whether such a traverse is possible and to develop techniques for recording deep reflections consistently, some preliminary testing was planned in the Mildura and Broken Hill areas.

The Mildura area was selected for the first tests because some very deep reflections were recorded there during a survey in 1960. Tests were made to study the noise likely to interfere with the reflections, and to determine the best shot and geophone arrangement for recording them.

Much of the noise was of very low frequency, less than 10 Hz, and as the frequency content of the reflections was above 15 Hz, this noise could best be removed by electronic filtering during recording. The most troublesome noise remaining had a velocity of 2000 metres/second, and a pattern length of 100 metres was required to reduce this noise. It was also found desirable to keep the unit charge fairly small (less that 50 lb), as these charges generated less low-frequency noise.

The initial recording was done using $4\frac{1}{2}$-Hz geophones, but as the reflections were of high frequency the usual 14-Hz geophones were satisfactory for recording them, and also did not pick up the low-frequency noise. The geophone arrangement eventually arrived at was sixteen 14-Hz 14S-J geophones in line and spaced at 6 metres. The shot-hole pattern used was controlled by the drilling power available to the party. A 3-hole in-line pattern with a spacing of 33 metres and 50 lb in each hole was used, but had more drilling power been available, a much larger pattern would have been used. Using these parameters, deep reflections were recorded in a time from 9 to 11 seconds, but were only of poor to fair quality.

An expanded spread was shot out to a distance of 32 kilometres in order to study the variation of reflection quality with offset, and to measure the vertical velocity from the move-out time of the reflections. It was difficult to trace the reflections across this expanded spread, as their quality was inconsistent and they showed signs of being interfered. Further work will be done to try to improve the quality of these reflections.

Towards the end of 1968, the party will move to the Broken Hill area to attempt similar experiments in a different geological environment.

Seismic data processing centre

Equipment currently operated in the centre includes: the basic MS42 analogue processing and display equipment for high-quality sequential processing of seismic data; a Sinclair dip-plotting machine for migrating seismic reflection data in cross-section form; a complete seismic field recording and playback system, including twenty-four 7000B amplifiers, DS7 magnetic recorder, and ER66 oscillograph camera for simultaneous playback of 24-trace seismic magnetic tapes; and an analogue-to-digital strip chart conversion unit. A "Laserscan" optical processing system for filtering seismic data in cross-section form will be in operation before the end of the year.

An average of 40 cross sections per month were processed on the MS42 system, by one or two operators. In addition, personnel of the centre supervised the preparation of field seismic recording equipment performance; provided advice on seismic data processing within the Geophysical and Petroleum Exploration Branches; and used the CSIRO CDC3600 computer to process and edit the output of the analogue-to-digital conversion unit. Sixteen sonic lags from wells in the Roma Shelf area were digitised on the conversion unit prior to preparation of synthetic seismograms. Four seismic traces from the Roma Shelf

1967-68 survey were digitised for input to an autocorrelation programme using the CSIRO CDC3600 computer. Several digital programmes for seismic data processing were revised, and new programmes were prepared.

Cross-sections and/or test playback of magnetic tapes have been produced, mainly in variable area/wiggle trace form, for the surveys listed below:

Roma Shelf, 1967-68. Test sections and records were produced with various filters, AGC, gains etc. Single-coverage and two-fold vertical stack sections for elimination of ghost reflections were processed for most traverses shot. A twelve-fold C.D.P. section was produced for Traverse C. A number of sections are being processed digitally at GSI in Sydney.

Ngalia Basin, 1967-68. Cross-sections have been produced from the 1967 survey results. Currently magnetic tapes are being sent from the field and sections are being produced for assessment of the results of the work being carried out in 1968.

East Otway Basin, 1967. Final cross-sections were produced for inclusion in a Record on this survey.

Surat Basin, 1960. Cross-sections were produced for some of the work carried out in this early survey in the Surat Basin.

Sydney Basin surveys. Most of the private company seismic work in the Sydney Basin is being reprocessed in an attempt to improve the quality of the reflection information for basin study purposes. The uniform presentation of results has been found to assist greatly in the integration of the seismic data. The improvement in quality of the results on the cross-section has justified reprocessing of most of the seismic work shot.

Quail subsidised seismic survey. The reflection work on Traverse P was reprocessed at the request of the subsidy group for the purpose of assessing the playback technique.

General. Further processing to be done in 1968 will include work from the Roma Shelf 1967-68, Ngalia Basin 1967-68 (including reprocessing of the Pacific American seismic work to integrate it with the BMR work), and Gosse Bluff BMR and Magellan seismic surveys.

Well logging, Great Artesian Basin, QLD

Reports covering 1965 and 1966 contract logging programmes are approaching completion. The balance of the field work for the 1967 contract logging was completed. Tenders were called for the 1968 contract logging. The report on BMR's 1966 logging was revised.

Marine geophysical surveys

The 1967 marine geophysical survey of the Timor Sea area (Plate 6) was completed in December 1967. This survey, done under contract to BMR by United Geophysical Corporation, completed 13,050 nautical line miles during the 70 days spent at sea between 23

September and 20 December. Lines were mainly east-west spaced nine nautical miles apart, with some tie-lines. Continuous gravity, seismic, and magnetic recording was carried out.

Reduction of gravity, navigation, and magnetic data was done by United Geophysical Corp. in Melbourne from January to June 1968. The final navigation plots are the result of fitting smoothed v.l.f. data to independent and more accurate fixes (radar ranges, celestial fixes) and adjusting buoyed intersections. The average mistie in the v.l.f. plots at 42 buoyed intersections was 1.2 nautical miles. The sonar doppler system, intended to give the east-west component of the ship's velocity, performed unsatisfactorily for more than half the survey, and the east-west speed was measured instead from the slope of the longitude time plots where sonar doppler data were not available. The average gravity mistie was 2.5 milligals for 170 line intersections; most of this error is probably from navigation errors. The gravity meter was an Askania stabilised-platform meter. The gravity results were presented as contour maps at a scale of 1:250,000, and a reduced compilation of the results is shown in Plate 6. Seismic results were generally poor on the continental shelf, owing to water bottom multiples and poor penetration, but were good on the continental slope.

The principal tectonic forms which are obvious in areas of good seismic results include a belt of faulting and folding along the continental slope and shelf edge, parallel to the shelf edge. The continental slope is an erosional surface. Runs made over seismic features previously considered to be intrusions in the Jospeh Bonaparte Gulf area showed little or no gravity or magnetic expression. Interpretation of the seismic data continued, but no analysis of the magnetic data has been done.

A survey is being conducted on the continental shelf off north-western Australia in 1968 (Plate 6). The contractor is Ray Geophysics (Australia) Pty Ltd, which is using the 165-foot motor vessel "Robray 1". To the 1967 equipment have been added a satellite navigation unit and seismic refraction (airgun/sonobuoy) equipment. The vessel left Broome to commence the survey in late September.

Airborne geophysical surveys

Northern Great Artesian Basin, 1965. This contract was let to AMEG Pty Ltd in 1965 and the flying was completed in 1966. Preliminary aeromagnetic contour sheets of the 1:250,000 sheet areas concerned have been received and checked except for MANUKA and HUGHENDEN, which are expected soon.

Scribed sheets of fair drawn aeromagnetic contours of BOULIA, SPRINGVALE, TANGORIN, and MUTTABURRA have been received and checked. JULIA CREEK and MACKUNDA sheets are in progress of checking. The contractor expects all the work specified by contract to be completed by January 1969.

Detailed interpretation of the data has not yet commenced. Inspection of the contoured sheets received shows that the survey was successful in delineating magnetic anomalies due to deeply buried basement rocks in the Basin, and those due to shallower basement in the

south-western part of the area. Near-surface volcanics were partly delineated by the anomalies recorded in the north-eastern part of the area.

Central Great Artesian Basin, 1968. An airborne magnetic survey was flown over two areas in the centre of the Great Artesian Basin during the period March to June 1968. The survey covered parts of 1:250,000 map areas BRIGHTON DOWNS, MANEROO, LONGREACH, JUNDAH. BLACKALL, WINDORAH, ADAVALE, EROMANGA, QUILPIE, THARGOMINDAH, and TOOMPINE.

The sediments of the Great Artesian Basin are Mesozoic and younger and unconformably overlie rocks ranging from Precambrian to Permian in age. Thus the Mesozoic succession obscures younger structures. Oil "shows" have been encountered at many points in the Basin, and have stimulated considerable interest in the area. The aim of the survey was to obtain pre-Mesozoic structural information.

The magnetic interpretation is shown in Plate 7, together with the deeper bores in the area and pre-Mesozoic structure inferred from bore, seismic, and geological data.

In the west of BRIGHTON DOWNS, depth determinations are unreliable owing to rapid variations in the magnetic field, and magnetic basement contouring has not been attempted. Zones of similar magnetic amplitude have been delineated, and are believed to indicate basement lithology changes. Two areas of granitic intrusion were postulated by Gibb (BMR Report 129) to account for gravity "lows" and this interpretation is compatible with the magnetic data. Magnetic basement in the west of BRIGHTON DOWNS is believed to consist predominantly of Lower Proterozoic metamorphic rocks.

The four bores shown in MANEROO bottom at depths close to magnetic basement, which is interpreted as phyllite. Magnetic basement variations here and in LONGREACH are believed to relate to crystalline basement features. Further geophysical investigation of the magnetic basement "highs" is recommended.

The magnetic data are compatible with discontinuities or steep gradients along the Hulton-Rand and Tara structures, and with the mapped position of the Barcaldine Ridge. The Galilee Basin is interpreted as having a magnetic basement depth of approximately 12,000 ft below sea level, rising to the south-east.

In JUNDAH, a Lower Palaeozoic trough is postulated, with a depth of approximately 16,000 ft below sea level. Further investigation of this feature is warranted, as it may contain source beds for hyrocarbons.

In BLACKALL a magnetic basement ridge running south corresponds with a gravity "high" and may represent a basement structure. Springleigh No. 3 shows that magnetic basement in this region probably consists of Palaeozoic metamorphic rocks rather than of crystalline rocks.

The Canaway Ridge, Cooper Basin, and Adavale Basin are reflected in the magnetic results, but magnetic information in the southern portion of the survey area is sparse. The Canaway Ridge appears to become narrower to the north, and not to enter the northern portion of the survey area. Magnetic basement here is interpreted as consisting of Lower Palaeozoic metamorphic rocks. In the extreme south of the survey area, magnetic basement becomes shallower southwards. In this region crystalline and magnetic basements are interpreted as coinciding, in view of the fair correlation between magnetic, gravity, and bore data.

Papuan Basin and Basic Belt, 1967. This contract survey was commenced by Compagnie Générale de Géophysique in June 1967 and the survey flying was terminated in November 1967. At October 1968 the final magnetic contours and reports on interpretation have yet to be delivered.

The intermediate interpretation of the aeromagnetic data over the Papuan Basin and the Basic Belt reveals a number of anticlinal, synclinal, and faulted structures in the magnetic basement of the Papuan Basin. The form of the Basin is clearly outlined by the magnetic results with the exception of its eastern boundary, which still remains unknown; intermediate magnetic anomalies due to complex tectonics and volcanics conceal any basement anomalies in this eastern zone and thus it is not possible to determine whether basement rises or deepens to the east.

With the exception of this eastern region, the Basin appears to be nearly symmetrical with a maximum depth at approximately 8°00' south 144°30' east. From here the basement rises sharply to the north and then deepens again north of latitude 7°30' south. Westwards and southwards the basement rises in a similar manner. To the south the basement rises from about 25,000 ft to about 14,000 ft at latitude 9°15' south. This southern area is interpreted as being the most promising for oil search, in particular the structural feature A4.

The magnetic results in the Papuan Basic Belt reveal that immediately east of the Owen Stanley Fault, basic rocks of the ultramafic belt represent only a thin veneer overlying metamorphic rocks. The thickening of these basic rocks increases sharply at the Timeno Fault; the dip of the fault plane is estimated at 20° to 30°.

Numerous magnetic anomalies which trend NW to NNW in KIKORI, WAU and YULE are indicative of shallow volcanic horizons. Granodiorite intrusions are interpreted from the magnetic data in WAU and some volcanic plugs have been delineated in BUNA.

The survey of the Astrolabe area, included in the same contract, is referred to under Metals Search.

2. METALS

Ground surveys

Chewton-Castlemaine, Victoria (gold). The main geophysical anomaly found during the 1967 survey in the vicinity of the Mona workings was drilled by the Victorian Department of Mines during 1968.

The first hole (M_1) was drilled to 519'2" and passed through a sequence of alternating sandstone and shale with occasional quartz stringers. No mineralisation was encountered. It was felt that the hole may have passed beneath the source of the anomaly, and a second hole (M_2) was drilled vertically in the centre of the anomaly to a depth of 501'4". Similar geology to M_1 was encountered, with no mineralisation. A third hole (M_3) was drilled on Reconnaissance Traverse C, about 5500 feet South of Wattle Gully No. 1 Shaft, to a depth of 624'5". A shale and sandstone sequence with quartz stringers was again encountered, with no mineralisation.

The geophysical work by the BMR during 1968 consisted of electrical and radiometric logging of drill holes and testing of core specimens for IP response. Generally the sandstones showed high resistance and the shales showed low resistance. A few narrow horizons within the shale showed anomalously low resistivity and high self-potential values. In nearly all cases these zones exhibited high IP chargeability values. The lithology of these zones is a dark spongy shale. There are probably more horizons than were recognised in the recovered core and their presence may account for the strong IP effects measured on the surface.

Tennant Creek NT (gold and copper). The interpretation of the results of the 1967 ground magnetic survey extended into 1968. Twelve diamond-drill holes and six waggon-drill holes were recommended for testing. The NT Mines Branch under the supervision of the Resident Geologist at Tennant Creek has been drilling these targets since May 1968. The waggon-drill holes were intended to test near-surface anomalies in Area C_{11}. All recommended holes were drilled intersecting ironstone at anticipated target depths.

The diamond-drill holes were recommended in areas 2, 3, 4, C_6, and C_{11}. (see Plate 9) Drilling commenced in Area C_{11} where DDH1 has been drilled to 60 ft and DDH3 to 480 ft.

DDH3 intersected a 2-ft section at 426 ft containing chloritic slate with native copper averaging 5% Cu, and a 25-ft section (450' - 475') containing quartz hematite with sparse copper mineralisation. The calculated target depth was 435 ft.

During interpretation extensive use was made of Parker Gay's curve fitting method utilising published families of curves for anomalies due to infinite dykes and for finite horizontal cylinders of infinite length. These curves were supplemented by curves for thin finite dykes and uniform spheres which were programmed during the interpretation of the Tennant Creek results on the CSIRO computer.

For interpretation of magnetic anomalies caused by bodies of irregular shape a computer programme (MAGSIM) has been developed which plots the vertical intensity anomaly of a given body of arbitrary cross-section for any given magnetic inclination. The body is assumed to be composed of a series of spheres, and the magnetic effect of each sphere is summed to give the magnetic anomaly. The anomaly is plotted as a profile on a graph paper. This programme is efficient for small bodies but becomes less so for larger bodies and needs minor modifications.

Queenstown, Tasmania (copper). Drilling of the 1965 BMR geophysical anomalies at Comstock by the Mount Lyell Company revealed large formations of limestone and not sulphide bearing schists as had been hoped. At the Company's request the Bureau conducted an investigation of the drilling results in March 1968.

Only one hole could be logged due to cave-ins in the other holes. The hole was logged using radiometric, and electrical methods. Induced Polarisation (IP) measurements were made on drill cores. Conductivity tests and analysis of water samples in all holes were also carried out.

The results indicated that the 1965 IP anomalies are probably due to graphitic material in the limestone. The EM anomalies are probably due to low resistivity zones such as graphitic zones or caverns of saline waters. There does not appear to be any way of discriminating between such zones and sulphide zones in this area.

While at Mount Lyell, the Bureau party learned that the Company was also drilling the 1966 BMR geophysical anomalies at Cape Horn. Five drill holes have been investigated and all intersected high grade sulphides which explain the geophysical results remarkably well. Subsequently the Company has announced that the Cape Horn ore body contains 3.4 million tons of ore averaging 2% copper. It appears that the IP and EM methods are very useful in the Mount Lyell area in regions devoid of limestone.

Darwin Uranium Group

The areas surveyed by the Group in 1968 are shown in Plate 11.

Manton area. Reconnaissance Slingram and surface radiometric surveys were made in the Manton Area on north-south traverses 1200 ft apart; readings were made every 100 ft. The Manton area was surveyed to examine the Coomalie Dolomite and the Golden Dyke Formation for mineralisation. The Slingram results reflect the geology; the Golden Dyke Formation is conductive and the Coomalie Dolomite is not. No significant anomalies were found. One radiometric anomaly was found in ferruginous rock in Coomalie Dolomite.

Huandot area, Rum Jungle East. Slingram, S-P and surface radiometric surveys were made in the Huandot area to fill the gap between the 1967 survey areas Coomalie Gap West and Area 44 Extended; these areas are all in Coomalie Dolomite and Golden Dyke Formation. No significant anomalies were found. The Slingram results reflect the

geology as in the Manton area.

Coomalie Gap West, Rum Jungle East. An S-P survey was made in the Coomalie Gap West area between 400S and 454S. This is an area of known Slingram anomalies in the Golden Dyke Formation. The object of the survey was to find out whether the large S-P anomaly found in 1967 in the northern part of the Coomalie Gap West area is unique. Results show that there is a series of large S-P anomalies in the Coomalie Gap West area.

Acacia area. S-P surveys were made over the major geochemical anomalies found in the Acacia area in 1967. An S-P anomaly was found about 300 feet west of the L2 geochemical anomaly. The geochemical anomalies covered were L_1, L_2, L_3, L_4, Z_1, C_1, C_2 and Co_1.

Waterhouse No. 2 and Mount Minza areas, Gould area. An S-P survey was made in the Waterhouse No. 2 area to compare the results with Mount Minza, where the geological setting is similar. Strong EM and S-P anomalies due to carbonaceous shale occur at Mount Minza, and strong EM anomalies also due to carbonaceous shale occur at Waterhouse No. 2, but without S-P anomalies. This is as yet unexplained.

IP surveys were made over the EM conductors at 447E, 201S and 448E, 213S in the Mount Minza area. The 1966 and 1967 surveys in this area showed an apparent correlation between S-P and IP anomalies. The 1968 results show no such correlation and the correlation found previously was fortuitous.

Mount Fitch North area. Slingram, S-P, and IP surveys were made in the Mount Fitch North area to investigate a Slingram anomaly found in 1963 and to follow it north. A surface radiometric survey was also made. Results show that the Slingram anomaly is due to an unmineralised shear which extends north to 520N. No significant radiometric, S-P, or IP anomalies were found.

Mount Burton area. S-P and IP surveys were made on traverses 372N and 384N on the Mount Fitch No. 1 grid. Slingram surveys were made on these traverses in 1963 and some of the conductors found were subsequently drilled. The S-P and IP surveys were made to examine whether the drilling had adequately established the sources of the EM anomalies. The results indicate that the drilling had done so.

Browns South-west area. Slingram and S-P surveys were made in Browns South-west area. The strike here is roughly NNW, and traverses were pegged ENE. Previous surveys in this area were over traverses in various other directions. No anomalies were found. The Slingram results show that unweathered rock is beyond the effective depth penetration of the method.

Rum Jungle Triangle. Two areas within the 1964 Rum Jungle Triangle area were re-surveyed. In the first area, bounded by coordinates 254N/110E, 254N/150E, 218N/150E and 218N/110E, the geological strike is roughly east-west and the original traverses were also east-west. Traverses were pegged north-south and S-P and Slingram surveys were made. A localised S-P anomaly was found at 244.5N/146E near a quartz outcrop.

The second area was bounded by co-ordinates 142N/109E, 142N/121E, 126N/121E and 126N/109E. S-P, IP, and Turam surveys were made to examine a Slingram anomaly found in the 1964 survey. The results show the boundary between Coomalie Dolomite and the Crater Formation. The Coomalie Dolomite in this area is conductive, possibly owing to a series of shears.

Area 55B. Turam, S-P and IP surveys were made in Area 55B to investigate EM anomalies known to exist. Results indicate that the anomalies are due to shears and faults with no associated mineralisation.

Power Line area. The southern part of the Power Line area was repegged, and Turam and S-P surveys were made to examine further the Slingram anomaly found in 1967. A weak Turam anomaly was found. The EM anomalies are due to unmineralised carbonaceous slate.

Batchelor Laterites Extended area. Part of the Batchelor Laterites Extended area was repegged over a known Turam anomaly, and IP and S-P surveys were made. These were supplemented by IP laboratory tests on core specimens for this area. Results indicate that the Turam anomaly is due to unmineralised carbonaceous slate.

Surveys over the Rum Jungle Granite Complex. These surveys were gravity, resistivity, Slingram, surface radiometric, and magnetic surveys.

A gravity survey was made to study the western boundary of the Complex. This complements the survey made in 1967 to study the eastern boundary. Traverse 120S, Rum Jungle East grid, of the 1967 survey was extended from 220W to 642W. Results indicate that the western edge of the Complex has a very steep dip. A magnetic survey across the western edge showed no anomaly.

Resistivity and Slingram test surveys were made across the Complex to locate faults showing no surface expression. These are of interest as possible zones of uranium concentration. Traverse 120S, Rum Jungle East grid, was used for the tests. Giants Reef Fault produced Slingram and resistivity anomalies, and several other similar zones were found in the Complex. The conclusion reached is that Slingram is the preferred method but resistivity methods are useful as checks. A surface radiometric survey was made across the Complex, but no significant anomalies were found.

Airborne surveys

SANDSTONE and YOUANMI airborne magnetic and radiometric survey, WA (VA-MIN). This survey of the two 1:250,000 map areas was flown between July and October 1968. This is a continuation of an extensive aeromagnetic and radiometric survey over the Archean Yilgarn Block, a subdivision of the Western Australian Shield.

The objectives were to aid the systematic regional geological mapping of the shield and to assist in the search for metals.

The high-intensity magnetic anomalies correlated with known regions of greenstones, and are due to banded ironstones and probably basic lavas and ultrabasic bodies. A geanticlinal structure at Sandstone is rep-

resented by intense anomalies which trend NE and NW; the apex of this structure is north of Sandstone. The magnetic data show that a greenstone region near Youanmi is subdivided into two belts, one of which trends northwards towards the geanticline at Sandstone, whilst the other trends southwards from Youanmi. A region of greenstones in the east of YOUANMI is narrower than depicted by the geological maps. A greenstone area in the south-western corner of SANDSTONE is moderately anomalous, and probably represents a continuation of a gabbroic complex which crops out in the south-eastern part of CUE 1:250,000 map area.

The radiometric contours of SANDSTONE and YOUANMI distinguish areas of granite from the greenstones. Breakaways and some topographic features, granite outcrops, and salt lakes are outlined. The dry salt lakes are outlined as areas of radiometric "highs", and lakes filled with water are "lows".

Ninety radiometric point sources were found in SANDSTONE and YOUANMI. It was found that 25 of these anomalies occurred over breakaways, and 19 over dry salt lakes. Of the remaining 46 point sources, only 19 were considered worth-while for ground investigation. Five of these occurred near or over outwash areas.

A number of specimens for crushed susceptibility determinations were collected from the survey area and from known serpentinite bodies near Meekatharra. The results of these will be used as a guide to the interpretation of the magnetic anomalies.

Western Victoria detailed aeromagnetic survey (VH-GEO). This survey was made at the request of Geological Survey of Victoria to assist in the search for economic brown coal deposits. The prospective brown coal areas of western Victoria are extensively covered by basalt flows. The brown coal can be recovered economically only where the basalt cover is thin or absent. This survey was a continuation of a project commenced in 1967 to detect breaks or "windows" in the basalt by detailed aeromagnetic surveying.

The 1967 survey covered the 1:63,360 areas of Skipton, Lismore, and Rokewood. From March to May 1968 the 1:63,360 areas of Beeac, Colac, and Cobden were covered. The Cessna aircraft VH-GEO, towing a proton precession magnetometer detector, was used at a line spacing of 1/5th mile and a ground clearance of 400 ft.

An assessment of the probability of basalt cover was made directly from the magnetometer charts and plotted against the flight paths, thus enabling a zonal interpretation of the results to be made (Plate 14). Zone A delineates areas considered to be free of basalt cover, and zone B, delineates areas where basalt is considered to be thin and possible weathered. Zone C represents areas where the basalt is probably thick. Magnetic zone 6 delineates areas of most intense magnetic disturbance, which are probably associated with volcanic centres. Probable volcanic necks or cones inferred from other supporting evidence are also shown on the plate. Generally the magnetic results are in agreement with the mapped geology.

MANN and WOODROFFE aeromagnetic survey, SA and NT. This aeromagnetic survey of parts of MANN and WOODROFFE 1:250,000 areas at 1-mile spacing was programmed as the first to be made with the new

Aero Commander aircraft VH-BMR, during July and August.

Owing to the late delivery of the aircraft and unexpected delays in the modification of the aircraft for its survey role, it was not possible to meet this schedule and the survey was postponed until the early part of the 1969 field season.

VH-MIN training and test flights, CANBERRA. This survey was primarily designed to check the geophysical instrumentation in VH-MIN following the annual routine overhaul. During the course of equipment test flights 2400 line miles were surveyed in the northern half of CANBERRA 1:250,000 map area. The magnetic data have not been interpreted, and it is expected that further work will be done during test flights in the period November 1968 to March 1969.

Victoria River contract aeromagnetic survey, NT. A contract for the surveying of four 1:250,000 areas in the Victoria River Basin was let to Adastra-Hunting Geophysics Pty Ltd in 1966. A contract for a further three 1:250,000 areas was let to Geophysical Resources Development Co. in 1967 (Plate 13). The work was completed in September 1968.

The survey was flown at 500 ft above ground level along east-west lines at one-mile intervals. The survey data were accepted by BMR in the form of preliminary contours, which are being fair drawn for publication. Some difficulty was experienced in resolving many magnetic anomalies which are small in areal extent when compared to the flight-line spacing.

Interpretation of the data has not commenced, but a preliminary examination suggests that the magnetic contours might not easily distinguish the Antrim Plateau Volcanics from the Proterozoic rocks which they overlie. The cause of some of the more extensive anomalies in the southern part of the survey area is not immediately obvious.

Astrolabe contract aeromagnetic survey. This area was included in the contract aeromagnetic work done by CGG in TPNG. The area was covered by a grid with 2-mile east-west spacing and 1-mile north-south spacing.

In the Astrolabe area magnetic trends were found to be oriented NW to NNW. Two basic intrusions were outlined. The recognition of these basic intrusions relies mainly on the similarity of these magnetic bodies to one observed south of Laloki River in a region of known gabbro intrusions. Further geological or geophysical investigations are recommended for these areas to determine their economic significance.

VH-BMR installation. The twin-engine Aero Commander aircraft VH-BMR purchased as a replacement for the Cessna VH-GEO was accepted by BMR on 10 May. Contracts to make airframe and electrical modifications in accordance with our equipment installation requirements were let to TAA on 6 April and 11 June. TAA sublet this work to two companies, Paspa Aircraft Co. and Executive Air Services Pty Ltd. This divided responsibility caused administrative problems and delays;

consequently the work was not completed until 10 September. However, the result was most satisfactory and DCA approval for the modifications was readily obtained.

The design and construction by the geophysical laboratory of a power distribution panel, a timer, a new bird, and special camera mounts was commenced early in 1968. Most of these items were completed by October, and compatability tests between the various equipment systems commenced soon after the arrival of the aircraft in Canberra. It is expected that this work will be completed, and a programme of flight testing and equipment evaluation commenced, by the end of 1968.

Airborne gamma-ray spectrometer investigation. A gamma-ray spectrometer was purchased by BMR in September 1968. This equipment will be installed in the Aero Commander VH-BMR before the commencement of the 1969 survey season. The equipment will be used initially for experimental survey work to evaluate the potential of airborne gamma-ray spectrometry in Australia.

To facilitate future instrument system development the electronic equipment purchased was of modular form. Acceptance testing of the equipment has been completed, and the resolution for the system at the Caesium 137 peak has been measured as 10.1%.

3. ENGINEERING AND HYDROLOGY

Rabaul crustal investigation

About 450 seismic records and seaborne magnetic traverses were processed. These and other data were used to prepare a Moho contour plan, a total magnetic intensity map, and a bathymetric map of the survey area.

The interpretation disclosed a crustal depression in the Rabaul area, formed under the weight of the formerly large volcano whose remnants constitute the present Rabaul caldera. A north-south anomaly in the Moho discontinuity, with steep gradients just west of the Duke of York Group, coincides with an area of shallow earthquakes. An extraordinary range of seismic velocities was found below the Moho discontinuity.

Preparations are being made for another survey in the New Britain area in March 1969. The Universities of Hawaii, Queensland, New England, ANU, and the University College of Townsville are co-operating with BMR in this project.

Laboratory study of flow through porous media using radioisotope tracers.

BMR and the Isotope Division of AAEC jointly prepared for publication a paper dealing with relations between various hydrological parameters. Completion of a second paper concerned with the spread of tracers during flow depends on further calibration measurements.

Adelaide River and Stapleton Creek dam site

This survey was done for the NT Water Resources Branch. 11,000 feet of seismic traversing was done to determine bedrock and overburden characteristics. Elastic constants of bedrock were determined with a dynamic method. Some resistivity profiles were made. Magnetic work did not yield any results.

Christmas Island underground water

An interpretation was made of magnetic and resistivity data collected by the British Phosphate Commission. Drilling targets for water were chosen.

ACT engineering surveys

Camp Hill area. A short seismic survey was made to determine foundation conditions at proposed office building sites. A higher-velocity refractor at 130 feet was recorded.

CSIRO headquarters site, Campbell. Seismic results showed that depth to partially weathered bedrock ranges from 15 to 35 feet.

High Court of Australia site. Weathered bedrock was recorded at depths between 8 and 26 feet.

Mount Ainslie approach road, vibration test. Ground vibration from blasting by a contractor was shown to be of insufficient amplitude to be recorded at a specified distance, and so could not be considered damaging to buildings.

Molonglo sewer outfall project. About 10,000 feet of seismic traversing was done at Sullivan Creek, Black Mountain Creek, and Coppins Crossing. Results showed that the proposed tunnel will lie mostly in unweathered rock with seismic velocity ranging from 11,000 to 15,000 ft/s. Deep weathering was disclosed at Black Mountain Creek.

Corin Dam. At various stages of construction, tests were made to determine the velocity and period of seismic waves in the dam wall. This was done to gather data and develop methods for possible future use in seismically active areas. Tests were also conducted to try to locate leaks in the wall.

Miscellaneous

A shallow water bore was logged at Lake George for the Geological Branch. Several geological parties were instructed in the use of bore-logging equipment.

The following optional projects could not be carried out for lack of time, staff etc:

Duricrust investigation in Qld by seismic refraction
Deep resistivity, Great Artesian Basin
Development of infrared photographic techniques to detect salt water invasion and water seepage
Great Artesian Basin logging by BMR
Resistivity modelling techniques
Induced polarisation applied to hydrology

4. REGIONAL SURVEYS

Regional Gravity Group

BMR pendulums. No observations were made with this equipment during 1968. The results of test swings and observations at Canberra, Sydney, and Darwin in 1967 were further analysed to assess the equipment's performance. Preliminary values for the gravity intervals Canberra-Sydney and Canberra-Darwin agree with adopted Isogal valves within the large experimental error (± 1 milligal) of the pendulum observations. Statistical techniques for assessing knife edge behaviour were investigated. These may be useful when testing the new extreme low profile knife edges developed by CSIRO National Standards Laboratory. The construction of the new pendulums by CSIRO is proceeding much more slowly than expected, and they will now not be tested this year. The design of a set of solid-state electronics and recording unit to replace the present cumbersome units advanced further. This will facilitate comparative testing of the GSI and CSIRO pendulums by providing more-detailed data and by almost eliminating the time involved in data scaling and reduction.

Isogal surveys. Follow-up work on various Isogal gravity base stations throughout Australia continued as opportunity arose during the year. Several new bases were established at the Sydney and Canberra airports prior to the destruction of the old bases. Essential ties were completed at several places, notably along the west coast of Australia, and station marker discs were placed in several areas, both by BMR field parties and by other organisations, particularly the Universities of Tasmania and New England and the South Australian Mines Department. At the beginning of the year, the Department of the Interior commenced a programme of levelling all Isogal stations. Isogal stations at about 30 places were levelled in 1968 by survey parties passing through the area.

Calibration ranges. The results of various runs on the Canberra calibration range by overseas and BMR observers during 1966-1967 indicated that the preliminary value (54-72 mgal) accepted for this range was in error. During January two observers, each reading six quartz-suspension gravity meters, made check observations on the Melbourne and Canberra ranges. A revised value of 54-76 mgal was confirmed conclusively.

During the year several measurements were made on the proposed Port Moresby calibration range by observers passing through Port Moresby en route to gravity surveys in TPNG. It is expected that a preliminary value of approximately 48.83 mgal will be assigned to this range.

Control network analysis. Further progress was made towards the integration of all control measurements made in Australia by local and overseas organisations. Most Isogal data have now been fed into the computer for analysis and adjustment.

Gravity meter performance investigation. Little progress was made in the field during 1968 because staff were committed on other

projects. The setting up of a North American gravity meter as a tidal recorder has contributed valuable data about the performance limitations of this type of meter.

Earth tides. The programme commenced this year, as mentioned above. Some records had been obtained in Melbourne with this meter, but the associated electronics require far more rigorous control than was then possible. Investigation of the performance continued throughout the year. The internal temperature of the meter is now kept constant to better than 10^{-3} centigrade degrees, and the temperature record can be resolved to about 10^{-5} centigrade degrees. Temperature has proved to be the major problem with both the meter and the associated electronics. All temperature-sensitive elements are now enclosed in thermostatically controlled enclosures, and the ambient temperature of the room is also controlled. Several different highly stable d.c. power supplies are used to provide stable voltage for meter heating, amplifier, and temperature measuring bridges. Early in the year the meter was calibrated on the Canberra range. Later it was calibrated by raising and lowering it through about 16 inches. The gravity difference was measured also by two La Coste meters. Problems now under investigation are long-term drift in the gravity and temperature records and short-term fluctuations of the order of ten microgals in the gravity record.

TPNG reconnaissance gravity survey. Two hundred and eighteen new gravity stations were established during follow-up helicopter gravity work in eastern Papua in March. The main achievements were to confirm the unusual gravity pattern on Normanby Island, the steep gravity gradients at the head of Milne Bay, and the gravity "high" and steep gradients on Cape Vogel. Well over half the new stations were read on Cape Vogel because of possible association of clinoenstatite lavas in that area with the ultramafic belt.

The results of the reconnaissance gravity surveys in TPNG over the last 3 years are being interpreted by a BMR officer at Imperial College, London and will be the basis of a Ph.D. thesis. Plate 15 shows preliminary Bouguer anomalies in eastern Papua.

Canberra gravity survey. A detailed gravity survey of the northern suburban area of Canberra was made during the 1967/68 university vacation. The work was done by university students under supervision, to provide training and experience in all aspects of gravity field work and data processing. The work will be extended during the next few vacations.

Gosse Bluff gravity survey. A detailed gravity survey of the Gosse Bluff structure is being done to assist in joint investigation into the origin of this structure by the US Geological Survey and BMR. Pegging and levelling by the Department of the Interior have been delayed by rain, which has also interfered with gravity operations. About one-third of the grid will not be finished until next year.

Automatic computing and mapping. The major programme GRAVHTS was again modified to extend its usefulness and to conform with changes in CSIRO's CDC3600 computer. Subroutine "meanslope" was expanded to accommodate flights of 50-200 stations, "fileman" was expanded and rewritten so that the programme COPYTAPE is now superseded,

"leastsquare" is now capable of handling 120 nodes instead of 60, the Askania and La Coste tables section was enlarged to accommodate several more meters, and provision has been made for change to gravity meter calibration factors.

The programme FIXSAF was completely rewritten for facility of operation, superseding subroutine "copytape". The station capacity of this programme has been increased from 800 to virtually limitless.

A programme BARD was written to compute anomalies from principal facts listed on cards or magnetic tape.

The results of more than 20 gravity surveys were reduced during the year, and the principal facts of the 1967 contract helicopter gravity survey have been added to the magnetic tape library. The principal facts of about 12,000 stations observed by the US Navy vessel "Shoup" during 1968 have also been put on tape.

The programme LOCATE has been used extensively to extract height data or full gravity data both for our own purposes and for other organisations.

The University of Hawaii has compiled the principal facts of about 10,000 Australian gravity stations to approximately the same gravity datum. BMR has been provided with a card image listing of these principal facts, and with free-air and Bouguer anomaly maps of selected areas of Australia at 1:1,000,000 scale. The data on which this compilation is based were provided by BMR in 1965 from our own gravity files and from subsidy reports.

Regional Magnetic Group

Progress was made in the two types of survey now undertaken. Twenty-five 1st-order stations were reoccupied in southern and eastern Australia and on Lord Howe Island and Norfolk Island. At 22 of them the BMR 3- component fluxgate variograph was fielded for its first season. Although this instrument still needs some improvement, it enabled corrections to be made for diurnal variations to the required accuracy (5 gammas).

A 3rd-order survey covered an area measuring about 900 miles by 200 miles in northern NSW and southern Queensland. Over most of this area, observations were made (to 20-gamma accuracy) at nominal 10-mile intervals along all passable roads and tracks.

Some 3rd-order stations were occupied on the Antarctic coast, mostly in the region of the Amery Ice Shelf.

Field data were computed currently. Programmes were devised to update earlier data for secular variation adjustment, and to plot observed data on a Mercator map projection.

A minor test was made at the Nowra Air Station to meet a request from the Navy.

Proposed recordings at selected stations for diurnal variation or magnetotelluric studies had to be deferred because they depended on the fluxgate variometer; after the 1st-order survey in October this instrument was returned to the laboratory for modifications and improvements.

5. OBSERVATORIES

Regular observatory programmes in geomagnetism and seismology were continued at Mundaring (WA), Port Moresby (TPNG), Toolangi (VIC), Macquarie Island, and Mawson (Antarctica). Ionospheric programmes were maintained at Mundaring and Port Moresby, and seismographs were operated at Kalgoorlie, Meekatharra, Kununurra (in collaboration with the WA Public Works Dept), Darwin, Lae, Goroka, Wabag, and Norfolk Island.

At Wabag a building for a permanent station was completed, and recording commenced there, in place of the Goroka temporary station, in November.

At Darwin a Bennioff vertical seismometer replaced a Willmore in November in preparation for the upgrading of the station and relocating it at a better site. This freed the portable Willmore for installation on Norfolk Island, where it is serviced by a resident IPSD officer.

Recordings were made at selected sites in the isthmus area at Macquarie Island, extending the noise tests begun in 1967. They showed that the signal-to-noise ratio is unlikely to be significantly improved in this area; investigations will be made next on the northern part of the plateau.

Three long-period seismometers were transferred from TPNG to WA for installation at Kalgoorlie and Meekatharra; these will eventually provide surface wave data for the WA geotraverse project. Tests of a long-period system in the unfavourable conditions at WA outstations were begun before procuring galvanometers or other components.

Regional and crustal seismological studies were pursued in WA and TPNG. A contribution was made to the new seismicity map of Australia, the section on WA being based on Mundaring activities. Refinements were made to the seismicity map of TPNG by using the increased and better data available in recent years.

Special investigations were made of the effects of earthquakes near Wewak (TPNG) and Meckering (WA). After the first shock at Wewak on 8 September a seismograph was installed; this measured many aftershocks from the first event, and a later series of shocks nearby which began on 27 September.

Aerial inspection near Meckering showed a ground fracture about 17 miles long with an upthrust of one to two feet on the eastern side. Data were collected on building damage and other earthquake effects and equipment was set up to locate aftershocks. The estimated magnitude of the earthquake is 6.8 to 7.0, equal to or greater than the largest earthquake previously recorded in Australia.

During the year, Port Morseby Observatory personnel installed four M02 accelerographs. Two, owned by CRA, were installed at Kieta on

Bougainville; two others, owned by the Commonwealth Department of Works, were installed at Rabaul and in the Upper Ramu area near the proposed damsite. Further instruments are to be installed at Lae, Wewak, and Port Moresby (2), and a second instrument in the Upper Ramu. Equipment record changes are arranged locally, and records (few so far) are being held in Port Moresby.

Magnetic reductions were set back early in the year by a reduction in the number of scaling machine operators and professional staff. Nevertheless data from the three mainland observatories were produced currently, and the backlog was reduced to 8 observatory-years. The backlog of conversions fell from 35 to 27 observatory-years - a very satisfactory result in the circumstances. Until a technical position included in the reorganisation proposals is filled, there will be no improvement in this situation. Mainly because of staff shortage, none of the proposed analyses of magnetograms were done.

6. LABORATORIES

Design and Development Group

The Group completed several projects during the year, and work continued on others. Some were worked on only intermittently owing to urgent requirements for field equipment.

The marine seismic equipment again occupied a good deal of the Group's time. Basic modifications were made to the basic timer and to the Egerton Germeshausen and Grier recorder. Modifications included accelerating circuits to improve the stop-start performance of the recorder, and the inclusion of sweep-delay facilities so that no record is lost when operating in deep water.

A sonobuoy telemetering system for refraction recording was integrated into the overall system. The receivers normally used on aircraft were modified for use on AC mains power. Preliminary tests indicate that refractions were received up to about 6 miles, and the direct water wave to 9 miles, but improvements in the receiver antennae can be expected to improve this range.

A detailed investigation into the feasibility of using an on-line computer for data acquisition and processing of common depth point marine seismic records was made in conjunction with the seismic group. Tenders for the equipment have been called.

The group was also involved in the installation of equipment for the new Aero-Commander aircraft VH-BMR. Details of racks to mount the equipment and cables were specified . Two new units, a timer for correlation of records and a power distribution and control unit, were designed and built. Tests of the overall installation are continuing.

Design and testing of the new general purpose proton magnetometer continued intermittently throughout the year. Although this project is considered very important, the man doing the work has also baan involved in other duties. This magnetometer is expected to be tested soon in VH-BMR. A considerable part of this year's design effort on the magnetometer was concerned with further work on d.c. converter power supplies.

Improvements were designed for the electronic control systems in both the 35-mm "fish-eye" and 70-mm reconnaissance cameras, and both these cameras and the Aeropath strip camera are now to be fully compatible and interchangeable in each aircraft installation.

The automatic microbarometer, an instrument designed to give a printed reading at selected intervals from a Mechanisms microbarometer, was completed and is being used in a survey by the Gravity Group. With the possible exception of the commercial printer used, bench tests have shown that the unit is extremely reliable and meets all required specifications. Further evaluation will be made during the survey.

A project brought forward from 1966 involved a new system design for the electronics for the GSI pendulums. The preliminary system design was reviewed and many improvements made - notably the use of integrated circuits which will permit some "on-line" computation in the portable equipment. An overall system for the GSI absolute pendulum equipment has now been designed, and equipment for it has been ordered.

Several magnetograph calibrators similar to the prototype designed in 1967 but built under contract were accepted for the Observatory Group for installation in all observatories.

A new airborne fluxgate magnetometer detector channel, MFS6, was completed during the year and will be finally tested after this year's survey work. Feasibility studies into a total feedback magnetometer for possible future application were started. Several design improvements were made to the aidborne fluxgate calibrator MCS1. Other smaller projects for the Airborne Group included the design of a proton magnetometer test oscillator which can be operated in the towed bird, and the design and construction of an outboard scintillometer channel.

BMR's VLF navigation equipment was received and given extensive laboratory tests before its use in the marine survey in September.

At the request of the Rock-testing Group, a feasibility study was commenced into a method of resistivity measurement that depends on the change in Q-factor of an r.f. tuned circuit.

As time permitted, work on an automatic digital magnetic observatory continued. This included studies of available light sources and detectors, and the suitability of different types of variometer. The project is now waiting on Helmholtz coils and optical hardward to be designed by the Mechanical Design Group.

A precise single-pulse generator was designed for the Seismic Group to enable the system response of the PT700 seismic system to be evaluated.

A means of providing time marks on the records from storm-warning magnetometers was designed using Bulova clocks and automatic sensing of the polarity of the required timing mark.

During the course of construction of the non-magnetic test hut at Kowen Forest, all building materials were tested for magnetism. On-site measurements were also made before and after the hut was built, to ensure that there was no significant change attributable to the hut.

Work continued during the year on gravity equipment in co-operation with the Gravity Group. Most time was spent on tidal gravity recording using equipment from the obsolescent underwater gravity meter. Considerable success was achieved, but much remains to be done to convert other gravity meters and tidy up the recording equipment.

Because of staff shortage, the Instrument Laboratory worked at a minimum level; the main activity was to organise outside servicing of faulty equipment.

Maintenance and Testing Group.

The primary function of this Group, which is to service and repair geophysical instruments, occupied most of the available man-hours. Major works undertaken in 1968 were the preparation of equipment for the 1968 marine seismic survey and the installation of equipment in the Aero-Commander aircraft VH-BMR.

The rock testing laboratory fulfilled all demands for measuring of elastic and magnetic properties of rocks. This group also produced a review of existing instrumentation and techniques for measuring magnetic susceptibility of rock samples.

Acceptance testing of new equipment assumed greater importance during 1968. The Chesapeake marine seismic streamer especially comsumed much effort in this respect.

7. WORKSHOPS

The Mechanical Design Section completed designs for a "printing read-out" system for microbarometers, gearboxes for E.G.G. recorders, and a light-weight sparker array with variable depth control. An existing micro level was modified to give greater accuracy. A great variety of other, mostly smaller, jobs were done.

The machine shop completed the construction and assembly of a strip camera. A microbarometer housing for use in desert areas was constructed. An ASW-8 magnetic detector head was stripped and overhauled. A sparker array unit of light alloy was constructed. Many smaller jobs included construction of panels and chassis for various new instruments.

The heavy workshop reconstructed a heavy cable drum for use with the 5000' logger by fitting a motor drive and brake arrangement. Several vehicle installations were done to specifications laid down by various seismic, regional magnetic, and engineering field parties. Many stationary engines were overhauled.

Some instruments were made by outside contractors. These included a number of 35-mm strip film viewers, stereo stands with interchangeable parts, prototype birds for a proton magnetometer detector head, and boxes for the housing of microbarometers. As usual, many of the test instruments that need yearly calibration - e.g. Tektronix oscilloscopes-were overhauled by their makers or agents.

8. MISCELLANEOUS INVESTIGATIONS

Palaeomagnetism

The major part of the year has been occupied with the alternating field cleaning of specimens from the Bowen Basin, to remove unstable magnetic components. This technique gives a more reliable estimate of the directions of magnetisation of the specimens.

The rock units completed are the Lizzie Creek Volcanics (lower Permian); Connors Volcanics (Devonian to Carboniferous); Camboon Andesite (Lower Permian); Carmila Beds (Lower Permian); Mount Rankin Beds (Upper Devonian to Lower Carboniferous); and Bulgonunna Volcanics (Upper Carboniferous). One tentative conclusion reached from these results to date is that a short Normal Period of magnetisation exists at the base of the Permian, which could be used possibly as a marker horizon. However, final results from all the Bowen Basin rock units sampled are needed before a definite conclusion can be reached.

A report was written for publication on the secular variation pattern shown by Recent basalts from New Guinea. This shows that the directions of magnetisation fit the pattern given by the Random Perturbation Model of the Earth's magnetic field as suggested by Irving and Ward ("A Statistical Model of the Geomagnetic Field". Pure Appl. Geoph., 57, 47, 1964)

During the year, experience was gained in instrumentation techniques by assisting in the construction of a new Helmholz coil system for the ANU's thermal cleaning apparatus, and by assisting in the construction and maintenance of the alternating field cleaning apparatus.

Computer programme for airborne reductions

Programmes have now been developed for Stage 1 (data editing and production of reduced scale profiles) and for Stage 2 (line/tie intersection values and differences) of the reduction process.

Stage 1 has been in use during the 1968 VH-MIN surveys. A number of small modifications have been made to it to increase its usefulness. Several blocks of data from the 1968 surveys have been processed using Stage 2.

The final stage, Stage 3 (plotting of contour-cuts), is currently being tested by CDC and should be available for use shortly.

Aeromagnetic map of Australia

The compilation of an aeromagnetic contour map and a basement contour map of Australia at a scale of 1:2,534,000 was continued in the early part of the year. Because of drafting difficulties which arose in attempting uniform presentation of data of differing contour interval and interpreted basement features from many sources, it was decided to discontinue the compilation of these maps at present. The project in

its present stage of completion has been available for inspection by interested persons.

Crustal study

During 1968, computer programmes were developed for filtering magnetic data. Considerable time was spent in writing programmes to check the quality of data on paper tape punched in the old format and also to read the magnetic tapes currently produced.

A range of linear wavelength filters were produced with cut-off wavelengths from $\frac{3}{4}$ mile to 24 miles. These are available for use in future interpretation of data, whether in crustal investigations or normal horizons under study.

The filters were applied to some data from the Western Australian Precambrian Shield, but without revealing any useful information on deeper crustal structure. When time is available the method will be applied to Amadeus Basin data to test whether it is any more successful over a sedimentary basin area.

In 1969 it is proposed to use the filters in the normal interpretation of survey areas. Use of the filters should enhance the data analysis and should provide a further check on the possible application to the study of deep-seated horizons.

AFMAG tests

During February and March 1968 an AFMAG field unit purchased from McPhar Geophysics was tested over several traverses selected in the Captains Flat, Braidwood, and Lake George areas. These tests were inconclusive, partly because of weak AFMAG fields and power-line interference and partly because of instrumental faults. The unit was returned to McPhar for repairs and for testing against their AFMAG field units.

On completion of repairs the field unit was tested again at Captains Flat before it was sent to Darwin for more tests. During October several traverses were surveyed in the Rum Jungle area. Interesting results were obtained over the Mount Minza and Huandot areas. Tests were done also over the Mount Fitch and the Giants Reef faults.

A comprehensive study of the behaviour of AFMAG fields at various localities throughout Australia has been commenced. Continuous recording equipment loaned to BMR by McPhar Geophysics of Canada was installed at Rum Jungle and Mundaring. More recording units are expected to be delivered by McPhar in the near future to enable simultaneous recording at several stations. The recording work is to be continued during 1969.

Turam model tests

The 1968 model tests were designed to complement the 1967 tests and to provide information on model situations not studies during 1967.

A series of models representing sheet-like orebodies was

studied to obtain systematic information on the effects of varying geometry and conductivity. Some models designed to represent geological features such as folds and conductive overburden were also observed.

The results were reduced and plotted using a computer programme. This programme also produced and plotted real and imaginary components and calculated various other parameters considered necessary for detailed analysis of the results.

A study of the results shows that depth determinations from the ratio curves are as accurate as those from the real and imaginary component curves but more rapid.

An attempt was made to establish a set of curves to determine dips, but the results are only accurate within about 15° and are highly sensitive to reading and orientation errors. It appears that this system would be of little practical use.

An attempt to establish an empirical method of determining conductivity directly from the field curves also produced inaccurate results because it requires accurate dip determinations. This suggests that the interpretation method of Bosschart (1964) must still be used, but a detailed study of the Bosschart method is leading to the conclusion that it is only slightly more accurate than the empirical method developed in BMR. The failure of both methods is due largely to the fact that the theory is based on the simple case of a line conductor in a non-conducting medium.

Despite many shortcomings the model tests proved quite useful for qualitative interpretation.

Magnetotelluric study

Little progress was made on the study of applicability of the magnetotelluric method for metalliferous prospecting. However, it has been found out that metalliferous magnetotelluric surveys were carried out in Canada (CGS) and France (SNPA).

Between 22 and 26 July 1968, a magnetotelluric party of the Societié Nationale des Pétroles d'Aquitaine (SNPA) was visited at Terry Range, WA., where the natural electric and magnetic field fluctuations at the surface of the Earth were recorded (numerically and digitally) successively in three frequency bands at stations spaced about seven miles apart. Normal surveying time of one station was seven hours.

The final interpretation of magnetotelluric results is carried out at SNPA's research centre at Pau (France), where computing and playback facilities exist. Preliminary interpretation of the Terry Range results suggests good correlation with previously known seismic reflection results.

The magnetotelluric method used at Terry Range is applicable for sedimentary basins only, and thus is of no use for metalliferous prospecting.

VLF investigations

During October and November 1968 the Ronka EM 16 equipment which used VLF transmitting stations as energising source was tested in the Captains Flat area. The naval radio station at North West Cape, WA, provided a convenient source of electromagnetic radiation at 22.3 kHz. The primary field emitted by this station is horizontal, and if used as an energy source for electromagnetic prospecting gives minimum interference from horizontal conducting overburden.

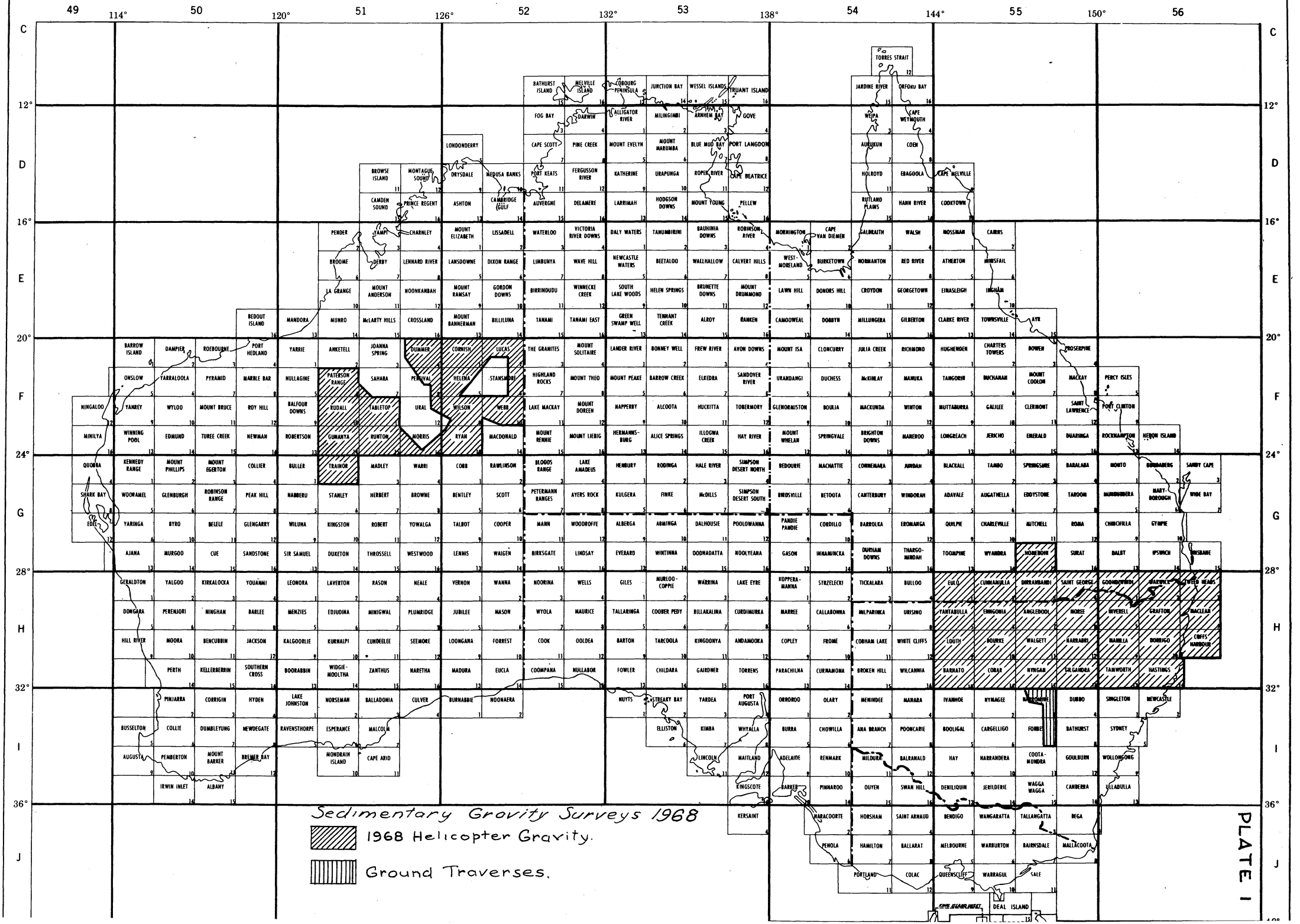
Initial results suggest that the VLF signal is strong enough to survey anywhere within Australia, but a major problem arises from the fact that bodies which are nearly parallel to the field will not normally be detected. In other parts of the world this can be overcome by using two or more radio stations at different bearings. In Australia, NWC is the only station strong enough to be detected with the Ronka EM 16, and many geophysical targets are in unsuitable environments for optimum detection. Further investigations on the feasibility of increasing the sensitivity of the instrument to detect other stations (e.g. NPM, Hawaii) are being carried out.

Department of National Development

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

PLATES TO ACCOMPANY

RECORD No. 1968 / 116


Sedimentary Gravity Surveys 1968
1968 Helicopter Gravity.
Ground Traverses.
PLATE I

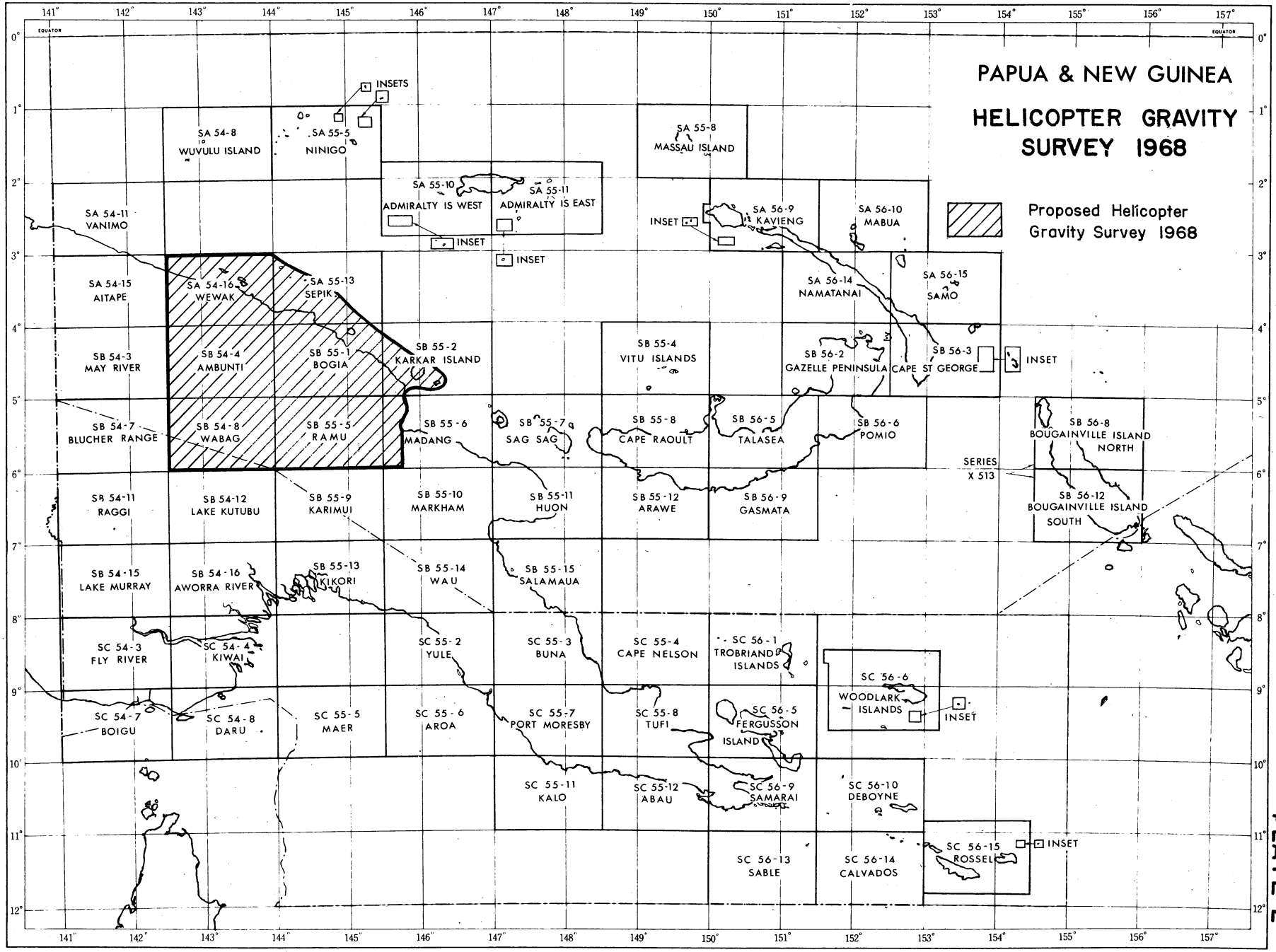


PLATE 2

(BASED ON PNG/BO-5)

PNG/B2-6

PLATE 3

144°00'

Thargomindah
Toompine
Wyandra
Homeboin
Surat
Dalby
Ipswich
Brisbane
MORETON I.
BRISBANE
47
Toowoomba
Ipswich
N. STRADBROKE I.

Bulloo
Eulo
Cunnamulla
Dirranbandi
St George
Goondiwindi
Warwick
Tweed Heads
River

Urisino
Yantabulla
Enngonia
Angledool
Moree
Inverell
Grafton
Maclean

Barwon
45 Walgett
Bourke
Bourke
Walgett
Narrabri
Mehilla
Dorrigo
Coffs Harbour

White Clifts
Louth
46 Armidale

Wilcannia
Barnato
Cobar
Nyngan
Gilgondra
Tamworth
Hastings
43 Cobar

Darling

Manara
Ivanhoe
Nymagee
Narromine
Dubbo
Singleton
Newcastle

1968 HELICOPTER GRAVITY SURVEY NSW - QLD

PRELIMINARY BOUGUER ANOMALIES

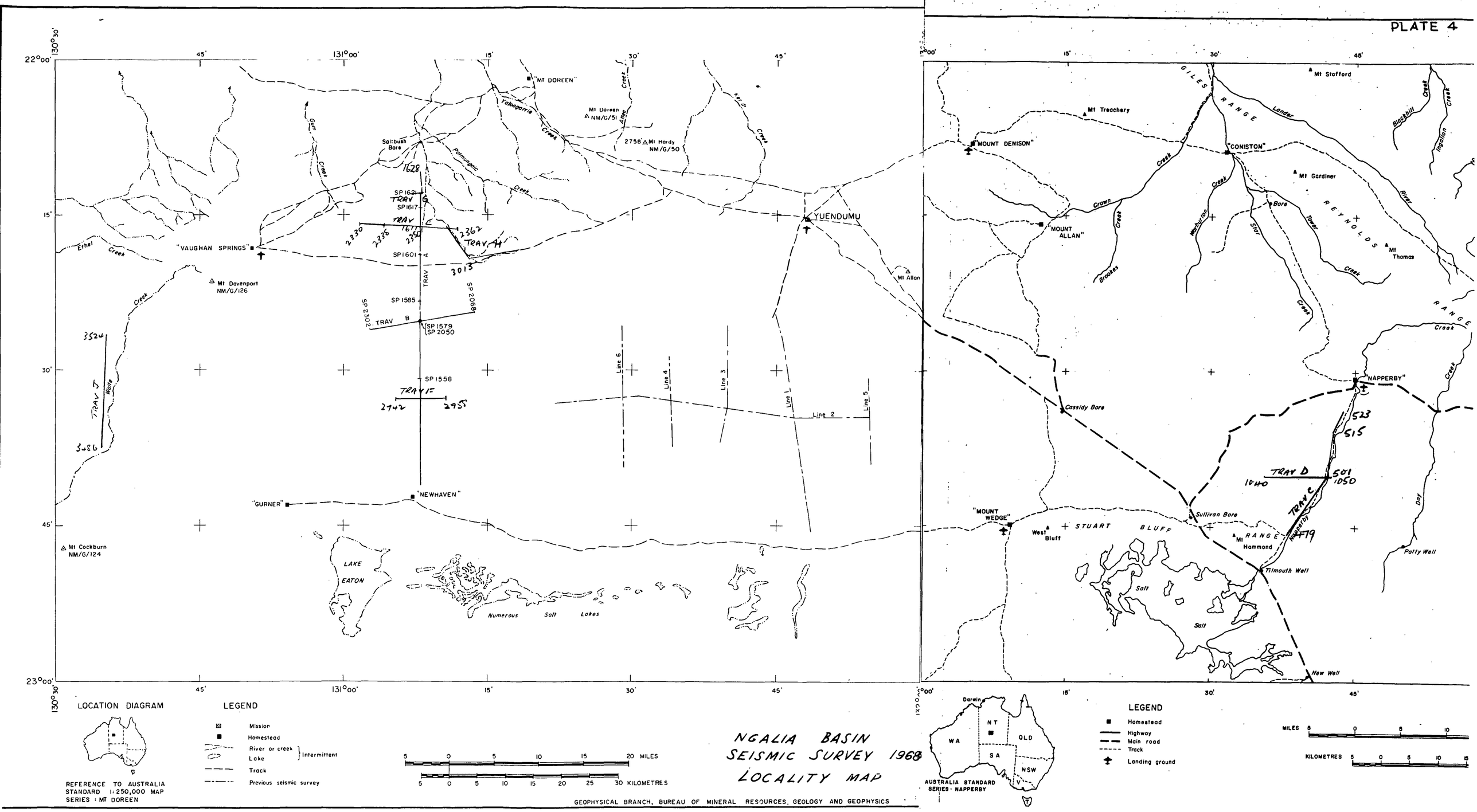
Maitland
Newcastle

Pooncaira
Booligal
Cargelligo
Lachlan
Forbes
44 Parkes
Bathurst
Sydney

SOUTH PACIFIC OCEAN

N/52-11

PLATE 4



LOCATION DIAGRAM

REFERENCE TO AUSTRALIA STANDARD 1:250,000 MAP SERIES : MT DOREEN

LEGEND

- Mission
- Homestead
- River or creek } Intermittent
- Lake } Intermittent
- Track
- Previous seismic survey

5 0 5 10 15 20 MILES

5 0 5 10 15 20 25 30 KILOMETRES

NGALIA BASIN SEISMIC SURVEY 1968 LOCALITY MAP

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

AUSTRALIA STANDARD SERIES : NAPPERBY

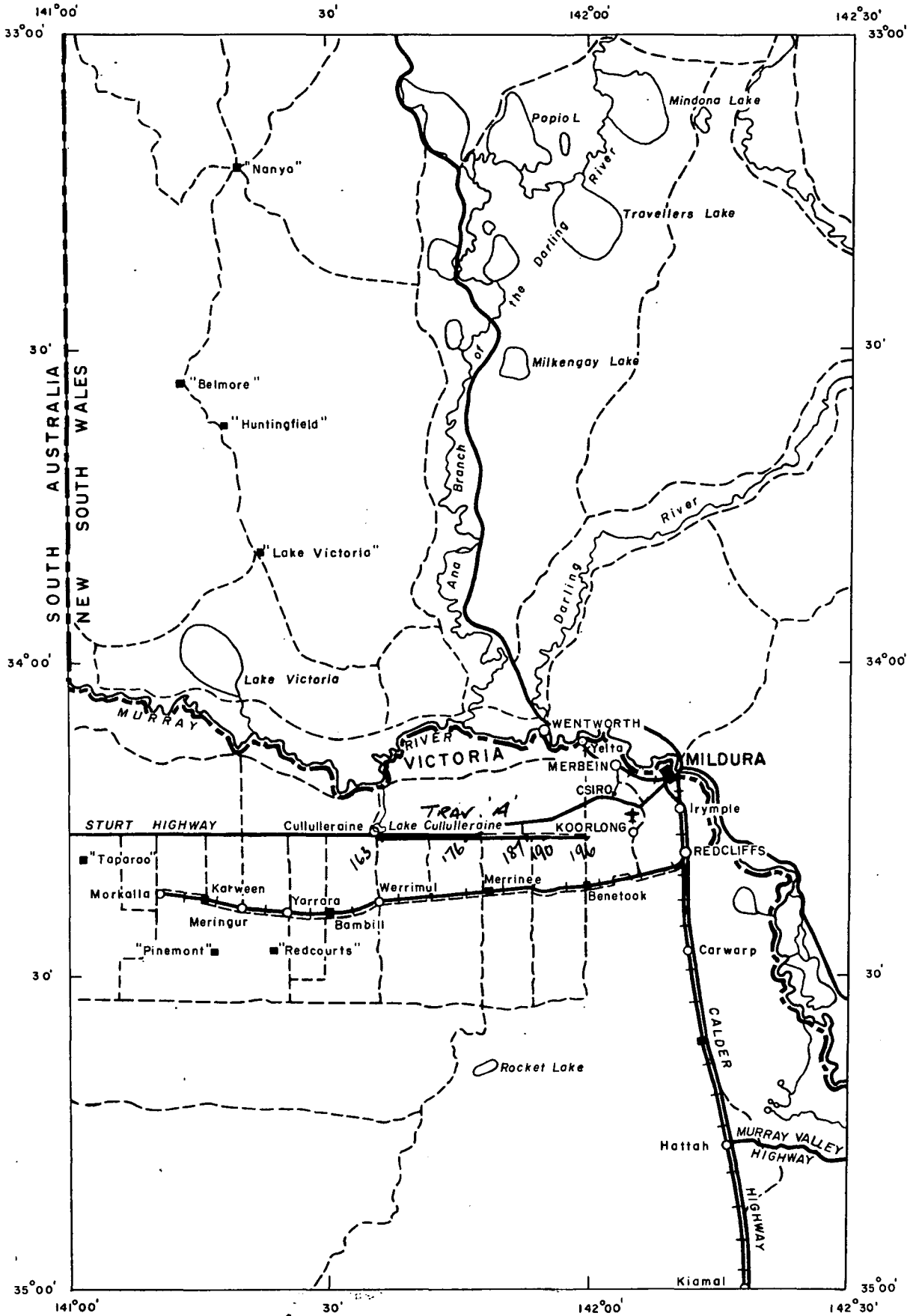
LEGEND

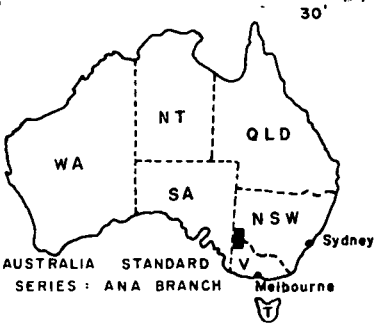
- Homestead
- Highway
- Main road
- Track
- Landing ground

MILES 5 0 5 10

KILOMETRES 5 0 5 10 15

PLATE 5





REFERENCE TO AUSTRALIA STANDARD 1:250,000 MAP SERIES: ANA BRANCH AND MILDURA

DEEP SEISMIC REFLECTION SURUEY 1968

10 0 10 20 30 MILES

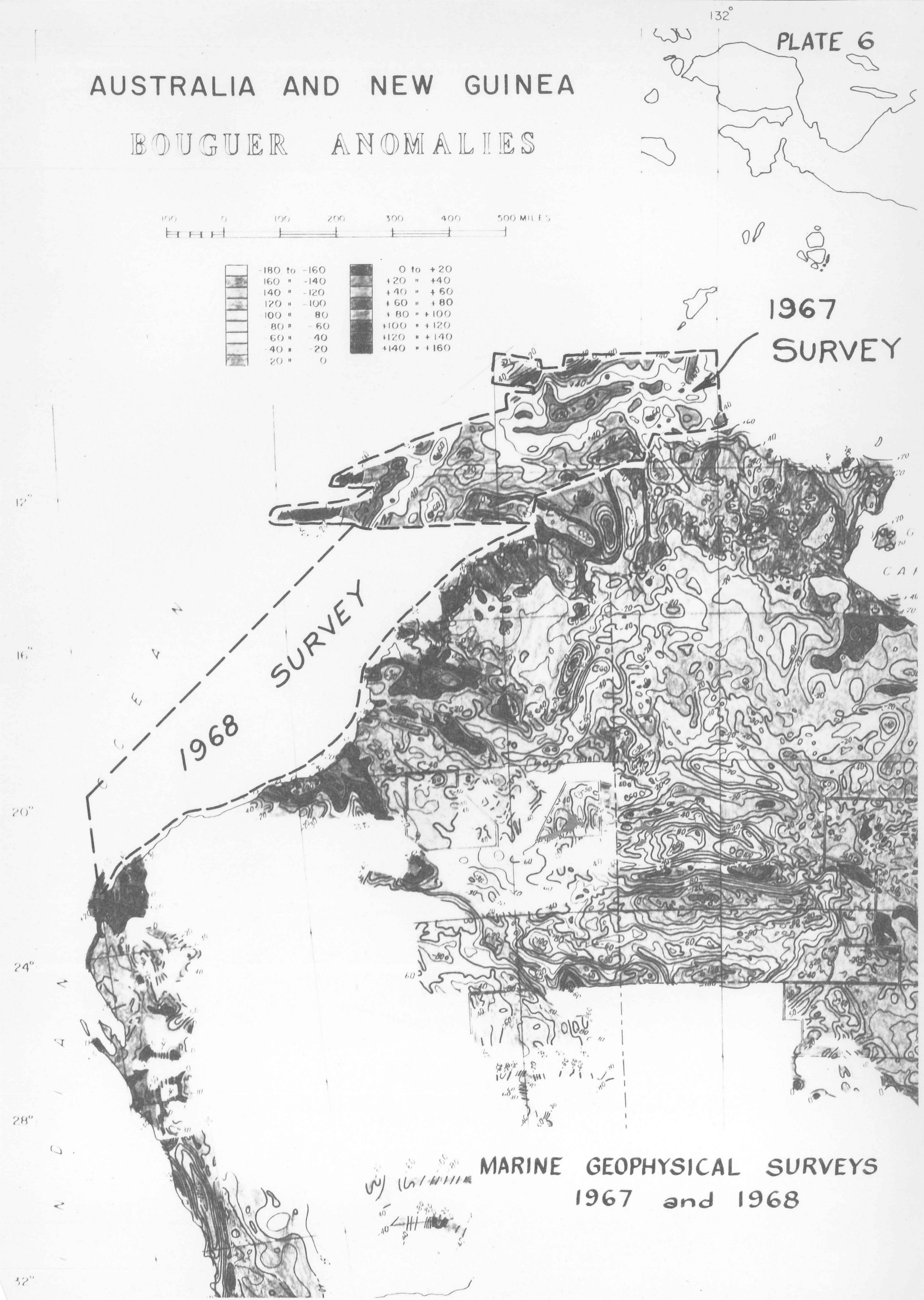
10 0 10 20 30 KILOMETRES

154/B3/2

PLATE 6

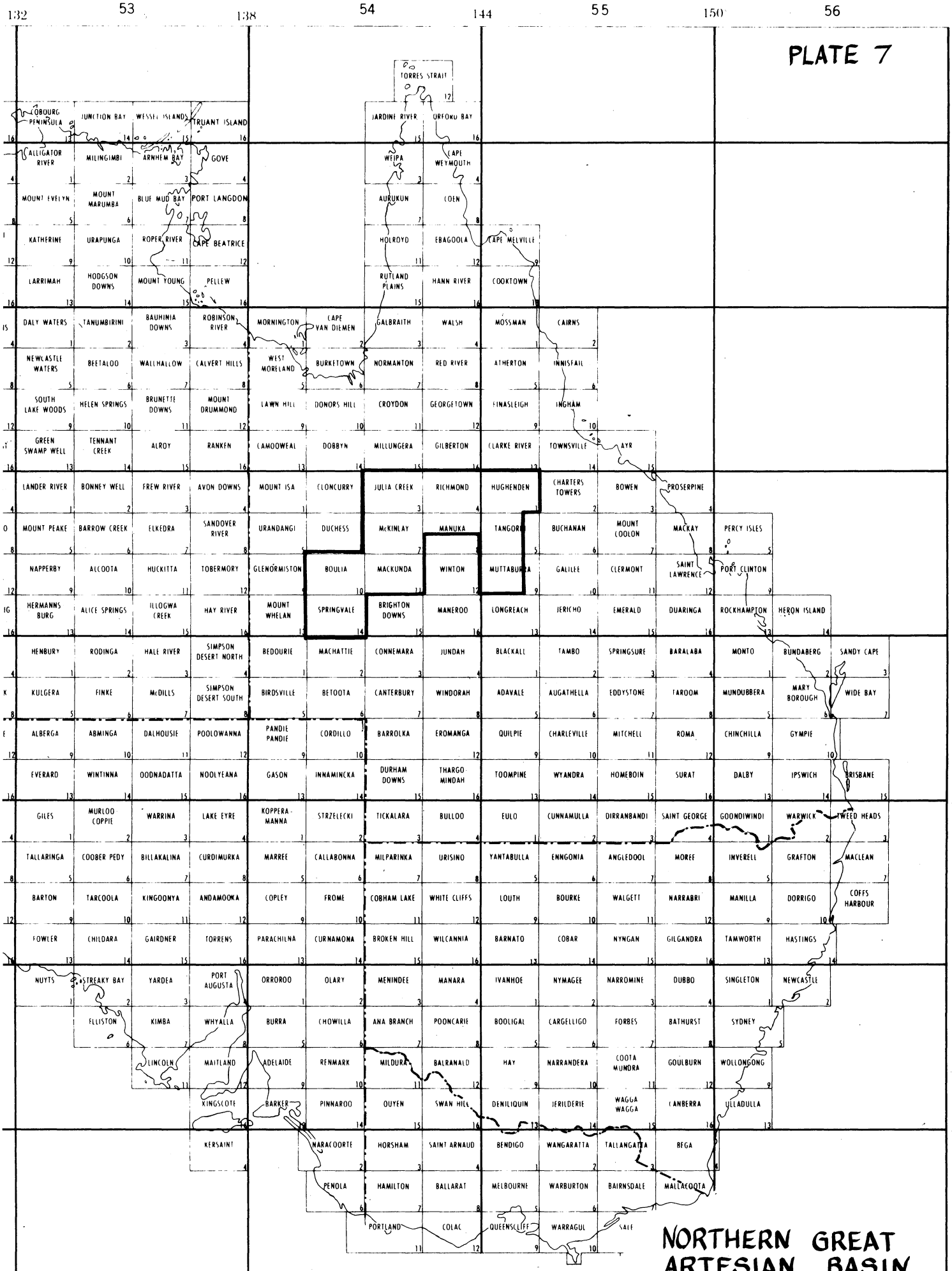
AUSTRALIA AND NEW GUINEA

BOUGUER ANOMALIES



MARINE GEOPHYSICAL SURVEYS
1967 and 1968

PLATE 7



NORTHERN GREAT ARTESIAN BASIN

AEROMAGNET SURVEY 1965

PLATE 8

AIRBORNE SURVEY, CENTRAL GREAT ARTESIAN BASIN, QLD, 1968

MAGNETIC INTERPRETATION

GEOLOGICAL STRUCTURE AND BORES

SCALE

20 10 0 20 40 60 80 MILES

20 0 20 40 60 80 100 120 KILOMETRES

LEGEND

TOPOGRAPHICAL

- Named place
- Highway
- Road
- River or creek
- Homestead
- Survey boundary

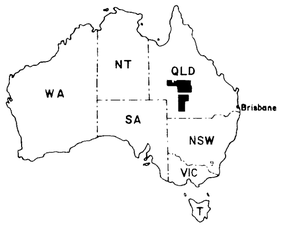
GEOPHYSICAL

- 2000 — Magnetic basement depth contour (depth in feet below sea level)
- C — Magnetic basement zone
- Magnetic basement depth discontinuity
- 5000 — Extended source depth estimate
- •5000 — Point source depth estimate

GEOLOGICAL

- Fault
- Structure
- Syncline
- Anticline
- Pre-mesozoic structural boundary
- •Orient N°2 — Bore

LOCATION DIAGRAM



INDEX TO ADJOINING SHEETS

BOULIA	MACKUNDA	WINTON	MUTTABURRA	GALILEE
SPRINGVALE	BRIGHTON DOWNS	MANEROO	LONGREACH	JERICHO
MACHATTIE	CONNEMARA	JUNDAH	BLACKALL	TAMBO
		WINDORAH	ADAVALE	
		EROMANGA	QUILPIE	
		THARGOMINDAH	TOOMPINE	

EXPLANATORY NOTES

THIS SURVEY WAS MADE WITH A DC-3 AIRCRAFT AT AN ALTITUDE OF 2000 FEET ABOVE SEA LEVEL ALONG EAST-WEST LINES SPACED TWO MILES APART.

FOR INTERNAL USE ONLY

54/81-35)
54/81-36)
54/81-38)

PLATE 9

133°45' 134°00' 134°15' 134°30' 134°35'

19°15' 19°30' 19°45' 19°50'

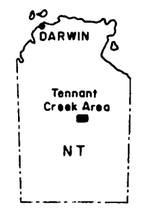
Area 4
Area 3
Area A1
Area A2
Area A5
Area C5
Area C6
Area C7
Area C8
Area C11
Area 2B
Area 2C

Phillip Creek
Edna Beryl
Whippet
North Star
Northern Star
STUART HIGHWAY
BARKLY HIGHWAY
Bishop Ck
Orlando
Great Western
Warrego
Quartz Hill
Station Hill
Red Bluff
Ivanhoe
Tennant Creek
Goodenia Ck
Mary Lane
Mascot
Jubilee
TENNANT CREEK
Juno
Peko
Mt Rugged
Mt Samuel
Eldorado
Nobles Nob
White Hill
Mt Cleland
Gigantic
Gum Ridge
Rocky Range
Channingum Creek
Gosse River

LEGEND

- River or creek
- Highway or main road
- Secondary road
- Road or track
- Bore
- Mine
- Aerodrome or landing ground
- Boundary of 1964 BMR airborne survey
- " " 1966 " " "
- " " 1967 " " "
- " " AGGSNA ground magnetic survey
- " " BMR " " "
- Telephone line
- Builtup area

LOCATION DIAGRAM



TENNANT CK MAGNETIC SURVEY LOCALITY MAP SHOWING SURVEY AREAS IN RELATION TO PREVIOUS SURVEYS

MILES
4 2 0 4 8

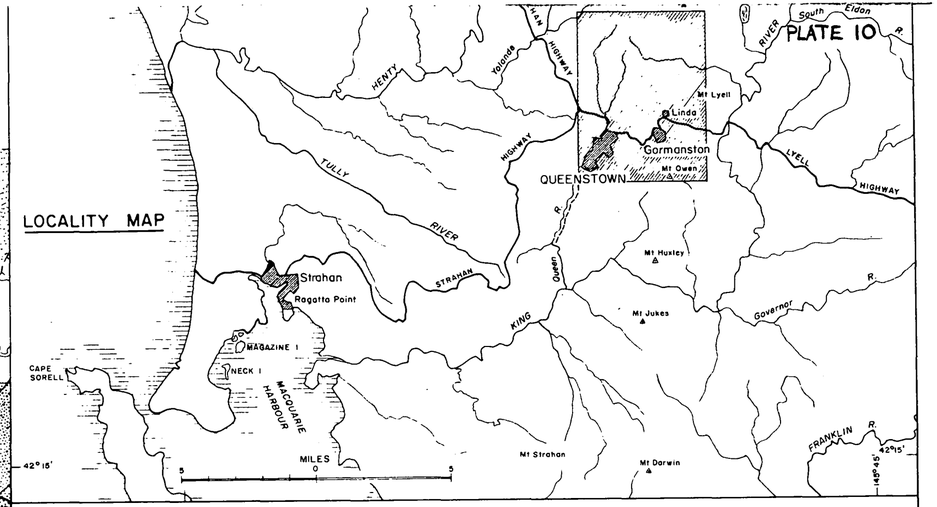
LEGEND

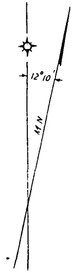
- Pleistocene Moraine — Pleistocene
- Eldon Group — L. Devonian to Silurian
- Gordon Limestone — Ordovician
- Upper Owen Conglomerate — Ordovician
- Middle Owen Conglomerate — Ordovician
- Lower Owen Conglomerate — Ordovician
- Jukes Conglomerate — Ordovician
- Mount Read Volcanics (including Lyell Schists) — Cambrian

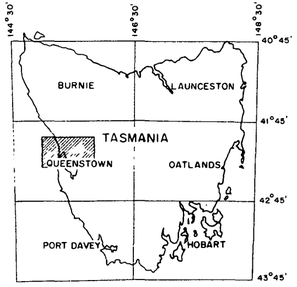
- Observed geological boundary
- Approximate " "
- Observed fault
- Approximate "
- Approximate position of Lyell Shear
- Syncline (with plunge)
- Anticline
- Mine for copper
- Au — Unless marked gold
- Quarry
- Trigonometric station
- Main road
- Vehicular track
- River or creek
- Outline of geophysical survey areas prior to 1949
- BMR geophysical surveys 1949-1966
- Rio Tinto geophysical survey 1959
- Traverses on which anomalies have been drilled
- 350/12 — FeS intersection in ft.
- Av. percent FeS

CROWN HILL
ZONE OF ALBITISATION
COMSTOCK 1959
COMSTOCK 1964/65
COMSTOCK 1957
COMSTOCK
FAULT
Comstock Creek
100/8
200/6
75/10
30
50/4
350/12
Queen River
West Queen River
East Queen River
CAPE HORN
CORRIDOR 1955/56
NORTH LYELL FAULT
NORTH LYELL BLOCKS
ROYAL THARSIS
WEST LYELL
BLOCKS TRAV 1965
LINDA
THE BLOW
GLEN LYELL
GLEN LYELL 1955/56
Conglomerate Creek
GORMANSTON
GORMANSTON 1964
NORTH LYELL
COPPER ESTATES MINE
QUEENSTON
GREAT LYELL 1957
MOUNT OWEN
Mt Owen 3360

LOCALITY MAP







REFERENCE TO AUSTRALIA STANDARD 1:250,000 MAP SERIES: QUEENSTON

QUEENSTOWN, TASMANIA, 1968
LOCALITY AND REGIONAL GEOLOGICAL MAP

MILES
1 0 1 2

AFTER MT LYELL M. AND R CO LTD, QUEENSTON AREA GEOLOGICAL MAP

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics K55/BZ-199

PLATE II

GEOPHYSICAL SURVEYS
1968
RUM JUNGLE AREA

DARWIN

ACACIA AREA

8 West

00

L4

336 N

Z1

312N

288N

192E

264 N

L3

Col

240 N

216N

Acacia Creek

192 N

196E

168 N

144 N

120N

L2

96 N

C1

C2

72 N

48 N

L1

24 N

00

RIVER

MANTON

ADELAIDE RIVER

24S

48S

72S

24E

96S

120S

Tie

72E

MANTON AREA

Manton Dam

Darwin River

RUM JUNGLE COMPLEX

560 N
MT FITCH NORTH
500N

Australian Railway

530 W

344 W

SLINGRAM, RESISTIVITY AND RADIOMETRIC SURVEYS

GRAVITY SURVEY

220 W

176 W

70 W

FAULT

120S RUM JUNGLE EAST GRID

TO 642 W

MT FITCH

North

384 N
372 N
MT BURTON AREA

MT BURTON

RUM JUNGLE

GIANTS REEF

168 S

48 E

WOODCUTTERS AREA

260S

AREA 44 EXTENDED

90 W

16 E

288 S

HUANDOT

312 S

12E

48E

360S

COOMALIE GAP WEST

48 S

72 S

BROWNS S-W

254N
RUM JUNGLE TRIANGLE (NORTH)
218 N

110E

150E

AREA 55B

AREA 55

FINNS

RIVER

142N
RUM JUNGLE TRIANGLE (SOUTH)
102E
126N
72E

RUM JUNGLE CREEK SOUTH

BATCHELOR

POWER LINE

Airfield

BATCHELOR LATERITES EXTENDED

COOMALIE GAP WEST

480S

COOMALIE

STURT HIGHWAY

21 S

GOULD Airfield

509E

GOULD AREA

WATERHOUSE

GRANITE

201S
213 S

MT MINZA AREA

509E

333 S

WATERHOUSE NO 2 PROSPECT

ADELAIDE RIVER

12°50

13°00'

131°00'

131°10'

132°00'

PINE CREEK

Reference to Australian standard 1:250,000 map series

MILES

1 0 1 2

LEGEND

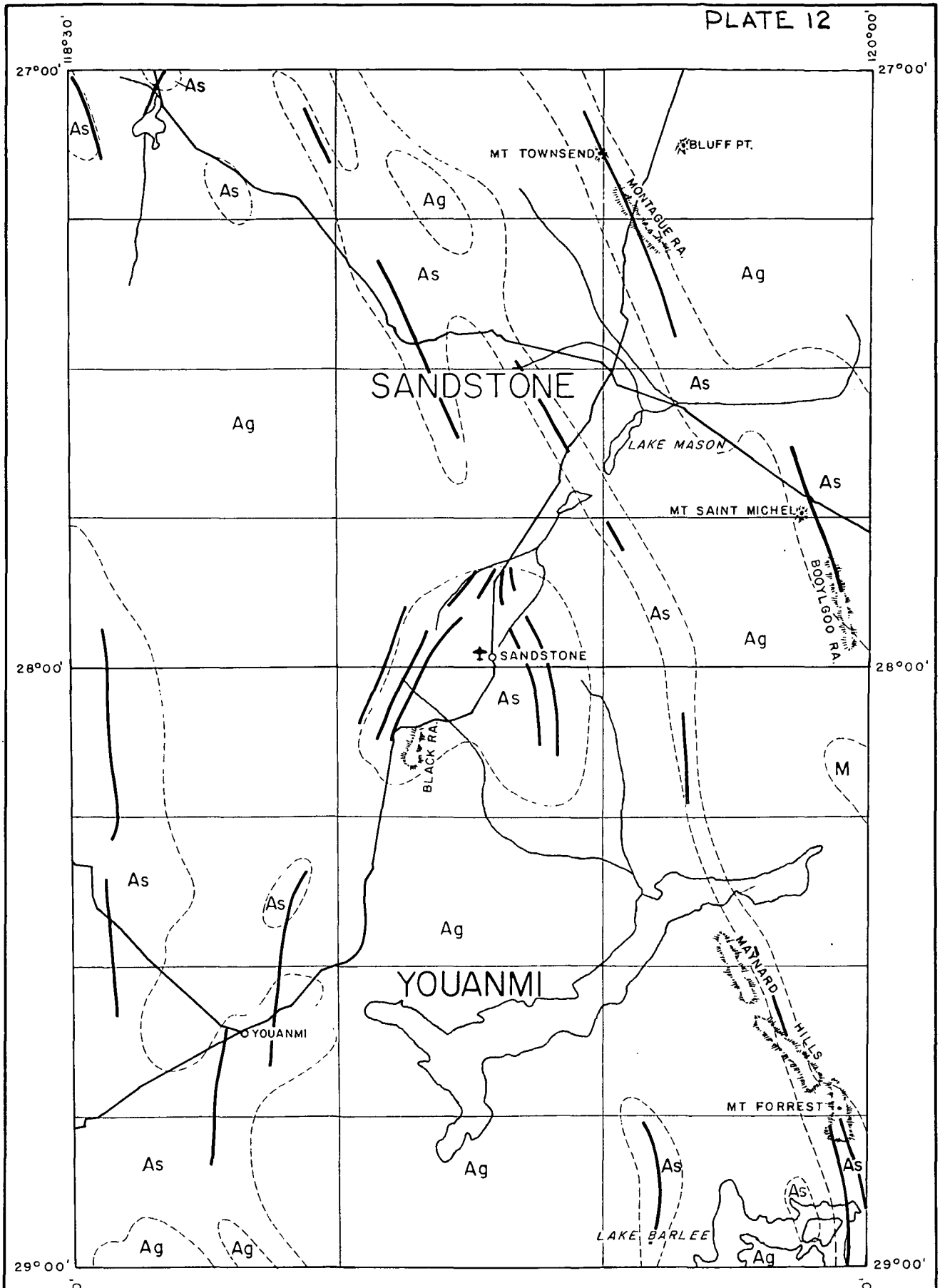
Geochemical Surveys 1967

Geophysical Surveys 1968

BASED ON D52/87-360

~~D52/87-442~~

PLATE 12



AIRBORNE SURVEY, SANDSTONE — YOUANMI, W A 1968

REGIONAL GEOLOGY AND MAGNETIC TRENDS

10 0 10 20 30 40 50 MILES

10 0 10 20 30 40 50 60 70 KILOMETRES

As — *Archaean sedimentary rocks contains basic igneous rocks*	M — *Zones of high grade metamorphism and zones of migmatite and gneiss*
Ag — *Archaean granite*	*Magnetic trend*

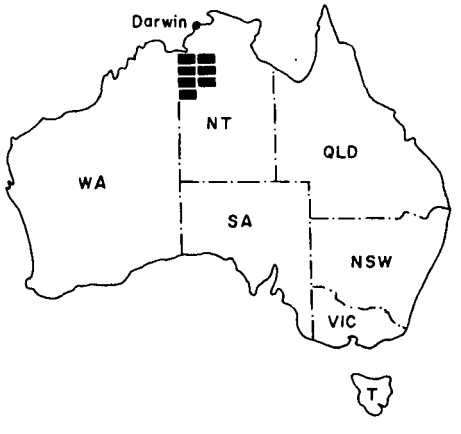
G50/BI-40

PLATE 13

INDEX TO 1:250,000 MAP SERIES

127°30'	129°00'	130°30'	132°00'	133°30'	
MEDUSA BANKS	PORT KEATS	FERGUSSON RIVER	KATHERINE		14°00'
CAMBRIDGE GULF	AUVERGNE	DELAMERE	LARRIMAH		15°00'
LISSADELL	WATERLOO	VICTORIA RIVER DOWNS	DALY WATERS		16°00'
DIXON RANGE	LIMBUNYA	WAVE HILL	NEWCASTLE WATERS		17°00'
GORDON DOWNS	BIRRINDUDU	WINNECKE CREEK	SOUTH LAKE WOODS		18°00'
BILLILUNA	TANAMI	TANAMI EAST	GREEN SWAMP WELL		19°00'
					20°00'

LOCATION DIAGRAM



AEROMAGNETIC SURVEY

VICTORIA RIVER AREA, N T

E52/B1-21

PLATE 14

DETAILED AEROMAGNETIC SURVEY, WESTERN VICTORIA

1968

NOTES

GEOLOGY AFTER 1:250,000 SCALE GEOLOGICAL SHEET, COLAC, NO. SJ54-12, PROVISIONAL EDITION, 1966, MINES DEPARTMENT, VICTORIA.

INDEX TO ADJOINING SHEETS

CORANGAMITE	BEEAC	GEELONG
COBDEN	COLAC	ANGLESEA
PRINCETOWN	BEECH FOREST	

GEOPHYSICAL INTERPRETATION

MILES 0 1 2 3 4 5 6 MILES

KILOMETRES 0 1 2 3 4 5 6 7 8 9 10 KILOMETRES

GEOPHYSICAL LEGEND

- Zone boundary, definite
- Zone boundary, indefinite
- A — Magnetic zone; free from superficial basalt
- B — Magnetic zone; probably covered by thin and/or weathered basalt
- C — Magnetic zone; probable areas of thick fresh basalt
- Probable volcanic neck or cone
- Zone of power line interference
- Trend of magnetic zone 6

J54/BI-40

PLATE 15

EASTERN PAPUA
PRELIMINARY BOUGUER ANOMALIES
(DENSITY 2·67 g/cm³)

Metamorphic rocks

50 25 0 50 100 MILES

75 50 25 0 50 100 150 KILOMETRES

(BASED ON PNG/BO-10)

PNG/B2-11