copy 4

COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record No. 1969 / 140

Geophysical Branch Summary of Activities 1969

CONTENTS

ILLUSTRATIONS

1. METALLIFEROUS AND AIRBORNE SECTION

Ground Surveys

Tennant Creek, NT (gold and copper). A ground magnetic survey was conducted at Tennant Creek from May to July 1969. Most of the work was done in the Aeromagnetic Ridge area about three miles east of the township, but some work was done at Area A, 24 miles NE of Tennant Creek, and one test traverse was run in the former BMR reservation area No. 3, 20 miles SSW of Tennant Creek (Plate 1).

All traverses were surveyed with a vertical-component magnetometer, and interesting areas were surveyed also with a horizontal-component magnetometer and a gravity meter. The test traverse at BMR Area No. 3 was surveyed also with AFMAG equipment, but the results were of no obvious value. Magnetic interpretation was based on curve-fitting methods developed by BMR.

The main Aeromagnetic Ridge anomaly appears to be due to a source about 1800 feet deep. Models of dykes dipping about 50° to the south and a triangular wedge gave the best fits to the observed data.

The test traverse at BMR Area No. 3 (Traverse 205W) was surveyed because drilling there revealed the only known Archaean basement in the Tennant Creek area. It was hoped that these results would indicate whether the main Aeromagnetic Ridge anomaly is due to magnetic members of the Archaean basement or to ironstone masses. Unfortunately the magnetic results were inconclusive. Neither at BMR Area No. 3 nor over the deep-seated magnetic anomalies at Aeromagnetic Ridge was there a gravity anomaly of the type encountered at the Comet prospect, which is an ironstone body on the southern flank of the Aeromagnetic Ridge.

Smaller anomalies in the Ridge area appear to be due to ironstone, and about six targets will be selected for drilling. One target also will be selected in Area A. The number of targets is small relative to the number of aeromagnetic anomalies because the anomalies are mainly of a form unsuitable for detailed interpretation.

AFMAG tests. Testing of the AFMAG field unit purchased from McPhar Geophysics continued in the Captains Flat area, NSW, during January and February 1969. Readings were normally difficult to obtain. Anomalies were obtained over the Tiger Cat and Narongo Faults, but the position of the cross-over in the latter case changed its location from day to day. Irregular and unrepeatable readings encountered on several occasions emphasise the basic unreliability of the method.

During February and March, six weeks were spent in the Buchan area, Victoria (Plate 2) traversing with the AFMAG equipment over probable faults and over known mineralisation. The same difficulties as encountered at Captains Flat occurred again, but clear anomalies were obtained over faults in the Basin, Pyramids, and Limonite Quarry areas. Mineralisation in the Back Creek area did not give a recognisable response; anomalies in this area were very small and were attributed to minor faulting.

Recording of AFMAG field strengths continued at sites close to Perth and Darwin, but breakdowns were frequent at both stations; broken styli and discharged batteries appeared as the main causes. Diurnal and seasonal variations showed up clearly on records, with some correlation between the two localities.

Some theoretical investigations of elliptical polarisation of electromagnetic fields were undertaken with particular reference to AFMAG and VLF work.

The main conclusions of the work were that an improved method using AFMAG fields cannot be constructed simply, because of the random nature of the field and because the ground AFMAG as it operates at present loses sensitivity rapidly as the field becomes elliptically polarised, and will not operate at all when the field is near-circularly polarised.

VLF tests. The testing of Ronka EM16 equipment, which uses very low frequency (VLF) transmitting stations as energising sources was carried out in Tasmania and Western Australia during 1969. The naval radio station of North West Cape, WA provided a strong source of electromagnetic radiation at 22.3 kHz. Signals from other stations could not be picked up with the Ronka EM16 in Australia.

During February and March, tests were carried out in the Queenstown, Comstock, Zeehan, Razorback, and Cuni areas of NW Tasmania, where geology was known and geophysical results from previous surveys were available. Some success was indicated in locating geological contacts and near-surface geophysical conductors, but no real indication of depth penetration of the VLF method was obtained. A major difficulty in many areas was the unfavourable orientation between the VLF signal and the strike of conductors.

In June, tests were conducted in the Geraldton and Mount Magnet areas, WA but had to be discontinued owing to temporary close-down of the transmitting station. The tests were continued in August and September in the Kalgoorlie and Wiluna areas. In the Kalgoorlie area the depth penetration of the method was shown to be quite limited in areas of low resistivity. In areas of 10 ohm-metre surface resistivity the depth penetration was less than 100 feet.

In the Wiluna area, an attempt was made to trace fresh water aquifers using the VLF method, but although the contact between granite and water-bearing calcrete was well defined there was no obvious correlation between VLF results and the known aquifers.

Magnetotelluric study. Background reading on the applicability of the magnetotelluric method of metalliferous prospecting was continued when time permitted, during 1969. Enquiries were made for the purchase of a portable wave impedance equipment operating in the 10-1000 Hz range for initial experiments in conjunction with other metalliferous survey techniques. A computer programme to evaluate the attenuation and orientation of electromagnetic waves in layered media with special application to magnetotellurics was developed. A study was made of magnetotelluric curve-matching techniques.

Turam model tests. During January and February 1969, additional Turam model tests were carried out to allow production of an interpretation diagram based on the theory developed during the tests. A draft of the final model test report was completed.

The main findings of the tests, which were confined to tabular bodies, were:

1. Depth to top of the body and conductivity/thickness ratio can be determined directly from the ratio and phase curves, making the tedious calculations of real and imaginary components unnecessary.

2. The intensity of an anomaly decreases with distance from the energising source for at least the first 2000 feet.

3. While the effect of dip is quite noticeable, only qualitative estimates can be made for dip.

4. Parallel bodies (en echelon lenses) sometimes respond as single sources, giving erroneous depth and conductivity estimates.

5. Results were obtained from models designed to simulate fences, conducting overburden concealing a dipping body, and an insulator in a conducting medium.

6. Some models of fold systems showed results similar to horizontal bodies even when the folding was isoclinal.

Two papers dealing with aspects of Turam calculation and interpretation have been prepared for publication in an overseas journal.

Gosses Bluff, NT; ground magnetic investigations. During August 1969 a ground magnetic survey was conducted over two areas situated south of Gosses Bluff. The aim of the survey was to investigate anomalies thought to be due to remanent magnetisation in the impact breccia in the hope that it could help determine the time at which an extraterrestrial body collided with the Earth and formed the Bluff. This work was a follow-up to an airborne survey carried out by G.A. Young of BMR. in 1968. Young observed a close correlation between occurrences of impact breccia and airborne anomalies in the vicinity of Mount Pyroclast and in an area immediately south of Gosses Bluff proper.

The ground magnetic results in the Mount Pyroclast area confirmed the correlation between the outcropping impact breccia and magnetic anomalies. The ground magnetic results in the area immediately south of Gosses Bluff (Plate 3) revealed two distinct anomalies in an area exhibiting featureless background. Depth calculations were made assuming that the bodies were of spherical shape. The calculated depth to the centre of the sphere was 78 feet in each case. Curves could be fitted to the magnetic profiles if field inclination was $+70^{\circ}$ to $+80^{\circ}$.

Both breccia throughout to 80 feet, and oriented core samples (five from each borehole) were obtained. These are being investigated by E. Manwaring of BMR at the Australian National University palaeomagnetic laboratory.

targets (Hermannsburg No. 38 and 39) were drilled in quartzitic

Darwin Uranium Group

Alpha surveys (measurements of alpha particle concentrations in boreholes) were made in three localities in the Rum Jungle area. These localities are shown on Plate 4. In the Crater Formation the alpha-particle activity was found to be due to daughters of thorium. In the Rum Jungle Creek South and Mount Fitch areas, alpha anomalies coincide with gamma anomalies, and the alpha surveys produced no information not available from gamma surveys.

Radiometric, resistance, and self-potential logs were made of 24 diamond-drill holes in the Woodcutters L5 area, two diamond-drill holes in the Rum Jungle Embayment area, one in the Acacia area, and one in Area 44 Extended.

A gamma-ray spectrometer was installed early in the year; about 120 samples have been analysed for prospectors, prospecting companies, Mines Branch, and BMR. The requests accompanying the samples have been for uranium-thorium ratios or for equilibrium analyses, and not for routine radiometric assaying.

An AFMAG recorder has been kept in continuous operation. The Darwin seismograph station has been maintained, and preliminary bulletins have been prepared and issued.

Airborne surveys

Murchison-Yalgoo goldfield. An airborne magnetic and radiometric survey was flown between March and July 1969 by DC.3 aircraft VH-MIN. The survey covered the BELELE, CUE, and KIRKALOCKA 1:250,000 map areas and the eastern thirds of BYRO, MURGOO and YALGOO (Plate 5); it constituted a continuation of the aeromagnetic and radiometric programme over the Archaean Yilgarn Block of Western Australia.

The objective of the survey was to aid the systematic regional geological mapping of the shield and to assist the search for minerals by delineating greenstone belts.

Many high-amplitude magnetic anomalies correlate with known regions of greenstones, and are attributed to banded ironstones and/or basic and ultrabasic igneous rocks. The most intense anomalies occur over Mount Lulworth and Mount Hale in BELELE, and south of Lake Annean in CUE. In these areas, broad multiple anomalies which rise to 18,000 gammas indicate that rocks within the respective greenstone belts strike predominantly north-east.

Two major elongate greenstone belts were interpreted in the southern part of the survey area from anomalies mainly attributed to banded iron formations. One of these belts extends through the YALGOO sheet from north-east of Yalgoo along the Gnows Nest Range to the southern border of the survey area. The other extends from east of Cue through Mount Magnet to Canning Hill. Both have been mapped geologically over much of their lengths as greenstones.

Four areas, where anomalies of intermediate magnitude and poor linearity were delineated, are recommended for ground investigation owing to the possible presence of basic and ultrabasic rocks. One of these areas lies in the Mount Luke region of MURGOO, whereas the other three lie in southern and north-eastern KIRKALOCKA. The area in MURGOO coincides with mapped granites; however the character of the magnetic anomalies indicates greenstones. In north-east KIRKALOCKA, part of the magnetically disturbed area coincides with mapped gabbros. This area is probably one of extensive greenstone distribution where rocks strike approximately east-west. The other two areas lie east and west of Canning Hill and display predominantly north-south strike directions. Nine fold axes have been interpreted in YALGOO; the two of greatest significance are shown on the sketch map.

The radiometric data display good correlation between granite outcrops and anomalous areas; however, it does not appear possible to delineate different granitic types on the basis of these data. One hundred and forty-nine radiometric anomalies satisfying the point source criteria were detected; of these, 77 are significant with respect to local geological noise and may warrant ground investigations.

Southern Cape York Peninsula airborne magnetic and radiometric survey. This survey was flown between August and November 1969. It aimed to cover the WALSH, MOSSMAN, and CAIRNS 1:250,000 map areas and parts of HANN RIVER and COOKTOWN. Because of delays due to adverse weather and pilot illness the programmed survey was not completed.

The objectives of the survey were to determine structures and sediment thicknesses in the Laura and Carpentaria Basins as an aid to petroleum prospecting, and to provide magnetic and radiometric data to assist mineral exploration in the Cooktown, Mossman, and Cairns regions. The offshore part of the survey area was flown as an aid to the study of crustal structure in this area.

Plate 6 illustrates the preliminary results obtained from the magnetic data together with the distribution of the major geological units in the survey area.

The Precambrian rocks show little magnetic relief. The magnetic trends over rocks of the Tasman Geosyncline reflect the regional NNW strike. Within this geological unit, rocks of the Hodgkinson Formation are generally non-magnetic, Featherbed Volcanics produce anomalies with amplitudes less than 100 gammas, and the Nychum Volcanics are characterised by numerous low-amplitude magnetic anomalies in the range 10 to 50 gammas. Anomalies are also associated with Palaeozoic serpentinites.

Strike corrected basement depths in the eastern part of the Carpentaria Basin indicate that the basement deepens westwards from 250 feet above sea level to 1750 feet below sea level. Depth estimates also suggest a slight basement rise in the south-west of WALSH. Anomaly configuration in the central and eastern parts of the basin indicates that the basement rocks may be strongly folded.

In the COOKTOWN and HANN RIVER areas there is little magnetic relief, the largest anomalies occurring over the Laura and Carpentaria Basins. Over most of this region the magnetic profiles are flat with isolated anomalies of up to 25 gammas in amplitude. Some of these have been correlated with basalt, but most occur over sediments and are due to either intrasediment or basement features.

Statistical analysis of the radiometric data indicates that four broad geological divisions may be resolved, namely: Cainozoic alluviums; Middle Devonian to Lower Carboniferous sediments and residual soils; Archaean to Lower Devonian sediments and residual soils; Permian and Triassic volcanics.

MANN-WOODROFFE airborne survey, SA and NT. This survey of the MANN 1:250,000 map area and parts of WOODROFFE, BIRKSGATE, LINDSAY, and PETERMANN RANGES was flown from March to July 1969. Aero Commander VH-BMR was used, towing a proton precession magnetometer along north-south lines, spaced at 1 mile, at an altitude of 500 ft above ground level.

The objectives of the survey were to aid geological mapping in the area and to delineate regions where the potentially nickeliferous rocks of the Giles Complex are close to the surface.

Magnetic trends were delineated and the area has been subdivided into zones of differing anomaly amplitude range (Plate 7). The geological significance of the zone types is presented in the following table.

Zone type	Description	Geological significance
1	Anomalies with amplitudes less than 100 gammas and with few trends	Sedimentary rocks and possibly some granitic rocks. Any trends that are delineated probably represent sedimentary bedding or reflect underlying basement layering. They may also represent slightly basic parts of granitic rocks.
2	Anomalies in the range 100 to 500 gammas with some trends	Granitic rocks, acid granulites of the Musgrave-Mann Metamorphics. Trends probably represent layering in the granulites, basic layers in granites or minor dykes.
3	Anomalies in the range 500 to 1000 gammas with many trends, some of them strong	Basic granulites, amphibolites of the Musgrave-Mann Metamorphics and intermediate to to basic intrusives. The stronger trends probably represent dykes.
4	Anomalies greater than 1000 gammas with many trends, most of them strong.	Basic to ultrabasic intrusives of Giles Complex rocks, major dykes, and dyke suites. The trends represent dykes and layering in the intrusives.

Zones of type 1 were correlated with the Officer Basin (in the south-west of the area), the Levenger Arkose, and areas of anorthosite and granitic rocks. The Officer Basin appears to have a faulted contact with the basement rocks, and the edge of the basin has been interpreted as being farther north than was originally supposed.

Zones of type 2 and 3 occupy a large part of the area. Where these zones contain magnetic trends they are thought to represent regions of granite gneiss or acid granulites. Where trends are absent, the zones have been interpreted as representing granites.

Small zones of type 3, such as those south-east and south-west of Mount Sir Thomas, generally flank zones of type 4. This zonal configuration has been interpreted as representing a gradation from ultrabasic to less basic rock types, possibly where an ultrabasic intrusive has partially assimilated the surrounding host rocks.

Correlation of zones of type 4 with Giles Complex intrusives is very apparent along the southern side of the Mann Fault and in the Tomkinson Ranges. The elongated type 4 zones east and west of Hanging Knoll and the zone trending east from Mount Davies suggest continuity at depth of the intrusive bodies, which have been mapped at only a few localities on the surface.

The large type 4 zone between Mount Harcus and Mount Tietkens is probably caused by ultrabasic material that has intruded shear zones at depth. These shear zones are reflected by the strong positive and negative magnetic lineations which extend up to 20 miles. Several small zones of type 4 containing one or more magnetic trends have been correlated with dolerite dykes.

The small ultrabasic intrusives along the Woodroffe Thrust do not give rise to any significant magnetic anomaly. These bodies are probably 'Woodroffe Type' intrusives as opposed to the 'Giles Type', which occur farther west and have strong anomalies associated with them.

Both the Mann and Hinkley Faults give rise to magnetic anomalies which were traced across the area. There also appears to be some magnetic expression of the Davenport Fault and Woodroffe Thrust, but the anomalies are not very continuous.

Thorntonia and Burke River airborne spectrometer survey, Qld. This survey was made with aircraft VH-BMR during the period August to October 1969, and covered known areas of phosphatic outcrop in the Thorntonia and Burke River areas of western Queensland.

The survey had two aims: (a) to evaluate the recently purchased airborne gamma-ray spectrometer, with regard to operating parameters, and data reduction logistics; (b) to determine the potential of the spectrometer as a prospecting instrument for phosphates. Experience elsewhere indicates that marine phosphate deposits are frequently associated with uranium concentrations, and it was hoped that the associated gamma-radiation would be detectable from an aircraft.

The spectrometer utilises two 6-inch by 4-inch Harshaw NaI crystal detectors. Their combined output is divided into three channels which are chosen to discriminate between the radiation energy levels of thorium, uranium, and potassium. A fourth channel covers the total energy spectrum.

The Thorntonia area lies approximately 70 miles NW of Mount Isa, the Burke River area the same distance south-east (Plate 8). In both regions the phosphate deposits occur in the Cambrian Beetle Creek formation, which comprises cherts, siliceous silt-shales, and limestone.

In the Thorntonia area the Beetle Creek formation showed good correlation with uranium anomalies over most of its extent. Although no details of phosphate concentration have been released for this area, in regions of known phosphate concentration anomalous highs were obtained on the uranium channel. Thorium and potassium anomalies in combination occurred over most of the Precambrian rocks traversed, and thorium anomalies were observed over much of the laterite in the area and over some of the river sands.

Analysis of the Burke River data is incomplete at present, but correlation of the phosphate deposits with uranium anomalies is apparently good. Thorium anomalies in this area are frequently large, and appear predominantly over laterite deposits.

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 1115 line miles were surveyed in the south-west and north-east quadrants 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 January 1970 to March 1971.

VH-BMR installation. The installation of survey equipment in the recently acquired Aero Commander aircraft VH-BMR was completed in March, and three field surveys were successfully completed during the year.

The installation included the MNS-1 proton precession magnetometer with towed bird and associated cable winch, a 4-channel gamma-ray spectrometer with two 6" x 4" detecting crystals, two camera wells and associated mounts for all of the department's aerial cameras, a BMR-designed timing system, and a power distribution system. These equipments are mounted in two instrument racks on the left side of the cabin, and when they are in position it is possible to mount seats for two persons as well as the pilot.

When all of these systems are mounted it is possible to carry sufficient fuel for a survey mission of five hours' duration plus a reserve of one hour. This also appears to be the fatigue limit for a single-pilot operation at low levels.

Apart from the survey equipment all essential flying aids and navigation systems have been duplicated and a gyrosyn compass installed. As a consequence the aircraft has been granted a limited I.F.R. rating by the Department of Civil Aviation. This means that aircraft movements are not subject to the weather limitations, which have restricted the operations of departmental aircraft in the past.

During the year, the improved proton precession magnetometer MNS-2, currently being designed by Geophysical Services Section staff, was test flown in VH-BMR. The indications are that no major problem can be expected in installing this magnetometer in the aircraft, and this project will proceed in 1970.

VH-BMG Twin Otter procurement. A contract for the procurement of a De Havilland DHC-6 Twin Otter aircraft, to replace the DC3 VH-MIN, was placed in October. This aircraft is expected to be handed over to BMR in January 1970. Contracts to make airframe and electrical modifications in accordance with our equipment installation requirements are expected to be let in late 1969 or early 1970.

Geophysical instrumentation purchased during 1969 for installation in the Twin Otter includes two ASQ10A fluxgate magnetometers, one Hamner-Harshaw gamma-ray spectrometer which meets BMR design, and a Marconi AD 560 L doppler navigator. Tenders were also called for the supply of an airborne data acquisition system which involves a small general purpose digital computer. This plant item is expected to be delivered in early 1970.

Rum Jungle detailed airborne radiometric survey. This survey had been programmed to test the new gamma-ray spectrometer in a uranium environment. It was proposed that the Hundred of Goyder be flown with VH-BMR at a line spacing of one-tenth of a mile, and that contours of gamma-ray intensity be produced for each of the four channels: potassium, uranium, thorium, and total count.

Owing to delays encountered earlier in the year, the survey flying did not commence until 4 November. Consequently the interpretation of results will not be completed until 1970.

Contract airborne surveys

Northern Great Artesian Basin, Qld. Estimates of depth to basement rock were made on aeromagnetic data in Julia Creek, Richmond, Hughenden, McKinlay, Manuka, and Tangorin 1:250,000 sheet areas. Depth calculations are continuing on the remainder of the survey area.

Victoria River Basin, N.T. Preliminary work was commenced in correlating geological mapping with aeromagnetics in the northern part of the basin.

East Papua. The contract for the aeromagnetic survey of the East Papua mainland and adjacent islands was awarded to Compagnie Générale de Géophysique in August 1969. The survey party was positioned in Papua in early November. Operations had not commenced owing to equipment faults.

Airborne reductions and contracts

The reduction of airborne magnetic field data was severely hampered during 1969 by lack of professional and subprofessional staff.

Automatic Data Processing and programme development. To date a total of 90,500 flight-line miles of digital magnetic data has been edited and stored on magnetic tape.

For 1969 to the end of October 43,320 flight-line miles of data has been processed for magnetic tape storage and profile-plotted for the 1:250,000 map scale extended sheet presentation.

Parameter decks have been prepared for the Stage 2 (Datum Analysis) program for 41,180 line miles of magnetic data and the programme run on 20,200 miles of these data. Currently the parameter decks for the Stage 3 (Magnetic Contour Plotting) programme are being prepared for the data already processed under the Stage 2 programme.

The Stage 3 programme was used to prepare a section of data in the SANDSTONE 1:250,000 map area for use in a sample production of machine contouring by Engineering Computer Services of Sydney. The resultant contour map was highly satisfactory. The same data are currently being used for the development of BMR's own contouring programme, which it is felt will be superior to that used by Engineering Computer Services.

A grogramme has been developed to automate various manual drafting processes used in flight path recovery. It outputs, relative to the base mapping, the X-Y co-ordinates of the checkpoints plotted on aerial photographs, for use by a plotting programme and by the contouring programme being developed. It establishes the best-fit east-west flight-line position and the distances between successive plotted checkpoints, for use by the magnetic profile-plotting programme.

Manual data reduction. Work was completed on the LAVERTON WA and EDJUDINA WA 1:250,000 map areas, and the SIR SAMUEL WA and the DUKETON WA areas are being worked on currently whenever staff can be freed from processing the incoming data from the present field season.

Contracts. Final delivery was taken of the scribed contour mapping and interpretation reports for the C.G.G. 1967 contract survey of the Papuan Basin, Papuan Basic Belt, and Astrolabe regions.

Final delivery was taken of the scribed contour mapping for the A.M.E.G. 1965 contract survey of the northern Great Artesian Basin.

A contract was let to C.G.G. in August for an airborne magnetic survey for the mainland and offshore of East Papua. Delivery of the scribed contour mapping and interpretation reports is expected in October 1970.

Tender specifications are being prepared for an airborne magnetic survey in 1970 over the three 1:250,000 map scale sheets of GLENGARRY, WILUNA, and KINGSTON in WA.

The contract let in September 1966 to C.D.C. for the development of processing programmes for aeromagnetic data, has not yet been finalised. Debugging of the Stage 2 programme is delaying final acceptance.

2. SEISMIC AND MARINE SECTION

Gravity surveys

Introduction. One reconnaissance gravity survey and one detailed gravity survey will be completed in 1969: (a) a contract helicopter gravity survey of two areas in Western Australia and (b) a detailed gravity survey north of Julia Creek, Queensland (Plate 9). In addition, work continued on the gravity map of Australia, on the collation of density determinations on cores, and on development of computer programmes.

Contract helicopter gravity survey, WA. The survey commenced at Kalgoorlie on 9 May, and was not completed at the time of writing, but 6389 stations had been occupied up to the end of October 1969. Only the results from the southern area have been received (Plate 10). They show an intense Bouguer anomaly gradient associated with the Fraser Fault, and permit the Fault to be traced beyond its outcrop. The Bouguer anomaly high to south-east of the fault-zone indicates a large near-surface mass excess. The lows on either side are relatively more negative than values over adjacent and geologically similar areas of the shield. This could indicate a regional downwarping of the base of the crust as compensation for the local large mass excess.

The station spacing (7 miles) is too large to indicate local mineralisation, but regional changes in Bouguer anomaly pattern may be associated with regional changes in near-surface density, which may be related to rocks containing mineralisation. An example of this is a Bouguer anomaly high trending south from Kalgoorlie. This can be qualitatively correlated with a narrow band of ultrabasic rocks from which gold has been mined. Other highs in JACKSON, SOUTHERN CROSS, and HYDEN 1:250,000 map areas may have a similar correlation.

A major feature in Plate 10 is the NNW-trending gradient extending from BREMER BAY to MOORA. This gradient corresponds closely to the Yandanooka/Cape Riche Lineament. The change in level of Bouguer anomaly values across this Lineament could suggest that the crust thickens to the east or that the grade of metamorphism is greater to the west.

Millungera detailed gravity survey, Qld. This survey was made in July 1969, at the request of the Geological Branch, over Mount Brown and Mount Fort Bowen. These are Precambrian inliers in the southern part of the Mesozoic Carpentaria Basin. The object of the survey was to determine the Precambrian surface configuration beneath the Mesozoic close to the inliers. The results are shown in Plate 11, however interpretation has not been completed at present. It does appear, however, that the Precambrian surface could dip steeply away from outcrop to a depth of approximately 1000 feet and the inliers may in fact be fault controlled.

Formation density project. All available core densities were collected and are stored in the Group. A computer-orientated storage and retrieval system will be initiated when staff are available. A system for measuring surface sample densities has been discussed with Petroleum Technology Section and a start is expected soon on samples from the Ngalia Basin.

Gravity map of Australia. A 3rd edition of this map, with data up to the end of 1967, was forwarded to the Government Printer. An accompanying report was prepared for ECAFE.

Computer programmes. Development of interpretation programmes continued, but the main effort was put into development of programmes for gravity data presentation - e.g. drawing, contouring, and isometric sketches.

Seismic surveys

(Plate 11A)

Ngalia Basin seismic survey. An investigation of the Ngalia Basin commenced in 1967 as a joint project between the Geological and Geophysical Branches. Seismic Party No. 1 returned in 1969 for a two-month programme to complete the investigation.

Reflection profiling in 1968 in the Waite Creek area, 26 miles south-west of Vaughan Springs homestead, had indicated that the western end of the northern margin of the Ngalia Basin is affected by large-scale overthrust faulting. In order to clarify the picture, further reflection work was done in 1969 in the same area along Traverse K, which extends for ten miles in a NW direction across the apparent fault. A number of fair quality events were recorded down to a maximum depth of 16,000 feet and to a distance of about eight miles beyond the surface expression of the fault. A reflection from the thrust plane showed up very strongly in the section. No coherent events occurred above the thrust plane. Some limited reflection work to the south (Traverse N) indicated that the fault peters out to the south-west as the section thins.

Two reflection traverses (O and F) were surveyed to connect the 1967/1968 BMR work to that in the middle of the basin by Pacific American Oil Company. It is hoped by this means to extend to the middle of the basin the correlations with surface outcrops made in 1968.

(Plate 12)

Deep crustal reflection surveys. BMR undertook 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 including if possible the structure near the base of the crust. Preliminary feasibility tests for deep crustal reflections were carried out in 1968 in the Mildura, Vic., and Broken Hill, N.S.W., areas and early in 1969 in the Tidbinbilla, A.C.T., and

Braidwood, N.S.W., areas. Fair to poor quality deep crustal reflections were obtained in each of the areas tested and a six months crustal reflection survey commenced on the "Geo-Traverse" across the West Australian Precambrian Shield early in June 1969.

In the Mildura and Broken Hill areas fair quality reflections were obtained from within the crust. Reflections at times of 10.10s and 11.35s were considered to be from the Moho Discontinuity at depths of approximately 30 km. and 35 km. in the respective areas. Experimental reflection shooting using various geophone and shot-hole patterns, charge sizes and depth of shot-holes was carried out in attempts to improve reflection quality. On the granites in the Broken Hill area it was necessary to use an explosive charge of 10,000 lb. to obtain fair quality deep crustal reflections.

Experiments carried out at Tidbinbilla and Braidwood were designed to determine the practical limitations of using 4.3 km geophone spread lengths compared with 2.15 km geophone spreads and to investigate the efficiency of common depth point (C.D.P.) shooting using small charges. Further objectives were to sample another two areas near Canberra prior to embarking on a major survey on the "Geo-traverse". The results indicated that the use of long spreads did not seriously affect the quality of deep crustal reflections and that C.D.P. shooting using small charges did not improve reflection quality.

In the Tidbinbilla and Braidwood areas poor quality reflections were obtained to 12s and 10s respectively, i.e. from depths of approximately 38 km and 30 km.

Work on the Western Australian Geo-Traverse comprised crustal reflection probes at Fraser Range, Widgiemooltha, Boorabbin, and Doodlakine (Plate 12). A further probe will be conducted before the end of the year. The reflection party commenced operations on the Geo-Traverse at a location about 80 miles east of Norseman, on the east side of the Fraser Range Structure. Because of the poor reflection results obtained initially the party commenced sampling across the structure. Test shots fired on each geological unit between Balladonia and Norseman yielded poor quality reflections at times of 2.3 s at Balladonia, 9 to 11 s at the crest of the Structure and at 6 to 9 s. at the west of the structure. None of these reflections were of sufficiently good quality to consider conducting a full scale reflection and velocity probe.

At Widgiemooltha in the greenstone belt of rocks of the Coolgardie-Kalgoorlie mineralised zone a programme of experimental shooting, offset reflection/refraction profiling and CDP shooting was carried out. Fair quality reflections were recorded to 5.5s. and there is evidence of deeper events at 8 to 9 s. The near surface rocks were found to have an average refraction velocity of approximately 6.1 km/s. and the average vertical velocity to the reflecting horizons at about 9.5 km. was found to be about 5.8 km/s.

Fair quality reflection events were recorded to 7 s. and poorer quality events at 11 to 12 s. in the Boorabbin area using charges of about 10,000 lb. Geophex equivalent. Reflection events recorded at Doodlakine are of poor quality at times to 11 s.

At the commencement of the reflection probe in the Boorabbin area, a supplementary refraction recording programme was initiated to utilise the large explosions from the reflection shots for refraction profiling in the crust between Kalgoorlie and Mundaring. Recordings of each shot were made at the Geophysical Observatory sites at Mundaring and Kalgoorlie and at mobile seismograph stations operated by observatory and seismic party personnel at selected locations on this line.

Preliminary results from the refraction profile indicate velocities of 5.6 to 6.2 km/s from intermediate layers within the crust and 8.1 km/s from the Moho Discontinuity. Detailed analysis of the reflection/refraction data is continuing in the attempt to use the seismic method to provide information on structure within the crust on the Geo-Traverse.

During the course of the seismic surveys in the Gosses Bluff area of the Amadeus Basin and in the Mt. Doreen area of the Ngalia Basin, brief tests were carried out to determine the feasibility of recording deep crustal reflection information in Central Australia. In both tests fair to good quality deep crustal reflections were obtained with no major effort. Strong reflection events at 12.0s. and 12.7s. in the Amadeus and Ngalia Basins respectively were considered as probably from the Moho Discontinuity. In the Amadeus Basin a strong event was recorded at 8.5 sec. from an intermediate crustal layer. Analysis of this data is continuing.

Experiments using a method of controlled directional reception were carried out during the Gosses Bluff Seismic Survey in order to test the method and to use it to determine the attitude of the shallow strata near the centre of the Gosses Bluff structure. Analysis of this data is continuing. However initial results indicate some success with the method in this case in areas of steep dip.

Gosses Bluff seismic survey, NT. A joint BMR/US Geological Survey project on Gosses Bluff commenced in 1967 using combined geological and geophysical techniques. Seismic Party No. 1 carried out a survey between April and August 1969.

Two main reflection traverses each about 16 miles long were shot through the Bluff from south-west to north-east and from north-west to south-east. Single coverage was used away from the Bluff where reflection quality was good, but it was necessary to use multiple coverage, variously 3-, 6- and 12- fold, close to the Bluff where reflection quality was poor. Continuous coverage was achieved under the walls of the Bluff by using offset shooting.

No reflections were recorded in the immediate vicinity of the Bluff shallower than about 18,000 feet although good continuous reflections occur deeper than this. Good reflections from shallower than 18,000 feet occur at distances from the Bluff greater than about 4 miles. From this and known geology it is deduced that the zone of disruption associated with Gosses Bluff is a shallow saucer of diameter about 14 miles superimposed on a roughly hemispherical bowl of diameter 8 miles and depth $3\frac{1}{2}$ miles.

Detailed vertical velocity information was obtained at various locations around the Bluff by shooting expanded spreads and by statistical analysis of normal reflection records. It was found that the velocities for the locations north of the Bluff were significantly higher than for those south of the Bluff.

Marine geophysical surveys

North-west continental shelf. This survey was completed in December 1968 by Ray Geophysical Division of Mandrel Industries Inc. Plate 13 shows the traverse layout. About 15,000 miles of gravity, magnetic, and seismic profiling was done over a period of 75 days. Seismic refraction profiles using sonobuoys were shot every two or three days. Navigation was by a combination of satellite doppler fixes, sonar doppler, and VLF radio location; because of various troubles, navigational accuracy was only 0.2 to 0.5 mile.

The final data reduction is being carried out by computer, and some unforeseen problems and inadequacies in data collection have been detected. At this stage (November), the results are still being processed by the Ray Geophysical Division in Houston, Texas. Preliminary data have been described in Record No. 1969/99.

Considerable effort has been made to define the requirements for the 1970 marine survey of the Gulf of Papua and the Bismarck Sea. The on-board data acquisition systems have been defined more specifically than in previous surveys, as have the requirements for on-line data quality checking. The computer processing required has been broadly outlined. The programmes presently available in BMR will be made available to the successful contractor.

BMR acquired a Hewlett Packard 2116B computer in October for the on-board processing and CDP stacking of the six-channel seismic data that will be obtained on the next marine survey. The computer is being checked out, and programmes are being developed by contract for the required processing.

Development of computer programmes for reduction of marine survey data and for presentation and interpretation of results has been a continuing part of the group's work. Automated methods of interpreting Bouguer anomaly profiles in terms of simple basinal and plutonic features have been introduced, as well as computation of the gravity profiles over two-dimensional and three-dimensional bodies. A simple programme for drawing isometric three-dimensional pictures of Bouguer anomaly results has been developed, which has applications in any field where pictorial presentation of data is required.

A sophisticated open-ended map and data plotting and contouring system is being developed. Both sparse and closely spaced data may be presented at any scale on any one of several map projections. A contouring method applying the basic laws of continuity of potential fields has been evolved, which will soon be capable of handling up to 200,000 grid points and could be extended further. This programme will be able to handle both sparse helicopter gravity survey data and intense aeromagnetic survey data. Further development into automated interpretation in three dimensions using the output from the contour programme is anticipated.

Seismic data processing

The group is concerned currently in the operation of the following equipment :

(1) MS-42 analogue processing and display system for high-quality sequential processing of seismic records.

(2) LASERSCAN optical filtering aparatus for rapid evaluation of frequency content and production of frequency- and dip-filtered diagrams.

(3) SINCLAIR dip-plotting machine for migrating seismic reflection data in cross-section form.

(4) Complete seismic recording and playback system, including 24 type 7000B amplifiers, DS7 magnetic recorder and ER66 oscillograph camera for simultaneous playback of 24-trace seismic magnetic tapes.

(5) Strip chart analogue-to-digital conversion unit for producing punched paper tapes from continuous analogue data such as single seismic traces, sonic logs, ship-borne gravity and magnetic records.

The monthly average production of seismic record sections on the MS-42 equipment was 42. Personnel of the group carried out maintenance on the equipment and supervised the preparation of field seismic recording equipment for survey work. Instruction in operating the analogue-to-digital strip chart converter was given

as well as assistance and advice on use of the CSIRO computer at Black Mountain to edit the digital data and record them on magnetic tape for permanent storage. The Laserscan apparatus was used to test filtering techniques on data from a number of seismic projects including Gosses Bluff 1968/69, Deep Crustal studies 1968, Ngalia Basin 1968/69, S.E. Georgina Basin 1963/64 and Southern Georgina Basin 1965, N.W. Shelf Marine survey 1968 and several subsidised surveys. Two photogeologic structural trend diagrams were directionally filtered for statistical analysis by the photogeology section of the Geological Branch.

The projects for which record sections were produced on the MS-42 equipment are as follows:

Ngalia Basin 1968 and 1969	39 sections
Deep Crustal Reflection Survey 1968/69	45
Geotraverse 1969	15
Gosses Bluff 1962 and 1969	130
Belconnen 1969 (for Engineering Section)	1
Flinders River 1967	5
Roma Shelf 1967/68	50

Sections produced from subsidised survey data and other work outside BMR are:

Singleton-Camden Woronora-Dural Newcastle	Sydney Basin	132 sections
Roma-Arbroath-Richmond		8
Napperby		22
Kareela		21
Troubridge Island		7
S.A. Mines - Mount Willoughby		7
Qld Mines - Moura-Kianga		7
Ooraminna - Mount Rennie		2

A variety of standard forms and multi-frequency sections were produced for test use and standardisation of the Laserscan apparatus.

During the remainder of the year revised and final record sections will be produced for the Gosses Bluff and Ngalia Basin surveys, and processing will continue on Geotraverse data. It is expected that Laserscan processing of a large amount of marine data will also be commenced during this period.

3. OBSERVATORIES AND REGIONAL SECTION

Observatories

Geomagnetic and seismological observatory programmes were continued at Mundaring (WA), Port Moresby (TPNG), Toolangi (Vic.), Macquarie Island and Mawson (Antarctica). Ionospheric programmes were maintained at Mundaring and Port Moresby; at the latter the ionosonde was out of action for about two months while it was extensively overhauled and modernised in co-operation with IPSD. Seismographs were operated at Kalgoorlie, Meekatharra, Broome (from July), Kununurra (in co-operation with WA Public Works Dept), Darwin, Lae, Goroka, Wabag, Manus Island (from October) and Norfolk Island.

The station at Broome is temporary as there is no satisfactory foundation for high-magnification recording; pending the establishment of a permanent, sensitive seismograph in the north-west, it provided useful information on the nearby zone of minor seismic activity.

At Manus Island the buildings for the permanent station were completed in July; a short-period vertical seismograph was operated and will be supplemented by horizontal components when equipment is delivered.

Acquisition of sites and arrangements for construction of buildings at Lae and Talasea for permanent seismographs were completed.

On Macquarie Island several sites were tested on the isthmus and the northern plateau in the search for a better location for the seismograph. One on the plateau may be satisfactory and will be thoroughly checked in 1970.

Negotiations were made for the acquisition of a site and provision of services at Manton Dam and at Alice Springs, for the establishment of first-class seismograph stations. The intention is to use telemetry between Manton Dam and the Darwin office.

The Observatories Group contributed to the New Britain crustal study by providing three men and seismographs from Headquarters, Mundaring, and Port Moresby. Mundaring also co-operated in the Geotraverse project through the fixed stations and two portable instruments.

The magnetogram scaling backlog was eliminated, preliminary reduction of current data was maintained, and good progress made in the final tabulation of IGY (1957-58) results. Continued understaffing precluded analyses of observatory hourly values.

Crystal-controlled power and timing supplies were introduced as the standard for all seismograph stations. The EMI system selected has given some teething troubles which have been referred to the Electronic Maintenance Group and the maker; otherwise they have operated within specifications and were used in WA, TPNG, Toolangi, Darwin, Norfolk Island, and Mawson.

Other instrumental improvements introduced were electromagnetic calibrators for Benioff and Willmore seismometers, and light sources and orientation coils for La Cour magnetographs. Standardised power and timing systems and magnetograph controls for Antarctic observatories were devised for installation during 1970-71.

Regional magnetic surveys

The first-order survey of Australia and TPNG was almost concluded. The nine stations in TPNG and one on Guadalcanal were occupied during April-June, and 25 in northern Queensland, NT, and WA during July-October. The remaining 10 in Australia were planned to be occupied by the end of the year.

A preliminary isogonic map for epoch 1970.0 was drawn. Although not all first-order station results were available it will meet most requirements pending the issue of the final maps much later.

Full third-order surveys covered NSW and Victoria, and partial surveys were made near the first-order stations occupied from July onwards.

The results of the surveys show that some of the first-order stations (e.g. Halls Creek, Rabaul) differ significantly from the regional pattern. Areas around these stations will be re-examined, primarily to improve the first-order network to meet charting and secular variation requirements.

The fluxgate variograph operated satisfactorily and the accuracy of the data was within that aimed for. Some instrumental and recorder failures occurred and temperature effects still require the use of heavy insulation. The knowledge gained from the extensive field use in 1969 is expected to allow effective re-design of parts of the system.

Palaeomagnetic investigations

New Guinea. The greater part of 1969 was occupied with evaluation of the palaeomagnetic data from New Guinea.

A Record was written on the magnitude of the secular variation of the earth's magnetic field in the region as shown by the

palaeomagnetism of Recent basalts. The variation appears to have been greater in the past than at present.

A second Record was written on the data obtained from the older rocks collected. This shows an anticlockwise rotation of New Guinea of approximately 90°. Because of its tectonic implication, further collection is desirable to improve the results obtained and to extend the study in the region. This would correlate with other work being done.

BMR astatic magnetometer. The Record on the magnetometer housed at Australian National University was completed. This describes both the theory and the practice of measurement, as well as a description of the mechanics and specifications of the instrument.

Bowen Basin. Further routine measurements were made of Bowen Basin specimens. The study is not yet complete.

Miscellaneous. The staff gained instrumentation experience by assisting ANU staff to set up the automatically monitored field compensating coils of their furnace equipment.

A study of some core samples from Gosses Bluff was initiated late in the year, and maintenance of the astatic magnetometer was carried out throughout the year as required.

Regional gravity surveys

Prince Charles Mountains, Antarctica. Gravity observations were made by BMR Geologists during the period Jan. - Mar. Although only nine new gravity stations could be established; the existence of a strong gravity gradient sub-parallel to the shoreline was clearly demonstrated. An accurate log of the behaviour of the LaCoste gravity meter and its associated equipment proved the feasibility of using this type of meter under the prevailing conditions. Further co-operative work of this nature is proposed for 1970.

New Britain, Rabaul and New Ireland. The programmed helicopter gravity survey of New Britain was extended east to New Ireland and offshore islands. Five hundred and fifty new gravity stations were occupied. Owing to rugged terrain and dense primary forest, helicopter landing sites were scarce in many parts of the region, and the station spacing varied from five to twelve miles. A more detailed survey of Rabaul was conducted in association with the crustal investigation.

The preliminary Bouguer contours indicate positive anomalies and steep gradients associated with areas of topographic relief. The Kamdaru fault line is well expressed and a strongly negative anomaly indicates a probable crustal depression in southern New Ireland.

Marine data collected by USNOO and coastal gravity work by USAMSFE is being included in the New Ireland mapping. A structural interpretation of the results is programmed.

Gosses Bluff gravity survey. This survey was commenced in 1968 when scattered traverses totalling about one half of a 15-mile by 15-mile grid were completed.

The 1968 gravity data were integrated with the relevant part of Magellan's Missionary Plain survey to produce a preliminary Bouguer anomaly map - see Plate 14. Two gravity shelf areas are superimposed on the anticipated circular Bouguer anomaly low. The relatively low shelf of -138 mgal to the NW of the Bluff coincides with a breccia which is in some areas at least 500 feet thick, as shown by Hermannsburg No. 1 Bore. The relatively high shelf of -135 mgal to the SSE of the Bluff cannot yet be explained.

During 1969, gravity observations over the grid were completed, and the grid was extended to the east and the south. Owing to the rough topography 81 regular grid stations in the central uplift area were replaced by 74 station sites located where the surrounding terrain was reasonably flat.

It is expected that the topographic survey results of the Gosses Bluff grid will be available at the end of November. Terrain corrections will be applied to the gravity results and a structural interpretation is programmed for 1970.

Canberra gravity survey. Detailed gravity surveying of the Canberra suburban area was continued during the 1968/69 university vacation. Students under supervision completed gravity observations on benchmarks south of Lake Burley Griffin and reduced the results by digital computer.

This work giving training, experience and understanding of gravity measurement will be continued.

Western Pacific Calibration Line. Gravity meter measurements were made along the international Western Pacific Calibration Line by two BMR observers using four La Coste and Romberg gravity meters. This line extends from Australia to Alaska and includes base stations in countries on the west coast of the Pacific Ocean. The party measured the gravity intervals between the international airports en route and made gravity ties to important base stations and excentres. Measurements were also made along the national calibration line of Japan. This work will assist the International Union of Geodesy and Geophysics in setting up international networks and will enable the Australian national network to be integrated with the overseas gravity data.

Australian Calibration Line. The programmed gravity meter measurements along the Australian Calibration Line (east coast of Australia) have been postponed to the first half of 1970.

G.S.I. gravity pendulum development. Very little progress was made with this project during the year. National Standards Laboratory (CSIRO) completed the raw construction of the new set of pendulums with extreme low-angle knife edges in October. The System Development Group is proceeding with design and construction of electronics to improve the speed, accuracy, and convenience of period determination.

Earth tides - variations in the intensity of gravity. This project is awaiting development of improved electronic units by the Systems Development Group.

Earth tides - deflections of the vertical. No progress was made with this project owing to other staff commitments.

Isogal follow-up regional gravity connections. This work continued intermittently throughout the year using staff from current surveys in relevant areas. Several outside organisations have also assisted.

Gravity maps and automatic computing. A further nine surveys were put on magnetic tape this year and principal facts are now available for over 40,000 stations. In addition, the data from USNS Shoup were incorporated into principal facts listing. This added a further 12,000 stations.

A 40-mile key map of Australia and maps of individual 1:250,000 sheet areas showing all available gravity surveys have been completed. All BMR and subsidised gravity surveys together with all available private surveys have been integrated into the computer-orientated filing system. Major improvements were made to the manual data storage and retrieval system to facilitate recomputation of surveys and provision of data to outside organisations.

The gravity reduction programme was further modified to print out base and field readings and allow easy location of punching errors. Up to 400 network links can now be handled by the least-squares facility.

A National Mapping programme to convert northings and eastings to latitudes and longitudes was modified to suit gravity survey data.

Input-error-detecting subroutines were incorporated into other programmes. Informal station names were introduced on to the magnetic tapes of principal facts. This facility also proves useful in that water depths for stations read at sea may be placed in the informal station name and used to calculate Bouguer anomalies for sea stations. Terrain corrections may also be recorded by use of this facility.

Driving instructions for the reduction, storage, and retrieval programmes were drafted in three BMR Records. Write-ups were also produced for several copying and printing programmes.

A programme which uses the E.A.E.G. tidal correction tables to give corrections to observed data was developed and tested. To obviate use of the tables, further development towards a programme based on the equations of motion of the sun and moon were carried out.

Isogal and A.C.L. data analysis. Little progress was made this year owing to other staff commitments. However, preliminary observed gravity values and station descriptive material for all Isogal stations in Australia and TPNG are now available. Good progress has been made by the Department of the Interior in the levelling of Isogal stations throughout Australia, and over 200 now have accurately known elevations to M.S.L. datum.

Reconnaissance gravity surveys, TPNG. Evaluation of gravity data from eastern Papua, including the ultramafic belt, continued throughout the year. A report on this work is being prepared by a staff member as a Ph.D. thesis at Imperial College, U.K.

Detailed survey ELDO launch site, Woomera. During the year a brief survey of the ELDO launch site was requested and this work was added to the programme. As at October approval for this work had not been obtained from ELDO headquarters in Paris.

Regional structural surveys

The original programme for this group was revised to include collation and evaluation of data from the New Britain Crustal Survey originally programmed for other groups. A review of crustal study projects in which BMR has been involved was commenced. Twenty-two projects are being assessed from the point of view of motivation, cost, results, and significance.

New Britain crustal survey. This survey included four marine/land deep refraction stages and marine magnetic and sparker profiling, together with a land gravity reconnaissance of New Britain and New Ireland, reported separately by the Regional Gravity Group.

Field work was undertaken between February and May, and involved personnel from both Geological and Geophysical Branches of BMR, Dept of the Interior, the Hawaiian Institute of Geophysics, Australian National University, and the University of Queensland.

The refraction programme was designed to:

(1) Determine the extent of abnormally high upper mantle compressional wave velocities of up to 8.9 km/sec found beneath the western end of the Gazelle Peninsula in the 1967 Rabaul Crustal Survey.

(2) Determine the boundary between continental and oceanic type structure east of New Ireland.

(3) Seek more structural detail beneath the Rabaul caldera.

(4) Explore the extent and structural form of the ridge beneath St George's Channel.

(5) Evaluate velocities and interface depths beneath central New Britain.

Plate 15 shows the locations of shots and recording stations for stages 1& 2 and the 2500 km of marine sparker profiles for the whole survey. Shot and recording stations positions for stages 3 & 4 and locations of marine magnetic profiles (1650 km), recorded by both vessels are shown in Plate 16.

Shooting and sparker profiling were conducted from the 104-ft long survey ship MV Coral Queen and magnetic work was shared with the small supply vessel MV Lahara. Surveying work was undertaken by the Dept of the Interior together with a contractor supplying land based "Hifix" mobile radio location beacons.

A total of 18 field recording parties occupied 47 sites and observed 54 shots ranging in size from 100 to 1650 lb. Observations were also made at 5 permanent stations of the Rabaul network. Refracted events were recorded beyond 350 km in some instances. Data recovery of 78% included about 4000 readable arrivals.

Structural analysis will be commenced early in 1970 when all basic data are collated in a suitable form for detailed multi-disciplinary evaluation.

Miscellaneous. The Western Australia surface wave dispersion project was deferred pending availability of equipment.

Records issued during 1969

1968/119	Visit to the 40th ANZAAS Congress Christchurch N.Z.	D. Denham
1968/135	Toolangi Geophysical Observatory Annual Report 1967	C.A. van der Waal

1968/142	Preliminary Report on the 14 October 1968 Earthquake at Meckering W.A.	I.B. Everingham
1969/4	Geomagnetic micropulsation symposium, University of Newcastle August 1968	D.M. Finlayson
1969/5	Regional magnetic surveys in Australia 1965 and 1966	J.van der Linden
1969/21	Port Moresby Geophysical Observatory Annual Report 1967	D. Denham
1969/22	P-wave residuals at Australian seismograph stations	I.B. Everingham
1969/95	A scheme to increase the signal-to-noise ratio of teleseismic records	R. Whitworth
1969/96	Mundaring Geophysical Observatory Annual report 1967	I.B. Everingham and P.J. Gregson
1969/10	Programme for New Britain crustal study project	
1969/31	Revision of the gravity meter calibration range interval, Canberra 1968.	J.S. Milsom and N. Mohammed
1961/34	Detailed gravity survey, Canberra, December 1967 to February 1968	J.R.H. van Son
1969/48	Airstrip preparation and ground ties for the 1967 Isogal survey	J.R.H. van Son
1969/83	A graphical method for preliminary location of earthquakes	R.J.S. Cooke
1969/84	Macquarie Island Geophysical Observatory Annual Report 1965	R.J. Sutton
1969/101	A study of observed azimuths of New Guinea earthquakes recorded at Port Moresby	D. Denham
1969/108	Seismic travel times from explosions, W.A. 1960-1965	I.B. Everingham

Reports issued

No. 132	Seismicity of Western Australia	I.B. Everingham

Papers in outside journals

"Seismicity of the Australian continent". J. Geol. Soc. Aust., 15, Pt. 2, Dec. 1968, p. 295. H.A. Doyle, I.B. Everingham, and D.J. Sutton.

"Distribution of earthquakes in the New Guinea-Solomon Islands Region". J. geophys. Res. Vol. 74, No. 17, August 1969. D. Denham

"A thrust fault scarp produced by an earthquake in the Western Australian Shield". Nature, August 1969. I.B. Everingham, P.J. Gregson and H.A. Doyle.

"Rayleigh waves in southern New Guinea I. Higher Mode Group Velocities". Bull. Seism. Soc. Am., 59, 945-958, (April) 1969. J.A. Brooks.

"Rayleigh waves in southern New Guinea II. A shear velocity profile". Bull. Seism. Soc. Am., 58, 2017-2038, (October) 1969. J.A. Brooks.

Addresses to scientific bodies

Australian Institute of Physics - Symposium on crustal studies in the Australian region (August 1969).

"Basement depth in the Perth Basin". I.B. Everingham and P.J. Gregson (delivered by Gregson)

"Earthquake focal mechanism in the New Guinea region". I.D. Ripper

International Association of Geomagnetism and Aeronomy, Madrid, September 1969.

"Digitization of data from Australian geomagnetic observatories" (G.R. Small) (read by I.B. Everingham)

International Association of Seismology and Physics of the Earth's Interior, Madrid September, 1969.

"The Meckering (W.A.) earthquake of 14 October 1968". I.B. Everingham

Earthquake engineering symposium (I.E.A. and A.I.P.) October 1969

"Recent damaging earthquakes in New Guinea". D. Denham

"Meckering earthquake intensities and notes on earthquake risk for Western Australia". I.B. Everingham

"A storage and retrieval system of seismic data for the New Guinea-Solomon Islands region". D. Denham and W.M.J. Byrne (delivered by Denham)

Symposium on Crustal Studies in the Australian Region, Adelaide, 15 August.

"Rayleigh wave dispersion in New Guinea". (J.A. Brooks)

"Deep refraction surveys in New Britain, 1967-1969"
(J.A. Brooks and W.A. Wiebenga, presented by J.A. Brooks)

"Local velocity studies using geophone arrays" (J.C. Dooley).

Earthquake Engineering Symposium, Melbourne, 16-18 October.

"The national seismic coverage" (J.A. Brooks)

ANZAAS Congress, Adelaide, 18-22 August.

"Seismology applied to studies of Australian crustal structure" (J.C. Dooley).

4. GEOPHYSICAL SERVICES SECTION

The section comprises three sub-sections, Electronic, Mechanical, and Services, and the activities of the Section are reported under these headings.

Electronic Sub-section

As a result of the Geophysical Branch reorganisation the former Design and Development Group and Electronic Maintenance and Testing Group of the Geophysical Laboratories have been incorporated in an Electronics Sub-Section divided into three groups: The Instrument Development, Systems Development, and Electronic Maintenance Groups. The Instrument Development Group is primarily concerned with the design and construction of new instruments required for geophysical measurements and not available commercially. The Systems Development Group looks at recent and novel developments in geophysical techniques and is concerned with system design and instrumentation when these techniques are proposed for use within the Branch. The Electronic Maintanance Group deals with the overhaul and maintenance of all electronic equipment, the acceptance testing of new equipment, and the installation of mobile equipment in vehicles and aircraft.

Instrument Development Group. During the latter part of 1968 and continuing well into 1969 the section assisted in the commissioning of the new Aero Commander survey aircraft (VH-BMR) by integrating new equipment including the gamma-ray spectrometer and by further development design modifications to the proton magnetometer and towed bird.

A second fluxgate magnetometer detector was built for the DC.3 survey aircraft (VH-MIN) and some design modifications were incorporated. Assistance was also given in replacing the existing radiometric equipment with modular units compatible with the gamma spectrometer in the Aero Commander aircraft.

Planning of equipment for the Twin Otter was commenced. A complete set of gamma-ray spectrometer equipment was ordered, and work has commenced on the conversion of military magnetic airborne submarine detection equipment for use as an airborne magnetometer. A complete computer-based digital data acquisition system was devised and an order for the equipment is being placed.

The design and testing of the portable proton precession magnetometer continued and the production of three prototypes is planned to be completed early in 1970. Performance is satisfactory for most applications but some further work is necessary to obtain rapid readings of adequate accuracy for the airborne applications.

Construction of additional 3-component fluxgate magnetometers for observatory and regional magnetic groups has commenced. Some design improvements over the prototype constructed in 1968 are being incorporated. Completion of these units is planned for mid-1970.

The integration of an on-line computer with the marine seismic recording equipment was completed. Specifications were also prepared for a similar computer to be used for navigation data acquisition. Several general purpose feedback amplifiers and filters were designed and two versions are being constructed to interface the navigation equipment to analogue recorders and to the computer.

Many smaller projects were completed. Two portable VLF field strength meters for use in metalliferous surveys were designed and built. The control circuitry for the wide-angle 35-mm aircraft cameras was improved and standardised. Recorder amplifiers were designed and seismic timing systems were modified for the New Britain crustal project. Two units of induced polarisation test equipment were designed and built. An accurate pulse generator for evaluation of the seismic system frequency response was completed. General purpose counter-display modules were designed for a number of applications including radiometric scalers, clock displays, and the proton magnetometer.

An investigation of high-order active filter and phase-lock amplifiers was commenced. These will have applications in a number of future projects.

Systems Development Group. Work on the tidal gravity measurement project was continued. Little work was done in the first six months of 1969 as recorders were required for other projects. Much of the equipment used in previous tests is obsolete and unreliable and a new amplifier and oscillator have been designed to replace this equipment. Some additional measurements using the old equipment were made but it is expected that this can be replaced by January 1970.

An investigation into remote sensing techniques was carried out with particular emphasis on infrared photography and scanning. This work arose as a result of a request to investigate water seepage problems in Victoria and also for possible application in coastal erosion problems in Southern Queensland. Recommendations include the use of ordinary colour and infrared colour photography and the possible future use of infrared line scanners. Passive microwave systems also show promise for future applications.

The redesign of electronic circuitry for the pendulum absolute gravity measurement equipment has been completed. Items of commercial equipment required have been specified and orders were placed at the end of 1969. Equipment construction should be completed by January 1970 and extensive testing will then commence.

The automatic digital acquisition system for magnetic observatories has been given higher priority for completion this year, and work is now well advanced. Tests on the measurement circuitry have been commenced and tests on recording equipment should commence early in 1970.

A project to test the feasibility of using sonobuoys for seismic refraction work in swamp country, particularly in New Guinea, was commenced. Modifications to equipment to improve low-frequency response have been made. Marsh geophones have been successfully used with the sonobuoys in place of the original hydrophones. Short range land tests have been successful. Flight tests are planned before the end of the year and if successful a full scale test survey is planned for 1970.

Electronic Maintenance Group. The work of this group was confined mainly to its usual role of repair and overhaul of field geophysical equipment, and acceptance testing of new equipment. The airborne groups made fairly heavy demands on the group while the aircraft were in Canberra and work this year included installation of equipment in VH-BMR and assistance with the installation of the new radiometric equipment in VH-MIN.

A large effort was made in preparation of equipment for the New Britain crustal study. There was also a considerable amount of work involved in overhaul of this equipment after its return.

Equipment was prepared for loan to universities and to private companies for use in subsidised oil search surveys. Some work was also done for other Branches within BMR, particularly for the Engineering Geology group.

Mechanical Sub-section

The Mechanical Sub-section, formerly known as Geophysical Workshops, comprises three groups: Mechanical Design, Mechanical Instrument Construction, and Mechanical Maintenance and Testing. The creation of the last group has greatly improved the capabilities of the Sub-section, but the Mechanical Instrument Construction Group still experiences difficulty in filling Instrument Maker positions.

Mr W. Olbrich, who has been in charge of the Mechanical Design Group since 1950, retired during the year and his position has yet to be filled.

The normal programme of maintenance and repair of instruments and equipment accounted for most time in the Mechanical Sub-section during the year. Much of the repair work and new work was let to contract.

Many of the jobs in the Mechanical Instrument Construction Group arose as support work for major projects in the Electronic Sub-section. In this category were components for a digital recording magnetic observatory, proton precession and fluxgate magnetometers, a computer based marine seismic profiling system, towed bird for airborne magnetic surveys, and several vehicle installations. Other jobs wholly or almost wholly mechanical were an immersion film gate for the Laserscan seismic data processing equipment, a marker and recovery buoy

which trails the Chesapeake marine seismic streamer cable and carries an automatic emergency transmitter and beacon, and a storage and handling drum for the Chesapeake cable. Other jobs at design stage are a seismic helical drum recorder for regional surveys, an induced polarisation logging tool, and a number of minor jobs.

Services Sub-section.

The Services Sub-Section comprises four groups viz. Procurement, Rock Measurements, Engineering Geophysics, and Drafting. The work of the Procurement and Drafting groups is essentially service work and will not be mentioned further.

Rock Measurements Group. There was little activity during 1969 as the officer-in-charge of the Group was absent on study leave for most of the year. One Record "A review of equipment and techniques for measuring magnetic properties of rocks" was drafted. Ultrasonic and electrodynamic measurements were made on a number of rock cores to determine their elastic properties for engineering and other purposes.

Engineering Geophysics Group. At the beginning of the year only three of the seven positions were filled, but two more were filled in July.

During the first half of the year the group was solely engaged on the New Britain Crustal Studies project both in preparing for the survey in Canberra and in manning parties in the field. The group is still involved in production of the report. In the second part of the year the group, strengthened by the addition of two new members, carried out a number of engineering and miscallaneous surveys:

(1) Jervis Bay Foundation Investigation

The purpose of the survey was a preliminary assessment of the foundation conditions at Jervis Bay with a view to selecting one of two sites to be fully investigated as the site for a proposed nuclear power station. Seismic refraction work revealed a very uneven thickness of the dune sand overlying a sandstone characterised by a relatively low seismic velocity. Following the survey a site near Murrays Beach was selected and a detailed seismic refraction survey of this site will commence in January 1970.

Dynamic measurements made in the laboratory on cores from boreholes drilled on the site indicated low values of elastic moduli for the sandstone. An investigation of the relation between compressive strength of wet rock, seismic velocity, and elastic moduli will be made in the laboratory.

(2) Lake Windermere Groundwater

Lake Windermere is used as a water supply reservoir for the Jervis Bay township and for the RAN base at Jervis Bay. It may

be used in future as a standby supply or service reservoir for the proposed nuclear power station. Four seismic refraction traverses were surveyed across a suspected buried valley thought to form an outflow passage from the lake. It was found that the valley is wider than expected. The work will be continued in 1970 using additional geophysical methods: gravity, magnetic and resistivity. The project is a joint undertaking with the Geological Branch.

(3) Silcrete Survey, Windorah Qld.

This survey was intended: (a) to find a geophysical method that could determine the continuity of a silcrete horizon buried beneath Quaternary deposits, or alternatively to find and trace other marker horizons; (b) to determine the existence of shallow aquifers above the silcrete horizon, and the salinity of water enclosed in them; (c) to investigate the applicability of deep resistivity probing and magnetotelluric measurements to deep aquifer investigations in the area.

In the seismic refraction work the silcrete is characterised by a seismic velocity of about 11000 ft/sec. The horizon was followed easily for a distance of about $4\frac{1}{2}$ miles from outcrop, and it was also possible to locate it at correct depths in areas where boreholes have proved its existence. Seismic reflection work was not successful as the silcrete horizon is too shallow to provide readable reflections. Other methods were also used; gravity and magnetic data still require assessment, and resistivity depth probes may indicate some horizons although they cannot detect the relatively thin silcrete zone.

The sections indicated by the seismic refraction method as containing water were investigated using resistivity depth probing with the Schlumberger electrode arrangement. Good data have been obtained and will be evaluated.

One resistivity depth probe using a dipole-dipole arrangement was carried out to a spacing of $2\frac{1}{2}$ miles. Results of this probe and some experimental magnetotelluric recording were sufficiently encouraging to warrant consideration of the use of these techniques for deep aquifer and basement investigations in the area.

(4) Minor Surveys, ACT.

During 1969 the following surveys, using the seismic refraction method, were done for the Department of Works and the National Capital Development Commission: (a) Molonglo Outfall Sewer, to determine rock conditions above the tunnel level; (b) Molonglo Bridge, to determine foundation conditions for a bridge on the proposed Weston Creek-Bellconnen Way road; (c) Barry Drive, to measure seismic velocities in an area of deep excavations for correlation with rippability; (d) Cotter-Stromlo Pipeline, to investigate the depth of weathering along a proposed trench for the new water supply pipeline; (e) Burton Building Site, to ascertain the depth of weathering on a site for a monumental building.

(5) Riverside Expressway, Brisbane.

The survey will be carried out in November 1969. The purpose of the survey is to determine the location of a fault thought to cross the line of the proposed structure, part of which will be carried on high pylons along and in the Brisbane River. The seismic refraction method will be used.

(6) Earthquake Engineering, Corin Dam

Measurements were made in 1968 of the natural frequency of vibration and the velocities of the longitudinal and the transverse waves on the wall of the dam. The third set of measurements in the series planned was carried out in 1969 when the dam was completed but the reservoir was still empty. The last test of this series will be done in 1970 when the reservoir is full.

(7) Vibration Test at Evans Head

The test will be carried out in November 1969. The purpose of the test is to measure the magnitude of vibrations resulting from aerial bombing on a RAAF test range and to measure the rate of attenuation of this energy in rocks in this area. The survey was requested by the RAAF.

(8) Christmas Island Groundwater

The British Phosphate Commission is using geophysics in the search for water on Christmas Island. Field measurements using magnetic and resistivity techniques are made by the staff of the Commission; the Engineering Geophysics Group interprets the data and suggests drilling targets. The techniques have proved useful in delineating the most promising drill sites. Nevertheless only one bore has found water and this site is being developed as a water supply. Further work to locate areas where groundwater flows into the sea has been suggested.

(9) Resistivity Models and Analogue Electrical Modelling

The relationship between the depth probes obtained in several electrode configurations (Wenner, Schlumberger, dipole-dipole, etc.) is being investigated using conductive paper to construct the analogue models. The work will be continued.

(10) Vibration Measurements

Determinations of the frequencies and magnitudes of industrial vibrations were carried out at the CSIRO Chemical Laboratory, Black Mountain in positions where sensitive instruments are to be installed.

(11) Well Logging

Contract gamma-ray logging of the Great Artesian Basin continued in 1969 in two phases. The first phase was the completion of field work of the 1968 contract. Twenty-two boreholes were logged in March and April on the Homeboin and Dirranbandi 1:250,000 sheet areas. The second phase was the letting of the1969 contract. Field work commenced in July, and up to October 78 bores had been logged for the regional coverage of the Carpentaria Basin. Further logging will be carried out in the Surat Basin under the contract. A feature of the 1969 contract is the inclusion of an experimental programme of gamma-ray spectroscopy in boreholes. A special tool required for this work has been imported by the contractor, and the technique will be tested in one or two bores during the remaining period of the contract.

5. PUBLICATIONS

The following Reports and Bulletins have reached the stages shown:

Bulletin 101	Great Lake North engineering geophysical surveys, Tasmania.	Delivered by printer.
Bulletin 105	Ice thickness measurements in MacRobertson Land.	Page proof.
Bulletin 118	Laverton-Edjudina airborne magnetic and radiometric survey.	Editing complete.
Bulletin 119	Standard curves for the magnetic anomalies due to spheres.	Editing complete.
Bulletin 120	Magnetic survey of the Savage River and Long Plains iron deposits, Tasmania.	Editing complete.
Report 129	Western Queensland reconnaissance gravity surveys.	Distributed.
Report 131	North Eromanga and Drummond Basins gravity surveys.	Blueline proof copy.
Report 132	Seismicity of Western Australia.	Distributed.
Report 133	Amadeus and South Canning Basins gravity survey.	Blueline proof copy.
Report 136	Strangways Range detailed aeromagnetic survey.	Justified proof.
Report 138	North Bowen Basin gravity survey.	Blueline proof copy.
Report 139	Daly River detailed aeromagnetic survey.	Justified proof.

During the year, the Assistant Editor left the Group, and work on geophysical Reports and Bulletins has now been suspended indefinitely in order to process a large backlog of Records that await editing.

The following 57 geophysical maps were drawn and sent off for printing:

Aeromagnetic maps

Aworra River	Kiwai	Daru
Kikori	SC 55-1	Maer Island
Wau	Yule	Aroa
Salamaua	Buna	

Delamere NE, NW, SE, SW
Victoria River Downs NE, NW, SE, SW
Wave Hill NE, NW, SE, SW
Illogwa Creek
Auvergue NE, NW, SE, SW

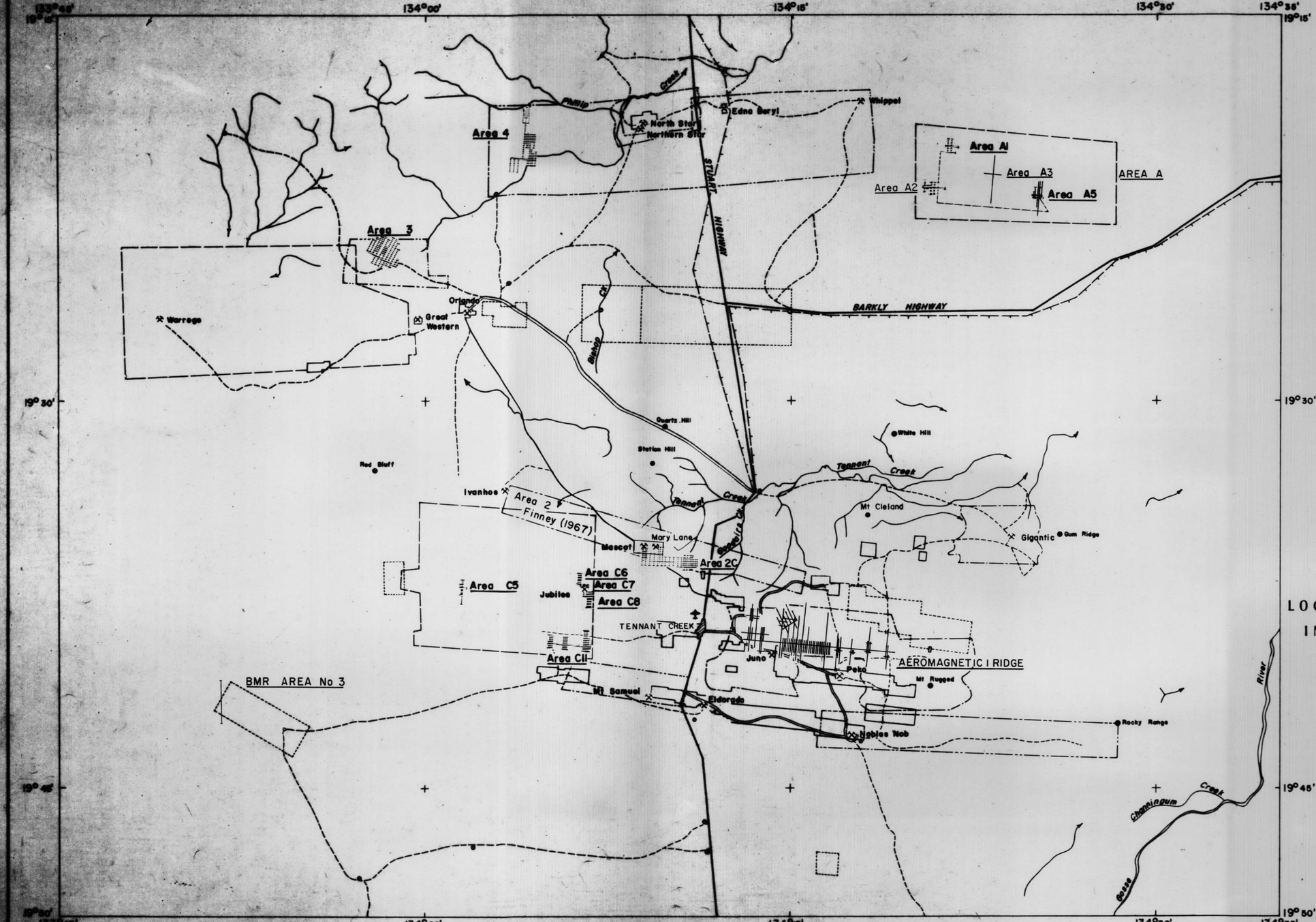
Aeromagnetic and radiometric maps

Alice Springs	Rodinga	Hermannsburg
Henbury	Kulgera	Mount Liebig
Lake Amadeus	Ayers Rock	Bloods Range

Gravity maps

Canberra	C51-14	C52-7	C52-13
Goulburn	C51-15	C52-8	C52-14
Wagga	C51-16	C52-9	D51-3
Ulladulla	C52-5	C52-10	D51-4
C51-12	C52-6	C52-11	D52-1

PLATE 1

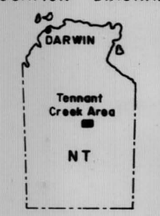


(Based on F53/B7-77)

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 " " "
- 1967 BMR traverse layouts
- 1969 BMR traverse layouts
- Telephone line
- Builtup area

LOCATION DIAGRAM



TENNANT CREEK MAGNETIC SURVEY, 1969

LOCALITY MAP SHOWING SURVEY AREAS IN RELATION TO PREVIOUS SURVEYS

MILES

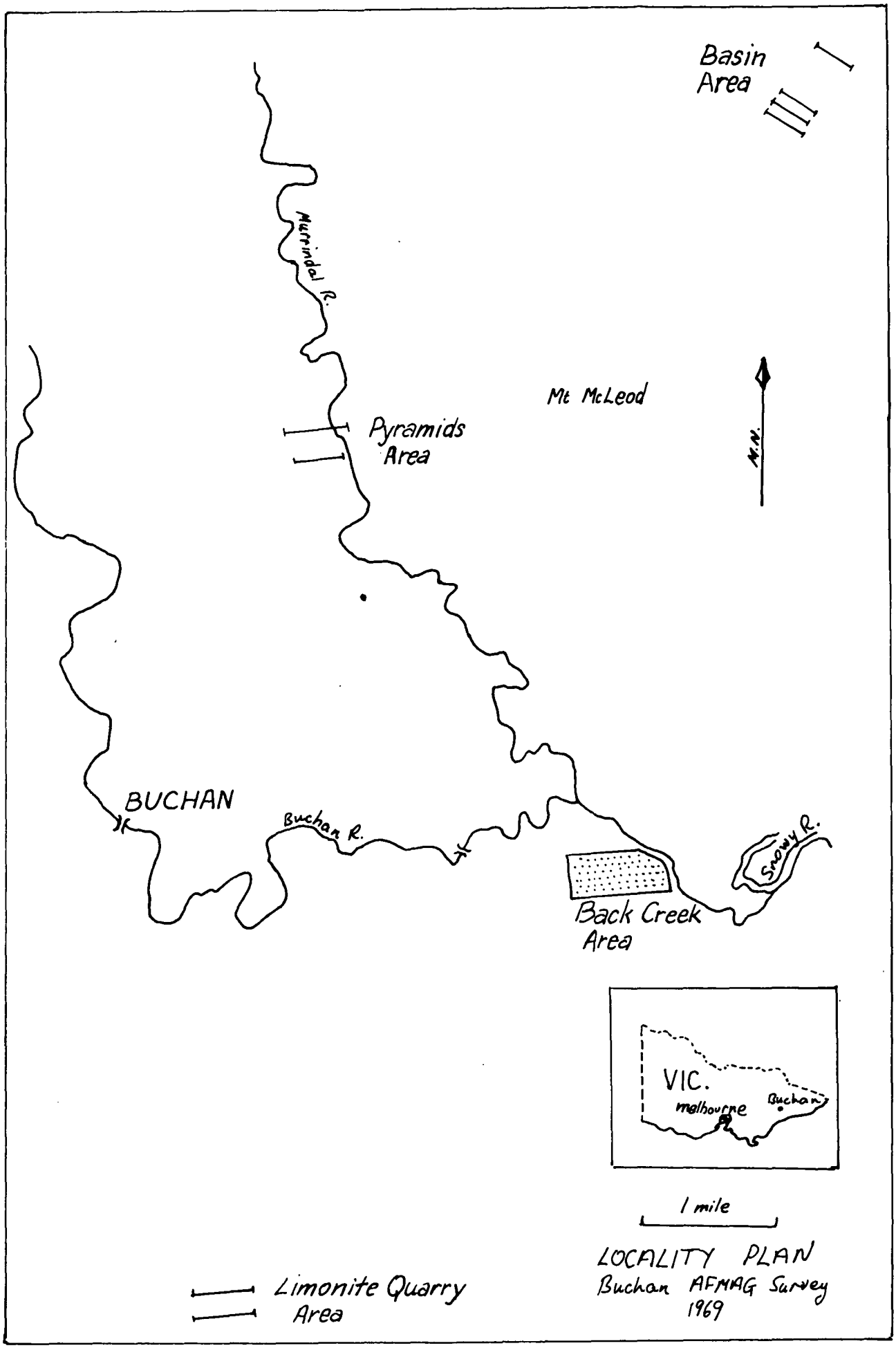
4 2 0 4 8

PROOF COPY ONLY

To accompany Record No.

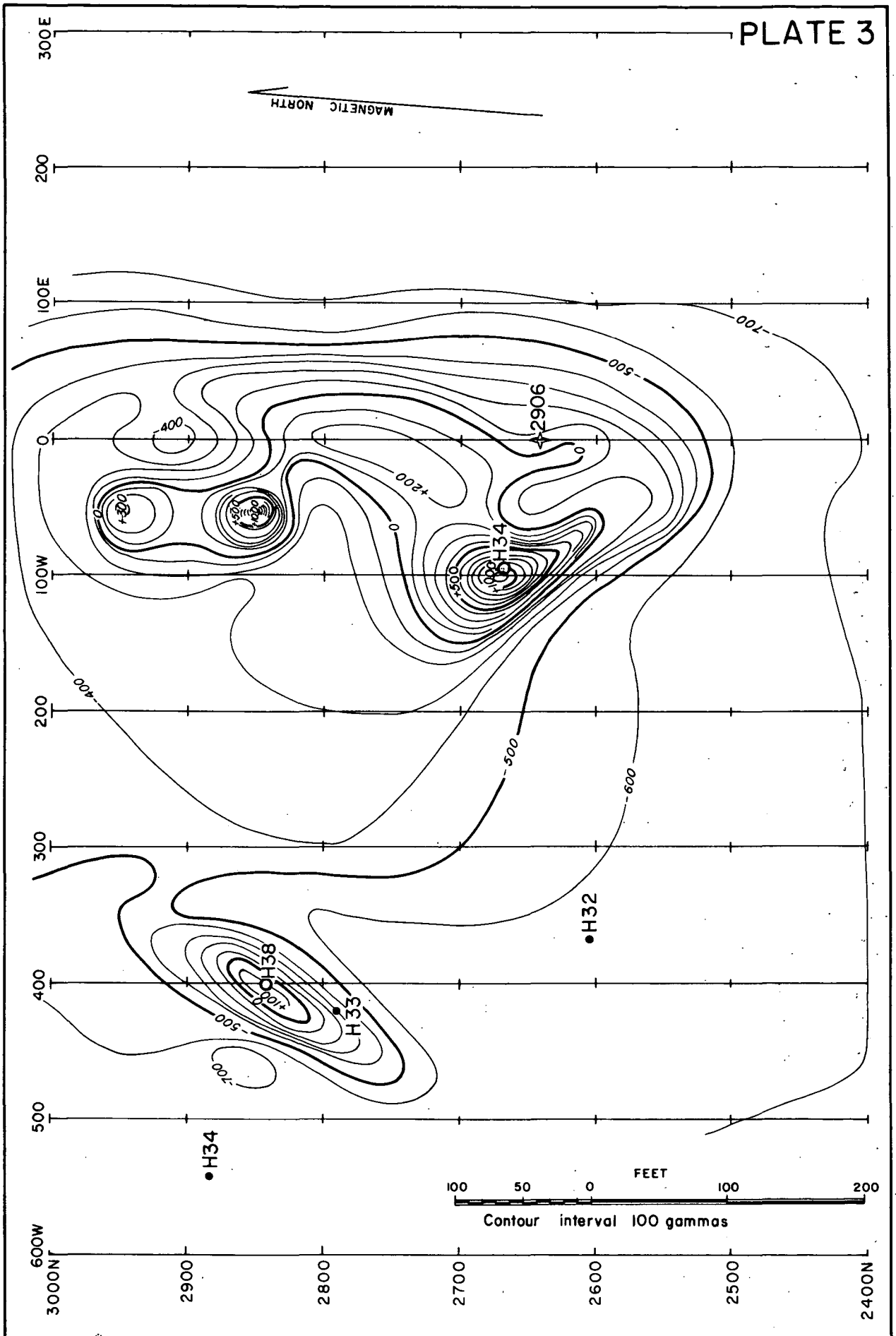
~~E53/B7-112~~

PLATE 2



LOCALITY PLAN
Buchan AFMAG Survey
1969

PLATE 3



LEGEND

- ● Recommended by D. Milton
- ○ Recommended by E. Sedmik
- ●○ Drill hole
- ✧ Gravity station

GOSSE BLUFF AREA 2 1969

VERTICAL FORCE MAGNETIC CONTOURS

~~F53/B7-33~~

Gosse Bluff N.T. Area 2 1969

PLATE 4

131°00'

NORTH AUS

MT FITCH

GIANTS REEF FAULT

MT BURTON

Embayment Area

WHITES

DYSONS

BROWNS

DOLERITE RIDGE

13°00'

13°00'

Rum Jungle Granite

AREA 55

RUM JUNGLE SIDING

MT FITCH FAULT

RUM JUNGLE CREEK

RUM JUNGLE CREEK SOUTH

CRATER TRAVERSE 1

CRATER TRAVERSE 2

BATCHELOR

AIRFIELD

CASTLEMAINE HILL

LATERITES

SCALE

0 1 2 3 MILES

380E

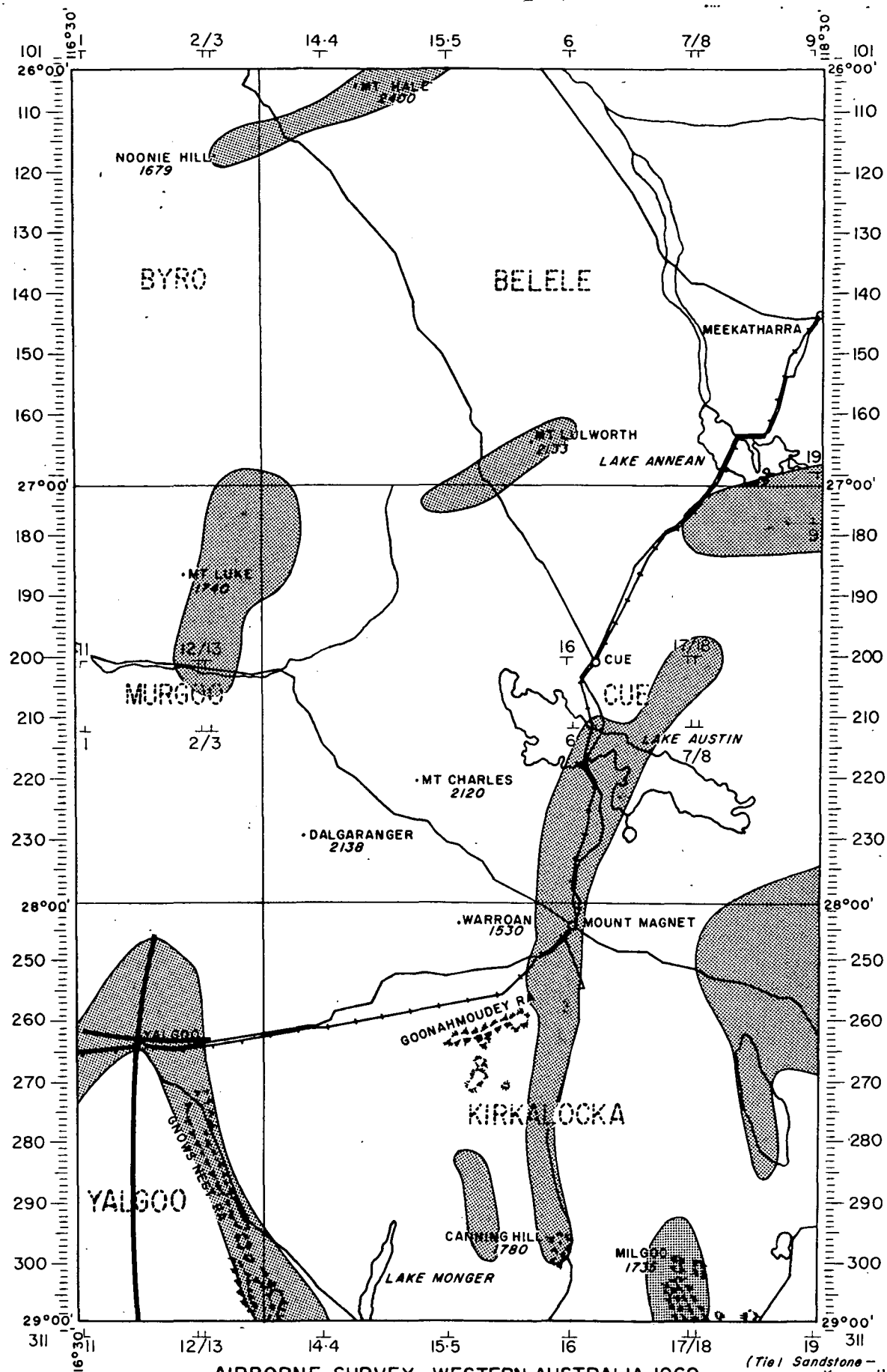
131°00

LEGEND

Alpha surveys 1969

RUM JUNGLE DISTRICT

PLATE 5



AIRBORNE SURVEY, WESTERN AUSTRALIA 1969

FLIGHT-LINE AND TIE-LINE SYSTEM

SUMMARY OF ACTIVITIES, 1969

MILES 25 0 25 50 75 MILES

KILOMETRES 25 0 25 50 75 100 125 KILOMETRES

Greenstone belts

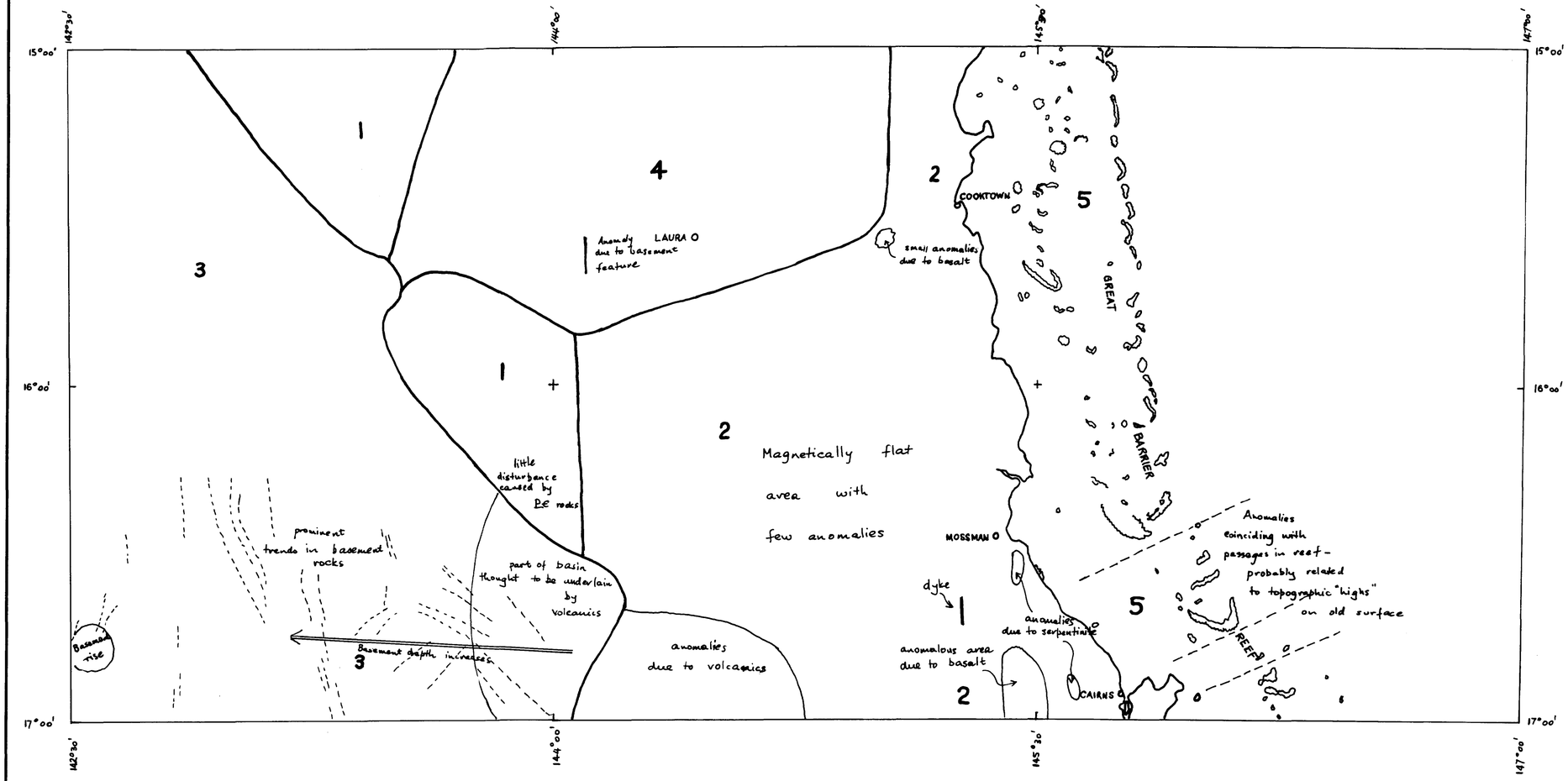
Interpreted Fold Axis

G50/BI-53

PLATE 6

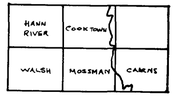
AIRBORNE SURVEY, SOUTHERN CAPE YORK PENINSULA, QLD. 1969

PRELIMINARY RESULTS



MILES
10 0 10 20 30 40

LOCATION DIAGRAM



MAJOR GEOLOGICAL UNITS

1. Precambrian
2. Palaeozoic/Mesozoic Tasman Geosyncline
3. Mesozoic Carpentaria Basin
4. Mesozoic Laura Basin
5. Barrier Reef Platform

E55/BI-16

PLATE 7

MAGNETIC INTERPRETATION AND GEOLOGY

BASED ON G52/80-17

GEOLOGICAL LEGEND

ADELAIDEAN

SANDSTONE, SILTSTONE, ARKOSE

CARPENTARIAN

LEVENGER ARKOSE

CARPENTARIAN AND OLDER PRECAMBRIAN OF MUSGRAVE BLOCK

DOLERITE DYKES

MAFIC AND ULTRAMAFIC ROCKS OF THE GILES COMPLEX INCLUDING THE WOODROFFE NORITE

BIOTITE GRANITE

CHARNOKITIC GRANITE (HYPERSTHENE-ADAMELLITE)

HORNBLENDE GRANITE, GRANITIC GNEISS AND INTRUSIVE GRANITE

ANORTHOSITE

UNDIFFERENTIATED MUSGRAVE-MANN METAMORPHICS AND INTRUSIVE ROCKS COVERED BY THIN SAND VENEER

GEOLOGICAL BOUNDARY

FAULT

SHEAR ZONE

FOLIATION

UNCONFORMITY

GEOLOGY AFTER GEOLOGICAL SURVEY OF SOUTH AUSTRALIA DEPARTMENT OF MINES, ADELAIDE

TOPOGRAPHICAL LEGEND

ROAD OR TRACK

RIVER OR CREEK

HILL FEATURE

LANDING GROUND

GEOPHYSICAL LEGEND

MAGNETIC TREND POSITIVE

MAGNETIC TREND NEGATIVE

2 MAGNETIC ZONE

INTERPRETED FAULT

LOCATION DIAGRAM

INDEX TO ADJOINING SHEETS

SCOTT	PETERMANN RANGES	AYERS ROCK
COOPER	MANN	WOODROFFE
WAIGEN	BIRKSGATE	LINDSAY

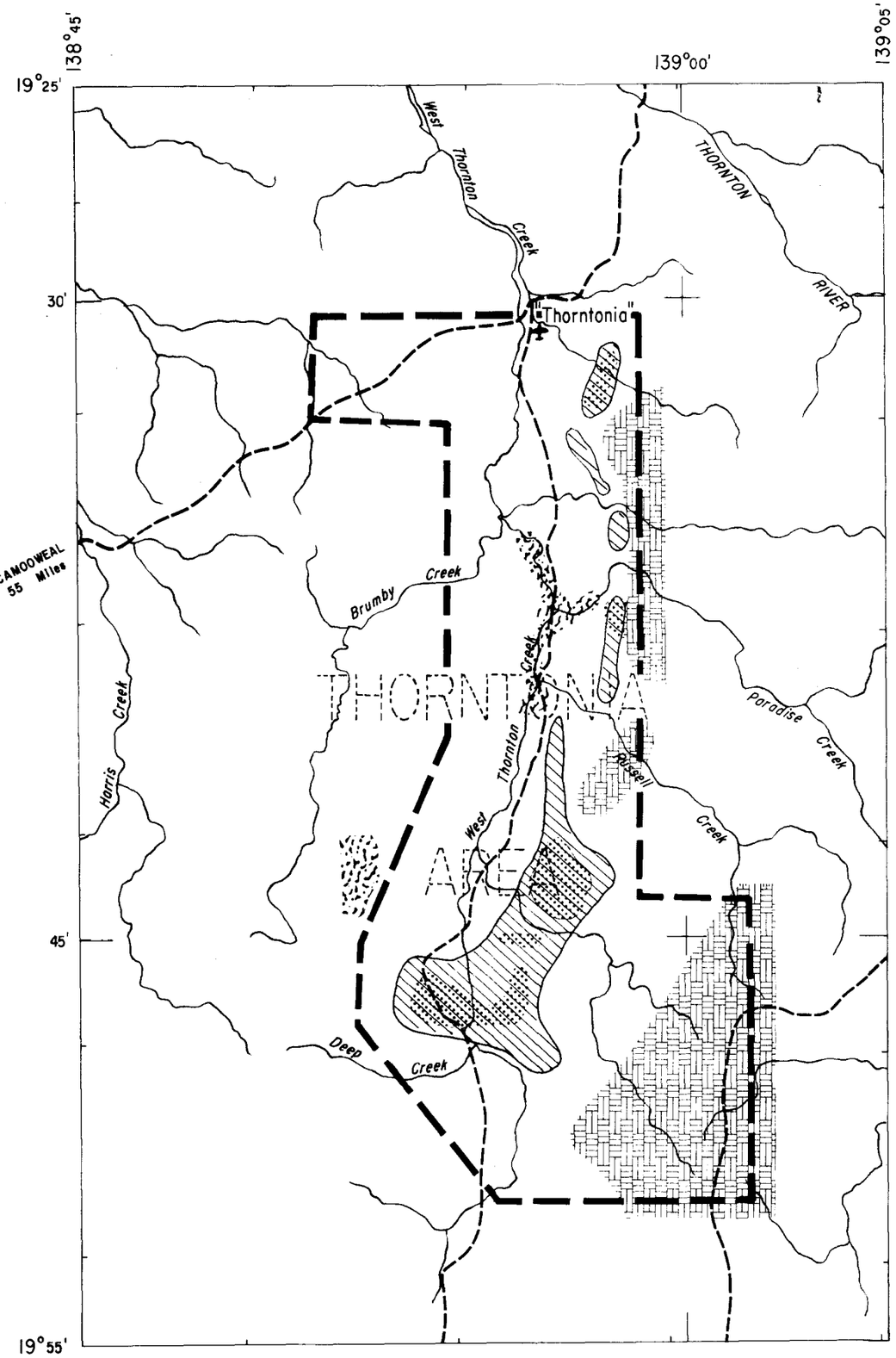
10 5 0 10 20 30 40 MILES

10 0 10 20 30 40 50 60 KILOMETRES

PLATE 8

AIRBORNE RADIOMETRIC SURVEY BURKE RIVER - THORNTONIA QLD 1969

LOCALITY MAP



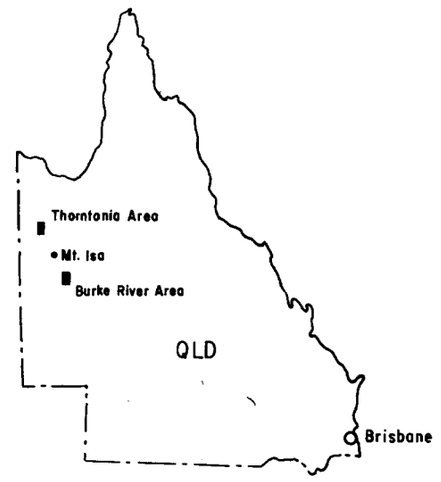
5 0 5 10 15 20 MILES

5 0 5 10 15 20 25 KILOMETRES

SUMMARY OF ACTIVITIES, 1969

LEGEND

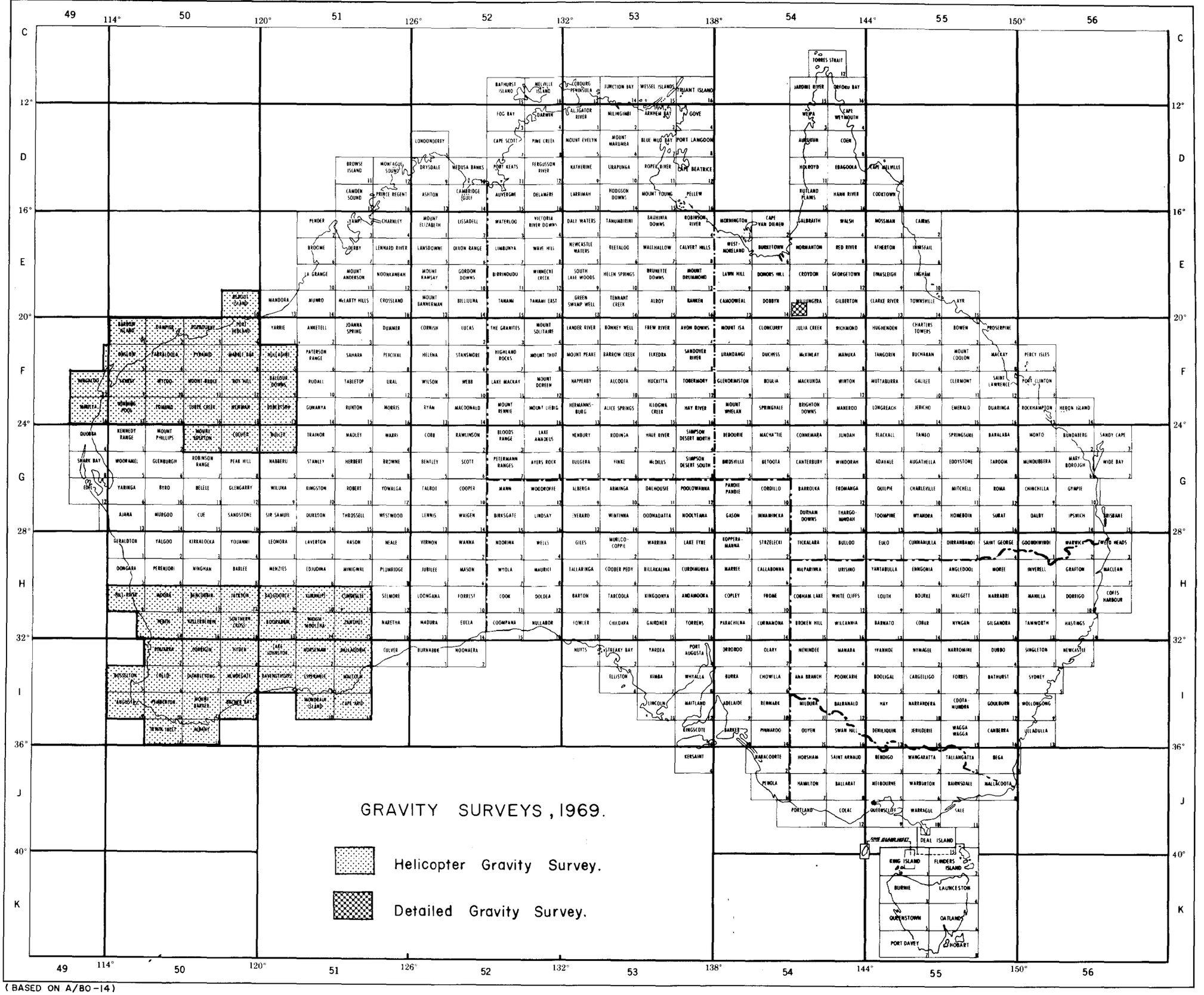
- Main areas of Beetle Creek formation.
- Uranium anomalies.
- Thorium anomalies.
- Thorium and Potassium anomalies.



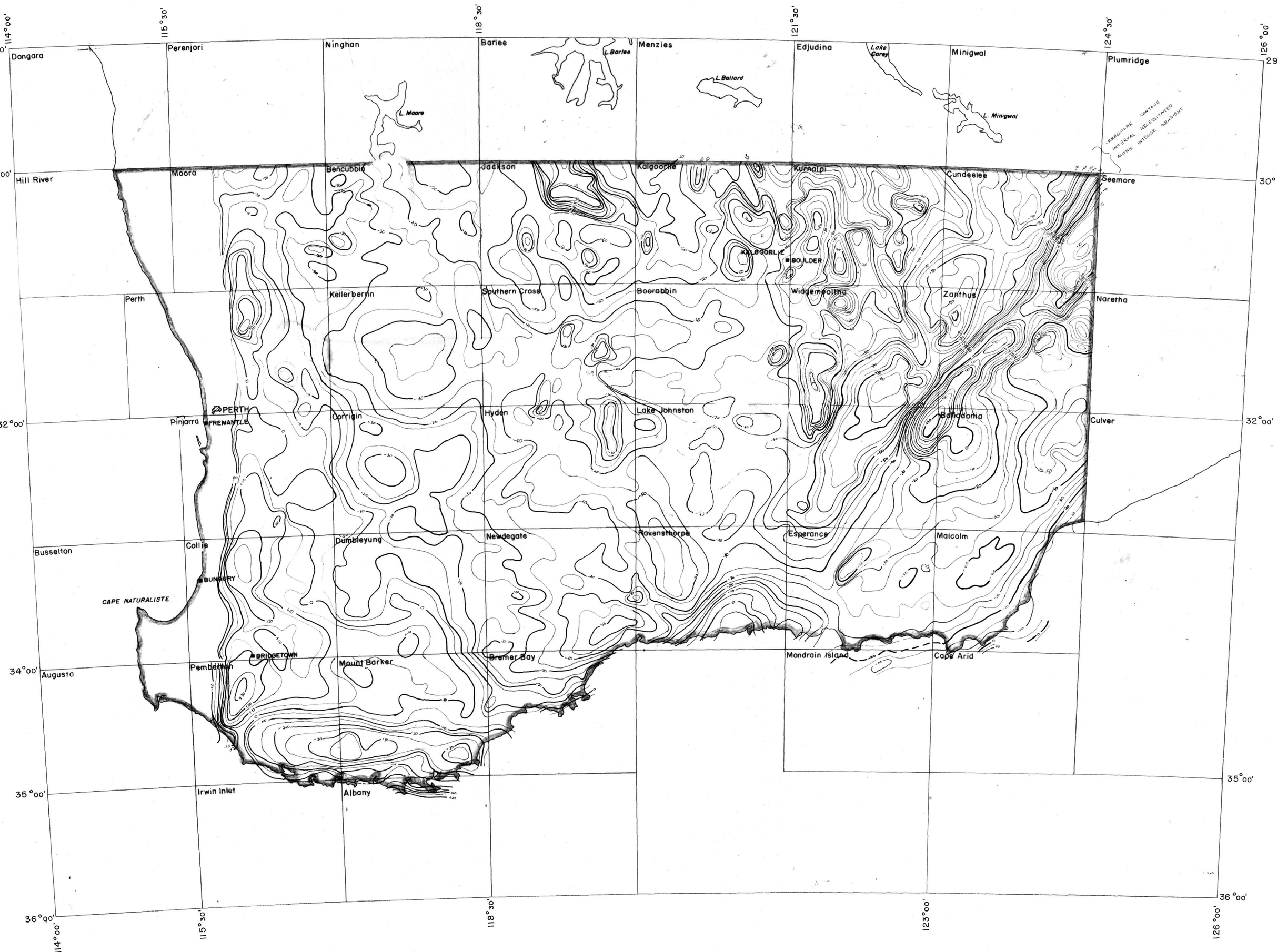
Survey boundary — — —

E54/BI-27

PLATE 9



(BASED ON A/BO-14)



LEGEND

Boundary of survey area

Perth — 1: 250,000 map area

AREA "A"

1969 HELICOPTER GRAVITY SURVEY

WA (BY CONTRACT)

SCALE

40 30 20 10 0 40 80 120 MILES

~~WA/B2-11~~

PLATE 11

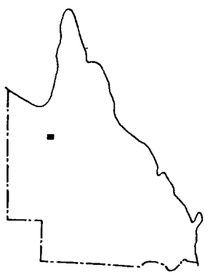
141°5' 10' 15' 20' 25' 141°30'

19°30' 35' 40' 45' 19°50'

-10 -15 -20 -25 -30

6610.4879 -18·1
6610.4880 -19·1
6612.4889 -13·0
6611.3604 -15·5
6612.4882 -16·9
6610.4881 -20·7
6610.4886 -12·1
6610.4878 -21·5
6612.4883 -24·1
6611.3603 -23·3
6612.4884 -26·6
6610.4918 -22·8
6610.4887 -20·8
6612.4885 -25·7
6610.4930 -21·2
6612.4886 -20·9

LOCALITY MAP



MILLUNGERA DETAILED GRAVITY SURVEY, 1969

BOUGUER ANOMALIES

· Gravity station

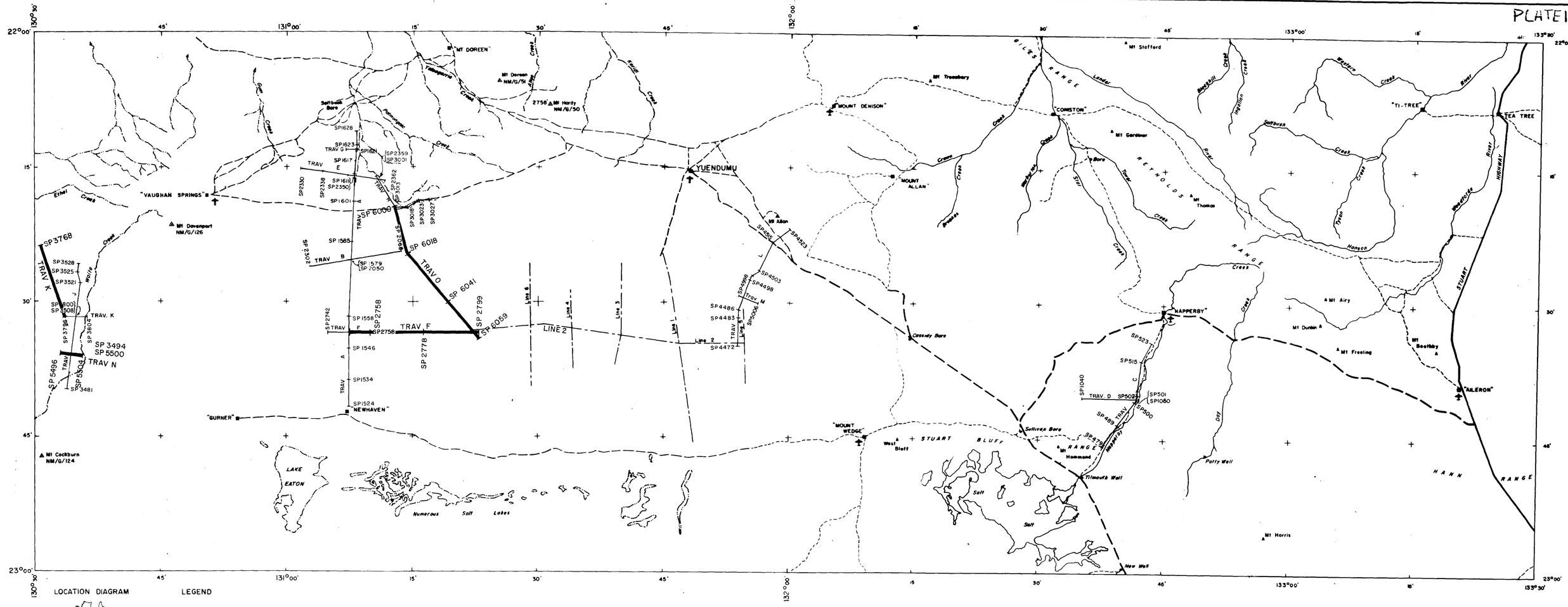
—15— Isogal

Note All stations have prefix 6920, unless otherwise shown

SCALE 1:100,000

E 54/B2-28

PLATE II A



LOCATION DIAGRAM

LEGEND

- Mission
- Homestead
- River or creek } Intermittent
- Lake } Intermittent
- Track
- Previous seismic survey
- 1969 Survey.

5 0 5 10 15 20 MILES

5 0 5 10 15 20 25 30 KILOMETRES

Based on F52/B3 – 21

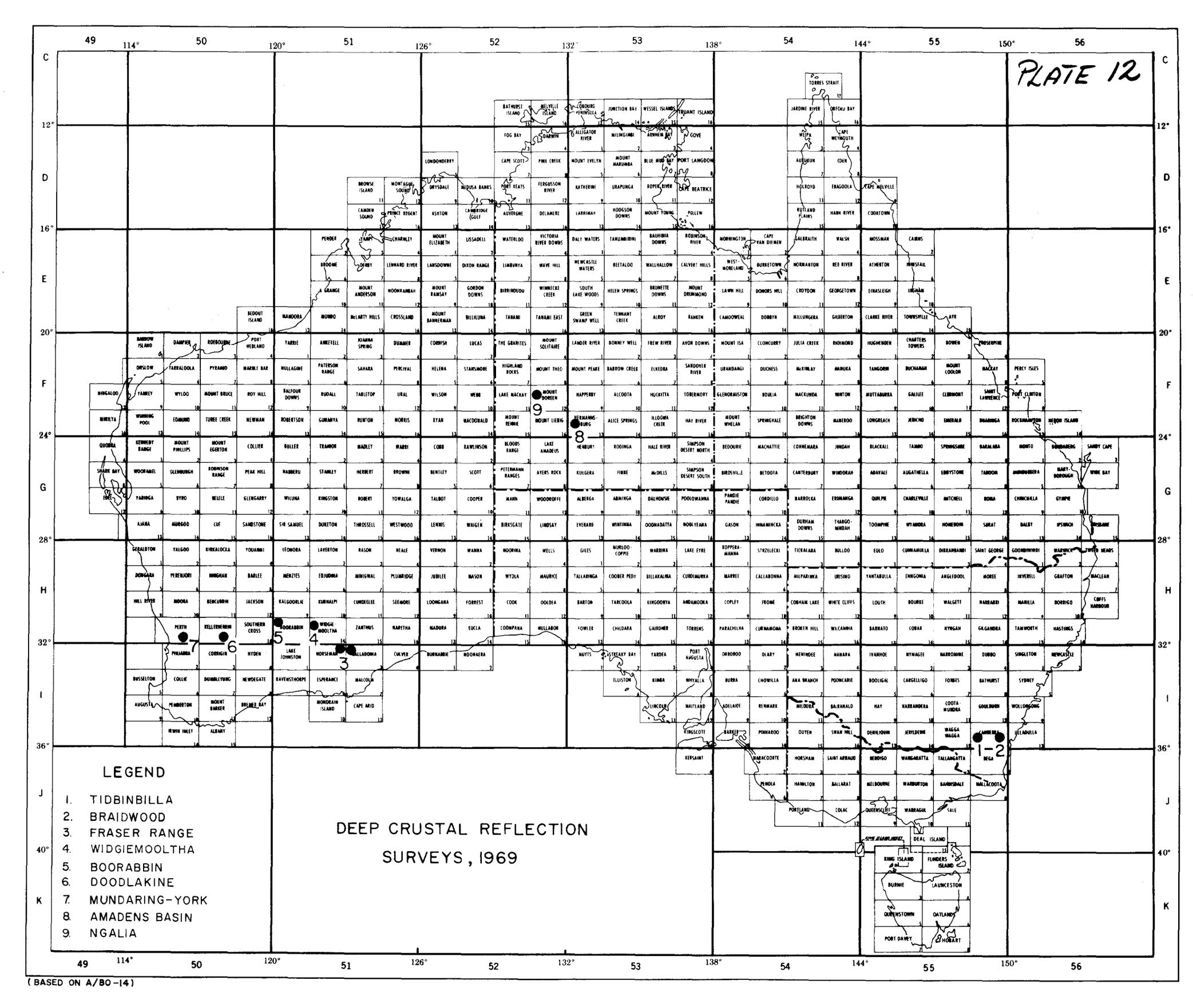
REFERENCE TO AUSTRALIA STANDARD 1:250,000 MAP SERIES : MT DOREEN

NGALIA BASIN SEISMIC SURVEY 1967 – 69

LOCATION OF TRAVERSES

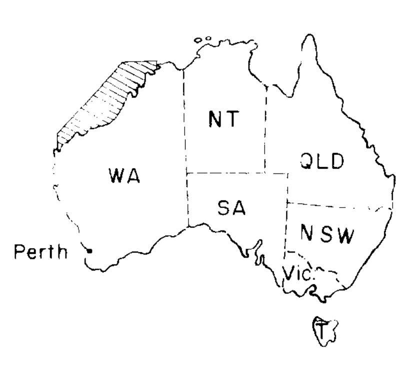
TO ACCOMPANY RECORD No. 1968/136

PLATE 12



(BASED ON A/80-14)

PLATE 13



Yampi 1:250,000 Map area

MARINE GEOPHYSICAL SURVEY OF THE NW CONTINENTAL SHELF, 1968
TRAVERSE PLAN

SCALE

40 20 0 40 80 MILES

- 1967 WORK
- FIRST CRUISE 1968
- SECOND CRUISE 1968
- THIRD CRUISE 1968
- REFRACTION SPREADS

TO ACCOMPANY RECORD No. 1969/99

~~WA/B8—4~~

PLATE 14

GOSSE BLUFF DETAILED GRAVITY SURVEY 1968

PRELIMINARY BOUGUER ANOMALIES

(BASED ON F53/B2-41)

Road or Track
LINE 2-E Seismic Traverse Line
BMR Seismic Line

A = 6815
B = 6111

SCALE 1 0 1 2 3 4 MILES

F 53/B2-47

PLATE 15

148°E

152°E

4°S

8°S

NEW IRELAND

GAZELLE PENINSULA

ST GEORGES CHANNEL

NEW BRITAIN

KILOMETRES

100 0 100 200

NEW BRITAIN CRUSTAL SURVEY 1969

SPARKER TRAVERSES
REFRACTION — STAGES 1,2

LEGEND

- X Stage 1 shot point.
- \+ Stage 2 shot point.
- Δ Stage 1 station.
- ▽ Stage 2 station.
- —— Sparker traverses.

8°S 148°E (Based on B56/80-29)

152°E

8°S

B56/B10-7

PLATE 16

148°E

152°E

4°S

4°S

NEW IRELAND

GAZELLE PENINSULA

ST GEORGES CHANNEL

RABAUL ENVIRONS

NEW BRITAIN

KILOMETRES

100 0 100 200

LEGEND

X Stage 3 shot point.

\+ Stage 4 shot point.

Δ Stage 3 station.

▽ Stage 4 station.

——— M.V. Coral Queen } Magnetic traverses

– – – M.V. Lahara }

NEW BRITAIN CRUSTAL SURVEY 1969

MAGNETIC TRAVERSES

REFRACTION — STAGES 3,4

8°S 148°E

(Based on B56/B0-29)

152°E

8°S

B56/B10-6