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DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

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GEOPHYSICAL BRANCH SUMMARY OF ACTIVITIES, 1965

CONTENTS

1. OIL SEARCH

Seismic Party No. 1 - Southern Georgina Basin

Seismic work in the Southern Georgina Basin on the Tobermory 1:250,000 sheet in 1965 was preceded by several weeks' experimental seismic work in the Cockroach Waterhole area in the latter part of 1964. Seismic Party No. 1 commenced work near BMR 12 (Cockroach) Bore about 10 miles south-west of the 1964 survey on 20th April 1965.

The main traverse was surveyed for about 50 miles north-east from BMR 12 Bore towards Tobermory (see Plate 1). Surface shooting conditions proved to be very variable, drilling was mostly slow and difficult, and reflections, even of poor quality, were very difficult to obtain. Near BMR 12, unconsolidated sediments were encountered from the surface to a depth of over 100 feet, and the split spread technique developed in the later part of 1964 for use in an area where hard carbonate rocks occurred at shallow depths proved unsuccessful. In this area 6 miles of reflection profile were surveyed using collinear offset shots consisting of 10-hole patterns 2600 feet from the geophone spread of 24 geophones per trace. For this work it was necessary to use unusually large charges of up to 400 lb of explosive per shot. A prominent refracted or reflected event was recorded about 0.25 sec after the first breaks, but this presented difficult problems in computing reflections. Air shooting was also tried over several miles of profile using collinear offset patterns with charges of 130 lb and geophone spreads with 24 geophones per trace. Air shots sometimes produced results, but these were generally poorer than with hole shots.

It became evident that, where hard limestone or dolomite was encountered by the shot-hole rigs at depths up to about 40 feet, poor quality reflections, mostly at times less than half a second, could be recorded using 5 to 20-hole shot patterns and 24 geophones per trace. Where the first high-velocity layer was deeper, it was almost impossible to obtain any useful reflections using conventional seismic means. Because of this it was decided to concentrate effort on those portions of the traverse most likely to yield reflections because of suitable surface conditions. Surface conditions were explored in advance of the main drilling crew by drilling one or two holes at each shot-point with a light rig and shooting shallow refraction shots in them to record first-break times over the normal reflection spread. About 22 miles of reflection profile using the split spread method were shot on selected portions of the traverse. Poor to fair reflections were recorded over portions totalling about 7 miles of traverse, while the remaining portions were devoid of useful reflection results. Reflections obtained were mostly in the first half-second and indicated little or no dip.

Near BMR 12, where there was a considerable thickness of unconsolidated sediments near the surface, collinear offset shots were tried over an interval of six miles, with little success. In an effort to improve results on a portion of the traverse on which poor reflections were obtained, six-fold multiple coverage was tried using five-hole shot patterns every 600 feet and 24 geophones per trace. This work did not result in any improvement to reflection quality. A number of noise test spreads were shot on the traverse to permit analysis of surface noise.

Several short exploration traverses were surveyed north of the main Cockroach-Tobermory traverse. On each of these, surface conditions were investigated as described above and a noise test spread was shot as well as split spread reflection profiling using 5-hole shot patterns and 24 geophones per trace.

A four-mile reflection traverse was surveyed near Manners Creek homestead. A few poor shallow reflections were recorded on this traverse and also a number of moderately strong deeper events with reflection times up to 2.75 sec. Some of the latter indicated strong southerly dip.

About 3 miles of reflection traverse were surveyed across the Mulga Hill structure near Alliance Mulga No. 1 Bore on the Sandover River 1:250,000 sheet. Only a few poor reflection events were recorded. These could not be correlated

from record to record. Four miles of reflection traverse were shot about 10 miles north of the bore to test a gravity 'low', but no useful reflections were recorded.

About 9 miles of reflection profile were shot on a traverse extending southwards from Bulgera Waterhole on Gordon Creek. This traverse was surveyed with the aim of finding seismic evidence regarding a major fault in this area postulated on the basis of aeromagnetic results. No significant reflections were recorded over the greater part of the traverse, but over an interval of about a mile at the northern end near Gordon Creek a number of poor-quality events were recorded at reflection times between 0.2 and 1 second.

Four miles of reflection traverse were surveyed near the centre of a large aeromagnetic basement depression in the south-western corner of Urandangi 1:250,000 sheet. Results were generally poor, but some reflections at about 0.5 sec indicated gentle dips to the north. Field work was completed on 29th October 1965.

Seismic Party No. 2 - Experimental seismic survey for comparison with the "Vibroseis" survey, Otway Basin (Victoria and South Australia) and Sydney Basin (NSW)

A new seismic technique - the "Vibroseis" - has recently been introduced to Australia; this uses vibrators on the surface as its source of energy. The Bureau engaged a contractor (S.S.L.) during 1964 to demonstrate the Vibroseis in various problem areas of the Otway and Sydney Basins. The objectives of this experimental survey were :

(1) To show the capabilities of the method in difficult areas.

(2) To assess its cost for comparison with shot-hole seismic methods.

(3) To assess the potential of this new method which is not yet fully appreciated.

At the end of April 1965, Seismic Party No. 2 commenced an experimental shot-hole seismic survey in the same areas, to try to obtain a valid comparison of the quality of results obtainable by the two methods, and the relative costs of production techniques.

(1) Basalt-covered areas in the Portland Sunklands - Traverses V2 and V3 (see Plate 2).

(2) Gambier Limestone outcrop areas in the Gambier Sunklands - Traverses GL2 and GL3 (Plate 3).

(3) Sand dunes in the Gambier Sunklands - Traverse SD2 (plate 4).

On Traverse V2, drilling conditions were variable with a general southward increase in the proportion of clay to basalt and rapid local variations in thickness and hardness of the basalt. Average penetration rate was 50 to 60 ft/hr. The arrangement of holes and geophones arrived at was 7 holes 50 ft apart, with 20 lb per hole; and 48 geophones per trace in two rows, 30 ft apart, each of 24 geophones 15 ft apart. Over the whole of the traverse the main reflection between 0.65 and 0.75 seconds was strong and clear. The quality is thought to be slightly better than that of the Vibroseis. Traverse V3 was surveyed with the arrangement determined for V3; reflection quality is poor on this traverse, and the comparison obtainable is not good.

Drilling conditions on Traverse GL2 presented no problem. The arrangement of holes and geophones arrived at was the same as for Traverse V2. The resulting records were thought to be slightly better than those from the Vibroseis. Recordings on Traverse GL3, using the same arrangement, gave results superior to the Vibroseis.

On Traverse SD2 the arrangement arrived at was 5 holes, 70 ft apart, with 20 lb per hole; and 48 geophones per trace in three rows, 30 ft apart, each of 16 geophones 20 ft apart. The general record quality was good. Where the sand became thicker, the shot had to be increased to 10 holes in line, 35 ft apart with 30 lb per hole.

Although the relative costs have not yet been computed, the shot-hole methods required to obtain records equivalent to, or slightly better than, the Vibroseis have been fairly heavy; in particular, large quantities of explosive have been used.

The noise test on Traverse GL2 indicated the presence of some transverse noise. An investigation subsequent to the work mentioned above led to recordings of improved quality using a diamond pattern of 9 holes and a square of 48 geophones.

Areas covered by Triassic Hawkesbury Sandstone in the Sydney Basin are problem areas because of the rugged outcrops, costly drilling, and poor record quality. Traverses HS1 to HS4 (Plate 4), which were surveyed by the Vibroseis, are at the time of writing being surveyed by the shot-hole method. Results to date appear to show that the main problem in improving record quality is one of low energy return.

Marine gravity and seismic "Sparkarray" survey

From 19th July to 8th October, Geophysical Associates Pty Ltd made a combined marine surface-gravity and seismic "Sparkarray" survey for the Bureau in the Timor Sea area of north-western Australia. The survey was originally planned mainly as a gravity survey, with the Bureau's seismic Sparkarray equipment added to possibly provide near-surface information on the sedimentary structure. However, the seismic results obtained were very good, and as the survey advanced, the seismic results became as important as the gravity results.

Gravity readings were made continuously along traverses, using a surface marine gravity meter; accurate control stations were set up with an underwater meter. The weather during most of the survey was very good, and consequently the gravity data were of higher quality than is usual for this type of survey. There was considerable trouble in keeping the electrodes of the Sparkarray unit in operation, but nevertheless seismic sections were obtained along almost the whole of the traverses. The problem of operating the seismic equipment at the boat speed required for the gravity work was not serious; it was found that satisfactory seismic sections could be obtained at speeds up to 7 or 8 knots, which was the cruising speed of the boat.

The most serious problem was the failure of the radio-positioning equipment at night, owing to interference from "sky waves". This limited the normal working day to about 8.30 am to 5.00 pm, and thus seriously reduced the area covered.

A total of 3790 miles of traverse was run; this covered the 1:250,000 sheet areas of Fog Bay, Cape Scott (the sea part), D52-6, and parts of Port Keats, Medusa Banks, Londonderry, D52-1, and D52-2 (See Plate 5).

A rough preliminary calculation of the gravity data has produced the Bouguer anomalies shown in Plate 5. These indicate northerly trends on the eastern side of Bonaparte Gulf and north-westerly trends on the western side. These trends agree approximately with the strikes on the margins of the Bonaparte Gulf Basin as inferred from on-shore geology, aeromagnetic interpretation, and siesmic work during the present survey. However, a large positive regional Bouguer anomaly, which is an extension of the previously known anomaly at the mouth of Queens Channel, occupies a large part of the Basin. The seismic and magnetic evidence here suggests thick sediments; therefore it seems likely that the anomaly is due to an intra-basement feature.

The seismic sections along both the eastern and western margins of the Basin are generally very good. There are generally two or three reflecting horizons that are recorded quite strongly while they are fairly shallow - say down to 1.2 seconds - but they are usually obscured by noise towards the deeper parts of the Basin. Consequently the sections recorded in the central part of the Basin are much poorer; the reflections are quite deep, and the shallower reflecting horizons that appear are of poor quality. Nevertheless, it is often possible to follow the continuity of the deep horizons. The section shown in Plate 6 is fairly typical of the quality of records on the eastern margin.

The seismic work has indicated the general shape of the Bonaparte Gulf Basin in the area of Joseph Bonaparte Gulf. The east-west sections along the south-eastern shoreline show that the sediments gradually thicken westward from the coast. Immediately west of Darwin the sediments are either absent or very thin, but from longitude 130°E the westerly plunge into the Basin commences. Approaching the coastline in the south-west, the sediments gradually thin again, and the strike is roughly parallel to the coast. The thickness of sediments in the centre of the Basin is at least 10,000 ft, and probably much greater. Structures are evident along both the eastern and western margins of the Basin; the one shown in Plate 6 is on the eastern margin, west of Cape Scott. The folding on the western margin is more intense, and probably is accompanied by faulting.

Seismic playback centre

The playback centre equipment has continued to function fairly satisfactorily, and standard routines have been established for processing of tapes and finalising of cross-sections. The centre continues to handle the output from the two BMR seismic parties and processing of tapes from the 1964 contract Vibroseis survey. It is expected that some cross-sections will be prepared for the Sedimentary Basins Study Group. An average of 25 to 30 cross-sections per month are currently being prepared.

Experimental delay line filtering has been done using the new C.G.G. delay line that has been incorporated into the system. In addition, considerable testing has been carried out with common-depth-point stacking and mixing techniques on most surveys.

Full and reduced size cross-sections, for inclusion in reports, were prepared for the following :

Thargomindah-Noccundra 1963
Bullsbrook 1964
Byro Basin 1963
S.E. Georgina Basin 1964 (part)
S. Carnarvon Basin 1964 (part).

Full size cross-sections were prepared and finalised for the following :

S.E. Georgina Basin 1964 (part)
Giles-Carnegie 1961-1962
S. Carnarvon Basin 1964 - Gascoyne Junction area.

These reduced and full-size cross-sections have been distributed to interested parties inc BMR, State Governments, and private companies.

Cross-sections have also been prepared (but drafting is not yet finalized) for the following :

Otway Basin 1964 - Vibroseis Contract Surveys
Otway Basin 1965 - Conventional Comparison Surveys
Sydney Basin 1964-1965 - Vibroseis and conventional comparison surveys (part)
Amadeus Basin 1961-62 (part)
Georgina Basin 1965 (part)

S.E. Georgina Basin 1963 (part)
St. George-Innamincka 1963 (part)

In addition to the above work, sections are being processed for the following surveys :

Amadeus Basin 1961-1962 - to be completed
Carnarvon Basin 1964 - reprocessing of part
Georgina Basin 1965 - continue experimental processing of sections
Otway-Sydney Basins (1964-1965) - continue with further experimental processing and comparison of conventional and Vibroseis work.

Airborne magnetic and radiometric survey, Amadeus Basin, N.T. (VH-MIN)

An airborne magnetic and radiometric survey was flown over the greater part of the Amadeus Basin and the surrounding Precambrian basement during the period May to November 1965. The area surveyed includes the MOUNT RENNIE, BLOODS RANGE, PETERMANN RANGES, MOUNT LIEBIG, LAKE AMADEUS, AYERS ROCK, HERMANNSBURG and ALICE SPRINGS and parts of the HENBURY, KULGERA and RODINGA 1:250,000 map areas.

The survey was designed primarily to provide the magnetic data needed to determine the basement structure within the sedimentary basin, to aid oil exploration and geological mapping. The radiometric data were required for testing the possible appreciation of this method in the exploration for phosphate deposits in the Ordovician sediments.

The main features of the Amadeus Basin are the thick pile of sedimentary rocks extending in age from Upper Proterozoic to Middle Palaeozoic, which range in thickness to over 30,000 feet, and the development with the sediments of great anticlinal structures, which parallel the Basin edges and extend over great distances.

Reduced scale magnetic profiles obtained from flight-lines spaced at 4-mile intervals and ties spaced at 15-mile intervals are shown in Plate 7. Preliminary interpretation of the magnetic results in the form of basement depth contours is included on this map.

The boundary of the sedimentary basin is clearly shown by the abrupt change in magnetic character. In general the boundary obtained from the aeromagnetic data approximately coincides with that geologically mapped. The interpretation has not yet advanced to the stage where it is possible to specify or confirm the nature of the basement/sediment contact along the northern and southern boundaries of the Basin. The abrupt change in basement depth along the Basin boundaries and the general absence of regional magnetic anomalies, typical of faults or high angle contacts, does however favour interpretation involving structures which include recumbent folding in the HERMANNSBURG, ALICE SPRINGS, and BLOODS RANGE areas.

Magnetic trends are only discernable from the tie profiles in the northern area of basement outcrop, and these are oriented approximately east-west. A change in basement rock type is apparent across the northern part of the survey area near the line of maximum gravity gradient. This change involves an increase in the basic nature of the basement rocks northwards, which most probably accounts for the form of the Bouguer anomaly to the north of the sedimentary-basin/basement contact. The Ormiston and Arltunga Nappe Complexes in the HERMANNSBURG and ALICE SPRINGS areas appear to correlate with areas of low susceptibility contrasts typical of acidic basement rocks, to the north of which the magnetic data indicates more basic basement.

The magnetic basement surface shows similar form to that indicated by previous gravity and seismic surveys in this area. The deepest parts of the basin appear to be located in the south-western and south-eastern corners of the MOUNT LIEBIG area. where maximum indicated basement depths are 43,000 and 36,000 feet

below sea-level respectively. There is an easterly extension of this basement "low" into the ALICE SPRINGS area, at the south-western corner of which the basement "low" reaches 23,000 feet below sea-level. The general rise in the basement southwards from latitude 24°S is deformed by numerous local basement "highs" and "lows". The basement "highs" about the western, southern, and eastern boundaries of the LAKE AMADEUS area can be correlated with gravity "highs". The north-west-trending basement escarpment in the east of the HENBURY area coincides with a geological inferred fault. Another basement high is postulated in the west of the MOUNT RENNIE area. Basement deepening in the northern part of the RODINGA area and the eastern part of the ALICE SPRINGS area closely follow gravity features.

High-amplitude magnetic anomalies in the north of the ALICE SPRINGS area are probably associated with iron and copper mineralisation. One such anomaly is included in a detailed magnetic survey (VH-GEO Strangways Range, 1965) within an area where mineralisation was known to be present.

Low-amplitude magnetic anomalies occurring in the south-west of the Basin are probably caused by dykes.

The radiometric data have revealed radioactive anomalies associated with Ordovician and ?Upper Devonian sediments within the Amadeus Basin. These radioactive "highs" are common in the HENBURY and LAKE AMADEUS areas, being associated with parts of the Gardiner Range, James Range, Mereenie, Johnny Creek, and Ochre Hill anticlines. Radioactive "highs" have also been observed over basement rocks to the north and south-west of the Basin, and in addition Ayers Rock has a significant anomaly associated with it.

The magnetic data collected will probably suffice for reconnaissance requirements. If accurate detailed magnetic contour maps are needed in areas of basement outcrop, further survey flying would be required, reducing the line spacing to less than one mile and possibly reorienting flight-line direction north-south. No areas have yet been selected where the magnetic results and economic geology indicate that more-detailed surveying is required.

Minor magnetic disturbance in the southern and south-western parts of the Basin cannot be correlated with surface geology. More-detailed aeromagnetic work is needed to establish the form of this magnetic disturbance to assist geological mapping. It is expected that anomalies have a north-west trend and are caused by dykes.

No further aeromagnetic work should be commenced in the Amadeus Basin or in the area of surrounding basement outcrop, however, until the present survey data have been fully reduced, contour maps of total magnetic intensity have been produced, and the results reinterpreted using digital computation methods involving derivative and residual anomaly techniques.

The radiometric "highs" obtained within the Amadeus Basin in areas of Ordovician and ?Upper Devonian outcrop require re-flying at an altitude of 200 ± 20 feet above ground level. This is necessary to obtain greater resolution of the radioactive anomalies. If radioactive minerals are found to be associated with the phosphate occurrences, ground geophysical, geological, or geochemical surveys for economic phosphate deposits should be greatly assisted by such a detailed low-altitude survey.

Contract aeromagnetic survey, Northern Great Artesian Basin, Qld

The contract aeromagnetic survey of JULIA CREEK, RICHMOND, McKINLAY, MANUKA (part), TANGORIN (part), MACKUNDA, BOULIA and SPRINGVALE 1:250,000 areas was awarded to AMEG Pty. Ltd. for the sum of £36,025. An extension to the contract for an amount of £13,975 was awarded to AMEG for additional survey coverage of HUGHENDEN and MUTTABURRA (part), the total contract being for £50,000.

Surveying is to commence in mid-November. The survey consists of E-W traverses spaced 4 miles apart, with provision for fill-in lines in areas nominated by a BMR representative.

Preliminary drafting and photo-centre marking for use in map compilation are in progress.

Aeromagnetic survey, Sydney Basin, NSW (VH-MIN)

The commencement of this survey has been delayed by the late completion of the Amadeus Basin survey. This survey will consist of a series of E-W traverses across the western part of the SYDNEY 1:250,000 area. It will be flown at the same time as the Goulburn survey, and is expected to be completed by the end of December 1965.

Gravity surveys, NT and Qld

The 1965 helicopter gravity survey is still in progress. Preliminary Bouguer anomaly contours for the following 1:250,000 areas have been completed:

NAPPERBY, MOUNT PEAKE, BARROW CREEK, BONNEY WELL, LANDER RIVER, MOUNT SOLITAIRE, THE GRANITES, TANAMI, TANAMI EAST, GREEN SWAMP WELL, TENNANT CREEK, FREW RIVER, ALROY, BRUNETTE DOWNS, HELEN SPRINGS, SOUTH LAKE WOODS, WINNECKE CREEK, BIRRINDUDU, WAVE HILL, NEWCASTLE WATERS, BEETALOO, BAUHINIA DOWNS, TANUMBIRINI, DALY WATERS, VICTORIA RIVER DOWNS.

Plate 8 shows the preliminary results of Part 1 of the survey. Several major gravity provinces are marked on this map.

A large gravity "low" named the Lander River Gravity Low, centred on the LANDER RIVER 1:250,000 area, has been mapped; it is suggested that this is caused by a major sedimentary basin in that area. Several other gravity provinces have been mapped during the course of the survey. They are:

(1) Napperby Regional Gravity Low, which correlates with outcrops of granite on the Napperby 1:250,000 area.

(2) Willowra Regional Gravity Ridge, which is thought to delineate a zone of mineralisation within the Lower Proterozoic rocks.

(3) Coomarie Regional Gravity Complex, which comprises anomalies having a marked north-west trend, thus suggesting that the Lower Proterozoic rocks of THE GRANITES area are related to the rocks of the Halls Creek Mobile Zone.

(4) Renner Regional Gravity Plateau, which is an area of relatively high Bouguer anomaly. The individual anomalies are rather weak, and rocks in the area are evidently of fairly uniform density.

(5) Buchanan Regional Gravity Platform, which possibly delineates an area of relatively thin sediments.

Coverage of several gravity units and provinces partially mapped during previous surveys has been completed. These features are:

(1) Papunya Regional Gravity Ridge (province)

(2) Ooratipra Gravity High (unit)

(3) Ammaroo Gravity Depression (unit)

(4) Caroline Gravity Ridge (unit)

The survey has been tied to Department of the Interior benchmarks for the purpose of elevation control. Gravity control has been maintained by tying

in to "isogal" stations established in 1964 by the Regional Gravity Group.

The following statistics apply to Part 1 of the helicopter survey:

New Readings	2703
Grid stations	2284
Loops	345
Area covered	94,250 square miles

Upon completion of the basic station network, all apparent misreadings will be checked and some additional readings will be made at selected points where it is considered that extra station density is desirable to delineate an important gravity feature more adequately.

During the course of the survey, preliminary Bouguer anomalies were roughly computed using rapid computing techniques. Preliminary maps at a scale of 1:250,000 and a progressive map at 40 miles to 1 inch have been prepared. Final Bouguer anomaly values will be produced using automatic computing techniques. The final values and 1:250,000 maps are expected to be available by January 1966.

Well logging, Great Artesian Basin, by BMR - A. Radeski

Six holes were logged; three were gamma-ray and electric, and three were gamma-ray only.

Well logging, Great Artesian Basin, by contract - Schlumberger Seaco

This company logged 63 holes using gamma-ray techniques. The results indicate an easy correlation of the holes, using the Tambo and Roma Formations.

2. METALS SEARCH

Mount Lyell ground investigation for copper, Tasmania

Comstock area. Geophysical work done in the Comstock valley in early 1965 for the Mount Lyell Mining and Railway Company (Plate 9) completed the survey initiated in 1964. The aim of the survey was to investigate the possible occurrence of sulphide mineralisation similar to that already known in Mount Lyell area.

An area of 6400 feet by about 4000 feet was surveyed with the Turam method. Interesting features revealed by the Turam method were then investigated with the I.P. method. Geophysical anomalies were recorded with both methods, and the I.P. anomalies coincided with the main Turam anomalies. A test I.P. traverse was also observed over the known lodes of the Tasman mine for comparison.

The most important Turam anomaly extended across the area in an east-west direction. Comparison with the I.P. results over the Tasman mine suggests that part of this anomaly is due to sulphide mineralisation. The mineralisation is probably strongest in the eastern section. It appears to weaken in the central section, and may be accompanied by shear zones. Other Turam anomalies are accompanied by very weak I.P. anomalies, and may be due to weak mineralisation or shear zones. They are not considered as important as the main anomaly.

The proposed explanation of the geophysical results is in accordance with the known and inferred geology of the area, making the prospect very promising.

Drill holes were recommended to test the main geophysical findings. It is expected that drilling will commence in March 1966.

Blocks Area. One I.P. test traverse was observed over the copper clay deposits in the Blocks Area during the 1965 Comstock survey. The copper clay deposits are shales of the Gordon Limestone Formation that have been altered by hydrothermal processes to ferruginous clay containing disseminated native copper.

A resistivity anomaly is apparent over the clay deposits. The weak I.P. effects recorded on the traverse do not seem related to the native copper as was hoped. The availability of more accurate geological information may aid the final interpretation and make conclusions more definite.

Hoddles Creek ground investigation for gold-antimony, Victoria

The survey was made at the request of Messrs K. and L. McRae on behalf of a syndicate which recently acquired mining rights over the Gem and Surprise Gully mines with the intention of exploring and reopening the mines if sufficient mining-grade ore is proved. The aim of the survey was to provide suitable drilling targets for the exploration programme. The surveyed area was approximately 1000 ft x 1000 ft.

The Gem and the Surprise Gully mines produced appreciable tonnages of gold-stibnite ore until 1952, when mining operations ceased due to depressed market conditions. The known lode is from 6 inches to 2 feet wide and follows the hanging wall of a decomposed feldspar porphyry dyke which intruded the Silurian siltstone and sandstone country rocks. The lode contains some pyrite besides gold and stibnite, but its concentration is not known.

Self-potential, magnetic, electromagnetic (Turam and E.M. Gun), and induced polarisation methods were used. No significant anomalies were detected over the known mineralisation, but a pronounced electromagnetic and induced polarisation anomaly was detected approximately in line with the lode about 400 ft south-west of the Gem shaft.

This anomaly was tested by diamond drilling, carried out by the Victorian Mines Department. Their shear planes of concretionary pyrite were intersected between 41 and 70 ft but it is doubtful whether these are sufficient to explain the observed anomalies. The drill hole was extended to 130 ft, 30 ft past the target, but no sign of the feldspar porphyry dyke or the gold-stibnite lode was discovered. Immediately the hole was completed the casing was drawn and the hole collapsed, so no geophysical logging was possible.

Ravensthorpe ground investigation for copper, WA

A geophysical survey was conducted in the Ravensthorpe area of WA between 8th June and 17th September 1965, using magnetic, electromagnetic, self-potential and induced polarisation methods (see Plate 10). The main object of the survey was to find extensions to the Elverdton-Desmond copper orebody or to find new, similar orebodies nearby. Accordingly most of the geophysical work was concentrated on areas A (over the Elverdton-Desmond workings), B and C (north and south of the Elverdton mine respectively), and D (near the old Ironclad workings). In addition, three test traverses were surveyed at The Gap, seven test traverses at Marion Martin, and two test traverses at Mount Cattlin.

After some preliminary tests the self-potential and E.M. Gun methods were discarded. Areas A, B, C, and D were surveyed completely with a Sharpe Fluxgate Magnetometer and A.B.E.M. Turam equipment, and the main Turam anomalies were tested with the Geoscience induced polarisation equipment. Numerous Turam anomalies were encountered near the Elverdton Mine; in particular, what appears to be an extension of the Elverdton-Desmond shear could be traced through area B. Several significant Turam anomalies were also found in areas

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C and D but generally they were not accompanied by I.P. anomalies. Good I.P. anomalies were detected over known mineralisation near the Desmond shaft and along the Elverdton shear but the only other I.P. anomalies were weak and generally did not coincide with Turam anomalies. Magnetic work in the area detected several magnetic bodies but was not very effective as a means of mapping greenstone, the most common rock for copper mineralisation. During the latter half of the survey about approximately 250 soil samples were collected for geochemical investigation. Samples were taken at 50-ft intervals, one foot below the surface, along selected traverses in areas A, B, and C near the Elverdton Mine.

The Gap area gave rather unsatisfactory results. Turam and magnetic work detected only small anomalies, and I.P. measurements were hampered by the extremely low resistivities encountered.

Turam and I.P. measurements at Marian Martin were quite promising; both methods showed significant anomalies over the known mineralisation, and these anomalies were traced beyond the known area. A new line of I.P. anomalies north-east of the proven ore was detected, and probably indicates another mineralised zone. No magnetic measurements were made at Marian Marton.

The work at Mount Cattlin was very brief. Two test traverses were surveyed with I.P. and no magnetic or Turam work was done. The two I.P. traverses both detected significant anomalies, which probably indicate a line of copper mineralisation.

The survey party completed approximately 2 miles of self-potential, 5 miles of E.M. Gun, 28 miles each of magnetic and induced polarisation, and 32 miles of Turam during the three months spent in the Ravensthorpe district. Several drill sites will probably be recommended when the geophysical results have been checked and analysed in detail.

Liontown ground investigation (I.P. test survey), Qld

This project was first programmed for 1964, but owing to staff shortage was deferred until 1965. In the meantime, McPhar Geophysics Pty Ltd had conducted an I.P. survey in the Liontown area for Broken Hill South Ltd. The results of this work were made available to the Bureau and provided practically all the information the Bureau had hoped to obtain from its own survey. Consequently there was little purpose in going ahead with the Bureau's proposal, and the project was deleted from the programme.

Chewton-Castlemaine ground investigation for gold, Vic

Early in 1965, the Eureka Gold Mining Syndicate requested geophysical work, particularly I.P. surveys, in the Chewton-Castlemaine Goldfield to assist the search for gold-bearing reefs. Examination of the request raised doubts as to the applicability of geophysical methods. In particular the chance of success with the I.P. method seemed rather poor because of the narrow and complicated shape of the gold reefs and their low sulphide content. However, the Bureau agreed that the proposal would be considered at the annual programme conference and a decision would be made as to whether or not the geophysical work would be included in the 1966 programme.

In order to obtain further information to assist in assessing the proposal, the area was inspected and several I.P. test traverses were surveyed between 18th and 21st October. The I.P. results were much better than expected.

I.P. anomalies were recorded over the gold-bearing "leather jacket formations" of the Wattle Gully mine. It appears evident that the anomalies are due to these lodes.

Anomalies were recorded over the saddle and fissure reefs of the Eureka and Eureka Vineyard, but they are less pronounced and harder to interpret. They are probably due to lodes with a very low pyrite content.

Some anomalies occur over areas where no known mineralisation occurs. One such anomaly may be the extension of the Mona Reef, 500 feet away, and should be investigated further.

As the I.P. method has not previously been used in this field, these results are important and justify a more extensive geophysical survey of the area. It is recommended that a survey of approximately two months should be programmed for 1966. In addition to the I.P. method, other methods such as electromagnetic and potential-drop-ratio would be included.

Watsonville drilling, Qld

Drilling of further 5 drill holes totalling 1434 feet, during the first half of 1965, completed the drilling programme commenced in 1964.

The results were rather disappointing in as much as no economic mineralisation was discovered except in N.S.1 (Site A aimed to test AGGSNA Indication A) where a section of core (104'7"-111'9") assayed between 7 and 8% Cu and 3% Sn. However, sufficient sulphides were encountered in all holes but one (N.S.4) to fully explain the cuase of geophysical anomalies.

N.S.2 also aimed to test the AGGSNA Indication A. Sulphide mineralisation was encountered in core section 83'9"-17'0" and 322'0"-535'11". An 8 foot 1 inch section (114'7"-122'8") averaged 0.3% Sn while another 2 foot 3 inch section (335'7"-349'0") averaged 0.2% Sn.

N.S.3 (Site C) was selected on geological grounds under the old North Australian workings. Drilling encountered sulphide mineralisation averaging 0.22% Sn over a 9 foot section (177'0"-186'0"), 0.18% Sn over a 10 foot section (210'0"-220'0") and 0.24% Sn over another 10 foot section (240'0"-250'0").

N.S.4 aimed to test the AGGSNA Indication E. This drill hole intersected a vertical fault zone and was stopped at 101 ft because of drilling difficulties. No mineralisation was encountered.

N.S.5 (Site H, aimed to test the AGGSNA Indication A) intersection sparse sulphide mineralisation between 13'0" and 109'0". Core section 26'2"-33'1" assayed 0.53% Sn.

N.S.6 (Site J, aimed to test the AGGSNA Indication B) intersected three mineralised sections, namely 97'10"-140'5", 176'0"-177'10", and 208'4"-215'3". The last two sections assayed 0.44% Sn and 0.51 Sn respectively.

N.S.7 was not drilled.

N.S.8 (DDH8, situated east of the AGGSNA grid) intersected light sulphide mineralisation in core section 98'7"-115'3" assaying 0.04% Cu and 0.08% Sn.

N.S.9 (DDH5, aimed to test the area south of Easter Monday workings) encountered sulphide mineralisation (pyrite, chalcopyrite, pyrrhotite) at intervals in core section 55'7"-319'11". The core section 55'7"-94'0" averaged about 0.03% Sn, the core section 139'11"-196' averaged 0.14% Cu while the core section 290'2"-319'11" averaged 0.07% Cu and 0.06% Sn. Some silver (up to 8 dwt/ton) and traces of gold were also found.

N.S.10 (DDH4) intersected light pyrite and pyrrhotite mineralisation in core section 35'4"-190'0". No Cu assays were made, and only traces of tin were found.

N.S.11 (DDH1) intersected sulphide mineralisation averaging 1.25% Cu over a length of 13 feet 6 inches of core section 86'0"-99'6" and 0.5% Cu over

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a length of 9 feet 8 inches of core section 122'0"-131'8".

N.S.12 (DDH7) intersected sulphide mineralisation averaging 0.35% Cu over 42 feet 6 inches of core section 91'6"-134'0". Weak Sn mineralisation was found in section 40'1"-44'10" and also in section 187'3"-204'6".

Darwin Uranium Group activities (Plate 11)

Gould Airstrip area. This survey was the principal field project for 1965. It started on 7th June and finished at the end of October.

An initial reconnaissance survey was made with Slingram and surface radiometric methods on 14 traverses 2400 feet apart. A zone of strong Slingram anomalies was located in the south-eastern part (Mount Minza area). A line of weaker anomalies was found to extend from near Mount Minza northwards to Area 65 (Waterhouse No. 1).

The Mount Minza area was investigated in more detail with Slingram, Turam, and surface radiometric methods on traverses 400 and 200 feet apart. The electromagnetic work indicated a group of very strong conductors. The geological environment of these conductors appears similar to that at the Waterhouse No. 2 Prospect. Some of the conductors are probably mainly graphite, vut others may be sulphides.

Several weak radiometric anomalies (approximately 2 x background) were located, and these coincide in part with the electromagnetic anomalies.

Magnetic readings were taken on selected traverses with the aim of determining the origin of the aeromagnetic anomalies in the Gould Airstrip area. The results have not yet been analysed.

Rum Jungle East area. Follow-up work was done in two parts of the 1964 Rum Jungle East survey area. Slingram and surface radiometric methods were used on traverses 400 feet apart in the Coomalie Gap West and Woodcutters areas.

In the Coomalie Gap West area the work consisted of a southern extension of the 1964 follow-up work. The results showed that the electromagnetic anomalies located in 1964 become weaker and terminate less than half a mile to the south.

In the Woodcutters area the traverses were put in to cover a geochemical anomaly found in the 1964 reconnaissance work. Several weak conductors were located in the area, but none appears to be associated with the geochemical anomaly.

Davenport Range area. At the request of the Mines Branch, Northern Territory Administration, two days in April were spent doing Slingram tests in the Davenport Range area.

Two known copper lodes were selected. Five traverses, each 500 feet long, were surveyed over one lode and three traverses, each 500 feet long were surveyed over the other lode. No significant Slingram anomalies were discovered over the lodes, and the tests were discontinued.

Geophysical Laboratory. Regular maintenance and repairs were made to the Bureau laboratory, seismic observatory, and field equipment. Privately owned prospecting instruments were repaired when requested.

A programme of Slingram model experiments was started in February and was continued for about five weeks. The preliminary results are interesting, and it is proposed to continue the programme when the opportunity occurs.

The radiometric assaying of samples of Waterhouse and Rum Jungle Granite collected in 1964 was completed. The heavy mineral fraction (less magnetite) of the samples gave the highest assay values.

Seismological Observatory. Three recorders were in continuous operation, except for minor breakdowns, up to May. From then, only two recorders have been in operation. The third recorder is waiting for a glavanometer.

Provisional bulletins were issued twice a week. I.S.R.C. cards were sent regularly to Edinburgh.

A geological report on the drilling at the Manton Observatory site was forwarded to the Observatory Group, Melbourne, on 9th April by the Senior Geologist, Darwin Uranium Group.

Overseas Fellows. Instruction and training in geophysics were provided for A. Wiriasumita and N. Prawoto during their time with the Darwin Uranium Group.

Orroroo-Parachilna airborne magnetic & radiometric survey, SA (VH-MIN)

This survey of the ORROROO and PARACHILNA 1:250,000 areas, requested by the South Australian Department of Mines, was flown during March and April 1965. This area forms part of the Central and Southern Flinders Ranges. The objectives of the survey were to assist geological mapping, to detect structures associated with mineralisation, and to determine the regional subsurface structure where possible.

Two distinct magnetic horizons were recognised. Firstly a deep magnetic basement underlies a thick geosynclinal sedimentary sequence. Determinations of depth to this basement were made and contours of basement topography were drawn, mainly in the PARACHILNA area (Plate 12). The basement deepens towards the centre of this area exceeding 25,000 ft. below mean sea level. Troughs deeper than 20,000 ft. belowM.S.L. trend north-west and south-west from the centre of the PARACHILNA area. Beneath the Bibliando Dome, the basement rises to 3000 ft below M.S.L. In the west of the ORROROO area the basement is about 20,000 to 27,000 ft below M.S.L.

In parts of the survey area, particularly in the south-east of the ORROROO area, the magnetic effect of the deeper basement is masked by steep narrow magnetic anomalies of both positive and negative polarity, which are due to bodies at or near the surface. In order to assist in the mapping of surface rocks, the survey area has been divided into a series of zones defined by the dominant amplitude range of the 'surface' anomalies (Plates 12, 13). Magnetic trends have also been resolved in the ORROROO area, and are shown in Plate 13. Listed below are the zone types and their magnetic character:

Zone Type	
1	Positive anomalies mainly less than 25 gammas
2	" " " in the range 25 to 100 gammas
3	" " " " " " 100 to 200 "
4	" " " " " " 200 to 600 "
5	" " " greater than 600 gammas
6	Negative anomalies

A partial correlation was observed between zones, magnetic trends, and known geology. Zones of type 3 are largely attributed to the Wilpena Group; zones of type 5 are due to outcrops of the Holowilena Ironstone of the lower glacial unit; zones of type 6 are exclusively due to the Tildelpina Member, a series of pyritic pyrrhotitic shales, thought to be remanently magnetised, which form the base of the interglacial sequence. In general the magnetic trends closely follow the geological bedding strike.

In many localities, zones of disturbed field may be directly correlated with known diapirs, structures which commonly have associated mineralisation. As a result of this correlation, six localities, shown shaded in Plates 12 and 13, have been proposed as worthy of ground investigation to test for a diapiric origin.

The general increase in magnetic disturbance towards the south-east of the ORROROO area is ascribed to either a regional increase in magnetic sedimentary iron due to a variable depositional environment, or to a regional metamorphic gradient possibly the result of a buried igneous body similar to the Anabama Granite to the east.

The general level of radioactive intensity, as determined by an inboard scintillometer of 10-second time-constant, is 40 counts per second (c.p.s.). The highest values of 80 c.p.s. were recorded over Cainozoic alluvium, and with one exception are confined to the south-east of the ORROROO area. The Wilpena and Umberatana Groups generally have a slightly higher radioactive content than the Burra Group and Cambrian sequence.

An outboard scintillometer of 1-second time-constant was used to detect anomalies due to sources of small areal extent. Sixteen such anomalies of significant amplitude were detected, of which ten are considered worthy of ground investigation.

It can be seen from the magnetic results that the three aims of the survey have been largely achieved. Contours have been drawn in much of the area showing the probable thicknesses of non-magnetic sediments; part of the area has been zoned such that certain types of magnetic disturbance can be used with care as marker horizons; six localities have been delineated as possible areas of mineralisation. The significance of the radiometric survey is difficult to determine without ground investigation. However, the highest readings were detected in the south-east of the ORROROO area, where a granite body has been tentatively postulated to explain the increase in magnetic disturbance.

It is therefore considered that the reconnaissance magnetometer survey is a useful tool in such an area, where geological mapping is incomplete but sufficiently advanced to provide geological control for geophysical interpretation. The value of the radiometric survey is compromised in the Flinders Ranges by the rugged terrain. The topographic relief renders it impossible to maintain the desired constant ground clearance of the scintillometer detector.

Goulburn airborne magnetic & radiometric survey, NSW (VH-MIN)

The commencement of this survey has been delayed by the late completion of the Amadeus Basin survey.

The survey of the GOULBURN 1:250,000 area, consisting of E-W traverses spaced one mile apart, is expected to commence in mid-November and to be completed by the end of December 1965.

Kalgoorlie detailed aeromagnetic survey, WA (VH-GEO)

The survey took place immediately around Kalgoorlie and Boulder and to the south-south-east as far as Feysville (Plate 14). The aim of the survey was to assist the geological mapping in the survey area. The area is mainly covered with Recent soil and alluvium. The known geology has been derived from the mine workings in and around the Golden Mile, some drilling results, and surface mapping of the meagre rock outcrop. The rocks are Precambrian, and the sequence consists of ultrabasic intrusives, meta-gabbro and meta-quartz-dolerite intrusives, meta-lavas, sediments, and acid porphyries.

The results of the 1965 survey, combined with those of the 1964 detailed aeromagnetic survey north-west of Kalgoorlie, give a contour map of roughly 200 square miles of country immediately surrounding Kalgoorlie. From the magnetic profiles over these areas, beds have been delineated and the identification of the rock type forming individual beds has been suggested in terms of the above-mentioned sequence. The rock type identification was based mainly on the amplitude of the anomaly arising from each bed. From this interpretation, an overall structure for the areas has been suggested.

The north-eastern corner of the 1965 survey area has been interpreted as consisting of a sedimentary sequence unrelated to the igneous complex forming the Golden Mile. A proposed fault, the Parkeston Fault, indicated in the results by a lineation of negative anomalies, divides the north-eastern corner from the remainder of the area. The greater part of the survey area has been interpreted as consisting of the Golden Mile igneous complex in the form of a major anticline, the Mount Hunt Anticline. This Anticline has a north-north-west strike and is transected on the east by the Boulder Fault. East of the Boulder Fault, the south-plunging Kalgoorlie Syncline-Anticline structure of the Golden Mile evidently reappears with a north plunge to the east and south of Hannans Lake. This north-north-west-striking Kalgoorlie Syncline-Anticline structure is interpreted as a drag fold on the eastern limb of the Mount Hunt Anticline.

The results of the survey have not had any direct bearing on mineralisation prospects. The ore genesis does not appear to be sufficiently well understood to allow predictions of possible mineralisation.

Surveying in the above manner could continue in Western Australia over thousands of square miles of the Precambrian Shield. However, there appears to be little point in continuing until some assessment has been made of the success of the interpretation and the worth of the survey results.

Mount Masson detailed aeromagnetic survey, NT (VH-GEO)

Between 18th June and 30th July 1965, a detailed aeromagnetic survey was made of part of the Mount Harris Tinfield in the Northern Territory. The area of 55 square miles is centred about ninety miles south-east of Darwin. The survey was programmed following an examination of the results of the 1963 Darwin-Pine Creek aeromagnetic survey, which was flown with a line spacing of half a mile.

The objective of the detailed survey was to assist in the location of tin-bearing bodies or extensions to existing lodes, and it was considered that this might be achieved by evaluating the geological structure of the area. To increase anomaly resolution the flight-lines were spaced 1/10 mile apart, and the detector was maintained at a nominal 350 ft above ground level.

The magnetic contour map (Plate 15) shows a series of major sub-linear anomalies slightly distorted by minor magnetic features. The average amplitude of the major anomalies is about 500 gammas, but amplitudes up to 1700 gammas were recorded. The contour pattern forms a zone of disturbed magnetic field, three to four miles wide, encircling the Cullen Granite, an intrusion presumably associated with tin mineralisation. The zone is situated over arenaceous and argillaceous sediments of Lower Proterozoic age which form the host rocks for the tin. These sediments have little magnetic expression at distances greater than four miles from the contact with the granite. It is evident therefore that an association exists between the intrusion of the granite and the magnetic disturbance. In the north-central region the magnetic trends appear to reflect the dominant fault direction but elsewhere the trends of magnetic features are generally parallel to the bedding strike and to quartz and quartz-haematite veins.

Many of the anomalies have been analysed to determine the width and depth of burial of their sources. The widths range from 400 ft to 2400 ft and the depths of burial from zero to 800 ft.

Calculations of magnetic susceptibility gave values from 3×10^{-3} to 7×10^{-3} c.g.s. units. The average value of 5×10^{-3} c.g.s. units is approximately equivalent to a rock containing either 1% magnetite or 4% phyrrhotite.

A process of low-grade thermal metamorphism of the sediments is considered responsible for the observed magnetic pattern. It is also considered that the lateral extent of magnetic disturbance defines the lateral extent of the granite beneath the sediments. These inferences are based on the following facts:

(1) The zone of magnetic disturbance skirs the granite outcrop,

and the sediments away from the granite are non-magnetic.

(2) The magnetic trends are parallel to the general geological strike suggesting that original lithological variations had a controlling influence on the magnetic pattern.

(3) The highest-amplitude anomaly (that crossed by section Q-Q') was detected over an area mapped as granite, but which is probably an unmapped roof pendant.

(4) There is no obvious correlation between the magnetic pattern and the few small outcrops of dolerite in the area.

It is further suggested that an association exists between the highest-amplitude magnetic anomalies and higher grades of metamorphism, and perhaps therefore between the amplitudes of anomalies and the proximity of granite beneath the surface. As cassiterite is a high-temperature mineral generally deposited close to the margin of the parent granite, such a hypothesis would therefore imply that the areas of high magnetic intensity represent areas of increased tin prospects. Plate 15 shows that almost all known tin occurrences are situated close to the axes of magnetic "highs".

Some inferences on geological structure have been made but these are confined to faulting, as known folds have no magnetic expression. The possible faults have been inferred from one or more of the following observations:

(1) A different magnetic character either side of the fault plane.

(2) The co-linear termination of anomalies at the fault plane.

(3) A change in magnetic trend direction.

(4) An abrupt lateral displacement of isogammas.

It is recommended that the surface anomalies crossed by sections Q-Q' and T-T' be first inspected on the ground to determine whether they are due to metamorphosed roff-pendants. If the presence of metamorphics is confirmed, sampling of traverses and possibly drilling of the major anomalies would be justified. The large anomaly crossed by sections B-B', C-C', and D-D' is recommended as a first target area, as it appears to be due to a body, partially fault-bounded, at a similar depth to that at Mount Masson mine.

Without the results of such a follow-up programme, it is impossible to determine the value or desirability of further aeromagnetic work in the tinfield.

Strangways Range detailed aeromagnetic survey, NT (VH-GEO)

A detailed aeromagnetic survey of five small areas in the Strangways Range (Plate 16) commenced in September 1965. Three of the areas have been completed to date, and the survey is expected to end on 16th November 1965. The results have not been fully processed, but the following observations can be made at this stage.

Area 3. Mud Tank Bore. The eastern half of this area is relatively flat magnetically, and exhibits a north-westerly trend. In the western half, elongated anomalies of 1700 gammas peak trend north-east and are associated with near-surface sources presumed to be mainly lenses of amphibolite. The three known magnetite-apatite outcrops yielded anomalies of 700, 1000, and 1700 gammas.

Area 4. Pinnacles. Steep anomalies of amplitude up to 2000 gammas arise from a complex magnetic pattern of varying trends. The five known copper deposits north-east of Southern Cross Bore have no obvious magnetic expression, but one to the north-west of the Bore is marked by an anomaly of 1400 gammas.

Areas 1 and 2. Almost no interpretation has been made of these areas. An anomaly of over 5000 gammas in the western half of Area 1 (Redrock Bore) occurs over mapped quartz-garnet-magnetite.

Davenport Range Detailed aeromagnetic survey, NT (VH-GEO)

Between mid-August and mid-September, the Cessna aircraft was used to survey 87 square miles of country adjacent to Whistleduck Creek in the Davenport Range. The aim of the survey was to obtain greater resolution of the magnetic anomaly previously recorded over this area by a regional aeromagnetic survey, and to define the structure of the metabasaltic block causing the anomaly. Copper mineralisation has been discovered within the block but a structure favourable to concentration of this mineralisation is needed to provide a mining prospect.

The survey area consists of a block of metabasaltic lava flows surrounded by sediments of the Lower Proterozoic Hatches Creek Group. The results of the survey (Plate 17) define the boundary of this basic block and indicate that the Hatches Group must contain a hitherto unrecorded sequence of basic extrusive lava flows amongst the arenaceous sediments. The survey results also indicate the trends of the lava flows within the basic block. These trends reflect the structure already apparent in the surrounding sediments, so the survey added a little to the geological knowledge of the area.

The centre of the survey area appears to be highly folded and faulted, and might contain concentrations of copper mineralisation. The amygdaloidal and vesicular parts of the lava flows should occur in the regions of low magnetic field between the large-amplitude anomalies, and these regions should be inspected for mineralisation.

There has been little interest in the results of the survey, and it would appear that the mineralisation in the Whistleduck Creek area is nothing more than the usual low concentration of chalcopyrite associated with basalt. As this mineralisation is unlikely to be of economic importance and as the survey has added little to the knowledge of the area, further detailed magnetic surveying in the Davenport Range is not recommended. A detailed study of the data available from the regional aeromangetic survey should be undertaken before other Cessna surveys are proposed for this area.

Included in the programme for the Davenport Range survey was some detailed surveying of the Skinners Pound area, 14 miles south of the Whistleduck Creek area. A test flight in this area has yet to be flown. The results of this flight should confirm the conclusions for the Whistleduck Creek area and give slightly more detail than that already available from the results of the regional survey.

Rock magnetism study (B.A. Dockery)

References in the literature were studied and summarised during early 1965. However, as a whole, these references did not present a coherent picture of rock magnetism and further literature study was found necessary. This work was resumed later in the year.

During 1966, an attempt will be made to apply the rock magnetism studies to a practical case. In the proposed detailed aeromagnetic survey in Western Victoria, drill cores will be available. Thus measurements can be obtained of the susceptibility and remanance of the basaltic rocks, which should be detected by the survey. In addition, a mathematical study will be made of the field to be expected over a thin horizontal plate (the model representing the horizontal basaltic lava flows). The expected field derived from the mathematical study, using the measured values of susceptibility and remanance, will be compared with the actual field measured during the survey.

This should be instructive, as the normal empirical method of interpretation of the results of detailed surveys has ignored the effects of remanent magnetisation. Usually the remanent magnetisation of basic igneous rocks is 2 to 10 times the strength of the induced magnetisation; thus it is surprising that the empirical interpretations should give useful results.

Radiation sensors study (W. Finney)

Investigations into this project have been confined to consulting the available literature in order to assess the previous work done. The radiation considered is confined almost entirely to the Infra-red (I.R.) part of the spectrum, although some minor consideration has been given to other frequencies of electromagnetic radiation.

At present no mineralogical exploration using radiation sensors, is being actively pursued. It would appear that the most successful application of I.R. detectors has been in understanding meterological phenomena.

Successful radiometers have been developed in which the I.R. radiation directed to, and reflected from, the surface of the Earth can be measured with reasonable accuracy. The net radiation flux can be estimated and hence the amount absorbed by the ground is determined also. This energy is largely dissipated in the evaporation co-efficients of surfaces of varying texture can be determined.

It would appear to be possible to infer from the absorptive and reflective abilities of surfaces something about the texture of the foliage cover and hence to the soil or rock underneath. This is in effect an extension of photo-geological techniques to I.R. radiation and presumably this could be extended to U.V. as well. The advantages of this additional information do not appear to justify the time and expense outlaid in obtaining it.

I.R. and U.V. radiation has been utilised by the United States Geological Survey in some surface temperature studies of the Kilauea volcano in Hawaii, and from their results they suggest that these methods could be used in exploration for ore deposits associated with abnormal temperatures.

New and better detectors are being developed, but much of this work is being carried out by the American Military establishments, and their results remain classified. Contact has been made with the United States Geological Survey which is at present studying the use of scanning radiometery in geophysical exploration. Through the Survey, publications of the Remote Sensing Symposiums held in the University of Michigan are being made available to the Bureau.

The only action proposed at the moment is to contact Mr Dana C. Parker of the University of Michigan to confirm the arrangements concerning these publications.

Computer programme for airborne data reduction (R. Wells)

In 1962 a programme was written to process aeromagnetic data digitally recorded in aircraft VH-MIN on the SILLIAC digital computer at the University of Sydney.

A project to rewrite this programme for use in the CDC 3600 computer at the CSIRO, Canberra, was programmed for 1965. Owing to a staff shortage caused by resignations, this project has not proceeded beyond the planning stage. It is again proposed for 1966.

Aeromagnetic interpretation study (G.A. Young)

A basic course in the use of the CDC 3600 computer was completed. Some progress was made in the development of primary programmes for computing the effects due to induced magnetisation of small uniform cells contained within a 3-dimensional

lattice. The magnetic anomalies due to a series of 3-dimensional modal sources will be synthesised from these primary cells.

It is proposed during 1966 to complete these programmes and apply them to actual problems of aeromagnetic interpretation.

3. ENGINEERING AND HYDROLOGY

Crustal investigations, NSW

In cooperation with the Australian National University, three out of five explosions of depth charges let off by the R.A.N. were recorded. The maximum distance between the recording point and the charge was 136 kilometres. Two refraction spreads at right angles were used to enable calculations to be made of dip and true velocity of the refracting layers. Calculation of results is not yet complete.

Stradbroke Island hydrological survey, Qld

The survey, which is the continuation of the 1964 survey, is being made to find the hydrological conditions of the southern part of the island. It is proposed to supply the water to the Brisbane City Council. In all, 13,800 feet of seismic refraction, 30 resistivity depth probes, and 78 gravity stations were measured. The thickness of the dune sand in this part of the island is less than that found in the previous year (930 feet). Resistivity measurements indicate that salt or brackish water is present only close to the island shore.

Victoria Bridge and Hamilton Crossing survey, Qld

Thirty-five miles of Sonar-boomer traversing and 12,000 feet of seismic traverses were recorded in the lower Brisbane River area at the request of the Coordinator-General of Public Works. At Victoria Bridge the contours of the top of the bedrock were mapped and velocities of about 12,000 feet/sec in the bedrock were recorded. At Hamilton Crossing the old river valley was found buried under 137 feet of alluvium, about 1000 feet north of the present river valley. Laboratory measurements on the cores gave the value of 16×10^6 lb/sq. in. for Young's modulus.

Clare, Qld

This survey was deleted from the programme, as IWSC advised that it was not required.

Burdekin Delta, Qld

Repeat measurements were deferred until 1966.

Coober Pedy bore logging, SA

Single-point resistivity, SP and gamma logs were obtained to the depth of 1850 feet. The hole produces brackish water.

Ground Water School, Adelaide

Five members of the Section attended the School. W.A. Wiebenga, P.E. Mann, and E.J. Polak gave lectures and demonstrations.

King's Bridge, Launceston

At the request of the Mines Department an investigation has been carried out for the foundations of the proposed bridge. Six traverses in the mouth of Cataract Gorge indicated that the mud layer at the bottom of the river is very thin. Four traverses on the bank of the river gave the thickness of the overburden as

between 10 and 80 feet.

Risdon Brook dam site, Tasmania

At the request of the Mines Department 18,000 feet of seismic refraction traverse were shot on the sites of the proposed dam, saddle dam, and borrow pit to determine the thickness and the character of the overburden and the character of the bedrock and to find suitable material for the dam construction. In addition, the velocities of longitudinal and transverse waves in various directions were determined to obtain the dynamic properties of rocks.

ANZAAS Congress, Hobart

The following papers on engineering geophysics and underground water were delivered at the ANZAAS Congress in August.

Seismic surveys in water-covered areas, by P.E. Mann.
The Measurement of elastic properties of rocks in situ, by J.C. Dooley
Assessment of in situ rock properties from laboratory measurements, by E.J. Polak.
Geophysics in underground water problems, Burdekin Delta, by M. Wainwright.
Salt water encroachment, by E.J. Polak.
Radioactive tracer tests in the Burdekin Delta, by W.R. Ellis (AAEC) and W.A. Wiebenga (read by E.J. Polak).

Kooweerup, Victoria

Resistivity depth probes were measured using DC and AC instruments with several electrode arrangements. The purpose of the test was to find the difference in the results obtained, and how far this difference could influence the interpretation.

Nillahcootie dam site, Victoria

At the request of the State Rivers and Water Supply Commission, investigations have been made to find the character and the thickness of the overburden and the character of the bedrock.

In all, 19,500 feet of the seismic traverse were shot using longitudinal waves. At two localities longitudinal and transverse waves were recorded to obtain the dynamic elastic properties. In addition five samples of cores were investigated in the laboratory.

The survey indicated that the axis of the proposed dam should be rotated to avoid an area of a very deep bedrock (220 feet) and probable shear zone.

Young's modulus of the bedrock is high, reaching 8.2×10^6 lb/sq. in. in the laboratory determination and 7.7×10^6 lb/sq. in. in the field determination.

Bore logging, Victoria

Two holes were logged to provide a basis for correlation, at the request of the Victorian Mines Department. One near Echuca was 600 feet deep, and the second near Jeparit 900 feet deep.

Vibration studies, Victoria

In cooperation with the State Rivers and Water Supply Commission, investigation of the magnitude of vibrations resulting from large explosions (up to 1000 lb explosives) were started at the Bellfield dam site.

Flow of water through porous medium

In cooperation with the Australian Atomic Energy Commission the first

stage of the investigation was completed. It consisted of the checking of equipment and familiarisation with procedure.

Adelaide River, NT

The Geological Branch did not require the expected work to be done here. A logger was lent to the Geological Branch, and its operation was demonstrated for use in the Wiso area.

4. REGIONAL SURVEYS

Pendulum gravity measurements

No field work was done during the year.

Analysis of the 1964 field data and a series of laboratory tests indicated that the knife edges of the pendulums and the agate plate of the swinging chamber are not true. Arrangements have been made to return the equipment to the manufacturer for repair.

Isogal regional gravity survey

The 1964 "Isogal survey" was completed during early 1965. The base stations established throughout Australia are shown in Plate 18.

The results of a run along the east coast of Australia (see Gravity meter readings along the W.P.C.L." below) were computed in "Australian milligals". These were used to provide reasonably accurate datum values for the east-west traverses. The provisional observed gravity values at the various base stations, excentres etc. are known as the "May 1965 Isogal Values" and are given relative to N.G.B.S., Melbourne.

Analysis of the accuracy of these results indicates a standard error of 0.1 mgal in the relation of the gravity value at a station to the basic east-west traverse passing through that station. The standard error in the relation of the gravity value at a station to the network as a whole cannot be properly assessed as yet but is expected to be 0.2 mgal.

The stations have been adequately sketched, photographed and described to permit accurate relocation. The preparation of final station description drawings is nearly complete.

Most sites have been temporarily marked with red paint, and permanent marking with brass discs is progressing.

Gravity map of Australia

A composite map was assembled using all available data. The sedimentary work is at various density values; reduction of the whole using a uniform density of 2.67 g/cm^3 cannot be carried out because of other commitments.

Earth-tide recording

Because of a shortage of staff none of this work was carried out during the year.

Gravity meter readings along the W.P.C.L.

Early in the year one geophysicist joined a party of I.U.G.G. observers to obtain gravity meter readings over the Australian portion of the W.P.C.L. (Darwin-Brisbane-Cairns-Melbourne). One Bureau La Coste (No. G-20) and 4 other La Coste gravity meters were used for the project.

The results have been reduced and used in conjunction with the Isogal results to produce "May 1965 Isogal" gravity values. Final values for the W.P.C.L. stations will depend on the analysis of long-term drift and an adjustment of calibration factor based on readings over the E.C.L. These adjustments will be carried out by the U.S. Department of the Air Force at their base at Wyoming, U.S.A.

Automatic computing procedures

All programmes are now working for the reduction of raw field data to final free-air and Bouguer anomaly values. These programmes are for the SIRIUS machine at Monash University Computing Centre.

A start has been made on conversion programmes to transfer computing to the CDC 3600 machine at CSIRO, Canberra. At the same time, refinements will be introduced into some of the new programmes; these refinements are possible with the larger (and faster) machine.

Reorganisation of the filing system and renumbering of gravity data in preparation for getting all data ready for the CDC 3600 is progressing.

Conferences, etc.

The following papers on regional gravity were presented at the A.P.E.A. Congress in Adelaide in March :

Regional gravity studies in Australia, by J. C. Dooley

Programming gravity data, by W. J. Langron.

The following papers were presented in a symposium on "The measurement of gravity" at the ANZAAS Congress in Hobart in August.

Gravity measurements with the G.S.I. pendulum apparatus, by J. Shirley.

Establishment of a uniform gravity network in Australia, by B.C. Barlow.

The calibration of gravity meters, by B.C. Barlow.

Problems of Antarctic gravity measurements, by W.J. Langron.

Mr. Dooley attended the meeting of the International Gravity Commission in Paris, and presented the national report on gravity from 1962 to 1965.

Regional magnetic and palaeo-magnetism

Iso-magnetic maps of Australia and Antarctica and a secular variation map of Australia (1915-65) have been prepared. A complicated and rapidly changing pattern of secular variation has existed in Australia during the last half-century. Similar instabilities have been found in other continents.

A programme for computation of azimuth observations by the CDC 3600 was developed and used to compute last year's detailed declination traverse of Queensland.

A portable fluxgate variograph sufficiently stable for use at first-order stations was designed and partly built. However, it was not ready for the first-order survey this year.

The first-order survey, covering 14 stations in NSW and Queensland, was carried out during October and November.

The Serson fluxgate variograph operated in Hobart throughout the year. It was on loan to Mr Bisdee. Late in the year one of the Askania variographs was lent to the University of Queensland.

In response to a request, a compass swinging survey was carried out at Kingsford Smith Airport.

The astatic magnetometer, built in the BMR workshops for palaeomagnetic work some years ago, was examined to determine how much work would be required to bring it into operating condition.

5. OBSERVATORIES

Headquarters (Canberra)

Most of the year was devoted to reprogramming the magnetic data reduction program for the CDC 3600. This has incorporated many improvements on the former programme for SILLIAC.

Scaling of magnetograms continued slowly. There were many interruptions due to equipment failure after the group moved to Canberra. Because the service personnel were still in Melbourne, these failures resulted in a large loss of operating time. Failure of the coding disc late in the year has brought the scaling programme to a stop until a new disc can be obtained.

Almost no progress has been made in analysis of 1964 Antarctic magnetic data because of lack of computing staff. The two computing assistant positions have been vacant since the group moved to Canberra. A limited amount of checking of computations has been done by geophysicists.

Toolangi and Antarctic Observatories

The normal programme of geomagnetic recording continued at Toolangi, using a normal-run La Cour. A pulsation recorder was operated for the University of Queensland for most of the year. Intercomparisons with magnetic instruments going to Antarctic Observatories were carried out. An extensive set of tests was made on the proton magnetometer with vector coils, as a result of which the results are considered absolutely correct within 3 gammas.

The normal programme of seismic recording was continued at Toolangi using short-period Benioff and long-period Press-Ewing seismometers. A visible recorder, fed by a distant seismometer, has been installed in the Melbourne office.

Normal geomagnetic and seismic recording was continued at Macquarie Island, using normal-run and rapid-run La Cour magnetographs and a short-period vertical Benioff seismometer. The old declinometer was replaced by an Askania.

Normal geomagnetic and seismic recording was continued at Mawson, using normal-run La Cour magnetographs of high and low sensitivity, a Selzer type fluxmeter, long-period horizontal, and a short-period vertical, Benioff seismometers.

Normal geomagnetic and seismic recording was continued at Wilkes, using Ruska normal and rapid-run magnetographs, a Grenet short-period vertical and three Press-Ewing long-period seismometers. The CIW declinometer was replaced by an Askania, but the latter is behaving erratically. Recording of the geomagnetic vertical component has been much more stable since replacing the Ruska magnet by a La Cour. Also the usefulness of the seismic recording has been improved by the construction of a new hut.

Mundaring Observatory

The normal programme of geomagnetic recording has been continued, using an Eschenhagen magnetograph. A vertical loop inductometer has been operated on RWD.

The normal programme of seismic recording was continued using a World Standard set of seismometers (three short-period Benioffs and three long-period Sprengnethers) and a short-period Benimore. One field seismometer was operated at Kalgoorlie throughout the year and a second was installed in November.

The normal programme of recording with the Cossor ionosonde continued with very little record loss.

Records on crustal structure and seismicity were written. The high mantle velocity found last year has been confirmed and shown to extend between Mundaring and Kalgoorlie.

Port Moresby Observatory

The normal programme of geomagnetic recording was continued using normal and rapid-run La Cour magnetographs. A dynamic calibration of the rapid-run magnetograph was made during tye year. It was found to be underdamped.

The normal programme of seismic recording was continued using a World Standard set, two long-period low-magnification horizontal Sprengnethers, two Wood-Anderson seismometers and a Wilson-Lamison vertical seismometer.

The field programme of surface wave recording became operational by the middle of the year. Very little serious difficulty has been experienced since then. The first triangle of stations will have been completed by the end of the year. The instrument at Popondetta will then be moved to Kerema. A preliminary value of the crustal thickness within the first triangle (the western part of the Owen Stanley Ranges) is 45-50 km. Attempts at machine calculation of phase velocity have not yet been successful.

Advice has been given on seismicity and earthquake risk to several organisations. Extreme value methods seem to be valuable in zoning for earthquake risk.

The normal programme of ionospheric recording was continued. Considerable loss of record was experienced during the first half of the year. This was improved somewhat when new modules were installed in the middle of the year, but the quality of ionograms is kept low by the signals from nearby broadcast and aviation transmitters. Radio transmission from an artificial satellite is recorded twice daily for Sydney University.

6. LABORATORIES

Design and Development Group

Proton Magnetometer development. Work continued on improving the performance of the MNS1 magnetometer. Most of this work involved the design of a low-noise preamplifier. Assistance in this matter was provided by an extension course at Melbourne University.

Design aspects of the detector coil are being investigated, as is the development of a digital filter for automatic narrow-band tuning.

Fluxgate magnetometers. An MFD3 storm-warning magnetometer was built for VH-GEO.

The MFR3 3-component variograph was built for the Observatory Group, but there was trouble with low gain in the detector amplifier. A new amplifier is now being developed.

Seismic cable tester STC1. Final development of the fault detector for this unit was completed.

Crystal clock. The NCD1 crystal clock at Toolangi was fitted with an external oven-controlled crystal, which has reduced the rate to near zero.

The NCD2 crystal clocks at Port Moresby have had their mechanical units modified.

The NCD2 prototype has been upgraded, and the development of an all electronic read-out commenced.

G.S.I. Pendulum gravity equipment. Preliminary re-design of the electronics was completed.

VH-MIN scintillograph. A transistorised ratemeter was designed and constructed. The prototype was successfully used throughout the year.

Sparkarray marine seismic equipment. A fiducial marking system and tape recorder power supply were designed and integrated with this equipment.

Magnetic observatory digitisation. Preliminary design of a photo-cell feedback system for this purpose was concluded.

Circuit development and component evaluation. An investigation was made of the use of monolithic integrated semi-conductor circuits. It was decided that these would be used wherever possible. Various types of counter circuits were compared, using transistors, uni-junction transistors, and integrated circuits. Both-way counters and binary counters were developed to drive numerical displays.

A 1 Mc/s crystal oscillator was developed for use in VH-MIN digital equipment.

The use of constant-voltage transformers with square-wave drive was investigated.

A project was commenced to study the use of solar cells for battery charging.

Miscellaneous. Miscellaneous tasks included the building of a 28-volt power supply for laboratory testing of aircraft equipment, the completion of a new design for the ratement for the Widco 500-ft logger, and improvements to the Toolangi time-signal amplifier.

Maintenance and Testing Group

During the year the group was concerned mainly with installing and testing new geophysical equipment.

Sonar Boomer and Sparkarray marine seismic equipment were received and field tested in Port Philip Bay. Integration and installation of a new FM recorder and other equipment with the type 7000B seismic reflection amplifiers were completed.

A telemetry system was developed whereby the output from a seismometer at Melbourne Observatory in the Domain could be recorded at Wentworth House. The design was completed and the equipment built and installed successfully. The link between the Observatory and the office in Wentworth House is by P.M.G. line.

Some modifications and additions were made to the seismic central playback equipment to increase available facilities.

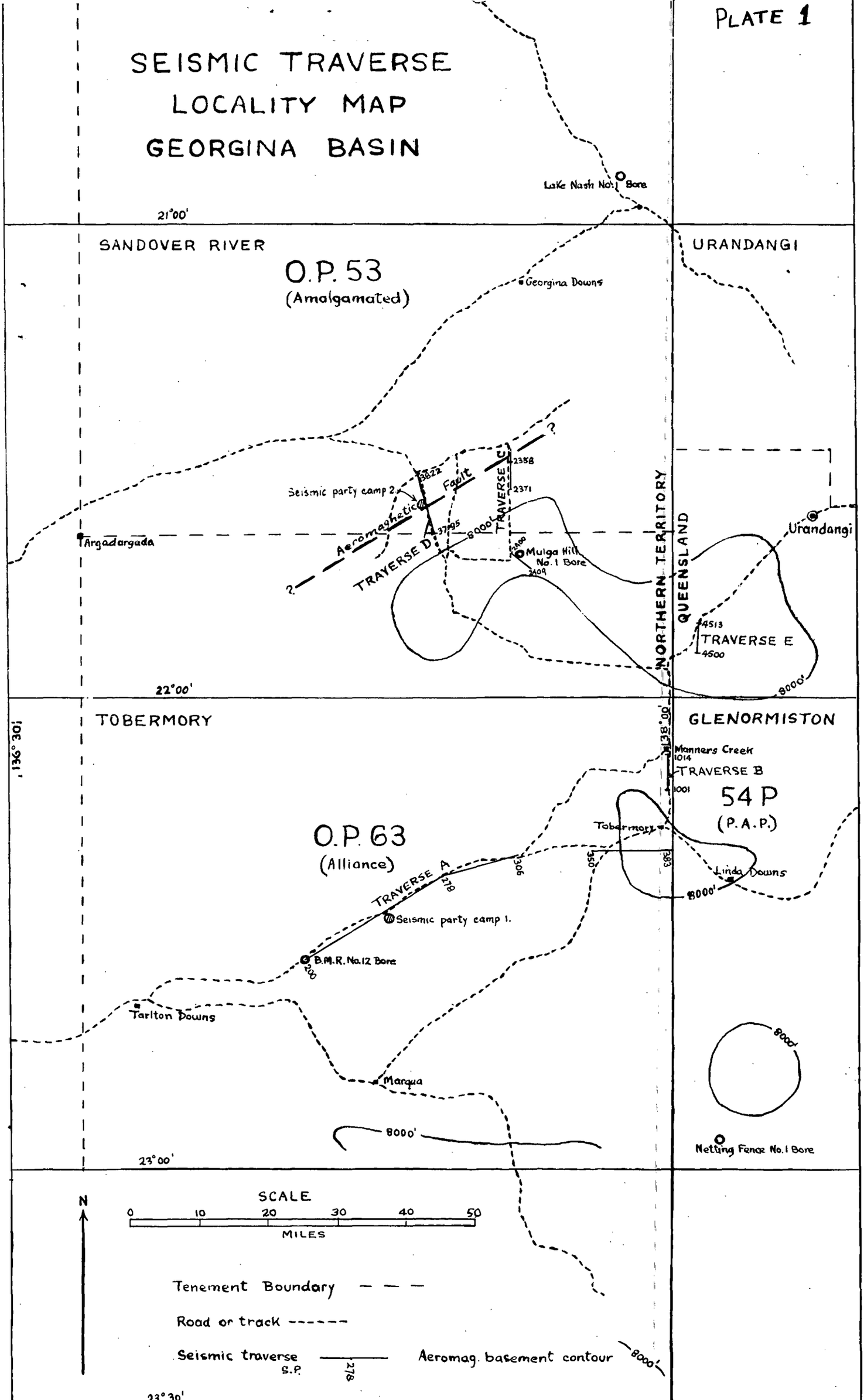
A start was made at installing two 10,000-ft well loggers on trucks; the equipment is being overhauled for the 1966 field season.

7. WORKSHOP

The workshop operated to its capacity throughout the year, constructing new equipment and repairing modifying existing equipment. This group, like the Laboratory group, worked under considerable difficulties because of staff shortage.

PLATE 1

SEISMIC TRAVERSE
LOCALITY MAP
GEORGINA BASIN



SEDIMENTARY ROCKS

RECENT
- Alluvium.
- Deep Soil Cover.

PLEISTOCENE
- Silicious Sand.
- Aeolinites

LOWER PLIOCENE
- Loxton Sands

MIOCENE: OLIGOCENE
- Limestone. Glenelg group.

IGNEOUS ROCKS

RECENT TO LATE PLEISTOCENE
- Stony

UPPER PLIOCENE
- Basaltic Tuff and Scoria
- Basalt

+5 Isogal

Positive Gravity Anomaly

Negative Gravity Anomaly

HAMILTON
BRANXHOLME
Condah
Myamyn
Milltown
HEYWOOD
Yatchaw
HIGHWAY
HENTY
SUNDAY
Muddy
Ck
Camp
Creek
Darlot
LAKE CONDAH
TRAVERSE
TRAV. V.3
+5
+10
+15
+20
0
-5
200
193
185
184
180
178B
175B
171
172B
169B
165

EXPERIMENTAL SEISMIC SURVEY,

OTWAY BASIN VIC.1965

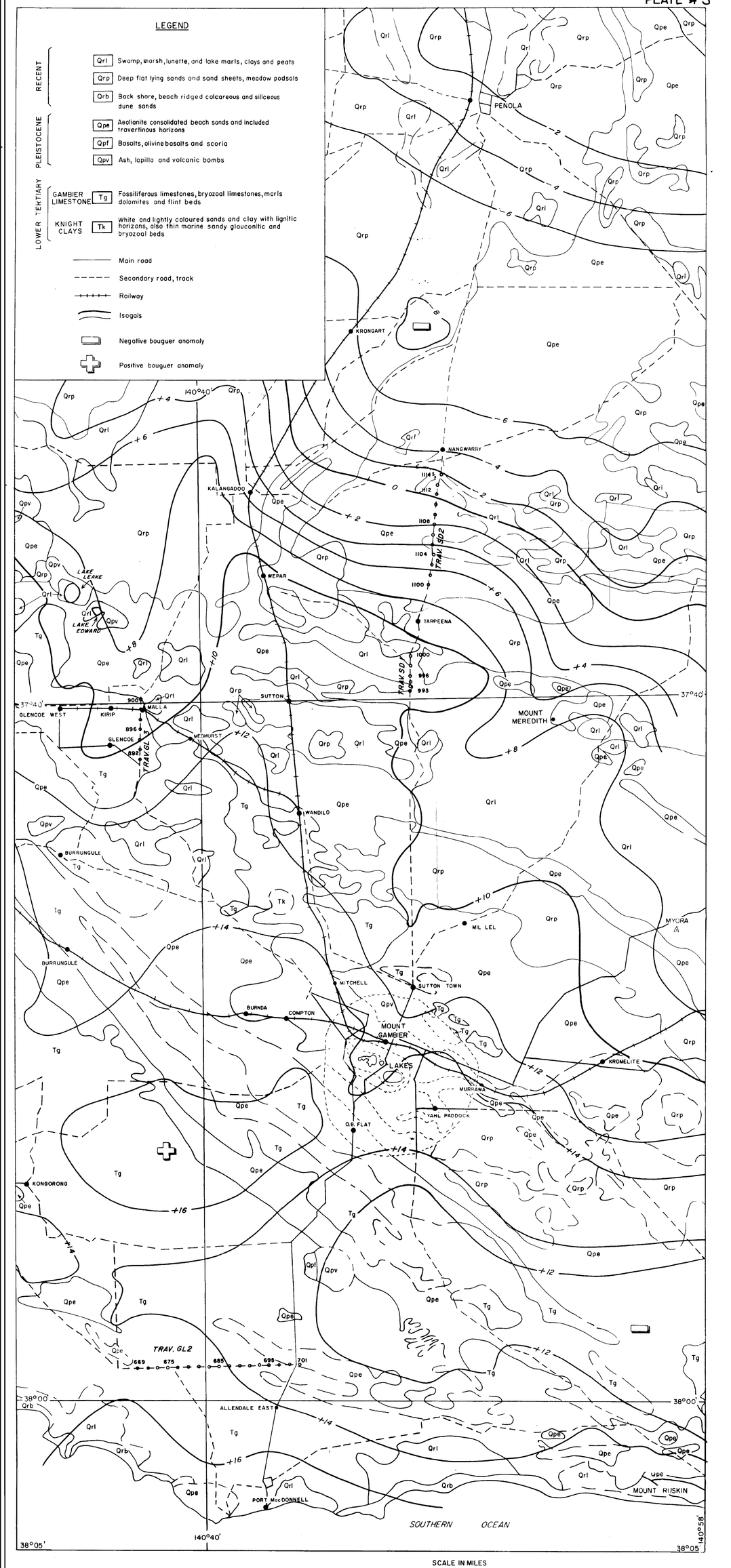
SEISMIC TRAVERSES SURFACE GEOLOGY, BOUGUER ANOMALIES

MILES

2 1 0 2 4 6

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. G 438-10

PLATE 43

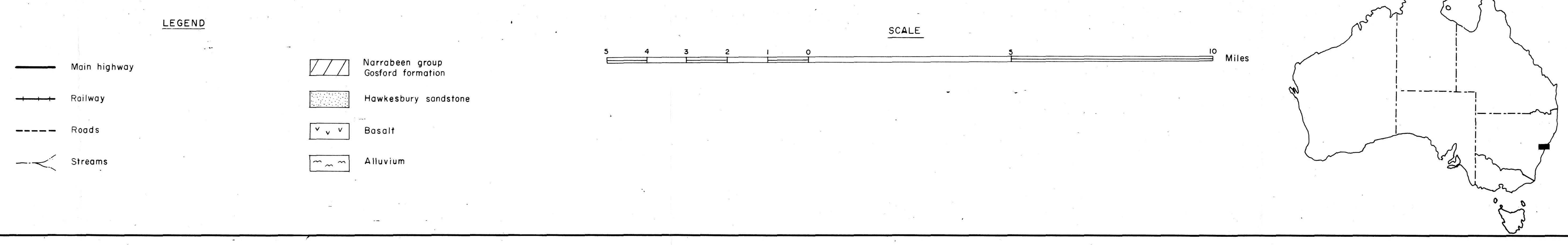


EXPERIMENTAL SEISMIC SURVEY

OTWAY BASIN S A 1965

SEISMIC TRAVERSES, SURFACE GEOLOGY BOUGUER ANOMALIES

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS G438-11



EXPERIMENTAL SEISMIC SURVEY

SYDNEY BASIN NSW, 1965

LOCALITY MAP

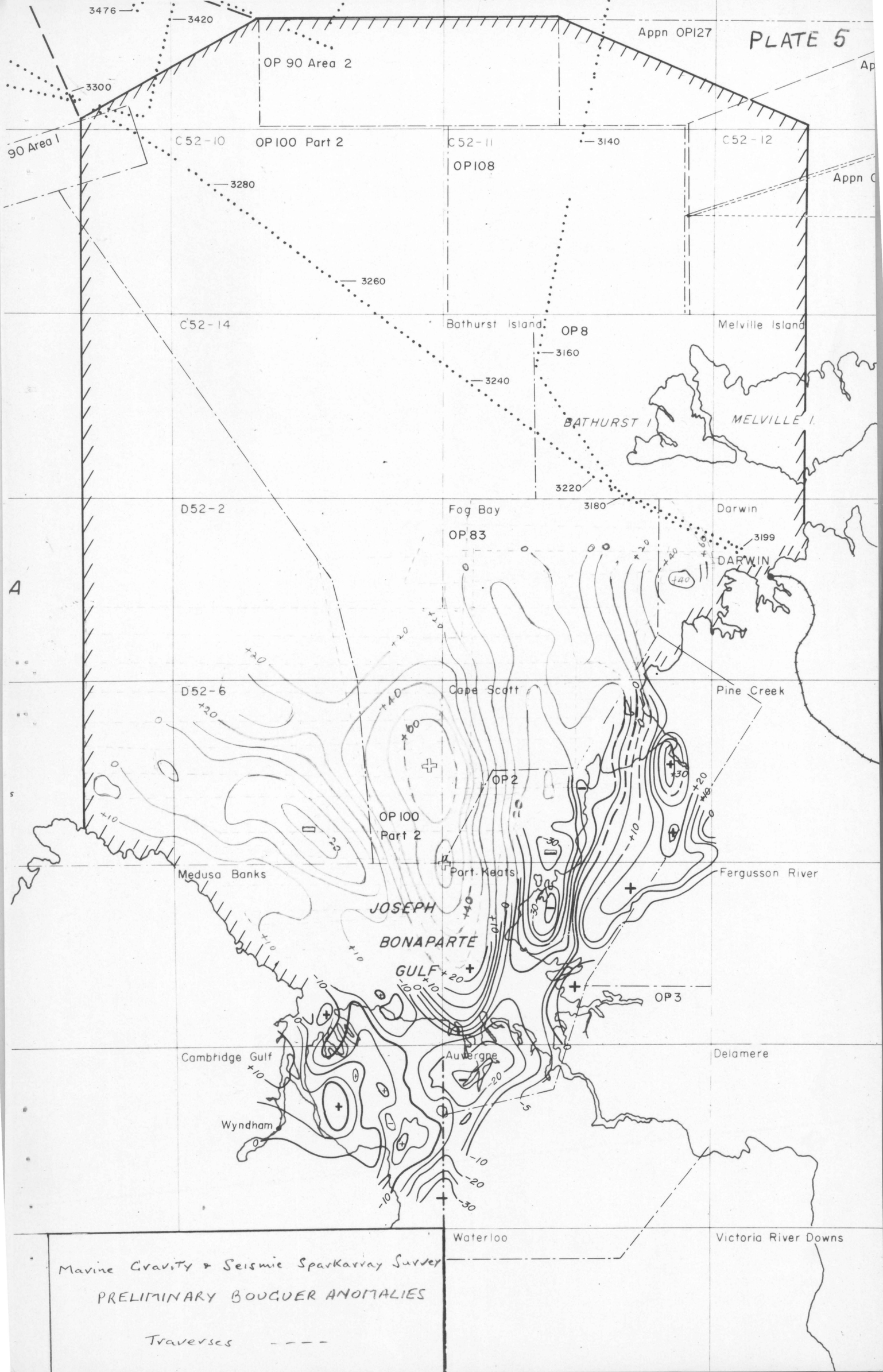


PLATE 5
3476
3420
3300
Appn OP127
OP 90 Area 2
90 Area 1
C52-10
OP100 Part 2
C52-11
OP108
3140
C52-12
3280
3260
C52-14
Bathurst Island
OP8
3160
3240
BATHURST I.
MELVILLE I.
Melville Island
3220
D52-2
Fog Bay
OP83
3180
Darwin
3199
DARWIN
A
D52-6
Cape Scott
Pine Creek
OP2
OP100
Part 2
Port Keats
Medusa Banks
Fergusson River
JOSEPH
BONAPARTE
GULF
OP3
Cambridge Gulf
Auvergne
Delamere
Wyndham
Waterloo
Victoria River Downs
Marine Gravity & Seismic SparkArray Survey
PRELIMINARY BOUGUER ANOMALIES
Traverses

TIMOR SEA - JOSEPH BONAPARTE GULF AREA
NORTH-WEST AUSTRALIA

MARINE SEISMIC "SPARKARRAY" SECTION

TRAVERSE P-10

SHIP: M.V. Moorah   DATE: 27. 7. 65

EQUIPMENT

Energy Source:	E.G.G. 14,000 Watt-sec System
Transducers:	E.G.G. "Sparkarray," Model 267-Two
Receiving System:	Chesapeake "Towflex," Model 12
Hydrophones:	Chesapeake Model PC-100
Recorder:	E.G.G. Model 254

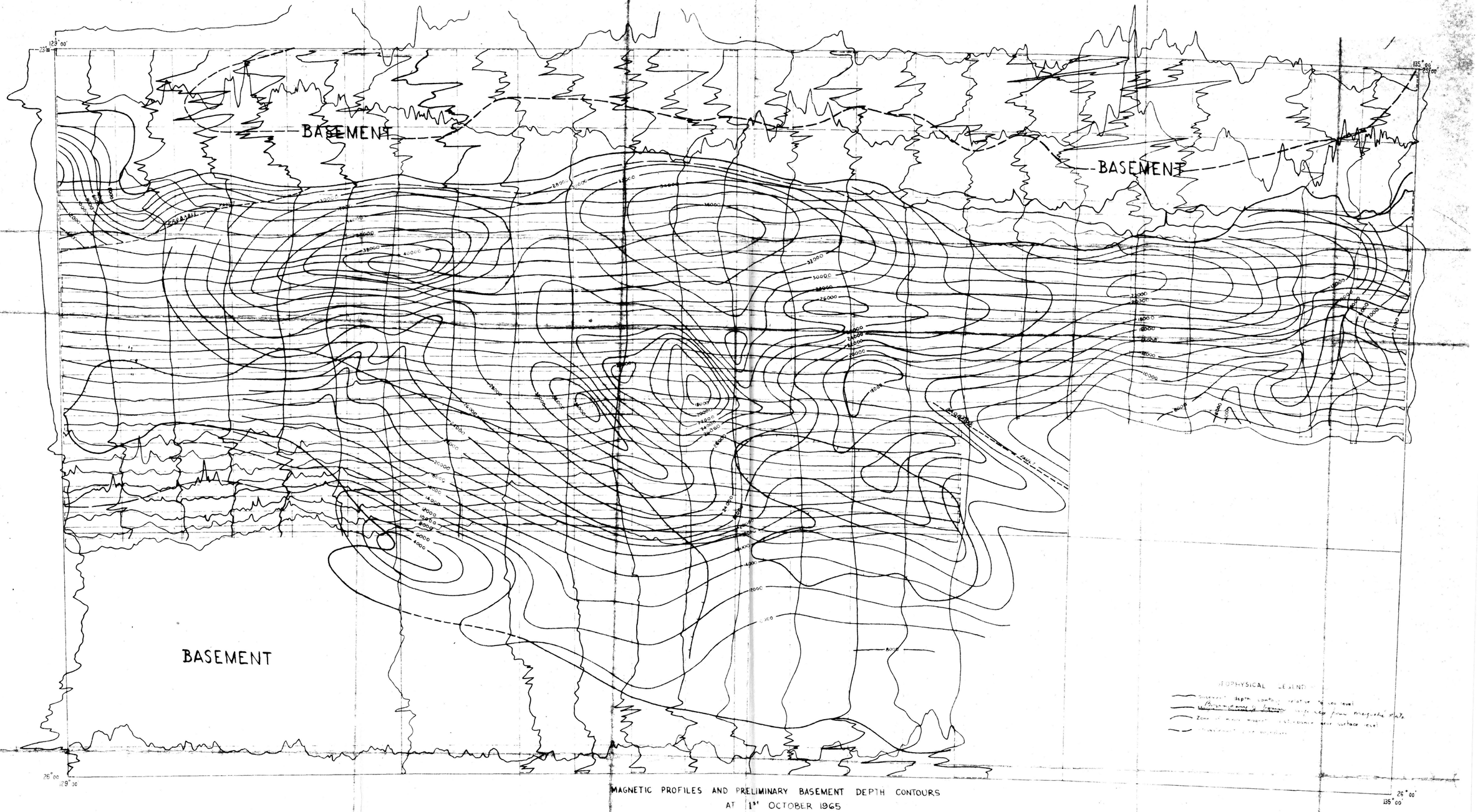
RECORDING INFORMATION

Source Power:	12 K.W.S.
Firing Rate:	4 seconds
Hydrophone Array:	6 at 30 ft
Source - Receiver Distance:	1100 feet
Source Depth:	8-10 feet.
Receiver Depth:	
Gain (i) Receiver Amp:	
Gain (ii) Recorder Amp:	x1, 300
Filter:	20-80
Print Mode:	Negative
Paper Speed:	15 inches per hour
Boat Speed (i) Engine Revs:	1350 r.p.m
Boat Speed (ii) Approx. Speed:	9 miles per hour

DIRECTION	⟼ E
HORIZONTAL SCALE	1" = 3/4 mile

REMARKS

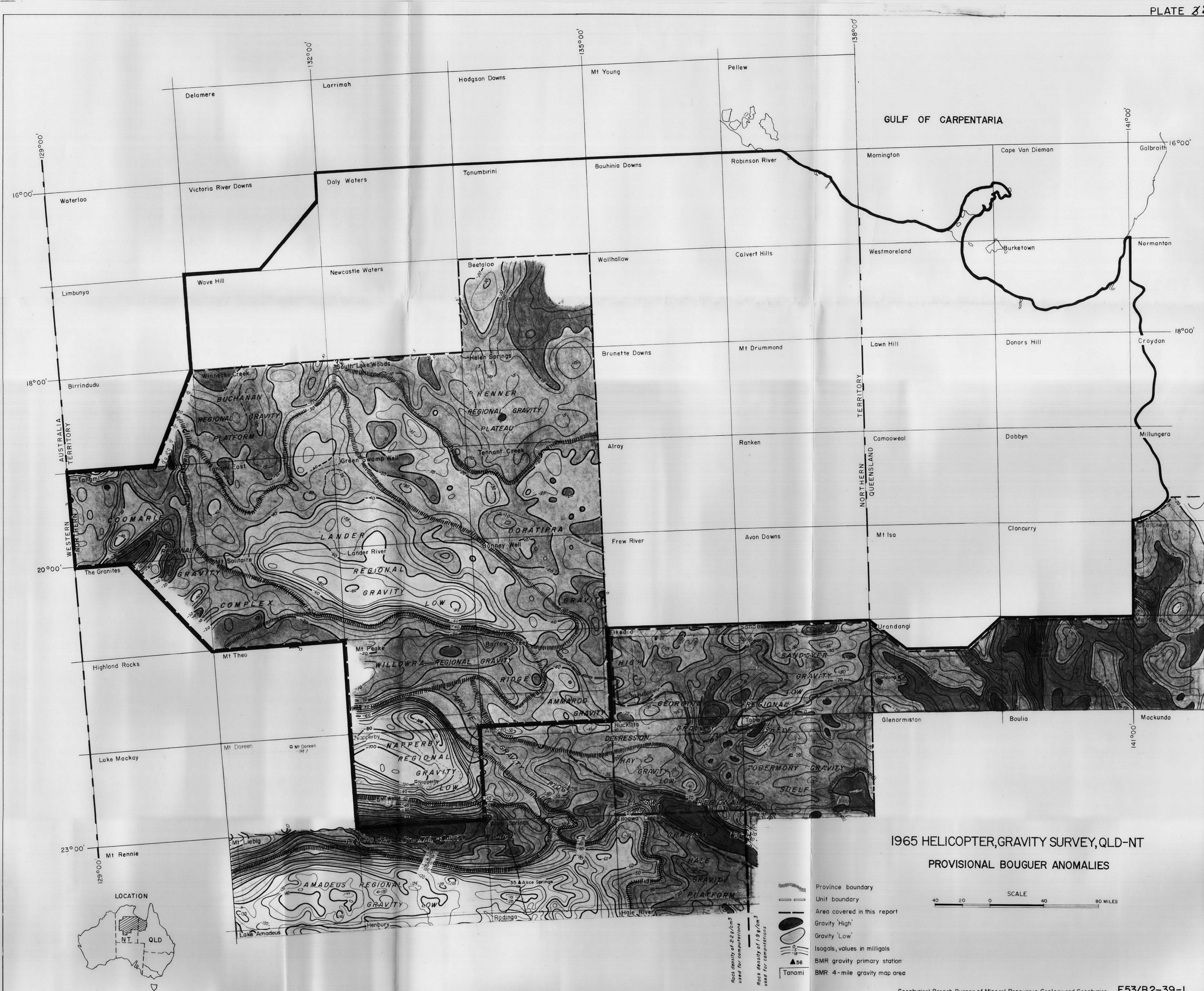
BASED ON G85/3-46)   *Recorded by: Geophysical Associates Pty. Ltd.*



MAGNETIC PROFILES AND PRELIMINARY BASEMENT DEPTH CONTOURS
AT 1ST OCTOBER 1965

GEOPHYSICAL LEGEND

SENSITIVITY 1000 GAMMAS PER INCH.
GRID TAKEN FROM GRAVITY MAP, SCALE 1:1,000,000
(BASED ON GG5-475-2)

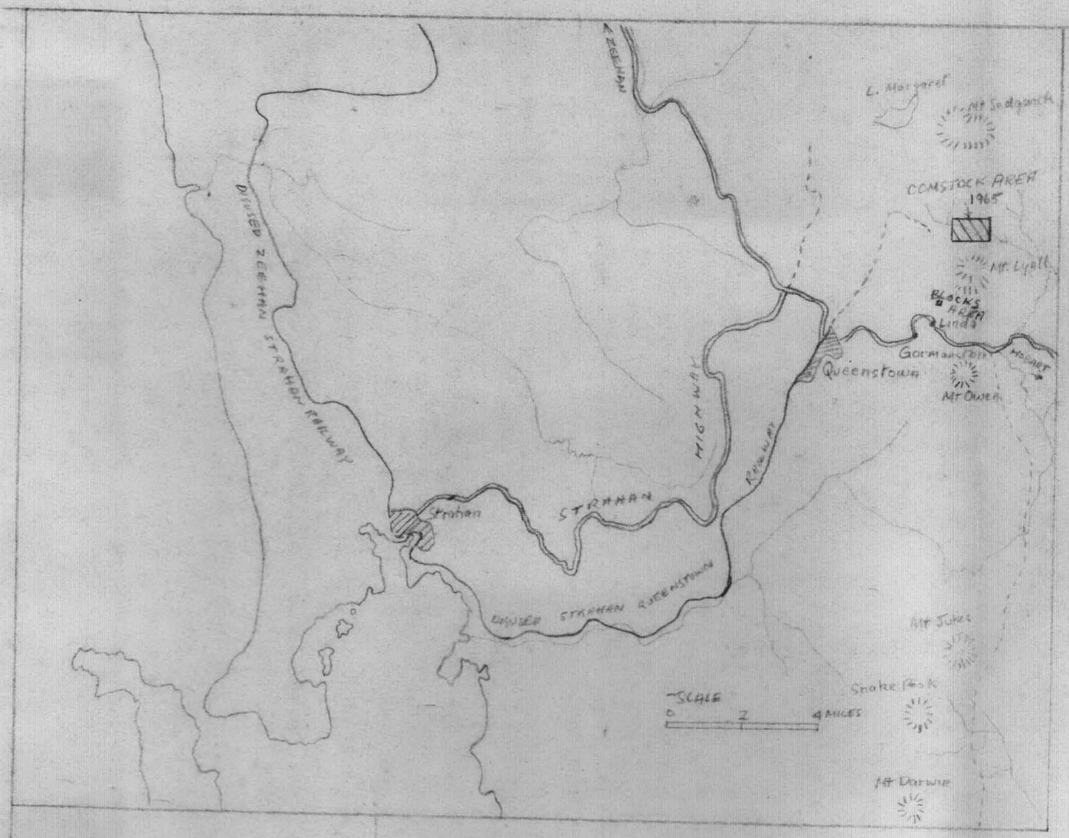


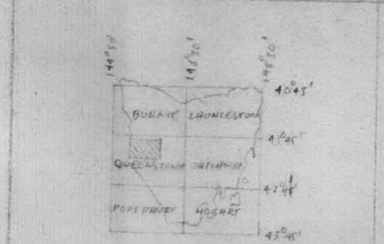
1965 HELICOPTER, GRAVITY SURVEY, QLD-NT

PROVISIONAL BOUGUER ANOMALIES

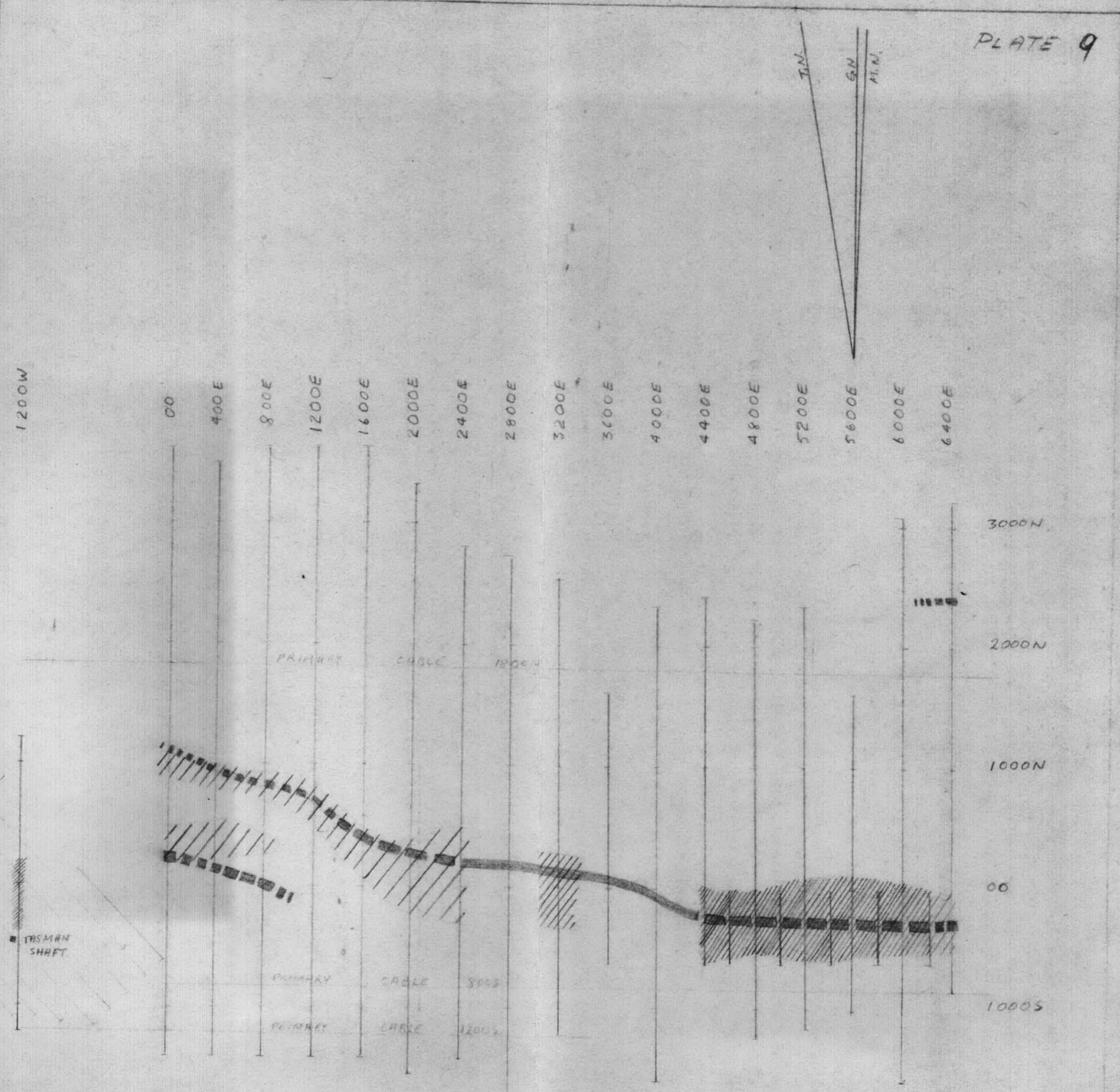
Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics E53/B2-39-1

PLATE 9





REFERENCE TO AUSTRALIA 1:250,000 MAP SERIES



COMSTOCK AREA 1957

LEGEND

Traverse surveyed by any geophysical method, 1965

WEAK — STRONG Axis of turam anomaly.

WEAK STRONG Zone of I.P. anomaly.

BMR. GEOPHYSICAL SURVEY
COMSTOCK AREA, 1965.

LOCALITY MAP AND GEOPHYSICAL INDICATIONS.

1000' 3 2 1 0 1000 FEET