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COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD No. 1961-154

GEOPHYSICAL BRANCH - SUMMARY OF ACTIVITIES, 1961

The information contained in this report has been obtained by the Department of National Development, as part of the policy of the Commonwealth Government, to assist in the exploration and development of mineral resources. It may not be published in any form or used in a company prospectus or statement without the permission in writing of the Director, Bureau of Mineral Resources, Geology and Geophysics.

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GEOPHYSICAL BRANCH - SUMMARY OF ACTIVITIES 1961.

It is the practice of the individual Branches of the Bureau to prepare for the annual programme discussions held each year at the end of November or early December, a brief statement covering their programme of operations for the year immediately preceding these discussions.

These notes are, for many surveys, prepared before the data have been analysed completely and the conclusions reached are therefore very tentative. Nevertheless these tentative conclusions and comments will be of general interest to all members of the Bureau. For this reason the notes covering the activities of the Geophysical Branch for the period 1st January, 1961 to mid-November, 1961, have been assembled in this Record so that copies will be available not only for those attending the programme discussions but also for Bureau officers within the respective branches and at outlying establishments such as the geophysical observatories and regional offices.

The tentative nature of the conclusions and comments is emphasised and use should not be made of the data without first checking with the Geophysical Branch as to its validity. Preferably potential users of the data within the Bureau should await the full analysis of the data and the issue of Records covering the individual projects.

The notes which follow are arranged in the order in which the various projects are set out in the Bureau's official programme of operations for 1961.

OIL SEARCH.

1. Seismic Surveys.

a. Goondiwindi, Qld.

An east-west traverse across the Surat Basin from Goondiwindi to St George indicated the extension of the Meandarra trough southward towards Morree. The Mesozoic formations reach a maximum depth of 9000 ft beneath Toobeah and refraction shooting indicated a depth of Pre-Permian basement of about 14,000 ft. This compared with depth of 14,000 ft to the base of the Mesozoic and the depth of Pre-Permian basement of about 19,000 ft beneath Meandarra. A north-south traverse between Meandarra and Morree indicates that the trough gradually becomes shallower to the south, with the depth of the Mesozoic less than 5,000 ft near Morree. The reflections representing the Pre-Mesozoic indicate that the Permian sediments disappear against a rising basement about 15 miles north of Morree. The results (and particularly refraction confirmation) were not conclusive as difficulties were encountered in drilling pebble beds. A further month's work in this area would be desirable.

The margin of the trough on the eastern side is marked by a basement fault with a throw of over 2500 ft 3 miles west of Goondiwindi. The western side of the boundary is probably step faulted beneath and east of Talwood. Westward from Talwood the Surat basin was apparently formed over a shelf like feature at least as far west as St George.

Goondiwindi, Qld. (contd.)

Between Toobeah and Goondiwindi an anticlinal structure showing east-west reversal was found. The structure is faulted and the top of the Permian sediments represented by the L horizon are apparently eroded from the crest. The reversal may be as large as 1500 ft.

b. Tambo-Augathella.

This survey will be done in November/December, 1961.

c. Georgina Basin.

Deleted from 1961 programme.

d. Black Mountain (Georgina Basin).

Deleted from 1961 programme.

e. Camooweal.

Work is still in progress in the Undilla Basin between Mt. Isa and Camooweal.

Refraction shooting has indicated that there is not enough difference in the velocities of the Cambrian and Proterozoic sediments to make the mapping of the interface between them possible. There was, however, a refractor of 19,500 ft/second recorded at an approximate depth of 1,300 ft within the eastern margin of the Undilla basin and a refractor of a similar velocity at a depth of about 6,000 ft in the expected deepest part of the basin. It is thought that these refractors are within the Proterozoic sequence. It was difficult to record refraction breaks of reliable quality even with heavy charges over short distances.

With reflection shooting, using pattern holes and up to 36 geophones per trace, poor quality reflections were recorded at depths of about 4000 and 8000 ft north of Mailchange. As drilling is difficult through the hard surface limestone air shooting was used with some success. Noise studies are being made to try to improve reflection quality.

The survey has not progressed far enough to draw any conclusions on the nature of the margins of the Undilla basin and the relationship of the Camooweal Dolomite to the Middle Cambrian Limestones.

f. Amadeus Basin (Southern Margin).

Refraction and reflection traverses were recorded at selected regions between Finke and Alice Springs. Reflection results, presented as variable area cross-sections, showed several well-defined reflectors of persistent character, presently identified as Lower Palaeozoics, and at least one good reflector probably in the Proterozoic. At Deep Well, just north of Rodinga, the section shows 10,000 feet of sediments still thickening towards the north. South of Rodinga at Mt Charlotte the reflection records show a series of sediments thickening towards the south until at least 8,000 feet of Palaeozoic (and possibly Proterozoic) are present. Still further south at Horseshoe Bend, refraction shows that the crystalline basement lies very close to the surface.

The survey has shown that the sedimentary basins both north and south of the Rodinga region are readily investigated by relatively simple seismic reflection techniques although

Amadeus Basin (Southern Margin) (contd.)

movement across the terrain can be at times difficult or even impossible.

Reflection results show that there is a strong possibility of character correlation between reflectors in different parts of the basin, and that it might be possible to discover facies changes on the basis of character variations. The value of refraction depth probes may be seriously limited by the presence of a very high-velocity refractor within the Cambrian sediments which may prevent penetration to deeper basement.

Further work is proceeding in the Palm Valley area.

g. Giles -Carnegie.

At selected regions between Giles and Signpost, refractor velocities were measured on crystalline basement, Lower Proterozoics, Upper Proterozoics, Upper Palaeozoics, and Mesozoics. Five refraction and reflection traverses were recorded between Signpost and Mt Beadell (100 miles west).

Refraction results indicate that the depth to the crystalline basement increases westward from Signpost. At Mt Beadell simple reflection techniques indicate that there is a reflector with good continuity at 1.3 seconds, and if a conservative value of reflection velocity of 8,000 ft per second is assumed, this provides proof that there is at least 5,000 feet of sediments at this point. No structural feature was found.

Cored geological samples were taken from the bottom of shotholes at six widely spaced locations. A water bore was established at 11 miles south of Signpost; the water is not suitable for sustained drinking. A water bore with good water was established 72 miles west of Signpost.

2. Aeromagnetic Surveys.

a. Chowilla, S.A.

The Chowilla survey was flown for the S.A. Mines Department and the results sent to them at the end of the survey. The survey covered the southern three-quarters of the Chowilla 4-mile area and was flown at a line spacing of 1-mile and at an altitude of 500' a.g.l.

Over the larger part of the area the magnetic profiles are flat and featureless. Along the western and northern margins of the area the field is moderately disturbed with the trends of the anomalies varying between N-S and NE-SW. The line of division between these areas is interpreted as the western edge of the Murray Basin in this area. The greatest depth to magnetic basement is in the south-eastern corner, where estimated depth is of the order of 2,000 feet below ground level.

No radiometric anomalies were recorded. A change in level of radiometric intensity occurs near the boundary of the basin. The higher intensity corresponds to the main region of magnetic activity.

b. Carnarvon Basin, W.A.

The two areas planned for coverage in 1961 were completed. The northern area consisted of parts of the Yanrey and

Carnarvon Basin, W.A. (contd.).

Glenroy 4-mile areas and all of the Yarraloola 4-mile area. The southern area consisted of the Geraldton and part of the Yalgoo 4-mile areas. The survey was flown with a line spacing of 1 mile and at an altitude of 500' a.g.l.

In the Yanrey-Glenroy area, the magnetic profiles are extremely flat and featureless over the North West Cape and Exmouth Gulf, indicating a great thickness of sediments. The eastern boundary of the basin is marked by a transition to more disturbed magnetic conditions. Within the basin, a broad anomaly suggests a continuation of the Wandagee ridge to the coastline near Point Locker. From there the ridge appears to extend out to sea in a north-westerly arc. A probable branch of this basement ridge continues to the north-north-east in the direction of Barrow Island.

The central and south-eastern portions of the Yarraloola 4-mile area show fairly intense magnetic anomalies up to a maximum of about 10,000 gammas.

In the Geraldton-Yalgoo area, the magnetic results clearly delineate the eastern boundary of the basin and the Precambrian inlier (Greenough Block) within the basin. A broad anomaly trending north-north-west appears to be associated with the concealed Urella Fault.

Over the Precambrian east of the basin two areas of intense anomalies were recorded. One was at Tallering Range, where the maximum anomaly recorded was about 3000 gammas; the other extended discontinuously for about 40 miles near the boundary of the survey area south-west of Yalgoo, with five main centres of magnetic disturbance and maximum anomaly of about 15,000 gammas.

Several reconnaissance traverses were flown up to 200 miles off-shore between North West Cape and Shark Bay. The profiles show evidence of a broad ridge in the magnetic basement about 100 miles off-shore between latitudes 22°S and $25\frac{1}{2}^{\circ}\text{S}$.

The radiometric results of the survey showed only one anomaly. This was located in the Yarraloola area near Mt Salt. Pronounced changes in the level of radioactive intensity were noted in the southern area in fair correlation with the Precambrian boundaries.

The 1961 Carnarvon Basin work completes the aeromagnetic coverage of the Carnarvon and Perth Basins. The need for further aeromagnetic coverage is indicated to the south and east of Yarraloola and over the remainder of the Yalgoo 4-mile area to follow up anomalous features partly revealed in those areas.

c. Bowen Basin, Qld.

The 4-mile areas of Emerald, Duaringa and Clermont were surveyed at a line spacing of 2 miles. The western part of the survey area was flown at a height of 500 feet a.g.l. and the eastern part at an altitude of 1500 feet a.s.l.

The survey of the Emerald 4-mile area showed a belt of magnetic disturbance trending NNW, corresponding to the Anakie High. The magnetic results clearly indicate the boundaries of the Anakie Metamorphics, the Devonian Volcanics and the Tertiary Volcanics and hence the limits of the sedimentary basin in this

Bowen Basin, Qld. (contd.)

region. A considerable thickness of sediments is suggested in the Drummond Basin on the west of the Anakie High.

The belt of magnetic disturbance continues north through the Clermont 4-mile area but the anomalies are generally of lower amplitude. The main source of the magnetic anomalies is attributed to the extensive outcrops of Tertiary Volcanics. The metamorphic rocks of the Anakie Inlier appear to produce only minor magnetic effects in the Clermont area. The eastern boundary of the Tertiary Volcanics is well defined.

In the eastern part of the Duaringa 4-mile area, the magnetic results show a zone of disturbance trending NNW, which is probably associated with the Lower Bowen Volcanics and/or metamorphic rocks of the Gogango structural high and appears to establish the eastern boundary of the Bowen Basin. In the central part of the Basin, the magnetic basement appears to deepen from approximately 3,000 feet on the Comet Platform to possibly over 12,000 feet in the troughs to the east and west.

The two-level scintillograph system was operated over the areas surveyed at 500 feet a.g.l. No radiometric anomalies were detected.

In addition to the systematic survey of the three 4-mile areas, five reconnaissance traverses, totalling 860 miles, were flown in the northern part of the Bowen Basin. To date, no assessment has been made of the results on these traverses.

Surveys are programmed for 1962 over the adjoining areas north and south of the 1961 survey area.

d. North New Guinea Basin.

Adastra Hunting completed this contract survey on 17th November. The reduction of the results is in progress and is expected to be completed during December.

e. Officer Basin, W.A.

A traverse between Carnegie Homestead and Forrest of approximately 1000 miles at 1500 feet a.g.l. was planned to provide further information on the Officer Basin. The traverse was satisfactorily completed.

A preliminary appraisal of the results indicates a broad basin averaging 5000 feet in depth and shallowing along its western edge near Carnegie. Towards the south the basement rises to 1500 feet near Forrest.

3. Gravity Surveys.

a. Artesian Basin (W. Qld.)

In the Great Artesian Basin an area of nearly 50,000 square miles was surveyed, comprising the following 4 mile sheet areas: Bedourie, Birdsville, Machattie, Betoota, Canterbury, Connemarra and Brighton Downs. In this area a total of 974 new stations was established in 238 flying hours.

The gravity pattern in general is very clearly expressed. The results indicate the southward extension and limit

Artesian Basin (W. Qld.) (contd.)

of the Toko Syncline into the Bedourie area, the edge of the Boulia Shelf followed from the Brighton Downs area to the Birdsville area, and confirm the position of NNW trending anticlinal structures in the Betoota and Canterbury areas.

b. Georgina Basin, N.T.

The following 4 mile areas totalling approximately 25,000 square miles were covered : Huckitta, Elkedra, Alcoota (part), Sandover River and Mt. Whelan (completion of 1960 work) and 500 new gravity stations were established. A total of 198 hours were flown - this included some sorties made by the Bureau geologist working in the area.

The Bouguer anomaly pattern generally is indicative of shallow sediments. The gravity picture is confused because of the effects due to outcropping Arunta complex and numerous intrusions both basic and acid. It is therefore difficult to correlate the gravity results with known geology. However, a satisfactory correlation is obtained on the Mt Whelan area where the Toko syncline is well expressed in the gravity results.

c. Amadeus Basin, N.T.

Six 4-mile sheets were covered (Alice Springs, Hermannsberg, Rodinga, Henbury, Charlotte Waters and Kulgera) which together with overlap, covered approximately 49,000 square miles. 1,122 new gravity stations were established in this area. Using 2 helicopters a total of 284 hours were flown on charter.

The gravity pattern exhibits considerable relief with a general W-E alignment of gravity features. A second set of gravity trends strike approximately N-NW but the significance of this trend is not known. The margins of the Basin are clearly expressed by the gravity results, and the southern margin appears to be interrupted by faulting. A definite eastern edge to the Basin has not yet been established although considerable shallowing of the sediments is indicated. The gravity results show clearly that the Basin consists of two asymmetrical troughs separated by a platform area. The troughs show considerable (and as yet undefined) development in their western portion. The eastern portion of the Basin narrows considerably and a trough south of Alice Springs has limited development. Many closed anticlinal structures recognized from air photos agree in position with gravity features.

d. Gravity readings along seismic traverses.

The following seismic work has been included:

- (a) B.M.R. seismic traverses, eastern Amadeus Basin
- (b) " " " Goondiwindi area, Qld.
- (c) Phillips Petroleum seismic traverse, Blackall to Quilpie, Qld.

A preliminary examination of the results shows that the gravity work is a useful adjunct to the seismic survey, particularly for interpolation along non-continuous seismic profiles. It is considered important to read all seismic traverses with gravimeter in future.

4. Water-Bore Logging.

a. South-western Queensland.

An experimental gamma ray logging programme, involving logging of existing water bores in west-central Queensland is being carried out at present. This follows the 1960 commencement of this work when correlation of the logs was very difficult.

The present series of logs are showing an excellent marker bed, thought to be the Toolebuc member which lies between the Tambo and Roma formations of the Rolling Downs Group.

Although this marker gives structural data in the upper part of the sedimentary section, it is doubtful whether this has much value because correlation of the drillers logs gives information to a greater depth.

It has been more difficult to get access to the required bores than in 1960, chiefly because of the reluctance of the station owners to allow interference with them because of drought conditions.

Following early equipment failures, operation of the thermally insulated gamma-ray probe was limited to bore temperature of 180°F and lower.

5. Palaeomagnetic Dating.

Measurements on core samples from Innamincka and Buckabie were continued. The age of the Buckabie "red-beds" appears to be Carboniferous. This is supported by a potassium-argon age determination of the beds below (Devonian), and the discovery of overlying Permian beds to the north.

Samples collected from the Bowen Basin were catalogued and sorted.

Results of measurements of cores were sent to H.E.C., Tasmania.

A preliminary reconnaissance survey of an area near Mt. Stromlo was carried out to find a site suitable for a new palaeomagnetic laboratory.

Well dated Ordovician andesites were collected from Cargo and Mandurama (near Orange, N.S.W.).

A programme for IBM 1620 to convert astatic magnetometer values into direction and intensity of magnetisation has been prepared.

METAL SEARCH

1. Ground Metalliferous Surveys

a. Savage River, Tasmania

An area of about 2 miles by $\frac{1}{2}$ mile to the south of the 1960 survey area was surveyed with the magnetometer. The magnetic anomalies continue to the southern-most traverse but over a section of about 3000 feet the anomalies are weak and suggest relatively barren ground. Drilling targets were supplied on request to the Mines Department.

The area of the 1959 reconnaissance survey north of the Savage River was resurveyed with closer traverse spacing.

The 1961 work completes the investigation of the main Savage River anomalous area of about $4\frac{1}{2}$ miles by $\frac{1}{2}$ mile. Barometric levelling was carried out over the whole of this area. All traverses were accurately located by the topographic survey party. Further magnetic surveys in the region are planned to commence early in December, 1961. These consist of a detailed investigation of the "Rio-Tinto" anomaly shown by the aeromagnetic survey, and reconnaissance of the area between this anomaly and the Savage River area. The total area proposed is approximately 3 miles by $\frac{1}{2}$ mile.

b. Gladstone, Tasmania

In October, 1961, a survey was commenced over areas in North Eastern Tasmania, selected by the Mines Department as possibly containing stanniferous channels. The gravity method is being used. The first traverses have shown interesting results but the survey is not far enough advanced to give any estimate of their importance. Seismic refraction surveys will follow the initial gravity work.

c. New England, New South Wales

A short extension was made to the survey previously carried out over the Graveyard lead in the Emmaville-Tingha District, N.S.W.

An area of about 6000 feet by 3000 feet was surveyed by the refraction seismic method over the Topper Mountain lead.

One traverse 3000 feet long was surveyed over the Jealousy lead.

In all areas, the results appear well defined, and should provide targets for testing.

d. Tallebung, New South Wales

A refraction seismic survey was made at Tallebung to search for possible stanniferous leads in an area to the north of the previous workings. The area covered was about 3 miles long, with an average width of about 3000 feet. It was hoped that the known lead could be traced to a presumed outlet in a gap between two outcrops of bedrock about 3 miles north of the workings.

The results are difficult to interpret, owing to the nature of the bedrock. This consists of tightly folded Ordovician sediments, mainly shales and quartzites. There appear to be considerable variations in the depth of weathering and in the seismic velocities in the bedrock with the result that in general it was found difficult to trace a single refractor along the full length of a traverse.

There is some evidence of a continuation of the known lead for a distance of 1000 to 1500 feet, but further north the bedrock appears to take the form of a broad shallow depression with

Tallebung, New South Wales (Cont'd)

only slight undulations and without any well defined deep channels. In general, the results are disappointing and the area surveyed appears by no means to be as good a tin prospect as was expected.

e. Scott River, Western Australia

A test survey using a vertical magnetometer was made over a deposit of bog iron ore near Scott River, W.A. Very disturbed magnetic conditions were observed over the known deposit. It appears that the magnetic method would be useful in prospecting such deposits, in that any area over which the magnetic field is much disturbed would be worth testing. However, it is unlikely that all the ore is magnetic, or that the intensity of the magnetic anomalies would be related to the thickness or assay value of the ore.

2. Aeromagnetic Surveys

a. Childara - Gairdner, South Australia

The area programmed for survey in 1961 comprised parts of the Childara, Gairdner, and Tarcoola 4-mile map areas. The survey was flown for the S.A. Mines Department and the records forwarded to them at the end of the survey.

Magnetic activity throughout the area is generally low. Most of the anomalies are confined to two zones - one in the centre and the other near the western edge of the area. The distribution of the anomalies continues the trends apparent in previously surveyed areas to the south. Eight anomalies exceeding 1,000 gammas were recorded. There is insufficient geological information available at present to establish any correlation with magnetic data.

One radiometric anomaly was recorded by the dual altitude system. The level of gamma radiation throughout the area was generally low.

Narromine-Bathurst N.S.W. Magnetometer and Scintillograph (DC3)

b. The survey of the Narromine and Bathurst 4-mile areas commenced in October. Parts of both these areas were flown in 1960 when the survey of the Forbes 4-mile area was extended to the north and east. The area is being flown at a line spacing of 1-mile and at an altitude of 500' a.g.l. A late request was received from the N.S.W. Mines Department to extend the survey of the Bathurst area to the east as far as the western boundary of the Hunting Adastra aeromagnetic survey of the Sydney basin. The extension increased the area to be surveyed by about 1,000 square miles.

The Narromine 4-mile area was completed on 10th November. The results show low to moderate magnetic disturbance throughout the area. Approximately 190 anomalies exceeding 250 gammas and 20 exceeding 1000 gammas have been recorded. The survey of the Bathurst area is at present in progress.

These surveys will complete the central-western areas of N.S.W. requested by the N.S.W. Mines Department in 1959. The only areas specified in the 1959 request still to be surveyed are the six 1-mile areas in the New England district. These are programmed for 1962.

URANIUM SEARCH

1. Darwin Group

The following field surveys were carried out by the geophysicists attached to the Darwin group.

a. Rum Jungle Area

Nine areas, selected by T.E.P. as worth examination for uranium deposits on the basis of surface radioactive anomalies, were surveyed using E.M. methods. The work involved a total of 70 miles of traverse. Several strong anomalies were located, and it is considered that the results will form a valuable basis for testing both for uranium and base metals.

b. South Alligator Area

Extensive surveys using the S.P. method were made in the South Alligator uranium field. Strong and persistent anomalies were located. The cause of the anomalies is far from clear, but they appear to be associated with a particular black slate horizon which is favourable for the occurrence of uranium. Preliminary testing has disclosed ore near El Sherana.

c. Iron Ore Surveys.

Test surveys using the magnetic method were made over iron ore prospects near Stapleton and in the Burrundie area. The ore bodies are comprised mainly of haematite. Results show that the magnetic method is of little or no value in prospecting such deposits.

2. Airborne Surveys

The light aircraft programme for 1961 was disrupted by unexpected delays in repairing the damage sustained by the aircraft at the end of 1960. As a result the survey programmed for the Durack Range, (W.A.) area was not flown. Surveying commenced in July on the Killi-Killi, Tanami area. This was followed by surveys in the Mt. Isa (Q'ld) and Wide Bay (Q'ld) areas.

a. Killi-Killi, Western Australia

Three separate areas were surveyed, the Killi-Killi, Gardiner Range and Tanami areas. The areas were surveyed at 200' a.g.l. with a line spacing varying between 1/5 and 1/3 of a mile.

The results of the survey in the Killi-Killi area show an anomaly over the Killi-Killi prospect No.1. A ground inspection showed radioactive grit almost completely overlain by sandstone. In the Gardiner Range area seven anomalies were recorded. These anomalies were inspected on the ground and were found to be caused by surface laterite. Several anomalies were located in the Tanami area. Only one of these was recommended for ground follow-up, the remainder being caused by surface laterite.

The overall results do not encourage further airborne radiometric work in this area.

b. Mt. Isa, Queensland

The survey of the Mt. Isa area was continued north, and adjacent to, the area completed in 1960. 1140 square miles were surveyed at 200' a.g.l. at a line spacing of about 1/4 of a mile.

No anomaly was recorded.

Over two-thirds of the Mt. Isa area has now been surveyed and the remaining third is programmed for 1962.

c. Wide Bay, Q'ld.

An area of 2,700 square miles has been programmed for 1961. This survey is at present in progress and no results have yet been received.

The area being surveyed is approximately half of the area proposed by the Queensland Mines Department.

3. Ground Inspection of Radio-Active Anomalies

a. Carnarvon Region, W.A. Ground Inspection of Radiometric Anomalies

A ground inspection of radiometric anomalies detected during the Carnarvon Basin (1959) airborne survey was programmed for July-August, 1961, in co-operation with the W.A. Mines Department. The purpose of the inspection was to investigate the anomalies geologically and at the same time collect data to assist in assessing the dual altitude recording system. Thirty of the fifty two anomalies located in 1959 were inspected.

The inspection showed laterite and its derivatives was the source of eighteen anomalies; granite, granite contacts and granitic sand accounted for ten anomalies; calcrete was the source of one anomaly and one was not found. None of the anomalies are associated with economic uranium mineralisation.

The data collected is still being studied in connection with the performance of the dual altitude recording system.

ENGINEERING GEOPHYSICS

1. Engineering Investigations

a. Launceston Landslip

An investigation was carried out by seismic, gravity and resistivity methods at the Queen Victoria hospital site. The surface of the dolerite bedrock showed some features which would appear to counteract any tendency towards slipping in this area.

b. Tasmania, H.E.C. Projects.

Wilmot power scheme. Seismic, magnetic, and resistivity surveys were used to determine the depth and character of overburden on the Wilmot damsite, inlet portal, penstock and power station.

Barrington damsite and power station. The depth and elastic properties of bedrock were determined by the seismic method.

Walter's Marsh. Seismic refraction surveys were carried out at three damsites on the Upper Mersey River, and the depth to bedrock was determined.

Donaldson damsite. An underwater seismic survey was carried out on the Pieman River in an average depth of 55 ft. of water. The depth of mud and the character of the bedrock were determined.

Delville Saddle damsite. Pieman River. Determinations were made of the depth to dolomite and of the seismic velocities in the dolomite.

c. Herbert River Damsite Q'ld. The survey for the Co-ordinator-General's Department is still in progress. Seismic work has been completed at the Upper and Lower Blencoe Creek damsites, and at the Upper Herbert damsite.

c. Herbert River Damsite Q'ld. (Cont'd)

The survey on the Lower Herbert site is in progress.
No results will be available until after the return of the party.

d. Buffalo River damsite

A test survey was carried out near Myrtleford for the State Rivers and Water Supply Commission, who are considering establishment of their own geophysical party. The survey was successfully carried out in a broad alluvial valley. Seismic, gravity, and magnetic methods were used.

e. Bell Bay Aluminium Plant.

Determination was made of the depth to basalt on the proposed site for extensions to plant.

f. Cotter River Site E and Googong Damsite

Seismic work was used to determine the elastic constants at Damsite E. Seismic work was also carried out at the Googong damsite, but the results have not yet been finally computed.

2. Vibration Tests

Tests were carried out to determine the frequency and amplitude of vibrations for the following organizations:

Royal Australian Navy, effects of gunfire on nearby buildings

Victorian Railways, vibrations at Wangaratta.

Ingersoll Rand, effects of air compressors installed at General Motors Holden factory at Fishermen's Bend.

Balm Paints, possible effects of external vibrations on an indentation testing machine at Clayton.

Gardner and Naylor, Hawthorn; tests of effect of a ventilating fan to be installed in a city building.

Australian Broadcasting Commission, possible effects of vibrations due to electric trains on a proposed extension to their studios at Ripponlea.

Prentice Bros. and Minson, effects of explosions used during construction of Ringwood outfall sewer on nearby buildings.

Monash University, extent of vibrations at various places in the Chemistry School where sensitive apparatus is to be installed.

Bryant and May, effects of new match-making machine installed in their factory at Richmond.

The Bureau co-operated with the Melbourne University in carrying out tests on the effect of vibrations on long piles for the Country Roads Board.

Discussions were held with various firms who might be interested in doing this sort of work on contract.

REGIONAL SURVEYS.

1. Regional Gravity Surveys.

(a) Regional Survey, N.S.W.

An additional 407 gravity stations were established in N-E N.S.W. as part of the regional gravity coverage of N.S.W. The work was tied in to previously established B.M.R. gravity stations and to the pendulum station at Walgett. Levels were obtained by means of a Western Elevation Meter installed in the vehicle or from the Railways and Main Roads Departments.

Good gravity closures were obtained around all loops provided that the season's work was not tied in to more than one previously established gravity station. It is obvious that a distribution of previously obtained values will have to be made on the basis of a recent readjustment of pendulum values before an over-all correlation of this work can be obtained.

(b) Regional Survey, Eastern Victoria.

A further 265 gravity stations were established in the regional coverage of Victoria. Station elevations were usually obtained using microbarometers; station positions were located on Lands and Survey or 4-mile Military Maps. It is estimated that approximately 3 weeks field work remains to complete the coverage of Eastern Victoria.

Only preliminary results have been worked out so far. There are some extensive areas which are inaccessible by road, but preliminary contours have been drawn and these suggest a fairly uniform gravity pattern with contours generally trending in the direction of the mountain system. There appears to be a distinct gravity "low" located over the Bogong High Plains - Mt. Buffalo region. This "low" also appears to be developing further in the direction of Mt. Kosciusko. This of course is to be expected from isostasy.

(c) Gravity Map of Australia.

Stations were added to the 1 degree square files. Data was obtained either from regional surveys or from the reduction of sedimentary work to density 2.67.

The analysis of the data has not been carried further because of the shortage of staff.

(d) Earth-tides Recording.

The North American Underwater Gravimeter was set up at the Old Melbourne Observatory. Some satisfactory records were obtained but generally the apparatus worked only intermittently owing to electrical faults which could not be rectified at the Observatory and to the fact that no one person was able to devote sufficient time to the project.

The circuitry of the apparatus is unnecessarily complicated for this work and it is proposed that one of the Heiland gravimeters be modified to provide a simpler piece of equipment. This will have the added advantage that a Heiland meter will be put in service and that earth-tide recordings will not be interrupted when off-shore work has to be done.

(e) Other Projects.

- (1) W-E pendulum ties using the Bureau's Cessna aircraft were not carried out because the aircraft could not be made available.
- (2) It is proposed to carry out a series of gravimeter performance tests over the December-January period.

2. Regional Magnetic Surveys.

(a) Giles Survey.

The regional magnetic survey of the Gibson and Victoria deserts was carried out between May and November, 1961.

(b) Antarctic.

Regional magnetic observations were carried out on the Antarctic Coast during the trip of M.S. Thala Dan between Mawson and Oates Land from January to March, 1961.

(c) Variographs.

An Askania Variograph was operated at Moggill, Queensland, until the middle of February. Another variograph was installed at Wyndham, W.A. in February and continued to operate until August.

(d) Garbutt Drome, Townsville, Qld.

At the request of the Department of Air, a magnetic survey was made at the Garbutt Aerodrome, Townsville, to find a site at which the magnetic "noise" was low enough to permit magnetic airborne detector equipment to be serviced.

Eleven sites were investigated using a recording fluxgate magnetometer. The measurements showed several sites to be satisfactory and enabled the most suitable one to be selected.

OBSERVATORIES.

1. Geophysical Observatories.

(a) Toolangi Magnetic Observatory.

Normal activities continued, no changes were made during the year.

(b) Toolangi Seismological Observatory.

The new seismological observatory buildings were completed. The seismographs have not yet been transferred from Melbourne Observatory.

(c) Melbourne Seismological Observatory.

The instruments at this Observatory have been operating continuously. No changes were made during the year.

(d) Macquarie Island Observatory.

The magnetic instruments were operated continuously without change.

The Wood-Anderson and Grenet seismographs were replaced by a 3-component Benioff short period seismograph in January, 1961. The new instrument has been recording continuously since then.

(e) Mawson Observatory.

The seismic and magnetic instruments were maintained in continuous operation. No changes were made during this year.

(f) Wilkes Observatory.

The seismographs were operated continuously throughout the year.

In April the wooden piers for the magnetic recording variometers were replaced by concrete ones supporting a slate slab for mounting the instruments. The same instruments were used and were operated continuously before and after the construction of the new piers.

(g) Mundaring Geophysical Observatory.

Normal recording with the magnetic, seismic and ionospheric instruments was continued.

The seismic recorder piers were modified to suit them for the standard recorders of the U.S. World-Wide Network, which will be installed later.

(h) Port Moresby Geophysical Observatory.

The magnetic and seismic instruments were maintained in continuous operations. No changes were made.

The installation of the ionospheric recorder was completed in May 1961, and recording continued throughout the rest of the year with some minor interruptions.

(i) Darwin Seismological Observatory.

Wilmore seismographs have been installed in a temporary vault and provisional bulletins are being issued.

LABORATORIES.

1. Electronic Design and Development.

The principle and application of the proton precession magnetometer were investigated. This is a recent development in magnetic measurement which will have wide application in the Bureau. There is immediate use for such equipment in observatory, airborne and field survey work.

An observatory proton magnetometer was designed and constructed. This prototype, using water as the proton source has proved adequate in absolute measurement of the total

Electronic Design and Development (contd.)

magnetic force. A vector coil system was designed and constructed to remove the horizontal component of the field so that the vertical force can be measured. Work on this project is continuing.

Preparations are under way for airborne testing of the prototype proton magnetometer in a Cessna aircraft. The prototype has been modified for rapid automatic cycling and recording. A small winch and "bird" are being constructed for this work. A "base station monitor" proton magnetometer has been designed. It includes a crystal drive for a recorder and a 12 hour clock developed in the Instrument Group. It will replace older equipment used to monitor diurnal fields and detect magnetic storms during magnetic survey flights.

Some field survey work has been done at Laverton using the prototype equipment as a field magnetometer. With Kerosene as the proton source, a maximum of one reading every two seconds, with an error of plus or minus one gamma can be achieved.

The development of fluxgate magnetometers is continuing. These do not measure absolute values as in the proton instruments. However they have other features which make them very useful. They can measure small variations continuously in the direction of the axis of the fluxgate which the proton instrument cannot do. A set of total force recording fluxgate equipment with crystal controlled time marking circuits, was designed and built. It is now operating with the aircraft VH-MIN on survey work.

An electro magnetic rock tester was designed and built. No suitable equipment could be purchased. This equipment is ready for the determination of susceptibility and conductivity of rock specimens at frequencies ranging from 33 to 8,333 cycles per second, and in DC fields from 0 to 100 oersted.

One of the problems encountered in several geophysical methods is the accurate measurement of time. A standard of 100 kilocycles/second has been chosen for time and frequency reference in B.M.R. equipment. A very stable transistorized quartz crystal oscillator has been developed. These will be used in proton and fluxgate magnetometers, the EM rock tester and the Benioff seismograph recorder and Synchronome drive. Considerable assistance was received from the P.M.G. Quartz Crystal Laboratory in investigating quartz crystal characteristics.

Because the Footscray area is very disturbed magnetically and seismically, permission was sought and granted for the Bureau to test sites at Laverton R.A.A.F. base for a "quiet" area for a test site for sensitive instruments. The investigation is continuing.

Satisfactory progress has been made on the design and construction of a suitable fluxgate magnetometer for magneto telluric work. However work has been halted temporarily pending the completion of arrangements with R.A.A.F. for a testing site at Laverton, which it is expected will be sufficiently free from magnetic disturbances to enable the development of a high sensitivity (± 0.01 gammas) magnetometer to proceed. Work has also been done on the modification of the old Century 12-channel seismic recorder to use with the magnetometer.

2. Electronic Maintenance and Testing.

The recorder of the magnetometer on aircraft VH-MIN was adapted to give a digital signal. An electronic unit was designed and built to receive this signal and feed it to punched paper tape. The tapes are then handled by electronic computers.

An electronic control unit was designed and constructed to print out automatically on an electric typewriter information on punched paper tapes.

A device for locating breaks in multi-conductor geophone cables is being developed, and equipment for the transmission by radio of the time break signal in seismic prospecting is being investigated.

A continuous service was provided to maintain electrical and electronic equipment and to check and calibrate new and repaired instruments.

3. Automatic Computing Procedures.

(a) Airborne Data.

The development of an electronic computer programme for reduction of aeromagnetic data on the SILLIAC computer at Sydney University was completed during the year.

The first stage of this programme extracts and compares magnetic values at flight line and tie line intersections and prints the difference values. After a process of error estimation and distribution by computing staff, a further stage of the programme applies the corrections proportionately to the digital aeromagnetic data, locates the positions of the contour levels selected for presentation and prints this information in a form suitable for transfer to the flight line map.

The aeromagnetic data from the Lake Johnston 4-mile area was completely processed by this method in October.

(b) Gravity Data.

The development of Automatic Computing Procedures for gravity reductions is proceeding satisfactorily.

(c) Magnetic Observatory Data.

Work is in hand on the design and construction of a scaling device to convert magnetic chart reading into digital form on punched tapes suitable for automatic processing.

4. Cessna Aeromagnetic Survey Project.

Work on the project proper started in September, although much work had already been done on proton magnetometers in general, by the Design and Development Group. The project can be divided into steps, as follows:

1. Comparison of the results of previous aeromagnetic and ground surveys, where these covered the same anomalies to assess the probable value of low-level aeromagnetic surveying.

2. Estimation of the accuracy of the survey for various navigational and positioning arrangements - in particular to determine what configurations would give results of sufficient detail and accuracy to obviate the need for subsequent large scale ground magnetic surveys.
3. Development of a suitable proton magnetometer and recording system.
4. Tests to discover possible sources of interference due to the aircraft.
5. Design and construction of an experimental towed bird installation to test the magnetometer in flight.
6. Flight test of the magnetometer.
7. Flight tests to determine the limitations of the visual navigation and positioning method for close line spacing in areas of (a) poor feature, and (b) rugged terrain.
8. Investigation of suitable navigational and positioning aids.
9. Development of surveying, reduction and plotting techniques.
10. Design and construction of final installation for magnetometer and other equipment.
11. Development of interpretation technique.

Sufficient work has been done on 1 and 2 to enable later steps to be proceeded with.

Step 3 is largely the concern of the Design and Development Group. It is well advanced but detailed work remains to be done on the detector head design. The recording system to be used for tests is almost complete but the final system has not reached an advanced stage.

Step 4 has been completed. The design work of Step 5 is almost complete and construction should start as soon as D.C.A. approval is obtained. Step 6 should be completed in December, but this will depend on obtaining the necessary priority in the Workshop. Step 7 will be taken some time after the return of VH-GEO from the field.

Some progress has been made with 8 and 9 but 10 and 11 have not been started.

5. Scintillation Probe.

During the year modifications to one of the conventional gamma-ray probes were carried out to provide thermal insulation.

The temperature limit of the normal probes is 140°F which is frequently exceeded in the Great Artesian Basin where the Bureau's experimental logging programme was carried out.

Scintillation Probe (contd.)

The modifications consisted essentially of construction of a new outer case (with a greater diameter than the original one) and the insertion of a pyrex glass vacuum flask between this case and the electronic components of the original probe.

The probe has produced good logs but some difficulty has been experienced with breakage of the vacuum flask and destruction of the battery power supply by heat in a very hot bore (230°F). Use of the probe is arbitrarily limited at present to 180°F.

6. Terrella Project.

Intermittent work has been done on this when time was available. Plastic hemispheres have been acquired for formers. Preliminary tests with a flat model indicate that deep mantle conductivity is probably important; this will complicate the model. A primary coil to represent a magnetic bay current system has been designed. The workshop has succeeded in bending small copper sheets into spherical shape.

WORKSHOPS.

The usual programme of routine maintenance and testing of geophysical instruments and equipment continued throughout the year. More than half the workshop capacity was used in the construction of new equipment or components for new equipment, although the only major instrument to enter the workshop was the gravity integrator for 2 dimensional vertical sections. This instrument is still under construction. The newly formed Research and Development Group and the Electrical and Electronic Maintenance and Testing Groups made very considerable demands on workshop time.

One result of the economic recession was a record number of applicants for instrument maker's positions and there was a short period when all positions were filled. Unfortunately the general standard of the new tradesmen's work was not good and there was a fairly rapid turnover of staff. Sub-professional grades are needed in the workshop and our experience this year emphasized the value the sub-professional positions would also have in attracting good tradesmen into the workshops.

The training of 2 second year apprentice instrument makers now in the workshop took a very considerable amount of time. In the long run this scheme may prove the best means of recruiting instrument makers.

The appointment of a D.O.2 to the mechanical design staff in October provided some relief in a section that is always hard pressed.

MISCELLANEOUS INVESTIGATIONS.

1. Antarctic Ice Thickness.

A traverse has been carried out 50 miles south-eastwards from Wilkes to S.2, thence 80 miles southwards. Elevation measurements and seismic determinations of ice-thickness have been

Antarctic Ice Thickness (contd.).

made at about 20 mile intervals. The rock surface is close to sea-level between Wilkes and S.2, while the ice surface rises to about 4,000 ft. The rock surface then rises to 1,200 ft at 20 miles south, falls to nearly 8,000 feet below sea-level at 60 miles south, and is 1,260 ft below sea-level at 80 miles south of S.2. The deep rock depression corresponds to a depression of over 1,000 feet in the ice surface.

Much trouble has been experienced with drilling and other equipment. The gravity meter was damaged during landing operations, and the gravity programme had to be abandoned.

2. Seismic Equipment Test - Rosedale (Vic.).

Although this short survey was used principally to test new reflection seismic equipment, some results were obtained which are of interest in the investigation of the brown coal deposits of the Latrobe Valley.

Reflection and refraction traverses were recorded in the Rosedale-Traralgon area, beginning at APM No. 1 Bore at Rosedale and extending southwards across the Baragwanath anticline and westwards as far as the edge of the Tertiary at Toongabbie. Reflection records were usually good but showed the presence of many interfering multiple events that made interpretation difficult. Results showed that the top of the Jurassic can be followed with some certainty by refraction methods owing to the marked velocity difference between the Tertiary overburden and the underlying Jurassic. Although shotpoint offsets up to eleven miles were used, no refractor velocity was found that could be associated with crystalline basement.

Several horizons were followed and a section was produced showing the location of three coal seams, the top of the Jurassic, and a stratum (probably shale) within the Jurassic. The seismic work showed no definite evidence of major faulting on the northern flank of the Baragwanath anticline at the point where the traverse was located. The seismic profile of the Jurassic sediments shows that the Jurassic is mainly responsible for the shape of the gravity profile over the same traverses, but the seismic work suggests some small structures that are not clearly evident from gravity alone.

3. Gravity Surveys for S.E.C. (Vic.).

(a) Billy's Creek and Hazlewood Areas.

Semi-detailed gravity surveys were carried out in the adjoining Billy's Creek and Hazlewood areas in January and December, 1960 respectively. A total of 243 new stations were established during the two surveys.

The purpose of the Billy's Creek survey was to establish in more detail Bouguer Anomalies in relation to local structure and in particular in relation to suggested faulting.

The Hazlewood survey was carried out to test a statement by the State Electricity Commission's Geologist (Mr. C. S. Gloe) that "another structure on which there is little evidence on the gravity maps is the Hazlewood Dome", (reference Gloe, C.S., The Geology of the Latrobe Valley Coalfield, Page 99). In actual fact there was up to the time of this statement practically no gravity work done in that particular locality.

Gravity Surveys for S.E.C. (Vic.) (contd.)

Briefly the results of the Billy's Creek survey indicate:

- (a) the position of the Boolarra Fault.
- (b) the outcrop of Ordovician rocks near Bellbrook Creek (reference Thomas, D.E., and Baragwanath, W., 1949-51) to be in a gravimetrically high position, probably produced by an isolated fault block.
- (c) the presence of a terrace-like feature between the Budgeree and Boolarra Faults on the northern flank of the South Gippsland Hills. Tertiary volcanics crop out on this feature.
- (d) a graben-like depression following the course of Middle Creek between the Boolarra and Budgeree Faults.

In the Hazlewood area the gravity results indicate the presence of two anticlinal areas about $\frac{3}{4}$ mile apart running in a slightly arcuate but generally north-easterly direction. The southerly and major feature is about 2 miles long, the other $\frac{1}{2}$ mile long. These two gravity features are separated by a sharp low, with a contrast of about 1 milligal, having a similar north-easterly trend. The S.E.C. drilling results on which the "Hazlewood Dome" is based are not inconsistent with this interpretation.

(b) Longford Area.

A semi-detailed gravity survey was carried out in the Longford area during January 1960 in which 63 new gravity stations were established.

The purpose of the survey was to obtain more complete gravity information over the eastern part of the Baragwanath Fault Block as an aid to the elucidation of local structures.

The results indicate that the eastern nose of the Fault Block is separated from the main part of the Block by a north-south fault and also that the Rosedale Fault which bounds the Block to the north is slightly displaced dextrally by this fault.

(c) Gormandale Area.

A semi-detailed gravity survey was carried out in the Gormandale area during December 1960 - January 1961 in which 208 new stations were established.

The purpose of the survey was to provide more complete gravity information on a western portion of the Baragwanath Fault Block as an aid to the elucidation of local structures at the request of the State Electricity Commission.

The results of the survey indicate that the simple gravity pattern shown on the 1" maps of Rosedale and Carrajung is more complex. East of the Rosedale-Willung road a separate gravity high has now been established. Immediately west of this road the Rosedale Fault trend is interrupted by a cross-feature probably indicative of a local sunken area. Further west the simple gravity high shown north of Gormandale on the earlier maps is now revealed to be a rather complex feature probably due to variations in the basaltic layer beneath the Coal Measures.

4. Underground Water.

(a) Farm Area (Alice Springs).

A short refraction program was carried out in the Farm Area in order to extend the previous work of Dyson and Wiebenga in investigating the water resources of the area. The work was suspended to begin the Giles-Carnegie program and there is as yet no sufficient data available to give a clear interpretation, but it appears that the area consists of a shallow porous cover lying on a 'basement' comprised of the eroded edges of steeply dipping Palaeozoic or Proterozoic sediments. The identification of these sediments on the basis of a comparison between their refraction velocities and the velocities previously measured in the Amadeus Basin is being investigated. Further refraction profiles are planned.

Attempts to obtain reflections from the steep beds underlying the Farm Area were unsuccessful.