REPORT 190

Geophysical Branch
Annual Summary of Activities
1974

DEPARTMENT OF MINERALS AND ENERGY
BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

REPORT 190

Geophysical Branch Annual Summary of Activities 1974

AUSTRALIAN GOVERNMENT PUBLISHING SERVICE
CANBERRA, 1975

DEPARTMENT OF MINERALS AND ENERGY
MINISTER: THE HON. R. F. X. CONNOR, M.P.
SECRETARY: SIR LENOX HEWITT, O.B.E.

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS
ACTING DIRECTOR: L. C. NOAKES
ASSISTANT DIRECTOR GEOPHYSICAL BRANCH: N. G. CHAMBERLAIN

Published for the Bureau of Mineral Resources, Geology and Geophysics by the Australian Government Publishing Service

ISBN 0 642 01111 7

MANUSCRIPT RECEIVED: JANUARY 1975
ISSUED: OCTOBER 1975

Printed by Watson Ferguson & Co., Stanley Street, Brisbane.

SUMMARY

Metalliferous and Airborne Section

The locations of the activities of the Section during 1974 are shown in Figure MA 1.

The Metalliferous Subsection continued a program of investigation of down-hole geophysical techniques utilizing drill holes made available by companies at Woodlawn and near Cobar, NSW. In conjunction with these investigations, recently acquired Huntec time-domain and Austral frequency-domain induced polarization equipment was tested and a design for a continuous down-hole IP logging system was commenced. A Scintrex DHP-4 down-hole electromagnetic system was also tested near Canberra.

The investigation of transient EM response involving model studies continued, including the use of a dual-loop transmitter/receiver configuration.

Major survey activities were concentrated in the Northern Territory uranium province of Rum Jungle and Alligator Rivers. Surveys were designed primarily to assist current BMR 1:100 000 geological mapping programs. At Rum Jungle, work was specifically directed at mapping the Coomalie Dolomite/Golden Dyke Formation boundary in areas of no outcrop. Resistivity and IP methods proved to be the most effective of many tested, favourable results being obtained south and southeast of the Rum Jungle Complex and north and south of the Waterhouse Complex.

A gravity survey was also made at Rum Jungle to investigate the relation between the Rum Jungle and Waterhouse Complexes and the surrounding Lower Proterozoic formations. It was found that gravity data did not assist the mapping of the boundary between Coomalie Dolomite and the Golden Dyke Formation.

In the Alligator River area, a survey was made in the northwestern portion of the Jim Jim 1:100 000 Sheet area to establish the effectiveness of ground geophysical techniques for mapping Koolpin equivalent rocks. Success appears to be limited to areas devoid of structural complexity.

Studies were made of geophysical data in the Tennant Creek, northwest Queensland, and Georgetown Precambrian areas. Proposals were advanced for regional ground metalliferous surveys in all areas.

The Darwin Uranium Group geophysical staff provided radiometric assaying and logging services as required, operated the Manton seismic station and made preliminary analyses of the results, and made the Rum Jungle area gravity survey.

BMR's Twin Otter aircraft carried out the major part of airborne survey activity during 1974, the operation of the Aero Commander aircraft being impaired by shortage of technical staffing and by equipment problems.

The Twin Otter commenced its field season with the surveying of the Ballarat 1:250 000 Sheet area in May-June and then moved to Cape York Peninsula to continue the Carpentaria Basin survey commenced in 1973. The Cooktown, Hann River, and Rutland Plains 1:250 000 Sheet areas were flown by the end of August. The survey had to be terminated in mid-September because no aviation fuel was available in this region. The aircraft was moved to Darwin where the onshore parts of the Darwin, Fog Bay, and Cape Scott, and the northern halves of the Pine Creek and Katherine 1:250 000 Sheet areas, were flown by the end of October. The St Arnaud 1:250 000 Sheet area is programmed to complete the aircraft's workload for 1974 following major servicing in the first half of November.

Although the operation of the Aero Commander was severely restricted during 1974, it assisted the Twin Otter on broad reconnaissance surveys of the Deniliquin, Narrandera, Jerilderie, Hamilton, and parts of Hay and Horsham 1:250 000 Sheet areas, yielding data to be included in the Magnetic Map of Australia. Minor detailed surveys were also flown by the Twin Otter in the Darwin and Alligator River areas, and work continued on the coverage of the Canberra and Wagga Wagga 1:250 000 Sheet areas.

A contract was let for a major aeromagnetic survey of the West Australian portion of the Officer Basin, covering sixteen 1:250 000 Sheet areas, to be flown in 1974. Financial problems experienced by the contractor forced the company to seek withdrawal from the contract in August. This was agreed to, and it is hoped that a new contractor will be secured for work to proceed in 1975.

Throughout 1974, the resources of the Airborne Reductions Group have been directed towards processing airborne geophysical data from BMR and contract surveys, and supervising contracts associated with the production of the Magnetic Map of Australia.

Considerable program development was achieved during a time when a high work-load was imposed on the Group by the transfer of data processing from the CDC 3600 to the Cyber 76 computing system.

Seismic, Gravity and Marine Section

The Seismic and Gravity Groups continued to work mainly on completion of interpretation and reporting tasks from previous surveys (see Figs. SGM 1 and SGM 2), and the backlog of such work was much reduced. Reviews of previous work were conducted, particularly of seismic work in the Eromanga Basin in joint projects with Geological Branch and of seismic work in other basins towards the formulation of new programs.

The reconnaissance gravity survey of New South Wales, Victoria, and Tasmania, made under contract by Wongela Geophysical, was the only major field survey in the Section during the year. This survey completed the gravity reconnaissance of the Australian mainland.

Again the main activity of the Section was the Continental Margin survey. Although the field work was completed in 1973, the assessment, processing, and presentation of data, and the interpretation and reporting of results, continued throughout 1974 and will do so through 1975. Staffing for the high level of marine activity has again been maintained at the expense of other seismic and gravity activities. Large quantities of defective data (water depths, gravity, and magnetic), have had to be corrected, and various studies into these matters have

been continued. Much of the six-fold seismic data from the survey, particularly over marginal plateaus, has been digitally processed by private companies. Particular areas where interpretational studies have been made this year are the Exmouth Plateau, the Queensland Trough, the Naturaliste Plateau, and the Timor Trough. Magnetic surveys were continued on the boat conducting a bathymetric survey of the northwest shelf for the Division of National Mapping.

Observatories and Regional Section

The Observatories Subsection functions through four Groups: at Canberra Head Office, and at the Mundaring (WA), Port Moresby (PNG), and Toolangi (Vic) Geophysical observatories. Operations in the Northern Territory and Antarctica are directed from the Canberra Group.

The basic programs were continued at five geophysical observatories and at 20 seismograph stations; three of the seismograph stations were installed in 1974. In addition a network of 27 accelerographs was maintained, and an ionospheric program was carried out at Mundaring in collaboration with the Ionospheric Prediction Service, Department of Science.

Long-term plans to modernize the magnetic observatories were advanced by two steps: an automatic digital observatory at Kowen Forest, ACT, was proved to be a reliable precise replacement for the classical analogue magnetographs; and proton vector magnetometers (PVM) at Kowen Forest and Mundaring were introduced into regular service to replace semi-absolute magnetometers that depend on overseas standards.

The data processing programs at Canberra were curtailed by continued problems with the obsolete digitizing machine and problems in converting to the Cyber 76 computer; positive steps were taken in conjunction with the ADP and Geophysical Services Sections to overcome the former.

A well-attended and well-received one-day symposium on 'Seismicity and Earthquake Risk in Eastern Australia' was conducted at BMR in December 1973 and the papers were compiled for publication as a BMR Bulletin. The participants represented a wide range of interests; they included geologists, geophysicists, seismologists, engineers, and insurers; and the topics discussed reflected their various viewpoints.

The set of first-order regional magnetic stations in Australia, PNG, and some Pacific Islands was occupied to provide data for the isogonic chart, epoch 1975.0. A planned third-order survey of remote areas was deferred because of problems in arranging a contract for logistic support; these were solved by September, but the survey will not begin until March 1975.

Late in 1973 the US Geological Survey proposed cooperation in the Seismological Research Observatory (SRO) project, which aims at establishing a global network of about 13 advanced seismograph systems to update and supplement the World Standard Network. By September 1974 the necessary top-level approval to participate had been given by the Australian and Western Australian Governments, and detailed planning was initiated. The Australian SRO will be at Narrogin (sensor)/Mundaring (recorder) and is scheduled to be operating by mid-1975.

Officers of the Subsection continued to represent BMR on various committees, sub-committees, or working groups, including: Antarctica Planning, ANCAR, ANCOGG, International Geodynamics Project, IAGA, National Committee for Earthquake Engineering, and the WA and PNG Advisory Committees on Seismology.

The most important activities of the Regional Gravity Group were those involving international co-operative projects and the compilation of Australian gravity data.

Joint Soviet-Australian gravity work continued with Soviet pendulum measurements between Moscow, Port Moresby, and Hobart; visits to Moscow by P. Wellman and D. A. Coutts; loan of Soviet gravity meter calibration apparatus; and publication of BMR Bulletin 161 on the 1973 gravity meter measurements on the Australian Calibration Line.

Earth-tides will be recorded at eight sites in Australia and Papua New Guinea using recording gravity meters on loan from the Observatoire Royal de Belgique; the first meter was installed in Port Moresby by Belgian experts during September.

D. A. Coutts made gravity ties to and within New Zealand and Antarctica in co-operation with the NZ Department of Scientific and Industrial Research and the US National Science Foundation.

Recomputation of gravity data to common gravity, height, and position datums was accelerated by the letting of a major contract to a private geophysical organization. ADP data manipulation and map production coped well with increased work flow except for periods of breakdown in the computer service.

P. Wellman attended a symposium in Zurich on recent crustal movements and a meeting of the International Gravimetric Commission in Paris during an overseas visit.

Other activities of the Group included recording of earth-tides using horizontal pendulums at Armidale, reduction and interpretation of gravity results from surveys in Papua New Guinea and Antarctica, supply of gravity data and advice to industry, and maintenance of gravity equipment.

The Regional Structural Surveys Group carried out the East Papua Crustal Survey during late 1973 in cooperation with other sections of BMR, universities, and other organizations. High recovery of record from the large number of shots and recording stations has provided a huge volume of seismic data which is now being processed and analysed. Interpretation will take several years using advanced techniques such as digital data analysis and synthetic seismograms. Computer programs have been developed to handle the data, and interpretative programs are being written to extract the maximum information from the seismic records.

The seismic tape-recording equipment has been calibrated so that amplitude studies can be introduced as an interpretative technique in crustal investigations. Further improvements to the tape-recording system have been designed and a prototype is under test. An improved playback system for Akai tapes is under construction.

Interpretation of data from earlier surveys in the Bismarck Sea, Solomon Sea, and Ontong Java Plateau continued. Magnetic data from the 1970 marine survey of the Bismarck Sea have been compiled into a more accurate contour and profile map which has been interpreted to give new and important information on crustal structure in that region.

A crustal model of the Bowen Basin has been interpreted from seismic refraction data recorded in 1973.

In co-operation with Macquarie University, microseismic investigations are being tested as a possible means of determining the depth of sedimentary basins.

J. P. Cull continued heat flow research at the University of Oxford. He has developed new types of probes which facilitate measurement of thermal conductivities at high pressures.

D. M. Finlayson examined seismic techniques of crustal investigation at a number of overseas institutions.

Geophysical Services Section

The section comprises three Subsections: Electronics, Mechanical and Services. The Electronics and Mechanical Subsections are concerned primarily with equipment development, construction, and maintenance; the Services Subsection covers procurement and utilization of equipment, measurement of physical properties of rocks, engineering geophysics, and geophysical drafting.

The Electronics Subsection completed the MFS-7 magnetometer and other installations in the Twin Otter aircraft. A new digital data acquisition system was installed in the Aero Commander aircraft and the need was established for a magnetometer boom installation to reduce magnetometer noise to an acceptable level. Work continued on deep crustal seismic equipment and observatory equipment including controllers for new digital recording magnetic systems.

Major tasks in the Mechanical Subsection were the completion of the 3000-m bore logger, a depth controlled underwater tow-fish to carry nine sparker elements, and a 12-tonne hydraulic rock core splitter. Both the Mechanical and Electronics Subsections were continuously involved in the preparation of equipment for current surveys.

In the Services Subsection the Engineering Geophysics Group made many small surveys in support of engineering geology in the ACT, made hydrological surveys at Aurukun near Weipa on Cape York Peninsula, at Tatura and Strathmerton in the Goulburn Valley, Victoria, and at Kavieng and Madang in Papua New Guinea, made a magnetic survey in the Nebo Coalfield, Qld, made landslide investigations at Kundiawa, Papua New Guinea, and was involved in magneto-telluric software development and surveys. Many blast and vibration measurements were made. The 3000-m bore logger was used on its first major logging survey since it was rebuilt.

1. METALLIFEROUS AND AIRBORNE SECTION
(G. A. Young)

METALLIFEROUS SUBSECTION (E. C. E. SEDMIK)

Geophysical tests near Cobar, NSW (R. Ogilvy)

A geophysical test survey was carried out near Cobar between January and March to test newly acquired equipment and develop down-hole geophysical systems. The principal geophysical techniques used were time and frequency domain IP; magnetic and gravity measurements were also made.

An IP traverse, carried out using frequency domain equipment with dipole-dipole electrode configuration, produced a broad anomaly in an area where the results were adversely affected by thick conductive overburden. Time domain IP measurements using the gradient array were carried out using newly acquired Huntec equipment. Considerable difficulties were encountered with the synchronization of the receiver using normal operational procedures; tests showed that inductive coupling may have been the cause and that in areas of conductive overburden the input specifications of the receiver were inadequate, necessitating alternative arrays or receiver modifications. Despite the difficulties, IP and resistivity measurements were made and a moderate chargeability anomaly was obtained. Time domain results appeared to be better than frequency-domain ones.

Down-hole IP measurements in a diamond-drill hole using time and frequency domain equipment recorded anomalies associated with mineralization; these results were used as an aid to interpretation of the surface data. During the course of the down-hole IP work it became apparent that alternative techniques could be used, and proposals have been made to develop and test techniques such as directional down-hole IP and the use of down-hole electrodes to enhance surface IP response.

Rum Jungle area gravity survey, NT (J. A. Major, D. H. Tucker)

From May to September a gravity survey was made in the Rum Jungle area with the objectives of investigating the relation between the Rum Jungle and Waterhouse Complexes and the surrounding Lower Proterozoic formations, and of determining if gravity data can aid mapping of the boundary between the Coomalie Dolomite and the Golden Dyke Formation.

Bouguer anomaly values were calculated using a density of 2.67 g/cm^3. The preliminary contoured results, relative to an arbitrary base, are shown in Figure MA2. Approximately 750 line-km were surveyed with a station spacing of $\frac{1}{2}$ km; in addition approximately 25 line-km were surveyed across the Coomalie Dolomite/Golden Dyke Formation boundary with a station spacing of 40m. Most of the levelling was done by a team from the Department of Services and Property, but some was done by the gravity party using microbarometers. A program of density determinations of drill core was carried out.

Preliminary interpretation of the gravity data indicates that the low over the Waterhouse Complex could be caused by a relatively simple geometrical body such as a truncated cone broadening with depth and extending downwards about 3 km. The dip of the eastern edge is estimated to be about 60°, the southeastern edge about 90° and the western edge about 75°. A low occurs over the southern part of the Rum Jungle Complex; a high caused by Lower Proterozoic rocks encroaches on the low in the Embayment area. The gravity profile across the Embayment area is complex and not easy to interpret, but a thickness of a least 2 km is estimated for the Lower Proterozoic rocks. The weak low over the northern part of the Rum Jungle Complex has not been interpreted as yet. It may reflect a density difference within the Complex or it may be due to an increase in thickness of the complex. The trough of Lower Proterozoic rocks between the Rum Jungle and Waterhouse Complexes is estimated to be no more than $2\frac{1}{2}$ km deep. The southern boundary of the Rum Jungle Complex is estimated to have a dip of 50°.

The detailed gravity results indicate that it is not possible to map directly the boundary between the Coomalie Dolomite and the Golden Dyke Formation. These results show gravity lows over parts of the Coomalie Dolomite, which cannot be explained by

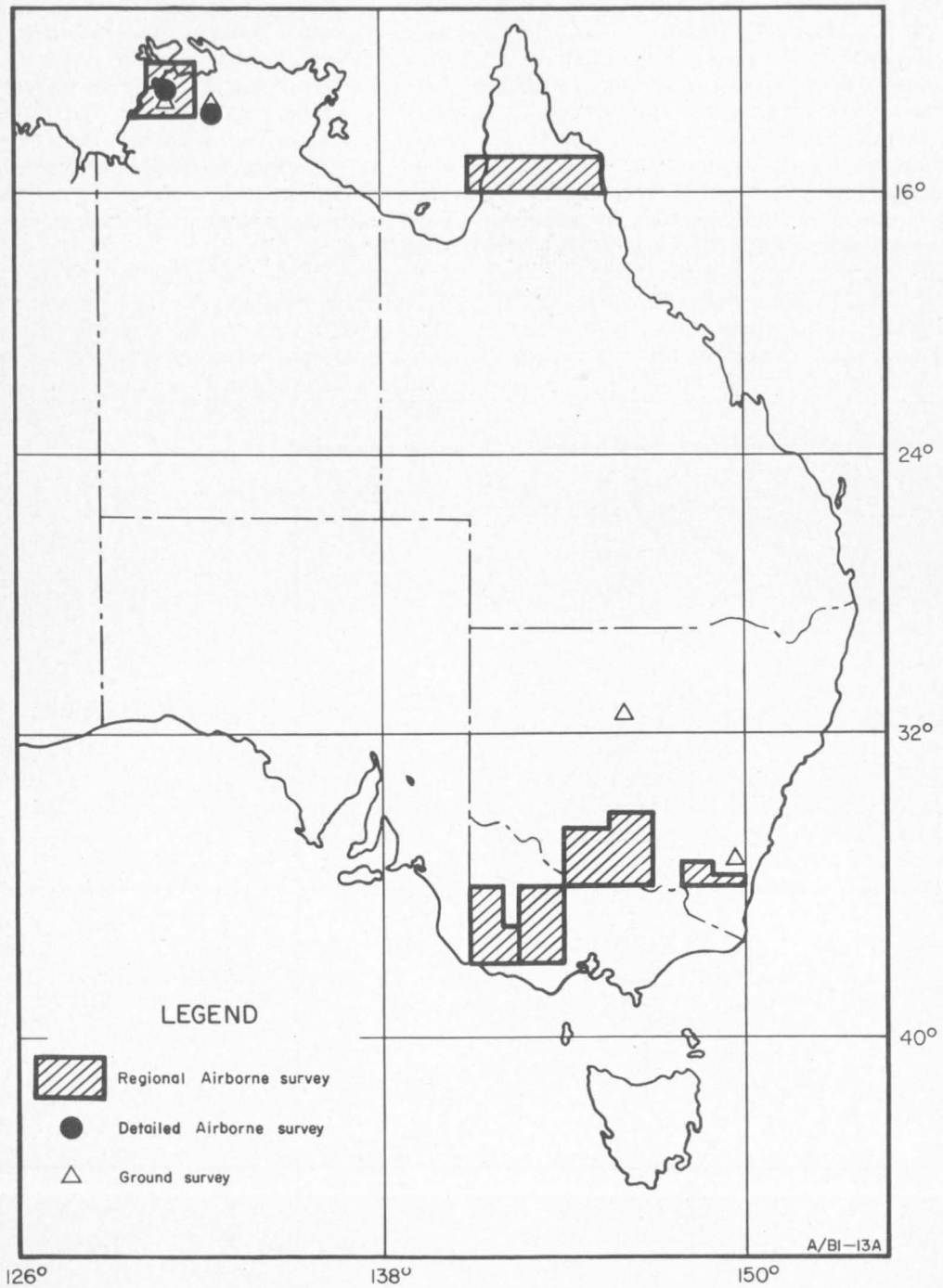


Fig. MA 1. Metalliferous and Airborne Section field activities, 1974.

density measurements made on drill core and indicate that the Coomalie Dolomite may be highly porous.

Rum Jungle area geophysical survey, NT (R. Ogilvy, I. Hone, D. Wilson)

A geophysical survey was made in the Rum Jungle area from 2 June to 10 August with the objective of assisting the Rum Jungle area geological survey party, with specific reference to mapping the Coomalie Dolomite/Golden Dyke Formation boundary in areas of no outcrop. Geophysical techniques used included IP, resistivity, transient EM, magnetics, and gravity; the gravity work was done as part of the Rum Jungle area regional gravity survey, and the results are described in the report on the gravity survey. The traverses surveyed are shown in Figure MA 2.

South and southeast of the Rum Jungle Complex the Coomalie Dolomite/Golden Dyke Formation boundary was successfully defined for over 5 km using IP/resistivity profiling techniques, the IP results giving more diagnostic information than the resistivity results. The transient EM results also defined the boundary, but only on traverses where the weathering was shallow. Total-field magnetic measurements did not detect any significant difference in response between the Coomalie Dolomite and the Golden Dyke Formation; this was predictable from aeromagnetic data.

North of the Waterhouse Complex, IP/resistivity profiling defined a distinct geophysical boundary characteristic of the Coomalie Dolomite/Golden Dyke Formation boundary south of the Rum Jungle Complex. East of the Waterhouse Complex no recogniz-

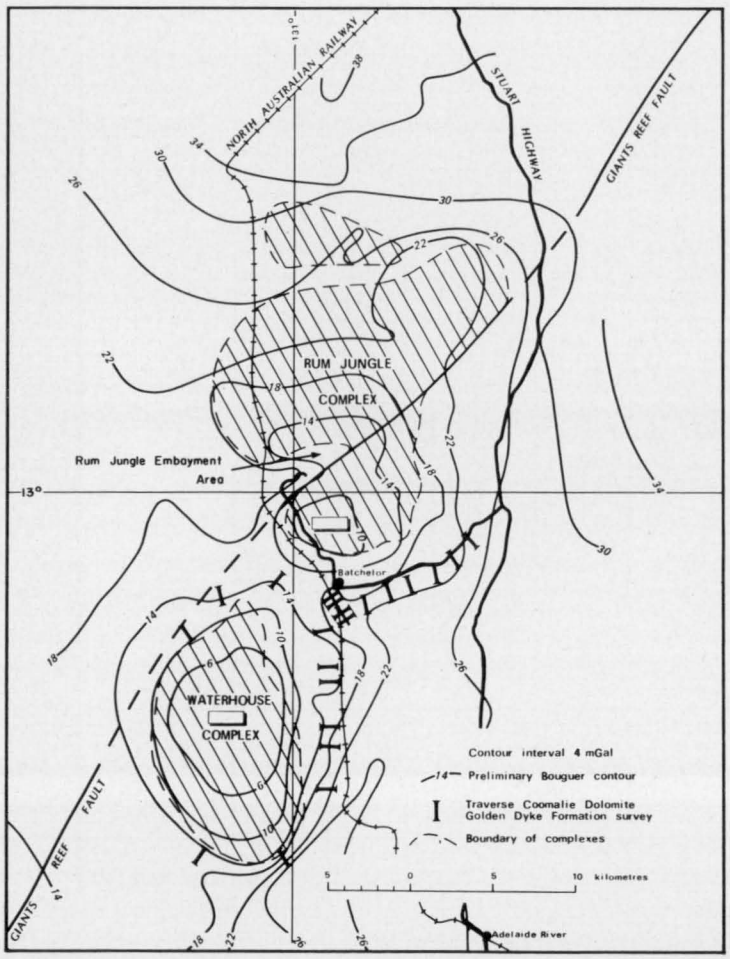


Fig. MA 2.

Geophysical surveys in the Rum Jungle area, 1974.

able geophysical response was obtained from the boundary. South of the Waterhouse Complex resistivity profiling defined the edge of the Coomalie Dolomite, but no IP contrast was obtained.

Down-hole IP logging was carried out in selected stratigraphic drill holes to define more clearly the IP/resistivity characteristics of rock types and assist interpretation.

The geophysical investigations defined the Coomalie Dolomite/Golden Dyke Formation boundary south and southeast of the Rum Jungle Complex and north and south of the Waterhouse Complex, but failed to define the boundary east of the Waterhouse Complex. Geological mapping supported by stratigraphic drilling has also defined the Coomalie Dolomite/Golden Dyke Formation boundary around the Rum Jungle and Waterhouse Complexes except in the area east of the Waterhouse Complex where the boundary is tentative. The geophysical survey results indicate that it is possible to apply geophysical techniques to aid geological mapping.

Radiometric, S-P, and resistance logs were made for the Rum Jungle geological party in 56 stratigraphic holes drilled in the area in 1974. In general the resistance and radiometric logs distinguished between the various formations drilled and between rock types within formations.

Alligator River area geophysical survey, NT
(R. Ogilvy, I. Hone, D. Wilson, A. Mutton)

A geophysical survey was carried out in the northwestern portion of the Jim Jim 1:100 000 Sheet area (Fig. MA 3) from mid-August to early October with the primary objective of determining if it was possible to establish the relation between Koolpin equivalent rocks

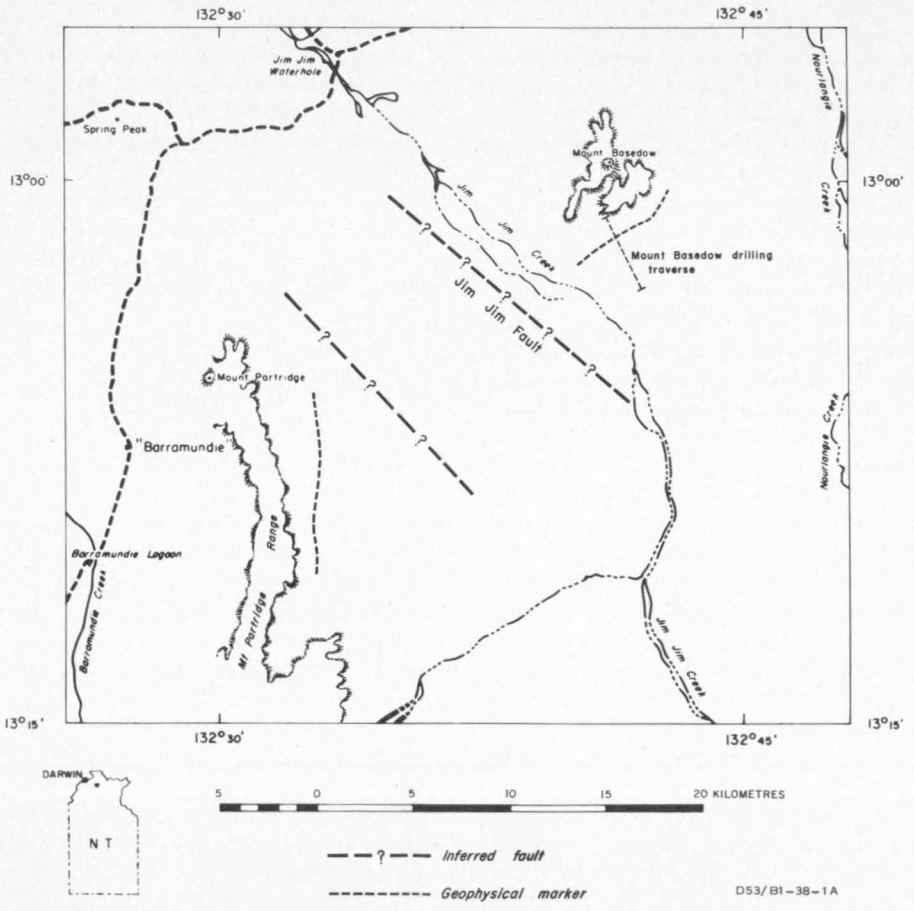


Fig. MA 3. **Alligator River area, NT, 1974. Summary of results of ground geophysical surveys.**

near Mount Basedow and those east of Mount Partridge Range by geophysical techniques.

Preliminary IP/resistivity profiling over the Koolpin equivalent rocks in the Mount Basedow area detected an anomalous response associated with a quartzite/quartz-mica-schist contact. Further profiling for 4 km along the Mount Basedow stratigraphic drilling traverse showed the quartzite to be the only consistent geo-electric marker within the Koolpin equivalent sequence; it was mapped subsequently for over 5 km.

Attempts to locate a continuation of the quartzite marker southwest of the Jim Jim Fault failed to produce a recognizable response, and no geophysical correlation could be established between adjacent traverses. Resistivity measurements in different azimuths to determine the geo-electric strike showed that it was not possible in general to distinguish between stratigraphic and structural trends and that IP/resistivity profiling would be unlikely to assist mapping in the area southwest of the Jim Jim Fault.

IP/resistivity and S-P profiling were carried out east of Mount Partridge Range to establish the geo-electric properties of the Koolpin equivalent rocks and to continue stratigraphic mapping in a relatively undisturbed area. A narrow but distinct geo-electric marker was detected, characterized by low resistivities and moderate S-P response. This marker, interpreted as due to a carbonaceous unit, was mapped for 8 km before encountering the problem area southwest of the Jim Jim Fault.

Ground magnetic measurements in the Mount Basedow area detected distinct magnetic horizons in the Koolpin equivalent. These horizons were attributed to magnetite-bearing quartz-mica-schist and showed a similar stratigraphic trend to the IP/resistivity quartzite marker. The aeromagnetic results of the detailed survey flown earlier in the year were received towards the end of the survey, and ground magnetic measurements were made to supplement aeromagnetic data. Dolerite dykes in the area showed a variable magnetic response. Some magnetic anomalies were associated with the dolerite but offset from the outcrop, suggesting the anomalies are due to magnetite in metamorphosed sedimentary rocks adjacent to intrusive dolerite. Other magnetic anomalies were directly related to dolerite. The ground magnetics provided positive control for the aeromagnetic data and showed that in some areas, e.g. near Mount Basedow, the magnetic data can be used to map stratigraphy, but in general the magnetic data have to be interpreted with care.

The application of geophysical techniques in the area established distinct stratigraphic trends in the relatively undisturbed areas near Mount Basedow and east of Mount Partridge Range but appear to have failed to resolve the stratigraphy in the more complex area southwest of the Jim Jim Fault. As only preliminary interpretations of the IP/resistivity and magnetic data have been made to date, this conclusion will require confirmation by more detailed interpretation.

Radiometric, S-P, and resistance logs were made for the Alligator River geological party of all stratigraphic holes drilled on the Mount Basedow, Koongarra, and Jabiru traverses, about 140 holes in all.

The radiometric and resistance logs distinguished between zones of schist and amphibolite in holes in the Koolpin equivalent sequence. The radiometric logs gave better correlation with rock types because the resistance logs were affected by weathering variations.

Investigation of down-hole techniques and of time-domain methods (R. Ogilvy, J. Williams, R. Cobcroft)

The Huntec time-domain induced polarization equipment was given a series of surface and down-hole tests in the first part of the year at Kowen Forest, Woodlawn, and Cobar. The results indicate that the equipment is working to design specifications and that synchronization malfunctions which occurred are caused by coupling. Design of a continuous down-hole time-domain IP logging system was started.

The Austral frequency-domain IP equipment was tested down-hole at Cobar and Kowen Forest and results proved consistent with other data.

The Scintrex DHP-4 down-hole electromagnetic system was tested at Kowen

Forest and a number of minor faults were rectified.

Investigation of digital recording of time-domain electromagnetic data was started.

Both time-domain and frequency-domain IP systems were used extensively in the Rum Jungle and Alligator River areas, NT, from May to October.

Transient EM modelling (B. R. Spies)

Further transient EM model studies were made to aid interpretation of the 1973 field data; the models were aluminium blocks and sheets in air. The two main studies made were (1) the decay curves attributable to horizontal tabular bodies of various sizes at various depths, and (2) the response from a dual-loop configuration over thin dipping bodies.

In the first study, the transient decay curves were exponential in all cases and the time constant was independent of the depth of the model and the loop size. The time constant increased with the size of the model but no simple relation was found between the value of the time constant and the size or the conductivity of the model. The fall-off of the amplitude of the reponse with depth of the model was exponential.

In the second study, the dual-loop configuration over a thin dipping model produced a complex anomaly centred over the model in contrast to the single-loop configuration which gives an anomaly on either side of the model; a method was found of determining the dip of the model from the dual-loop profile.

Minor equipment tests (R. A. Almond, N. Sampath)

During August, a Geonics EM16R resistivity meter was field tested at Captains Flat and Woodlawn, NSW. In the highly resistive environment at Captains Flat, known resistivity anomalies were clearly resolved. At Woodlawn, where background resistivities are low, weak to moderate resistivity anomalies were recorded over the orebody. These tests demonstrated that the use of the EM16R meter is very restricted, the tool being best suited to the rapid production of superficial resistivity data.

Tennant Creek region, NT (D. Wilson)

Gravity and magnetic data from the Tennant Creek and surrounding areas were studied and the possible sources of various anomalies were analysed.

Bouguer anomalies were divided into zones. These zones and the aeromagnetic trends define the probable near-surface extent of rocks of the Warramunga, Tomkinson Creek, and Hatches Creek Groups, The gravity and magnetic results also defined several granitic batholiths and one basic intrusion.

On a broader, regional scale the Bouguer anomalies and magnetic trends suggest a block structure for the area. The Hatches Creek and Tomkinson Creek Groups each overlie a block; the Warramunga Group overlies a third block between these two (Fig. MA 4). There appears to have been relative vertical movement of these blocks. Walpole & Smith postulated similar block structures to the south.

Recommendations were made for geophysical investigation of the boundary between the Hatches Creek and Warramunga Group blocks and for a gravity survey of the Warrego Granite, shown as a gravity low 55 km west of Tennant Creek in Figure MA 4.

Northwest Queensland and Georgetown Precambrian areas (N. Sampath)

A study was made of the application of geophysics in the Mount Isa/Cloncurry and Georgetown areas in order to establish what assistance ground geophysical projects could make towards BMR's future activities in these areas. Three proposals for regional surveys and five proposals for more detailed surveys were made.

The first proposal for a regional survey is in the Cloncurry 1:250 000 Sheet area in an area around the Mount Remarkable Fault, including alluvium-covered Corella Formation. The area contains aeromagnetic anomalies with an associated gravity high and geology favourable for mineralization; the Corella Formation is faulted against the Leichhardt Metamorphics. Gravity, magnetic, and resistivity surveys are recommended to provide information on structure and mineralization.

The second proposal for a regional survey is

also in the Cloncurry 1:250 000 Sheet area in an area of Cainozoic and Mesozoic sediments with scattered granitic outcrops. Aeromagnetic anomalies similar to those observed over outcropping Corella Formation to the west and an associated gravity high occur in this

Fig. MA 4. Tennant Creek study. Interpretation of geophysical results.

area. The area immediately west contains no aeromagnetic anomalies but a gravity low. Depths to basement from borehole data are approximately the same as those obtained from magnetic interpretation, and the bodies causing the anomalies are estimated to be at shallow depths. Gravity, magnetic, and resistivity surveys are recommended to map the Precambrian structure and rock types beneath the Cainozoic and Mesozoic cover.

The third proposal for a regional survey is in the Georgetown 1:250 000 Sheet area. Gravity and resistivity surveys are proposed to determine the thickness of the Newcastle Range Volcanics over the Forsayth Granite in the Newcastle Range cauldron subsidence area.

The five projects proposed for more detailed survey are directed at assisting the search for further mineralization in areas of known mineral occurrences.

The first area is near the Surprise mine in the Prospector 1:100 000 Sheet area, in rocks of the Corella Formation. The second area is near the Sunset and Kings Cross prospects in the Mary Kathleen 1:100 000 Sheet area, also in rocks of the Corella Formation. The third area is in the Cloncurry 1:100 000 Sheet area and is over the Uncle Tom, King Edward, and Herbert group of prospects in Corella and Soldiers Cap Formations east of Cloncurry. The fourth area is in the southern part of the Dobbyn 1:250 000 Sheet area in the Argylla Formation where mines such as Little Wonder, Mighty Atom, and Mussolini occur. The fifth area is in the Forsayth 1:100 000 Sheet area near the Jubilee Plunger mine. IP, S-P, EM, and magnetic methods are recommended in these five areas.

The second and third regional survey proposals and the fifth detail survey proposal are under consideration for inclusion in BMR's 1975 program.

Applicability of geophysics to resources evaluation of beach sands (E. C. E. Sedmik)

The applicability of geophysics to beach sands exploration was studied with the objective of appraising its use in the search for new deposits.

Mineral concentrates derived from beach sands deposits, namely rutile, ilmenite, zircon, and monazite, constitute an important source of export revenue for Australia amounting to over $50 million per year. Most of the rutile and zircon produced in Australia comes from the beaches of NSW and Qld, and most of the ilmenite comes from WA. The world reserves of beach sand minerals are very limited and there is need for intensive exploration for new deposits.

The use of geophysics on onshore beach sand deposits has been rather limited because prospectors found scout drilling more expedient. However, during the last decade the search for beach sand minerals has been extended offshore and it is there that geophysics has been applied extensively on a regional scale.

The magnetic properties of beach sand minerals suggest the magnetic method as the most obvious choice when prospecting for buried beach sand deposits. Advances in magnetometer design enable accurate readings to be obtained, and continuous recording methods are available both for ground surveys and at sea. Radiometric measurements can assist in locating monazite-bearing sands within about 1 m from the detector crystal. Electrical resistivity and seismic methods can be used to outline buried sand dunes for further investigation in more detail.

Offshore exploration methods combining Sparker profiling techniques with bathymetry to determine submerged beaches under sand layers were used by the Planet Group during the period 1969-1972. This company developed a very effective laser-beam positioning technique which enabled accurate positioning of the drilling boat. Work of Planet has proved the existence of a beach line under 30 m of water south of the Tweed River mouth. However, poor rutile values encountered away from shore made the project uneconomic.

An experimental survey over a known onshore deposit has been proposed for 1975 to evaluate various geophysical techniques.

Darwin Uranium Group (J. A. Major)

Routine maintenance and testing of field and laboratory equipment was carried out; this equipment included the Widco Portalogger, the Slingram equipment, the multichannel gamma-ray spectrometer system, and the seismograph system. Samples from the

Alligator Rivers area were analysed with the multi-channel gamma-ray spectrometer for the Airborne Subsection.

Personnel from the Darwin Uranium Group were involved in the Rum Jungle area gravity survey from 13 May to 20 September.

The Manton Seismic Station was kept in operation. Only two components were recorded: the vertical and north-south components until March, and then the vertical and east-west components. Record loss was mainly due to APO line troubles. A time code generator was installed in June by Observatory Group personnel from Head Office to relay time signals to the ABC, Darwin. Routine analyses of seismograms continued and results were forwarded to Head Office. First-arrival seismic data were telegraphed to NOAA.

Airborne Subsection (J. H. Quilty)

Ballarat airborne survey, Vic (VH-BMG) (J. E. Olsen)

A regional airborne magnetic and radiometric survy of the Ballarat 1:250 000 Sheet area was completed in May-June 1974. The Twin Otter aircraft VH-BMG, equipped with a fluxgate magnetometer and a 4-channel gamma-ray spectrometer system, was flown at an average ground clearance of 150 m along east-west lines spaced 1.5 km apart, data being recorded digitally.

The magnetic data, as expected, showed a

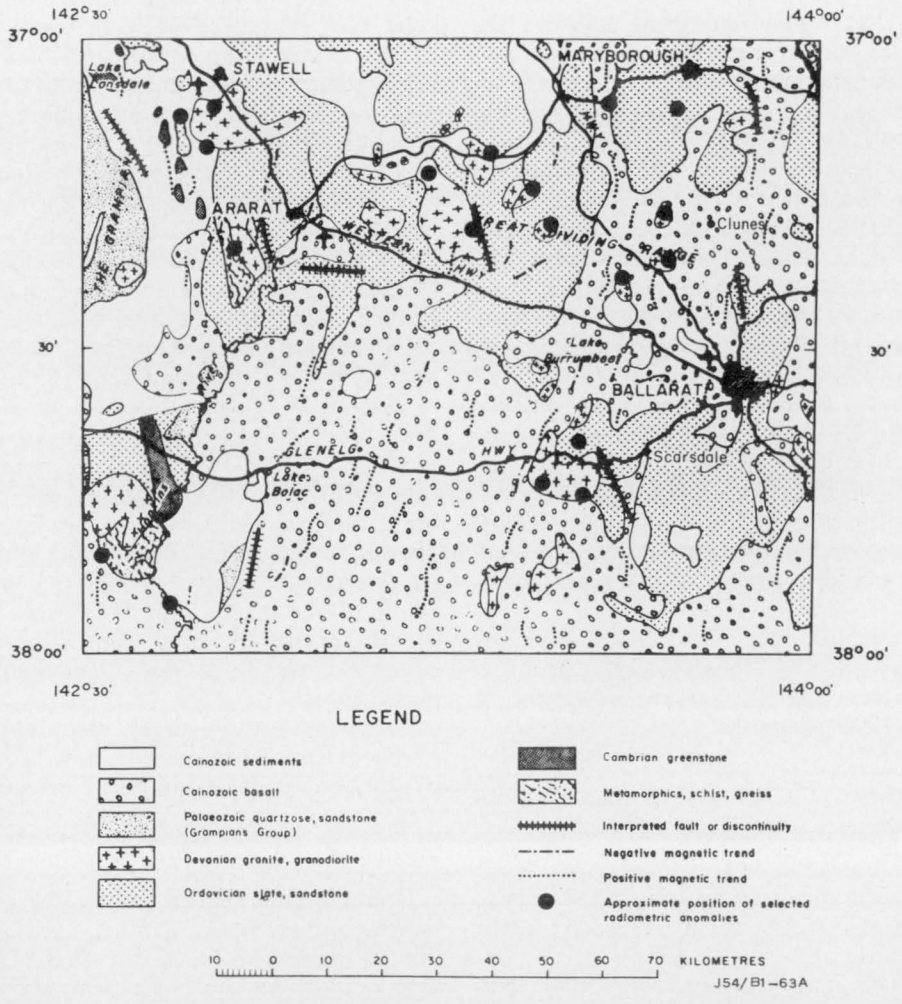


Fig. MA 5. **Ballarat 1:250 000 Sheet area. Magnetic and radiometric interpretation and geology.**

good correlation with the general geology of the area (Fig. MA 5). Sharp anomalies of several hundred gammas magnitude were recorded over the greenstones in the northwestern corner of the Sheet area, but much broader anomalies, indicative of deep-seated structures, over the Grampian Mountains. The magnetic field was generally

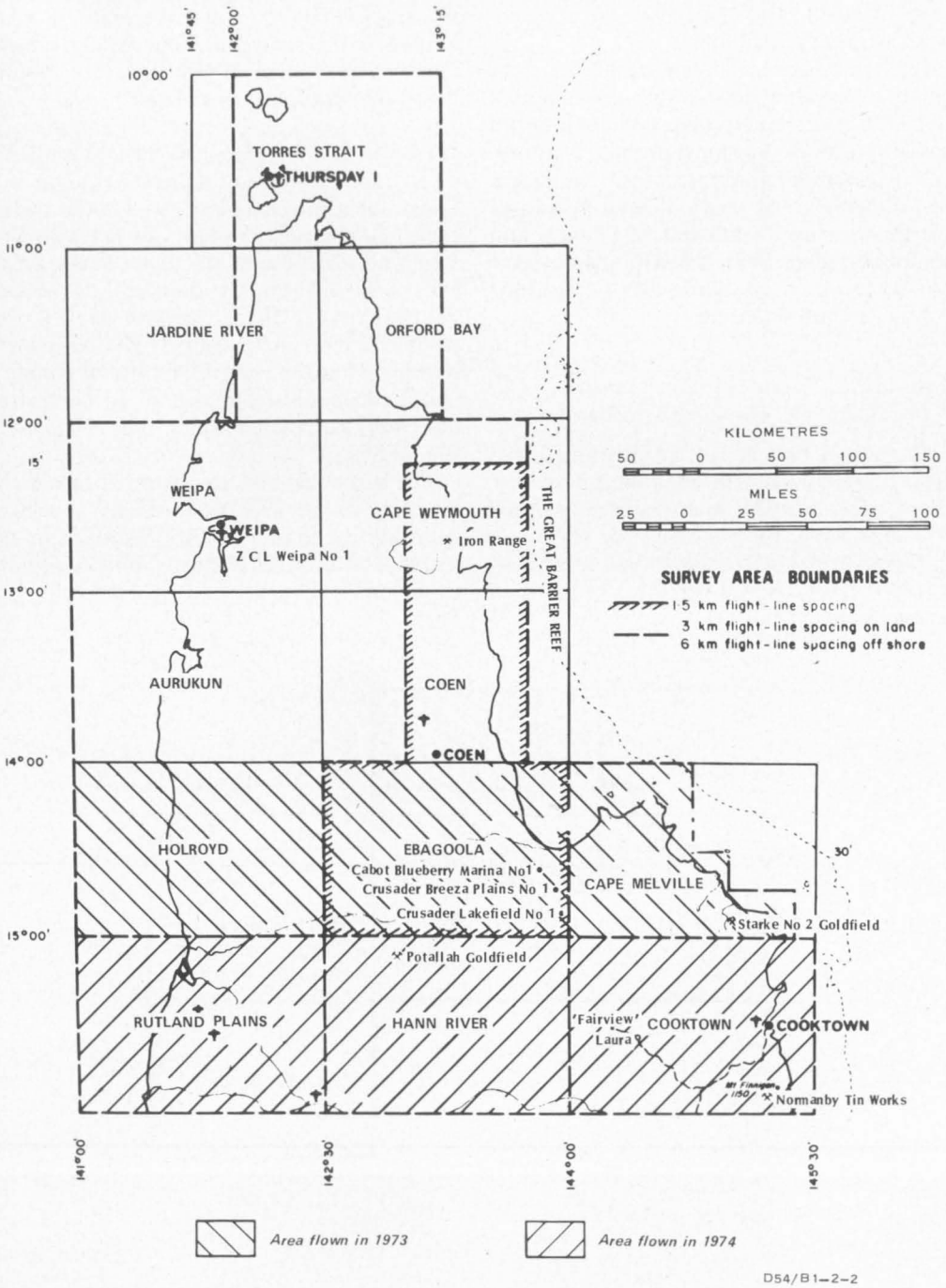


Fig. MA 6. Carpentaria Basin airborne survey. Locality map.

undisturbed over the Ordovician sandstones, in sharp contrast to its highly disturbed character over the basalts. The most significant results obtained from the magnetic data are interpreted extensions to mapped areas of basalt and the definition of lineaments within these basalts.

The radiometric anomalies detected were mainly in the northern half of the Sheet area (Fig. MA 5), and often correspond to mapped granitic outcrops. The most prominent anomalies detected are associated with granites in the following areas: south of Stawell, east of Ararat, west and southwest of Clunes, and west of Scarsdale. Some small anomalies were also recorded in the Ordovician sandstone and the Cainozoic basalt.

Carpentaria Basin airborne survey, Qld (VH—BMG) (K. Horsfall, S. S. Lambourn)

The completion of the Carpentaria Basin airborne magnetic and radiometric survey, commenced in 1973, was programmed for 1974 (Fig. MA 6). Surveying of the three southern 1:250 000 Sheet areas was completed in July-August, using Cooktown as the base for operation.

The party then moved to Weipa to survey the northern Sheet areas, but shortage of aviation fuel at Weipa forced the abandonment of the survey in mid-September. The work completed included fill-in lines and ties to complete coverage of Cape Melville, Ebagoola, and Holroyd 1:250 000 Sheet areas flown in 1973. No program has been established to complete this survey.

Darwin-Katherine region airborne survey, NT (VH-BMG) (S. S. Lambourn, V. Laats)

An airborne magnetic and radiometric survey of the onshore parts of Darwin, Fog Bay, and Cape Scott 1:250 000 Sheet areas, and of Pine Creek, Katherine, and Mount Evelyn (part) 1:250 000 Sheet areas, NT, was commenced on 23 September. The survey was terminated at the end of October to enable a major overhaul of the aircraft to be carried out. Work completed at that time is shown in Figure MA 7.

The survey results are expected to aid the mapping of the Pine Creek Geosyncline, to delineate its boundaries and to assist in the search for mineral deposits in the region. Completion of the survey is scheduled for late 1975.

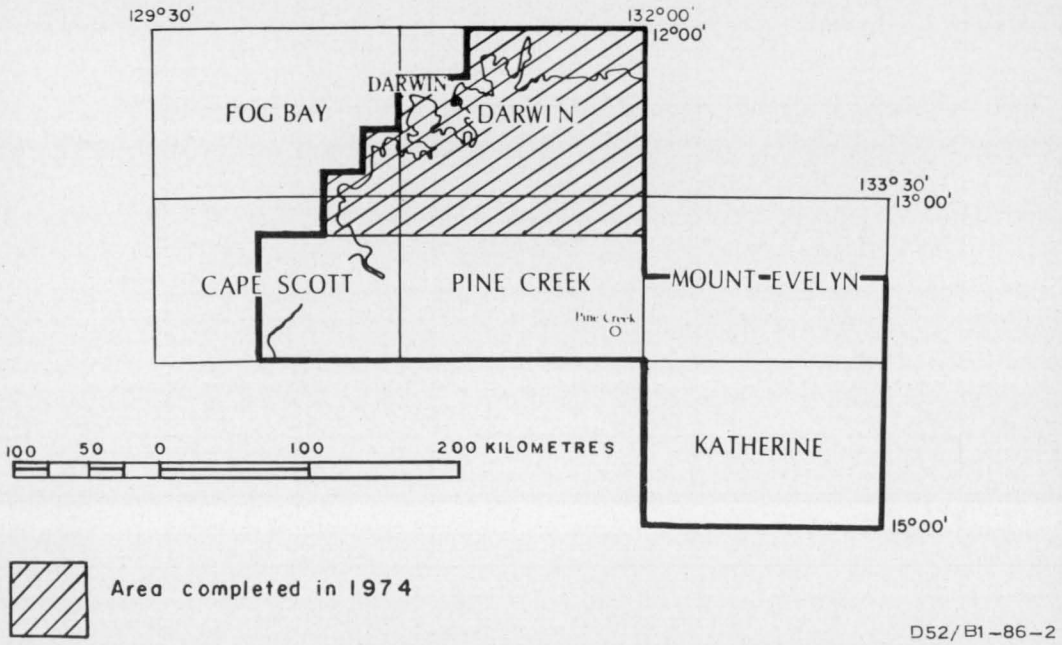


Fig. MA 7. Katherine-Darwin region airborne survey. Area completed in 1974.

Darwin East Urban Development area airborne survey, NT (VH-BMG) (S. S. Lambourn)

On 16 July, the Twin Otter aircraft made a detailed airborne magnetic and radiometric survey of approximately 250 km^2 over the Darwin East Urban Development area (Fig. MA 8). The survey, which was requested by Engineering Geology Group, Geological

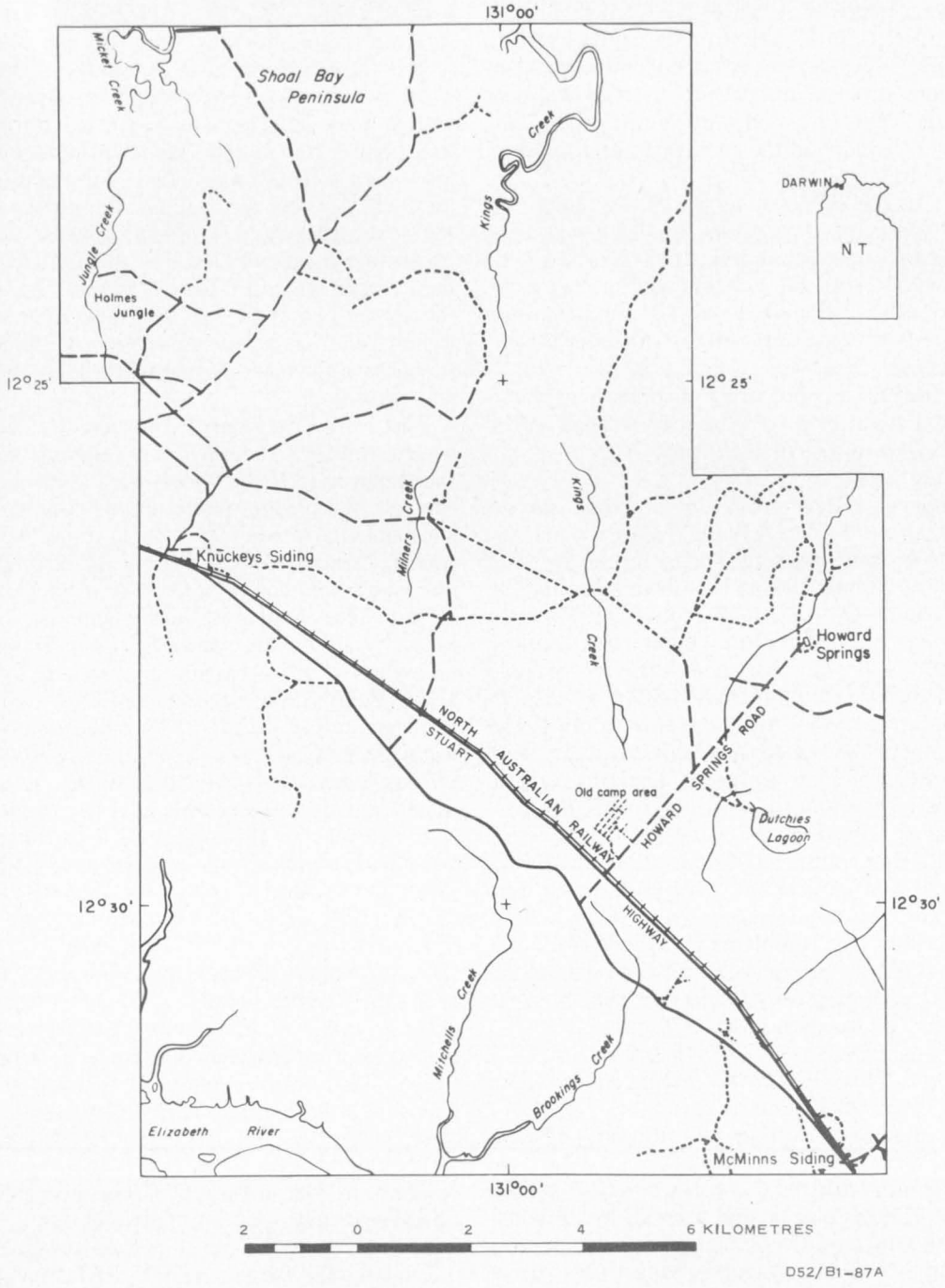


Fig. MA 8. **Darwin East Development. Area covered by detailed airborne survey.**

Branch, was made along east-west lines spaced 500 m apart and at an altitude of 80 m above ground level.

In the Development area, Cretaceous rocks overlie those of early Proterozoic age. Magnetic trends were mapped by North Broken Hill N.L. in Lower Proterozoic rocks in an adjacent area. It was hoped that any extensions of these trends into the Development area would be revealed by the airborne survey and thereby aid the geological interpretation of structure.

As the outcropping rocks are similar to those mapped at Rum Jungle, it was considered important that the area also be mapped with the airborne gamma-ray spectrometer. Anomalies recorded were expected to show some correlation with laterite outcrops.

Results of the survey in preliminary contour map form have been forwarded to the Engineering Geology Group.

Wagga Wagga/Canberra airborne survey, NSW (VH-BMG) (P. G. Wilkes)

This aeromagnetic survey began in 1973 and continued during 1974 as weather and the availability of VH-BMG permitted. The coverage obtained as at the beginning of October 1974 is shown in Figure MA 9. The coverage of the eastern block (east of 148°) was 47% complete at that time. The eastern block was flown at 1680 m above sea level with east-west lines spaced 1.5 km apart. Digital magnetic and navigational data were recorded. Processing of data from the western block (west of 148°) has continued. A magnetic contour map at 1:250 000 scale has been produced for this block. It is expected that flying of the eastern block will be completed by March 1975, and that total magnetic intensity contours for the Wagga Wagga and Canberra 1:250 000 Sheet areas will be released in 1975.

Twin Otter VH-BMG testing and training program (R. Wells)

Equipment testing and training of new personnel commenced in February, in conjunction with the Canberra-based surveying of Wagga Wagga and Canberra 1:250 000 Sheet areas and fill-in flying of nearby areas in support of the Magnetic Map of Australia project.

Early test flights revealed a lack of repeatability in both production-model MFS-7 magnetometers, together with intermittent noise associated with the aircraft installation. These faults proved to be difficult to locate owing to their intermittent character, and it was not until mid-May that the magnetometers were considered to be ready for field work. Malfunctions in the digital acquisition system were detected and corrected during this period, and a thermal teleprinter with associated software was added. This teleprinter made possible the in-flight monitoring of the acquisition and Doppler systems and provides a means of checking the completed data record while the aircraft is returning to the survey base. Changes were also made to the Doppler navigator radome in an attempt to improve the return signal when flying over smooth water.

The Twin Otter party departed for Melbourne in May to commence the surveying of the Ballarat 1:250 000 Sheet area. Although several equipment malfunctions occurred subsequently during the year, they were quickly cleared and did not, as in 1973, contribute significantly to survey production losses. This improved equipment performance was the main reason for an improved data yield in 1974. However, experience has shown that the quantity and complexity of the instrumentation in VH-BMG calls for continuous technical support of a high calibre if serious losses of data production are to be maintained at an acceptable level. Continued staff shortage in this area of the Airborne Subsection represents the main problem to be faced in 1975 for the successful operation of the aircraft.

Aero Commander VH-BMR equipment testing program (E. P. Shelley)

A succession of equipment faults and lack of technical staff resulted in the aircraft not fulfilling its commitment to survey the Darwin-Katherine and Red River areas in 1974.

The digital acquisition system which was received in December 1973 was not fully operational until August. This was due to a number of faults in the unit itself, delays in interfacing the various geophysical systems with the unit, and a shortage of components

for the gamma-ray scalers. The digital system is now operating satisfactorily and an order has been placed for the manufacture of a second unit.

The new radio-altimeter was installed in January and operated satisfactorily. A small modification was made to it to provide a digital data output.

Investigation of the sources of magnetometer noise continued. A strainer cable system was developed for the towed bird as part of a program to minimize the noise. However, this was not successful as the increased drag on the signal cable caused the detector to oscillate in windy conditions. This resulted in an increase in magnetic noise including a component with a period of a few seconds.

Plans are well in hand for the installation of a tail boom to replace the towed bird system to improve the quality of magnetic data recorded. Measurements of the magnetic field of the aircraft indicate that the gradients in the vicinity of the proposed boom-mounted detector are not excessive and may be readily compensated.

Approximately 40 hours were flown in the Canberra region during the year to test geophysical equipment and train personnel. 65 hours were flown to obtain magnetic data in parts of southern NSW and western Victoria for the Aeromagnetic Map of Australia. The aircraft was also used to obtain 70-

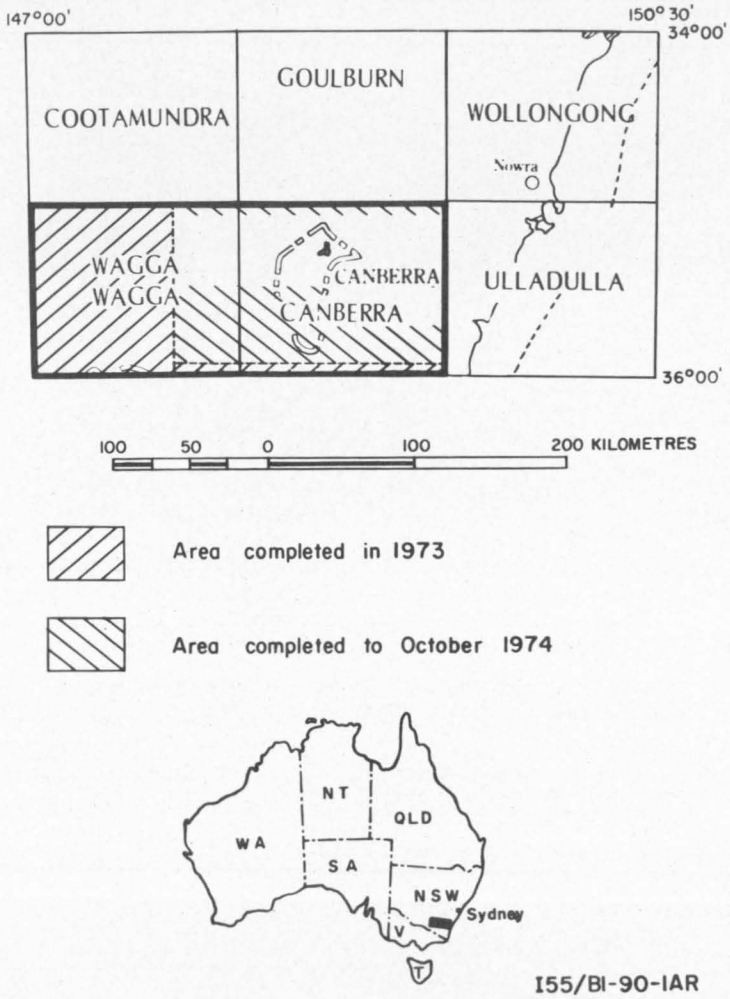


Fig. MA 9. Wagga Wagga/Canberra airborne survey. Area covered.

mm colour photography over selected areas in the Amadeus Basin, NT.

Georgetown area airborne survey, Qld, 1973: interpretation (R. J. Taylor)

An airborne magnetic and radiometric survey of Georgetown 1:250 000 Sheet area was flown by BMR in 1973. The objectives of the survey were to aid regional and detailed geological mapping and to aid a study of the distribution and sources of the uranium mineralization in this area. The interpretation of the survey data was completed during 1974; the more significant results are shown in Figure MA 10.

The area is generally of low magnetic relief, although some anomalies with amplitudes in excess of 1000 gammas are present. Magnetic anomalies which occur over the acid volcanics of the Newcastle Range Volcanics are considered to be produced by basic igneous rocks at a depth of 500 m. A number of these anomalies are negative and are attributed to remanently magnetized basic rocks. Lower-amplitude negative anomalies occur elsewhere in the Sheet area, all attributed to remanently magnetized basic rocks.

The magnetic anomaly density is far greater in the eastern half of the Sheet area than in the western half. Much of the western half is

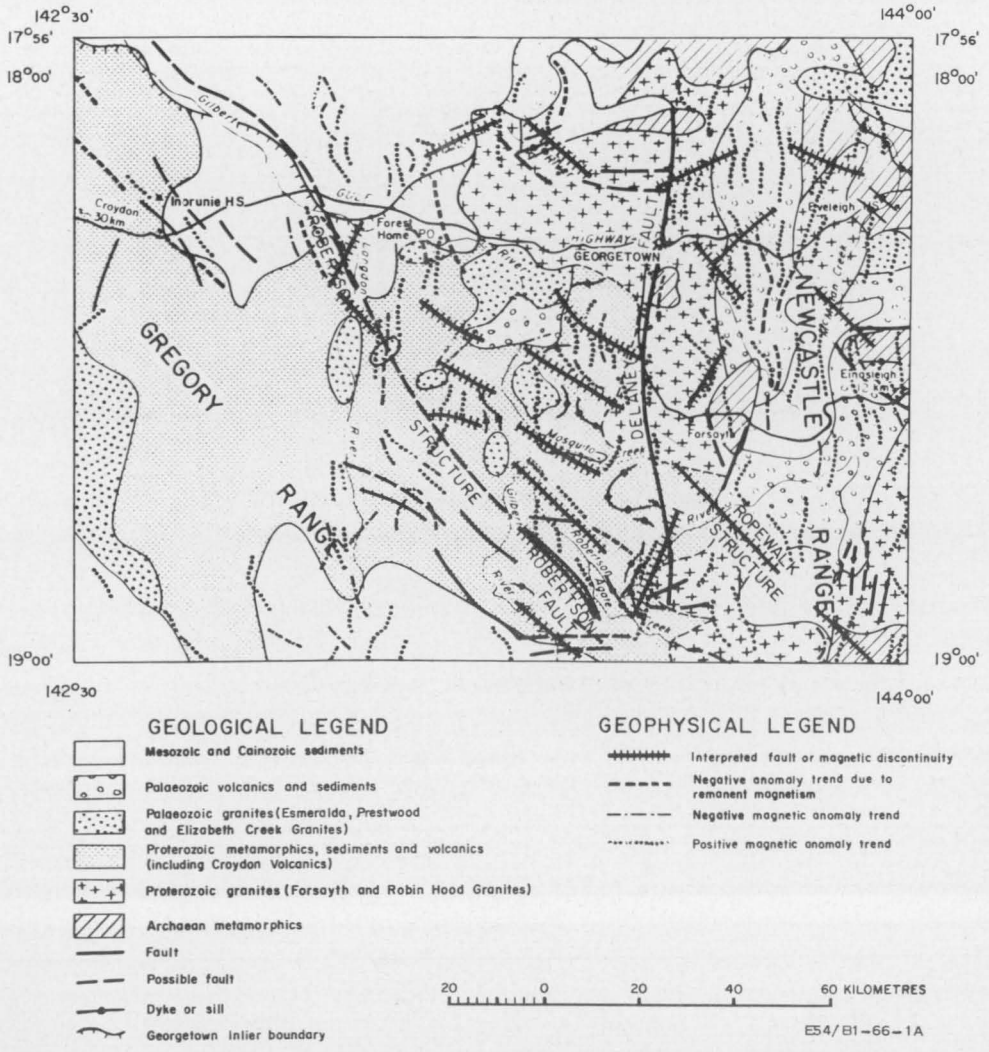


Fig. MA 10. **Georgetown 1:250 000 Sheet area. Magnetic and radiometric interpretation and geology.**

covered by the acid Croydon Volcanics which, from the magnetic data, appear to be of more acidic composition than the Newcastle Range Volcanics.

Two predominant magnetic trend patterns are present. Short trends which strike between north and northeast reflect the local geological structure whereas major northwest trends parallel faults, lineaments, and fold axes. The latter trends are prominent along and northeast of the Robertson Fault and Robertson Structure.

There are four main areas of high radioactivity: to the northwest of Inorunie Homestead; in the central west; in the far northeast; and in the Forsayth area. The first two are attributed to the Croydon Volcanics and the other two are attributed to the Elizabeth Creek Granite and Forsayth Granite respectively.

Cobourg Peninsula, Alligator River, and Mount Evelyn (northern half) airborne survey, NT, 1971-72, and Koolpin area detailed airborne survey, NT, 1974 (P. G. Wilkes)

The interpretation of the 1971-72 magnetic and radiometric survey data was completed during 1974. Total magnetic intensity contours and radiometric interpretation maps are shown in Figures MA 11 and MA 12.

A detailed magnetic and radiometric survey was flown over a small part of the area (the Koolpin area), as shown in Figure MA 3, during 1974. This survey was flown at 80 m ground clearance along east-west flight-lines spaced 500 m apart, and was designed to assist ground geophysical investigations in the Mount Basedow/Mount Partridge area referred to earlier in this summary.

Rock samples collected during follow-up work in August 1973 were analysed to determine their uranium and thorium concentrations. Measurements were made using X-ray fluorescence and delayed neutron analysis, the latter for uranium only. Uranium analyses from the two methods were in good agreement. Measurements on samples of laterite associated with the Gilruth Volcanic Member of the Kombolgie Formation indicated uranium concentrations in the range 5-42 ppm except for one site where samples contained up to 280 ppm uranium. Corresponding thorium concentrations were in the range 2-11 ppm. Measurements made on laterite samples associated with the Nungbalgarri Volcanic Member of the Kombolgie Formation indicated uranium concentrations in the range 16-18 ppm and thorium in the range 14-18 ppm. These results confirmed the interpretation of the airborne data which showed high uranium-to-thorium ratio anomalies over laterites associated with the Gilruth Volcanic Member and lower ratio anomalies over laterites associated with the Nungbalgarri Volcanic Member.

Samples of bauxitic laterite from Cobourg Peninsula analysed for their uranium and thorium concentrations as a result of the airborne radiometric data showed good correlation between thorium anomalies and areas of bauxitic laterite. This finding was confirmed by the analytical results which indicated thorium concentrations in the range 35-54 ppm and uranium concentrations below 8 ppm.

Results from the 1971-72 airborne survey have been included in the following combined geological/geophysical papers written by BMR staff:

(1) The Alligator Rivers Region Environmental Fact Finding Study (BMR Record 1973/208).

(2) The AIMM Metals Volume (in press) (BMR Record 1974/17).

(3) The proceedings of an IAEA conference on the genesis of uranium (held in Athens, 1974) (BMR Record 1974/37).

Tennant Creek area airborne surveys review, NT (E. P. Shelley)

Brief records were prepared on the recontoured magnetic data from the 1960 regional survey, and on the data available from 1970 surveys in the Tennant Creek (detailed radiometric) and Bonney Well (regional magnetic and radiometric) 1:250 000 Sheet areas. No further progress was made on the review of the regional and detailed magnetic surveys.

Perenjori, Ninghan, Bencubbin, and Moora areas aeromagnetic survey, WA, 1972: interpretation (B. Wyatt)

An aeromagnetic survey of Perenjori, Ninghan, Bencubbin, and part of Moora 1:250 000

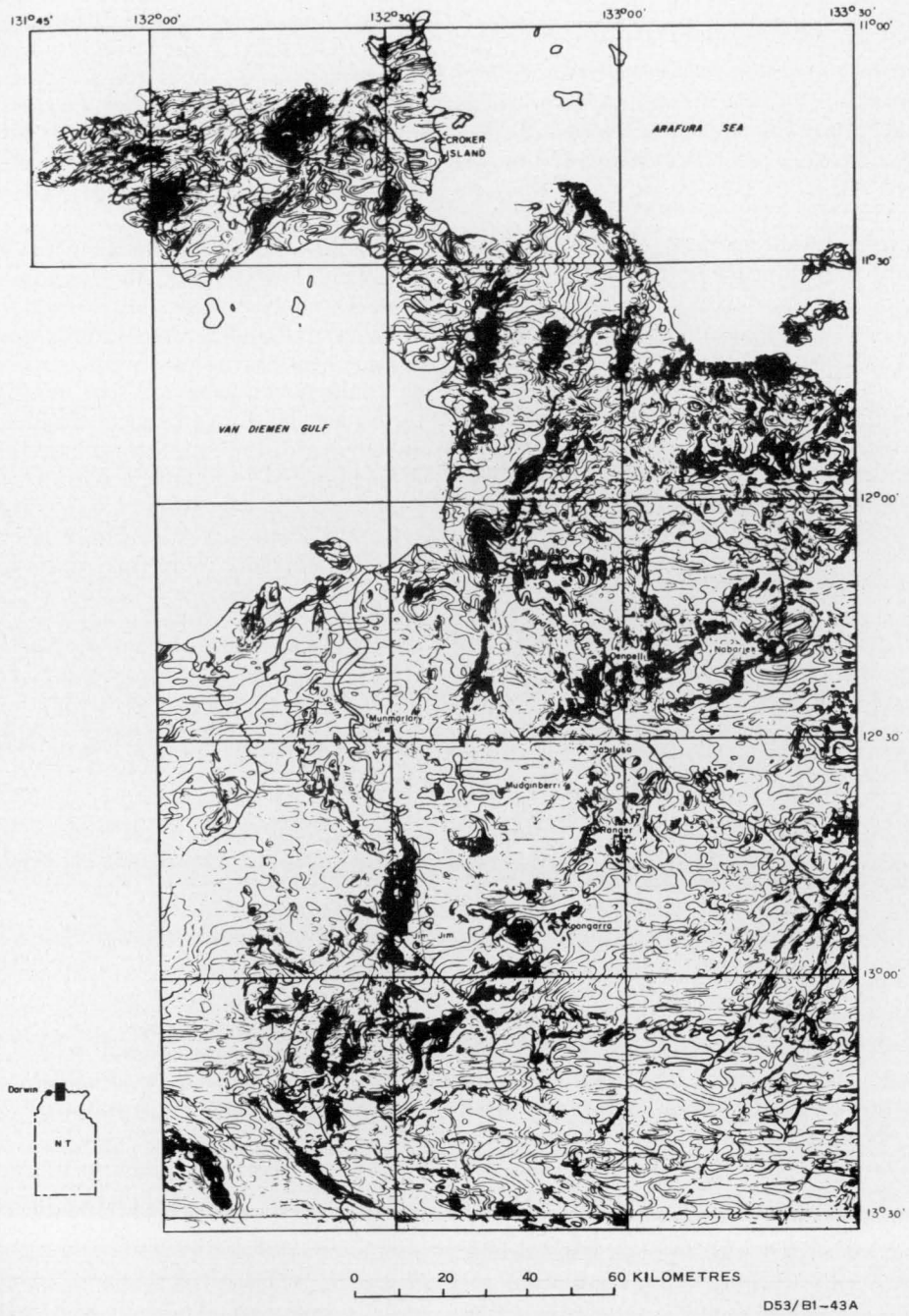


Fig. MA 11. **Alligator River region airborne survey 1971-72. Total magnetic intensity contours.**

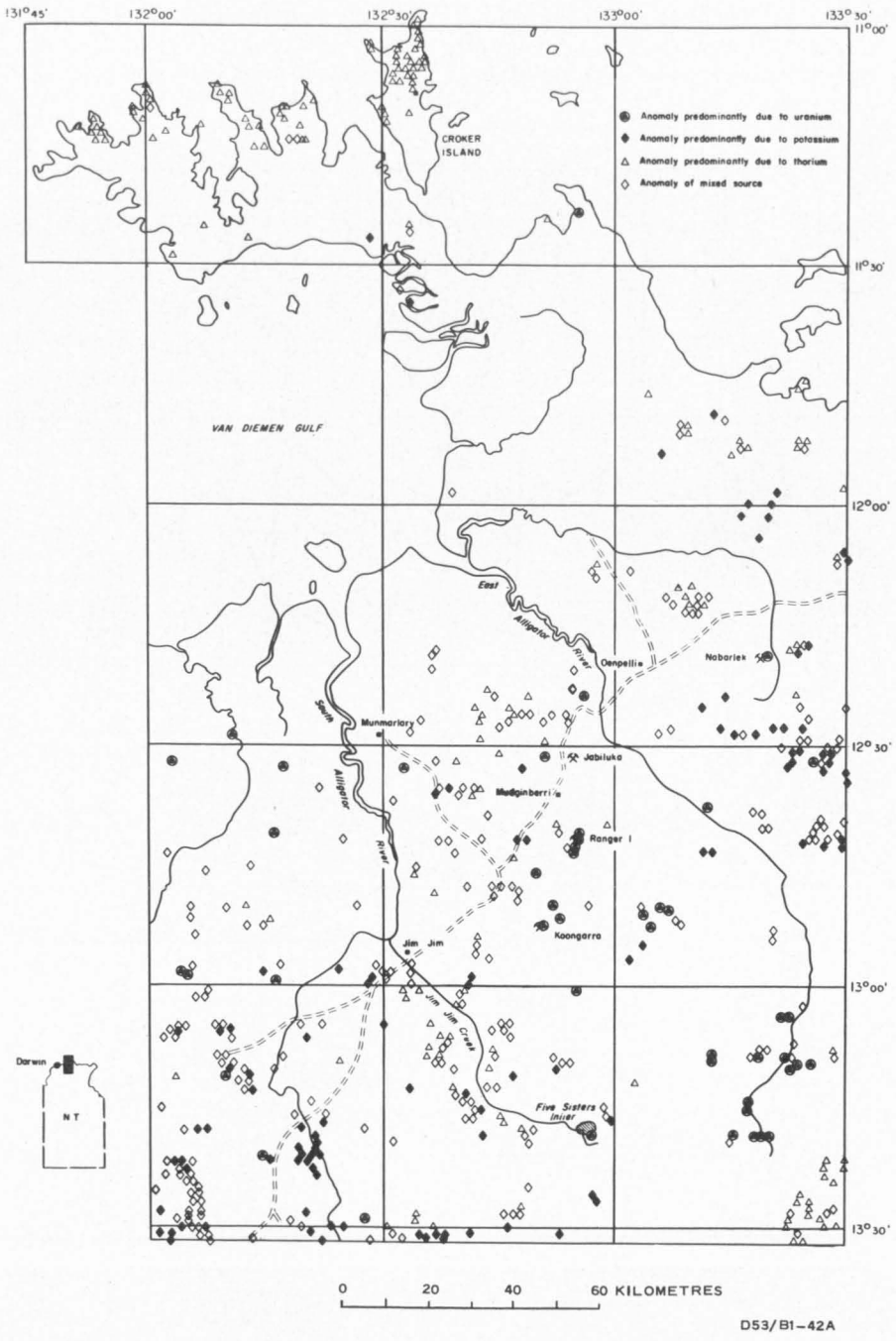


Fig. MA 12. **Alligator River region airborne survey 1971-72. Radiometric interpretation.**

Sheet areas was flown by Aero Service in 1972 under contract to BMR. The objectives of the survey were to assist the systematic regional mapping of the Western Australian Precambrian Shield and the search for minerals. The data were interpreted during 1974, and Figure MA 13 displays the results obtained.

The magnetic data have defined the major faults controlling the eastern edge of the Perth Basin and Irwin Sub-basin. Most of the Shield area is occupied by granite and gneiss. Banded iron formations give rise to large arcuate anomalies which reflect structure within greenstone belts and indicate possible

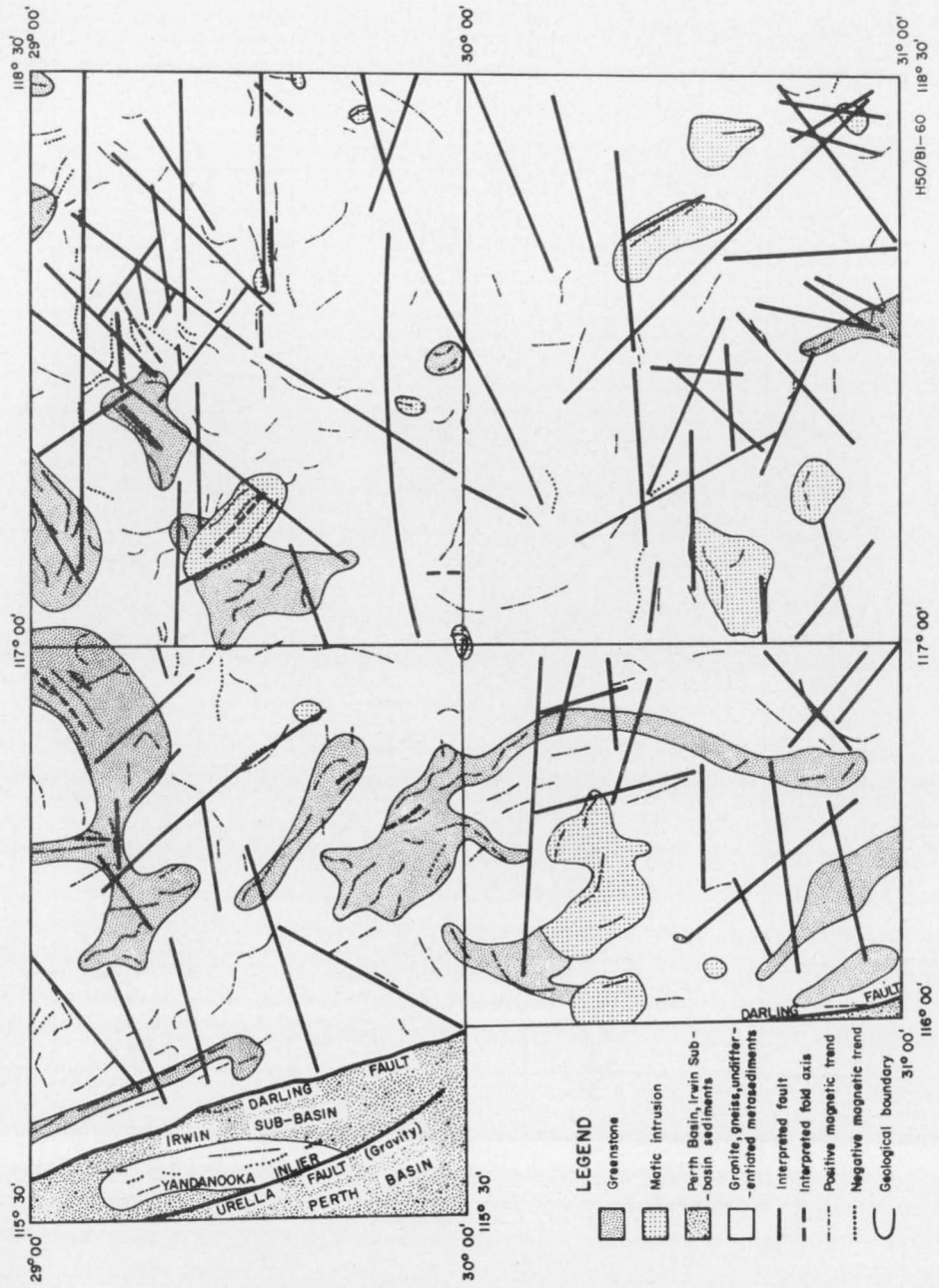


Fig. MA 13. **Perenjori, Ninghan, Bencubbin, and Moora 1:250 000 Sheet areas, WA. Magnetic interpretation and geology.**

extensions of known iron-rich formations. Several areas have been interpreted as being likely to contain mafic and ultramafic intrusives.

Most trends are north-northwest, parallel to the regional trend of the Yilgarn Block. Other trends in northeast and east directions are considered to be due to the doming effect of granite batholiths and the intrusion of basic dykes respectively. Most interpreted faults trend east to northeast, northeast, or northwest. Interpreted fold axes trend between northwest and northeast.

Areas recommended for further work include the more anomalous parts of the greenstone belts and the interpreted mafic or ultramafic intrusives.

Robinson Range, Peak Hill, Nabberu, Stanley, and Glenburgh areas aeromagnetic survey, WA, 1972: interpretation (B. Wyatt)

An aeromagnetic survey of Robinson Range, Peak Hill, Nabberu, Stanley, and part of Glenburgh 1:250 000 Sheet areas was flown by Aero Service in 1972 under contract to BMR. The objectives of the survey were to assist the systematic regional mapping of the Western Australian Precambrian Shield and the search for minerals. Interpretation of the survey results, commenced in 1973, was completed in 1974.

The magnetic data have defined the boundaries of most tectonic units in the area. The eastern edge of the Carnarvon Basin and the northern margin of the Yilgarn Block are fault controlled. Areas of greenstone within the Yilgarn Block are widespread and trends within these areas vary widely in direction. Within the Bangemall Group, north of the Yilgarn Block, trends are generally between west and west-northwest except near the margins of the Yilgarn Block, where they parallel the margin. Interpreted faults generally strike northeast or northwest. This pattern may be the result of the Bangemall Basin being compressed southwards against the Yilgarn Block.

Banded iron formations give rise to large arcuate anomalies which reflect structure and indicate possible extensions of known iron-rich formations.

Areas recommended for further work include the more anomalous parts of the greenstone belts in the Yilgarn Block and structurally deformed areas of banded iron formation and anomalous areas in the Nabberu and Stanley 1:250 000 Sheet areas.

Perth, Pinjarra, Kellerberrin, and Corrigin areas aeromagnetic survey, WA, 1972-73: interpretation (E. Olsen)

An aeromagnetic survey of the Kellerberrin and Corrigin, and part of the Perth and Pinjarra 1:250 000 Sheet areas was flown by Geosearch in 1972-73 under contract to BMR. The Cessna aircraft VH-KPF equipped with a proton-precession magnetometer was used for the survey. The aircraft was flown at an average ground clearance of 150 m along east-west lines spaced 1.5 km apart, data being recorded digitally.

Interpretation of these data commenced in 1974. Initial results indicate that the magnetic field is disturbed over much of the area, near-surface anomalies of several hundred gammas magnitude being quite common. The largest anomalies detected have magnitudes in the range 1000 to 3000 gammas, and are found northeast of Northam, northeast of Chittering, south of Manyup, northeast of Merredin, and in the vicinity of Corrigin. These anomalies are generally attributed to either mafic intrusives or greenstone areas.

Interpreted faults or discontinuities are generally north-northwest. Some easterly trends are also evident. The Darling Fault is clearly outlined by the magnetic data.

Gamma-ray spectrometry project (P. G. Wilkes and B. Wyatt)

The objectives of this project were to study, and make improvements and recommendations, in the areas of acquisition, processing, and interpretation of airborne gamma-ray spectrometry and related ground and laboratory measurements.

The project has been conducted under seven inter-related headings: airborne instrumentation, survey techniques, data processing, interpretation, calibration problems, ground radiometric surveys, and the laboratory determination of the radioelement content of rock samples.

Computer programs have been written to handle digital spectrometer data. These perform the following operations: background

subtraction, height correction, energy stripping, filtering, ratio calculation, and interfacing with BMR contouring programs. The programs have been used to produce examples of different types of output, e.g. profiles of various ratios and height-corrected total-count contour maps.

In conjunction with work in the Alligator Rivers area, rock samples have been analysed to determine their content of potassium, uranium, and thorium. The importance of this to the gamma-ray project was to establish which analytical techniques could be used for routine analysis of samples from test areas and ultimately from field surveys. Potassium analyses were obtained by atomic absorption analysis. Uranium analyses were made using X-ray fluorescence, delayed neutron, and gamma-ray analyses. Thorium analyses were obtained from X-ray fluorescence and gamma-ray analyses. Good agreement was obtained between uranium determinations made by X-ray fluorescence and delayed neutron analyses. Gamma-ray analyses did not agree closely with the other methods, but improvements in technique and data reduction should improve their accuracy.

Recommendations include the use of increased detector volume with the airborne spectrometers, a program of test flying to investigate the variation of non-geological background radiation as a function of ground clearance, and the evaluation of test areas. Ground radiometric measurements should be made on these areas and samples collected for analysis. It is also recommended that consideration be given to establishing calibration facilities for airborne and ground spectrometers.

Airborne Reductions and Contracts Group (C. O. Leary)

Program Development. Development work during the year was concentrated on establishing basic data management, processing, and presentation systems to support production requirements. A position has been reached now where some effort can be directed to the development of analytical and interpretative facilities for integration with the total data processing system to aid the geophysical interpretation of the massive volume of data being acquired and stored in the data base.

Specific areas of program development were: processing of data files from VH-BMG Doppler recovery, gradient adjustment, filtering, graphic plotting, correction of gamma-ray spectrometer data for height variation and Compton scattering effects, the production of gamma-ray spectrometer data ratios, mapping presentation, stacked profile presentation, automatic levelling and adjustment of data, composition diagram plotting, IGRF correction, refinements to the contouring package, and digitizing of flight-path recovery.

Documentation of programs and specification of the operating system are in progress. All plotting and digitizing are now done in-house employing BMR hardware facilities. Field tapes are processed with advantage by the ADP Section's HP2100 computer on which copying, verifying, and merging services have been provided.

Survey data processing. The staffing of the Reductions Group was restructured during 1974 to meet the current demands on routine data processing. Staffing restrictions have not enabled the restructuring to become fully effective and may lead to data production problems in 1975.

Production schedules were frustrated throughout 1974 first by the sudden loss of the CSIRO 3600 processing service and subsequently by the inevitable operational problems associated with the introduction of a new computer processing service operated by CSIRO.

The status of the processing and contour presentation of survey data expected as at the end of 1974 is shown in the Table. Additionally all generations of data are available as time-based profiles and the final data generation is expected to be available in stacked profile form where this is required.

Magnetic Map of Australia. The Magnetic Map of Australia compilation contract was awarded to Technical Computing and Graphics Pty Ltd in December 1973. The flow of all relevant materials to the contractor for the compilation work is on schedule. Problems have been encountered by the contractor with hardware installation and software development. This has necessitated a new production schedule to be drawn up which retains the final delivery date as September 1975.

TABLE: DATA PROCESSING AND PRESENTATION FOR 1974
P = PROCESS COMPLETE E = EDITING COMPLETE

PROJECT	MAP AREAS	SURVEY CONFIGURATION COVER						DATA STATUS		CONTOUR MAP PRESENTATION				REMARKS
		MAG	γ RAY	DOPPLER	LINE SPACING KM	ALTITUDE METRES	APPROX I	MAG	γ RAY	NO MAPS	SCALE	DATA	TYPE	
CARPENTARIA	CAPE MELVILLE	X	X	X	3	150AGL	5800	P	E	1	250 000	MAG		
	EBAGOOLA	X	X	X	1.5	150AGL	13000	P	P	1/1	250 000	MAG	γ RAY	
	HOLROYD	X	X	X	3/6	150AGL	6300	P	E	1	250 000	MAG		
	COOKTOWN	X	X	X	3/6	150AGL	6600	P	E	1	250 000	MAG		
	HANN RIVER	X	X	X	3	150AGL	7200	E	E					
	RUTLAND PLAINS	X	X	X	3/6	150AGL	6300	E	E					
LACHLAN GEOSYN.	WAGGA-WAGGA	X	X	X	1.5	150AGL	8800	P	E	2/3	250 000	MAG		
	CANBERRA/WAGGA	X		X	1.5	1700ASL	8800	P		4	100 000	MAG		SURVEY NOT COMPLETE
	BALLARAT	X	X	X	1.5	150AGL	13200	P	E	1	250 000	MAG		
	ST ARNAUD	X	X	X	1.5	150AGL	13200	E 1/2	E					
KOOLPIN FORMATION	ALLIGATOR RIVER PART	X	X	X	.5	80AGL	650	P	P 1/2	.5	50 000	MAG	γ RAY	JOINT PROJECTS WITH
	MT EVELYN PART	X	X	X	.5	80AGL	2650	P	P	1	50 000	MAG	γ RAY	METALLIFEROUS S/S
DARWIN URBAN DEV.	DARWIN PART	X	X	X	.5	80AGL	600	P	P	1/1	25 000	MAG	γ RAY	AND GEOLOGY BRANCH
ALLIGATOR RIVER	DARWIN/FOG BAY (PT.)	X	X	X	1.5	150AGL	13000	E	E 1/2					
	PINECK./CAPE SCOTT	X	X	X	1.5	150AGL	17000	E	E 1/2					
YILGARN	RASON/MINIGWAL	X			1.5	150AGL	24000	P		2	250 000	MAG		
	PLUMRIDGE	X			1.5	150AGL	12000	P		1	250 000	MAG		
	CUNDEELEE	X			1.5	150AGL	12000	P		1	250 000	MAG		CONTRACT
	PERTH/KELLERBERRIN	X			1.5	150AGL	16500	P		1 2/3	250 000	MAG		
										10	100 000	MAG		
	PINJARRA/CORRIGIN	X			1.5	150AGL	16500	P		1 2/3	250 000	MAG		
										10	100 000	MAG		
GROUND WATER	DENILIQUIN/JERILDERIE (PTS)	X			.5	150AGL	500	P		1	100 000	MAG		GOULBURN RIVER VALLEY FOR ENGINEERING SECTION
MAGNETIC MAP OF AUSTRALIA	HORSHAM/HAMILTON	X			10	450ASL	4500	P		1 1/2	500 000	MAG		
	NARRANDERA/HAY	X			10	300ASL	4500	P		1 1/2	500 000	MAG		
	DENILIQUIN/JERILDERIE	X			10	300ASL	6000	P		2	500 000			
	INFIL VARIOUS AREAS	X			10	450ASL	16000	P		5 1/3	500 000	MAG		
	OUYEN/SWAN HILL	X			8	450ASL	6000	P		2	500 000	MAG		DIGITIZED FROM
	HORSHAM (PT.)	X			8	450ASL	6000	P		1/2	500 000	MAG		MURRAY BASIN SUBSIDY SURVEY
	CONTROL DATA TRAVERSES	X				750ASL	5000	P						CONTRACT DATA
W.A. 1972 γ RAY	GLENBURGH (PT.)		X		1.5	150AGL								
	ROBINSON RANGE (PT.)		X		1.5	150AGL	31000		E 1/2					CONTRACT DATA
	PEAK HILL (PT.)		X		1.5	150AGL								
EUCLA BASIN	COOMPANA/NULLARBOR	X	X	X	1.5/3	150AGL	24150	P	E	2	250 000	MAG		FOR S.A. MINES
	FOWLER/NUYTS (PT.)	X	X	X	1.5/3	150AGL		P	E	1	250 000	MAG		

Projects related to the map compilation are as follows:

(1) A contract to fly control traverses was awarded to Geometrics in October 1973 to supply absolute total-field magnetic data to which magnetic mapping could be tied. Final delivery of these data was taken in

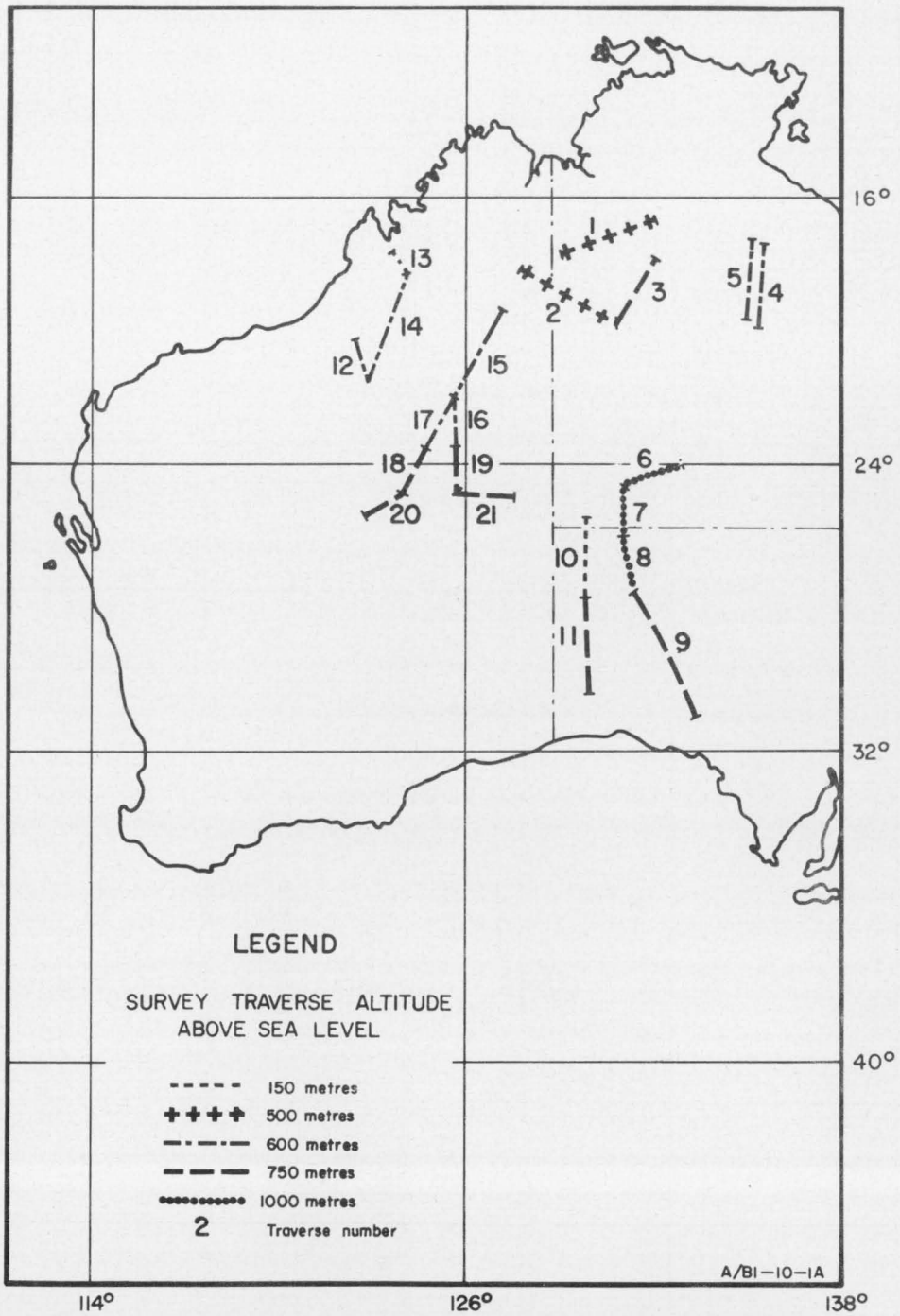


Fig. MA 14. **Aeromagnetic traverses for the acquisition of absolute total magnetic intensity data.**

September 1974. The approximate locations of the traverses are shown in Figure MA 14.

(2) Regional aeromagnetic infill surveys were flown by BMR's aircraft VH-BMR and VH-BMG in two areas in NSW and Victoria originally devoid of reconnaissance coverage. These areas as shown in Figure MA 15 were flown at 10 km line spacing with ground clearances between 100 and 500 m. The data acquired will be contoured at the scale of 1:500 000 and released by BMR in 1975.

(3) Residual magnetic data (the difference between observed and International Geomagnetic Re-

Fig. MA 15. Fill-in flying, 1974, for the Aeromagnetic Map of Australia.

ference Field values in the year of observation) have been compiled from data acquired by the Marine, Observatories, and Airborne Sections. These residual data have been supplied to the compilation contractor to use as levelling control.

Officer Basin, WA. The major contract survey planned for 1974 was the acquisition of 132 436 line-km of aeromagnetic data over the Officer Basin (Fig. MA 16). The contract was awarded to AMEG Pty Ltd in March 1974 after numerous delays. The contractor sought an amendment to the contract to recognize the escalation of costs since it first submitted a tender in 1973, and an appropriate amendment was duly issued in May 1974. The contractor subsequently encountered difficulties financing the operation in the credit conditions operative in mid-1974 and accordingly sought to withdraw from the contract in August 1974. The Central Contract Board approved the cancellation of the contract on 24 September 1974 and this was finally ratified on 22 October. It is hoped that a new contract will be awarded by early 1975, to enable the project to proceed and be completed in 1975.

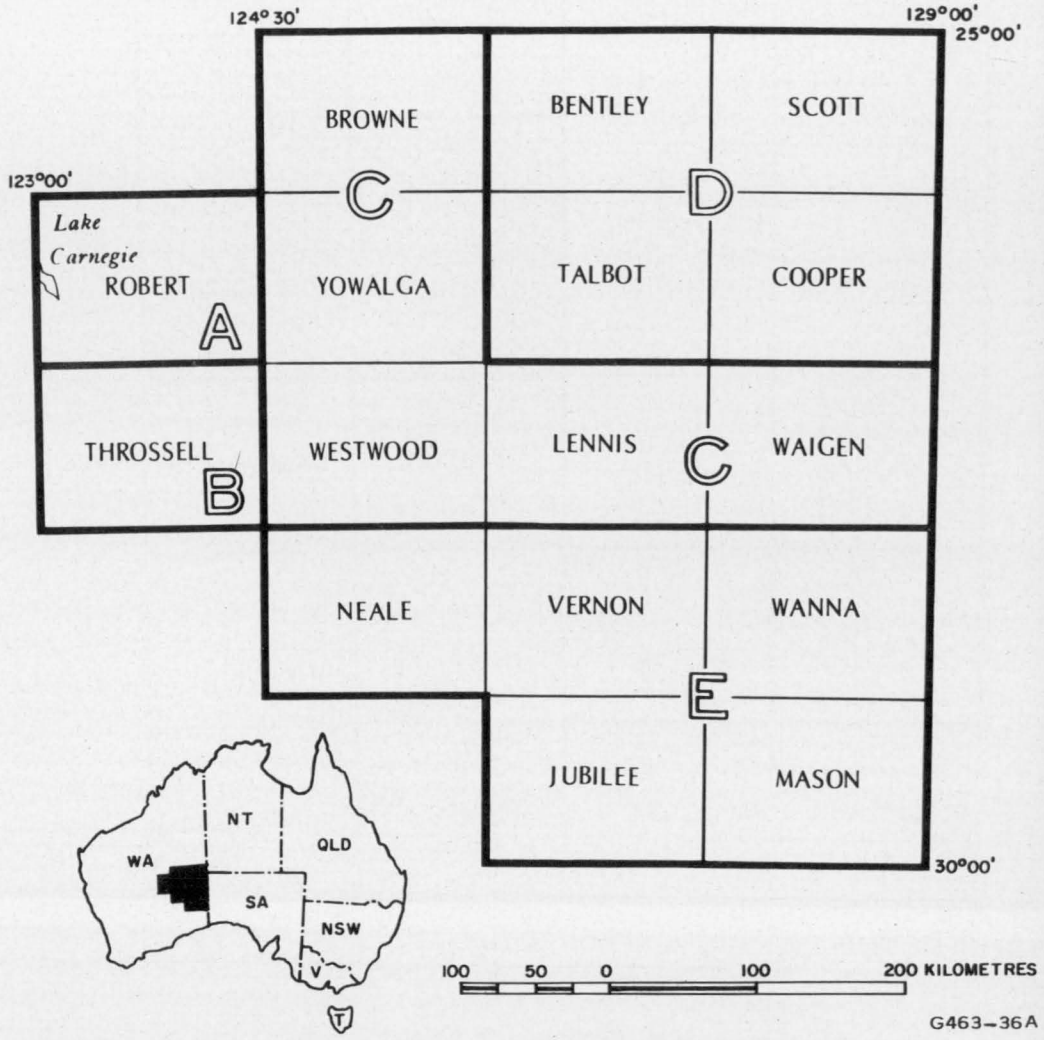


Fig. MA 16. **Officer Basin contract aeromagnetic survey.**

2. SEISMIC, GRAVITY AND MARINE SECTION
(A. Turpie)

Little field work was done by the Section during 1974. The only major survey was the helicopter reconnaissance gravity survey of New South Wales, Victoria, and Tasmania made under contract by Wongela Geophysical. The major tasks in the Section were the assessment and processing of data and the interpretation of results from the Continental Margin survey, 1970-73. These tasks will continue through 1975. Some professional and technical staff from Seismic and Gravity Groups continued to work in the Marine Group to supplement the effort there. The Seismic and Gravity Groups continued to work largely on interpretation and reporting of results from previous surveys, and the backlog of such work was much reduced. Some reviews of previous work were also conducted, particularly of seismic work in the Eromanga Basin in joint projects with Geological Branch and of seismic work in other sedimentary basins towards the formulation of new programs. Both Seismic and Marine Groups face major tasks in the formulation of and preparations for future programs. following the engrossment of the Section with the Continental Margin survey in recent years and with the changing emphasis in exploration.

This year's survey of New South Wales, Victoria, and Tasmania completed the helicopter gravity reconnaissance survey of the Australian mainland; also all of the helicopter gravity reconnaissance surveys from 1963 onwards have had principal facts listings reduced to standard format on magnetic tape.

Seismic Surveys (F. J. Moss)

The areas covered by the reports and reviews done by the Seismic Group are shown in Figure SGM 1.

Explosives comparison test survey, Waaia, Victoria, 1974 (S. P. Mathur, G. L. Abbs)

Further examination of the results of the tests made at Jervis Bay, ACT, in 1973 on the seismic efficiency of Anzite Blue, Geophex, and TNT indicated that incomplete detonations of the TNT and insufficient comparisons had led to inconclusive results. More tests were made at the start of the Goulburn Valley survey to compare the seismic efficiency of Molanite, TNT, and Anzite Blue.

Seismic signals generated by equal amounts of these explosives in shot-holes were recorded under identical conditions, and the amplitudes of the refracted and reflected waves were measured and compared. Molanite and Anzite Blue are equally efficient but TNT is about 10 percent less efficient. The TNT is less plastic than Molanite and Anzite Blue and thus it is more difficult to load in shot-holes. Slightly larger charges of TNT would be required to produce the same energies as the other explosives tested, and more drilling and handling of explosives would be required. Cost comparisons indicate that there is no obvious saving in using TNT instead of the safer proprietary brand seismic explosives.

Northern and western Eromanga Basin, Qld (P. L. Harrison, J. Bauer, L. E. Hemphill)

Seismic survey results obtained by BMR and private companies in the northern and western Eromanga Basin were examined. The locations of seismic traverses were plotted on maps at 1:100 000 scale. Structure contour maps of the base of the rolling Downs Groups (the Cretaceous/Triassic boundary) and the base of the Eromanga Basin sequence were compiled by integrating the seismic information from the survey reports with well and borehole data.

The seismic results from the basins below the Eromanga Basin were examined briefly during the review. The seismic data at large depths are generally of poorer quality than the Eromanga Basin data, and no attempt has been made to draw structure contour maps of the deeper sedimentary formations. Areas with possible thick sedimentary sections have

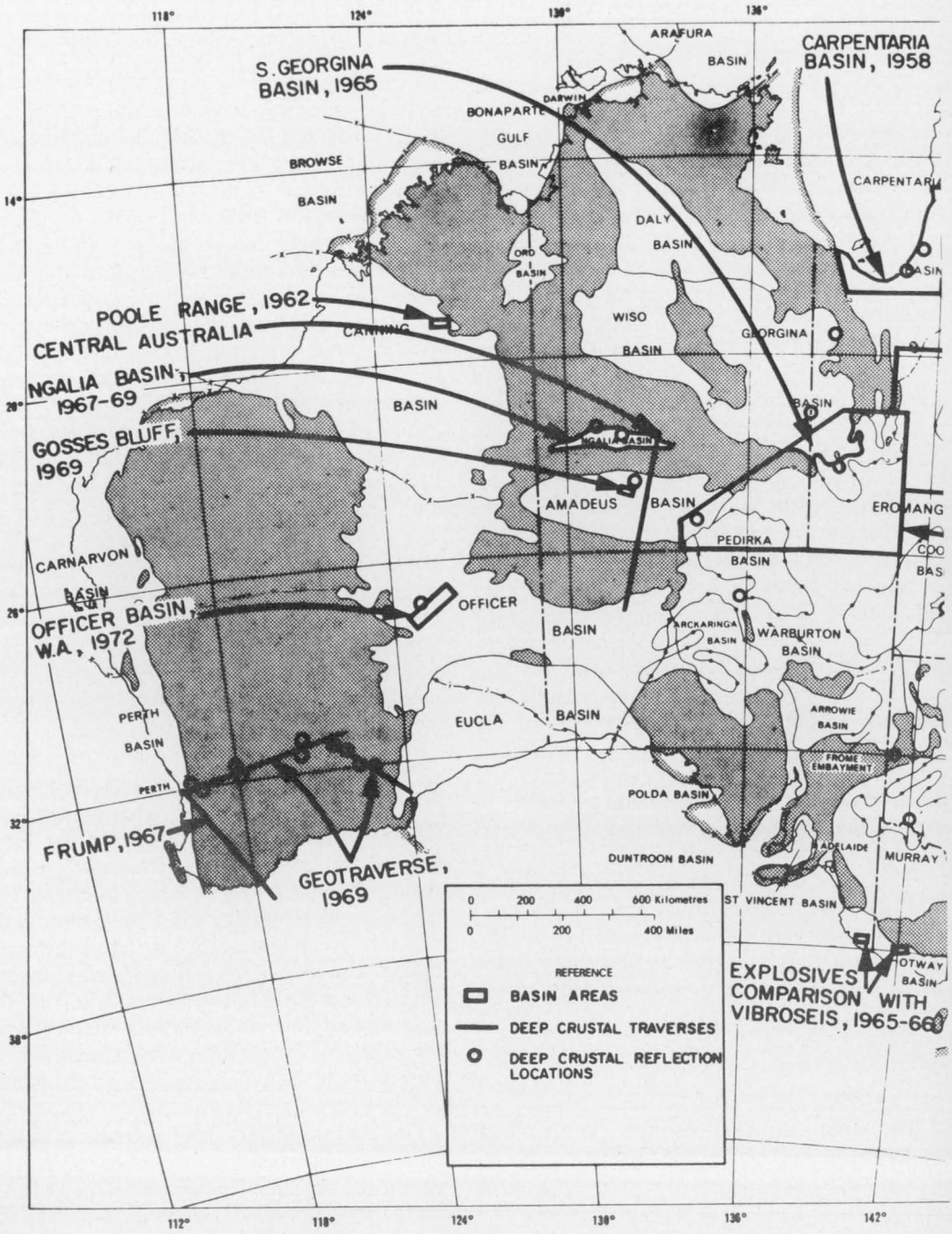
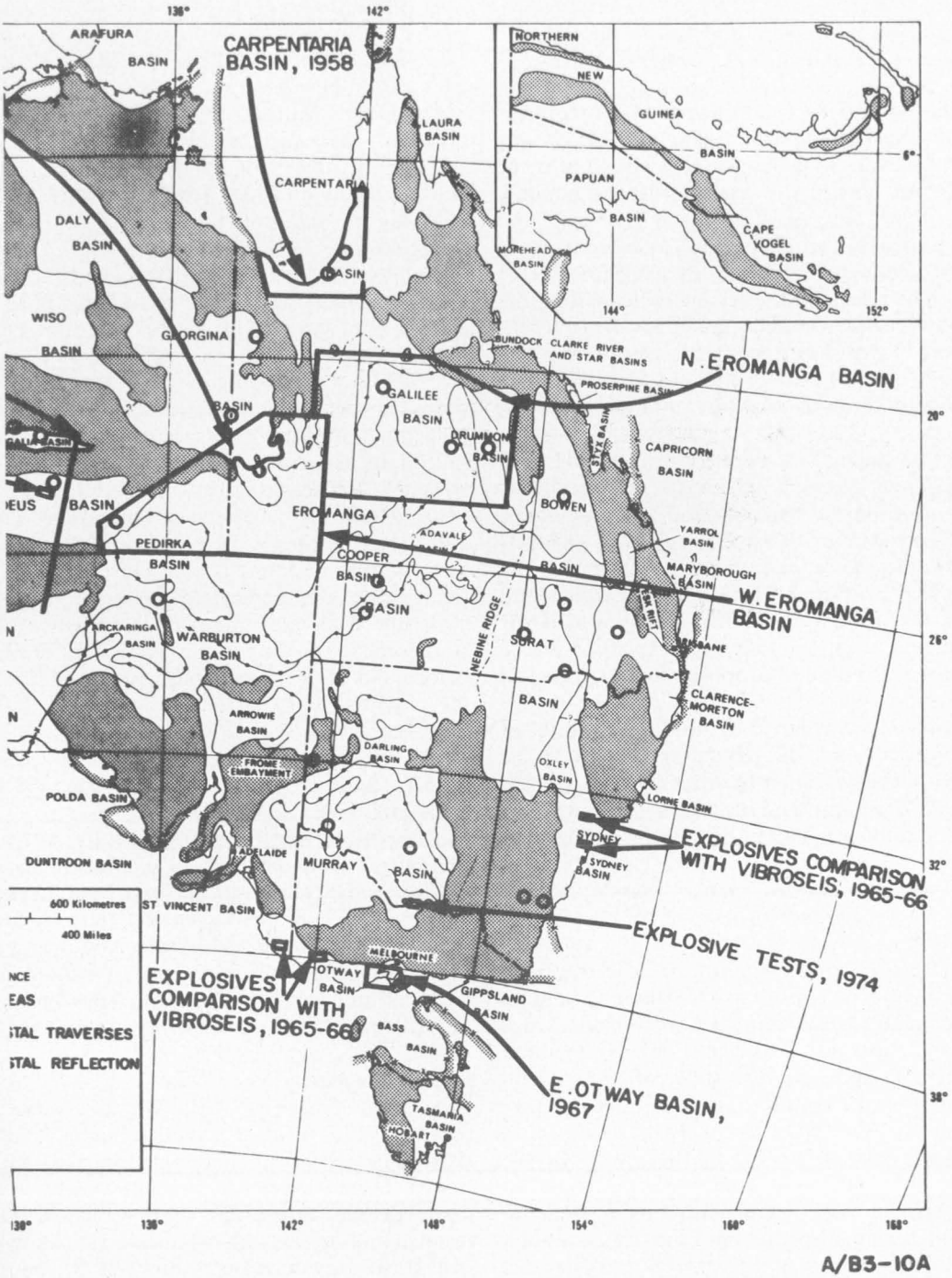


Fig. SGM 1. Areas covered



by seismic reviews and reports.

been noted and will be considered in proposals for more detailed studies and further seismic surveys.

Long-term seismic program review (S. P. Mathur, J. Bauer, G. L. Abbs, F. J. Moss)

A brief review of existing geological and geophysical information in all major sedimentary basins in Australia was made to assess the deficiencies in geological knowledge in those areas where further seismic surveys, possibly by BMR, may assist in solving geological and geophysical problems and to determine seismic techniques required for such surveys.

The results of the review indicate that in a few basins, including the Wiso, Daly River, and Ord Basins, reconnaissance seismic surveys are still required to obtain basic information on the structure and thickness of sediments, and that detailed seismic surveys using high-effort recording techniques are required in most basins to provide information on the structure and lithology of the sediments, on subsurface relations to overlapping basins, and on basin margins.

It is proposed to continue this review and make firm proposals for a long-term BMR seismic program, related wherever possible to past, current, and proposed BMR geological mapping projects. The preliminary review points particularly to the poor state of knowledge of the extent and form of the deeper basins under the Great Artesian Basin, and it is proposed to make more detailed studies of the geophysical results in this area.

Deep crustal and upper mantle seismic reflection/refraction studies (F. J. Moss, S. P. Mathur)

Records on a proposal for a deep seismic sounding survey in central Australia, and its cost, have been completed and issued.

A paper on the results of an integrated seismic and gravity study of the crustal structure in southwestern Australia was prepared for publication in *Tectonophysics*. A more detailed report on the results of the seismic survey on the Geotraverse is in preparation for publication as a Bulletin. Further detailed studies of the reflection data prepared in a statistical form add considerable support to the interpretation based mainly on the refraction and gravity data.

Work continued on the compilation of the results from the deep seismic reflection soundings made during normal seismic survey operations.

Gosses Bluff (D. J. Milton of USGS; F. J. Moss, P. L. Harrison)

Dr D. J. Milton, the principal USGS geologist working on this project, visited BMR for three months during which he collaborated with BMR geophysicists in contributing to the Bulletin on the joint investigation.

An investigation was made of the near-surface velocity variations caused by brecciation and weathering of rocks within the disturbed zone outside the uplifted area. Time corrections were applied to take account of the effect of these variations on the deeper reflections resulting in advancement of these reflections and modification of the apparent structure. Reflection record cross-sections are being produced by applying corrections to successively bring each principal reflecting horizon to a horizontal position in an attempt to recreate the geological history of the structure. This is of importance not only in studies related to the structure of Gosses Bluff before and after impact, but in determining the potential of the structure for petroleum prospects.

Seismic data processing (G. L. Abbs, W. Trenchuk, L. E. Hemphill)

The work carried out involved the use of the SIE MS-43 analogue playback equipment and marine tape-transcription and playback equipment. Seismic cross-sections were processed for a number of projects on which reports and reviews were made, including Gosses Bluff, East Otway Basin, Wiso Basin, and Laura Basin.

Seismic equipment

An order has been placed for an 'Aquatronics' Telseis Radio Telemetry System. The six-channel seismic system will be used in survey areas where the use of cables is impracticable, to preview seismic refraction results, and to extend expanded reflection spreads to provide velocity information. The equipment has other applications including land-marine ties in shallow water areas in-

accessible to normal marine seismic surveys. The receiver can also be used in association with sonobuoys.

Gravity Surveys (F. J. Moss, A. R. Fraser)

The reconnaissance gravity survey of Australia was completed during the year when parts of NSW, Victoria, SA, and Tasmania were surveyed by contract. In addition to supervising the contract survey, the Gravity Group staff completed reporting on a number of previous reconnaissance and semi-detailed gravity surveys, reported on gravity survey techniques and equipment and completed the processing of gravity data from previous reconnaissance surveys. The areas covered by the Group's activities are shown in Figure SGM 2 and the completed preliminary Bouguer anomaly map of Australia is shown in Figure SGM 3.

Contract reconnaissance helicopter gravity survey, NSW, Vic, SA & Tas, 1973-74 (I. Zadoroznyj, A. R. Fraser)

Flying of the survey area began in November 1973 and continued to June 1974. By September, all preliminary 1:250 000 Bouguer anomaly contour maps had been drawn. Follow-up flying to check suspect readings and increase the station density over local anomalies of interest is scheduled for late 1974.

7658 new readings were made, mostly at 11 km spacing but at 7 km spacing in Tasmania, in Broken Hill and Menindee 1:250 000 Sheet areas in NSW, and in Pinnaroo and Renmark 1:250 000 Sheet areas in SA. A wide variety of operational problems were encountered by the survey party. Topography ranged from flat open plains to rugged mountainous terrain, vegetation from sparse scrub growth to dense forests, and population density from remote pastoral districts to large cities and towns. Landing sites for the helicopter were difficult to find in the forested mountainous regions of eastern Victoria, and some stations were established well away from their planned positions. Gravity stations in the suburbs of Sydney and Melbourne were established by road traversing.

The preliminary Bouguer anomaly contours indicate a number of regional gravity features of tectonic interest. These include a region of low gravity covering a large part of southeastern NSW and northeastern Victoria, a large Bouguer anomaly rise towards the NSW coastline, and a broad north-trending gravity ridge in central NSW flanked by a gravity trough to its west. The Willyama and Wonaminta Blocks in western NSW are represented by north-trending slightly arcuate gravity highs which are separated by an elongate gravity depression corresponding to the Bancannia Trough. Contour trends over NSW and Victoria generally reflect north-northwest trends in the Lachlan Geosyncline except in southwestern NSW, where the contour trend is northeast. In Tasmania, Bouguer anomalies increase from negative inland to positive at the coast.

Gravity survey reporting projects (A. R. Fraser, I. Zadoroznyj, W. Anfiloff)

Reports were completed on several reconnaissance, semi-detailed, and detailed surveys. The major reports are as follows:

Reconnaissance helicopter gravity survey, Northern Queensland, 1966. The report includes brief summaries of the survey operations and results, and comprehensive lists of references on previous geological and geophysical work in the survey area.

Reconnaissance helicopter gravity survey, Canning Basin, WA, 1968. A qualitative interpretation of the gravity field over the southeastern part of the Canning Basin is given.

Reconnaissance helicopter gravity survey, SA, 1970. The report discusses the gravity field in the western part of SA covering parts of the Musgrave and Gawler Blocks and parts of the Officer and Eucla Basins.

Reconnaissance helicopter gravity surveys, WA, 1971-72 and in the northwest and southwest of WA, 1969. Revisions were made to Records for publication as Reports.

Gravity survey along seismic lines in the north Eromanga Basin, 1967. Gravity results along seismic lines were interpreted and it was concluded that gravity relief is caused mainly by basement density variations rather than basement topography.

Kalgoorlie detailed gravity survey, WA, 1973. The survey in southwest WA consisted of widely separated semi-detailed traverses across interesting gravity features indicated by the reconnaissance gravity survey over the Yilgarn Block and the Albany-Fraser Province. Results were interpreted with the aid of the reconnaissance data and 1:250 000 geological maps of the survey areas. Local gravity highs in the Yilgarn Block are correlated with basin metamorphics, 3 to 5 km thick, which in places contain acid intrusives. Local gravity lows in the same areas are associated with granite. A major gravity high over Fraser Range is interpreted as being caused by a basic granulite block thrust at

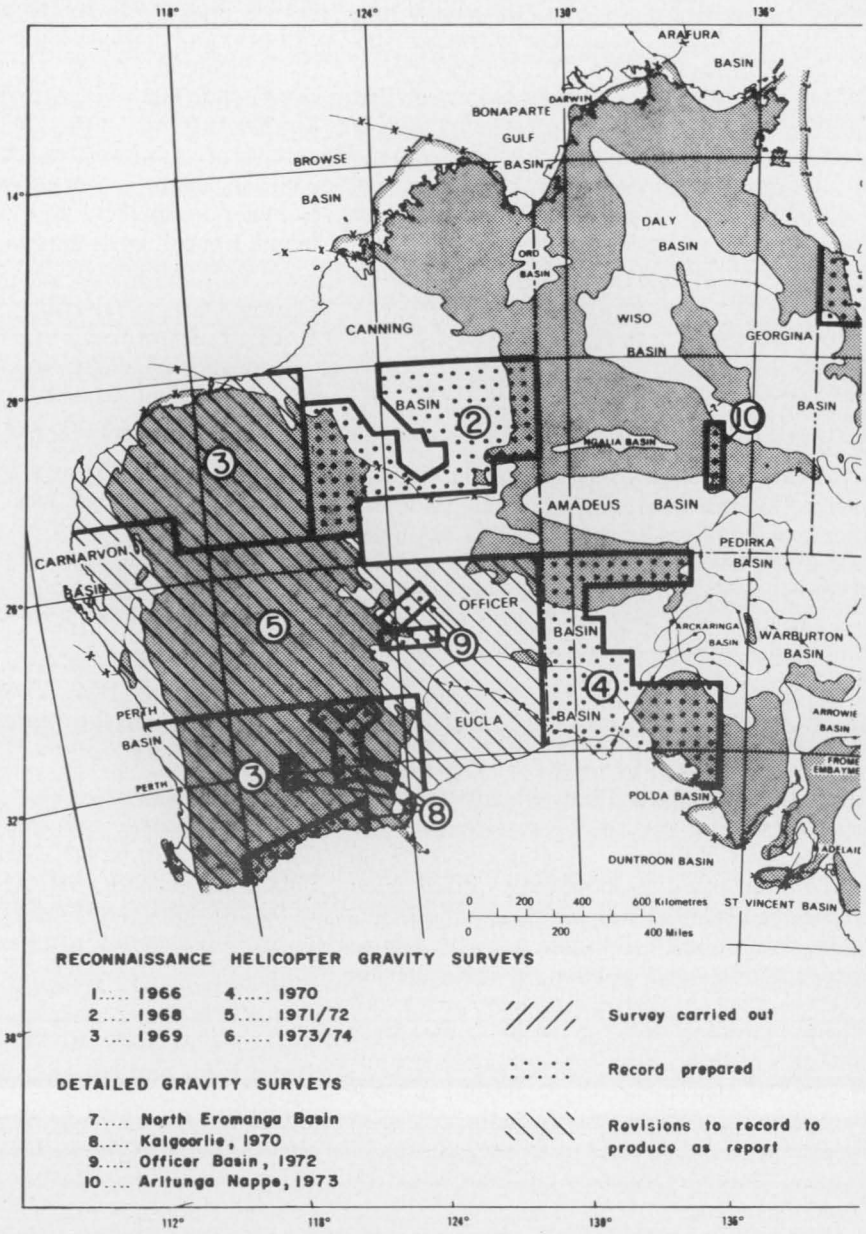
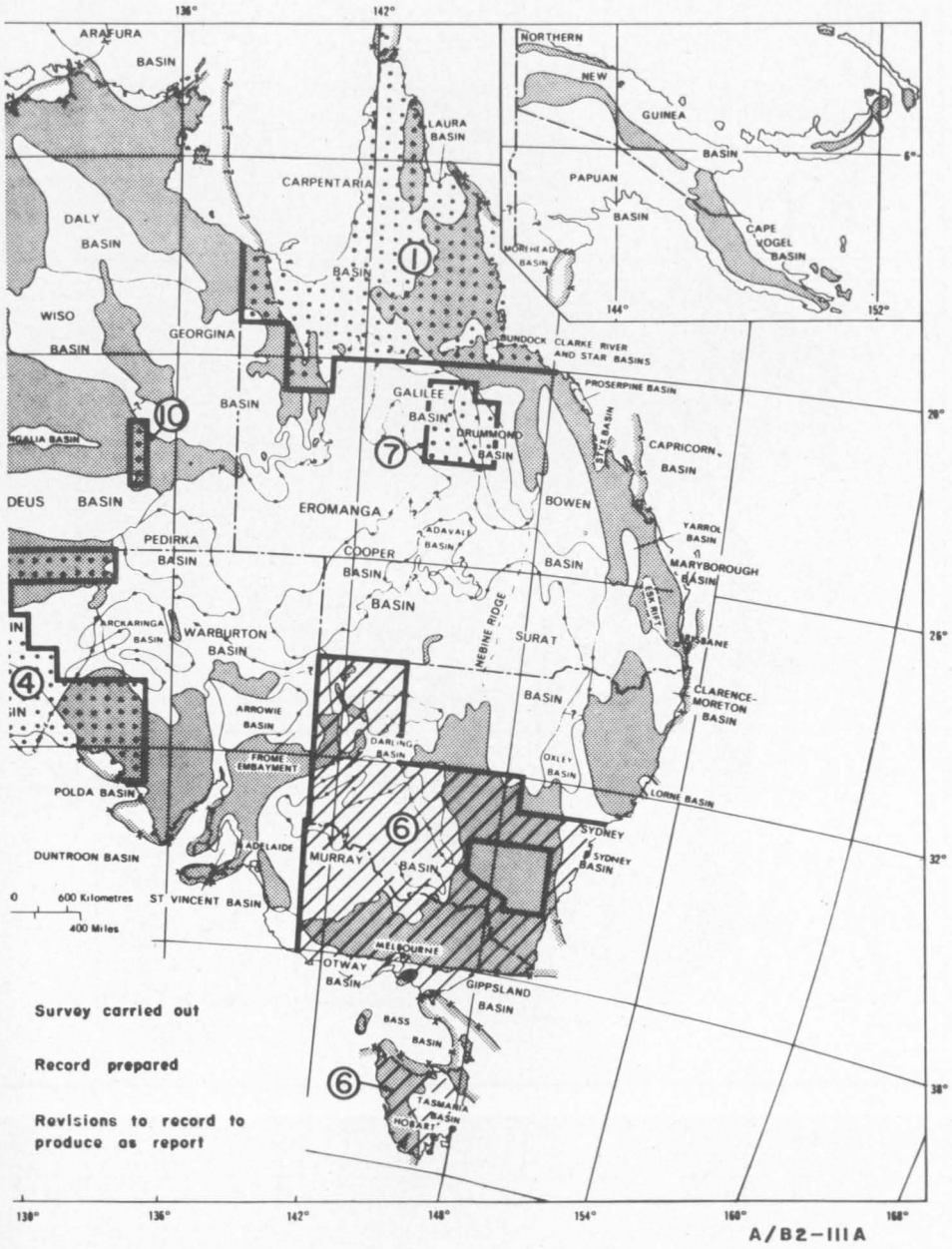


Fig. SGM 2.

least 4 km up through granitic rocks, without any apparent present-day dislocation in the lower crust. The width of the gravity high is approximately equal to the mapped width of the granulite on the surface, suggesting that there are large horizontal density contrasts in the near-surface zone or that the granulite body has a near-vertical attitude. The bulk density of the Fraser Range granulite was calculated to be 2.962± 0.012 g/cm³ using a profile matching technique. The results of the surveys appear to support the idea that rocks in the Albany, Esperance, and Fraser Range areas are part of a single tectonic unit.

Arltunga Nappe detailed gravity survey, NT, 1973. The interpretation of a detailed gravity



Gravity survey coverage.

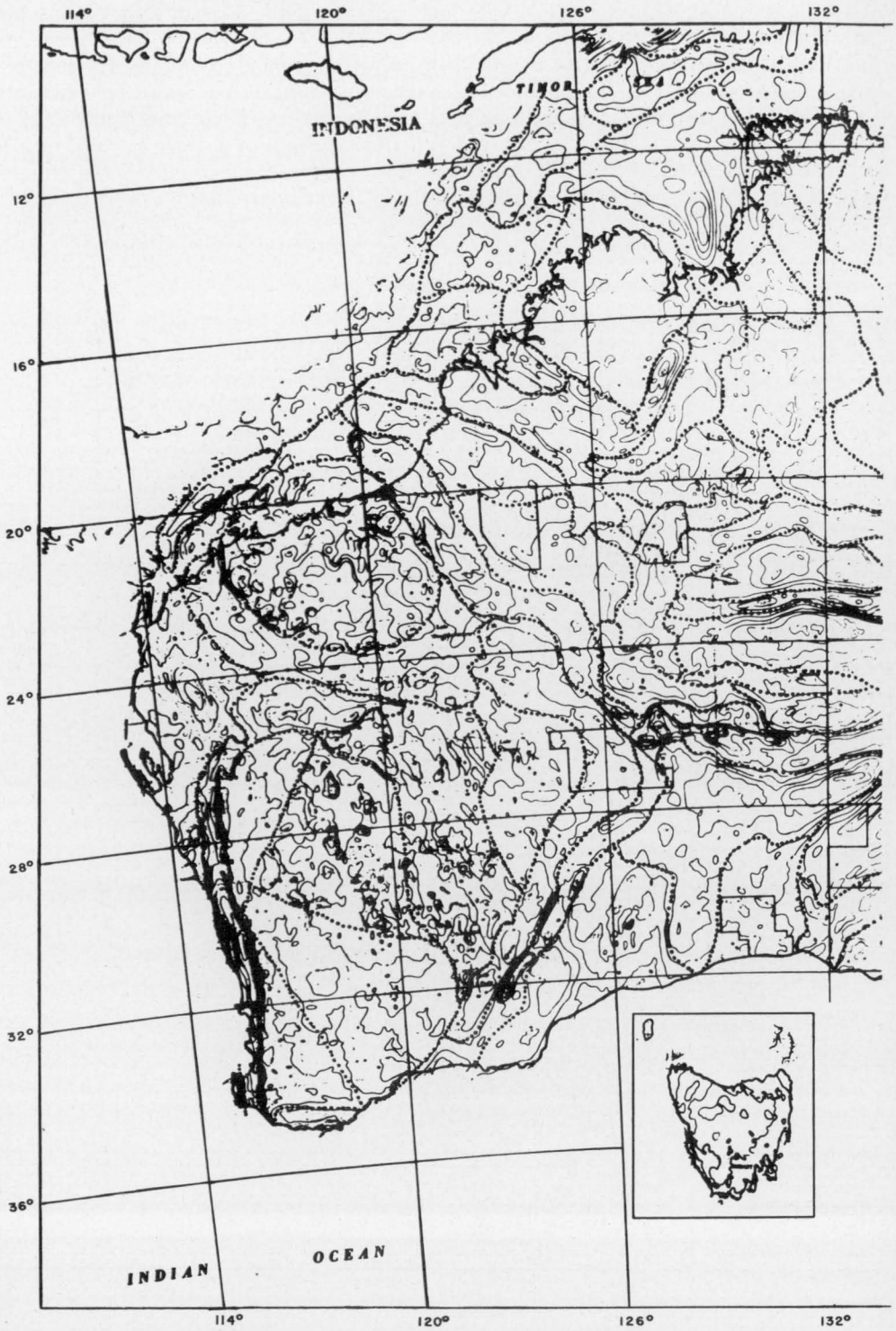


Fig. SGM 3. Preliminary Bouguer

anomaly contours and gravity provinces.

profile across the northern edge of the Amadeus Basin, the Arltunga Nappe, and part of the Arunta Complex (Figs. SGM 2 and SGM 4) suggests that there is no deformation of the basement beneath the Arltunga Nappe, and that the Nappe may therefore have been moved from the north along the Arltunga Thrust. This thrust plane appears to dip at a very low angle. Another thrust, the Riddock Thrust, is identified and linked with the uplift of the Harts Range. A multiple density profiling technique gave a density estimate of 2.85 g/cm^3 for the 350-m high Harts Range, a value which appears to hold for the bulk density of the Arunta Complex metamorphics in the area. Three anomalous bodies are identified within the Arunta Complex, the largest of which is deduced to be a 15-km-wide zone of dense subcropping possibly ultrabasic rocks. The Arunta Complex north of the Arltunga Nappe is known to be a zone of major Proterozoic uplift, but the small gravity anomaly over it precludes the possibility of corresponding major lateral density variations at depth. It is suggested that the density irregularities at depth caused by major upthrusting in the Proterozoic have since been removed by processes such as phase change and diffusion.

Gravity review projects (W. Anfiloff, J. Bauer)

A review was undertaken of the gravity coverage of Papua New Guinea to determine the areas in need of further reconnaissance coverage at 11 km or closer spacing. An area equal to about six 1:250 000 Sheet areas was delineated, mainly in the northern and central highlands, and it is estimated that the completion of coverage by helicopter would take no more than about 1000 flying hours.

W. Anfiloff reviewed the gravity of central Australia and the Fraser Range area in WA, and, with R. D. Shaw, completed a paper on the gravity effects of the Arunta, Musgrave, and the Fraser Range granulite blocks.

Processing and computation of reconnaissance helicopter gravity data (W. Anfiloff, J. C. Allen, O. Terron)

Processing and computation of reconnaissance helicopter gravity data were completed. The work included the complete reduction of data from the 1963 and 1967 surveys, the partial recomputation of data from the 1971-72 survey, and the extensive checking of the 1964, 1966, 1968, and 1969 data. Updated listings of principal facts on magnetic tape were then forwarded to Regional Gravity Group for retention. The Gravity Group is engaged in production of machine-contoured 1:1 000 000 maps at 5-mGal contour interval over unit blocks of nine 1:250 000 Sheet areas from which drawing office staff are producing a 1:5 000 000 map for publication.

MARINE SURVEYS (R. WHITWORTH, F. W. BROWN)

Continental margin survey, 1970-73, and Gulf of Papua and Bismarck Sea survey, 1970

The Marine Group continued to work on assessment, processing, and display of the data, and interpretation and reporting of the results, from these surveys carried out by Compagnie Générale de Géophysique (CGG) under contract. Under the terms of the contract, data processing through to production of final maps was the responsibility of CGG, but with large involvement of BMR personnel in paralleled tasks. Before 22 October 1973, a planned program of work was under way with assignment of BMR and CGG personnel such that CGG might have been expected to finish their work on the processing of the gravity, magnetic, bathymetric, and navigation data by mid-January 1974. Circumstances were such at that time that there were marked advantages to be seen for BMR, both financially and in achieving better control of priorities, by delaying this program. BMR therefore took over responsibility for completing the data processing and CGG were allowed to complete their commitment on data processing in mid-January as expected.

The financial advantage was seen as accruing from transfer of the data processing from the CDC 6600 computer in Sydney to CSIRO's new Cyber 76 system in Canberra. This transfer has not taken place without difficulties and is still proceeding. Little production has been done and mostly the work during the year has been on further assessment of data and development of new programs. Also and most importantly a greater

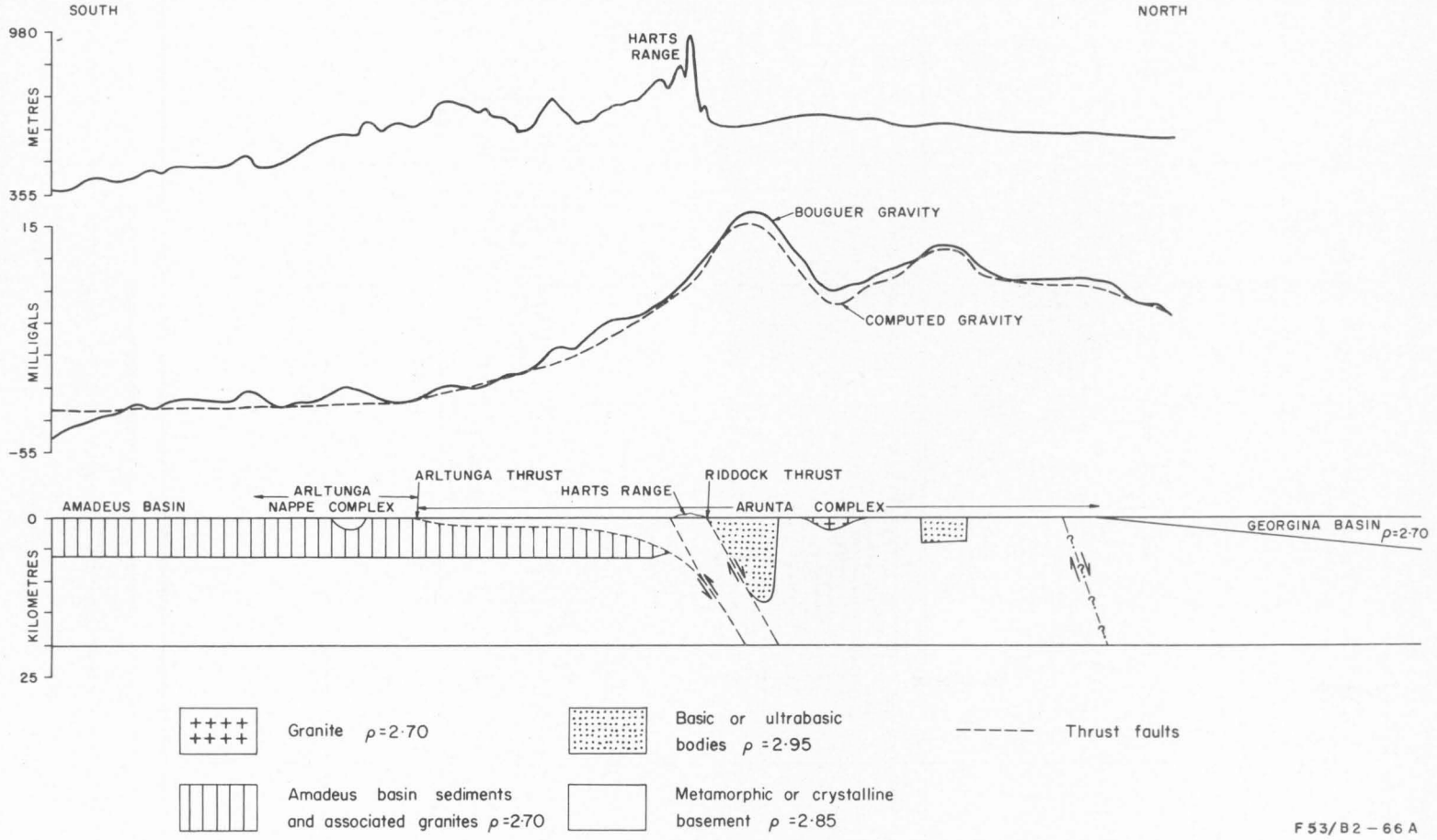


Fig. SGM 4. **Arltunga Nappe gravity survey. Structural interpretation.**

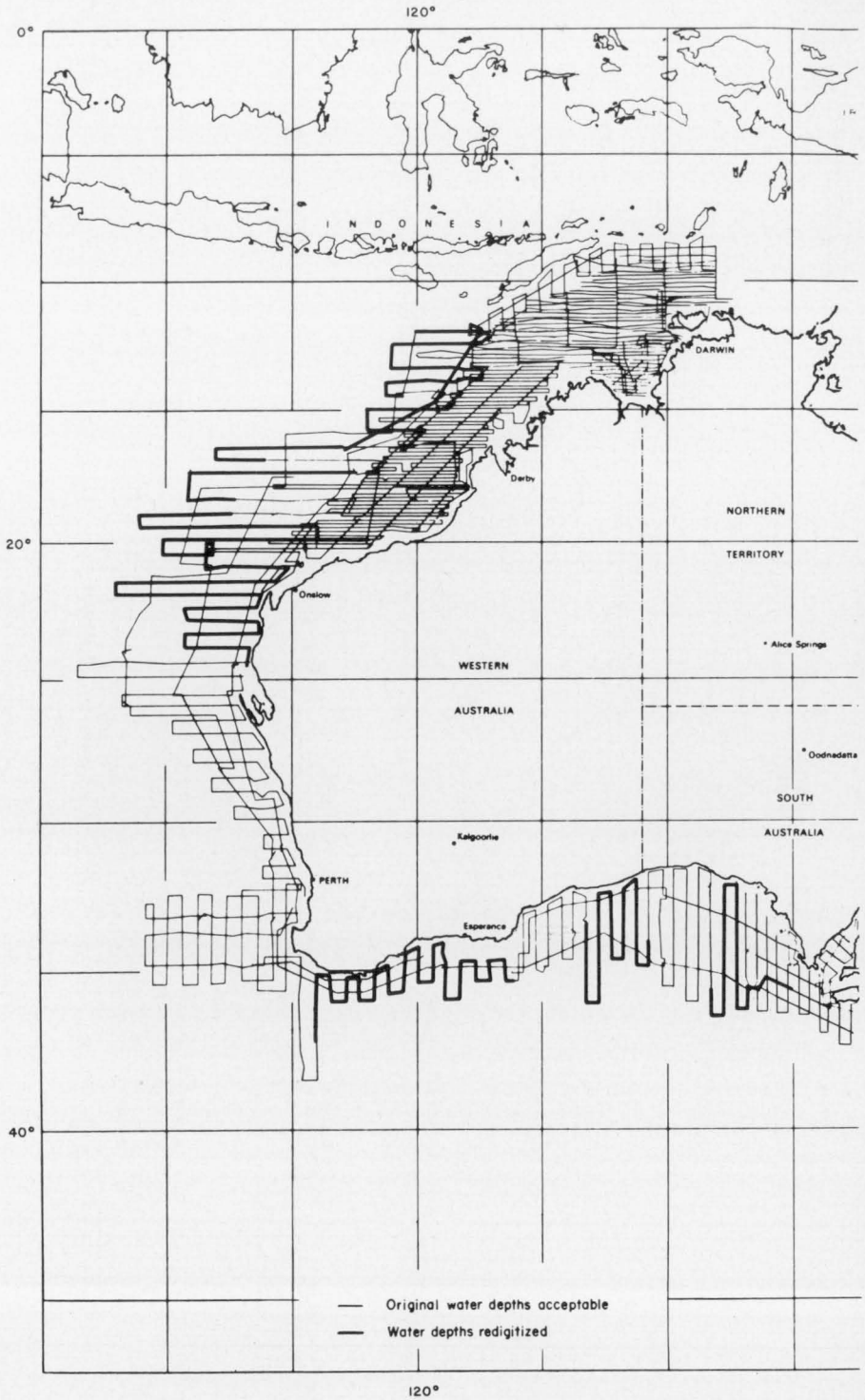
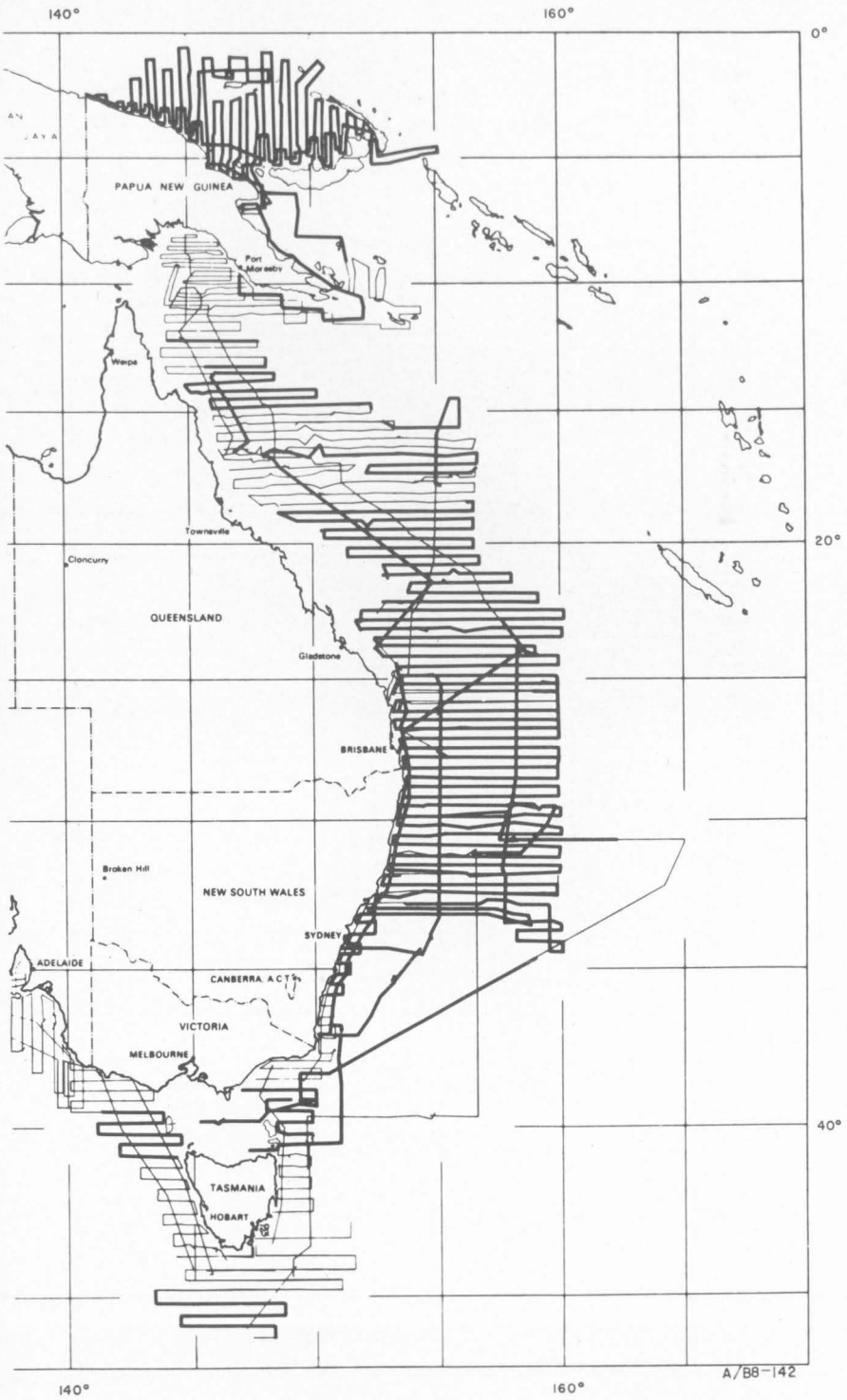


Fig. SGM 5. **Continental margin survey.**



Data quality—redigitized water depths.

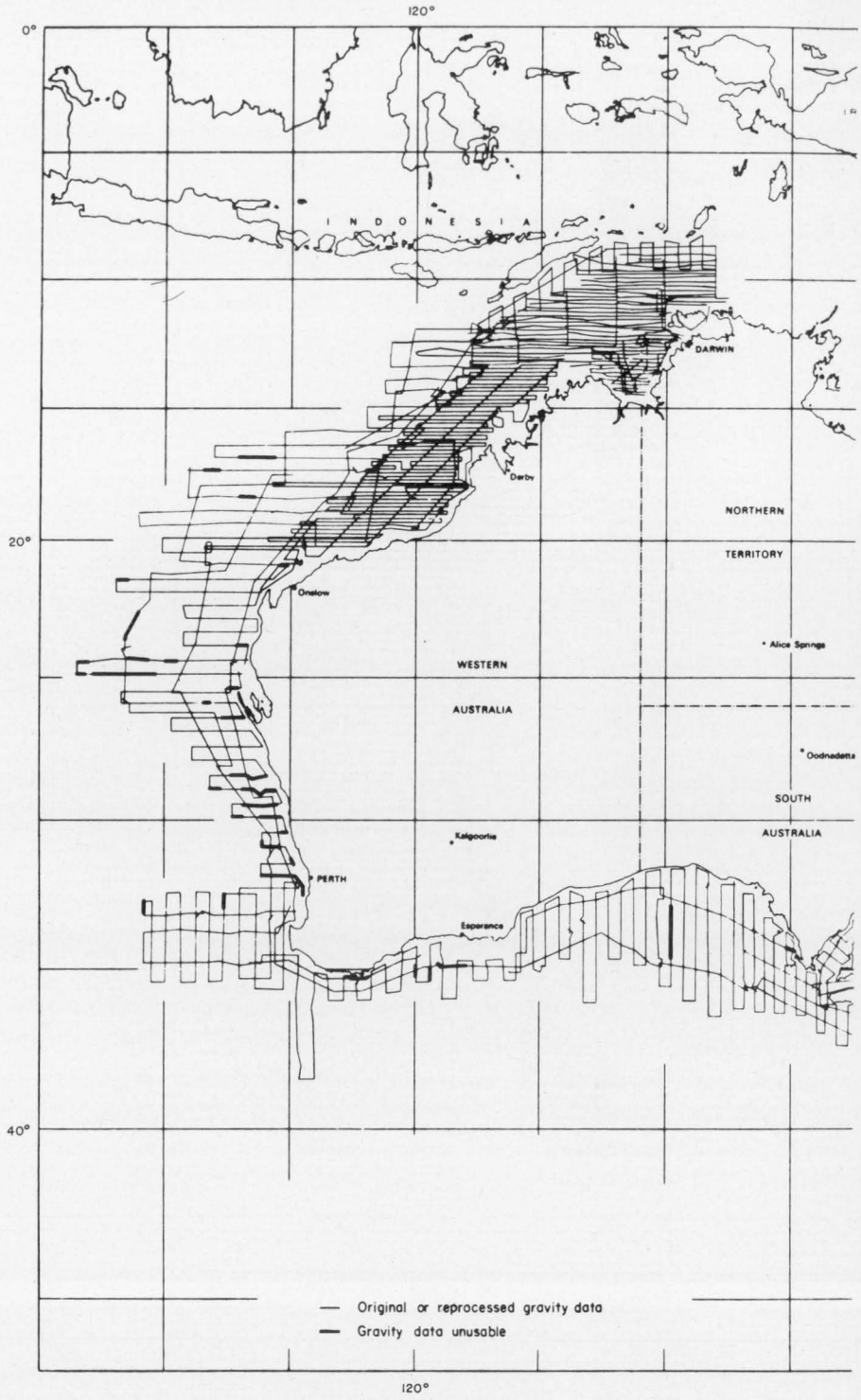
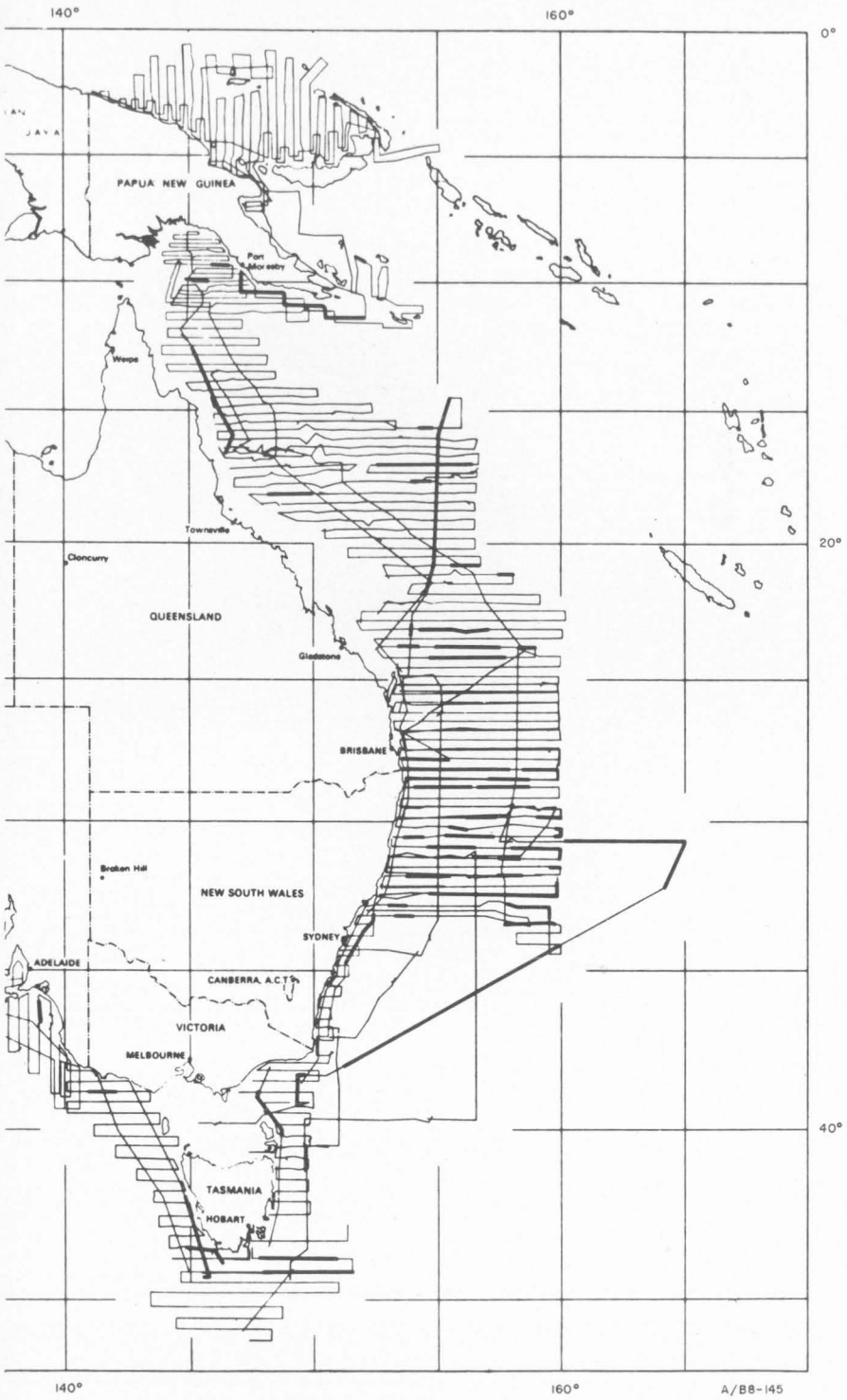


Fig. SGM 6. **Continental margin survey.**



Data quality—unusable gravity data.

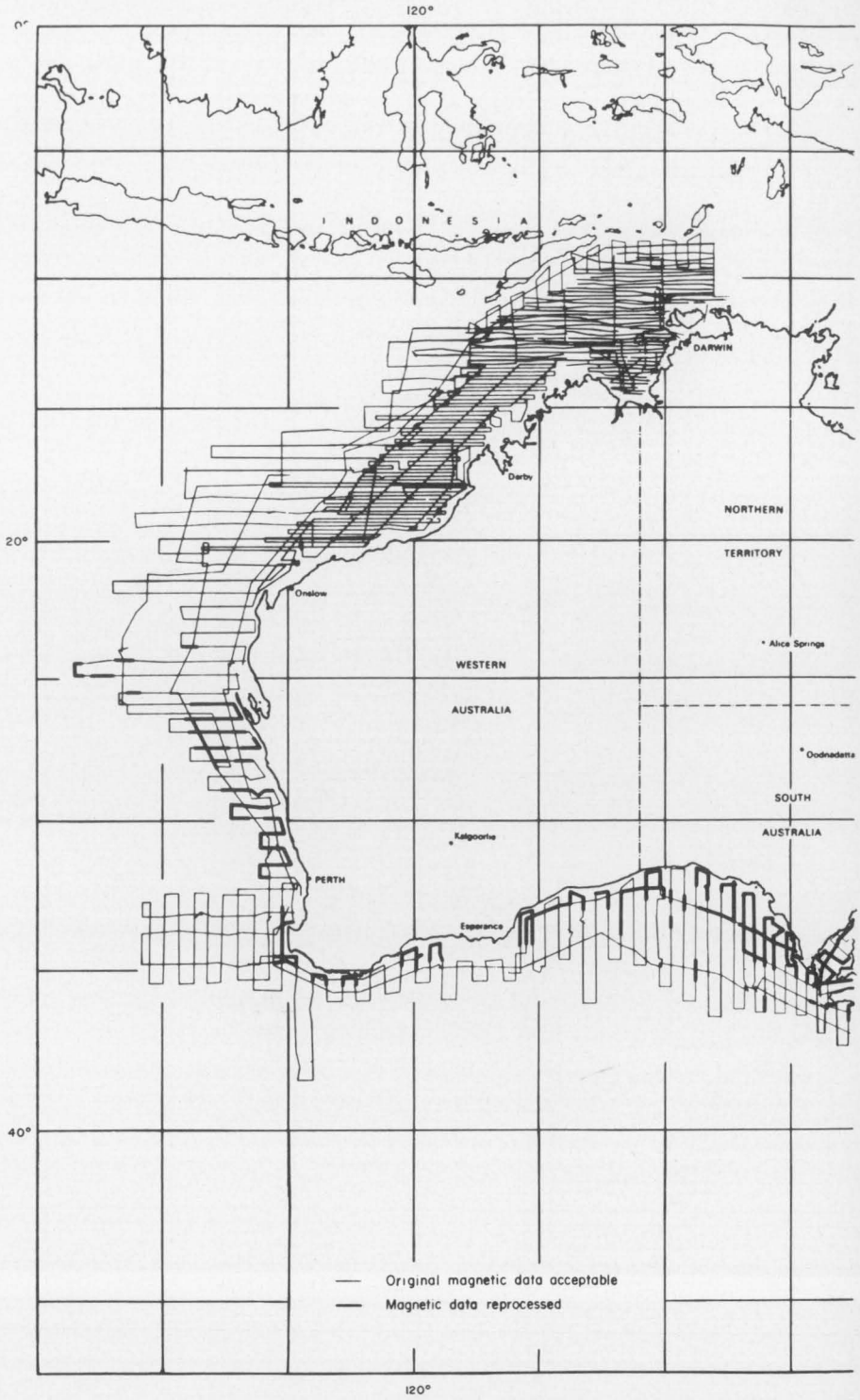
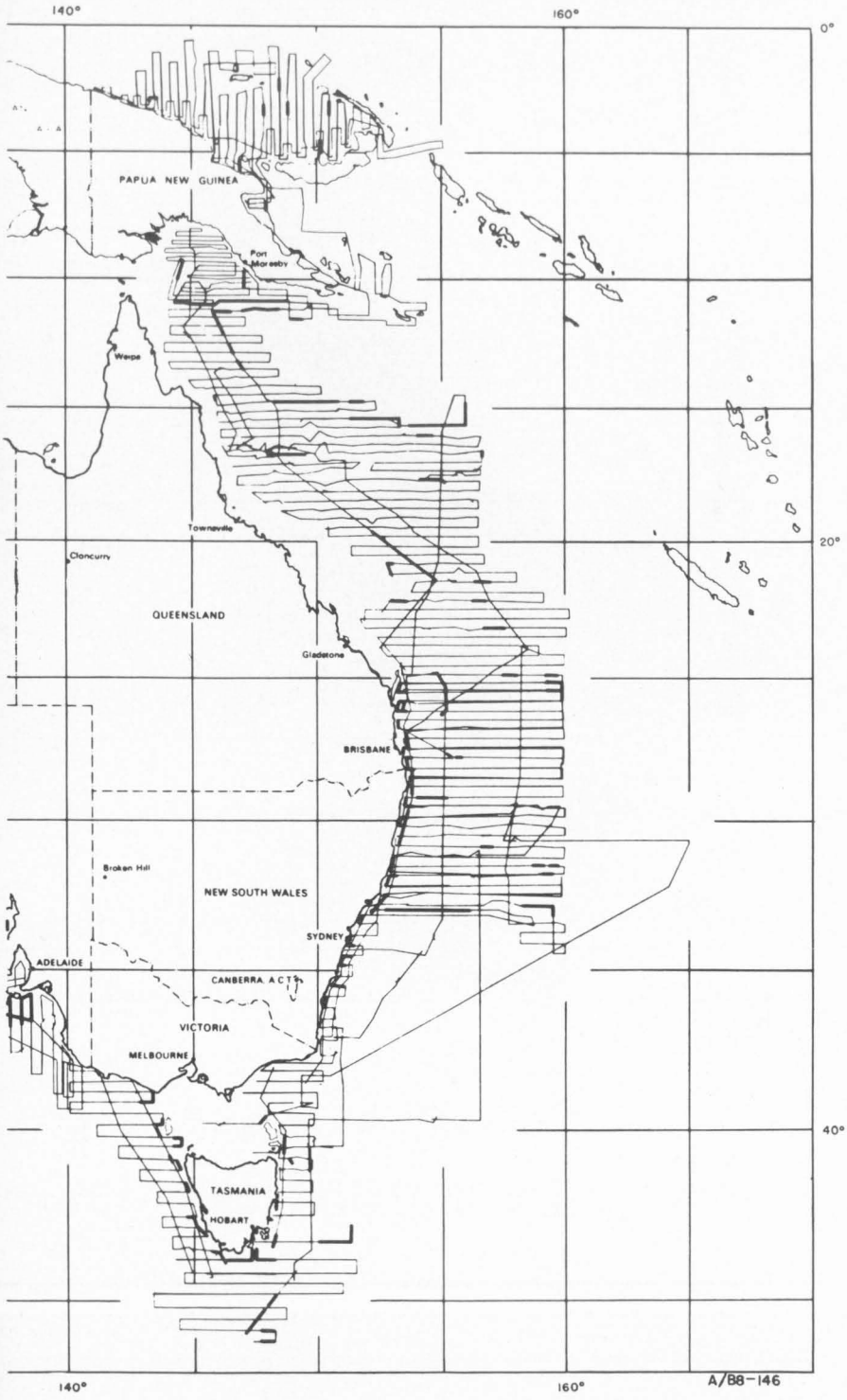


Fig. SGM 7. Continental margin survey.



Data quality—reprocessed magnetic data.

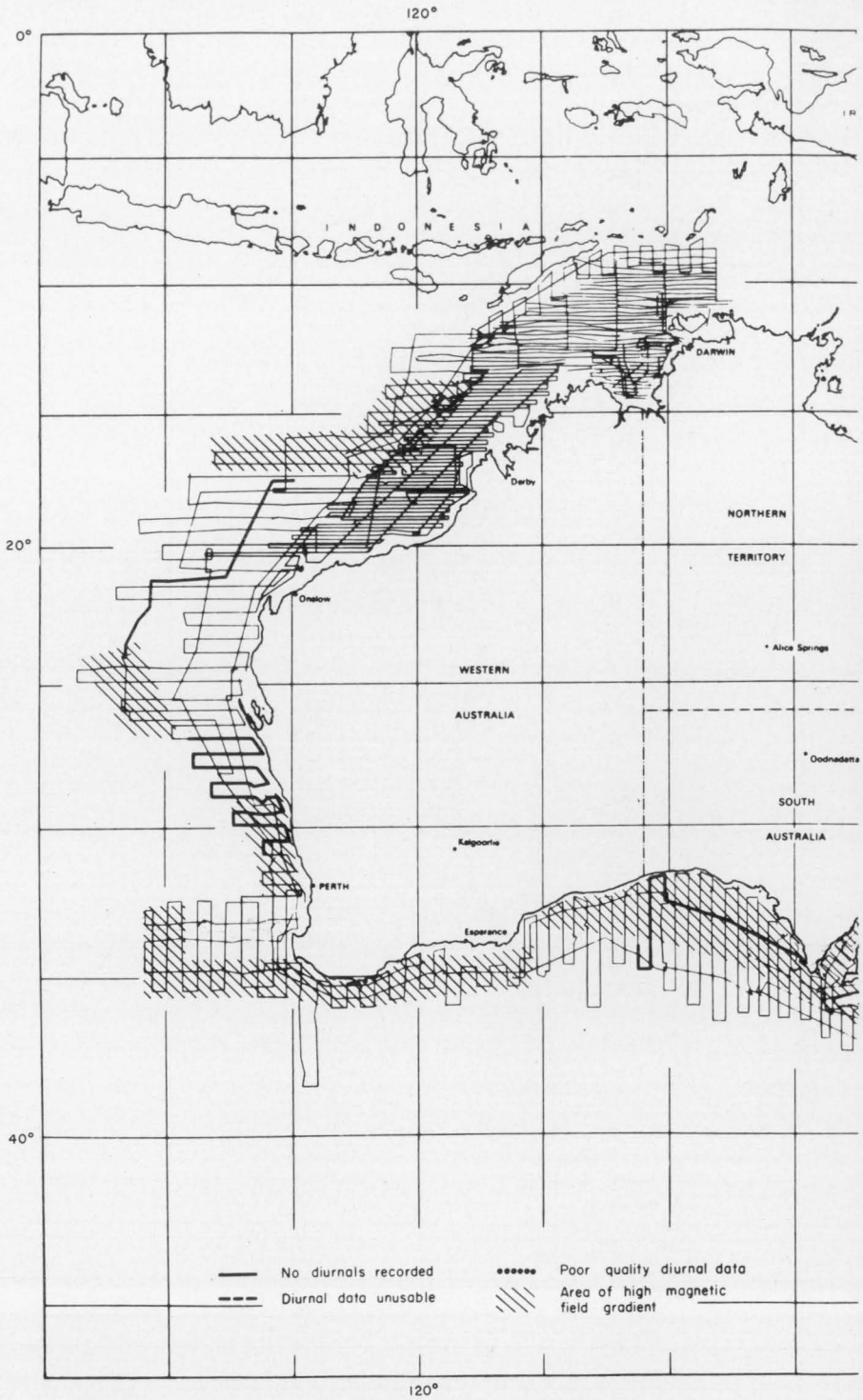
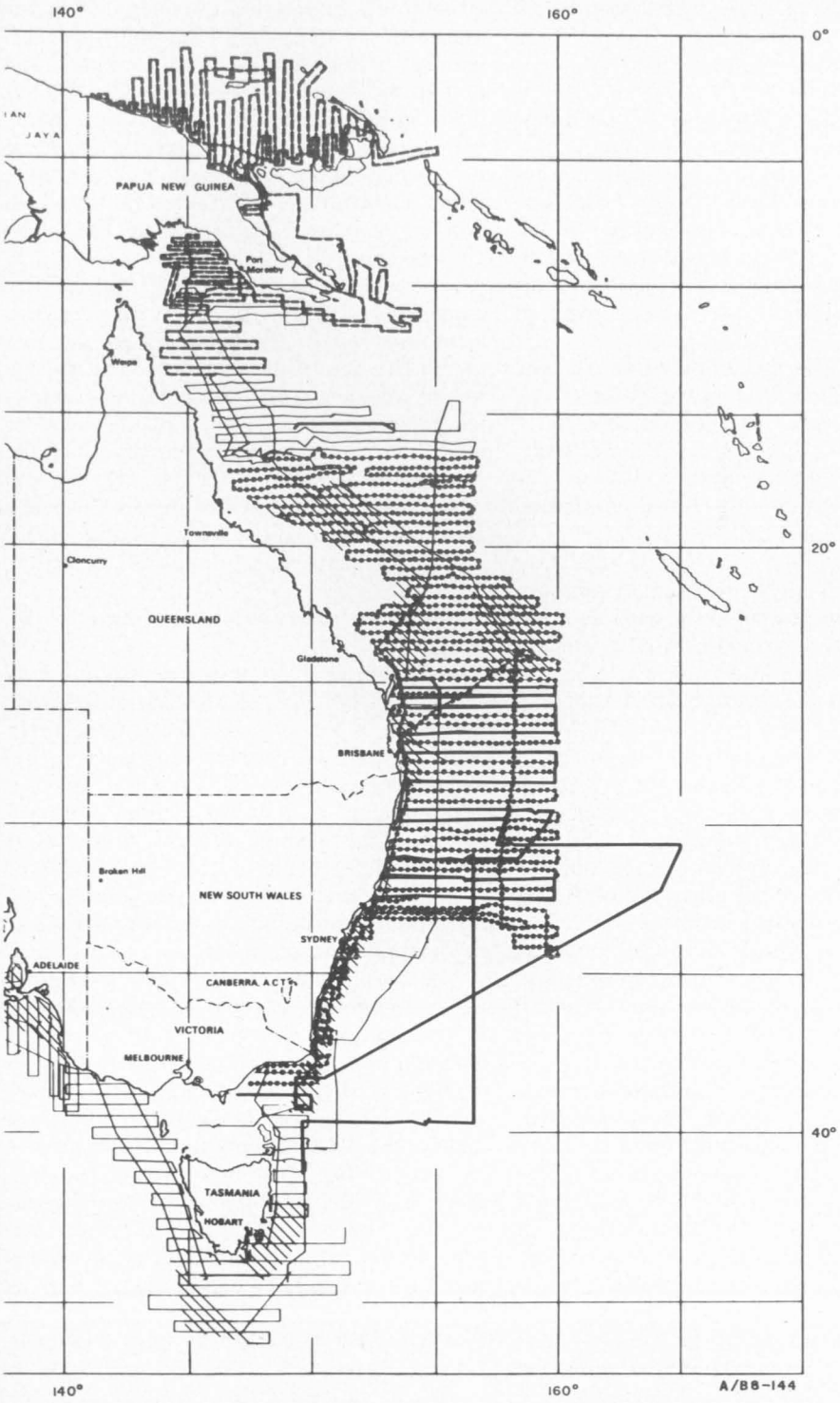


Fig. SGM 8. **Continental margin survey.**



Data quality—magnetic diurnals.

proportion of staff has been assigned to interpretation and reporting.

Data quality

At various times during the Continental Margin and Gulf of Papua and Bismarck Sea surveys, data collected by a particular system proved to be of lower quality than was acceptable for direct incorporation in the marine data processing stream described in the Summary of Activities, 1973. The examination of doubtful data was completed during 1974.

Navigation. The resolution of ship's position from satellite fix data was found to be more difficult than had been believed previously. It was studied by R. A. P. Garnett, who found that accurate velocity determination was the most critical parameter. His work is outlined below.

Water depths. The variation in reliability and range of the systems used to measure water depth contributed to the variable quality of records, and particularly to the problem of a uniform datum. Additional digitizing has been found necessary to establish a reasonable uniformity in the data quality (Fig. SGM 5).

Gravity data. The ship's motion in rough seas produced oscillations in the record. A criterion of 6 mGal peak-to-peak oscillation in gravity within any 10-minute period was agreed on with the contractor as the limit for field acceptability of the gravity data. It was foreseen, however, that a proportion of the data that did not satisfy this criterion would be recoverable by subsequent processing. Figure SGM 6 shows the traverses on which the gravity data are believed to be irrecoverable within acceptable error limits.

Marine magnetic data. The original records contain numerous sections of noisy data which resulted from malfunction of the magnetometer or its interaction with other equipment on the ship (Fig. SGM 7). Additional processes were developed to treat noise in cases where the noise was too severe or the field gradient was too steep for the existing filter processes to be adequate.

Magnetic diurnal data (Fig. SGM 8). The magnetic diurnal was recorded in analogue form at various shore bases, located appropriately around the coast as the survey progressed. The records were digitized initially at 10-minute intervals for use in reducing the marine data. It was found that diurnal events with a period less than 10 minutes and amplitude sometimes reaching 20 gammas were fairly common and correlated reliably with events in the marine record. Therefore the records were redigitized at a 1-minute interval to avoid the retention of spurious field anomalies as well as to reduce loop misclosures more effectively.

In some areas no diurnal record was recorded and magnetic observatory records were substituted. During work in the Bismarck Sea and Gulf of Papua, the diurnal record was excessively noisy and observatory records were used. A prolonged period of noisy diurnal records during surveying off the east coast of Australia could not be recovered in this way, however, because observatories are too remote, and therefore the original 10-minute digitizing of this data was retained.

Satellite fix processing (R. A. P. Garnett, J. W. Hudspeth)

The main problem in the computation of accurate satellite Doppler fixes recorded at sea has been in the minimization of the error caused by uncertainties in the ship's velocity. This error exceeds all others and is of the order of one quarter of a nautical mile per knot error in speed for medium-altitude passes. It is particularly difficult to control in areas of deep water where the sonar Doppler system operates by backscatter from within the water mass and not off the sea-floor.

The satellite navigation system used during the Continental Margin survey provided Doppler counts over two-minute periods which limited the number of counts obtained during a pass to a maximum of eight. Fixes were originally computed with the three parameters, latitude, longitude, and reference oscillator offset frequency, treated as variables. As fewer than eight counts per pass was not uncommon the degree of statistical improvement obtained from the multiple counts was not very high. Two independent lines of approach have been considered in an effort to reduce the errors caused by uncertainties in velocity.

The first approach to solving the velocity problem was to treat the ship's north and east velocities as additional unknown variables

thus avoiding the necessity of accurately measuring them. To reduce the number of unknowns the offset frequency was averaged over long periods, when the drift is close to linear, and was then used as a known constant. Computation of a series of fixes taken at the wharf in Port Adelaide by this method produced an unacceptably wide scatter in the positions (Fig. SGM 9).

By treating the east velocity as known and varying only the north velocity, a considerable improvement was effected since the latter is less sensitive to changes in the Doppler counts. Results however are still far from attaining the accuracy of stationary fixes. The main limitation in the method appears to be in the use of two-minute Doppler counts with the restricted number of counts that can be obtained during a pass.

The recording of shorter counts such as the 24-second intervals used in the Magnavox system would probably improve the accuracy of a variable velocity technique to an acceptable level, though there still appears to be difficulty in determining the east velocity satisfactorily. Meanwhile we are computing the correction necessary to the north velocity to minimize the Doppler residuals, and comparing this with the estimated current measured between consecutive satellite fixes as a further assessment of the quality of a fix.

The second approach was to eliminate the need for assuming a constant velocity for the ship during the recording of a fix by supplying velocities for each two-minute Doppler count directly from the navigation data. There are two significant advantages in this approach. One is that a major course or speed change during a fix will no longer affect its accuracy, whereas previously such a fix was unusable. The other is that water currents off the continental shelf introduce uncertainty of one to two knots into the ship's velocity. This can introduce errors up to half a nautical mile into the initial fix computations. When the initial fixes are used to tie down the dead reckoning navigation, the new velocities obtained will have the major part of the current removed, and the residual error is not likely to exceed 0.25 knot assuming the period between fixes is only about two hours. These new velocities can then be used to recompute the fixes, and one such iteration should be sufficient to reduce the errors in the satellite fix positions to around 0.1 mile.

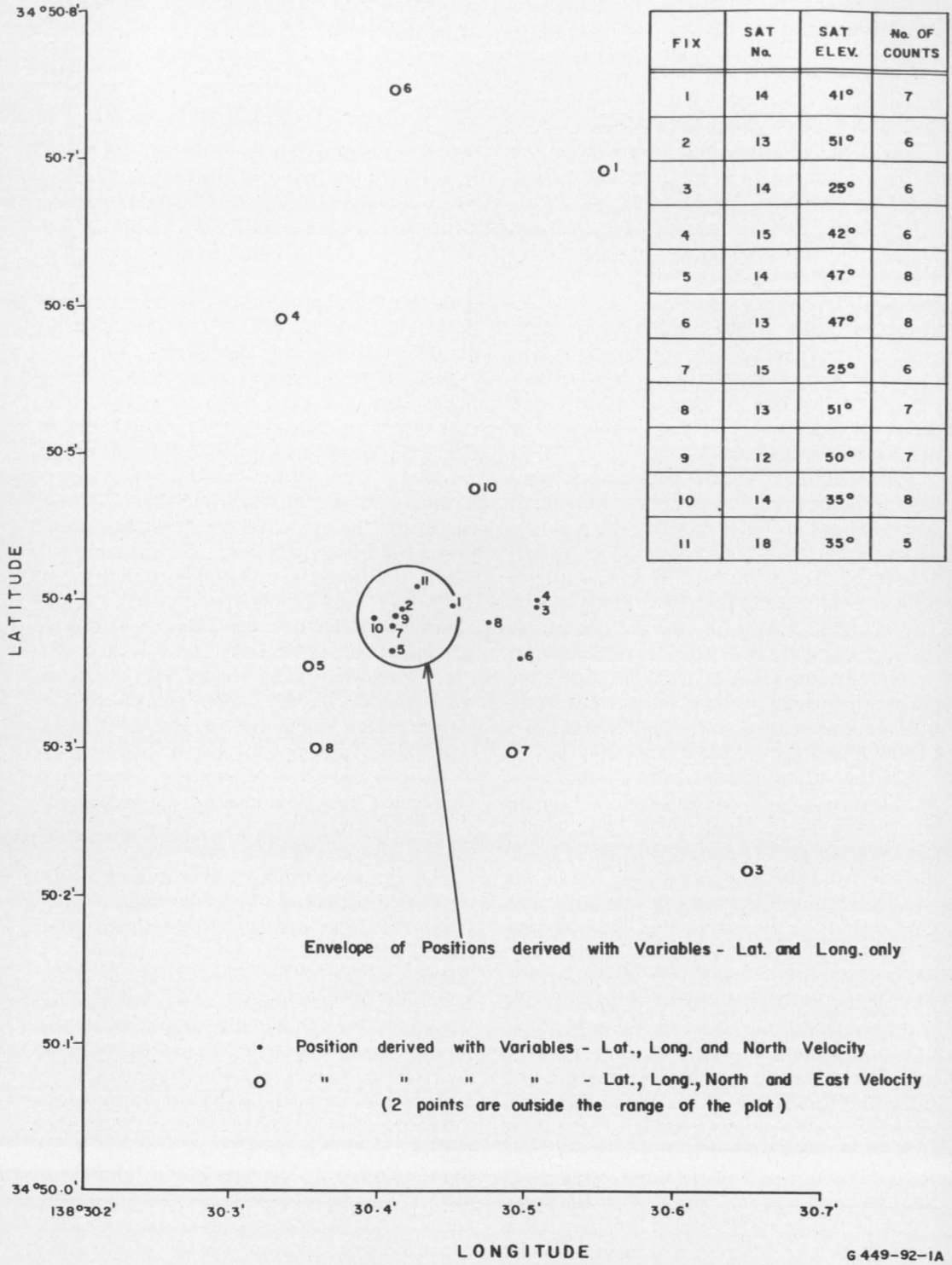
Digital water depths (C. R. Johnston, H. W. Stagg)

Acquisition of digital water depths during the Continental Margins survey suffered mixed fortunes. In the continental shelf areas, where sea-bed slopes are gentle and the water bottom reflector could be followed or 'tracked' by the sounding equipment, digital depths were obtained satisfactorily mainly with an Atlas depth sounder. However, in the deeper water areas off the continental shelf digital acquisition was a problem.

Two separate approaches to acquiring digital depths in deep water were tried. The first used an Edo Digitrak digital depth converter coupled to an Elac Capella echosounder. The second used a Raytheon bathymetric system which included a cross-correlator to improve the signal-to-noise ratio. Neither system worked satisfactorily. The Edo suffered from loss of bottom track in deep water and on medium to steep slopes. Sparker interference was also a problem because of the poor signal-to-noise ratio of the Elac. Somewhat better results were obtained using the Raytheon system, which had a greater depth range and in general tracked more reliably, though there were long periods of time when loss of bottom lock went undetected or lock could not be recovered. The Raytheon system was used only during the last quarter of the survey.

The digital water depth files in deep water have been produced mainly by hand digitization from Elac, seismic, and Raytheon chart recordings. Problems were encountered in integrating depths from the various sources. The only information of consistent quality available throughout the duration of the survey was the seismic data, so it seemed necessary to demonstrate that these data were adequate for controlling the integrations.

The precision of Raytheon digital depths is believed to be better than half a metre, more than adequate to provide a benchmark for seismic depths. To achieve an estimate of the accuracy of the seismic control over a range in depth, seismic reflection times were measured on medium to steep slopes. After allowance for offset, source depth, and so on, a scatter of



FIX	SAT No.	SAT ELEV.	No. OF COUNTS
1	14	41°	7
2	13	51°	6
3	14	25°	6
4	15	42°	6
5	14	47°	8
6	13	47°	8
7	15	25°	6
8	13	51°	7
9	12	50°	7
10	14	35°	8
11	18	35°	5

Fig. SGM 9. Satellite fixes in Port Adelaide (16.280534-16.300746).

± 15 m relative to the Raytheon depths was obtained (Fig. SGM 10). Accuracy in areas of flat bottom should be significantly better.

This test also demonstrated clearly systematic delays within the digital system. Other investigations have shown that these systematic errors can be determined independently by comparing the digital depths with those from the Raytheon echo sounder. After allowing for a +47 m systematic error in the Raytheon depths and a —4 m shot delay correction in the seismic times, the average error in the seismic depths is close to zero in the example given in Figure SGM 10.

The digitized depth data were checked against seismic depths on a cruise-by-cruise basis. Errors in the data were detected and tracked down to such problems as previously undetected gradual variations in speed of the Elac sweep motor over long periods of time, and errors in previous digitizing. A sample of differences range from —120 to +70 m (Fig. SGM 11). As the errors are highly variable and unpredictable, the correction procedure adopted is to strap down the data to seismic depths at regular intervals and use the existing values to interpolate between those intervals.

Magnetic secular variation in the Australian region (J. J. Petkovic)

It has been evident for some time that secular variation trends predicted by the International Geomagnetic Reference Field (IGRF) compare unfavourably with observed trends in and around Australia. This in turn has led to difficulties in merging magnetic data from different BMR surveys using the IGRF for regional field removal, particularly along the west coast. The discrepancy between the observed and predicted values for F is expected to be as high as 600 gammas in the Australian area by 1975.

The problem has been aggravated by the decision at the meeting of the I.U.G.G. in Kyoto, Japan, in 1973 not to change the IGRF despite significant errors in secular variation prediction in several parts of the world. It was therefore attempted to define an Australian Geomagnetic Reference Field (AGRF) while maintaining as much basic compatibility with the IGRF as feasible. The strategy adopted was to assume the validity of the space coefficients in the spherical harmonic representation of the IGRF as these are based on great numbers of data, and to modify the time coefficients so that the predicted values of secular variation using the AGRF would fit the observed trends in the Australian area.

Since these trends were mostly parabolic over the period concerned (1960-1975), quadratic time-term coefficients appeared essential if a significant improvement to the fit was to be obtained. A program was written to analyse the monthly mean values at the Australian and neighbouring geophysical observatories in terms of polynomial curves with respect to time. A good fit was obtained for all the data

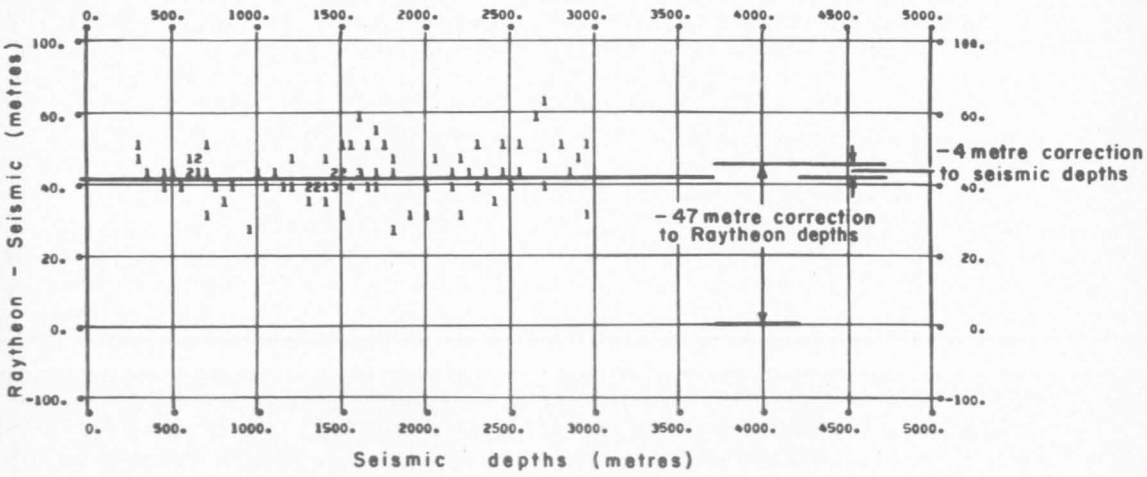


Fig. SGM 10. Comparison between Raytheon and seismic water depths.

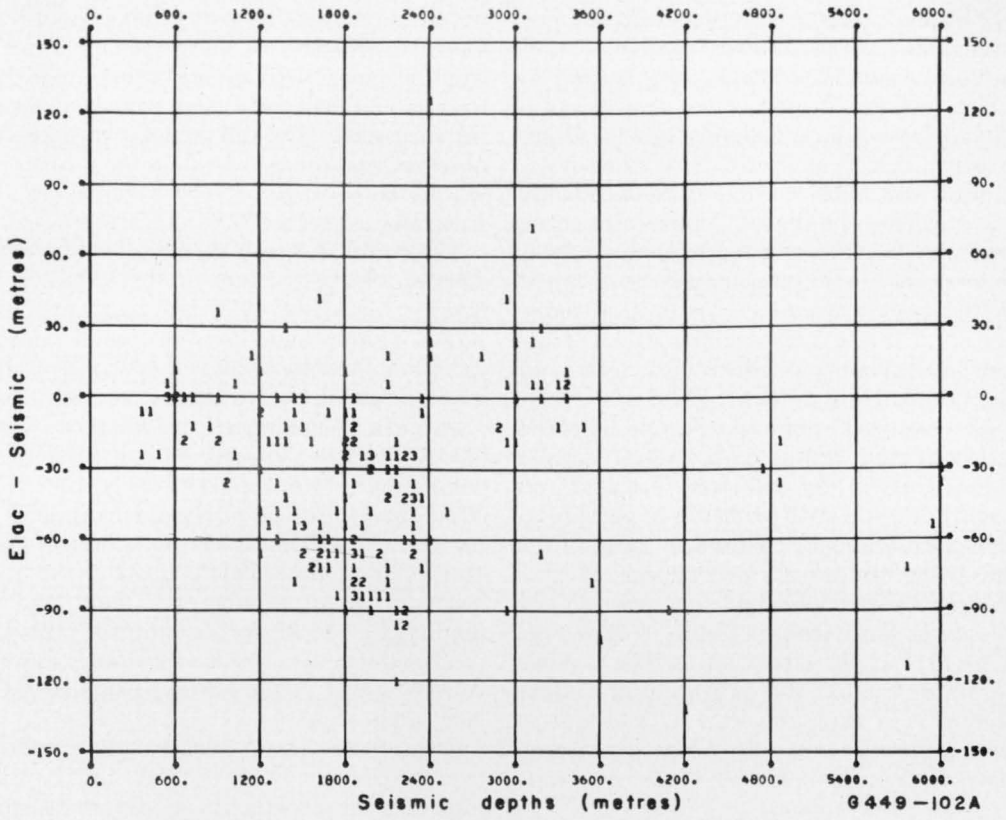


Fig. SGM 11. **Example comparison between Elac and seismic water depths.**

using terms up to the quadratic, and it was felt that higher-order terms could be safely neglected.

The method selected for determination of the time-term coefficients was an adaptation of the methods of Cain et al. (1967) and Fougere (1969). Both the techniques are iterative and use least-squares minimization of the residuals while accounting for the non-linear relation between coefficients and data. The program developed allowed the use of any or all of the magnetic field components H, D, Z, and F.

Numerous difficulties were encountered because of the unreliability of the data and their uneven distribution. Frequently the only way to identify poor data was to redetermine all coefficients a number of times. As the observations were essentially restricted to the land, anomalous solutions occurred in the oceans. The original data were extended to include data from the surrounding region as far as Africa, Asia, New Zealand, and Antarctica and a more stable and realistic solution was obtained in this way.

The large number of data tend to slow down convergence to the final solution. This requires many iterations and increases computer costs. However, it is felt that the final solution should agree with the trends at the geophysical observatories, which have by far the most reliable information and contribute substantially to the quality of data. Various methods were tried to force convergence at the geophysical observatories without detracting from the result at other observation points or creating problems elsewhere. The best approach at this stage appears to be the use of smoothed values based on quadratic polynomials fitted to all acceptable observations by least-squares.

Analysis of the secular variation was attempted using individual field components, but significant deviations in the other compo-

nents then resulted. The best results were obtained using a large number of independent observations of all components, supplying greater constraints on the coefficients. The r.m.s. difference between IGRF and observed values is 120 gammas (or nT), combining all components and observation points available from 1960 to the present, reduced to 1965.0. At the time of writing the corresponding difference using the AGRF in place of the IGRF is 30 gammas. It is anticipated that the final accuracy using the AGRF will approach 20 gammas, which is about the accuracy of the data from the first-order stations. Figure SGM 12 illustrates the difference between the IGRF and AGRF for epoch 1975.0.

Seismic data transcription (J. K. Grace, R. Dulskie, M. Amar)

Transcription of analogue magnetic tapes of marine seismic records from the Continental Margins survey was continued. Ninety-eight tapes were transcribed in 1974 including 81 from the western margin. This compares with a total of 249 transcribed in 1973 including 122 from the western margin. Since transcription started, a total of 359 copied tapes has been lent to companies, some to more than one company. The geographical distribution of seismic data lent is shown in Figure SGM 13. The number of tapes recorded altogether during the survey was 1200.

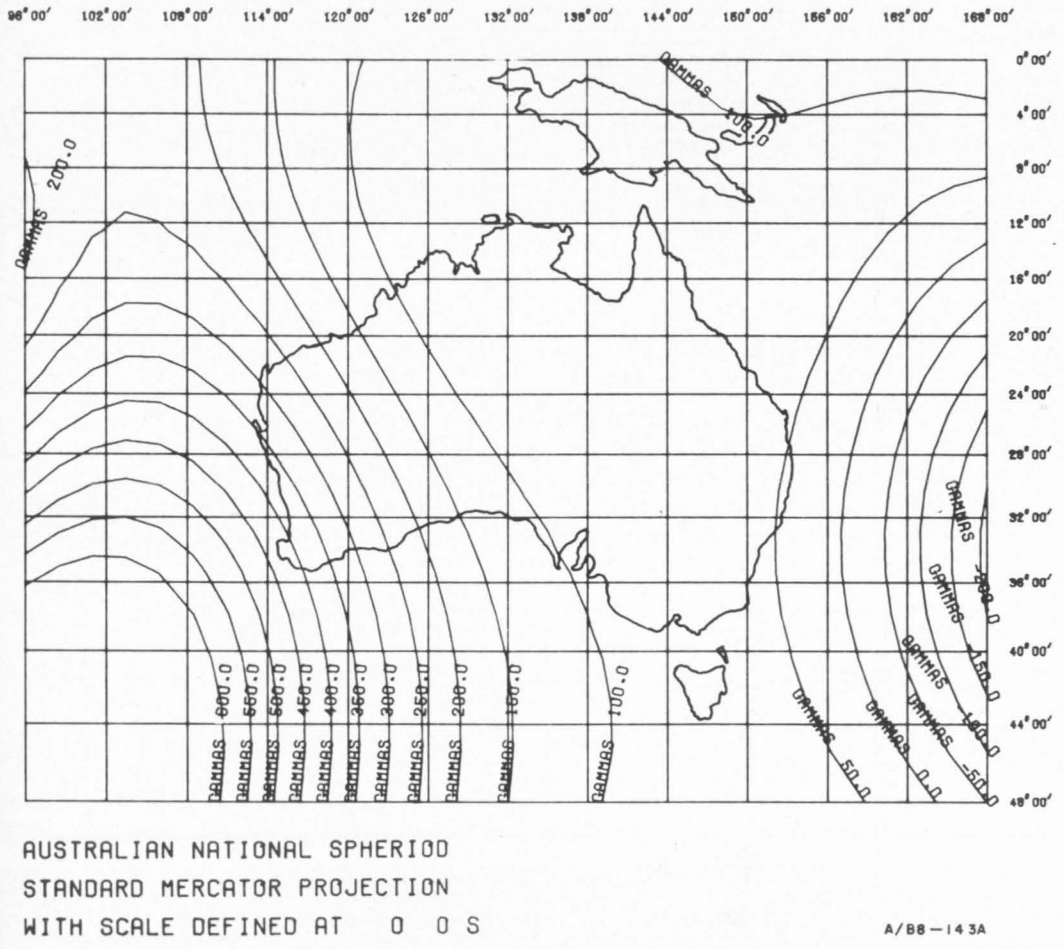


Fig. SGM 12. **Difference between total force values, International Geomagnetic Reference Field minus Australian Geomagnetic Reference Field, epoch 1975.0.**

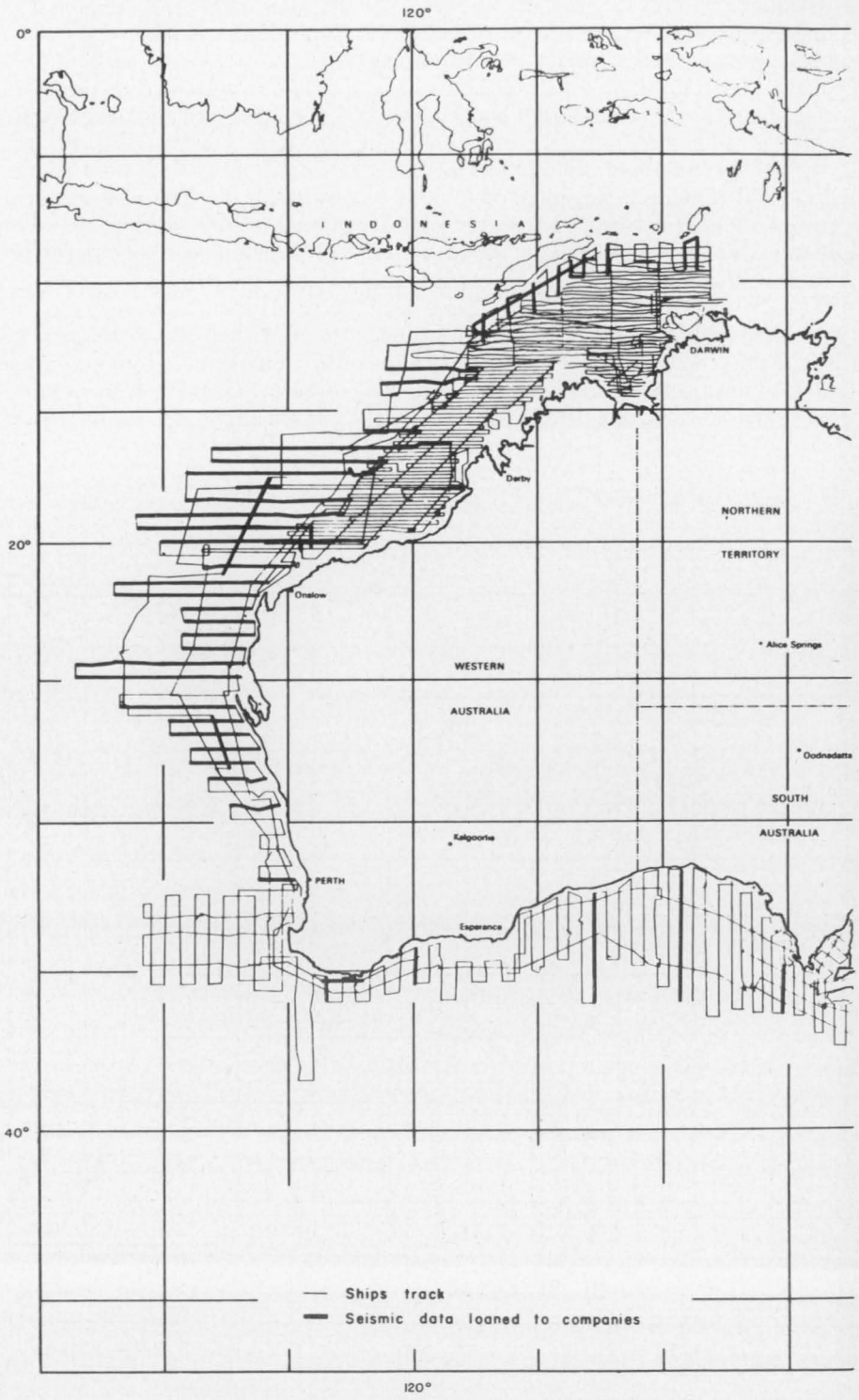
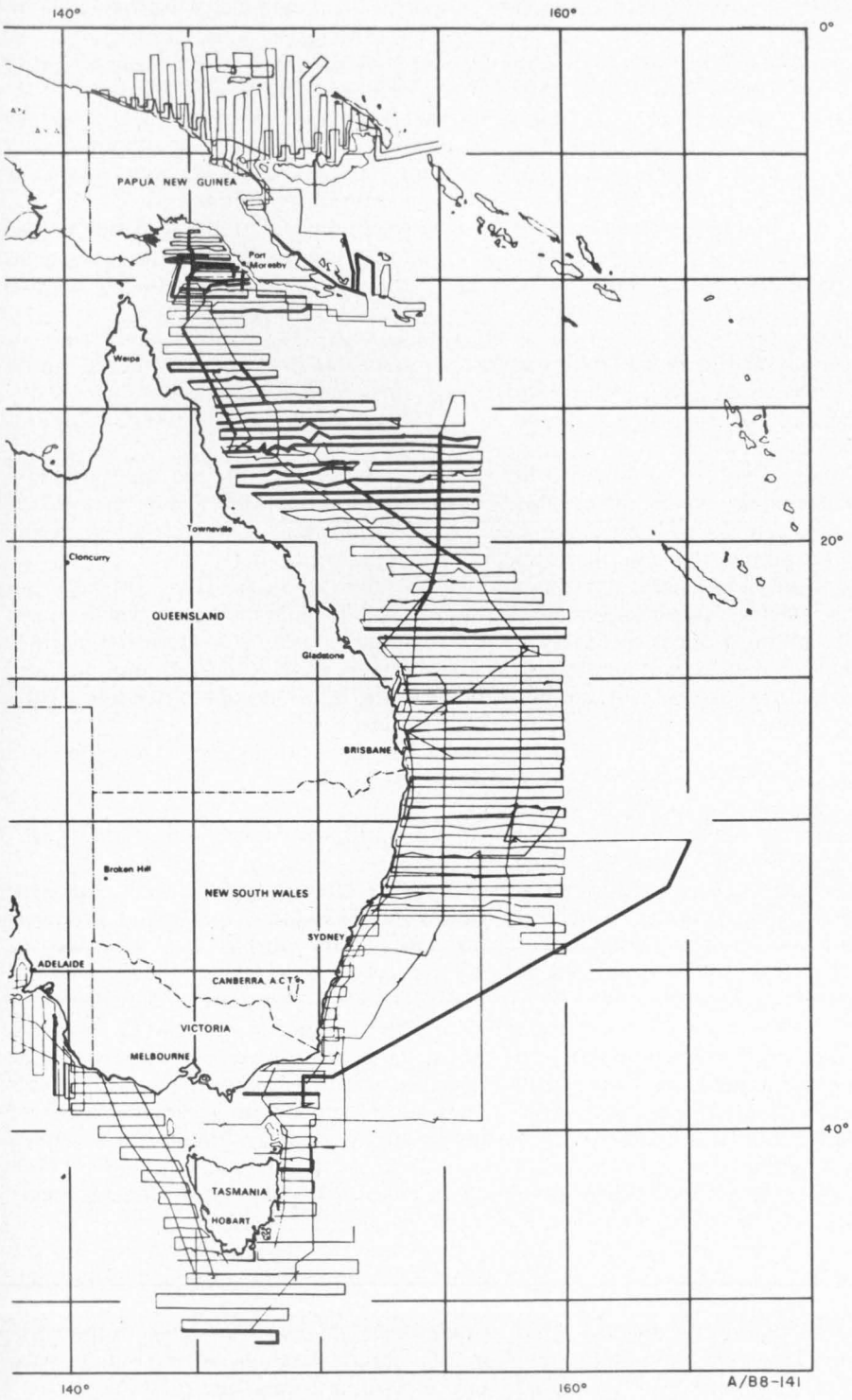


Fig. SGM 13. **Continental margin survey. Analogue**



seismic records loaned to companies for digital processing.

Each tape represents nearly 70 nautical miles of seismic profiling.

The analogue copies of the tapes are lent to the companies for conversion to digital form to allow digital processing at the companies' discretion. They undertake to provide copies of the results of their digital processing. Several companies have returned initial results which show some improvement. More intensive work is in progress, in particular using complete trace stacking procedures.

Machine contouring (A. Hogan)

In marine geophysical work by BMR, the data are collected continuously along lines and contouring may be done from selected data points as highly asymmetric as 20 to 1 along and at right angles to the direction of traverse. This asymmetry has an undesirable effect with presently developed triangular and surface-fitting programs; the cost increases proportionally to the square, and sometimes cube, of the asymmetry. As one of the most effective ways of editing geophysical data is to visually inspect such data in contoured form, an economic contouring program is desirable, even if it has limitations in the form of presentation.

Tests indicated that a simplified version of I.C. Briggs's surface-fitting technique would achieve the objective. The program has been developed in highly modular form and in such a fashion that extensions can be introduced later that will allow the production of final maps. Also an efficient restart capability has been developed, so that a job is not completely lost if it fails part-way through.

The high degree of logical modularity in the program has introduced some overheads in the complexity of the data used for overall program control as compared with a program that does a single job. This complexity has been offset by modular design of the control data, which are largely standardized and easily learnt, and by the wide range of user options that provide more versatility than was originally expected.

Map plotting can be divided into two distinct phases: creation of the plot tape, and plotting. Proper design of the program and the way in which the plot tape is generated allows important user options to be initiated in either phase. Nominally the use of various options at creation time will provide a plot tape from which a suite of maps can be produced. Most of the programming effort to date has been concentrated in allowing decisions to be made at creation time as the production of edit plots is simplified and expedited by making all necessary decisions then and none at plot time.

At present the major options available are:

—Choice of the input data type and format; the area covered; degree of overlap with surrounding maps

—Grid size; the degree and type of smoothing, starting from the initial surface approximation

—Definition of plotting area, map projection etc.

—Presentation of selected areas of data from one map sheet

—User controlled restart facility including point of restart.

Work now in progress will provide user options at plot time including: where to put the contour labels, pen type for various contour levels, shifting of annotation to avoid overwriting, and automated drafting of descriptive information.

An example of the contouring is shown in Figure SGM 14.

A program library system on the Cyber 76 (C. J. Watt)

A simple, efficient system has been devised for maintaining, developing, and accessing programs on the Control Data Corporation (CDC) Cyber 76 computer, using two standard CDC system programs. These programs are used to maintain program libraries of two types: card image, called update program libraries; and binary, called relocatable user libraries. The first type is required for card image editing of the programs. The second is used for running jobs, as its members do not have to be compiled and are randomly accessible by the loader.

Computing routines developed by the Marine Group have been divided into several groups, mainly according to their functions in processing the data from the continental margin survey. Each group of routines with one exception forms one relocatable user library and one update program library (Fig. SGM 15). Storage space requirements on

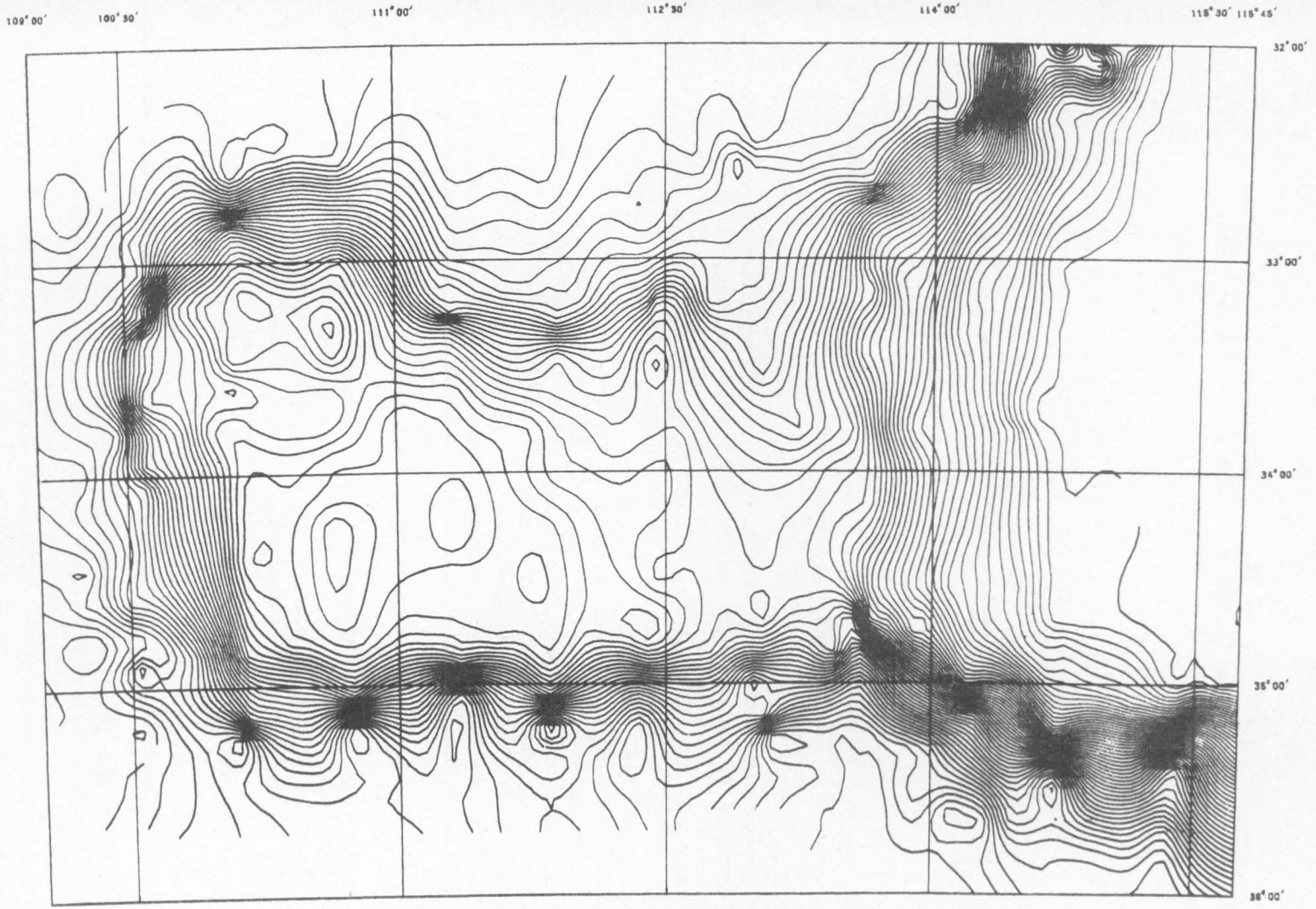


Fig. SGM 14. Machine-contoured map. Contour interval 100 metres, grid spacing 3 minutes, smoothing 20 iterations, data asymmetry 3:1.

WA / 88-57A

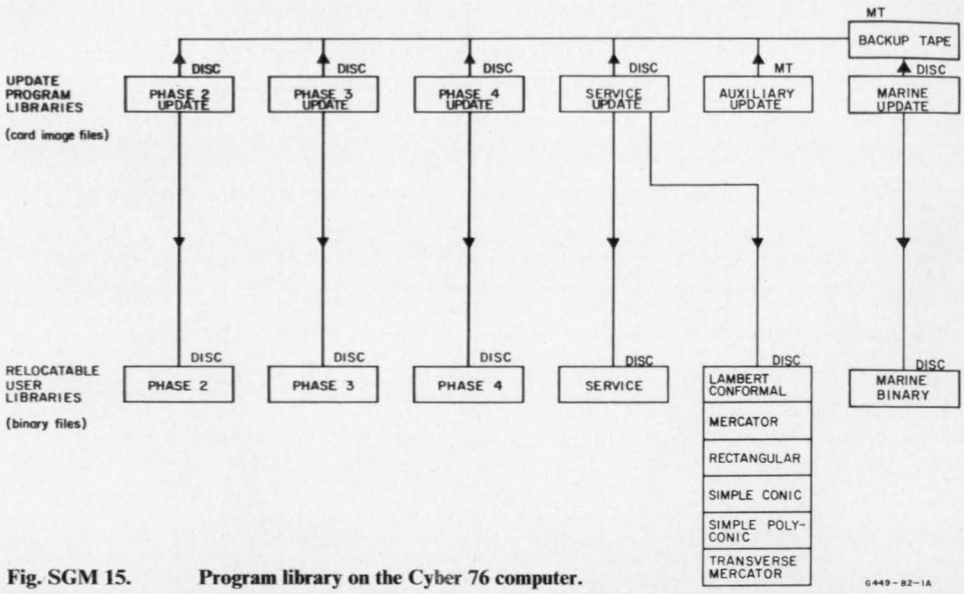


Fig. SGM 15. Program library on the Cyber 76 computer.

magnetic disc and tape are minimized by the elimination of multiple copies of binary routines.

For production processing a job deck submitted by the user specifies for attachment to the job those relocatable user libraries known by the user to contain the routines called by the user's program. The computer then automatically loads from the requested libraries only those routines. This takes no more computer time than to load a single monolithic file containing all the required routines together. Thus it is possible to prepare one or more of a variety of programs for execution by linking individual binary coded routines. The overall simplification of job runs using this system permits the use of less experienced staff.

The update program libraries provide a ready means of revising and amending routines without disrupting their use in production processing. An edited routine in one of the update program libraries may then be compiled into binary form and used to replace the previous version in the relocatable user library. The editing procedure requires remaking the update program library files being edited. Several console programs have been written to carry out manipulation of the library files which editing entails. The console programs remove direct file manipulation from the operator, substituting indirect control through console instructions. This reduces the chance of accidentally purging files, by eliminating the possibility of errors in punched card input.

Sediments and structures of the Australian continental slope bordering the Indian Ocean (J. C. Branson, A. Turpie)

In the north, the Australian continental margin contains the southern slope of the Timor Trough formed by gentle downwarping since the Pliocene. Elsewhere, bordering the Indian Ocean, the continental slope is mostly complex and largely block-faulted and has been formed by rifting along the northwest and west coasts until the Jurassic and Cretaceous, and along the south coast until the Eocene (Figs. SGM 16, 17, 18).

The Timor Trough has a simple convex southern slope and irregular northern slope. Sedimentary sequences lie parallel to the seafloor in the southern slope, which appears to be overthrust by the northern slope. The youngest downwarped sediments are Upper Pliocene.

The northwestern and western continental margin contains a complex slope with plateaus and terraces formed of faulted blocks of late Triassic and older sediments overlain

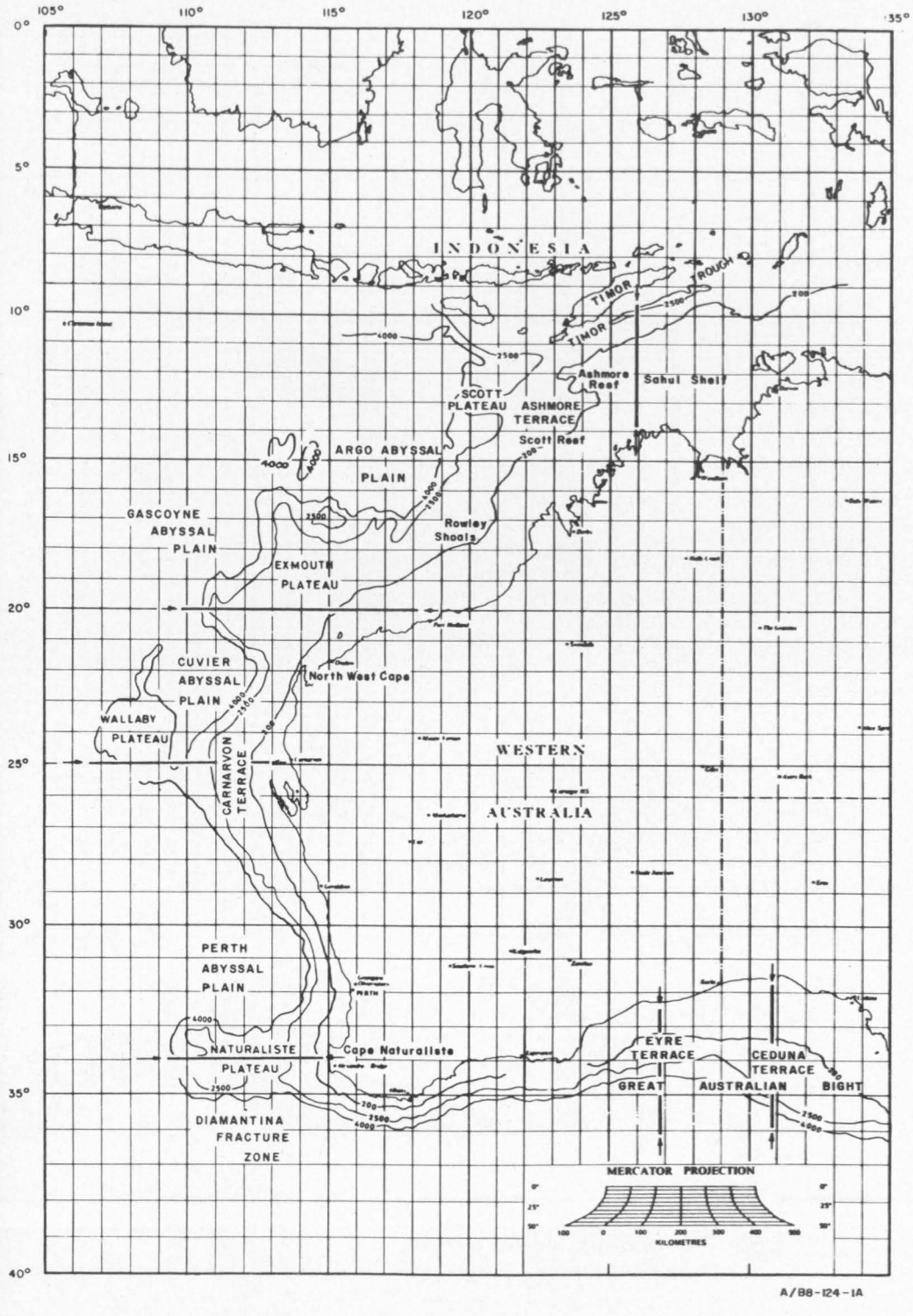


Fig. SGM 16. Australia/Indian Ocean margin—bathymetry.

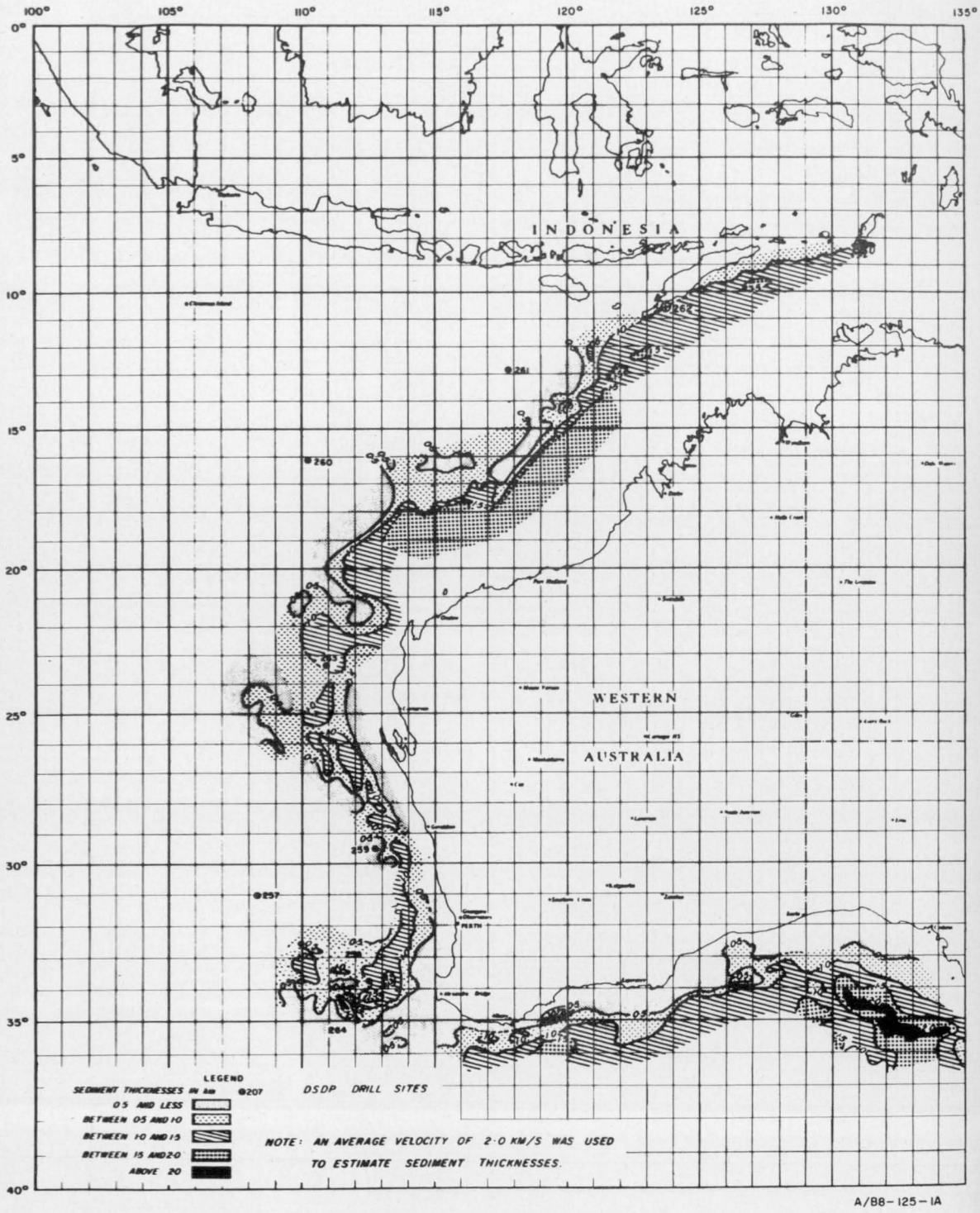


Fig. SGM 17. **Australia/Indian Ocean margin—minimum sediment thicknesses and DSDP sites.**

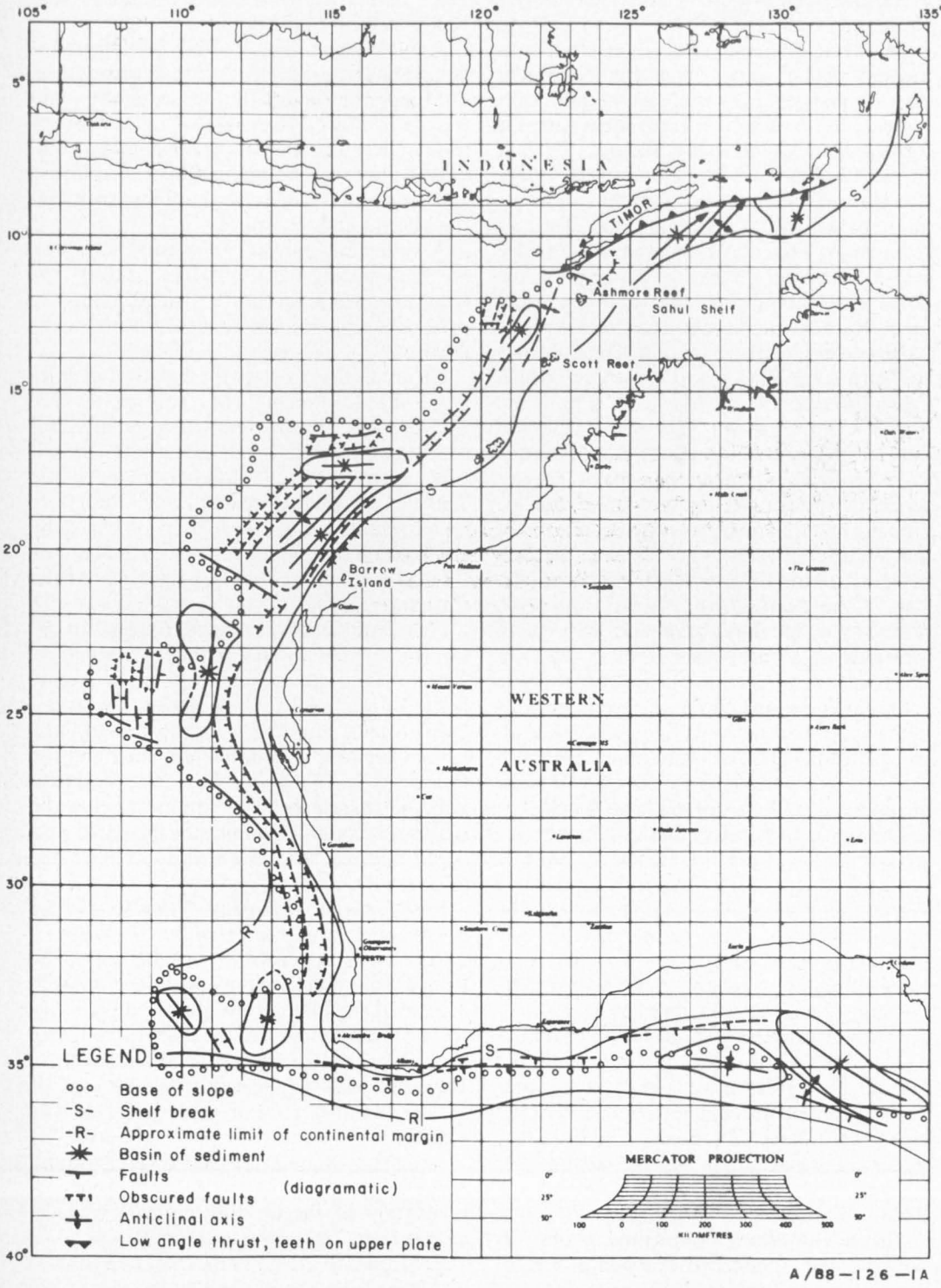


Fig. SGM 18. Australia/Indian Ocean margin—schematic sedimentary structures.

by extensive mantles of Jurassic and Lower Cretaceous sediments.

The Scott Plateau contains a narrow sedimentary horst and a western region of oceanic material. On the east of the Scott Plateau, the Ashmore Terrace (new name) is formed of pre-Cretaceous horsts near the shelf break. The Exmouth Plateau forms an extensive area of block-faulted Triassic and Permian rocks with Cretaceous and Tertiary sedimentary cover. A northeast trend in the central Exmouth Plateau is truncated in the north by a dextral fault and east-west structures which isolate at least three sedimentary blocks on the northern margin. The Plateau's southern margin has a northwest trend which controlled some early Mesozoic deposition. The Wallaby Plateau and the Carnarvon Terrace (new name) were formed as Mesozoic and Tertiary sedimentary mantles over a series of linear and arcuate horst blocks. Oceanic material forms the western margin of the Wallaby Plateau; the Plateau's eastern margin is almost detached from the base of the slope. The Naturaliste Plateau was least affected by block-faulting and may have remained at or near shelf level in the continental slope until early Tertiary time. There are sedimentary troughs in the saddle regions of the Scott, Exmouth, Wallaby, and Naturaliste Plateaus. The Ashmore and Carnarvon Terraces are underlain by troughs of sediments bounded by marginal horst blocks.

The southern continental margin contains the Eyre and Ceduna Terraces in the slope of the Great Australian Bight, and the extensive Tasmanian Plateau south of Tasmania. The Eyre Terrace has a thin mantle of sediments over an irregular block-faulted acoustic basement containing grabens of sediments. The Ceduna Terrace is underlain by a basin of Cainozoic? sediments held behind a marginal barrier. Between the Ceduna Terrace and the Tasmanian Plateau, block-faulted pre-Tertiary sediments form the major part of the continental slope. Deep-water sedimentary basins are present at the base of the slope and in the continental rise to the west of the Ceduna Terrace.

The northwestern continental slope has probably the highest hydrocarbon potential. Parts of the less explored southern slope are also believed to have a fairly high potential.

The Exmouth Plateau (J. B. Wilcox, N. Exon, P. Petkovic, J. Petkovic)

J. B. Willcox and P. Petkovic started a detailed interpretation of seismic records over the Exmouth Plateau during September, and were joined by N. Exon of Geological Branch in October. The work is principally to evaluate the hydrocarbon potential of the Plateau and adjacent trough by mapping sediment thicknesses and structures.

A systematic network of seismic lines with 55 km spacing was obtained during the Continental Margin survey. Data obtained by private companies will be incorporated when released.

Figure SGM 5 shows the location of lines from the Continental Margin survey and Figure SGM 19 shows bathymetry contoured at 250-m intervals.

Six seismic horizons have been mapped (see Table); four of them extend over the entire area. Tentative ages have been obtained by comparison and analogy with well data on the Northwest Shelf and with the geology of the Carnarvon Basin.

The bathymetric features appear to be directly related to the geological structure. The pre-Jurassic sediments form a highly faulted anticline which underlies the entire Plateau and adjoins a syncline beneath the trough between the continental shelf and the Plateau (Fig. SGM 20). The anticline has a north-northeast strike with its crest below the shallowest water. Its amplitude increases with depth and reaches 2-3 km in the Palaeozoic (Horizon 6).

Post-Jurassic sediments appear to be draped over the earlier structures. They have a maximum thickness of about 2000 m in the trough and pinch out towards the western margin of the Plateau. Jurassic sediments are thickest near the crest of the Plateau, resulting in a post-Triassic section of about 2000 m. However, they are absent from the tops of Triassic fault-blocks on the flanks of the Plateau.

Extensive faulting affects the Triassic and Jurassic (Horizons 4 & 5) and some rejuvenation of the faulting appears to have affected the Cretaceous and Tertiary.

Figure SGM 21 shows the thickness in two-way time from the sea-bed to the top of the block-faulted horizon (5). Figure SGM 22

Seismic Horizons

Horizon	*Characteristics*	*Overburden in plateau area**	*Possible age*	*Comment*
1.	Uppermost unconformity lying at base of semi-transparent flat-bedded zone. It separates the flat-bedded horizons from buckled and faulted beds below.	0.2 —0.45 (250— 500 m)	Tertiary: probably Miocene	Traced throughout area. Reef-like structures are observed below Horizon 1 near crest of Plateau.
2.	Unconformity marking base of sediment-filled troughs in NE part of Plateau. Almost coincident with Horizon 1 in some areas.	0.3 —0.75 (350— 900 m)	Tertiary: probably Oligocene	Traced throughout area. Diffractions indicate extensive limestones in Tertiary section.
3.	A strong reflector marking an unconformity. The horizon shows draping over the faulted blocks indicated by Horizon 5. A few faults intersect Horizon 3.	0.7 —1.05 (900—1300 m)	Near base of Tertiary	Traced throughout area. Draping is probably due to sediment compaction in Jurassic and Cretaceous section. Faults appear to be a rejuvenation of earlier structures.
4.	Marks the top of a zone of northeasterly prograding sediments in southwest of the Plateau. It can be traced as a weak reflector over most of the area. Frequently marks the top of sediments which lie between faulted blocks.	0.7 —1.5 s (1000—2000 m)	Near top of Jurassic	Traced through most of the area but some uncertainty. Missing in places. May overlie Jurassic delta in southwest of Plateau.
5.	Strong reflector marking an unconformity near the top of faulted blocks. Most faults terminate at this horizon or extend to Horizon 4. Faults are generally normal and fault blocks dip eastwards.	0.8 —1.5 s (1200—2000 m)	Near top of Triassic	Traced beneath the Plateau, but at greater depth and difficult to identify beneath southern part of the Trough.
6.	Deep reflectors beneath northern part of the Plateau, which outline a large faulted anticline near its western edge.	1.2 —2.05 (1800—2500 m)	Palaeozoic; possibly near top of Permian	Traced in northern part of Plateau.

*Seconds two-way time
Metres: assuming seismic velocity of Tertiary = 2.5 km/s
and pre-Tertiary = 3.0 km/s

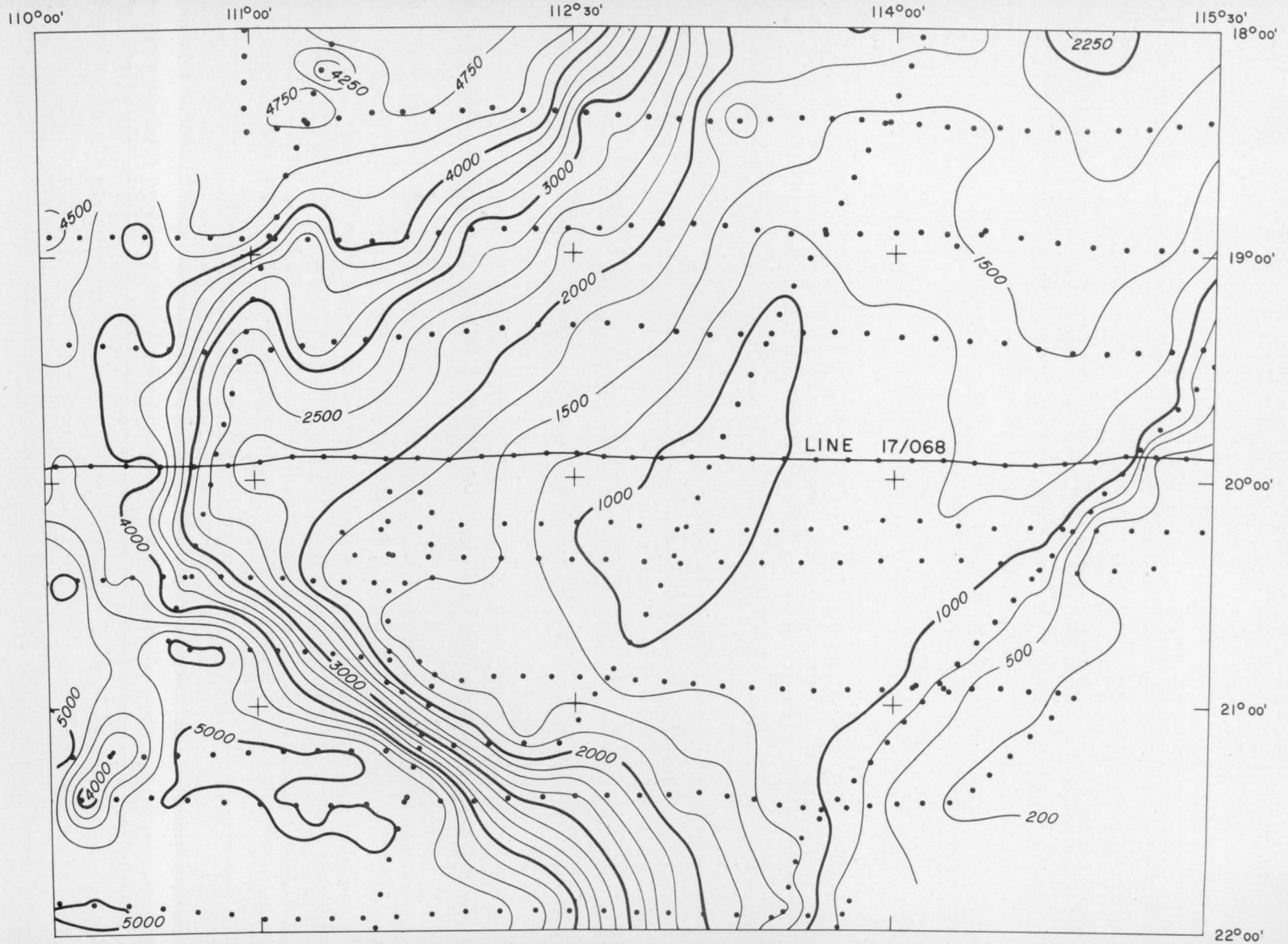


Fig. SGM 19. Exmouth Plateau—water depths in metres. Dots are data points.

shows the depth to the top of the block-faulted horizon.

Several of the seismic horizons have been traced to the Rankin Trend, some 200 km east of the central part of the Exmouth Plateau, and have been tentatively correlated with the seismic horizons mapped in the Carnarvon Basin. Assuming that the correlations are correct, the geological history of the Exmouth Plateau seems to be similar to that of the Carnarvon Basin, which is comparatively well known. A speculative outline of developments in the Exmouth Plateau region follows. This will be refined as work continues.

The Exmouth Plateau appears to be a part of the Australian continent, and was probably receiving shallow marine sediments in late Permian times. Carnarvon Basin data suggest a westerly source area during the Triassic, and up to 500 m of marine and fluvial detrital sediments was deposited across the Exmouth Plateau area during a slow regression.

Early to Middle Jurassic uplift and block-faulting led to the erosion of any older Jurassic sediments. During an Upper Jurassic transgression several hundred metres of claystone and sandstone was deposited in low areas, and a sequence prograding northeastward in the southwest of the Plateau probably represents an Upper Jurassic delta.

Similar deposition of shallow marine and fluvial sediments (Barrow Group) continued into the Neocomian, until seafloor spreading apparently removed the landmass to the west, and the sea flooded the area, Lower Cretaceous deposition of sandstone, siltstone, and claystone gave way slowly to the deposition of marl and carbonates which characterize the Upper Cretaceous. The Cretaceous sequence is up to 500 m thick and, by analogy with the Carnarvon Basin, may contain several disconformities.

By Tertiary time no detrital sediment was reaching the area, and deposition was exclusively of biogenic carbonate. More than 1000 m of Tertiary sediments is preserved, and these are characterized by slumping, prograding, and several unconformities. On the Rankin Trend the major unconformities are of Middle Eocene, Oligocene, and mid-Miocene ages, and last for about 5, 15, and 5 million years respectively. These breaks pro-

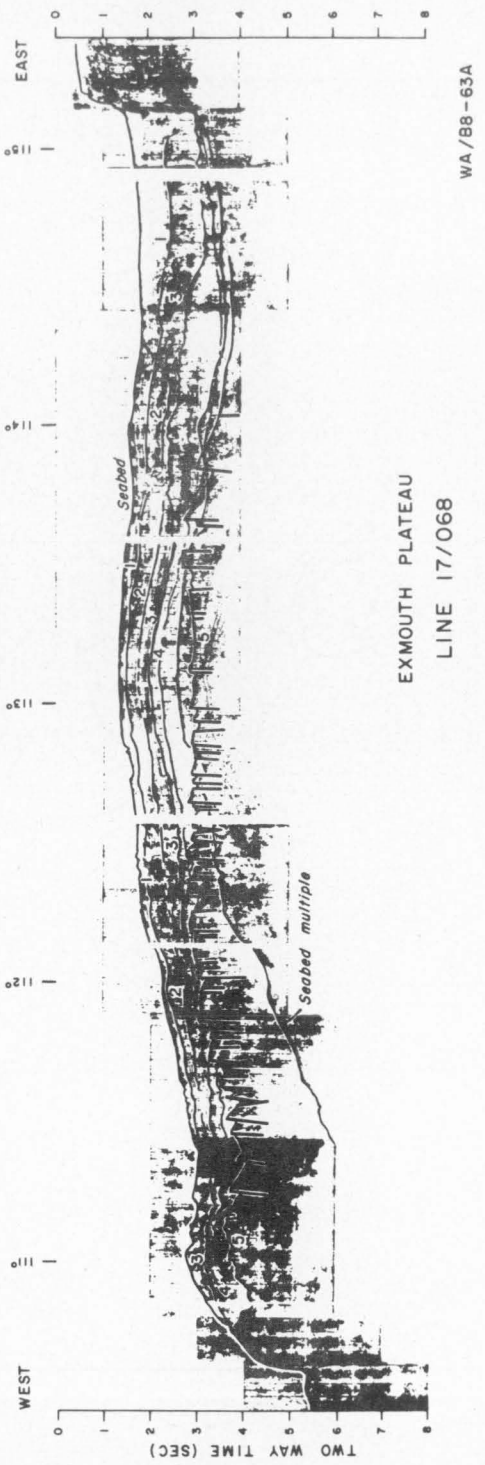


Fig. SGM 20. **Seismic section over the Exmouth Plateau.**

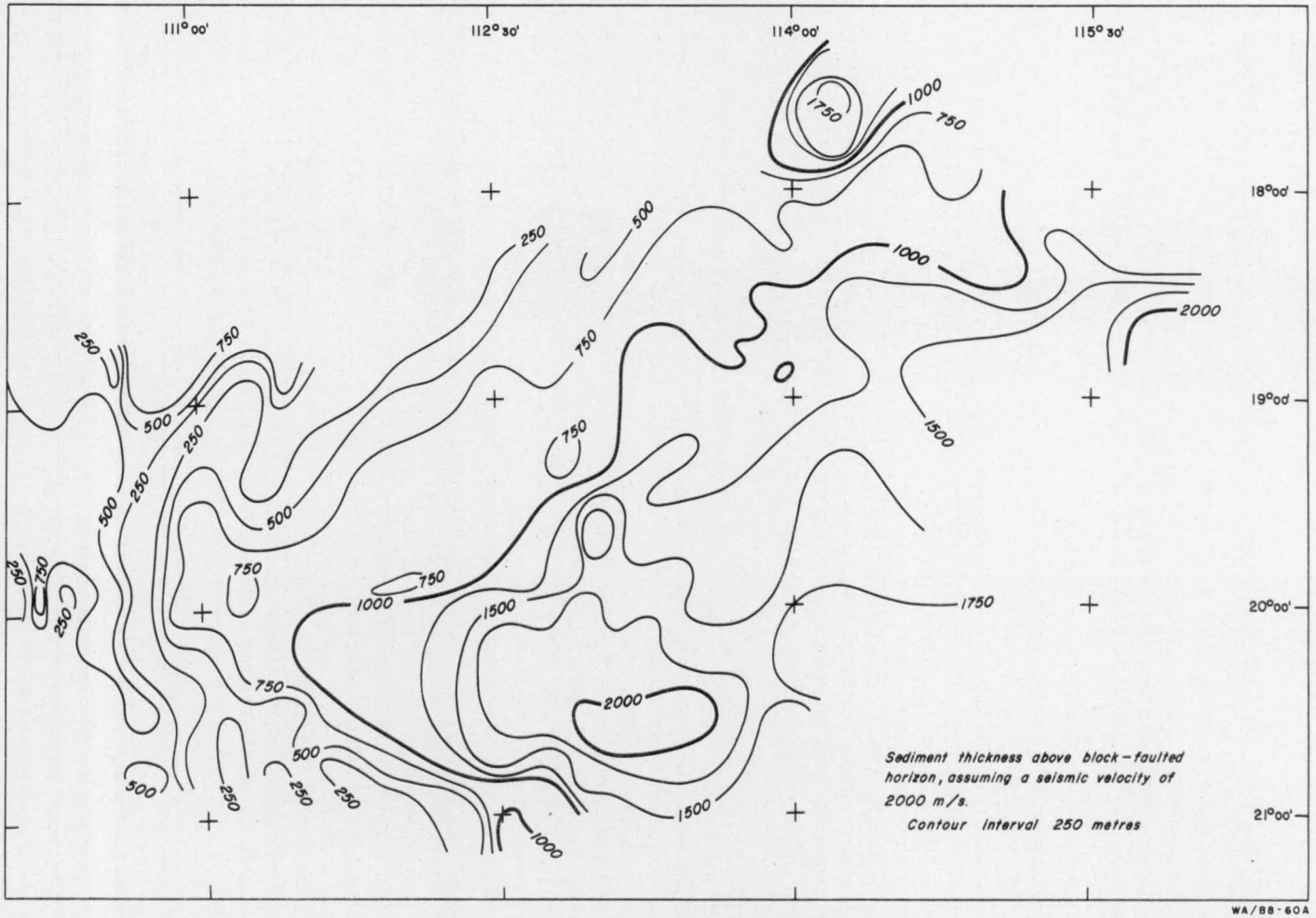


Fig. SGM 21. **Exmouth Plateau—post-Triassic isopach map.**

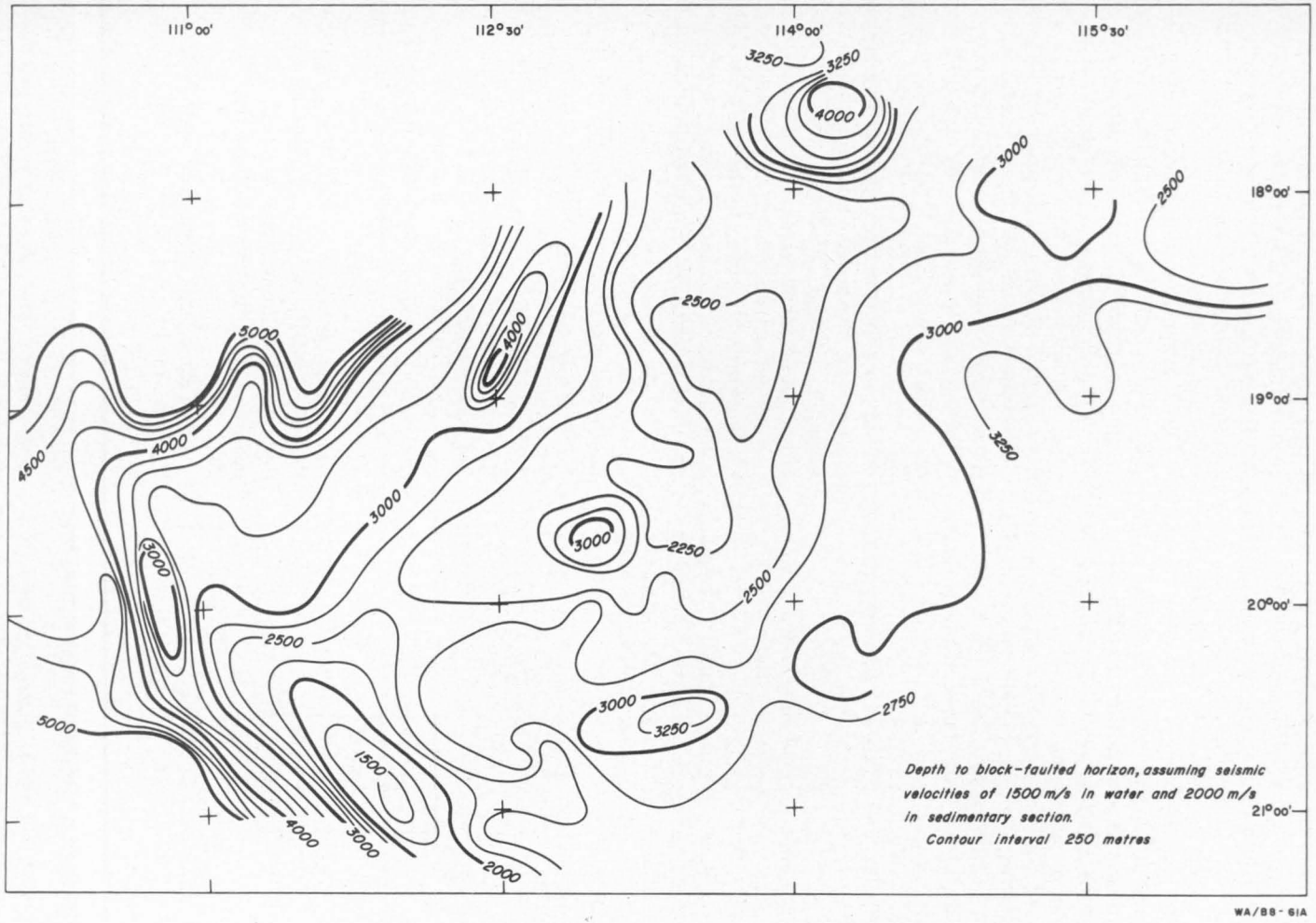


Fig. SGM 22. Exmouth Plateau—structure contours on top of Triassic.

bably represent emergence rather than submarine erosion or non-deposition.

Today the Exmouth Plateau lies in more than 900 m of water, and is separated from the Rankin Trend by a trough several hundred metres deep. Present-day sediments are entirely pelagic carbonates. The topographic grain of the Plateau is controlled by the northeast structural trends first established in the Jurassic. Its southwestern margin is sharp and relatively straight, and may be the result of transcurrent rifting associated with continental drift. The northwestern margin is also relatively straight, although more complex than the southwestern margin, and was probably formed by Neocomian rifting related to seafloor spreading. The northern margin, not shown in the illustrations, is a complex of fault-blocks, and its history is poorly understood.

The Queensland Trough: some recent geophysical results and its petroleum potential (J. Pinchin, J. W. Hudspeth)

The most extensive and systematic geophysical survey of the area to date is that conducted by BMR during 1971 as part of the survey of the Australian continental margin (Fig. SGM 23).

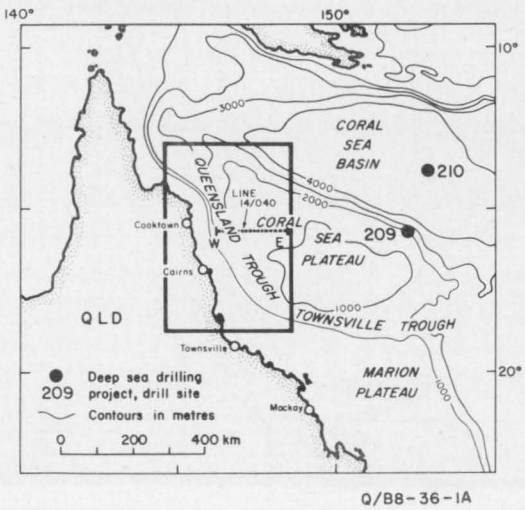


Fig. SGM 23. Queensland Trough—locality map.

The BMR sparker seismic sections (Fig. SGM 24) show a rugged and eroded basement surface. It is concluded that this represents the top of mildly metamorphosed Palaeozoic sediments of the Tasman Geosyncline which were uplifted, folded, and faulted during the Late Permian and were subsequently severely eroded. In places coral reefs have grown from this basement surface. Some are now buried, and some, especially those on top of basement highs, are still growing.

The Eocene/Oligocene unconformity encountered in DSDP hole 209 on the outer edge of the Coral Sea Plateau can be traced as an unconformity over the entire Plateau and as a conformable Eocene seismic horizon over most of the Trough. This horizon lies close to the basement over much of the Plateau and at least 1.5 km above the basement in the centre of the Trough. It is overlain by about 0.5 km of pelagic sediments over both the Trough and the Plateau.

It appears that the Trough was low relative to the Plateau and the mainland since the beginning of the Mesozoic, and received terrestrial and shallow marine sediments.

Regional subsidence of the Trough and Plateau probably began in the early Eocene. Small basins on the Trough's eastern margin and on the Plateau were formed by differential subsidence along rejuvenated basement faults. These small basins contain early to middle Eocene shallow marine sediments.

Petroleum prospects appear favourable in the south of the Trough, especially in the Trough's marginal reef development and in the region of pre-Eocene pinchout against Palaeozoic basement.

Origin of the Naturaliste Plateau (P. Petkovic)

The combination of geophysical data from the BMR survey of the continental margin and drilling data from the Deep Sea Drilling Project (DSDP) permits a more objective assessment of the sedimentary and tectonic history of the Naturaliste Plateau (Fig. SGM 25).

The seismic results show four major unconformities in the east: A, B, C, and D (Fig. SGM 26). About half the total volume of sediments lies above unconformity B. The DSDP data show them to be largely of Cretaceous age, i.e. laid down before the separation of Australia and Antarctica. Between B and C, DSDP 258 recovered Albian clays, which suggests that C is of Neocomian age, and this is supported by evidence of Neo-

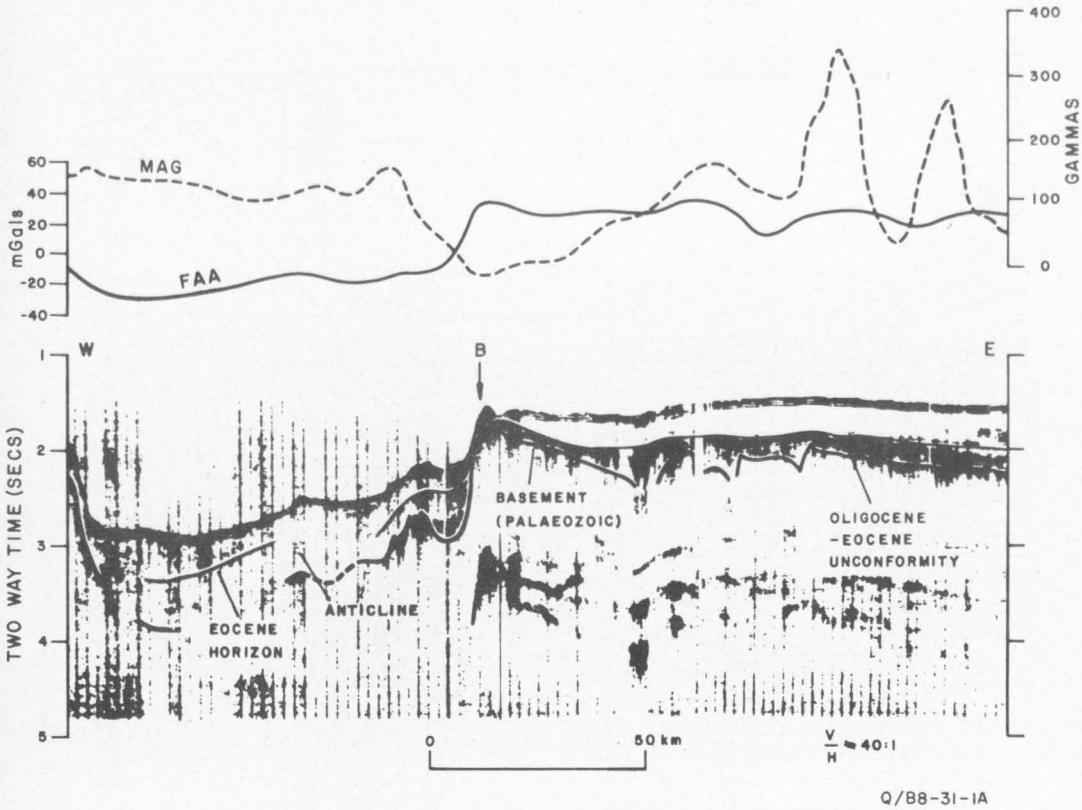


Fig. SGM 24. **Queensland Trough—seismic section, line 14/040.**

comian tectonic activity on the nearby continent. The sediments below C lie unconformably on seismic basement. They are well stratified and virtually undisturbed, but drilling has not penetrated them. The basement itself shows sporadic intrabasement reflection events; this suggests a basement of sedimentary origin, at least in parts. Elsewhere intrusive basement forms are evident.

The large-amplitude, short-wavelength magnetic anomalies which are particularly evident over the western part of the Plateau suggest a basement comprising metamorphosed sediments invaded by basic igneous intrusions. The gravity results may be simulated most readily by a model having the base of the crust 22 km deep relative to a standard crust of 31 km; i.e. an intermediate crustal thickness. This combination of magnetic and gravity inferences points to a continental composition for the basement of the Plateau.

The synthesis of these results indicates, therefore, that the Naturaliste Plateau is of continental origin and existed in pre-Cretaceous time as part of Gondwanaland, probably attached to Antarctica. Since the Cretaceous it has remained essentially in the same position relative to Australia that it now occupies, judging by the continuity of horizons above the basement unconformity.

The Timor Trough (C. J. Watt)

The Timor Trough (Fig. SGM 27) was surveyed during October and November 1972, as part of BMR's offshore seismic, gravity, and magnetic survey of the Australian continental slope.

The two flanks of the Trough show a contrasting appearance on the seismic profiles (Fig. SGM 28). Discontinuous reflecting horizons occur in the Timor flank, but they become increasingly obscured by diffractions below about 500 m. These diffractions are probably produced by widespread faulting and strong folding of the rock sequence. The

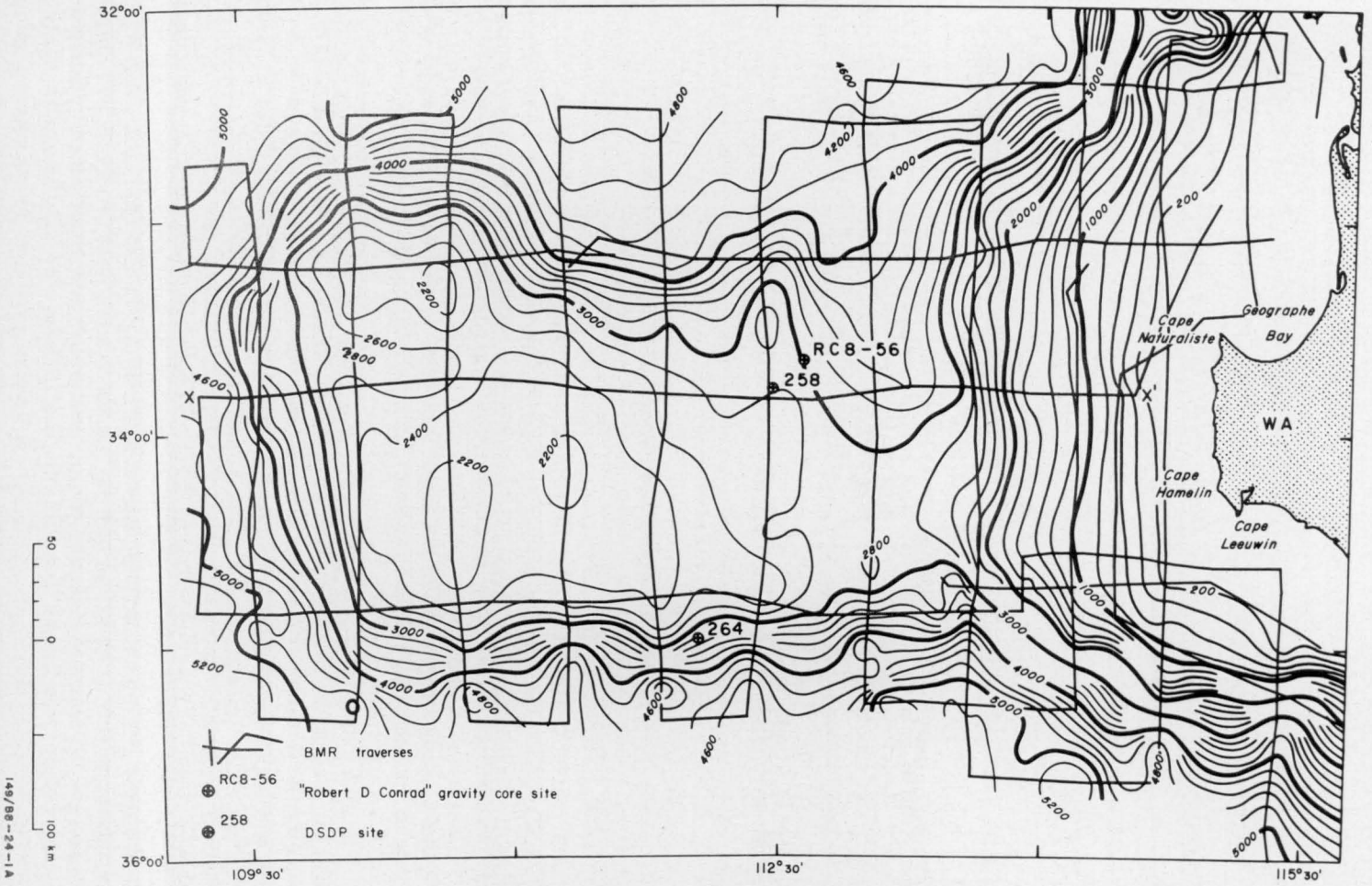


Fig. SGM 25. Naturaliste Plateau—bathymetry.

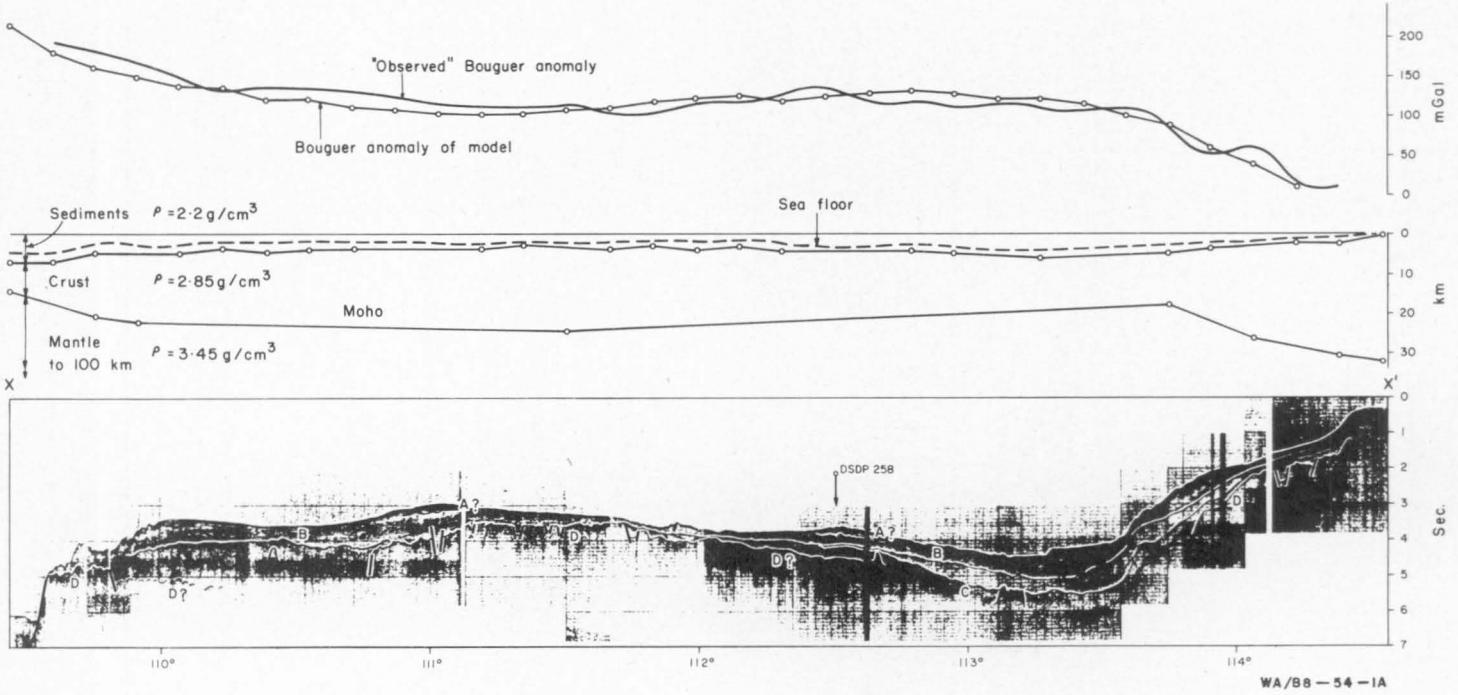


Fig. SGM 26. Naturaliste Plateau—gravity crustal model and seismic interpretation.

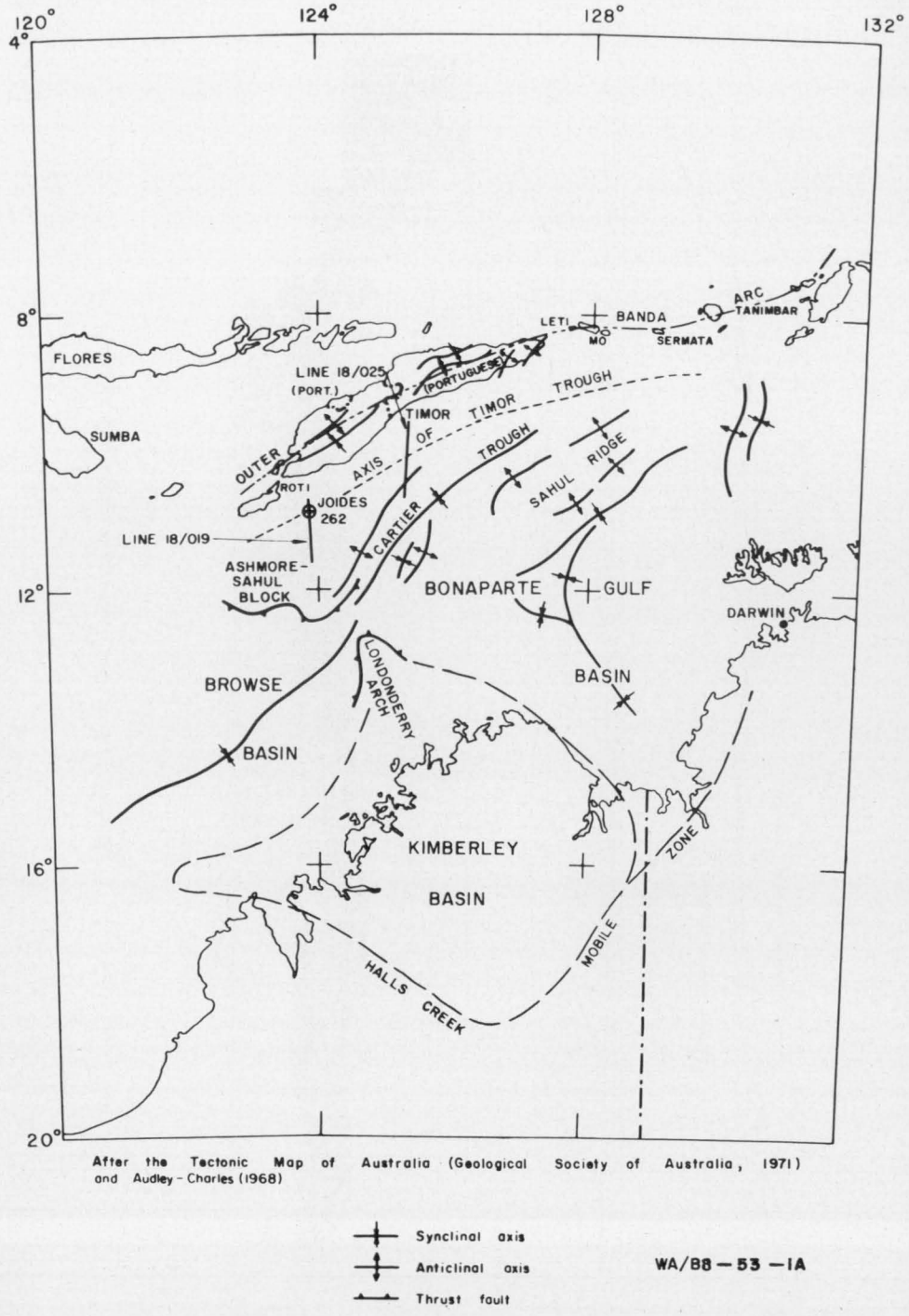


Fig. SGM 27. **Timor Trough—structural sketch map.**

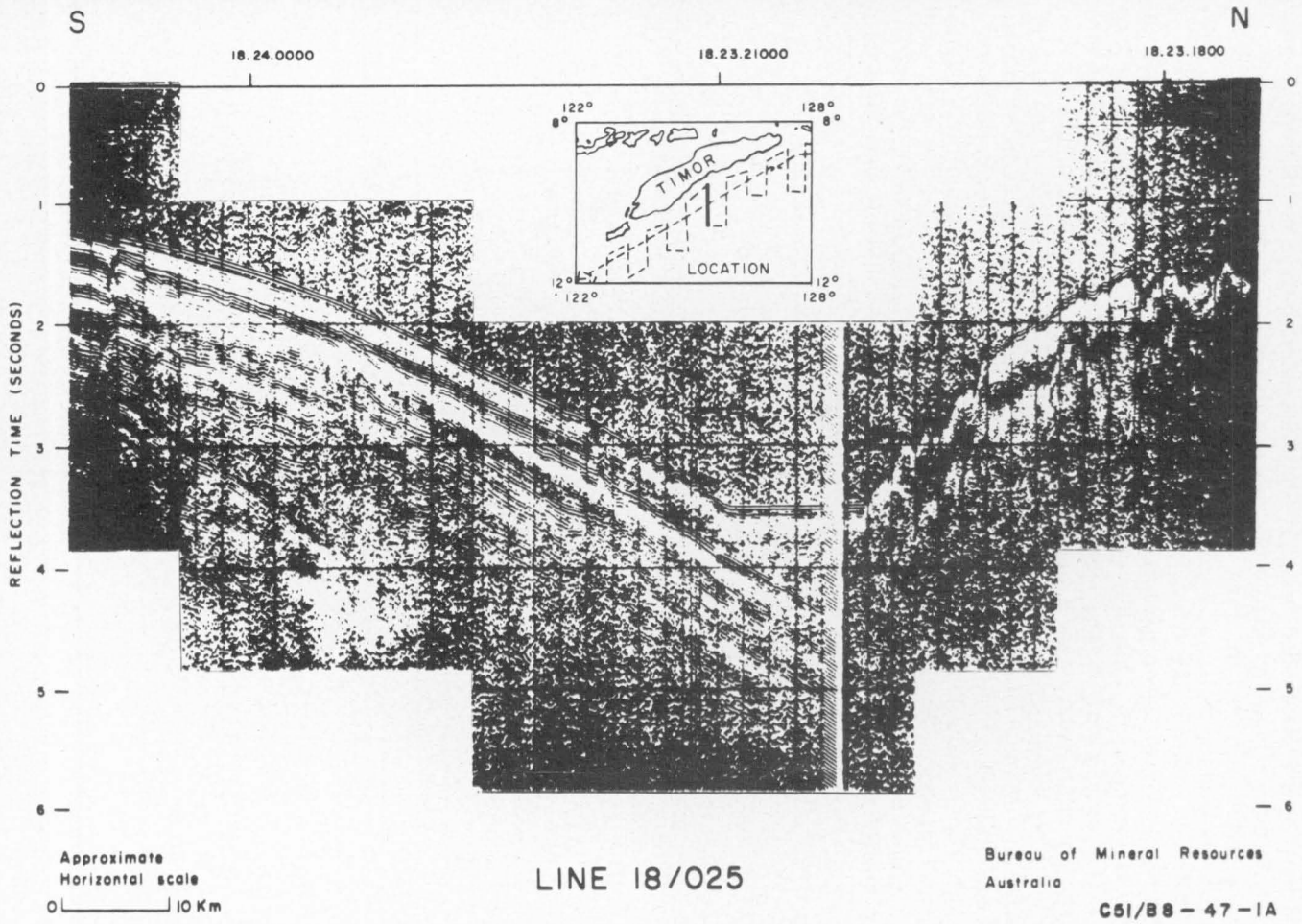


Fig. SGM 28. Timor Trough seismic section.

Australian flank, in contrast, contains more than 2 km of well stratified sediments, with bedding subparallel to the sea-floor. The sediments have been block-faulted, usually with the down-thrown block on the north. Acoustic basement is below the limit of seismic penetration on this flank.

The DSDP hole, drilled in the axis of the Trough in a water depth of 2300 m, penetrated infraneritic Quaternary and upper Pliocene sediments. It is unclear whether these sediments are in situ or derived from the Trough flanks. The steeply folded, faulted, and contorted sediments of the Timor flank were probably deformed since the Pliocene, as Pliocene and younger sediments in the axis of the Trough all show signs of deformation.

The magnetic field recorded over the Trough is quiet, having broad, gentle magnetic anomalies with no marked change across the Trough. Thus the magnetic basement on both sides of the Trough is deep, and it is likely that the contorted rocks on the northern side are of sedimentary origin.

Marine magnetic surveys (F. W. Brown, J. K. Grace, R. Dulski)

A marine magnetic survey continued in 1974 in association with contract bathymetric survey Number 4 by Division of National Mapping over part of the northwest shelf. That survey was incomplete at the end of 1973, when work was suspended to permit routine maintenance in Darwin of the survey ship, M.V. *Ataluma*. Recommencement was delayed by problems with the ship, and further delays were caused during the year by mechanical failures, notably when the ship's

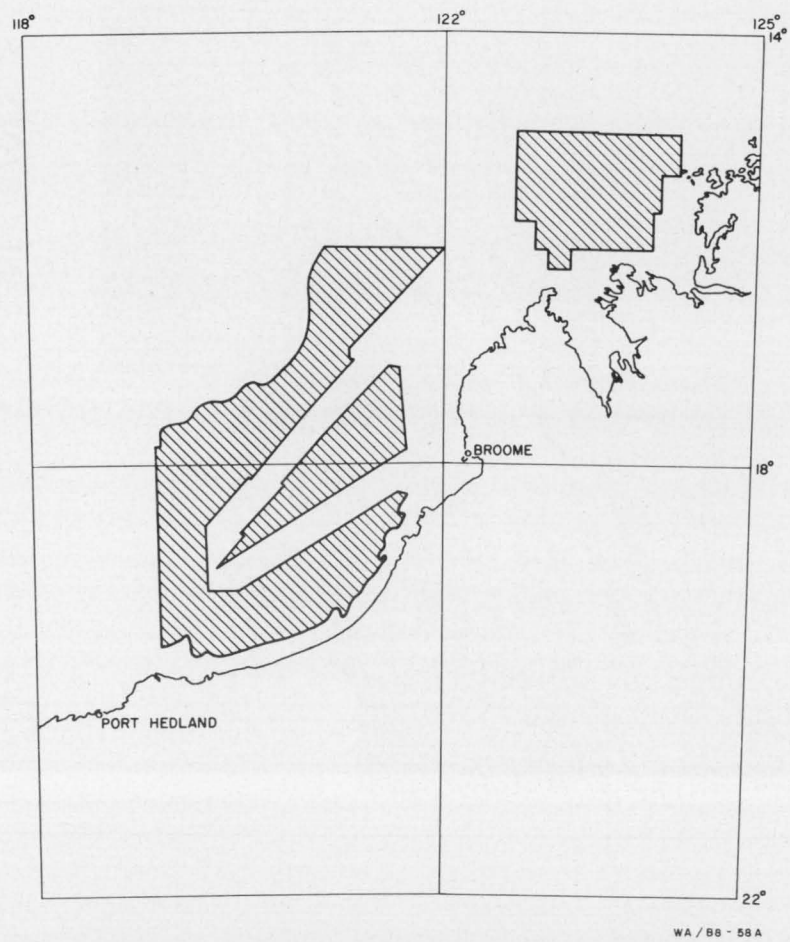


Fig. SGM 29. **Magnetic surveys on the northwest shelf—locality map.**

generator burnt out. In September the ship ran aground and the survey was transferred to another vessel, M.V. *Bluff Creek*. It is hoped that the bathymetric and magnetic work will be substantially complete by the end of the year.

The contract was for at least 13 000 nautical miles, and this was extended during 1974 by

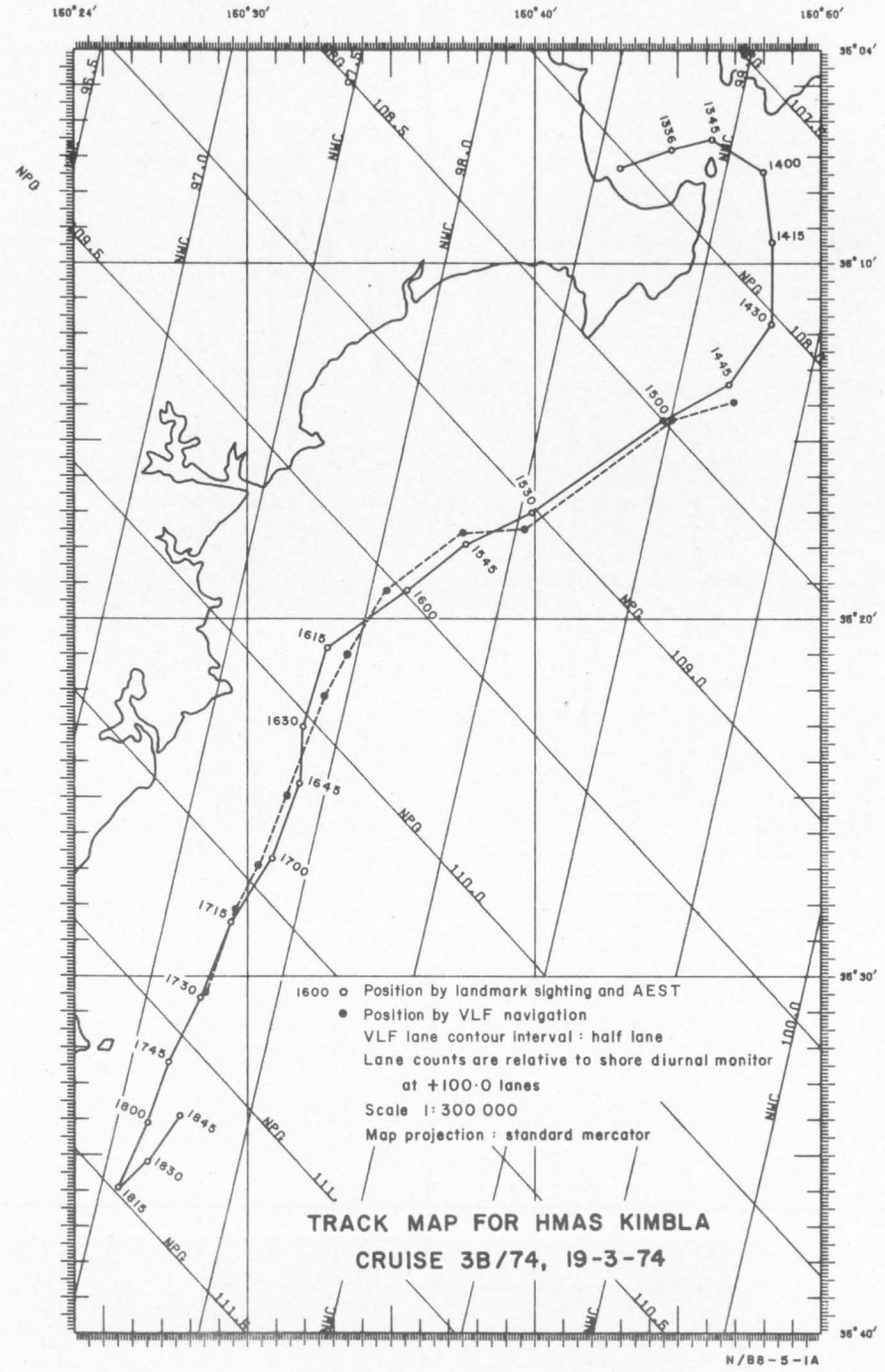


Fig. SGM 30. VLF navigation test.

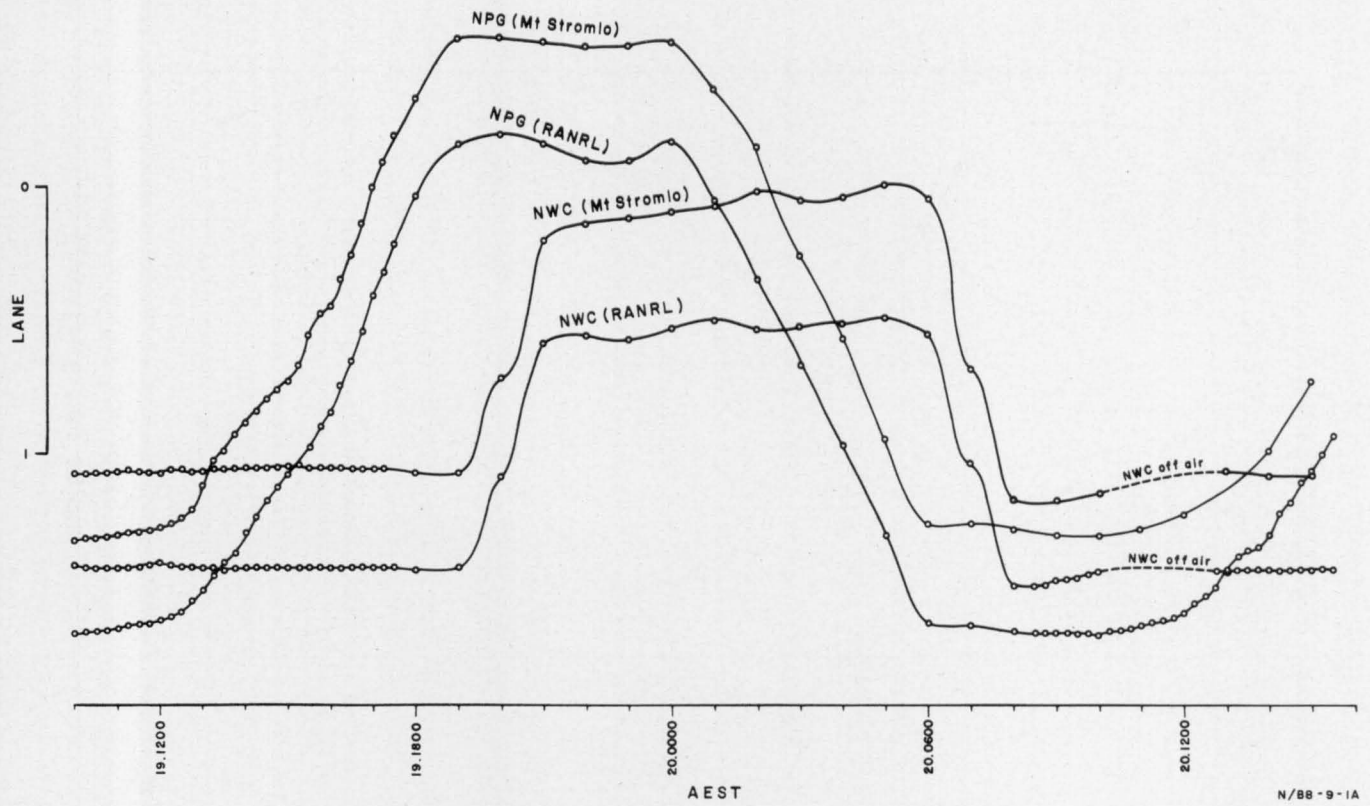


Fig. SGM 31. VLF navigation tests—diurnals.

some 7000 nautical miles. About half of the total will have magnetic readings. A considerable amount of magnetic recording was missed during breakdowns of the magnetometer or recording equipment (Fig. SGM 29).

During 1974 the shore magnetometer station located in Broome in conjunction with the magnetic survey was operated under contract by a local man.

VLF navigation tests (P. Petkovic, J. K. Grace)

A test using BMR VLF navigation equipment was carried out in HMAS *Kimbla* during March 1974 in co-operation with the Royal Australian Navy Research Laboratories (RANRL). *Kimbla* travelled along the coast to a distance of 170 km south from the shore diurnal monitor at RANRL in Sydney. It was intended that navigation would be done using the VLF equipment, and that *Kimbla*'s absolute position be calculated by sextant triangulation on land features along the coast. Equipment faults did not allow communication with RANRL shore monitor, and precluded navigation by VLF. However, later analysis of RANRL diurnal data yielded VLF positions with an accuracy of 1 km relative to the positions determined by the triangulation techique (Fig. SGM 30).

A similar accuracy was obtained when the VLF positions were computed using diurnal data from Mount Stromlo, ACT, which is 160 km from the test area. The diurnals monitored at Mount Stromlo and Sydney are compared in Figure SGM 31.

3. OBSERVATORIES AND REGIONAL SECTION
(J. C. Dooley)

OBSERVATORIES SUBSECTION (P. M. MCGREGOR)

Headquarters Observatory Group
(D. Denham)

Geomagnetism. Thirty observatory-months of magnetograms were scaled and 27 observatory-months were reduced. Many problems were experienced with breakdowns of the scaling machine, the Typetronics paper tape equipment, and the CDC 3600 computer processing system. As a result about 22 observatory-years remain to be reduced. Conversion of the programs and data tapes to the Cyber 76 computer was started.

The monthly issues of Volume 22 of the Geophysical Observatory Report were prepared and distributed.

The Elsec automatic magnetic observatory (AMO) at Kowen Forest operated continuously except for losses due to tests, a major power failure, and mechanical breakdowns in the sensor and paper tape punch. The sensor was modified to provide better cooling, and a spare tape punch was purchased, and record losses then became negligible. Work began on a magnetic tape recording unit for the AMO. Semi-weekly calibration observations were made until May with a proton vector magnetometer (PVM) for inclination (I) and an Askania declinometer for declination (D). The results showed that weekly calibrations would suffice to yield results of conventional observatory precision. Standard deviations were: I, 0.09′, D, 0.3′; the I results are equivalent to errors in derived horizontal and vertical intensities of 1.4 nT and 0.5 nT respectively. Baseline drift rates, presumably due to tilting of the bias coil assembly, were acceptably small. In summary, the Elsec AMO is a suitable instrument for magnetic observatory purposes, provided that a highly stable pier and a thermally stable sensor room are used.

An Adkin autodigital magnetometer was received and testing began in October. This is a fluxgate system capable of providing digital and analogue data. It may prove acceptable for observatory purposes as well as for first-order regional magnetic surveys.

Because of other commitments the proposed revival of the La Cour Feedback magnetograph was shelved indefinitely.

Analysis of geomagnetic variations was limited to an examination of secular variation data for the previous 20 years; the Marine Group utilized the data to provide a better alternative to IGRF 1965.0, which fits poorly in the Australian region after 1968.

Seismology. The positions of BMR observatories, seismograph stations, and accelerographs are shown in Figure OR 1. Ownership of the Hobart Worldwide Standard Seismograph (TAU) was transferred to BMR in January 1974, and it was operated under contract by the University of Tasmania. The seismograms are still analysed at the University and all phase and hypocentre data from the Tasmanian network are now set systematically to BMR.

Analysis of the Alice Springs seismograms continued throughout the year and preliminary bulletins were prepared and distributed for this station and for Manton (Darwin), Toolangi, Norfolk Island, Bellfield, Stephens Creek, Macquarie Island, and Mawson. Final phase data for the International Seismological Centre (ISC) for all seismological institutions within Australia, Papua New Guinea, and the British Solomon Islands were processed for the period November 1971-November 1972 and sent to Edinburgh on magnetic tape. Each month about 6000 P phases were sent to ISC. Time-sorted bulletins for the same period were also prepared and distributed. Figure OR 2 shows the number of P phases reported by each seismograph station.

The seismographs at Manton and Alice Springs were serviced in June. At Manton new filters were fitted to evaluate the most suitable combination—since the opening of a new bridge over the nearby Stuart Highway in-

terference from road trains has become a nuisance. A BMR 'time-pip generator' was connected to the Manton digital clock (in the Darwin Office) and its output made available to the local ABC. It now provides the standard hourly time signals for the region. Staff of the Darwin Uranium Group continued to attend the seismograph and analyse the seismograms.

Three new short-period, vertical-component seismograph stations were commissioned. They were all Helicorder systems recording directly (using BMR TAM-5 preamplifiers) or by FM telemetry (using Geotech components). Some station details are:

Name/Code Locality/date	*Peak magnification at (period, s)*	*Type*	*Co-operating authority*
Stephens Creek (STK) near Broken Hill, NSW March	85 000* (0.6)	Direct	Broken Hill Water Board
Cooney (COO) near Armidale, NSW August	290 000 (0.14)	Telemetry	University of New England
Giles (GLS) Meteorological station, WA September	550 000 (0.2)	Direct	Bureau of Meteorology

*Prototype TAM-5 used. Modified version will increase magnification several times.

The seismograms were analysed by: STK—Toolangi Group; COO—Headquarters Group; GLS—Mundaring Group. Figure OR 3 shows the STK seismometer and recorder which are representative of all the stations.

The regional earthquake file was fully operational throughout the year and about 19 000 hypocentres from the area 0–90°S, 75–165°E have now been stored on the file. Earthquake hypocentres were provided by the United States Geological Survey, the University of Adelaide, the University of Tasmania, the Australian National University (ANU), and BMR. Unfortunately ANU stopped regular computing of earthquake hypocentres during 1973 and so results from southeastern Australia have been obtained only up to the end of 1972. During the year several earthquakes were relocated and magnitudes of PNG earthquakes from 1958 onwards were scaled from the Port Moresby Wood-Anderson seismograms. Extensive use of the regional earthquake file was made throughout the year and about 50 requests from both within and outside BMR were handled.

Strong ground motion. Problems in processing accelerograms were experienced because of failures of the digitizer, conversion of computers, and staff shortages. However, 12 accelerograms from Lae were analysed, and the restructuring of the computer programs used to process the data was completed by August 1974.

A symposium on 'Seismicity and Earthquake Risk in Eastern Australia' was held at BMR on 5 December 1973. Fifteen papers were presented at this meeting which was attended by about 70 delegates from all states except Western Australia. The proceedings will be published as a BMR Bulletin.

Several meetings of the National Committee on Earthquake Engineering were attended, and a preliminary zone map for the Australian Continent was prepared, in collaboration with Dr Underwood of the Tasmanian Hydro-Electric Commission.

A Kinemetrics accelerograph was installed (October) near Dalton, NSW, close to the centre of the Dalton-Gunning seismic zone.

Draft maps for an atlas containing all isoseismal maps obtained from Australian earthquakes were prepared and submitted to the Drawing Office. These will be used to prepare better zoning parameters.

Crustal movements project, Papua New Guinea. Meetings of an intradepartmental committee comprising Messrs Aronsen, Denham, and Dow (BMR); Murphy (National Mapping), and Williams (Head Office, Minerals & Energy) were held during the year to manage the crustal movements project in Papua New Guinea. Analysis of the first set of measurements made in the Markham Valley

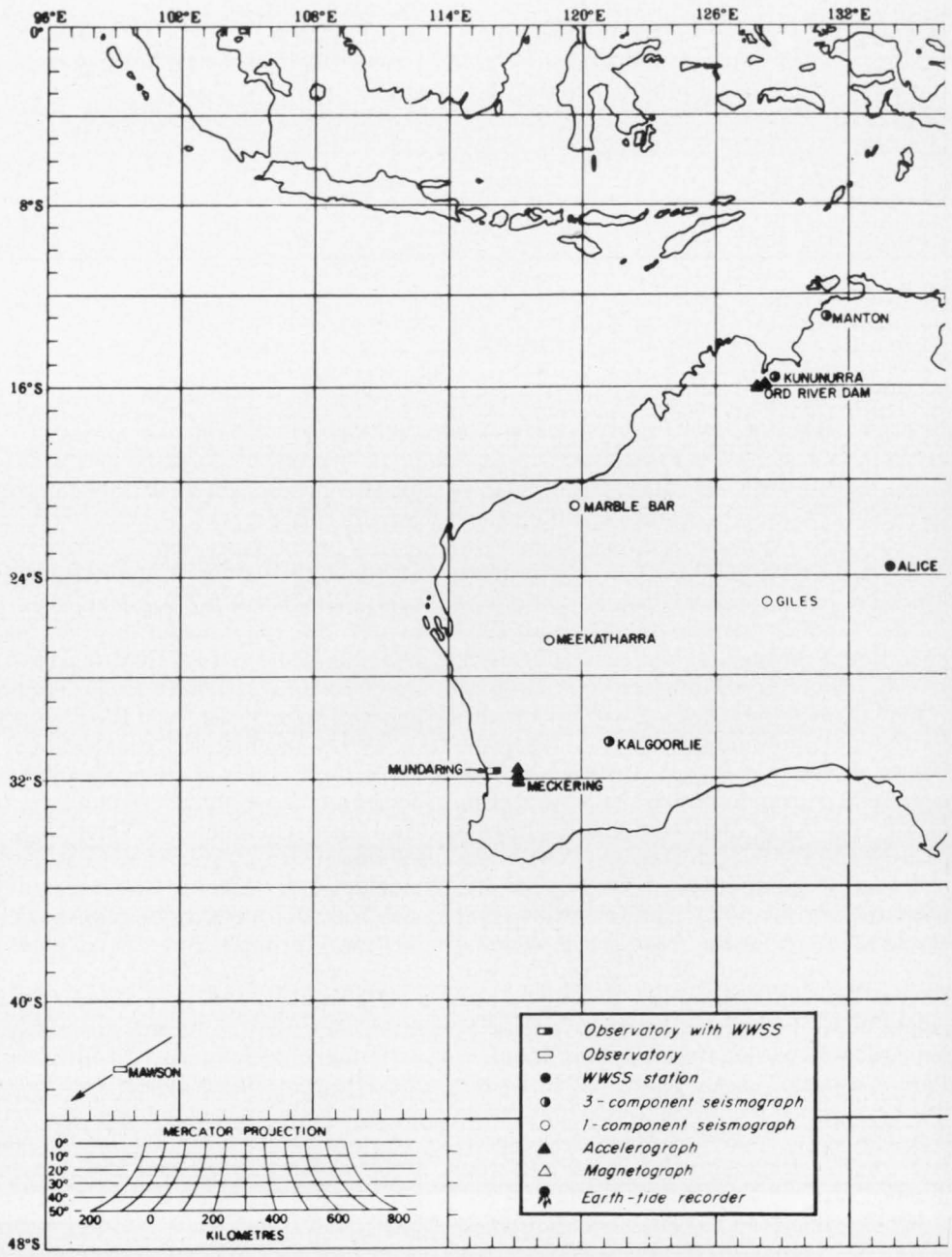
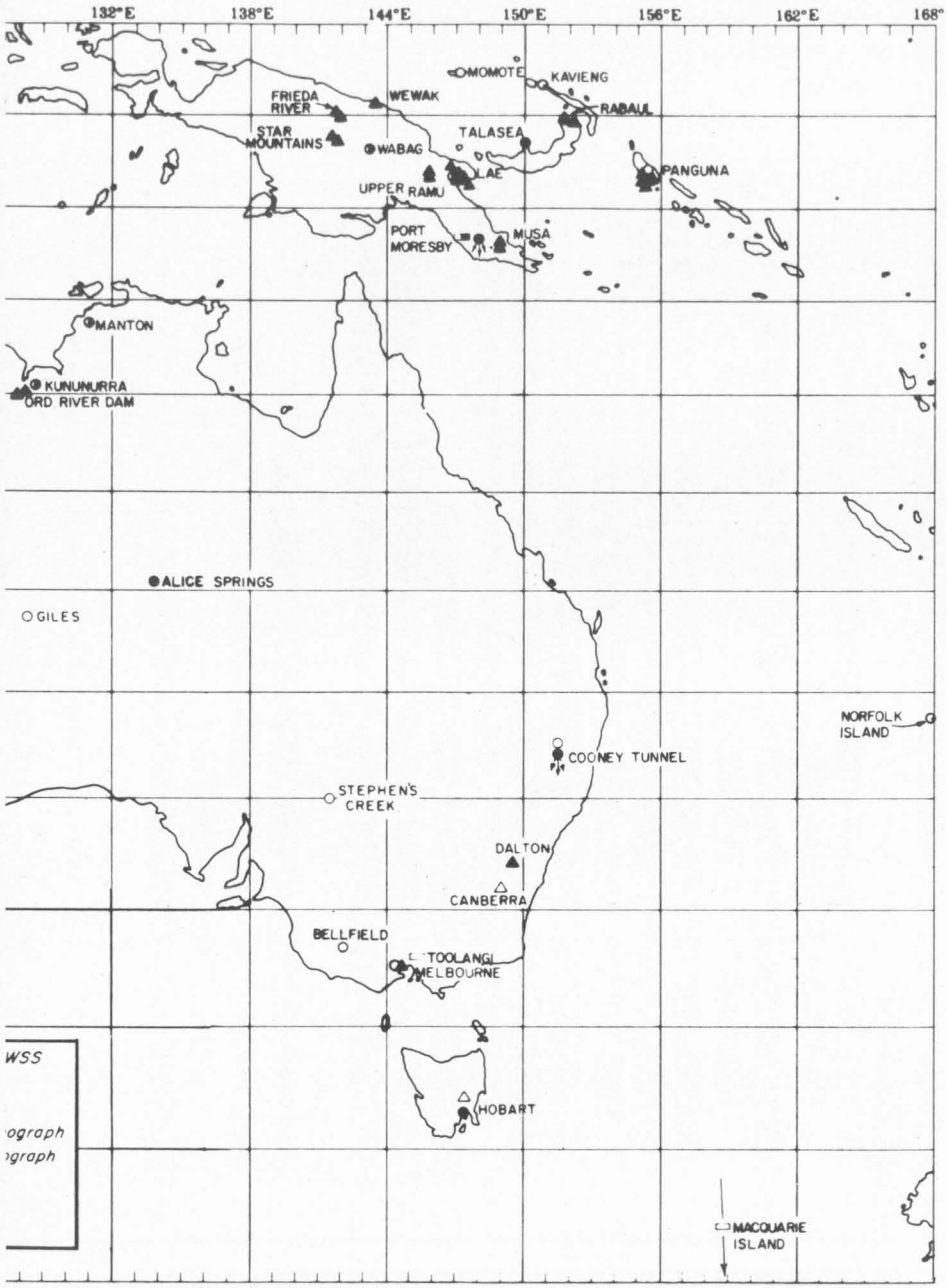


Fig. OR 1. **BMR observatories**



and recorder stations.

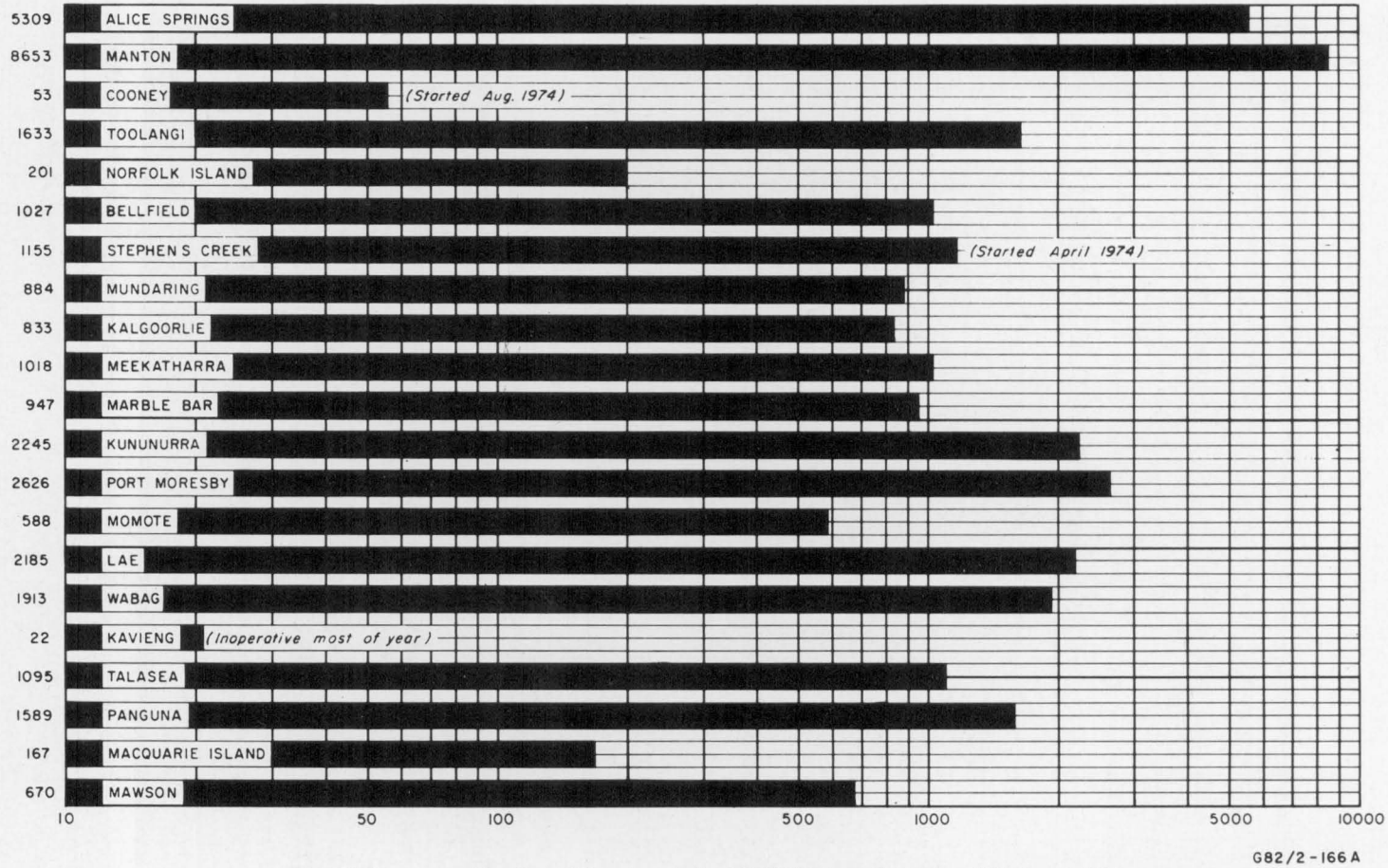
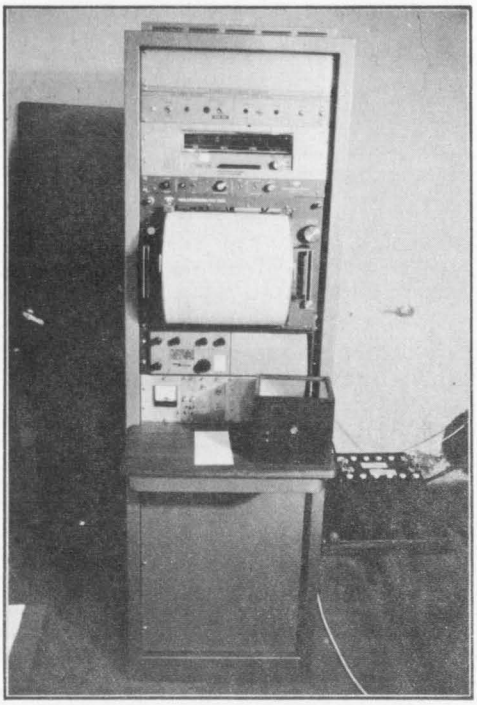
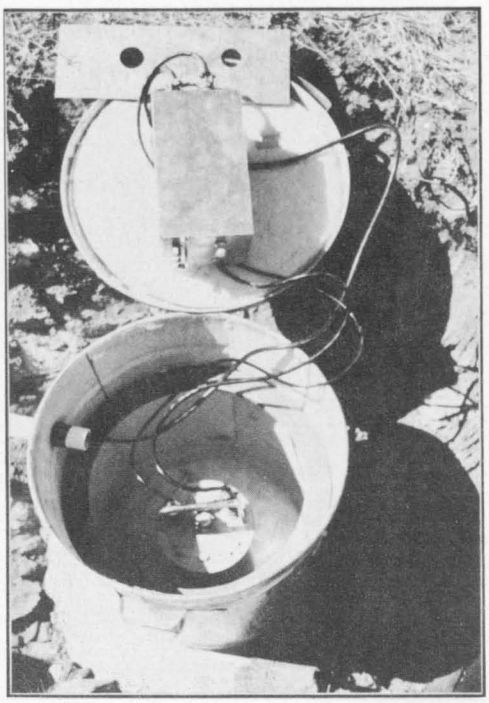


Fig. OR 2. Numbers of P-wage arrivals at BMR Stations, September 1973-August 1974.



RECORDER



SEISMOMETER SITE

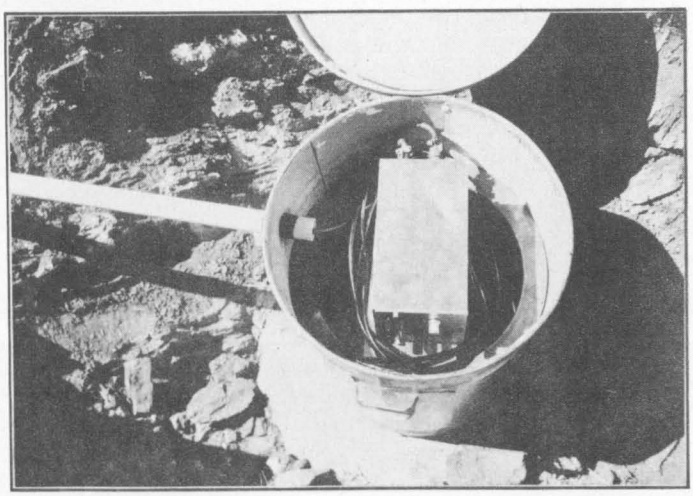


Fig. OR 3.

Short-period vertical seismograph at Stephens Creek.

was completed and a start was made to erect permanent markers in the St Georges Channel region. Preliminary gravity measurements (with only one gravity meter) were made in November 1973.

Stress measurements study group. A meeting of a stress measurements study group was held in February and a review of all known reliable stress measurements that have been made in Australia is being prepared. It is proposed that BMR and CSIRO co-operate to take stress measurements at selected sites to build up a picture of the regional stress patterns in the Australian continent. The sites have yet to be selected but will be either in shallow boreholes or in mines.

Seismological Research Observatory (SRO). Negotiations were completed with the Department of Foreign Affairs in September for Government approval of the Project. In February the Chief of the USGS Seismological Centre and officers from Headquarters and Mundaring selected a site for the borehole sensor near Narrogin, WA. Final site requirements and arrangements for drilling the hole were completed in September during a visit of a representative of the US contractor (Unitech). It is planned to complete the installation before mid-1975. The sensor outputs will be transmitted by APO circuits to recorders and processors in the Mundaring Observatory.

Regional magnetic surveys. The proposed third-order survey of Central Australia using two helicopters and a ground support crew did not go ahead as planned because of difficulties encountered with letting the contract. It is now anticipated that the survey will start in March 1975.

First-order surveys were carried out in Australia (Aug-Dec 1973), Papua New Guinea, the Solomon Islands, Nauru, Norfolk Island, Lord Howe Island, and Willis Island (January to July 1974). Measurements of *D*, *H*, and *F* were made at each station and a fluxgate variograph provided variation control for all places except Willis Island. Figure OR 4 shows the stations that were occupied. Those in Australia were occupied using a chartered aircraft for transport; the variograph was operated at the central places shown in the figure.

New computer programs were written and others modified to place all data from first- and third-order surveys onto magnetic tape. From there the data can be plotted for the 1975 epoch charts.

Seven third-order stations were occupied during January and February in the Prince Charles Mountains, Antarctica.

Mundaring Geophysical Observatory Group (P. J. Gregson)

Geomagnetism. An Eschenhagen normal-run magnetograph was operated continuously and calibrated regularly. An Elsec Proton Vector Magnetometer (PVM) came into regular use for *H* and *Z* absolute measurements by May and displaced the semi-absolute QHMs and BMZ. Corrections to the QHM 290 and 460 series, and BMZ 120, were measured with respect to the PVM. Preliminary data were distributed to the usual Australian and overseas agencies; microfilm copies of the magnetograms were lodged in World Data Centre A.

Ionospherics. An IPS Type IIIE ionosonde was operated continuously and data were distributed as required. Equipment failures were reduced relative to other years. A riometer and radio-noise recorder were operated for Ionospheric Prediction Service between 20-30 June to cover the solar eclipse of 20 June. Special ionosonde runs were made for three days centred on the eclipse.

Seismology. Data from the seismographs at Mundaring, Kalgoorlie, Meekatharra, Marble Bar, and Kununurra were distributed to Canberra HQ, the international centres, and other interested agencies. A mobile film-recording seismograph was operated for short terms at Wagin, Talbot Brook, and Bally Bally to monitor tremors in the southwest seismic zone; and a Regional Crustal Surveys tape-recording seismograph was operated in the Beverley-Brookton area in February when microtremor activity recommenced there after several years' quiescence. Over 500 microtremors were recorded during an 8-day interval.

A magnitude 4.3 earthquake, the largest since October 1968, occurred near Meckering on 9 July. An iso-seismal map was drawn from questionnaire replies: the earthquake was felt over a 200-km radius and the maximum

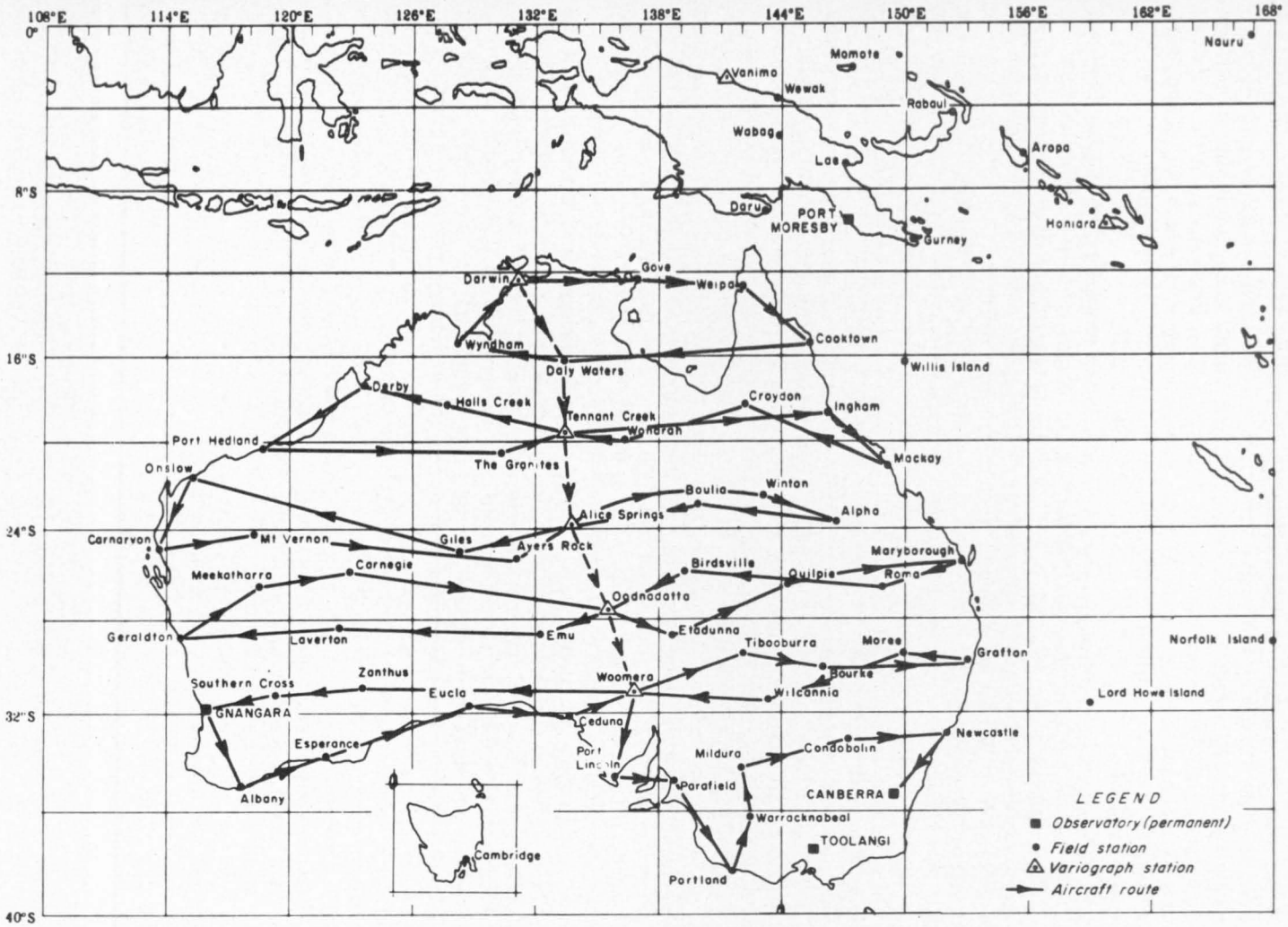


Fig. OR 4. First-order regional magnetic measurements, August 1973-July 1974.

intensity was MM V; the intensity at Perth was MM III.

A telemetry seismograph was installed in the Swan View Tunnel in July but unfortunately the sensor equipment was wrecked by vandals after one day's operation. Negotiations were completed to resite the Marble Bar components when telemetry equipment becomes available.

Port Moresby Geophysical Observatory Group (I. B. Everingham)

Standard programs. A La Cour normal-run magnetograph, a Worldwide Standard and supplementary seismographs were operated continuously. The results were distributed regularly, as for Mundaring.

The seismicity computer storage and retrieval file was maintained. Earthquake hypocentres and intensity data from the area 0–12 °S, 130–163 °E were added to the file.

Regional seismology. Seismographs were operated at Kavieng, Lae, Momote, Talasea, Wabag, and Madang (installed in September). In addition, the seismograms from the Bougainville Copper Limited station at Panguna were analysed. Record losses were caused by pen recorder breakdowns (Kavieng), a staff vacancy (Talasea), and unreliable mains power supply (Momote).

There were 20 accelographs in Papua New Guinea operated by BMR, other Australian and Papuan New Guinean government departments, the University of Technology, and mining companies. The accelerograph network needed maintenance visits every four months. Copies of accelerograms are available from the Strong Motion Data Centre at BMR, Canberra.

Studies and reports were made or continued on seismicity, earthquake focal mechanisms, strong-motion results, and earthquake risk.

Earth-tide recording. Equipment for recording earth-tides, received from the International Centre for Earth Tides (Belgium), was installed in September and operated in collaboration with the Regional Gravity Group.

Toolangi Geophysical Observatory Group (R. L. Paine, E. P. Paull)

Standard programs. A La Cour normal-run magnetograph and 3-component short-period and long-period seismographs were operated continuously at Toolangi. At Melbourne an accelerograph was maintained for the year but was not triggered, and the short-period visual seismograph was inoperative until 18 July. Physicists from the Antarctic Division were trained in geomagnetic measurements, for application at Davis and Casey in 1975.

Regional seismology. Short-period vertical seismographs were operated at Bellfield and Norfolk Island; analysis of seismograms from the Stephens Creek (NSW) station was undertaken from April.

Minor earthquakes in Victoria were in the Echuca-Kerang area (24 Aug, ML 4.0, not felt), near Erica (7 Sep, ML 3.2, MM IV) and off Cape Everard (16 Sep, ML 3.5, MM II at the lighthouse).

Antarctic programs. These programs were carried out in collaboration with the Antarctic Division, Department of Science. Continuous recordings were made at Macquarie Island (La Cour normal-run and rapid-run magnetographs; short-period vertical-component seismograph) and Mawson (normal-run and sensitive magnetographs; 3-component short-period seismograph). Preliminary data were distributed via the Toolangi Group.

At Macquarie Island the landline to the plateau seismometer proved difficult to maintain, and the isthmus seismograph was used for most of the year. The Flinders University tide gauge and the University of Alaska micropulsation equipment were maintained.

At Mawson the vertical seismometer was moved into the vault 15 m underground. This was the first step of planned improvements to the seismograph station.

Regional magnetic and gravity field observations were made in the southern Prince Charles Mountains during the 1973-74 summer program.

REGIONAL SUBSECTION (W. A. WIEBENGA, B. C. BARLOW)

Regional Gravity Group (B. C. Barlow, P. Wellman)

Gravity Map of Australia. The gravity coverage of Australia was examined to determine which surveys need to be recomputed before the Bouger anomaly map with com-

mon datum and common Bouguer density can be produced at scale 1:5 000 000. A list was compiled of surveys covering areas which are not covered by the BMR helicopter surveys. Most of the surveys were done by private companies under the Petroleum Search Subsidy Act and the data were given to the contractor for recomputation. The remaining surveys are being recomputed by BMR. Proof maps were produced on the drum plotter for all areas covered by data which have recently been recomputed or were already considered to be of acceptable accuracy. The maps were checked for obvious errors in station positions, anomalies, and survey datum, and for multiple values at individual stations. All detected errors were corrected on the magnetic tape files, and production of 1:1 000 000 contour maps was commenced. The Drawing Office will reduce the 1:1 000 000 maps to 1:5 000 000 as the basis for the Gravity Map of Australia. The map sheets which have data coverage of acceptable accuracy and station density for reconnaissance purposes are shown in Figure OR 5. The manual filing system of gravity surveys and data was brought up to date and preliminary work was started on the computer-based index to the files.

Recomputation of gravity survey data. The contract recomputation of gravity data was delayed for three months owing to problems associated with the change of computers at CSIRO. The $20 000 pilot contract is expected to be completed by the end of 1974. The first $100 000 annual contract was awarded to Layton and Associates in June after delays due to internal company problems. Thirty-one surveys comprising about 98 000 stations were passed to the contractor, who has prepared assessment reports for about half the surveys and is making good progress in the recomputation. Figure OR 6 shows the surveys which have been passed to the contractor under both contracts. The Figure also indicates the surveys which have been assessed and those for which computation and final reports have been completed.

In-house recomputation of BMR surveys in the Kimberleys was hampered by lack of Australian Height Datum control. The 1960 helicopter survey in the Canning Basin requires only AHD values for the elevation control points before recomputation can be completed. Road surveys in northwest Australia and western Victoria were recomputed and added to the tape files. Composite maps were produced for areas covered by recomputed private company, road, and helicopter surveys.

Computing and calculating. The suite of programs for processing gravity data was completely converted from the CDC 3600 to the Cyber 76 computer by the end of February. The conversion of the tape files was completed in January. No major modifications were made to the data processing system but several errors and limitations were removed. The program package for plotting and contouring was modified so that the BMR drum or flat-bed plotter could be used instead of the CSIRO plotter. This change was made necessary by the slow turnround and frequent equipment failures at CSIRO and the reduction in computer cost which would be achieved. The Record entitled 'The Australian National Gravity Repository Computer System' was issued.

The program GRAVCYL for calculating the gravity effect of vertical cylinders was found to be inaccurate for bodies very close to the sampling points. A formula was derived for the exact calculation of the gravity effect of a trapezoidal prism; this was incorporated in a program named 3DGRAV for the Hewlett-Packard 9100B calculator and will be used to improve the accuracy of GRAVCYL.

Earth-tides. Throughout the year deflections of the vertical were recorded at Cooney Observatory near Armidale using two sets of Verbaandert-Melchior horizontal pendulum equipment. Maintenance visits were made to repair faults in the equipment and to improve the quality of the traces on the records. The traces have often been seriously affected by what appears to be long-period seismic noise. Seismometers were installed in and around the Cooney Observatory tunnel in an unsuccessful endeavour to trace the source of the noise. After several weeks of recording at Cooney the seismometers were moved to Kowen Forest test site where they were operated for a month for control and calibration purposes. Shortage of staff has prevented any analysis of the tidal records during the year.

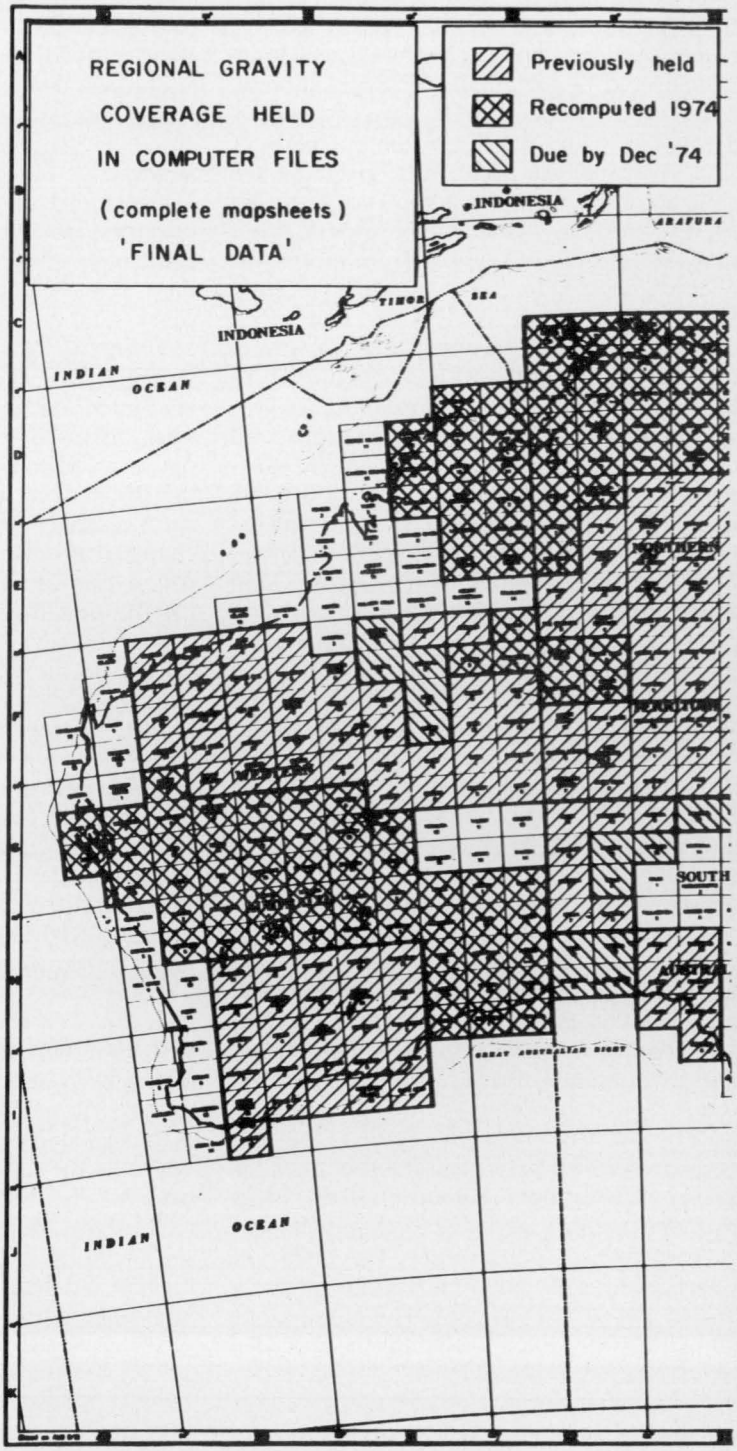
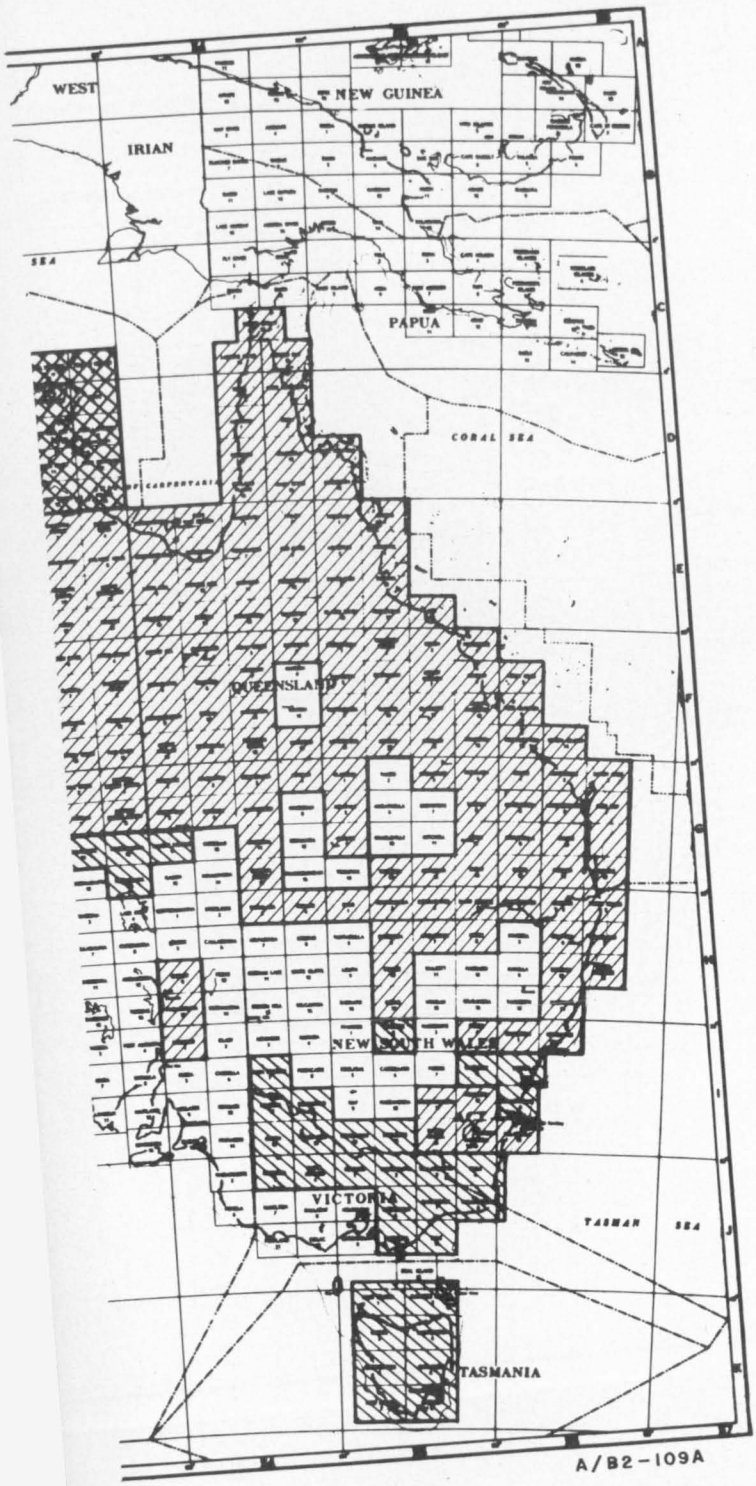


Fig. OR 5. Regional gravity



coverage held in computer files.

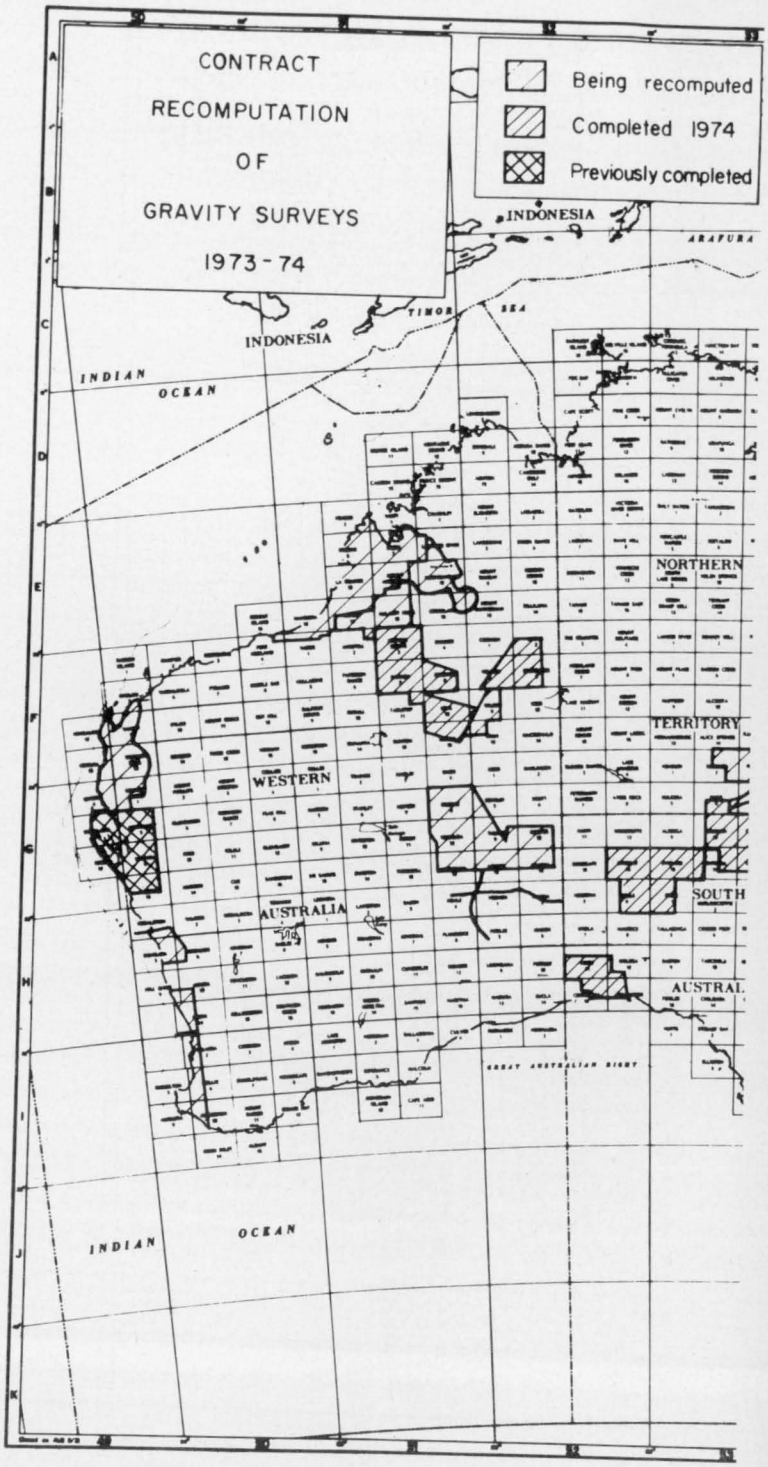
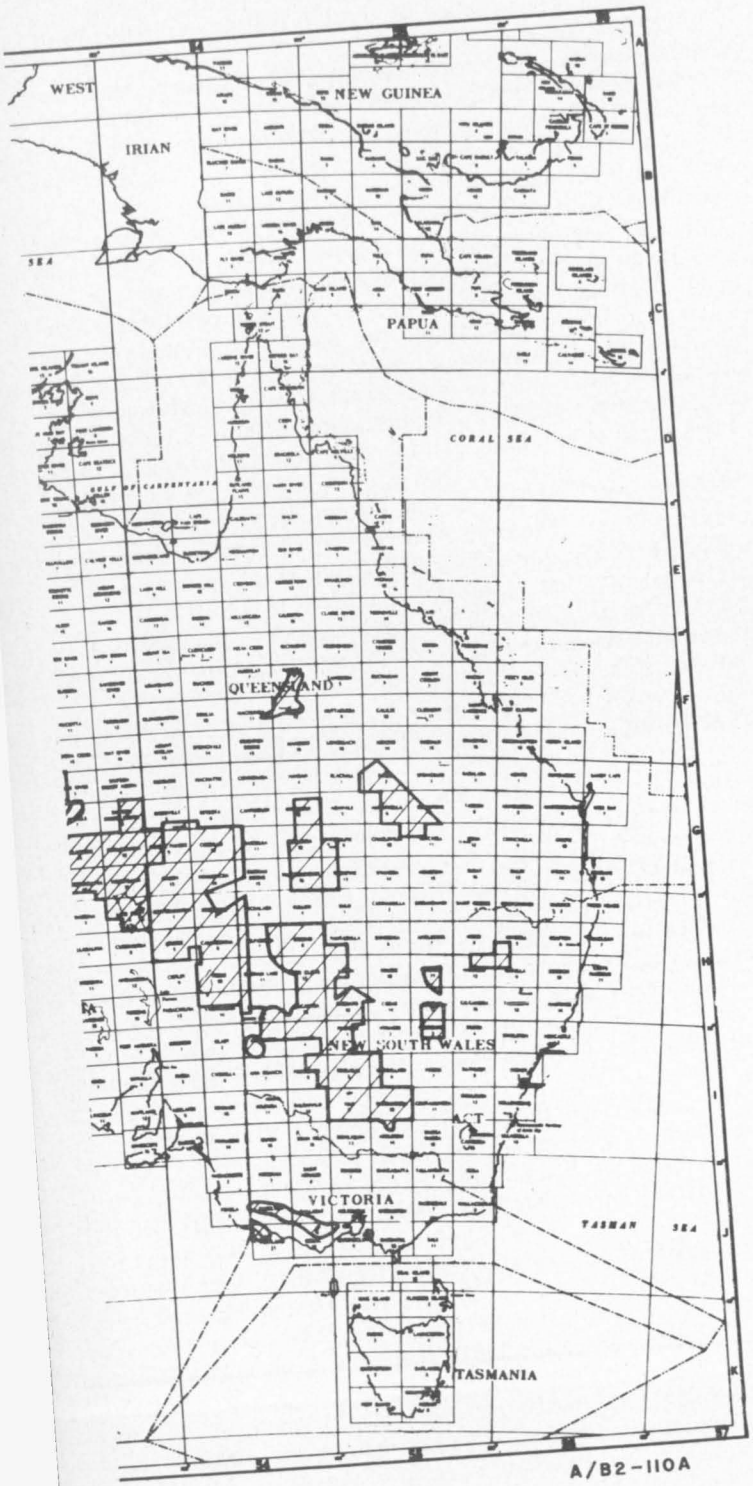


Fig. OR 6. Contract recomputation



of gravity surveys.

In September Professor P. Melchior and Dr B. Ducarme of the Observatoire Royal de Belgique installed a recording tidal gravity meter, on loan to Australia, in the seismic vault of the Port Moresby Geophysical Observatory. Five months of recording at Port Moresby will be the first stage in a joint project between the International Centre for Earth Tides (Belgium), University of New South Wales, Division of National Mapping, and BMR for the measurement of tidal variations in the intensity of the Earth's gravity field at eight sites in the Australian region. Four Belgian tidal gravity meters will be on loan to Australia in 1975 and early 1976, and tentative sites for the recordings are Port Moresby, Darwin, Alice Springs, Charters Towers, Perth, Broken Hill, Hobart, and Canberra.

Soviet pendulum observations. The gravity intervals between Moscow, Port Moresby, and Hobart were measured using five Russian OVM pendulums. This survey was similar to the 1972 tie between Sydney and Moscow. The measurements, made by a team of seven Russian scientists, comprised observations each for a period of about seven days at Moscow, Port Moresby, Hobart, Port Moresby, and Moscow. The results from this survey should provide more accurate gravity values for Port Moresby and Hobart relative to international standards. They will also give an independent measure of the gravity interval Hobart-Port Moresby, and hence of the gravity scale on the Australian Calibration Line.

Gravity ties to New Zealand and Antarctica. In December 1973 BMR co-operated with the New Zealand Department of Scientific and Industrial Research in the establishment of a New Zealand Calibration Line (NZCL). Observations were made at existing stations at Auckland, Wellington, Christchurch, and Dunedin airports, and ground ties were made to city stations in each case. Air ties made use of commercial aircraft, and each station was occupied at least five times by five LaCoste & Romberg gravity meters (3 BMR and 2 NZ).

After completing the NZCL work D. Coutts with the three BMR meters made gravity ties from Christchurch to the McMurdo, Scott, and South Pole Bases in Antarctica using US Air Force transport arranged by the US National Science Foundation.

Before returning to Canberra the three BMR meters were 'ghost-flighted' (unaccompanied by BMR personnel) between Christchurch and Sydney to strengthen the gravity tie between these cities.

Antarctic gravity surveys. New gravity stations were established in the southern Prince Charles Mountains area of Antarctica. All gravity values from BMR surveys were computed using the scale determined by the Australian-Soviet work on the ACL. The 1969-74 ties between Canberra, Mawson (A), Creswell Camp, and Mount Stinear were computed on the Soviet scale and mean values were obtained. A complete list of gravity values in the Mawson area was sent to National Mapping in Melbourne for calculation of the deflections of the vertical and the effect of these deflections on the geodetic network. No further work is planned in the near future in the Prince Charles Mountains area.

East Papua gravity survey. Delays have occurred in reducing the results of the 1973 gravity survey made in conjunction with the East Papua crustal survey. The main purpose of the survey was to measure the gravity changes across the tectonic plate boundary between the Solomon Sea and Australia. Regional coverage was completed on the Aroa, Buna, Port Moresby, Wau, and Yule 1:250 000 Sheet areas. Field sheets and aerial photographs from this survey were forwarded to the Drawing Office for plotting onto base maps. Recently issued base maps of the area show discrepancies when compared with the older bases, and replotting of existing stations in the area is required.

Equipment. A tilt table for calibrating quartz-type meters is on loan to BMR from the Soviet Institute of Physics of the Earth for twelve months from October 1974. D. Coutts made a visit to the Soviet Union in September for instruction in the use of the tilt table, and he calibrated BMR gravity meters Worden 169 and Sharpe 145 in Moscow. All available quartz movement gravity meters will be calibrated on this equipment during the twelve-month period of the loan.

Two Dry-Fit 12-volt sealed lead-acid batteries were purchased and tested and were

found to compare very favourably with the nickel-cadmium batteries.

Overseas visits. D. Coutts made a visit to New Zealand and Antarctica in December 1973 to make the gravity ties reported above. P. Wellman had discussions with officers of the Gravity Division, Canadian Department of Energy, Mines & Resources in Ottawa and attended the Symposium on Recent Crustal Movement in Zurich and the Seventh Meeting of the International Gravimetric Commission in Paris during his overseas visit.

P. Wellman and D. Coutts travelled to Moscow for discussions with Soviet scientists

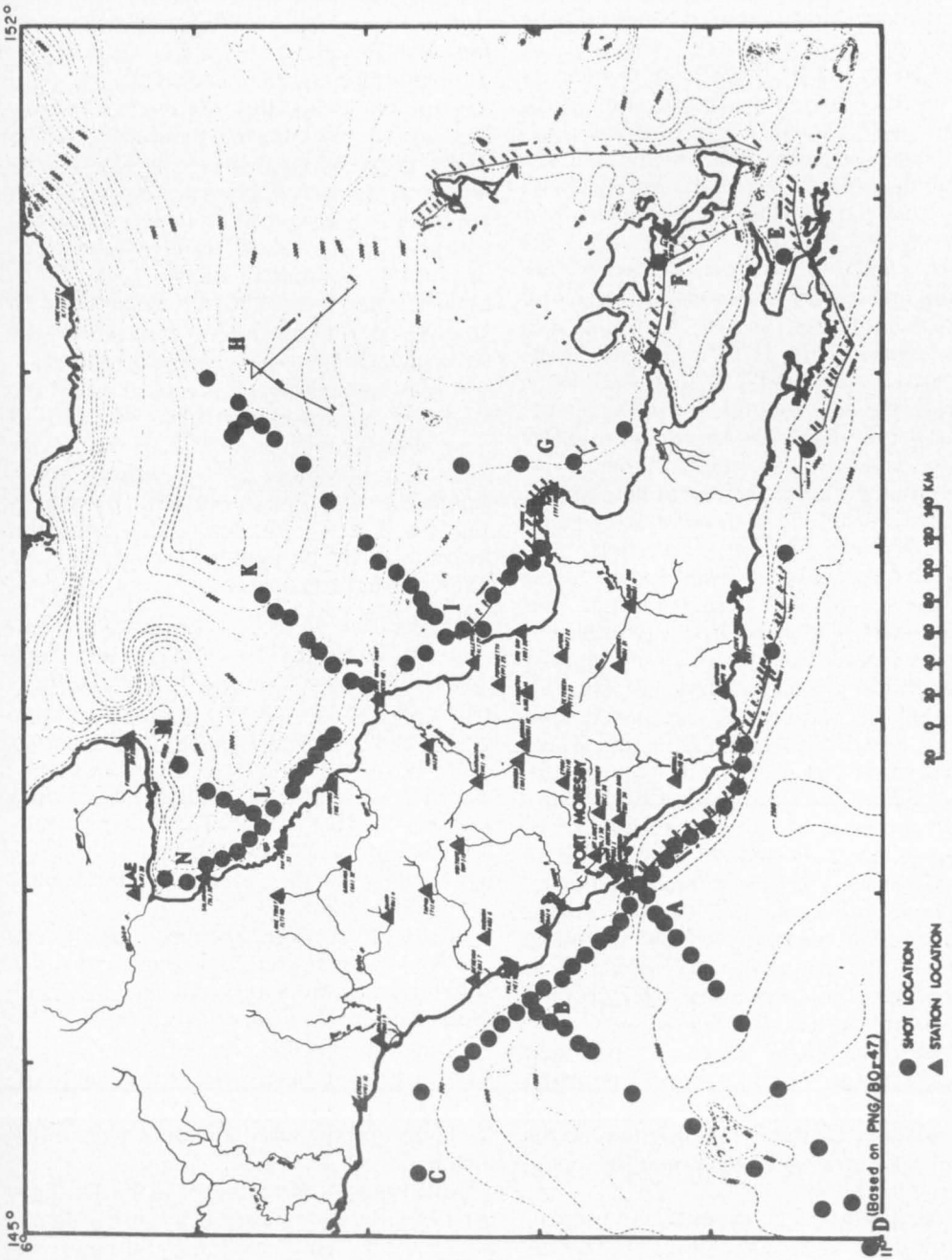


Fig. OR 7. East Papua crustal survey 1973—shot and station locations.

at the Institute of Physics of the Earth, Moscow University, and the Institute of Arctic Geology, and for training in the use of the tilt table for calibrating gravity meters (see above).

Regional Structural Surveys Group (D. M. Finlayson)

East Papua crustal survey. Date processing and interpretation of results commenced. The survey was made by BMR from October to December 1973, with the co-operation of the Australian National University, the Universities of Queensland and Melbourne, the Hawaii Institute of Geophysics, and the PNG Geological Survey. During the survey 111 shots were fired on two traverses along the northeast and southwest coasts of the Papuan peninsula and along traverses into the Coral and Solomon Seas, and 43 recording sites were occupied (Fig. OR 7). Gravity observations were made at 150 new stations to complete the regional gravity coverage in the area. A survey of this size is a major project by world standards and presents major interpretation problems because of the complex tectonic features and high contrasting structural relief throughout the survey area.

The first replaying of seismic tapes to give analogue records has been completed, but further replay will be required with improved playback facilities and filtering techniques as the records are examined in detail. All analogue records have been examined and significant seismic travel-times plotted. These data are stored on a permanent computer data file at CSIRO and on computer cards. Data were made available to all participants. All records were examined at least twice to eliminate errors and personal bias from data.

Preliminary interpretation of data from the traverses along the northeast and southwest coasts of the peninsula has begun. It is expected that comprehensive interpretation will take at least a further two years.

Bowen Basin seismic survey. Interpretation of data from the 1973 deep seismic refraction survey in the Bowen Basin, Central Queensland, gave further information on the crustal structure and upper mantle topography of the Basin.

All recording was on magnetic tape and all tapes were played back except for five recordings at two stations which cannot be played back at present because of speed variations of the recorders.

Seismic record sections were made-up for both northern and southern shots as an aid in identifying phases (Fig. OR 8).

From near-shot-point data, including a geophone spread placed at one of the mines, a surface layer with an average thickness of 1.2 km and P-wave velocity of 4.0 km/s is assumed to be continuous over the length of the traverse. Below this, the P-wave velocity increases to 5.53 km/s to a depth of 6.1 km in the north and 6.3 km in the south. The velocity then increases to 6.39 km/s in a layer 23 to 24 km thick which, according to second-arrival data, overlies the lowest crustal layer in which the velocity is approximately 7.1 km/s. The top of the upper mantle lies at a depth of 33.8 km in the north and 37.9 km in the south; the upper mantle P-wave velocity is 8.13 km/s.

A ray-tracing program was used to test the model, and the travel-time curves thus derived were found to agree well with the major features of the observed travel-time curves. Amplitude studies on the data are in progress and it is expected that synthetic seismogram techniques will be used to provide a more detailed interpretation.

Seismic tape recording equipment development. BMR operated 19 sets of remote seismic tape recording equipment during the 1973 East Papua crustal survey. The performance of the equipment was disappointing, and only a massive airborne logistic exercise for checking and servicing the equipment ensured satisfactory record return. The main problems were wiring and connector faults, accumulator power supply faults, and occasional component failures.

A prototype Akai tape-recording system was built with improved wiring, with low-power oven-controlled crystals, and motors to reduce power requirements.

Temporary playback facilities for $\frac{1}{4}$-inch Akai tapes were inadequate, so a new playback facility is being developed to cope with variations in tape speed and poorly recorded signals.

Little progress was achieved in the development of seismic recording arrays using the PI 5100 $\frac{1}{2}$-inch tape recorders because of

difficulty in obtaining additional components from the manufacturer.

Seismic instrument calibration. BMR remote seismic tape-recording systems used for long-range seismic refraction work were calibrated for amplitude studies to enhance interpretation of crustal data.

Frequency responses and gains of the TAM5 amplifiers were obtained, and the consistency between amplifiers was checked. The motor constant of the internal calibration coil of each seismometer was found by applying known currents to the coil from the calibrator and carrying out weight-lift tests on

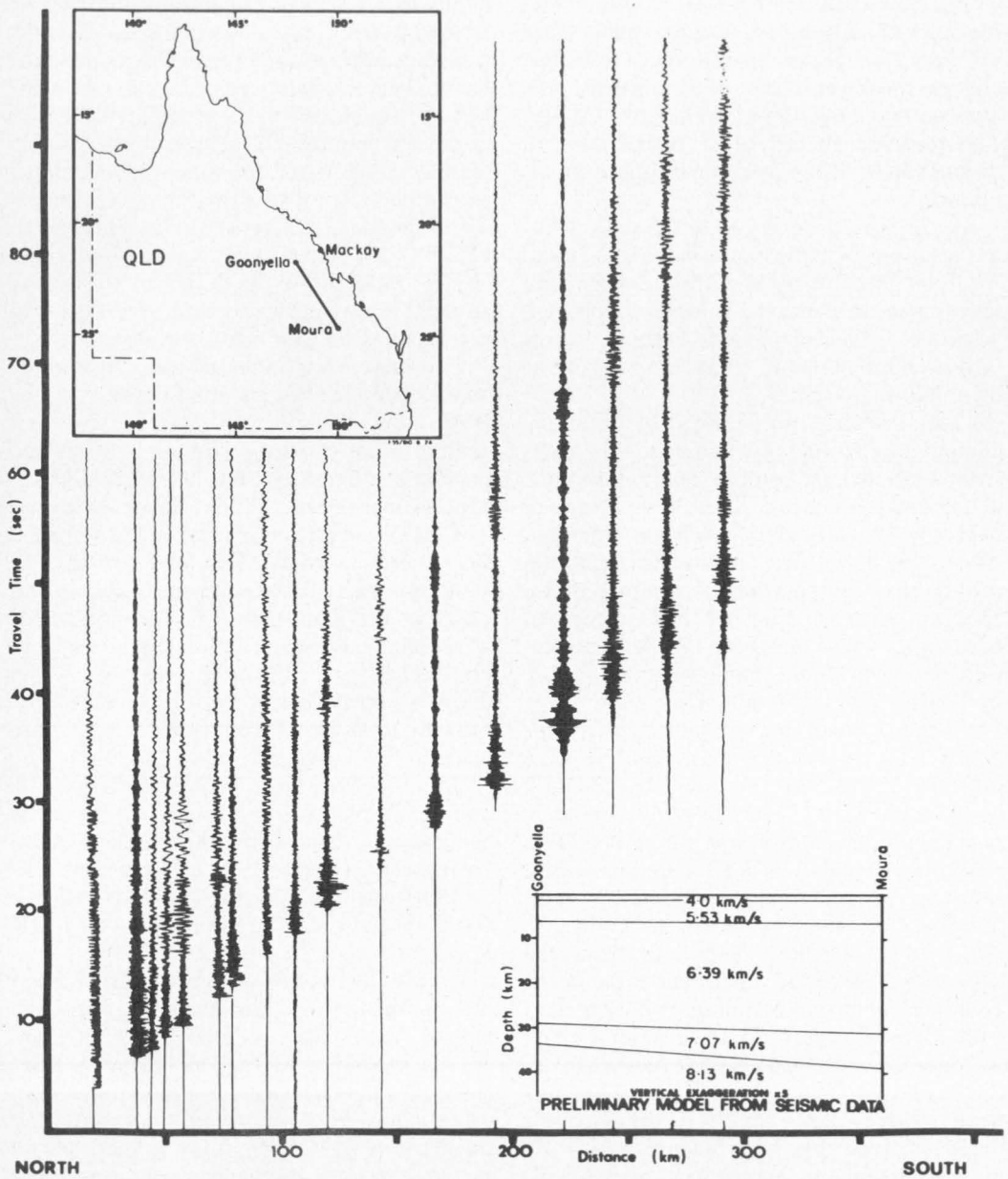


Fig. OR 8. **Bowen Basin seismic survey. Seismic records of shots at Goonyella and Peak Downs coal mines, at northern end of traverse, and simplified interpretation.**

the seismometer. Sinusoidal currents were then applied to the calibration coil to obtain the magnification of the system at various frequencies. The outputs from the calibrators were checked and the playback system was calibrated for different chart sensitivities.

The characteristics of the various components tested were found to be consistent within close limits. For typical recording and playback conditions, i.e. for an amplifier gain of 72 dB, filter passband of 0.01 Hz to 20 Hz, and playback sensitivity of 100 mV/div, the average magnification at 1 Hz is 6.7×10^3. The response for all other operating conditions can be found from the response curves obtained.

Synthetic seismogram techniques. Most interpretations of explosion seismological studies of the Earth's crust and upper mantle have been based on the travel times and apparent velocities of seismic phases without taking into account dynamic characteristics of the recorded wave train.

Crustal models can be tested by obtaining computer-generated synthetic seismograms from the model and comparing the amplitude, phase, and frequency of arrivals with those of the actual field records. Work has commenced on running a synthetic seismogram computer program, and in particular it is hoped that a program written by Fuchs at the University of Karlsruhe, which has been applied successfully to crustal studies, can be adapted for use by BMR.

Computer program development for seismic data processing and digital data analysis. The Group's presentation and interpretation data handling computer programs were completely rewritten to handle the large amounts of data resulting from the 1973 East Papua crustal survey. This rewriting was done in conjunction with the change to the Cyber 76 computer at CSIRO. The data from the survey were placed in a permanent file in the computer for ease of handling. Published data from all previous crustal surveys undertaken in Australia were also collated and added to the file. Programs for plotting record sections were written. Early in 1975 the Group's magnetic tape playback facilities will be interfaced with an analogue-to-digital converter used in conjunction with BMR's Hewlett-Packard 2100 computer. Programs for data enhancement using digital techniques are being developed to enable digitization of records, application of bandpass filters, and plotting of results as a record section to facilitate interpretation to be carried out.

Microseismic investigations in conjunction with Macquarie University. Professor Vozoff of Macquarie University proposed that the depth of a sedimentary basin could be determined from the characteristics of microseismic surface waves travelling across the basin. The characteristics of interest are the phase differences for a particular wave at a number of points. To measure these characteristics three BMR portable seismic tape-recording systems were used in a joint survey with Macquarie University in the Hay region of NSW. M. Asten of Macquarie University was responsible for the design of the survey and BMR provided a Technical Officer and vehicle to assist with field operations.

The survey was intended as a pilot study and was designed to test the suitability of the BMR recording sets and the best configuration of sites to obtain information on phase differences. The teleseismic waves which are of interest in this type of survey are of fairly long period and the seismometers were therefore adjusted to long period. The Willmore Mark II seismometer is only quasi-stable at this setting, and no usable records were obtained because of inadequate setting-up and testing in the field. Heavy rain and floods stopped field operations prematurely. Further tests by Macquarie University are planned for November 1974.

Bismarck Sea geophysical interpretation. A marine geophysical survey of the Bismarck Sea was conducted by the BMR Marine Group in August 1970. Preliminary interpretations of magnetic and seismic reflection data have been produced as BMR Records.

During the current year this interpretation was completed for outside publication. The interpretation includes detailed magnetic and gravity modelling along 5 north-south traverses, a magnetic contour and profile map using values at 5-minute intervals along the traverses (Fig. OR 9), and a map of all earthquake focal mechanism solutions along the Bismarck Sea seismic lineation.

The only prominent lineations in the mag-

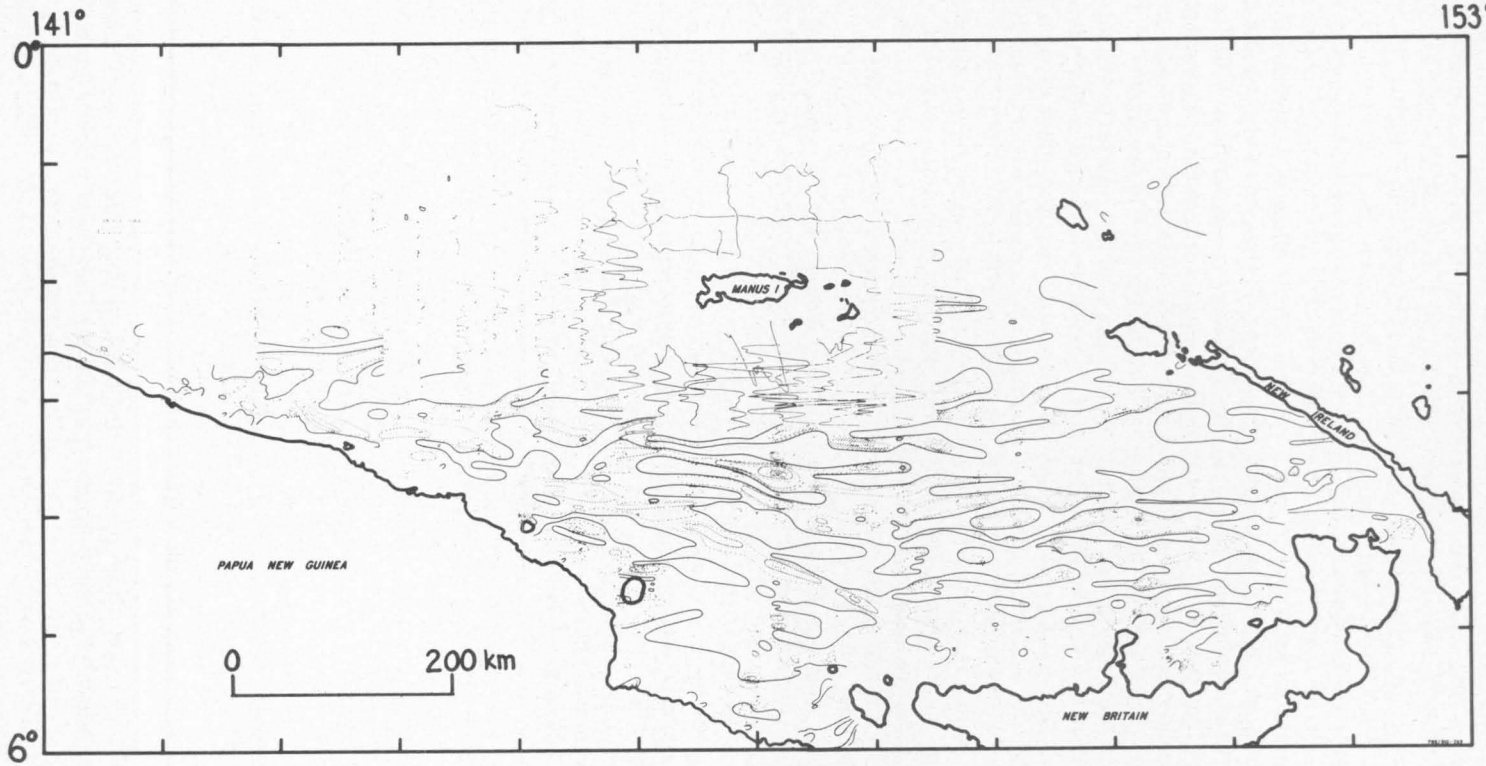


Fig. OR 9. Bismarck Sea regional magnetic anomalies.

netic contour map are in the eastern half of the Sea apart from a single lineament parallel to the New Guinea coast. The strong lineaments in the eastern part of the Sea show amplitudes of about 1000 nanoteslas peak-to-peak. The area south of Manus Island has intense short-wavelength anomalies with similar amplitudes, but over the rest of the Sea the amplitudes are more moderate.

Detailed magnetic and gravity modelling along the five traverses confirm the previous interpretation that the Bismarck Sea floor contains predominantly reversely magnetized blocks which have been subject to recent intrusions and earth movements. The Sea can be divided into eastern and western provinces by a line along the northeastern edge of the Willaumez-Manus Rise, which appears to be a diapiric structure with a complex series of recent extrusions along its northern edge. Magnetic modelling shows upfaulting of the reversed block to form the southern part of the Rise, and gravity modelling shows a mass deficiency under the Rise and a thickening of the crust. The New Hanover-Manus Rise appears to be a dome of sediments underlain by normally magnetized material and considerable crustal thickening. Its southern boundary appears to be a complex fault system, and recent earthquake epicentres show that it is still active.

Recent extrusions appear to be restricted to areas immediately north and south of the seismic lineament; these areas contain wide bands of sediment-free, normally-magnetized material attributed to rapid north-south extension which has been greater in the eastern province of the Sea. The extension has probably ceased at the present time and has been replaced by left lateral movement as evidenced by earthquake focal-mechanism solutions.

It is suggested that the reversely magnetized block originated as part of the ancient floor of the Pacific Ocean which formed during Permian time when the Earth's field was reversed for an extended period. It would follow that the islands surrounding the Sea were formed later and have not changed their relative positions except to allow for limited north-south extension.

Tectonics of the Bismarck Sea/Solomon Sea region. In co-operation with Dr Furumoto of the Hawaii Institute of Geophysics, the seismic, gravity, and magnetic structural trends were studied to obtain an overall tectonic framework for the Bismarck Sea, Solomon Sea, and Ontong Java Plateau.

The Bismarck Sea is a region of positive free-air gravity anomaly. This may be due to a high crustal density resulting from a tensional regime which enabled a low-melting-point. high-density fraction of upper mantle material to rise closer to the surface. Relatively high seismic apparent velocities in some areas may indicate a general high velocity for the region, and certain magnetic lineaments in the Bismarck Sea could be interpreted as supporting the hypothesis. Detailed interpretations of shallow structures were made along a number of the marine sparker profiles in the Bismarck and Solomon Seas.

The area of the Rabaul volcanoes was considered as a potential source of geothermal energy.

Heat flow research. Since May 1973, J. P. Cull has been engaged in heat flow research at the Geology Department, University of Oxford, U.K., financed by an Australian Government Post-Graduate Scholarship. This Scholarship was initially for one year, but has since been extended to two years.

A major objective is development of a method for measuring solid-rock thermal conductivities quickly and easily in field conditions. Two conductivity probes have been developed: one uses a 6-cm line-heat source with a thermocouple offset centrally by about 1 mm, and the other uses a circular heat source 1.5 cm in diameter with a central thermocouple. Both probes are sandwiched in thin polythene sheeting and are robust and portable. The probes are only 0.2 mm thick and can be inserted in rock samples sliced by a diamond saw.

Using these probes, thermal conductivities of rocks and minerals can be measured at high pressures which simulate conditions in the Earth's crust and upper mantle. So far potassium chloride and quartz crystals have been examined in the high-pressure anvils at the Geology Department of the University of Edinburgh. Heat flow in boreholes in England has been measured by standard methods.

Overseas visit. D. M. Finlayson made an overseas visit from 27 March until 29 May

1974, during which he examined the seismic techniques of crustal investigation used by a number of institutions in USA, Canada, and UK, and presented a paper at the American Geophysical Union Annual Meeting in Washington on the interpretation of the Trans-Australia seismic survey data.

Although BMR and other Australian institutions are probably keeping pace with field instrument development, there is a need for considerably greater effort to go into the data-processing techniques and interpretation of seismic record sections. The use of calibrated seismic tape recording instruments in Australia in the last 2-3 years is a first step towards digital data processing. Future interpretation of seismic record sections should include identification of many seismic phases and study of their amplitudes. The techniques of seismic modelling and the production of synthetic seismographs will lead to a far greater understanding of record sections and are a necessary development within BMR, most likely with outside assistance.

4. GEOPHYSICAL SERVICES SECTION
(M. G. Allen)

ELECTRONICS SUBSECTION (K. J. SEERS)

Instrument and Systems Development Group
(Y. Liu, P. J. Hillman)

MFS7 airborne fluxgate magnetometer. Although both production models were operational by the end of 1973, a number of problems arose during survey use in VH-BMG. Most were easily solved but two entailed much effort. These were:

(1) An apparent baseline shift each time the magnetometer was turned on or was subjected to power-supply surges. This was ultimately traced to an effect in the the detector element, still not fully understood but curable by applying a high detector drive level for a short time after turn-on. A circuit was developed to do this automatically.

(2) A temperature-dependent beating effect between the magnetometer and its 400-Hz inverter. The resultant magnetometer output had a beat of a few nanoteslas' amplitude and varying frequency. The effect was traced to earth currents; rearranging the earth wiring within the magnetometer cured the problem.

Both production models have continued to operate without further trouble since July.

Work continued spasmodically on a third production model embodying constructional changes intended to increase ruggedness. The changes necessary were determined by extensive testing on the vibration table. The unit should be finished by the end of the year.

Proton magnetometers. Following a theoretical investigation by D. Kerr into the time response necessary in an airborne magnetometer for faithful reproduction of anomalies, an investigation was started on the static (non-cycling) and dynamic (cycling) response of both the BMR-designed MNS2 and the Geometrics G80 3-HP magnetometers. The investigation was not completed because the MNS2 was required in the field and the Geometrics developed a fault and had to be sent to the USA for repair. However, considerable insight was obtained into the factors limiting the response of this type of magnetometer, and this has already proved of value in compiling and assessing specifications for purchasing. A report will be written when the investigation is completed.

An opportunity was taken to incorporate into the MNS2 phase-locked loop two circuits designed by the Group for other applications, viz. a voltage-controlled oscillator and a phase comparator using CMOS logic. As predicted, the new circuits produce less count scatter than the originals, thus improving the MNS2 in one of its weak areas. These circuits will be incorporated into all production models. Work was completed on a delayed cycling facility for ground station use of the MNS2.

Two MNS1 magnetometers were built for ground station use.

Tests were performed to establish the effect of the proximity of a metal boom on a proton-precession magnetometer detector. The results were used to specify tail booms for PPM installations in each of BMR's aircraft.

Radiometric scaler RRS1. Digital scalers were designed and built for use with the four-channel gamma-ray spectrometers used in each of BMR's aircraft. The first production model has been thoroughly flight tested. Three further units are being constructed so that each aircraft will have one operating and one spare unit.

Aero Commander data acquisition system. A commercial unit built to BMR specifications was delivered and testing commenced late in 1973. Several design problems meant that the unit had to be returned to the manufacturer on two occasions. Various mechanical factors adversely affected reliability and the system was not finally acceptable until after mid-1974. There is still a suspicion that interference from a switching regulator in the system is causing malfunctions in other equipment. Various additional timing circuits and a

radio-altimeter digitizer were incorporated into the unit.

Radio-altimeter digitizers. Because of the change to Collins radio-altimeters in each aircraft new digitizer circuits had to be designed. One version using TTL logic was built for VH-BMG, another using CMOS was built for VH-BMR. In addition buffer amplifiers were built into the altimeter chassis.

Aero Commander installation. Two problems have caused concern in the proton magnetometer installation in VH-BMR. Firstly, towed-bird cable noise causes a high count variation. An attempt to alleviate this noise by fitting a strainer cable was unsuccessful because of cable stresses in the pulley system, which could not be easily changed. Secondly it has been well established that there is a strong magnetic field associated with the aircraft itself which causes noisy records when there is relative motion between the bird and the aircraft.

A tail boom is to be fitted which should overcome both these problems, but to determine the source of the interfering field an exercise to map the aircraft's field in three dimensions was investigated. Preliminary results show the most likely noise sources to be the steel equipment racks and/or the 'bird cage'. Rough calculations indicate that there is sufficient iron in the racks to account for observed effects. The mapping will also be useful for assessing the compensation necessary for a boom installation.

A toroidal detector was designed for use in this installation, but other priorities have deferred its evaluation.

Twin Otter timing system. The NZA1 prototype timer in VH-BMG was considerably modified in the interfield season to improve reliability. A new timer, NZA2, is being designed to overcome many problems still inherent in the NZA1 and should be ready to install early in 1975.

Regional Structural Group remote recording seismographs. Seventy dual modulators, TMF2, were constructed under contract to replace the TMF1 units, which were prone to system interference. A proposal to repackage the recording system to reduce size, weight, and power drain was examined, and work started to test the idea on one unit. The use of a temperature compensated crystal oscillator for timing and a d.c. tape drive motor is also under consideration.

Regional Structural Surveys Group playback system. The project has been delayed for lack of manpower, but an assessment was carried out which revealed deficiencies in the original tape speed control concepts. A different design approach has been partly tested, and the speed control module should be completed by the end of the year. Demodulators and time decoder are still to be designed.

TAM5 seismic amplifier. Modifications to the filter response in some of these units were found to be necessary for observatory applications. It appears that the original filters did not give the required characteristics. This led to a basic review of the seismometer/filter composite response, and when this is complete it may be necessary to implement different filtering techniques.

Observatory magnetogram digitizer. Work started on a control unit for this system, which is to be built round a mini-computer. The system will replace one built over ten years ago which is now very unreliable.

Automatic magnetic observatory. Work started on the design of two different controllers for interfacing magnetic tape recorders to observatory systems. One controller is specifically for use with the Elsec automatic magnetic observatory, the other is for more general applications.

Component mounting standards. As a result of equipment failure caused by poorly mounted components a set of notes on component mounting was produced and a catalogue containing mounting information for every board-mounted component currently used in BMR design was compiled. Included in the catalogue are maximum dimensions, lead spacings, hole sizes, printed circuit card land sizes etc. It is intended to keep this document updated and have it circulated to all sections of BMR where equipment is constructed.

Miscellaneous. A computer interface was designed and built for the Kennedy 1400 incremental magnetic tape recorder.

Three sequencing units were built for map displays for the BMR Open Days.

A switching unit was designed and constructed for use with a resistivity power supply.

Work started on an electronic timing circuit and display for a lectern for the 25th International Geological Congress. Assistance was given to the Rock Measurements Group in the circuit design of a demagnetizer for palaeo-magnetic measurements.

A 35-Hz oscillator was designed and constructed for the Engineering Geophysics Group for seismic system calibration.

Electronic Maintenance and Testing Group (A. G. Spence)

The principal activity of the Group has been the preparation of equipment for geophysical surveys and maintenance and repair of equipment during service.

The Observatory Group was assisted in preparing and installing seismic recording stations at Broken Hill, Armidale, and Giles. Equipment for further stations at Mawson and Kowen Forest has been received, and work on these systems will commence soon. In addition, two existing stations at Darwin and Alice Springs were maintained in service. Two time-signal generators were constructed and put into service at Darwin and Port Moresby. A by-product of this work has been the design and production of an interface 'box', fully approved by the Australian Post Office, for use wherever BMR equipment is connected to telephone lines. Throughout the year a constant stream of observatory equipment—mainly digital clocks, magnetometers, accelerographs, and recorders—has been repaired or modified.

Four portable borehole loggers were prepared for service and issued to the Darwin Office, Metalliferous Geophysical Group, and sedimentary geological parties throughout the year. A fifth logger, the Austral Multi-logger, was received but owing to various faults was not put into field service this year.

The Engineering Geophysics Group was assisted in preparations for surveys in Queensland and Papua New Guinea. A new seismic recording cab was fitted-out for engineering refraction seismic surveys.

One geophysicist has been engaged for practically the whole year on investigations into problems associated with induced polarization and transient EM equipment on behalf of the Metalliferous Geophysical Group. He has developed a number of computer programs simulating equipment operation to aid in solving these problems. He has checked and documented BMR's modifications to the Russian-built MPPO-1 transient EM equipment.

A rocksaw was installed and laboratory furnaces, centrifuges, microscopes, and projectors were repaired for the Geological Branch. The Marine Geology Group was assisted in preparation for its 1974 continental margin survey. The ACT groundwater section has been assisted with various equipment problems.

The ADP Section called upon the Group to provide cabling interconnecting the HP2100 computer on the ground floor with various data-input points throughout the building.

Throughout the year urgent repairs were carried out on equipment from the Drawing Office and the Photographic Group.

MECHANICAL SUBSECTION (J. H. MULDER)

The Subsection comprises three groups: Mechanical Engineering Design, Mechanical Instrument Construction, and Mechanical Maintenance and Testing.

Mechanical Engineering Design Group (D. B. Stewart)

Equipment for the 1974 marine geology survey. A depth-controlled underwater 'towfish' was developed to make use of the increased energy from a nine-array configuration of sparkers. A new feature of the equipment is the enhanced strength of the seismic pulse which results from the positive reflection of sonic pulses underneath the solid boundary of the 'towfish'. An added bonus is the freedom from harmonic noise from free-surface negative reflections. The towing characteristics of the vessel were investigated by conducting similarity tests on a quarter-scale model, and this resulted in the development of a self-regulating hydrofoil which may be preset for a desired towing depth.

Two Raytheon pingers were built into a streamlined fibreglass and foam plastic surfboard-like vessel for use in a pinger correlator system designed for high-resolution profiling.

12-tonne hydraulic rock splitter for Palaeontology Section. Original design work involved

a motorized hydraulic system with manual controls to enable the operator to position and clamp a rock with the splitting knives under low pressure and then to split the rock under high pressure. 'Off the shelf' hydraulic components were used throughout.

Vehicle-mounted boom for Engineering Geophysics Group. A 12-m long boom was mounted on a 30-cwt truck and was suspended by flexible wire rope from a vertical mast to support an underwater sparker and hydrophones for shallow profiling of irrigation channels. The entire structure was of lightweight construction to minimize the tendency to overturn the vehicle.

Demagnetizer for Rock Mechanics Group. Design modifications were made to the existing alternating-field demagnetizer and this involved a telescopic drive for the specimen tumbler to enable easy extraction of the rock specimen from the demagnetizing coil.

Moulding press for X-ray fluorescence samples for Geochemical Section. Convenient hand operation was the criterion involved in the original design of a moulding press for manufacture of X-ray fluorescence samples. One hand lever was linked to the mould and its cylindrical plunger to achieve separation of plunger and mould for entry of the molten material and also for ejection of the fluorescence disc from the mould after solidification.

Magnetometer container. A non-magnetic, non-metallic container was designed for housing a solenoid detector coil in liquid for the Electronics Subsection. Sealing the container against leaks and the entry of cables was the difficulty encountered.

Laser-triggered spark gap. A laser-triggered spark gap was designed for switching the 10-kV source used in the pulsed laser in lunar laser ranging equipment being set up by the Division of National Mapping. After a trial period some further work will be necessary to ensure erosion-resistant electrodes. It may also be necessary to alter the electrode geometry.

Distance event marker for Engineering Geophysics Group. An event marker was designed for fitting to a Land Rover speedometer drive shaft for distance correlation associated with geophysical field measurement.

Modification to La Cour magnetographs for Observatory Section. Design modifications were made to increase the chart rate to the standard 20 mm per hour as recommended by IAGA.

Portable cable reels for Metalliferous Group. Modifications were made to portable chest-mounted cable reels to ensure dust proofness of the gearboxes and to ensure easy hand operation by fitting of ballrace bearings.

Survey on metric fasteners. A survey was conducted in BMR to estimate the future requirements for metric screwed fasteners in response to a request from the Interdepartmental Coordinating Committee on Metric Conversion, Department of Science.

Reduction of seismic records. After much analysis and reporting on an optical reduction method (scanning slit) for reducing the overall size of stacked seismic profiles and enhancing the profiling for interpretation it was indicated by the user group that there was insufficient need for the equipment to justify continuation and consequently the project was dropped.

Consulting work: 20-kVA diesel alternator. A detailed inspection was made of the trailer-mounted diesel alternator which recently seized-up the engine crankshaft and bearings for the third time since it was purchased new in 1970. Recommendations were made for design modifications to the unit to overcome the dynamic effects on the engine bearings whilst under tow, and this work will be done during 1975.

Mineral sand sampling. The offshore mineral sand sampling drill for the Marine Geology Group has reached the stage where public tenders will soon be called on the basis of manufacture to a design specification or for optional equipment against a user specification.

The Daffen seismic energy source. A feasibility report was prepared of a non-explosive seismic energy source which was proposed by Mr Daffen through the Minister for Minerals & Energy. The energy source consisted of a pneumatically powered ram which made impact with a striker plate on the earth.

Drafting services. A small number of detailed working drawings were prepared in conjunction with the Electronics Subsection and included instrument front panels, chassis

modifications, and a seismometer enclosure.

Mechanical Instrument Construction Group

This Group, comprising the Machine Shop, the heavy workshops, and the modelmaker's shop, was mainly concerned with the construction of equipment and instruments, with modifications of existing equipment, and with the construction of prototype experimental equipment. Major projects to which the Group contributed were:

Rebuilding of the 3000-m well logger. This project was a continuation of that commenced in 1973 and involved the shops in: installation of hydraulic system; installation of logging winch; fitting of cable reel; fitting of lever to operate hydraulic by-pass valve; strengthening of the assembly for the level wind on the logging winch and for the mounting arm to take the sheave-driven selsyn assembly for sensing the logging speed and cable depth; fitting of a flexible shaft from winch speed controller to serve on the hydraulic pump; fitting of a water tank; construction of a frame for a plate glass window which separates the logging cabin from the winch platform; modifications to the logging cable load transducer actuator; replacing front bumper-bar with strong channel section including timber buffer; construction of protective frames and fitting them to the front and sides of vehicle; installation of a wire screen in front of the radiator cowling; installation of in-line coupled engine-alternator-hydraulic pump, together with hydraulic control valves. The work was completed in July 1974.

Seismic and Marine Surveys Groups. Construction of a tape slack eliminator for the Akai tape decks used in remote recording seismographs; manufacture of fibreglass benches and their installation in a recording cab; construction of a 9-element sparker-carrying tow vessel; construction of a tow vessel to carry two Raytheon pingers.

Geophysical Engineering Surveys Group. A 12-m long vehicle-mounted experimental boom to support a sparker and hydrophones was constructed; a distance event marker was made to fit a speedometer drive shaft; a specimen tumbler drive for a rock demagnetizer is under construction.

Geophysical Metalliferous Surveys Group. A number of chest-mounted cable reels were made.

Observatory Section. Modifications commenced on a number of La Cour magnetographs. A large number of electronic chassis components and panels were made for the Broken Hill, Giles, and other automatic recording stations.

Drafting Office. A precision four-station round-hole punch was manufactured for accurately locating mapping paper on a flat-bed plotter.

Palaeontology Section. Work commenced on a 12-tonne hydraulic jack-mounted rock-splitting press. A rock saw which had arrived from overseas in a badly damaged condition and which had been wired contrary to Australian safety standards was repaired and rewired. Guards were made and mounted around the drive belts.

Geochemical Section. Construction of a small hand press for preparing glass fusion discs, commenced earlier in the year, is nearing completion.

Petroleum Exploration Branch. A cabinet was manufactured to exhaust fumes from the Core and Cuttings Laboratory.

Mechanical Maintenance and Testing Group

After a number of test runs a rebuilt 35-mm strip camera was handed over to the Airborne Subsection. Two theodolites were modified to allow fitting of a Roeloff's solar prism; the instruments were adjusted for slack and wear.

The Group overhauled, repaired, and tested field instruments such as Mechanism microbarometers; Elsec proton magnetometers; Widco logger; strip-film viewers; two Vinten and one Gianinni flight cameras; Esterline-Angus, Speedomax, Rustrak, and Hewlett-Packard recorders; a Creed tape perforator; a vacuum pump; a BC-8A blaster and a number of seismometers.

A towed-bird, housing a proton magnetometer detector head, was modified to reduce its weight after it was balanced. A number of seismometer calibrators were manufactured.

Services Subsection (M. G. Allen)

The Services Subsection comprises four groups: Procurement, Rock Measurements, Engineering Geophysics, and Geophysical Drawing Office.

Procurement Group (P. E. Mann)

The Group prepared specifications ranging from single items to full instrument systems, and carried out associated enquiries, technical investigations, and assessment of tenders for plant and equipment purchases in the Geophysical Branch.

Rock Measurements Group (M. Idnurm)

Some 450 rock and sediment samples were measured during the year. All requests came from within BMR. The measurements were principally magnetic susceptibilities, rock strengths, ultrasonic velocities, electrical properties, and palaeomagnetic parameters.

A long-term program of palaeomagnetic sampling and measurement in the Tuggeranong and Pine Ridge sewer tunnels was concluded with the completion of the tunnel excavations. Altogether 150 oriented samples were collected. The measurements were made using the palaeomagnetic equipment of the Research School of Earth Sciences, ANU. Three or more specimens were cut from each oriented sample, and of these one pilot specimen was subjected to step-wise demagnetization in an alternating field. The other specimens were measured for the initial and stable remanences. The results give a pole position for the Siluro-Devonian period in southeastern Australia and indicate geological features such as contact zones along the tunnel line. Evidence for a possible geomagnetic field reversal and for palaeosecular field variations is still being examined.

A brief palaeomagnetic reconnaissance was carried out on Christmas Island oriented basalt samples collected in 1973 by the Engineering Geophysics Group. The measurements showed most of the samples to be unsuitable for palaeomagnetic studies because of weathering. Further work is therefore not recommended unless fresh rock can be obtained.

A study of earth stress measurement techniques was carried out in connexion with stress determinations within the Australian continent. The results of this study were summarized in a brief report.

A shear-wave transducer was designed and manufactured for ultrasonic tests. A laboratory time-domain induced polarization unit, partly constructed in 1968, was redesigned and put into operation. A portable instrument for testing rock strength by point contact loading was purchased by Engineering Geology Group, and a long-term program was initiated to correlate the point load strength index with the well established uniaxial compressive strength. Trial runs were carried out on Colana thermo-conductometer equipment borrowed from the Research School of Earth Studies, Australian National University, to determine the suitability of this type of equipment for thermal conductivity measurements on rock samples. A rock-holding vice was designed and constructed for the Group's 30-cm diamond saw. Work on the designs of an alternating field demagnetizer commenced in co-operation with the Mechanical and Electronic Subsections. The construction of the demagnetizer is expected to begin in early 1975 when the main components become available.

Engineering Geophysics Group (E. J. Polak)

The Engineering Geophysics Group conducted field surveys in Papua New Guinea, Queensland, Victoria, NSW, and ACT.

ACT engineering surveys. Figure GS 1 shows the locations of the surveys.

(1) *Road work.* The purpose of geophysical work prior to construction of roads and freeways is to determine the maximum depth of excavation without the use of explosives and to predict the rippability of the rock and type of equipment to be used. The following surveys were carried out:

(1a) *Googong access road.* Seismic refraction work was carried out at 10 proposed cuttings and it was determined that blasting will be required for most of the excavation for the road.

(1b) *Molonglo Parkway.* An extensive seismic refraction survey was carried out between Lake Burley Griffin and the slopes of Black Mountain. Depth of weathering averaged about 10 m with an average velocity of about 2700 m/s. Lower velocities were recorded in the narrow zone of the Deakin Fault.

(2) *Building sites.* Seismic refraction surveys were undertaken on areas designated as future building sites. Some of these sites will be built on within the near future while others have been investigated to aid long-term planning. The primary aim of these surveys is to provide

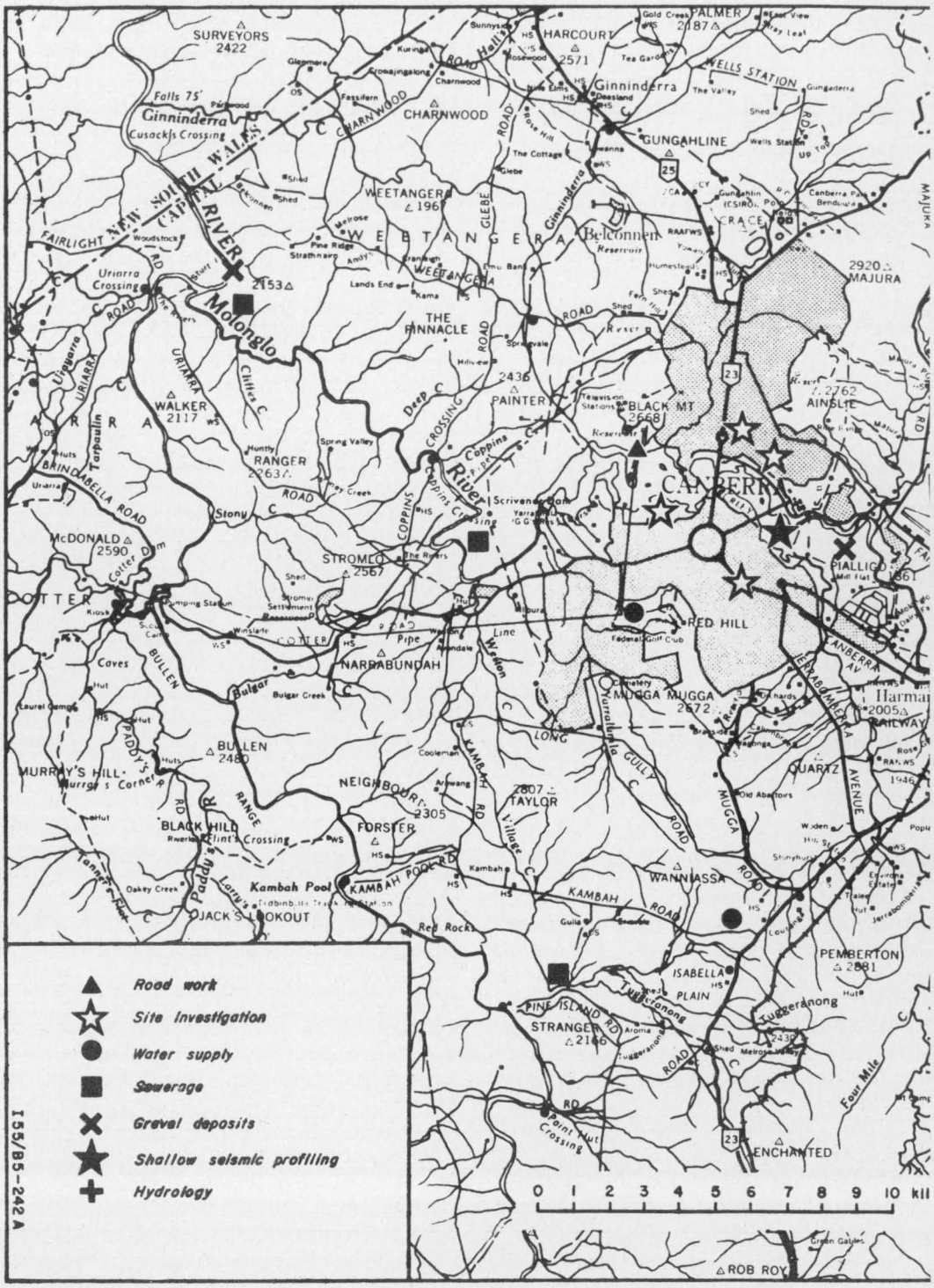
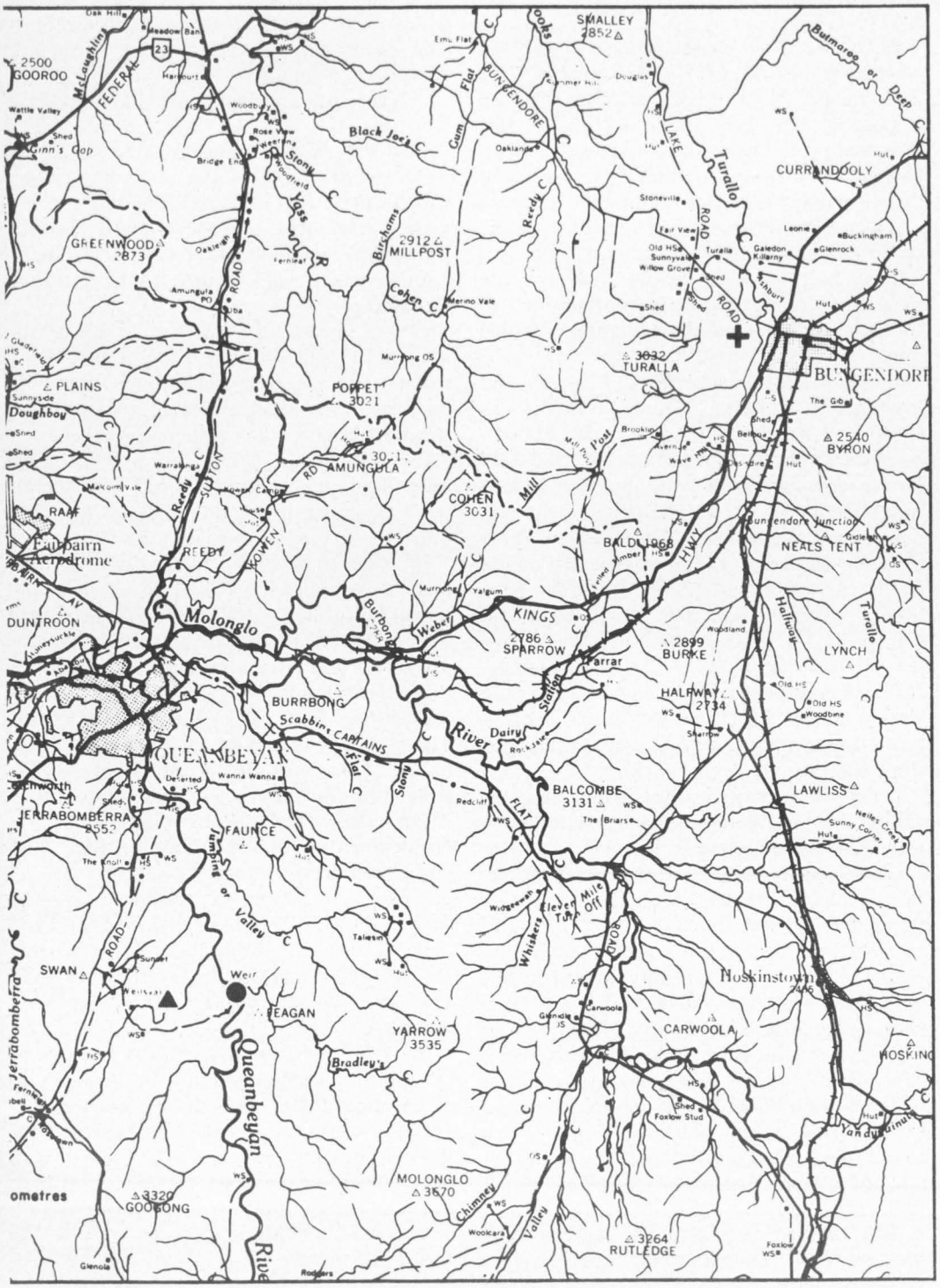


Fig. GS 1. Engineering geophysical



surveys in the ACT—locality map.

data on foundation conditions to guide further planning.

(2a) *City East building site.* Seismic refraction work was carried out on the car parks and vacant blocks east of Civic Centre. Special efforts were made to obtain this information following drill hole results which showed the depth of weathering to exceed 60 m. The work was carried out on Sundays with assistance from the ACT police. The seismic results indicated that weathering was relatively deep over the whole area, and the results of the investigation eventually led to the redesigning of buildings planned for this area.

(2b) *Russell, Campbell, Reid, Kingston, and Yarralumla.* Seismic refraction work was completed on vacant land in these suburbs. All sites with the exception of that near Reid House are connected with long-term planning. The location of the Deakin Fault was determined for sites in Kingston and Yarralumla, and a major fault was located on the Reid site. Steeply-dipping bedrock gave highly variable velocities at Russell and Campbell.

(3) *Water supply.* Investigations were carried out on pipeline, reservoir, and pumping station sites. Generally the work centred around determining ease of excavation and slope stability.

Reservoir sites were investigated in Gungahlin, Hughes, Wanniassa, and South Taylor using seismic refraction techniques.

(3a) *Googong pumping station and pipeline.* Sites close to the Googong Dam were investigated to determine ease of excavation and to supply data for tender documents. Generally heavy blasting will be required in this area. The pipeline from Googong Dam crosses the Molonglo River a few hundred metres upstream from Lake Burley Griffin. This river crossing was investigated using hydrophones. The results show that the western side of the proposed crossing has foundations of unconsolidated gravels and silt and the eastern side may have consolidated sediments similar to those at Russell Hill.

(3b) *Tuggeranong Dam.* The centre line of the proposed Tuggeranong Dam was investigated with seismic techniques. This dam is designed to create a water feature, similar to Lake Burley Griffin, in the Tuggeranong Valley.

(4) *Sewerage lines.* Geophysical surveys were used to investigate proposed tunnel lines. The main aim was to predict tunnelling conditions from seismic velocities and electrical resistivities and hence provide a guide to tenderers.

(4a) *Pine Ridge* tunnel forms part of the proposed Molonglo Valley interceptor sewer which will be used to direct effluent to the new Lower Molonglo treatment plant. Seismic refraction data indicate several low-velocity regions which will require support during tunnelling.

(4b) *Ryan tunnel* also forms part of the Molonglo Valley interceptor sewer. Both seismic and resistivity techniques were used on this tunnel. Several previously unknown shear zones and faults were mapped.

(4c) *Tuggeranong sewer pipeline.* A seismic refraction survey indicated that the pipeline will be located in rippable material throughout.

(5) *Gravel deposits.* These surveys were made to establish the availability of sand and gravel for future construction in the ACT and to provide a basis for compensation for properties taken over by the Department of the Capital Territory.

(5a) *Dairy Flat resistivity and seismic survey.* This survey was made to determine thicknesses of unconsolidated sediments. Results show that the depth to consolidated rock varies from a few metres to greater than 30 m. No distinction could be made between sand and gravel deposits and clay deposits.

(5b) *Sturt Island.* A seismic refraction survey of a sand deposit near Sturt Island was made to help determine the volume of sand and gravel for the Department of Services and Property. Thicknesses up to 13 m were recorded.

(6) *Vibration measurements.* A number of vibration investigations in the ACT were made during 1974, mostly to ensure that ground vibrations from blasting did not threaten nearby structures. The limit of 0.75 in/s particle velocity set by the Australian Standards Association was not exceeded.

Industrial vibration measurements in the region of proposed locations of sensitive equipment in buildings were also carried out for CSIRO and National Mapping.

(7) *Shallow seismic profiling.* Four traverses were run across the East Basin of Lake Burley

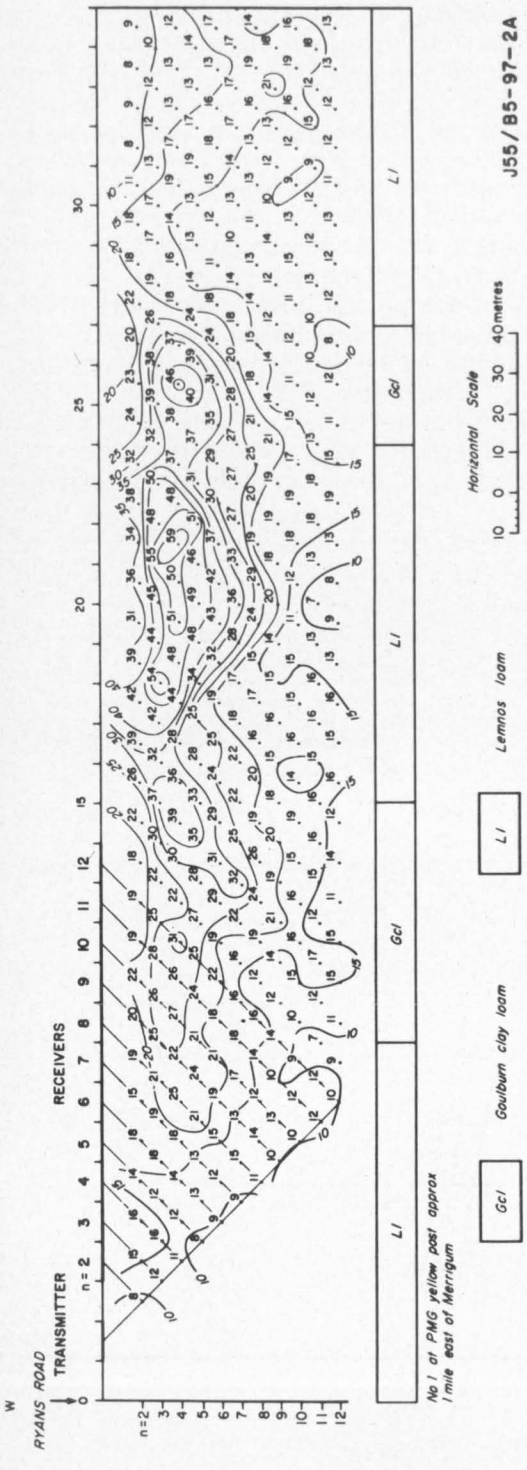


Fig. GS 2.

Dipole-dipole resistivity results, Tatura, Victoria.

Griffin. A shallow-water sparker system and the Raytheon correlator system were used. Both systems recorded the water bottom but only weak reflections were recorded from the sub-bottom. No sand thickness determinations were made.

Goulburn Valley groundwater survey, Vic. The survey, which started in 1972, is being made in conjunction with the Geological Survey of Victoria and the State Rivers and Water Supply Commission. Shallow resistivity profiling and deep seismic refraction work were carried out in 1974 near Tatura and Strathmerton, Vic.

In the resistivity profiling a dipole-dipole arrangement of electrodes was used with $a =$ 10 m and n up to 12. Seven kilometres of traverses were surveyed. In the northern part of the area the resistivity of the ground was very low owing to high salinity and clay content. Several anomalies indicating prior streams were located, and drilling has been recommended in a number of locations. A resistivity high due to a prior stream is shown in Figure GS 2.

Approximately 40 seismic refraction depth probes were completed at widely spaced locations throughout the valley. The results indicate the presence of up to 200 m of unconsolidated sediments and up to 1100 m of Permian sediments in some areas. The results will assist in mapping the pre-Tertiary land surface.

Bungendore IP and resistivity survey, NSW. Some dipole-dipole resistivity and IP traversing was carried out to assess the capability of the techniques and equipment to locate sand and gravel deposits; the location is shown in Figure GS 1.

Madang geophysical survey, Papua New Guinea. Twenty-seven resistivity depth probes with the Schlumberger electrode arrangement were carried out to help locate fresh aquifers. Geological conditions were variable and models ranging from three layers in areas of sea water instrusions to seven layers close to the edge of the mountains were necessary to interpret the curves. The depth to the fresh water/salt water interface could be determined from the curves.

Seismic depth probing on the Gogol River 16 km south of Madang was done to estimate the thickness of sand and gravel deposits required for construction work at Madang.

Results indicate that there is no sand and gravel present, only mud and clay.

Kavieng groundwater survey, Papua New Guinea. Twenty-five resistivity depth probes were completed using the Schlumberger electrode arrangement. The depth probes indicate that below the water-table a sheet of fresh water 9 to 14 m thick rests on salt water. Some depth probes were distorted by the lateral changes in resistivity due to the existence of coral reefs. Figure GS 3 shows the theoretically determined shape of depth probes close to a proposed pumping well in which the fresh water/salt water boundary fluctuates between depths of 4 and 14 m. In this situation resistivity probing can be used to monitor the effect of pumping on this boundary.

Cape York Peninsula groundwater survey, Qld. Resistivity and electromagnetic techniques were used to determine the best geophysical methods for locating shallow (less than 30 m) water-bearing sand lenses at Aurukun in the Weipa area. These sand lenses (resistivities 90-300 ohm-m) underlie high-resistivity (1000 to 10 000 ohm-m) surface laterite and bauxite with an underlying layer of clay (1 to 5 ohm-m).

A representative 8 km traverse line, which had a number of geological test holes drilled along it, was chosen for a detailed geophysical investigation. A VLF traverse with 10 m between readings, and a Wenner traverse (a = 10 m) using a Megger resistivity meter, were made along the complete length of the line.

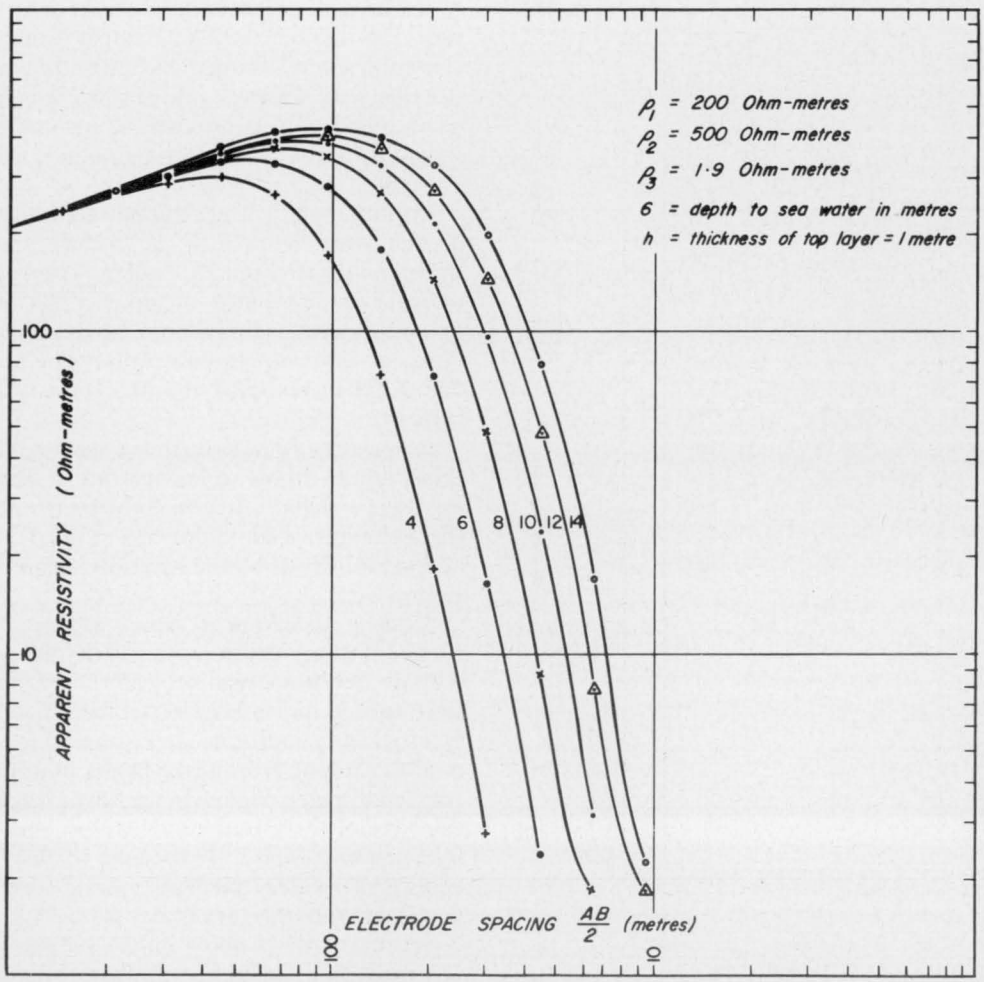


Fig. GS 3. **Theoretical resistivity curves for different depths to fresh water/salt water interface.**

Depth probes using pole-dipole and Alfano (subsurface layer electrode) configurations were carried out around selected drill holes. A pole-dipole traversing technique (a = 20 m, b = 50 m) with a reading interval of 20 m was then used to cover the complete 8 km line.

The VLF and Megger results are presently being analysed. Results from the pole-dipole traversing and subsequent drilling based on these results indicated that anomalous resistivity lows coincide with two known main aquifer zones (of width 90-120 m) as well as several other areas of higher permeability. The Alfano sounding method proved to be uneconomically slow, and successful interpretation of results was hampered by a decrease in resistivity from the base of the bauxite to the top of the watertable. It is considered that drilling and electric logging would be more economical and successful. 56 holes were drilled and logged along the traverse line to provide geological correlation for the geophysical results.

Nebo Coalfield magnetic survey, Qld. A continuous magnetic recorder was used to measure the total magnetic intensity along lines of drill holes in proposed open-cut coalfields in the Nebo area. The magnetic records successfully detected known and unknown intrusions, which was the primary aim of the survey. These magnetic records occasionally showed anomalies over known faults, but in general no anomalies were detected over known faults where intrusions do not exist. It has been recommended that the equipment and technique be developed further. Figure GS 4 shows a magnetic profile over a basalt intrusion at Kemmis Creek.

Kundiawa landslide investigations, Papua New Guinea. Landslides have caused considerable damage to the Highlands Highway in the Chimbu District. Seismic refraction techniques were used to determine the thickness and extent of unstable material at ten landslide locations. The thickness of unstable material was generally 10 to 20 m. Resistivity depth probes were made at two sites. A low-resistivity zone which correlated with the base of the slip zone as determined by seismic results was detected at both sites.

Well logging. The Engineering Geophysics Group was responsible for technical supervision of contract logging surveys in the Great Artesian Basin. Bores were logged in Queensland in the Surat Basin and in the northwest corner of NSW. Gamma, neutron, temperature, differential temperature, flow-meter, and caliper logs were obtained.

The transfer of the BMR 3000-m logger to its new truck was completed in July 1974. Logging of boreholes was carried out by G. Jennings in the Eromanga-Quilpie area, Cape York Peninsula, the Gulf Country, Charleville, and Gosford; using gamma, neutron, temperature, differential temperature, flow-meter, and caliper tools. The vehicle travelled almost 16 000 km and both vehicle and equipment performed well.

Magneto-telluric software development. The major part of time spent in the first half of 1974 was in software development. D. Kerr (ADP Section, Operations Branch), with assistance from R. F. Moore, has written comprehensive acquisition and processing programs for BMR's Hewlett-Packard computers (2116, 2100). Programs have also been written for magneto-telluric modelling on these computers. Full processing and tensor analysis aided by modelling facilities can be undertaken in the field., This was not possible during the 1973 Murray Basin survey. The magneto-telluric analysis program MAGTAN being written by Geotronics for the CDC 6600 and Cyber 76 computers was delivered in late August.

Murray Basin magneto-telluric survey. Model interpretations were made on the 1973 Murray Basin data by Professor Vozoff of Macquarie University. On some sites there is evidence of very much greater thicknesses of sediments than expected, and this is confirmed by recent gravity data. Evidence for folding and faulting and strike direction in some layers is also apparent. Information on earth resistivity to depths of about 100 km was obtained.

Cooper Basin magneto-telluric survey. Despite floods and breakdowns, BMR and Macquarie University made a joint magneto-telluric survey in the southern Cooper Basin, SA. Considerable assistance was obtained from the chief operators in this part of the Basin, namely Delhi International Oil Corporation and Santos Limited. This assistance allowed extensive model studies to be conducted, using electric logs from wells drilled in

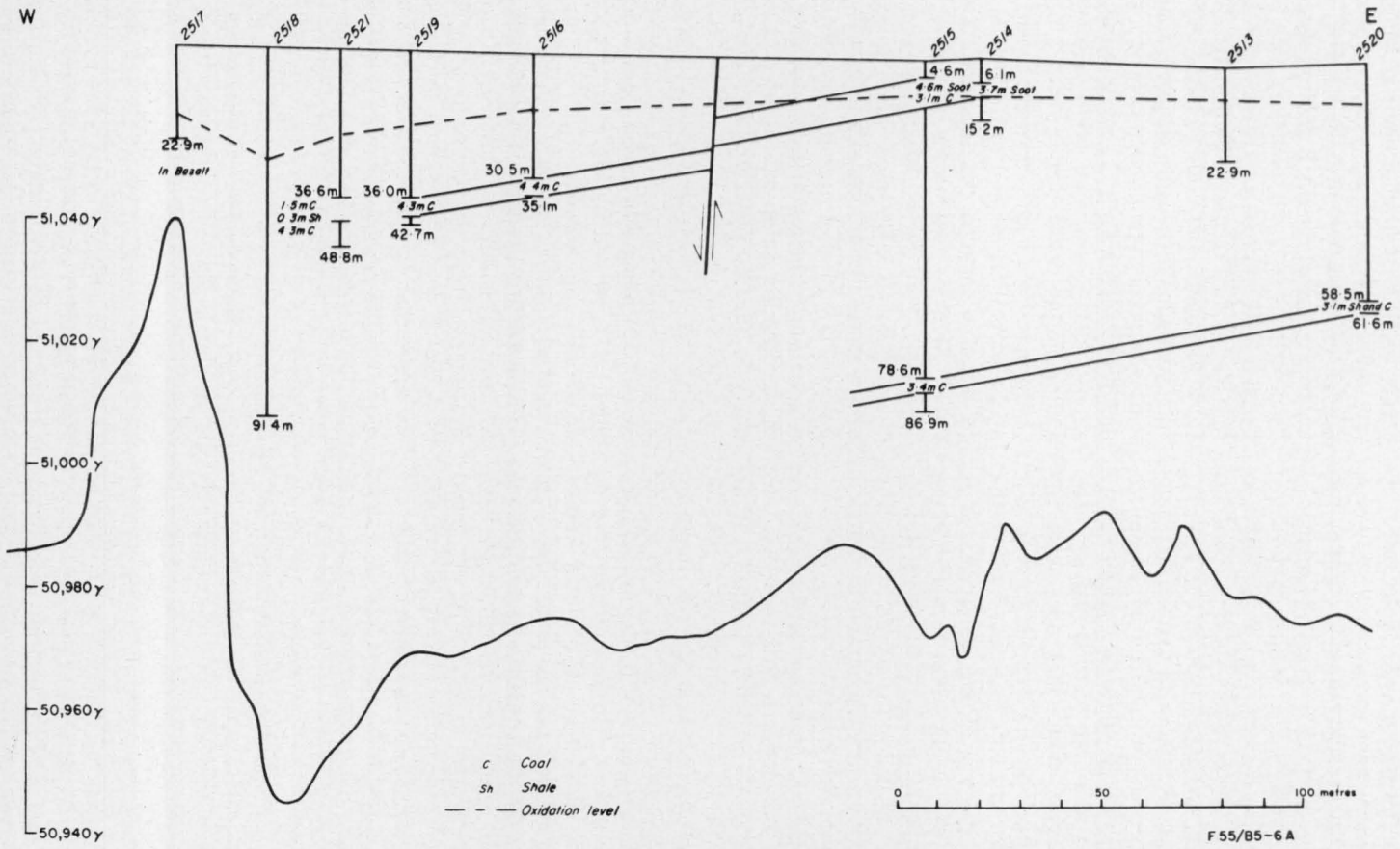


Fig. GS 4. **Nebo coalfield. Magnetic profile over intruded coal seams at Kemmis Creek, Queensland.**

the Basin. On survey, five sites were completed in a three-week period of around-the-clock recording, which provided evidence that the best data are to be acquired in the very early hours of the morning. Following some preliminary in-the-field processing, exceptionally good agreement between anticipated and actual data was found. It is hoped that this survey will, as well as giving more information about the Cooper Basin, provide some indication of the accuracy and resolution of the method in sedimentary and crustal studies.

REPORTS, MAPS, LECTURES

Listed in the following pages are BMR publications issued in 1974, BMR publications in preparation, papers published in outside journals, addresses delivered at meetings and conferences, BMR Records issued in 1974 and in preparation, and aeromagnetic, radiometric, and gravity maps printed.

BMR PUBLICATIONS

Bulletins and Reports issued in 1974

Bulletin 161	WELLMAN, P., *BOULANGER, YuD., BARLOW, B.C., *SHCHEGLOV, S. N. & COUTTS, D. A. (*USSR Acad. of Sciences)	Australian and Soviet gravity surveys along the Australian Calibration Line.
Report 169	DENHAM, D.	Seismicity of the New Guinea/Solomon Islands Region, 1968.

Bulletins and Reports in preparation or in press

Bulletin 152	HAIGH, J. E. & SMITH, M. J.	Standard curves for interpretation of magnetic anomalies due to thin finite dykes.
Bulletin 164	DENHAM, D. (co-ordinator)	Symposium on seismicity and earthquake risk in Eastern Australia. Canberra, Dec. 1974 (selected papers).
Report 175	HARRISON, P. L., ANFILOFF, W., & MOSS, F. J.	Galilee Basin seismic and gravity survey, Qld, 1971
Report 176	EVERINGHAM, I. B.	Seismological report on the Madang earthquake of 31 October 1971 and aftershocks.
Report 177	WIEBENGA, W. A., POLAK, E. J., ANDREW, J. T. G., WAINWRIGHT, M. & KEVI, L.	Burdekin delta underground water investigation, North Queensland, 1962-63.
Report 178	RIPPER, I. D.	Some earthquake focal mechanisms in the New Guinea/Solomon Islands region, 1963-68.
Report 179	MUTTER, J. C.	A structural analysis of the Gulf of Papua and northwest Coral Sea region.
Report 180	EVERINGHAM, I. B.	Catalogue of tsunamis for the New Guinea/Solomon Islands region 1968-72.
Report 182	REES, J. E., & TAYLOR, R. J.	Tottenham detailed aero-magnetic survey, NSW, 1971.
Report 183	BRANSON, J. C., MOSS, F. J., & TAYLOR, F. J.	Deep crustal reflection seismic survey, Mildura, Vic, and Broken Hill, NSW, 1968.
Report 184	DENHAM, D.	An analysis of strong-motion accelerograms from Yonki, Papua New Guinea, 1967-72.
Report 185	DOWNIE, D. N.	Digital data acquisition system in geophysical survey aircraft VH-BMG.
Report 187	YOUNG, G. A. & SHELLEY, E. P.	Amadeus Basin aeromagnetic survey, NT.
—	FRASER, A. R.	Reconnaissance gravity survey of the northwest of Western Australia, 1969.
—	FRASER, A. R.	Reconnaissance gravity survey of the southwest of Western Australia, 1969.
—	FRASER, A. R.	Reconnaissance gravity survey, WA, 1971-72.
—	RIPPER, I. D.	Earthquake focal mechanisms in the New Guinea/Solomon Islands region, 1969-71.

EXTERNAL PUBLICATIONS

BARLOW, B. C., COUTTS, D. A. & SYDENHAM, P. H.	Tidal deviation of the vertical at Armidale, Australia. Proc. of the Symposium on Earth's gravitational field and secular variations in position. Univ. New South Wales, Sydney, 1974.
BRANSON, J. C.	Structures of the western margin of the Australian continent. *Oil and Gas* (Australasia-South East Asia), 20(9), Sept. 1974.
BRIGGS, I. C.	Machine contouring using minimum curvature. *Geophysics*, 39(1), 39-48.
CULL, J. P.	Thermal conductivity probes for rapid measurements in rocks. *J. of Phys. (E), Scientific Instruments*, 7.
CONNELLY, J. B.	Magnetic and seismic profiler records in Bismarck Sea, Melanesian Archipelago. *J. geol. Soc. Aust.*, 21(4), (in press).
COUTTS, D. A.	Gravity observations. *Antarctic Journal of the United States*, 9(4), July-August 1974
DENHAM, D.	Seismicity, the World and Australia. Proc. of Seminars on Earthquake Engineering, Adelaide and Perth, April 1974. Standards Association of Australia, 1974.
DENHAM, D., GREGSON, P. J. & EVERINGHAM, I. B.	East Canning Basin earthquake, March 1970 *J. geol. Soc. Aust.*, 21, 353.
DOOLEY, J. C.	Seismological studies of the upper mantle in the Australian region. Proc. of the Second Indian Symposium on Upper Mantle Project, Dec. 1970. National Geophysical Research Institute, Hyderabad, 1972.
DOOLEY, J. C.	The gravity anomalies of central Australia and their significance for long-term tectonic movements. Proc. of Symposium on Earth's gravitational field and secular variations in position. Univ. New South Wales, Sydney, 1974.
EVERINGHAM, I. B.	Large earthquakes in the New Guinea/Solomon Islands area 1873-1972. *Tectonophysics* (in press).
FINLAYSON, D. M., CULL, J. P., & DRUMMOND, B. J.	Upper mantle structure from the trans-Australia seismic survey (TASS) and other seismic refraction data. *J. geol. Soc. Aust.*, 21(4) (in press).
GREGSON, P. J.	Seismicity of Western Australia. Proc. of Seminars on Earthquake Engineering, Adelaide and Perth, April 1974. Standards Association of Australia, 1974.
MATHUR, S. P.	Crustal structure in southwestern Australia from seismic and gravity data. *Tectonophysics* (in press).
SMART, P. G., WILKES, P. G., NEEDHAM, R. S. & WATCHMAN, A. L.	The geology and geophysics of the Alligator Rivers region. AIMM metals volume (in press).
WELLMAN, P., & McDOUGALL, I. (ANU)	Cainozoic igneous activity in eastern Australia. *Tectonophysics*, 23, 49.
WELLMAN, P., & McDOUGALL, I. (ANU)	Potassium-argon ages on the Cainozoic volcanic rocks of New South Wales. *J. geol. Soc. Aust.*, 21, 247.

BMR RECORDS (an unpublished series)

1969/37	DARBY, F. & FRASER, A. R.	Reconnaissance helicopter gravity survey, WA, 1968.
1973/84	NEUMANN, F. J. G. & LONSDALE, G. F.	Gravity surveys in the Traralgon South area, Gippsland, Vic, 1949-59.
1973/85	LONSDALE, G. F. & HASTIE, L. M.	Gravity surveys in the Billys Creek/Middle Creek/Hazelwood area, Gippsland, Vic, 1960.
1973/86	NEUMANN, F. G. J. & LONSDALE, G. F.	Gormandale gravity survey, Gippsland, Vic. 1960-61.
1973/87	NEUMANN, F. J. G.	Gravity readings on seismic traverses in the Moree area, Surat Basin, NSW, 1962.
1973/93	NEUMANN, F. J. G.	Gravity readings on seismic traverses at Ooraminna, 1961-62, and Alice Springs detailed gravity survey, Amadeus Basin, 1959.
1973/205	DOOLEY, J. C.	The gravity anomalies of central Australia and their significance for long-term tectonic movements.
1973/206	McDOWELL, M.	Tuggeranong Freeway Stage II seismic refraction survey, ACT, 1972.

1973/208	NEEDHAM, R. S., WILKES, P. G. SMART, P. G. & WATCHMAN, A. L.	Alligator Rivers Region environmental fact-finding study: geological and geophysical reports.
1973/212	CONNELLY, J. B. & COLLINS, C. D. M.	Bowen Basin seismic refraction survey, May-June 1973; operational report.
1973/213	CONNELLY, J. B.	Use of a graphic display terminal to match magnetic curves.
1973/214	BARLOW, B. C., COUTTS, D: A., & SYDENHAM, P. H.	Tidal deviations of the vertical at Armidale, Australia, (Proc. Internat. Symp. on Earth's Gravitational Field and Secular Variations in Composition. Syd., Nov 1973).
1974/2	DENHAM, D., EVERINGHAM, I. B. & GREGSON, P. J.	East Canning Basin earthquake, March 1970.
1974/3	PETTIFER, G. R.	Tuggeranong urban development area, seismic refraction and resistivity surveys, ACT 1971-1972.
1974/4	ANFILOFF, W. & SHAW, R. D.	The gravity effects of three large uplifted granulite blocks in separate Australian shield areas.
1974/6	IDNURM, M. & SCHEIBNER, E.	Palaeomagnetic measurements on the Kempsey Block, NSW.
1974/7	PINCHIN, J.	BMR proposals for co-operation with Woods Hole Oceanographic Institution in the East Indian Ocean, 1975.
1974/8	DOOLEY, J. C.	Translations of papers on seismic reflection and refraction methods by N. N. Puzyrev and others of the Institute of Geology and Geophysics, Siberian Branch of the Academy of Sciences, Novosibirsk, USSR.
1974/10	RIPPER, I. D. & GAULL, B. A.	Port Moresby geophysical observatory annual report, 1972.
1974/15	CGG	Marine geophysical survey of the Australian continental margin 1970-1973: field progress reports.
1974/17	SMART, P. G., WILKES, P. G. NEEDHAM, R. S. & WATCHMAN, A. L.	The geology and geophysics of the Alligator Rivers region.
1974/23	DOLAN, B. H. & SIMPSON, G. B.	Lunar Laser Ranger site foundation investigation, Orroral Valley, ACT, 1973: Pt. 1, seismic refraction survey; Pt. 2, geological technical note.
1974/26	FRASER, A. R.	Reconnaissance gravity survey of the southwest of Western Australia, 1969.
1974/27	FRASER, A. R.	Reconnaissance gravity survey of the northwest of Western Australia, 1969.
1974/33	WYATT, B. W.	Preliminary report on airborne magnetic and radiometric survey of the Alcoota 1:250 000 Sheet area, Northern Territory.
1974/34	GAULL, B. A.	PNG earthquake strong motion recordings.
1974/35	YOUNG, E. E.	BMR Symposium, Canberra, 30 April-1 May 1974.
1974/36	DENHAM, D.	Seismicity, the World, and Australia.
1974/37	DODSON, R. G., NEEDHAM, R. S., WILKES, P. G., PAGE, R. W., SMART, P. G. & WATCHMAN, A. L.	Uranium mineralization in the Rum Jungle/Alligator Rivers area.
1974/42	HSU, D.	Aeromagnetic interpretation of northern Eromanga and Galilee Basins, Queensland.
1974/43	PIEUCHOT, M. (CGG)	Poole Range seismic survey, 1962.
1974/45	CGG	Field report of marine geophysical survey No. 5 of the Gulf of Papua and Bismarck Sea.
1974/47	TUCKER, D. H.	Presurvey report: Officer Basin aeromagnetic survey, Western Australia, 1974.
1974/48	EVERINGHAM, I. B.	Large earthquakes in the New Guinea/Solomon Islands area.
1974/49	MOSS, F. J. & JONES, P.	Ngalia Basin seismic survey, Northern Territory, 1967-1969.
1974/55	EVERINGHAM, I. B.	Faulting associated with the major north Solomon Sea earthquakes of 14 and 26 July 1971.
1974/60	HILL, P. J.	Macquarie Island geophysical observatory, annual report 1973.

1974/61	FINLAYSON, D. M., CULL, J. P. & DRUMMOND, B. J.	Upper mantle structure from the trans-Australia seismic survey (TASS) and other seismic refraction data.
1974/62	BULLOCK, P. W. B.	The follow-up of an airborne gamma-ray spectrometer survey in the Rum Jungle area, Northern Territory.
1974/63	DUCKWORTH, K.	Slingram model tests.
1974/64	BRANSON, J. C.	Structures of the western margin of the Australian continent.
1974/65	PETTIFER, G. R.	Markham Valley gravity survey, PNG, 1972.
1974/67	OGILVY, R. D.	Down-hole induced polarization and electric applied potential tests at Basin Creek No. 1 prospect, MEL 200, Tumut, NSW 1973.
1974/68	MURRAY, A. S.	The Australian National Gravity Repository computer system.
1974/69	MATHUR, S. P.	A proposal for a deep seismic sounding and associated gravity survey in central Australia.
1974/71	MICHAIL, F. N. & HOHNEN, P. D.	Hughes reservoir site investigation, Deakin, ACT.
1974/80	HONE, I. G.	Ground geophysical survey, Tennant Creek, NT, 1971.
1974/81	MATHUR, S. P.	Costs of a proposal for a deep seismic sounding and detailed gravity survey in central Australia.
1974/82	GAULL, B. A.	Accelerograph recordings of the Musa earthquake, 16 September 1972.
1974/83	FINLAYSON, D. M. & DRUMMOND, B. J.	Trans-Australian seismic survey (TASS) 1972, operational report.
1974/88	PETTIFER, G. R. & FRASER, A. R.	Reconnaissance helicopter gravity survey, SA, 1970.
1974/89	DAVIES, J. S.	Southern Georgina Basin seismic survey, Northern Territory and Queensland, 1965.
1974/92	MANWARING, E. A.	A palaeomagnetic reconnaissance of Papua New Guinea.
1974/98	CAMERON, P. J. & PINCHIN, J.	Geophysical results from offshore Tasmania.
1974/99	PETKOVIC, P.	Origin of the Naturaliste Plateau.
1974/102	DENHAM, D., SMALL, G. R., CLEARY, J. A., GREGSON, P. J., SUTTON, D. J. & UNDERWOOD, R.	Australian earthquakes 1897-1972.
1974/103	GREGSON, P. J. & SMITH, R. S.	Mundaring geophysical Observatory annual report, 1973.
1974/110	CGG	Marine geophysical survey of the continental margins of Australia, Gulf of Papua and the Bismarck Sea 1970-1973: Data Processing.
1974/111	CGG	Marine geophysical survey of the continental margins of Australia, Gulf of Papua and the Bismarck Sea 1970-1973: Equipment description.
1974/114	WELLMAN, P.	National report on gravity in Australia, July 1970 to June 1974.
1974/115	McMULLAN, M. W.	Macquarie Island geophysical observatory annual report, 1972.
1974/116	MUTTER, J. C.	Geophysical results from the Coral Sea: continental margins survey report.
1974/121	WELLMAN, P., BARLOW, B. C. & COUTTS, D. A.	Comparison of Western Pacific and Australian Calibration Line scales and an evaluation of secular variations.
1974/123	DOLAN, B. H., HENDERSON, G. A. M., JACOBSON, G. & VANDENBROEK, P. H.	Geological and geophysical investigations of the City East development area, Canberra, ACT.
1974/125	MOSS, F. J.	Overseas visit to Mexico and USA, 18 October to 24 November 1973.
1974/126	SPIES, B. R.	The dual loop configuration of the transient electromagnetic method.
1974/130	PETTIFER, G. R.	Report on the International Atomic Energy Agency symposium on isotopic techniques in groundwater hydrology, Vienna, March 1974.
1974/132	DOLAN, B. H. & MICHAIL, F. N.	Sturt Island sand and gravel deposits refraction survey, Murrumbidgee River, ACT, 1974.

1974/133	BRANSON, J. C.	Overseas visit: 3rd Indonesian Petroleum Association convention, Jakarta, 31 May-15 June 1974.
1974/134	POLAK, E. J. & RAMSAY, D. C.	Goulburn Valley resistivity survey, Vic, 1974.
1974/135	SAMPATH, N. & OGILVY, R. D.	Cloncurry area geophysical survey, Qld, 1972.
1974/136	BRANSON, J. C.	Continental margin survey: preview report for Eastern Tasmania and the New South Wales coast.
1974/137	HORSFALL, K. R.	Presurvey report on Cooktown, Hann River and Rutland Plains magnetic and radiometric survey, Qld, 1974.
1974/140	SHIRLEY, J. E. & ZADOROZNYJ, I.	Reconnaissance helicopter gravity survey, Northern Queensland, 1966.
1974/142	CHENON, C.	Notes on seismic reflection testing.
1974/146	BRANSON, J. C. & TURPIE, A.	Sediments and structures of the Australian continental slope bordering the Indian Ocean (9th World Petroleum Congress, Tokyo).
1974/147	WILCOX, J. B.	Geophysical results from the Great Australian Bight.
1974/152	SPIES, B. R.	Transient electromagnetic model studies, 1973.
1974/155	TILBURY, L. A.	Continental margin survey: preview report for Western Tasmania and the Eastern Bight.
1974/156	SHELLEY, E. P.	Recontoured magnetic data from part of the 1960 airborne survey of the Tennant Creek 1:250 000 Sheet area, NT.
1974/157	SCHWING, E. H. (IFP) & MOSS, F. J.	Experimental seismic survey using explosives for comparison with a Vibroseis survey in the Otway and Sydney Basins, 1965-66
1974/160	NEUMANN, F. J. G.	BMR gravity surveys, Gippsland Basin, Vic, 1943-61.
1974/164	WILKES, P. G.	Results of radiometric surveys in the Alligator River and Cobourg Peninsula area of the Northern Territory (AIMM, June, 1975).
1974/166	MICHAIL, F. N.	Mary River area geophysical survey, NT, 1972.
1974/169	MATHUR, S. P. & ABBS, G. L.	Explosive tests for comparison of seismic efficiency of Molanite, TNT, and Anzite Blue, Vic, 1974.
1974/170	PINCHIN, J. & HUDSPETH, J. W.	The Queensland Trough: some recent geophysical results, and its petroleum potential (APEA Journal).
1974/171	HONE, I. G.	Ground geophysical survey, Tennant Creek, NT, 1972.

1:250 000 AEROMAGNETIC AND RADIOMETRIC MAPS PRINTED

Survey	*Year*	*Type*	*Map Name*
Western Australia	1956, 1961 & 1969	Mag/Rad	Murgoo, Byro, Yalgoo
Goulburn	1969	Mag/Rad	Goulburn
Western Australia	1969	Mag/Rad	Belele, Cue, Kirkalocka
Southern Cape York Peninsula	1969	Mag/Rad	Walsh, Mossman, Cairns
Western Australia (contract)	1970	Mag	Glengarry, Wiluna, Kingston

PRELIMINARY GEOPHYSICAL MAPS RELEASED

The following preliminary maps were released and became available from the Australian Government Printer and the relevant State Mines Departments.

Aeromagnetic profile maps at 1:250 000

Survey	*Year*	*Type*	*Map Name*
Queensland	1973	Mag/Rad	Cloncurry, Georgetown, Westmoreland
Northern Territory	1972	Mag/Rad	Alcoota

Aeromagnetic contour maps 1:100 000

Preliminary data released during 1974. These are listed in alphabetical order under the 1:250 000 Sheet name.

1:250 000 Sheet area	*1:100 000 Sheets released*
Corrigin	Brookton, Corrigin, Kulin, Narembeen, Narrogin, Yealering.
Kellerberrin	Bruce Rock, Cunderdin, Dwoerin, Kellerberrin, Merredin, Trayning.
Perth	Chittering, Goomalling, Northam, Wooroloo.
Pinjarra	Beverley, Crossman, Dwellingup, Jarrahdale.

Proposed preliminary data release (November-December 1974)

Survey	*Year*	*Type*	*Map Name*
Carpentaria Basin Queensland	1973/74	Mag/Rad	Cape Melville, Ebagoola, Holroyd, Cooktown, Hann River, Rutland Plains
NSW	1973/74		Wagga Wagga
Victoria	1974	Mag/Rad	Ballarat
Eucla Basin SA	1972/73	Mag/Rad	Coompana, Fowler, Nullarbor

Tennant Creek (magnetic) 1960 recontoured at 10-gamma intervals—1:100 000 Sheets concerned are Barkly, Billiatt, Gosse River, Kelly, and Tennant Creek.

Bouguer anomaly maps

Bouguer anomaly maps for the following 1:250 000 Sheet areas covering the 1967 helicopter gravity survey were released through the Government Printer and relevant State authorities.

Alligator River
Arnhem Bay
Ashton
Auvergne
Bathurst Island
Birrindudu
Blue Mud Bay
Cambridge Gulf
Camden Sound
Cape Beatrice
Cape Scott
Charnley
Cobourg Peninsula
Darwin
Delamere
Derby
Dixon Range
Drysdale
Fergusson River
Fog Bay
Gordon Downs
Gove
Highland Rocks
Hodgson Downs
Junction Bay
Katherine
Lake Mackay
Lansdowne
Larrimah
Lennard River
Limbunya
Lissadell
Londonderry
Melville Island
Medusa Banks
Milingimbi
Montague Sound
Mount Doreen
Mount Elizabeth
Mount Evelyn
Mount Marumba
Mount Ramsay
Mount Theo
Mount Young
Noonkanbah
Pellew
Pine Creek
Port Keats
Port Langdon
Prince Regent
Roper River
The Granites
Truant Island
Urapunga
Victoria River Downs
Waterloo
Wessel Islands
Yampi

GRAVITY MAPS PRINTED

1:500 000 Bouguer anomaly maps of the following 1:250 000 Sheet areas for 1971/72 helicopter gravity survey were printed.

Ajana
Barlee
Belele
Burnabbie
Byro
Glengarry
Jubilee
Kennedy Range
Kingston
Kirkalocka
Laverton
Lennis
Leonora
Loongana
Madura
Mason
Menzies
Minigwal
Mount Phillips
Cooper
Cue
Culver
Dongara
Duketon
Murgoo
Nabberu
Naretha
Neale
Ninghan
Peak Hill
Perenjori
Plumridge
Rason
Robert
Robinson Range
Sandstone
Seemore
Sir Samuel
Edjudina
Eucla/Noonaera
Forrest
Geraldton
Glenburgh
Stanley
Talbot
Throssell
Vernon
Waigen
Wanna
Westwood
Wiluna
Wooramel
Yalgoo
Yaringa
Youanmi
Yowalga