BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

REPORT 231

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GEOPHYSICAL BRANCH
SUMMARY OF ACTIVITIES
1980

DEPARTMENT OF NATIONAL DEVELOPMENT AND ENERGY
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Secretary: A.J. Woods

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SUMMARY

METALLIFEROUS AND AIRBORNE SECTION (G. Young)

Consistent with the trend established over recent years, a reduced work program was planned for the Section for 1980 to adjust to the steady decrease in staff and financial resources. As predicted in the Annual Summary for 1979, little field activity was possible for the Metalliferous Subsection this year as priority had to be given to data handling and to reporting backlogs generated by staff losses which peaked in 1979 and predictably continued through 1980. It is expected that these backlogs will be cleared during 1981 enabling a limited number of projects to resume or commence in the areas of methodological research and regional geophysics.

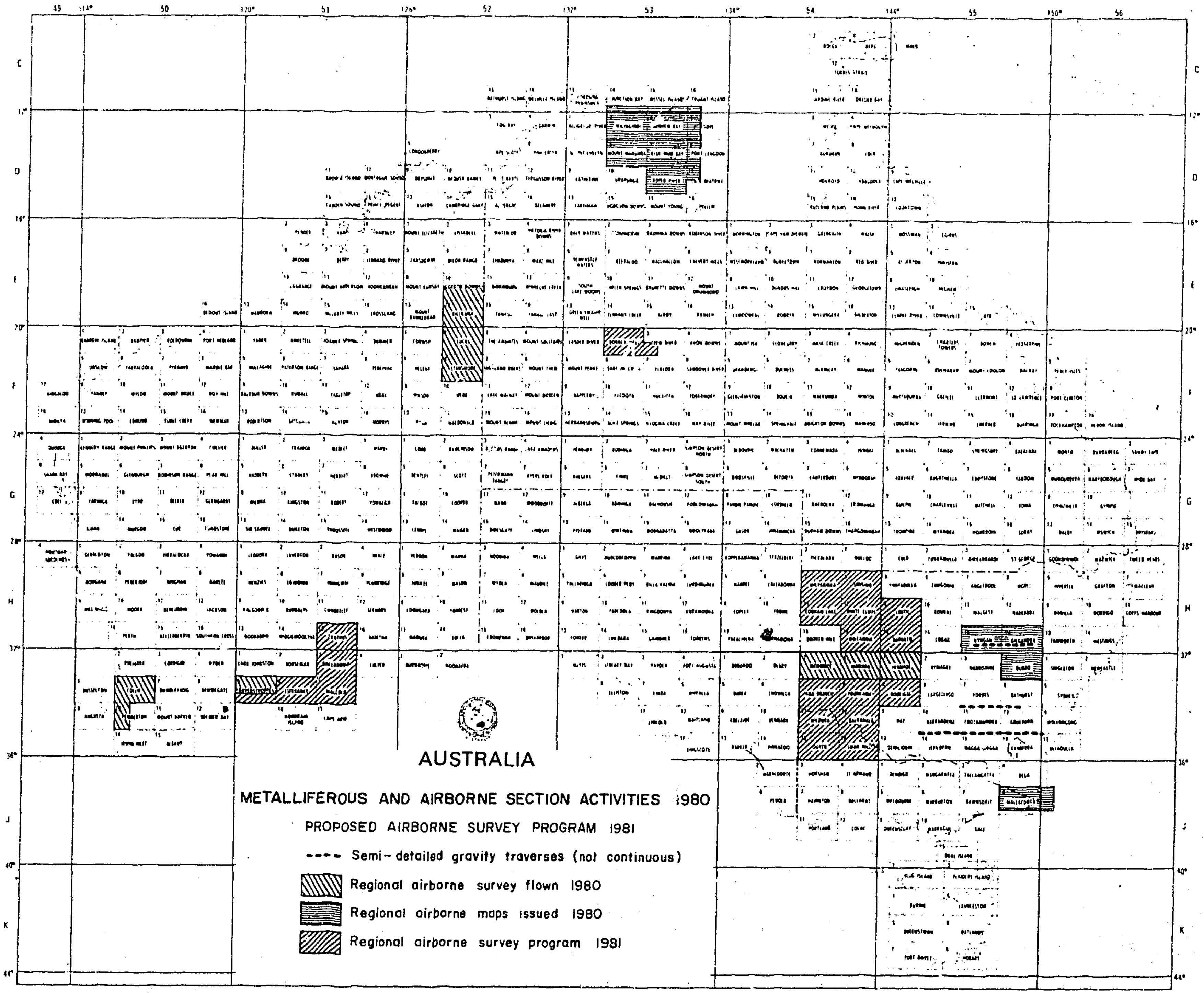
At the start of the year a proposal was made to Government that BMR's program of airborne reconnaissance geophysical mapping should be accelerated with a view to completing the basic coverage of continental Australia by 1989. This proposal entailed the return of the Aero Commander VH-BMR to survey operations, and a major increase in the work rate of BMR's principal survey aircraft, Twin Otter VH-BMG. Funds have been provided in the current financial year to enable the accelerated program to commence in 1981. Agreement had not been obtained by December 1980 for the progressive engagement of additional staff necessary to attend to this increase in program.

Figure MA-1 shows the location of the field activities of the Section during 1980. The major part of such activities was the airborne survey program, which was flown basically according to schedule. Figure MA-1 also illustrates the proposed airborne survey program for 1981 indicating the major acceleration in coverage, directed towards aiding petroleum search, as both aircraft return to optimum utilisation. Work programmed in the Darling and Murray Basin regions will be flown at 3 km line spacing.

Staff from the Metalliferous Subsection attended to data analysis and reporting in two basic program areas during 1980:

1. Regional geophysical studies of the Lachlan Fold Belt, and to a lesser extent, Mount Isa Block and Pine Creek Geosyncline.
2. Methodological research in metalliferous geophysics.

Work on the Lachlan Fold Belt project during 1980 concentrated on the processing, interpretation, and reporting of the previous year studies with a minor amount of fieldwork done to define more clearly selected gravity anomalies.



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Maps were released for the 1979 airborne surveys of DUBBO, NYNGAN, and GILGANDRA*, and the results were studied as a key element of airborne geophysics data appreciation for the study of the Fold Belt in NSW. Work continued on the processing and interpretation of data acquired along transects indicated in the 1979 Annual Summary. The limited gravity surveys referred to above were made along parts of these transects to enable a more complete interpretation of geophysical data to be undertaken. Initial findings in the form of gross regional subdivisions of the geophysical characteristics have been made. Laboratory analyses and entry of results into a computer data base formed a major work element for staff engaged in measuring and assessing the properties of 1000 rock samples collected in 1979 from the major Palaeozoic rock groups in the region. Information on site location, geology, magnetic susceptibility and remanence, gamma-ray spectrometry, density, petrology, and some geochemical data are included, the geochemical information being provided through a cooperative project with Bundesanstalt fur Geowissenschaften und Rohstoffe (BGR).

Specific studies of certain aspects of the geophysics of the region have been the subject of numerous papers presented this year. An empirical relation observed between the gamma-ray spectral signature of granitoids and their prospectiveness for hosting tin and tungsten has been the subject of considerable interest since it was drawn to industry's attention at the 4th Australian Geological Convention at Hobart in January 1980. The magnetic, electrical (including EM), gravimetric, and physical characteristics of the Elura deposit have been the subjects of a number of papers prepared by Metalliferous Subsection staff for inclusion in a special edition of the Bulletin of the Australian Society of Exploration Geophysicists. The source of some regional magnetic anomalies in the Cobar Trough, and characteristics of near-surface magnetic sources in the Cobar area plus their discrimination from deeper seated bedrock sources, have been the subject of additional reports completing studies in these areas based on work commenced in 1979.

A regional overview of the geophysics of the Mount Isa Block was started in August in support of a geological synthesis of the region to be done by Geological Branch, BMR. This work will be completed early in 1981 and will provide a guide to factors controlling the geophysical anomalies recorded in the region.

A gamma-ray spectrometer study of the radio-element concentrations of the Koolpin Formation was completed in early 1980. Results showed that massive ironstone and banded iron formations within the Koolpin Formation are commonly

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*In this Report, 1:250 000 Sheet areas are in capital letters to distinguish them from ordinary place names.

enriched in uranium, and by virtue of above average uranium/thorium ratios form good markers for regional mapping in the Pine Creek Geosyncline, using high-sensitivity airborne gamma-ray spectrometry.

Feasibility studies into the application of electrical and ground magnetic methods to assist the assessment of, and search for, petroleum in the Central Eromanga Basin commenced in mid-1980. Initial results indicate that electrical methods will suffer from severe problems of EM coupling due to low resistivities of the sedimentary section. Further work planned in 1981 is included in the Central Eromanga Basin Project summary.

The main activity in methodological research was the documentation of studies commenced in 1979. In the field of nuclear geophysics, analysis and reporting is progressing on the results of alphameter, emanometer, and surface and downhole gamma-ray spectrometer surveys at selected sites in the Pine Creek Geosyncline. This study has highlighted the efficiency of emanometry if U/Th ratios, rather than total count data, are presented, and the observation that the radio-element concentration of surface rocks in this region commonly reflects radio-element concentrations in underlying bedrock.

In the field of electrical geophysics (including EM), a comprehensive report was prepared by B. Spies on his visit to geoscientific institutions in USSR in 1979. The report provides an extensive review of the application and interpretation of these geophysical methods in USSR. Model studies of downhole TEM continued at BMR using a Macquarie University facility. Experimental surveys were carried out to test the SIROTEM downhole probe and the BMR developed omni-directional probe. Results of all the above topics should become available in early 1981.

An investigation into the application of the Cole-Cole dispersion model for interpretation of complex resistivity was completed. Results showed that extreme care should be exercised in accepting the results of such interpretation. Model studies of responses from simplified representations of Elura and Roxby Downs mineral deposits were completed and reported on, with attention directed at key parameters involving the detectability of such targets using the TEM method.

The Bureau's Twin Otter aircraft was operational for 948 hours in 1980, enabling 99 000 line-km to be surveyed.

The first major project of the year commenced in late January with a program to survey COLLIE, PEMBERTON (western third), and RAVENSTHORPE. Survey operations were terminated in late March when the aircraft had to proceed to Brisbane for overhaul. At that time 21 000 line-km had been flown, with the southern half of RAVENSTHORPE remaining to be surveyed. Initially, it was planned to complete RAVENSTHORPE in late 1980. However, following advice that the airborne survey program was to accelerate in 1981, it was determined that a more efficient program would result by completing all outstanding work in south-western Western Australia early in 1981 as shown in Figure MA-1. Processing of the 1980 survey data will commence early in 1981 and results will be released as they become available through 1981.

The second major project of the year involved the surveying of STANSMORE, LUCAS, BILLILUNA, and GORDON DOWNS (southern half) involving 55 000 line-km of flying. Work commenced in late May and was completed by mid September. Results of this survey are unlikely to become available for public release before the end of 1981.

The third, and final, project of the year involved the surveying of MENINDEE, MANARA, and IVANHOE. Work on this project commenced in October and is scheduled for resumption and completion in August 1981. Surveying on this project will total 27 000 line-km. Figure MA-1 indicates major extensions to the airborne geophysical surveying of the Darling and Murray Basins proposed for 1981 as mentioned earlier. Results from the 1980 survey are unlikely to become available for public release before early 1982.

As in the previous two years, most Airborne Subsection personnel contributed to work in the Airborne Reductions Group for long periods during the year. Processing was undertaken on 24 1:250 000 Sheet areas; this resulted in the production of 95 maps of which 60 were released and a further 14 will be released early in 1981, and the remainder retained for inspection at BMR. Figure MA-1 illustrates sheet areas for which maps were released.

During the year, there was a marked increase in the requests by outside organisations for the supply of copies of airborne geophysical data. As at the end of October, 51 requests had been received involving a total of 173 Sheet areas. These requests were almost evenly balanced between accessing recent digital data and older analogue data, the latter producing considerable problems in organising microfilm copying.

Subsection personnel were also involved in the development of computer programs to deal with specialised processing and interpretation of airborne geophysical data, a review of the adequacy of aeromagnetic coverage of sedimentary basins in continental Australia, interpretation in conjunction with CSIRO of survey results obtained in 1979 over the Western coalfields, NSW, and upgrading radiometric data presentation for surveys flown in the Yilgarn Block, WA, prior to 1960.

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

The main field activities of the Seismic and Gravity Groups were on the Central Eromanga Basin Project. Other activities involved data processing, interpretation and reporting on other projects, and reviews of geophysical and geological information in areas where further surveys may be required to solve stratigraphic and structural problems, particularly relating to petroleum search.

Staff shortages continued to curtail the programs of the two groups. However, the groups continued to be actively involved mainly in cooperative projects including: the McArthur and Georgina Basin projects; the Gundary Plains deep crustal reflection survey in the Lachlan Geosyncline with the Regional Geophysics Sub-section; Ngalia Basin reporting with the Geological Branch; Denison Trough project with the Geological Survey of Queensland (GSQ); and the Central Eromanga Basin Project with others in BMR and with GSQ.

The main objectives of the central Eromanga Basin seismic and gravity surveys were to provide structural and stratigraphic information on the Eromanga and underlying basins. The new information is being integrated with good quality seismic and gravity information obtained previously, and with other geophysical and geological information now being obtained by the BMR and private companies, to assist in defining the structural and depositional history of the area and its petroleum resource potential. A series of mainly east-west regional multicoverage seismic reflection traverses were recorded west of the Canaway Fault to investigate the Eromanga Basin, the underlying Permio-Triassic Cooper Basin, and the Warrabin Trough, which contains Devonian sediments of Adavale Basin age. The groups were also considerably involved in reviewing previous survey information to assist in planning the 1980 and 1981 surveys.

Major projects at the writing-up stage include the McArthur Basin gravity and seismic surveys, and the Denison Trough seismic surveys. Considerable interest has been shown by private mineral exploration companies in the results of the gravity surveys in the McArthur Basin; these are being written up as a Record. The results of the Denison Trough regional surveys have been of considerable assistance to the petroleum exploration lease holders and others with interests in the area. Renewed company activity, particularly involving seismic surveys tied to the BMR regional traverses, has provided high quality data and indicated several potential petroleum prospecting plays, some of which will be drilled in the near future.

Deep crustal seismic reflections were again recorded in the Gundary Plains area in the Lachlan Geosyncline in SE Australia, and in the central Eromanga Basin area in SW Queensland. In the latter area approximately 500 km of mainly 6-fold common-depth-point seismic reflection data, being obtained to provide information on the sediments, were recorded to 20s to provide information at depth. This is the most productive concentrated effort undertaken so far by the BMR in recording seismic reflection data from the lower crust and Upper Mantle. A considerable effort will be required to process the data, which it is hoped will provide definitive information on the structure of the deep crust. It is proposed that some of the data will be processed in the USA at Cornell University in cooperation with personnel involved in the Consortium of Continental Reflection Profiling (COCORP) project. Preliminary results from data recorded in 1975-78 in NE Australia were presented at the 17th General Assembly of the International Union of Geodesy and Geophysics (IUGG) meeting held in Canberra in December 1979.

The Marine Group was able to take part in three separate survey projects this year; the Great Barrier Reef survey, a cruise to Heard Island, and cruises in Antarctic waters.

The survey of the central Great Barrier Reef was the first stage of a joint survey with National Mapping, using M.V. Kalinda. BMR installed and operated a computerised system for recording navigational, bathymetric, and magnetic data. An application to the Australian Marine Science and Technology Advisory Committee Funding Advisory Panel (AMSTAC/FAP) for funding was successful and it is foreseen that more intensive study of the Great Barrier Reef geological setting and development will be made in succeeding years, using seismic and shallow geological sampling methods supported by these funds.

Further close study was made of practical means and cost to mount geoscience marine surveys. Submissions on the subject were provided to AMSTAC. Magnetic, bathymetric, and navigational data were also recorded on a cruise to, and around Heard Island, using Natmap's M.V. Cape Pillar. This year saw the start of marine geophysics in the Antarctic using M.V. Nella Dan. During cruises in Antarctic waters 32 600 km of magnetic data were recorded. Equipment is now being installed on M.V. Nella Dan to record deep bathymetric and navigational data. M.V. Nella Dan has been extensively modified for scientific research on board; this includes installation of an instrument laboratory and a modified stern to take winches that can be used for seismic cables. BMR proposals to the Antarctic Research Policy Advisory Committee (ARPAC) for M.V. Nella Dan include comprehensive surveys of the southeast Indian Ocean using a multichannel seismic system.

Data processing undertaken by the Marine Group included mainly processing of navigational and magnetic data from Arafura Sea, Antarctic, Heard Island, and pre-1970 surveys of the Northwest Shelf and Bonaparte Gulf. In addition, a new compilation of all survey ships' tracks around Australia has been started.

Interpretation work completed this year included a study of the Naturaliste Plateau, its origins, crustal thickness and plate tectonics of the surrounding region. Interpretation of the data collected by R.V. Sonne was completed, with a study of the rift grabens on the Queensland and Papuan Plateaus. A general study of rift basins all around Australia was also undertaken.

Technical advice was given to the Department on Law of the Sea matters by P.A. Symonds, and to the Committee for Co-ordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas (CCOP/SOPAC) by J.C. Branson.

Development of computer acquisition and processing systems continued. MUSIC - a system for the digital acquisition of marine seismic data - was nearly completed. Basic operating systems have been written, but a link to the marine DAS (Data Acquisition System) has yet to be made.

Development of the seismic processing system concentrated on the assimilation of newly purchased hardware, using funds from the National Energy Research and Development Demonstration Program (NERDDP). Several major items, such as the array transform processor (ATP), were purchased, and process control software was written. A new system for the digital recording of navigation data on board R.V. Sonne was developed; a system for the digital recording of shore base magnetometer data was also developed.

GEOMAGNETISM, SEISMOLOGY, AND REGIONAL GEOPHYSICS SECTION

The 17th General Assembly of the International Union of Geodesy and Geophysics, which was held in Canberra from 2-15 December 1979, dominated the first few months of the report period. All members of the Section were involved, particularly in the organisation of the IAGA (International Association of Geomagnetism and Aeronomy) and IASPEI (International Association of Seismology and Physics of the Earth's Interior) sections of the conference. Twelve papers originating from the Section were presented during the Assembly; J.P. Cull, D. Denham, D.M. Finlayson, and P.M. McGregor convened symposia or workshops at the Assembly, and P.M. McGregor and D. Denham were, respectively, the local representatives of IAGA and IASPEI, responsible for the administrative arrangements for these associations. P.M. McGregor was appointed Chairman of IAGA's Working Group V-5 (Magnetic Surveys and Charts), and several other members of the Section are serving on other Working Groups.

By all accounts the Assembly was highly successful, scientifically and organisationally. About 1400 scientists from overseas attended the meeting and several of these visited the Section either during or after the Assembly.

Earthquake seismology

The normal seismological, magnetic, and ionospheric observatory programs were maintained during the year, but staff shortages necessitated a reduced program of seismological analysis for some of the stations. Phase data continued to be telexed to the National Earthquake Information Service in Golden, USA for the preliminary determination of hypocentres, and final data for the Australian and Melanesian regions were despatched on magnetic tapes to the International Seismological Centre in Newbury, UK, for the period January 1978 - February 1979.

There was an increase in the number of requests for seismological data, information, and advice from both Australia and overseas. During 1980, requests were received on average at a rate of a little over 10 per month and significant resources had to be deployed to deal with them.

No large, damaging earthquakes took place in Australia during the report period, but aftershocks of the June 1979 Cadoux earthquake (magnitude 6.5), which caused about $4 million worth of damage, occurred throughout the year. Studies of the effects of the Cadoux earthquake have continued; isoseismal maps were prepared and a focal mechanism from the P-wave data was determined.

In February 1980, as part of a joint BMR/CSIRO study of crustal stress in the Australian region, in situ stress was measured in shallow holes (<10 m) at five sites near the epicentre of the Cadoux earthquake and at four other sites between Cadoux and Wagin, in the South West Seismic Zone, WA.

The results indicated a high crustal stress (20-30 MPa) near Goomalling and Wongan Hills and showed that the whole of the southwest of the Yilgarn Block is being compressed. Near Cadoux the stress dropped from about 20 MPa, 25 kilometres from the epicentral region, to between 4 and 8 MPa near the fault scarp caused by the earthquake.

P. McGregor attended the 9th and 10th meetings of the Group of Scientific Experts of the Committee of Disarmament to advise on the seismological detection of nuclear explosion. These took place in February and July at Geneva. He was appointed convener of a study group on 'Format and Procedures for the Exchange of Level 1 Data' and, during October 1980, an experiment was conducted to test data exchange procedures.

In April, D. Denham visited China under the auspices of the Scientific and Technical Exchange Program sponsored by the Academia Sinica and the Australian Academy of Science. He inspected geophysical facilities - mainly involved with earthquake prediction studies - at Beijing, Kunming, and Kwangchou, and gave lectures on the BMR/CSIRO stress measurement program and the BMR's crustal studies work.

Geomagnetism

The Section participated in the MAGSAT (magnetic vector satellite) project by establishing 1st order magnetic stations at Charters Towers in February and at Port Hedland in March. It was not possible to get a berth on the expedition to Heard Island to provide additional ground control for the satellite but a surveyor was instructed in making 2nd and 3rd order magnetic observations. The satellite was launched on 30 October 1979 and operated until 11 June 1980. During that time, mean hourly values of the magnetic field from Gnangara, Port Moresby, and Canberra were despatched to the USA for use in the project.

Reports for geomagnetic data and information were received on average at a rate of more than 6 per month and required considerable effort to process. The 1980 epoch magnetic charts will be delayed because of staff shortages, but it is hoped to have a preliminary D map available early in 1981.

In the Antarctic, B. Gaull completed a regional magnetic survey in Enderby Land. This involved re-occupying at least nine stations and putting in several new ones. S. Scherl carried out an aeromagnetic and ice-radar survey also over Enderby Land, and obtained several thousand kilometres of profiles. Scherl also collected 88 oriented hand samples from mafic dykes in Enderby Land for a palaeomagnetic study.

On Macquarie Island, a magnitude 6.4 earthquake in March severely affected the variometers, and a supervisory visit was carried out by A. McEwin to realign and re-calibrate the recorders.

Explosion seismology

A deep crustal seismic refraction and reflection survey was carried out in the central Eromanga Basin over a 300 kilometre profile to study the main structural features of that part of the Basin. Interpretation of the results obtained in the McArthur Basin, the Lachlan Fold Belt/ Sydney Basin region, and between Tennant Creek and Mount Isa continued. A paper on the crustal structure of the Sydney Basin/Lachlan Fold Belt region was submitted for publication. It showed that the crust beneath the Sydney Basin is similar to that beneath the main Lachlan Fold Belt and therefore suggests that the Sydney Basin was formed on continental and not oceanic crust. In December, Dr C. Prodehl from W. Germany and Dr R. Mereu from Canada visited BMR. Mereu came as a technical specialist and wrote a program on Tau Inversion, and Prodehl discussed the possibility of a joint West German/Australia project in explosion seismology. Prodehl's visit was followed in August by Professor K. Fuchs, also from Karlsruhe, West Germany, who spent two months in Australia as a visiting scholar under the Australian-European Awards Program. He visited the Alice Springs area, and the Eromanga and Bowen Basins in Queensland. He also gave a number of lectures, and led a two-day workshop on 'Calculation of Synthetic Seismograms by the Reflectivity Method'. The workshop was held in BMR during October and was attended by over 20 participants, including several from interstate.

Professor Fuchs also discussed with BMR,the Australian National University (ANU), and the University of Queensland, a proposal to survey a Lithospheric Profile in Australia during 1982 and 1984.

Analysis of the 1977 Pilbara survey was continued by B.J. Drummond at the ANU where he is completing a PhD on 'Proterozoic Sedimentary Basin Formation' under a Public Service Board Scholarship. Drummond presented his preliminary findings at the International Archaean Symposium held in Perth in August 1980.

Gravimetry

In the Regional Gravity group, systematic checking of gravity data in 1:250 000 Sheet areas continued, and data for the 1:1 million sheets Hamersley Range, Meekatharra, Melbourne, Sydney, and Canberra were finalised. Computer programs were modified to incorporate automatic drawing of map legends, and map production is expected to start in 1981.

The upsurge of exploration activity during the year put an added strain on facilities by causing a large increase in the number of data requests. During 1980, requests were running at over one per week and, as they are usually non-standard, they are time consuming to deal with.

Between 30 January and 1 April, measurements were made at Isogal stations throughout the Australian continent using seven La Coste and Romberg gravity meters. The observers were P. Wellman and J. Williams of BMR, and M. Untung of the Geological Survey of Indonesia. Air ties were made using 165 hours of flying with a chartered aircraft, and two permanent stations were established or reobserved at 56 airports. Values were established for these stations accurate to 0.2 to 0.3 $\mu m.s^{-2}$. During the Isogal strengthening survey, the gravity intervals were more accurately determined on seven gravity meter calibration ranges and the airport stations were tied to five absolute gravity sites by more accurate ties.

A study was undertaken by P. Wellman on geodetic strain measurements in each state by analysing repeat measurements of angles made during the original surveys in the 1890's and within the last ten years.

A co-operative program was prepared for geodetic and gravity measurements in the South West Seismic Zone, and a gravity survey along benchmarks near Cadoux was carried out in October/November.

A team of gravity observers from Japan, headed by Dr Nakagawa, measured gravity with 7 gravity meters at Sydney, Townsville, Port Moresby, and Hobart during September and October 1980.

G. Karner left in January 1980 for a two-year spell at Lamont-Doherty Geological Observatory, where he is undertaking a Ph.D study on 'The rheological and mechanical properties of the continental and oceanic lithospheres as applied to the formation of sedimentary basins'.

The contract recomputation of gravity data should be completed during 1981; as a result of this work, which has extended over several years, the principal facts from over 200 000 new gravity stations were added to the data file and are now in computer-compatible format.

Geothermal program

The geothermal program continued during 1980 with the analysis of data collected during 1979, and J.P. Cull spent three months in France visiting the Bureau de Recherches Geologiques et Minières (BRGM) at Orleans. A second conductivity bridge was constructed to double the speed of measuring thermal conductivities.

Magnetotellurics

Magnetotelluric field work was completed in the McArthur Basin, where 17 sites were occupied across the Batten Trough during October/November 1979, and a 2D model over the Emu Fault was determined. In September/October 1980, 12 sites in the central Eromanga Basin were occupied along the same profile as that shot by the seismic refraction survey. In the McArthur Basin, the results are complicated, with obvious anisotropy at shallow depth to the west of the Emu Fault, but the data are comparatively simple in the Eromanga Basin, with resistivity contrasts at the base of the economic (for hydrocarbons) sediments and at the base of the Lithosphere(?).

Palaeomagnetism and rock measurements

The palaeomagnetic samples were collected in southeast Queensland in August 1980 (123 samples), and Tarago/Braidwood in November 1979 and August 1980 (270 samples) for studies on Cainozoic weathered profiles. Analysis of these results has continued throughout the year and weathering events from mid-Oligocene onwards have been identified.

J. Giddings visited the Vogelkop region of Irian Jaya during November 1979 and collected 350 oriented drillcore samples from sedimentary sequences spanning a time range from early Mesozoic to mid-Tertiary. An Indonesian geologist returned with him to BMR for a four-month stay to work on the samples. Advice was provided to the Indonesian Geological Survey on palaeomagnetic facilities required to set up a laboratory in Bandung, and tender specifications were prepared.

With the help of the ADP Section, work continued on the development of the palaeomagnetic data reduction system for the Black Mountain Palaeomagnetic Laboratory.

The work on the SA stranded beach dune sequence was completed, and the results, which confirm the Milankovitch theory of ice ages during the Quaternary, were published in Nature.

1. METALLIFEROUS AND AIRBORNE SECTION

(G.A. Young)

The Section comprises two Subsections: Metalliferous, and Airborne. The Metalliferous Subsection is principally concerned with providing geophysical support to multi-disciplinary studies of mineral provinces, and research into the development and application of improved ground geophysical methods to assist mineral exploration. The Airborne Subsection is principally concerned with providing basic airborne geophysical data coverage of the continent at a regional scale. These data, published in the form of maps and interpretative reports, are seen as an essential component of background information required to assist mineral exploration and for the assessment of mineral potential.

METALLIFEROUS SUBSECTION (D. Stuart, J. Gardener)

Staff losses severely restricted the nature and amount of work undertaken by the Subsection during 1980. Staff have been primarily engaged in completing projects which commenced in 1979 but remained unfinished owing to the loss of staff. The backlog of reporting and data analyses has now been substantially overcome and some new projects commenced in the latter part of the year.

As in 1979, many of the subsection staff were engaged in studies of the geophysical characteristics of the Lachlan Fold Belt and its mineral deposits in NSW. Other projects underway during the year were regional studies of the Mount Isa Block and Pine Creek Geosyncline, and methodological research into the use of magnetic, electrical, and nuclear methods in mineral exploration and regional geological studies.

Lachlan Fold Belt geophysics (Project coordinator - D. Stuart)

Owing to staff shortages, the original objectives of this project have been scaled down. No additional work is planned in the mineral deposit geophysics and mineralised domain sub-projects, and the regional work has been restricted to a study of the Fold Belt in NSW.

During 1980 work concentrated on the processing, interpretation, and reporting of the extensive program of field work undertaken during 1979. A small amount of new field work was undertaken to resolve better some of the gravity features of the region.

Regional airborne geophysical surveys (B. Wyatt)

Airborne magnetic and radiometric data from the 1979 surveys of DUBBO, NYNGAN, and GILGANDRA were processed during 1980 and the maps produced were released publicly as they became available. A review of the results of the data from these sheet areas is included in the summary of activities of the Airborne Subsection.

Geophysical transects (B. Wyatt, V. Carberry, H. Reith)

Work continued on the interpretation of magnetic, radiometric, and gravity data along transects at 31°32'S, 34°31'S, and 35°5.3'S. As described in the 1979 Annual Summary of Activities, each of these transects was covered by multiple height airborne magnetic and radiometric surveys in 1979. During 1980, gravity surveys were made along selected sections of these transects to provide better information on the source of regional gravity gradients within the Fold Belt, and the airborne transect data were processed and plotted in a variety of forms. The gravity surveys comprised 250 km of traverses at 500 m station spacing, and all data are being added to the Australian National Gravity Repository. A comparison of geology, magnetic, gravity, and radiometric data along 35°5.3'S is shown in Figure MA-2 and highlights three geophysical domains. In domain 1, the strong magnetic and radiometric response reflects the abundance of igneous rocks (granitoids, ignimbrite), andesite, basalt, dolerite, gabbro, and ultrabasic rocks emplaced under shallow marine or terrestrial conditions. In domain 2, a reduction in magnetic response reflects the lessening of volcanic rises and the deeper marine environments involved. The gravity lows are associated with belts of granitoids but appear to be due more to crustal thickening than to the low density of the granitoids. In domain 3, the smooth magnetic and gravity response indicates the transition from rocks of the Lachlan Fold Belt to the flat-lying sediments of the Darling Basin.

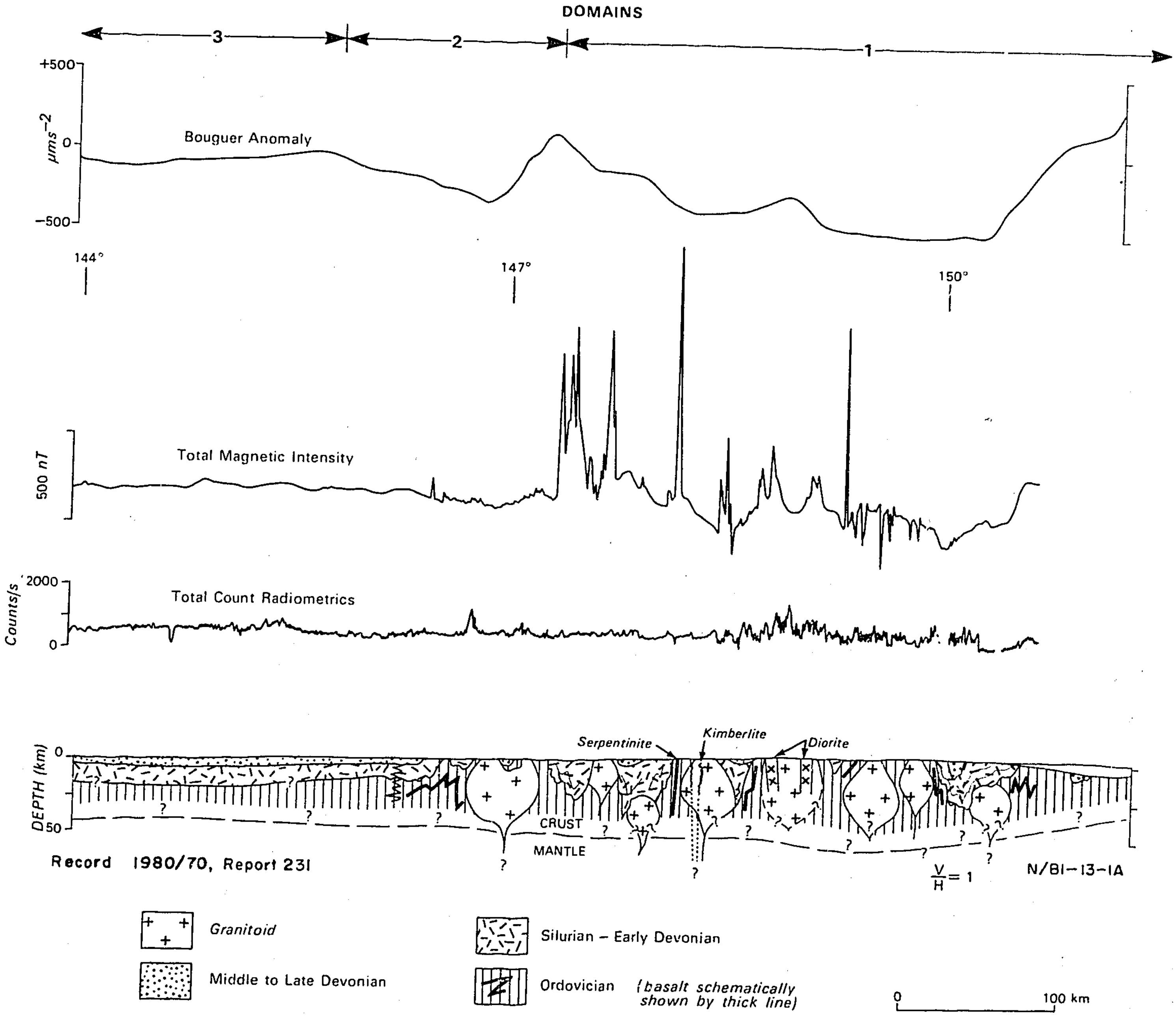


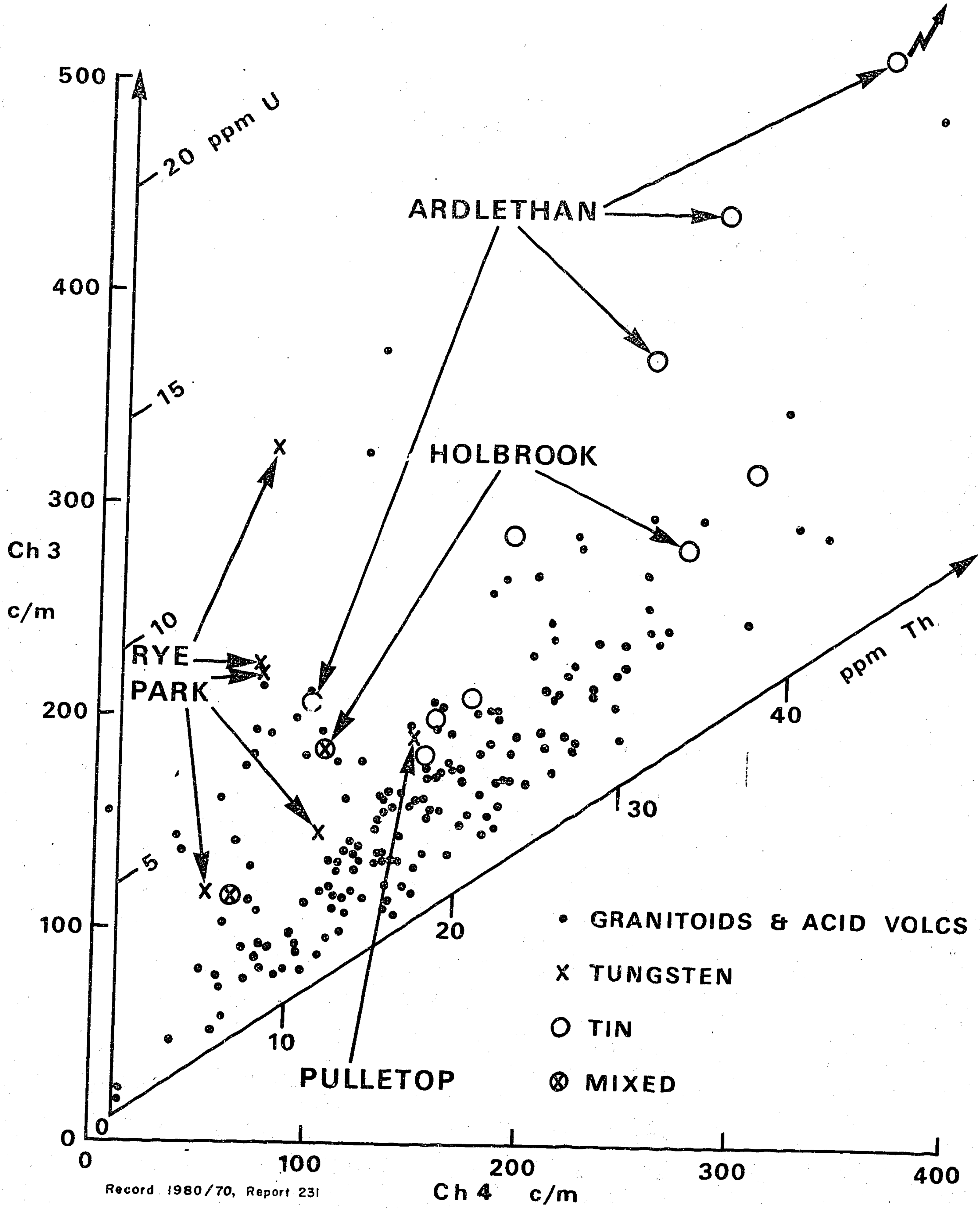
Fig MA2 . Comparison of geophysical and geological data along transect 35° 5·3' S

Rock property data base (A. Yeates, B. Wyatt, V. Carberry, H. Reith)

To assist in understanding the source of regional magnetic, radiometric, and gravity features in the Fold Belt, the physical, geochemical, and geological characteristics of the major Palaeozoic rock groups and outcropping sources of geophysical anomalies are being documented through a program of field observations and laboratory measurements. Most of the field work for this study was completed during 1979 when a program of geophysical surveys, geological observation, and rock sampling was undertaken at approximately 1000 sites. During 1980, work has concentrated on completing laboratory analyses and compiling a computer data base for storing and sorting the information pertaining to the sample sites. The data base contains information on site location, topography, geology, structure, in situ magnetic susceptibility, and four-channel gamma-ray spectrometry. These data are being supplemented by laboratory measurements of density, porosity, and magnetic remanence, and petrological descriptions. Some major and trace element geochemistry data are being provided through a cooperative project with the Bundesanstalt fur Geowissenschaften und Rohstoffe (West German Federal Geological Survey). It is anticipated that the data base will be completed by the end of 1980.

Gamma-ray spectrometry, and the recognition of granites prospective for tin and tungsten mineralisation (A. Yeates, B. Wyatt)

An analysis of gamma-ray spectrometer results recorded over granitoids in the Lachlan Fold Belt suggests an empirical relation between the spectral signature (or radioelement concentration) of granitoids and their prospectiveness for hosting tin and tungsten deposits. The results of this analysis are shown in Figure MA-3 and suggest that granitoids hosting Sn mineralisation are characterised by high U and variable Th values. Granitoids hosting W mineralisation appear also to have a high U concentration but apparently a low Th concentration. These results are probably consistent with the behaviour of U, Th, Sn, and W during the magmatic fractionation of granitoids. Owing to the large atomic size of U, Th, Sn, and W, they are excluded from the lattices of common rock-forming minerals during early crystallisation. Consequently, late-stage granitoid melts become progressively enriched in these elements. Further investigations of the relation between the radioelement concentration of granitoids and their potential for hosting Sn and W mineralisation will be



MA 3. Analyses of gamma-ray spectrometer results recorded over granitoids of the Lachlan Fold Belt

undertaken in late 1980. Work to be undertaken will include detailed high-sensitivity airborne gamma-ray spectrometer surveys of selected granites and trace element geochemical analyses of rock samples.

Source of semi-regional magnetic anomalies in the Cobar Trough (I. Hone, P. Gidley, R. Curtis-Nuthall)

The source of the 'magnetic ridge', which is a 50 km long north-northwest trending, low amplitude, positive magnetic anomaly passing through Cobar, was investigated by laboratory analyses of core samples and modelling. The core samples were obtained from drilling by BMR during 1979, and the modelling was based on the results of BMR carborne and airborne magnetic surveys conducted during 1978 and 1979. Laboratory work included magnetic susceptibility, remanence, density, porosity, resistivity, induced polarisation, and petrological, mineralogical, and chemical analyses. The results of this work indicate that the source of the magnetic ridge is a tabular-shaped body about 95 m deep, about 200 m thick, and with an apparent susceptibility of $4{,}000 \times 10^{-6}$ SI. Physical property measurements indicate that over 85 percent of the magnetisation is the result of remanence parallel to the earth's present field. The source of the magnetic ridge appears to be stratigraphically controlled, and due to the presence of pyrrhotite. A report on the results of this work has been completed and should be released early in 1981.

Geophysical characteristics of the Elura deposit (I. Hone, B. Spies, P. Gidley)

A series of papers dealing with the magnetic, EM, electrical, and gravimetric response and physical characteristics of the Elura deposit has been prepared for inclusion in a special edition of the Bulletin of the Australian Society of Exploration Geophysicists. These papers are based on the results of airborne, surface, downhole, and laboratory geophysical investigations undertaken by BMR during 1978 and 1979.

Downhole resistivity logging (Fig. MA-4) shows that at Elura the resistivities of intensely weathered country rocks, comprising shales, sandstones, and siltstones, just below the watertable are less than 30 ohm-m and in some instances as low as 1 ohm-m. Resistivities increase with depth as rocks become less weathered; at 200 m, resistivities of approximately 2000 ohm-m were recorded. Induced polarisation (IP) logging (Fig. MA-4) indicates that the chargeability of country rock is approximately 10 mV/V just below the water-

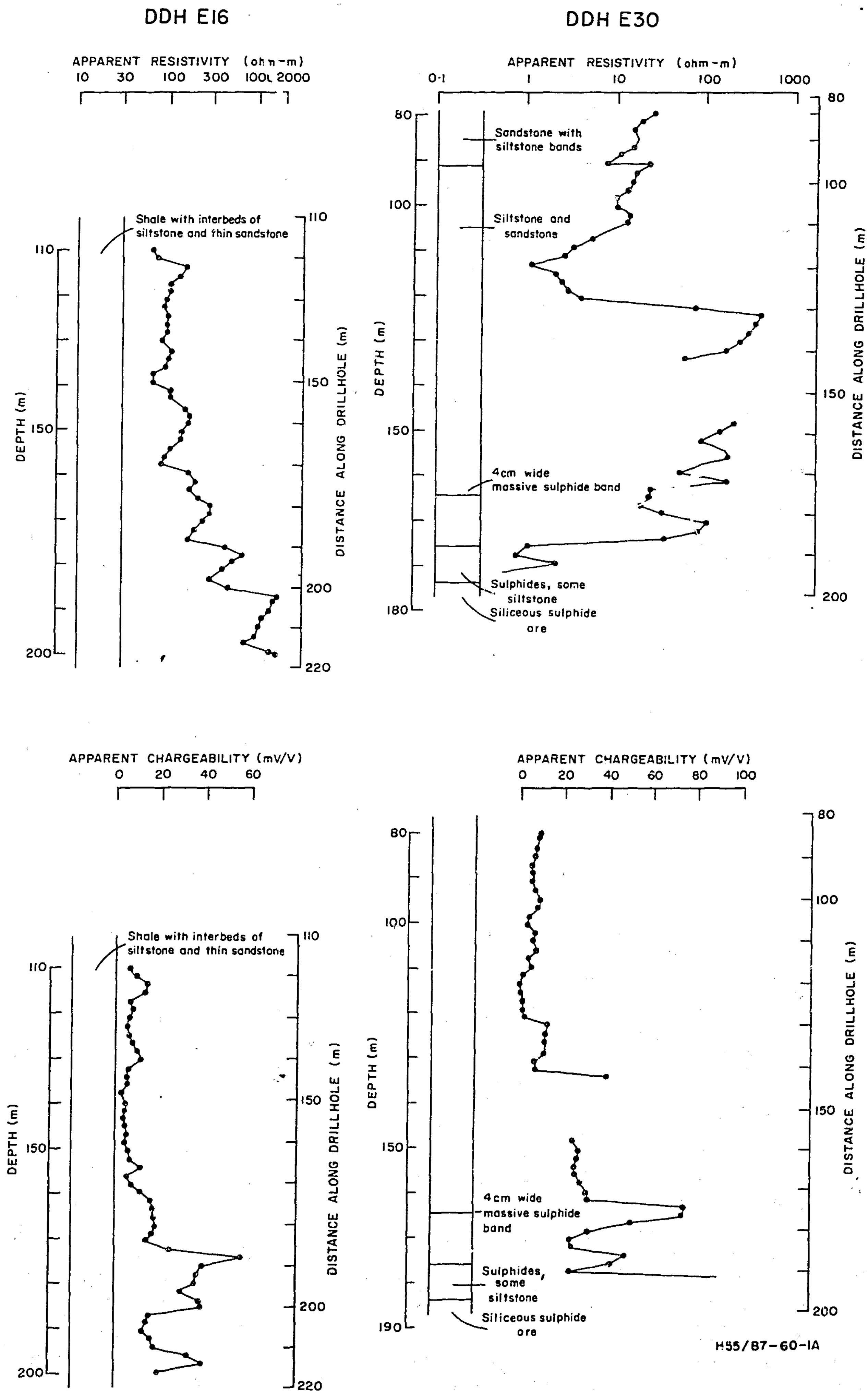


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Fig MA 4 IP and Resistivity logs of drill holes at Elura

table and increases to approximately 20 mV/V at 200 m depth. Laboratory measurements and results of logging indicate that the mineralisation has a resistivity of about 0.2 ohm-m, and a very high chargeability.

Airborne, ground, carborne, and downhole magnetic surveys and laboratory magnetic measurements on core samples show that the magnetic anomaly at Elura is caused mainly by a remanently-magnetised, pyrrhotitic zone within the Elura deposit (Table MA-1). However, near-surface magnetic sources contribute to the anomaly at low altitudes.

TABLE MA-1 Magnetic properties of core samples from Elura

ROCK UNIT	MAGNETIC SUSCEPTIBILITIES $K \times 10^{-6}$ SI UNITS* (CGS) UNITS			KOENIGSBERGER RATIO (Q)		
	SAMPLES	RANGE	MODE	SAMPLES	RANGE	MODE
Weathered Country Rock	11	2-480 (0-38)	300 (25)	3	0.05-0.5	0.1
Unweathered Country Rock	5	5-500 (04-40)	400 (32)	3	0.05-0.5	0.1
Gossan	28	301-1580 (24-120)	710 (57)	5	2.8- 4.5	3.1
Siliceous zone	6	340-414 (27-33)	378 (30)	3	0.1	0.1
Pyritic zone	8	527-791 (42-63)	649 (50)	3	0.05	0.05
Pyrrhotitic zone	22	28800-47300 (2290-3760)	37800 (3007)	6	2.09-76	4.1

* To calculate K(magnetic susceptibility) in cgs units, divide SI values by 4π.

Extensive coincident-loop TEM surveys by BMR indicate an anomaly at Elura of approximately twice background at times greater than 2 ms (Fig. MA-5). At early times the response is due almost entirely to overburden effects. The most promising method of TEM interpretation in this area appears to be the analysis of the time constant of the decay.

Characteristics of near-surface magnetic sources in the Cobar area (P. Gidley, V. Carberry)

A study of the characteristics of near-surface magnetic sources was commenced in 1979 and completed in 1980. A report on this investigation has been finalised and should be published early in 1981. During the study, three areas known to have prominent aeromagnetic anomalies but noisy ground magnetic responses were investigated by drilling and laboratory analyses, which show the near-surface magnetic materials to be a combination of the minerals maghemite and hematite. As shown in Figure MA-6, the distribution and physical properties of these mineral concentrations vary rapidly both laterally and vertically, and the surface magnetic minerals occur in layers only a few metres thick. Magnetic anomalies produced by this material are the result of two effects. Firstly, that due to the surface magnetic minerals which have high susceptibilities up to $250\ 000 \times 10^{-6}$ SI and, secondly, that due to their high remanence which is reflected in Koenigsberger ratios up to 92. Orientated measurements on material collected from surface magnetic sources suggest the remanent component is parallel to the Earth's present field.

Discrimination of surficial and bedrock magnetic sources in the Cobar area (P. Gidley)

A study of methods to discriminate between surface and bedrock magnetic sources in the Cobar area was commenced in 1978 and completed in 1980. A report on this investigation has been completed and will be published in early 1981. This work shows that the spectral signatures for most bedrock and near-surface sources are sufficiently different for spectral analysis techniques to separate the effects of bedrock and surficial sources (Fig. MA-7). However, the effective use of spectral techniques to discriminate between bedrock and near-surface sources requires the acquisition of low level, high resolution magnetic data.

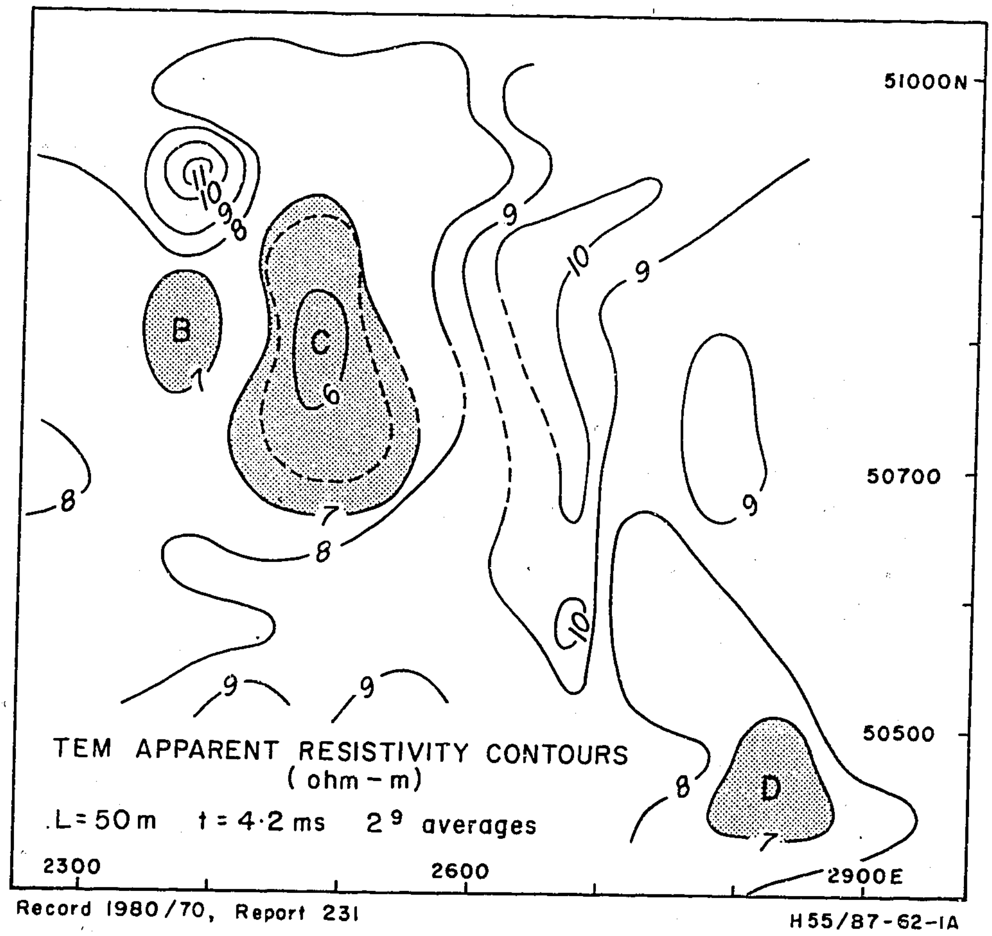

Fig MA 5 TEM response at Elura

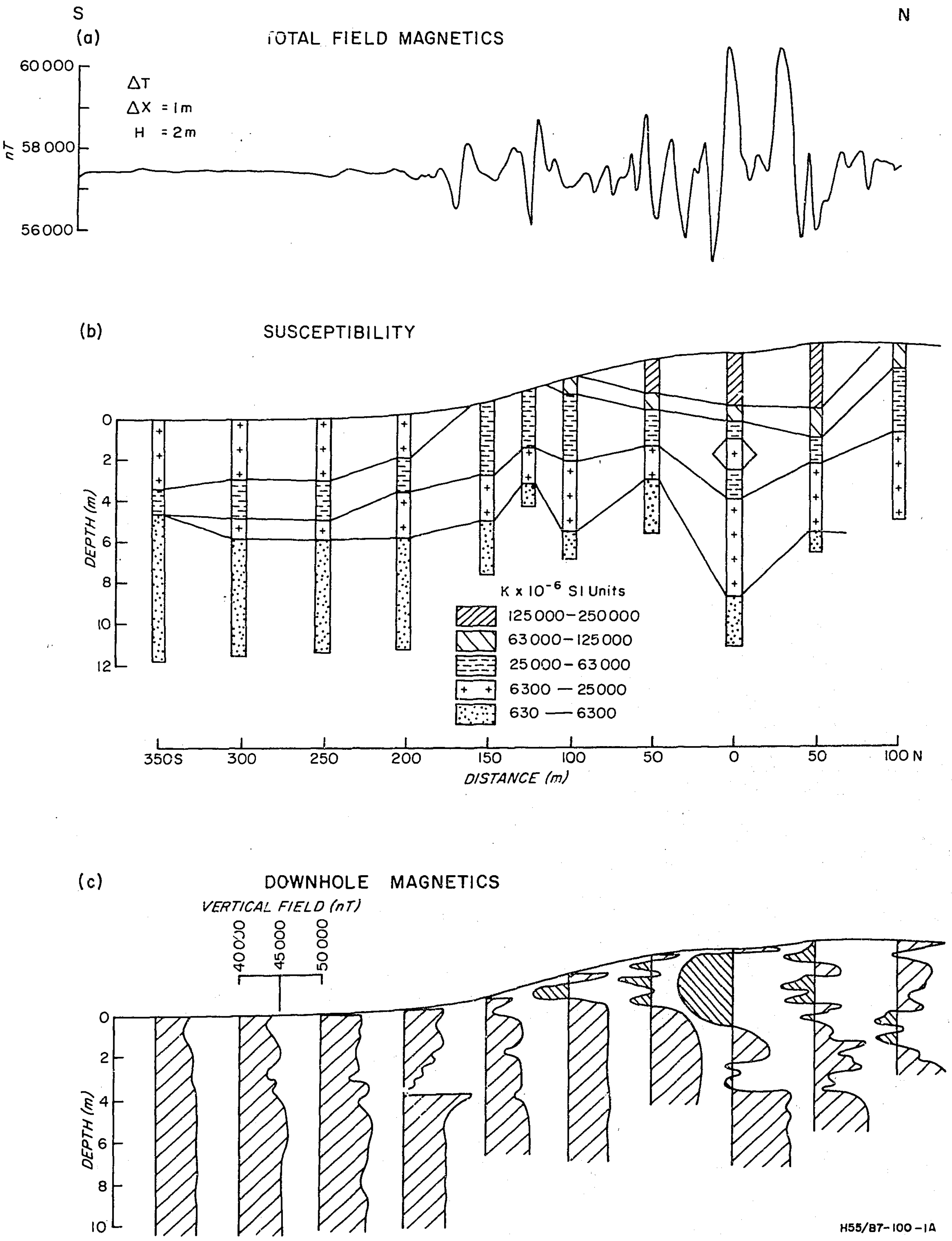

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Fig MA 6 Down-hole logs through a surface magnetic concentration in Cobar area

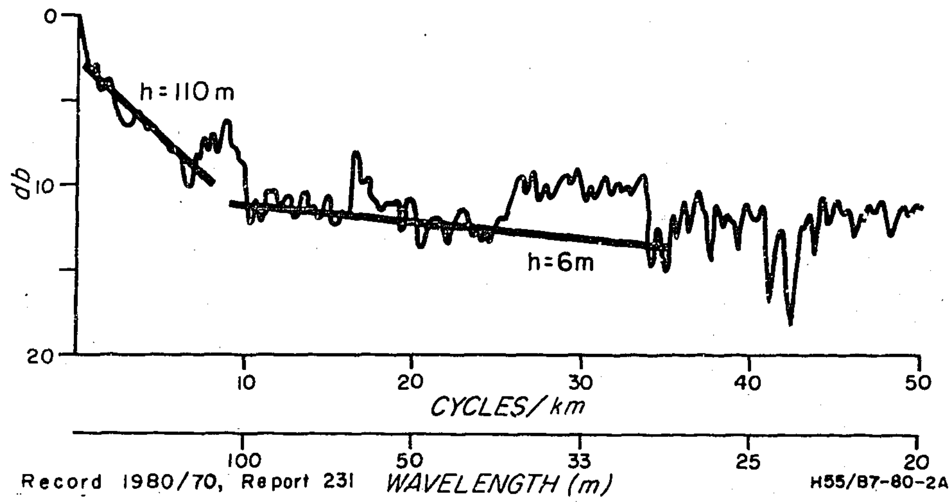


Fig MA 7 Spectral analysis of carborne magnetometer results, Elura deposit

Mount Isa Block geophysics (I. Hone, V. Carberry)

A regional overview of the geophysical characteristics of the Mount Isa Block commenced in August 1980 and will be concluded early in 1981. This work will provide a general guide to the principal geological factors controlling the magnetic, gravimetric, and radiometric response of the region. The work is intended to support a geological synthesis of the Mount Isa Block to be undertaken by the Geological Branch. Work has so far concentrated on the documentation and presentation of magnetic and gravity data, the correlation of geological and geophysical features, and the preparation of a limited physical property data base. Products produced to date include reprocessed gravity and second-derivative gravity maps at a scale of 1:1 000 000, compilation maps of aeromagnetic data, and a stratigraphic-geophysical response index.

Radioelement characteristics of the Koolpin Formation, Pine Creek Geosyncline (A. Mutton, A. Warnes)

A ground gamma-ray spectrometer study of the radioelement concentration of the Koolpin Formation was commenced in late 1979 and completed in early 1980. The results have been reported in BMR Record 1980/49. Typical results are shown in Figure MA-8, and indicate that thick units of massive ironstone and banded-iron formation within the Koolpin Formation are commonly enriched in uranium, and have uranium/thorium ratios of 0.4 or more. By comparison, neighbouring rocks have uranium/thorium ratios of less than 0.2. The iron-rich Koolpin Formation rocks are also characterised by a low potassium concentration. The results suggest that high-sensitivity airborne gamma-ray spectrometry can be used to map Koolpin Formation rocks on a regional scale, and to assist in the delineation of areas which are prospective for buried uranium mineralisation.

Central Eromanga Basin - electrical and magnetic methods (J. Major)

During 1980 a review of the application of EM, electrical, and ground magnetic methods in the multidisciplinary Central Eromanga Basin Project was commenced. It was anticipated that high resolution ground magnetics might locate surface concentrations of magnetic minerals which could be associated with structural traps and/or hydrocarbon emanators. Similarly, it was intended to investigate the use of high sensitivity EM/electrical methods to study the structure and accumulation of hydrocarbons in the Eromanga Basin; such methods having reportedly been successfully used for oil prospecting work

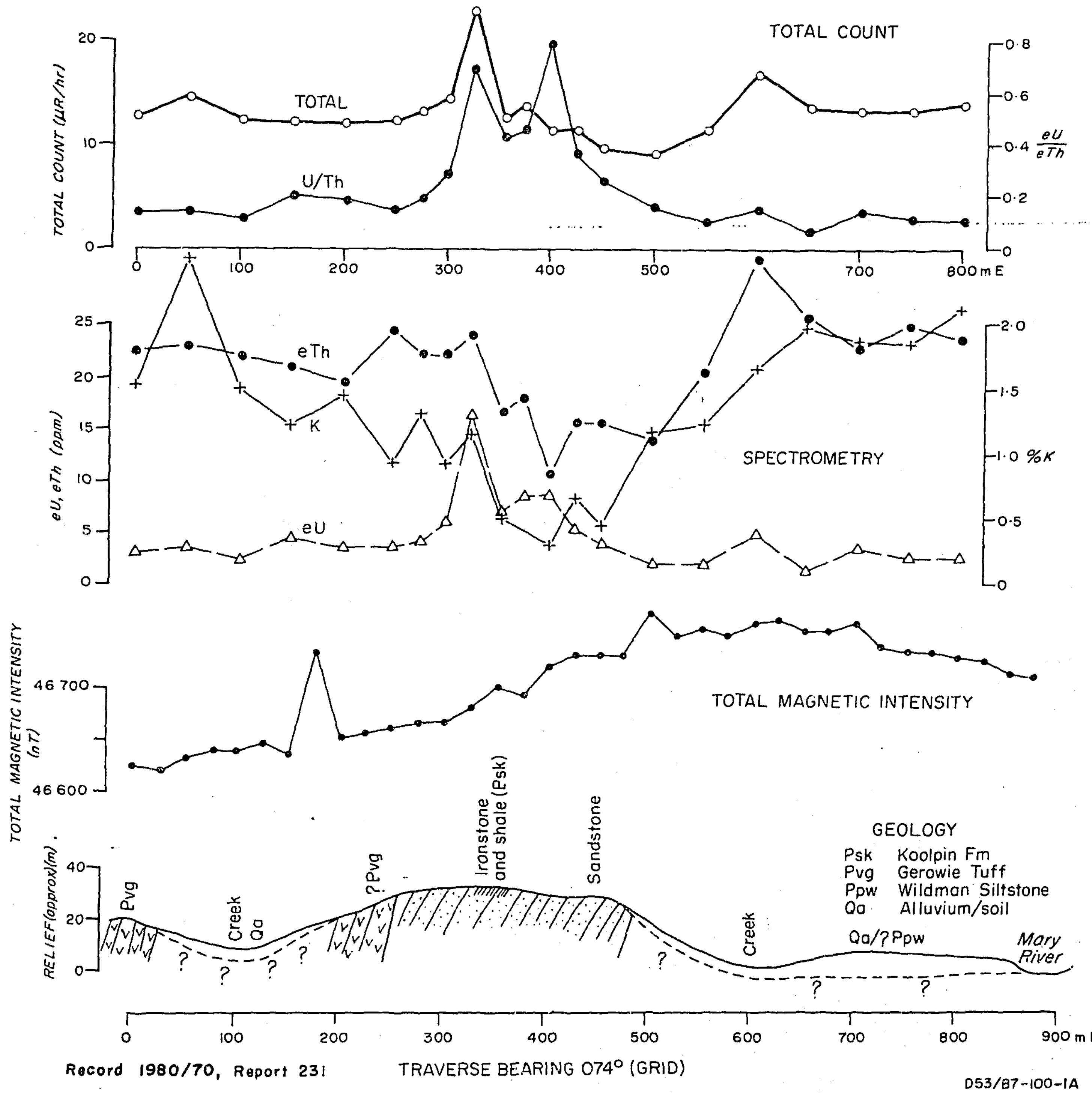


Fig MA 8 Radioelement characteristics of rocks in the Annaburroo area NT in USA and USSR. However, owing to the lack of manpower and suitable equipment, no field work was possible and the study was restricted to establishing geoelectric sections from well logs, resistivity modelling of these sections, and the design and construction of a boom for the BMR carborne magnetometer system. The well logs show the section to have a resistivity of less than 3 ohm-m through most of the Cretaceous sequence (approximately 1 km). The resistivity of the underlying Jurassic rocks is higher than that of the Cretaceous section and includes a sharp increase in resistivity at approximately 1700 m. Resistivity modelling based on this information indicates that the method has a low sensitivity to changes in the geoelectric section which might be associated with structure or hydrocarbon accumulations, and there are severe problems with EM coupling and logistics. Accordingly, deep resistivity soundings are not an effective means of investigating the geology of the basin. A further discussion of this work is included in the Central Eromanga Basin Project Annual Summary.

Nuclear methods research

Work continued on the analysis, interpretation, follow-up, and reporting of work undertaken in the Pine Creek Geosyncline during 1979.

Radon techniques (A. Warnes, A. Mutton)

Reports will be completed early in 1981 on the results of alphameter, emanometer, and surface and downhole gamma-spectrometer surveys at sites around Rum Jungle and at Austatom and Ranger 1. These results indicate that the majority of radon anomalies can be attributed to a concentration of daughter products within the surface soils and rocks. In such cases, detailed gamma-ray spectrometry is a more efficient and effective radioelement mapping technique than alpha-detection surveys. However, at least one case was found in which a strong radon anomaly was not associated with a surface or subsurface (approximately 20 m) concentration of gamma-emitting daughters. This anomaly suggests that under some circumstances radon anomalies might be a unique guide to buried uranium mineralisation. The experimental work with various radon detectors also highlighted the efficiency of emanometry if U/Th ratios rather than total-count data are plotted.

Downhole gamma-ray spectrometry (A. Warnes, A. Mutton)

The role of downhole gamma-ray spectrometry in reconnaissance exploration was investigated during a program of drilling and downhole and surface gamma-ray spectrometer surveys during 1979. The downhole spectrometer was a Geometrics GR-410A with a 7.6 cm x 3.5 cm detector, and holes were logged to a maximum depth of 36 m. The results of this work indicate that large stripping ratios and difficulties of maintaining energy calibration preclude the use of downhole spectrometry in areas of low radioelement concentration. Owing to the high U/Th ratios of uranium deposits in the Pine Creek Geosyncline, there is no advantage in spectrometric logging of ore grade intersections. The most important result of this work was the observation that the radioelement concentrations of surface rocks in the Pine Creek Geosyncline are frequently representative of the radioelement concentrations in underlying bedrock. Reporting on this work is still in progress.

Electrical methods research, USSR/Australian science agreement (B. Spies)

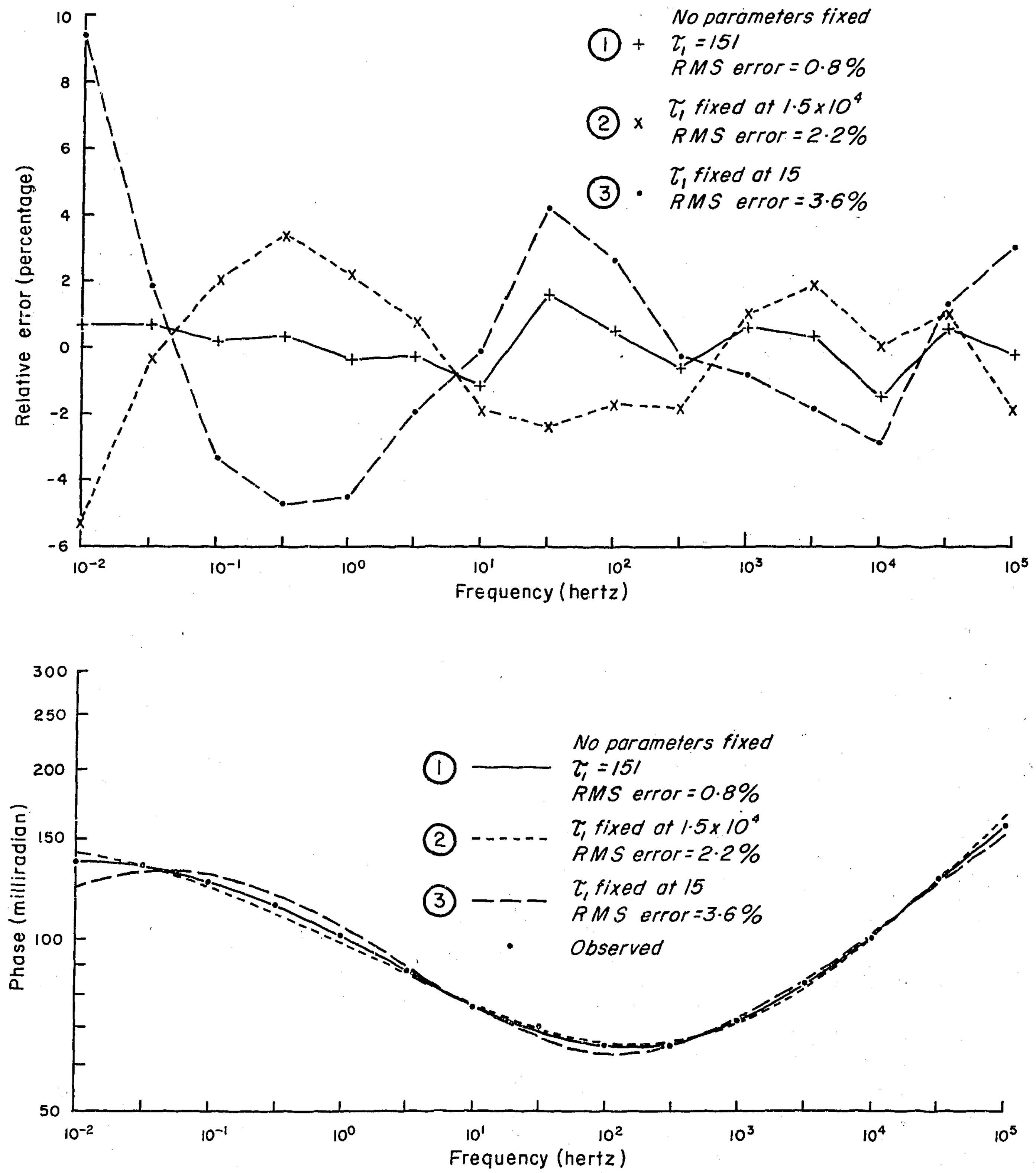
A comprehensive report was prepared on Mr Spies' visit, from 14 September 1979 to 2 November 1979, to geoscientific institutions in the USSR. The objective of the visit was to review the application and interpretation of electromagnetic and electrical geophysical methods in the USSR. Visits were made to a total of 9 institutions, including various institutes of the Ministry of Geology and the Academy of Sciences of the USSR at Moscow, Novosibirsk, and Leningrad. The result of this visit highlights the wide use of EM and electrical geophysics in all aspects of geological study and prospecting in the USSR. EM and electrical methods (magneto-telluric, transient EM, and induced polarisation) are widely used to investigate sedimentary basins and to search for oil. Airborne (helicopter and fixed wing) and carborne EM systems are widely used for exploration and geological mapping in the western plains of the USSR. Routine, detailed airborne EM mapping of selected areas is in progress. Downhole electrical geophysical methods are well advanced and are used in a wide variety of modes to determine the geometry and electrical/chemical properties of mineral deposits, and to extend the exploration effectiveness of drillholes. A substantial program of research and development of new methods and interpretation techniques is underway in most institutions and includes the development of very high power transmitters, SQUID detectors, and sophisticated 2D and 3D modelling techniques. Also under development or in use are techniques for piezoelectric prospecting and a variety of electrochemical probes and survey techniques.

Downhole EM investigations (R. Cobcroft, I. Hone, J. Major)

The application of downhole EM methods in exploration and physical property logging was further investigated during 1980. Work included a program of downhole TEM modelling using the Macquarie University facility (temporarily at BMR), and experimental surveys with the SIROTEM downhole probe (in conjunction with CSIRO) and the BMR developed omni-directional downhole probe. Tests with the SIROTEM probe, and the results of downhole modelling at Elura indicate that coupling relations between the surface loop, overburden, conductive target, and probe are complex and may result in positive or negative effects. Analyses of the SIROTEM results from Elura will be published in a special edition of the Bulletin of the Australian Society of Exploration Geophysicists, and show that Elura might be detected at distances up to 200 m with a downhole TEM probe and 100 m x 100 m transmitting loop located over the deposit. Tests with the omni-directional probe and surface transmitter loop are still in progress. However, plotting of omni-directional probe results from the Peelwood area of NSW as major and minor axes of the polarisation ellipse indicates increased sensitivity to conductive zones compared with the axial component measurements. The potential advantage of the omni-directional probe is to minimize the effects of probe-source geometry (rather like TEM), retain the advantages of high noise rejection implicit in FEM, and assist in interpretation. Owing to manpower shortages it is intended to discontinue the omni-directional probe investigations at the end of 1980.

Complex resistivity investigations (J. Major)

An investigation of the application of the Cole-Cole dispersion model for the interpretation of complex resistivity data was completed and a report by J.A. Major, and J. Silic (no longer with BMR) on the work has been accepted for publication in the journal Geophysics. The results show that the interaction between the induced polarisation and inductive coupling effects will in general be more complicated than a multiplication of two Cole-Cole dispersions representing these effects separately. The inversion of published data (Fig. MA-9) shows that the time constant (τ) of the IP effect is often a poorly



①	②	③
R = 100	R = 100	R = 100
τ_1 = 151	τ_1 fixed at $1{\cdot}5\times10^4$	τ_1 fixed at 15
c_1 = 0·273	c_1 = 0·218	c_1 = 0·345
m_1 = 0·719	m_1 = 0·848	m_1 = 0·609
τ_2 = $1{\cdot}4\times10^{-}$	τ_2 = $1{\cdot}11\times10^{-7}$	τ_2 = $1{\cdot}88\times10^{-7}$
c_2 = 0·305	c_2 = 0·336	c_2 = 0·270

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Fig MA 9 Comparison of modelled and observed complex resistivity data

defined parameter. Hence, small changes in the parameters used to approximate inductive coupling by a Cole-Cole dispersion can produce very large changes in the calculated value of τ and so lead to ambiguity as to the mineralogy of the IP source.

TEM modelling (B. Spies)

A program of model studies based on simplified representations of Elura and Roxby Downs mineral deposits was completed and documented. The results of the Elura deposit modelling have been generalised to represent any pipe-like conductor (Fig. MA-10). For this model the response of the deposit is masked by the response of the overburden for early times for both one and two-loop TEM geometries. At late times the response of the deposit in both systems is two to three times background (Spies, 1980). Generalised modelling of the response of a tabular body representing a rough analogue of the Roxby Downs deposit shows that the detectability of a target with this geometry depends to a large extent on the size of the deposit and the conductivity contrast between the deposit and host rock. A large body, of size 1500 m by 300 m and 150 m thick, can be detected at a depth of 350 m if the conductivity contrast between the body and the host is over 50. A deposit with dimensions of 900 m by 180 m and 90 m thick requires a conductivity contrast of 1000 to be detected at the same depth. The tabular model study results will be reported in the Bulletin of the Australian Society of Exploration Geophysicists.

TEM response and viscous magnetisation (B. Spies, M. Gamlen, W. Burhop)

Following studies by CSIRO which indicated that the effects of viscous magnetisation in surface soils resulted in erroneous EM measurements at late times/low signal levels with the coincident and single loop configurations, BMR conducted tests at several localities in the Cobar area to investigate and quantify the effects reported by CSIRO. The work undertaken involved the use of various loop configurations and two independent TEM instruments. The work confirmed the presence of a near-surface effect that is manifest as a "tail" decaying with a 1/t fall off (Fig. MA-11). The tail has a magnitude up to 1 μV/A per 100 m of cable, and is more likely to be a problem with small rather than large loops. In areas where a tail is recorded, it is necessary to separate the loops (e.g. an in-loop configuration) to enable quantitative interpretation of low signal levels.

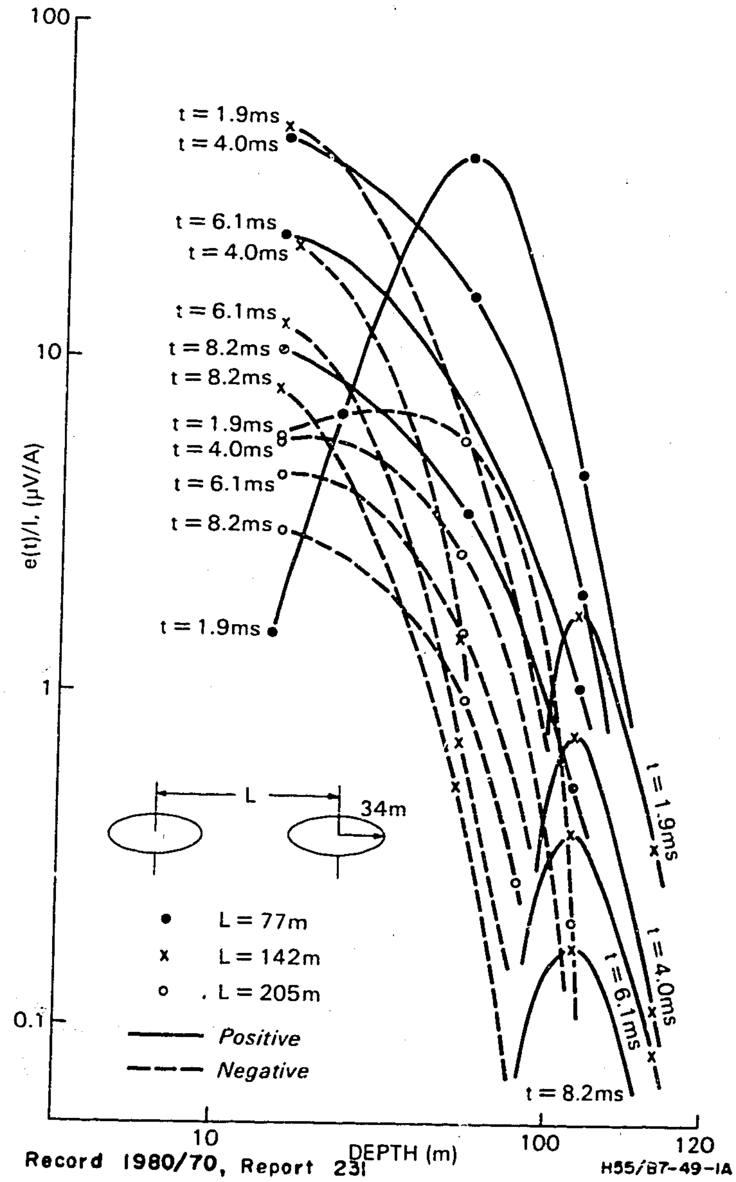


Fig MA 10 Two-loop TEM model response of the Elura deposit

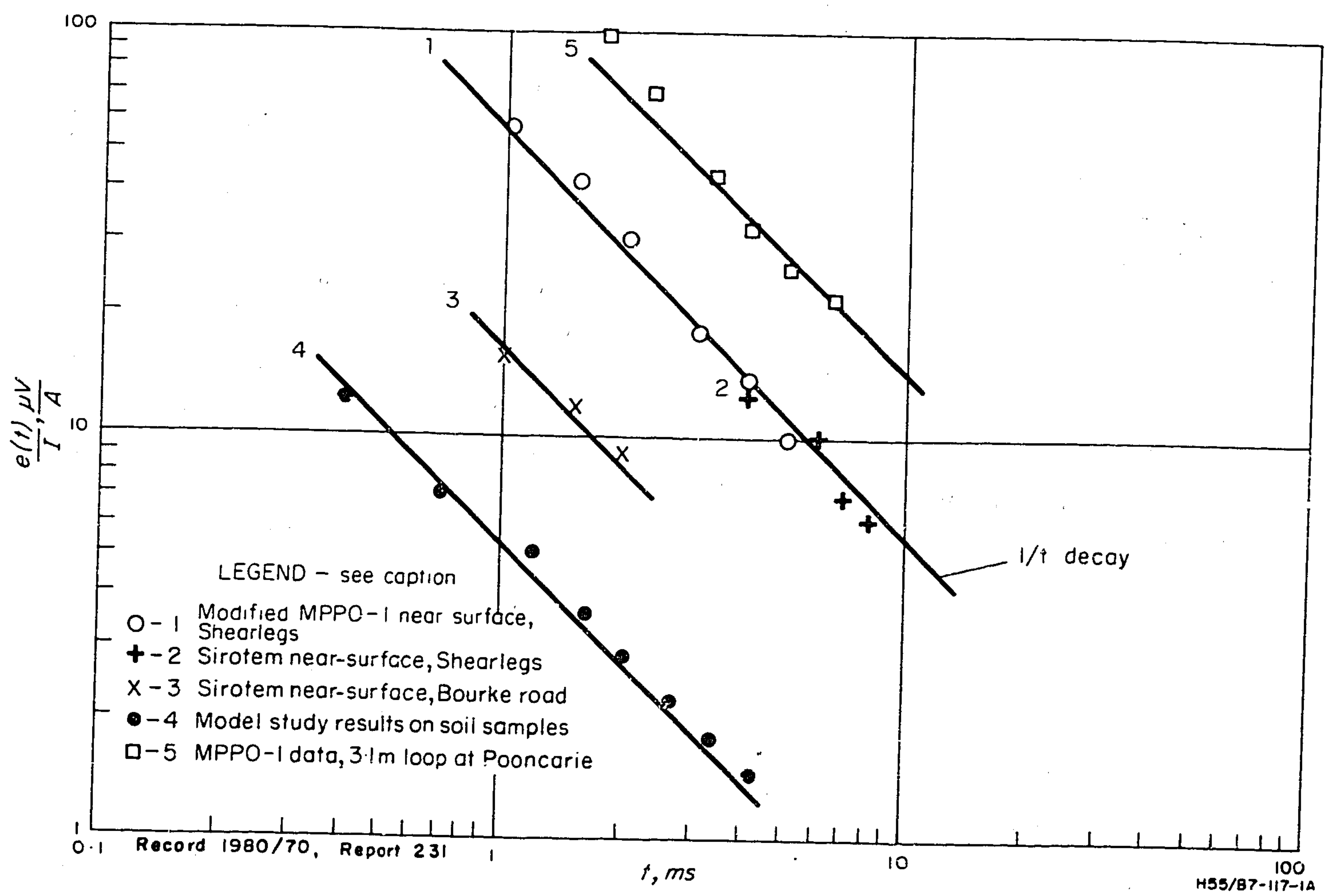


Fig MA 11 Decay characteristics of viscous magnetisation TEM response

Magnetic methods research - magnetometer systems development (R. Curtis-Nuthall, P. Gidley)

Work continued on plans to upgrade and develop BMR carborne, downhole, and vector magnetometer systems for use in BMR regional and detailed surveys. However, lack of manpower and resources restricted the amount of work done. Principal achievements were the construction of an aluminium boom and compensating coils for the carborne magnetometer, and the construction of a mounting and alignment system for the fluxgate vector magnetometer. Owing to staff shortages use of these systems was restricted to limited field tests. Work is continuing on the preparation of these systems for field work in 1981.

Modelling techniques (P. Gidley)

Work continued on the development and adaptation of modelling and data processing techniques to assist in the evaluation of regional and detailed geophysical data.

AIRBORNE SUBSECTION (R. Wells, C. Leary, J. Rees, J. Mulder)

During 1980 the Airborne Subsection flew approximately 78 000 line-km of survey traverses with the Twin Otter aircraft VH-BMG. The Bureau's other survey aircraft (Aero Commander VH-BMR) was not used for survey work during the year, however it was brought back into service in November to re-equip it for survey work scheduled to commence early in 1981. The Subsection's depleted staff were assigned primarily to data processing and minor review and interpretative projects.

A total of 84 maps was released (see Table MA-2).

Albany-Fraser Block airborne magnetic and radiometric survey, WA 1980
K. Horsfall, G. Green, S. Wilcox)

At the request of the Western Australian Geological Survey, an airborne magnetic and radiometric survey, totalling approximately 21 000 line-km, was flown over COLLIE, PEMBERTON (western one-third), and RAVENSTHORPE (northern half) (Figures MA-12 to MA-14) in a two month period commencing late January. The eastern two-thirds of PEMBERTON had been flown previously in 1977, and the remainder of RAVENSTHORPE will be flown in 1981.

AIRBORNE DATA PROCESSING/MAPPING/RELEASES

TABLE MA-2

R - MAPS AND DATA RELEASED
C - PROCESSING COMPLETED
S - DATA STOCKPILED
P - PROCESSING IN PROGRESS
TMI - TOTAL MAGNETIC INTENSITY
TC - TOTAL COUNT RADIOMETRIC

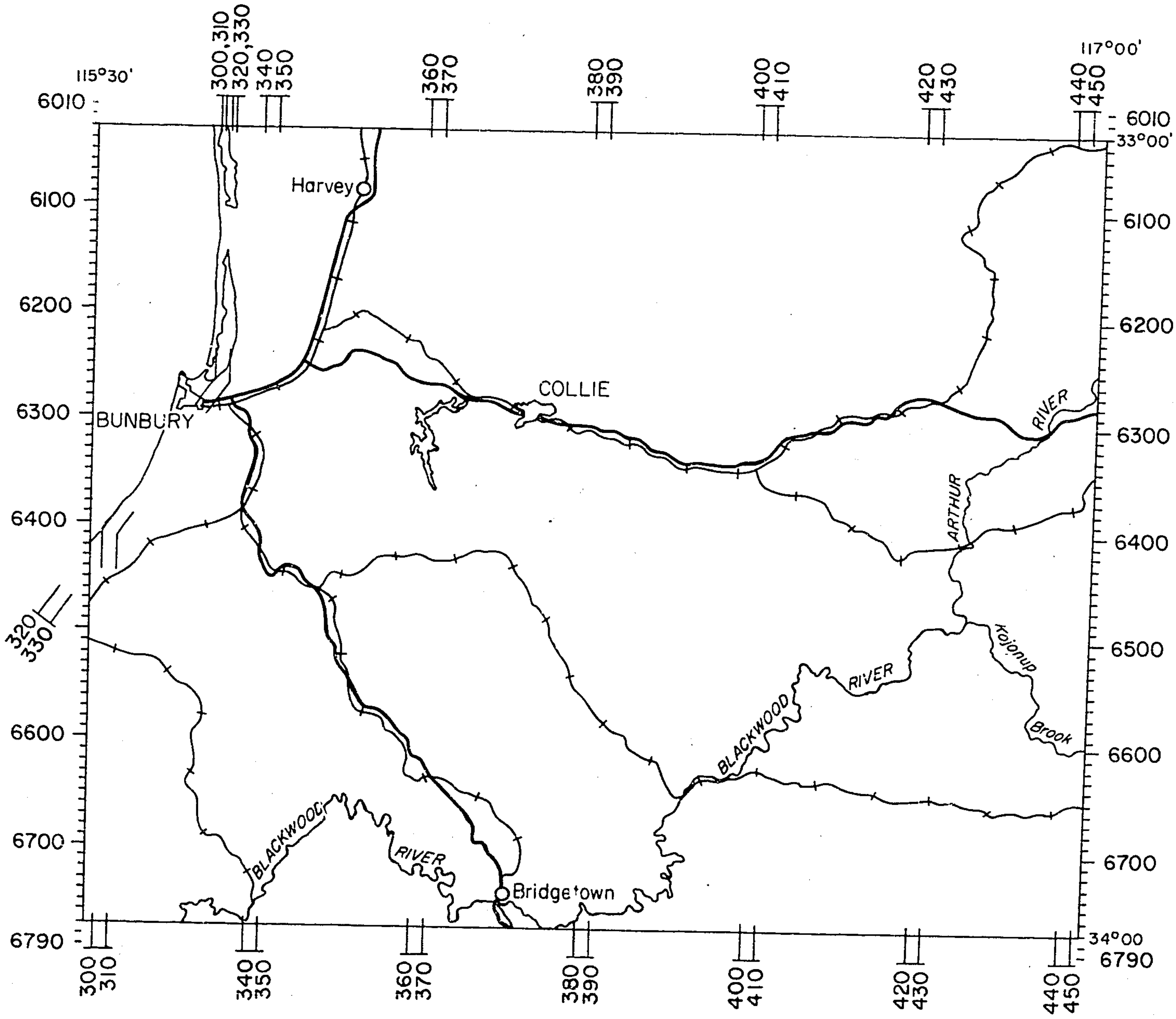
STATE	SHEETS	SURVEY CONFIGURATION				PROCESSING	MAPPING				COMMENT
		MAG	RAD	SPACING km	ALT m	DATA STATUS	SCALE	No. MAPS	CONTOURS	PROFILES	
NSW	GILGANDRA	X	X	1.5	150	R	1:250 000	1	T.M.I.		10 nT
	"					C	"	1	T.M.I.		50 nT
	"					C	"	1	T.C.		
	"					C	"	1		T.M.I.	
	"					C	"	5		RADIOMETRIC	
	"					C	"	1		FLIGHT PATH	
	DUBBO	X	X	1.5	150	R	1:250 000	1	T.M.I.		10 nT
	"					C	"	1	T.M.I.		50 nT
	"					R	"	1	T.C.		
	"					R	"	1		T.M.I.	
	"					R	"	5		RADIOMETRIC	
	"					R	"	1		FLIGHT PATH	
	"					R	"	3		RATIOS	
	NYNGAN	X	X	1.5	150	C	1:250 000	1	T.M.I.		10 nT
	"					C	"	1	T.M.I.		50 nT
	"					P	"	1	T.C.		
	"					P	"	1		T.M.I.	
	"					P	"	5		RADIOMETRIC	
	"					C	"	1		FLIGHT PATH	
	"					P	"	3		RATIOS	
	MENINDEE	X	X	1.5	150	S	1:250 000	-			
NSW/	MALLACOOTA	X		1.5	1650	C	1:250 000	1	T.M.I.		
Vic.	"					R	"	-		T.M.I.	1979*
	"					R	"	-		FLIGHT PATH	1979*
Vic.	HORSHAM	X	X	3.0	150	S	1:250 000	-			
NT	ROPER RIVER	X	X	3.0	150	R	1:250 000	1	T.M.I.		
	CAPE BEATRICE					R	"	1	T.C.		
	"					R	"	-		T.M.I.	1979*
	"					R	"	-		RADIOMETRIC	1979*
	"					R	"	-		FLIGHT PATH	1979*

Table MA-2 (continued)

STATE	SHEETS	SURVEY CONFIGURATION				PROCESSING		MAPPING			COMMENT
		MAG	RAD	SPACING km	ALT m	DATA STATUS	SCALE	No. MAPS	CONTOURS	PROFILES	
NT	MOUNT MARUMBA	X	X	3.0	150	R	1:250 000	1	T.M.I.		
						R	"	1	T.C.		
						R	"	1		T.M.I.	
						R	"	5		RADIOMETRIC	
						R	"	1		FLIGHT PATH	
	BLUE MUD BAY	X	X	3.0	150	R	1:250 000	1	T.M.I.		
	PORT LANGDON					R	"	1	T.C.		
						R	"	1		T.M.I.	
						R	"	5		RADIOMETRIC	
						R	"	1		FLIGHT PATH	
	MILINGIMBI	X	X	3.0	150	R	1:250 000	1	T.M.I.		
	JUNCTION BAY					R	"	1	T.C.		
						R	"	1	T.M.I.		
						R	"	5		RADIOMETRIC	
						R	"	1		FLIGHT PATH	
	ARNHEM BAY	X	X	3.0	150	R	1:250 000	1	T.M.I.		
	WESSEL ISLANDS					R	"	1	T.C.		
						R	"	1		T.M.I.	
						R	"	5		RADIOMETRIC	
						R	"	1		FLIGHT PATH	
	GOVE	X	X	3.0	150	R	1:250 000	1	T.M.I.		
	TRUANT ISLAND					R	"	1	T.C.		
						R	"	1		T.M.I.	
						R	"	5		RADIOMETRIC	
						R	"	1		FLIGHT PATH	
SA	NARACOORTE	X	X	1.5	150	P	1:250 000	-			
WA	PEMBERTON	X	X	1.5	150	P	1:250 000	-			
	COLLIE	X	X	1.5	150	S	1:250 000	-			
	GORDON DOWNS	X	X	1.5	150	S	1:250 000	-			
	BILLILUNA	X	X	1.5	150	S	"	-			
	LUCAS	X	X	1.5	150	S	"	-			
	STANSMORE	X	X	1.5	150	S	"	-			

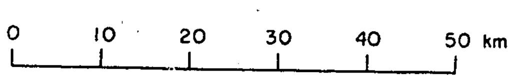
1979* Information relating to these maps released at the end of 1979 is included in the 1979 Geophysical Branch Summary of Activities.

MA-12

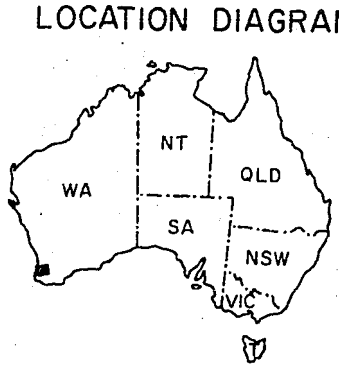


AIRBORNE SURVEY COLLIE, WA, 1980

LOCALITY MAP
AND
FLIGHT LINE SYSTEM

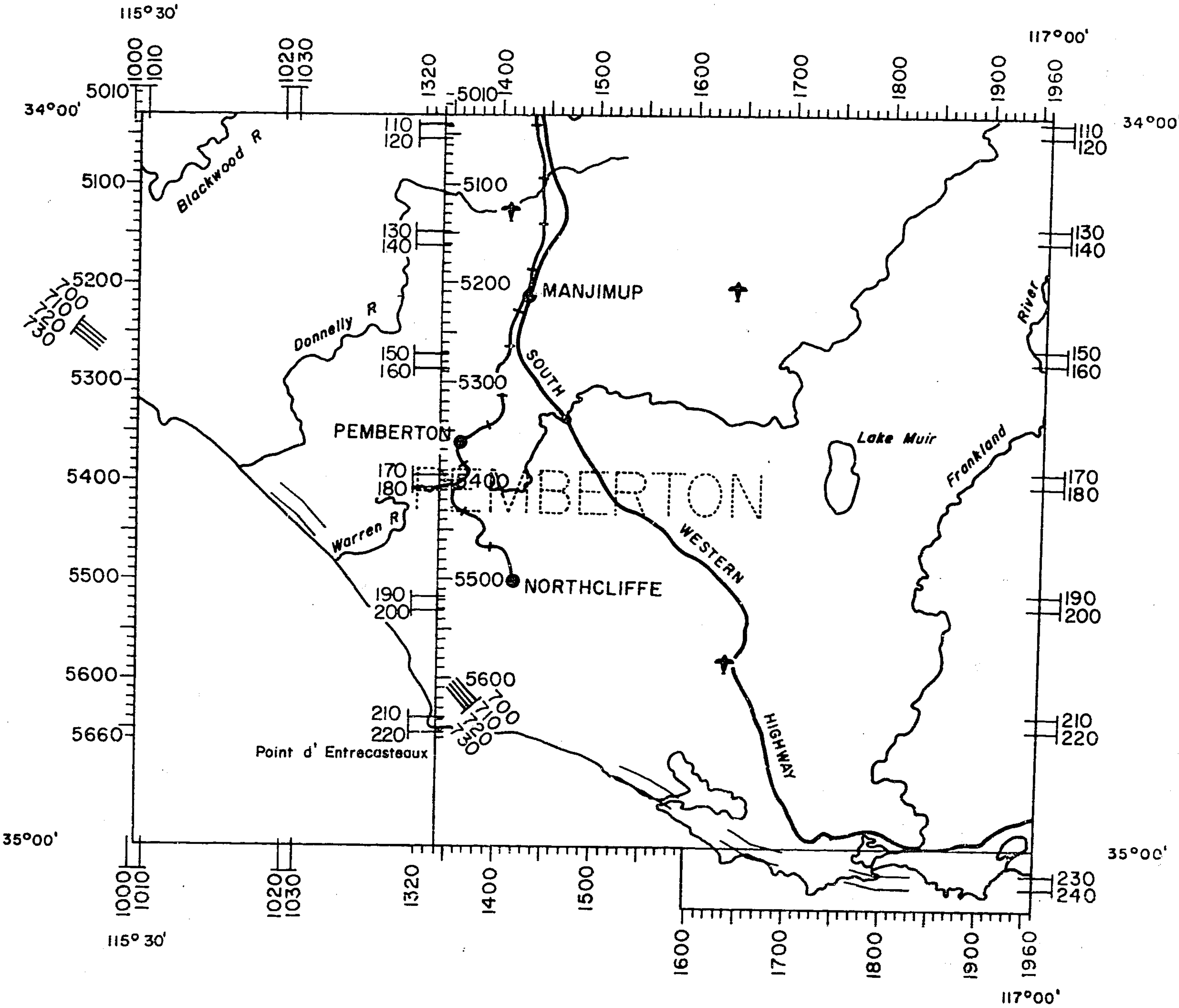


LOCATION DIAGRAM



REFERENCE TO 1:250 000 SERIES

	PINJARRA	CORRIGIN
BUSSELTON	COLLIE	DUMBLEYUNG
AUGUSTA	PEMBERTON	MOUNT BARKER



AIRBORNE SURVEY PEMBERTON, W A, 1980

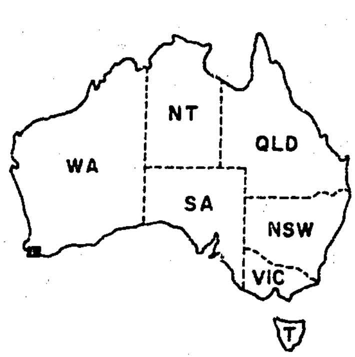
LOCALITY MAP

AND

FLIGHT-LINE SYSTEM

0 10 20 30 40 50 km

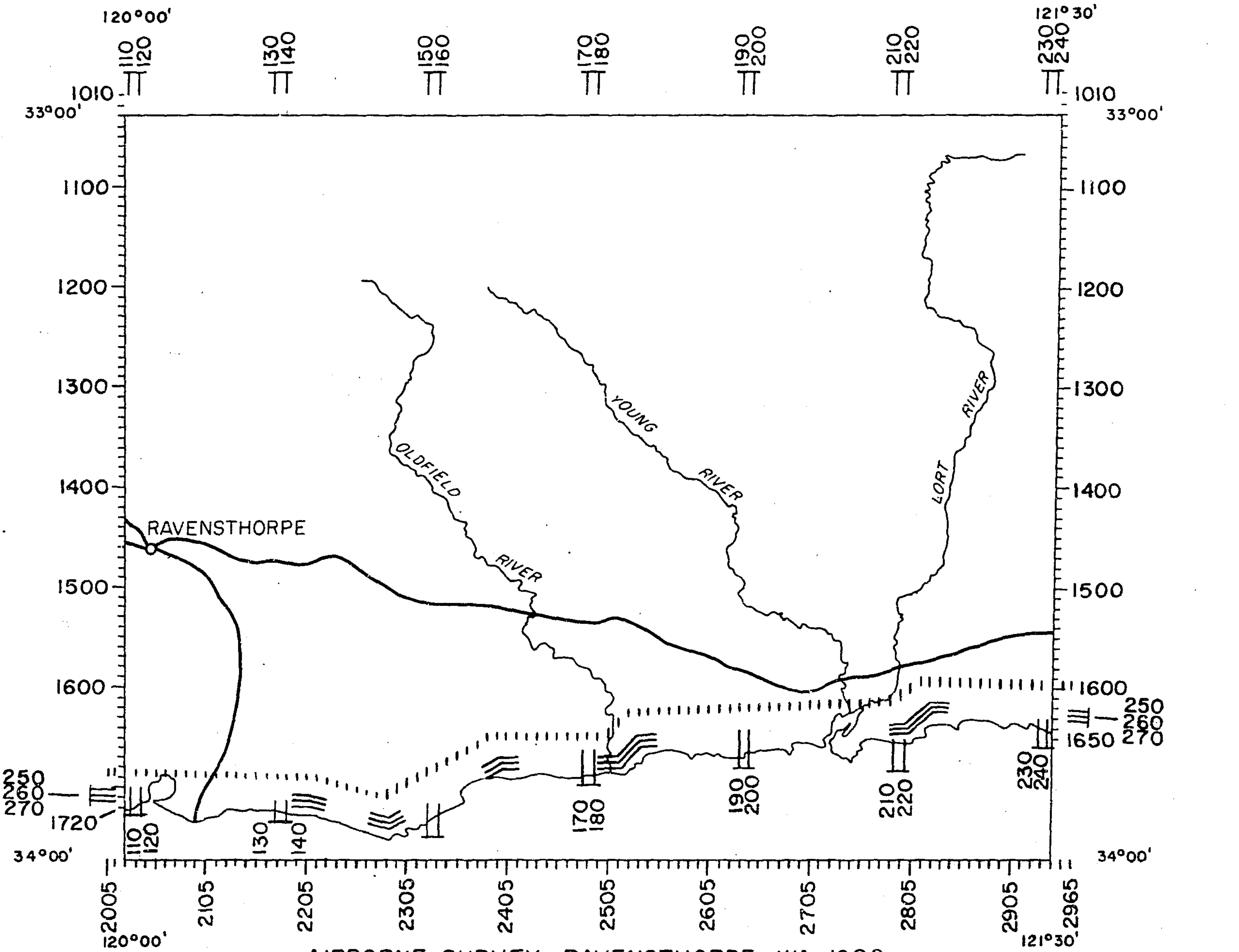
LOCATION DIAGRAM



REFERENCE TO 1 : 250 000 SERIES

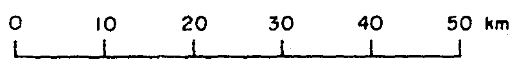
BUSSELTON	COLLIE	DUMBLEYUNG
AUGUSTA	PEMBERTON	MOUNT BARKER
	IRWIN INLET	ALBANY

MA-14



AIRBORNE SURVEY RAVENSTHORPE, WA, 1980

LOCALITY MAP
AND
FLIGHT LINE SYSTEM



LOCATION DIAGRAM

REFERENCE TO 1:250 000 SERIES

HYDEN	LAKE JOHNSTON	NORSEMAN
NEWDEGATE	RAVENS-THORPE	ESPERANCE
BREMER BAY		MONDRAIN ISLAND

The Twin Otter aircraft, VH-BMG, equipped with a fluxgate magnetometer and a 4-channel gamma-ray spectrometer, was used on the survey. It was flown at 150 m above ground level, along flight lines bearing east-west. These lines were spaced 1.5 km apart. A Doppler system was used to aid navigation and flight path recovery. All data were digitally recorded.

Processing of the data will commence in 1981, and preliminary release of survey results will be made as they become available.

COLLIE-PEMBERTON The magnetic results in COLLIE and PEMBERTON (western one-third) exhibit strong north-south trends which define the eastern boundary of the Perth Basin, along the Darling Fault. The amplitude of these anomalies ranges from 250 nT to 1500 nT. Farther east, fairly linear trends associated with rocks of the Yilgarn Block are apparent.

In the Perth Basin the profiles are generally fairly flat. Exceptions are areas where anomalies (both positive and negative) are probably associated with expanses of near-surface basalts noted in earlier surveys of the Perth Basin. These anomalies can be traced through western PEMBERTON and may reflect basalt fillings of old stream beds.

The radiometric data exhibit large amplitude thorium anomalies (150 to 200 cps). These were recorded over the major part of the survey area, with the exception of the coastal areas west of the Darling Fault. They are mainly attributed to the large laterite exposures, some of which possibly contain bauxite.

A few areas which exhibit anomalies in the potassium channel correlate with exposures of granite. No uranium anomalies were recorded.

RAVENSTHORPE The magnetic field in RAVENSTHORPE is moderately disturbed, with anomalies recorded in the range 250 nT to 500 nT. Some of the more prominent anomalies trend north-south or north-west/south-east, which probably reflect greenstone belts. Much of the area is covered by alluvium which prevents a direct correlation between anomaly and source rock; however, a comprehensive regional interpretation planned for 1982 should lead to a better understanding of the geology.

The radiometric data show fairly large thorium and potassium anomalies over the granitic areas in the west of the survey area. Some thorium anomalies are also associated with claypans. There are several uranium anomalies associated with the stream deposited sediments of the Lort River, and others have been recorded on the edge of Lake Tay. No uranium anomalies were recorded over the remainder of the survey area.

Canning Basin East airborne magnetic and radiometric survey, WA, 1980 (S. Sheard, J. Eurell, E. Chudyk)

An airborne magnetic and radiometric survey of the eastern margin of the Canning Basin was flown in the period 22 May to 17 September covering STANSMORE, LUCAS, BILLILUNA, and GORDON DOWNS (southern half) as shown in Figure MA-15. A total of 55 000 line-km was flown, including reflown and infill lines.

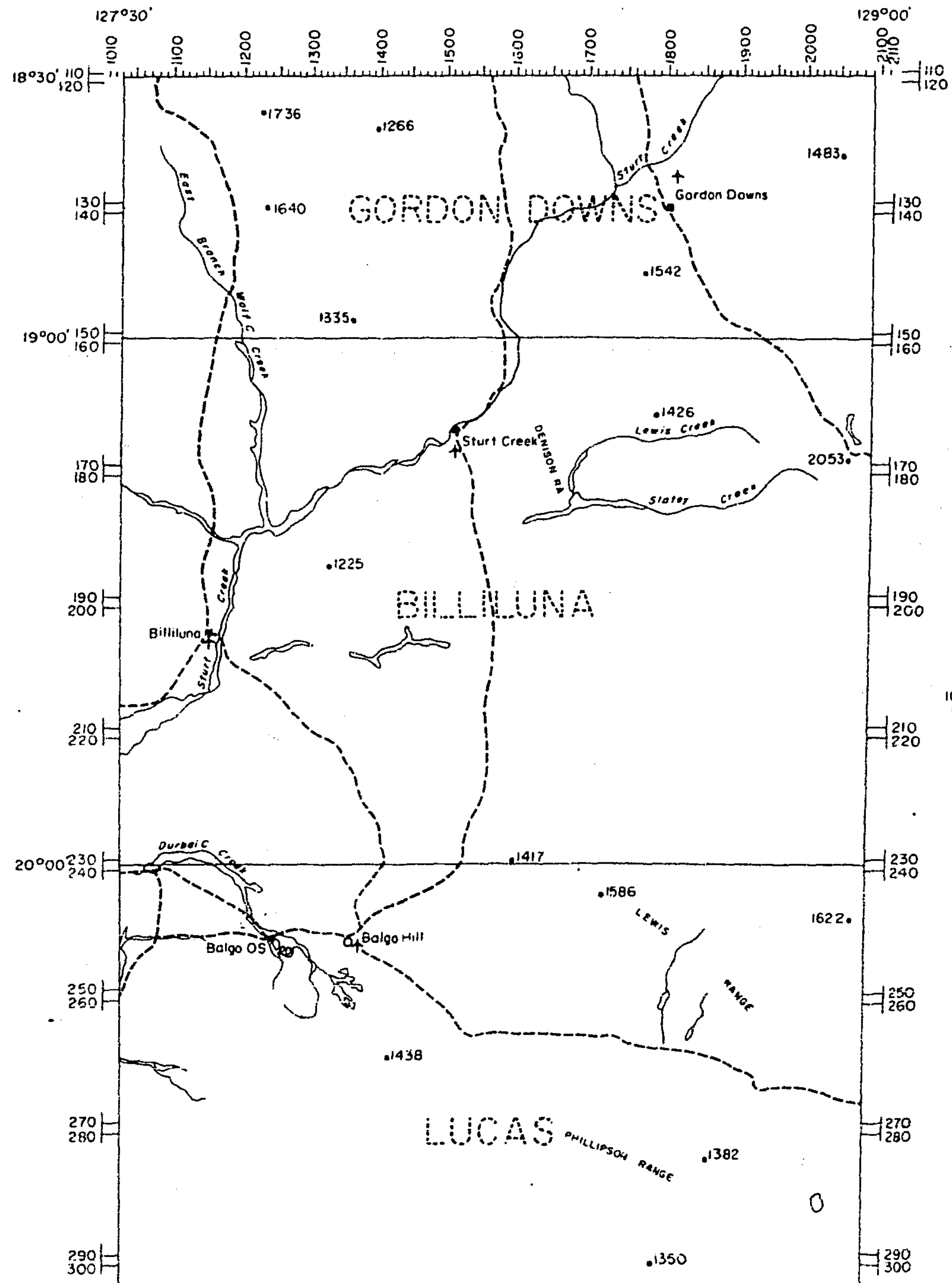
The survey was flown at 150 m above ground level along north-south flight lines, 1.5 km apart. Double tie-lines were flown east-west every 15 minutes from the sheet boundaries.

The Twin Otter aircraft, VH-BMG, equipped with a fluxgate magnetometer, a 1024 cu. inch sodium iodide crystal gamma-ray detector, a HP 21MX computer, and a doppler navigation system, was used for the survey.

The data quality was upgraded at the start of the survey by the introduction of an Inotech multichannel analyser for digitisation of radiometric data, and a Sperry C12 compass system to improve navigation and flight path recovery. Magnetic data were measured at 1/5 second intervals to an accuracy of 1 nT, and the standard spectrometer channels Total Count, Potassium, Uranium, and Thorium were recorded every second. Multichannel data (256 channels corresponding to the 0-3 meV energy band) were acquired every 300 seconds and recorded as an aid to data interpretation and future system development.

Preliminary interpretation of the magnetic results indicates that the Canning Basin margins can be identified, and intra-basin structures such as the Billiluna Shelf, Betty Terrace, Gregory Sub-basin, and the Barbwire Terrace can be delineated. The east-west tie-line data define three magnetically different zones. These represent the Canning Basin, the Birrindudu Basin, and the granites of the Granites-Tanami Block. The boundary of the Canning and Birrindudu Basins strikes north-south and should be more clearly defined when the magnetic contour data are available. The magnetic expression of the Granites-Tanami Block is the most dominant feature of the region and the large positive, short period anomalies will provide a means of identifying granites not already mapped.

The multichannel radiometric data will assist in delineating the surface boundaries of the various geological provinces. Preliminary indications are that the whole area is predominantly thorium rich, with radiometric highs correlating well with lateritised Permian sediments.

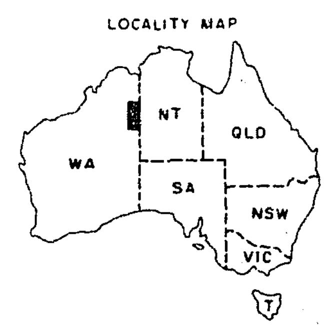


AIRBORNE SURVEY
CANNING BASIN, WA 1980

BILLILUNA, GORDON DOWNS
LUCAS, STANSMORE

LOCALITY MAP
AND
FLIGHT-LINE SYSTEM

10 0 10 20 30 40 50 60 70 80 90 km



INDEX TO 1:250 000 MAP SHEETS

LANSDOWNE	DIXON RANGE	LIMBUNYA
MOUNT RAMSAY	GORDON DOWNS	BIRRINDUDU
MOUNT BANNERMAN	BILLILUNA	TANAMI
CORNISH	LUCAS	THE GRANITES
HELENA	STANSMORE	HIGHLAND ROCKS
WILSON	WEBB	LAKE MACKAY

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Processing of survey data is expected to commence early in 1981 with release of preliminary maps later in the year. A preliminary interpretation of results will be commenced in 1981 to provide a guide for programming further data acquisition around the basin margins.

Darling Basin airborne magnetic and radiometric survey, NSW 1980 (P. Gidley, K. Horsfall, G. Green, S. Wilcox, J. Mangion)

At the request of the Petroleum Exploration and Geological Branches, BMR, a regional airborne magnetic and spectrometer survey totalling approximately 27 000 line-km was commenced over MENINDEE, MANARA, and IVANHOE during October and November (Figs. MA-16 and MA-17). The survey of MANARA and IVANHOE was not completed in 1980 but should be completed by mid to late 1981.

The Twin Otter aricraft, VH-BMG, which is equipped with a fluxgate magnetometer and a 4-channel gamma-ray spectrometer system, was used on the survey. It was flown at an average height of 150 m above ground level along flight lines bearing north-south over MENINDEE, and east-west over the remainder of the survey area. The line spacing was 1.5 km for MENINDEE and 3 km for MANARA and IVANHOE. A doppler system was used to aid navigation and flight path recovery. All data were digitally recorded.

Processing of the survey data will commence in 1981. Preliminary release of these data will be made as they become available.

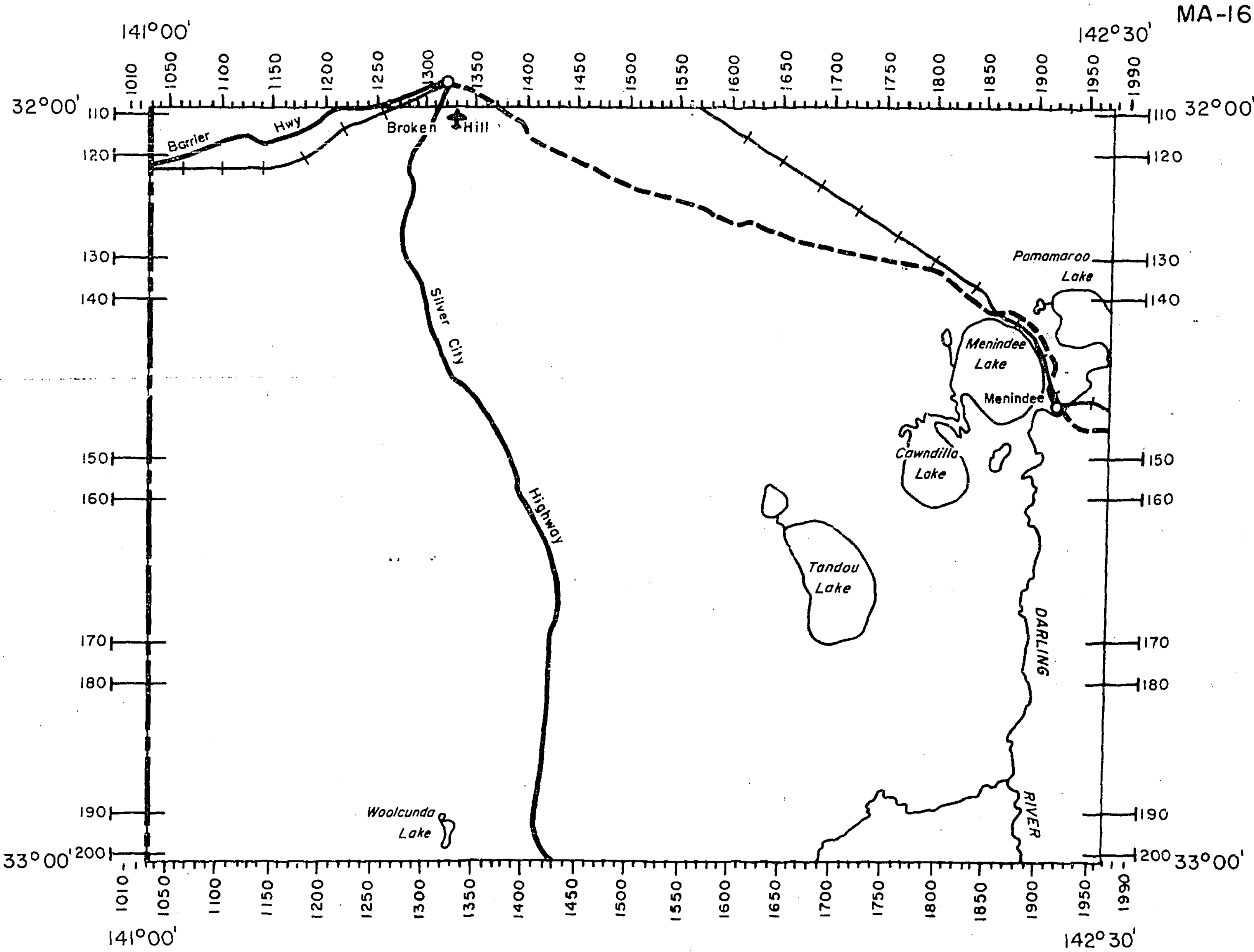
This survey will contribute to BMR's program of airborne surveying of the Murray and Darling basins which will cover an area of 320 000 km^2 in western N.S.W. and Victoria, extending from the Queensland border to well south of the Murray River. Both BMR's survey aircraft will be used in 1981 to complete the program, which will provide data for a geological interpretation of the basins in 1983.

Warburton aeromagnetic survey, 1979-preliminary assessment of data (S. Sheard)

The total magnetic intensity contour and profile maps of WARBURTON (Figure MA-18) were relased in January. Rocks of the Lachlan Fold Belt cover all but the southeastern corner of the sheet where Cainozoic sediments of the Gippsland Basin outcrop.

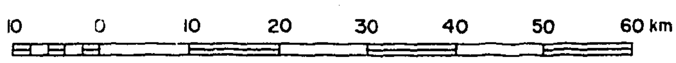
The magnetic pattern over the Mount Buller granodiorite dominates the northeastern part of the area. The two separate, complex anomalies indicate two distinct intrusives which may be linked at depth. In the northeastern corner, the Mount Selwyn granites of Devonian age give rise to two circular, short

MA-16

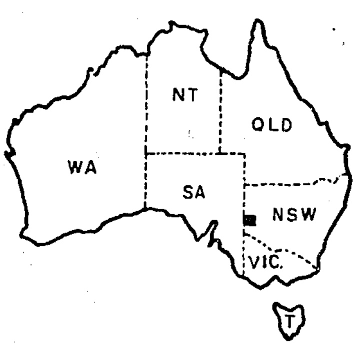


AIRBORNE SURVEY, MENINDEE, NSW 1980

LOCALITY MAP
AND
FLIGHT-LINE SYSTEM

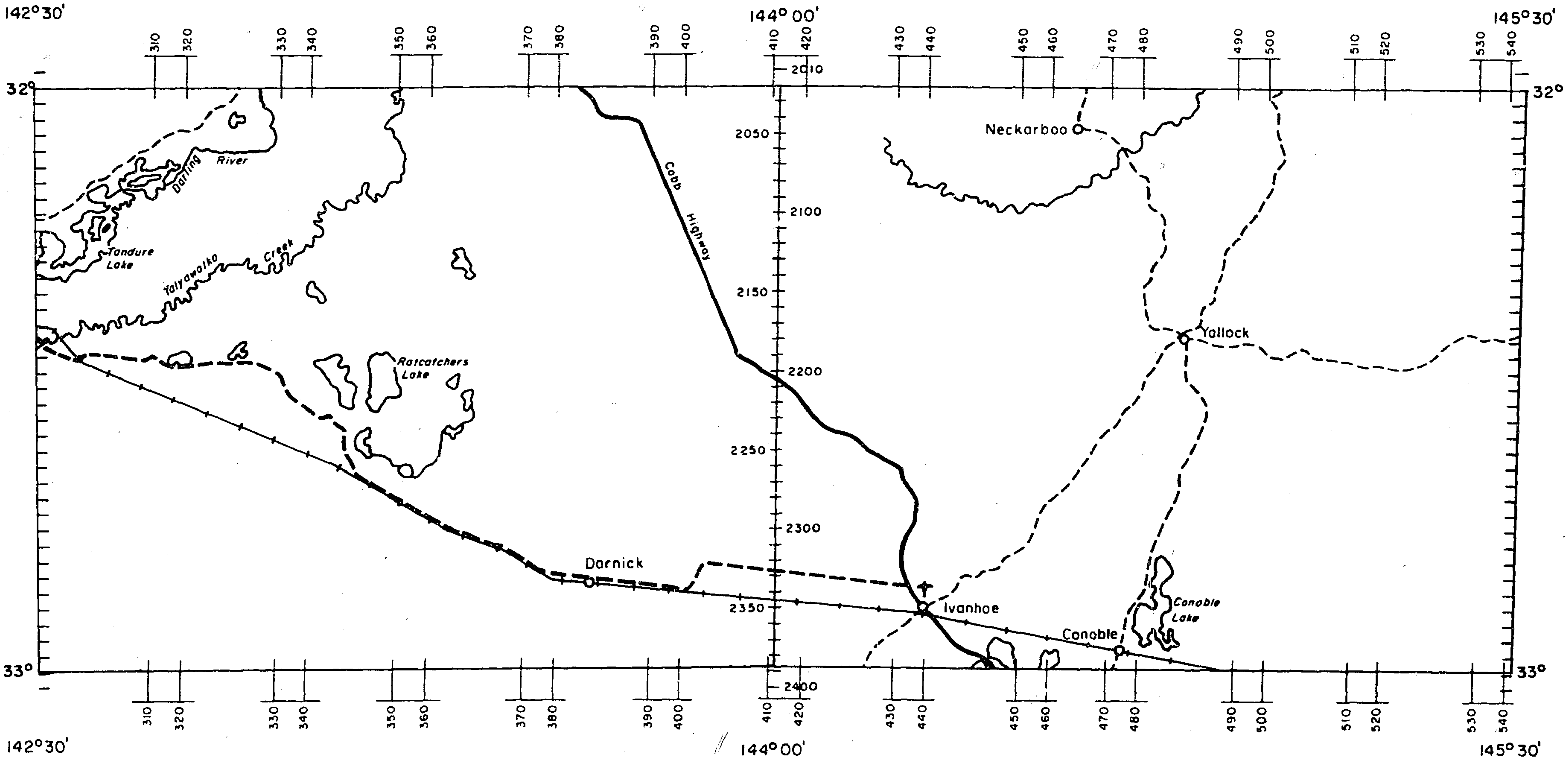


LOCATION DIAGRAM



REFERENCE TO 1:250000 MAP SERIES

CURNAMONA	BROKEN HILL	WILCANNIA
OLARY	**MENINDEE**	MANARA
CHOWILLA	ANA BRANCH	POONCARIE



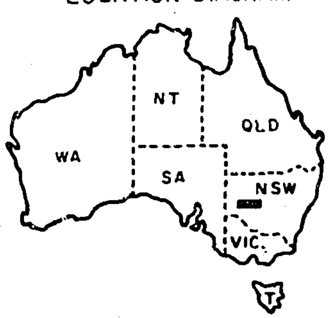
AIRBORNE SURVEY, MANARA AND IVANHOE, NSW 1981

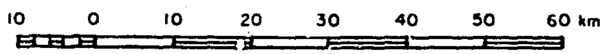
LOCALITY MAP

AND

FLIGHT-LINE SYSTEM

LOCATION DIAGRAM





REFERENCE TO 1:250 000 MAP SERIES

BROKEN HILL	WILCANNIA	BARNATO	COBAR
MENINDEE	MANARA	IVANHOE	NYMAGEE
ANA BRANCH	POONCARIE	BOOLIGAL	CARGELLIGO

MA-17

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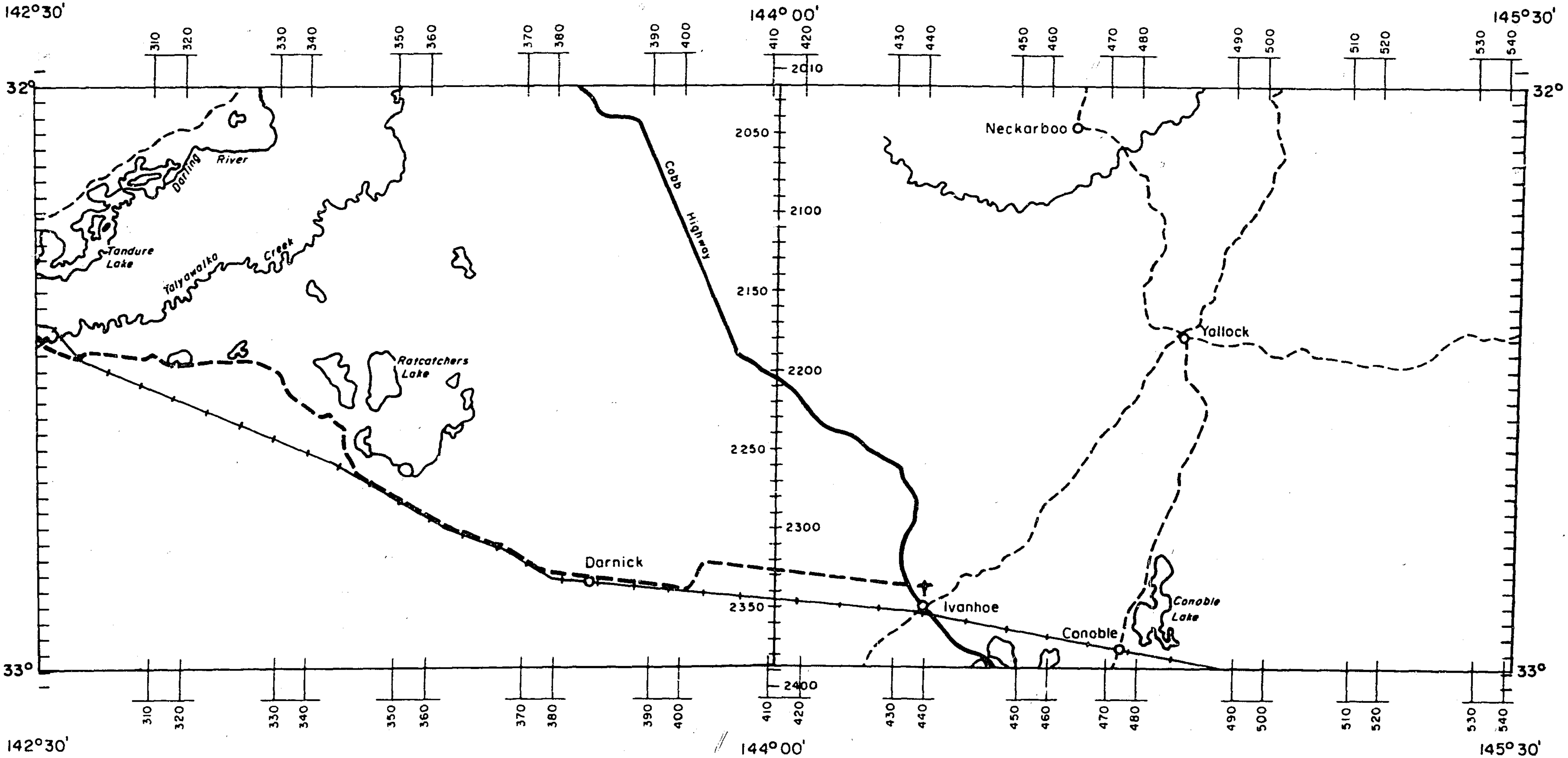


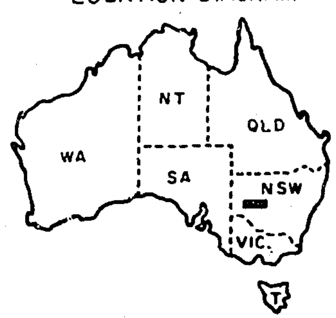
AIRBORNE SURVEY, MANARA AND IVANHOE, NSW 1981

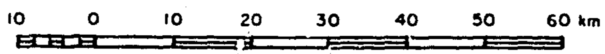
LOCALITY MAP

AND

FLIGHT-LINE SYSTEM

LOCATION DIAGRAM





REFERENCE TO 1:250 000 MAP SERIES

BROKEN HILL	WILCANNIA	BARNATO	COBAR
MENINDEE	MANARA	IVANHOE	NYMAGEE
ANA BRANCH	POONCARIE	BOOLIGAL	CARGELLIGO

MA-17

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N/B1-17A

wavelength anomalies similar in form to a circular anomaly 8 km north in WANGARATTA. The two more-northerly anomalies occur over outcropping granites. The southernmost anomaly suggests an intrusive source located about 200 m below the surface.

Some Tertiary basalts in the northwest of the area produce short wavelength anomalies, whereas all the flows mapped in the southwest of the sheet have no magnetic expression. The Upper Devonian basalts in the northeast produce a continuous string of intense magnetic anomalies which strike south along the eastern margin of the MacAlister Synclinorium. These basalts lie conformably within the sediments of the syncline dipping to the west. The magnetic anomaly wavelengths increase to the south, suggesting a continuous basalt flow following the topographic decline to the south. In a similar fashion, Upper Devonian basalts underlie the sediments of the Snowy Bluff Syncline 12 km to the east, with the magnetic pattern indicating the thickening of sediments to the south.

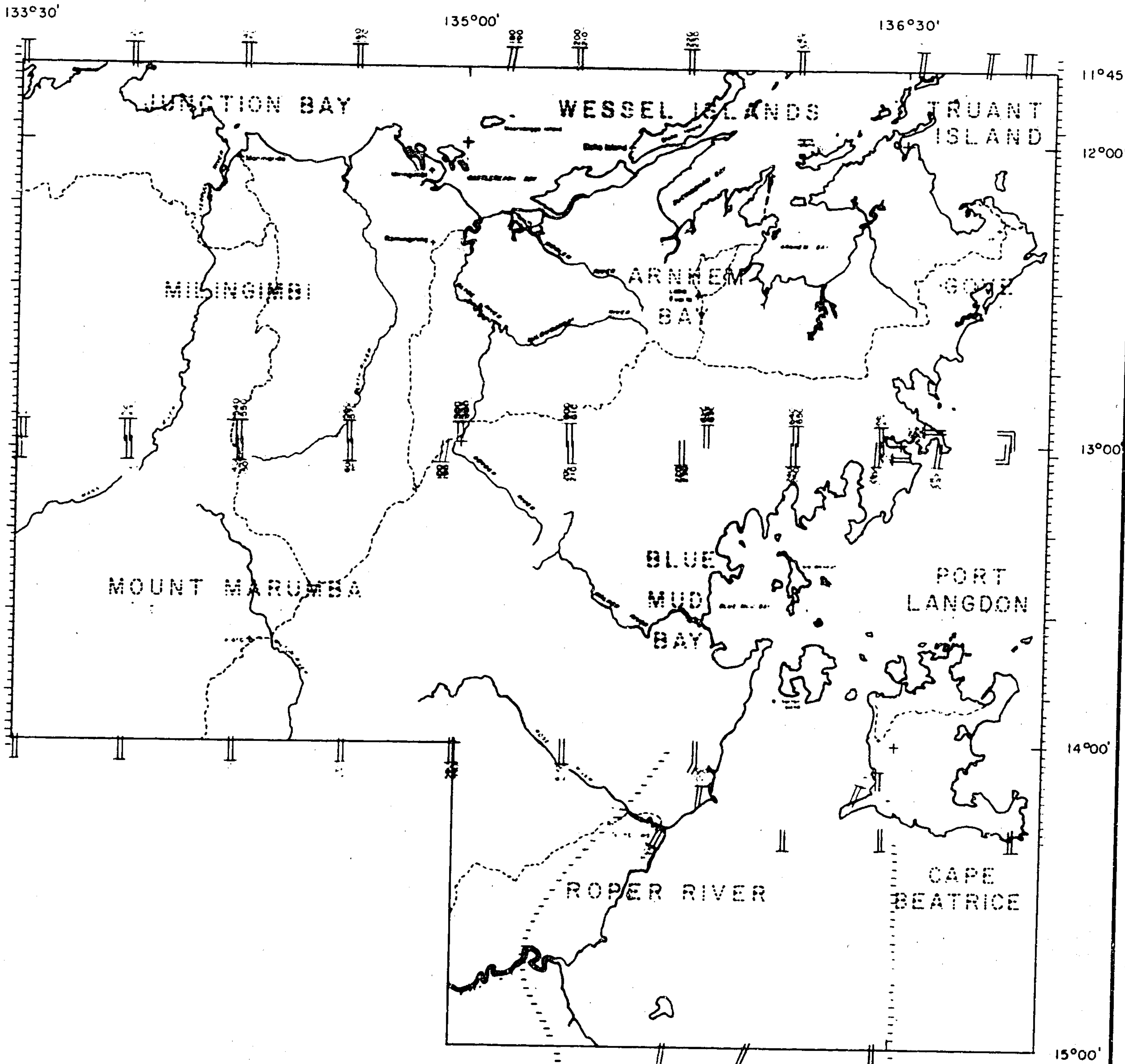
The very deep magnetic basement under the sediments of the Lachlan Fold Belt in the central region of the sheet has a north-easterly trend. This trend is altered by the Upper Devonian intrusives and extrusives that cover a significant part of the western side of WARBURTON. The Cerberean Cauldron, a large outcropping extrusive, exhibits no major magnetic response except on its eastern margin. A second major extrusive, the Acheron Cauldron, and the intrusives to south and east, have little magnetic expression but are nevertheless distinguishable from the regional trend.

A detailed interpretation of the airborne magnetic and radiometric data of WARBURTON will be of particular importance in an assessment of the regional geophysics of the Lachlan Fold Belt in Victoria.

<u>McArthur Basin airborne survey, 1978 - data processing and preliminary interpretation</u> (I. Zadoroznyj)

Production of maps for release through the Australian Government Printer Copy Service, or inspection at BMR, continued from the end of 1979 until this phase of the project was completed in October 1980. A total of 72 maps was produced from survey data acquired in 1978 for the area shown in Figure MA-19.

MA-19

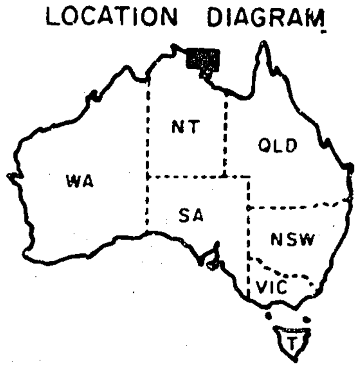


AIRBORNE SURVEY, McARTHUR BASIN, NT 1978

LOCALITY MAP AND FLIGHT-LINE SYSTEM

10 0 20 40 60 80 100 km

LOCATION DIAGRAM



REFERENCE TO AIRBORNE GEOPHYSICS MAP SERIES

COBOURG PENINSULA	JUNCTION BAY	WESSEL ISLANDS	TRUANT ISLAND
ALLIGATOR RIVER	MILINGIMBI	ARNHEM BAY	GOVE
MOUNT EVELYN	MOUNT MARUMBA	BLUE MUD BAY	PORT LANGDON
KATHERINE	URAPUNGA	ROPER RIVER	CAPE BEATRICE
LARRIMAH	HODGSON DOWNS	MOUNT YOUNG	PELLEW

Magnetic data. The total magnetic intensity contour maps of the area (Figs. MA-20 to MA-25) show a range in magnetic anomalies from short wavelength (about 2 km) high amplitude (100 nT) features, to broad flat features varying by only a few tens of nanoteslas over 50 km or more, as well as several relatively broad but high amplitude magnetic anomalies.

The anomalous areas occupy nearly all of MOUNT MARUMBA and that part of MILINGIMBI lying west of a diagonal line running northwest across the sheet. There is an overall northeasterly trend in the anomalies, more pronounced in MOUNT MARUMBA, indicating that this is the predominant structural trend. A weaker, northwesterly trend cuts across MOUNT MARUMBA parallelling the fault lineations.

Other anomalous zones are separated by areas of lesser magnetic relief. A belt of north-northwest trending anomalies extends from the north of BLUE MUD BAY across the middle of ARNHEM BAY area, while other anomalous areas occur in the northwestern and southwestern corners of GOVE, with extensions into adjoining sheets, and over much of Groote Eylandt.

Most of the anomalies in MOUNT MARUMBA and MILINGIMBI can be attributed simply to the ubiquitous Proterozoic dolerite sills found in the McArthur Basin, and basalts in the western parts of these sheets.

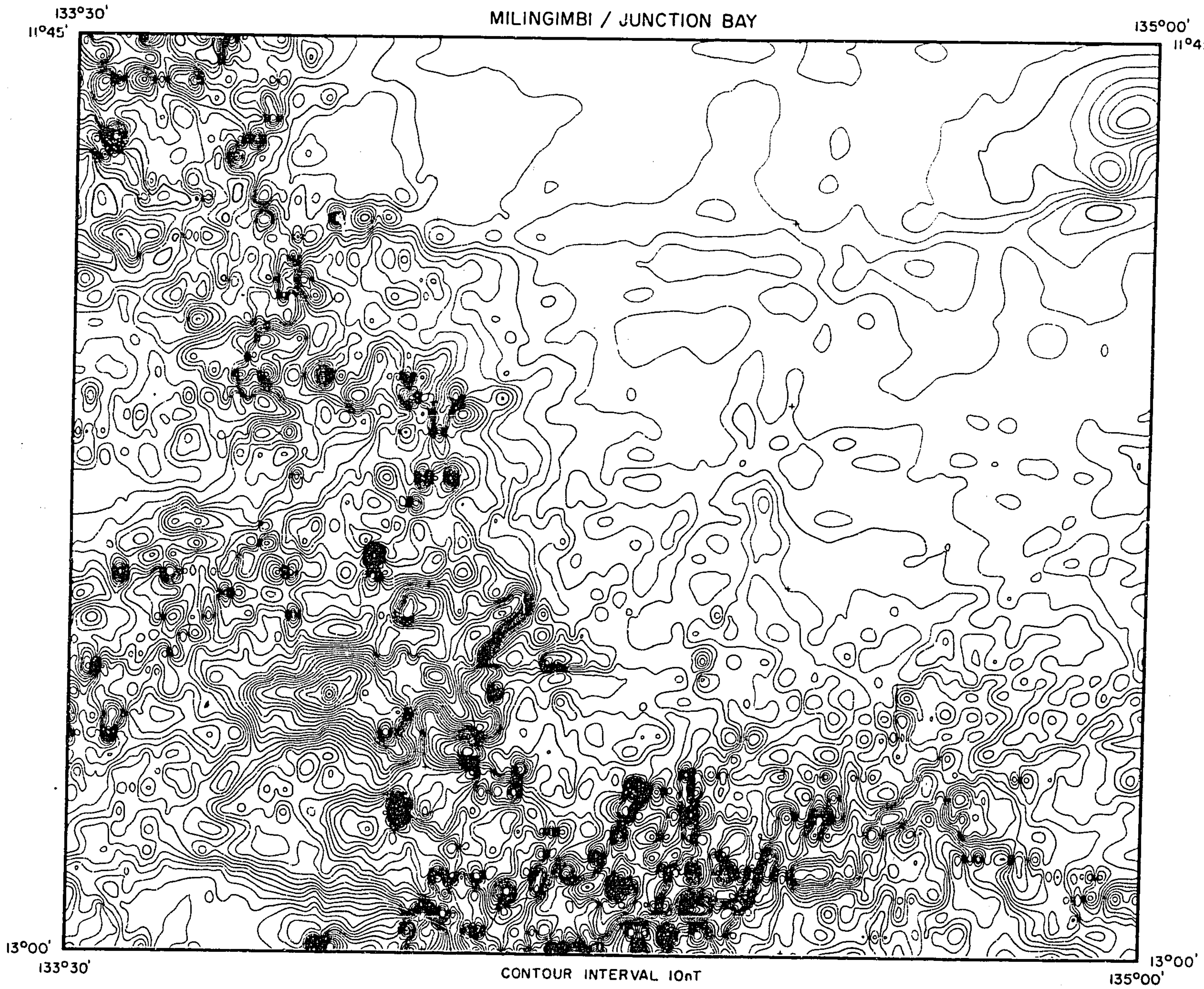
The belt of magnetic anomalies extending across ARNHEM BAY correlates with a major structural feature - a zone where Lower Proterozoic sediments and Archaean/Proterozoic acid plutonics (Mirarrmina Complex) are exposed and are very strongly faulted. The magnetic anomalies are probably associated with Proterozoic dolerites. Deeper basic intrusives are interpreted as the source of the broader anomalies in the north.

The rocks of the Mirarrmina Complex exhibit very little magnetic effect. In contrast, Proterozoic plutonic rocks appear to be the cause of the magnetic anomalies in the northwestern and southwestern parts of GOVE.

The higher level of magnetic activity over Groote Eylandt suggests a high concentration of magnetite within the sediments of the Groote Eylandt Beds.

Radiometric data. The total count contour maps (Figs. MA-26to MA-31) generally show low count rates over most of the region, particularly where the cover is composed of younger sediments. Slightly higher counts were recorded over older sediments.

MA-20



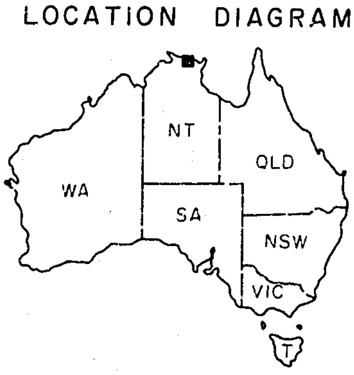
AIRBORNE SURVEY, McARTHUR BASIN, NT 1978

TOTAL MAGNETIC INTENSITY

SCALE 1:1 000 000

10 0 10 20 30 40 50 km

LOCATION DIAGRAM

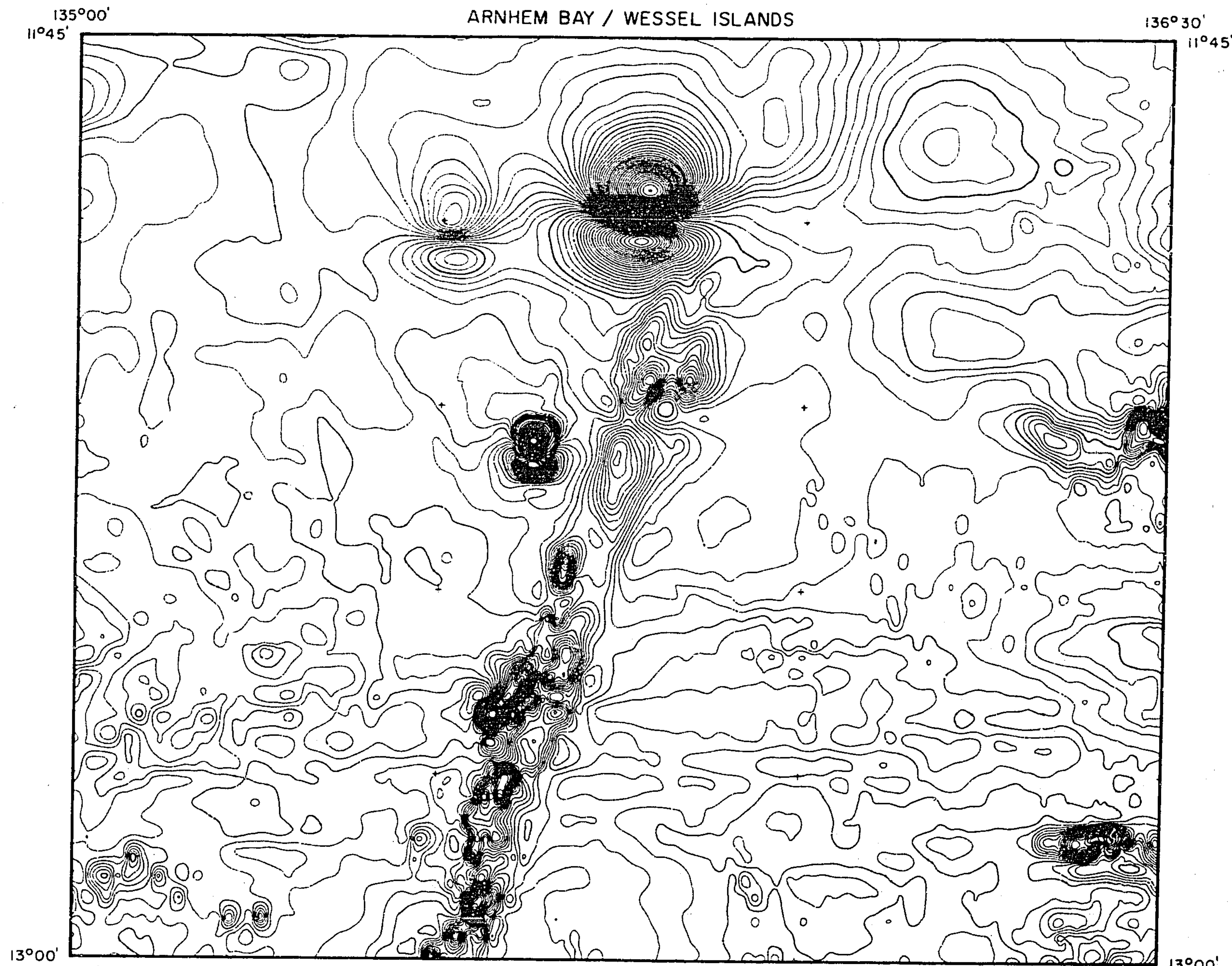


REFERENCE TO 1:250 000 MAP SERIES

COBOURG PENINSULA	JUNCTION BAY	WESSEL ISLANDS
ALLIGATOR RIVER	MILINGIMBI	ARNHEM BAY
MOUNT EVELYN	MOUNT MARUMBA	BLUE MUD BAY

MA-21

ARNHEM BAY / WESSEL ISLANDS



CONTOUR INTERVAL 10nT

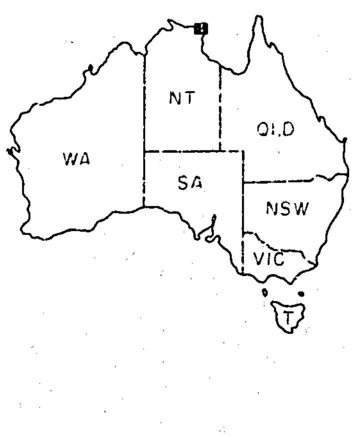
AIRBORNE SURVEY, McARTHUR BASIN, NT 1978

TOTAL MAGNETIC INTENSITY

SCALE 1:1000 000

10 0 10 20 30 40 50 km

LOCATION DIAGRAM

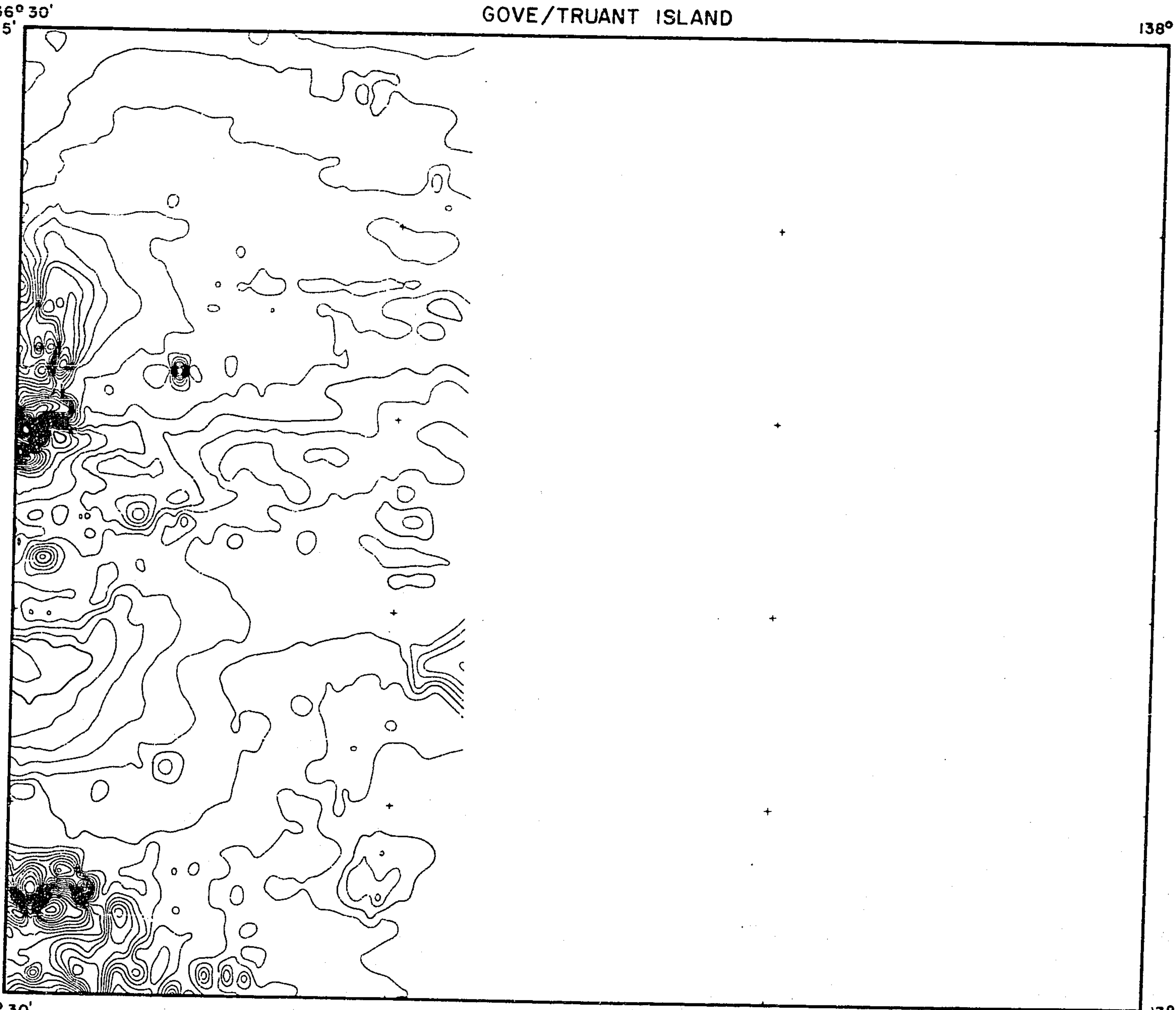


REFERENCE TO 1:250 000 MAP SERIES

JUNCTION BAY	WESSEL ISLANDS	TRUANT ISLAND
MILINGIMBI	ARNHEM BAY	GOVE
MOUNT MARUMBA	BLUE MUD BAY	PORT LANGDON

MA-22

GOVE/TRUANT ISLAND



CONTOUR INTERVAL 10 nT

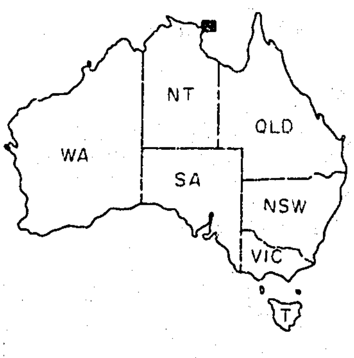
AIRBORNE SURVEY, McARTHUR BASIN, NT 1978

TOTAL MAGNETIC INTENSITY

SCALE 1:1 000 000

10 0 10 20 30 40 50 km

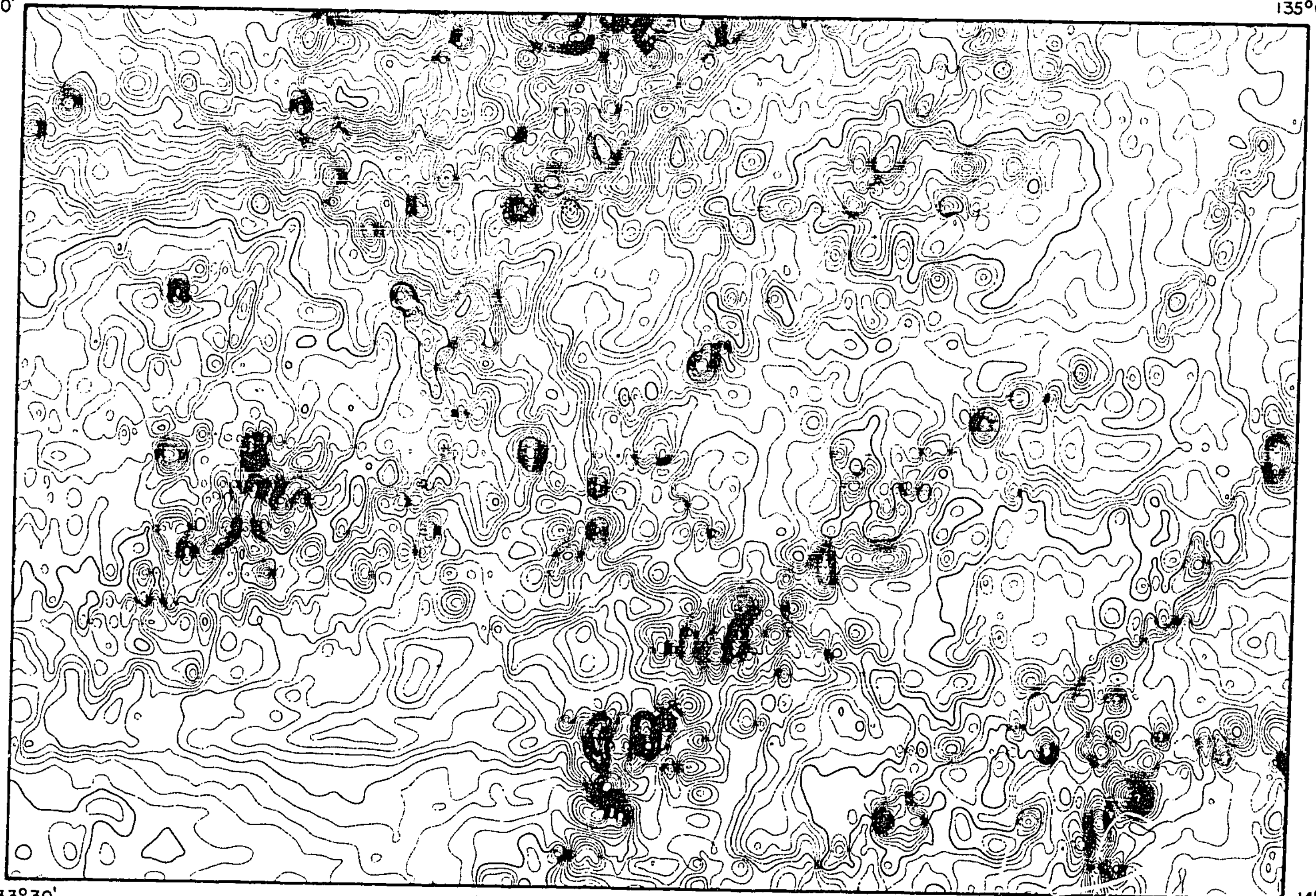
LOCATION DIAGRAM



REFERENCE TO 1:250 000 MAP SERIES

WESSEL ISLANDS	TRUANT ISLAND	
ARNHEM BAY	GOVE	
BLUE MUD BAY	PORT LANGDON	

MA-23



CONTOUR INTERVAL 10nT

AIRBORNE SURVEY, McARTHUR BASIN, NT 1978

TOTAL MAGNETIC INTENSITY

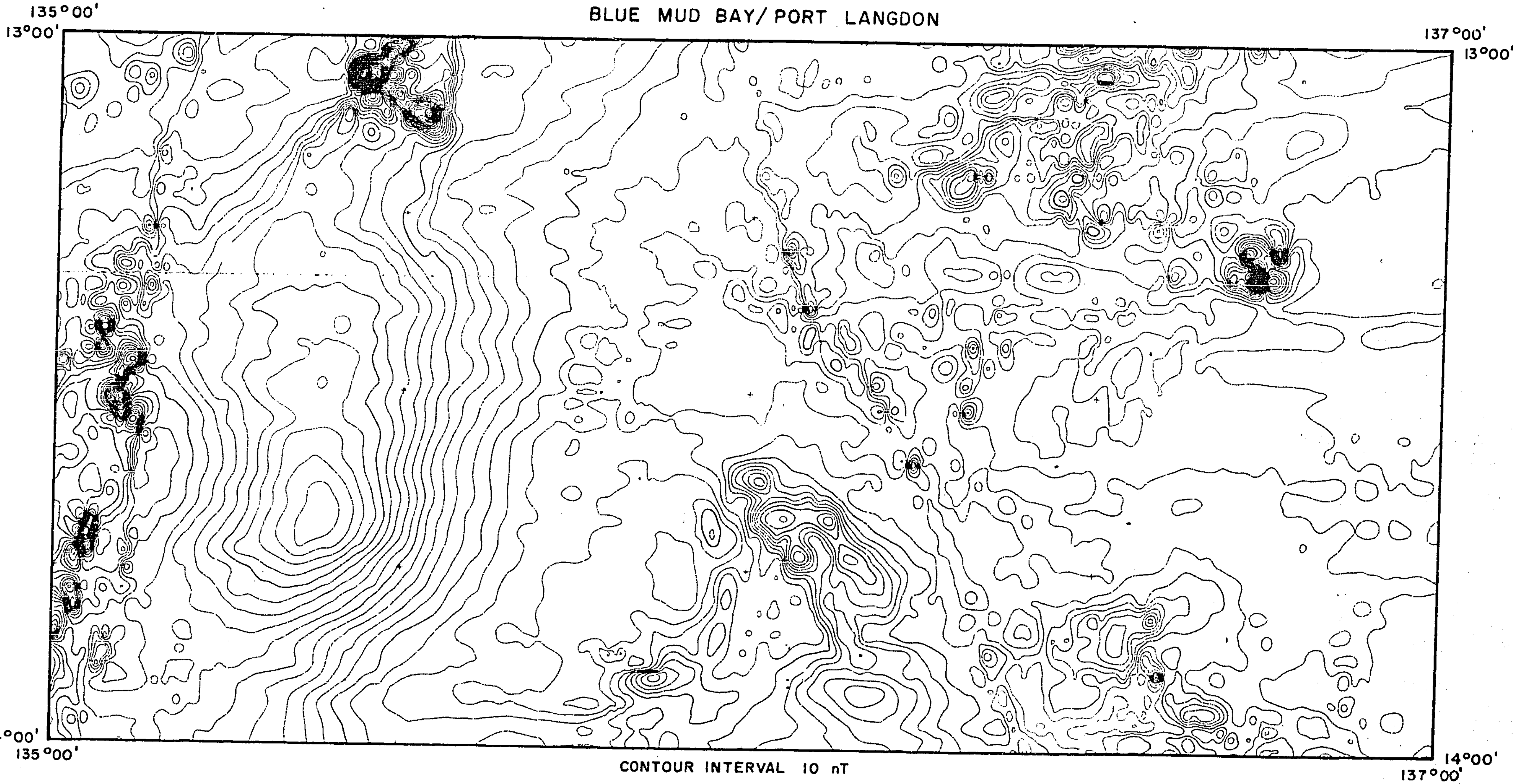
SCALE 1:1000 000

10 0 10 20 30 40 50 km

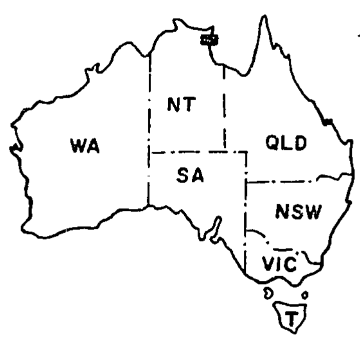
LOCATION DIAGRAM

REFERENCE TO 1:250 000 MAP SERIES

ALLIGATOR RIVER	MILINGIMBI	ARNHEM BAY
MOUNT EVELYN	MOUNT MARUMBA	BLUE MUD BAY
KATHERINE	URAPUNGA	ROPER RIVER



LOCATION DIAGRAM



AIRBORNE SURVEY, McARTHUR BASIN, NT 1978

TOTAL MAGNETIC INTENSITY

SCALE 1:1000 000

10 0 10 20 30 40 50 km

REFERENCE TO 1:250 000 MAP SERIES

MILINGIMBI	ARNHEM BAY	GOVE
MOUNT MARUMBA	BLUE MUD BAY	PORT LANGDON
URAPUNGA	ROPER RIVER	CAPE BEATRICE

MA-24

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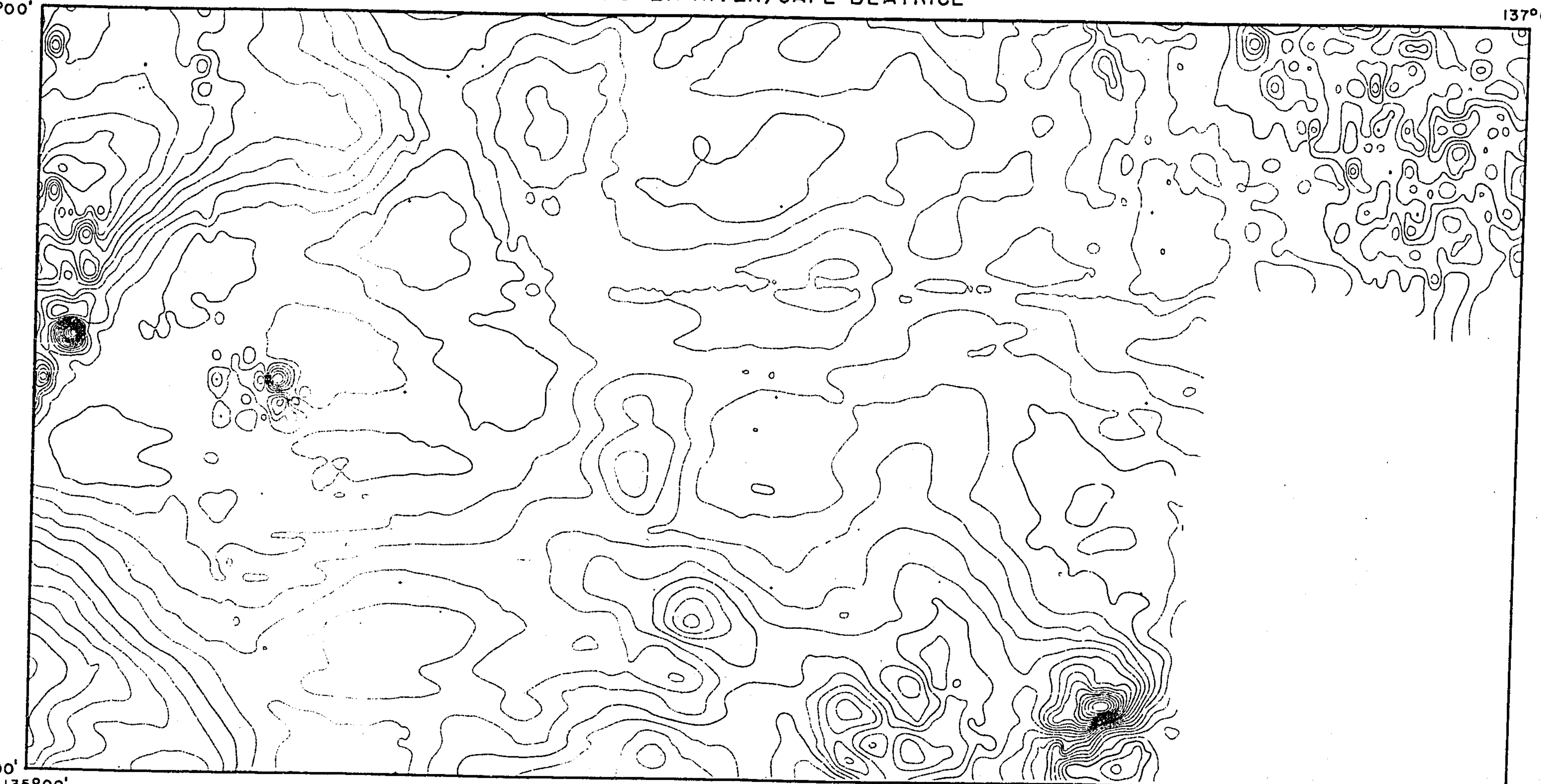
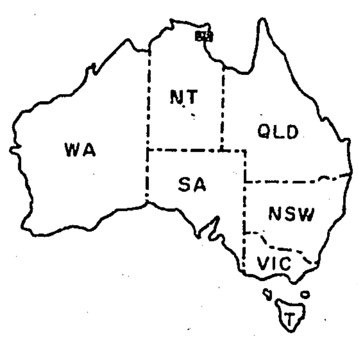
ROPER RIVER/CAPE BEATRICE



CONTOUR INTERVAL 10nT

LOCATION DIAGRAM



AIRBORNE SURVEY, McARTHUR BASIN, NT 1978

TOTAL MAGNETIC INTENSITY

SCALE 1:1000000

10 0 10 20 30 40 50 km

REFERENCE TO 1:250 000 MAP SERIES

MOUNT MARUMBA	BLUE MUD BAY	PORT LANGDON
URAPUNGA	ROPER RIVER	CAPE BEATRICE
HODGSON DOWNS	MOUNT YOUNG	PELLEW

MA-25

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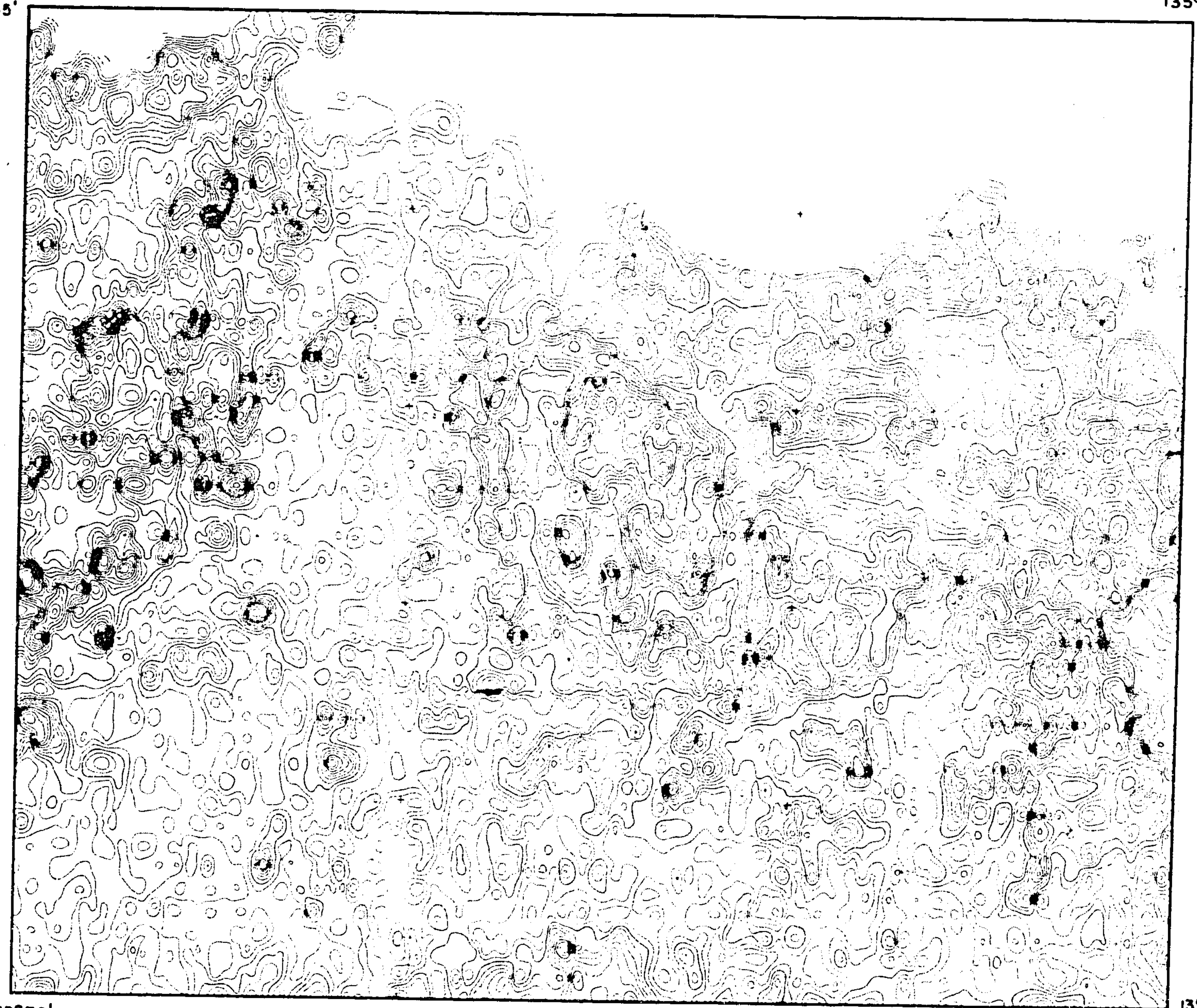
D53/B1-225AR

MA-26



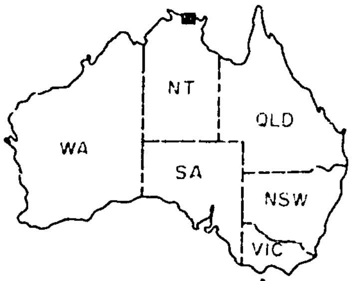
AIRBORNE SURVEY, McARTHUR BASIN, NT 1978

RADIOMETRIC CONTOURS
TOTAL COUNT

SCALE 1:1 000 000

10 0 10 20 30 40 50 km

LOCATION DIAGRAM

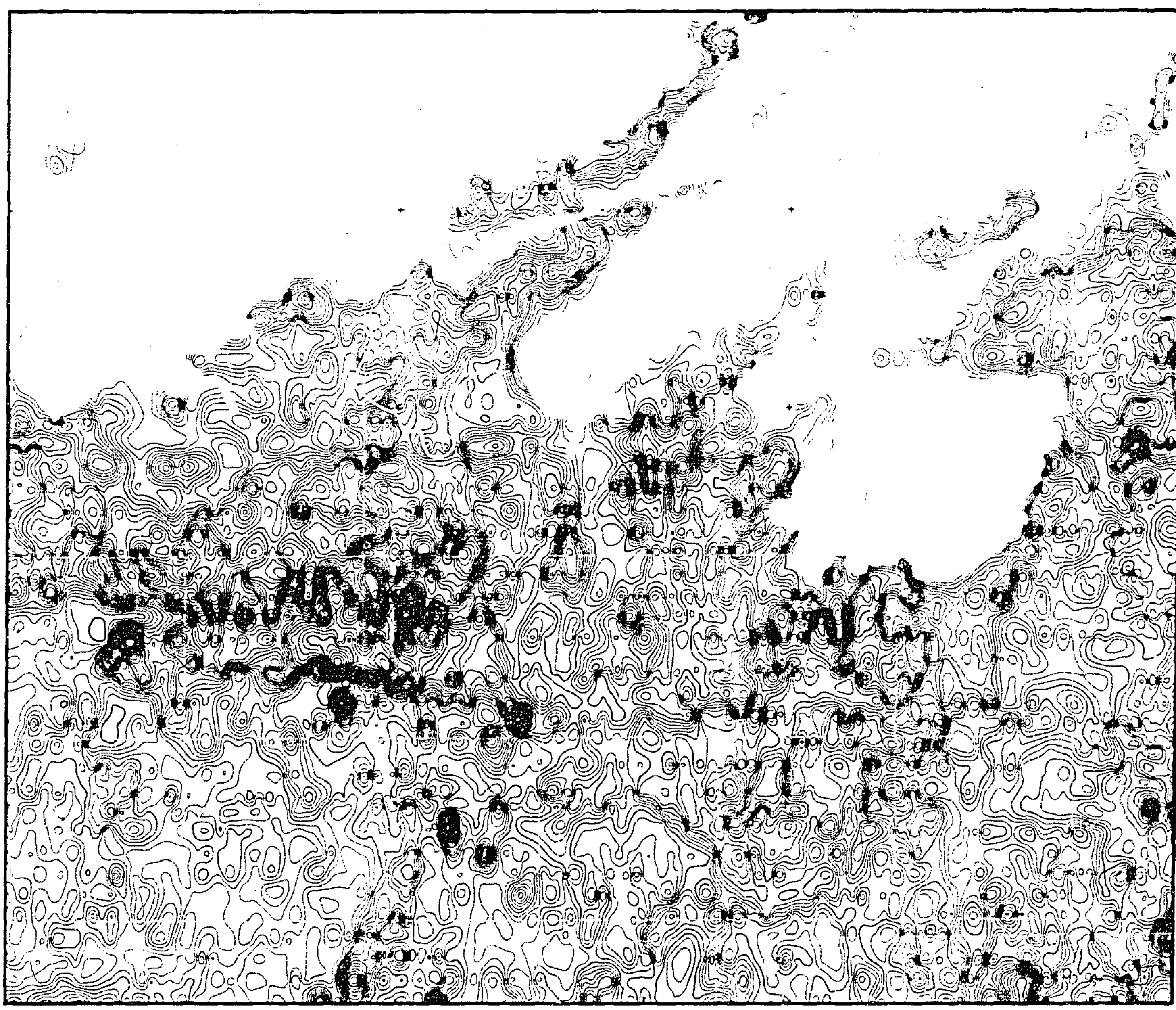


REFERENCE TO 1:250 000 MAP SERIES

COBOURG PENINSULA	JUNCTION BAY	WESSEL ISLANDS
ALLIGATOR RIVER	MILINGIMBI	ARNHEM BAY
MOUNT EVELYN	MOUNT MARUMBA	BLUE MUD BAY

MA-27

ARNHEM BAY/WESSEL ISLANDS



CONTOUR INTERVAL 10 COUNTS/S

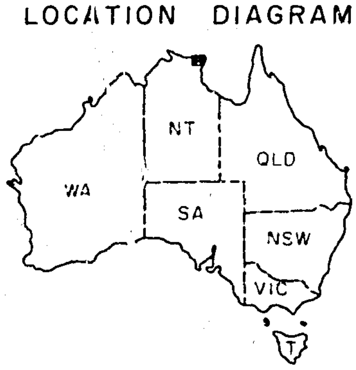
AIRBORNE SURVEY, McARTHUR BASIN, NT 1978

RADIOMETRIC CONTOURS
TOTAL COUNT

SCALE 1:1 000 000

10 0 10 20 30 40 50 km

LOCATION DIAGRAM



REFERENCE TO 1:250 000 MAP SERIES

JUNCTION BAY	WESSEL ISLANDS	TRUANT ISLAND
MILINGIMBI	ARNHEM BAY	GOVE
MOUNT MARUMBA	BLUE MUD BAY	PORT LANGDON

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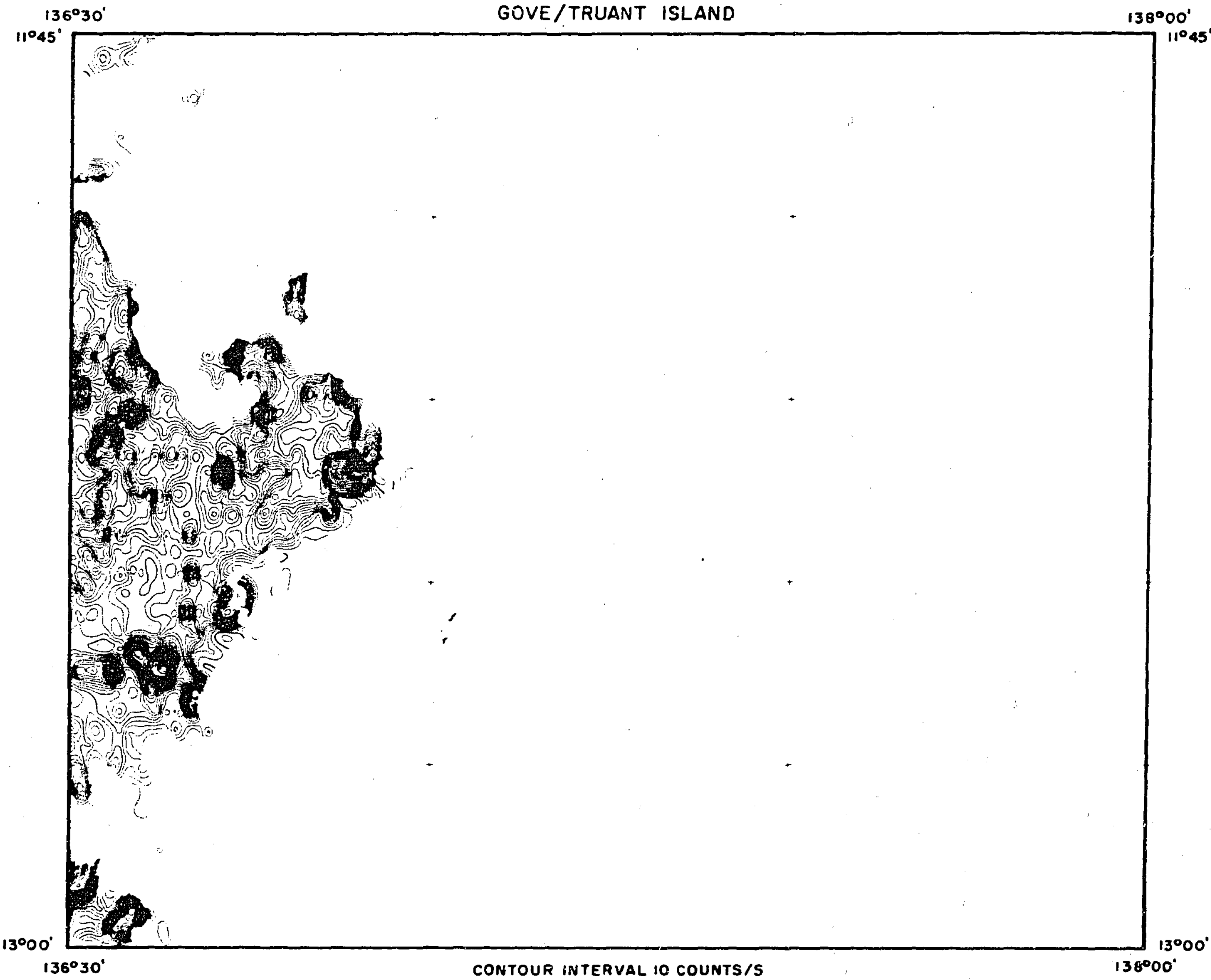
D53/B1-204AR

MA-28



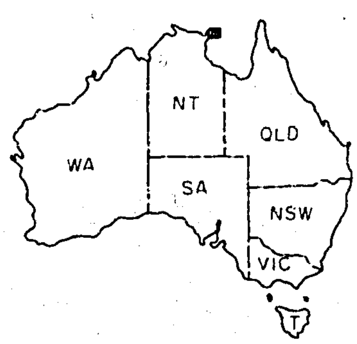
AIRBORNE SURVEY, McARTHUR BASIN, NT 1978

RADIOMETRIC CONTOURS
TOTAL COUNT

SCALE 1:1 000 000

10 0 10 20 30 40 50 km

LOCATION DIAGRAM

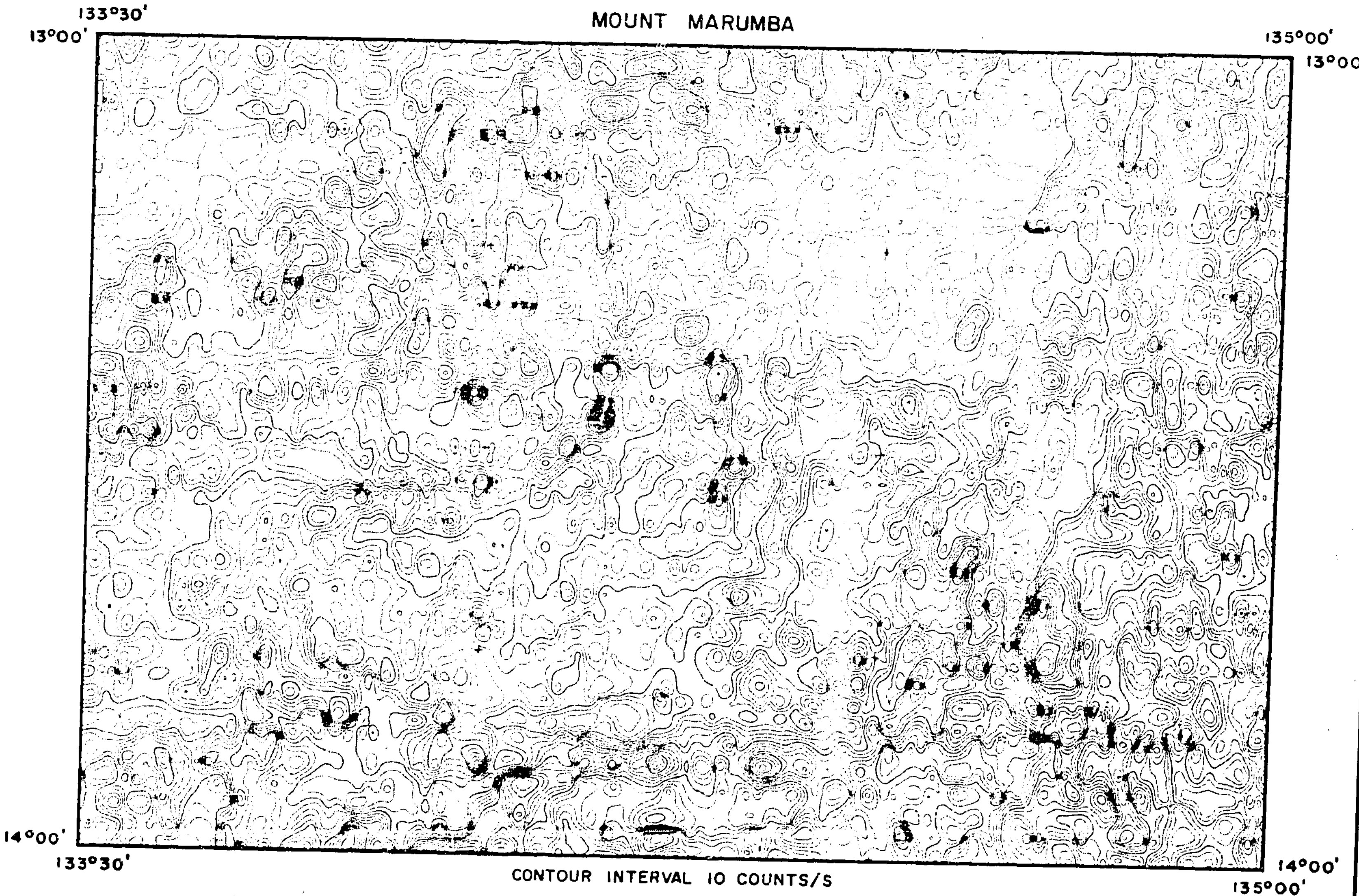


REFERENCE TO 1:250 000 MAP SERIES

WESSEL ISLANDS	TRUANT ISLAND	
ARNHEM BAY	GOVE	
BLUE MUD BAY	PORT LANGDON	

MA-29

MOUNT MARUMBA



CONTOUR INTERVAL 10 COUNTS/S

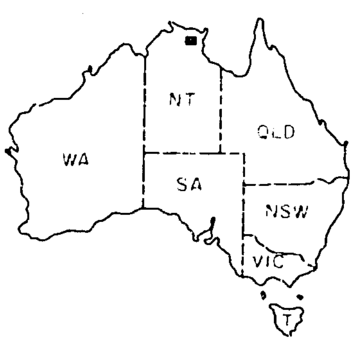
AIRBORNE SURVEY, McARTHUR BASIN, NT 1978

RADIOMETRIC CONTOURS
TOTAL COUNT

SCALE 1:1 000 000

10 0 10 20 30 40 50 km

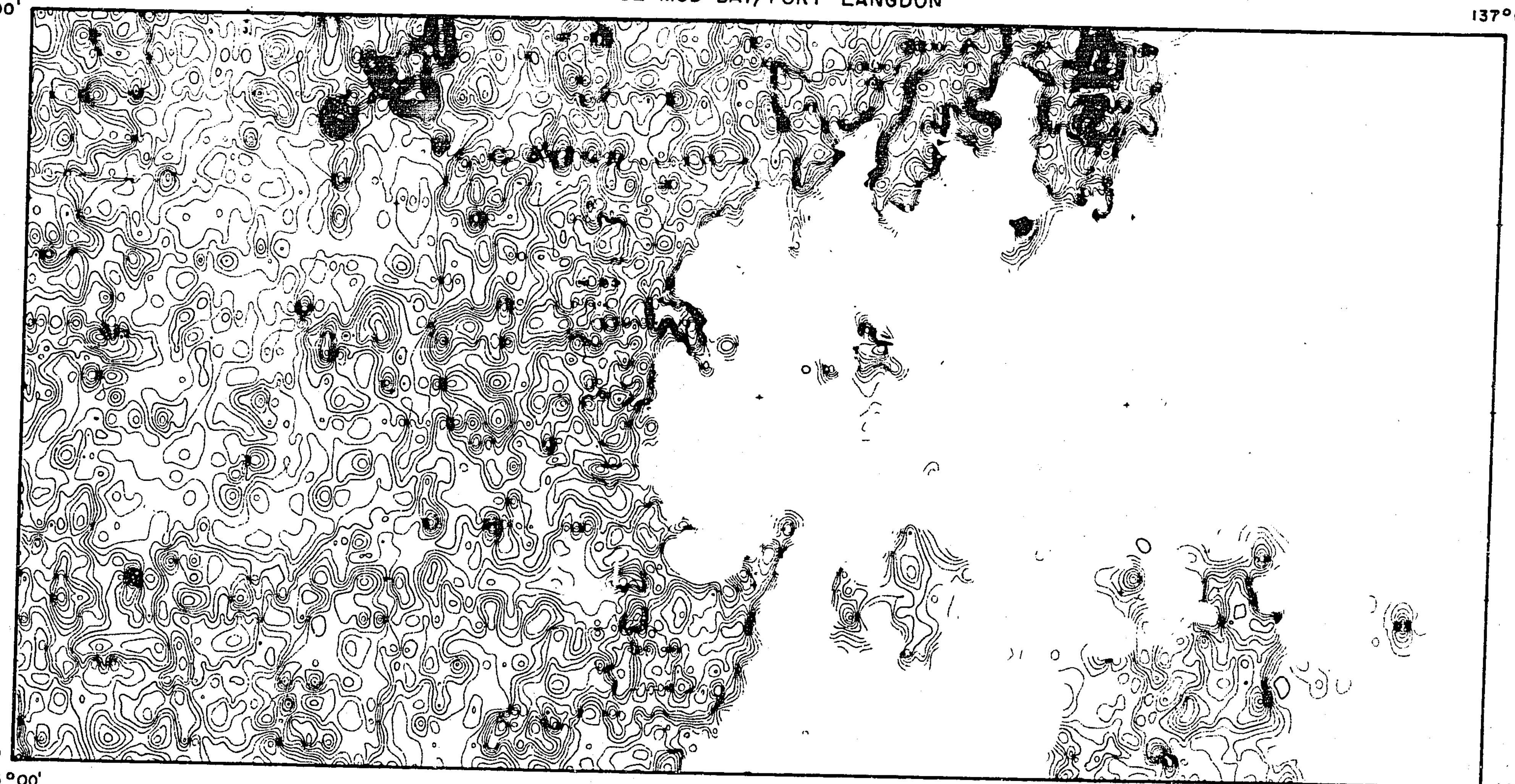
LOCATION DIAGRAM



REFERENCE TO 1:250 000 MAP SERIES

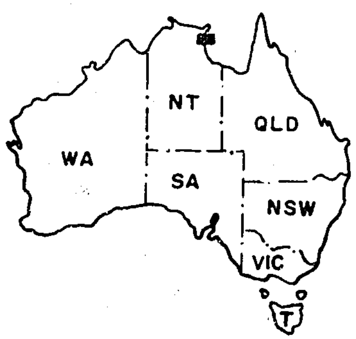
ALLIGATOR RIVER	MILINGIMBI	ARNHEM BAY
MOUNT EVELYN	MOUNT MARUMBA	BLUE MUD BAY
KATHERINE	URAPUNGA	ROPER RIVER

BLUE MUD BAY/PORT LANGDON



CONTOUR INTERVAL 10 COUNTS/S

LOCATION DIAGRAM



AIRBORNE SURVEY, McARTHUR BASIN, NT 1978

RADIOMETRIC CONTOURS TOTAL COUNT

SCALE 1:1000 000

10 0 10 20 30 40 50 km

REFERENCE TO 1:250 000 MAP SERIES

MILINGIMBI	ARNHEM BAY	GOVE
MOUNT MARUMBA	BLUE MUD BAY	PORT LANGDON
URAPUNGA	ROPER RIVER	CAPE BEATRICE

MA-30

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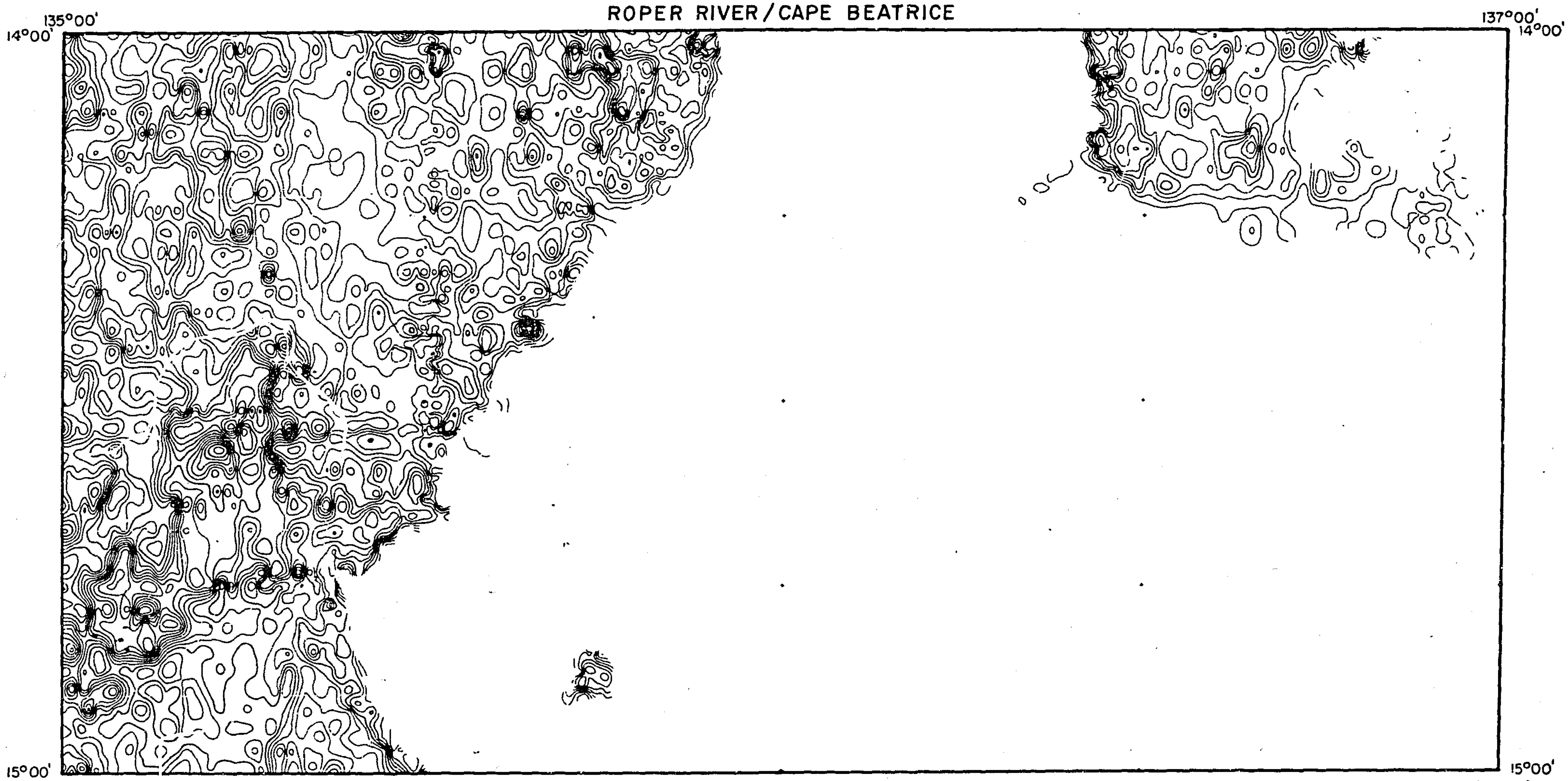
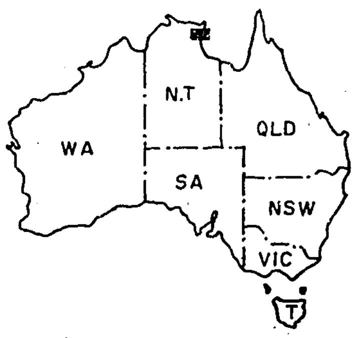
ROPER RIVER/CAPE BEATRICE



CONTOUR INTERVAL 10 COUNTS/S

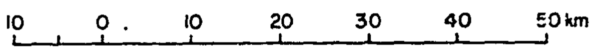
LOCATION DIAGRAM



AIRBORNE SURVEY, McARTHUR BASIN, NT 1978

RADIOMETRIC CONTOURS
TOTAL COUNT

SCALE 1:1 000 000



REFERENCE TO 1:250 000 MAP SERIES

MOUNT MARUMBA	BLUE MUD BAY	PORT LANGDON
URAPUNGA	ROPER RIVER	CAPE BEATRICE
HODGSON DOWNS	MOUNT YOUNG	PELLEW

MA-31

Record 1980/70, Report 231

D53/B1-232AR

Higher count rates are observed in a few areas and relate to particular rock formations, namely the granitic regions in northwestern and southwestern GOVE, the Spencer Creek Volcanics in northeastern ARNHEM BAY, the Fagan Volcanics in ARNHEM BAY and BLUE MUD BAY, and the Mangbalgarri Volcanic Member in MILINGIMBI.

Dubbo, Nyngan, and Gilgandra airborne magnetic and spectrometer survey, NSW, 1979 - preliminary data assessment (B. Wyatt)

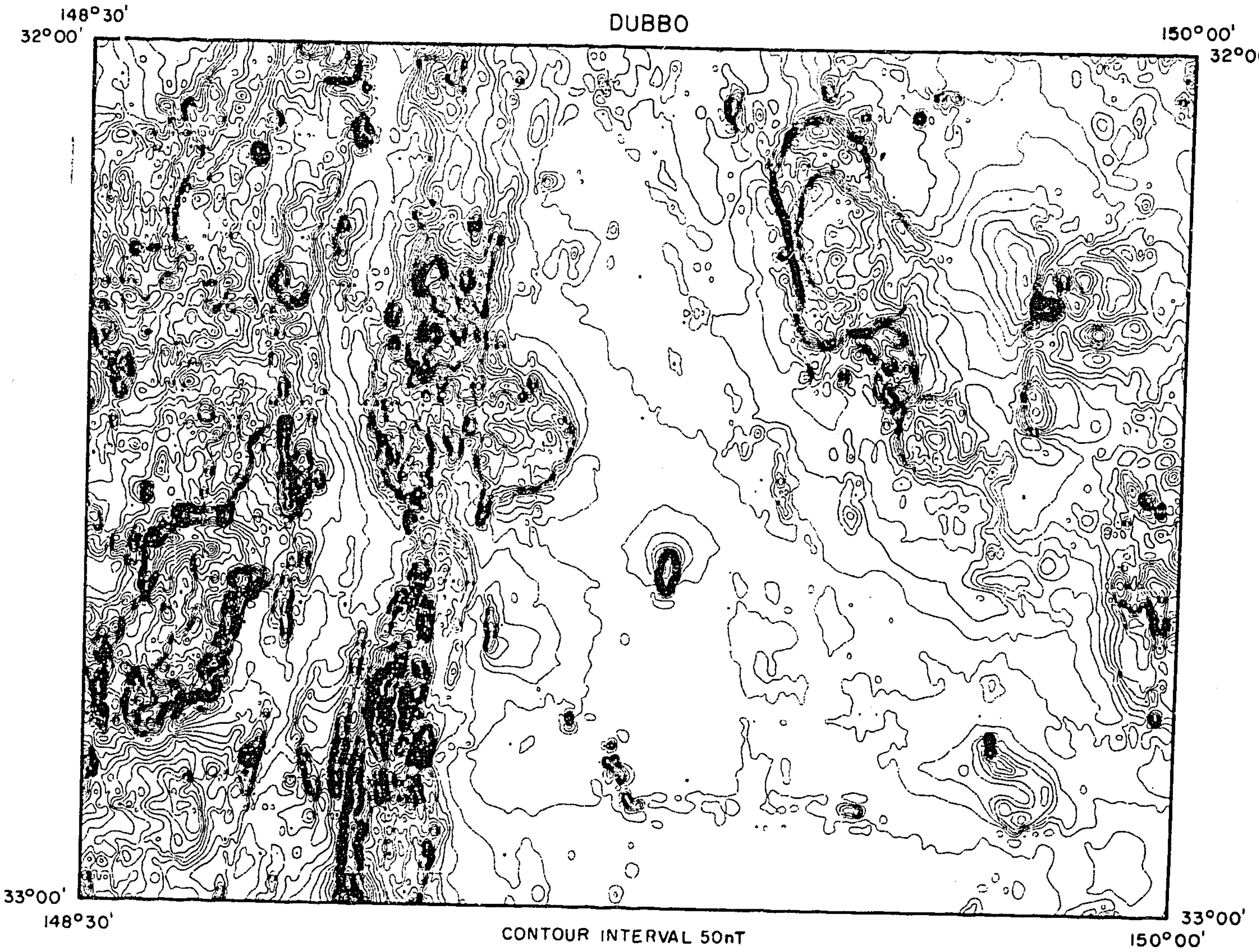
These data were processed during 1980, and public releases of results were made as they became available. Interpretation of the results is proceeding as part of the Lachlan Fold Belt Geophysical Project. The following summarises the findings to date.

Magnetic data. Rocks of the Lachlan Fold Belt form a magnetic basement in DUBBO, NYNGAN, and GILGANDRA. Magnetic trends vary from north to north-northwest in DUBBO (Fig. MA-32) and from north-northwest to northwest in NYNGAN (Fig. MA-33). These trends reflect magnetic volcanic markers within, and parallel to, Ordovician to Devonian sediments of the Tullamore Syncline, Cowra Trough, Molong Rise, and Hill End Trough.

The Lachlan Fold Belt rocks are covered on NYNGAN, most of GILGANDRA, and the northern and eastern parts of DUBBO by Quaternary alluvium, by flat lying quartzose sediments of the Sydney and Eromanga Basins, and by extensive areas of Tertiary igneous rocks including basalt, trachyte, and phonolite, and Jurassic volcanics. The basic rocks produce short wavelength, complex and isolated anomalies over extensive areas of GILGANDRA (Fig. MA-34), in the northwest of DUBBO, and in the southeast of NYNGAN. These anomalies tend to mask anomalies from deeper sources, but it is apparent that the Cowra Trough and Molong Rise continue north beneath the Sydney Basin for a few tens of kilometres into GILGANDRA. The Tullamore Syncline extends about 40 km north into NYNGAN.

Most granitoid plutons exposed on DUBBO are magnetic, giving rise to extensive, complex anomalies of several hundred nT amplitude. Magnetic anomalies imply the presence of extensive concealed granitoids in the northeast of DUBBO, 15 km northeast from Gilgandra, and in the central north of NYNGAN. It can also be inferred that the Yoeval and Gulgong plutons each consist of several different phases and that many of the granitoids are of limited depth extent.

MA-32



AIRBORNE SURVEY, DUBBO, NSW 1979

TOTAL MAGNETIC INTENSITY

SCALE 1:1 000 000

10 0 10 20 30 40 50 km

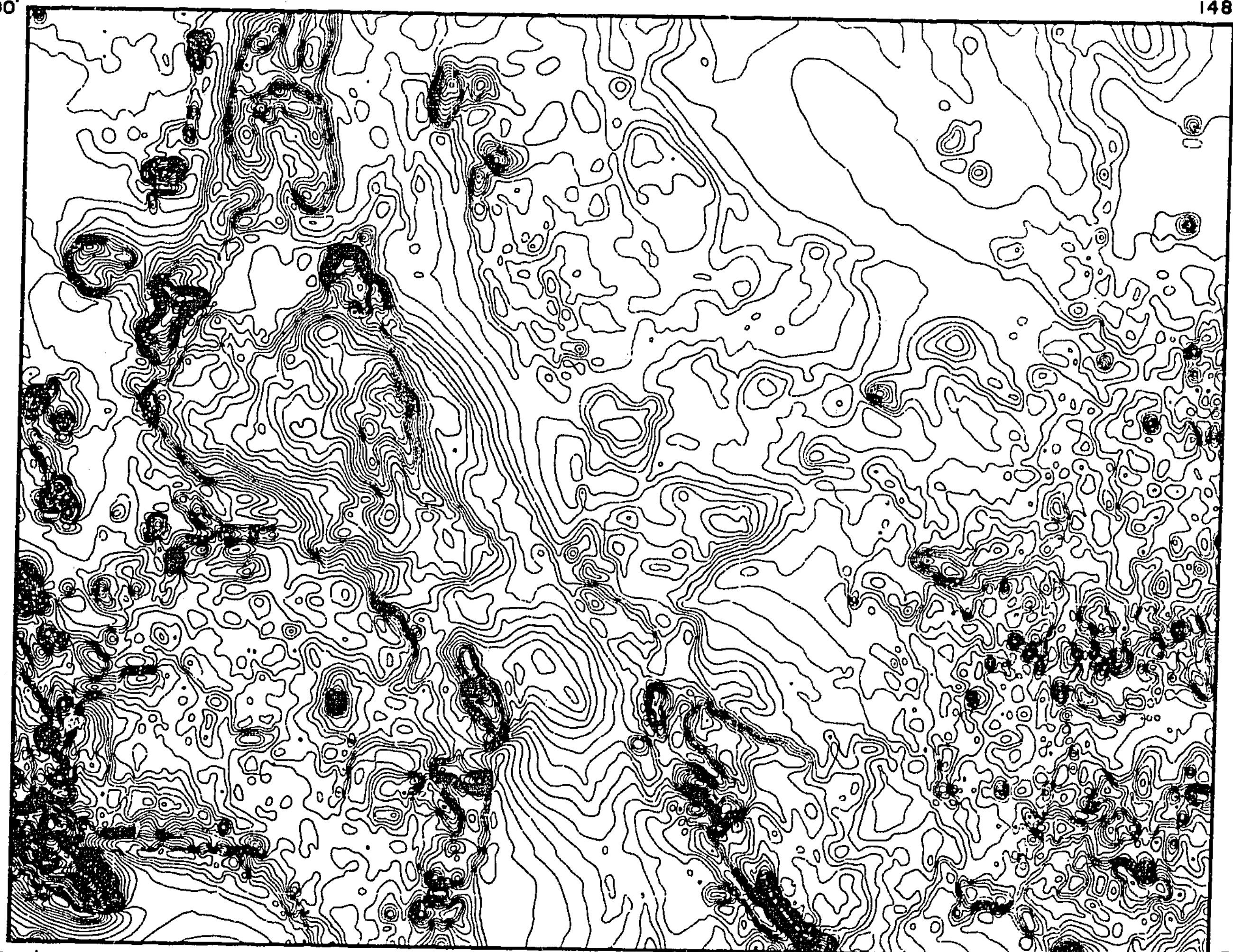
LOCATION DIAGRAM

REFERENCE TO 1:250 000 MAP SERIES

NYNGAN	GILGANDRA	TAMWORTH
NARROMINE	DUBBO	SINGLETON
FORBES	BATHURST	SYDNEY

MA-33

NYNGAN



CONTOUR INTERVAL 50 nT

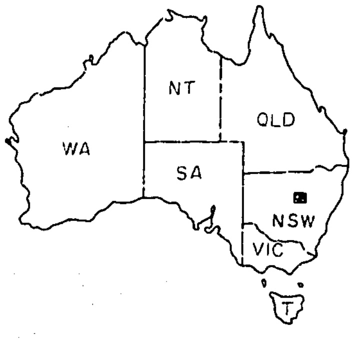
AIRBORNE SURVEY, NYNGAN, NSW 1979

TOTAL MAGNETIC INTENSITY

SCALE 1:1000 000

10 0 10 20 30 40 50 km

LOCATION DIAGRAM



REFERENCE TO 1:250 000 MAP SERIES

BOURKE	WALGETT	NARRABRI
COBAR	NYNGAN	GILGANDRA
NYMAGEE	NARROMINE	DUBBO

MA-34

AIRBORNE SURVEY, GILGANDRA, NSW 1979

TOTAL MAGNETIC INTENSITY

SCALE 1:1000 000

10 0 10 20 30 40 50 km

LOCATION DIAGRAM

REFERENCE TO 1:250 000 MAP SERIES

WALGETT	NARRABRI	MANILLA
NYNGAN	GILGANDRA	TAMWORTH
NARROMINE	DUBBO	SINGLETON

The largest (amplitude) anomalies occur in the western third of NYNGAN, and are presumably caused by extensive areas of concealed ultrabasics and basics related to the serpentinites and hornblendite which crop out on the eastern edge of COBAR, and the pyroxenite and diorite intrusives in western NARROMINE. These large anomalies are coincident with well-defined, positive Bouguer anomalies, and should be investigated for possible precious and base metal mineralisation, particularly copper and gold.

The thickness of post Lachlan Fold Belt cover is less than 200 m over most of the area. The sources of some anomalies in north NYNGAN and GILGANDRA occur at a maximum depth of several hundred metres.

Radiometric data. Higher radioactivity is associated with the extensive area of trachyte in the Warrumbungle Range west of Coonabarabran and with igneous rocks of the Lachlan Fold Belt.

In DUBBO (Fig. MA-35), the most radioactive units are the Gulgong granite, Dulladerry rhyolite, Canowindra porphyry, Yoeval granite, Rylestone tuff, isolated outcrops of Cainozoic trachyte south of Dubbo and northeast from Mudgee, and several small granitoid plutons. Linear anomalies over the Hill End Trough and Cowra Trough delineate acid volcanics within the sedimentary sequence. Different phases within the Gulgong granite and Yoeval granite are indicated by variations in total radioactivity as well as different relative concentrations of potassium, uranium, and thorium. Radioelement ratio anomalies also clearly delineate the Wuuluman granite, Burranah Formation, drainage features, linear trends within the Molong Rise, and the extent of the Sydney Basin rocks.

Higher radioactivity is recorded over Lachlan Fold Belt igneous outliers at Mount Foster and Mount Harris in NYNGAN, north of Coonabarabran, and in the southern part of GILGANDRA (Fig. MA-36). The extensive area of potassium-rich trachyte in the Warrumbungle Range produces a striking radioactivity contrast with the Sydney Basin sediments. Drainage-channels off these rocks also produce well-defined anomalies of lesser amplitude. Small phonolite and trachyte intrusives in the northeast of GILGANDRA are defined by several high amplitude anomalies. In southeast GILGANDRA a slight contrast exists between the Tertiary basalt flows and Sydney Basin sediments.

Small but well defined changes in gamma radiation levels indicate northwesterly trending boundaries which extend for tens of kilometres across NYNGAN. Some of these changes follow drainage channels while others reflect differences in composition of the Quaternary alluvial cover. A belt of very low radiation follows a series of State forests northwest from Gulargambone in the northeast of NYNGAN.

MA-35

CONTOUR INTERVAL 20 COUNTS/S

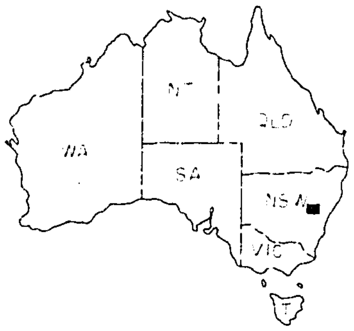
AIRBORNE SURVEY, DUBBO, NSW 1979

RADIOMETRIC CONTOURS
TOTAL COUNT

SCALE 1:1 000 000

10 0 10 20 30 40 50 km

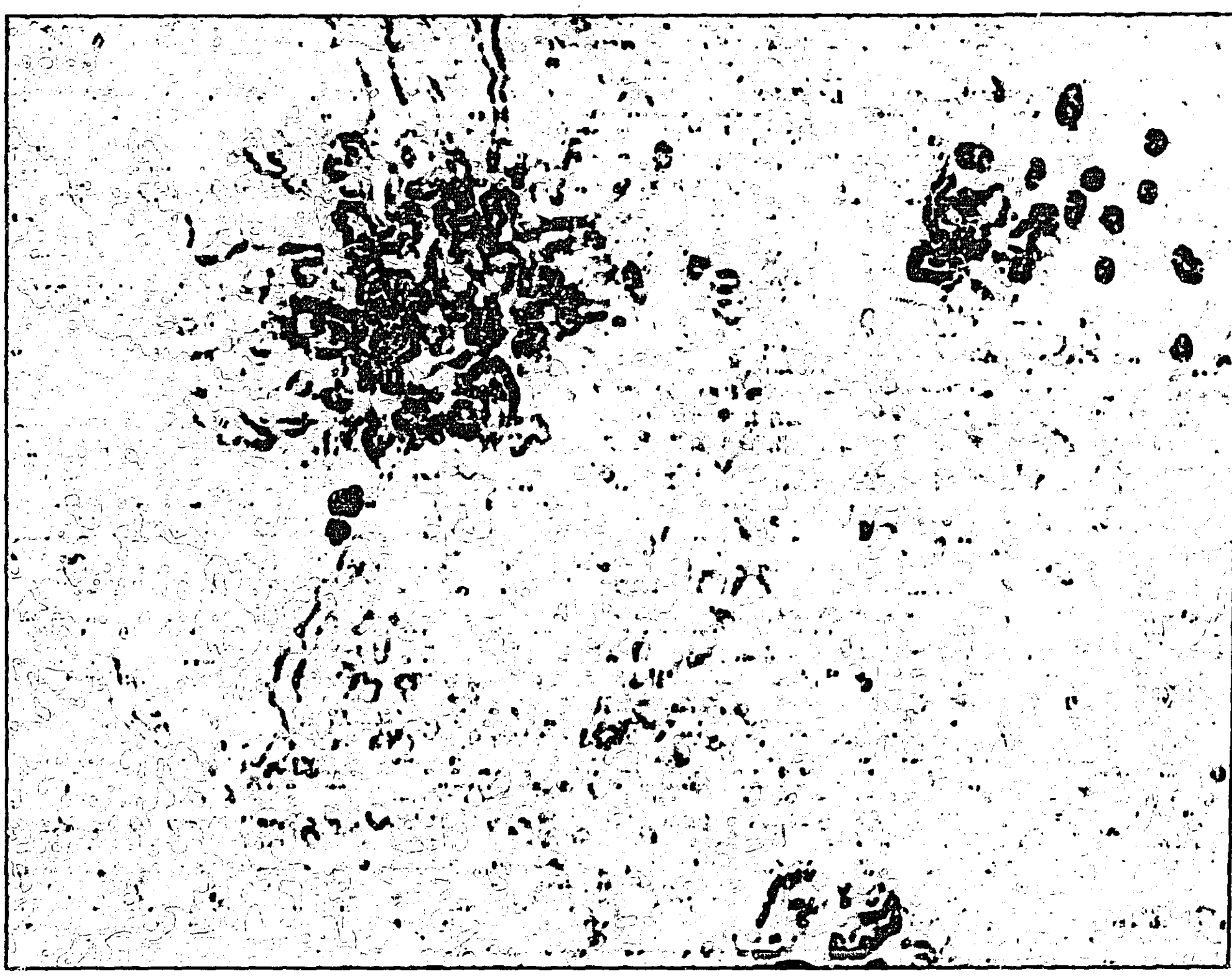
LOCATION DIAGRAM



REFERENCE TO 1:250 000 MAP SERIES

NYNGAN	GILGANDRA	TAMWORTH
NARROMINE	DUBBO	SINGLETON
FORBES	BATHURST	SYDNEY

MA-36



CONTOUR INTERVAL 10 COUNTS/S

AIRBORNE SURVEY, GILGANDRA, NSW 1979

RADIOMETRIC CONTOURS
TOTAL COUNT

SCALE 1:1000 000

0 10 20 30 40 50 km

LOCATION DIAGRAM

REFERENCE TO 1:250 000 MAP SERIES

WALGETT	NARRABRI	MANILLA
NYNGAN	GILGANDRA	TAMWORTH
NARROMINE	DUBBO	SINGLETON

AIRBORNE REDUCTIONS AND CONTRACTS GROUP (C. Leary, S. Sheard, I. Zadoroznyj, N. Sampath, A. Luyendyk, D. Souter, P. O'Rourke, P. Black).

Airborne data processing

The status of data processing, mapping, and mapping releases for 1980 is shown in Table MA-2. During the year, work commenced or continued on data sets for 24 1:250 000 Sheet areas; 14 of these were processed to completion. The total output was 95 geophysical maps, of which 60 were released through the Australian Government Printer Copy Service and a further 14 will be released early in 1981. A further 21 radiometric ratio maps are available from BMR on application. Data processing on 3 1:250 000 sheets will continue into 1981, and data for 6 areas await processing in 1981. Total count and total magnetic intensity contours at 1:1 000 000 scale are shown in Figure MA-18 and in Figures MA-20 to MA-37.

Supply of data to outside users

During the period January-October 1980, there were 26 requests from 13 organisations for access to, or microfilm copies of, the analogue data for a total of 103 1:250 000 Sheet areas. The requests were for data on 38 Sheets in WA, 33 Sheets in NT, 14 Sheets in Queensland, and 18 Sheets in SA. To date these requests have been satisfied to the extent of 28 Sheets in WA, 16 Sheets in NT, 7 Sheets in Queensland, and 5 Sheets in SA.

For the same period there have been 28 requests from 13 organisations for copies of digital survey data for a total of 97 1:250 000 Sheet areas. The requests were for 40 Sheets in WA, 22 Sheets in NT, 9 Sheets in Queensland, 14 Sheets in SA, 7 Sheets in Victoria, and 5 Sheets in NSW. Data were supplied for 71 Sheet areas. The data most frequently sought were for Albany-Fraser Block, Eucla Basin, Officer Basin, and McArthur Basin.

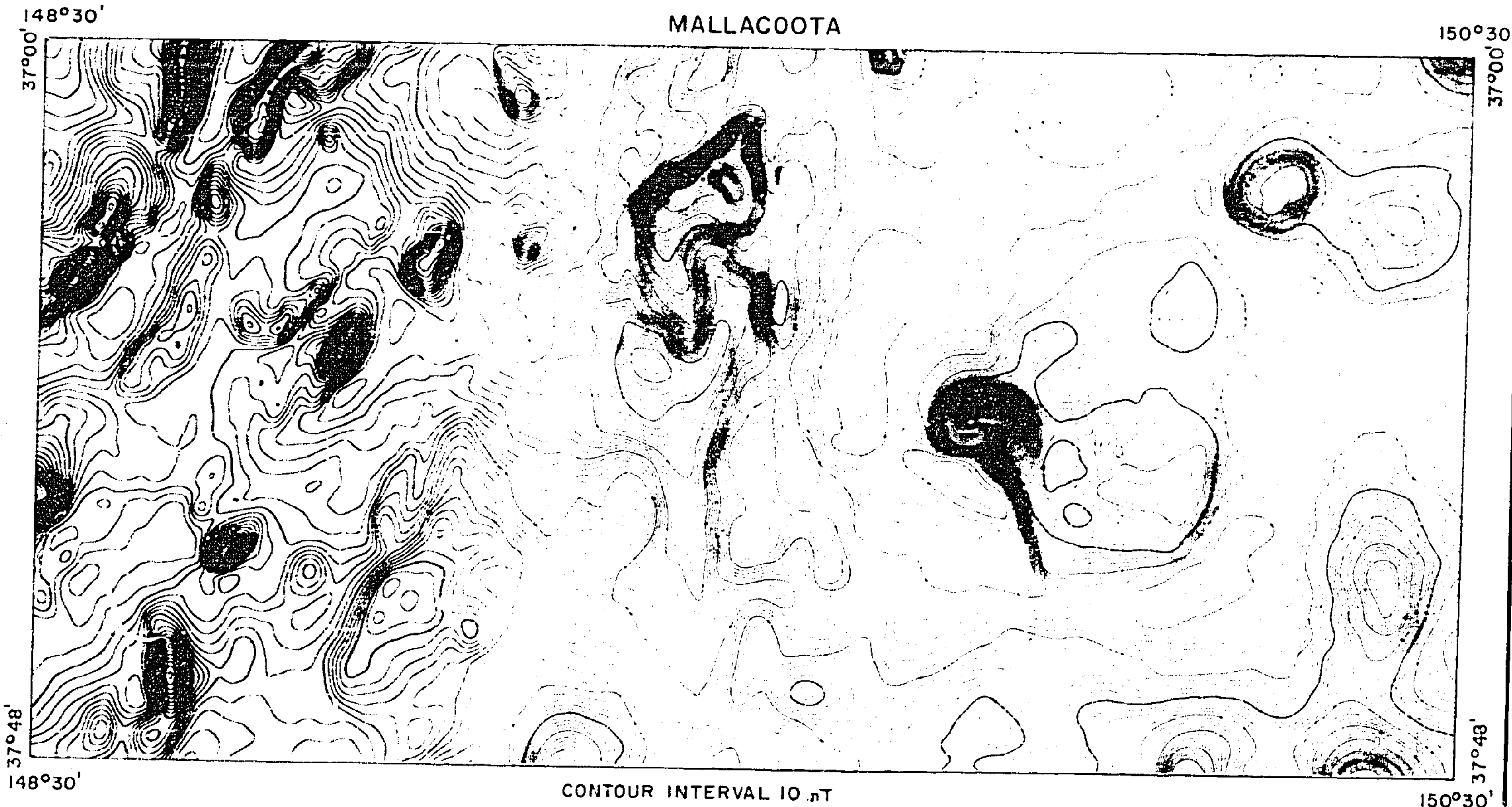
Two maps have been produced which display the availability of digital magnetic and radiometric data for Australia (see Figs. MA-38 and MA-39).

Airborne A.D.P. system development

Major program developments were undertaken in the following areas:

1. a review of the gridding/contouring programs was undertaken, and a decision made to rewrite them. Design and development of these programs continued throughout the year, the new gridding program being almost completed.

MA-37



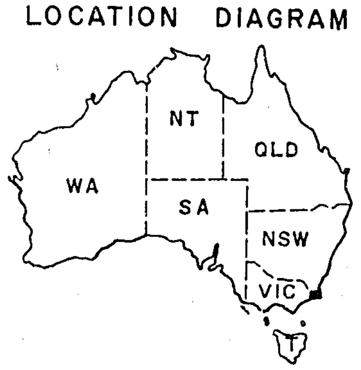
AIRBORNE SURVEY, MALLACOOTA, NSW, VIC 1977/79

TOTAL MAGNETIC INTENSITY

SCALE 1:1 000 000

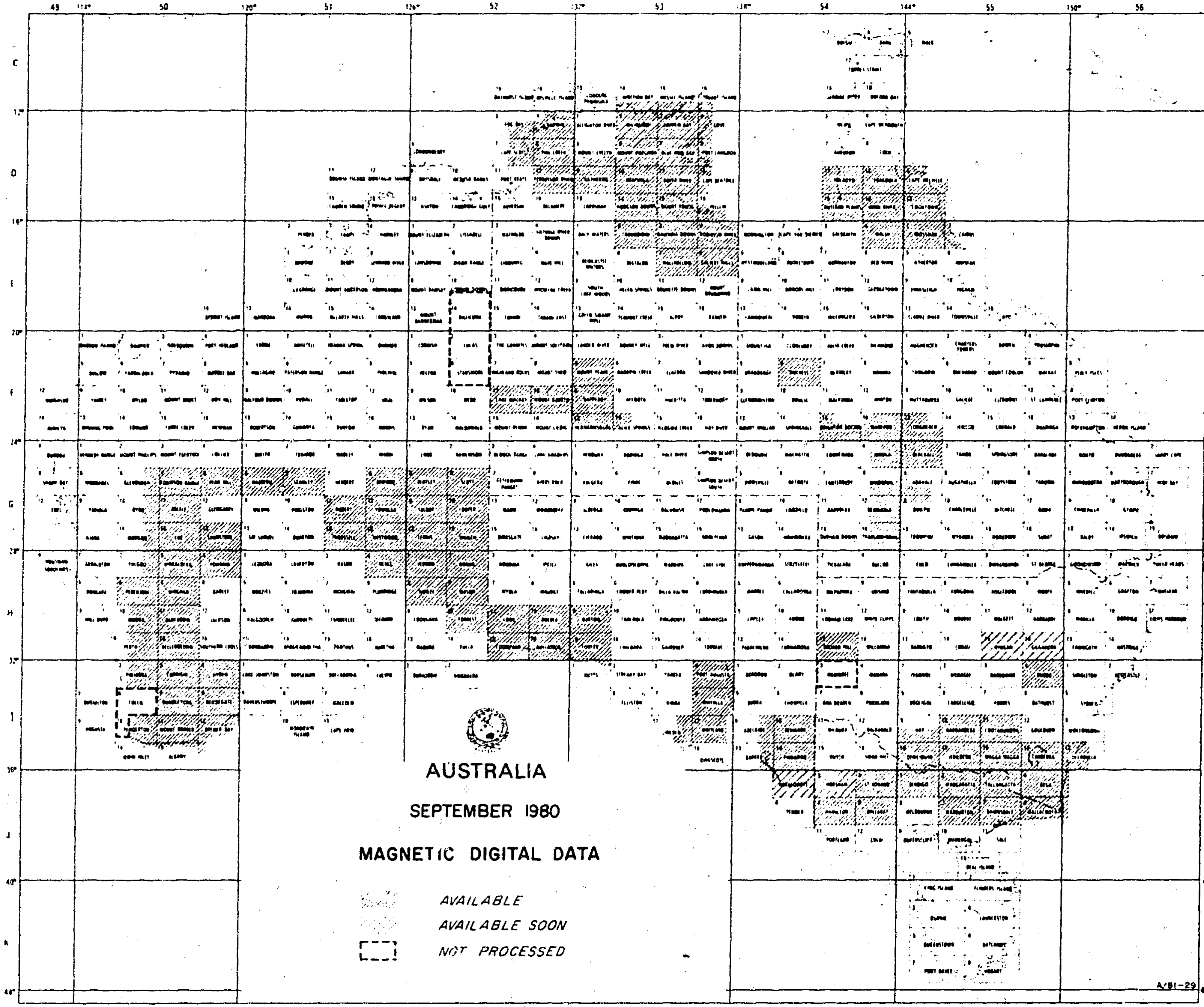
10 0 10 20 30 40 50km

LOCATION DIAGRAM



REFERENCE TO 1:250 000 MAP SERIES

TALLANGATTA	BEGA	
BAIRNSDALE	MALLACOOTA	
SALE		



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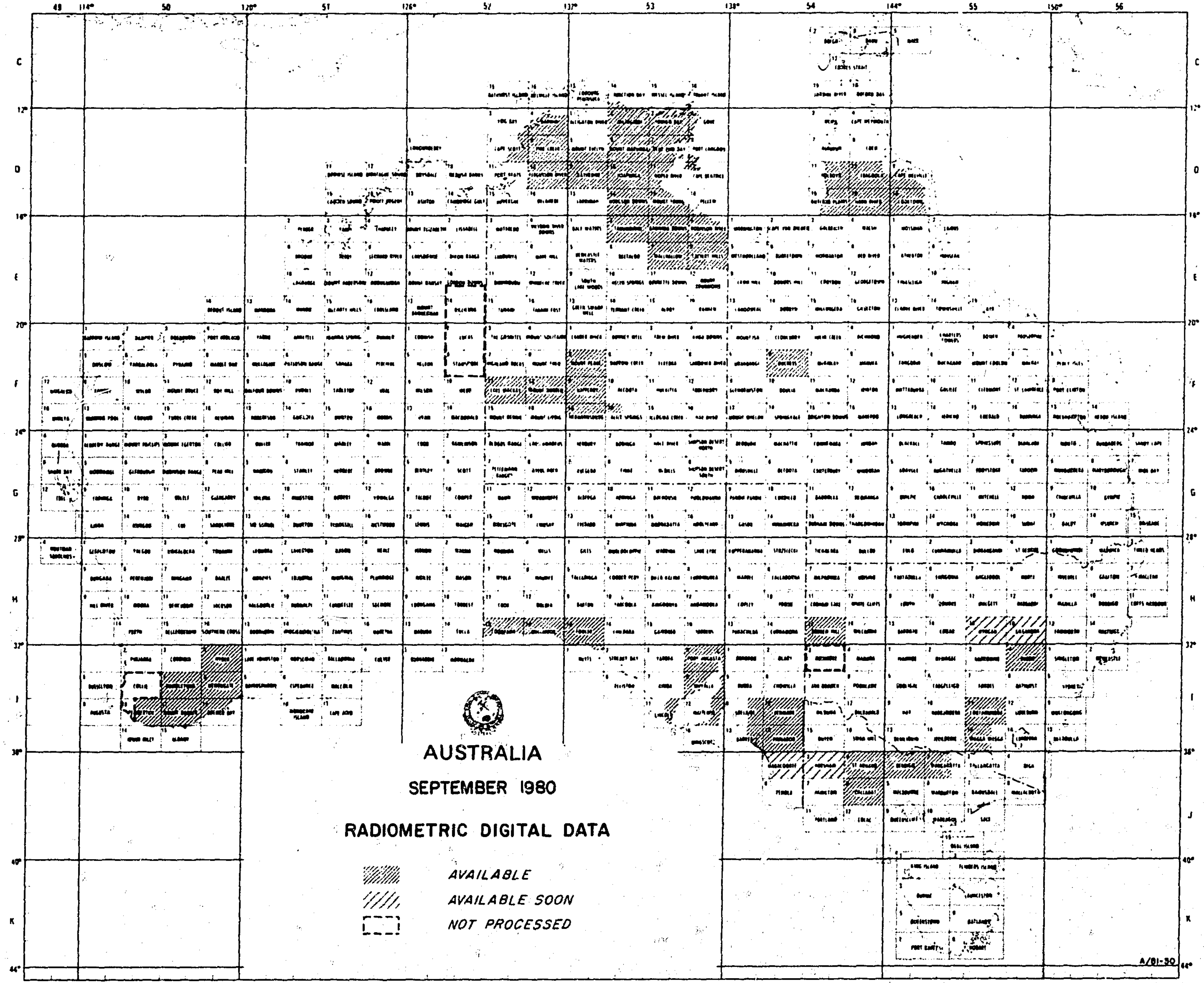
A/BI-29-1A

MA-38



A/81-30-1A

MA-39

2. the old gridding program was modified so that, in conjunction with other programs, filtering processes could be carried out on the surfaces.
3. a program to extract parts of existing data channels from specified lines was developed. This allows selected parts to be subjected to "specialised" processing without affecting the original data.
4. to enable approximate stacked profiles to be produced for the field party during a survey, a program was written to generate, artificially, navigation data based on the proposed flight path for the survey. Such maps are not available for public release.
5. owing to repeated errors being encountered in diurnal and background measurements, a program was developed to validate all such measurements.
6. a series of console programs was developed to allow users to interactively submit standard jobs to CSIRO's computer.
7. a library of repeatedly used job-control statements was created to simplify processing using CSIRO's computer.

Airborne data conversion project (R. Wells)

This project was mounted to convert airborne magnetic data recorded during the 1960s on 5-hole paper tape to the format currently used in BMR aircraft, and to transfer these data to magnetic tape so that they can be accessed by the ARGUS processing system and made available to the public.

In 1979 an SCM paper-tape reader was interfaced to the HP 2114 computer in use by the Observatory Section. This enabled the 5-hole paper-tape data to be copied to magnetic cassette, and then accessed by the HP 2100 computer in BMR and stored as a disc file. During 1980 a program (PT5) was written which reformats these data, removes backing-off steps, and carries out checks for data errors.

Samples of data flown during 1961 and 1962 have been processed in this manner. The results indicate that much of it was corrupted by intermittent failure of the paper-tape punches used at that time. As time permits, data flown in 1963 to 1965 with improved tape punches will be similarly tested. At this stage none of the digital data recorded on 5-hole paper tape is available for public release in either its original, or reformated forms.

Upgrading of equipment systems in aircraft VH-BMG (D. Downie, G. Green)

The doppler navigation system and the gamma-ray spectrometer system were both upgraded in March, during the preparation for the Canning Basin airborne survey.

A Sperry C12 compass was installed to provide a more accurate and stable heading reference for the Marconi doppler navigation system than that provided by the Sperry C14 compass previously in use. Preliminary field tests during the flying of the Canning Basin survey indicate that the system is capable of a high degree of accuracy. However, occasional erratic performance was experienced, the cause of which has yet to be determined. A 256-channel digital analyser was also installed in the gamma-ray spectrometer system in April to replace the analogue pulse-height analysers previously in use.

Further details of these system changes are included in the Annual Summary of the Operations Branch; the Operations Branch was responsible for the equipment interfacing and the development of new software for the aircraft's data acquisition computer system.

Sedimentary basins aeromagnetic coverage review (K. Horsfall, J. Rees, S. Wilcox)

A review of the aeromagnetic coverage of all Australian sedimentary basins was made in order to establish the areas where the existing coverage and/or interpretation was inadequate. The review examined data flown by BMR (including BMR contracts) and data acquired by BMR under the Petroleum Search Subsidy Act (PSSA).

In assessing the existing data, the following were compiled for each basin area:

(i) an aeromagnetic contour map, at a scale of 1:1 000 000.

(ii) a composite 1:1 000 000 scale depth to magnetic basement map, compiled from company and BMR interpretation reports

(iii) details of the flight-line spacing, flying altitude, data quality, data type (digital or analog), data availability, and mapping.

The data were examined to determine whether they meet the present BMR standard for line density (commonly 3 km) and data quality.

It was found that in some cases, the flight-line separation was too wide to allow a reliable contour presentation to be made. In other cases the data were of poor quality or were not available. In such cases it was recommended that the areas be reflown. The highest priority for the reflying was given to areas where no coverage existed (neither BMR nor PSSA). Areas covered by broadly spaced traverses were given the next highest priority. The third priority was given to areas where aeromagnetic contour maps had been produced but the original raw data are not held by or accessible to BMR.

In addition to the regional aeromagnetic coverage, areas of special interest were examined with the aim of solving specific geological problems. The Central Eromanga Basin was one such area, and further collection of aeromagnetic data was recommended. For 1981, an orientation survey has been proposed along some of the 1980 BMR seismic traverses. This work will be directed at a study of small amplitude magnetic anomalies (5 nT) which may prove useful in the determining of structure in the eastern Cooper Basin and Canaway Ridge area. A more detailed account of the Central Eromanga Basin study is included in another section of this Report.

A report on the findings of this project is in production and will become available for inspection at BMR early in 1981.

Airborne A.D.P. applications (J. Rees)

Investigations into techniques of data analysis and interpretation were constrained by other priorities throughout the year. Items dealt with in applications design, development, and evaluation included:

- improvements in the design of filter operators to perform continuation, vertical derivatives, and reduction to the magnetic pole;
- operator design to improve the quality of magnetic and spectrometer data;
- a program to perform two-dimensional spectral analysis and presentation; and
- implementation of multivariate classification schemes and presentation techniques for the analysis of airborne gamma-ray spectrometer data.

Ad-hoc support and advice were provided on analysis and interpretation of aeromagnetic and spectrometer data for the Lachlan Fold Belt, Amadeus Basin, and Central Eromanga Basin projects. Assistance was given to training overseas students in airborne interpretation techniques. Numerous discussions were held with data acquisition and data processing contractors and visiting geophysicists.

Ulladulla aeromagnetic data - downward continuation (J. Rees)

A request was received from the Royal Australian Navy in March 1980 for detailed information on the Earth's magnetic field at sea level in an area offshore from Ulladulla. This request was attended to by carrying out a downward continuation of the magnetic field mapped by BMR in 1976 from a survey flown at 1100 m above sea level along lines flown 3 km apart with data sampling at 50 m.

After smoothing the original data with a low-pass filter, with a cutoff at 0.334 cycles per km to avoid aliasing, the data were sampled at 1500 m intervals for interpolation onto a regular grid with 500 x 500 m cells. This surface was smoothed with a two-dimensional low-pass filter of 21 x 21 coefficients, with cutoff frequencies at 0.5 cycles per km in the east-west direction and 0.36 cycles per km in the north-south direction, designed with a narrow stop band to suppress spurious east-west trends caused by positioning, levelling, and gridding problems.

Radially-symmetric downward continuation operators were designed in the frequency domain using a modified version of Fuller's (1967) method. Figure MA-40 (c) and (d) illustrate the results obtained with particular reference to the effect of varying high frequency suppression (fc). Figure MA-40 (a) illustrates the original data.

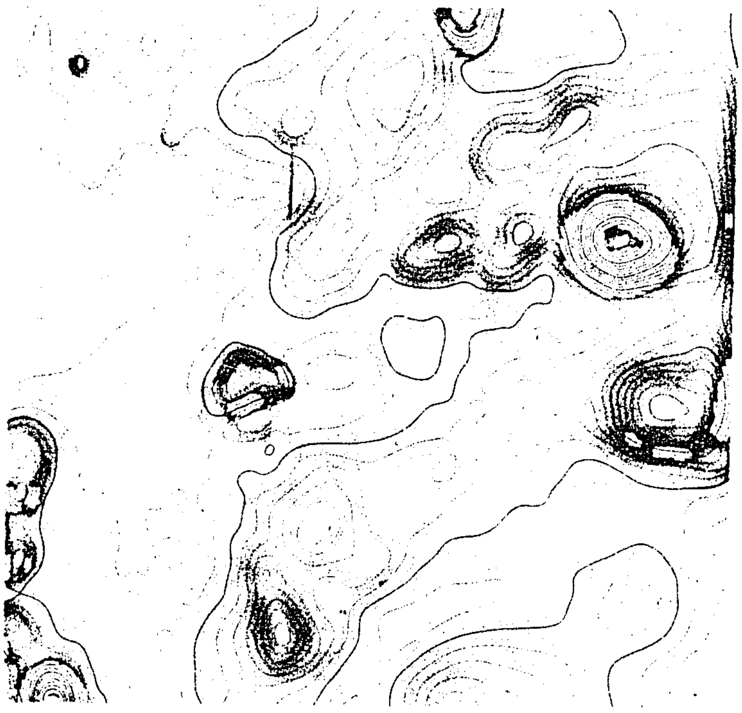
Western coalfields project (J. Rees)

In early 1979, BMR in conjunction with CSIRO commenced a project to evaluate the use of airborne magnetic and remote-sensing methods to delineate basement features and relate them to structures observed in the coal measures over a portion of the Western Coalfields area in NSW. Following survey work and basic data processing in 1979, BMR completed its part in the project in June 1980 with a contribution to the final interpretation. This involved further processing of aeromagnetic data used to study lineament correlation and basement composition and structure.

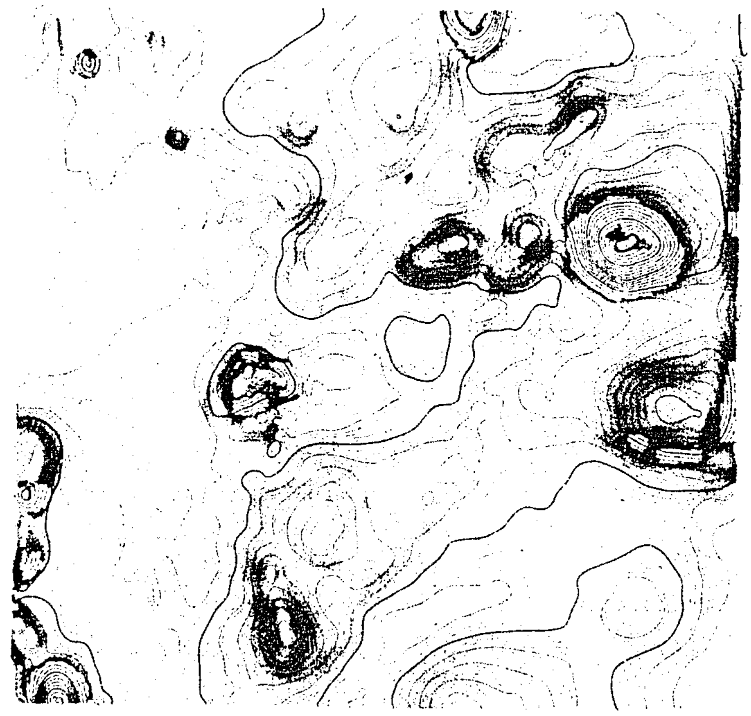
The final report to NERDDC (National Energy Research and Development Demonstration Council) on this project is being compiled by CSIRO and will include the results of aeromagnetic, Landsat, drilling, and geological mapping. It should be completed by early 1981.

A paper on the results of aeromagnetic data processing is in preparation for the BMR Journal.

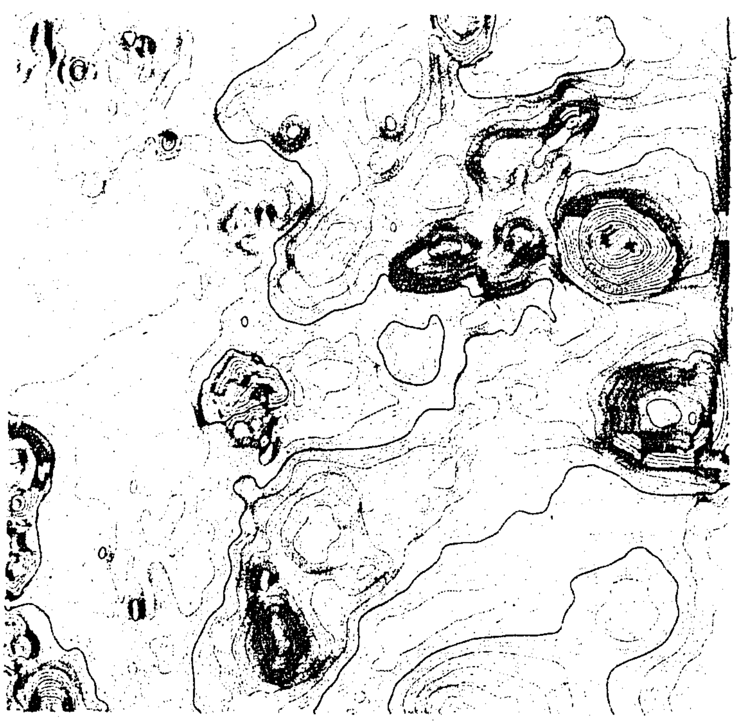
MA-40



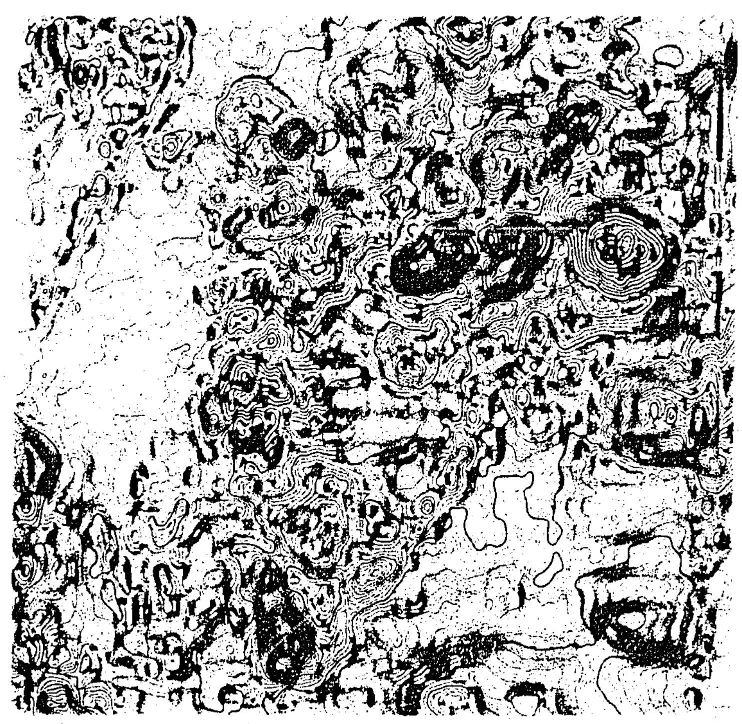
(a) 1100m asl-original data



(b) 600m asl-15x15 coefficients
-fc=0·45 per km



(c) Sea Level-15x15 coefficients
-fc=0·45 per km



(d) Sea Level-21x21 coefficients
-fc=0·8 per km

DOWNWARD CONTINUATION-ULLADULLA AEROMAGNETIC DATA

CONTOUR INTERVAL 10nT

0 10 20 30 40 50km

ADAB - Foreign Affairs - consulting (J. Rees)

Negotiations were completed with the Philippines Government in Manila during February to finalise the terms and conditions of the proposed 5 year Uranium Exploration Training Program. A report analysing costs and bilateral funding arrangements was prepared for the Australian Development Assistance Bureau (ADAB).

Ad-hoc advice was given to ADAB throughout the year to assist in the preparation of the terms of reference for the project management contract.

Yilgarn Block radiometric study (J. Mulder, G. Young)

Prior to 1964, the only presentation of airborne radiometric data acquired by BMR over the Yilgarn Block was in the form of marked locations of localised sources of radioactivity on total magnetic intensity contour maps. After 1964, radiometric data from all surveys have been processed to enable total count contour maps to be published, a factor which contributed to the discovery of the Yeelirrie uranium orebody in northeast SANDSTONE.

The first objective of this project is to complete the systematic contour presentation of data over that part of the Yilgarn Block for which radiometric results are available. Figure MA-41 illustrates the form of data presentation involved. During 1980, results from BYRO (east), BELELE, MURGOO (east), CUE, YALGOO (east), KIRKALOCKA, and BARLEE were added, and are available for inspection at BMR.

It is expected that processing of data between latitudes 30°S to 33°S will be completed during 1981 and 1982, after which time, limited gamma-ray spectrometer surveys will be carried out to aid the interpretation of the more outstanding regional total-count anomalies.

MA-41

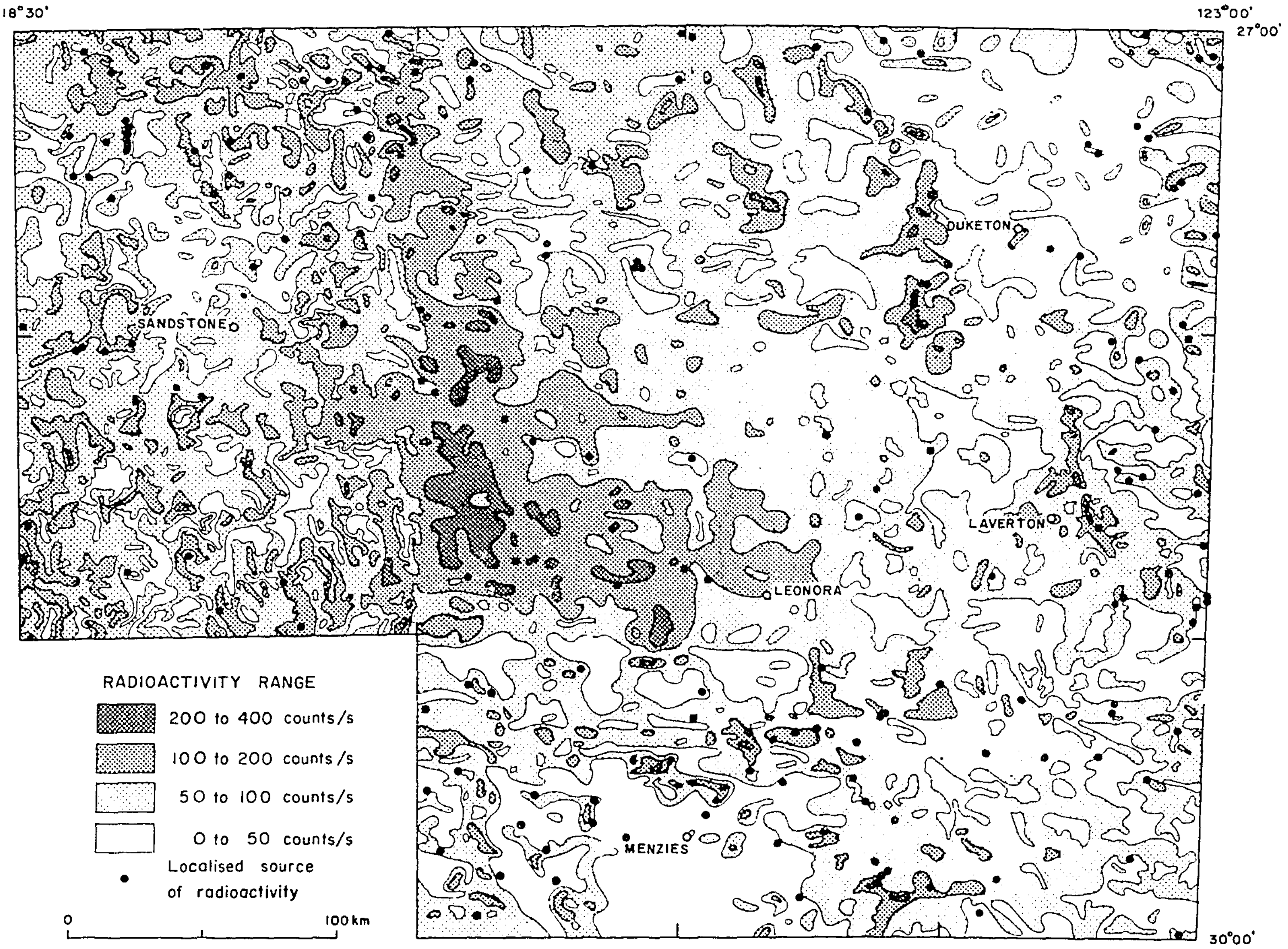
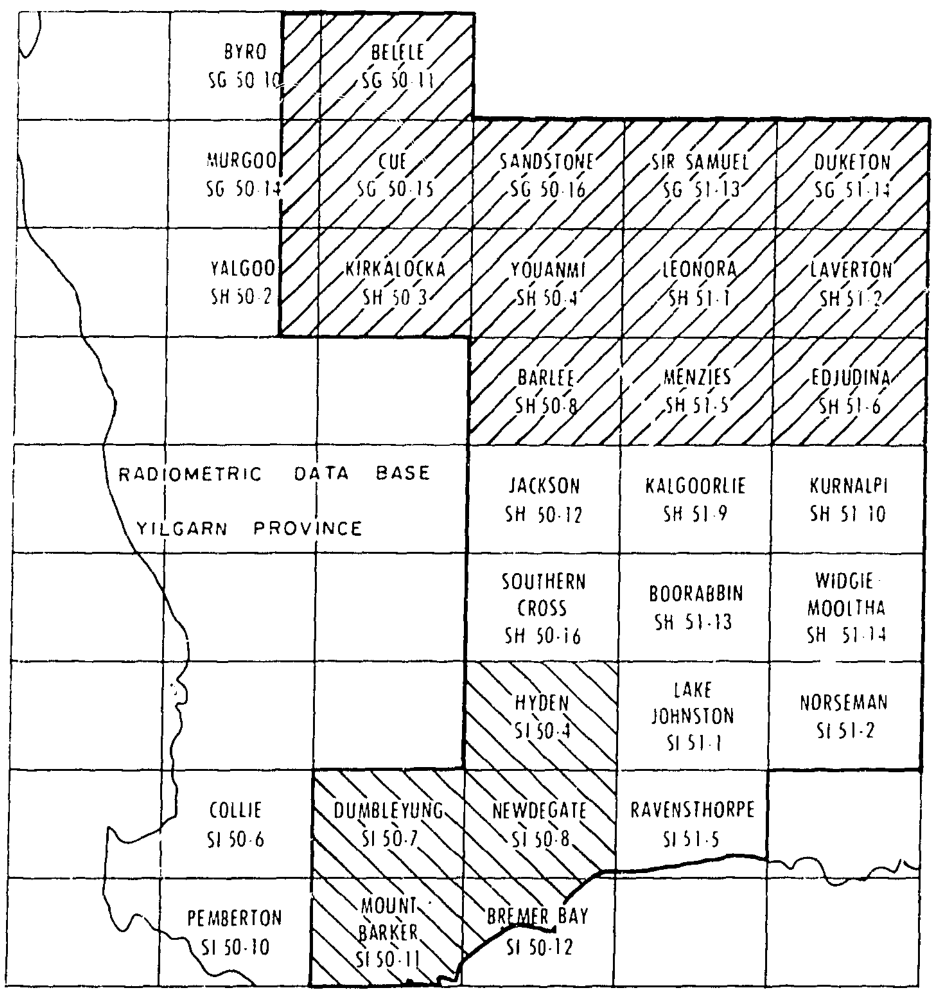


Figure Anomalies and contours of radioactivity, Murchison and North Coolgardie gold fields. From BMR Record 71/78



Sheet areas with total count radiometric contours derived from analogue data available for inspection.

Sheet areas with total count radiometric contours derived from digital data available for inspection.

2. SEISMIC, GRAVITY, AND MARINE SECTION

(A. Turpie)

SEISMIC AND GRAVITY SURVEYS (F.J. Moss)

The areas concerned in the work of the seismic and gravity groups are shown in Figure SGM-1.

Central Eromanga Basin seismic and gravity surveys, 1980 (J. Pinchin, S.P. Mathur, M.J. Sexton, K. Wake-Dyster, O. Dixon (GSQ), J.K.C. Grace, D. Gardener, D. Pfister, G. Price, R.D.E. Cherry, L.A. Rickardsson, D.K. McIntyre, A.C. Takken, J.A. Somerville, J.A. Bauer, F.J. Taylor, F.J. Moss, W. Anfiloff)

The broad objectives for seismic and gravity surveys in the central Eromanga Basin area and the preparatory review work undertaken during the first half of 1980 are outlined in BMR Records 1980/32 and 1980/60. Studies relating to the seismic reflection and gravity work are discussed in detail in the multidisciplinary studies summary.

Seismic traverses recorded in the central Eromanga Basin area in the July-November period are shown in Figure SGM-2. The shot-program consisted of three regional east-west traverses, each about 150 km long, and some short north-south and east-west lines tied to previous company seismic surveys and petroleum exploration wells. The traverses were shot mainly using 6-fold CDP recording techniques with a 48-channel DFS IV system with 83 1/3-m geophone station interval, 16 geophones per station, and single shot holes to 40 m deep. Parts of some traverses, particularly the western part of Traverse 1 towards Mt Howitt 1, were shot with 41 2/3-m geophone station interval and correspondingly closer shots in attempts to obtain higher resolution seismic data over several possible faults within the Eromanga sequence as interpreted from studies of Landsat imagery.

Reflection recordings were made to 20s record-time in attempts to obtain deep crustal and upper mantle reflection information.

Gravity measurements were made along the BMR seismic traverses and along petroleum exploration company seismic lines in order to extend the reconnaissance gravity coverage.

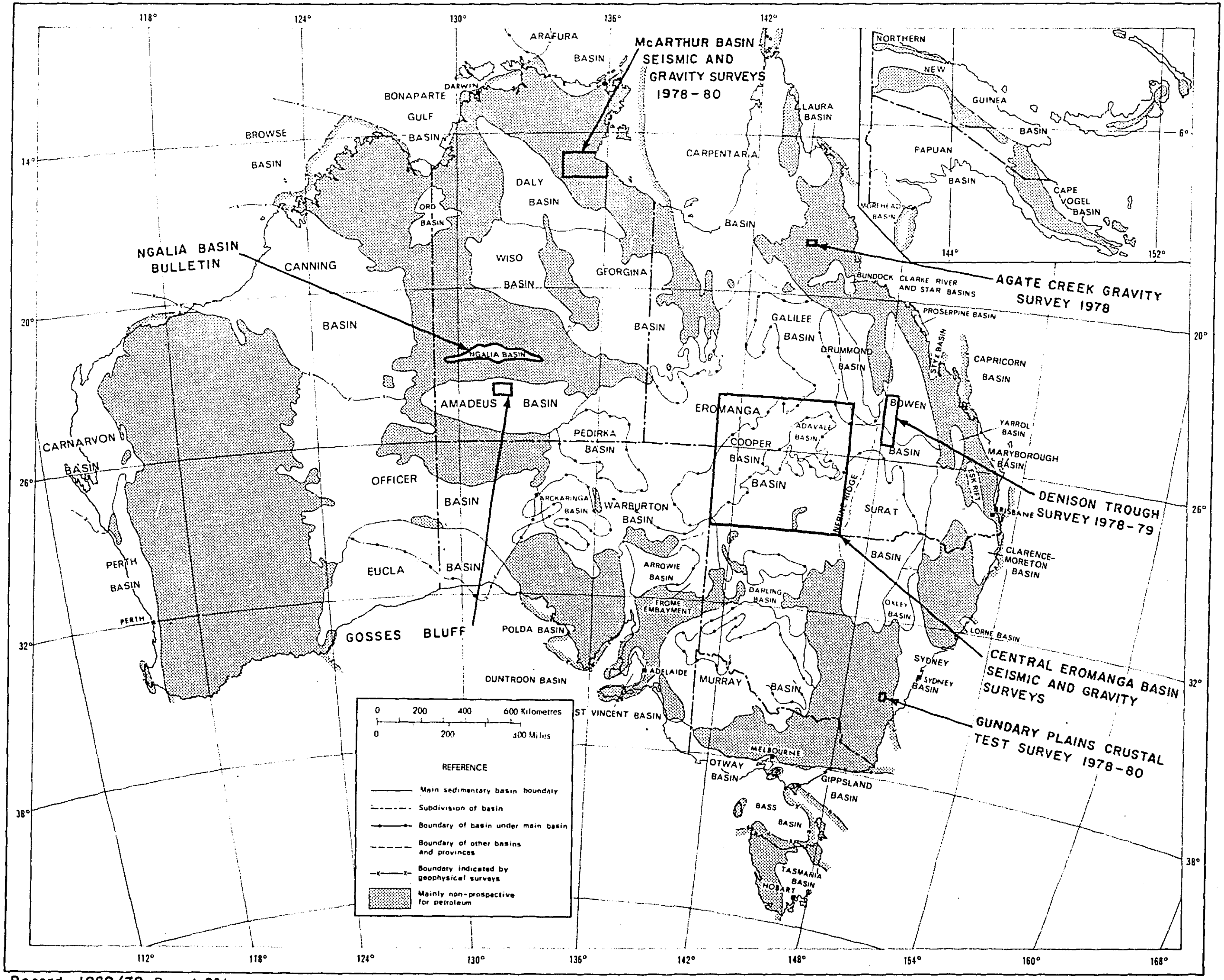
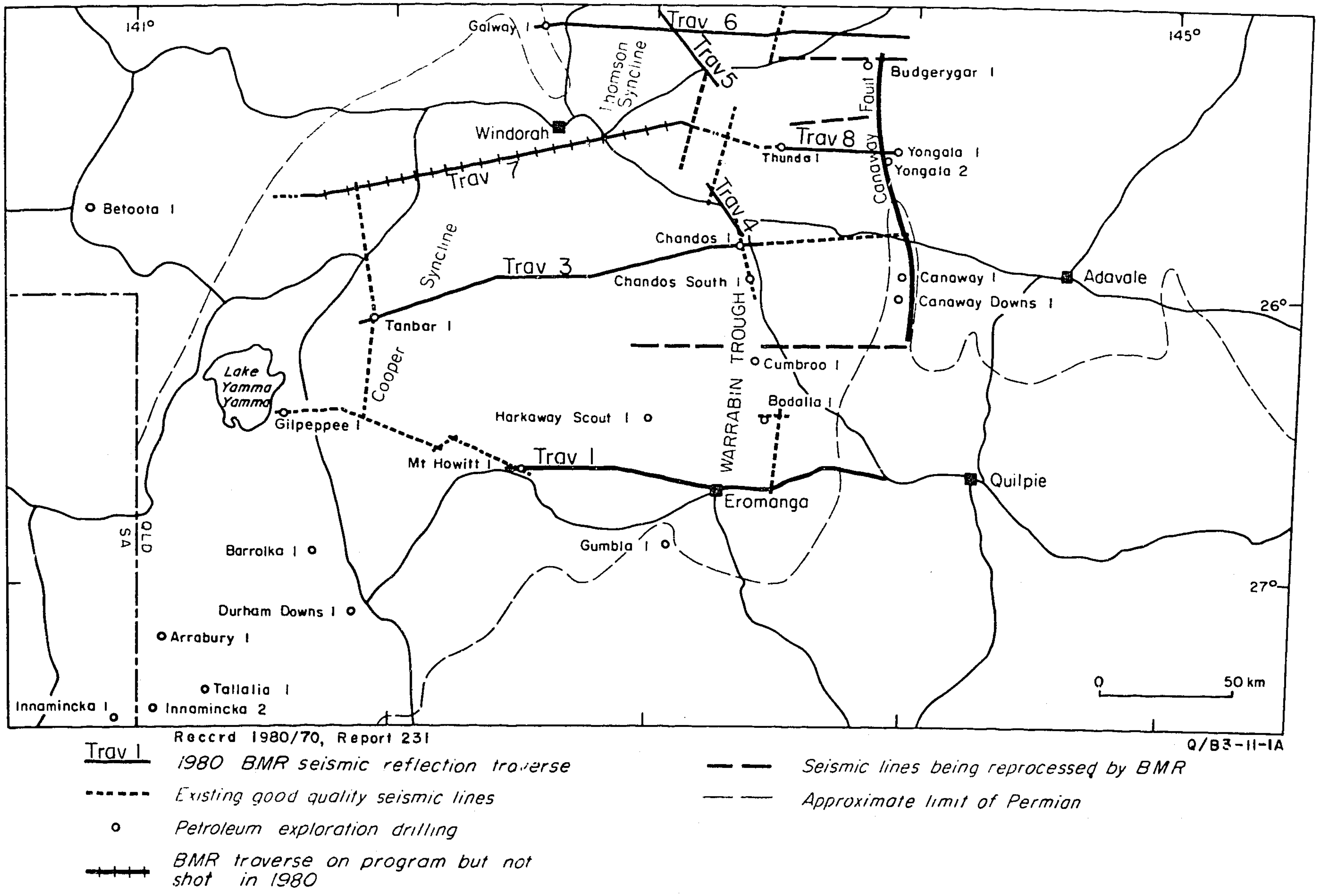


Fig SGM 1 Areas covered by seismic and gravity reviews, reports and surveys



SGM 2 Central Eromanga Basin Project
Seismic reflection and gravity traverse 1980

Operationally the seismic survey was difficult, and numerous camp moves were undertaken to reduce travel time to and from the survey area. Traverses were cleared using a bulldozer and grader. Because of the distances between traverses it was often necessary to set up independent camps for the surveyors and drillers, and for the recording team.

The quality of the seismic data is very good. It is being processed by Geophysical Services International (G.S.I.), Sydney. The seismic results obtained are being integrated with the results from previous seismic surveys and new seismic surveys done by the petroleum exploration lease holders to provide information to assist in a better understanding of the structure and stratigraphy of the area.

Gravity data from part of the BMR survey have been processed to produce principal facts. Reduction of the data from the remainder of the traverses is necessary to produce principal facts prior to interpretation.

Denison Trough seismic and gravity surveys, Queensland, 1978-1979 (J.A. Bauer, A. Nelson (Shell, ex-GSQ), O. Dixon (GSQ), W. Anfiloff)

During 1978 and 1979 BMR conducted a seismic survey in the southern Denison Trough to study the structure of the Trough and to examine facies distribution. The study complements detailed work on the stratigraphy of the Trough being carried out by the Geological Survey of Queensland (GSQ). 450 km of 6-fold CDP seismic reflection traverse (Fig. SGM-3) was recorded, and gravity observations were made at 500 m intervals along the seismic traverses. Generally, very good data quality was achieved.

Digital processing of the data has been completed, and interpretation is nearing completion. Analysis of the data has enabled a much better understanding of structure and facies distribution than was possible from the earlier data. Major results of the survey include:-

(i) identification of several major and minor phases of deformation;

(ii) better definition of the extent of important structural units, e.g. the Comet Platform (see Fig. SGM-3);

(iii) location of several previously undiscovered structures, particularly of interest to petroleum exploration;

(iv) reliable mapping of most Permian formations along the seismic lines; and

(v) demonstration of considerable potential for the existence of hydrocarbon traps.

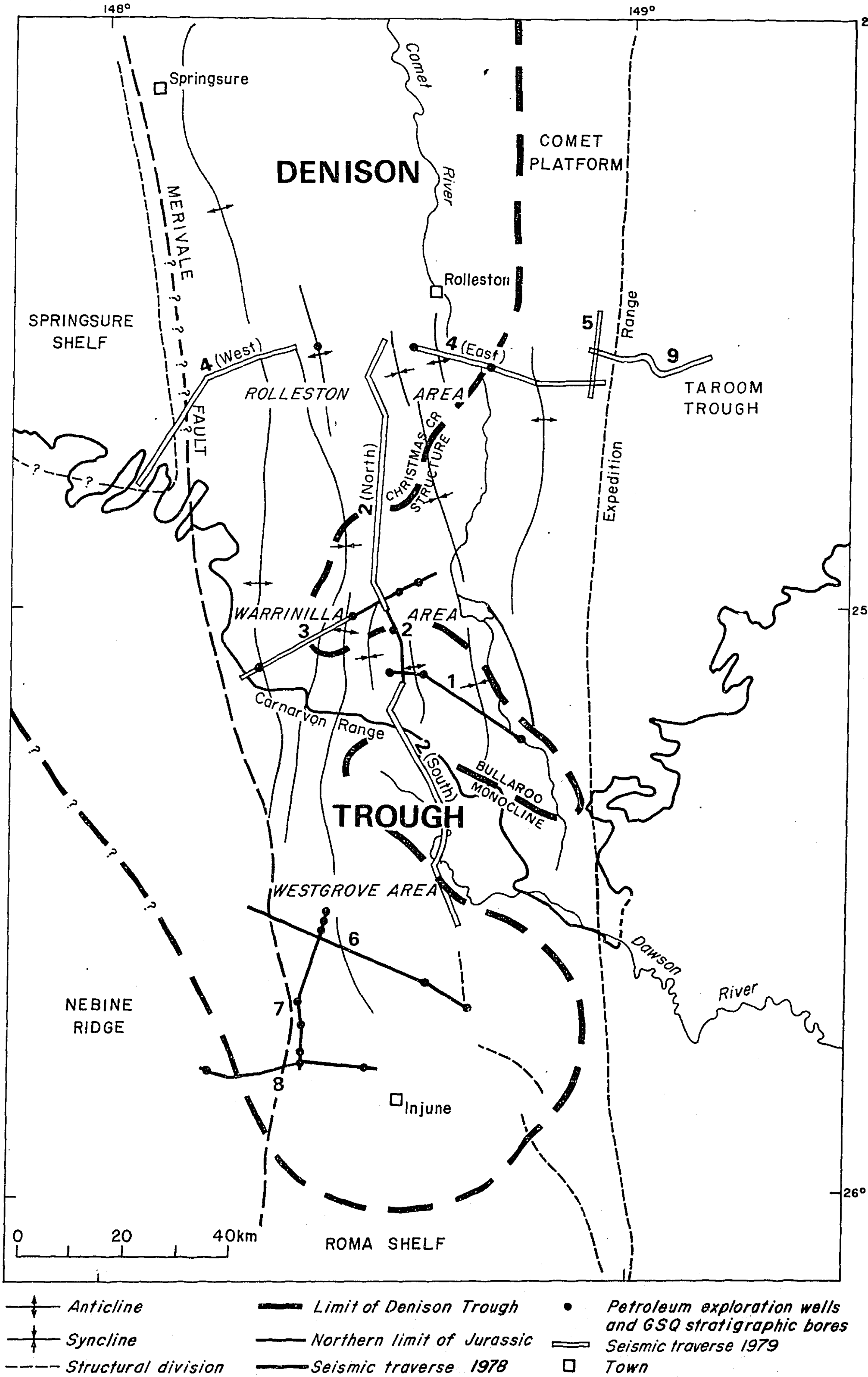


Fig SGM 3 DENISON TROUGH SEISMIC SURVEY, QLD 1978-79
REGIONAL SETTING AND SEISMIC TRAVERSES

Record 1980/70, Report 231 G55/B3-166A

Further seismic investigations are now being made by Associated Australian Resources Ltd, the main tenement holder in the area. They were commenced late in 1978 and are still in progress aimed at locating specific petroleum prospects.

Results of the project have been presented at the 1980 Australian Petroleum Exploration Association (APEA) Conference and the 1980 BMR Symposium. Papers have so far been published in the Queensland Government Mining Journal and the APEA Journal on the results of the 1978 survey. Three additional papers are presently in preparation, to be published in the Queensland Government Mining Journal and the BMR Journal of Geology and Geophysics; these papers will complete reporting on the project.

Gundary Plains deep crustal reflection test survey, NSW, 1978-1980

(J. Pinchin, J.K.C. Grace, D. Pfister, L.A. Rickardsson, A.C. Takken)

Seismic recording equipment being prepared for the 1980 Central Eromanga Basin seismic survey was again field tested on a deep crustal reflection test survey in the Gundary Plains, south of Goulburn, NSW, during May 1980.

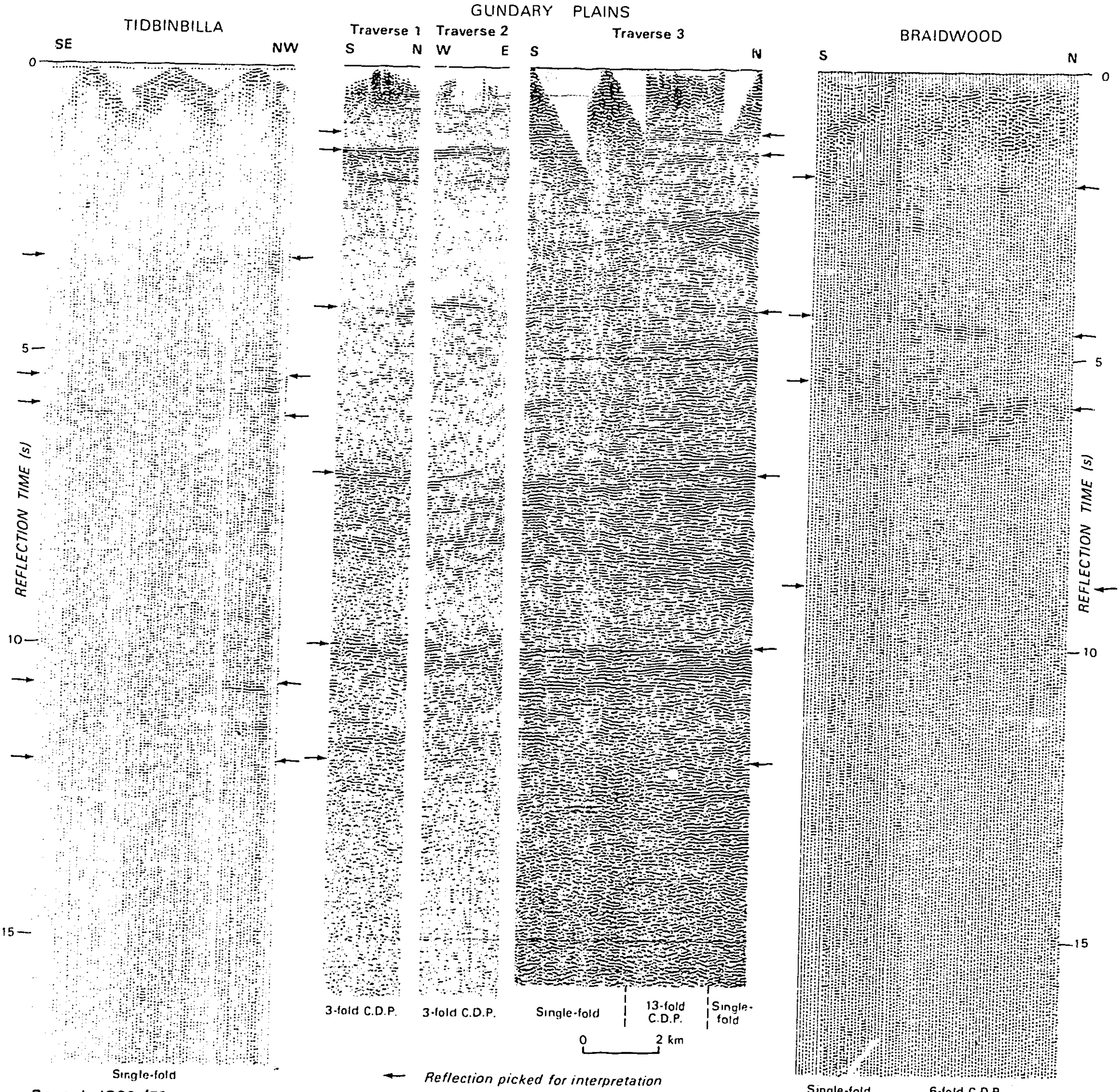
The 1980 recordings extended the 1979 traverse to the south by 12 km using 6 shots of 50 kg each to obtain a single coverage section. The data have been processed by G.S.I., Sydney. The good reflections recorded on the 1978 and 1979 traverses do not extend southwards, although some deep reflections do reappear at the extreme south end of the 1980 traverse (Fig. SGM-4).

Results and interpretation of the 1978 and 1979 work have been prepared for an article in the BMR Journal. Good reflections were recorded down to the Moho, at an estimated depth of 41 km. The intracrustal reflections are characterised by bands of seismic energy that probably represent velocity transition zones within the crust.

Seismic reflection studies of the crust and upper mantle in NE Australia

(S.P. Mathur)

Deep crustal seismic reflection data recorded in the Galilee, Georgina, and Bowen Basins during 1975-1978 were processed in attempts to improve the data quality. The digitally recorded and processed sections show variations in amplitude, frequency, and complexity of reflections, occurrence of zones of concentrated short reflections or no reflections, and a varying number of



Record 1980/70, Report 231

155/83-20-1

Fig SGM 4 Deep crustal seismic reflection at Gundary Plains, Tidbinbilla and Braidwood diffractions, refractions, and other coherent unwanted events. Attempts made to migrate the data using both time-domain and frequency-domain processing improved the continuity of the reflection events.

Prominent reflections comprise several bands of discontinuous events about 1-2 km in length which show considerable lateral variations in character over longer distances. There is a distinct difference in reflection character between recordings made in the Georgina Basin overlying the Arunta Block and those made in the Galilee and Bowen Basins. The seismic information supports evidence from gravity and magnetic information that there are two distinct sub-basement blocks in the two zones.

Distinct bands of reflections at about 9.0 and 11.0 s, particularly apparent in the Bowen Basin, are thought to indicate the boundaries of the deeper layer in the crust. The bands of reflections suggest that the boundaries are transition zones consisting of thin layers of alternating higher and lower velocities.

A paper on these studies was presented at the IUGG meetings in Canberra in December 1979.

Geosutures in the Australian continent (S.P. Mathur, R.D. Shaw (Geol. Branch))

In response to a request from Dr R. Black, one of the organisers of the 1980 International Geological Congress (IGC) Symposium on Palaeogeodynamics and Plate Tectonics, a paper was prepared, in association with R.D. Shaw, reviewing the geophysics and geology of the Australian geosutures. The review indicated that the Australian Mobile and Fold Belts, containing geosutures, represented several stages, degrees, and styles in the development of orogenic belts. They vary from simple fault systems penetrating the crust, to features having wider zones of tensional fracturing and faulting related to mantle upwelling and tapping of basaltic and ultramafic sources, to wide spreading zones giving rise to small ocean basins, and to features with characteristics of collison tectonics. The belts also illustrate that the orogenic activity consisted mainly of ensialic intra-plate and plate-margin rifting during the Precambrian and early Palaeozoic, and of ensimatic plate-margin collision during the late Palaeozoic. The paper could not be presented at the IGC meetings in Paris, but it is to be published in a special issue of Precambrian Research.

Ngalia Basin, NT (F.J. Moss, A.T. Wells (Geol. Branch))

A number of editorial matters relating to the Bulletin on the structure and stratigraphy of the Ngalia Basin were attended to. The draft of the geophysical plate for the Bulletin was lost and a new preliminary draft had to be checked again and revised as necessary.

Gosses Bluff impact structure (F.J. Moss, W. Anfiloff)

In the absence of B.C. Barlow, F.J. Moss attended to comments and amendments on a paper which Mr Barlow prepared on the gravity field at Gosses Bluff for the BMR Journal. W. Anfiloff prepared a note for the Journal in which he discussed the relative merits of gravity surveying over the grid as done at Gosses Bluff compared with surveying radial lines perpendicular to the strike of the major uplifted units. He considered that better estimates of the densities of the units would have been obtained using radial traverses and density profiling techniques.

No progress was made on the compilation of geological and geophysical data for the Bulletin.

Seismic technical services (J. Pinchin, J.K.C. Grace, D. Gardner, D. Pfister, R.D.E. Cherry, L.A. Rickardsson, D.K. McIntyre)

The main improvement to the seismic recording system this year was the purchase of an electrostatic 54-channel S.I.E. ERC-10 oscillograph camera. This was installed in the recording cab, and the dark-room was removed. Variable area records are no longer developed in the cab, and wiggle trace records are now used for field monitors. If variable area records are required they can still be produced on the old oscillograph and developed in a dark-room tent. The ERC-10 oscillograph required considerable repair and modifications to its timing-line circuit, but it is now working well.

The DFS IV digital seismic recording system developed several faults within the read/write module, which meant the loss of several days field recording. The DFS IV was also used for A/D conversion of analogue field tapes from subsidized seismic surveys within the Central Eromanga Basin. Two types of original magnetic tapes were involved; the S.I.E. tapes were digitised using the old PMR-20 recorder which was overhauled for the occasion, and the Techno tapes were digitised using part of the MS-42 analogue playback system. Special cabling had to be prepared for these tasks, and the digitised tapes were sent to G.S.I. for further processing.

A new Landrover tray-top truck was fitted-out as a shooting truck to replace the old tanker formerly used. An instrument power distribution board was installed in the recording cab. A calibrated voltage source, for testing the DFS IV, and two more spread cables were purchased. The geophones and cables were once more tested and repaired between field seasons.

A new two-year contract for digital seismic data processing was again awarded to Geophysical Service International (G.S.I.), Sydney.

Further details of the work carried out on the seismic technical services are given in the report of the Interim Engineering Services Branch.

McArthur Basin gravity surveys, 1978-80, and deep crustal reflection seismic surveys, 1979 (W. Anfiloff, J. Pinchin)

Detailed information on the gravity and seismic investigations is included in the Project Progress Reports, BMR Records 1979/82, 1980/5, 1980/38, and 1980/55, and in the multidisciplinary projects summary report.

The preliminary results of the 1978-79 gravity surveys and the 1979 seismic survey were presented at the 1980 BMR Symposium. A record has been prepared on the gravity results; however, a joint interpretation of the reflection data together with the refraction data is awaiting final processing of the refraction records by the Regional Group. The results of detailed gravity work in 1980, extending the detailed gravity coverage westwards along the Carpentaria Highway, southwards down the Stuart Highway as far as Newcastle Waters, along part of the Buchanan Highway, and along the Beetaloo Road, are not yet available.

Agate Creek gravity survey, 1978 (W. Anfiloff)

Interpretation of the results of a gravity survey carried out across the 'Agate Pocket' to investigate the units of the Agate Creek Volcanics, and their relation to basement rocks, was completed and a draft report was prepared.

The interpretation hinges on the analysis of the effect on the density profiling process of the curvature caused by anomalous bodies. A large ridge of rhyolitic rocks provides key information in the form of a bulk density value and a density contrast for the roots of the rhyolite below the surface. The same contrast applies to adjacent andesitic volcanics, and establishes their thickness at about 400 m. The agate-bearing andesitic volcanics overlie a homogeneous basement. They are bounded by a steep interface on the southwestern side, and abut against the roots of the rhyolitic volcanics on the northeastern side.

WA detailed gravity survey, 1970 (A.R. Fraser, W. Anfiloff)

An operational report for the detailed gravity survey in southwestern WA was prepared and issued as a Record (1980/52). The traverses were located across prominent Bouguer anomaly features revealed by the BMR reconnaissance helicopter gravity survey in 1969. The report describes operational details of the survey, and presents gravity and elevation data as profiles.

Shot-point and well-location compilation (S.P. Mathur, D. Pfister)

Digitisation of shot-point locations for most of the seismic surveys in the Central Eromanga Basin was completed. The numbering system of the digitised data was revised so as to avoid duplication and indicate clearly the area, year, and sequential number of the survey. Preliminary maps were plotted mainly at 1:250 000 scale by computer, and checked for errors.

Data from exploration wells in Australia and Papua New Guinea were sorted according to year and state, and checked for errors.

Production of synthetic seismograms (S.P. Mathur, D. Pfister)

Synthetic seismograms were produced for several wells including Rolleston 1, Warrinilla 1, Warrinilla North 1, and Kia Ora 1, using the SEISSYN program and the Cyber-76 computer system. The seismograms were used to correlate the seismic reflections with the stratigraphic horizons in the Denison Trough.

Requests for seismic and gravity information (F.J. Moss, J. Pinchin, W. Anfiloff)

Discussions were held with industry representatives on seismic results and field recording parameters in areas including the Gaililee, Bonaparte Gulf, Darling, Bowen, Amadeus, and Ngalia Basins. The general increase in company activity during 1980 has resulted in considerable demand for information on previous BMR surveys and BMR reviews.

Preliminary maps produced to display seismic shot-point and well-location information have been found by the private companies to be very useful for planning future surveys and reviews.

Requests for information on seismic equipment and techniques have been received mainly from Government organisations.

Exploration companies with interests in the McArthur Basin area have been keenly interested in the gravity results, and discussions have been held with numerous visitors.

Future seismic programs (F.J. Moss, S.P. Mathur)

Work continued on assessing possible future seismic survey proposals in consultation with other BMR officers, State Government Geological Surveys and industry. A proposal was prepared to obtain additional funding to extend the seismic field season from 4 to 8 months per year; however, the proposal was rejected.

Future program proposals already researched include possible surveys in the Darling, Bonaparte Gulf, and Amadeus Basins.

MARINE SURVEYS (R. Whitworth, F.W. Brown)

Coral Sea Basin margin co-operative study with BGR (P.A. Symonds, P.J. Cameron, D.C. Ramsey)

The 1978 co-operative BGR (West German Federal Geological Survey)/BMR survey in the Coral Sea on R.V. Sonne indicated two outstanding results: the presence of sediment-filled rift grabens beneath the outer margin of the Queensland and Papuan Plateaus; and, features interpreted as large drowned fossil reefs, clearly observed underlying the Oligocene/Eocene unconformity beneath the outer slopes of the Queensland and Papuan Plateaus. These results were important because they upgraded the long-term petroleum prospectivity of an area ideally suited to research into the fundamental problems concerning the development of continental margins.

Mr Cameron returned to BMR in January, 1980 after a 5 months visit to BGR in Hannover, where he worked with BGR scientists on the processing and interpretation of data from the 1978 SONNE survey. Up until March 1980, when he resigned from BMR, he carried out detailed interpretation of newly-processed seismic sections, and began a paper on the results of the study.

As a continuation of that study, co-operative geophysical and geological sampling cruises on R.V. Sonne have been planned in the Coral Sea Basin area from 30 November 1980 to 9 January 1981. The main aims of the 1980/81 surveys are to determine the extent, nature, and development history of the rift grabens and the ocean/continent boundary around the Coral Sea Basin, and to obtain information on the lithofacies, age, and palaeo-environment of the Mesozoic and Cainozoic sediments in the area. Other problems that will be investigated are the nature of possible fossil reefs beneath the slopes of the Queensland and Papuan Plateaus, and the structure and tectonic history of the Aure-Moresby Trough and the Osprey Embayment.

Mr Symonds prepared a research proposal seeking funding for the continuation of the Coral Sea Basin study from the Department of Science and the Environment under the Federal Republic of Germany/Australia Science and Technology Agreement. He also made a review of the 1978 SONNE survey results in preparation for the 1980/81 surveys.

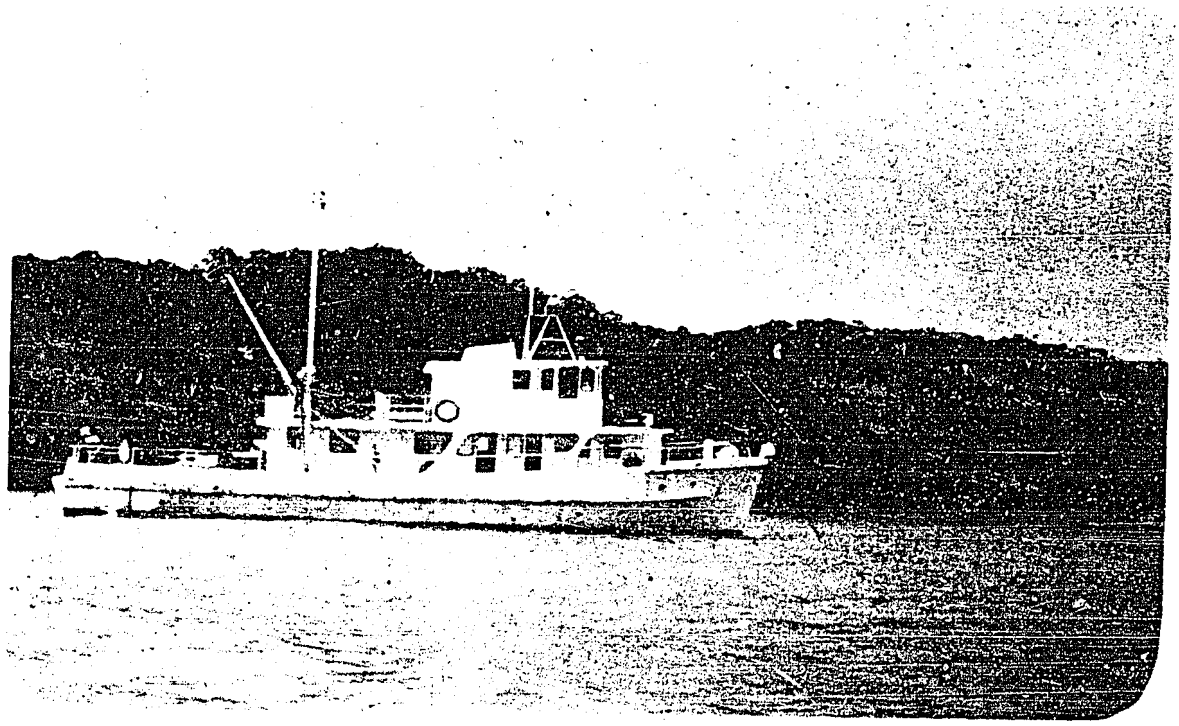
Geophysical surveying in the central Great Barrier Reef (R. Whitworth, F.W. Brown, D.C. Ramsey, J.K.C. Grace, R.A. Dulski, G.B. Price, T.R. Hegvold)

Late in 1979 it was determined that BMR and Division of National Mapping (NATMAP) could combine forces to mutual advantage on survey work in the Great Barrier Reef. BMR could provide the computer hardware and software necessary to collect the data in digital form and NATMAP could provide and operate a HIFIX radio positioning network necessary to ensure precise navigation control in the central reef area, which is beyond the range of line-of-site systems. The objectives of the survey were, for NATMAP, to construct a modern map of the reef area bathymetry, and for BMR, to determine inter-reefal basement structure, sedimentation patterns, horizon correlation, and models of reef evolution and development, as part of a larger project studying many facets of modern and relict reefs and reef sediments.

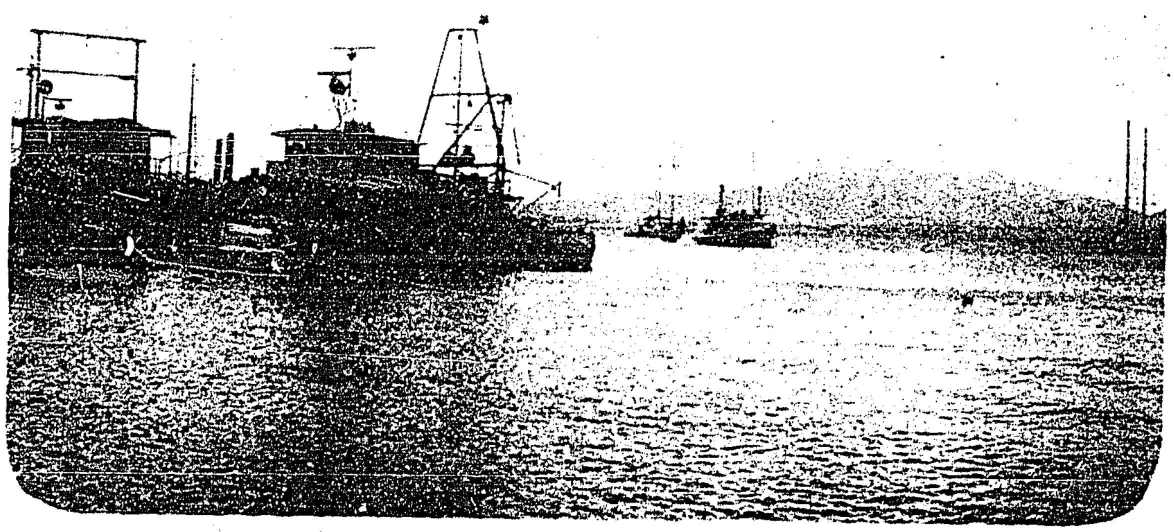
Funding was sought through the Australian Marine Science and Technology Advisory Committe (AMSTAC) to purchase a light-weight, multichannel seismic cable and to hire a geological coring device, but the initial application was unsuccessful. Therefore, the operation in 1980 consisted of a magnetic and bathymetric operation. NATMAP chartered a 20 m converted trawler, R.S. Kalinda (Fig. SGM-5), and, together with BMR, installed their shipboard navigation, radio, and depth-sounding equipment, and BMR's data acquisition and magnetometer equipment. NATMAP also installed Mini-Ranger and HIFIX shore stations at appropriate points along the coast and on islands and reefs where the Australian Survey Office had provided precise position co-ordinates.

The BMR computer not only carried out an acquisition function, collecting on cassette tape digital values of Mini-Ranger and HIFIX, water depth, and magnetics, all related to 10-second time values, but it also stored a sail line, which the party leader identified by start-of-line and end-of-line co-ordinates, and provided a VDU display updated every 10 seconds including computed values of the ship's course and speed, progress along the sail line and deviation from it. The equipment was installed in the after-cabin on the main deck, and an intercom allowed course adjustments to be signalled to the bridge.

The survey began on 25 May and concluded for the year on 20 September. A region between Innisfail in the north, and the southern end of Hinchinbrook Island, about 110 km to the south, was covered by a set of E-W magnetometer traverses at 4 km spacing in the open water between the reef and the shore, and by traverses of opportunity within the reef zone and as tie lines (Fig. SGM-6). About 2100 km of magnetic profiling was done. In addition much of the reef zone in this region was surveyed bathymetrically by executing 'star' patterns around



R.S.KALINDA



R.S.KALINDA

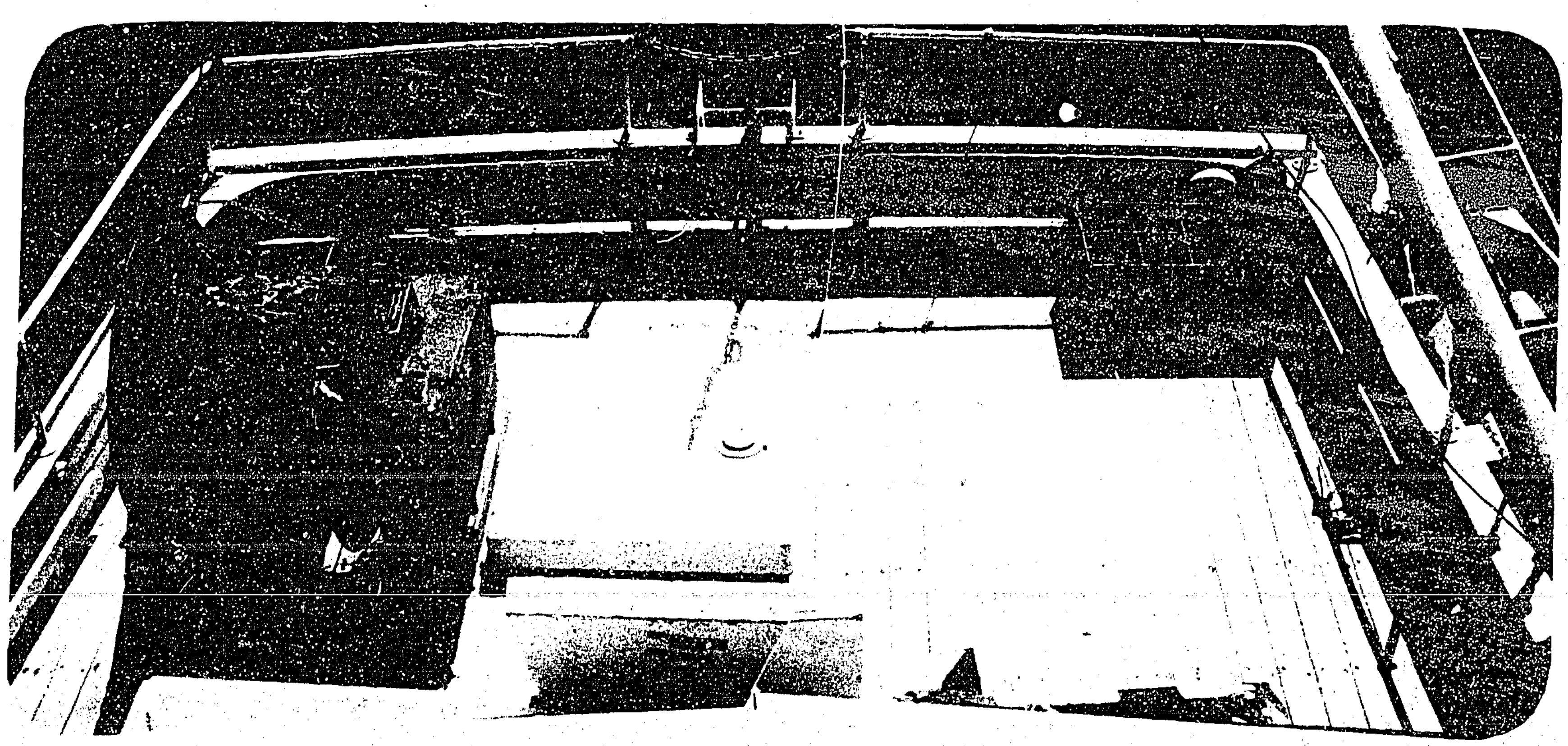


Fig SGM 5 R.S.KALINDA - After deck showing magnetometer winch

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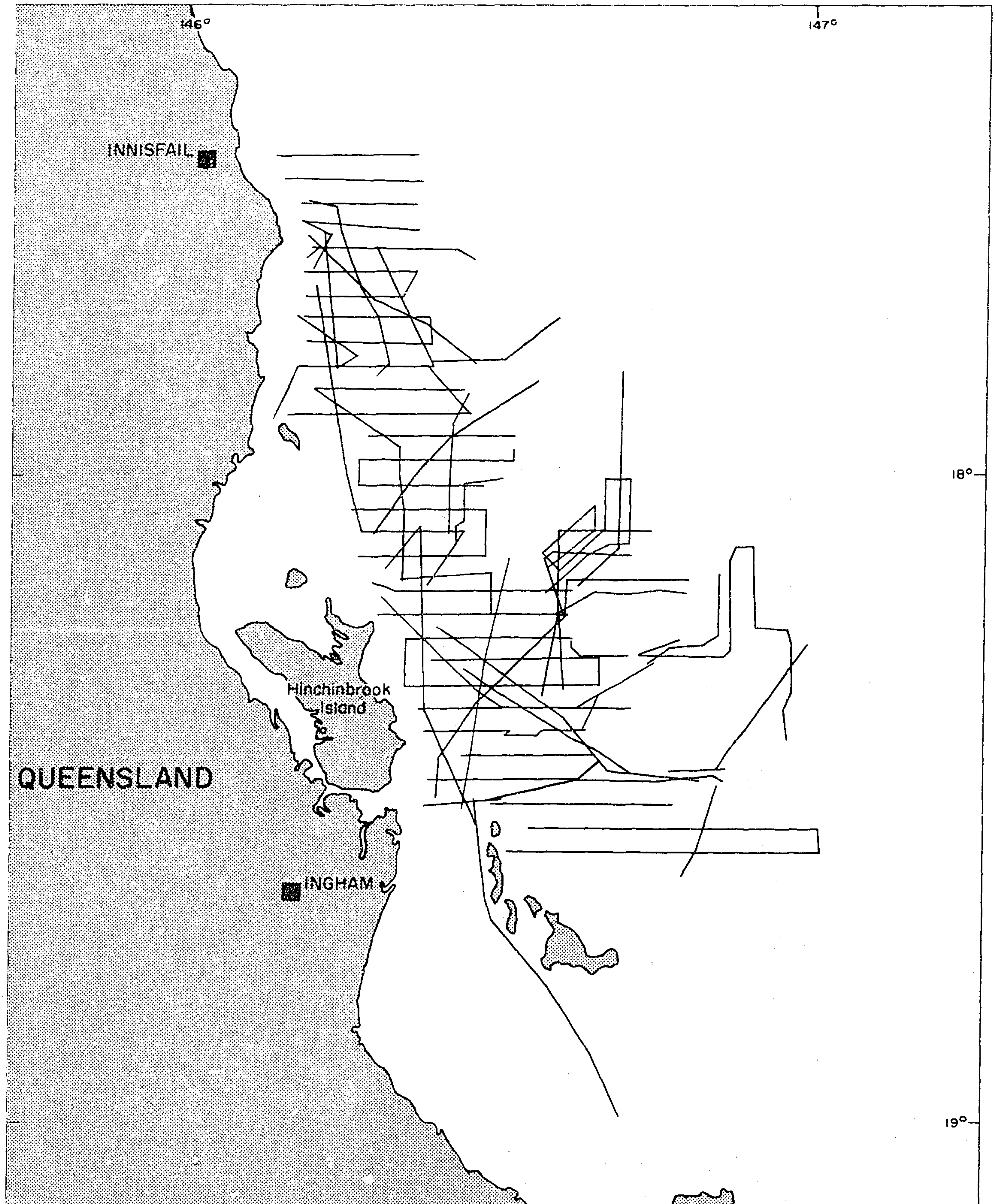

Fig SGM 6 Track map GBR-1980

individual reefs, to within a ship's length of exposures in many instances. The magnetometer sensor could not be streamed during this phase of operations, because the ship was frequently stopping or reversing. At other times, the sensor was streamed 70 m behind the ship from a winch mounted on the after deck Fig. SGM-5). The ship was operated by a crew of three, and scientific/survey staff comprised one or two BMR officers and two or three NATMAP officers.

A computer-based magnetic shore monitor station was established at seismic observatory station operated near Charters Towers by officers of the University of Queensland. It was intended to produce a digital record on a cassette tape of the variations in the Earth's magnetic field. Initially, a computer software problem restricted recording to an analogue strip chart, but in August the software problem was resolved. Digital recording has proceeded satisfactorily since then. The equipment is being kept in operation continuously because the marine operation is intended to resume in 1981 and the magnetic record will be more valuable and diagnostic if it is continuous. Also, the Observatory Section wish to establish a magnetic observatory at this site and have requested that the observations be continued.

Data processing is in progress. Only preliminary plots of hand-calculated values are available at present. They indicate strong magnetic variations between the reef and the shore, reducing to slight variations within most of the reef area traversed this year. This suggests the possibility of a faulted basement margin near the inner edge of the reef, deepening eastward under the reef.

Naturaliste Plateau region (J.C. Branson)

During the second half of 1979 Mr Branson studied the structural elements in the oceanic and continental crust in the region 100° to 120°E and 30° to 40°S. Following the compilation of the magnetic and gravity data from a number of sources in 1979, a new bathymetric compilation (Fig. SGM-7) and a number of bathymetric and magnetic profiles were prepared during 1980. Four major problems associated with the tectonic development of this extensive region surrounding the Naturaliste Plateau were identified. They can be summarised as:-

a) What is the origin of the Naturaliste Plateau? Is it continental, oceanic, or a mixture of both types of crust?

b) What is the origin of the Diamantina Zone? Is it a fracture Zone, a site for a jump in sea-floor spreading, or a site of unusual ocean floor formation during normal seafloor spreading?

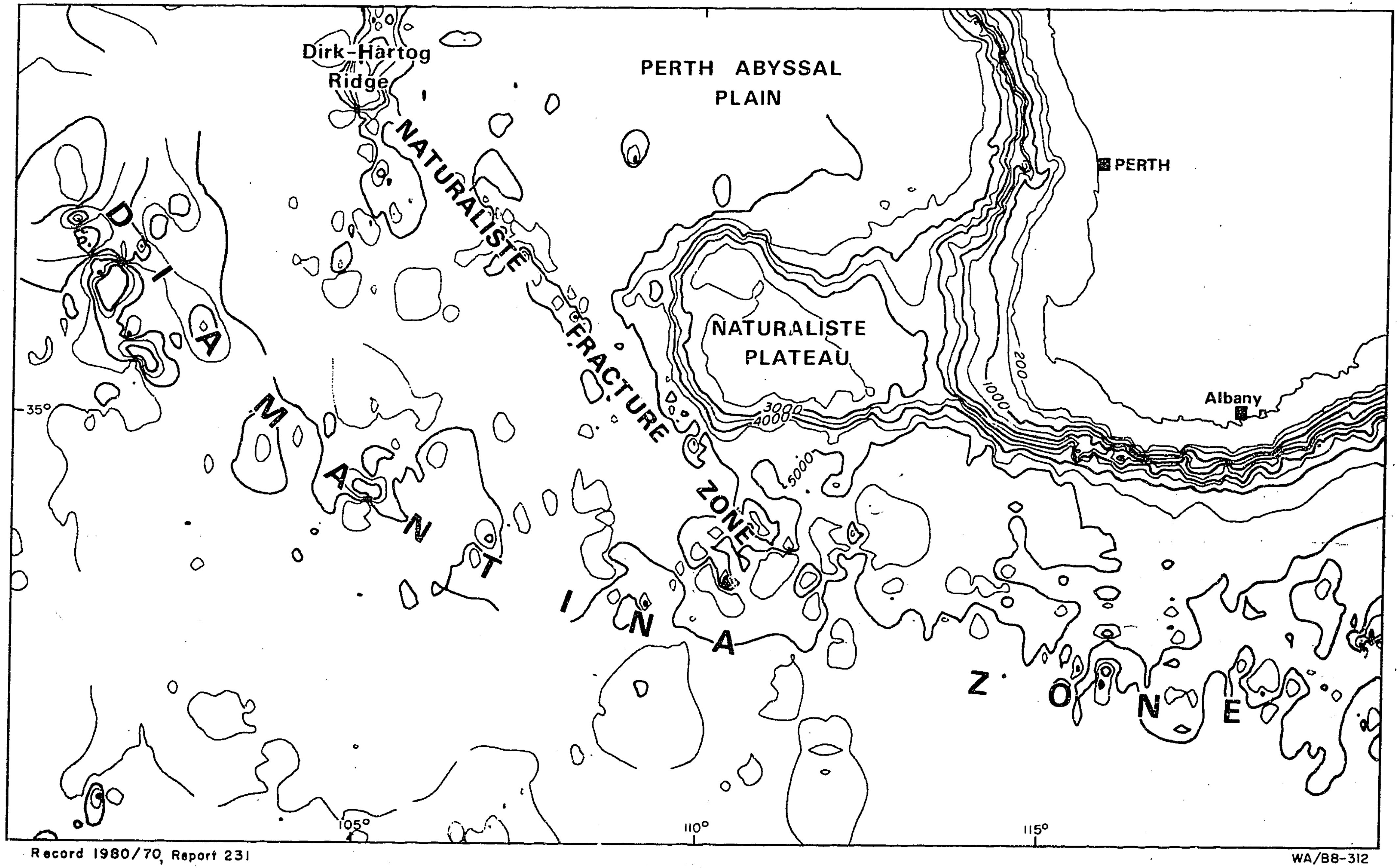

Fig SGM 7 Computer contoured bathymetric map

c) What is the age of the ocean floor in the 'magnetic quiet zone', i.e. the region between the continental slope and the Diamantina Zone?

d) Was there an open seaway between Australia and Antarctica during the Mesozoic and if so was it floored by oceanic crust?

Discussion of any one of these problematic features involves assumptions about the age and formation of the other three. Mr Branson assumes that the western part of the Naturaliste Plateau is continental and was separated from an adjacent continental margin in the Mesozoic. From this proposition the Diamantina Zone is considered a site where seafloor spreading stopped and then re-commenced in the early Tertiary. Therefore, the "magnetic quiet zone" is floored by oceanic material formed during the Mesozoic.

Regarding question a), the combined magnetic and gravity data did not lead, at this stage of the study, to a definite conclusion as to the origin of the Naturaliste Plateau. The magnetic signature of the plateau does not indicate an oceanic origin for the main plateau basement except at the extreme northwestern corner. The central region of the plateau can equally be considered continental or oceanic because the magnetic patterns of the anomalies are indistinguishable from those over the Archaean and Proterozoic regions of Western Australia. This indirect evidence calls for re-appraisal of the seismic stratigraphy; the study of Jongsma and Petkovic indicates the oldest sediments deposited on the plateau pre-date the breakup unconformity. Hence a continental(?) origin or very old oceanic crust is favoured for the centre of the Naturaliste Plateau.

The Diamantina Zone requires further surveying to define its morphology in more detail and provide answers to question b). This new bathymetric compilation shows an extension of the deep ocean floor from the Perth Abyssal Plain around the Naturaliste Plateau and along the southern continental margin. The Diamantina Zone forms a clear step in basement topography; the deepest parts are north of the Zone. Although long, narrow, and rapidly undulating features are poorly contoured by present computer methods, a zig-zag pattern in the Diamantina Zone morphology suggests that transform and rift style tectonics parallel to that of the Abyssal Plain spreading may have controlled formation of this feature, possibly during the Mesozoic. However, other bathymetric features in the continental slope south of the Naturaliste Plateau are dominantly east-west.

Free-air gravity contours demonstrate extensive negative free-air anomaly values west and north of the Naturaliste Plateau. The strongest negative values are confined to a narrow band in the magnetic quiet zone and in a few sections of deep ocean. Generally zero free-air gravity values south of the Diamantina Zone indicate normal oceanic crust and mantle in these regions. Bouguer anomalies are plotted with a constant water layer replacement density of 2.67 t/m^3. Bouguer values at Dirk-Hartog Ridge reflect variations in the base of the crust. Although the dominating feature of the magnetic map is the Naturaliste Fracture Zone, this feature has only a minor gravity (Bouguer anomaly) expression, and can be considered a crustal feature maintained by crustal rigidity rather than by crustal roots.

Sea-floor spreading is poorly portrayed by the total residual intensity magnetic map. The Mesozoic spreading anomalies (M series) can be discerned north of the Naturaliste Plateau in the Perth Abyssal Plain. Correlation of unidentified anomalies south of the Plateau can only be made from comparison of magnetic profiles. These southern magnetic anomalies lie between the Diamantina Zone and the continental slope, and are too few in number, and too indistinct in character, to determine a possible age.

There is a dislocation of the magnetic and gravity anomaly pattern across the Diamantina Zone which indicates a difference in sea-floor spreading ages to the north and south of this feature. The Zone is therefore considered the site of a sea-floor spreading jump from this location to the present site, which now lies centrally in the southeastern Indian Ocean.

Major problems posed by questions (c) and (d) can be considered together; they relate to the age and presence of any open seaway south of the continent prior to the Tertiary. The dominant feature of the magnetic and bathymetric maps and profiles is the Naturaliste Fracture Zone. This feature clearly contains remanent magnetic anomalies which may provide evidence for its age. Markl (1978)[1] considers the Zone a transform fault of Mesozoic age whereas Veevers (1980)[2] considers the feature is Tertiary. It crosses the magnetic quiet zone and must therefore be considered together with the ocean floor origin in the magnetic quiet zone.

Standard crustal densities fail to provide a satisfactory model for the magnetic quiet zone. If the crust and mantle have normal densities then the model requires unusually thin crust (about 3 km thick). Refraction data to the east suggest that the crust contains continental material and is about 7 km thick.

This study recommends that a number of geophysical surveys be used to determine the crustal velocities, and magnetic and morphological trends south

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[1] Marine Geology, 26, 41-48.

[2] Earth and Planetary Science Letters, 47, 131-143.

and west of the Naturaliste Plateau. Deep sea drilling is required to obtain the age of the basement between the Naturaliste Plateau and the Diamantina Zone.

A Mesozoic seaway south of the Australian continent prior to the Tertiary sea-floor spreading event, in which Antarctica finally separated from Australia, has great significance for the petroleum potential of the southern margin. A marine restricted environment along the southern margin of Australia in the Mesozoic would enhance source rock potential and improve the prospectivity of older sediments.

Further studies of slope stratigraphy farther east are needed to determine if the two-stage breakup proposed for the ocean floor is present in the sedimentary section, particularly in the Great Australian Bight Basin and the Otway Basin.

Rift basins on the Australian continental margin (J.B. Willcox, P.A. Symonds)

Schneider (1969)[3], Dewey & Bird (1970)[4], Falvey (1974)[5], and others have proposed models for the development of passive (rifted or Atlantic-type) margins that start with the formation of a broad thermally-induced arch whose axis is downfaulted to form a rift-valley. After progressive distension the arch is split, usually but not always symmetrically, to become the site of a youthful ocean basin. It appears that the process of continental rifting occupies a protracted period, often of the order of 50 million years, and is generally associated with distinct phases of structural development and sedimentation within the zone of rifting. Because sediments deposited within the zone are frequently relatively thick, and because they often include a high proportion of organic matter, the extent of the zone has considerable bearing on the petroleum potential of the margin.

A sketch map showing the distribution of the zone of rifting around Australia was presented at the second Circum-Pacific Energy and Mineral Resources Conference in 1978 (Willcox, in press, fig. 20). More detailed mapping of the zone has now been carried out in response to a request from the Circum-Pacific Council for Energy and Mineral Resources, to be used in preparation of their SW Quadrant Map, 1:10 000 000 Thematic Series. The new map shows a 'zone of rifting', which is a broad zone affected by rift tectonics, and

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[3] Geological Society of America, Abstracts with Programs, Volume 7, 291-292.
[4] Journal of Geophysical Research, 75, 2625-2647.
[5] Journal of the Australian Petroleum Exploration Association, 14(1), 96-106.

the 'rift-grabens' which lie within it. This division is in accord with Veevers' (1977)[6] concept for the Exmouth Plateau, in which he considers it as a 'rim basin', flanked to its east and west by distinct rift-grabens.

The zone of rifting encircles the Australian continent, except in the north (Gulf of Carpentaria - Arafura Sea region), and extends along the flanks of the South Tasmania Rise, Lord Howe Rise, and West Norfolk Ridge, and over the Kenn Plateau and other deep-water features which have become detached from the continental margin of Queensland and Papua New Guinea. It ranges in width from as little as 10 km off New South Wales to 300 km or more in the Exmouth Plateau area. The zone incorporates all major offshore sedimentary basins except for those laid down in shallow epicontinental seas (e.g. Eucla Basin, Gulf of Carpentaria). The rift-grabens, which have been located using seismic profiles and Werner deconvolution of magnetic profiles, are generally distributed along both the landward and seaward edges of the plateaus and terraces, and along the lower continental slope when the margin is of a simple type.

The location of the rift-grabens may be important in petroleum exploration for they would presumably have been sites for deposition of marine sediments over a long period, and perhaps through a significant part of the rift-valley stage. The prospect of having had liptinitic kerogen associated with a marine source, the possibility of deposition in relatively isolated grabens under reducing conditions, and the likelihood of higher than normal heat-flow during rifting, may well have favoured oil generation.

This project has led to the preparation of two papers (in prep.): the first briefly discusses the extent of the zone of rifting and its significance; and the second involves evolution of specific parts of the margin, particularly the southern margin.

<u>Lord Howe Rise project</u> (J.B. Willcox, P.A. Symonds)

Some time was spent interpreting processed seismic data from the cooperative BGR/BMR work on Lord Howe Rise. Lectures were prepared for the BMR Symposium, and for the CCOP/SOPAC Workshop 1980 in Noumea, and a paper was published in the September issue of the BMR Journal. Editing was carried out for the BMR Report on Lord Howe Rise.

Further work, which could include integration of company data to provide a regional stratigraphic and structural interpretation, and analysis of refraction data, was recommended for a future review of Lord Howe Rise.

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[6] Tectonophysics, 14, T1-T5.

1980 Heard Island expedition (L.A. Tilbury)

During the period 29 February to 7 April 1980, the Division of National Mapping (NATMAP) and BMR conducted a co-operative survey in the Heard Island-Kerguelen Plateau region using the M.V. Cape Pillar.

The survey of the northern 'Australian' sector of the Kerguelen Plateau had the main objectives of carrying out NATMAP's program of bathymetric surveying of the Heard Island region, position fixing of islands and rocks within this region, and aerial photography of Heard and McDonald Islands, together with BMR's program of magnetic surveying aimed at defining the extent and possible thickness of any sedimentary basins, and elucidating the magnetic anomaly pattern in the deep ocean adjacent to the Kerguelen Plateau.

A total of 12 600 km of data was collected, comprising about 5 300 km over the Kerguelen Plateau, and the remainder in the two transit lines over the southeast Indian Ocean. Figure SGM-8 shows the traverses over the Kerguelen Plateau, together with existing ship's tracks and bathymetric contours.

This survey provided BMR's first opportunity since 1973 to use the deep-sounding Raytheon bathymetric system. Further, it was the first time that an array of nine transducers was available with the system, and consequently the first time that record quality approached specification. Overall, records were good, with up to 200-ms sub-bottom penetration (Fig. SGM-9) being obtained. Digital depths were generally reliable in water shallower than 1500 m, but, in deeper water, digital values were, for the most part, poor and unreliable.

The Kerguelen Plateau is a broad topographic high situated in the south-central Indian Ocean. It is about 2000 km in length, stretching from about 300 km north of Kerguelen Island to more than 1000 km southeast of Heard Island, to within 200 km of the Australian Antarctic Territory.

Bathymetric contours of Schlich and others (1979) for the Heard-Kerguelen region are shown in Figure SGM 8. This region includes only the shallowest part of the Kerguelen Plateau, defined approximately by the 1000 m isobath. The eastern margin is a steep scarp which drops abruptly from 1000 m depth to the deep ocean floor at about 3500 m water depth. Bathymetric profiles collected during the survey show this scarp in detail, and support earlier interpretations that this margin is fault controlled. Associated with this margin is a rugged bottom topography, presumably caused by numerous volcanic extrusions.

In contrast, the western margin is not as steep, deepening gradually from the plateau edge at about 1000 m to the deep ocean floor at about 4500 m. This ocean basin is significantly deeper than the southeast Indian Ocean basin adjoining the eastern margin, leading to the speculation that it is much older.

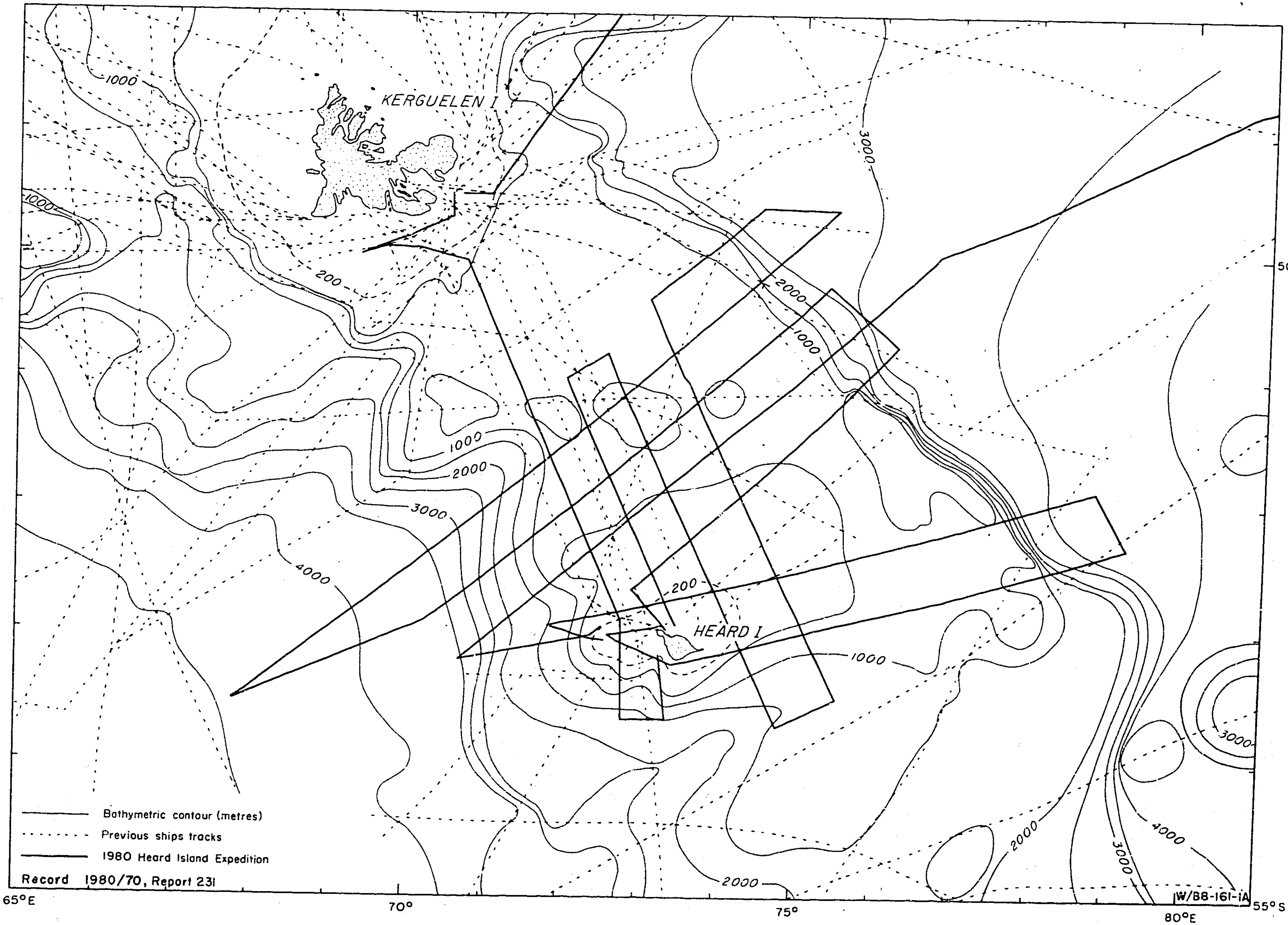


Fig SGM 8 Bathymetric contours and tracks over the Kerguelen Plateau

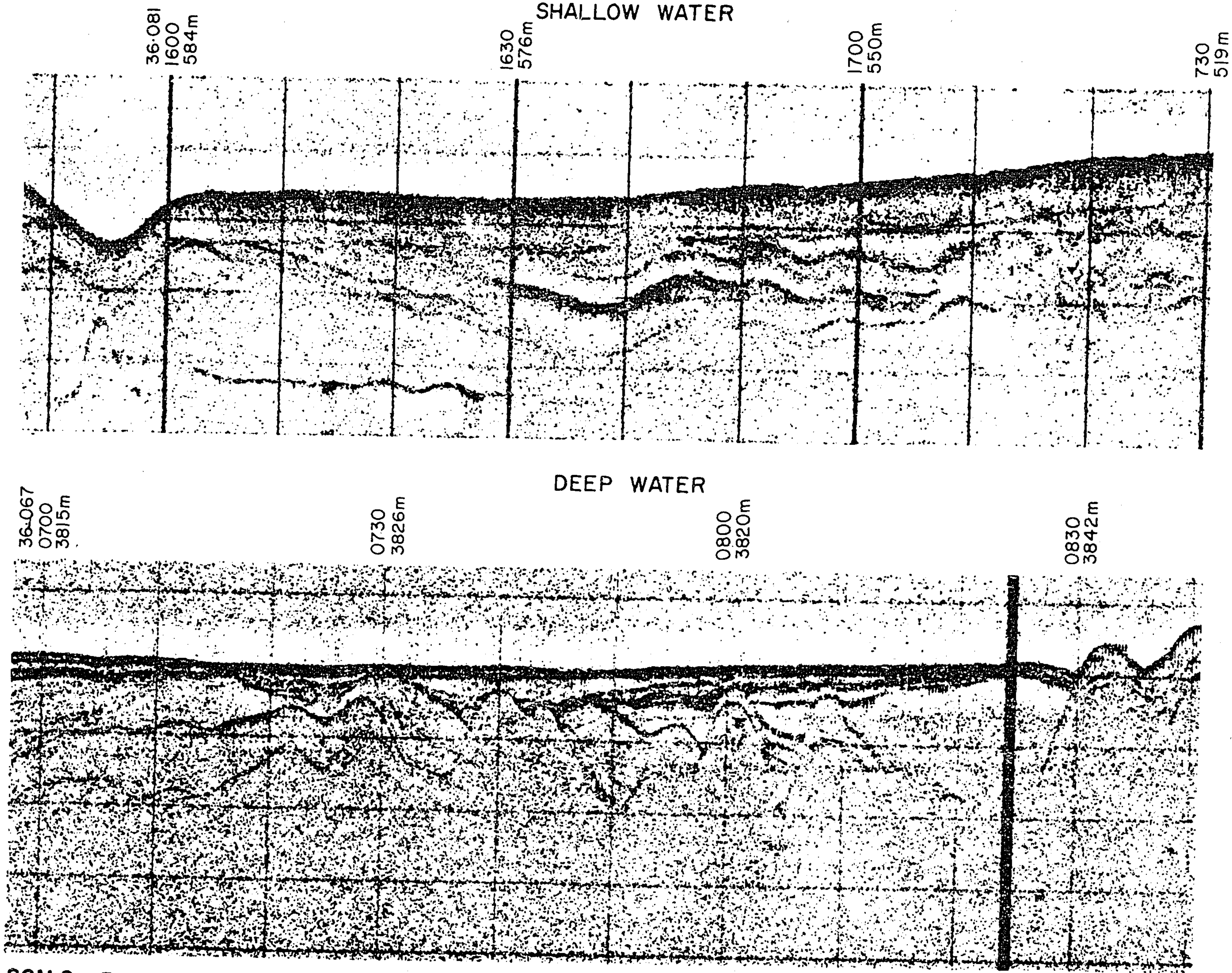


Fig SGM 9 Raytheon bathymetric system – examples of 'penetration' Record 1980/70, Report 231 W/B8-169-1A

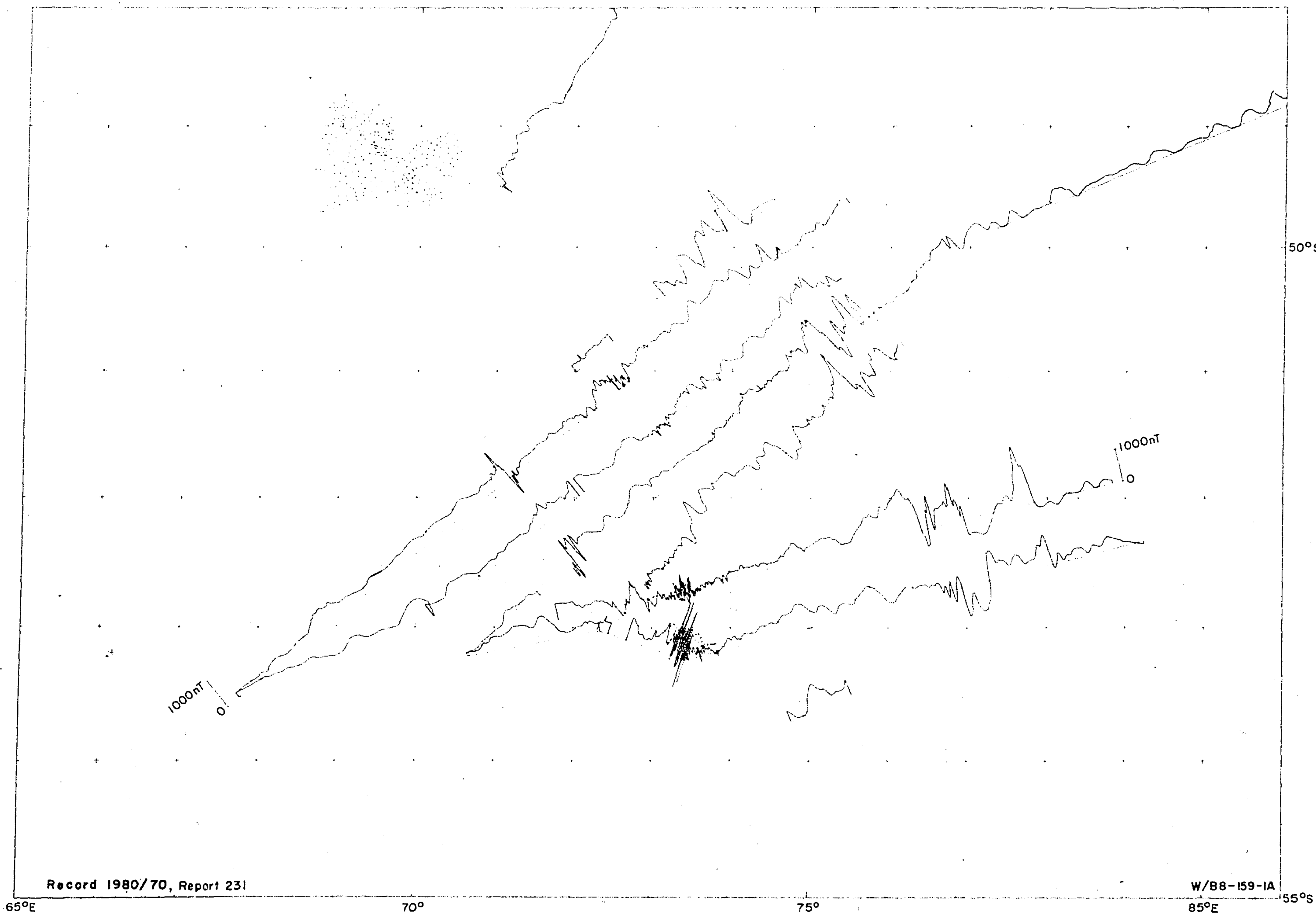


Fig SGM 10 Magnetic profiles across Kerguelen Plateau

Magnetic anomalies over the Heard-Kerguelen region (Fig.SGM-10) are highly disturbed overall, owing to the shallow basement and/or abundant volcanics within the region.

A zone of high-amplitude high-frequency anomalies along the eastern margin of the plateau is probably related to the volcanic/igneous complex shown in the Eltanin seismic data. Anomalies within this zone have amplitudes up to 2000 nT. Both amplitude and frequency of anomalies decrease westwards, reflecting the change to a more subdued basement topography.

Near Heard and McDonald Islands, extremely high-frequency anomalies of about 500 nT are associated with the shallow volcanic basement around these islands.

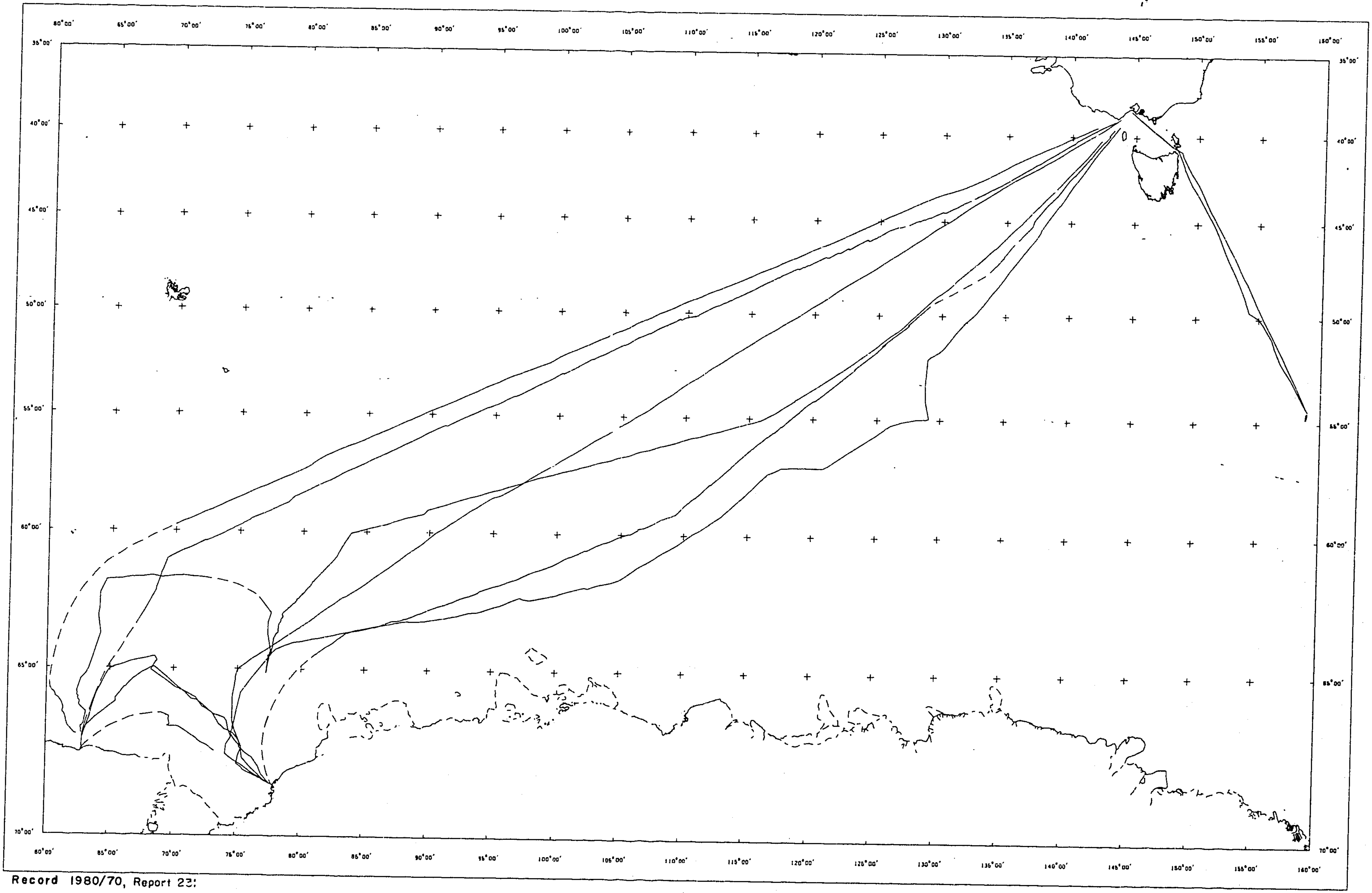
The two transit lines between the Kerguelen Plateau and Fremantle filled a gap in the existing traverse network and allowed the magnetic anomaly pattern to be better resolved. The most significant result is the identification of anomaly 17 immediately adjacent to the northeastern margin of the plateau. This anomaly, previously identified in the south, is now known to extend along most of the eastern margin of the Kerguelen Plateau. Several previously identified fracture zones have been extended southwestwards almost to the plateau margin.

A BMR Record outlining the operations and preliminary results has been prepared. A precis of this record will be published in NATMAP's report on the 1980 Heard Island Expedition.

Antarctic marine surveys, 1979/80 and 1980/81 seasons (L.A. Tilbury, H.M.J. Stagg, R. Whitworth, A.R. Fraser, B. Devenish, R.A. Dulski, D.C. Ramsey, L.W. Miller, J. Rutledge)

During the 1979/80 Antarctic season, BMR started a moderate Antarctic marine geoscience program using the Antarctic supply vessel MV Nella Dan. The aim was to collect magnetic data over the Antarctic margin, the plateaus surrounding Australian sub-Antarctic Island Territories, and the southeast Indian Ocean. A total of 32,600 km of magnetic data was collected on the three Antarctic relief cruises and the cruise to Macquarie Island (Fig.SGM-11). Although excellent coverage was obtained over the Kerguelen Plateau and the southeast Indian Ocean, only about 1000 km of data were collected over the Antarctic margin because the sea ice prevented streaming of the sensor for part of the time.

Several extensions to the program are presently being implemented for the 1980/81 season to maximise the scientific return, to increase the accuracy of the navigational data collected, and to ease the workload for post-processing



Record 1980/70, Report 23:

Fig SGM II NELLA DAN MARINE SURVEYS, 1979-1980
TRACK MAP

——— SHIPS TRACK
– – – APPROXIMATE TRACK

W/B8-153-1A

at BMR. The most significant is the installation of BMR's deep sounding Raytheon echo-sounder to obtain water depths over the deep ocean basins. This will supplement the echo sounder of the Australian National Antarctic Research Expeditions (ANARE) which obtains depths to a maximum of 3000 m and can only cover the Antarctic margin and adjacent plateaus, a small fraction of the total traversing.

Navigational data, previously logged manually every 10 minutes or so at best, will this season be collected digitally every 10 s. The TRACOR satellite navigator is being modified by BMR to obtain digital output of the navigational data, comprising time, latitude, longitude, course, and speed.

The Nella Dan has been extensively modified for Antarctic Division to carry out its Marine Science program (Biology) during the First International Biomass Experiment (FIBEX) cruise in the 1980/81 season. This has resulted in a benefit to BMR because the ship is now a viable platform for marine geophysics. In particular, there is now a proper instrument laboratory for the computer-based data acquisition equipment, and a wet and dry laboratory; the stern of the ship has also been cleared to allow for the installation of winches, for example a seismic cable winch.

ARPAC proposals for Antarctic research projects (L.A. Tilbury, R. Whitworth, H.M.J. Stagg)

Two proposals were submitted to ARPAC (Antarctic Research Policy Advisory Committee) for marine geoscience programs using the Nella Dan.

The first, 'Magnetic surveys of the Antarctic margin and southeast Indian Ocean', formalised the program that was started on the Nella Dan during the 1979/80 Antarctic season. The major objectives are:

(a) a reconnaissance magnetic investigation of the Antarctic continental margin as a basis for and precursor to more concentrated seismic work. The estimation of depth to magnetic-basement, and hence an estimate of the sediment thickness, is the dominating interest because of the possible economic potential of the margin. Work will be concentrated in the Prydz Bay region between Davis and Mawson, over the offshore extension of the Lambert/Amery Ice Shelf rift;

(b) investigation of plateaus surrounding Australia's sub-Antarctic Island Territories. The Heard Island region in particular requires resolution of its tectonic history and possible economic potential. Studies will be oriented to further defining the structural framework and evolution of these regions using the adjacent magnetic anomaly patterns;

(c) to further define the structural elements and 'magnetic' age of the southeast Indian Ocean region so as to obtain a better understanding of the evolution of the Australian and Antarctic plates following the break-up of Gondwanaland;

(d) secular variation studies over the southeast Indian Ocean. Further development of an Australian Geomagnetic Reference Field (AGRF) using estimates of secular variation obtained by comparison at intersections with tracks of earlier surveys, particularly Eltanin.

The second proposal, 'Seismic surveys of the Antarctic margin and southeast Indian Ocean', was a notice of intent that BMR should pursue marine seismic work in the Antarctic region without delay. Once a viable platform and supplementary seismic equipment (streamer and energy source) are available, BMR intends carrying out a comprehensive geophysical survey in the Antarctic region.

The proposed survey is divided into two stages. The first would be carried out using a single channel (or small multichannel) cable and moderate air-gun source. The Nella Dan would be suitable for this stage.

The second stage would use a long multichannel cable, at least 12-24 channels, and a large air-gun source. This stage would probably require a more suitable marine geoscience vessel. The major objectives are:

Stage 1

i) identification of major sedimentary basins and structural elements of the Antarctic margin and sub-Antarctic plateaus;

ii) comparison of major unconformities on the Antarctic margin with those of the Australian southern margin to determine extent and thickness of pre and post-rift sediments;

iii) identification of unconformities in the deep sea sediments and their relation to circulation patterns, in particular the advent of the circumpolar current;

iv) detection and study of layering within basement similar to the Argo Abyssal Plain and Labrador Sea.

Stage 2

i) using multichannel seismic to define the structure and seismic stratigraphy of the offshore extension of the Lambert Graben in the Prydz Bay region;

ii) investigate the Kerguelen Plateau region, in particular the thick sediment accumulations within rift zones and resolve their possible economic potential. Further define the structural framework and evolution of the Kerguelen Plateau, and resolve, if possible, an oceanic or continental origin for the plateau.

iii) outline the sediment distribution, areal extent, and thickness of any major sedimentary basins found in Stage 1. Resolve any possible economic potential of the Antarctic margin.

Law of the Sea (P.A. Symonds, J.B. Willcox, J.C. Branson)

This is a continuing commitment, attending to requests from the Oil and Gas Division of the Department of National Development and Energy for information and advice relating to the UN Law of the Sea negotiations. A large part of BMR's effort in this area goes into providing a broad understanding of the physiography, geology, and petroleum prospectivity of the regions offshore from Australia and its territories.

Mr Symonds took part in interdepartmental discussions about Australia/France maritime delimitation, and was a member of the Australian delegation for the Australia/France Officials' Talks on Maritime Delimitation, which were held in Canberra from 30 September to 2 October 1980. He provided technical advice, in the form of maps, Professional Opinions, and minutes, on the three regions around Australia and its territories that were affected by delimitation with France; namely, the southern Coral Sea region, the Norfolk Ridge, and the Kerguelen Plateau.

CCOP/SOPAC and the Second International Workshop (J.C. Branson, J.B. Willcox)

A Second International Workshop sponsored by the Committee for Co-ordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas (CCOP/SOPAC) - and the Intergovernmental Oceanographic Commission/ Programming group for the West Pacific (IOC/WESTPAC) was held in Noumea, New Caledonia, from 9 to 15 October 1980. J.B. Willcox and R.W. Johnson of BMR presented scientific papers during the first two days of the conference. J.C. Branson attended as Technical Adviser to CCOP/SOPAC, and H.F. Doutch attended as the new Chairman to the Circum-Pacific Map Project, SW Quadrant Panel.

The Second International Workshop considered the main areas of scientific interest which require investigation during the next five years in the South Pacific region. Three working groups were set up to consider projects under the three main headings:-

Group A: Tectonic evolution of arcs and back-arc basins;

Group B: Deep crustal structure, petrogenesis, and thermal evolution of the lithosphere;

Group C: Stratigraphy, sedimentary provenance, and metallogenesis.

Under the first title, five projects were recommended by the workshop:-

- A1 Study of island arc sedimentary basins: correlation of reference sections and seismic stratigraphy;
- A2 Solomon Islands palaeomagnetic project;
- A3 Definition of the Indian/Pacific Plate Boundary north of Fiji;
- A4 The geophysical and geochemical consequences of subduction at the Woodlark spreading system of the Solomon Islands arc-trench system;
- A5 Effects of subduction of aseismic ridges and small plateaus in the South Pacific.

Under the second title, three projects were recommended:-

- B1 Ophiolites, emplacement mechanism variations, mineral resources;
- B2 Mechanical properties of the oceanic lithosphere studied through bending processes;
- B3 The thermal regime of the descending oceanic lithosphere.

Under the third title, three main projects were recommended:-

- C1 Stratigraphy
- C2 Metallogenesis
- C3 Sedimentary provenance.

These were subdivided to make nine subprojects in Group C.

The main recommendations, besides those of the work program, were:

1. 'that the Chairman of the Workshop transmit for approval the adopted Summary Report of the Workshop (including Recommendations and Programmes of Research) to the next session of CCOP/SOPAC, to be held in Tarawa, Kiribati, 20-28 October 1980, and to the Secretary of IOC for submission to the next session of the IOC Executive Council, to be

held in May or June 1981 in Spain, as well as to the next session of the Programme Group for the Western Pacific (WESTPAC), to be held in Jakarta, September 1981;

2. that UNESCO (United Nations Economic, Scientific, and Cultural Organisation) and its IOC, CCOP/SOPAC and ESCAP (Economic and Social Commission for Asia and the Pacific) provide immediate training in marine geology, geophysics and mineral resources as well as in data handling, so as to avoid delays in the implementation of the Programmes of Research.

3. that UNESCO arrange for a meeting of operators of seismographic networks with interested representatives of island groups, in order to discuss (1) the improvement of communication between existing networks and the establishment of a regular exchange of seismographic bulletins, (2) the exchange of technical information on instrumentation, and (3) the establishment of new networks in critical areas.

4. that UNESCO and its IOC examine and improve, as a matter of priority, the coordination and interpretation of the seismic information system in Vanuatu, Fiji, Samoa and Tonga, and tsunami warning communication system in the region.'

<u>CCOP/SOPAC Ninth Session</u> (J.C. Branson)

The Ninth Session of CCOP/SOPAC was held in Tarawa, Kiribati from 20 to 28 October 1980 following the Second International Workshop in Noumea. It was attended by representatives of the following countries:- Cook Islands, Fiji, Kiribati, New Zealand, Samoa, Solomon Islands, Tonga, and Vanuatu. Technical advisers were provided from Australia (J.C. Branson), France, Japan, USSR, UK, and USA. Also in attendance were representatives of ESCAP, IOC/UNESCO, UNDP (United Nations Development Programme), and observers from Guam, Trust Territory of the Pacific Islands, and the University of the South Pacific. H.F. Doutch, as new chairman of the Circum-Pacific Map Project, SW quadrant panel attended with the retiring chairman M.J. Turman (USA).

The session was organised under the following ten headings:

- General: - dealing with recruitment and vessel charter
- Surveys carried out:- described by minerals under the headings
    - Hydrocarbons
    - Manganese Nodules
    - Phosphates and phosphorites
    - Sand and gravel and coastal engineering
    - Precious Coral

Brick clay

Other surveys

- Data information and management
- CCOP/SOPAC Publications
- Training
- Evaluation of hydrocarbon resources
- Advances in technology
- Consideration of the CCOP/SOPAC - IOC/WESTPAC Second International
- Workshop recommendations at Noumea
- Formulation of a work program
- Funding

The technical advisers considered the CCOP/SOPAC work program and the report of the UNDP Mineral Resources Sector Review Mission. They provided the session with six conclusions, supporting the objective of continued offshore surveys for manganese nodules, metalliferous sediments, and hydrocarbons, and recommending strongly that the level of financial support should rise above the recommended minimum level of $US 3 500 000 if possible.

A proposal for the setting up of a volcanological institute in the South Pacific was recommended by the Noumea Workshop 1980 but not acted upon by the Ninth Session in Tarawa. This recommendation is to be considered by IOC in Spain in 1981. However the Workshop recommended to CCOP/SOPAC 'to establish a South Pacific Information Centre in which all published and unpublished material can be centralised, with a specialised library' and that the Technical Secretariat of CCOP/ SOPAC carry out discussions with the Office of Scientific Research of Overseas Territories (ORSTOM) and other organisations to determine a site for and feasibility of setting up such a library.

Specific projects from the Noumea Workshop were annotated by the Technical Advisory Group with directions to institutions in Australia and other parts of the world for direct implementation. The Australian contribution to the program of training in bathymetric drafting is continuing and further support for the future of this program with Australian help is being sought. Other projects requiring BMR assistance are shallow water drilling, stratigraphic correlations, and advice on interpretation of maturation analysis.

<u>Data processing</u> (L.A. Tilbury, H.M.J. Stagg, R. Whitworth, T.R. Hegvold, J.C. Branson, G. Price, W. Meyer)

Data processing was carried out on an opportunity basis, subject to staff availability. Most of the processing was done in June and July when two geophysicists and three technical officers were available.

a) Arafura Sea, Survey 29.

Data were transcribed from cassette tape, converted and reformatted at CSIRO, and processed through the initial stages of Phase 1 (data cleaning and editing). Editing is essentially complete. Navigation adjustment is the major outstanding process to be applied. Preliminary track maps were drawn for editing and internal use.

b) Antarctica, Surveys 31 and 32.

These surveys have also been processed through the initial cleaning and editing stages. Bit problems in the digital recording of magnetics were fixed, and the minor editing required was completed. Data is ready for filtering prior to resampling to one-minute values for the continuation of the processing.

Navigational data were a problem as these were manually recorded at irregular intervals. Programs were written to check the course and speed between consecutive intervals to pinpoint errors in the navigation. Editing is essentially complete, and the navigation data should be incorporated with the geophysical data by the end of the year.

c) Heard Island, Survey 36.

This survey has also been processed through the initial stages of Phase 1 including plotting of all raw data, although no editing has been carried out as yet. Bit problems in the digital recording of magnetics was the only significant part to be fixed. Preliminary track maps were drawn for internal use.

d) Pre-CMS Surveys (Northwest shelf, Survey 04; Timor Sea, Survey 03; and Bonaparte Gulf, Survey 01).

The data from these surveys were resurrected from old magnetic tapes and converted to make their format compatible with the current Marine Geophysics Data Base. Data were plotted, checked, and edited if necessary, especially the Timor Sea survey, prior to inclusion in the data base.

The standard 1:1 million trackmaps of northwest Australia were updated to include the Northwest Shelf and Timor Sea surveys (9 maps in all) and released to the public through the Copy Service, Australian Government Printer (Production) and the Western Australia and Northern Territory Geological Surveys. Processing of the Bonaparte Gulf survey data is still in progress.

<u>Compilation</u> (L.A. Tilbury, T.R. Hegvold)

A new compilation series of trackmaps at 1:2.5 million scale was started this year. These maps show all available ships' tracks along which bathymetric, magnetic, gravity, or seismic data were collected. The first 15 map sheets have been completed for internal use (Fig. SGM-12), and cover the region from Australia to Antarctica, and Kerguelen Island to New Zealand. These Sheets were primarily produced for the 1980 Heard Island Expedition, and the Nella Dan surveys. When line labels have been finalised, they will be released through the Government Printer.

The data incorporated in the maps include tracks of BMR surveys, Lamont-Doherty Geological Observatory (<u>Eltanin</u> and <u>Vema</u>), Scripps Institution of Oceanography, JOIDES (Joint Oceanographic Institutions Deep Earth Sampling Programme; <u>Glomar Challenger</u>), and Ocean Research Institute of Tokyo (<u>Umitaka</u> and <u>Hakuho Maru</u>). Considerable effort was spent in conversion and editing of the data.

<u>Automated map production</u> (R. Whitworth, L.A. Tilbury)

Several revisions and extensions were made to the computer routines for automated map production. The legend routines were modified to allow more flexibility in producing map legends. In particular, provision was made for an extra 'note' panel, and two 'sources of information' panels. The user can now optionally choose up to two 'notes' and up to two 'sources of information' panels.

A further extension of the map production facilities involved the automatic labelling of ships' tracks for the track-plotting programs. A master file containing the start and stop time, and the line label for each line is required. Once the file is made, it can be accessed by any track-map computer job which will locate those lines or parts of lines on the map, and label them appropriately using the standard BMR convention.

<u>Archiving</u> (L.A. Tilbury, U. Hammerling)

Considerable effort has been expended this year to archive magnetic tapes from the continental margin survey (CMS) and other marine geophysical surveys.

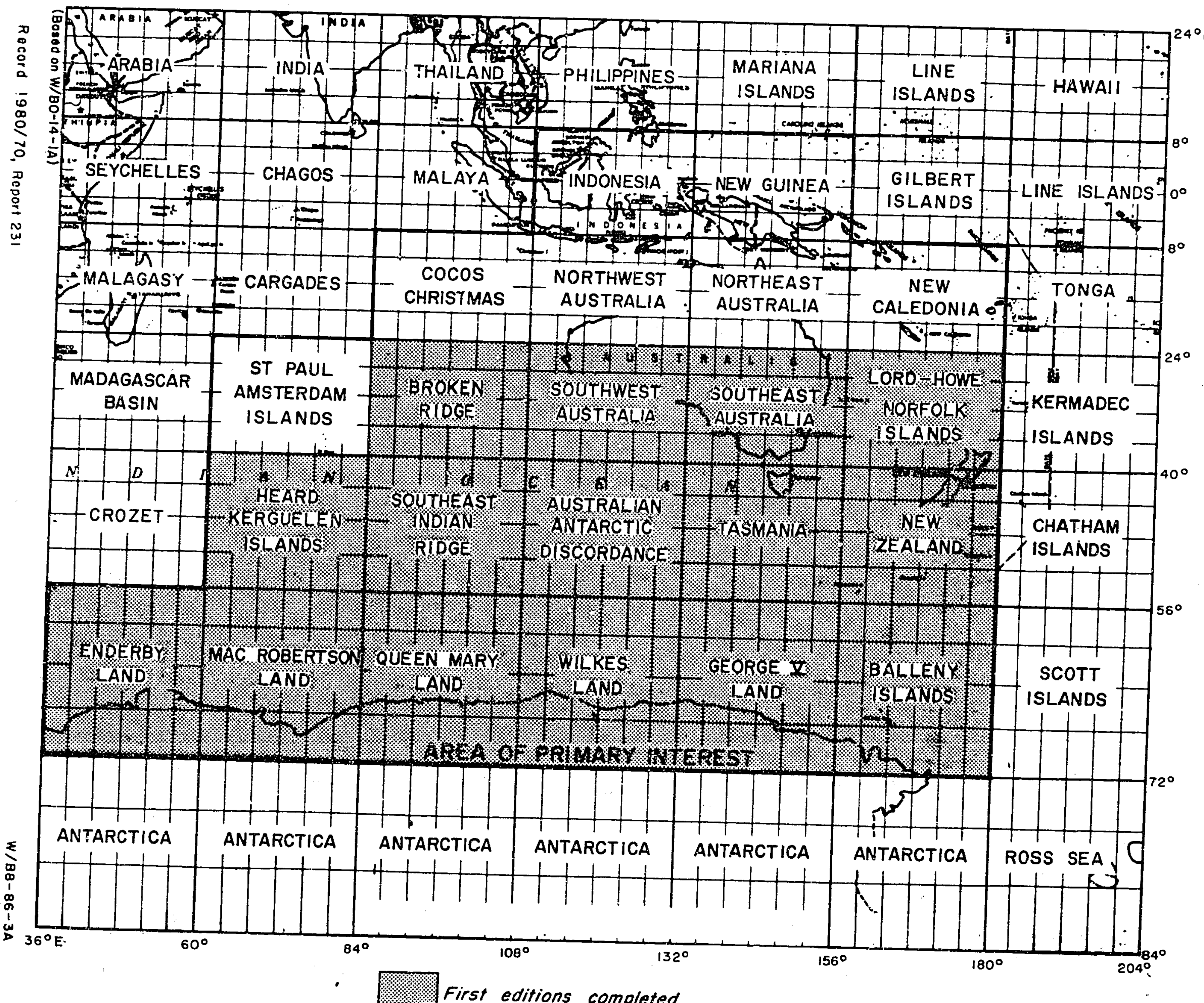


Fig SGM 12 1 : 2·5 million sheet areas

Some 250 digital tapes were archived in the ADP (Automatic Data Processing) section's tape archiving system. These included the original field tapes from the data acquisition system (106 tapes) and satellite navigation system (36 tapes), the processing tapes from PHASE 1 (80 tapes), and original tapes received from overseas institutions. Appropriate paperwork was completed for indexes and the ADP section's data base to facilitate retrieval of data.

Seismic analogue tapes (564 tapes) were also sorted, labelled, indexed, and archived into the Marine Geophysics Group's archive accession series (serial CRS A2544) for seismic analogue tapes at the Australian Archives Office. Tapes from the Timor Sea survey, 1967, were extracted from archives, top-numbered, and returned for incorporation into the correct archive series noted above.

Duplicate copies of the CMS seismic analogue tapes (400+ tapes) were also archived. This was done because all external seismic processing is carried out using copies of the field tapes, and producing these copies is both time consuming and costly. When all seismic tapes have been converted to digital form the analogue tapes will be redundant.

<u>Multichannel digital seismic acquisition system (MUSIC)</u> (H.M.J. Stagg, R. Whitworth)

This project was initially reported in the 1979 Geophysical Branch Summary of Activities. The aim of the project is to provide the Marine Geophysics group with the facility to acquire multichannel digital seismic data. The system is built around a Hewlett-Packard minicomputer with 32 K of memory and a Phoenix A/D converter; data are sampled at a 1,2, or 4 ms rate and recorded on 9-track magnetic tape. Data are recorded in demultiplexed format to make it possible to process them on the BMR in-house seismic processing system. As reported in 1979, the system is to be built in two stages - viz:

Stage I - a BCS-based system limited by the available computer memory to 18000 data values per shot (e.g. 12 channels, 1 ms sampling, 1.5 s record).

Stage II - an RTE-based system using a moving-head disc as a large input buffer area. This stage will not be built until a disc (and staff) becomes available. Stage I would then provide a back-up should the disc fail.

Writing of the software for Stage I was severely curtailed in 1980 because of the commitment of computer equipment to field surveys. This software can be split into 4 parts -

(1) Basic acquisition and recording on magnetic tape. This section has been written and extensively tested with simulated inputs.

(2) Data display and quality control. Data will be displayed on cathode-ray screens (CRO's), EPC graphic recorders, and a strip-chart recorder. CRO displays will include multiplexed data from all channels, shot pulse, and a single-channel trace from each shot. EPC displays will include fast and slow single-channel monitors and a 'cycling' display which will display data from each channel for 10 minutes; all EPCs will operate on continuous high-speed sweep to enhance the display. The strip-chart recorder will probably be used to record water depth. The software for this section is largely written but still untested.

(3) \ suite of operation programs to control recording and display parameters has been written and tested.

(4) It is intended to provide a link between the DAS and seismic computers to enable the transfer of time, navigation, and bathymetric data. This software has not yet been written.

<u>Seismic processing system development</u>

(C.R. Johnston, F.M. Brassil, D.N. Downie, P. Fowler, B. Devenish)

A second application to the National Energy Development and Demonstration Council (NERDDC) was successful, increasing the project's allocation of NERDDC funds to $124,800.

These NERDDC funds were mostly spent on hardware purchases. The items purchased include an array transform processor (ATP), an ATP programmer's control panel, a master display controller, a line printer, a graphics VDU, two VDU terminals, additional computer memory, a terminal multiplexer, and miscellaneous items. The remainder of the funds were spent on an ATP training course. This course, which was conducted by the ATP manufacturer, was held at BMR in July. The course was attended by eight BMR officers.

Software development activities were mainly centred around building a framework of processing control facilities required to ensure efficient usage of hardware and to permit specific seismic processes to be included within the system with a minimum of effort. The major components of this framework include a hardware resources manager (RMGR) to ensure that multiprocessing activities are both attainable and manageable, an I/O control system (SPOCK) which provides the necessary I/O facilities for each seismic process, and a data copying facility (COPY) for moving and combining SEG-Y format seismic data.

The specific seismic processes that have been added to this system during the year include a first attempt seismic display program, a revised demultiplexing program and a revised CDP gather program.

In addition to the above activities approximately 2,500 km of Continental Margin Survey (CMS) analogue seismic data from the Capricorn Basin was transcribed into digital form for K. Lockwood (Petroleum Exploration Branch). These data were required for subsequent processing at (Geological Services International (GSI), Sydney. Also, approximately 60 km of CMS data from Exmouth Plateau was transcribed and displayed on the digital plotter for N. Exon (Geological Branch). These data were required for publication purposes.

Provision of navigation system for mineral sands survey on R.V. Sonne
(D.C. Ramsey, R. Whitworth)

The Marine Geophysics Group was involved in providing a navigation system for the mineral sands geological cruise on the R.V. Sonne during September-November 1980. The Decca Trisponder radio-location system owned by Australian Survey Office (ASO) was modified in BMR and linked to a BMR data acquisition system (DAS) to give on-line positions every 10 s and the corrections required to return to a chosen track.

Before the survey, the Trisponder system was modified by Interim Engineering Services Branch to receive four remote stations instead of the normal two. This was considered necessary to be sure of receiving at least two stations at all times, in order to calculate a position. In practice, the operator chooses the two stations which will give the most accurate fix, and the ship's position is calculated from the two distance measurements.

The heart of the DAS is a mini-computer which calculates such parameters as distance to beginning and end of line, cross-course error, and speed, once the operator has entered the desired track by specifying the co-ordinates of the start and end points of the line. The above information is up-dated at 10-second intervals and displayed both on a visual display unit, and as hard-copy on a teletype. The operator/navigator then manually plots the ship's position on a chart to give a record of the ship's track. The same information is also stored on magnetic tape, for later processing, if required.

The system was hurriedly mounted in two racks on the bridge of the Sonne while in Sydney, and final debugging of the system took place in and off Newcastle. Operators were provided by both BMR and ASO.

Development of a recording digital magnetic shore monitor station
(D.C. Ramsey, R. Whitworth, H.M.J. Stagg)

In the past, magnetic shore monitor data for marine magnetic surveys have been recorded in analog form, thus requiring tedious digitising before being input to the Marine Group's processing system. For the 1980 Great Barrier Reef Survey it was decided to develop a digital shore station, based on an HP 2116B computer. For a number of reasons, this station was sited at Charters Towers, at the same location as an existing seismic monitoring station.

The digital system comprised a Geometrics G806 base-station magnetometer, a BMR clock, and the computer with teletype terminal and Facit cassette recorder. Magnetic values were recorded at intervals of 10 s, and blocks of these values, with the appropriate times, were recorded on magnetic tape and printed out by the teletype. There were also analog chart recordings of the magnetic field value as a back-up to the digital system. Because of slight differences in computer parameters, early versions of the shore monitor program, developed on a separate computer, failed to run in the 2116B at Charters Towers. It was not until another identical 2116B became available at BMR that the final version of the program could be written and tested. When this was taken to Charters Towers, the system sprang immediately to life.

As a further step in this development, it is intended to simplify the system by replacing the computer, teletype, and Facit with a small digital cassette data logger. Hopefully this new system will be available for surveys in 1981.

ENGINEERING GEOPHYSICS GROUP (F.J. Taylor, G.R. Pettifer, D.C. Ramsey, D.G. Bennett, G.S. Jennings, P.J. Swan, D.H. Francis, L.W. Miller, R.J. Wilson)

This year saw the further decline of the Engineering Geophysics Group. Since it is no longer within the Bureau's policy to do engineering-type surveys, very little work of this nature was completed this year.

G. Pettifer left in March to join the Geological Survey of Victoria; D. Francis left at the same time to take up a contract with the Geological Survey of PNG. D. Bennett left in May to join Petroleum Exploration Branch. R. Wilson left in June to work for Layton Geophysics. D. Ramsey and L. Miller have joined Marine Geophysics Section. F.J. Taylor has joined the Seismic Section.

Slope stability investigation, Blackwater, Qld

At the request of CSIRO Division of Applied Geomechanics, BMR undertook a seismic survey at Utah Development Company's Blackwater coal mine. The seismic survey was part of a major investigation of the stability of the high wall at the open-cut mine, being conducted jointly by CSIRO and the Utah Development Company. The object of the survey was to determine the effect of a large overburden blast on the rock which would form the new high wall, immediately behind the blasted area.

The work entailed measurements before and after the blast. Three different types of seismic measurements were made: (1) normal refraction spreads recorded at the surface; (2) surface shots recorded on down-hole geophones; and (3) cross-hole shooting with down-hole shots recorded on the same down-hole geophones as (2).

The results of the survey indicated that the overburden blast had little immediate effect on the seismic properties of the rock in question. However, the rock extending for a considerable distance back from the open-cut pit was considered to be abnormally weakened; this was presumably caused by the cumulative effects of all the blasting, and to the existence of the pit itself.

Wireline logging

A moderate program of logging was completed this year, with holes in and around the ACT, western NSW, and Qld.

A series of holes was logged at Pialligo, Long Gully, and West Belconnen refuse dumps in the ACT, to monitor radioactive waste pollution. This work was done for Geological Branch.

In NSW, eight holes around Bungendore and two near Lake Cargelligo were logged for groundwater. Again the client was Geological Branch.

Oil shale holes formed a significant part of the logging program this year. One hole was logged in the Darling Basin, near Menindee, for Petroleum Exploration Branch. Another hole near Tibooburra was logged for Geological Branch; for this hole a density tool was hired, to provide extra data. Then, fourteen holes were logged in the area between Charleville and Barcaldine, an oil shale investigation project funded by NERDDC. Gamma, neutron, density, and caliper logs were run in all holes, with resistivity and SP in two deep holes only. Lastly, four holes were logged in the Mt. Isa area, again investigating oil shale, the client being Geological Branch.

Vibration measurements at Puckapunyal army range

At the request of the Department of Defence, the BMR measured ground vibrations resulting from the shooting of various types of weapons at the Puckapunyal army range near Seymour in Victoria. The vibration levels were monitored at four sites within the range, the distances from measuring sites to impact zone being between 5 and 8.5 km.

At no time did energy passing through the ground from the impact of the explosive device exceed the background noise level. Only vibrations caused by ground-coupling of the air blast were detected, the maximum value being about 0.5 mm/s peak particle velocity.

Interpretation of seismic refraction data from Tennant Creek, NT

The NT Department of Transport and Works conducted a seismic refraction survey with the aim of delineating zones of deep weathering in the area around Tennant Creek. It was hoped that such zones might be the sites of groundwater accumulations. Since they were somewhat lacking in expertise in interpreting such data, the records were sent to the BMR where they were plotted up, and interpretations made. The results of the interpretation were forwarded to the originating department in the NT.

Interpretation of resistivity data from Tarawa, Kiribati

A groundwater survey, including resistivity depth probing, was carried out by private consultants on behalf of the British government, as an aid project to Tarawa, Kiribati, (formerly the Gilbert Islands). Subsequently, the Australian Government was asked to review the interpretation of this data, and to carry out further field work.

Engineering Group became involved when asked to check the interpretation of a representative selection of the depth probes, using computer programs developed for this type of work. Later, following discussions with officers of the Department of Housing and Construction (DHC), the Group was asked to recommend portable resistivity equipment for similar work on Tarawa and other Pacific islands. Eventually, an ABEM resistivity measuring system was purchased by DHC, tested at BMR, and then sent to Tarawa to carry out further work. This work is in progress at the present time.

3. GEOMAGNETISM, SEISMOLOGY, AND REGIONAL GEOPHYSICS SECTION

(D. Denham)

REGIONAL GEOPHYSICS SUBSECTION (D. Denham, D.M. Finlayson)

Stresses in the Australian crust: evidence from earthquakes and in situ stress measurements (D. Denham).

During 1980 BMR continued its program to study the stresses in the Australian crust using the results from earthquake focal mechanisms and in situ stress measurements (Fig. OR-1). This project was carried out in co-operation with the CSIRO Division of Applied Geomechanics; most of the effort was concentrated on the South West Seismic Zone of Western Australia and the Dalton/Gunning region of New South Wales.

South West Seismic Zone, WA. During February/March 1980 in situ stress measurements were carried out in the South West Seismic Zone, WA. BMR provided the drilling facilities and selected the sites while CSIRO undertook the overcoring measurements. Tests were completed at five sites within 25 km of the 1979 magnitude 6.5 Cadoux earthquake, and at four sites farther south near Goomalling, Pingelly, Narrogin, and Wagin.

The stresses near Cadoux show a consistent east-west trend for the maximum stress axis, with the size of the stress decreasing from about 19 MPa near Wongan Hills (25 km from the fault scarp) to 4 MPa close to the scarp at Cadoux. The Wongan Hills site was about 5 m from the site that was measured before the Cadoux earthquake in 1976 and the results are very similar as shown below:

Date	Maximum principal stress in MPa	azimuth (E of N)
1976	21 ± 5	66 ± 11
1980	19 ± 2	76 ± 18

where the errors are standard deviations.

Figure OR-2 summarises the measurements taken during 1980 and also shows the results of the 1976 work.

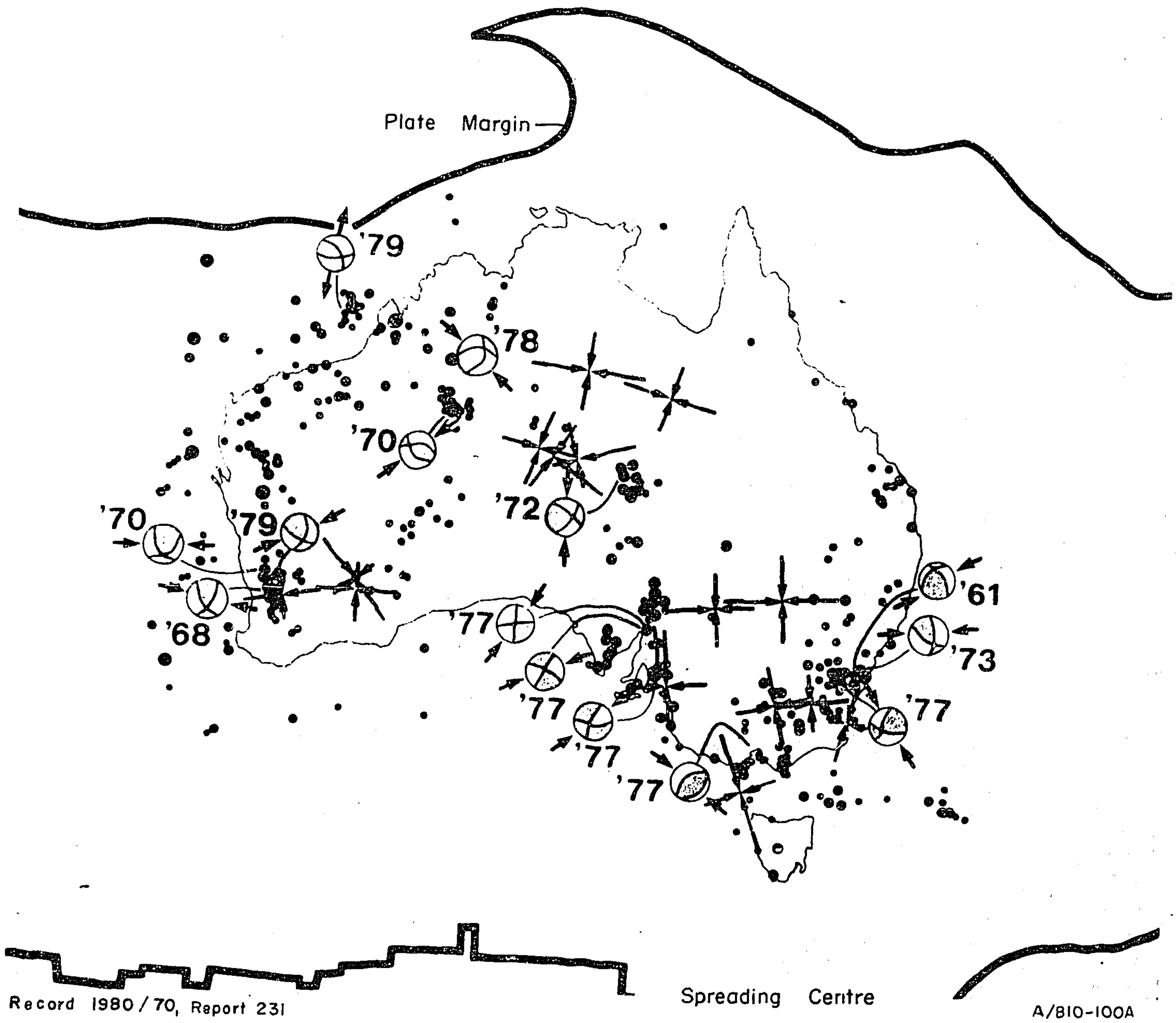


Fig OR I Australian stress measurements and earthquake fault plane solutions

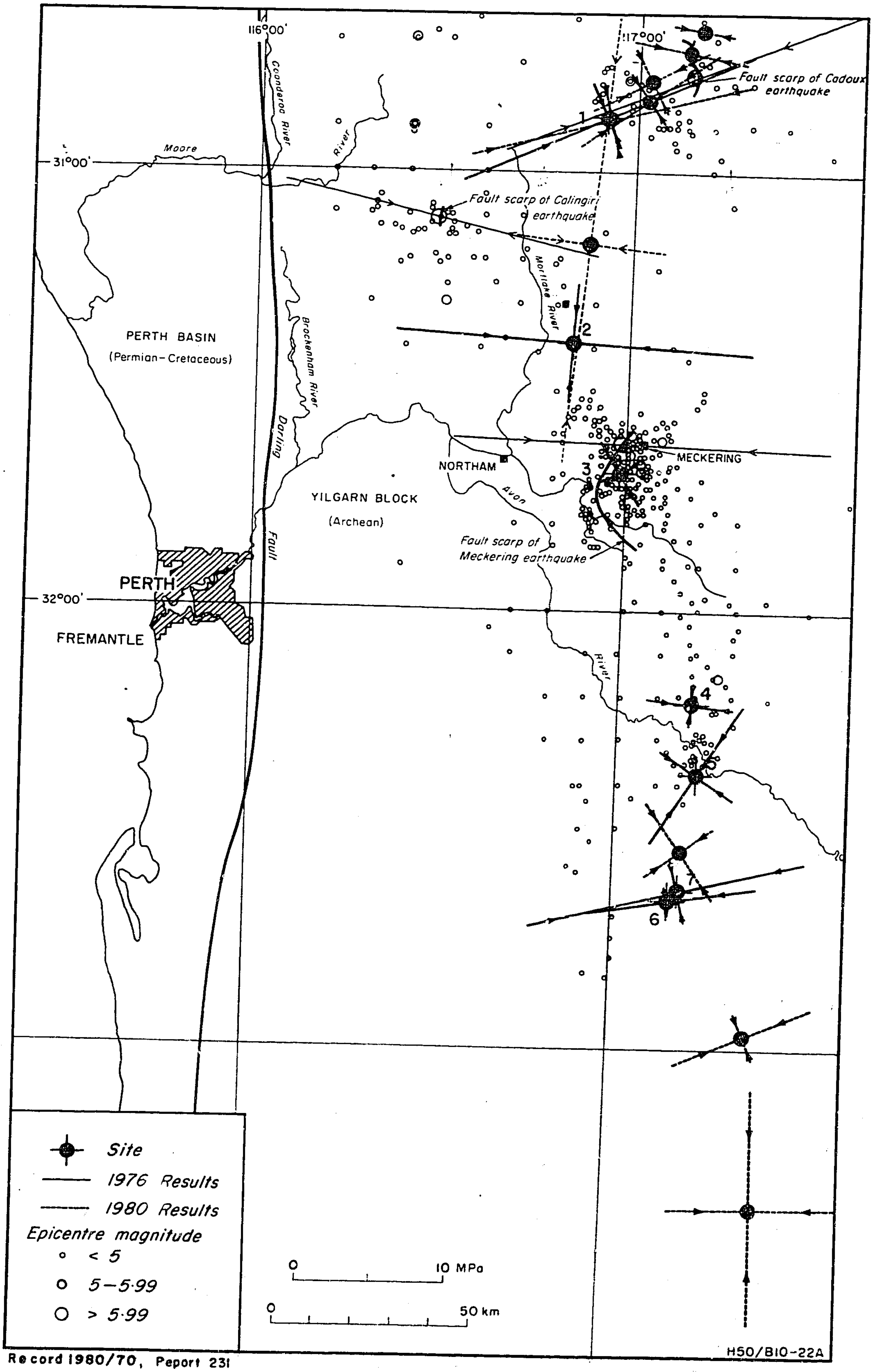


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Fig OR 2 Stress measurements in WA, 1976 and 1980

<u>Dalton/Gunning Region, NSW</u>. From 5 March to 17 April 1980 six continuously-recording tape recorders were installed in the Dalton/Gunning region to study any earthquakes that may have occurred there in that period.

The Dalton/Gunning area is one of the more seismically active areas in NSW and several damaging earthquakes have occurred there during the last 80 years. Figure OR-3 shows the distribution of all known earthquakes recorded by 5 or more seismic stations since 1900, the sites of the portable tape recording stations, and the routes of the Moomba/Sydney gas pipeline and the Canberra spur.

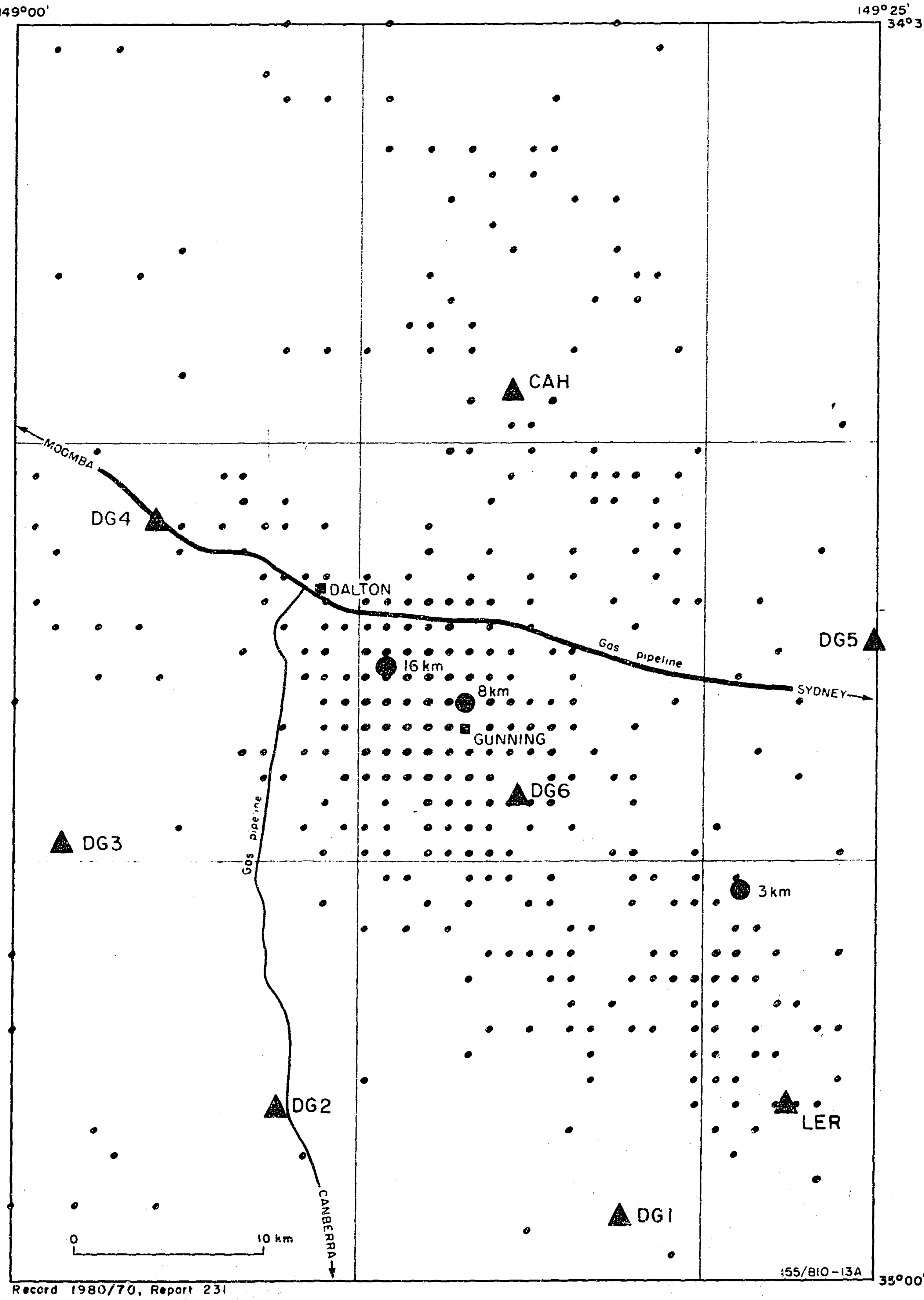
Three earthquakes from within the network were located (also shown on Figure OR-3) using the Menlo Park HYPO 71 program and a crustal model as shown below

<u>Crustal Model</u>

Velocity (km/s)	depth (km)
5.65	0
5.85	2
6.00	5.5
6.45	15.5
6.95	26.5
7.20	34.0
7.50	38.0
7.70	41.0
7.90	44.0
8.00	56.0

All these three earthquakes had magnitudes of less than 2 on the Richter Scale and it was not possible to determine a focal mechanism for any of them.

It was therefore decided to examine all the large earthquakes that had occurred in the Dalton/Gunning region since 1970 that had been recorded by 10 or more stations. Ten earthquakes were selected, but only five gave reliable focal



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▲ Seismograph stations (LER & CAH belong to the permanent ANU network; DG1-6 were portable BMR tape recording stations)

● Earthquake located during the period of operation of the BMR portable stations (depth of hypercentre indicated).

• Epicentres of earthquakes recorded since 1900 by 5 or more stations

Fig OR 3 Location of earthquakes and recorders, Dalton/Gunning region

mechanisms. Figure OR-4 shows two of the more reliable solutions. They indicate that the earthquakes are associated with left-lateral strike-slip faults caused by a mainly east-west compressive stress.

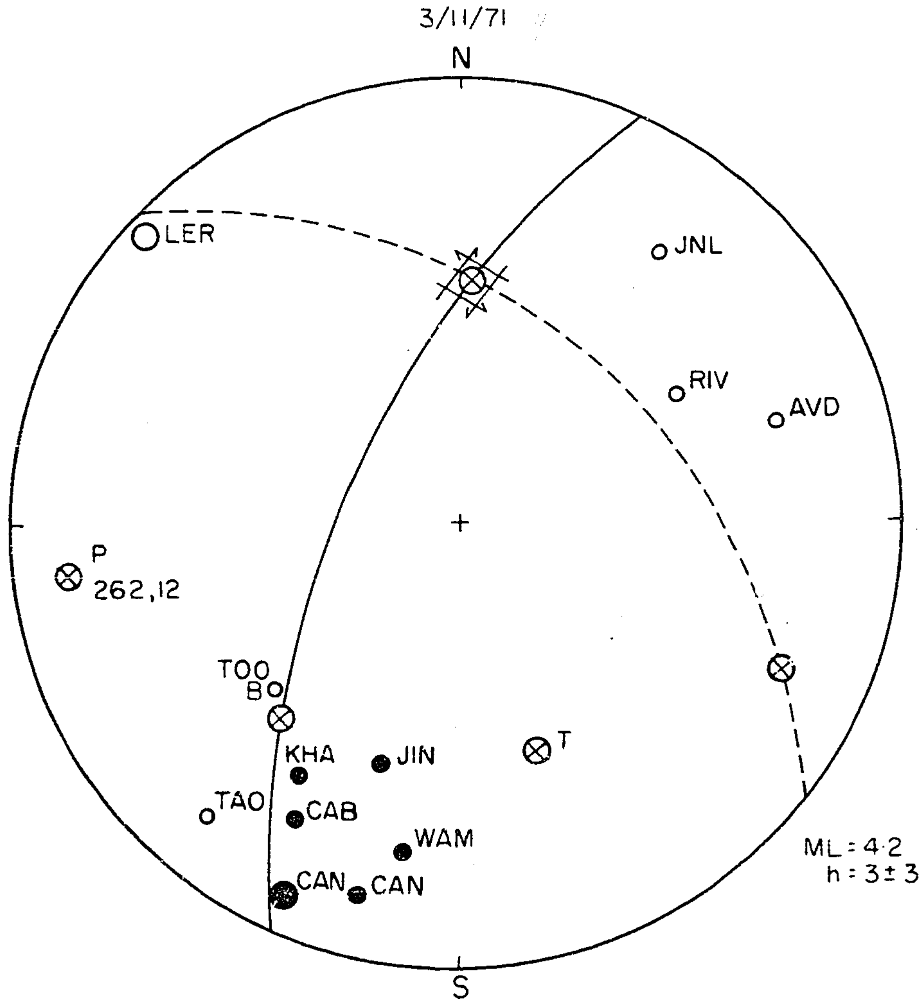
SE Australia crustal seismic investigations
(D.M. Finlayson, H.M. McCracken)

During 1980 the interpretation of seismic data recorded in 1978 was completed and submitted for publication.

Seismic models of crustal structure across the Sydney Basin and northern Lachlan Fold Belt (Fig. OR-5) indicate that there is no substantial difference in the depth to the upper mantle across the boundary between the two provinces. This is consistent with the Basin overlying part of the Fold Belt. The upper 20 km of crust, to which 85% of earthquake activity is confined (Fig. OR-6), demonstrates considerable inhomogeneity in its velocity/depth structure. This structure can probably be resolved in more detail only by joint seismic reflection/refraction investigations. The Moho depths are up to 10 km less than farther south in the Lachlan Fold Belt. The earthquake activity is greater under the northern Fold Belt/Sydney Basin region than under the region of thicker crust to the south.

The results of this, and earlier seismic work, indicate that the Lachlan Fold Belt has the velocity-depth structure of continental crust (Fig. OR-7), with a thickness exceeding 50 km under the region of highest topography in Australia, and in the range 41-44 km under the northern Fold Belt and Sydney Basin. There is no evidence of high upper crustal velocities normally associated with marginal or back-arc basin crustal rocks. The lower crustal velocities are consistent with an overall increase in metamorphic grade and/or mafic content with depth where areas near granites are excluded. The continuing tectonic development throughout the region and the negligible seismicity at depths greater than 30 km indicate that the lower crust is undergoing ductile deformation.

Geochemical evidence indicates that pre-Ordovician rocks were present in the region during the Devonian, consistent with the existence of continental or quasi-continental crust (possibly fragmented) to the east of present-day Precambrian outcrops. These fragments would contribute to the thickness of the crust under southeastern Australia.



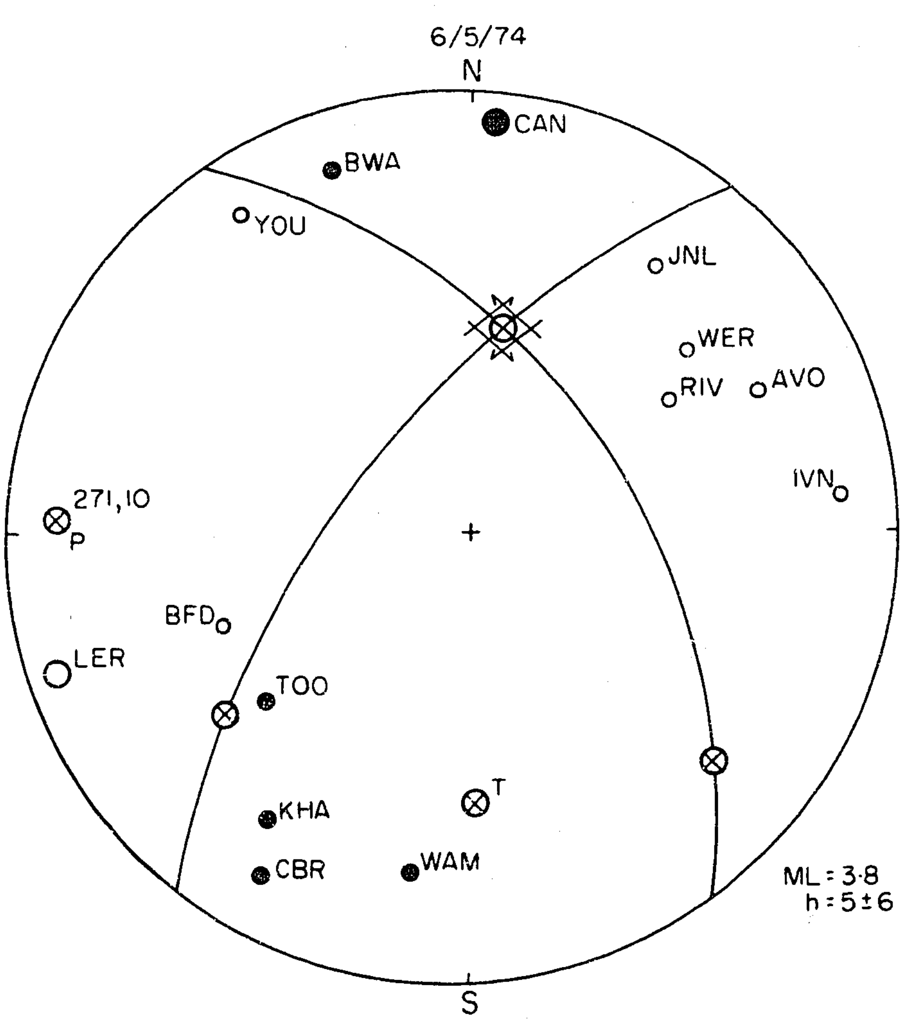


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Fig OR 4 Fault plane solution of Dalton/Gunning earthquakes of 1971 and 1974

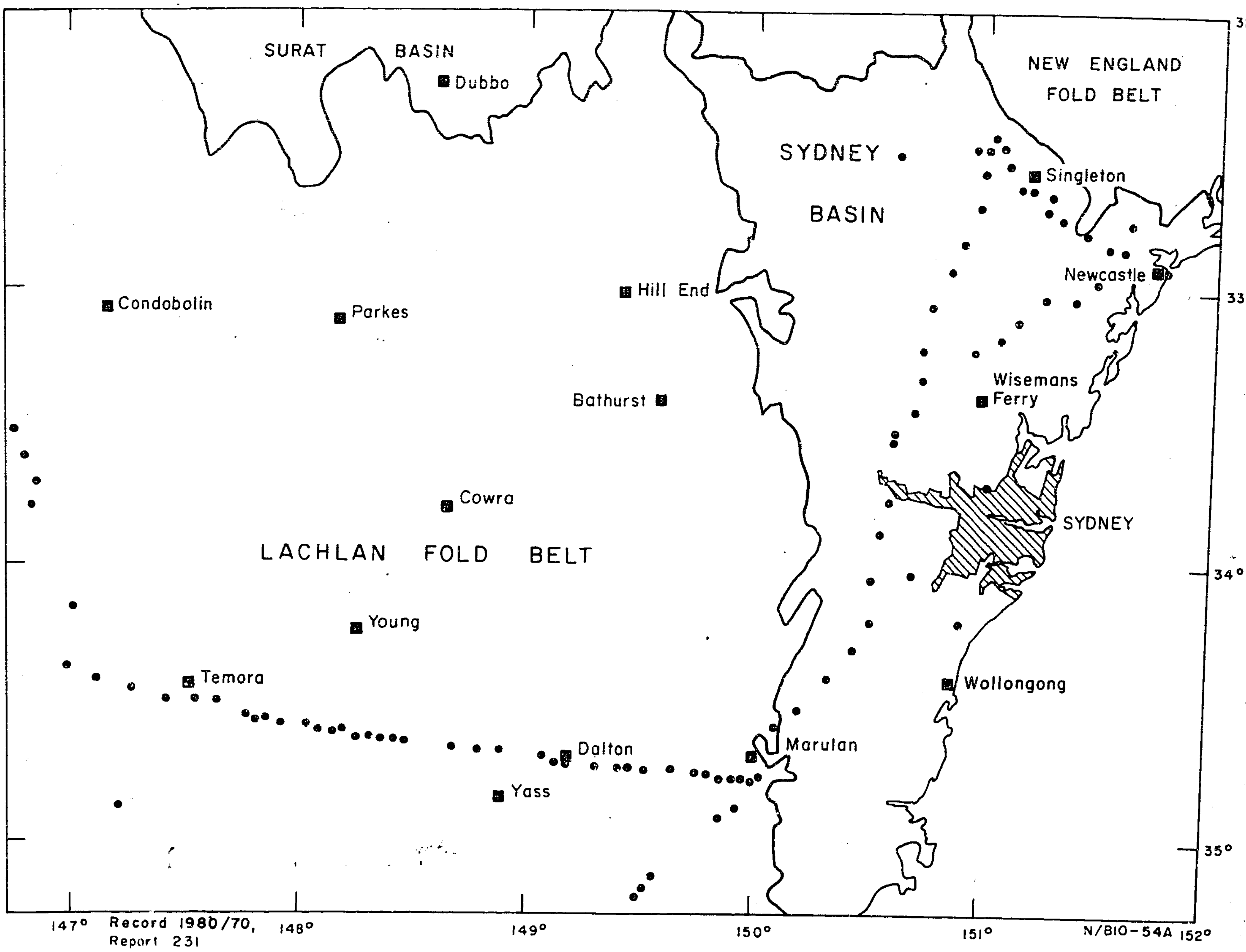

Fig OR 5 Seismic recording stations, Sydney Basin and northern Lachlan Fold Belt

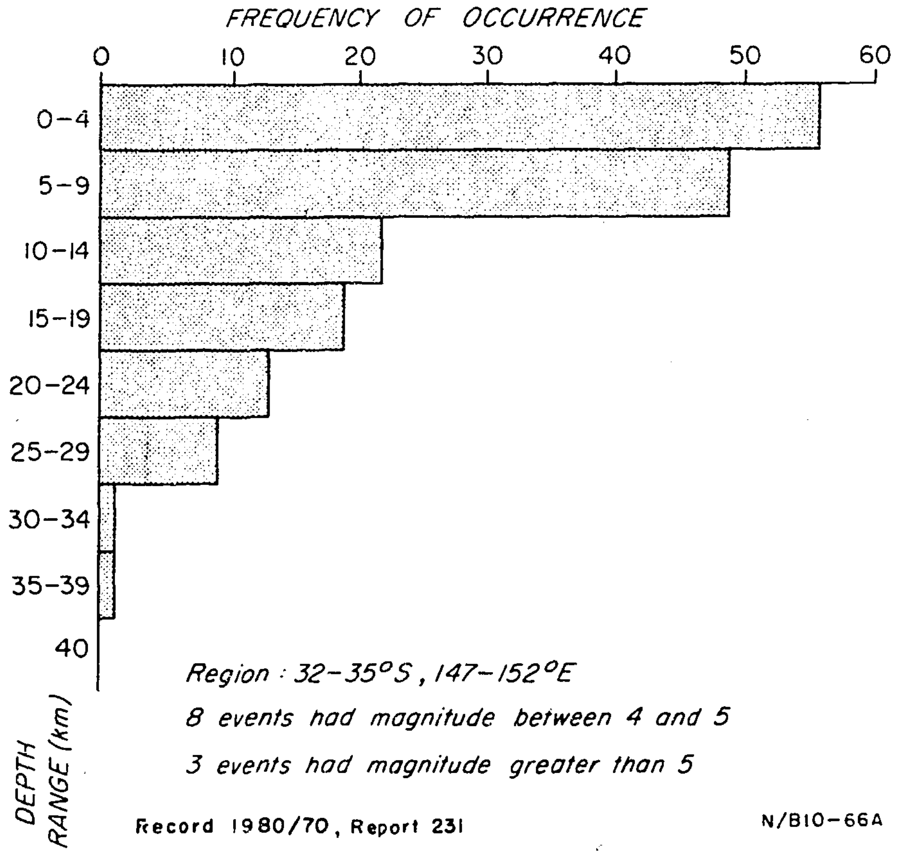

Fig OR 6 Earthquakes depth distribution, northern Lachlan Fold Belt

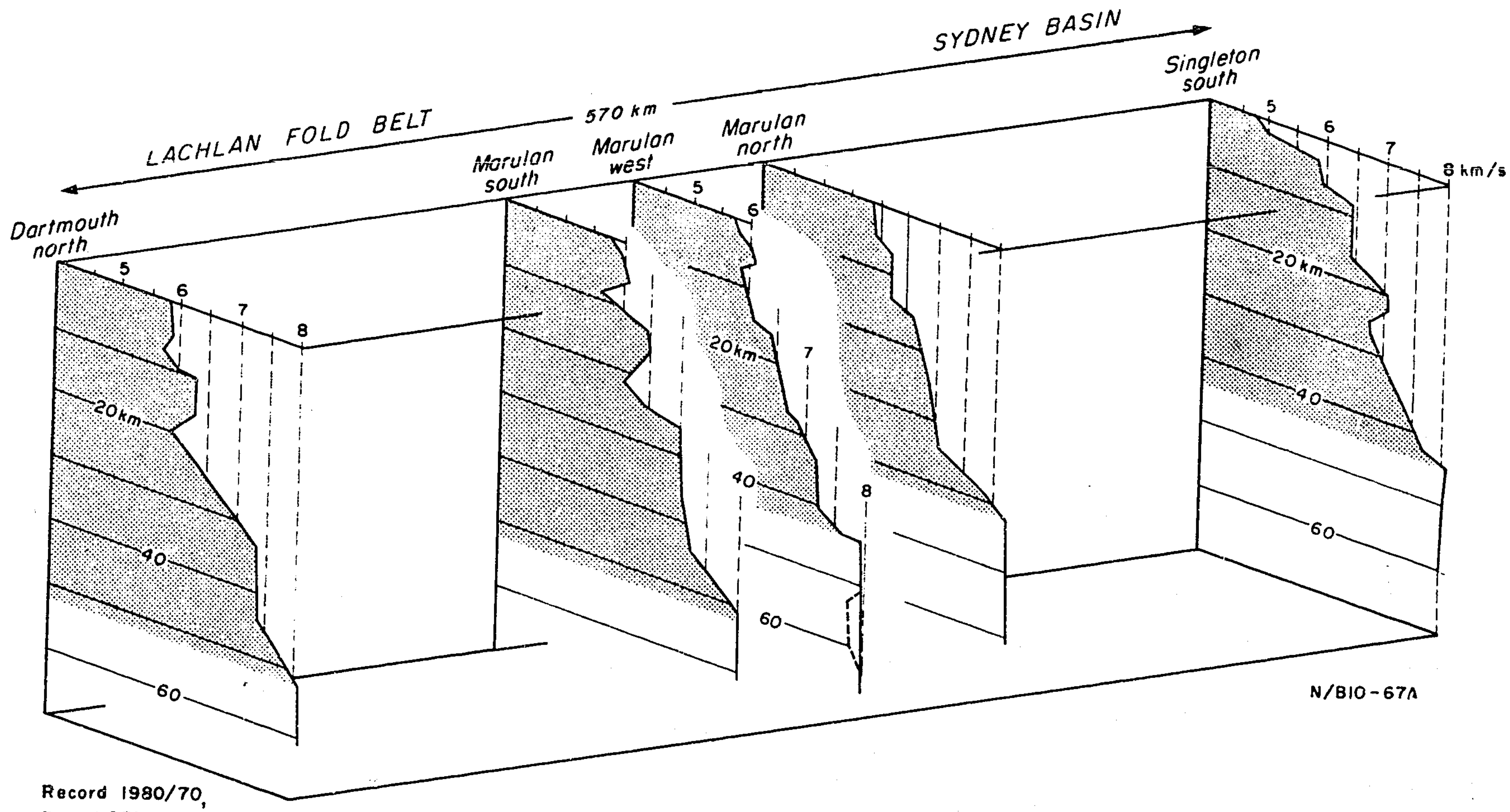

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Fig OR 7 Crustal velocities/depth distribution, Eastern Highland and Sydney Basin

The upper crustal velocities below the Sydney Basin are in the range 5.75-5.9 km/s to about 8 km, increasing to 6.35-6.5 km/s at about 15-17 km depth, where there is a high-velocity (7.0 km/s) zone of about 9 km evident in results from one direction. The lower crust is characterised by a velocity gradient from about 6.7 km/s at 25 km, to 7.7 km/s at 40-42 km, and a transition to an upper mantle velocity of 8.03-8.12 km/s at 41.5-43.5 km depth (Fig. OR-8).

Across the northern Lachlan Fold Belt, velocities generally increase from 5.6 km/s at the surface to 6.0 km/s at 14.5 km depth, with a higher-velocity zone (5.95 km/s) in the depth range 2.5-7.0 km.

In the lower crust, velocities increase from 6.3 km/s at 16 km depth to 7.2 km/s at 40 km depth, then increase to a velocity of 7.95 km/s at 43 km. A steeper gradient is evident at 26.5-28 km depth, where the velocity is about 6.6-6.8 km/s. Below the Moho, an upper mantle low-velocity zone in the depth range 50-64 km is interpreted from strong events recorded at distances greater than 320 km.

McArthur Basin crustal seismic investigations
(C.D.N. Collins, J. Pinchin)

Two long-range seismic refraction traverses were recorded during June-July, 1979, east and west of the Emu Fault. Deep vertical reflection recordings were made at each of the six shot-points, and at a seventh site at Starvation Hill. Both traverses were about 300 km long, and each comprised 34 recording stations. The first traverse was between Daly Waters and the H.Y.C. mine, along the Carpentaria Highway. Two large shots of 2000 kg each were detonated at Daly Waters and the H.Y.C. mine respectively. Two smaller shots of 400 kg each were fired at H.Y.C. and 100 km west of the H.Y.C. mine, near O.T. Downs. For the larger shots, the station spacing was about 15 km, while for the smaller shots, the spacing was about 5 km. A similar pattern was recorded along the second traverse, east of the Emu fault, with large shots at Borroloola and Westmoreland, and smaller shots at Borroloola and Robinson River.

Good vertical reflections were recorded at all sites except Daly Waters and O.T. Downs (see Record 1979/57). Reflections were recorded down to depths [illegible]out 45 km, and Moho reflections correlate well with the refraction data. A [illegible]acteristic strong-reflection band east of the fault correlates with a 6.39 [illegible]m/s sub-basement refractor; the band also appears west of the fault, near the H.Y.C. mine, but is displaced upwards by 1.8 km (see Record 1980/38). The

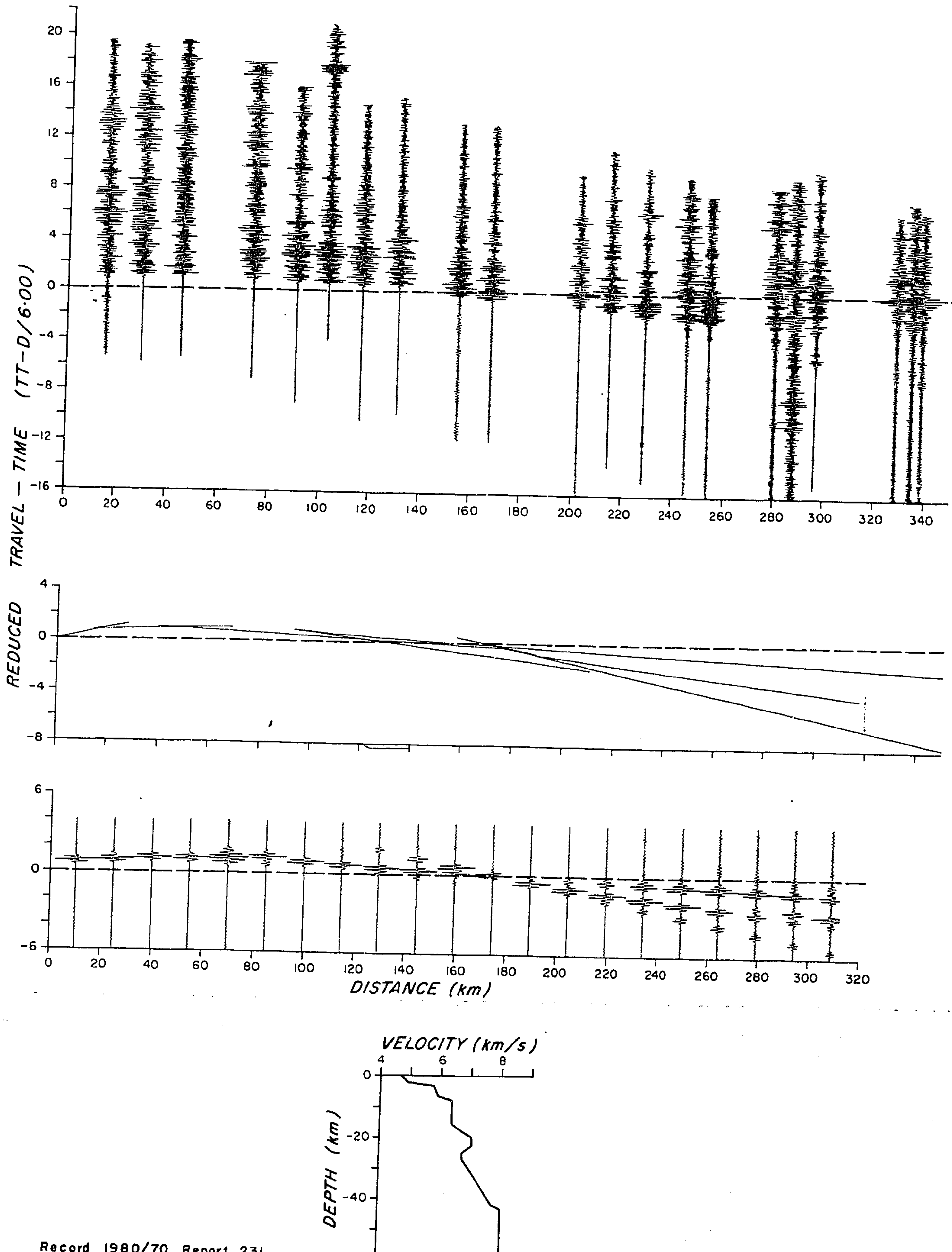

Fig OR 8 Seismic record section and interpreted velocity/depth function, Singleton to Marulan basement appears to be 3.9 km deep west of the fault at the H.Y.C. mine and 5.7 km deep east of the fault at Starvation Hill. From these reflection results, and from stratigraphic control of the McArthur Group west of the fault, the Tawallah Group apparently thins towards the Fault Zone.

The refraction data between Daly Waters and O.T. Downs show a wedge of low velocity (4.6 km/s) material, 4 km thick at Daly Waters, and pinching out just east of O.T. Downs. This wedge probably consists mainly of Cambrian rocks of the Northern Georgina Basin covered by thin Mesozoic sediments. Below this wedge the refractor velocity is 5.6 km/s and probably represents the Roper Group. Between the H.Y.C. mine and O.T. Downs the surface refractor velocity is 5.9 km/s; this high velocity, probably due to carbonates of the McArthur Group, masks any deeper refractors. East of the Emu fault (Fig. OR-9) a 5.98 km/s refractor correlates with the reflection basement of the McArthur Basin succession. Below basement, a dipping 6.39 km/s refractor correlates with strong reflections, as mentioned earlier.

There appear to be strong gradients in the lower crust where the velocity increases from about 7.9 km/s to perhaps 8.3-8.4 km/s at the Moho. These high velocities are based on recordings made at the end stations of the long traverses and are therefore not well defined. However, the lack of strong wide-angle reflections from the Moho requires the velocity gradients to occur over a broad zone. A maximum depth for this gradient zone of 55 km fits the data fairly well, but an extension of the recordings beyond 300 km is desirable to interpret the data properly.

Crustal seismic instrumentation

(D.M. Finlayson, C.D.N. Collins, C. Rochford, D. Gardner)

Routine maintenance of the seismic recording and playback equipment was carried out throughout the year. A prototype NCE-3 clock was tested in the field during the Eromanga survey. This clock has lower power requirements and reduced weight compared with the NCE-1 clocks currently in use. A liquid-crystal display replaces the LED display of the NCE-1, reducing power consumption and improving daytime visibility. The production of 36 new clocks for all 21 existing remote seismic recorders, and for new recorders yet to be built, is proceeding.

Tests were made on a Geotech 42.50 amplifier and S500 geophone. Response characteristics were established and comparison tests with TAM5 amplifiers and Willmore seismometers were run at Kowen forest. The S500

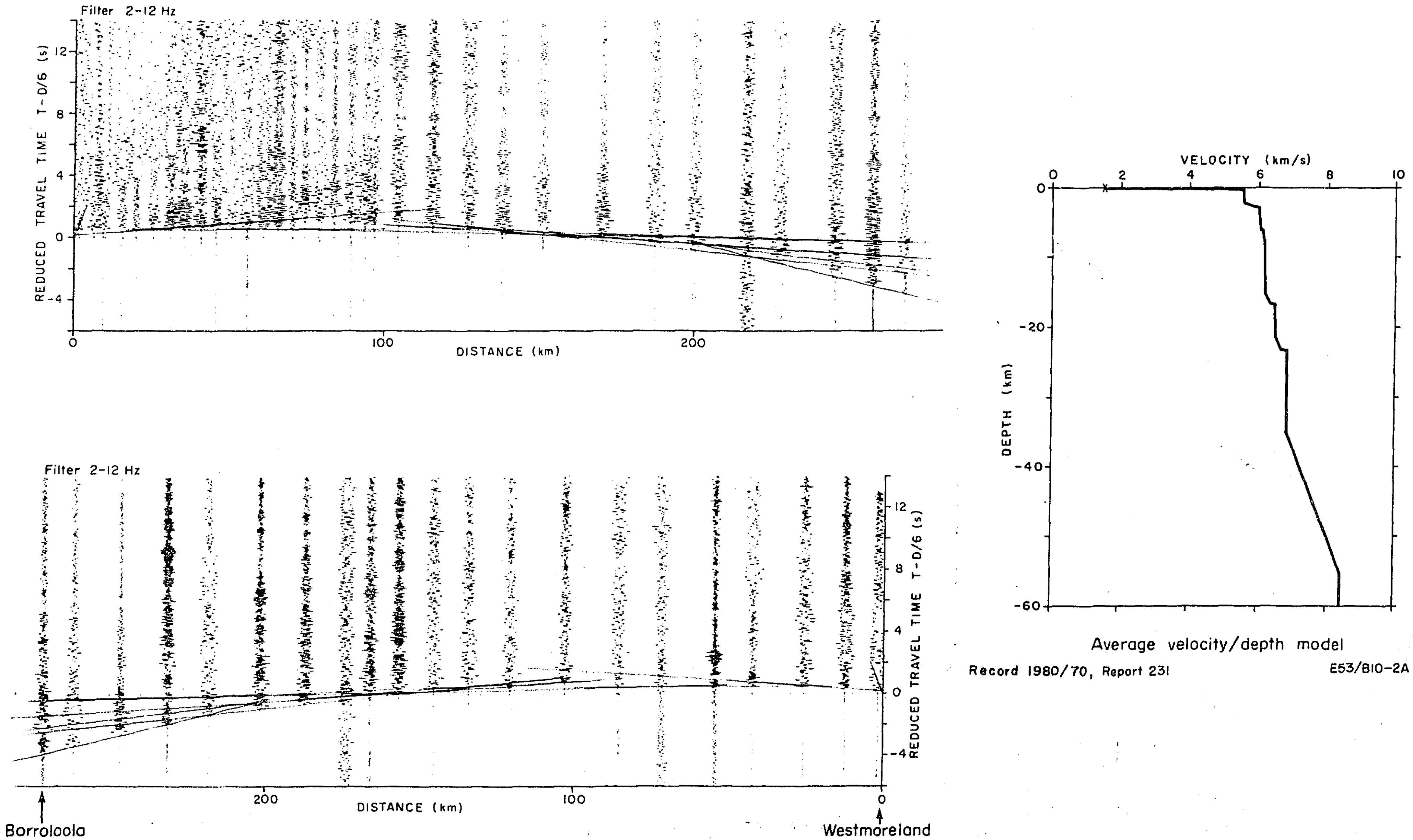

Fig OR 9 Record sections from the traverse east of the Emu Fault geophone uses feedback techniques to give it a wide-band response. A 2 Hz SIE geophone was also compared with the Willmore seismometers normally used.

To reduce power consumption of the XTA-1 recording systems, a new motor and gearbox was purchased and is currently undergoing testing. These motors will be installed in twelve new XTA-2 recording systems being built. A new summing amplifier was built for the playback equipment to eliminate cross-talk problems between channels.

Central Eromanga Basin crustal seismic investigations (D.M. Finlayson, C.D.N. Collins, J. Lock, C. Rochford)

Long-range seismic refraction recordings were made to determine the deep crustal structure and the velocity depth profile of the basement beneath the basins in the Central Eromanga Basin area. Recordings were made along a 300 km east-west traverse (Fig. OR-10) crossing the Quilpie Trough, Canaway Ridge, Warrabin Trough, and part of the Cooper Basin.

The refraction recording was divided into two phases. The first phase involved recording along the 150 km section of the traverse covered by deep crustal vertical and wide-angle seismic reflection recording (Fig. OR-10). This traverse was divided into four 37.5 km traverses placed end to end. 200 kg shots were fired at the ends of each traverse, and a 400 kg shot was fired in offset positions 37.5 km from each end. Analog recordings were made at 21 stations, 1.875 km apart, along each traverse. This arrangement effectively provided four adjacent reversed traverses, each of 37.5 km, and three overlapping reversed traverses 75 km long, all recorded at 1.875 km spacing.

The second phase involved recording on a 300 km traverse along which heat flow and M-T measurements were also made. Recording was along two 150 km traverses, end to end, designed to record arrivals from refractors down to and including the upper mantle. 750 kg shots were fired at the ends of each traverse and a 2500 kg shot was fired at a distance of 150 km from the nearest station in the traverse. Analog recordings were made at 41 stations with a station interval of 7.5 km. This arrangement effectively provided a reversed traverse of 300 km and, within this traverse, two adjacent reversed traverses 150 km long, all recorded at 7.5 km station spacing.

The latitude and longitude of shot points and station sites for the extreme eastern and western ends of the line (shown as dotted lines in Fig. OR-10) were determined from locations marked on ortho-photo maps of the region. Those for the surveyed central section of the line (shown as a solid line in Fig. OR-10) were calculated from AMS co-ordinates.

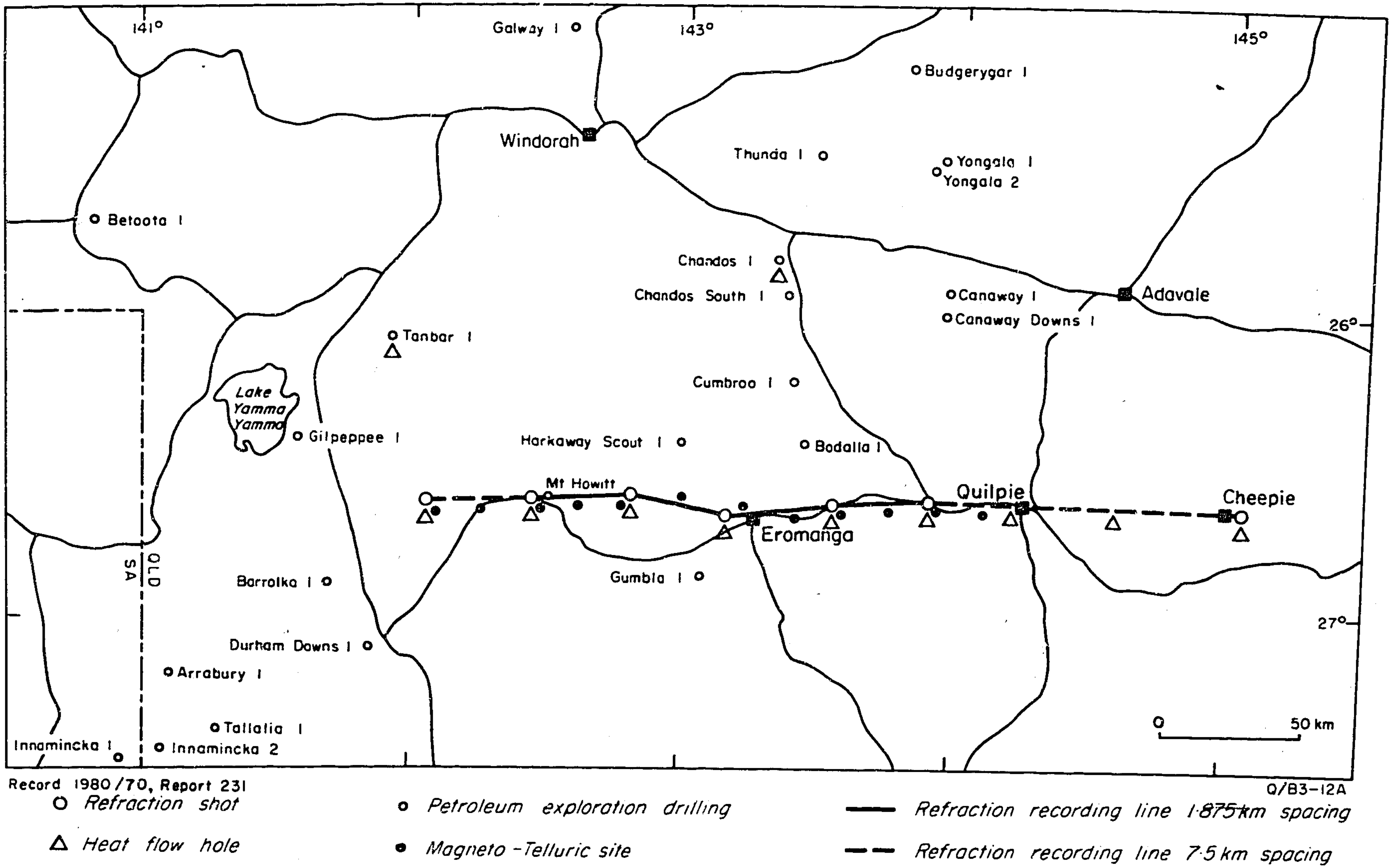

Fig OR10 Proposed locations of seismic refraction shot-points, heat flow holes and M-T sites

The analog recordings from 20 shots at 101 station sites recorded by 21 instruments are being processed digitally for the compilation of seismic record sections; these sections will be interpreted to infer the seismic velocity/depth profile of the Basin.

Crustal seismic interpretation and data processing
(D.M. Finlayson, C.D.N. Collins, B.J. Drummond)

Minor modifications were made to the seismic interpretation programs during the year.

The synthetic seismogram program REFLEX was updated following the visit to BMR by the author of the program, Professor Karl Fuchs of the University of Karlsruhe, Federal Republic of Germany. A two-day workshop was held at BMR on 8-9 October and was attended by 25 participants from within and outside BMR. Both the theory and practical application of the reflectivity method of computing synthetic seismograms were discussed in the workshop (see BMR Record 1980/64), and the computer program was run by the participants to test various features. Options added to the BMR version of the program include a source-signal generating subroutine, a facility for spherical-earth correction, and a new time-saving routine for calculating the reflectivities.

Professor R. Mereu of the University of Western Ontario visited BMR in November and December 1979 and worked on the adaptation of a tau-inversion program for inverting seismic travel-time data. BMR now has this program on tape and it is currently being developed. A program by G. Müller of the University of Karlsruhe that computes travel-time curves from spherical or flat-earth models has been running successfully on the CSIRO CYBER-76 and is being adapted to run on the BMR's H.P. computer. A ray-tracing program to calculate travel-time curves in more complex models is available on magnetic tape but has not been run yet.

The data-processing system was upgraded during the year. Modifications were made to the record-section plotting programs on the BMR H.P. computer to improve their flexibility and speed.

Tennant Creek - Mount Isa crustal investigations (D.M. Finlayson)

Seismic data recorded during 1979 in the Tennant Creek area were interpreted in terms of upper crustal structures. Shot sources at the Nobles Nob and Warrego mine sites, and a special purpose shot in an old gold mine (Skipper extended mine), were used (Fig. OR-11).

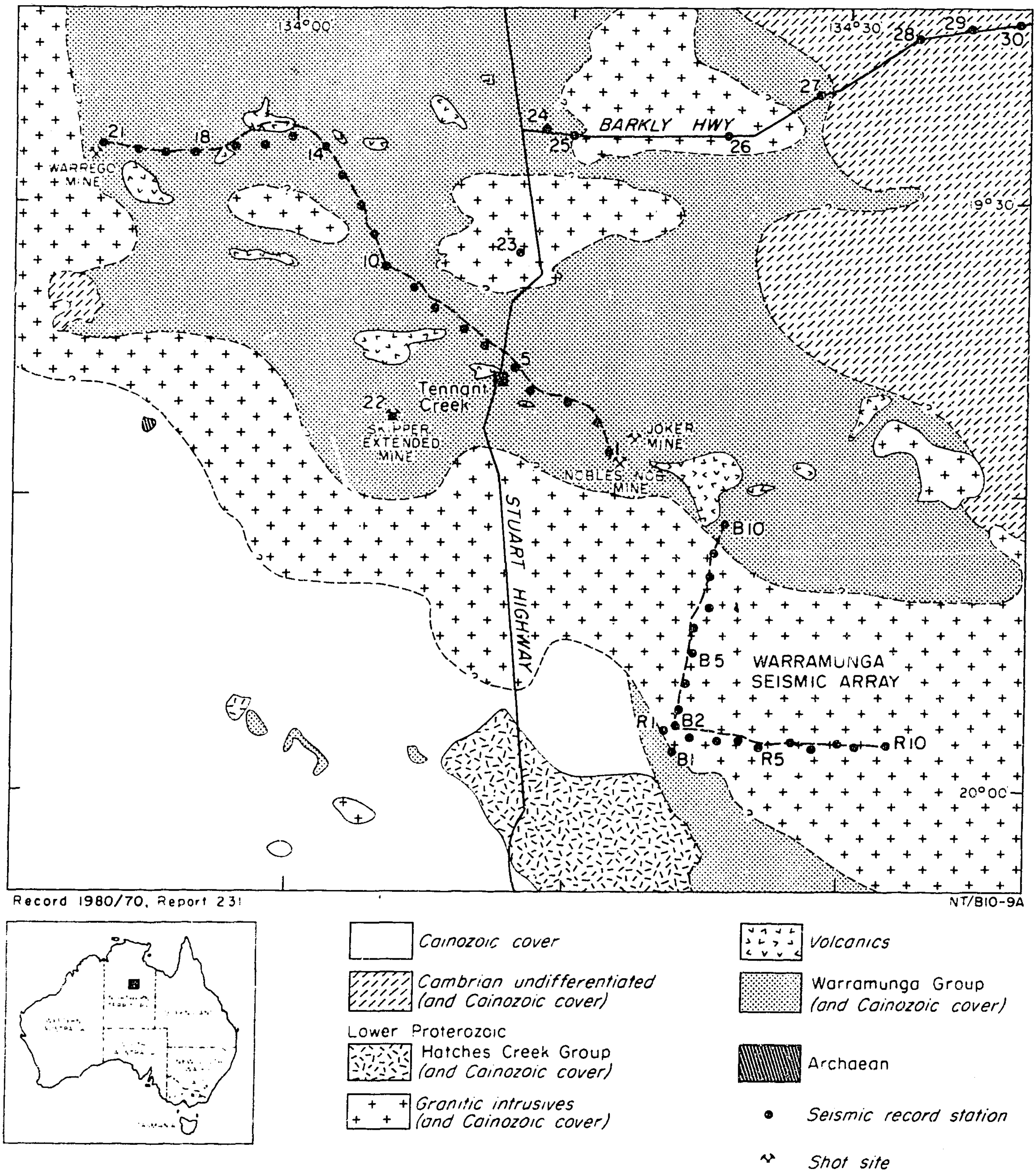

Fig OR11 Location of Shot and Recording sites and General Geology Tennant Creek Block

The data indicate that the Warramunga Group rocks have P-wave velocities in the range 5.22 to 5.62 km/s (average 5.47 km/s) and S-wave velocities in the range 3.26 to 3.41 km/s (average 3.34 km/s). The P-wave velocity beneath the surface rocks is 6.06 km/s. A simple layered model for the thickness of Warramunga Group rocks gives values of about 2.6 km near Nobles Nob mine, shallowing to about 1.2 km near Warrego mine.

South of the Warramunga Group rocks, granitic rocks have an estimated upper value for the P-wave velocity of 5.69 km/s, and an S-wave velocity of 3.26 km/s. Underneath, the P-wave velocity of 6.06 km/s is the same as that further north, but the depth to this velocity is up to 0.7 km less than under the Warramunga Group rocks. The S-wave velocity for the deeper rocks is in the range 3.53 to 3.59 km/s.

The nature of the change between the surface and 'basement' rocks is likely to be complex, resulting in a velocity transition zone rather than a simple boundary. The estimated depths to 'basement' are therefore minimum estimates. Because of the increase in the seismic velocity of the rocks when subjected to overburden pressures equivalent to depths of 2-3 km, there is little evidence from the present work that the 'basement' is compositionally or lithologically different from the surface rocks. In areas of Precambrian outcrop in other parts of the world however, seismic reflection and refraction methods have been used to determine structure, and these methods could be applied to some targets in the Tennant Creek area.

Interpretation of recordings made at distances out to 600 km from shot sources at Tennant Creek and Mt Isa are continuing. Some data suggest that the complex geology in the basement under the intervening Georgina Basin is producing scattering effects which mask seismic events after the first onset of seismic energy.

Pilbara region crustal investigations (B.J. Drummond)

In 1977, BMR, in conjunction with the Research School of Earth Sciences of the Australian National University, undertook a seismic refraction and gravity survey of the crust and upper mantle of the Pilbara region of northwest Australia. Reduction and interpretation of the seismic data continued throughout 1980. All of the seismic data, including those of the ANU, have now been digitised, and record sections of both on-line and fan shots have been produced.

Several interpretation techniques are being applied to the data. All profiles have been interpreted using the intercept method. The latest results confirm the models from earlier interpretations of some of the data - the crust under the Pilbara Craton is thin (27-33 km), and that under the northern Yilgarn Craton is thick (about 50 km). The region between the cratons is complex, and the seismic data cannot discriminate between alternative models. The seismic velocities observed within the crust along the axis of the Hamersley Basin are slightly higher than elsewhere in the region. This is consistent with the crust having been depressed by up to 10 km during the formation and filling of the Hamersley Basin, as suggested by the regional metamorphic patterns.

Synthetic seismogram modelling of the amplitude data is in progress, and will continue into 1981. Results so far are as expected - the seismic boundaries within the crust, and the crust/mantle boundary are gradational, and velocity gradients occur within the crust and upper mantle. There is no conclusive evidence yet of low velocity zones within the crust or upper mantle.

The travel-time data from both on-line and off-line blasts are being prepared for time-term interpretation. The upper mantle seismic velocity in the north/south direction under the Pilbara Craton is 8.34 km/s, but along an east/west profile in the Hamersley Basin, but still within the confines of the Pilbara Craton, the seismic velocity may be as low as 7.8 km/s. This may imply seismic anisotropy in the uppermost mantle under the Pilbara Craton. The time-term interpretation will test for anisotropy. This will be an opportunity to test for upper mantle seismic anisotropy under continents. The presence of seismic anisotropy has important implications for the effects of plate tectonics on the upper mantle beneath continents, and if it is present under the Pilbara Craton, BMR will be able to make a major contribution to the understanding of plate tectonics processes.

The gravity data collected during the survey were interpreted during 1980. The major applications of the gravity data were to test the seismic models, and to study basement structures in the Hamersley Basin. The results of the gravity interpretation should be available early in 1981.

Aspects of deep lithospheric structure were also examined using the seismic data recorded during 1977. Recordings made of a series of major earthquakes in the Indonesian region enabled the velocity/depth structure at depths of 150-250 km to be interpreted. World-wide evidence for a Lehmann Discontinuity under continents and oceans now exists. The data recorded in the Pilbara confirmed that the discontinuity at about 200 km is present under an ocean-continent transition. A velocity difference ($\sim$0.3 km/s) across the

Discontinuity under both continents and oceans now exists. The data recorded in the Pilbara confirmed that the discontinuity at about 200 km is present under an ocean-continent transition. The velocity difference ($\sim$0.3 km/s) across the Discontinuity is similar to that observed under continental northern Australia. Arguments presented overseas suggests that the Lehmann Discontinuity represents the lithosphere-asthenosphere boundary, and that it is a world-wide feature, superseding earlier arguments that continents have deep "roots" of about 400 km.

<u>Heat flow</u> (J.P. Cull)

In response to a request from Western Mining Corporation (WMC), a thermal parameter analysis was conducted on 22 core samples from Roxby Downs. Thermal conductivities were determined using divided bar techniques while thermal diffusivities were measured using observations of heat-pulse transients. The data were subsequently verified by comparing measured and calculated values of heat capacity. Thermal conductivities varied from 3 to 8 $W\ m^{-1}\ K^{-1}$, correlating with thermal diffusivities from 1.1 to 3 $\mu m^2\ s^{-1}$. However, heat capacity appeared to be more consistent with representative values near 700 $J\ kg^{-1}\ K^{-1}$.

Determinations of heat flow for Roxby Downs remain contentious; thermal gradients vary abruptly with the extremes in thermal conductivity, and average values may be subject to large sampling errors. However, a trend in the data is consistent with the pattern of uranium mineralisation. Heat is produced according to the decay rate of ore-body isotopes, and heat-flow anomalies detected in surface layers result from summation of individual contributions. Similar observations were made for Andamooka where 'basement' values of 64 $mW\ m^{-2}$ are contrary to previously determined regional values but are consistent with data obtained for similar tectonic units elsewhere in the world. A professional opinion was completed and forwarded to WMC.

One constraint on the number of heat-flow data which are currently available is the requirement that borehole observations be conducted under conditions of thermal equilibrium. In BMR a routine period of 12 months is specified for this purpose. Consequently, casing must be inserted in each critical borehole to preserve access down the hole. Cost and logistics are therefore a major problem in securing heat-flow data. Feasibility studies have now indicated the possibility of using disposable in-situ heat-flow probes. These instruments can be inserted after drilling and observations can be completed after the normal period of equilibration. Field trials are proceeding in the Eromanga Basin to detect changes in relative heat flow associated with basement topography. A BMR record has been compiled describing this technique.

Geothermal energy in France (J.P. Cull)

In view of the economic and physical constraints associated with the supply of fossil fuels it is now essential to consider the extent of indigenous alternatives including all types of geothermal energy. Consequently BMR supported an independent application to the French Government seeking the award of a scholarship for research in Science and Technology. Facilities were made available at the Bureau de Recherches Géologique at Minières (BRGM) in Orleans for a 3-month period (June-August 1980) and provision was made for a living allowance and a one-way air fare Paris/Sydney.

BRGM (a semi-private French Government agency) maintains an active role in both high and low-enthalpy geothermal research. It is responsible for many innovations in exploration and exploitation, and the emerging scientific and economic principles can be used as a model for BMR studies in Australia. BRGM experience in low-enthalpy systems has a special relevance since sedimentary basins occupy more than 60% of the total land surface in both France and Australia. Because the geological conditions are similar, the conclusions now emerging concerning exploitation of geothermal energy in France should also be valid for Australia. A report (Record 1980/80) documenting the principal facts of the visit has been completed.

Eromanga Basin heat flow measurements
(D.M. Finlayson, J. Lock, J. Williams, J.P. Cull, A.G. Spence)

Heat flow measurements were made at 6 sites with 40 km spacing in a profile generally coinciding with part of the MT profile and the seismic refraction line. Probes were designed to indicate geothermal gradients at a depth of 100 m. Data obtained at such depths are subject to climatic perturbations (see BMR Record 1979/55) and there are considerable difficulties in specifying absolute values of heat flow. However, the magnitude of any correction should be similar for all sites and, consequently, it is possible that relative values of heat flow can be determined. Any trend or anomaly associated with basin structure may then be used to construct detailed models of the thermal history related to depositional rates.

The probe components were housed in 4-m lengths of plastic tubing normally used as electrical conduit. Three thermistors, spaced 2 m apart, were sealed in each probe and were monitored using 110 m of twin core cable. A lead ballast was used to aid emplacement. The thermistors were calibrated against a platinum resistance thermometer standard before assembly, and the completed probes were tested to a depth of 100 m in a drill hole near the BMR building in Canberra.

Geothermal gradients in the Eromanga Basin were measured soon after each hole was completed. The probes were then left in place and the readings were repeated after a further delay of not less than 2 weeks. A drift was observed, consistent with the decay of thermal transients associated with drilling. However, some spurious values were noted, and probe failure is indicated for at least one site. All probes have been retrieved, and each thermistor will be recalibrated for greater accuracy. Values of heat flow will then be calculated, combining geothermal gradients with thermal conductivity data from identical depths. A 3.1 m bottom-core was taken in each hole for this purpose.

Magnetotelluric systems development

(A.G. Spence, B. Liu, A.J. Barlow, J. Whatman)

The present BMR system is a prototype system developed over a period of six years (Fig. OR-12). It has been adequately proved that good repeatable data can be obtained over the frequency range of 0.001 to 40 Hz. In terms of hardware sophistication and field processing capability, the BMR MT system is unique in Australia, but several defects are apparent.

From the first Murray Basin Survey in 1973, the digital portion of the MT system was borrowed from other sections of BMR. The analogue front-end equipment was of 1970 vintage, and becoming obsolete. Power provided by a 3 KV generator was poorly regulated, and the equipment was housed in a truck with poor suspension and no air conditioning. These factors account for most of the problems encountered in past surveys or pre-survey preparations.

Five new instruments, designed and constructed by BMR, were integrated into the MT system prior to the 1978 MacArthur Basin Survey; data quality and overall system reliability were greatly improved. However, a long time was required for pre-survey preparation because the MT has no dedicated digital acquisition system. In addition, troubles with the disc storage unit in 1979 and 1980 caused the loss of valuable time during both field seasons.

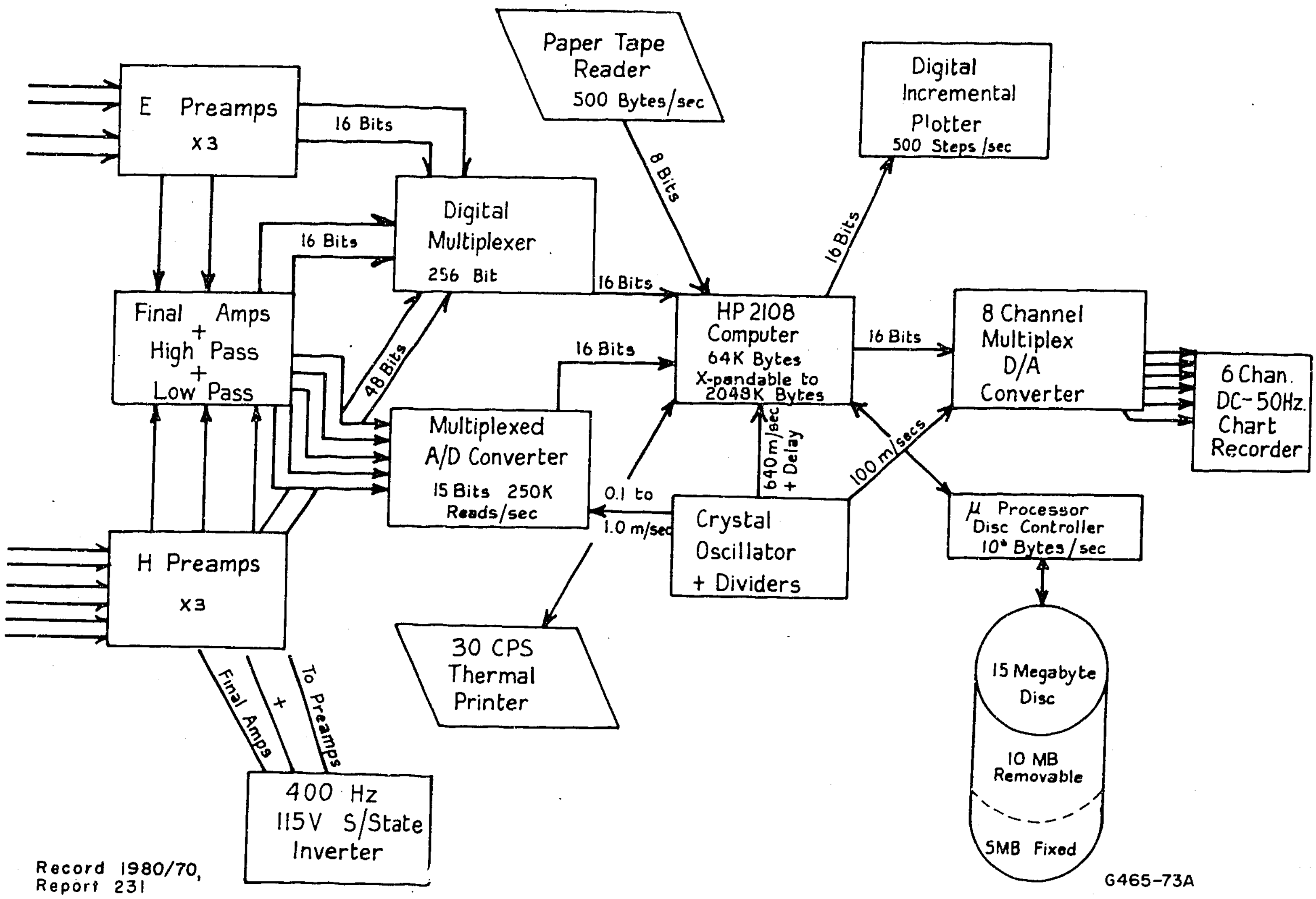

Fig OR12 BMR MT System block diagram

To allow BMR to undertake an expanding role in oil exploration using MT, a concerted effort must be made to upgrade the system and incorporate recent developments. Significant progress has been made over the past few years in several important areas of MT signal acquisition, processing, and interpretation, by research groups in USA, Russia, and Western Europe.

Grants have been requested from the National Energy Research and Development Demonstration Council (NERDDC), and BMR finance has been committed, to enable:

(1) upgrading of the existing system;
(2) implementation of remote reference system;
(3) implementation of Audio MT system.

Major expenditure will be required to purchase an up-to-date dedicated digital data acquisition system. Other finance will be required for the design and construction of magnetic and electric preamplifiers to replace the GSI units now approaching 12 years of age. This work will be done in BMR's electronic section and is expected to be completed by July 1981.

Further provisions have been made in the design for the implementation of a remote reference system. Some funds will be required immediately to construct a second set of magnetic and electric preamplifiers and post-amplifiers for use at the remote site. Subsequently a micro-wave link will be required to interface the remote reference system to the existing MT system.

Eromanga Basin magnetotelluric investigat ons (A.G. Spence, J. Whatman)

MT Records were obtained in the period August-October at 12 sites with 20 km spacing in a profile west of Quilpie. Seismic reflection, seismic refraction, and relative heat flow data have also been obtained on an identical line from the Cooper Basin to the margin of the Adavale Basin. As a result, the resolving power of MT in this area can be readily established.

Satisfactory recordings were obtained at all sites, but the initial data quality was affected by intermittent faults on one E-channel. Consequently the duration of the survey was extended to allow time for major repairs on the disc servo assembly. No inversions have been attempted since the data must first be screened to eliminate cross-over errors. However, the data are internally consistent, and orthogonal components are generally coincident. Major features may therefore be resolved with 1D analysis alone.

Some divergence in plots of apparent resistivity has been noted at periods less than 1 Hz for sites near Eromanga. It is possible, therefore, that there is some structure in the near-surface sedimentary sequence which can be detected by MT. Experience in the Cooper Basin (Moore & others, 1977) had suggested that, because of a lack of resistivity contrasts within the sedimentary sequence, only the base of the Cretaceous could be resolved. At the other extreme, it is probable that there is a major conductivity change at depths of about 90 km.

After filtering, the MT data obtained in 1980 will be integrated with other geophysical information along the same profile to determine dimensional parameters associated with each unit according to the structural and depositional history of the area.

McArthur Basin magnetotelluric investigations (A.G. Spence, J.P. Cull)

Processing of data from the 1978 McArthur Basin survey was completed to provide controls for a geological synthesis. The major features of the Emu Fault are visible in a pseudo-section of the data (Fig. OR-13). Apparent resistivities were inverted in both 1D and 2D analysis to generate the block sections shown in the diagram. These are readily interpreted in terms of regional stratigraphy. A BMR Record has been prepared.

The McArthur Basin survey was extended during 1979 and data were obtained at 17 sites in two profiles (Fig. OR-14). The first line was designed to supplement gravity data with the aim of determining the deep structure of the Bauhinia Shelf, while the second line was placed to supplement regional seismic refraction surveys. The quality of data was generally acceptable, despite extreme weather conditions, but readings at three of the sites were affected by thunderstorm activity. Comprehensive results are not yet available. Final inversions and interpretation will be carried out when the data have been screened for systematic errors. Processing will be complete in 1980 and the results will be interpreted with the 1978 data.

India/Australia magnetotelluric cooperation (J.P. Cull)

During December 1979 the NGRI (National Geoscience Research India) requested further assistance from Australia in developing magnetotelluric programs in India. It was agreed that Dr J.P. Cull would include a stopover in India during his return trip from duty in Europe. The visit was limited to the

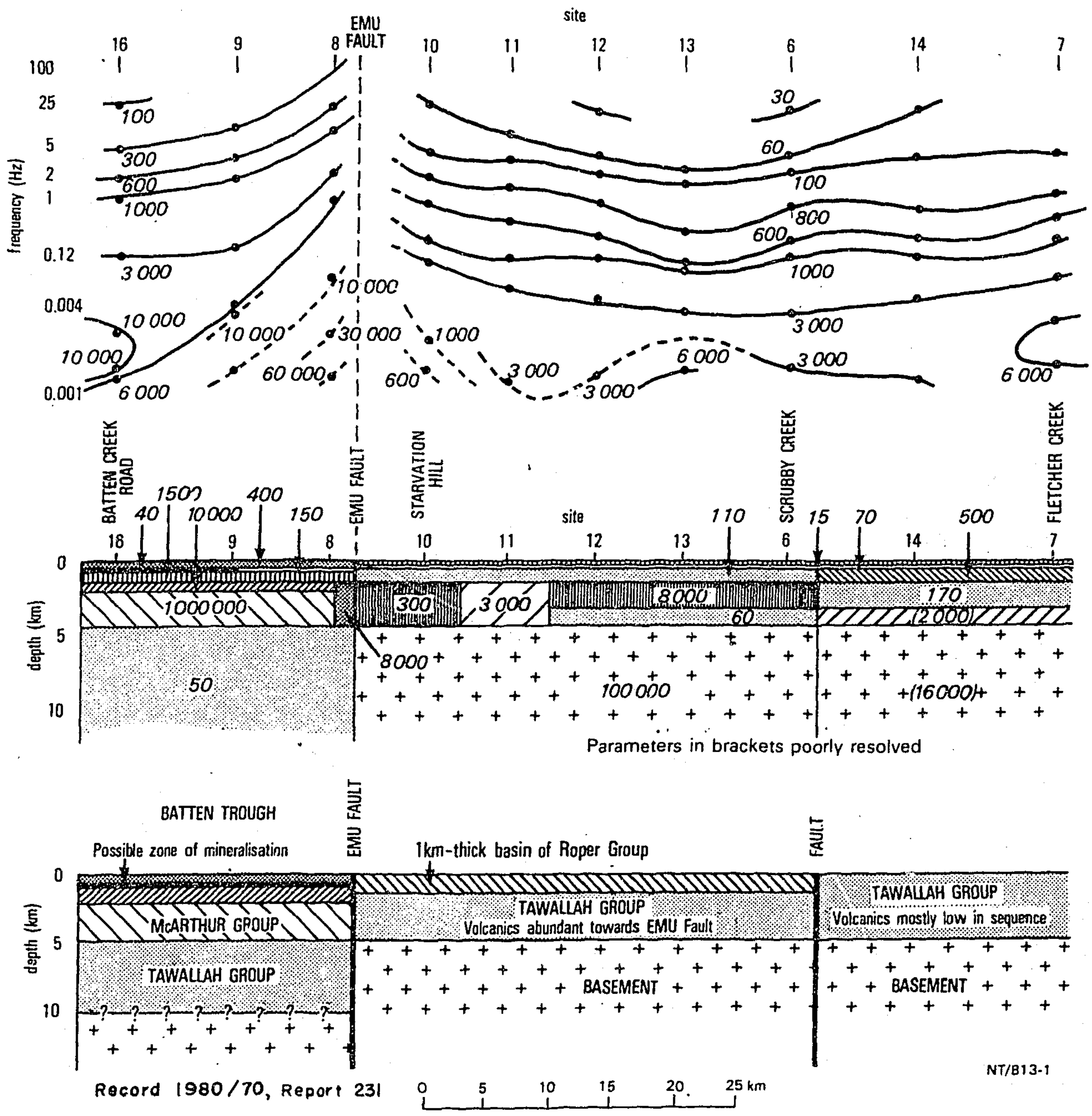

Fig OR 13 McArthur Basin: Conductivity structure across the Emu Fault

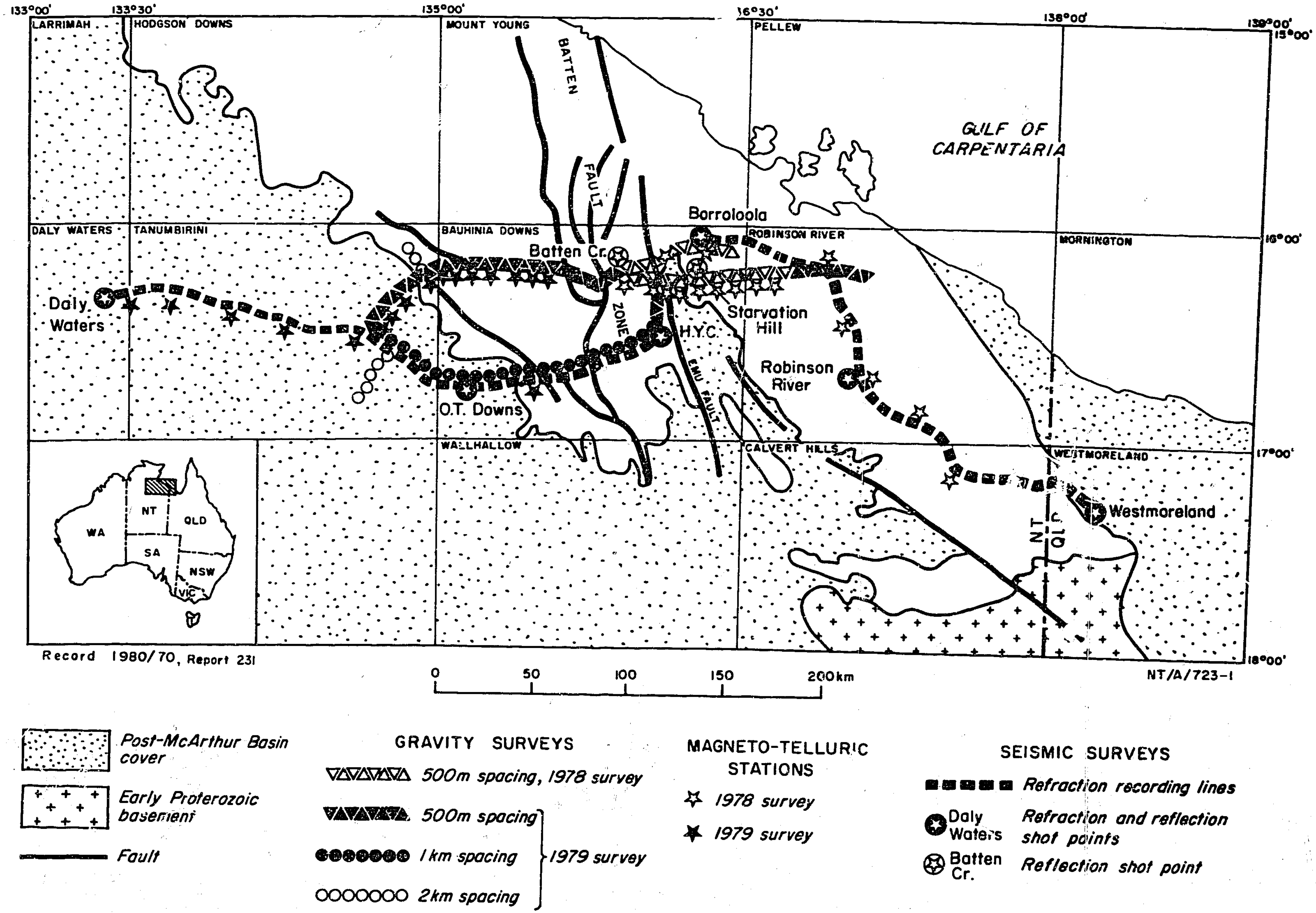

Fig OR 14 Locality map, geophysical surveys, southern McArthur Basin, 1978 – 79, showing 1:250 000 Sheet areas period 8-19 September 1980; the aim was to assess the current status of MT equipment in India and establish viable survey objectives.

At present only telluric ratios are measured, in an attempt to indicate geothermal prospects, by qualitative selection in zones of low resistivity. No magnetics are normally recorded, but coils are under construction and analogue recording will soon be possible. Prototype systems were used to obtain preliminary records during the 1979 total eclipse. The coil used in these tests was obtained from ex-Russian observatory equipment with input to indigenous amplifiers. These instruments are now fully constructed for 2-channel capacity with amplifier/filters for both H and E.

Analogue records will be made in Cuddapah Basin (15°N, 78°E) during 1981, depending on the availability of the NGRI 4-channel chart recorder. Records will be digitised by hand, and copies will be available to both groups for processing. BMR will provide a basic set of computer programs for this purpose but some modifications may be required. Only 1D inversion will be required for initial interpretations. The survey area has been chosen to provide a test of the resolving power of MT because seismic profiles have been run in the same area and deep horizons are well marked. At the same time MT may provide some additional information on shallow layers not identified by the seismic work.

Gravity data base (A.J. Murray, J.B. Connelly, H. McCracken, R. Tracey)

The production of the new series of Bouguer anomaly maps of Australia at 1:250 000 and 1:1 million scales commenced with the completion of the Canberra, Sydney, Rowley Shoals, Cloates, and Hamersley 1:1 million map sheet areas. The publication of these maps was delayed for several months to allow for the computer production of the legends. The data for Tasmania, western Victoria, and the remainder of New South Wales were checked.

The contract recomputation of gravity data proceeded very slowly because the contractor had redeployed staff on other projects. The completion date for the contract will now be in the middle of 1981. Several errors in previously recomputed surveys have been found, apparently because additional tie information is now available. The contractor will be required to check that all recomputed surveys are properly integrated at the end of the project.

The data base now contains approximately 550 000 gravity station principal facts. An additional 70 000 marine station values are being punched; these are from the Northwest Shelf surveys done by West Australian Petroleum Ltd.

The gravity data contouring program CONTOR, was modified to include the new legend subroutines.

R. Tracey made observations along road traverses in the Daly Waters region (NT) over a period of 6 weeks. This work was undertaken to complete the gravity coverage required for the McArthur Basin project.

Requests for gravity data (A.S. Murray, P. Wellman, J. Connelly, R. Tracey)

Requests of all types increased about threefold this year. The number of separate enquiries are listed below; some are for multiple information.

Gravity meters: loans, 11; tested for outside bodies, 2; evacuation, 1; buying advice, 1; training for outside bodies, 5.
Earth tides: printouts supplied, 12; programs supplied, 2.
Data listings: printout and microfiche, 10; tapes and tape enquiries, 15.
Tie station data: 38.
Maps: Gravity maps for BMR Bulletin, 2; dyelines of check maps, 12; scribed overlays for Geol. Branch, 8.
Requests for gravity programs, 7; training on gravity programs, 2.
Advice on interpretation, 8.

Isogal network (P. Wellman, J. Williams)

The Australian National Gravity Base station Network (Isogal Network) was strengthened during February-March by measurements using seven LaCoste & Romberg gravity meters and three meter readers (Fig. OR-16). Measurements were made at 67 airports covering Australia using a chartered Piper Navajo aircraft. Cars were used to observe on six gravity-meter calibration ranges. After the survey the gravity meters were tested for voltage and temperature effects. New gravity stations were photographed and finder diagrams drawn. The survey is strongly tied to six absolute gravity stations observed in a 1979 cooperative Soviet-BMR expedition. After reduction of results, values of gravity will be known to a relative accuracy of about 0.2 $\mu m.s^{-2}$, or 10 times more accurately than the values determined during 1964-1967.

Advice was given to a Japanese party reading gravity at Port Moresby, Townsville, Sydney, and Hobart during September/October 1980.

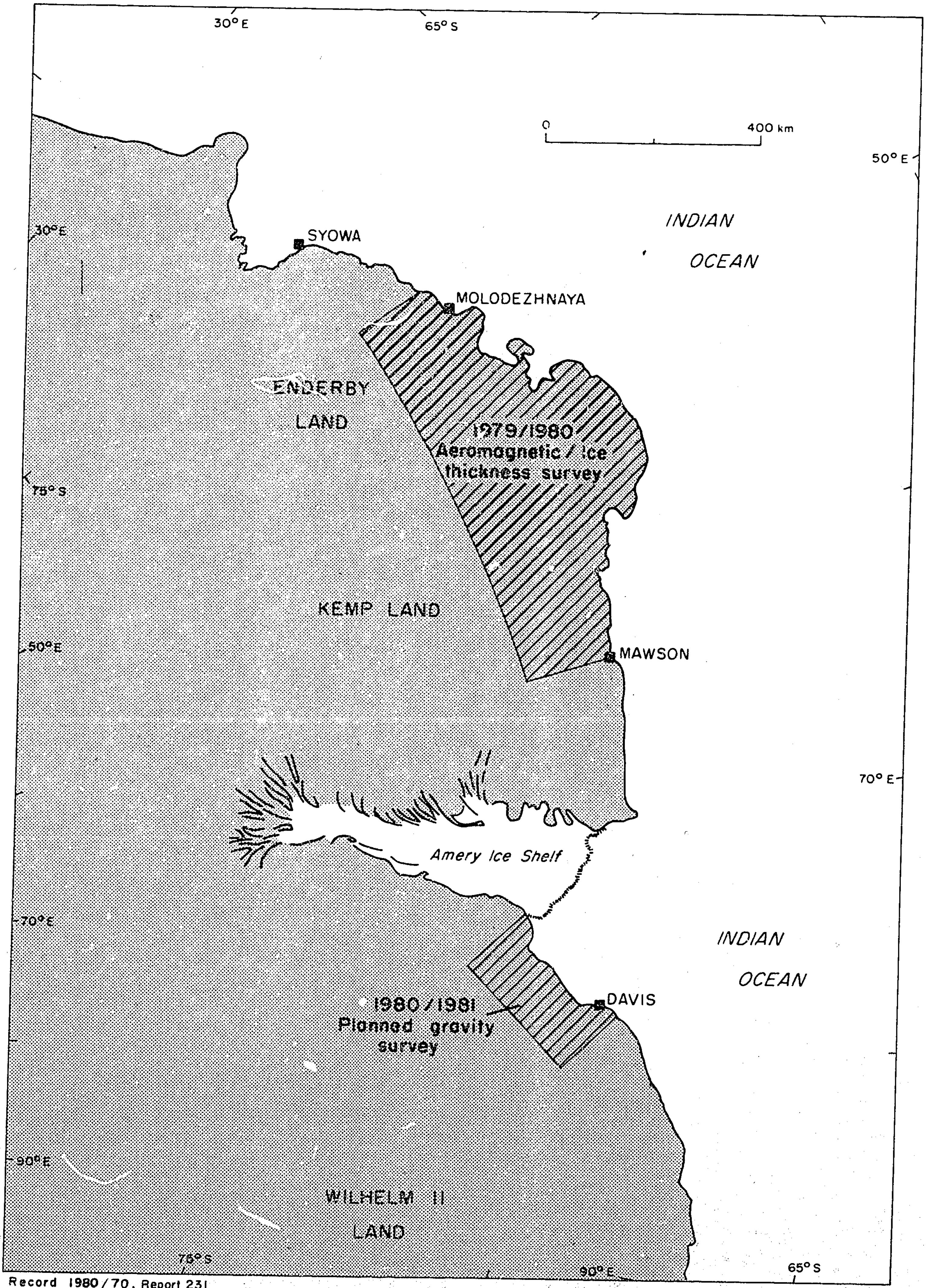

Fig OR 15 Geophysical surveys in Antarctica

Lachlan regional gravity and magnetic interpretation (J. Connelly)

Investigation of the spectral characteristics of magnetic anomalies associated with I-type granites in the Lachlan Fold Belt continued. It was concluded that the thickness of the granites cannot be determined directly from their spectral curves. However, most of the spectral curves show evidence of a deeper vertically-sided body beneath the granites. If the assumption is made that this body represents the feeder pipe for the granite, then the thickness of the granite may be obtained from the depth to the top of the feeder. A BMR lecture was given on this topic.

A published computer program was used in an attempt to model the applied tectonic forces at the time of intrusion of the granites.

Antarctic geophysics and geology (P. Wellman, S. Scherl)

During the 1979/1980 summer an aeromagnetic/ice-thickness survey was carried out over the coastal portion of the ice cap between Mawson and Molodezhnaya bases (Fig. OR-15). The survey was a cooperative venture between BMR and the Glaciology Section of Antarctic Division. Measurements were made during flights of a Pilatus Porter aircraft, the flight lines having an average spacing of 40 km. Continuous recordings were made of total magnetic field, ice thickness measured by radio-frequency echo, height of aircraft above the ice, and barometric pressure. Analysis of the data is proceeding.

Two papers were written on the erosion history of the Prince Charles Mountains using data provided by air photographs, barometric spot heights, and ice-thickness surveys. The first paper mapped the heights of old moraines above the present glacier level, and interpreted these old moraines as being due to repeated surging of the Fisher Glacier. The second paper interpreted the high-level erosion surface in the Prince Charles Mountains as a pre-glacial surface of low relief. The amount of glacial erosion was calculated using published ice-thickness results, and the amount of uplift was calculated on the assumption of isostatic equilibrium in the past. A BMR lecture was given on these topics.

Crustal strain measurements (P. Wellman)

Crustal strain measurements can be used to give estimates of the rate of storage of elastic energy in the crust, and hence the recurrence interval of major earthquakes. Crustal strain estimates together with other geophysical

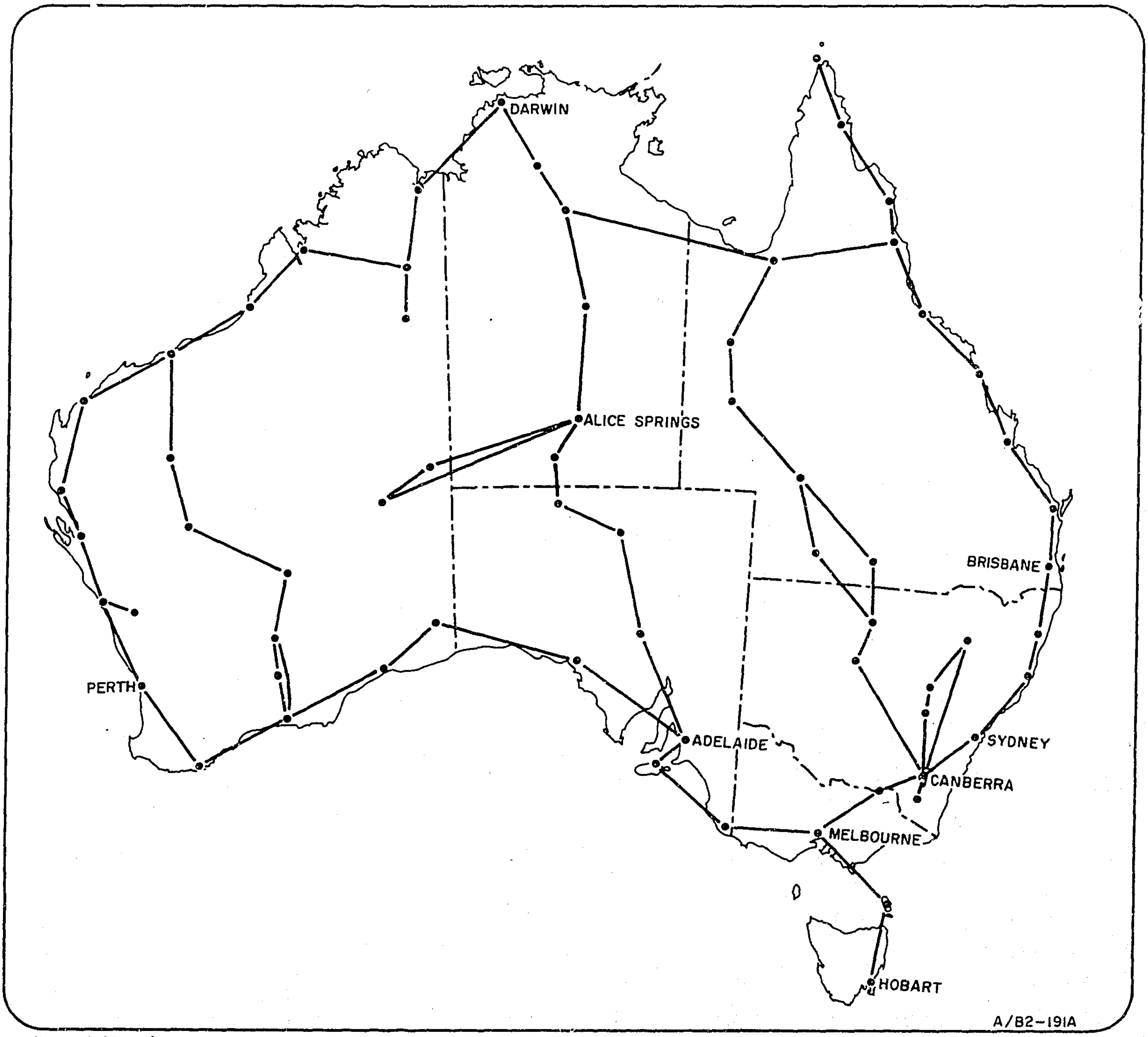

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Fig OR 16   1980 Isogal Regional Gravity Survey measurements should help our understanding of the cause of earthquakes and the mechanism of Cainozoic tectonic movements.

A cooperative program of distance, level, and gravity measurement in the SW Seismic Zone has been provisionally agreed to between BMR and the Geological Survey of Western Australia. A long-term program for other areas is under discussion between BMR and National Mapping. The first major crustal movement survey in Australia was a survey, carried out on BMR request by National Mapping, of the earthquake area north of Canberra containing the Dalton/Gunning and Bowning earthquake areas. Provisional discussions have been held on the applicability of satellite-laser and VLBI methods of measuring crustal movement across the whole of Australia.

To obtain strain from survey data three HP9825A computer programs were written to detect systematic changes in distance, angle, and direction.

Existing survey data were analysed for strain. In the ACT, preliminary calculations give angle changes of about 0.5 seconds over 90 to 100 years in the direction of a principal axis of compression varying from N to NW. In the Perth Basin, preliminary calculations give angle changes of 1.6 seconds over 30 years in the direction of a ENE principal axis of compression. In the SW seismic zone, crustal movement can be defined between a few first order trig. stations. The movements are 0.6 m or less in 10 to 20 years, the identified movements being in most cases close to the areas of major earthquakes. Significant strain was not identified from the poor data available in SE Queensland or eastern Victoria.

Palaeomagnetic investigations of Tertiary weathered profiles

1. Southeast Queensland (M. Idnurm, D.C. van Dijk (CSIRO), B.R. Senior)

Results obtained in 1979 from southeast Queensland were interpreted in terms of palaeoclimate and geomorphology, and a draft paper was written. The region investigated lies on the western slopes of the Eastern Highlands between Millerran and Surat, and covers an area of approximately 20 000 km^2. Weathering effects are prevalent, although only a few residuals of the complete profiles remain.

Palaeomagnetic data indicate two generations of weathered profiles of approximately 30 and 15 m.y. age. A third profile, characterised by a ferruginous zone at depth, was observed in the field but not sampled originally because of lack of suitable material at the sampling localities. Its age is tentatively inferred as probably 60 m.y. from previous work on similar types of weathered profile in SW Queensland. The region was revisited in 1980 to reassess the landscape relationships in terms of the weathering ages, to search for and collect samples from the earliest of the three profiles for confirmation of its age, and to sample several problem localities. Specimens were prepared from the supplementary samples, and laboratory measurements have commenced.

2. Shoalhaven River, NSW (M. Idnurm, B. Ruxton (CCAE), G. Taylor (CCAE))

Palaeomagnetic measurements were carried out on 150 samples from weathered profiles in the upper Shoalhaven River region east of Lake Bathurst. This work forms part of a more general project conducted by the Canberra College of Advanced Education on the geomorphic history of the region. The area sampled contains numerous scattered remnants of Tertiary weathered profiles including ferruginous bauxites, silcretes, manganocretes, and hill cappings of dense goethitic ironstone. At some localities, several of these contrasting weathered units are found within close proximity to each other, suggesting a complex history of weathering.

The ferruginous bauxites and ironstones gave a palaeomagnetic age of approximately 15 m.y. The bauxites also indicated a subsequent reweathering event. Additional samples were collected from these profiles during 1980 in order to improve the statistics of the directions, and to define more precisely the most recent weathering event. Specimens have been prepared from all samples, and measurements have commenced.

3. Central Australia (M. Idnurm, B.R. Senior)

Measurements were carried out on weathered profile samples collected from a number of localities east and northeast of Alice Springs. Weathered profiles have developed on Archaean metamorphics of the Arunta Complex in one region and on Tertiary sedimentary rocks in another (Hale River Basin). The directions of remanence of the two groups are indistinguishable, giving tentatively a common age of 30 m.y. Weathering effects of the same age can be traced through SW Queensland to the Eastern Highlands. Supplementary sampling is required to complete this project.

South Australian stranded beach ridges and the Pleistocene Ice Ages (M. Idnurm, P.J. Cook (ANU))

Measurements were concluded on a major sequence of stranded beach ridges that cover a significant part of southeastern Australia. The ridges are considered to mark the high stands of past oceans and to have become stranded by a gradual uplift of the region. Their significances for Pleistocene ice ages and for the ice age theories was recognised long ago, but those concepts were only partly developed because the ridge chronology remained elusive.

Remanences were measured on the South Australian part of the sequence between Robe on the coast and Naracoorte 100 km inland, in a systematic search for the first reversely-magnetised ridge. The reversed magnetisation, which records the most recent reversal of the geomagnetic field 720 000 yr ago, was located at Naracoorte, and has provided the first time constraint for the sequence. This time constraint and the ridge spacings were used to test the Milankovitch theory of ice ages, which attributes climatic change to quasi-periodic variations in the Earth's orbital elements. Those elements are: the eccentricity of the orbit, which accentuates seasonal contrasts and affects the year-averaged insolation; the tilt of the rotation axis, which causes seasonality; and precession of the axis, which fixes the dates of the equinoxes. According to the theory, ice ages are produced when all these effects combine to give a low insolation in the middle to high latitudes of the Northern Hemisphere.

The beach-ridge data were found to be consistent with the predicted climatic periodicities of approximately 20 000, 40 000, and 100 000 yrs, adding to the mounting evidence in favour of the Milankovitch Theory. However, significant descrepancies occur between the ridge evidence and the predicted phase and magnitude of the 100 000 yr cycle. Contrary to the Milankovitch theory, which assigns the 100 000 yr cycle a subsidiary role, this cycle dominates the climatic variations. Such dominance has been observed also in other types of palaeoclimatic record and remains an unsolved problem of the Late Cainozoic climate.

A paper was published on this work in Nature.

Antarctic palaeomagnetism: Enderby Land (M. Idnurm, P. Wellman, J. Giddings)

During the 1979/80 Antarctic field season, 88 oriented hand samples were collected from 23 Proterozoic mafic dykes in Enderby Land. The sampling was carried out by S. Scherl and S. Harley (University of Tasmania) in time available from their respective main work programs. This collection supplements a larger collection of oriented mafic and pegmatite dyke samples of Enderby Land (obtained in 1976/77) that yielded one well-defined and two less well-defined groups of directions.

Specimens have been prepared from all the supplementary samples, and a program of measurements has commenced.

Palaeomagnetic studies in Irian Jaya (J. Giddings, W. Sunata)

This project forms part of the Irian Jaya Geological Mapping Program, an Australian Government funded assistance program for the Republic of Indonesia. The project has two objectives:

(i) to assist geologists in solving a major problem in the tectonic evolution of Irian Jaya Province: how did the Bird's Head evolve into its present orientation with respect to the rest of the Province - rotation about a local axis, translation, or no change?

(ii) to provide the Indonesian Government with its own palaeomagnetic capability by training Indonesian personnel in the principles and techniques of palaeomagnetism and upgrading its laboratory facilities in Bandung.

Late in 1979, 345 oriented samples were collected from the Bird's Head. In a collecting area centred on Ajawassi (long.132.4°E, lat.1.2°S) and within half-an-hour's helicopter flying time, 17 localities were visited. Samples were taken from the following units which span the period Permo-Carboniferous to Miocene: Aifam Fmn - A,B, and C members; Tipuma Fmn; Kembelangan; Faumi, Sirga and Kais Limestones; Klasafet Fmn.

Specimens have been prepared, and initial NRM measurements made, on 80% of the collection. Intensities of magnetisation are invariably weak (0.1 - 2 mA/m). Detailed thermal demagnetisations have been carried out on specimens of the Aifam Fmn (A and C members), Sirga Limestone, and Klasafet Fmn. Some AF and chemical demagnetisation has been attempted, but the results are not encouraging.

Preliminary demagnetisation results from the Permo-Carboniferous Aifam Fmn, A member, have been examined in detail. In general, 3 components of magnetisation are present:

(a) a component of low thermal stability, removed in temperatures of 100°C or so, having no geological significance. This represents viscous remanence acquired in the laboratory during storage prior to measurement;

(b) a shallow, northerly-directed, upward-pointing component having intermediate blocking temperatures in the range 300°-400°C. This seems unrelated to the directions of the present and dipole fields, and may be the magnetic record of a somewhat older event in the member's history, perhaps uplift;

(c) a steeply-dipping, SSE-directed, downward-pointing component of high blocking temperature. This component is probably the original remanence of the A member, acquired in the reversed polarity field of the Kiaman Magnetic Interval during, or shortly after, deposition.

Further work in 1981 should yield an apparent polar-wander path for the Bird's Head; comparison of this with the equivalent path for Australia, should yield information on the presence, or otherwise, of relative motion.

Wahyu Sunata, an Indonesian geologist, spent 3½ months with BMR working on the project to gain experience in palaeomagnetic methods. It is hoped he will return to continue his training and assist with testing of equipment which has been ordered, or is being constructed, for the palaeomagnetic laboratory in Bandung. This comprises a Schonstedt Tumbling Specimen AF Demagnetiser; a large-volume, thermal demagnetiser with a feedback-controlled, 12-coil, field-cancellation system; and interfacing of a JR4 spinner magnetometer to an HP 1000 computer system.

<u>Eastern McArthur Basin palaeomagnetism</u> (M. Idnurm, J.W. Giddings)

Following the derivation of a tentative, first-order, magnetostratigraphic column in 1978 and 1979, attention was focussed in 1980 on the origin of the remanence in the Upper Tawallah to Middle McArthur Group sequences of the Kilgour River. For magnetostratigraphy to be valid the remanence must be either depositional or immediately post-depositional, with no more than a few hundred thousand years delay. Similarly, for palaeomagnetic pole determinations there exists a maximum acceptable time lag, which for the relatively poorly defined Precambrian pole path is a few million years. Unfortunately such time lags are often difficult or impossible to estimate, and at best only general, self-consistency tests can be applied.

The Kilgour River sequences show no evidence of metamorphism, but two types of post-depositional processes have taken place in the region that could result in remagnetisation. These are the extensive mineralisation, in the eastern part of the region (possibly by hydrothermal solutions), and karsting.

Two lines of evidence were examined in the Kilgour River sequences. The first was the direction of the remanence within a large drag fold that is associated with a prominent fault in the Upper Masterton Formation. The magnetisation was found to contain two stable components. One of these had an intermediate to high blocking temperature range with a fairly sharp cut-off at 400 to 450°C, and a direction that had not been observed in the Kilgour River sequences previously. The fold test indicated that this component is not of prefolding origin and, on the basis of its direction and blocking temperature characteristics, it was interpreted to have been acquired as a result of frictional heating during faulting. On this assumption the age of the regional block faulting was deduced as either 500 or 750 m.y.

The second component has a high blocking temperature and a direction similar to the remanence direction found in a weathered zone at the boundary between the Masterton and Mallapunyah Formations. This component lies close to the axial plane of the fold and, consequently, a sensitive fold test could not be applied. From field relationships it seems likely however that the weathered zone, and hence the magnetisation, predates the folding.

The second line of evidence is the variation of remanence direction within the Kilgour River sequence. These directions should change progressively up-sequence, unless late-stage magnetic overprinting has taken place, for example by Tertiary weathering or diagenesis. The results indicate a more or less progressive change, though several large and abrupt directional changes occur within the sequence. These changes are provisionally interpreted as major depositional breaks. Each abrupt change appears to coincide with a recessive unit, making it difficult to verify the depositional breaks in the field.

The evidence therefore tends to rule out late-stage magnetic overprinting of the remanence. Future measurements, in finer detail, on the existing collection of samples should define the time constraints for the remanence acquisition more closely.

The evidence that is now accumulating from the Kilgour River sequences points to a major error in the Australian middle Carpentarian pole path. A new path has been tentatively constructed, and will be confirmed and refined with additional measurements on the sample collection.

<u>Palaeomagnetism of Proterozoic igneous rocks of Australia</u> (J. Giddings)

This project is designed to improve the first-order apparent polar-wander path for Australia for the period 750 m.y. - 1800 m.y. for which, currently, few data exist. Rock units collected to date are: Stuart Dykes

(Central Australia, c 900 m.y.), Morawa Lavas (WA, c 1400 m.y.), and Edith River Volcanics (NT, c 1750 m.y.).

Little work has been done on this project during the year owing to the pressing requirements of other, higher-priority projects. Specimens were prepared from selected samples of the Edith River Volcanics. These, and other specimens from the Morawa Lavas, the underlying Neereno Sandstone, and the overlying Campbell Sandstone, were stepwise thermally demagnetised to temperatures of 670°C. The demagnetisation data are the key to the remanence histories of the rock units, but have yet to be analysed. However, this should be possible later in the year when the data-processing system is fully ope. tional.

Development of a comprehensive, palaeomagnetic data-processing system
(J. Giddings, F. Newman)

Introduction of the cryogenic magnetometer with its fast measuring time, and general acknowledgement of the value of looking at the complete remanence history of a rock unit rather than at its primary magnetising event, have led to an enormous increase in the amount of data and analysis generated by a palaeomagnetic project. To cope effectively with this increase of data, so that the amount of time spent on routine transfer, manipulation, and analysis of the data is minimised, a comprehensive palaeomagnetic data-processing system is being set up. It consists of two parts:

(a) a computer-based system to record, display, and interrogate magnetometer data at the joint ANU-BMR Black Mountain Palaeomagnetic Laboratory;

(b) a processing system, based on BMR's HP computer, to handle the palaeomagnetic measurements made at the laboratory.

The Black Mountain system in (a) was the focus of effort during 1979. This year, work has concentrated on the system mentioned in (b).

A 10 Mbyte palaeomagnetic database, PALMAG, has been set up as the only effective means of providing quick access to a large amount of data without the attendant problems of file management and file organisation. It forms the core of the processing system, and will contain not only measured and analysed directions and poles relating to BMR palaeomagnetic projects, but also, with a cross-reference capability, a comprehensive list of published global palaeomagnetic poles and their references. This list will be the data bank for automatic plotting of apparent polar wander paths by programs currently being tested for plotting and reconstructing continents.

To date, 5 interactive processing programs have been written. A sequence of 3 programs is concerned with transferring cassette-recorded remanence measurements, made at the Black Mountain Laboratory onto the data base. In the process, the data base is interrogated for sample orientation and bedding information so that the incoming directions can be corrected. Raw magnetometer data are fully listed for checking purposes; update lists and plots of corrected specimen directions added to the data base are provided if required. These permit a day-by-day appraisal of the data without the necessity of frequent data base interrogation. The other 2 programs calculate, and store on the data base, the field orientation and bedding correction relevant to each sample (using sun and magnetic compass measurements made in the field), along with comments and information on the sampling structure (the hierarchical organisation of localities, sites, and samples).

Interactive programs are expected to be developed in 1981 for the semi-automatic analysis of remanence into its component directions, using demagnetisation data and the Princeton graphics terminal. Their introduction will lead to considerable time savings on current hand-analysis methods. The total system, therefore, should permit faster turn-around times for palaeomagnetic projects.

Physical properties of rocks (M. Idnurm, J.W. Giddings, H. Hughes)

Approximately 900 rock samples (a record number) were measured in the laboratory during 1980. The work relied very heavily on assistance from the various client groups. The principal measurements were magnetic susceptibilities and remanences, and thermal conductivities. Except for minor work for the Geological Survey of PNG, all requests were received from within the BMR, and were related to interpretation of geophysical field data. A significant trend this year was towards massive sampling and measurements as an integral part of metalliferous geophysical projects. The breakdown of measurements is shown below:

Thermal conductivity	250
Magnetic susceptibility	620
Remanence	101
Resistivity (1Hz)	82
Resistivity (1000 Hz)	92
Induced polarisation	72
Specific gravity	741
Source velocity	1

GEOMAGNETISM AND SEISMOLOGY SUBSECTION (P.M. McGregor)

The Subsection re-organisation reported last year was approved Departmentally and had been put into practice as far as the depleted staff allowed. The new title of the Subsection (changed from 'Observatories') reflects the re-organisation, and describes its principal objectives.

The Subsection comprises the following groups:

1. Surveys, data, and reductions - G. Small, A.J. McEwin;
2. Canberra observatory - T.S. Smith, M.W. McMullan;
3. Special projects - T.B. Everingham and Antarctic observatory staff, B.A. Gaull (Mawson), P.M. Davies (Macquarie Is) K.D. Wake-Dyster (to May), M. Sexton (to June). A.S. Marks, W.H. Williams (from July, August respectively);
4. Technical support - W.K. Greenwood, G.H. Thomas, J. Salib, E. Smilek;
5. Mundaring observatory - P.J. Gregson, E.P. Paull, G. Woad, B.J. Page, Y. Moiler.

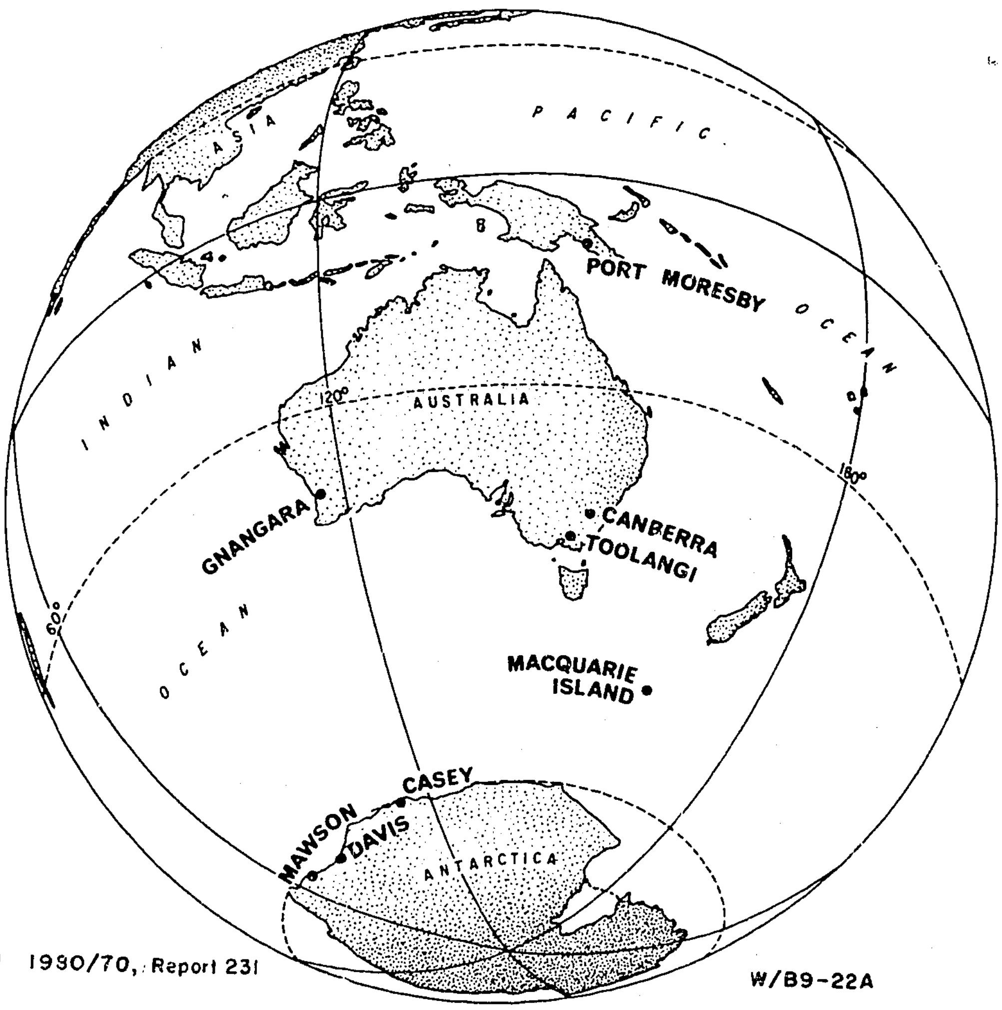
A significant improvement in operations resulted from the creation of an STO/1 in the IES Branch as a specialist dedicated to Subsection matters. Mr W.K. Greenwood was appointed to the position in July, and several recent improvements in instrumental performances can be credited to him.

Difficulty in maintaining the Subsection's program was caused by staff shortages, notably those of Science 2 and Science 1 (Geophysicists). A low Branch-recruiting priority was assigned to each position throughout the year.

The following summary covers the Subsection's actvities during the interval October 1979 to September 1980. The locality maps, Figures OR-17, OR-18, show the disposition of the magnetographs and seismographs respectively operated solely or jointly by the Subsection.

IUGG Congress

Members of all Canberra-based groups were heavily involved in the operation of the International Association of Geomagnetism and Aeronomy (IAGA) at the XVII General Assembly of the International Union of Geology and Geophysics (IUGG) in Canberra, 2-15 December 1979. Appointments to Working Groups or Commissions were made as follows:



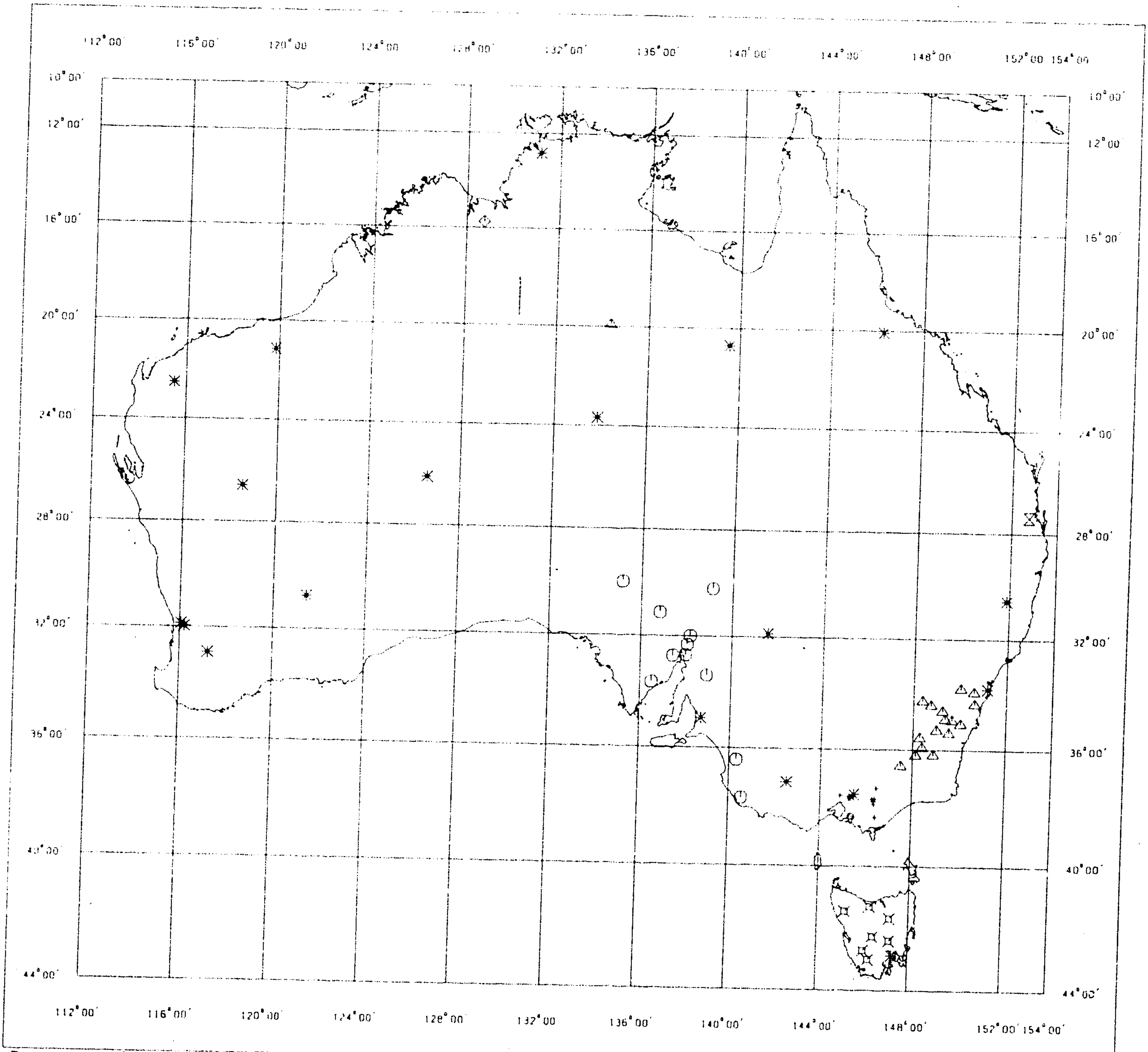
Record 1980/70, Report 231 W/B9-22A

Fig OR 17 Geomagnetic Observatories

AUSTRALIA

SCALE 1:30000000

EDITION OF 1980/11/03



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AUSTRALIAN NATIONAL SPHEROID
STANDARD MERCATOR PROJECTION
WITH NATURAL SCALE CORRECT
AT LATITUDE 0°00'

SEISMOGRAPH STATIONS 1980

AUSTRALIA

Fig. OR18

✳ Stations operated by BMR or jointly with another organization.

⏀ △ ⌘ + ⧗ ◇ Stations operated by Adelaide University, Australian National University, University of Tasmania, Preston Institute of Technology, University of Queensland and W.A. Public Works Dept.

IAGA : WGV-1 (Observatories and Instruments)
G.R. Small - Member
WGV-5 (Surveys and Charts)
P.M. McGregor - Chairman
WGV-10 (Ground based measurements for satellite surveys)
P.M. McGregor - Member

Mr McGregor was also appointed to membership of the Australia Academy of Sciences National Committee for Antarctic Research (ANCAR) Sub-committee for Geomagnetism and Upper Atmosphere Physics, and chairman of the Australian National Committee of Geodesy and Geophysics (ANCOGG) Sub-committee for Geomagnetism and Aeromony.

A joint paper was presented entitled 'Some implications of recently determined fault-plane solutions for Australian Earthquakes'. Figure OR-1 shows the fault-plane determinations for Australian earthquakes, the basis for the paper.

Two informal inspections of Canberra Magnetic Observatory were arranged for some 30 IUGG delegates.

R.S. Smith attended meetings of the International Association of Seismology and Physics of the Earth's Interior (IASPEI) Commission on Practice where a new issue of the 'Manual of Seismological Observatory Practice', to which he was a contributor, was released. He was nominated as a member of a new Sub-commission on the 'Determination of Algorithms for Earthquake Parameters', and volunteered to arrange Australian liaison for a project by World Data Centre A to microfilm important old seismograms.

Detection seismology

This term is becoming accepted as a name to describe activities related to the detection, location, and identification of nuclear explosions. P.M. McGregor continued to serve for the Department of Foreign Affairs as Australian representative on the Committee of Disarmament's Ad Hoc Group of Scientific Experts (GSE) established to advise on these matters. He attended the ninth and tenth sessions of GSE at Geneva in February and July. In conjunction with the tenth session, he attended a workshop on digital seismology at Erlangen (Grafenberg), Federal Republic of Germany.

A report on the 10th Session of the GSE was completed during September and passed to Foreign Affairs. Recommendations included participation in the 'Data Base Experiment', 1-15 October 1980 (proposed by Sweden) and the 'GTS Seismic Data Exchange' trial, 6 Oct - 28 Nov 1980 (proposed by Australia).

Geomagnetism

Observatories. Classical (photographic) magnetic variometers were operated continuously at Gnangara (WA), Toolangi (Vic), Macquarie Island, and Mawson (Antarctica), and a digital Automatic Magnetic Observatory (AMO) at Canberra. They provided analogue recordings from which geomagnetic disturbance indices and data on other transient phenomena were scaled. Control observations were made regularly at all stations other than Toolangi, and tables of mean-hourly-values are being produced. Preliminary monthly values were determined at these stations, and also at Casey and Davis (Antarctica) where observations are being made by officers of the Antarctic Division. The observations at Davis ceased in September 1979 because the observing site was being contaminated by new building activity, but were resumed at the same site in June 1980.

A new sensor, mounted in an elongated housing to improve cooling, was fitted to the AMO. However, intermittent failures of the control unit continued until August when modifications were made to improve reliability. Commissioning of a second AMO for Gnangara continued slowly. A faulty component was found in the magnetometer but noisy signals persist.

A fluxgate magnetometer was operated at the Canberra Magnetic Observatory (CMO) for Dr F. Chamalaun of Flinders University (SA), so that it could be checked against the observatory records, and an EDA fluxgate magnetometer borrowed from the BMR Metalliferous Surveys Group was similarly tested. The latter proved satisfactory for regional magnetic surveys and so it was packaged into a system with a proton magnetometer, thermograph, and chart recorder for use at Davis (summer 80/81).

A prototype 'photo-electronic-magnetograph' was assembled, using a photocell, servo-loop, and Helmholtz coils fitted as a null detector to a classical suspended magnet variometer; initial results are very encouraging.

Some instability was noted in absolute observations made with the MVS-2 proton magnetometers (BMR construction) so extensive environmental tests were initiated; these tests are continuing. Two units were checked, ready for deployment at Macquarie Island and Mawson in 1981.

General improvements made at CMO included the laying of concrete paths between huts, provision of a small dam, and commencement of grazing by sheep from an adjacent property.

A computer file of geomagnetic K-indices was set up for all stations from January 1980. It produces monthly data lists for distribution, and plots for quality control and investigations into the morphology of variations.

Differences in mean hourly values between Toolangi and Canberra were plotted for several months in early 1979 and station differences were adopted. Digital data from the AMO were edited and filed commencing January 1980 and the backlog for 1979 was filed to about June.

Data reduction

Magnetograms from observatories are reduced to absolute mean values (hourly, daily, monthly, annually) by the reductions group. The known backlog of magnetogram scaling has been completed. Older scalings are stored on data files at the CSIRO computer and will have to be transferred to the BMR computer for further processing. It is expected that there will be a small backlog of scaling corrections in these data; processing is expected to start early in 1981.

A special effort was made for the MAGSAT project, to produce mean hourly values within about 2 months of the data being recorded. Except for a few delays at the start data were sent on a regular basis to World Data Centre A in the USA for the duration of the project (September 1979 to June 1980).

The programs for the reduction of the digital data from the Canberra ADM (Automatic Digital Magnetograph) were completed except to onput 1 minute values on magnetic tape in IAGA format. The programs have been set up to be able to process the Gnangara ADM when it goes on line next year. The filing of the older ADM data on the computer was started and is progressing slowly.

Regional magnetics

The production of the 1980.0 isomagnetic charts was delayed again by the lack of full-time staff to work on the data. The reduction of the data continued slowly during the year.

Two stations were occupied for the MAGSAT project, a new station at Charters Towers, Queensland, and one at Port Hedland, Western Australia. The Charters Towers' station was established at the University of Queensland seismic station site with a second station on the airfield. The recording equipment was set up and calibrated, then left for a month and recalibrated. Preliminary results indicate that the equipment remained stable over the whole recording period. The station at Port Hedland was occupied for 6 days at the airport site, and the old station at the racecourse was revived as the second station. The reduction of the data from these stations should be completed by the end of the year.

A second-order reoccupation of the Heard Island magnetic station during the MAGSAT operation was successfully organised. Mr R. Streeter of the Division of National Mapping carried out the observations during his visit in March.

The magnetograms for the 1975/1976 and the 1977 secular variation surveys were digitised. The results from these surveys are again delayed by lack of staff to work on the results. The declination results will be produced first to aid the production of the 1980.0 D charts.

The drawing of the 1980.0 charts is now expected to commence early 1981 with D being the first chart to be produced. The others will follow as time permits.

A magnetic bearing for a new omni-direction beacon was established at Canberra airport (September 10); this was requested by the Australian Survey Office for Department of Transport.

Antarctic surveys

During the 1979-80 Australian National Antarctic Research Expeditions (ANARE) summer expeditions in Enderby Land, the fifth in this region and possibly the last for several years, second-order geomagnetic observations were made at seven stations by M. Sexton and at a further twelve stations by B. Gaull. A draft report on Gaull's survey was written by M. Sexton, who reduced results to epoch 1980.0 and calculated the secular variation in the region.

Ionospherics

An IPS-type 4B ionosonde operated throughout the year, taking soundings every 15 minutes. Six-hourly and the noon values of the F2 critical frequency were scaled at Mundaring. The ionograms were sent to IPS Sydney for the scaling of all other values.

Seismology

Data files. Preliminary phase data from all three component stations and several of the single-component (regional) stations were sent a few times a week to the United States Geological Survey (USGS) centre for 'Preliminary

Determination of Epicentres'. Final phase data from all agencies in Australia, Papua New Guinea, and the Solomon Islands for the interval December 1977 to February 1979, were sent to the International Seismological Centre (ISC) in accordance with the Centre's schedule. Data on about 4700 P phases and 55 hypocentres were sent monthly (Fig. OR-19 shows the details for BMR stations). The final data were also produced in time-sorted bulletins and distributed to co-operating agencies.

The regional Earthquake Data File (for the area 0-90°S and 75-165°E) was updated to the end of 1975. The file contains about 29 000 hypocentres from 1873 to December 1979. About 90 calls for data from the file were made from inside and outside BMR. The calls include requests for information on felt earthquakes from the public and insurance companies, and plots and lists of regional seismicity for numerous purposes.

No progress was made in setting up a world data file.

Seismograph stations. Seismographs were operated at the following places; (some jointly, with the co-operating agencies shown in parentheses):

(a) three or more components: Adelaide (University of Adelaide), Alice Springs (USAF), Charters Towers (University of Queensland), Kununurra (W.A. Public Works Department), Manton, Mawson, Mundaring, Narrogin, Hobart (University of Tasmania), Toolangi, and Riverview. Stations underlined are part of the 'World Wide Standard Seismograph Network'. Narrogin is a 'Seismic Research Observatory' (SRO) and Charters Towers is an Abbreviated SRO;

(b) single component: Bellfield, Canberra (from November 1979), Cooney, Kalgoorlie, Kowen (to November 1980), Marble Bar, Macquarie Island, Meekatharra, Mount Isa, Stephens Creek, Swanview, and Warburton.

Major causes of record loss in eastern Australia were: intermittent gain variations (probably the result of moisture in amplifiers and cables at STK and ISQ); lightning strikes (COO, TOO); recorders unservicable owing to lack of maintenance (BFD, ISQ, STK, TOO); telecom line interruptions (COO, MTN); and failed batteries not replaced owing to shortage of funds (COO, STK, BFD). Service visits were made to Cooney (February), Stephens Creek (April), Bellfield (May), and Toolangi, (July).

Owing to staff shortages it was found necessary to streamline the stamping and annotation of seismograms, and to reduce the number of events read to the more significant events only. Seismograms from Alice Springs are now being sent to Darwin for reading before forwarding to Canberra.

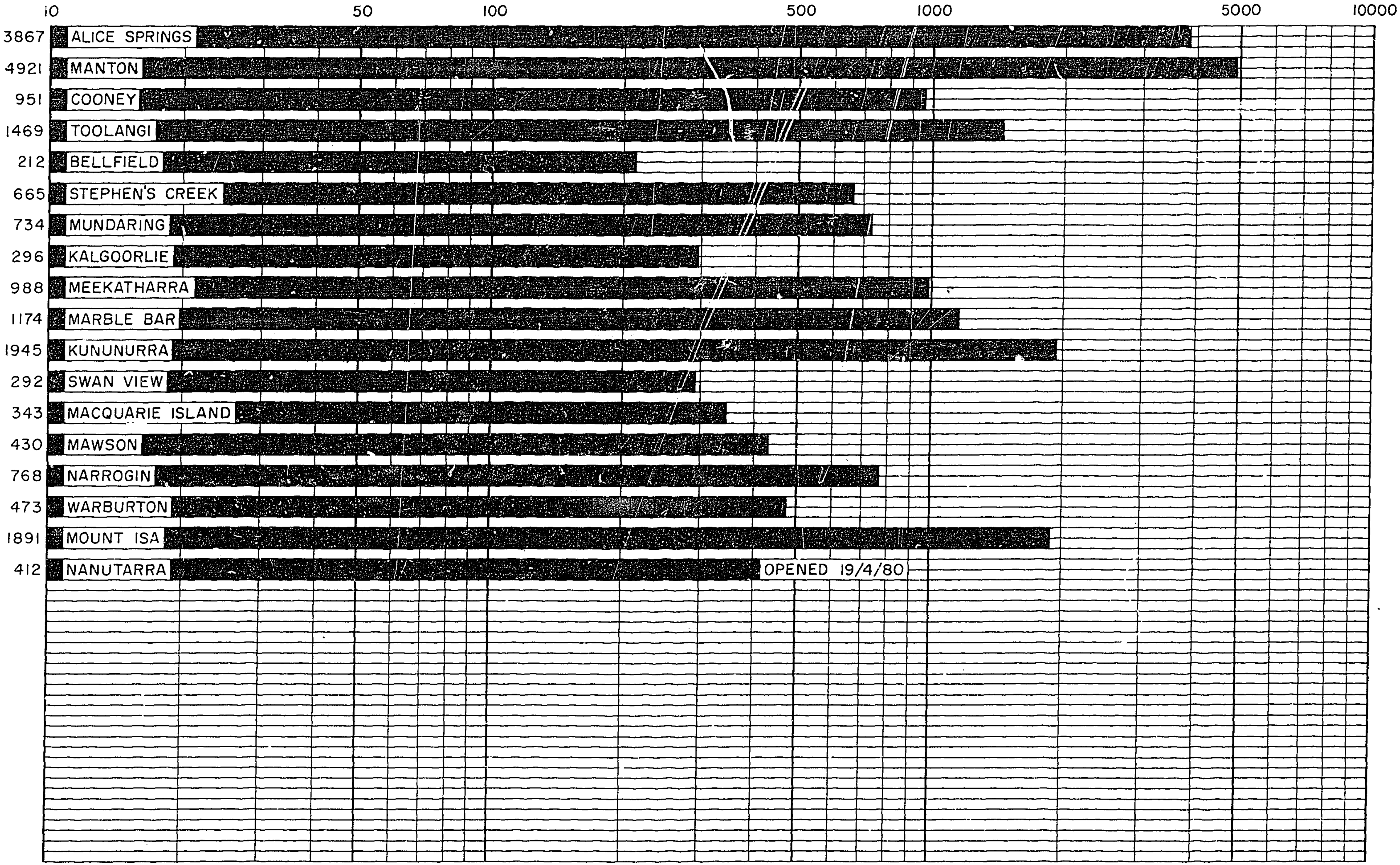

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Fig OR 19 P-Wave arrivals, BMR stations Sept 1979 – Aug 1980

Meetings were held with representatives from the Posts and Telegraphs Department to discuss the possible use of a proposed Australian Domestic Satellite for telemetry of seismological data.

A field survey was made of felt effects from the 2 July earth tremor near Cooma. The radius of the MM IV isoseismal was about 20 km and encompassed Cooma and Bunyan. The earthquake was felt as far away as Kybeyan (25 km SE) and Bredbo (25 km N), but no evidence of damage was found.

In Western Australia, recording on the seismograph at Warburton was disrupted from September 1979 till June 1980 because of operator and communication problems. The seismograph has been operating satisfactorily since a service and training visit in June 1980.

A seismograph was installed at Nanutarra (100 km SE Onslow) in April 1980. Peak magnification is 450 K at 0.25 s. The station is proving valuable in assisting in the location of earthquakes north of Meekatharra and off the northwest coast of Australia.

Three service visits were made by an Albuquerque Seismological Laboratory officer to carry out maintenance to the SRO at Narrogin. Failures in the SRO system included the data electronics board in the tape units (3 occasions), the remote inverter, the remote 5 V power supply, and the remote test set controller which prevented daily calibration of the system. The computer memory was increased from 8 K to 16 K to allow a new operating program to be used. The new program defers automatic calibrations as events are in progress, and allows time corrections.

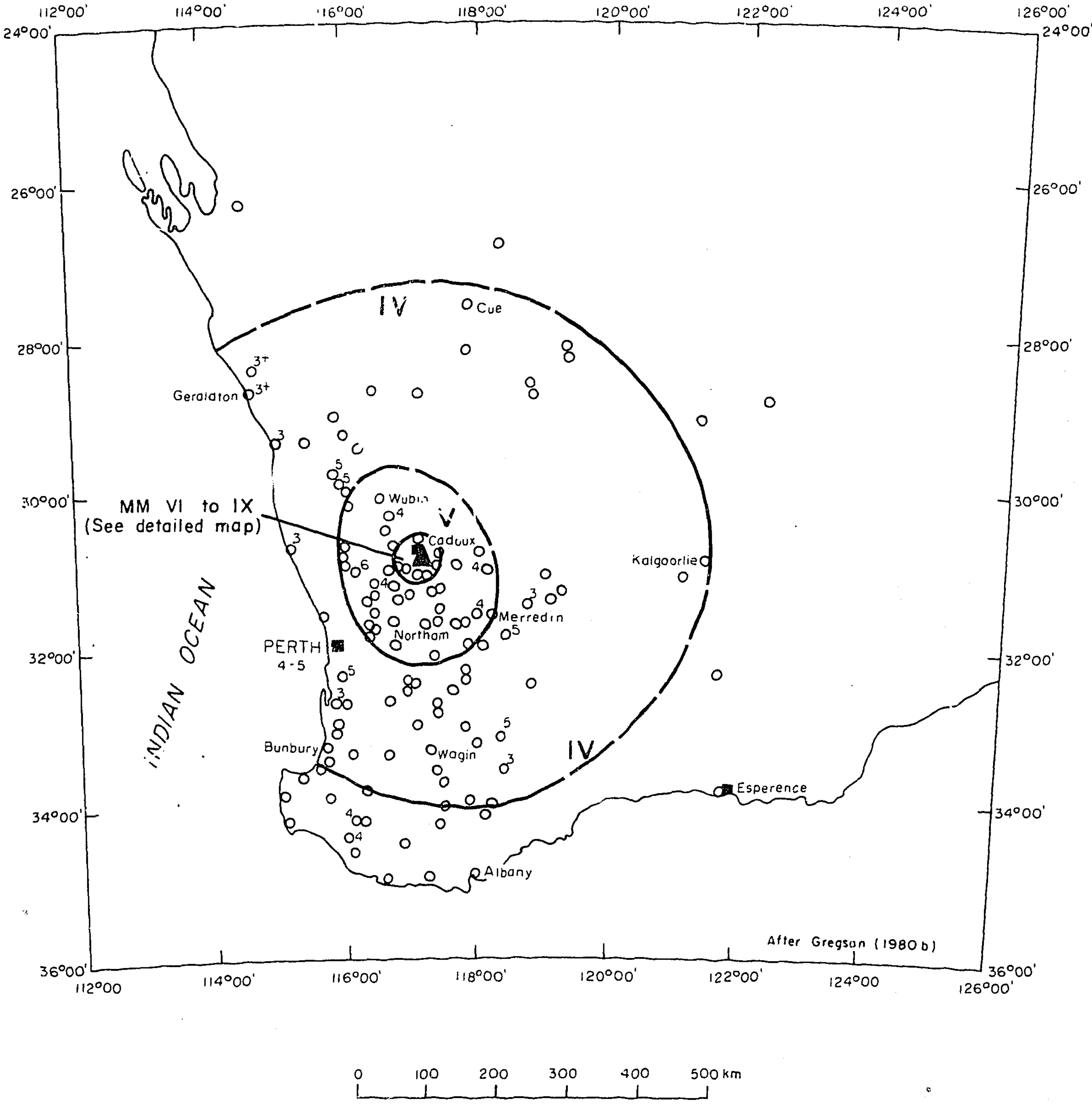
Service visits and minor modifications to the dc distribution were made at Marble Bar, Meekatharra, and Kalgoorlie. Faulty connections in the solar panels at the remote site at Marble Bar resulted in power problems over several months before the fault was isolated and corrected.

One seismograph was operated in the Meckering area until April 1980. Subsequently, the unit was transferred to Kellerberrin.

Isoseismal maps were prepared for the Cadoux earthquakes of 2 June 1979 (Figs. OR-20 & OR-21) and 11 October 1979.

Four accelerographs were operated in the Meckering area and two at the Ord River Dam (Kununurra). Accelerograms were obtained for earthquakes near Meckering on 27 November 1979 and 16 June 1980. Accelerograms recorded were:

ISOSEISMAL MAP OF THE CADOUX EARTHQUAKE, WA 2 JUNE 1979 Fig OR20



DATE : 2 JUNE 1979

TIME : 09·48·01·1 UT

MAGNITUDE : 6·2 ML (MUN), MB 6·3, MS 6·4

EPICENTRE : 30·79°S 117·15°E

DEPTH : 15 km

▲ EPICENTRE

○ EARTHQUAKE WAS FELT

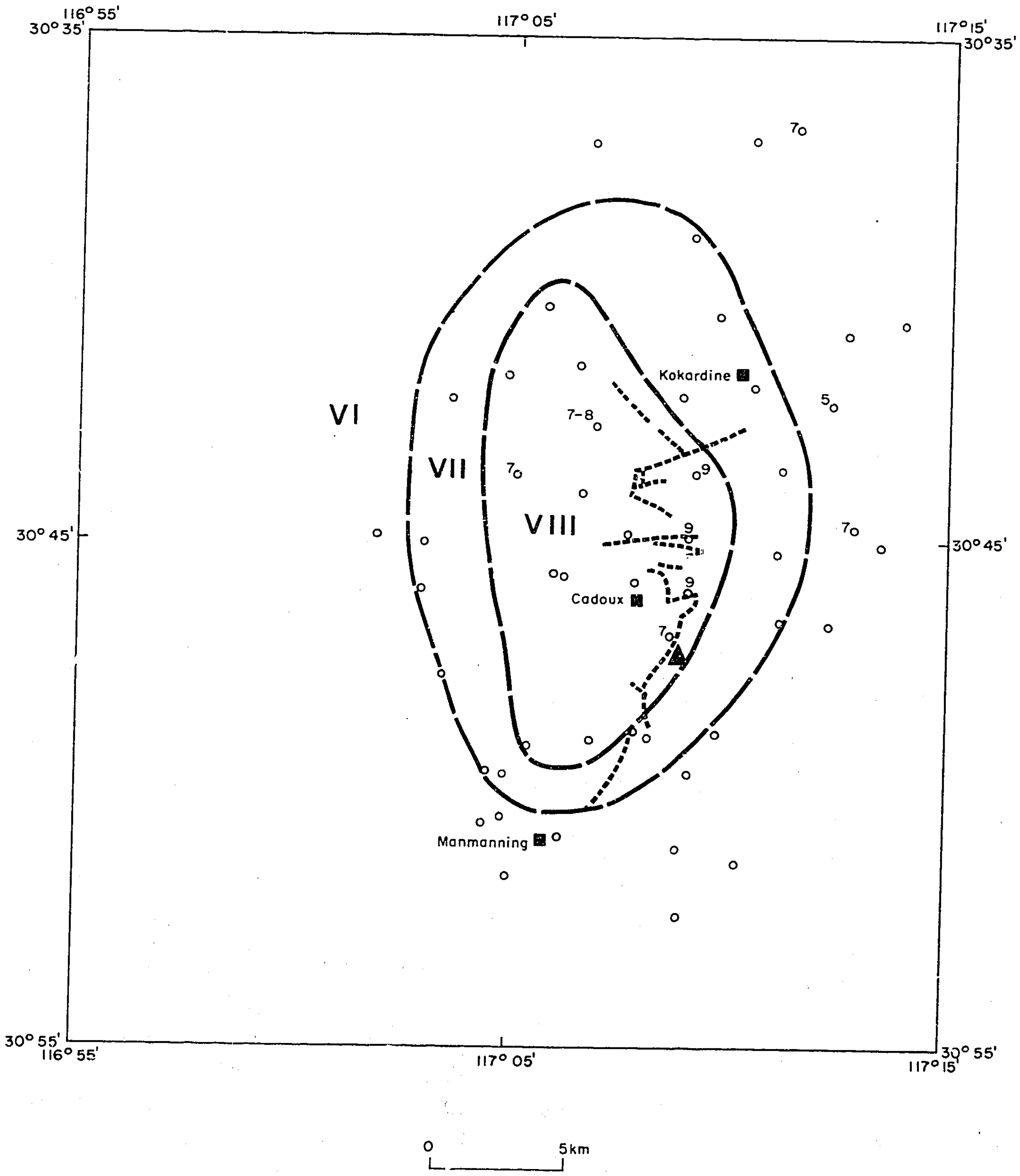
IV ZONE INTENSITY DESIGNATION (mm)

NOTE — DETAILS OF MEIZOSEISMAL ZONE SHOWN IN FOLLOWING MAP.

Small figure beside open circle indicates intensity is different from zone designation

ISOSEISMAL MAP OF THE CADOUX EARTHQUAKE, WA 2 JUNE 1979 - THE CADOUX AREA

Fig OR 21



DATE : 2 JUNE 1979

TIME : 09:48:01·1 UT

MAGNITUDE : 6·2 ML (MUN), MB 6·3, MS 6·4

EPICENTRE : 30·79°S 117·15°E

DEPTH : 15 km

▲ EPICENTRE

○ EARTHQUAKE WAS FELT

VI ZONE INTENSITY DESIGNATION (MM)

------ EARTHQUAKE FAULTING

Small figure beside open circle indicates intensity is different from zone designation

Based on 24/1

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WA/B9-52- 1A

Date	ML	Dist(km)	Peak acc.(m/s^2)	Ground period(s)
Nov 27, 1979	3.0	7	Z 4.4×10^{-1}	0.06
			N 8.6×10^{-1}	0.04
			E 8.8×10^{-1}	0.04
		18	Z 0.6×10^{-1}	0.02
			N 2.9×10^{-1}	0.02
			E 2.4×10^{-1}	0.02
Jun 16, 1980	2.8	3	Z 3.0×10^{-1}	0.04
			N 11.0×10^{-1}	0.04
			E 11.0×10^{-1}	0.04

Several sites in the Cadoux area were selected for in situ stress measurements to be made by CSIRO.

Australian seismicity

Significant earthquakes which occurred in Australia during the period October 1979 - September 1980 are listed below:

SIGNIFICANT EARTHQUAKES IN AUSTRALIAN REGION
1979 SEPTEMBER - 1980 AUGUST

Date	Locations	Magnitude ML	Remarks
1979			
Sep 02	260 km SW Albany	3.1	
10	8 km SSE Cadoux	3.3	
11	60 km SE Marble Bar	4.2	
21	3 km N Cadoux	3.1	
23	260 km NW Broome	4.0	
25	240 km NW Broome	3.5	
Oct 11	3 km SE Cadoux	4.8	Felt MM V.
21	260 km NW Broome	4.8	
21	260 km NW Broome	3.5	
26	82 km S Kununurra	3.1	
31	100 km W Barrow Island	4.5	

Date	Locations	Magnitude ML	Remarks
Nov 27	15 km SW Meckering	3.0	Felt MM IV.
Dec 08	15 km S Meckering	3.1	
11	23 km SSE Cadoux	3.1	
14	80 km NNW Dampier	3.4	
15	307 km from Kununurra	3.1	
17	21 km SSE Cadoux	3.9	
20	8 km SE Cadoux	3.3	
20	18 km SSE Cadoux	3.4	
26	5 km NE Cadoux	3.0	
1980			
Jan 18	30 km from Macquarie Island	5.4MB(ASP)	Felt MM V.
Feb 06	11 km SE Cadoux	3.2	
07	30 km from Macquarie Island	6.4MS	Felt MM VI+
09	210 k, SSE Broome	3.8	
10	210 km SSE Broome	3.0	
12	400 km NW Alice Springs	3.8	
Mar 08	80 km E Zanthus	3.5	
15	100 km SW Broome	4.7	
Apr 01	25 km N Derby	3.6	
01	160 km W Broome	3.9	
02	280 km NW Broome	4.0	
05	12 km SSE Cadoux	3.1	
09	330 km WNW Broome	3.9	
15	30 km N Port Augusta	4.2	
19	330 km NW Onslow	4.7	
22	100 km NW Port Augusta		
May 01	220 km N Port Hedland	3.0	
01	50 km S Mudgee	3.7	Felt MM IV
06	115 km NW Broome	3.5	
19	19 km E Bencubbin	2.8	Felt MM III
19	21 km E Bencubbin	3.0	Felt MM IV
22	230 km NW Meekatharra	2.9	
23	Banda Sea	(5)	Felt MM III

Date	Locations	Magnitude ML	Remarks
1980			
Jun 01	11 km SE Cadoux	3.7	Felt MM V
03	100 km NW Lake McKay	3.7	
05	150 km N Darwin	3.5	
07	400 km NW Alice Springs	3.4	
12	260 km W Meekatharra	3.2	
12	11 km S Dumbleyung	2.7	
16	20 km S Meckering	2.8	
22	300 km NW Broome	3.8	
22	280 km NNW Broome	3.6	
Jul 02	18 km NE Cooma	4.0	Felt MM IV
03	250 km W Broome	3.4	
06	260 km NW Broome	3.4	
07	90 km N Canberra	3.5	
20	430 km WNW Exmouth	4.2	
26	11 km SE Cadoux	3.1	Felt MM IV
Aug 01	101 km S Kununurra	2.7	
01	320 km WNW Broome	4.0	
02	355 km ENE Kalgoorlie	3.3	
07	250 km NE Kalgoorlie	4.4	
08	250 km NW Geraldton	3.3	

Most of the seismic activity was in the Western Australian region, and the activity off the northwest coast was notable. However, no known damage was caused by any of the earthquakes listed.

During 1980 the computer filing of Australian earthquakes was updated to include the 1978/79 results. Seismicity maps for all Australian earthquakes which occurred prior to 1980 were computer plotted for production of updated seismicity maps and slides. One such map, Figure OR-22, was used in an updated BMR Pamphlet on 'Australian Earthquakes'.

The computer file now contains details of 8280 Australian earthquakes. From Table OR-1, showing the number of earthquakes located instrumentally in various periods during 1900-1979, the sensitivity of the Australian seismograph network can be gauged. For example, the earthquake totals have increased with

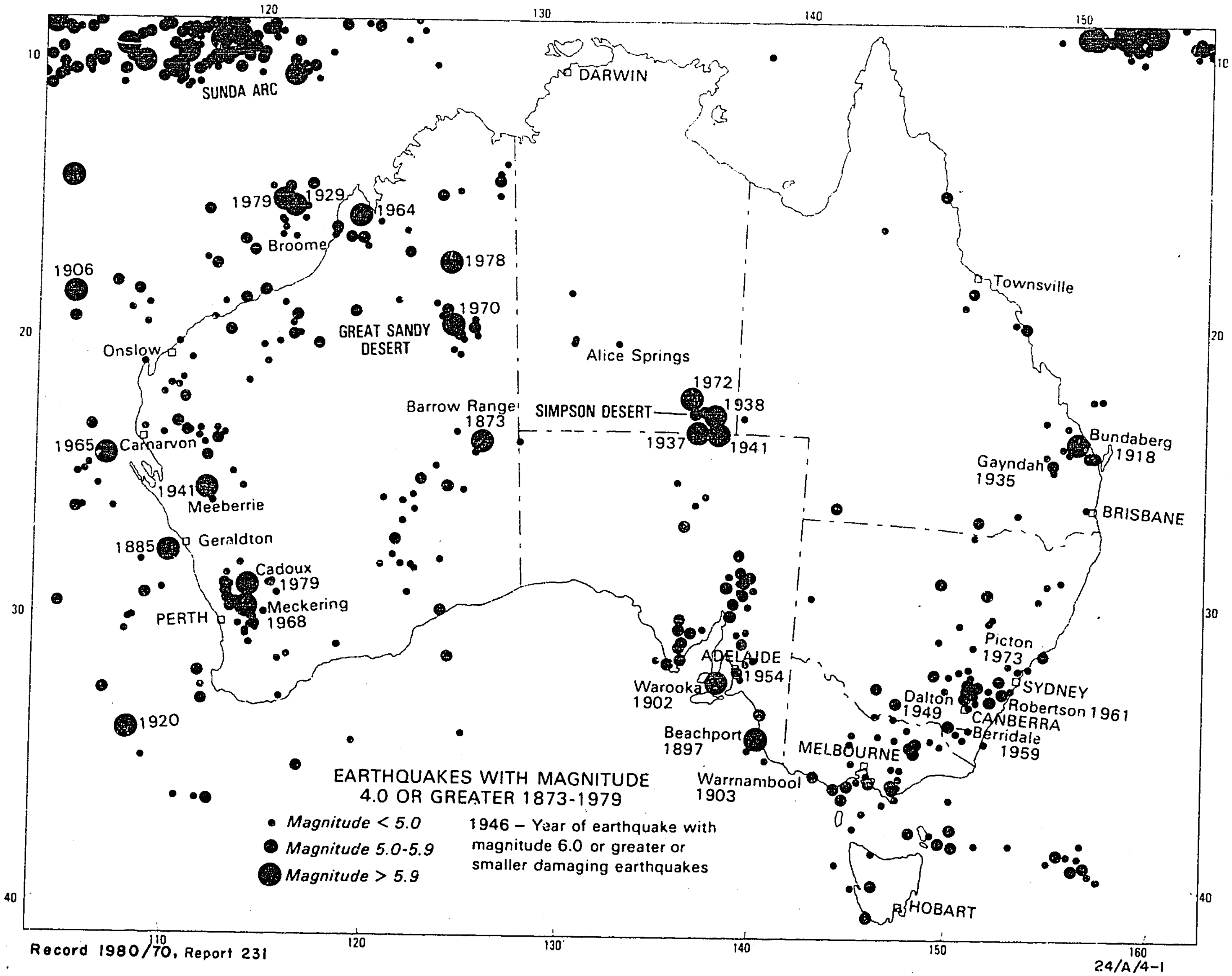


Fig OR 22 Australian Seismicity 1873-1979 the passage of time because of the increase in the number of seismograph stations; this is most apparent in the NW Australian quadrant, where new stations have been installed at Marble Bar and Nanutarra during the last few years. The need for a better coverage of Queensland is also evident in the Table.

Atlas of Australian Seismicity

A draft Atlas of Australian Isoseismal Maps has been prepared for presentation as a loose-leaf BMR Bulletin. The Atlas includes 66 maps, with a description and references for each map.

TABLE OR-1

1900-79 EARTHQUAKES LOCATED IN AUSTRALIA (8280)

LOCAL AREAS

		1900-59	1960-64	1965-69	1970-74	1975-79
SOUTH WEST AUST.						
29-35°S 115-120°E	ML>2.0	192	526	327	(177)	
	>3.0	41	169	48	91	
	>4.0	4	22	5	9	
	>5.0	-	5	1		
	All	207	612	335	180	
SOUTH AUST. 30-36°S 135-140°E	ML>2.0	37	163	203	259	
	>3.0	12	34	32	34	
	>4.0	7	10	3	2	
	>5.0	-	1	2		
	All	53	228	368	617	
SOUTH EAST AUST. 33-39°S 145-150°E	ML>2.0	290	417	384	494	
	>3.0	69	78	82	56	
	>4.0	7	8	9	4	
	>5.0	1	3	2	-	
	All	512	548	972	1185	

REGIONAL AREAS

		1900-59	1960-69	1970-79
SW	All	26	856	588
25-44°S 108-133°E	ML>3.0	21	257	267
	>4.0	20	33	24
	>5.0	7	3	8
	>6.0	2	1	1
SE 25-44°S 133-158°E	All	141	1671	4569
	ML>3.0	123	286	372
	>4.0	60	63	41
	>5.0	33	10	5
	>6.0	6		
NW 15-25°S 108-133°E	All	3	34	354
	ML>3.0	3	34	(194)
	>4.0	3	27	99 MB
	>5.0	3	(7)	(24)
	>6.0	3	2	4
NE 15-25°S 133-158°E	All	(14)	3	14
	ML>3	(14)	3	9
	>4	5	3	4
	>5	3	0	1
	>6	1	0	1

4. MULTIDISCIPLINARY PROJECTS

McARTHUR AND GEORGINA BASINS MULTIDISCIPLINARY PROJECTS

(G.E. Wilford)

The McArthur and Georgina Basin studies, in which staff from several Branches work together as a project team, continued during the year. The work of scientists from outside BMR is co-ordinated with that of the project team wherever feasible. K.A. Plumb has been responsible for project co-ordination in the McArthur Basin study and J.H. Shergold (1979) and C.J. Simpson (1980) for that in the Georgina Basin study.

Emphasis in the McArthur Basin project has been on sedimentological laboratory investigations and the interpretation of geophysical data. Quarterly progress reports have been issued as BMR Records, and tentative ideas on the structure of the southern part of the basin were aired at the BMR Symposium in April.

Significant results of the research include: the discovery of hydrocarbon residues in the 1600 million year old Looking Glass Formation; palaeontological evidence for the Early Cambrian age of the Bukalara Sandstone; and palaeomagnetic evidence for a revised mid-Carpentarian polar wondering curve. Preliminary interpretations of geophysical data from the southern part of the basin are tending to confirm the geologically predicted form of the Batten Trough, although there appears to be little gravity expression across the Emu Fault which, in part, forms its eastern margin.

Emphasis in the Georgina Basin Project has been placed on publishing the results of earlier field investigations. Twenty three papers were published during the year, and three 1:100 000 scale geological maps were issued. Particular advances were made in re-interpreting the stratigraphy of the southern part of the basin, in sedimentological studies of the carbonate units, and in petroleum source and reservoir rock investigations. Interpretation of the aeromagnetic data from the Glenormiston area is yielding information on basement lithologies and structure.

McARTHUR BASIN PROJECT

Compiled by
K.A. Plumb, Project Co-ordinator

STAFF: W. Anfiloff[2], K.J. Armstrong[1], C.D.N. Collins[2], J.P. Cull[2], T.H. Donnelly[3], J.M. Fetherston[1], J.W. Giddings[2], D. Gregg[1], M. Idnurm[2], M.J. Jackson[1], I.B. Lambert[3], M.D. Muir[1,4], J. Pinchin[2], K.A. Plumb[1], C.J. Simpson[1], A.G. Spence[2], R. Tracey[2], M.R. Walter[1].

1. Geological Branch
2. Geophysical Branch
3. CSIRO
4. Resigned during year

The basic aim of the McArthur Basin Project is to elucidate the evolution of the McArthur Basin, using stratigraphic, sedimentological, geochemical, geophysical, tectonic, and other studies, and to apply this information to the understanding of the genesis of ore deposits in the region and to the assessment of possible hydrocarbon potential of the basin.

Most staff only contribute to the project on a part-time basis. Geological studies were seriously curtailed by the resignation from BMR of M.D. Muir, in February, 1980. The only fieldwork during 1980 was a small gravity survey, to complete some unfinished lines from the 1979 survey. The emphasis during 1980 has been on geological laboratory investigations and data compilation, and the interpretation of geophysical data.

With the recent completion of data processing and map compilation of all the airborne data obtained by Geophysical Branch over the McArthur Basin, the project is about to enter an important phase, with a multidisciplinary synthesis and interpretation of all geophysical data over the whole McArthur Basin.

OBJECTIVES OF THE 1980 PROGRAM

The main objectives of the 1980 program were:

1) continue laboratory studies and data interpretation of the sedimentology and palaeogeography of the Wollogorang Formation, Masterton Formation, Mallapunyah Formation, and Amelia Dolomite;

2) continue laboratory studies and data interpretation of the sedimentology, palaeogeography, and micropalaeontology of the Balbirini Dolomite, Dungaminnie Formation, and their stratigraphic equivalents;
3) carry out Pb-isotope measurements of carbonate rocks from the McArthur Group, to assess the source of metals in the McArthur Pb-Zn deposits;
4) carry out mineralogical and geochemical studies of samples from the Eastern Creek Pb-Ba deposit;
5) continue investigations of the application of LANDSAT data to mapping and mineral exploration in the McArthur Basin;
6) continue laboratory measurements on magneto-stratigraphic samples collected during 1978;
7) interpret data from the 1978-79 crustal-seismic, magneto-telluric, and gravity surveys;
8) complete unfinished gravity lines from the 1979 survey.

REPORTING OF RESULTS

1. Progress of research has been regularly reported in Quarterly Reports - Records 1979/82 and 1980/5, 1980/38, and 1980/55.
2. Muir (1980) has presented palaeontological evidence for the Early Cambrian age of the Bukalara Sandstone (BMR Journal, 5, 159-160).
3. Muir, Armstrong, and Jackson (in press) have described Precambrian hydrocarbons in the Looking Glass Formation (BMR Journal, 5, 301-304).
4. A synthesis of the stratigraphy, structure, and evolution of the McArthur Basin and Mount Isa regions, by Plumb, Derrick, and Wilson (1980), has finally been published by the Geological Society of Australia, in "Geology and Geophysics of Northeastern Australia".
5. Jackson (1980) presented aspects of McArthur Basin sedimentology to the 4th Australian Geological Convention in Hobart, and to an M.Sc. Seminar at James Cook University.
6. A Record by Cull, Spence, Major, Kerr, and Plumb, describing the 1978 magneto-telluric survey, is being edited.
7. A Record by W. Anfiloff, describing the 1978-79 gravity survey, is being edited.

GEOLOGY

(M.J. Jackson, Task Leader)

STUDIES OF DRILLCORE MATERIAL (M.J. Jackson, M.D. Muir, K.J. Armstrong)

BMR Bauhinia Downs 4 (M.D. Muir, K.J. Armstrong)

Petrological studies of the 25 m of Looking Glass Formation, which was intersected in BMR Bauhinia Downs 4, indicate that the formation has undergone a complex sequence of post-depositional events, including 1) early vadose alteration of the original carbonates, with the production of vuggy porosity; 2) extensive silicification and the development of additional porosity; 3) sulphide mineralisation (including pyrite, chalcopyrite, and marcasite); and 4) trapping of oily material in vugs and veins. The oily material comprises black, hard bitumen in the form of globules, pore filling, or as fracture coatings, and a brownish liquid which liberated hydrocarbons during pyrolysis. The presence of hydrocarbon residues in 1600 million year old rocks indicates that Proterozoic basins should not be ignored in the search for hydrocarbons.

Australian Geophysical MA1 & MA2 holes (M.J. Jackson)

Core from these holes, drilled in the Mountain Home area (lat. 17°00'S, long. 136°30'E) in 1966, were examined at the Department of Mines in Darwin. The sequence comprises Amelia Dolomite, Mallapunyah Formation, and the upper part of the Masterton Formation, rather than just Amelia Dolomite, as described in the company report. The Amelia Dolomite is of similar thickness and lithology to that in the type section (60 km to the west) indicating that the alternating intertidal to supratidal environments in which the unit was deposited extended well to the east of the McArthur River area. The Mallapunyah Formation is also of similar lithology to that in the type area, near Mallapunyah, but it is reduced in thickness from 150 m to 80 m.

BMR Mount Young 2 (M.J. Jackson)

Detailed petrological and geochemical studies of the Wollogorang Formation in BMR Mount Young 2 (drilled in 1979) were started. In BMR Mount Young 2, the Wollogorang Formation is 132 m thick, and consists of an upper interval of fine to coarse-grained sandstone, overlying a thick sequence of dolomitic siltstone and claystone. The distinctive stromatolitic bioherms, present near the base and top of the formation to the south and east of this area, were not found, although the lower part of the drillhole did penetrate the 'ovoid' marker beds, characteristic of the formation elsewhere. Three intervals of breccia, interpreted as solution collapse or slump breccia, were intersected; these beds appear to be closely related to contorted beds of dolomite after evaporites.

The lower part of the formation comprises a 70 m-thick interval of laminated grey to black pyritic shale, which resembles the mineralised H.Y.C. Pyritic Shale Member of the Barney Creek Formation, the host to the McArthur River Pb:Zn:Ag deposit. A geochemical comparison between the Wollogorang Formation in this drillhole and drillhole sections of the H.Y.C. Pyritic Shale Member, as reported by I.B. Lambert (Journal of Geochemical Exploration, 2, 307-330, 1973) has been undertaken to assess the base-metal potential of the Wollogorang Formation. Metal values throughout the drillhole are surprisingly low, even though there are apparently rich sections of visible, disseminated sulphides. Copper values range from 2-1500 ppm, lead from 5-95 ppm, zinc from 5-55 ppm, and silver from 0-2 ppm. There are no anomalous zinc levels, but the highest (anomalous) copper and lead values occur near the base of the ovoid beds. There appears to be a relation between the base-metal concentrations and the organic carbon content, which is highest (6%) in the lower part of the ovoid beds. Although containing some of the features that Lambert considers attractive when prospecting for shale-hosted stratiform base metal deposits (i.e. pyritic black shales, vitric tuff bands, ferroan dolomites) the formation lacks the major zinc and lead anomalies that Lambert considers to be diagnostic of significant mineralisation.

Evaporite minerals (M.J. Jackson, M.D. Muir)

Based on a visual comparison with textures seen in newly-discovered Cambrian evaporites from the Officer Basin in South Australia, pseudomorphs after trona (hydrous sodium carbonate) and shortite (sodium calcium carbonate) have been tentatively identified in samples of chertified carbonates from the Lynnot Formation and Balbirini Dolomite. In the modern environment, trona and shortite are restricted to non-marine lacustrine environments.

MINERAL DEPOSIT STUDIES

Lead isotope tracer studies - McArthur Group (I.B. Lambert, Baas Becking Geobiological Laboratory)

The aim of this study is to directly assess the source of metals in the McArthur deposits by comparing the Pb-isotope compositions of the ores with those of trace Pb in McArthur Group rocks, stratigraphically beneath these sediment-hosted deposits. Potential source rocks must have Pb that is isotopically compatible with the ore Pb. The work was undertaken at the Federal Institute for Geosciences, Hannover, in collaboration with Dr Axel Hohndorf. Final interpretation must await the completion of further analyses and the following summary is based on a preliminary assessment of the results to hand.

Present indications are that:

(i) the bulk of the carbonate-rich samples have Pb that is much more radiogenic than ore galena (after correction of measured present-day results, on the assumption that the rocks have remained closed systems to U and Pb since the Middle Proterozoic);

(ii) residues left after reaction of the rocks with hot 2NHCl (i.e. feldspars, quartz, zircons, some phyllosilicates, etc.) have very radiogenic present-day Pb isotope ratios. However, when corrected for the concentration of U recovered from these samples, the calculated Pb isotope ratios at the time of ore formation are impossibly low in some cases. It is obvious that, for these residues, there has been over-correction for the U-supported radiogenic Pb generated since accumulation of the McArthur Group. The reason for this is uncertain at present, but possibilities include U addition since the Proterozoic, radon loss from the sedimentary rocks, or differential leaching of U and Pb during recovery of the metals by acid treatments.

Eastern Creek lead-barite deposit (T.H. Donnelly, Baas Becking Geobiological Laboratory; M.D. Muir, K.J. Armstrong)

Previous work has indicated that the barite occurrences are widespread, and appear to be related to the pre-Limman land surface. The host rocks are very shallow-water or non-marine dolomite and chert of the Kookaburra Creek Formation. The deposits are both cross-cutting and conformable. A complex mineral paragenesis is indicated. Copper minerals are usually associated with the galena, and the galena and barite mineralisation appear to be essentially different events (see Record 1979/16).

Preliminary isotope studies during 1980 indicate fairly constant ^{34}S values for the barite (av. +18.0°/oo), whilst a chalcopyrite sample has a ^{34}S value of +21.0°/oo and a galena sample +11.2°/oo. Dolomite has fairly constant ^{13}C and ^{18}O values (av. +1.1 and +21.8°/oo, respectively). Both ^{13}C and ^{18}O values are in agreement with a sedimentary marine (or modified marine) origin.

LINEAMENT ANALYSIS OF THE EMU FAULT ZONE (J.M. Fetherston)

An analysis of the lineaments along the Emu Fault Zone is in progress using two different methods of remote sensing. The study area is a 50 km wide strip, extending 220 km north-south along the fault zone, on the Bauhinia Downs and Mount Young 1:250 000 sheet areas.

Data is being compiled from conventional RC9 black-and-white aerial photography, at 1:80 000 scale, and from computer-enhanced, multiband, black and white Landsat imagery, at 1:1 000 000 scale. Lineament data is acquired from both types of imagery, both by vertical viewing and by low-angle oblique examination.

The objectives of the project are:

(i) to compare the lineament data acquired from conventional aerial photography with that acquired from Landsat imagery, in a semi-arid region;

(ii) to carry out a cost-effectiveness analysis of the two systems of remote sensing, based on the results obtained from each method versus the time taken to extract the data;

(iii) to attempt to locate the extension of the Emu Fault Zone beneath the Cainozoic cover in the northern half of the study area;

(iv) to detect relative horizontal displacement of blocks along the fault zone, by remote sensing techniques.

Compilation of data is almost complete, and a preliminary evaluation of the analysis is in progress.

PALAEOMAGNETISM

(M. Idnurm (Task Leader), J.W. Giddings)

Following the derivation of a tentative first order magnetostratigraphic column in 1978 and 1979, attention was focussed in 1980 on the origin of the remanence in the Upper Tawallah to Middle McArthur Group sequences of the Kilgour River. For magnetostratigraphy to be valid, the remanence must be either depositional or immediately post-depositional, with no more than a few hundred thousand year delay. Similarly, for palaeomagnetic pole determinations, there exists a maximum acceptable time lag which, for the relatively poorly defined Precambrian pole path, is a few million years. Unfortunately such time lags are often difficult or impossible to estimate, and at best only general self-consistency tests can be applied.

The Kilgour River sequences show no evidence of metamorphism, but two types of post-depositional processes have taken place in the region, that could result in remagnetisation. These are the extensive mineralisation, in the eastern part of the region (possibly hydrothermal solutions), and karsting.

Two lines of evidence were examined in the Kilgour River sequences. The first was the direction of the remanence within a large drag fold that is associated with a prominent fault in the upper Masterton Formation. The magnetisation was found to contain two stable components. One of these had an intermediate to high blocking temperature range with a fairly sharp cut-off at 400° to 450°C, and a direction that had not previously been observed in the Kilgour River sequences. The fold test indicated that this component is not of prefolding origin, and on the basis of its direction and blocking temperature characteristics it was interpreted to have been acquired as a result of frictional heating during faulting. On this assumption, the age of the regional block faulting was deduced to be either 500 or 750 m.y.

The second component has a high blocking temperature, and a direction similar to the remanence direction found in a weathered zone on the boundary between the Masterton and Mallapunyah Formations. This component lies close to the axial plane of the fold and consequently a sensitive fold test could not be applied. From field relationships it seems likely however that the weathered zone, and hence the magnetisation, predates the folding.

The second line of evidence is the variation of remanence directions within the Kilgour River sequence. These directions should change progressively up-sequence, unless late-stage magnetic overprinting has taken place, for example by Tertiary weathering or diagenesis. The results indicate a more or less progressive change, though several large and abrupt directional changes occur within the sequence. These are provisionally interpreted as major depositional breaks. Each abrupt change appears to coincide with a recessive unit, making it difficult to verify the depositional breaks in the field.

The evidence therefore tends to rule out late-stage magnetic overprinting of the remanence. Future measurements, in finer detail, on the existing collection of samples should define the time constraints for the remanence acquisition more closely.

The evidence that is now accumulating from the Kilgour River sequences points to a major error in the Australian middle Carpentarian pole path. A new path has been tentatively constructed, and will be confirmed and refined with additional measurements on the sample collection.

SUBSURFACE STRUCTURAL INVESTIGATIONS

During 1978-79, a geophysical profile was obtained across the southern McArthur Basin by integrated crustal seismic, magnetotelluric, and gravity surveys (Fig. D1). The aim of the surveys was to test the present geological model for the Batten Trough by obtaining information on the deep structure across the basin, particularly across the Emu Fault and across the poorly exposed area immediately to the east of the fault.

The emphasis during 1980 has been on interpretation and analysis of these data, and most of this work is entering its final stages. A major activity involved a preliminary attempt to integrate the analysis and interpretation of these data, for the BMR Symposium in April, 1980. Although this represented only a first attempt it has provided very significant constraints to the geological models which are possible (see SYNTHESIS), despite apparent disagreements which exist between the interpretations provided by individual methods.

SEISMIC SURVEYS (C.D.N. Collins, J. Pinchin)

Two long-range seismic refraction traverses were recorded during June-July, 1979, east and west of the Emu Fault (Fig. D1). Deep vertical reflection recordings were made at each of the six shot points, and at a site at Starvation Hill. Both traverses were about 300 km long, and each comprised 34 recording stations. The first traverse was between Daly Waters and H.Y.C. mine, along the Carpentaria Highway. Two large shots of 2000 kg each were located at Daly

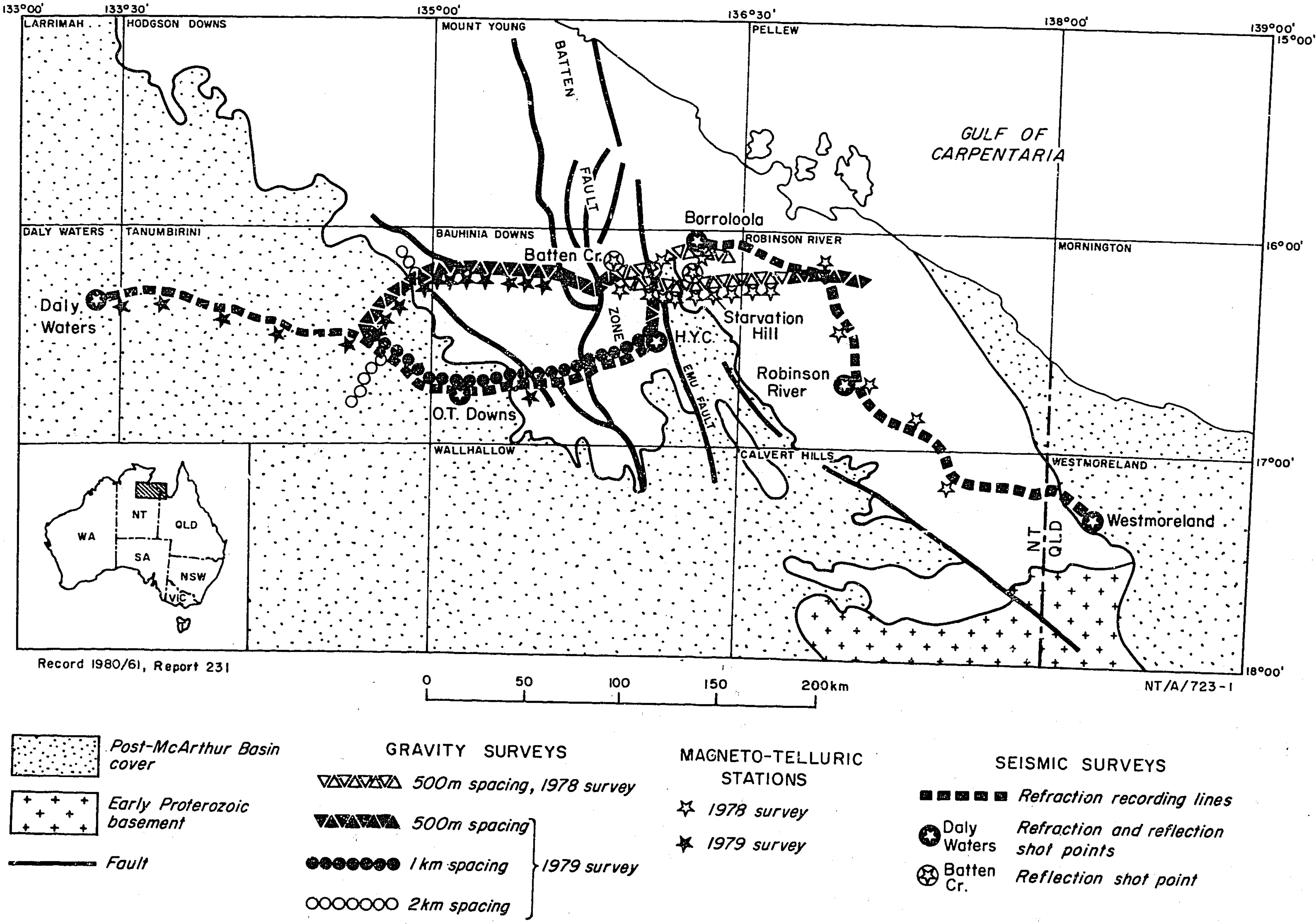


Fig. D1 Locality map, geophysical surveys, southern McArthur Basin, 1978-79, showing 1:250000 Sheet areas

Waters and H.Y.C. respectively. Two smaller shots of 400 kg each were fired at H.Y.C. and 100 km west of H.Y.C., near OT Downs. For the larger shots, the station spacing was about 15 km, while for the smaller shots, the spacing was about 5 km. A similar pattern was recorded along the second traverse, each of the Emu Fault, with large shots at Borroloola and Westmoreland, and smaller shots at Borroloola and Robinson River.

These data have now been processed and preliminary interpretations have been made. Analysis of refraction data is still proceeding.

Good vertical reflections were recorded at all sites except Daly Waters and OT Downs (see Record 1979/57). Reflections were recorded down to depths of about 45 km, and Moho reflections correlate well with the refraction data. A characteristic strong reflection band east of the fault correlates with a 6.39 km/s sub-basement refractor, and appears also to the west of the fault, near the H.Y.C. Mine, but is displaced upwards by 1.8 km (Record 1980/38). The basement appears to be 3.9 km deep west of the fault at H.Y.C., and 5.7 km deep east of the fault at Starvation Hill. From these reflection results and stratigraphic control provided by the McArthur Group to the west of the fault, the Tawallah Group is interpreted as thinning towards the Fault Zone.

The refraction data between Daly Waters and OT Downs show a wedge of low velocity (4.6 km/s) material, 4 km thick at Daly Waters, and pinching out just east of OT Downs (see Record 1980/38). This probably consists mainly of Cambrian rocks of the northern Georgina Basin, covered by thin Mesozoic sediments. Below this the refractor velocity is 5.6 km/s, and probably represents the Roper Group. Between H.Y.C. and OT Downs, the surface refractor velocity is 5.9 km/s. This high velocity is probably due to the known thick carbonates of the McArthur Group, and masks any deeper refractors.

The structure to the east of the Emu Fault is different. A 5.98 km/s refractor can be correlated with the reflection basement of the McArthur Basin succession. Below this a dipping 6.39 km/s refractor correlates with the strong vertical reflections, mentioned above.

There appear to be strong gradients in the lower crust, where the velocity increases from about 7.9 km/s to perhaps 8.3-8.4 km/s at the Moho. These high velocities are based on recordings made at the end stations of the long traverses, and are therefore not well defined. However, the lack of strong wide-angle reflections from the Moho requires the velocity gradients to occur over a broad zone. A maximum depth for this gradient zone of 55 km fits the data fairly well, but an extension of the recordings beyond 300 km is desirable to interpret the data properly.

MAGNETOTELLURICS (A.G. Spence, J.P. Cull)

During October-November 1979, all 17 sites which had been planned for the 1979 season were occupied. The northern line, recorded up to mid-October (Fig. D1), was designed to supplement gravity data, with the aim of determining the deep structure beneath the Bauhinia Shelf. Subsequent stations (not shown on Fig. D1) were occupied along the Carpentaria Highway to supplement regional seismic refraction surveys. The quality of data was generally acceptable, despite extreme weather conditions, although three of the sites were affected by thunderstorm activity. Comprehensive results are not yet available. Final inversions and interpretation will be carried out after the data have been screened for systematic errors. Processing will be completed in 1981 and the results integrated and interpreted along with the 1978 data.

During 1980, the data from the 1978 survey (see Annual Summary, 1979) were re-evaluated and reinterpreted. Qualitative examination of the data conclusively demonstrates a totally different resistivity structure to the east and west of the Emu Fault. These differences have been quantitatively detailed by further 2-D modelling (see Record 1980/38), designed to: 1) test the susceptibility of the models to different starting assumptions: 2) extend the models to greater depth, and eliminate some anomalies from earlier models (see Record 1979/57).

The different starting models did produce differences in detail in the model, but they did not alter the principal conclusions of the earlier model (see Record 1979/57), or of the qualitative assessment of the data.

To the east of the Emu Fault, the further modelling has confirmed a conductive sequence about 4.5 km thick, clearly representing the Tawallah Group, above a resistive basement. There is no indication of any significant body of resistive rocks that may correlate with the McArthur Group.

To the west of the Emu Fault, a layered sequence of highly resistive rocks about 4.5 km thick is confirmed at the top of the sequence, overlying a conductive unit. However, this conductive layer is now shown to be about 4 km thick and to overlie a resistive basement. The upper resistive rocks clearly correlate with thick carbonates of the McArthur Group, which crop out at the surface, and the conductive layer beneath correlates with the Tawallah Group.

The M-T modelling is clearly in agreement with the Batten Trough model as predicted from geological evidence.

GRAVITY (W. Anfiloff, R. Tracey)

During July-August, 1980 detailed gravity traverses were extended westwards along the Carpentaria Highway to Daly Waters, southwards along the Stuart Highway to Newcastle Waters, along part of the Buchanan Highway, and along the Beetaloo Road. The data have yet to be processed.

Interpretation of the 1978-79 surveys (Fig. D1) has been completed, and a BMR Record is being finalized. The data have produced a good qualitative picture of broad structure across the southern McArthur Basin, and have also delineated many of the local structures.

The main structural forms delineated are broad undulations in the basement, and the basement gradually deepens westwards from Robinson River to Tanumbirini. No major faults are identified in the eastern part of the survey area, including the Emu Fault. Major faults are identified over a wide zone to the west of the Emu Fault, but the anomalies do not exceed 15 mGal, and are not sufficiently distinctive to provide an accurate indication of basement depth. Some of the fault displacements are known to be of the order of kilometres, so the density contrast across the basement is unlikely to be greater than 0.1 g/cm^3. Considerable uncertainty remains with respect to formation densities, in the absence of suitable calibration by either a deep drill hole or seismic reflection data.

The Emu Fault appears to be the locus of only minor upfaulting, which in some areas may have elevated dense mineralised layers. Major displacements are not apparent from the gravity data, suggesting that the mineralisation may therefore have occurred in a tectonically inactive area.

SYNTHESIS (K.A. Plumb)

The presently available data provide some very specific constraints:

1) both seismic and magnetotelluric data indicate a major, deep-seated discontinuity at the Emu Fault;
2) both seismic and magnetotelluric data indicate a thick sequence of McArthur Group to the west of the Emu Fault (in agreement with the geology), while the Tawallah Group is indicated as being the principal sequence to the east, with no indication of any appreciable thickness of McArthur Group;

3) gravity indicates that there is little or no aggregate mass difference across the Emu Fault. This implies (but does not prove) a lack of any significant structural displacement or change in stratigraphy at the fault.

Figures D2.1 and D2.2, taken from the BMR Symposium lecture, illustrate alternative cross-sections which may be constructed across the Emu Fault (EF). The depths of the stratigraphic units were defined by alternative selections of seismic reflections and magnetotelluric soundings as at April, 1980, and by interpretation of surface geology. The density contrasts used in the gravity modelling were derived by analysis of reasonably well known structures in the Batten Fault Zone. However, subsequent analysis (see GRAVITY) has indicated that the particular density contrasts selected may be wrong, although better figures are still not available. Similarly, further 1-D magnetotelluric modelling and detailed seismic refraction analysis are proceeding, which may further modify the sections.

Despite these probable modifications to the models, the variations are expected to be limited and certain conclusions may be derived at this stage:

1) the combined geophysical and geological data can definitely be combined into a single compatible interpretation;
2) the combined data constrain possible geological models within definite limits, and will probably continue to do so;
3) the present integrated model clearly favours the geologically predicted model for the form of the Batten Trough.

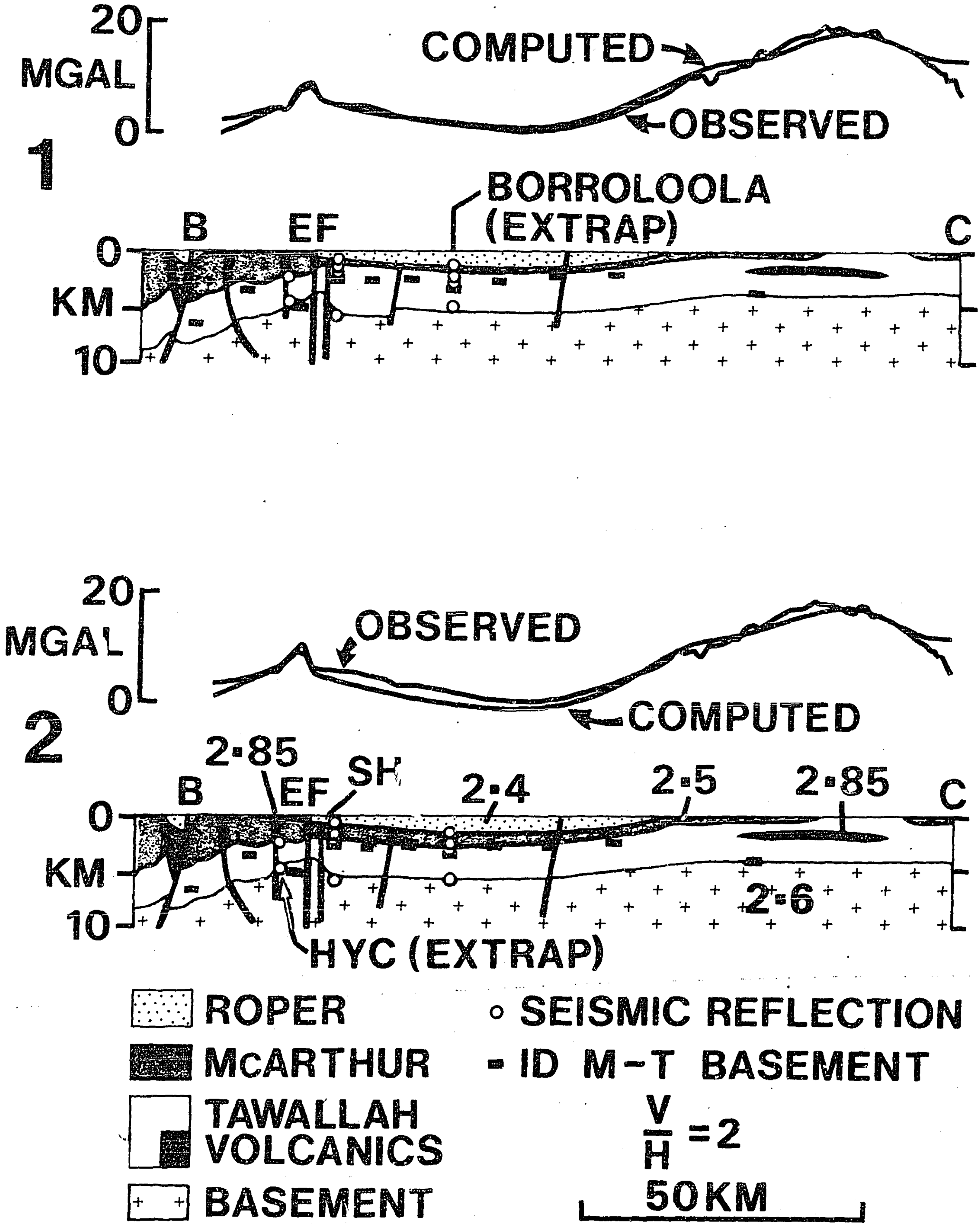


Fig. D2 Integrated structural section across Emu Fault, from combined preliminary geophysical and geological data (from BMR Symposiom 1980)

GEORGINA BASIN PROJECT

Compiled by
C.J. Simpson (Acting Project Co-ordinator)

STAFF: The following personnel (listed alphabetically) have contributed to the multidisciplinary project during 1980:
P.E. Balfe (GSQ), J.J. Draper (GSQ), E.C. Druce (Dept Trade & Resources), P. Duff, R.A. Fortey (British Museum), D. Gibson, P.M. Green (GSQ), P.L. Harrison (Alliance Oil Development), K.A. Heighway, A. Hutton (Wollongong Uni.), K.S. Jackson, P.J. Jones, P.D. Kruse (Sydney Uni.), I.N. Krylov (Geological Institute, Moscow), K.G. McKenzie (Riverina C.A.E.), M.D. Muir (CRA Exploration), R.S. Nicoll, W.V. Preiss (GSSA), B.M. Radke, J.E. Rees, J.H. Shergold, C.J. Simpson, P.N. Southgate (ANU), S. Turner (Queensland Museum), M.R. Walter, P. West (ANU).

GENERAL

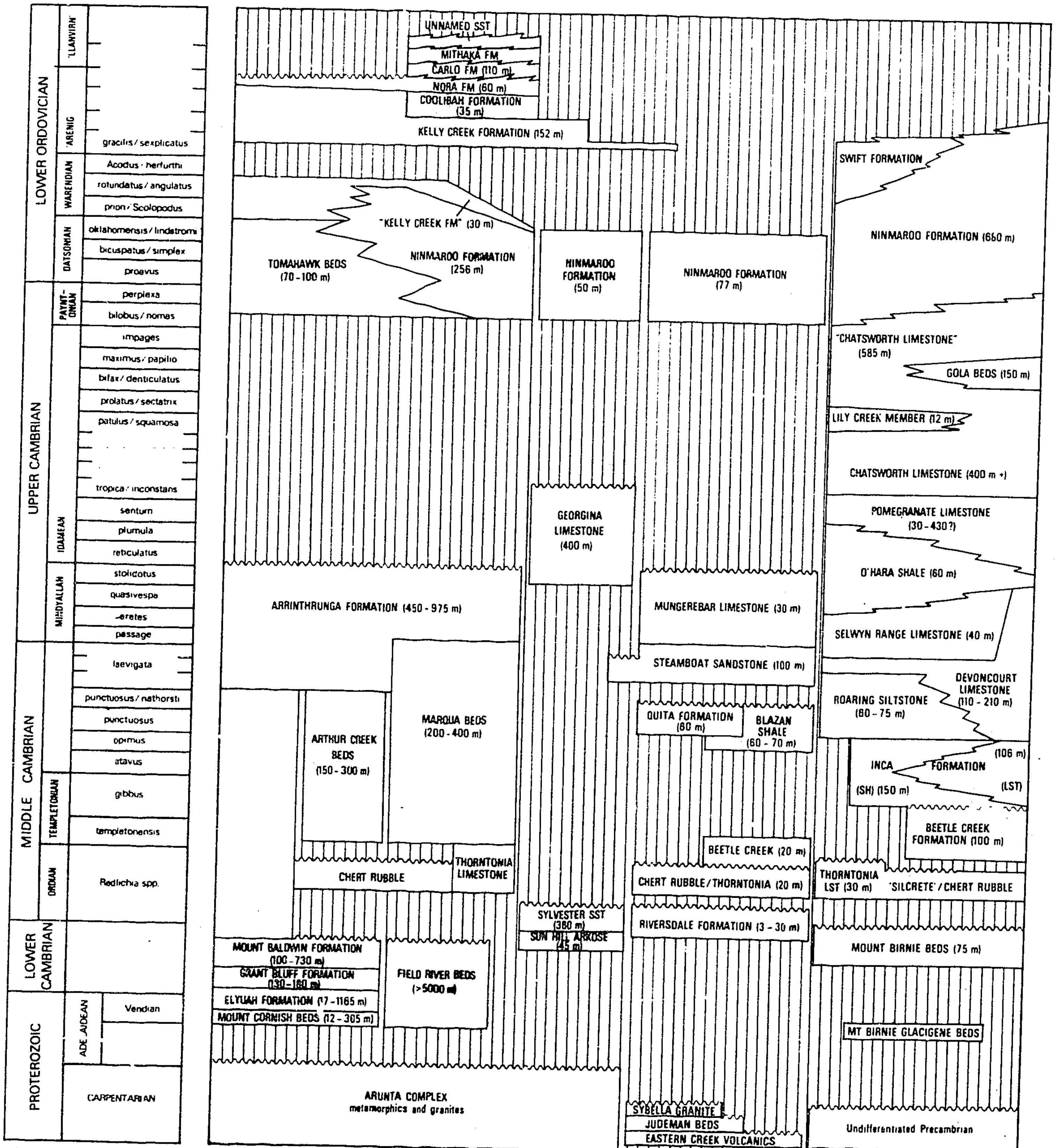
The Georgina Basin Project was initiated in 1974 as a pilot study for multidisciplinary projects in BMR, and was programmed to run for five years. During 1979/80, emphasis has been laid on completing the publication of results hitherto gathered during field-orientated geological and geophysical activities in the basin. These activities have laid the framework for a series of more specific studies that have been proposed for a second phase of research in the basin.

During the last 12 months, 23 papers and 3 x 1:100 000 scale maps relating to the Georgina Basin were released, bringing the total papers produced since 1974 to 75, and 1:100 000 scale maps to 5. A review paper summarising the activities and achievements of the project for the period 1974-79 was produced by J.H. Shergold and issued as BMR Record 1980/34.

STRATIGRAPHY AND SEDIMENTOLOGY

Correlation of rock units in the southern part of the Georgina Basin is shown in figure D3.

The Ethabuka Sandstone (shown as 'Unnamed SST' in Fig. D3) is a recently recognised Ordovician unit in the Georgina Basin. Sublabile to quartzose sandstone with minor mudstone, siltstone, and pebbly beds crop out along the inner margin of the Toko Syncline and are intersected in the subsurface in AOD Ethabuka No. 1. It is a marine unit containing trilobites,



Record 1980/61, 1980/70, Report 231

AUS1/699-1

Fig. D3: Correlation of rock units in the southern part of the Georgina Basin nautiloids, pelecypods, gastropods, and brachiopods. Numerous inorganic and biogenic sedimentary structures are present. A conformable relationship exists with the underlying Mithaka Formation and the unit is overlain unconformably by either Devonian or Mesozoic rocks. The lowermost part of the unit is transgressive; this is apparently followed by progradation so it is possible that much of the upper part of the unit is non-marine. Since the Ethabuka Sandstone is lithologically similar to the Nora Formation, Carlo Sandstone, and Mithaka Formation, it has been included with them in a redefined Toko Group from which the Coolibah Formation has been excluded.

The inclusion of the Ethabuka Sandstone in the Toko Group is based on lithological similarities with the underlying units, and on historical grounds.

The removal of the Coolibah Formation from the Toko Group is based on lithological grounds. The Coolibah Formation is dominantly a carbonate unit with the carbonates generally being fine-grained and of algal origin. On the other hand, the Nora Formation and the overlying units are siliciclastic rocks except for some skeletal limestones in the Nora Formation, which is transgressive on the Coolibah Formation. It is therefore considered that the Coolibah Formation does not have sufficient lithological features in common with the Nora Formation and overlying units to warrant its inclusion in the Toko Group (J.J. Draper).

Between July and November 1977, the Queensland Department of Mines drilled two deep stratigraphic bores (GSQ Mount Whelan 1 and 2) in the Mount Whelan 1:250 000 Sheet area. The two holes provided a cored section through the southeastern Georgina Basin sequence, on the eastern flank of the Toko Syncline. Overlap between the two holes was not obtained and, as a result, the section from the upper Georgina Limestone to the lower Ninmaroo Formation was not cored. With this exception, a complete and virtually fully-cored section was obtained from the Carlo Sandstone (Lower to Middle Ordovician) to Proterozoic granitic basement.

Gamma-ray log correlations between GSQ Mount Whelan 1 and 2, and the petroleum exploration wells PAP Netting Fence 1 and AOD Ethabuka 1, were carried out during 1980.

The Nora Formation thickens from 114 m in PAP Netting Fence 1 to 323 m in AOD Ethabuka 1 and 235 m in GSQ Mount Whelan 2. A similar trend of increasing thickness from north to south has been noted by Draper for the Carlo Sandstone. A sharp increase in gamma-ray response over the lower part of the Nora Formation allows correlation between PAP Netting Fence 1 and GSQ Mount Whelan 2. In both of these wells, a limestone interval occurs near the base of the formation.

The Coolibah Formation is a readily identifiable unit throughout the area, but its thickness varies irregularly, ranging from a minimum of 28 m in GSQ Mount Whelan 2 to a maximum of approximately 80 m in AOD Ethabuka 1.

The Kelly Creek Formation thickens markedly from 110 m in PAP Netting Fence 1 to 241 m in GSQ Mount Whelan 2, and shows some facies variations. In GSQ Mount Whelan 2, an interval of dolomitic, pelletal sandstone forms the uppermost part of the Kelly Creek Formation. This upper unit is not developed in PAP Netting Fence 1, where the bulk of the formation comprises dolostone, which is equivalent to the dolostone of the middle-unit in GSQ Mount Whelan 2. In AOD Ethabuka 1, a very thin sandstone sequence overlies dolostone and forms the top of the formation. The lowermost of the three subunits in GSQ Mount Whelan 2 is a sequence of sandstone and limestone with subsidiary dolomite, which is transitional in character with the upper Ninmaroo Formation. A similar sequence forms the basal part of the Kelly Creek Formation in PAP Netting Fence 1. The basal part of the Kelly Creek Formation was not drilled in AOD Ethabuka 1.

A sharp break in the gamma-ray log near the top of the Ninmaroo Formation is present in both GSQ Mount Whelan 2 and PAP Netting Fence 1. In each hole, interbedded sandstone and limestone with variable dolomite content forms the upper part of the unit. The clastic content of the unit decreases downward in both holes. The base of the Ninmaroo Formation was not intersected in GSQ Mount Whelan 2, but a number of correlatable gamma-ray log events indicate that relative rates of deposition between PAP Netting Fence 1 and GSQ Mount Whelan 2 were fairly uniform. From this information, it may be deduced that the base of the Ninmaroo Formation would lie at about 1 050 m at GSQ Mount Whelan 2.

In PAP Netting Fence 1, the lithostratigraphic nomenclature of the Cambrian section has not been firmly established, with various workers applying different subdivisions. Draper & others (1978) recognised the sequence above the Thorntonia Limestone as Marqua Beds and overlying Arrinthrunga Formation. Harrison (Journal of the Australian Petroleum Exploration Association, 1979, p. 30-42) subdivided the Arrinthrunga Formation in PAP Netting Fence 1 into the Steamboat Sandstone and overlying Georgina Limestone. In GSQ Mount Whelan 1, the Georgina Limestone section intersected is equivalent in age to virtually the entire post-Thorntonia Limestone pre-Ninmaroo Formation section in PAP Netting Fence 1. This assessment is based on the presence of fossil assemblages of the Glyptagnostus reticulatus Zone at 195.0 m near the middle of the Georgina Limestone in GSQ Mount Whelan 1, and the probable occurrence of a similar fauna at 1 497 m in PAP Netting Fence 1 near the base of the Arrinthrunga Formation.

Assemblages from near the base of the Georgina Limestone in GSQ Mount Whelan 1 and from near the base of the Marqua Beds in PAP Netting Fence 1 are of similar age. It seems, therefore, that the section in PAP Netting Fence 1 is fully represented by a thinner, deeper-water facies equivalent in GSQ Mount Whelan 1. The sandy middle portion (Steamboat Sandstone) of the PAP Netting Fence 1 section, which may represent deposition in beach shoal or barrier-bar environments, is not developed in GSQ Mount Whelan 1.

The interval with high gamma-ray response below the Georgina Limestone in GSQ Mount Whelan 1, the Inca Formation correlative, is not obviously developed in PAP Netting Fence 1. There is, however, an increase in the gamma-ray response over the basal part of the Marqua Beds.

The Thorntonia Limestone is a prominent low feature on the gamma-ray logs of both holes. The underlying units in GSQ Mount Whelan 1 are not developed in PAP Netting Fence 1, where the Thorntonia Limestone directly overlies granitic basement (P.M. Green and P.E. Balfe).

Phosphatic hardgrounds have been found within the Thorntonia Limestone near Riversleigh, Thorntonia, and D-Tree in the Undilla area, and at Rogers Ridge in the Burke River Structural Belt. A similar, non-dolomitised, phosphatic hardground sequence is present in the Currant Bush Limestone (Ptychagnostus atavus age) 3 km south of Thorntonia.

In the Riversleigh area west of the Gregory River, cauliflower chert nodules occur within the Thorntonia Limestone approximately 24 m above the Precambrian/Cambrian unconformity. The nodules are in a recrystallised dolomite 2 m thick, and are interpreted as pseudomorphs after anhydrite nodules. The nodules have a relict lath fabric and abundant $CaSO_4$ inclusions indicative of a primary anhydrite precursor. Phosphatic hardgrounds both underlie and overlie the anhydrite nodules which according to D.J. Shearman (Imperial College, personal communication, 1979) indicate subaerial sabkha diagenesis. Further evidence of either subaerial exposure or semi-emergent conditions was not observed because primary sedimentary structures have been obliterated by dolomitisation, recrystallisation, and stylolitisation. Lateral tracing of this unit during the 1980 field season provided further evidence of emergent and semi-emergent conditions in areas of reduced diagenetic overprinting (P. Southgate).

Recent investigations suggest that the intraformational conglomerates present in the Georgina Limestone were formed by the reworking of early lithification nodules within the sediment. An alternative explanation for the formation of the nodules is that they resulted from tectonic stress of the limestone. The features likely to form by this process include microstylolite swarms, pervasive solution dolomitisation, and stylolites. It is considered that the relationship exhibited by the nodules to the surrounding sediments can result from early lithification processes with subsequent modification by tectonic stress (P.M. Green).

The diagenetic history of the Cambro-Ordovician Ninmaroo Formation has been delineated using optical and cathodoluminescent petrographic techniques.

Diagenetic phases are:

1) eogenetic phase characterised by early aragonitic cementation, variable but generally minor dolomitisation, and emplacement of evaporitic sulphates;
2) early telogenetic phase established during subaerial emergence with significant dissolution of sulphides and some aragonitic carbonate, with partial silicification of remnant sulphates;
3) mesogenetic phase with burial, with continued silicification, extensive dolomitisation followed by later contemporaneous hydrocarbon migration, saddle dolomite and minor sulphide (pyrite, galena, sphalerite) emplacement; calcite, fluorite, barite, and anhydrite precipitation; pressure solution continued and accelerated towards the end of this phase;
4) late telogenetic phase is characterised by extensive dedolomitisation, the dissolution of late mesogenetic sulphate, carbonate dissolution to form cavern porosity, and additional silicification.

The late telogenetic phase was the most prolonged in most areas except the central Toko Syncline and deeper structures in the Burke River Structural Belt. Commonly, mesogenetic events were intermittent with this phase where deeper and warmer connate waters rose escaping through this near-surface telogenetic porosity (B.M. Radke).

PALAEONTOLOGY

Palaeontological studies continued throughout the year. Bulletin 186 by J.H. Shergold, on the Late Cambrian trilobites from the Chatsworth Limestone, was published, as were papers on: Early Ordovician ichnofossil from the Mithaka Formation (J. Draper, 1980)[7], new taxa, palaeobiography, and biological affinities of Middle Cambrian Bradoriida (Crustacea) (P.J. Jones & K.G. McKenzie, 1980)[8], Middle Cambrian Bradoriida (Ostracoda) (K.G. McKenzie & P.J. Jones, 1979)[9], and discussion on the archaeocyatha of the Georgina and Amadeus basins (P. Kruse & P. West, 1980)[10].

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[7] BMR Journal of Australian Geology & Geophysics, 5(1), 57-61.

[8] Alcheringa, 4(3), 203-225.

[9] Search, 10(12), 444-445.

[10] BMR Journal of Australian Geology & Geophysics, 5(3), 165-181.

GEOCHEMISTRY

Petroleum source rock studies

Petroleum source rock investigations continued during the year. Follow-up drilling was carried out in three holes in the Camooweal, Duchess, and Tobermory areas. The first two holes were aimed at assessing the distribution of the oil shale detected within the Inca Shale intercepted in Mt Isa No. 1 (near Camooweal) in 1978. Though organic matter and hydrocarbons were detected in the 1980 drilling, no true oil shales were recorded.

Petrographic and alginite content evaluation were undertaken on the oil shale from Mt Isa No. 1. The lamellar alginite in the oil shale from Mount Isa No. 1 is similar to the lamellar alginite of Tertiary age from Rundle, Queensland (termed alginite B by Hutton & others, 1980)[11] and was probably derived from green or blue-green algae. There is, however, a much higher percentage of humic-related macerals in the Mount Isa No. 1 oil shale than in the Rundle oil shale. The origin of this humic-related organic matter is not known. Although it resembles vitrinite in higher rank coals it cannot be derived from higher plant matter since it is of too great an age (early Palaeozoic or older). The percentage of alginite B is lower than would be expected for an oil shale which is stated to yield 81 litres per tonne. Oil shales with a similar yield from Rundle have approximately 25% by volume alginite B. This apparent anomaly between yield and alginite content could result from one of three factors -

1. Alginite B from Mount Isa No. 1 may yield more shale oil per unit volume than alginite B from Rundle.

2. The sample examined may have a lower alginite content than the sample assayed.

3. The vitrinite-like material has affinities with bituminite, and may yield more oil than vitrinite derived from higher plant matter.

There is insufficient evidence to ascertain the environment of deposition of the Mount Isa oil shale. However, the presence of pyrite indicates a reducing environment during or after diagenesis. Further studies are needed to determine vertical variations, if any, within the oil shale seam (A. Hutton).

In GSQ Mount Whelan 1 and 2, weak indications of solid and gaseous hydrocarbons were recorded. Solid bituminous hydrocarbons were noted, filling pore space in limestone of the Coolibah Formation in GSQ Mount Whelan 2. In

[11] Journal of the Australian Petroleum Exploration Association, 20(1), 44-67.

view of the similar occurrences in AOD Ethabuka 1 and PAP Netting Fence 1, the interval including the lower Nora Formation and the Coolibah Formation is considered to be the most prospective for heavy hydrocarbons.

The average organic carbon contents of the Georgina Limestone (0.54 percent based on 34 analyses) and the Thorntonia Limestone (0.44 percent based on 3 analyses) compare favourably with the organic carbon values of 0.47 percent of petroliferous (0.16 percent for non-petroliferous) carbonate provinces of the Russian Platform. The worldwide average organic carbon content for limestones is 0.20 percent. However, the good source potential of these limestones may be downgraded by their evident lack of permeability. Although the generation of gaseous hydrocarbons from such sources seems possible, it is doubtful whether significant liquid hydrocarbon accumulations will be found (P.M. Green and P.E. Balfe).

Elemental analysis of extracted kerogens from Mount Whelan No. 1 cores are considered of dubious value because of high ash content which seems related to a high S content. This relationship has not yet been explained. Gas chromatography of saturated hydrocarbon fractions shows no evidence of thermal immaturity. In conjunction with vitrinite reflectance data from the Australian Mineral Development Laboratories (AMDEL), it indicates that both Cambrian and Ordovician rocks are mature, with a likelihood of overmaturity in the Middle Cambrian Thorntonia Limestone (K.S. Jackson, BMR).

The extensive dolostone unit of the Lower Ordovician Kelly Creek Formation in the Toko Syncline has variable porosity and permeability, and significant potential as a hydrocarbon reservoir. The porous dolostone intersected in GSQ Mount Whelan No. 2 is 107 metres thick. Measured porosities from the unit averaged 11%, while averaged horizontal permeability (gas) was 234 md, and vertical permeability (gas) 28 md. Permeability is more variable vertically, being generally low but with randomly distributed higher values. Porosity is dominantly intercrystalline in mottled and stratified distribution, with associated vug, channel, fracture, and breccia types. The porosity developed late in diagenesis, during and after pervasive dolomitisation of the sequence. The sequence contains live 'hydrocarbons' indicating migration after late dolomitisation. Fluorescence intensity and colour of acritarchs in some samples suggests that the Lower and middle Ordovician section is oil-mature. This confirms similar conclusions drawn from reflectance data in the same sequence. The traces of liquid hydrocarbons in the dolostone, and previously reported gas flows from the overlying sandstone in AOD Ethabuka No. 1, indicate significant potential for these porous units as a reservoir in suitable structural traps (B.M. Radke).

Base metals

Geochemical analyses from GSQ Mount Whelan 2 show that one sample from the basal part of the Thorntonia Limestone contains strongly anomalous concentrations of lead (1,100 ppm) and zinc (780 ppm). Crystalline sphalerite was noted in the Ninmaroo Formation, in the lower and middle units of the Kelly Creek Formation, and in the limeston it of the Nora Formation. Both the Ninmaroo and the Kelly Creek Form s may have been suitable host rocks for Mississippi Valley type lead-zinc mineralisation (P.M. Green and P.E. Balfe).

MAPS

During the year, the 1:100 000 preliminary geological maps of Mount Whelan (produced by GSQ), Toko, and Abudda Lakes (produced by BMR) were published. These, together with the previously published southern Burke River Structural Belt, and Adam Special, completed the five 1:100 000 map sheets proposed in the first phase. It is anticipated that the above sheets, with some additional data from Mount Barrington Sheet area, will be reduced and compiled into a 1:250 000 special sheet.

GLENORMISTON AEROMAGNETIC INTERPRETATION

Study of the detailed aeromagnetic data flown by BMR in 1977 in the Glenormiston area continued as time permitted during the year. Further data processing was completed to enhance magnetic features and to prepare data for release through the Government Printer.

Interpretation to date has assumed a simple model with Palaeozoic (with or without Adelaidean) sediments overlying pre-Palaeozoic (?Arunta-type) basement in the west with shallower Mount Isa-type rocks as basement in the east.

Northerly-trending magnetic features in the centre and east of the area exhibit a high degree of correlation with trends in the Mount Isa block, and probably correspond to susceptibility contrasts within the basement. Some fold structures are also evident.

Less obvious northwesterly magnetic trends in the centre and west of the area are probably caused by basement faulting. There is no evidence from the magnetics to confirm a significant susceptibility contrast between basement rocks in the east and those in the west of the area.

Magnetic modelling has suggested a susceptibility contrast of 0.001 - 0.003 (SI units) between basement and sediments with thicknesses of 300 - 400 m in the northwest and central areas, 100 - 200 m in the northeast, and 200 - 100 m in the southwest. Contacts dip fairly steeply to the west. The stronger magnetic anomalies in the northwest and southwest of the area may be caused by granite intrusions and/or local basement relief.

Palaeozoic sediments thicken in the centre and south of the area, and a closed ?basin structure in the centre is defined by stronger N-S trends truncated to the north and south by north-west faulting (J. Rees).

CENTRAL EROMANGA BASIN PROJECT

Compiled by

F.J. Moss, Project Co-ordinator

Regional, multidisciplinary, geoscientific investigations in the Central Eromanga Basin area (Fig. CEB 1), which were outlined in BMR Record 1980/32 by P.L. Harrison & others, commenced early in 1980. The main objective of the project is to determine the petroleum resource potential of the area, and assist in efficient and comprehensive petroleum exploration.

Information is being obtained on the regional structural, and depositional and thermal histories of the area from 24° to 29°S and from 141° to 147°E. The principal area where surveys and studies were concentrated in 1980 is from 25° to 27°S and from 141° to 144°E, lying mainly west of the Canaway Fault.

During the period January to June 1980 the main activities were: review of existing geoscientific information; background research into techniques applicable to studies of the area; and preparation for surveys west of the Canaway Fault. These activities are described in BMR Record 1980/60 by F.J. Moss (Co-ordinator). The following contributions provide more details on the work undertaken, particularly in the July to December period.

The processing, analysis, and interpretation of the data are at an early stage, and further work will be required to assist in determining the petroleum prospects of the area.

Petroleum source rock studies (B.R. Senior)

The maturity and petroleum source rock potential of the Eromanga Basin sequence was reported by Senior & Habermehl (1980) in BMR Journal (Vol. 5). This work demonstrated that most of the Jurassic, and some of the deeply buried

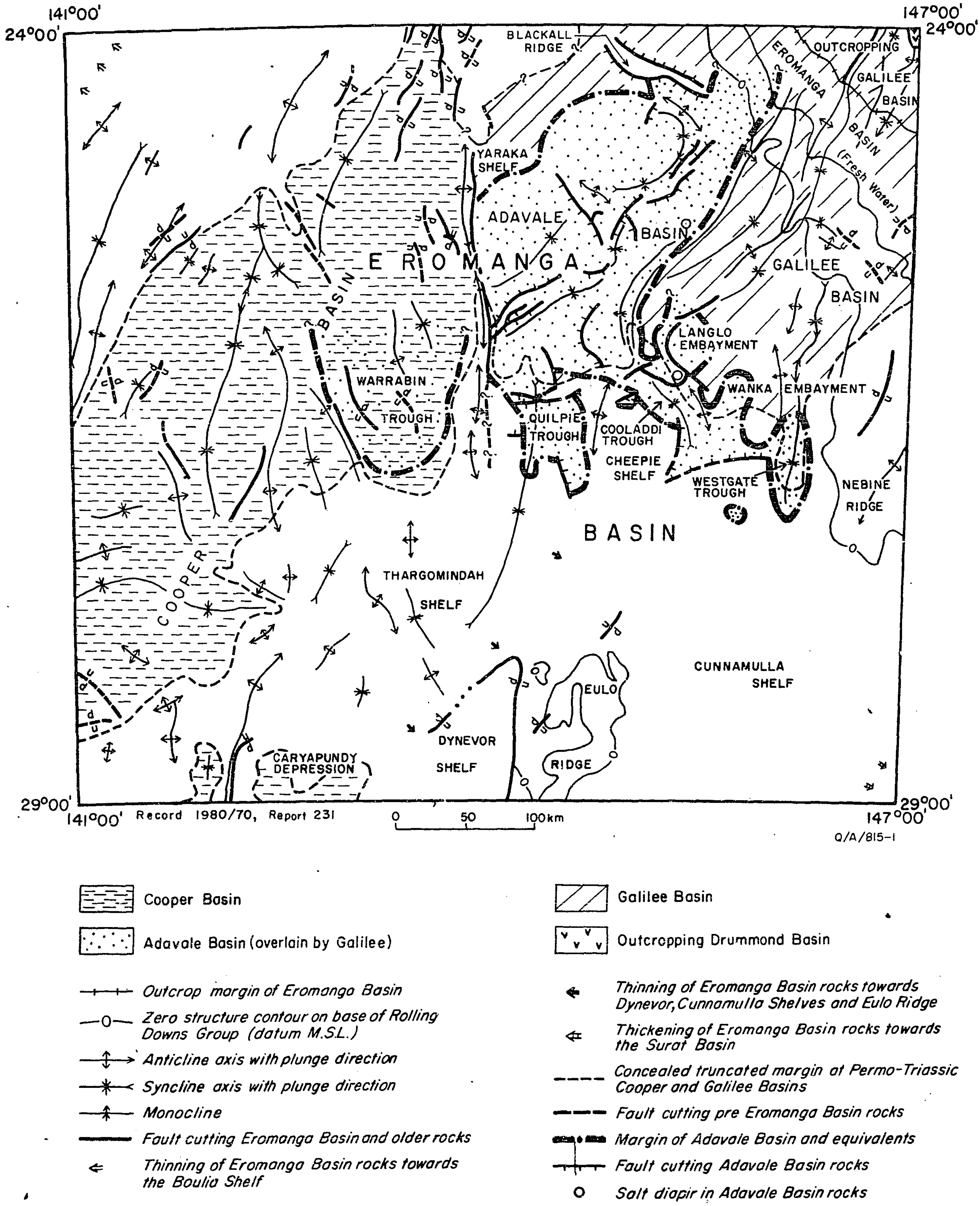


Fig CEB 1 Central Eromanga Basin Project.
Structure sketch map (from Senior and others, 1978)

Cretaceous rocks, have generated hydrocarbons from relatively abundant source rocks. These studies were expanded during the year to evaluate critical sections within individual petroleum exploration wells. Drill cuttings were selected at 10-m intervals from Galway 1, Bodalla 1, and Durham Downs 1, and are being analysed using the 'Rock Eval' pyrolysis technique. Results are not yet available, but visual examination indicates good source rocks in the Thomson Syncline area due to the presence of dark organic lutites in the Jurassic sequence in Galway 1.

Hydrogeology (M.A. Habermehl)

Part of the aim of the Central Eromanga Basin Project is to review the hydrogeological data of the multi-layered confined aquifer system in the area, and assess the results of the mathematical, computer-based model used to simulate the groundwater hydrodynamics in the Great Artesian Basin (Fig. CEB2).

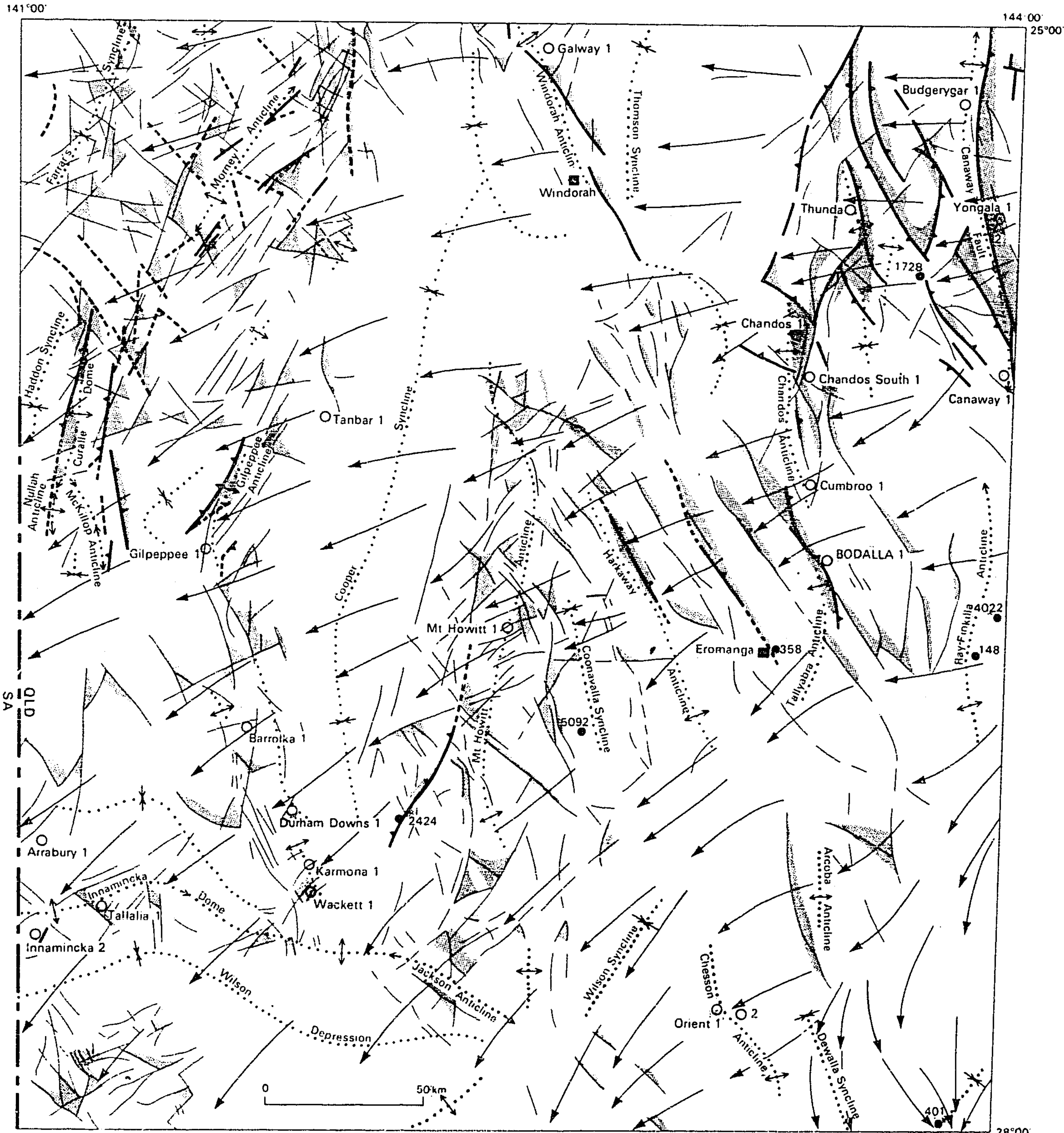
Isotope hydrology and hydrochemistry studies are part of the investigations; these provide information complementary to data obtained by conventional hydrological techniques, and also provide an independent check on derived hydraulic data. Additional information on rates of flow, flow patterns, and the possible transport of minerals and hydrocarbons is obtained.

As part of the hydrochemical study, forty-eight flowing artesian waterwells on fourteen 1:250 000 map sheets, located between 24° and 29°S, and 140° and 145°E, were sampled during a field trip in September 1980. All wells were sampled for chemical analyses and possible hydrocarbon content of the artesian groundwater; six selected wells were sampled with specially designed sampling tubes to obtain sealed throughflow grab samples, and ten selected wells were sampled for environmental isotope analyses ($\Delta^{13}C/^{12}C$), the analyses to be carried out by the Australian Atomic Energy Commission (AAEC).

Results from the analyses of the samples taken might assist in the studies of possible hydrocarbon migration and stagnation near structural and stratigraphic traps in the area west of the Canaway Fault, and define the hydrodynamic and hydrochemical character of the area. The results could also lead to further research and/or development of methods to aid hydrocarbon exploration.

Lithology studies (V. Passmore, W.Z. Hessler)

Little lithological work was undertaken owing to previous commitments of the geological staff. A lithological correlation north-south cross-section across the Warrabin Trough was prepared to show facies changes and formation



Record 1980/70, Report 231 AUS1/991-1

Typical regional groundwater flow-path (local disturbances due to faults not shown)

Area of possible groundwater stagnation

Anticline (showing plunge, concealed)

Syncline (showing plunge, concealed)

Fault determined by seismic surveys and/or geological reconnaissance (downthrown side indicated)

Inferred fault determined by seismic surveys and/or geological reconnaissance

Landsat interpreted linear features

Petroleum exploration well

Waterwell with registered number (QWRC) Queensland Water Resources Commission

Town

Fig CEB 2 Central Eromanga Basin Project. Regional groundwater flow in the Great Artesian Basin (from Senior and Habermehl, 1980) thickness as a guide to recognising seismic reflectors west of the Canaway Ridge. Two other cross-sections are planned through wells in the northern Cooper Basin.

Identification of seismic reflectors and interpretation of environments of deposition for the 1980 BMR seismic results is in progress.

Seismic reflection studies (J. Pinchin, A.R. Fraser, S.P. Mathur, P.L. Harrison (Alliance Oil Development), B.R. Senior (Geol. Branch), K. Wake-Dyster, M.J. Sexton, D. Pfister, F.J. Moss)

A brief selective review of existing seismic data was made to assist in planning the 1980 BMR seismic survey in the area west of the Canaway Fault. Good-quality seismic cross-sections were used, ties were made to wells in the southwest of the survey area, and interpretative line sketches were drawn along key sections. Seismic reflection traverses recorded by BMR in the area during the period July-November are shown in Figure CEB3.

The data currently being processed indicate generally high quality sections. Traverse 1 is the only section presently available for interpretation (Fig. CEB4). This traverse crosses the Warrabin Trough and indicates 3000 m of Devonian sedimentary rocks in a fault-bounded trough below the Cooper Basin sequence. The Warrabin Trough had been recognised on previous seismic sections, but little detail was available on its nature and likely stratigraphy. Traverse 1 shows a previously unknown eastern shoreline to this Trough; this raises questions of the palaeogeography of the area in Devonian times, the likely connection to the Adavale Basin, and the possibility of marginal marine, reefal or deltaic facies providing targets for petroleum exploration.

An interpretation of the seismic stratigraphy along Traverse 1 also reveals the onlap edge of the Permian coal measures, and planar cross-bedding within the Triassic Nappameri Formation, which could indicate a high energy sandy facies within this unit. This could also provide an attractive petroleum exploration target.

Several seismic sections from previous surveys have been reprocessed. The data were transcribed from analogue to digital form at BMR and sent to a contractor for processing. All sections have shown considerable improvement, and more will be treated in this way.

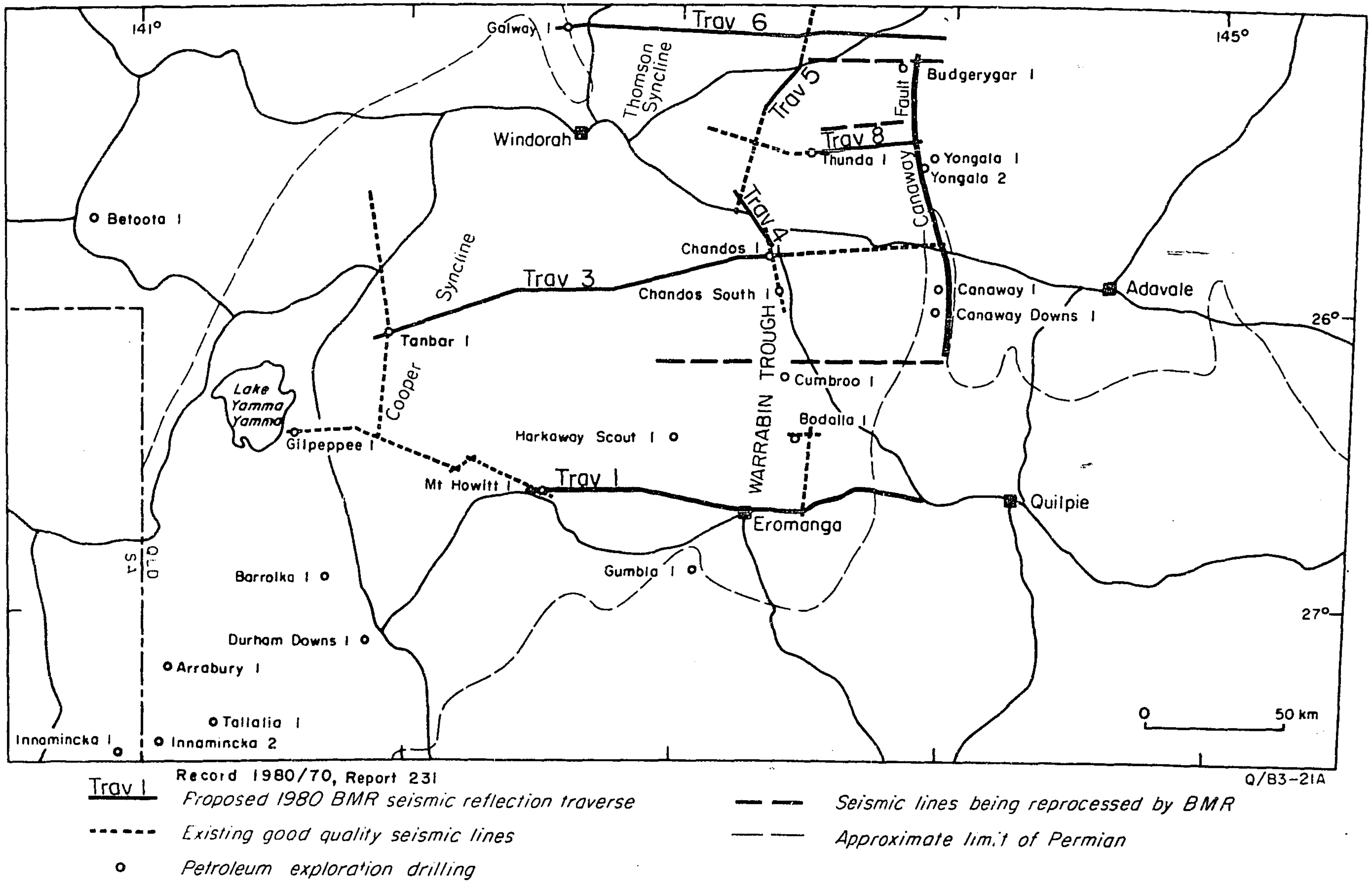


Fig CEB 3 Central Eromanga Basin Project. Seismic reflection and gravity traverses 1980

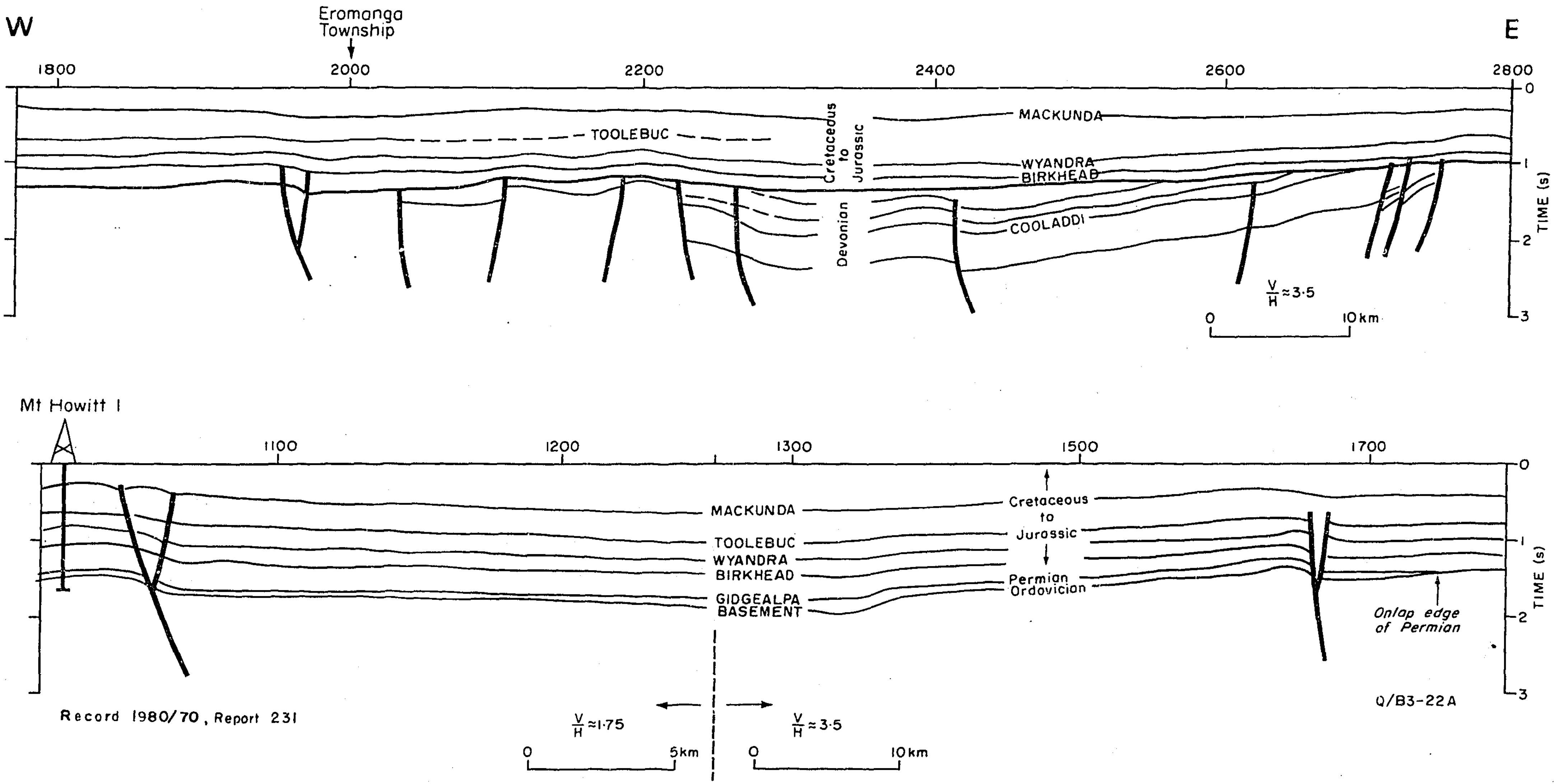


Fig CEB 4 Central Eromanga Basin Project
Sketch of seismic section for traverse I

The regional traverses recorded by BMR in 1980 will enable some of the earlier subsidised seismic lines to be reinterpreted. A computerised data bank of shot-point locations has been produced, and interpreted seismic horizons will be digitised to enable computer plotting of regional structure and isopach maps.

Wide-angle reflection recordings, made along Traverse 1 in conjunction with refraction recordings, are being analysed to provide vertical velocity information in the crust. The vertical reflection recordings made to 20 s on all traverses will be analysed to assist in determining the deep crustal structure of the area.

Gravity investigations (W. Anfiloff, K.L. Lockwood)

Bouguer gravity anomaly contour maps were produced for the area west of the Canaway Fault, covering the Canterbury, Windorah, Barrolka, and Eromanga 1:250 000 map sheets (Fig. CEB5). The data were obtained from the BMR gravity data bank that was used to compute the Gravity Map of Australia.

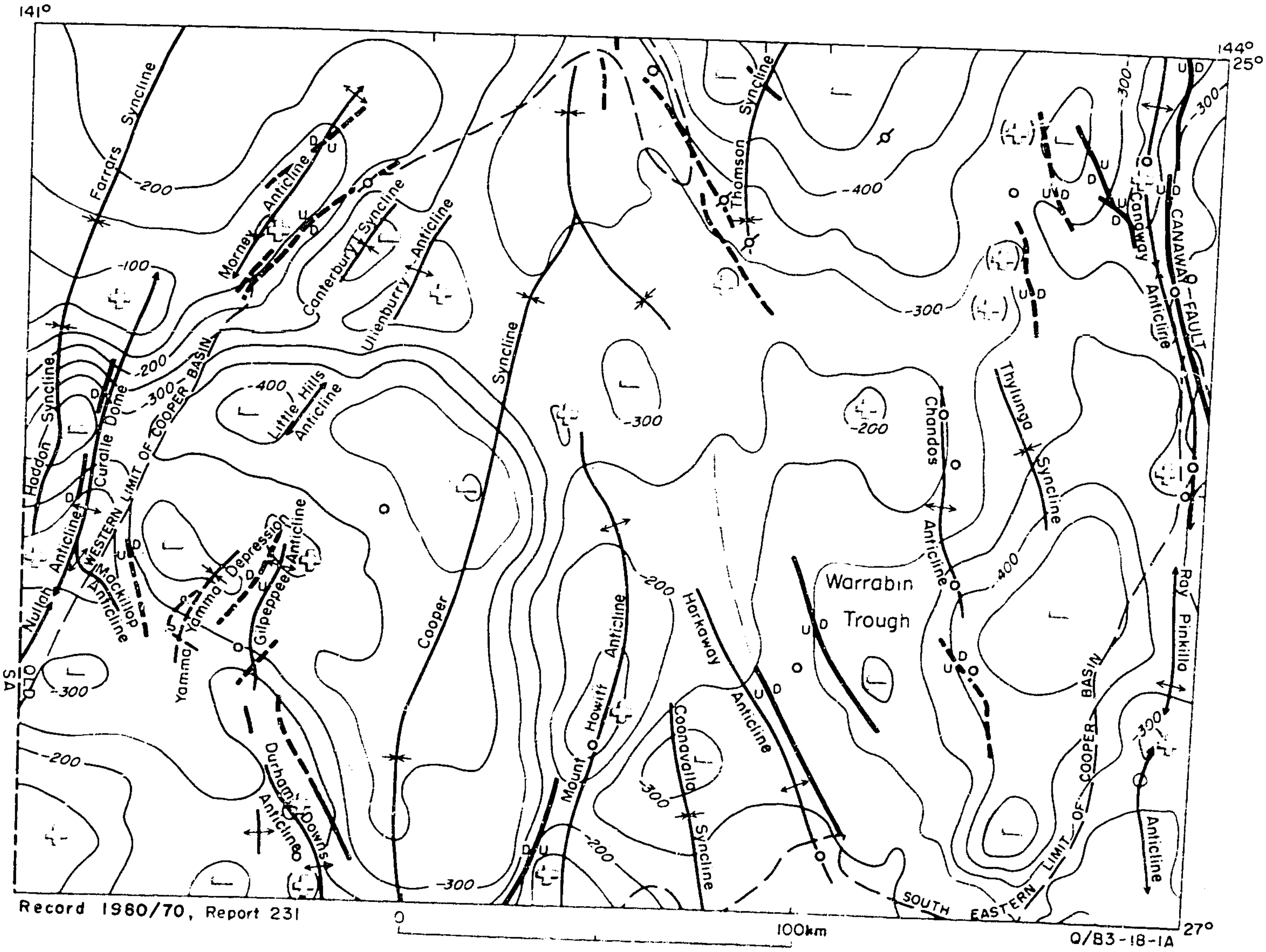
The correlation between regional gravity and structural features is generally fair throughout the area.

During the period July to November 1980, gravity measurements were made along the 1980 BMR regional seismic traverses (Fig. CEB3) and some company traverses, at 500 m intervals. The detailed information along the regional lines, surveyed mainly perpendicular to the strike of the faults and main structural features, will be used in deriving models to assist in resolving the regional structural picture.

Deep crustal seismic investigations (D.M. Finlayson, C.D.N. Collins, J. Lock, C. Rockford)

Long-range seismic refraction recordings were made to determine the deep crustal structure and the velocity-depth profile of the basement beneath the basins in the central Eromanga Basin area. Recordings were made along a 300 km east-west traverse (Fig. CEB6) crossing the Quilpie Trough, Canaway Ridge, Warrabin Trough, and part of the Cooper Syncline.

The refraction recording was divided into two phases. The first involved refraction recording along the 150 km section of the traverse covered by deep crustal vertical and wide-angle seismic reflection recording. This traverse was divided into four 37.5 km traverses, placed end to end. 200 kg



Truncation of Megasequence (Basin edge)
Anticline
Syncline
Fault (U,D indicate relative movement; up, down)
Petroleum exploration drilling
Bouguer anomaly contours (μms-2) Density 2·67t/m3
Relatively positive gravity anomaly or trend
Relatively negative gravity anomaly or trend
Trend not evident at this map scale and contour interval

Fig CEB 5 Central Eromanga Basin Project.
Bouguer anomalies and structural features

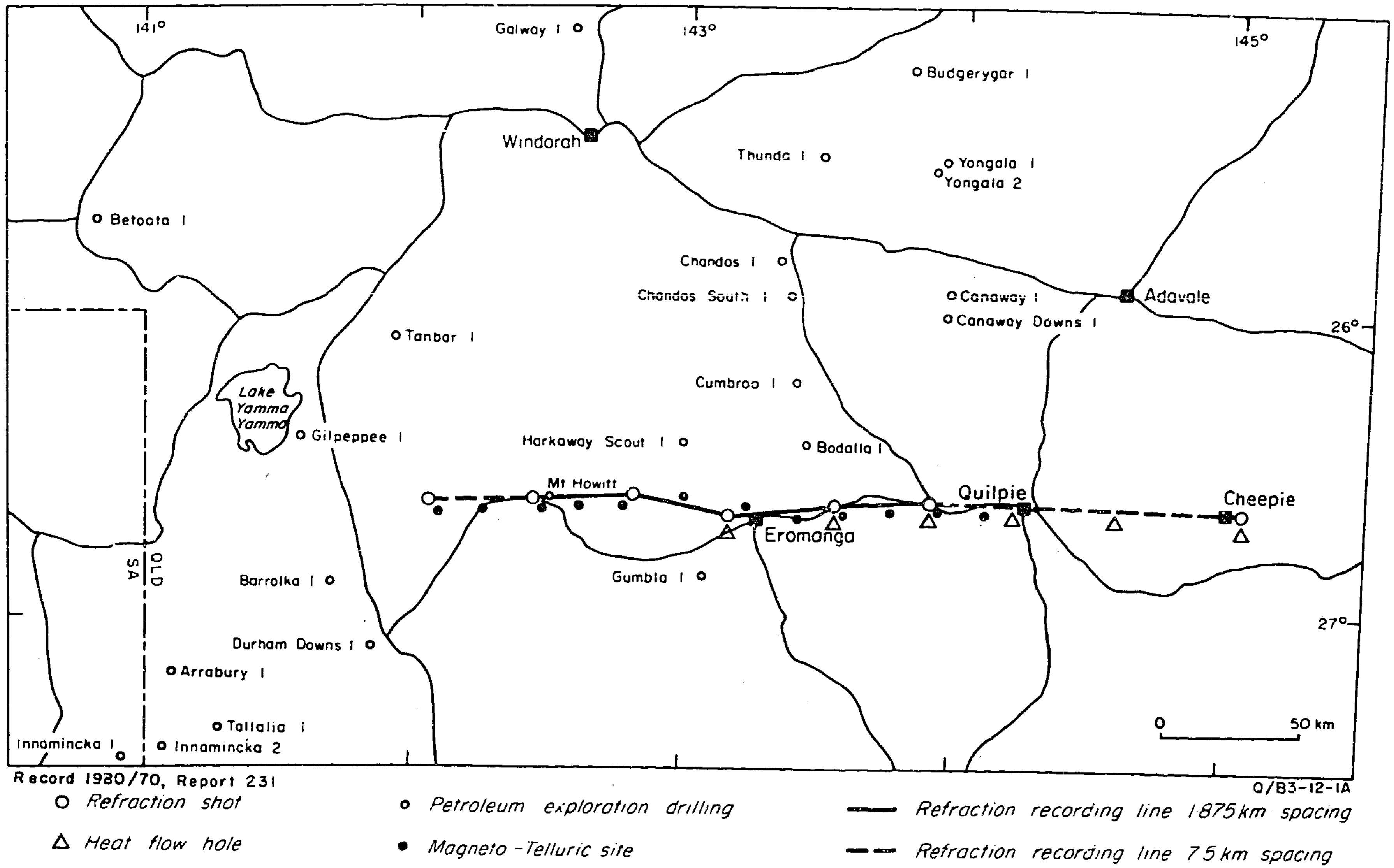


Fig CEB 6 Central Eromanga Basin Project
Locations of seismic refraction shot-points, heat flow holes and M-T sites, 1980

shots were fired at the ends of each traverse, and a 400 kg shot was fired 37.5 km from each end. Analog recordings were made at 21 stations, 1.875 km apart along each traverse. This effectively provided four adjacent reversed traverses, each of 37.5 km, and three overlapping reversed traverses 75 km long, all recorded at 1.875 km spacing.

The second phase involved recording on a 300 km traverse along which heat flow and magnetotelluric measurements were also made. Recording was along two 150 km traverses, end to end, designed to record arrivals from refractors down to and including the upper mantle. 750 kg shots were fired at the ends of each traverse and a 2500 kg shot was fired at a distance of 150 kg from one end of the traverse. Analog recordings were made at 41 stations with a station interval of 7.5 km. This effectively provided a reversed traverse of 300 km and, within this traverse, two adjacent reversed traverses 150 km long, all recorded at 7.5 km station spacing.

Latitudes and longitudes of shot points and station sites for the extreme eastern and western ends of the line (shown as dotted lines in Fig. CEB6) were determined from locations marked on ortho-photo maps of the region. Those for the surveyed central section of the line (shown as a solid line in Fig. CEB6) were calculated from AMG co-ordinates. The analog recordings from 20 shots at 101 station sites recorded by 21 instruments are being processed digitally for the compilation of seismic record sections, which will be interpreted to infer the seismic velocity/depth profile of the Basin.

<u>Heat flow measurements</u> (D.M. Finlayson, J. Lock, J. Williams, J.P. Cull, A.G. Spence)

Heat flow measurements were made at 6 sites with 40 km spacing in a profile generally coinciding with part of the MT profile and the seismic refraction line (Fig. CEB6). Probes were designed to indicate geothermal gradients at a depth of 100 m. Data obtained at such depths are subject to climatic perturbations (see BMR Record 1979/55) and there are considerable difficulties in specifying absolute values of heat flow. However, the magnitude of any correction should be similar for all sites, and consequently, it is possible that relative values of heat flow can be determined. Any trend or anomaly associated with basin structure may then be used to construct detailed models of thermal history related to depositional rates.

The probe components were housed in 4 m lengths of plastic tubing normally used as electrical conduit. Three thermistors, spaced 2 m apart, were sealed in each probe and were monitored using 110 m of twin core cable. A lead ballast was used to aid emplacement. Prior to assembly the thermistors were calibrated against a platinum resistance thermometer standard, and the completed probes were tested to a depth of 100 m in a drill hole 200 m southeast of the BMR building in Canberra.

Geothermal gradients in the Eromanga Basin were measured soon after each hole was completed. The probes were then left in place and the readings were repeated after a further delay of not less than 2 weeks. A drift was observed consistent with the decay of thermal transients associated with drilling. However, some spurious values were noted, and probe failure is indicated for at least one site. All probes have been retrieved, and each thermistor will be recalibrated for greater accuracy. Values of heat flow will then be calculated combining geothermal gradients with thermal conductivity data from identical depths. A 3.1 m bottom core was taken in each hole for this purpose.

Magnetotelluric investigations (A.G. Spence, J. Whatman)

MT records were obtained in the period August-October at 12 sites with 20 km spacing in a profile west of Quilpie (Fig. CEB6). Seismic reflection, seismic refraction, and relative heat-flow data have also been obtained on the MT line from the Cooper Basin to the margin of the Adavale Basin. As a result, the resolving power of MT in this area can be readily established.

Satisfactory recordings were obtained at all sites, but the initial quality was affected by intermittent faults on one E channel. Consequently, the duration of the survey was extended to allow time for major repairs on the HP disc servo assembly. No inversions have been attempted since the data must first be subject to screening for cross-over errors. However, the data are internally consistent, and since orthogonal components are generally coincident major features may therefore initially be resolved with one-dimensional analysis alone.

Some divergence in plots of apparent resistivity has been noted at periods less than 1 Hz for sites near Eromanga. It is possible therefore that there is some structure in the near-surface sedimentary sequence which can be detected by MT. Experience in the Cooper Basin (Moore and others, 1977) had suggested that because of a lack of resistivity contrasts only the base of the Cretaceous would be resolved. At the other extreme it is probable that there is a major conductivity change at depths of about 90 km.

After filtering, the MT data obtained in 1980 will be integrated with other geophysical information along the same profile to determine dimensional parameters associated with each unit to assist in determining the structural and depositional history of the area.

Electrical and electromagnetic investigations (J.A. Major)

The January-June progress report outlined the objectives, techniques, limitations, and survey design philosophy associated with the application of electrical methods to a study of the Eromanga Basin. Since submitting that report, forward models were run of the DC resistivity response of the geoelectric sections derived from the Mt Howitt 1 and Bodalla 1 well logs. The results showed that DC resistivity would not be a practical method to investigate the low-resistivity (1-3Ωm) sediments to depths in excess of 1 km. Electromagnetic sounding techniques may still be viable, but no modelling has yet been done. The future of this project will depend on the results of the current MT work and the analysis of further electrical well logs.

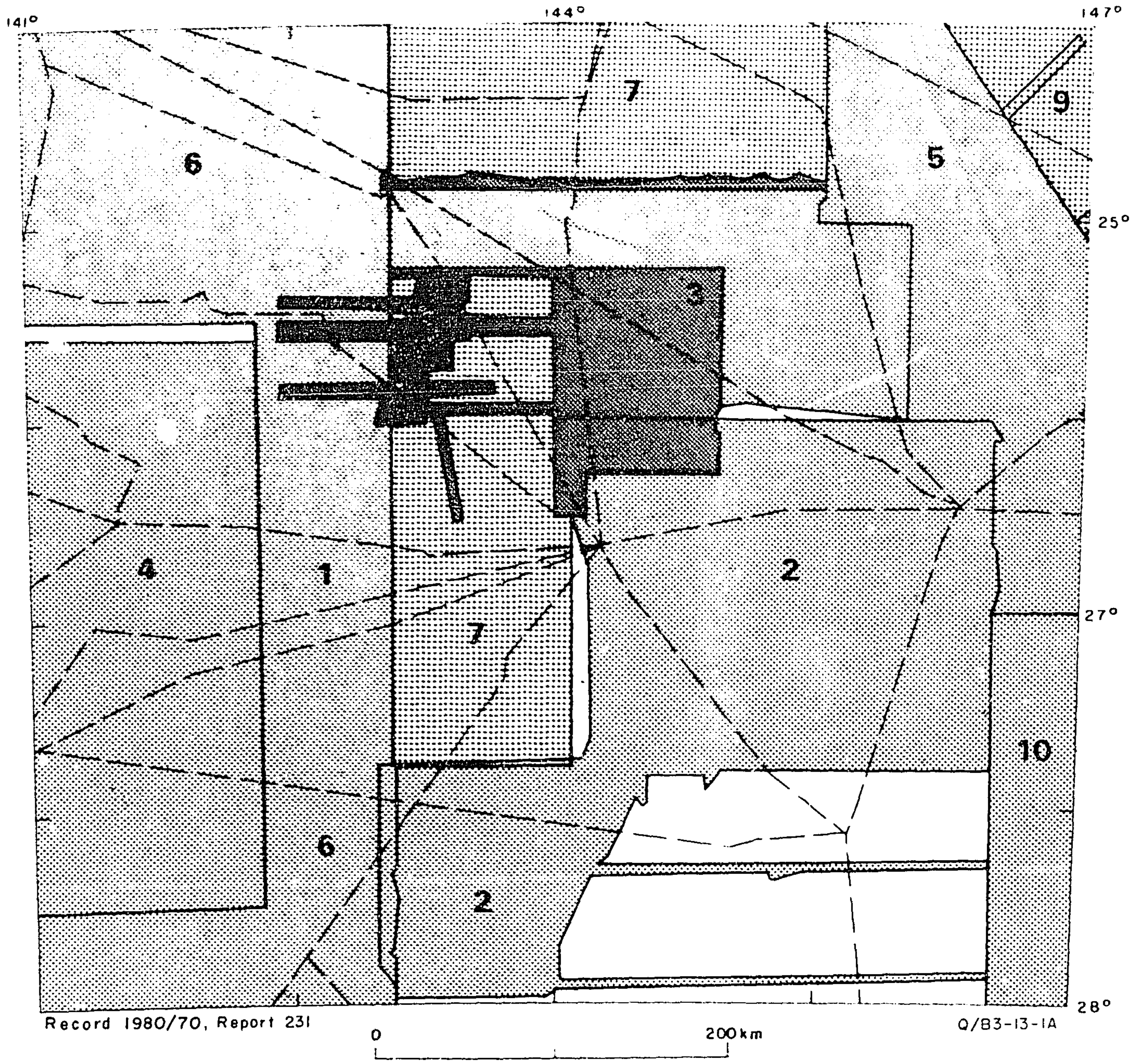
Ground magnetics (J.A. Major, R. Curtis)

A boom was constructed to carry the magnetic sensor behind a Land Rover. The original Geometrics G803 proton magnetometer on loan from the Airborne Subsection was required for aeromagnetic work, and a prototype G803 magnetometer now installed in the vehicle was found to be unreliable. Frequent breakdowns with the digital acquisition system result in the system as a whole being presently unsatisfactory for field use. When a reliable system is available, total magnetics can be read along the 1980 BMR seismic traverses in the Eromanga Basin in a period of two weeks.

Aeromagnetic review (J. Rees, K. Horsfall, S. Wilcox)

The results of aeromagnetic surveys over the central Eromanga Basin area were reviewed to determine the availability and quality of the data, and to assess the existing interpretations.

Ten aeromagnetic surveys provide poor to fair coverage over most of the area except in the southeast over the Gunnamulla Shelf (Figure CEB7). A composite total-magnetic-intensity contour map has been compiled at (Fig. CEB8). Only 35% of original data is available to BMR, and only 50% of this is in a digital form.



Surveys flown by subsidised companies and organisations who made data available to BMR on restricted or unrestricted basis

Area covered by both of the above

Surveys flown by or for BMR

Flight traverses

1 Great Artesian Basin 1958 BMR 60/14

2 Quilpie - Charleville - Thargomindah, Phillips Petroleum Company 62/1704 (subsidy)

3 Jundah - Windorah - Blackall Adavale - Augathella 1960, Phillips Petroleum Company, Queensland Mines Department

4 Innamincka - Betoota - S.A. Delhi Australian Petroleum 62/1709 (subsidy)

5 Tambo - Augathella 1962 Magellan Petroleum Corporation 62/1703 (subsidy)

6 Cooper Creek 1963 Delhi Australian Petroleum 63/1705 (subsidy)

7 Central Great Artesian Basin 1968 BMR 69/33

8 East Windorah 1974 XLX NL74/220 (subsidy)

9 Bowen Basin, 1961-3 BMR 66/208

10 Surat and Bowen Basin's, Qld 1960 Union Oil Development Corporation 62/1706, 62/1715, 62/1724, (PSSA)

Fig CEB 7 Central Eromanga Basin Project. Existing aeromagnetic coverage

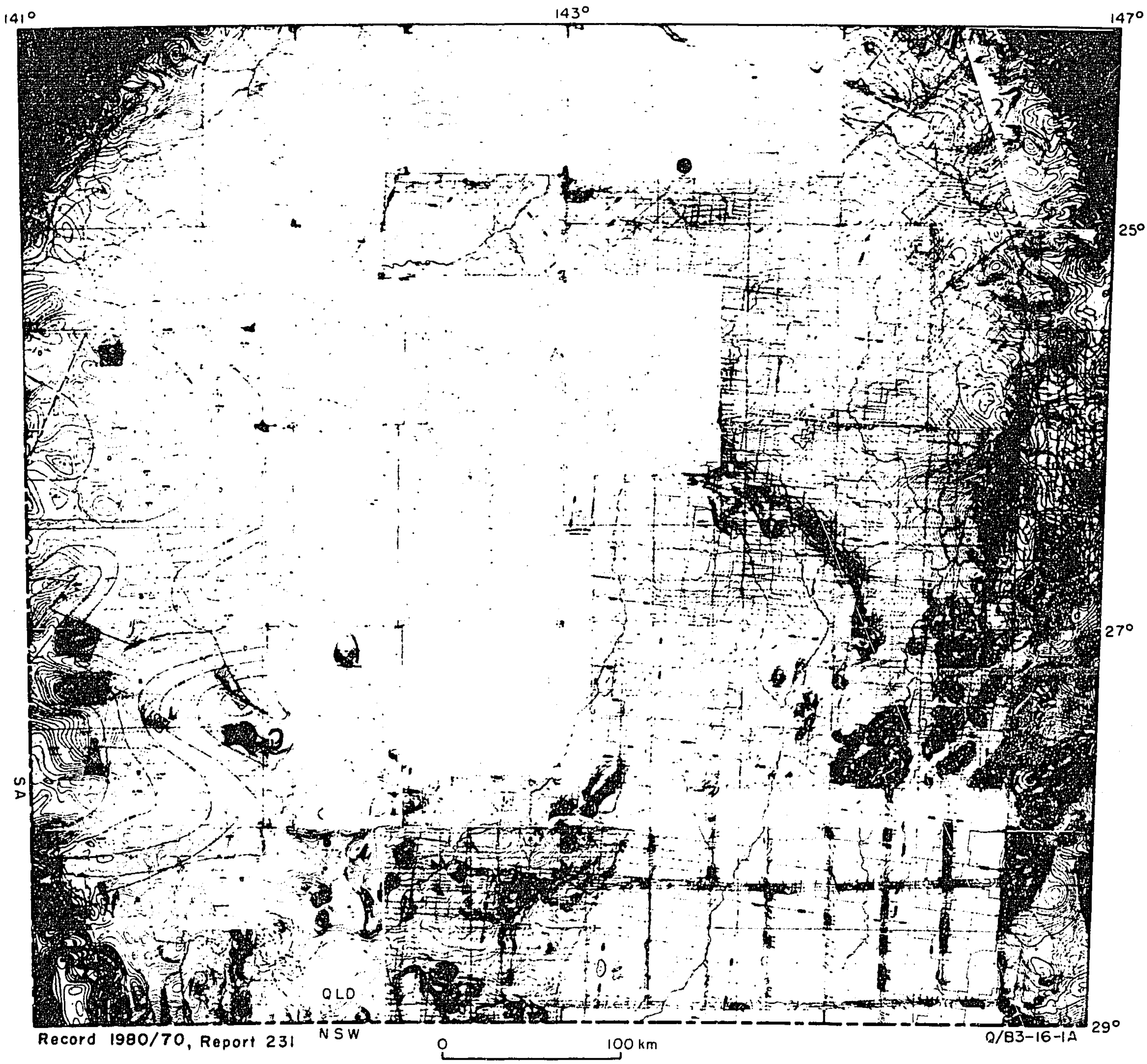
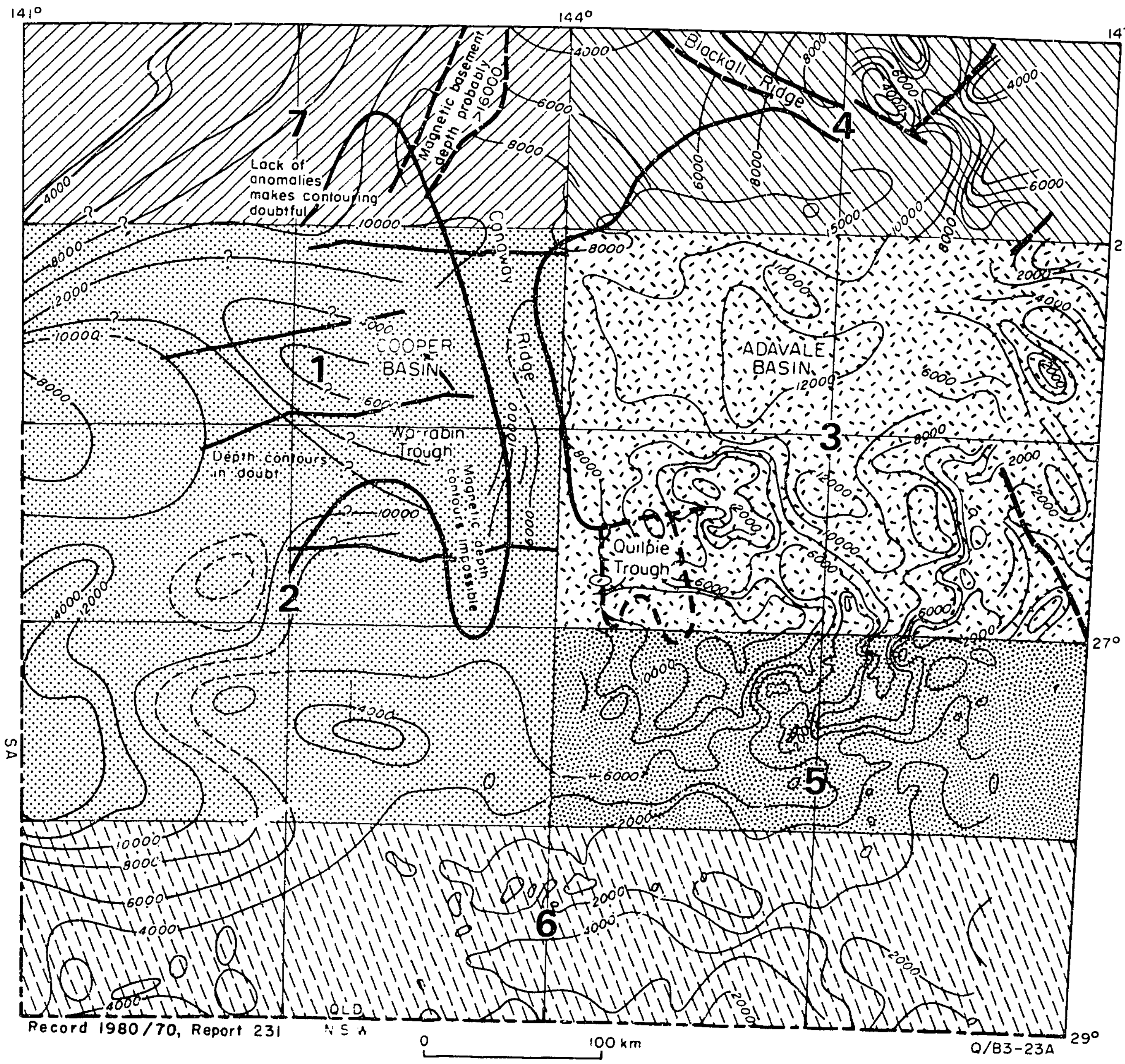


Fig CEB 8 Central Eromanga Basin Project. Aeromagnetic contours

Examination of original data and review of the results of previous surveys suggest that further systematic processing of existing data is warranted.

Additional surveying has been recommended (Figure CEB9). An orientation survey proposed for 1981 will provide interpretation control along seismic traverses in the Cooper Basin area, and attempt to resolve the structure of the Canaway Ridge. A high resolution (0.1 nT) magnetometer will be used to improve the definition of 1-5 nT anomalies, which were not resolved in previous surveys but are considered of fundamental significance for aeromagnetics to contribute to the mapping of the Eromanga Basin.

The results of the orientation survey will be used to define the requirements for further systematic airborne surveying.



2000 Depth to magnetic basement compiled from individual survey reports (feet below MSL)

Basin boundaries (from BMR record 1969/33, plate 7)

Fault or magnetic depth discontinuity

1 BMR seismic traverses 1981

2−7 Areas in order of priority

Fig CEB 9 Central Eromanga Basin Project
Previous results and further aeromagnetic survey priorities

5. REPORTS, MAPS, LECTURES, COURSES, AND OVERSEAS VISITS

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* Indicates non-BMR author.

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Report 218	ANFILOFF, W., & TERRON, O.	Bibliography of gravimetry in Australia.
Report	BRANSON, J.C.	Evidence for Mesozoic spreading south of Australia (in prep.).
Report 220	EVERINGHAM, I.B., & SHEARD, S.N.	Seismicity of the New Guinea/Solomon Islands region, 1972.

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Bulletin 196	FRASER, A.R., & PETTIFER, G.	Gravity surveys of Western Australia and the west of South Australia.
Report 236	GIDLEY, P.R.	Geophysical characteristics of some surficial magnetic sources near Cobar, NSW (in prep.).
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1979/64	BENNETT, D.G., & RAMSAY, D.C.	Field tests of Geonics EM31 and EM34-3 terrain conductivity meters.
1979/7	COLLINS, C.D.N.	Adaptation of the synthetic seismogram program 'REFLEX' to the CSIRO CYBER 76 computer.
1979/55	CULL, J.P.	Resolving heat flow anomalies in shallow boreholes - feasibility studies.
1980/80	CULL, J.P.	Geothermal energy in France.

1980/47	DENHAM, D.	Report on a visit to China 9-26 April 1980.
1979/77	EVANS, W.R., JACOBSON, G., & BENNETT, D.G.	Geological and geophysical investigation of the Pialligo landfill site, ACT.
1979/41	EVERINGHAM, I.B.	PNG earthquake intensity data, 1953-1959.
1980/52	FRASER, A.R., & ANFILOFF, W.	Gravity survey along traverses in the south-west of Western Australia, 1970. Operational Report.
1980/64	FUCHS, K. (Uni. Karlsruhe)	Workshop on calculation of synthetic seismograms by the reflectivity method.
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1979/63	HILL, P.J.	Detailed geophysical investigations, Tennant dam sites 2 and 3, ACT.
1980/14	JACOBSON, G., & HILL, P.J.	Groundwater resources of Niue Island.
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1980/6	MAJOR, J.A.	Geophysical investigation of regional aeromagnetic and radio-element anomalies in the Georgetown and Forsayth 1:100 000 Sheet areas, north Queensland, 1976.

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1978/94	MILSOM, J.	Papua New Guinea gravity survey, 1967.
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1980/48	STUART, D.C., & OGILVY, R.D.	Electrical geophysical mapping surveys, Rum Jungle area, NT, 1974.
1980/78	TUCKER, D.H.	Westmoreland Airborne Magnetic and Radiometric Survey, Qld, 1973.
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STAGG, H.M.J., & WHITWORTH, R.	Onshore magnetic data acquisition system - operations manual.
TILBURY, L.A.	1980 Heard Island Expedition: operations and preliminary results (1981/16).

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CLOATES
HAMERSLEY RANGE
ROWLEY SHOALS
BROOME
SD50
BRUNSWICK BAY
DARWIN
SC51
MELVILLE ISLAND

BMR Marine track maps, 1:2 500 000 scale, with CMS and 1968 data:

NW AUST
NE AUST
SW AUST
SE AUST
TASMANIA
PNG
NEW CALEDONIA
LORD HOWE - NORFOLK

Airborne maps - see Table MA-2

ADDRESSES TO MEETINGS AND CONFERENCES

ANFILOFF, W.	The Batten Trough: a structural problem in the McArthur Basin. Gravity evidence. BMR Symposium, 29-30 April 1980.
BAUER, J.A.	New information on the Denison Trough and its petroleum prospects from recent seismic surveys. BMR Symposium, 29-30 April 1980.
COLLINS, C.D.N., & PINCHIN, J.	The Batten Trough: a structural problem in the McArthur Basin. McArthur Basin crustal seismic survey. BMR Symposium, 29-30 April 1980.

CULL, J.P.	Geothermal evidence of climatic change and heat flow in Australia. Seminar, National Geophysical Research Institute, Hyderabad, India.
CULL, J.P.	Thermal diffusivity measurements. International Heat Flow Commission, European Geophysical Society, Budapest, Hungary.
FINLAYSON, D.M.	Deep seismic structure of southeastern Australia and the Cainozoic lithosphere. Geological Society of Australia CESEA Symposium, Canberra, November 1980.
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GIDLEY, P.R.	Magnetic property studies and magnetic surveys of the Elura prospect, Cobar, NSW. EZ Elura Symposium, Sydney, 12-13 February 1980.
GREGSON, P.J.	Conference of state emergency services, October, 1979.
GREGSON, P.J.	WA Astronomical Society, 10 March, 1980.
HONE, I.G.	Geo-electric properties of the Elura deposit, Cobar, NSW. EZ Elura Symposium, Sydney, 12-13 February 1980.
HONE, I.G.	The application of geophysics to exploration for heavy mineral beach sand deposits. ADAB/WAITAB Special Group Course - Exploration and Mining of Mineral Sands. Lecture given in Brisbane, 4 May 1980.
HONE, I.G., & PIK, P.	Results of experimental downhole surveys at Elura, Cobar, NSW. EZ Elura Symposium Sydney, 12-13 February 1980.
HONE, I.G., SPIES, B.R., & TYNE, E.D.	The influence of the geoelectric section on EM and IP surveys at Elura, Cobar, NSW. 9th BMR Symposium, Canberra, 29-30 April 1980

IDNURM, M.	Sedimentology and palaeomagnetism of southeast South Australia and the Milankovitch theory of ice ages. Research School of Earth Sciences, ANU, Seminar: with P.J. Cook.
IDNURM, M.	Chemical Weathering in SE Queensland and the Tertiary climatic decline. Geological Society of Australia CESEA Symposium, Canberra, November 1980: with D.C. van Dijk and B.R. Senior.
IDNURM, M.	South Australian stranded beach ridges and the Milankovitch theory of ice ages. Geological Society of Australia CESEA Symposium, Canberra, November 1980: with P.J. Cook.
MAJOR, J.A.	Restrictions on the use of Cole-Cole dispersion models in complex resistivity interpretation. Macquarie University Special Interest Seminar on Complex Resistivity and Elura, Sydney, 12-13 August 1980.
SPIES, B.R.	TEM results from the Elura deposit, Cobar, NSW. EZ Elura Symposium, Sydney, 12-13 February 1980.
SPIES, B.R.	Limitations and survey design parameters for time domain EM methods in mineral exploration. 9th BMR Symposium, Canberra, 29-30 April 1980.
SPIES, B.R.	The TEM method in Australia. Macquarie University Special Interest Seminar on TEM, Sydney, 9th October 1980.
STUART, D.C.	Review of magnetic and gravity surveys at Elura, Cobar, NSW. EZ Elura Symposium, Sydney, 12-13 February 1980.
WELLMAN, P.	Crustal movement in Australia from repeat surveying. Geodesy Research Seminar, 3-4 November, University of NSW.

WELLMAN, P.	Strain in Australia. Seminar on Stress and Seismicity in eastern Australia, 12 November, Melbourne.
WELLMAN, P.	Mechanism of uplift of the eastern highlands for K-Ar dating, regional gravity and repeat geodetic measurements. Geological Society of Australia, Symposium on the Cainozoic Evolution of continental southeast Australia, 26-30 November, Canberra.
WILLCOX, J.B.	Structure and petroleum potential of the Lord Howe Rise. BMR Symposium, Canberra.
WILLCOX, J.B.	Structure, seismic stratigraphy and petroleum potential of the Lord Howe Rise area. Second International Workshop on Geology, Mineral Resources and Geophysics of the South Pacific, Noumea, October, 1980.
WYATT, B.W., YEATES, A.N., & TUCKER, D.H.	The application of gamma-ray spectrometry to exploration for tin-tungsten deposits in granites of the Lachlan Fold Belt of New South Wales. 4th Australian Geological Convention, Hobart, 14-18 January 1980.
WYATT, B.W., YEATES, A.N., & TUCKER, D.H.	Lachlan Fold Belt: geological associations with regional geophysics. 9th BMR Symposium Canberra, 29-30 April 1980.
YEATES, A.N., WYATT, B.W., & TUCKER, D.H.	The relations between magnetic anomalies, gravity anomalies and surface geology in the Lachlan Fold Belt of New South Wales. 4th Australian Geological Convention, Hobart, 14-18 January 1980.

OVERSEAS VISITS AND CONFERENCES

BAUER, J.A.	Istanbul, Turkey: 42nd meeting of European Association of Exploration Geophysicists, 3-6 June 1980 (Return to duty during private overseas visit).

BRANSON, J.C.	Ninth Session, CCOP/SOPAC, Tarawa (Kiribati), 20-28 October, 1980.
CULL, J.P.	BRGM, Orleans, France, June/August 1980. Study geothermal energy applications in France.
CULL, J.P.	26th International Geological Congress, Paris, July 1980.
CULL, J.P.	European Geophysical Society, Budapest, Hungary, 1980.
DENHAM, D.	Visited China from 9-26 April 1980 under the auspices of the Scientific and Technical Exchange Program sponsored by the Academia Sinica and the Australian Academy of Science.
McGREGOR, P.M.	UN Ad Hoc group of Scientific experts Geneva; 9th, 10th Sessions. (February, July, 1980).
REES, J.E.	Philippines, Uranium Exploration Training Program, in collaboration with the Australian Development Assistance Bureau. February 1980.
WILLCOX, J.B., & BRANSON, J.C.	Second International Workshop on Geology, Mineral Resources and Geophysics of the South Pacific, Noumea, 9-15 October 1980.
YOUNG, G.A.	1980 Annual conference of the Australasian Institute of Mining and Metallurgy, Queenstown, New Zealand, 4-7 May 1980.

LOCAL CONFERENCES

GIDLEY, P.R., HONE, I.G., SPIES, B.R., & STUART, D.C.	EZ Elura Symposium, Sydney, 12-13 February 1980

BAUER, J.A., & MOSS, F.J.	APEA Conference, Surfers Paradise, March 1980.
WYATT, B.W., & YEATES, A.N.	4th Australian Geological Convention, Hobart, 14-18 January 1980.
MAJOR, J.A., SPIES, B.R., & STUART, D.C.	Macquarie University Special Interest Seminar, Sydney, 12-13 August, 1980.
DENHAM, D., & EVERINGHAM, I.B.; DOOLEY, J.C. (private visit)	50th ANZAAS Congress, Adelaide, May 1980.
EVERINGHAM, I.B., & McEWIN, A.J.	Workshop on calculation of synthetic seismograms, October 1979.
WILLIAMS, J.	Institute of Radio and Electronic Engineers, Canberra, Time and frequency services of Australia.
FINLAYSON, D.M., WELLMAN, P., & IDNURM, M.	Geological Society of Australia, The Cainozoic Evolution of Continental Southeast Australia, Canberra, 26-30 November 1980.
MUTTON, A.J.	Geological Society of Australia Symposium on weathering in Australia and its implication for mineral exploration, Sydney, 28-29 November 1979.
REES, J.E.	14th Symposium on 'Advances in the Study of the Sydney Basin'. Newcastle, 2-4 May, 1980.
SYMONDS, P.A.	Discussions between Australia and France on delineation of maritime boundaries. Canberra, September 1980.

TRAINING COURSES

External

BAUER, J.A.	Exploration for Sandstone and Carbonate Reservoirs, by D.A. Busch and G.M. Friedman - AMF, Adelaide, 28 July - 8 August, 1980.
BRASSIL, F.M., JOHNSTON, C.R., MATHUR, S.P., MOSS, F.J., PINCHIN, J., STAGG, H.M.J., SYMONDS, P.A., & WAKE-DYSTER, K.D.	Seismic data processing seminar - GSI, Sydney, 27 October, 1980.
CHERRY, R.D.E., & RICKARDSSON, L.A.	Shot firer's refresher course, Telecom, Sydney, 8-9 December, 1980.
TAYLOR, F.J.	Schlumberger well-log interpretation course, Sydney.
TAYLOR, F.J.	Seismic data processing course, Sydney.

Internal

HONE, I.G.	Geological environments and structural controls of ore deposits. Course given by Dr T. Hopwood in BMR, 7-14 November 1979.
LUYENDIJK, A.P.J.	HP-1000 Assembler course, 7-11 July 1980.
MAJOR, A.J.	Introductory HP-9825A computer programming course. BMR, 21-23 July 1980.
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