

1971/107

COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS



Record No. 1971/107

1970 ANNUAL REPORT

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 It may not be published in any form or used in a company prospectus or statement without the permission in writing of the Director, Bureau of Mineral Resources, Geology & Geophysics.



**BMR
Record
1971/107
c.4**

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS
DEPARTMENT OF NATIONAL DEVELOPMENT

1971/107

ANNUAL REPORT 1970

CONTENTS

	<u>Page</u>
FUNCTIONS AND ORGANIZATION	1
DIRECTOR'S REPORT	5
FIELD OPERATIONS	8
Australia	8
Papua - New Guinea	22
Antarctica	25
MARINE OPERATIONS	27
Geological	27
Geophysical	28
LABORATORY STUDIES	30
Palaeontology	30
Petrology, Geochemistry and Geochronology	31
Sedimentology	34
Photogeology	34
Palaeomagnetism	35
JOINT STUDIES	36
Crustal Study	36
Gosses Bluff	36
Mallacoota Inlet	37
Baas Becking Laboratory	37
Volcano Surveillance	38
OBSERVATORIES	39
Seismology	39
Ionospheric Recording	40
Geomagnetism	40
Regional Magnetic Surveys	41
ENGINEERING GEOLOGY AND GEOPHYSICS	43
RESIDENT GEOLOGISTS	45
Papua - New Guinea	45
Darwin Group	48
SPECIAL MAPS	50
Tectonic Map	50
Metallogenic Map	50
Gravity Map	51

	Page
Groundwater Maps	51
Geological Map	51
Geological Atlas	51
Burdekin Region	52
Northern Territory	52
Papua - New Guinea	52
INSTRUMENT DESIGN AND DEVELOPMENT	53
COMPUTER APPLICATIONS	55
BASINS STUDY	57
Core and Cuttings Laboratory	57
MINERAL RESOURCES	59
Mineral Economics	59
Mining Engineering	59
Petroleum Technology	60
PETROLEUM SEARCH SUBSIDY	61
LIBRARY AND INFORMATION SERVICES	63
Library	63
Information Services	63
Stratigraphic Index	64
PUBLICATIONS	65
Bureau Publications	65
External Publications	70
OVERSEAS VISITS	72
STAFF	75
Operations Branch	75
Geological Branch	78
Geophysical Branch	82
Mineral Resources Branch	87
Petroleum Exploration Branch	88
Staff Changes	89
FINANCE	91
INDEX	92

FUNCTIONS AND ORGANIZATION

The functions of the Bureau are as follows:

1. As a primary function, to obtain, study, publish, and provide basic geological and geophysical information necessary for the exploration and development of the nation's mineral resources; this to be done where appropriate in co-operation with State and Territorial authorities.
2. In order to support the function of obtaining basic information to undertake experimental studies and research into geology and geophysics.
3. To make basic investigations of the earth's magnetic and gravitational fields and in seismology and vulcanology.
4. To complement the work of the State and Territorial authorities by undertaking geological and geophysical investigations into the occurrence and distribution of underground water.
5. To undertake geological and geophysical investigations on behalf of other Commonwealth Departments and authorities including the provision of resident staff by arrangement with the Territories.
6. To obtain basic information on, and review the mineral resources of the Commonwealth and its Territories; to study the various sectors of the mineral industry both in the national and international spheres; to publish and provide information about the mineral industry.
7. To undertake such investigations in mining engineering and petroleum technology as are relevant to (1) and (6) above.
8. To prepare advice for Government on the mineral industry, including the exploration and development of mineral resources in the national interest.
9. When directed by Government, to administer schemes for the assistance of sectors of the mineral industry and to undertake special mineral projects.

The organization of the Bureau comprises five branches under the Director: Operations, Geological, Geophysical, Mineral Resources, and Petroleum Exploration. The functions of the individual branches are shown below.

Operations Branch

- . Plan and programme the current and long-term scientific work of the Bureau and negotiate with other government authorities, universities, and mining companies concerning the carrying out of the programme.
- . Co-ordinate the activities of the branches of the Bureau.
- . Provide information service on the mineral industry and the activities of the Bureau for officers of the Bureau, other government authorities and the public.
- . Maintain a related scientific library.
- . Provide editing of all Bureau publications.
- . Arrange printing and distribution of Bureau publications.
- . Prepare estimates, check purchases of equipment, oversight staffing, and provide general administrative services to all branches of the Bureau.

Geological Branch

- . Obtain, study, and provide basic geological information necessary for the exploration and development of mineral resources; including the conduct of geological surveys and the operation of supporting laboratories.
- . Undertake experimental studies and research in geology.
- . Make basic investigations in vulcanology, engineering geology, and geological factors related to the occurrence and distribution of underground water.
- . Undertake geological investigations on behalf of other Commonwealth Departments and authorities including the provision of Resident Staff by arrangement with the Territories.
- . Compile reports, scientific papers, and various types of geological maps in relation to surveys and investigations carried out.
- . Maintain comprehensive indexes of Australian geology and mineral deposits and maintain geological museum facilities.
- . Prepare advice for Government and the mineral industry on geological matters.

Geophysical Branch

- . Obtain, study, and provide basic geophysical information necessary for the exploration and development of mineral resources including the conduct of geophysical surveys by airborne, marine, and terrestrial methods.
- . Undertake experimental studies and research in geophysics including the design and development of geophysical methods and equipment and the maintenance of laboratories and workshops.
- . Make basic investigations of the Earth's magnetic and gravitational fields and in seismology; operate geophysical observatories.
- . Make basic geophysical investigations for engineering projects and into the occurrence and distribution of underground water.
- . Undertake geophysical investigations on behalf of other Commonwealth Departments and authorities.
- . Compile reports, scientific papers, and various types of geophysical maps and plans in relation to investigations and surveys carried out.
- . Prepare advice for Government and the mineral industry on geophysical matters.

Mineral Resources Branch

- . Obtain basic information on and review the mineral resources of the Commonwealth and its Territories; study the various sectors of the mineral industry both in the national and international spheres; provide information about the mineral industry.
- . Undertake such investigations in mining engineering and petroleum technology as are relevant to the Bureau's primary functions.
- . Prepare advice for Government on the mineral industry including the exploration and development of mineral resources in the national interest.
- . Provide and/or supervise drilling services for the Bureau.
- . Compile and edit reports.

Petroleum Exploration Branch

- . Carry out the technical aspects of the Petroleum Search Subsidy Act.
- . Initiate proposals concerning changes in petroleum exploration policy.

- . Review continuously the geology, geophysics, and physical properties of the sedimentary basins and assess their petroleum prospects.
- . Obtain, study, and store basic information and material resulting from petroleum exploration.
- . Compile and edit reports and provide information concerning petroleum exploration.

DIRECTOR'S REPORT

Although the Bureau of Mineral Resources is celebrating in 1971 its twenty-fifth anniversary, this is the first time it has issued an Annual Report. It is accordingly appropriate to review briefly some of its main activities over the twenty-five year period.

In its earlier days, a large part of the Bureau's effort was applied more directly to mineral and petroleum exploration - detailed examination of mineral and potential petroleum fields and the development in Australia of exploration geophysics. Regional geological mapping, however, particularly of the sedimentary basins, was always an important part of its programme, and this was progressively developed. Geophysical work also became more and more regional rather than local in character.

Pari passu with this emphasis on regional coverage, a considerable experimental and research programme developed. On the geological side, regional geochemistry, sedimentology, ore genesis, geochronology, and the like assumed greater proportions; in geophysics, design and development of instruments, experimental surveys to evaluate techniques and evolve new ones, paleomagnetism and mathematical research with evaluation and interpretation.

Agreement was reached at an early date with the State Geological Surveys on uniform conventions, symbols, colours, format, scales, and standards for geological mapping, and four miles to the inch (later changed to 1:250,000) was the scale selected for regional coverage of Australia. The Bureau concentrated its efforts on the northern parts of Australia - Northern Territory, Queensland and the northern half of Western Australia - and Papua-New Guinea. As a result of these mapping programmes by the Bureau, either jointly with the Queensland and Western Australian State Geological Surveys or on its own, geological maps at 1:250,000 are now available of more than 80 percent of Northern Australia, and compilation is well advanced for Papua and New Guinea.

On the geophysical side, a systematic gravity coverage of Australia at 10 km spacing is within two years of completion. Regional aeromagnetic surveys either by the Bureau or by exploration companies

have been carried out over 75 percent of Australia and New Guinea, and many regional seismic surveys have been devoted to investigation of the structure of sedimentary basins. Regional studies of seismicity and of crustal structure are an important part of Bureau activities, through its seismological observatories, outpost stations, and crustal study projects.

A programme of geological and geophysical mapping of the continental shelf areas has been a major activity of recent years; about 20 percent of the shelf has been covered by marine geological cruises and about 30 percent by a comprehensive gravity, magnetic, and seismic seaborne survey.

All these field activities, together with engineering geology and geophysics and hydrological investigations, require extensive research, laboratory, and workshop support, and also make considerable use of computer facilities. Well-equipped palaeontology, petrology and mineralogy, chemistry, geochronology, petroleum technology, systems and instrument development laboratories, fine and heavy mechanical workshops, and a seismic play-back centre have been developed to meet the varying needs of the field programmes.

In addition to its own field work, petroleum exploration subsidized by the Commonwealth under the Petroleum Search Subsidy Legislation has contributed an enormous amount of information which is maintained, published where appropriate, and made available by the Bureau. An important part of this is the Cores and Cuttings Laboratory at Fyshwick, Canberra, where samples are stored and can be examined. The Bureau also maintains a comprehensive library covering all aspects of the earth sciences.

An important part of the Bureau's work is its continuous study of the economics of the Australian Mineral Industry. Quarterly and Annual Reviews of the Mineral Industry are published, together with feature articles, information on metal and mineral prices, and also statistics of the mineral industry prepared by the Commonwealth Statistician in collaboration with the Bureau. The analyses and forecasts presented in these Reviews have become increasingly accurate and reliable and are widely used by both government and industry.

The Bureau's activities during 1970, which were distributed widely through Australia and New Guinea (and Antarctica), are summarized in this report. Out of so many projects it is difficult to select any for special mention, but the following may be included amongst the highlights of the achievements of 1970: the marine geophysical surveys in the

Papua-New Guinea area of the Bismarck Sea, Southeastern Papua and the Gulf of Papua, and the marine geological survey of part of the eastern Australian Shelf; the dating of the intrusive rocks in New Guinea, demonstrating the very young geological age of major orebodies in that area; the completion of a comprehensive study of Gosse's Bluff in Central Australia, showing that it was almost certainly caused by impact of an extra-terrestrial body; the progress towards completion of the surface mapping of the Great Artesian Basin; helicopter gravity survey of the Officer Basin and inauguration of geological mapping of that basin; detailed mapping in the Cloncurry - Mary Kathleen area; the commencement of the study of the Arunta rocks of Central Australia and the continuation of regional geological mapping in many areas; experimental remote sensing and airborne seismic surveys; the extension of studies of regional seismicity of Australia and, particularly, Papua-New Guinea; the commissioning of a new Twin Otter aircraft to replace DC3 VH-MIN after long and meritorious service; the completion of design studies of the Upper Ramu HE project, in a remote and geologically complex terrain; the compilation of a metallogenic map of Australia and the completion in co-operation with the Geological Survey of New Zealand of the compilation of the 1:5,000,000 geological maps of Oceania; and the maintenance, in spite of losses of experienced staff, of the publication programme of the Bureau at approximately the normal level.

FIELD OPERATIONS

The following summary outlines the principal field operations undertaken by the Bureau in Australia, Papua-New Guinea (TPNG), and Antarctica.

AUSTRALIA

Australia in General

Crustal and Upper Mantle Survey

In recent years, the Earth's crust and upper mantle have been studied extensively throughout the world, using various geophysical techniques. In 1968 and 1969, the Bureau conducted seismic surveys in Victoria, New South Wales, Northern Territory, and Western Australia. Large explosive charges were detonated in patterns of drill holes and the energy was recorded after reflection from deep within the Earth's crust and upper mantle. Analysis of the data has continued during 1970.

The Mildura, Victoria, study by J.C. Branson revealed a two-layer crust with 22 km of granitic material overlying about 7 km of higher velocity rocks. At both Mildura and Broken Hill, New South Wales, reflections were recorded which are believed to be from within the mantle at a depth of 50 km.

Good quality reflections were recorded from deep within the crust in Central Australia west of Alice Springs by a party led by A.R. Brown. The crust was shown to be 36 km thick, in two layers. A large-scale seismic reflection study of the crust in this area is now proposed in order to investigate the tectonic history of the sedimentary basins of Central Australia.

The results of the Western Australia traverses, by a party led by J.C. Branson across the Precambrian shield at the latitude of Kalgoorlie, were less definite; they indicated a total crustal thickness of 30-37 km at the points sampled, with the upper crustal layer averaging 20 km thick. The seismic data will be processed by digital computer to extract more detailed information about the form and nature of the crustal layer. Interpretation of seismic refraction data recorded at the same time gives broad agreement. A combined interpretation of the results of all geophysical measurements in the area, including seismic reflection and refraction, gravity, and magnetic, is being undertaken.

Base Station Gravity Network and Calibration System

In 1969, four of the Bureau's gravity meters were read at stations of the international Western Pacific Calibration Line, which extends from Melbourne, Victoria, to Alaska. A major Australian Calibration Line Survey was carried out by R.J.S. Cooke, to relate gravity values at Australian stations to the international standards



Sydney gravity station, Western Pacific Calibration Line

and to calibrate the Bureau's gravity meters. The line consists of 25 stations from Hobart, Tasmania, to Laiagam, TPNG, and spans a range of about 2,950 mgal. Nine gravity meters were used to ensure accuracy. The six calibration ranges in eastern Australian cities were checked by this survey, the only error being found in the Hobart range. A new calibration range was established at Port Moresby, TPNG, and new gravity stations were established as local alternatives ('excentres') to some of the main base stations.

QUEENSLAND

Great Artesian Basin

Surface mapping of the Great Artesian Basin in Queensland was completed in 1970. In view of the rather meagre outcrops, geological and geophysical surveys are being supplemented by a programme of logging of water bores throughout the basin. Between November 1969 and October 1970 gamma-ray logs of 35 bores were obtained under contract, as well as temperature logs of 33 bores and flowmeter/caliper logs of 28 bores. A hydrogeological study of the basin, to start in 1971, has been defined, and arrangements are being made to employ outside specialists to assist in the study.

Carpentaria Basin

The southern part of the Carpentaria Basin, which is the northern extension of the Great Artesian Basin, was mapped jointly by the Bureau and the Geological Survey of Queensland in 1969 and 1970 by a party led by H.F. Dutch. The succession ranges from Upper Jurassic to Lower Cretaceous. Its connexion with the northern part of the Eromanga Basin (also part of the Great Artesian Basin) was investigated by drilling eight shallow holes; Cainozoic cover obscures the succession in the area mapped except on the margins, where the outcropping Mesozoic formations can be correlated with some of those in the southern part with reasonable confidence.

Broad Sound Estuary

A study of the Cambrian phosphate deposits of northwestern Queensland showed they were of estuarine origin. It was therefore decided that certain modern estuaries should be studied in detail to examine the geological, chemical, and physical factors that determine the deposition and concentration of minerals in estuarine environments (see also Mallacoota Inlet, p. 37).

A comprehensive study of the Quaternary geology and geochemistry of the Broad Sound estuary and its hinterland, in Queensland, was begun in 1970 under the direction of Dr P.J. Cook. The sediments bordering Broad Sound were systematically sampled, and shallow cores taken of the sea bottom. The sound was traversed with echo sounder and sparker, and the hinterland is being mapped in detail. However, an abnormal



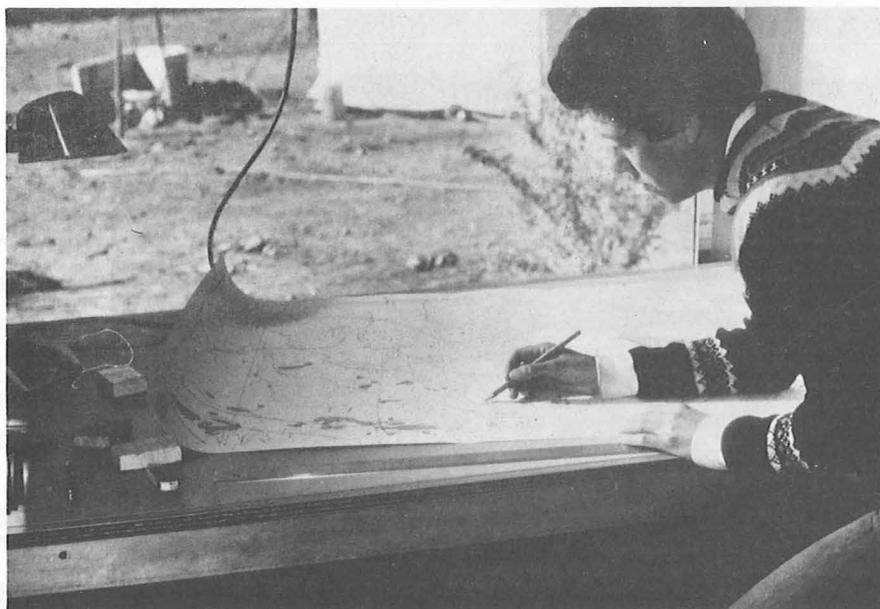
Intertidal, mangrove, and supratidal environments, Broad Sound.

drought caused stream input into the estuaries to cease and the study will be resumed when rainfall restores normal input of stream water and sediments into the sound.

Bowen Basin

The study of the sedimentology of selected Triassic sequences in the Bowen Basin, Queensland, continued during 1970 under the direction of A.R. Jensen and will be further continued in 1971. The sequences are among those that are targets for petroleum exploration, and the objective of the study is to resolve their composition in detail, to indicate how and in what environments they were deposited, and to show their lateral variations throughout the basin, as aids to future search.

A model constructed from detailed bedding analysis of the Clematis Sandstone fairly closely resembles a theoretical model of braided stream deposition, and it throws light on the environment of deposition of this formation. Analysis of stratification measurements casts doubt on earlier indications that the Rewan and Clematis Formations were deposited in the same drainage system.



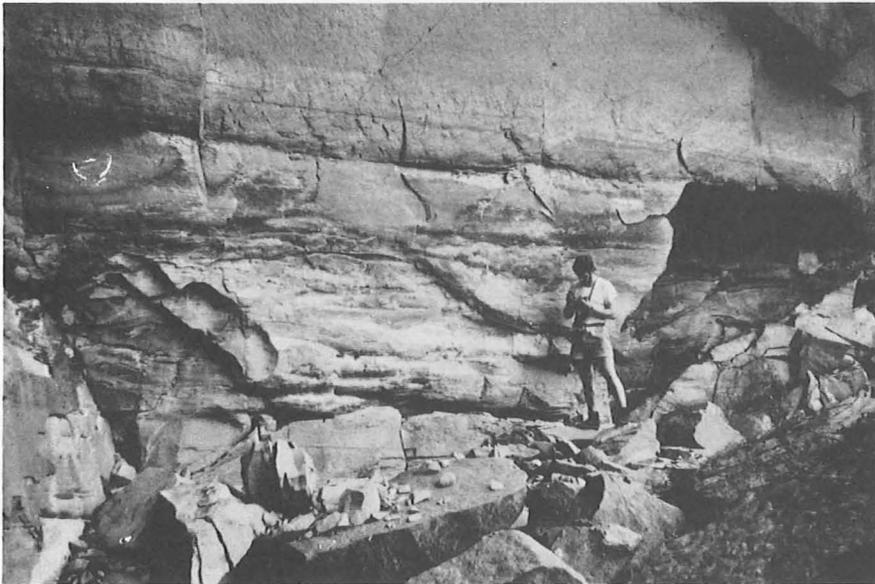
Draughtsman Miss Diana Pillinger at Lake Corella field camp, North Queensland

Detailed outcrop studies on the Moolayember Formation have provided new evidence on the source of its constituent sediments and the environment of deposition. In the Carnarvon Range area, it appears that the lower part of the formation was deposited in deltas, estuaries, and lakes, and the upper part from rivers.

Cloncurry - Mount Isa

The field study of the Cloncurry - Mount Isa area continued in 1970, when the Mary Kathleen and part of the Mount Isa 1:100,000 Sheet areas were mapped jointly by Bureau and Geological Survey of Queensland geologists led by G.M. Derrick. The work was facilitated by the use of colour air-photographs, which make much clearer the distinctions between, and boundaries of, different rock types; in addition, they greatly aided navigation, photointerpretation, the location of old workings, and indications of mineralization.

An airborne magnetic and radiometric survey led by R. Beattie complemented the geological mapping by defining the magnetic and radiometric characteristics of many of the formations.

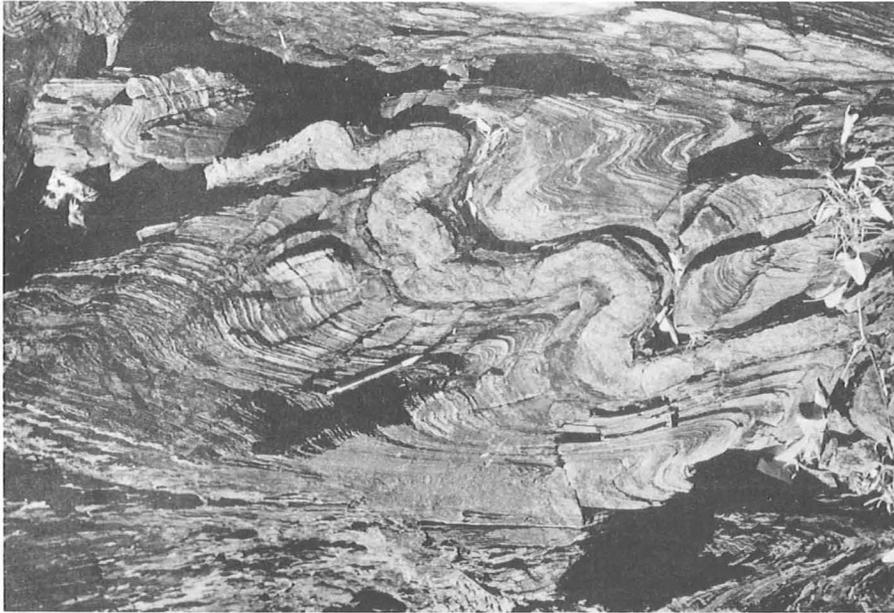


**Contact between Moolayember Formation and Precipice Sandstone,
Bowen Basin**

The area mapped contains elements of two Precambrian geosynclines that are separated by basement rocks and are extensively faulted. The stratigraphic sequence and the evolution of the geosynclines have been elucidated.

The western geosyncline, which was confined between basement blocks, strongly influenced by normal faulting, flooded by continental volcanics, and subsequently submerged, is strongly suggestive of a rift-valley structure; and the Mount Isa lead-zinc deposits, now generally considered to be syngenetic, may be comparable in origin to the Red Sea base-metal deposits.

In the eastern geosyncline, the lithological and stratigraphic associations of many copper deposits have been studied and a pattern is becoming apparent. Several fluorite and barite lodes were discovered during the survey and some may be of economic size and grade.



Folding in Proterozoic jaspilite, Overhang mine, North Queensland.

Moura Coalfield

F.J. Taylor, under the supervision of Dr E. Polak and F.J. Moss, experimented with geophysical techniques to investigate the structures of the Moura Coalfield, Queensland, and particularly to locate faults of sufficient displacement to affect mining operations. The workable coal seams in the area studied lie at depths between 0 and 300 metres.

Seismic reflection produced good results for coal seams deeper than 100 metres. Using an offset shooting pattern, a strong reflector closely associated with the uppermost coal bed was clearly traced, and areas of faulting were deduced from the differences in reflections, or from their lack of continuity. Seismic refraction was used to provide information on the depth of weathering for correction of the reflection results. The use of seismic refraction methods to delineate coal seams too shallow to follow by the reflection method produced irregular time-distance curves which could not be readily interpreted.

Gravity and magnetic measurements were taken. Bouguer anomalies and magnetic contours were plotted, but further interpretation is needed before the usefulness of these methods can be evaluated.

Coastal Erosion Survey

On behalf of the Beach Protection Authority of the Queensland Co-ordinator General's Department, the Engineering Geophysics Group conducted a marine survey in the coastal waters between Brisbane and

Maroochydore. The State Department provided the ship and ship's crew, navigation system, and surveyors.

The primary methods employed were sonar boomer and sparker seismic reflection profiling for measurement of the thickness of unconsolidated sediments. In addition, temperature and salinity records were taken to indicate current patterns.

The installation and operation of the geophysical equipment, especially the seismic profiling apparatus, proved to present difficulties which led to termination of the survey before the total programme was complete. However, towards the end of the survey, a system was devised that gave satisfactory high-resolution data in the shallow waters traversed.

New South Wales

Shoalhaven Catchment

At the request of the Division of Plant Industry, CSIRO, part of the Shoalhaven Catchment, New South Wales, was investigated by E.P. Shelley to detect broad variations in soil types using an airborne gamma-ray spectrometer. The spectrometer measured total count and the individual contributions of potassium, uranium and thorium.

An area of 80 x 15 km was flown and the data will be processed and analysed by CSIRO.

Hunter Valley

Drs J. Roberts and B.S. Oversby of the Bureau, in co-operation with the Universities of New England and Newcastle, are investigating the Carboniferous sequence of the Hunter Valley. Study of the Lower Carboniferous sediments has played an important role in unravelling the geological history and structure of eastern Australia, and precise and detailed knowledge of the Hunter Valley sequences can be applied in other areas.

During 1970, when most field work was concentrated in the Rouchel area, brachiopod zones were defined and the stratigraphical values of many species were modified. Within the succession are some persistent layers of welded tuff, which are distinctive; when they are



Upper Palaeozoic beds outcropping at Benmore, Hunter Valley.

mapped, therefore, their attitudes help considerably in revealing the structures of the area, and to some extent assist in checking the time-significance of the faunal zones defined. Structurally, the area consists of two sets of intersecting folds cut by many high-angle faults. They appear to have been developed at the same time in a field of high lateral pressures.

Victoria

Victorian Irrigation System

An aerial survey was undertaken by the Bureau to assist the Victorian Rivers and Water Supply Commission to delineate areas of water seepage and abnormal salinity. Colour and infra-red colour photographs were taken of irrigation channels in northern Victoria (see also Photogeology, p. 34).

Tasmania

Zeehan Survey

The VLF Electromagnetic method was tested by W.J. Langron and P.J. Gillespie over ground already well known at Zeehan, Tasmania. The results showed that well-defined anomalies can be indicated by this method where mineralization approaches to within 30 metres of the surface and the strike of the mineralized zone is more or less in the direction of the transmitting system.

South Australia

Southwest Eromanga Basin

The survey of the Eromanga Basin was extended into South Australia as a joint project by the Bureau and the Geological Survey of South Australia. Two 1:250,000 Sheets were mapped during the year.

The oldest exposed sediments are deeply weathered Winton Formation of Cretaceous age. They are overlain unconformably by quartzose sandstone, probably Tertiary, which in turn is overlain by silcrete, gypsum, and chalcidonic limestone. The whole sequence is largely obscured by a veneer of Quaternary material. A large anticline which dominates the structure has been affected by post-Tertiary block faulting.

Eucla Basin

At the request of the South Australian Mines Department, a Bureau field party led by D.R. Waller made an airborne magnetic and radiometric survey of three 1:250,000 Sheet areas in and around the Eucla Basin.

Interpretation has not been completed, but preliminary analysis of the magnetic data suggests several topographic features in the magnetic basement. They include a north-striking trough about 3,000 metres deep in the Ooldea Sheet area and a northwesterly trough some 2,500 metres deep in the Cook Sheet area.

South Australian Helicopter Gravity Survey

The reconnaissance gravity survey of Australia was extended by covering more than twenty 1:250,000 Sheet areas in South Australia, equivalent to about one-third of the State. Previous work by the South Australian Department of Mines and various oil companies had covered most of the rest. The survey, which was carried out by contract, was supervised by F.W. Brown and a preliminary interpretation has been made by G.R. Pettifer. Some 7,300 new stations were established using a uniform grid spacing of 7 1/4 km (4 1/2 miles).

Two areas were involved: a large area in the western part of South Australia and a smaller area in the Flinders Ranges. Numerous gravity stations of previous surveys were occupied to enable reliable integration of results. In the western area, gravity variations show correspondence with well-known geological provinces: a major gravity

minimum corresponding with the Officer - Eucla sedimentary basin area is flanked on the north and south by areas of higher gravity corresponding to the Precambrian Musgrave and Gawler Blocks. Further interpretation is being undertaken to obtain a more detailed picture of the structures in this area. In the Flinders Ranges, the gravity patterns are consistent with a more uniform geological setting of rock types, mainly Proterozoic sediments of the Adelaide geosyncline; two areas of negative Bouguer anomaly correspond with outcropping granite and serve to define the subsurface limits, while a negative gravity pattern to the west corresponds with the Pirie-Torrens sedimentary basin.

Western Australia

Officer Basin

The Bureau and the Geological Survey of Western Australia began a joint survey of the Officer Basin. A preliminary reconnaissance was undertaken and observations were recorded in the Great Victoria and Gibson Deserts; systematic mapping will start in 1971.

Outcrop is generally poor and widely spaced; much of the basin is blanketed by sandhills and laterite. Gently dipping coarse arenite exposed in the area may be of Peruvian age, but is apparently unfossiliferous. Close to the edge of the basin are several areas containing outcrops of Proterozoic, or perhaps early Palaeozoic, sedimentary rocks.



Sandstone and laterite exposures in Morton Craig Range, Officer Basin.

Meekatharra Aeromagnetic Survey

An aeromagnetic survey of the Wiluna, Glengarry, and Kingston 1:250,000 sheets, based on Meekatharra, was carried out for the Bureau by contract, and results will be computed. The survey is part of a continuing programme to provide regional aeromagnetic coverage of the Precambrian Shield in Western Australia.

Kalgoorlie Gravity Survey

The 1969 helicopter gravity survey revealed gravity maxima over mineralized greenstone belts. As a result, a ground survey led by A.R. Fraser was undertaken in 1970 to obtain a series of more detailed gravity profiles across distinctive anomalous highs, with the object of constructing and testing interpretative models.

Preliminary interpretation by W. Anfiloff shows no radical departures from the results of the helicopter gravity survey, though the maxima, minima, and gradient of anomalies were adjusted within closer limits. Where detailed ground work confirmed the earlier helicopter reconnaissance results, the greater accuracy of the ground survey in the measurement of elevation is valuable because the interpretative techniques require accurate field data for their successful application.

Remote Sensing Survey

A test survey directed by E.P. Shelley was flown over two areas near Leonora and Laverton, Western Australia, comprising multispectral photography and detailed magnetometer and gamma-ray spectrometer coverage. Interpretation of the data is continuing.

Northern Territory

Amadeus Basin

Two drill holes were put down in the Amadeus Basin, Northern Territory, as part of a study of evaporites and sulphur in sedimentary basins. One hole was completed to 305 metres to the north of the Gardiner Range, penetrating gypsum and claystone to 92 metres, then mainly halite to total depth. Another hole, drilled near Inindia bore, penetrated 305 metres of mainly gypsum with lesser amounts of shale and claystone. Wire-line logs of spontaneous potential resistivity, integrated acoustic velocity with caliper, and gamma-ray-neutron, were run in both holes.

Arunta Complex

Work continued on the compilation of a metamorphic map of Central Australia, with the collection and examination of some 500 rocks specimens from several districts. The construction of a metallogenic map of Central Australia was started.

Four areas in the Arltunga Nappe Complex were examined in detail by R.D. Shaw and geologists from the Australian National University. In the Atnarpa area, six major thrust slices were shown to be refolded against the complex Atnarpa Antiform, while in several places series of parallel subordinate thrusts forming an imbricate structure are cut off by a major thrust; the boundary between the uppermost slice of Heavitree Quartzite with the overlying but older Arunta Complex is a folded thrust. In the Georgina Range/Mount Laughlin area, an east-trending syncline was mapped in Heavitree Quartzite, the Northern limb being overturned to the south; in its core, thrust-slices of both the younger Bitter Springs Formation and the older Arunta Complex are preserved. In the Claraville Homestead area, mapping was carried out on the boundary between retrograde metamorphic rocks associated with the nappe complex and high-grade metamorphic rocks to the north. The contact is sharp, but there is no sign of a thrust at the boundary. Three generations of folding were revealed in metamorphic rocks south of Mount Brassey.

Prospects in the Alice Springs and Alcoota areas were examined. In the Alcoota area, work was concentrated on exposures of Precambrian metamorphic rocks in the southern part, 19 metamorphic units being distinguished by composition and structural characteristics and their relationships tentatively elucidated. Reconnaissance traverses were made across the Upper Proterozoic sediments further north.

Ngalia Basin

Field work, except for some stratigraphic drilling, was completed in 1969. Four stratigraphic holes were drilled in 1970 by BMR rigs, three in the Napperby and one in the Mount Doreen sheet area. The aggregate depth drilled was 768 metres.

A Bulletin incorporating surface geology, drilling, seismic, gravity, and aeromagnetic surveys is being written.

Tennant Creek

The Tennant Creek, Northern Territory, 1:250,000 Sheet area was mapped by a party led by J. Mendum, except for two 1-mile Sheet areas mapped previously.

The Precambrian rocks which underlie most of the area have been divided into the Warramunga and Tomkinson Creek Beds. The Warramunga is essentially a deep-water sequence, with two distinctive volcanic layers and a shallow-water sequence at the top. It is extensively intruded by granite and all the known mineralization lies within it. The Tomkinson Creek Beds, which are at least locally unconformable on the Warramunga, are a shallow-water sequence which also includes some volcanic rocks. Both sequences are folded, as well as dislocated by faulting.

A study by E.C.E. Sedmik of the methods of magnetic anomaly interpretation suggested that the susceptibilities of the anomalous bodies could be determined and used to distinguish the massive ironstone from iron oxide disseminations in igneous and sedimentary rocks. Representative drill cores are being obtained for measurement of susceptibility and it is proposed to pursue this investigation in 1971.

An airborne gamma-ray spectrometer test was conducted by J.E. Rees during a detailed survey of 150 sq km of the Tennant Creek area. The results suggest that rock types may be differentiated by their differing gamma-ray spectra.

Victoria River

Aeromagnetic surveys of the Victoria River district, Northern Territory, were flown in 1966 and 1968, and geological mapping was completed in 1969.

Preliminary interpretation of the aeromagnetic surveys by J.E. Rees shows that magnetic features can be related to strong lineations along the margins of the basin, broader features inside or below the basin, and high-frequency anomalies attributed to the Antrim Plateau Volcanics. The latter are being used to delineate areas of the volcanics under sedimentary cover.

R.J. Bultitude supervised stratigraphic drilling and sample collection for a more detailed study of the Antrim Plateau Volcanics. Nine holes were drilled and they indicated that the volcanics are made up of numerous basalt flows. Microscopic and geochemical investigations are continuing in order to interpret the distribution of the numerous copper showings within the volcanics and to define possible exploration targets.

PAPUA - NEW GUINEA

(see also Resident Geologists)

Astrolabe and Ormond River

Geophysical surveys led by J.E.F. Gardener were made in the Astrolabe and Ormond River areas primarily to test various geophysical methods - electromagnetic (Turam and VLF), magnetic, self-potential, induced polarization, and radiometric - in a particular type of tropical terrain. The electromagnetic and induced polarization methods proved the most suitable for sulphide mineral exploration in these areas. The self-potential results were inconclusive, but localized anomalies may occur over some sulphide bodies. The magnetic results showed numerous anomalies due to basic rocks and magnetite, and it appears difficult to distinguish them from anomalies due to sulphide bodies.

Central Highlands

Most of the Mount Hagen - Goroka area was mapped in 1968. During 1970, selected areas were mapped in detail and a reconnaissance made of the lower Jimi Valley. A helicopter gravity survey was carried out at the same time as the geological mapping, thereby completing the reconnaissance gravity cover between the north coast and Mount Hagen.



Minj gravity station, northern New Guinea

East Papua Aeromagnetic Survey

An aeromagnetic survey, by contract, was undertaken of mainland East Papua and of an offshore area north of the mainland.

The offshore survey has been completed but the mainland survey has been severely delayed by adverse weather. The interpreted basement contour map indicates that basement is at or near the surface in the island areas. An elongate trough having an estimated depth of 3,000 metres extends eastward from the coastline, and basement deepens to 3,000 metres on the eastern margin of the area. Basement also deepens rapidly along latitude 8°S on the northern margin of the area, but here the sea floor deepens correspondingly.

New Guinea Airborne Seismic Survey

The swamp and jungle of the Ramu-Sepik plains of northern New Guinea make conventional land seismic operations impracticable in some areas. What is believed to be the first experimental airborne seismic survey was made to try to establish a method for application of seismic surveys to such areas, as well as to investigate sub-surface geological problems in the New Guinea Basin.



Landing site in kunai grass, New Guinea airborne seismic survey.

A helicopter was used to place in position explosives, shooting equipment, and sonobuoy transmitters, signals from which were received in a conventional recording system mounted in an aircraft. The systems were tested near Canberra and then in the Madang area before being moved to Angoram for the main programme.

The operation was not successful, owing mainly to the failure of the sonobuoy transmitters to withstand high ambient temperatures, but it was considered feasible to modify the instruments so as to make the technique operable. The experience gained should also enable an improved recording system to be designed for any future similar surveys. Considerable interest in the new method has been shown by overseas authorities and prospecting companies.

Eastern Papua and Bismarck Volcanoes

Studies of active and recently extinct volcanoes in eastern Papua were begun. It is expected that this work will lead to an understanding of the genesis of the lavas and their place in the geological evolution of Papua - New Guinea.



Recently extinct volcano, Cape Gloucester, New Britain.

During the year, specimens were collected from the D'Entrecasteaux Group, the Amphlett Islands, the Lusancay Islands, and Egum Atoll. Their compositions range from olivine basalt on Goodenough Island to obsidian and rhyolite on Fergusson, Dobu and Sonarva Islands.

The volcanoes off the north coast of New Guinea, between New Britain and the Schouten Islands, were examined, and extensive rock collections made. Like the rocks from the eastern part of the Bismarck arc, they are saturated basalts, 'andesites', and dacites. However, augite phenocrysts are common in the western rocks, whereas plagioclase is prominent in the eastern; rhyolites, occasionally seen in New Britain, appear to be absent in the western rocks.

The results obtained from these surveys have added significantly to the understanding of the volcanic processes, and will provide a useful basis for assessing the likely future behaviour of volcanoes which are dormant or nearly extinct. Some of these volcanoes will be considered for inclusion in the New Guinea volcano surveillance network.

ANTARCTICA

(see also Observatories, p. 36)

Sixteen gravity stations in Antarctica, four near Mawson and twelve in the northern Prince Charles Mountains, were occupied in 1970. All stations were tied to the world network base station at Mawson. This work represented a continuation of the project begun in summer 1968-69 to obtain reconnaissance gravity information in these areas during a geological, glaciological, and surveying programme. Further gravity work will be undertaken next season.

Regional geological mapping of the northern Prince Charles Mountains was continued in 1970 by a party led by I.R. McLeod. A field base was established at Moore Pyramid, 350 km south of Mawson, and traverses were made on foot and by helicopter. Adverse weather conditions prevented completion of the planned field programme. Rock samples were collected for the continuing joint programme of the Bureau and the Australian National University of isotopic dating of the rocks in Australian Antarctic Territory. Samples were



Outcrop at end of Forbes Glacier, near Mawson.

collected from the Mawson Coast - Framnes Mountain area and from Moore Pyramid and Martin Massif in the northern Prince Charles Mountains. Work to date indicates that the rocks are principally high-grade metamorphics, with an area of unmetamorphosed Permian sediments in the northeastern Prince Charles Mountains.

MARINE OPERATIONS

Marine operations by the Bureau have the objective of mapping the sea floor and the sedimentary pile below the sea floor of the continental shelf; of determining the extent, content, and structure of the sediments of the shelf; and of plotting their source, their movements, and their history; all with the ultimate objective of locating undersea mineral deposits.

Geological surveys (which also use geophysical methods) are concerned with the floor and the top few feet of sediment, and any mineral deposits that may lie there, such as phosphate or heavy minerals (beach sands). Geophysical surveys map the sequence below the sea floor, and are more concerned with delineating rock-types and structures that may contain, for instance, petroleum.

Marine Geological Survey

The 1970 survey, under the leadership of Dr H.A. Jones, covered an area of continental shelf from the Capricorn Channel south to Port Macquarie.



M.V. "San Pedro Strait" on the 1970 marine survey.

Echo sounder profiles and sparker traverses were run to delineate the topography of the sea floor and the character of the upper layers of sediment, and grab and corer samples were taken on a grid pattern. There is a sharp contrast between the Capricorn Channel, which is a depositional zone with no clear distinction between shelf and slope, and the narrow continental margin off Fraser Island, which has considerable relief and is mostly swept clean of sediment by currents. A drowned shallow-water reef was located at 180 metres in the Capricorn Channel - a feature that suggests that this part of the shelf has undergone no warping since late Pleistocene time.

Erosional channels cut into the top of the continental slope in the Curtis Channel were plotted; they probably funnel coarse sediment from the coastal deposits to the south, and carbonate detritus from islands to the north, into the deep basin offshore.

Sarker profiles off Fraser Island revealed the presence of a strong reflector unconformably below Recent sediments, and cropping out on the upper continental slope, where it forms a subhorizontal terrace under 275 metres of water. Fossiliferous, slightly phosphatic bedrock was dredged from this surface.

Submarine canyons were also discovered on the upper continental slope farther south, between Cape Moreton and Coffs Harbour, and here they appear to be related to the existing onshore drainage pattern. The seismic profiles reveal slumped sediments on the steep canyon walls in this area and two distinct unconformities were detected in the upper 250 metres of section near the edge of the shelf. Concretionary ferruginous and phosphatic rock was dredged from the uppermost continental slope at a depth of about 200 metres in the region of Coffs Harbour.

Marine Geophysical Survey

A marine geophysical survey was carried out by contract in an area including the Bismarck Sea, the coastal waters off southeast Papua, and the Gulf of Papua, and comprised some 24,000 km of traverse. Continuous seismic reflection, gravity, and magnetic methods were used on traverses, while daily seismic refraction readings were taken to determine the velocities of seismic waves in the seabed.

Several sophisticated navigation techniques were used to provide the accurate position fixes and velocities required for marine gravity surveying, including a satellite for primary control. Three computers were used onboard: one to carry out computations associated with the satellite navigation system; one to process seismic data; and the third to handle the large volume of navigational gravity and magnetic data and to provide constant estimates of the ship's position.

Thick sediments were found throughout most of the Gulf of Papua and several structures favourable for petroleum exploration were indicated. Considerable interest was shown by the oil industry in the data gathered from southeast Papua, as exploration licences will soon be granted in this area. No evidence was found to suggest that the Northern New Guinea Basin extends offshore, but relatively thick sediments were found in the Vitiaz Strait and in the Kimbe Bay area of New Britain. Several geological structures previously mapped on land are seen to extend onto the sea floor. There is a pronounced correlation between east-west magnetic lineations measured and earthquake epicentres in the Bismarck Sea, providing further evidence of some form of suture in the earth's crust.

LABORATORY STUDIES

Palaeontology

Details of the extent and content of palaeontological laboratory work are set out in the attached figures.

Vertebrate Palaeontology. Throughout the year, the fauna collected at Bullock Creek, Northern Territory, has been investigated by M.D. Plane. The remains of an extinct family of grass-eating marsupials should extend considerably our knowledge of Australian Tertiary mammals.

The Pliocene marsupial Protemnodon otibandus Plane, first described from New Guinea, was identified in a marine sequence from Victoria and from Chinchilla, Queensland. It is, therefore, the widest ranging kangaroo yet known.

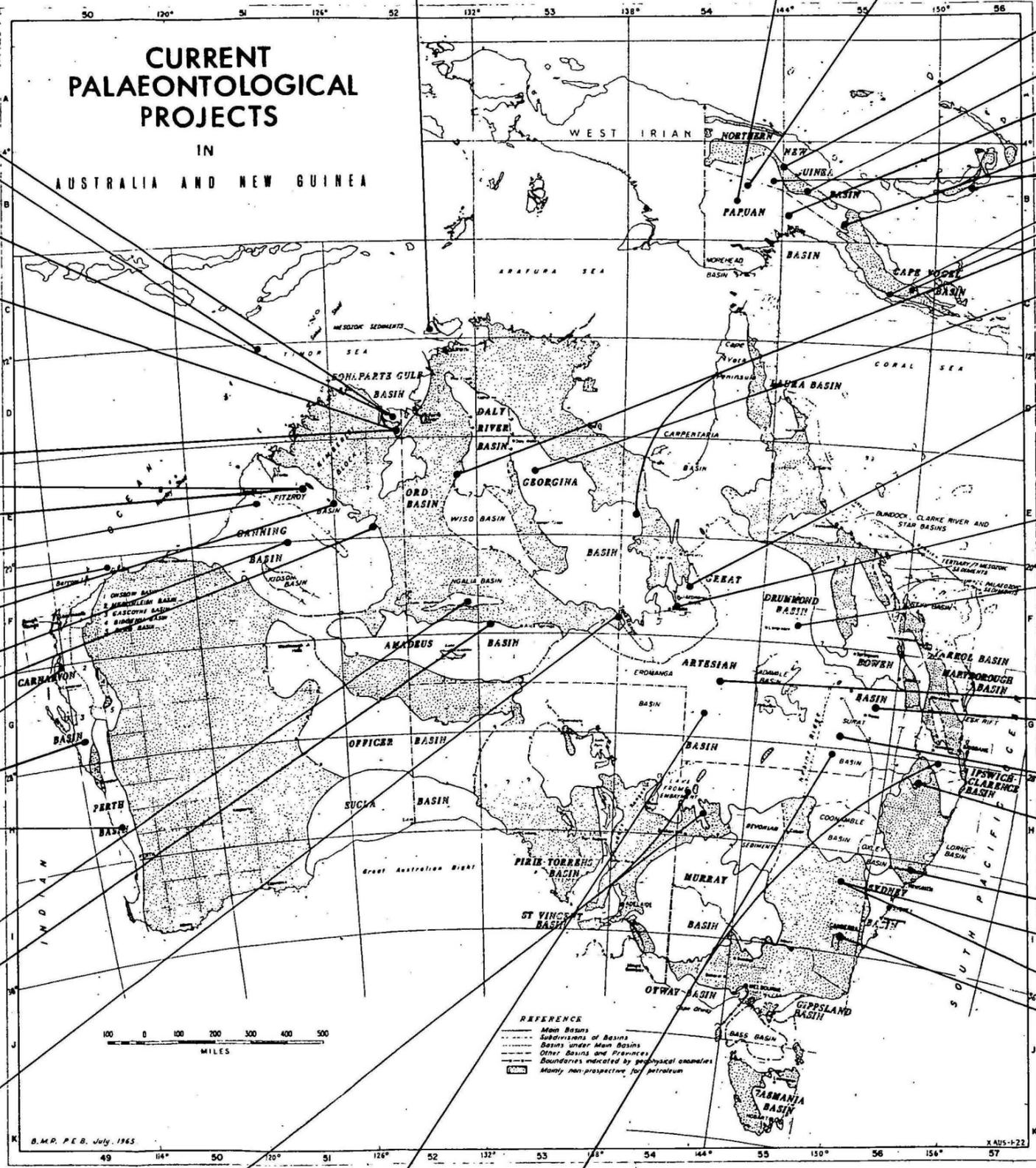
Invertebrate Palaeontology. Australian Lower Palaeozoic trilobites have been under intensive study for several years. Dr A.A. Öpik is in the late stages of a comprehensive investigation of Australian Agnostida, which are the main key to the dating of Middle and Upper Cambrian sediments, and has also completed monographic accounts of the family Dolichometopidae and the genera Xystridura and Redlichia. Dr J.H. Shergold is examining collections of late Cambrian and early Ordovician trilobites from Queensland, and Miss J. Gilbert-Tomlinson is investigating the dikelokephalinids of northern Australia. Dr D.L. Strusz and Dr Shergold are studying the Silurian trilobite Encrinurus, Dr Strusz having spent two months in Europe examining the classical areas of the Silurian and Devonian.

G.C. Young is working on collections of the Devonian fish Bothriolepis from New South Wales and Antarctica, and towards the end of the year joined a New Zealand Antarctic Expedition to make further collections of fossil fish.

Dr J.M. Dickins is the convenor of the organizing committee for the Third Gondwana Symposium to be held in Canberra in August, 1973.

Micropalaeontology. 2,324 samples were worked and prepared for examination of their microfaunal content; 835 thin sections of microfossils were prepared; and about 1,300 lb of rock samples were digested in acid to extract conodonts.

CURRENT PALAEOONTOLOGICAL PROJECTS IN AUSTRALIA AND NEW GUINEA



- Late Cambrian trilobites
- Tertiary foraminifera from offshore wells
- Upper Devonian brachiopods from the Bonaparte Gulf Basin
- Reworked Ordovician conodonts in the Upper Palaeozoic rocks of the Bonaparte Gulf Basin
- Lower Carboniferous brachiopods from the Bonaparte Gulf Basin
- Lower Carboniferous ostracods, Bonaparte Gulf Basin
- Lower Carboniferous and Upper Devonian ostracods, Canning Basin
- Upper Devonian conodonts from the Canning Basin
- Devonian floras of the Canning Basin
- Tertiary foraminifera from off-shore wells
- Upper Devonian receptaculitids from Fitzroy Basin, W.A.
- Ordovician faunas from Canning Basin
- Lower Ordovician Dikelokcephalinidae from northern Australia
- Upper Cretaceous foraminifera and nannoplankton, Western Australia
- Tertiary pollen grains, Napperby area
- Lower Ordovician conodonts from the Amadeus Basin, N.T.
- Ordovician trilobites (Rusophycus)

Late Cambrian and early Ordovician trilobites (Bancannia Trough)

Palynology of the Cretaceous Rolling Downs Group, Eromanga Basin (Qld, N.S.W.)

Neocomian-Albian-Albian palynological zonation in the Surat Basin (Qld)

- Cenomanian spores, pollen and microplankton, Bathurst Island
- Palynomorphs and microplankton of Jurassic and Cretaceous in the Papuan-Morehead Basins
- Land mammals Upper Cretaceous and Tertiary
- Lower Jurassic marine fauna
- Tertiary larger foraminifera, Papua & New Guinea
- Jurassic, Cretaceous and Tertiary palynomorphs from Papua
- New Guinea Tertiary rodents
- Tertiary larger Foraminifera, Papua & New Guinea
- Upper Cretaceous foraminifera, Papua-New Guinea
- Foraminifera from eastern Papua
- Tertiary mammals from N.T. and Qld.
- Agnostid trilobites from N.T. and N.S.W.
- Middle Cambrian trilobites of Northern Australia
- Late Cambrian trilobites (Chatsworth)
- Late Cambrian and early Ordovician trilobites (S. Burke River Structural Belt)
- Permian spores and pollen, Galilee Basin
- Jurassic and Cretaceous palynomorphs from the Great Artesian Basin
- Cretaceous ammonites from Australia
- Palaeozoic and Mesozoic plants
- Devonian, Carboniferous and Permian faunas from Warwick, Drake and Texas
- Carboniferous brachiopods of the Hunter Valley area
- Lower Devonian lichen trilobites from Wellington
- Lower Devonian brachiopods, south eastern Australia
- Silurian encrinurid trilobites of south-eastern Australia

Dr D.J. Belford is studying foraminifera from wells off-shore from Western Australia, Papua, and New Guinea. Lower Middle Palaeocene and possibly Lower Palaeocene (Danian) foraminifera were identified from Sahul Shoals No. 1 well, Western Australia. This is the first record of rocks of this age in the Australian region. Dr M. Owen has been studying the Cretaceous Foraminifera of Western Australia, so as to provide a detailed biostratigraphic framework for rocks of that age and throw light on the palaeoecology of the fossils. The early stages of a study of Upper Cretaceous calcareous nannoplankton from the same area have already indicated the stratigraphic value of this group.

Dr P.J. Jones continued his examination of ostracods from Lower Carboniferous rocks of the Bonaparte Gulf Basin, using computer techniques for numerical classification of certain species. Together with Dr Shergold and E.C. Druce, he has proposed a three-stage sequence of trilobite and conodont faunas around the Cambrian - Ordovician boundary in Western Queensland; these can be used for intra- and inter-continental correlation.

Larger foraminifera from New Britain were investigated by Dr J.G. Binnekamp. Several faunal assemblages have been defined, ranging from Upper Eocene to Middle Miocene. Younger assemblages of planktonic foraminifera from New Britain are also being studied.

Dr D. Burger studied the palynology of the Lower Cretaceous Rolling Downs Group, Queensland, and established a basis for correlation of sequences in different areas. He has begun a study of the palynology of the Carpentaria Basin.

Dr Burger has continued research into autofluorescence in pollen grains; pollen grains of different ages show different fluorescent colours under ultra-violet light and the current research project is investigating the significance of this feature for geological correlation. Dr M. Norvick is examining Permian spore and pollen assemblages from Queensland.

Petrology, Geochemistry and Geochronology

Geochemistry of Australian Granites. Dr J.W. Sheraton and Miss B. Labonne have continued investigations on the major project of the geochemistry of Australian granites. 869 specimens of north Queensland granites were collected, and are being examined both petrologically and chemically. The aim of the whole project is to delineate geochemical provinces and assemblages, relate them to known ore occurrences, and use the data and correlations to forecast areas of potential for mineral search.

Strangways Range Carbonatite. The only authenticated carbonatite so far found in Australia was recognized a few years ago by P.W. Crohn in the Strangways Range, Central Australia. The occurrence is being studied in detail by Dr D.C. Gellatly and P.W. Crohn (now with the Northern Territory Geological Survey). The carbonatite is stratiform, and drilling has revealed that the commonest rock type, rarely exposed, is a foliated biotite-calcite rock containing a little amphibolite and apatite.

Porphyritic dolomite-calcite carbonatite also makes up a substantial portion of the mass. Some of the drill cores have been analysed spectrographically, but the results are not yet complete. The carbonatite is of potential economic interest for apatite, rare earths, vermiculite, and gem-quality zircon.

Cloncurry - Mount Isa Rocks. Dr A.Y. Glikson, who was attached to the field party mapping the Cloncurry - Mount Isa area (see p. 12), is studying the metamorphic and igneous rock suites. Petrological and geochemical studies are being supplemented by mineralogical investigations with an electron microprobe, in which R.N. England is tracing the association of mineralogical changes with progressive metamorphism.

Electron Microprobe and Scanning Electron Microscope. R.N. England, together with Dr H.L. Davies, is undertaking a study of mineral variations in ultramafic and associated rocks in eastern Papua. This has revealed differences in mineral composition between cumulus and 'non-cumulus' ultramafic rocks. The cumulus ultramafic rocks have been formed by crystal settling from basaltic magma intruded into oceanic crust; the 'non-cumulus' ultramafic rocks have metamorphic texture and probably represent pre-existing mantle. Another investigation, of micas from the Dean Quartzite in Central Australia, has shown the presence of the mineral pyrophyllite. Kyanite is associated with the pyrophyllite, an unusual association which poses problems in physical chemistry not yet fully solved, though several lines of investigation are in progress.

Direct Reading Optical Spectrograph. 8,000 elemental determinations, and semi-quantitative analysis of about 200 specimens, were made during 1970.

X-ray Diffraction Laboratory. 939 mineral identifications were made for field parties, and the identity of 450 museum specimens checked. Assistance was given to the Royal Australian Mint with the problem of detecting forged sovereigns.

Geochemistry of Carbonate Rocks. 450 rock samples from the Macarthur River area, Northern Territory, were analysed by C.W. Claxton. This is part of a study of the depositional environment of certain carbonate

formations in the area in which a large silver-lead-zinc deposit is being investigated by Mount Isa Mines Ltd.

Corin Dam Leakage. The spring water flowing from the toe of Corin Dam, Australian Capital Territory, was continuously monitored, along with periodical checks of outlet tunnel leaks and springs near the dam. The pattern is one of gradual flushing from the rock-fill and abutment rock of water made acid by oxidation of pyrite.

Lake Burley Griffin Pollution Study. A.D. Haldane and Miss H.R. Lord, who conducted the Corin Dam investigations, began a study in collaboration with the Departments of Works and the Interior, designed to give a reliable basis for prediction of the behaviour of zinc in Lake Burley Griffin, Canberra, under varying conditions of flow in the feeding rivers. A feature already apparent is the high level of copper, lead, and particularly zinc, in sediment now being deposited in the lake.

Isotope Geology. Dr J.A. Cooper dated the Glen Gordon Volcanics of the Herberton - Mount Garnet area of Queensland by the Rb/Sr method; the volcanics provide good field control in establishing age relationships in the area as they represent the oldest igneous activity recognized. He also dated some glauconites from the Ngalia Basin, Northern Territory, by K/Ar and Rb/Sr method. At the invitation of the Woods Hole Oceanographic Institute of Massachusetts, Dr Cooper is contributing to a comprehensive study of Black Sea sediment cores.

New Guinea Geochronology. R.W. Page continued work on the geochronology of rocks from the New Guinea area, and has established a chronology of igneous and tectonic activity and mineralization for the Mesozoic and Cainozoic eras. All mineralization so far dated is less than 15 million years old, and some near the West Irian border is as young as one million years.

Exploration Geochemistry. Dr K.R. Walker spent two months overseas studying the latest advances in techniques of exploration geochemistry, and A.D. Haldane visited Ceylon to take part in an instruction course for geochemists and exploration geologists from South-East Asian countries.

Petroleum Technology. Studies were instituted by Dr T.G. Powell into three aspects of petroleum geochemistry: the diagenetic changes that organic matter of marine origin may undergo; the examination by gas chromatography of amino acids from cell walls of bacteria (in conjunction with the Baas Becking Geobiological Research Laboratory); and, as part of the Estuary Study Project, the composition of organic material in the sediments of Broad Sound as a potential petroleum source.

The laboratory undertook numerous core analyses and formation fluid analyses, which contribute to knowledge of reservoir characteristics; it also examined Australian deposits of barytes and bentonite to assess their suitability for use in drilling muds.

Sedimentology

The principal activity of the Sedimentology Laboratory during the year has been described in the Bowen Basin study (see p. 11).

New techniques evolved or adapted during the year include a method for disaggregating and photographing sandstone so that the sphericity of the quartz grains can be measured; and an adaptation of a known method of X-ray radiography of thin rock slabs to show internal sedimentary features. Both of these techniques aid in understanding the genesis of sedimentary rocks.

A computer programme for the correction of cross-stratification measurements for tectonic tilt, written by Dr B.G. Jones while at the Australian National University, was modified and adapted by him for use by the laboratory. The programme calculates the average orientation of various groups of data and gives a statistical analysis of the results.

Photogeology

Six 1:250,000 Sheets and two other areas were photo-interpreted for field use, and a special study was made of coastal erosion in south-east Queensland for the Engineering Geophysics Group. C.J. Simpson visited field parties in the Carpentaria Basin and Central Australia to check his photo-interpretations.

Colour and colour infra-red photographs taken by plane in northern Victoria (see p. 16) have proved useful for the detection of irrigation channel leakage and areas affected by groundwater salinity, as well as for several aspects of farm management.

An instrument was designed to allow stereoscopic viewing of uncut 70 mm strip film, and was constructed in the geophysical workshops.

For most of the year, C.E. Maffi was on loan to a United Nations Special Fund project in Brazil.

Palaeomagnetism

Rocks from the Bowen Basin and Gosses Bluff were measured by E.G. Manwaring. A new low-speed spinner magnetometer has been acquired and is being calibrated.

JOINT STUDIES

This section of the report deals with studies undertaken jointly with organizations other than State Geological Surveys (which co-operate with the Bureau in many field operations). See also Arunta Complex (p. 20), Hunter Valley (p. 15) and Antarctica (p. 25).

Crustal Study

During 1969, the Bureau conducted a comprehensive survey in the New Britain - New Ireland region aimed at gaining as much information as possible about crustal structure and composition. The Hawaiian Institute of Geophysics, the University of Queensland, the Australian National University, and the Department of the Interior, all contributed personnel to the project.

In 1970, attention was devoted first to ensuring that data from the geological, gravity, seismic, and magnetic surveys were presented in compatible forms, and later to the interpretation of the seismic data. For interpretation, a number of profiles were selected to which standard reciprocal seismic refraction interpretation methods could be applied. Interpretation is expected to be finished in 1971. Depths and velocities of the various refractors have been obtained and their relation to gravity and geological information is being investigated. Vulcanological studies are also proceeding for assimilation into the total picture.

Three officers of the Bureau took part in oceanographic investigations organized by the Hawaiian Institute of Geophysics. These comprised mainly a two-ship seismic refraction exercise in the Solomon Sea, Bismarck Sea, and the Pacific Ocean north of New Zealand. J.B. Connelly later visited the Institute to assist in the interpretation of results and to study its techniques.

Gosses Bluff

The investigation of the structure and origin of Gosses Bluff in Central Australia has been a detailed joint study by the Bureau and the United States Geological Survey. Geological mapping, aeromagnetic, ground magnetic, gravity, and seismic reflection surveys were completed in 1969. Analysis and interpretation, particularly of the gravity and seismic, was continued during 1970.

The present topographic expression of Gosses Bluff is a ring of hills only 4 km in diameter, but the overall structure has been shown to be 21 km across. The structure extends to a depth of 4½ km and the rocks have been brought to the surface in the centre of Gosses Bluff from a depth of 3 km.

Various theories have been proposed for the origin of Gosses Bluff, and the present study concludes that the Gosses Bluff structure was caused by the impact of a comet about 130 million years ago. A joint paper on the project will be published shortly.

Mallacoota Inlet

(For comparison with the Broad Sound estuary study see p. 10.) The Mallacoota Inlet on the New South Wales - Victoria border is being investigated jointly by the Bureau and the Australian National University. Geological, sedimentological, and geochemical surveys started in October 1970.

Baas Becking Geobiological Research Laboratory

The Baas Becking Geobiological Research Laboratory is controlled jointly by the Bureau, CSIRO, and the Australian Mineral Industry Research Organisation, staffed by the Bureau and CSIRO, and housed in the Bureau. It was set up to continue and extend the work of the late L.G.M. Baas Becking on bacterial influence on the formation of syngenetic ore deposits, and consists of two groups; a microbiological group staffed by CSIRO and a mineralogical group staffed jointly by the Bureau and CSIRO.

The work of the biological group has been based on the following projects; the physiology and biochemistry of sulphate - reducing bacteria (Dr P.A. Trudinger and Miss L.A. Chambers); the concentration of metals by bacteria (Dr Trudinger and Dr H.E. Jones); the toxicity of metals to micro-organisms (Dr B. Bubela); and the taxonomy and evolutionary status of sulphur-metabolising organisms (Dr Jones).

The mineralogical group has carried out the following studies: the effects of oxygen, temperature, and pressure on iron and copper sulphides (W.M.B. Roberts); the physical chemistry of mixed electrolytes (Dr C.J. Downes, CSIRO); the synthesis of scapolite, and

the melting point of sulphides in the presence of water (Dr I.B. Lambert, CSIRO); the precipitation of monomineralic bands from homogeneous multimetallic sources (Drs Lambert and Bubela); the reactions of volcanic thermal waters with surrounding rocks (Dr J. Ferguson); and the field study of metal enrichment in the volcano exhalative - sedimentary environment of Matupi Harbour, Rabaul (Drs Ferguson and Lambert).

Volcano Surveillance

G.A.M. Taylor, in collaboration with the Australian National University, has been studying the problem of telemetering water-tube tiltmeter data, a major problem in volcano surveillance.

OBSERVATORIES

The Bureau maintained five geophysical observatories in 1970. Their locations and the observers-in-charge are as follows:

- . Toolangi, Victoria - C.A. van der Waal (who died in 1971)
- . Mundaring, Western Australia - P.J. Gregson
- . Port Moresby, TPNG - I.B. Everingham
- . Macquarie Island - J.R. Meath
- . Mawson, Antarctica - M.J.M. Robertson

Each observatory operates geomagnetic and seismological recording equipment. Ionospheric sounders are operated at Port Moresby and Mundaring in co-operation with the Ionospheric Prediction Service Division of the Department of the Interior. A number of seismological outstations is attached to each main observatory.

Seismology

Seismological recordings are used in the studies of the times and locations of earthquakes, the risks of damage, the mechanism of earthquakes and the stresses in the Earth which cause them, and the structure of the interior of the Earth through which seismic waves travel.

Stations were operated in Western Australia at Mundaring, Kalgoorlie, Meekatharra, Kununurra (with Public Works Department of Western Australia), and Meckering (with Shire Council); in Papua-New Guinea at Port Moresby, Lae, Goroka, Wabag, and Momote; and at Toolangi (Victoria), Darwin (Northern Territory), Norfolk Island (with Ionospheric Prediction Service Division), Macquarie Island, and Mawson (Antarctica). Timing at all stations was brought to first class level by the addition of digital clocks.

Preliminary data from all fixed stations were distributed by Mundaring, Port Moresby, and Toolangi observatories. Final data for the International Seismological Commission were processed in Canberra; from July 1970, these data were transmitted on magnetic tape instead of the punched cards previously used.

After the damaging earthquake at Madang on 31 October 1970, two temporary stations were set up in the vicinity to record the after-shock sequence. Field stations had previously been established in the region as part of the Seismic Group's experimental airborne survey.

In June 1970, the Public Works Department of Western Australia organized a 500,000 kg explosion at the main Ord River dam site. Valuable travel-time data were obtained at portable field stations by parties from the Bureau, Australian National University, and Adelaide University.

A strong-motion data centre was established in Canberra, after strong support had been given by owners of accelerographs in Australia and Papua-New Guinea. This involved the setting up of schemes for copying and enlarging the records, digitization of the copies, and computer derivation of ground accelerations, velocity, and displacement.

Preliminary steps were taken to establish an earthquake data file for the Australian region (latitudes 0-90°S, longitudes 75-165°E).

Officers from Canberra and Port Moresby constituted a committee to review seismological operations in Papua-New Guinea. After inspecting establishments, the committee made recommendations aimed at streamlining and co-ordinating efforts in regional seismology.

Ionospheric Recording

Standard programmes continued at Port Moresby and Mundaring, and data were published by the Ionospheric Prediction Service Division.

Mundaring was selected by the Consultative Committee on International Radio as one of a world network of stations to provide the ionospheric index. A modern more powerful ionosonde has been installed at Mundaring.

Geomagnetism

The purposes for maintaining continuous recordings of changes in the Earth's magnetic field are:

- . to provide basic data for the preparation of charts of magnetic variations
- . to study magnetic disturbances and their effect on radio wave propagation
- . to provide corrections and warnings of disturbed conditions for mineral exploration magnetic surveys
- . to contribute to international investigations of the nature and sources of the Earth's magnetic field and its variations
- . in conjunction with satellite observations, to study the interaction of the Earth's outer atmosphere and magnetic field with the solar wind and inter-planetary medium.
- . to maintain standards for measurement of the magnetic field in Australia.

Standard programmes were maintained at Gngara (Western Australia), Port Moresby, Toolangi, Macquarie Island, and Mawson.

A monthly Geophysical Observatory Report was prepared and issued, magnetograms were digitized (59 observatory-months) and mean hourly values were derived (96 observatory-months). Data and magnetograms were supplied to prospecting companies and other organizations.

Regional Magnetic Surveys

The first-order survey of the Australian region comprises 70 stations established at about 500 km spacing, which are reoccupied every 5 or 10 years to determine secular variation of the magnetic field. This survey was completed in 1970 with the occupation of a few remaining continental stations and Cocos Island. All results were adjusted to epoch 1970.0, isomagnetic maps were drawn, and accompanying text was prepared.

In third-order surveys, measurements are made at intervals of about 15 km along available roads and tracks to fill in details of the field between first-order stations. During 1970, two third-order surveys were made, in northern Queensland and eastern South Australia. This completed the coverage of Australia east of the 138°E meridian, except for Tasmania. The results of earlier surveys in southern Queensland and New South Wales were updated to epoch 1970.0 and included as background to the first-order isomagnetic maps.

Observations in Antarctica in 1970 were confined to the Amery Iceshelf area, Prince Charles Mountains, and Davis.

Tests of three compass swinging bases at Tullamarine Airport showed that, at most, one of these may be suitable for calibrating aircraft compasses.

ENGINEERING GEOLOGY AND GEOPHYSICS

The Engineering Geology and Geophysics Groups, which work in close co-operation, have been engaged throughout the year in a variety of investigations, mostly in the Australian Capital Territory and the Territory of Papua and New Guinea. The Engineering Geology Group was led by Dr E.K. Carter and later by G.M. Burton, and the Engineering Geophysics Group by Dr E.J. Polak.

Principal activities were:

- . Supervisor of major projects in Papua and New Guinea - design investigations for the Ramu hydro-electric project; construction of the second stage of the Sirinumu dam; and preliminary investigations of the Rouna 3 and Musa Gorge hydro-electric projects (see p. 42).
- . Foundation investigations of the site for a nuclear power station at Jervis Bay, Australian Capital Territory
- . Feasibility studies of possible future dam sites within the Australian Capital Territory



Core from Googong dam site, A.C.T.

- . A continuing study of the hydrogeology of the Australian Capital Territory, and associated water supply and drainage problems
- . A continuing study of the hydrogeological regime of Lake George, New South Wales
- . Moura Coalfield Project (see p. 14).
- . Tunnel, roadway, and building site investigations, soil mapping for engineering purposes, and urban development mapping in advance of the construction of new towns in the Australian Capital Territory
- . Investigations of materials resources and testing of materials.

RESIDENT GEOLOGISTS

Apart from observatories, the Bureau maintains two resident groups outside Canberra. In Papua-New Guinea, it supplies the geological personnel and, where necessary, supervision of an office attached to the Department of Lands and Surveys. In Darwin, there is a small group which explores for, and investigates occurrences of, uranium and allied minerals in northern Australia.

PAPUA-NEW GUINEA

The Chief Resident Geologist, A. Renwick, had various special activities including membership of the Mining Advisory Board, the Petroleum Advisory Board, and the Science Faculty of the University of Papua and New Guinea. He was chairman of the Advisory Committee on Seismology and Earthquake Engineering and the Scientific Advisory Committee to the National Parks Board. In addition, a considerable amount of time was spent in preparing for the 1970 ANZAAS Congress, for which he was chairman of the organizing committee for Section 3, Geology. The congress was the first major scientific meeting ever held in Port Moresby.

Regional Mapping

In addition to taking part in some of the regional mapping projects mounted from Canberra, the Section has continued the mapping of the Markham, Port Moresby, and Buna 1:250,000 Sheets. In the Markham area, gaps in the geological coverage were filled, and compilation is under way. The Port Moresby Sheet is at the same stage, and the geological traverses undertaken in 1970 were extended into the Buna Sheet immediately to the north, which is also being compiled.

Mineral Investigations

The assessment of the mineral resources of the Territory is important to the country at this stage of its development. The work has hitherto been hampered by shortage of staff, but it is planned to play a bigger role in future activities of the section. Specific investigations included:

- . An assessment of the beach-sand potential of Karkar Island. Sampling and mineralogy revealed low proportions of heavy minerals in the beach sands with a few minor local concentrations of magnetite-rich sands. The physical conditions of beach formation on Karkar are not conducive to the accumulation of economic sands.
- . A reported copper occurrence in the Kwama River was investigated during the regional mapping. No copper was found in the reported position, but float material was submitted for assay to determine background values, and stream sediment samples were taken.
- . Throughout the regional mapping of the Markham Sheet, stream sediment samples and panned heavy mineral samples have been collected for geochemical analysis. The sample density is not high enough for direct mineral exploration, but is sufficient to give background values for the major rock types and may allow broad areas worthy of more detailed work to be outlined.

Engineering Geology

Major activities during the year were:

- . The Ramu 1 project envisages the construction of an underground power station to utilize more than 200 metres of head at the upper end of the Ramu gorge, and design investigations for the project have been proceeding throughout the year, under the general supervision of Dr E.K. Carter. The project is sited in deformed Miocene sediments, intruded by dolerite and overlain by unconsolidated Quaternary sediments. The power station will be excavated mainly in marble and dolerite and the associated underground and surface work in or on greywacke, shale, and dolerite, all deeply weathered in places.
- . The proposed hydro-electric scheme in the Musa Gorge of eastern Papua was also investigated; several alternative dam sites were mapped, with the aid of a Canberra-based geophysical party, and the most suitable one nominated. In and around the reservoir basin, 500 sq km were mapped and the possibility of increased seismicity due to the filled reservoir was assessed.
- . Work on the Laloki River hydro-electric scheme, which supplies power to Port Moresby, continued throughout the year.

- . Site investigations were made by Dr G.P. Robinson during the construction of the Sirinumu Dam Stage 2, which involves raising the main dam and five saddle dams by 7 metres and building three new saddle dams and a new spillway. The site for the Rouna 3 power station, and alternative sites for Rouna 4, were also investigated.
- . Dr Robinson and P.E. Pieters investigated groundwater possibilities at several localities in the Central District and recommended drilling programmes. P.E. Pieters continued the investigation of village water supplies in the Central District in collaboration with the Regional Health Officer.

Vulcanology

The Vulcanological Laboratory at Rabaul, under the supervision of W.D. Palfreyman, continued the surveillance of volcanic and allied seismic activity in the Territory:

- . Ulawun Volcano began activity in January 1970 after several years of quiescence. Activity built up from 9 January until 21 January, when dense ash-laden vapour was being ejected from three summit vents to a height of over 4,500 metres. On 22 January, a nuee ardente descended the northwest flank and devastated an area of forest about 2½ km square. Three lava flows followed in the next few days, but on 2 February activity slackened distinctly and the eruption ended on 9 February.
- . Manam Volcano was active on a reduced scale throughout the year, as was Bagana on Bougainville Island. Summit activity at Laugila was renewed during late May after seven months of repose, and built up to a peak in late July, when ash ejections averaged one per hour.
- . Considerable fumarolic activity was noted at and near the summit of Lamington, and a telemetered seismograph station was installed.

Throughout the year, the group collected and interpreted seismic, temperature, and tilt data from various stations in the Territory.



Ulawun Volcano erupting, January 1970.

DARWIN GROUP

Activities in 1970 were geological and geochemical mapping under the supervision of C.E. Prichard, and geophysical investigations by J. Williams and P. Bullock.

Active prospecting for uranium in the Rum Jungle district by the Bureau ceased in 1970, and areas previously under reserve were allotted to companies.

In order to test if subsurface alpha activity would indicate uranium provinces more effectively than surface gamma activity, a reconnaissance was made along the Sturt Highway from Darwin to Pine Creek. Gamma counts were recorded from the surface and alpha counts from an auger drill hole at each 5-mile post. Both methods proved equally effective.

Various self-potential and electromagnetic anomalies in the Rum Jungle area were investigated by rotary drilling and geophysical logging; they were found to be due to unweathered black slate at shallow depth.

Several of the anomalies located by the 1969 airborne gamma-ray spectrometer survey were investigated on the ground with a portable gamma-ray spectrometer, and two were drilled. Both were found to be due to the uranium series.

Slingram and radiometric traverses were made over an area of about 12 square km in the Stapleton area. Slingram results correlate well with known geological boundaries. The radiometry showed a high background over the Waterhouse Granite and an anomaly coincident with the boundary between the Celia Dolomite and Crater Formation. The Stapleton area was also surveyed by an auger drill pattern; it contained no geophysical or geochemical anomalies of economic significance, but geochemistry helped in distinguishing between rock units in an area of poor outcrop.

The Huandot and Celia magnesite localities were each tested by three rotary drill holes. Subsurface, the magnesite is interrupted by clayey beds and weathered and silicified zones, and could only be exploited by selective mining. Two 150-metre holes were drilled in the Shirley area to check structure in the Crater Formation and provide samples for mineralogy and radiometric examination.

Carbonaceous shale in the Coronation Hill area was located by self-potential tests. It is a host rock for uranium mineralization, and pattern drilling has been recommended.

SPECIAL MAPS

In addition to maps resulting directly from field work, an important part of the Bureau's map production programme is the compilation of special maps which represent another level in the generalization and synthesis of geological and geophysical knowledge. Some of these maps are compiled on behalf of other organizations, such as the Commission for the Geological Map of the World, a Commission associated with the International Union of Geological Sciences.

Tectonic Map of Australia and New Guinea (1:5,000,000)

The tectonic map is intended to show the deformational history of the region. It is to be published by the Geological Society of Australia as a contribution to the world tectonic map series of the Commission for the Geological Map of the World.

Small groups in the various States have been amassing and sorting information for several years, with the Bureau providing facilities for compilation and drafting. The Canberra committee, consisting of three officers of the Bureau (H.F. Douth, K.A. Plumb, and Miss R.G. Warren) and a member of the Australian National University staff, has been mainly responsible for determining the basic concepts of the map, its design and colour scheme. It has compiled the tectonic detail of most of northern Australia and of Papua and New Guinea, co-ordinated the drafts of other groups, and compiled the final map of the region.

The final compilation was being edited at the end of the year, and it is hoped to publish the map in 1971.

Metallogenic Map of Australia and New Guinea (1:5,000,000)

The metallogenic map, which shows the origin, geological history, and relationships of mineral deposits and mineral provinces of Australia, Papua, and New Guinea, is the Australian contribution to the Metallogenic Map of the World, also being compiled under the auspices of the Commission for the Geological Map of the World.

As the genesis of mineral deposits is closely tied to tectonics, I.R. McLeod and Miss Warren, who compiled the map, kept in close touch with those compiling the tectonic map, and an adaptation of the tectonic map was used as a base for the portrayal of metallogenesis.

Compilation of the metallogenic map, which began in 1966, was completed in 1970 and the accompanying commentary is now being written.

Regional Gravity Map of Australia (1 inch : 40 miles)

The Bureau has already covered much of Australia by a network of reconnaissance gravity surveys with a station density of at least one per 50 square miles (approximately 130 sq km). From these surveys, a map is gradually being compiled of Bouguer anomaly contours.

The map shows the difference between the theoretical value of the earth's gravity and the observed value, after corrections have been made to convert the observed value to a common basis. Bouguer anomaly maps are of value in exploration for minerals and particularly for petroleum.

A map in colour has been designed and will be issued in 1971.

Groundwater Maps of Australia

Four groundwater maps of Australia are being compiled for the Australian Water Resources Council by a sub-committee led by G.M. Burton. Three show the distribution and characteristics of different types of aquifer (fractured rock, alluvium, and sedimentary basins) and the fourth is a synthesis and generalization of the other three. At the end of the year, the first three maps were at the editing stage and compilation of the fourth was more than half completed.

Geological Map of Australia and Oceania (1:5,000,000)

There are 16 sheets in this series, of which 13 have been published and two others have been received from the Geological Survey of New Zealand and will be printed in 1971. Sheet 1, the title and general reference sheet, was compiled in 1970.

International Geological Atlas (1:10,000,000)

The final compilation, at scale 1:6,000,000, of sheet 15 - Australia and Oceania - was sent to the Commission for the Geological Map of the World. The Commission will publish the map at 1:10,000,000.

Burdekin Region Maps

A geological and minerals map of the Burdekin region, Queensland, was compiled at scale 1:1,000,000 by A.G.L. Paine and Miss R.L. Cameron. Together with accompanying notes, it has been sent to the Water, Power and Geographic Branch of the Department of National Development for publication in the Resources series. A geological map of the same area at scale 1:500,000 is being compiled.

Geology Map of the Northern Territory (1:2,500,000)

A geological map of the Northern Territory has been compiled by Dr G.E. Wilford. Structure, superficial deposits, and age data are being added.

Geological Map of Papua and New Guinea (1:1,000,000)

Work was begun in 1970 on a geological map of Papua and New Guinea.

INSTRUMENT DESIGN AND DEVELOPMENT

In the geophysical workshops, new instruments are designed and developed, and existing ones modified for particular purposes, tested, calibrated, and where necessary improved. Most instruments are required for geophysical surveys, but geological research also calls for instrumentation, some of which is developed in the Bureau.

Two major design projects were undertaken in 1970 under the supervision of K.J. Seers:

Proton Magnetometer. The second prototype of a general-purpose proton magnetometer was developed. It is portable and is accurate to within one gamma count under normal field operations. In the noisy environment of airborne applications and with the faster cycle time required, accuracy is reduced to about three gamma count. The construction of three production models is nearing completion.

Airborne Fluxgate Magnetometer. A fluxgate magnetometer, designed and normally used as a submarine detector, is being adapted for use in airborne magnetic surveys. Modifications are required to enable constant or slowly-varying magnetic fields to be recorded. A stability of one part in 100,000 puts stringent requirements on the electronic circuits used in the modification. The project is scheduled for completion early in 1971 for installation in the Bureau's new survey aircraft.

The purchase of the new survey aircraft has involved the group led by A.J. Barlow in a considerable amount of work designing and installing geophysical, navigational, and computer-based data acquisition systems. The aircraft is expected to be ready for survey operations in the first half of 1971.

P.J. Hillman has been investigating equipment and techniques used in remote sensing applications, particularly the use of infra-red and colour photography and infra-red scanners.

Other significant projects undertaken in 1970 were:

- the design of general-purpose feedback amplifiers and filters for DC and low-frequency AC application
- a digital clock and seismic profile recorders for marine geophysical surveys.

- . a data acquisition system for grainsize analysis
- . a sonobuoy system for airborne seismic applications
- . new timing equipment for pendulum gravity measurements.

COMPUTER APPLICATIONS

With the increasing volume and complexity of geological and geophysical data, the Bureau is turning more and more to the use of computers. The major use is by the Geophysical Branch, where the data can be conveniently acquired in a digital form and systems can be designed for direct input to a computer on location with the survey. This is best exemplified by the marine geophysical survey which began in the latter part of 1970 (see Marine Operations, p. 28).

On board MV Hamme are three computers. One is for processing the multi-channel seismic data; time corrections are applied to the incoming seismic signals and the common depth point reflections from the various channels are delayed and summed to give the desired result. Another computer is used to acquire the navigational, gravity and magnetic data in a digital form on a magnetic tape. Some on-line processing is carried out simultaneously. The third computer is used as an integral part of the satellite navigation system.

It has been necessary to introduce these computers in order to handle the vast quantity of data and for day-to-day control of such a complex operation. A marine survey is carried out on a 24-hour day basis. Samples of all navigational, gravity, and magnetic parameters are recorded every ten seconds, and this amounts to 600,000 samples a day. The six seismic tracers are each sampled 500 times a second, generating about 40 million samples in one day. Results are in a form suitable for input to further processing by large land-based computers so that information can be released quickly.

A similar computer-based system has been designed, and equipment procured, for installation in the Bureau's new Twin Otter aircraft. Aeromagnetic, aeroradiometric, and navigational data will be acquired in a digital form; the computer will be programmed to give profiles at map scale when the aircraft returns to base.

A remote teletype to the CDC 3600 computer at the CSIRO Division of Computing Research has been installed in the Bureau's office in Canberra. Much of the Bureau's computer processing is done on the CSIRO computer.

All sections of the Geophysical Branch and some sections of the other Branches make extensive use of computers in solving specific scientific problems in the analysis and interpretation of data.

Throughout the year the problem of storage and retrieval of geological information has been under scrutiny, and some progress has been made towards devising a system which can be used, not only by the Bureau, but also by other authorities.

BASINS STUDY

The Sedimentary Basins Study Section is led by Dr D.J. Forman. Its function is to assimilate all information on the sedimentary basins of Australia and present it in a series of maps and reports, as a preliminary to a scientifically based search for petroleum or water. Where gaps in the knowledge about a basin are found to exist in the course of such a study, the Section can undertake or commission field studies to fill these gaps (as for example the stratigraphic drilling mentioned below).

Work during 1970 was concentrated mainly on the Sydney Basin. Three wells were drilled by the Bureau in the Nowra area to resolve stratigraphic problems. Basin-wide geological correlations have been made, and checked with seismic correlations. A three-plate aeromagnetic map and a partly complete Bouguer anomaly map have been drafted, and isopach, lithofacies, and structure-contour maps started. A bibliography of the basin was compiled.

A start was made on a similar study of the Canning Basin of Western Australia with an assembly of columnar sections of wells and measured surface sections; a petrological study of Devonian rocks from two wells; preparation of a seismic locality map; and preparations for the reduction of seismic, gravity, and aeromagnetic maps.

Bibliographies of six sedimentary basins were compiled during the year.

Core and Cuttings Laboratory

The Core and Cuttings Laboratory is part of the Sedimentary Basins Study Section of the Petroleum Exploration Branch. In it, all cores, cuttings, and other well samples held by the Bureau are stored, and are accessible to petrological and chemical examination by both Bureau and visiting scientists.

In all, 84,943 core samples (over 11 km of core), 383,557 cuttings representing more than 1,200 km of drilling, and 2419 sidewall cores are stored and registered in the laboratory; and about as many again await registration. During the year, 25,172 core samples, 33,647 cuttings, and 38 sidewall cores were added to the collection.

The extent to which the collection is used is shown by the fact that the full facilities of the laboratory were used by Bureau officers for an equivalent of 312 working days and by visitors for 159 working days.

During 1970, officers of the laboratory have been experimenting in geological data processing. Successful trials, on the CSIRO CDC 3600 computer, were made of programmes for processing of general well data, sample data, results of tests, frequency calculations, metric calculations, metric conversions, etc. Programmes have also been written for the interpretation of Differential Thermal Analysis data.

MINERAL RESOURCES

Mineral Economics

The Mineral Economics Section was primarily occupied during the year in continuing studies of the resources, extraction and processing, utilization, and marketing of mineral commodities. This work refers particularly to Australia, but because the mineral industry is essentially international, the studies took into account both international and domestic factors. Members of the section kept in touch with developments and proposed developments in the mineral and allied industries by visits to the offices and operations of appropriate companies. Collection of mineral industry statistics continued jointly with the Bureau of Census and Statistics.

An inventory of Australian mineral resources, designed as a long term project to cover all major Australian mineral resources, was begun. A study of resources of black coal and coking coal was almost completed; a similar study of tin resources will commence in 1971.

Projections of mineral export earnings were made, in the long term for the Minister, and in the short term for the Department of Trade and Industry. A feasibility study of zirconium sponge production was completed.

During the year, material was assembled for meetings of the International Tin Council, the International Lead-Zinc Study Group, the United Nations Tungsten Committee, and for various inter-departmental committees. In addition, The Australian Mineral Industry Annual Review 1969 and Quarterly Reviews Vol. 21 No. 3 and 4 and Vol. 22 No. 1 and 2 were compiled.

Mining Engineering

The Mining Engineering Section continued to review mining developments in Australia, especially where financial assistance or export control was involved. It commented on a number of proposals and activities, and prepared a five-year forecast of royalties to be expected from mineral production, excluding petroleum.

All major gold mines in Australia were inspected and a report on gold mining operations was compiled.

The Chief Mining Engineer, G.F. Mead, participated in meetings of various committees, including the Conference of Chief Inspectors of Mines, the Wire Rope Research Committee (which is concerned with non-destructive testing of wire ropes), the working group on Radioactive Protection, and several committees and sub-committees of the Standards Association of Australia.

Petroleum Technology

The Petroleum Technology Section continued to collect data on petroleum exploration and development; information and statistics were compiled and distributed periodically.

The estimates of reserves of crude oil, natural gas, and natural gas liquids in Australia were brought up to date and published in The Petroleum Newsletter No. 42; recoverable reserves at 30 June 1970 were estimated to be 1,793 million barrels of oil, 275 million barrels of natural gas liquids, and 13.8 million million cubic feet of gas.

Several hundred analyses of natural gas samples obtained during formation tests were listed, and a study made of the 'success ratio' of exploration drilling in Australia. The receipt and storage of material received under the Petroleum (Submerged Lands) Act 1967-68 continued throughout the year.

The activities of the Petroleum Technology Laboratory, which is part of the Section, are described on page 33.

Drilling Operations

During the year, the Bureau drilled 377 holes, most of which were seismic shot points. The total depth drilled was 12,569 metres, of which 1,321 metres were cored. Conventional rotary drilling and coring, rotary percussion drilling, diamond coring, and drive sampling techniques were all used, while the introduction of polymer-based muds proved highly satisfactory.

PETROLEUM SEARCH SUBSIDY

Applications

During the year 1 January 1970 to 31 December 1970, the Subsidy Section of the Petroleum Exploration Branch received 109 applications for approval of operations under the Petroleum Search Subsidy Act 1959-1969. These consisted of 37 applications for exploration drilling operations and 72 applications for geophysical operations. At 31 December 1970, 86 of these applications had been approved by the Minister, one drilling application had been refused, one geophysical and three drilling applications had been withdrawn, and 18 applications were still pending.

Nine of the drilling applications were for wells to be drilled offshore in Western Australia, and of the geophysical applications, 63 were for seismic surveys, 5 of which included gravity readings and 12 were marine operations, 7 were for gravity surveys, and 2 were for aeromagnetic surveys.

Approvals

The Minister approved 109 operations under the Petroleum Search Subsidy Act 1959-1969 during the year 1970. Thirty-two of these were for exploration drilling operations, 67 for seismic surveys, 8 for gravity, and 2 for aeromagnetic surveys. In addition, 19 extensions to approved programmes were approved. The estimated financial commitment to the Commonwealth by way of subsidies as a result of these approvals and subsidy adjustments at time of final payment was \$9,163,826.

Expenditure

In the 12 months to 31 December 1970, the amount of \$11,237,019 was paid by the Commonwealth in subsidies to petroleum exploration companies under the Petroleum Search Subsidy Act 1959-1969. A breakdown of this expenditure is given in the table below.

Petroleum Search Subsidy Expenditure
1 January 1970 - 31 December 1970

State	Drilling Operations		Geophysical Operations		Total
	Onshore	Offshore	Onshore	Offshore	
Queensland	809,028	249,579	368,646	195,676	1,622,929
New South Wales	169,548	-	162,516	73,864	405,928
Victoria	137,228	312,914	218,507	63,230	731,879
Tasmania	-	364,434	-	30,610	395,044
South Australia	439,031	-	372,861	110,970	922,862
Western Australia	568,394	2,956,664	729,169	349,395	4,603,622
Northern Territory	525,268	215,544	75,471	245,029	1,061,312
Papua-New Guinea	632,832	-	819,440	41,171	1,493,443
	3,281,329	4,099,135	2,746,610	1,109,945	11,237,019

At 31 December 1970, the total expenditure by the Commonwealth in subsidies under the Petroleum Search Subsidy Acts was \$102,459,081, and the total commitment was \$108,440,028, on 534 drilling operations and 819 geophysical operations.

Features of Subsidized Exploration

Subsidized exploration during the 12 months to 31 December 1970 was scattered widely throughout Australia and Papua and New Guinea; however, there were some significant areas in which little work was done. No subsidized exploration was carried out in the Amadeus Basin or the Adavale Basin, while in the onshore Carnarvon Basin, only one gravity survey was undertaken. The only subsidized offshore drilling carried out during the period under review was off the coast of Western Australia in the offshore Canning, Carnarvon, and Perth Basins. Subsidized offshore geophysical work was carried out in waters adjacent to New South Wales, South Australia, Western Australia, and the Northern Territory.

During 1970, the only significant petroleum discovery of the subsidized wells was Roseneath No. 1, in the Cooper Basin, Queensland. Gas was produced at a rate of 8 MMcf/D from the Permian Gidgealpa Formation and the well was completed as a gas producer. Petrel No. 1 Well, which blew out while drilling at 13,052 feet on 6 August 1969, was finally plugged and abandoned on 12 January 1971.

LIBRARY AND INFORMATION SERVICES

Library

The Bureau library contains over 10,000 text books and more than 2,000 serial titles, some of which extend well back into the last century. The library may be used by visitors, and material can be borrowed on standard inter-library loan conditions.

During the year, 1,039 titles, including revisions, were catalogued. Staff loans totalled 19,984, while 1,581 loan requests were received from other libraries.

As in past years, the library has not been able to fulfil all its functions because of shortage of staff, the present establishment being barely adequate to cope with basic library activities.

Information Services

Requests from industry, organizations, and individuals for information on the Australian mineral industry and the results of the Bureau's activities continued to grow during the year. Many enquiries were met by providing copies of Bureau publications, but a considerable proportion required individual attention. The scope of enquiries ranged from requests for information for school projects to technical matters needing assistance from the specialist Branches.

The Bureau both generates and acquires a large volume of earth science information, pertaining especially to Australia, but also including material of a more general nature. Different groups within the Bureau index the information of interest to them and usually store it on simple card index systems, some of which are available for public perusal. These systems have been strained by the greatly increased flow of information resulting from the recent upsurge in geological exploration activity in the Australian region, and preliminary steps have been taken to establish a comprehensive information storage and retrieval system to meet the present and future requirements of the Information Services Section.

Stratigraphic Index

On behalf of the Geological Society of Australia, the Bureau maintains the Central Register of Australian Stratigraphic Names.

The first publication of a stratigraphic name accords it priority of usage under the terms of the Australian Code of Stratigraphic Nomenclature thereby avoiding the confusion that would arise if the same name were used for different stratigraphic units or different names used for the same unit.

The register contains stratigraphic names extracted from published maps and reports dealing with Australian geology, together with bibliographic details of the publication. Authors wishing to establish new stratigraphic units are encouraged to consult the register to check that the name proposed has not been used already. In practice, most authors consult the register, at the same time placing on record and reserving the names they propose to use.

During the year, 219 proposed names were reserved; 136 names previously reserved appeared in published reports; and 30 names which had not previously been reserved were used in published reports. Of these 30, four names were used informally, and one was invalid as the same name had already been used.

Every two months, the register issues a list of new names and variations to proposed names. It also contains a bibliography of published papers on Australian geology, classified under broad subject headings, which is stored in the Bureau library. Relevant material is also sent to State Mines Departments.

PUBLICATIONS

The following publications were issued by the Bureau in 1970.

Bulletins

de KEYSER, F. and LUCAS, K.G. - Geology of the Hodgkinson and Laura Basins, North Queensland. Bulletin 84: 254 pp, 24 pl.

SHERGOLD, J.H. - Oryctocephalidae (Trilobita: Middle Cambrian) of Australia. Bulletin 104: 79 pp, 12 pl.

DOW, D.B. and GEMUTS, I. - Geology of the Kimberley Region, Western Australia: the East Kimberley. Bulletin 106: 136 pp, 19 pl.

VARIOUS AUTHORS - Palaeontological Papers - 1967. Bulletin 108: 326 pp, 38 pl.

VEEVERS, J J. - Sedimentology of the Upper Devonian and Carboniferous Platform Sequence of the Bonaparte Gulf Basin. Bulletin 109: 86 pp, 42 pl.

OPIK, A.A. - Nepeid Trilobites of the Middle Cambrian of Northern Australia. Bulletin 113: 66 pp, 17 pl.

EADIE, E.N. - Magnetic Survey of the Savage River and Long Plains Iron Deposits, Northwest Tasmania. Bulletin 120: 69 pp, 15 pl.

Reports

DUNNET, D. and HARDING, R.R. - Geology of the Mount Woodcock one-mile Sheet area, Tennant Creek, Northern Territory. Report 114: 53 pp, 5 pl.

MOLLAN, R.G., DICKINS, J.M., EXON, N.F., and KIRKEGAARD, A.G. - Geology of the Springsure 1:250,000 Sheet area, Queensland. Report 123: 114 pp, 10 pl.

LONSDALE, G.F., and FLAVELLE, A.J. - Amadeus and South Canning Basins Gravity Surveys, Northern Territory and Western Australia, 1962. Report 133: 28 pp, 5 pl.

TIPPER, D.B. - Strangways Range Detailed Aeromagnetic Survey, Northern Territory, 1965. Report 136: 20 pp, 6 pl.

DARBY, F. - North Bowen Basin Gravity Survey, Queensland, 1963.
Report 138: 44 pp, 12 pl.

SHELLEY, E.P. - Daly River Detailed Aeromagnetic Survey, Northern Territory, 1966. Report 139: 14 pp, 3 pl.

McLEOD, I.R. - Bibliography of Reports on Geology, Geomorphology, and Glacial Geology Resulting from Australian Work in Antarctica.
Report 146: 9 pp.

1:250,000 Geological Maps, with Explanatory Notes

Ashton, W A.	Durham Downs, Qld	Mount Elizabeth, W.A.
Bonney Well, N.T.	Emerald, Qld	Mount Liebig, N.T.
Buchanan, Qld	Lansdowne, W.A.	Tambo, Qld
Clermont, Qld	Mount Coolon, Qld	Tangorin, Qld
		Windorah, Qld

Five Sheets and notes were published on behalf of the Geological Survey of Western Australia: Edmund, Kalgoorlie, Loongana, Naretha, and Wyloo.

Geophysical Maps

Aeromagnetic:

Alice Springs, N.T.	Delamere, N.T.	Kulgera, N.T.
Auvergne, N.T.	Henbury, N.T.	Lake Amadeus, N.T.
Ayers Rock, N.T.	Hermannsburg, N.T.	Mount Liebig, N.T.
Bloods Range, N.T.	Illogwa Creek, N.T.	Rodinga, N.T.
		Wave Hill, N.T.
Aroa, TPNG	Dura, TPNG	Maer Island, TPNG
Aworra River, TPNG	Kikori, TPNG	Salamau, TPNG
Buna, TPNG	Kiwai, TPNG	Wau, TPNG
		Yule, TPNG

Gravity: Bouguer Anomaly Maps at 1:500,000 Scale

Atherton, Qld	Donors Hill, Qld	Medusa Banks, W.A.
Aurukun, Qld	Ebagoola, Qld	Millungera, Qld
Ayr, Qld	Einasleigh, Qld	Mornington, Qld
Burketown, Qld	Fog Bay, W.A.	Mossman, Qld
Cairns, Qld	Galbraith, Qld	Normanton, Qld
Cape Melville, Qld	Georgetown, Qld	Orford Bay, Qld
Cape Van Diemen, Qld	Gilberton, Qld	Red River, Qld

Cape Weymouth, Qld
Clarke River, Qld
Coen, Qld
Cooktown, Qld
Croydon, Qld
Dobbyn, Qld

Hann River, Qld
Holroyd, Qld
Ingham, Qld
Innisfail, Qld
Jardine River, Qld
Lawn Hill, Qld
Londonderry, W.A.

Rutland Plains, Qld
Townsville, Qld
Walsh, Qld
Weipa, Qld
Westmoreland, Qld
C/54-11; C/54-12
D/52-2; D/52-6

Ambunti, TPNG
Bogia, TPNG
Boigu, TPNG
Daru, TPNG

Karkar Island, TPNG
Madang, TPNG
Ramu, TPNG
Sepik, TPNG

Wabag, TPNG
Wewak, TPNG

23 Bouguer Anomaly maps were reprinted.

Magnetic:

Boulia, Qld
Hughenden, Qld
Julia Creek, Qld

Mackunda, Qld
Manuka, Qld
McKinlay, Qld
Muttaborra, Qld

Richmond, Qld
Springvale, Qld
Tangorin, Qld

Magnetic and Radiometric (Each 4 Sheets at 1:125,000):

Edjudina, W.A.
Laverton, W.A.

Leonora, W.A.
Menzies, W.A.

Victoria River Downs, N.T.

Marine Geophysical:

Bathurst Is.
Darwin
Fog Bay
Londonderry
Medusa Banks
Melville Island
Port Keats
SC/51-12
SC/51-14
SC/51-15
SC/51-16

SC/52-5
SC/52-6
SC/52-7
SC/52-8
SC/52-9
SC/52-10
SC/52-11
SC/52-12
SC/52-13
SC/52-14
SC/53-6

SC/53-9
SD/51-1
SD/51-2
SD/51-3
SD/51-4
SD/51-6
SD/51-7
SD/51-8
SD/52-1
SD/52-2
SD/52-6

Gravity, Magnetic, and Seismic Profiles:

Fog Bay, N.T.
Londonderry, W.A.

Medusa Banks, W.A.
SD/52-6, N.T.

SD/52-B2-1, N.T.
SD/52-B2-2, N.T.

Other Publications

Australian Mineral Industry, Annual Review 1968.

Australian Mineral Industry, Annual Review 1969, Preprints: Aluminium, Black Coal, Copper, Iron Ore, Lead, Nickel, Petroleum, Tin, Titanium, Zinc.

Australian Mineral Industry, Quarterly Review, Vol 21, Nos. 3, 4; Vol 22, Nos. 1, 2.

Petroleum Newsletter, Nos. 39-42.

Petroleum Search Subsidy Acts Publication 88: Summary of Data and Results, Otway Basin, Victoria - Pecten Nos. 1 and 1A and Nerita No. 1.

Petroleum Titles Map.

Pictorial Index of Activities, 1968.

In press at the end of the year were:

Bulletins

- No. 56. Carboniferous and Early Permian Brachiopoda in Western and Northern Australia, by G.A. Thomas.
- No. 100. Geology of the Amadeus Basin, by A.T. Wells, L. Ranford, D.J. Forman, P.J. Cook and R.D. Shaw.
- No. 105. Ice Thickness Measurements in MacRobertson Land, 1957-1959, by K.F. Fowler.
- No. 107. The Lamboo Complex, by I. Gemuts.
- No. 110. Cambro-Ordovician Conodonts from the Burke River Structural Belt, Queensland, by E.C. Druce and P.J. Jones.
- No. 112. Late Upper Cambrian Trilobites from the Gola Beds, Western Queensland, by J.H. Shergold.
- No. 114. Redlichia in the Cambrian of Northern Australia, by A.A. Opik.
- No. 115. Palynology of the Devonian of the Bonaparte Gulf Basin, by G. Playford.
- No. 116. Palaeontological Papers, 1968, by various authors.
- No. 122. Devonian and Carboniferous Brachiopoda from Bonaparte Gulf, by J. Roberts.
- No. 128. Peridotite - Gabbro-Basalt Complex in Eastern Papua, by H.L. Davies.

Reports

- No. 127. Geology of the Townsville 1:250,000 Sheet area, Queensland, by D.H. Wyatt, A.G.L. Paine, D.E. Clarke, and R.R. Harding.
- No. 128. Geology of the Ayr 1:250,000 Sheet area, Queensland, by A.G.L. Paine, C.M. Gregory, and D.E. Clarke.
- No. 131. North Eromanga and Drummond Basins Gravity Surveys, Queensland, 1959-1963, by R.A. Gibb.
- No. 134. Review of the Otway Basin, by M.A. Reynolds.
- No. 135. ANARE 1961 Geological Traverses on the MacRobertson Land and Kemp Land Coast, by D.S. Trail.
- No. 137. Geology of the Charters Towers 1:250,000 Sheet area, by D.H. Wyatt, A.G.L. Paine, D.E. Clarke, C.M. Gregory and R.R. Harding.
- No. 141. Bibliography of the Geology of Eastern New Guinea (Papua - New Guinea) by W. Manser and C. Freeman.
- No. 147. Catalogue of Type and Figured Specimens in the Collection of the University of New England, by G.M. Philip.

Geological Maps and Notes

Adavale, Qld	Charleville, Qld	Muttaborra, Qld
Augathella, Qld	Charters Towers, Qld	Prince Regent/Camden Sound, W.A.
Baralaba, Qld	+ Cooper, W.A.	Quilpie, Qld
Barrolka, Qld	+ Culver, W.A.	Richmond, Qld
+ Bentley, W.A.	Drysdale-Londonderry, W.A.	Roma, Qld
Blackall, Qld	Duaranga, Qld	St Lawrence, Qld
Bulloo, Qld	Eromanga, Qld	Thargomindah, Qld
Cambridge Gulf, W.A.	Longreach, Qld	Toompine, Qld
Canterbury, Qld	+ Madura-Burnabbie, W.A.	Wyandra, Qld

+ For Geological Survey of Western Australia

43 maps and notes are being reprinted.

Other Publications

Australian Mineral Industry Annual Review 1969.

Australian Mineral Industry Quarterly Review, Vol. 22 No. 3.

Petroleum Search Subsidy Acts Publications:

No. 81. Summary of Data and Results, Sue No. Well, Perth Basin, Western Australia.

No. 82. Gippsland Shelf No. 4 Well, Victoria.

No. 83. Summary of Data and Results, Bass Nos. 1 and 2, Tasmania.

No. 85. Southeast Kidson Gravity Survey, Western Australia.

No. 86. Southeast Kidson Seismic Survey, Western Australia.

No. 87. Summary of Data and Results, Kidson No. 1, Western Australia.

The following publications by officers of the Bureau were printed in external journals etc in 1970 (BMR members of joint-author teams are marked *):

BLAKE, D.H., - Geology and Mineral Deposits of the Herberton Tinfield, North Queensland. Qld Govt Min. J., October, 1970.

*BLAKE, D.H. and SMITH, J.W. - Mineralogical Zoning in the Herberton Tinfield, North Queensland, Australia. Econ. Geol., 65, 993-997.

CROHN, P.W. - Geochemical Prospecting Programmes of the Bureau of Mineral Resources. Proc. Aus. Inst. Min. Metall., 236, 1970.

COOK, P.J. - Repeated Diagenetic Calcitization, Phosphatization, and Silicification in the Phosphoria Formation. Bull. geol. Soc. Amer., 81, 2107-2116.

DICKINS, J.M. - Correlation Chart for the Permian System in Australia. In Gondwana Stratigraphy, I.U.G.S. Symposium. UNESCO Earth Sci., 2, 1970.

*EXON, N.F. LANGFORD-SMITH, T., and McDOUGALL, I. - The Age and Geomorphic Correlations of Deep-Weathering Profiles, Silcrete and Basalt in the Roma-Amby Region, Queensland. J. geol. Soc. Aust., 17, 1, 21-30.

- EXON, N.F., and VINE, R.R. - Revised Nomenclature of the 'Blythesdale' Sequence. Qld Govt Min. J., Feb. 1970.
- FISHER, N.H. - Rock Weathering, Anatexis, and Ore Deposits. Search, 1, 3, 1970.
- GELLATLY, D.C. - Cross-Bedded Tidal Megaripples from King Sound, Northwestern Australia. Sediment. Geol., 4, 185-191.
- JAKES, P. and *SMITH, I.E. - High Potassium Calc-Alkaline Rocks from Cape Nelson, Eastern Papua. Contr. Miner. Petrol., 28, 259-271.
- JONGSMA, D. - Eustatic Sea Level Changes in the Arafura Sea. Nature, 228, 5267, 150-151.
- *MACKENZIE, D.E. and WHITE, A.J.R. - Phenolite Globules in Basanite from Kiandra, Australia. Lithos, 3, 309-317.
- *PAGE, R.W. and McDOUGALL, I. - Potassium-Argon Dating of the Tertiary f1-2 Stage in New Guinea and its Bearing on the Geological Time-Scale. Amer. J. Sci., 269, 321-342.
- *SHERGOLD, J.H. and BASSETT, M.G. - Facies and Faunas at the Wenlock/Ludlow Boundary of Wenlock Edge, Shropshire. Lethaia, 3, 113-142.
- STRUSZ, D. - *Cystiphyllum americanum* var. *australe* Etheridge Jnr. 1892, from North Queensland. In Campbell, K.S.W. (Ed.): *Stratigraphy and Palaeontology. Essays in Honour of Dorothy Hill*. Canberra, ANU Press, 1970.
- *STRUSZ, D., CHATTERTON, B.D.E., and *FLOOD, P.G. - Revision of the New South Wales Devonian Brachiopod '*Spirifer yassensis*'. Proc. Linn. Soc. N.S.W., 95, 2, 443.
- TAYLOR, G.A.M. et al. - Handbook for excursions, ANZAAS 42nd Congress, 1970.

OVERSEAS VISITS

Visits made by officers of the Bureau to overseas countries, excluding Australian Territories, during 1970 were:

BARLOW, B.C. - attended a meeting of the International Gravity Commission in Paris and presented a report on all gravity work carried out in Australia in the five years to 30.6.70; while overseas, he visited an earth-tide recording station in Belgium.

BURTON, G.M. - attended the First International Congress of the International Association of Engineering Geologists in Paris; while overseas, he attended the Second International Rock Mechanics Congress in Belgrade.

CONNELLY, J.B. - visited the Hawaiian Institute of Geophysics to assist in interpretations of the results of oceanographic seismic investigations (see p. 35).

DAVIES, H.L. - completed Ph.D. degree at Stanford University, California, while holding a Commonwealth Public Service Board post-graduate scholarship.

DENHAM, D., and RIPPER, I.D. - presented papers at the International Symposium on Recent Crustal Movements and Associated Seismicity, Wellington, New Zealand.

DICKINS, J.M. - attended the Second Gondwana Symposium in South Africa; while overseas, he visited the offices of the Geological Survey of India and the Geological Survey of Malaysia.

DOOLEY, J.C. - attended the Upper Mantle Symposium in Hyderabad, India.

DRUCE, E.C. - studied conodonts at the University of Michigan, while holding a Commonwealth Public Service Board scholarship.

EXON, N.F. - pursued research into sedimentology at Kiel University, Germany, while holding a Commonwealth Public Service Board scholarship.

FISHER, N.H. - attended a meeting of the Commission for the Geological Map of the World in Paris; while overseas he visited national geological and geophysical organizations in France, U.K., West Germany, and Holland.

- attended a meeting of the ECAFE Committee on Industry and Natural Resources in Bangkok.

HALDANE, A.D. - was a Technical Adviser to ECAFE at the second Symposium on Geochemical Prospecting Methods and Techniques in Ceylon.

HILLMAN, P.J., and PERRY, W.J. - visited the U.S. National Aeronautics and Space Administration establishments to study post-Apollo programmes, including the Earth Resources Technology Satellites and Skylab projects; while overseas, they visited other research centres for the application of remote sensing systems to geological and mineral exploration.

KONECKI, M.C. - attended the Eleventh International Gas Congress in Moscow.

McLEOD, I.R. - attended the Second Symposium on Antarctic Geology and Geophysics, and the Eleventh Meeting of the Scientific Committee on Antarctic Research, both held in Oslo, Norway.

MAFFI, C.E. - was on loan to a United Nations Special Fund project in Brazil.

NOAKES, L.C. - was a special Adviser on detrital minerals to the ECAFE Committee on Joint Prospecting for Mineral Resources in Asian Offshore Areas in Saigon; while overseas, he made an economic assessment of beach sand deposits in the Hue region, South Vietnam.

PERRY, W.J. - see also HILLMAN, P.J.; while overseas, he visited the Tektite II operation in the Virgin Islands; this underwater research project is designed to allow marine scientists to undertake in situ research missions under saturated diving conditions.

PHILLIPS, W.G.B. - attended the Fourteenth Session of the International Lead and Zinc Study Group in Geneva.

RIPPER, I.D. - See DENHAM, D.

ROBERTS, W.M.B. - studied aspects of ore genesis at Heidelberg University, Germany, while the holder of a Commonwealth Public Service Board post-graduate scholarship.

RYBURN, R.J. - attended 1970 meetings in Japan of the International Mineralogical Association, and the International Association on the Genesis of Ore Deposits.

STRUSZ, D.L. - visited Europe to study classical fossil areas of the Silurian and Devonian periods.

VALE, K.R. - attended the Joint Oceanographic Conference in Tokyo.

WALKER, K.R. - attended the Third International Geochemical Prospecting Symposium in Toronto, Canada, and the American Geophysical Union meeting in Washington; while overseas, he visited England, France and southern Africa to investigate recent developments in the application of geochemistry to mineral exploration.

STAFF OF THE BUREAU OF MINERAL RESOURCES

AT 31 DECEMBER, 1970

DIRECTOR

N.H. Fisher, D.Sc., M.Aus.I.M.M.

OPERATIONS BRANCH

Assistant Director	K.R. Vale, B.A., B.Sc., A.A.I.P.
Geologist Class 5	K.A. Townley, B.Sc.(Hons), A.R.C.S., M.Aus.I.M.M.
Geologist Class 4	I.R. McLeod, M.B.E., M.Sc., A.M.Aus.I.M.M.
Geophysicist Class 4	K.M. Kennedy, B.Sc., A.M.Aus.I.M.M. W.H. Oldham, B.E.
Geologist Class 3	M.E. Bartlett, Mrs, B.Sc. R.R.E. Jacobson, M.Sc., Ph.D.
Geologist Class 2	D.A. Senior, Mrs, B.Sc. R. Thieme, B.Sc.
Librarian Class 2	B.A. Wood, Miss, B.A., A.L.A.A.
Class 1	S. Attwood, Miss, B.A., Dip. Lib. M.A. Thompson, Mrs, B.Ec., A.L.A.A.
Library Officer Grade 1	C.A. Fitzsimmonds, Miss
Technical Officer Grade 2	L.C. Mundy
Clerk Class 8	B.M. Williams
Class 7	B.F. Hoare
Class 6	W.R. O'Neill G.C. Scott
Class 5	W.R.W. Dunn
Class 4	G. Channing A.R. Evans G.J. Hardy M.W. Trevethan P.B. Turner B.A. Woolmore, Miss

Class 2/3

I.C. Betts
P. Flanagan
C.D. Foulstone, Mrs
E. Fryk
B.J. Hodgson
E.P. Mahar, Mrs
E. Petrushevski
A.D. Preston-Stanley
M.L. Smith, Miss
A.H. Tasman
P. Ware

Class 1

I. Brookman, Miss
M. Coghlan, Miss
S. Gray, Miss
W. Hessler, Mrs
D. Humphreys
L. Kay, Mrs

Clerical Assistant Grade 5

K. Bendall
D. Crombie

Clerical Assistant Grade 4

G. Baska
C. McCarthy, Miss
P. Medway
E.A. Pasfield, Mrs
J. Tait, Mrs

Clerical Assistant Grade 3

P. Black
M. Ford, Mrs
P. Johnson
P. Levier
J. Price, Mrs

Clerical Assistant Grade 2

B. Barrett, Miss
S. Bresnan, Mrs
P. Daric, Mrs
R.B. Davis, Miss
M. Dawes, Mrs
N. Elgood, Mrs
J. Gowshall, Mrs
N. Hyett
A. Jansen, Mrs
I. McConnell
J. Morrissey, Mrs
D. Szeliewicz, Miss

Clerical Assistant Grade 1

B. Ballard
M. Hallam, Miss
M. Manser, Miss
F. Bennett, Miss
K. Moloney, Mrs
D. Parkes, Mrs
M. Schofield, Mrs
J. Stitt, Mrs
M. Tacon, Mrs
A. Witherdin, Mrs

Junior Assistant

R. Frisby, Miss

Stenographic and Typing

J. Ablett, Mrs
A.M. Brodrick, Miss
H.F. Bullock, Miss
S.G. Cotterill, Mrs
D.M. Donnell, Miss
C. Elliot, Miss
J.M. Grattidge, Mrs
J. Guiver, Miss
L.C. Kearney, Mrs
J. Keir, Miss
H.E. Kwaczynski, Miss
T. Lee, Miss
J. Lilly, Miss
P. Madge, Miss
M. McConnell, Mrs
J.L. O'Toole, Miss
C. Pennifold, Miss
J. Pettifer, Miss
L. Plumb, Miss
E.N. Smith, Mrs
H.E. Urquhart, Miss

Stores Supervisor

G.L. Tovey

Motor Driver

E. Boreham

Attendant

O. Domitrjak, Mrs
P. Hardin, Mrs
J. Oldfield, Mrs
O. Shipton, Mrs

Janitor

J. Pollard

GEOLOGICAL BRANCH

Assistant Director

J.N. Casey, B.Sc.(Hons), M.Aus.I.M.M.

Geologist Class 5

E.K. Carter, B.Sc., Ph.D., A.M.Aus.I.M.M.

W.B. Dallwitz, B.A., M.Sc.

G.E. Wilford, O.B.E., B.Sc., Ph.D., A.I.M.M.

Geologist Class 4

D.J. Belford, M.Sc., Ph.D.

G.M. Burton, B.Sc., A.M. Aus. I.M.M.

J.M. Dickins, M.Sc., Ph.D.

R.G. Dodson, M.Sc., Ph.D., M.Aus.

I.M.M., A.I.M.M.

H.A. Jones, M.A., Ph.D.

W.J. Perry, B.Sc.

A. Renwick, O.B.E., B.Sc.(Hons),

C.Eng., M.I.M.M.

W.M.B. Roberts, B.Sc. (Study leave)

R.R. Vine, B.Sc.

K.R. Walker, B.Sc. (Hons), Ph.D.

Geologist Class 3

P.J. Cook, B.Sc.(Hons), Ph.D.

J.A. Cooper, M.Sc., Ph.D. Dip.Ind.Chem.
(S.A.S.M.)

G.W. D'Addario, D.Sc.

H.L. Davies, M.Sc., Ph.D.

G.M. Derrick, B.Sc. (Hons)

H.F. Douth, B.Sc.

N.F. Exon, B.Sc.(Hons). (Study leave)

J. Ferguson, B.Sc. (Hons), Ph.D.

D.E. Gardner, B.Sc., Dip.Ed., M.Aus.
I.M.M.

D.C. Gellatly, B.Sc.(Hons), Ph.D.

D.J. Grainger, B.Sc.(Hons), D.I.C.,
C.Eng., A.M.I.M.M., A.M.Aus.I.M.M.

A.R. Jensen, B.Sc., M.Sc., A.M.Aus.
I.M.M.

N.O. Jones, B.Sc., Ph.D.

P.J. Jones, B.Sc.(Hons), M.Sc.

C. Maffi, B.Sc.(Hons), A.A.P.G.

W.D. Palfreyman, B.Sc.(Hons).

M.D. Plane, B.Sc.(Hons), M.A.

K.A. Plumb, B.Sc.(Hons).

C.E. Prichard, B.Sc. (Furlough)

J. Roberts, B.Sc.(Hons), Ph.D.

Geologist Class 3

B.R. Senior, M.Sc.
R.D. Shaw, B.Sc.(Hons).
C. Simpson, B.Sc., A.M.Aus.I.M.M.
S.K. Skwarko, M.Sc., Ph.D.
D.L. Strusz, B.Sc.(Hons), Ph.D.
I.P. Sweet, B.Sc.(Hons).
G.A.M. Taylor, G.C., M.Sc.
A.T. Wells, B.Sc.(Hons).

Chemist Class 3

A.D. Haldane, B.Sc.

Geologist Class 2

J.H.C. Bain, B.Sc.
J.G. Binnekamp, M.Sc., Ph.D.
D. Burger, M.Sc., Ph.D.
R.A. Davies, B.Sc.(Hons), Ph.D.
E.C. Druce, M.Sc. (Study leave)
J. Gilbert-Tomlinson, Miss, B.Sc.(Hons).
A.Y. Glikson, M.Sc., Ph.D.
G.A.M. Henderson, B.Sc.
G. Jacobson, B.Sc.
R.W. Johnson, B.Sc.(Hons), Ph.D.,
D.I.C., A.R.C.S.
D. Jongsma, M.Sc.
A. Medvecky, Promovany Geol.
J.R. Mendum, B.Sc.(Hons).
R.J. Ryburn, M.Sc.
J. Shergold, B.Sc.(Hons), Ph.D.
J. Smart, B.Sc.(Hons).
I.E. Smith, B.Sc.(Hons).
J. Smith, Mrs, B.Sc. (Hons).
R.J. Tingey, B.Sc.(Hons), S.E.G.
R.G. Warren, Miss, B.Sc.

Chemist Class 2

S.E. Smith, B.Sc.

Geologist Class 1

R. Bennett, Miss, B.Sc.(Hons), B.A.
R.J. Bultitude, B.Sc.(Hons), M.Sc.
W.A. Burgis, Miss, M.Sc.
R.L. Cameron, Miss, B.Sc.
I.H. Crick, B.Sc., (Hons), Dip. Ed.
J.C. Davies, Mrs, B.Sc.(Hons), Dip.Ed.
R.N. England, B.Sc.
J. Harris, B.Sc.(Hons), A.R.S.M.
S. Henley, B.Sc.(Hons), Ph.D.
R.M. Hill, B.Sc.(Hons).
M.J. Jackson, B.Sc.(Hons).

Geologist Class 1

P. Kennewell, B.Sc.
M.A.B Labonne, Miss, Lic. Es Sci.,
Dr. 111 cycle
G.C. Lau, B.Sc.(Hons)
L. Macias, Grad. Geol.
D.E. Mackenzie, B.Sc.(Hons).
J.F. Marshall, B.Sc.(Hons).
W. Mayo, B.Sc.
J.E. Mitchell, B.Sc.(Hons).
J.S. Morlock, B.Sc.
R.S. Needham, B.Sc.(Hons).
M.S. Norvick, B.Sc.(Hons), Ph.D., D.I.C.
B.S. Oversby, M.A., B.Sc. Ph.D.
J.A. Owen, Mrs, A.B., M.Sc., D.U.C.
M. Owen, B.Sc.(Hons), Ph.D.
R.W. Page, B.Sc.(Hons).
P.E. Pieters, D.Geol.
D.C. Purcell, B.Sc.
P.M. Rew, Miss, B.Sc.(Hons).
G.P. Robinson, B.Sc.(Hons), Ph.D.
S.L. Roddick, Mrs, B.A., M.Sc.
J. Saltet, M.Sc.
J.W. Sheraton, M.Sc., Ph.D.
G.B. Simpson, B.Sc.
J.A. Smith, Mrs, B.Sc., Dip.Ed.
P.C. Tonkin, B.Sc.(Hons).
G.C. Young, B.Sc.(Hons).

Chemist Class 1

C.W. Claxton, B.Sc.

Cadet Geologist

D.S. Hutchinson, B.Sc.(Hons).
A.N. Yeates, B.Sc.(Hons).

Technical Officer Grade 2

G.H. Berryman
F. Hadzel
J.R. Kellett
T.I. Slezak, Dip.Anal. Chem.

Technical Officer Grade 1

K.A. Armstong
H.M. Doyle
R.A. Dulski
D.W. Lea
M.W. Mahon
C.R. Robison
M.H. Tratt
D.G. Warren
J.C.W. Weekes
A.T. Wilson
T.K. Zapasnik

Technical Assistant Grade 2	R.W. Brown D. Foulstone D.E. Hunter L. Kraciuk, Mrs P.A. Lang J.D. Reid A.W. Schuett
Technical Assistant Grade 1	A. Ahearn, Miss W.C. Whitwell
Chief Draftsman Grade 2	H.F. Boltz
Chief Draftsman Grade 1	P.A. Boekenstein
Supervising Draftsman	H. Henning K. Matveev R.J. Molloy M.E. Nancarrow
Senior Draftsman	D.E. Brentnall I. Chertok E.H. Feeken A. Mikolajczak J.F. Roberts
Draftsman Grade 2	J. Den Hertog, Miss J. Fetherston I.D. Johnston I. Lamberts G. Matveev G. Millist M.R. Moffat R.G. Pennington D.M. Pillinger, Miss R. Swoboda
Draftsman Grade 1	P.H. Fuchs E. Jurello J. Koprás M.A. McLaren, Miss R. Ritchel I.W. Shafron J. Wedgebrow, Miss

Drafting Assistant Grade 2	R. Baldwin D.J. Callaghan S. Daric D.E. Green, Mrs E. Hawkins, Mrs L. Petkovic, Mrs D.B. Vitkunas, Miss
Drafting Assistant Grade 1	J. Higginbotham
Clerical Assistant Grade 2	C. Shooks, Miss J. Stewart, Miss
Photographer-in-Charge	J. Zawartko
Photographer	E. Kemenes D. Lawton
Assistant Photographer	R. Koprass, Mrs M. Potiri, Miss

GEOPHYSICAL BRANCH

Assistant Director	L.S. Prior, B.Sc.(Hons).
Geophysicist Class 5	M.G. Allen, B.Sc., S.E.G., E.A.E.G., Grad.A.I.P. N.G. Chamberlain, B.A., A.A.I.P., A.I.P.S. J.C. Dooley, B.A.(Hons), M.Sc., F.A.I.P., S.E.G., A.Inst.P. A. Turpie, B.Sc.(Hons), Grad. A.I.P., S.E.C., E.A.E.G.
Geophysicist Class 4	A.J. Barlow, B.Sc. J.A. Brooks, B.Sc., Ph.D., Grad.A.I.P. P.M. McGregor, B.Sc.(Hons), A.A.I.P., A. Inst.P. F.J. Moss, B.Sc., S.E.G., E.A.E.G. J.H. Quilty, M.Sc. E.C. Sedmik, Dip.Eng., A.M.Aus.I.M.M. W. Wiebenga, M.Eng., S.E.G.
Geophysicist Class 3	B.C. Barlow, B.Sc.(Hons), A.A.I.P. J.C. Branson, B.Sc.(Hons), F.G.S. A.R. Brown, B.A., A.Inst.P., Grad. A.I.P., S.E.G. F.W. Brown, B.A.Sc., Grad.A.I.P., S.E.G., E.A.E.G.

Geophysicist Class 3

D. Denham, B.Sc.(Hons), Ph.D., S.E.G.,
Grad.A.I.P.
I. Everingham, M.Sc., Grad.A.I.P.
D.M. Finlayson, M.Sc., A.A.I.P.
J.E.F. Gardner, B.Sc., A.M.Aus.I.M.M.
P.J. Gregson, B.Sc.(Hons).
P.J. Hillman, A.F.C., B.Sc.
C.O. Leary, Miss, B.Sc.
P.E. Mann, B.Sc., E.A.E.G., Grad.A.I.P.
J.M.J. Mulder, Dip.Geol./Geophys.
E.J. Polak, Dip. Min. Eng., Ph.D.,
S.E.G., E.A.E.G., M.I.E. (Aust.)
K.J. Seers, B.Sc., A.A.I.P., A.M.I.R.E.E.
E.P. Shelley, B.Sc.
A.G. Spence, B.Sc., B. Comm.
C. Van der Waal, Dip. Civil Eng.
R. Wells, B.A.
R. Whitworth, B.Sc.(Hons).

Geophysicist Class 2

I.C. Briggs, B.Sc.
J.B. Connelly, B.Sc.
R.J.S. Cooke, B.Sc., Grad.A.I.P.
D. Downie, B.Sc.
P.J. Hill, B.Sc.
M. Idnurm, M.Sc., Ph.D., Grad.A.I.P.,
Grad.I.P.
M. Mancini, Doc.Geol.Sci.
J. Rees, B.Sc.
I.D. Ripper, B.Sc.(Hons), M.A.I.P.
J. Silich, B.Sc.(Hons).
G.R. Small, B.Sc., Grad.A.I.P.
F.J. Taylor, B.Sc.(Hons).
D. Townsend, B.Sc., S.E.G., A.S.E.G.
S. Waterlander, Dip.Eng.
R.J. Whiteley, B.Sc.
J.R. Wilkie, M.Sc., A.A.I.P.
J.B. Willcox, B.Sc.(Hons), S.E.G.

Geophysicist Class 1

R. Almond, B.Sc.(Hons).
W. Anfiloff, B.Sc.(Hons).
P. Bullock, B.Sc., M.Sc.
J.P. Cull, B.Sc.(Hons).
B. Devenish, B.Sc.
B. Dolan, B.Sc., Dip.Ed.
P.J. Gillespie, B.Sc.

Geophysicist Class 1

P.L. Harrison, B.Sc.(Hons).
K. Horsfall, B.Sc.
S.J. Long, Miss, B.Sc.(Hons), A.R.C.S.
J.A. Major, B.Sc.
M.I. McDowell, B.Sc.
J. Meath, B.Sc.(Hons).
A.S. Murray, B.Sc.(Hons), Grad.A.I.P.
E.P. Paull, B.Sc.(Hons).
J.J. Petkovic, B.Sc.
G. Pettifer, B.Sc., Grad.Dip.
(App. Geophysics), E.A.E.G.
D.C. Ramsay, M.Sc.
E.J. Reisz, B.Sc.(Hons).
M.J. Robertson, B.Sc.,
R.S. Smith, B.Sc., M.A.I.P.
J. Van Son, Dip. Geophys. Polytech.
I. Zadoroznyj, B.Sc.(Hons), A.I.P.

Cadet Geophysicist

A.J. Black, B.Sc.(Hons).
P.J. Cameron, B.Sc.(Hons).
P.A. Symonds, B.Sc.(Hons), S.E.G.,
A.S.E.G.
L.A. Tilbury, B.Sc.(Hons).
B.W. Wyatt, B.Sc.(Hons).

Senior Technical Officer Grade 1

W. Burhop
J. Van Der Linden, Dip.Geophys.,
G. Van Erkelens, Dip.Civil Eng.
A. Zeitlhofer, Sen. Affiliate I.R.E.E.,
Dip. B.I.E.T.

Technical Officer Grade 2

G.L. Abbs
W.M. Byrne, Mrs
D.A. Coutts
R. Curtis-Nuthall
J.C. Grace
R.B. Grigg
R.L. Harrison
G.S. Jennings
M.S. Jones
K. Jurello
P.M. Ryan
A.S. Scherl, I.R.E.E.(Affiliate)
G. Woad

Technical Officer Grade 1

H. Alexander
W. Burns
M. Ciszek
F. Clements
W. Greenwood
L. Hemphill
H. Leuzinger
B. Page
C.I. Parkinson
P.J. Rootes
D.O. Stevens
G.H.Y. Thomas
W. Trenchuk
A. Waldron
J.R. Walker

Technical Assistant Grade 2

N. Ashmore
A.J. Crisp
J. Dickson
W. Harkness
D.W. Kerr
K. Mort
D. Park
S. Prokin
D. Tarlinton
R.J. Westmore
J. Williams

Technical Assistant Grade 1

R.L. Gibbs

Senior Computing Assistant

P.L. Crain, Mrs

Computing Assistant

D. Boucher
V. Bushell
U. Hamerling, Mrs
J.A. Knappstein, Mrs
L. O'Mara, Mrs
W.I. Turner, Mrs
R. Wang, Miss
A. Alps, Miss

Field Assistant

R.D.E. Cherry
H. Pelz

Maintenance Mechanic	E. McIntosh D.K. McIntyre
Typist	Y.M. Nardini, Miss
Assistant Grade 1	J Creaser
Clerical Assistant Grade 2	S.I. Sheard
Clerical Assistant Grade 1	D.J. Beal, Mrs
Senior Instrument Maker	G.A. Renton
Instrument Maker	R. Eaton J. Pethes C. Rochford
Model Maker	G. Lockwood
Labourer	G. Vassalakis
Chief Draftsman Grade 2	P. Gillespie
Chief Draftsman Grade 1	I.H. Mather
Supervising Draftsman	W. Gerula B.C. Hamilton R. Inglis R. Sandford
Senior Draftsman	L. Bonazzi W.R. Buckley A. Crowder G. Lamberts A. Rudka
Draftsman Grade 2	K.A. Barrett I.G. Cravino R. Gan J. Janualitis T. Kimber A.T. Knappstein L.M. O'Toole A. Parvey D.A. Peterson N.J. Price, Miss B.A. Tink R.C. Watson

Draftsman Grade 1	W.A. Crowle L. Hollands L. Kerec P. Kersulis R.A. Macaulay P.S. Moffat D.A. Souter
Drafting Assistant Grade 2	J. Eustice, Mrs P.G. Farquhar G. Langdown, Mrs A.J. Maxwell M. Shunke, Mrs S.J. Westwood
Drafting Assistant Grade 1	K. Dimakis R.E. Smith
Assistant (Plan Printing) Grade 2	I. Joicey
Assistant (Plan Printing) Grade 1	P. Nordhof, Mrs

MINERAL RESOURCES BRANCH

Assistant Director	L.C. Noakes, Legion of Merit, B.A., F.G.S., M.I.M.M., M.Aus.I.M.M.
Engineer Class 5	G.F. Mead, B.A., A.W.A.S.M., Chartered Eng., M.I.M.M., M.Aus.I.M.M.
Mineral Economist Class 5	Z. Kalix, C.E., D.Econ., M.Aus.I.M.M.
Petroleum Technologist Class 5	H.S. Taylor-Rogers, B.Sc.(Hons), A.R.S.M., M.Inst.Pet., M.S.P.E.
Mineral Economist Class 4	J. Ward, B.Sc., M.Aus.I.M.M.
Petroleum Technologist Class 4	M.C. Konecki, M.Min.Eng., M.A.I.M.M.
Engineer Class 3	A.T. Churchill, M.A. W.G.B. Phillips, B.Sc. (Eng.) (Mining), B.Sc.(Econ.), A.R.S.M., A.M.I.M.M., A.M. Aust.I.M.M.

Mineral Economist Class 3	R.Z. de Ferranti, B.Sc. M.Aus.I.M.M. A.J. Gourlay, B.Sc. A.M.Aus.I.M.M. J. Henry, A.C.S.M., A.F.Inst.Pet., M.Aus.I.M.M., M.S.P.E. B.A. McKay, B.Sc. (Geol.), M.S.P.E.
Chemist Class 2	D. McKirdy, B.Sc.(Hons), Dip.T. T.G. Powell, B.Sc.(Geol), Ph.D.
Technical Officer Grade 1	V. Laban, Dip. Tech. R.E. Moon
Technical Assistant Grade 2	Z. Horvath
Boring Supervisor	L. Hodgins
Driller Grade 2	E.H. Cherry B. Findlay
Driller Grade 1	L.A.C. Keast E. Lodwick K. Reine T. Shanahan
Drilling Assistant	K. Huth J. O'Donnell E.T. Reid

PETROLEUM EXPLORATION BRANCH

Assistant Director	L.W. Williams, B.Sc., A.A.I.P.
Geophysicist Class 5	E.R. Smith, B.A., B.Sc., A.A.I.P., S.E.G., E.A.E.G.
Geologist Class 4	D.J. Forman, B.Sc.(Hons), Ph.D. B.H. Stinear, B.Sc., M.A.A.P.G., A.M.Aus.I.M.M.
Geophysicist Class 4	C.S. Robertson, M.Sc., S.E.G., A.S.E.G.
Petroleum Technologist Class 4	J.A.W. White, B.Sc.(Hons), A.R.S.M.
Geologist Class 3	L.V. Bastian, B.Sc.(Hons). E.E. Young, Mrs, B.Sc.
Geophysicist Class 3	A.L. Bigg-Wither, B.A., B.Sc., M.Sc. K.F. Fowler, B.Sc. W.J. McAvoy, B.Sc.

Petroleum Technologist Class 3	F.H. Lepine, B.Sc., P.Eng.
Geologist Class 2	S.J. Mayne, M.A., M.Sc.
Geophysicist Class 2	J.C. Mutter, B.Sc. M.J. Raine, Mrs, B.Sc.
Geologist Class 1	E. Nicholas, Mrs, M.Sc.
Boring Supervisor	J.B. Morgans
Clerical Assistant Grade 4	D. De Smet
Senior Draftsman	J. McGovern, L.E.S.D. Cert.
Draftsman Grade 2	D.A. Lawry
Drafting Assistant Grade 2	N. Kozin, Mrs
Senior Technical Officer Grade 1	I.K. Kraitsowits, Dip.Geol.
Technical Officer Grade 1	S. Ozimic
Technical Assistant Grade 2	W.C. Brown A.P. Mathews L. Rixon
Technical Assistant Grade 1	P. Maylor D.C. Monckton
Assistant Grade 1	D. Ivansevic, Miss

Staff Changes

During the year, 123 officers commenced duty and 115 ceased duty with the Bureau. The respective totals include 33 and 51 officers in professional classifications. The number of professional officers in each classification who commenced and ceased duty during 1970 is shown in the table below. A measure of the loss of experience from the Bureau is the fact that 31 professional officers of Class 2 and higher ceased duty during the year, and only 4 commenced duty.

Changes in professional staff, 1970

	<u>Ceased Duty</u>	<u>Commenced Duty</u>
Geologist Class 4	3	-
Geophysicist Class 4	1	-
Geologist Class 3	9	1

	Ceased Duty	Commenced Duty
Geophysicist Class 3	2	-
Petroleum Technologist Class 3	1	-
Mining Engineer Class 3	1	-
Geologist Class 2	6	2
Geophysicist Class 2	8	-
Mineral Economist Class 2	-	1
Geologist Class 1	11	21
Geophysicist Class 1	5	10
Chemist Class 1	1	1
Librarian Class 1	3	2

FINANCE

The following expenditure (excluding Petroleum Search subsidy, for which see p. 53) was incurred by the Bureau in calendar year 1970:

Item	1/1/70-30/6/70 (\$)	1/7/70-31/12/70 (\$)	Total (\$)
Salaries and Extra Duty	1,359,981	1,736,747	3,096,728
Travel and Subsistence	156,624	228,442	385,066
Office Requisites	27,441	32,043	59,484
Telephone and Postage	43,479	33,414	76,893
Office Services	8,075	8,418	16,493
Publications - Printing and Distribution	93,275	64,924	158,199
Motor Vehicles	256,514	243,537	500,051
Bureau Aircraft	88,033	92,273	180,306
General Stores	92,424	179,248	271,672
Contract Investigations	369,464	1,061,469	1,430,933
Freight and Cartage	28,366	41,422	69,788
Minor Field Operating Costs	30,751	29,803	60,554
Repairs and Maintenance Equipment	*	11,177	11,177
Plant and Equipment	195,898	260,224	456,122
Riverview College Grant	-	4,000	4,000
Incidentals	27,349	12,307	39,656
Totals	<u>2,777,674</u>	<u>4,039,448</u>	<u>6,817,122</u>

INDEX

This index refers to all chapters of the annual report except Publications and Staff.

A

Adelaide Geosyncline, 18
Adelaide University, 40
Advisory Committee on
 Seismology and Earthquake
 Engineering, TPNG, 45
Aerial photography, 12, 16,
 19, 34
Airborne gravity surveys,
 17, 19, 22
Airborne magnetic surveys,
 5, 12, 17, 19, 21, 23
Airborne radiometric surveys,
 17, 21, 49,
Airborne seismic surveys, 23
Alcoota, N.T., 20
Alice Springs N.T., 8, 20
Amadeus Basin, 19
American Geophysical Union, 74
Amery Ice Shelf, Ant., 42
Amphlett Islands, 25
Angoram, TPNG, 24
Antarctica studies, 25-26
Antrim Plateau volcanics, 21, 22
ANZAAS Congress 1970, 45
Artlunga Nappe, 20
Arunta Complex, 7, 20
Astrolabe, TPNG, 22
Atnarpa Antiform, 20
Australian Calibration Line
 Survey, 9
Australian Code of Stratigraphic
 Names, 64
Australian National University,
 20, 25, 34, 36, 37, 40, 50
Australian Water Resources
 Council, 51

B

Baas Beeking Geobiological Research
 Laboratory, 33, 37
Bagana, Bougainville Island, 47
Barite deposits, 13, 34
Basins studies, 5, 10, 11, 17, 18, 19, 20,
 31, 34, 35, 57-58
Beach sand deposits, 46
Benmore, NSW, 16
Bentonite deposits, 34
Bismarck Sea, 7, 28, 36
Bismarck Volcanic Arc, 24, 25
Bitter Springs Formation, 20
Bonaparte Gulf Basin, 31
Bougainville Island, 47
Bowen Basin, 11, 13, 35
Brisbane, QLD, 14
Broad Sound, QLD, 10, 11, 37
Broken Hill, NSW, 8
Bullock Creek, NT, 30
Buna, TPNG, 45
Burdekin regional maps, 52
Bureau of Census and Statistics, 59

C

Canberra, A.C.T., 24, 30, 39, 40
Canning Basin, 57, 62
Cape Gloucester, TPNG, 24
Cape Moreton, QLD, 28
Capricorn Channel, 27, 28
Carnarvon Basin, 62
Carnarvon Range, QLD, 12
Carpentaria Basin, 10, 34
Celia, NT, 49
Celia Dolomite, 49

Central Register of Australian
Stratigraphic Names, 64
Chinchilla, QLD, 30
Claraville Homestead, NT, 20
Coal deposits, 14, 59
Clematis Sandstone, 11
Cloncurry, QLD, 7, 12, 32
Coastal erosion survey, 14,
Cocos Island, 41
Coffs Harbour, NSW, 28
Commission for the Geological
Map of the World, 50, 72
Computer applications, 6, 8,
29, 34, 55-56, 58
Conference of Chief Inspectors
of Mines, 60
Consultative Committee on
International Radio, 40
Cook Sheet, SA, 17
Cooper Basin, 62
Copper deposits, 13, 22, 46
Core and Cuttings Laboratory,
6, 57
Corin Dam, A.C.T., 33
Coronation Hill, NT, 49
Crater Formation, 49
Crustal and Upper Mantle
Surveys, 8
CSIRO, 15, 37
Curtis Channel, 28

D

Darwin, N.T., 39, 48-49
Davis, Ant., 42
Dean Quartzite, 33
D'Entrecasteaux Group, 25
Department of Lands and
Surveys, TPNG, 45
Department of National
Development, 52
Department of the Interior,
33, 36
Department of Trade and
Industry, 57

Department of Works, 33
Director's report, 5
Dobu Island, 25
Drilling Operations, 10, 19, 20, 22, 47,
48-49, 57, 60

E

Earth Resources Technology Satellite, 73
ECAFE Committee on Industry and
Natural Resources, 73
ECAFE Committee on Joint Prospecting
for Mineral Resources in Asian
Offshore Areas, 73
Egum Atoll, 25
Electrical surveys, 22, 48
Electromagnetic surveys, 16, 22, 48
Engineering Geology and Geophysics, 43
Eromanga Basin, 10, 17
Estuary studies, 10, 33
Eucla Basin, 17, 18
Evaporites study, 19

F

Fergusson Island, 25
Field operations, 8-26
Financial statement, 91
Flinders Ranges, S.A., 17, 18
Fluorite deposits, 13
Forbes Glacier, Ant., 26
Framnes Mountain, Ant., 26
Fraser Island, 28
Functions and Organization, 1-4

G

Gardiner Range, N.T., 19
Gawler Block, 18
Geochemical studies
See Petrology, Geochemistry and
Geochronology

Geochronology
See Petrology, Geochemistry
and Geochronology
Geological Map of Australia
and Oceania, 7, 51
Geological Map of Northern
Territory, 52
Geological Map of Papua-
New Guinea, 52
Geological Society of
Australia, 50, 64
Geological Survey of India,
72
Geological Survey of Malaysia
72
Geological Survey of New
Zealand, 7, 51
Geological Survey of
Queensland, 10, 12
Geological Survey of South
Australia, 17
Geological Survey of Western
Australia, 18
Geomagnetism, 40
Geophysical logging, 10, 19
Georgina Range, N.T., 20
Gibson Desert, W.A., 18
Gidgealpa Formation, 62
Glengarry Sheet, W.A., 19
Glen Gordon Volcanics, 33
Gnangara, W.A., 41
Gold deposits, 59
Gondwana Symposium, 30, 72
Goodenough Island, 25
Googong, A.C.T., 43
Goroka, TPNG, 22, 39
Gosses Bluff, N.T., 7, 35,
36-37
Gravity surveys, 5, 8, 9, 14,
17, 19, 22, 25, 28, 36
Great Artesian Basin, 7, 10
Great Victoria Desert, 18
Groundwater maps of
Australia, 51
Gulf of Papua, 28

H

Hawaiian Institute of Geophysics, 36, 72
Heavitree Quartzite, 20
Herberton, QLD, 33
Hobart, TAS., 9
Huandot, N.T., 49
Hunter Valley, N.S.W., 15, 16
Hydrogeological surveys, 10

I

Information Services, 63
Inindia Bore, N.T., 19
Instrument Design and Development, 53-54
International Association of Engineering
Geologists, 72
International Association on the Genesis
of Ore Deposits, 74
International Gas Congress, 73
International Geochemical Prospecting
Symposium, 74
International Geological Atlas, 51
International Gravity Commission, 72
International Lead-Zinc Study Group, 59, 73
International Mineralogical Association, 74
International Rock Mechanics Congress, 72
International Seismological Commission, 39
International Symposium on Recent Crustal
Movements and Associated Seismicity, 72
International Union of Geological Sciences, 50
International Tin Council, 59
Ionospheric Prediction Service Division, 39, 40
Ionospheric recording, 28

J

Jervis Bay, A.C.T., 43
Jimi Valley, TPNG, 22
Joint Oceanographic Conference, 74
Joint Studies, 10, 12, 15, 17, 18, 20, 25,
36-38, 50

K

Kalgoorlie, W.A., 8, 19, 39
Karkar Island, 46
Kimbe Bay, New Britain, 29
Kingston Sheet, W.A., 19
Kununurra, W.A., 39
Kwana River, TPNG, 46

L

Laboratory studies, 30-35
Lae, TPNG., 39
Laiagam, TPNG, 9
Lake Burley Griffin, A.C.T., 33
Lake Corella, QLD, 12
Lake George, N.S.W., 44
Laloki River, TPNG, 46
Lamington, TPNG, 47
Laugila, TPNG, 47
Laverton, W.A., 19
Lead-zinc-silver deposits, 13
Leonora, W.A., 19
Library services, 63
Lusancay Islands, 25

M

Macarthur River, N.T., 32
Macquarie Island, 39, 41
Madang, TPNG, 24, 40
Magnesite deposits, 49
Magnetic surveys, 8, 14, 17, 19,
21, 22, 23, 28, 36, 41
Mallacoota Inlet, N.S.W., 10, 37
Manam, TPNG, 47
Marine Operations, 6, 14, 27-29,
55
Markham, TPNG, 45
Maroochydore, QLD, 15
Martin Massif, Ant., 26
Mary Kathleen, QLD, 7, 12
Matupi Harbour, New Britain, 38
Mawson, Ant., 25, 26, 39, 41

Meckering, W.A., 39
Meekatharra, W.A., 19, 39
Melbourne, VIC., 9
Metallogenic Map of Australia and New
Guinea, 7, 50
Mildura, VIC., 8
Mineral Economics, 59
Mining Advisory Board, TPNG, 45
Mining Engineering, 59
Minister for National Development, 59
Momote, TPNG, 39
Moolayember Formation, 12, 13
Moore Pyramid, Ant. 25, 26
Morton Craig Range, W.A., 18
Mount Brassey, N.T., 20
Mount Doreen sheet, N.T., 20
Mount Garnet, QLD., 33
Mount Hagen, TPNG, 22
Mount Isa, 12, 13, 32
Mount Isa Mines Ltd, 33
Mount Langhlin, N.T., 20
Moura Coalfield, QLD, 14, 44
Mundaring, W.A., 39, 40
Musa Gorge, TPNG, 43, 46
Musgrave Block, S.A., 18

N

Napperby Sheet, N.T., 20
New Britain, 25, 31, 36
New Guinea
 see Papua-New Guinea
New Ireland, 36
New Zealand Antarctic Expedition, 30
Ngalia Basin, 20, 33
Norfolk Island, 39
Northern Territory Geological Survey, 32
Nowra, N.S.W., 57

O

Observatories, 39-42
Officer Basin, 7, 18
Ooldea Sheet area, S.A., 17
Ord River, W.A., 40
Ormond River, TPNG, 22
Overhand Mine, QLD, 14
Overseas visits, 72-74

P

Palaeomagnetism, 35
Palaeontological studies, 15, 30-31
Papua-New Guinea studies,
5, 6, 7, 22-25, 28, 29, 31, 32, 33,
39, 43, 45-48, 52
Perth Basin, 62
Petrel No. 1 well, 62
Petroleum Advisory Board,
TPNG, 45
Petroleum Search Subsidy,
61-62
Petroleum Technology,
33, 60
Petrology, Geochemistry, and
Geochronology, 5, 22, 25,
31-33, 37
Phosphate deposits, 10
Photogeology, 34
Pine Creek, N.T., 48
Pirie-Torrens Basin, 18
Port Macquarie, N.S.W., 27
Port Moresby, TPNG, 9, 39, 40,
41, 45, 46
Precipice Sandstone, 13
Prince Charles Mountains,
Ant., 25, 26, 42
Publications, 65-71
Public Service Board, 72, 74
Public Works Dept. of
Western Australia, 39, 40

Q

Queensland Co-ordinator General's Dept., 14

R

Rabaul, New Britain, 38, 47
Radioactive Protection Working Group, 60
Radiometric surveys, 12, 17, 21, 22, 49
Ramu, TPNG, 7, 23, 43, 46
Regional Gravity Map of Australia, 51
Remote sensing survey, 19
Resident geologists, 45-49
Rewan Formation, 11
Rolling Downs Group, 31
Roseneath No. 1 well, QLD, 62
Rouchel, N.S.W., 15
Rouna, TPNG, 43, 47
Royal Australian Mint, 32
Rum Jungle, N.T., 48

S

Sahul Shoals No. 1 well, W.A., 31
Salinity, marine measurements, 15
Schouten Islands, 25
Scientific Advisory Committee to the
National Parks Board, TPNG, 45
Scientific Committee on Antarctic
Research, 73
Sedimentology studies, 11, 37
Seismic surveys, 8, 10, 14, 15, 23, 28, 36
Sepik plains, TPNG, 23
Shirley, N.T., 49
Shoalhaven River, N.S.W., 15
Silver See lead-zinc-silver
Sirrinumu dam, TPNG, 43, 47
Skylab project, 73
Solomon Sea, 36
Sonarva Island, 25
South Australian Mines Dept., 17
Special Maps, 50-52

Staff, 75-90
Standards Association of
Australia, 60
Stapleton, N.T., 49
Strangways Range, N.T., 32
Stratigraphic Index, 64
Sturt Highway, N.T., 48
Sulphur deposits, 19
Sydney Basin, 57
Symposium on Antarctic Geology
and Geophysics, 73
Symposium on Geochemical
Prospecting Methods and
Techniques, 73

T

Tectonic Map of Australia
and New Guinea, 50
Tektite 11 Operation, 73
Temperature, marine
measurements, 15
Tennant Creek, N.T., 21
Tomkinson Creek Beds, 21
Toolangi, VIC., 39, 41
Tullamarine Airport, VIC, 42

U

Ulawun, TPNG, 47, 48
United Nations Special Fund
project, 34
United Nations Tungsten
Committee, 59
University of New England, 15
University of Newcastle, 15
University of Papua-New
Guinea, 45
University of Queensland, 36
Uranium deposits, 48-49
Upper Mantle Symposium, 72
U.S. Geological Survey, 36
U.S. National Aeronautical and
Space Administration, 73

V

Victoria River, N.T., 21
Victorian Rivers and Water Supply
Commission, 16
Vitiav Strait, 29
Volcanoes, studies, 24, 37, 47-48

W

Wabag, TPNG, 39
Warramunga Beds, 21
Waterhouse Granite, 49
Western Pacific Calibration Line, 9
Wiluna Sheet, W.A., 19
Winton Formation, 17
Wire Rope Research Committee, 60
Woods Hole Oceanographic Institute
of Massachusetts, 33

Z

Zeehan, TAS., 16
Zinc See lead-zinc-silver
Zirconium sponge study, 59