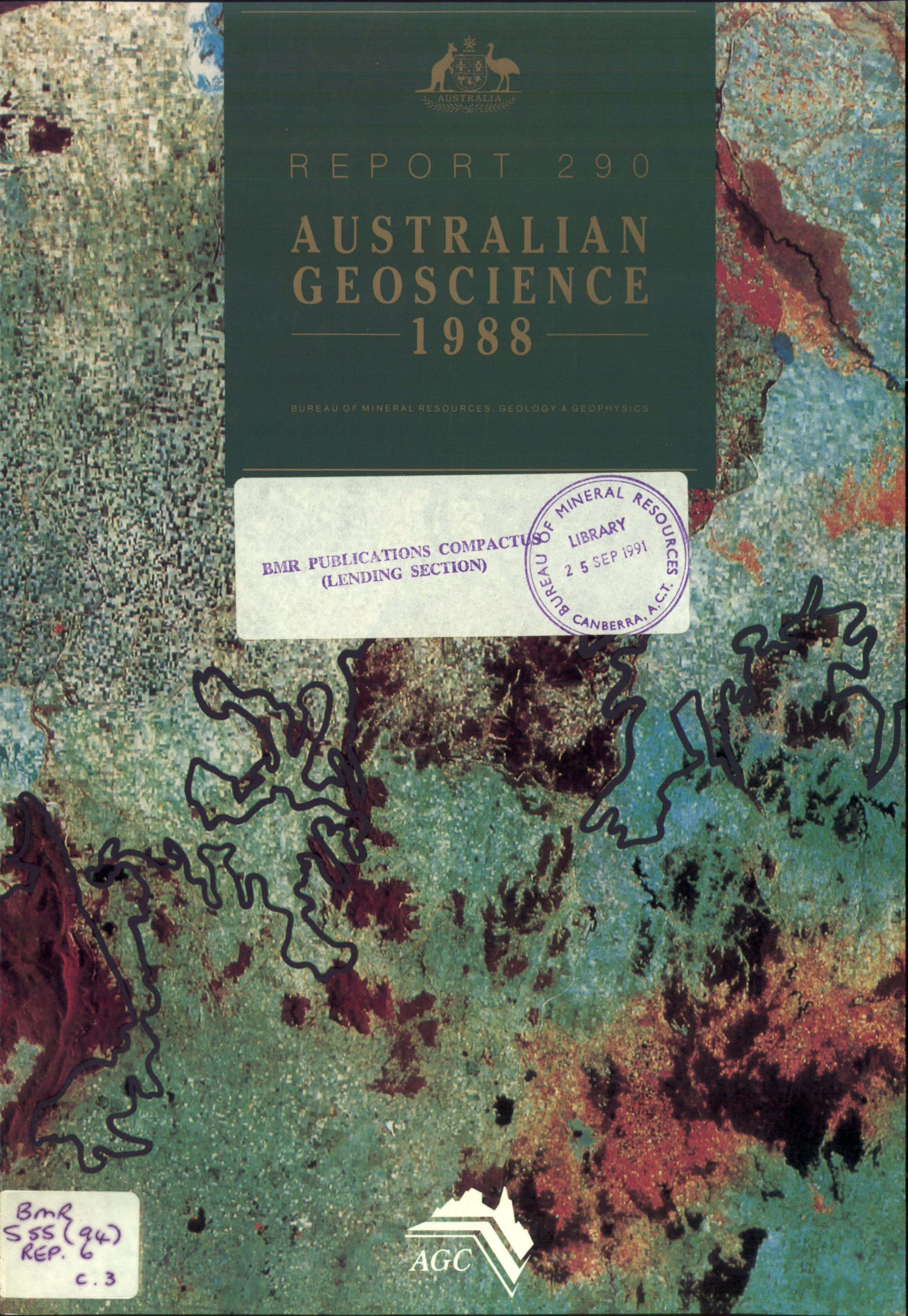

REPORT 290

AUSTRALIAN GEOSCIENCE 1988

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

DEPARTMENT OF PRIMARY INDUSTRIES & ENERGY
BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

REPORT 290

Australian Geoscience 1988

Annual Report of the Australian Geoscience Council Inc. The Council of Earth Science Societies in Australia

Compiled and edited by
E.P. Shelley

Bureau of Mineral Resources
Geology & Geophysics

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Cover: Part of a Landsat mosaic of the Murray Basin in Southeastern Australia. The Murray Basin has been the subject of extensive hydrogeological research which was reported during the *Murray Basin 88* conference held in Canberra in May 1988. A short report on the Conference heads the 'Highlights' section in this issue of *Australian Geoscience*. (Copies of this map may be purchased from the Bureau of Mineral Resources, GPO Box 378, Canberra ACT 2601.)

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ISSUES IN GEOSCIENCE IN 1987-88

Murray Basin 88 Conference

This conference was held in Canberra in May 1988 and was sponsored by the Australian Geoscience Council and the Groundwater Working Group of the Murray-Darling Basin Commission.

The conference was aimed at identifying the nature and extent of groundwater-related problems of salinisation in the Murray Basin and canvassing issues concerned with the formulation of resource management options. One hundred and seventy registrants attended the Conference and a total of fifty papers by 92 authors were presented. This report highlights the main conclusions and recommendations from the Conference.

The conference reinforced the fact that salinity problems in the Murray Basin are strongly groundwater-related. It revealed that many of the basic groundwater processes which result in salinity problems are reasonably well understood, but many aspects remain to be investigated. These include:

- the timescales of salinisation and groundwater movement,
- the mechanisms which control recharge and discharge.

The conference highlighted the fact that recharge of groundwater systems, owing to clearance of natural vegetation and leakage from irrigation areas, is a major cause of rising groundwater levels and hence salinity problems. Any further broadscale clearance should be discouraged. Revegetation is effective in solving local salinity as a salinity management tool. The groundwater systems must be fully understood before embarking on major revegetation programs. This will require the development of regional and basin-wide groundwater models.

Broadscale resource management options for the Murray Basin must be developed with the fullest consideration being given to hydrogeology and the role of groundwater in causing, and potentially in ameliorating salinity problems.

Groundwater levels must be lowered in many parts of the basin. The alternative is reduced agricultural productivity and continuing environmental destruction. A variety of strategies involving reduction in recharge and/or lowering of the water table by pumping and other methods are currently being evaluated and implemented. The underlying problem in most salinity-management strategies is the disposal of saline water in an economically and environmentally acceptable manner.

The collection of data and investigation of systems and processes which cause salinisation needs to continue in key areas. However, the emphasis of many current studies has now shifted to investigation of options for salinity management. Future emphasis should be placed on the development of predictive tools suitable for integrated management (eg hydrogeological maps, and groundwater modelling and monitoring).

High priority should be given to hydrogeological studies that will provide the basis for the development of an effective saline water disposal strategy.

The joint use of surface water and groundwater requires investigation. This will involve a comprehensive assessment of the fresh groundwater resources of the basin.

The development of community education programs is essential in order to raise the level of public awareness and provide support for government action.

There is a need for coordination of groundwater actions by Commonwealth and State authorities, because groundwater systems operate basin-wide.

Effective management of the Murray Basin depends on the development of appropriate institutional and consultative mechanisms, as well as a sound knowledge of the physical processes involved. These must be brought together at the earliest opportunity to avoid irreversible land degradation in the Murray Basin.

A summary report on the Conference has been published as BMR Record 1988/43.

Global change and the International Geosphere-Biosphere Program (IGBP)

As the magnitude of accelerating change resulting from human impacts on global terrestrial ecosystems increasingly threatens the sustenance of many biotic life-cycles and the function of human society, nations worldwide are being forced to take stock of their often precarious situation. These national situations, associated with global change, have been identified as forming a common theme or universal problem which should be addressed by the International Geosphere-Biosphere Program, now set to run for the decade from 1990 to the year 2000.

Rationale for IGBP

In the past 30 years, the world community of scientists has undertaken a number of broadly-based international programs of research aimed at increasing our knowledge in areas of the Earth and biological sciences, organised through the International Council of Scientific Unions (ICSU) and other international scientific organizations such as UNESCO, UNEP and the WMO. Among these programs were the International Geophysical Year, the International Biological Program, the continuing World Climate Research Program, Man and the Biosphere Program, International Hydrological Program, International Lithosphere Program, and the planned International Solar-Terrestrial Program. These and other major international efforts have tended to concentrate on individual components of the total Earth system: the atmosphere, the biosphere, the hydrosphere, the lithosphere, or the solar-terrestrial medium.

Progress in each of these areas now makes it possible to initiate a new and broader initiative aimed at a fuller understanding of the Earth as an interconnected whole. The International Geosphere-Biosphere Program will build on the foundations that other programs have laid and utilise their continued findings, to the benefit of both. Importantly, it will also initiate a set of new activities—uniquely appropriate for ICSU—that are directed at understanding the key interactions that link the various components of the Earth system, in an effort to fill the critical gaps between them. Its ultimate goals are a fuller understanding of the Earth as a system and a fuller awareness of the course and causes of significant global change.

The dominant changes that affect the environment and the course of life on Earth are natural ones, induced by such inexorable forces as natural selection, the shifting of winds and rivers, changing inputs from the Sun, the turbulent

dynamics of the atmosphere and oceans, the drifting of continental plates, the building of mountains, and the expansion and contraction of ice masses. But imposed on these is now another set of changes, more recent and immediate in consequence, that are the clear result of human activities. Our uses of energy and practices of intensive farming and technology have altered the albedo of the Earth, the composition of soil and waters, the chemistry of the air, the areas of forests, the diversity of plant and animal species, and the balance of the global ecosystem. To read the impacts of human actions - or to forecast their effects—requires a fuller knowledge of the natural background of change on which they are imposed, and the processes and feedbacks through which they work.

Immediate practical problems of the global environment such as acid rain, desertification, soil degradation and the build-up of greenhouse gases are much alike in that they involve interactive processes that transcend the bounds of single disciplines. In many cases uncertainties in our understanding of the complex interdependencies of the geosphere and biosphere restrict our ability to identify causes or effects, or to anticipate the costs and benefits—economic or environmental—of possible responses.

These interactions now loom as a major unknown in our understanding of the Earth as a system; and they are not fully addressed in existing research programs. What is needed is a transdisciplinary effort among segments of the earth and biological sciences, a way of consolidating the advances made in more discipline-oriented, ongoing programs, and the international organisation and national commitments necessary to mount a truly global study.

The IGBP will be a carefully-designed program of research directed at providing the information we need to assess the future of the Earth in the next 100 years, with an emphasis on processes that change on time-scales of decades to centuries. It will be a program of basic research with almost immediate practical applications in the management of resources at national and international levels and as a means of improving the reliability of warnings of global change of significance to our environment and to humankind.

The program will be tightly focused, with emphasis on interactive processes that are not addressed by other existing programs. Topics suggested for early emphasis in the IGBP include: (1) studies of biogeochemical cycles; (2) studies of the ocean euphotic zone; (3) studies of soil dynamics and soil chemistry; and (4) studies of variable solar inputs to the Earth. Emphasis is also put on the need for development of an adequate global data and information system. Such a system must be an integral part of the program.

It is recommended that ICSU create a Scientific Committee for the IGBP (SCGB) with responsibility for initiating a preparatory phase lasting about four years and for the implementation of an operational phase beginning in the early 1990s. The operational phase will last at least 10 years.

A primary responsibility of the Scientific Committee will be to ensure that the objectives of the program are well designed and that it complements current and planned international scientific programs. The Committee will also be responsible for the establishment and maintenance of liaison with international and national organisations responsible for related programs and for ensuring the coordination of inputs from other members of the ICSU family, including the National Members.

Australian activities for IGBP

The Australian Academy of Science has established a National Committee for the IGBP to provide scientific coordination of the development and implementation of Australia's plans to participate in the Program. In partnership with the federal government, it ran a four-day meeting in February 1988 to survey the outstanding scientific problems of the IGBP and to commence planning on the Australian scene for the IGBP proper.

In close liaison with the ICSU Steering Committee for the IGBP, the Australian National Committee will coordinate workshops in Australia in the next two years to define in detail Australia's participation in the main Program.

The Academy looks forward to collaborating with federal and state government agencies, universities, CSIRO and other agencies to ensure that Australia plays its rightful, responsible role in the IGBP.

Further enquiries about development of Australian plans to participate in the IGBP should be directed to:

Chairperson
Australian National Committee for the IGBP
Australian Academy of Science
GPO Box 783
CANBERRA ACT 2601
Telex No AA62406
Facsimile No (062) 48 0639
Phone No (062) 47 3966

Gordon Burch

Applied geoscience in the mineral industry

Professional geoscientists in the Australian mineral industry will take pride in the new discoveries announced in 1987-88, and in the substantial increases made to ore reserves, output and efficiency, especially in the gold sector.

The economic impact attributed in part to geoscience is shown by a lift in gold output from 87t worth about $1600 million in 1986-87 to an estimated 124t worth about $2100 million in 1987-88. The discoveries in Table 1 (supplied by BMR) comprise three base-metal, two mineral-sand and two gold deposits. This result signifies the breadth as well as depth of future resource developments. Such developments will continue to require the best application of geoscientific disciplines for their successful fruition.

The much feared adverse effects of the October 1987 stock exchange crash were belied by the fact that the mineral exploration industry spent about $690 million in 1987-88 compared with $557 million in the previous year. A Federal Government decision to propose a gold tax in 1991 spurred gold producers to increase short-term production activity. Geoscientists played a leading role in much of this action. As a result, professional employment trends remained buoyant over the period.

The Australian Mineral Foundation, Adelaide, made significant constitutional changes to better serve its industry clients in the areas of specialised technical education and geoscience information services. Some signs of rationalisation and better integration in tertiary institutions which teach geoscience began to appear. The changes are, in some aspects, in line with the Government's white Paper on tertiary education.

Competing multiple land-use claims and declining access to land for exploration continued to be an external issue of great concern to industry geoscientists. A noteworthy step forward in public education was the assessment

of the mineral potential of the north Queensland wet-tropical rainforests and southwest Tasmanian by experienced geoscientific consultants. The announcement of changed arrangements for exploration of a large tract of aboriginal land in the northwest of the Northern Territory, after many years of delay, gave hope for better progress on this difficult and sensitive topic.

For those keen to keep up with current developments there was an active international and national conference circuit. The highlight was the prestigious and successful *Bicentennial Gold '88* in Melbourne in May 1988 with the theme 'Gold and the Explorationist'. It attracted 1100 delegates, many from overseas, and over 300 papers. The Gold Coast was host to the *Pacrim Congress 87* in August 1987 with the theme 'Geology, Structure, Mineralisation and Economics of the Pacific Rim'. Some 740 delegates attended, 20% from overseas.

International and local geologists, geochemists and geophysicists supported the *Second International Conference on Prospecting in Arid Terrain* in Perth in April 1988. Over 200 of the mining fraternity conferred on '*Resources and Reserves*' in Sydney in November 1987 to try to achieve better public reporting terminology. A little-publicised seminar in Canberra on '*Risk and Survival: Mineral and Petroleum Exploration in Australia*' in April 1987 was voted by the few who attended as one of the best and most professional of its type.

Geoscientists who had any time to spare from these activities, not to mention holding down jobs, might be found tardily preparing papers for publication in the new AusIMM volume on *The Ore Deposits of Australia and Papua New Guinea* due for completion in 1989. Many will already have contributed to the Bicentennial Monograph on *Geological aspects of the discovery of important minerals in Australia* due to be published in late 1988.

Recognition of individual industry geoscientists was made by the award of the William Laurence Saunders Gold Medal of the American Institute of Mining Engineers to Roy Woodall AO, and the election of Don Zimmerman as President of the Australasian Institute of Mining and Metallurgy for 1987. The latter organisation conferred the AusIMM President's Award on Frank Hughes.

David Mackenzie

Issues in geoscience education

The Australian Geoscience Council and its Executive actively participated in several issues relating to geoscience education during 1987-88.

Higher education policy statement

A summary of the federal government's *Green Paper* was prepared and widely circulated. It was used by a variety of bodies to focus attention on the many issues raised. The Executive prepared a response to the *Green Paper* highlighting the main issues so far as geoscience was concerned. The submission was acknowledged by Mr Dawkin's office but it seems to have had little or no effect on the contents of the subsequent *White Paper*. Subsequently I addressed a meeting of the Canberra Branch of the Australasian Institute of Mining & Metallurgy on issues that geoscience bodies should be aware of in the implementation of the directives of the *White Paper*. A summary of this address has been circulated.

Creation science

The Executive wrote to all State and Territory Ministers for Education pointing out the educational and economic implications of creation science so far as geology was concerned. All have now responded indicating that they have considered the matter. All except Queensland have stated that creation science will not be taught as science in their schools. Queensland responded in a most equivocal manner, and so a second letter was sent. This produced a more subtle casuistic response, and we have decided not to proceed further.

Secondary teacher training in science and mathematics

The Executive made a submission to the Federation of Australian Scientific and Technological Societies (FASTS) Education Committee which is preparing a general submission to the Review of Secondary Teacher Training in Science and Mathematics. This emphasises general points as well as some specific to earth science. A second submission that deals only with earth science will be sent to the reviewers and will supplement a submission already made to Associate Professor John Mack who is a FASTS representative on the Review Committee.

Geoscience Awareness Program

We have supported the Geoscience Awareness Program (GAP) where we have been able to do so. This has been done mainly through direct contact with Robyn Stutchbury who has made requests for information or support on several occasions. She attended a Council meeting in May 1988 to describe the activities of GAP to members.

IGBP

The International Geosphere-Biosphere Program offers an excellent opportunity for earth scientists to become involved with a wide range of other scientists. We have organised a joint *Geology in Action/Biology in Action* to go to school children studying in both areas.

Immigration of geoscientists

Good contact has been made with the group in the Department of Employment, Education & Training that is responsible for the preparation of advice to government on the number of skilled immigrants who should be allowed into the country to fill positions in the earth sciences. The effects of overseas imports on the stability of the intake into tertiary geology departments has been forcibly emphasised.

Ken Campbell

STATUS OF THE GEOSCIENCES IN AUSTRALIA

The status of the geosciences within Australia was last reviewed in *Australian Geoscience 1984*.

The reports that follow have been provided by representatives of the constitent organisations of Council. They cover research and exploration activities over the period 1985-1987 and report on major achievements and problems and in some cases outline plans for future work. Reports on several subdisciplines are not included as they were not received prior to the publishing deadline.

Council thanks all those who contributed to the reviews.

Antarctic studies

The reporting period was an eventful one for Australia's Antarctic earth science program. It had been planned that summer operations would resume at the Edgeworth David base camp in the Bunger Hills but adverse ice conditions prohibited access. Operations were therefore transferred to the Larsemann Hills, about 120km southwest of Davis station.

These outcrops consist of high grade metamorphic rocks of probable Proterozoic age and detailed structural geology and metamorphic petrology studies were made by a post-graduate student from the University of Melbourne together with a PhD student from the University of Frankfurt (FRG) and a lecturer from Leoben University (Austria). A team from the Australian Defence Force Academy studied the area's lakes—which are apparently all freshwater—and its geomorphology.

The group that eventually reached the Larsemann Hills visited Commonwealth Bay, where the hut used by Sir Douglas Mawson's 1911-14 Expedition still stands, and mapped and sampled the bedrock exposures (originally mapped by F. L. Stillwell).

The other main locus of earth science field activity in the 1986-87 Antarctic summer season was at Heard Island where petrologists from the University of Tasmania studied the Big Ben volcano and sampled a flow erupted in 1986. Samples of much older volcanic and sedimentary rocks exposed at lower elevations on Heard Island were collected for stratigraphic and palaeontological study at the Antarctic Division and for palaeomagnetic investigation at BMR.

Away from the immediate area of Australian Antarctic operations, the Ocean Drilling Program vessel Joides Resolution successfully completed an Antarctic drilling leg in the Weddell Sea region. Airborne gravity and magnetic surveys were flown in the Antarctic Peninsula-Weddell Sea and Enderby Land-MacRobertson Land regions by United States and USSR scientists respectively.

After the summer field season Australia's Antarctic Earth Scientists congregated in Hobart in May 1987 for an informal second *Workshop on Antarctic Geology*. Financial assistance from the Antarctic Science Advisory Committee (ASAC) and 25th IGC fund of the Australian Academy of Science was used to subsidise travel expenses of participants.

The Workshop was organised to coincide with the Macquarie Island Symposium which had its own earth science component, and was opened by the Chairman of ASAC, Professor John Lovering. The Workshop was intended as an opportunity for participants to:

1. review past research;
2. prepare for the Fifth International Symposium on Antarctic Earth Science (see below); and
3. plan future programs.

As things turned out the Workshop was, in general, regarded as a success but with item 3 less satisfactorily covered than 1 and 2.

The *Fifth International Symposium on Antarctic Earth Science* was convened in Cambridge, England in August 1987. About 12 Australians attended and contributed to the symposium and the associated meetings of the Group of Specialists on the Structure and Evolution of the Antarctic Lithosphere, the Group of Specialists on the Cenozoic Palaeoenvironments of the Southern high latitudes (or Glacial history), and the Working Groups on Geology and Solid Earth Geophysics.

The above bodies are subsidiaries of the international Scientific Committee on Antarctic Research (SCAR) which is affiliated with the International Council of Scientific Unions (ICSU). Australian papers dealt with palaeontology, Cainozoic glacial geology, metamorphic and structural geology, and igneous petrology.

The 1987-88 season also started with a major shipping incident—the grounding and scuttling of *Nella Dan*—which threatened the summer field program. However the Antarctic Division were able to make alternative arrangements and maintain the program which included geological mapping in the Vestfold Hills, Rauer Islands, Larsemann Hills, and other outcrops on the east shore of Prydz Bay, and the east side of the Amery Ice Shelf.

The Ocean Drilling Program also drilled several holes in Prydz Bay early in 1987 apparently in response to a 1981 research proposal by BMR scientists. Geological studies of the bedrock exposures in the Windmill Islands near Casey Station were also resumed.

During 1987 BMR maintained and upgraded its seismic and magnetic observatories at Mawson and Macquarie Island. In recent years the Antarctic Division has upgraded telecommunications links between Australia and Antarctica and BMR is moving to take advantage of this for the telemetry of its Antarctic observatory data.

Coal geoscience

The international coal market became increasingly competitive between 1985 and 1987 with export coal prices substantially reduced in real terms. Despite this, total coal production in Australia continued to increase. However, exploration expenditure, a measure of industry confidence in the future, appears to remain very low.

The challenge to develop more efficient coal mining and coal preparation practices is being undertaken by the funding of research projects by the National Energy Research Development and Demonstration Council (NERDDC). Much of the research is performed by the Australian Coal Industry Research Laboratories (ACIRL) and the remainder by other organisations such as CSIRO, universities, companies, and government departments.

In New South Wales, NERDDC-funded studies of the Southern Coalfield are being conducted by the University of Wollongong and by the Department of Mineral Resources. Projects conducted by ACIRL have included applications of downhole geophysical logs in the prediction of

geotechnical conditions. Important developments related to the mining of thick underground black coal seams have included thick-seam single-pass and multislice longwall extraction techniques, which are being tested in the Bowen and Sydney Basins. Research being undertaken by ACIRL at Collie, Western Australia, is designed to increase coal recoveries where excessive groundwater occurs in weak roof strata over potentially-mineable underground coal seams.

CSIRO is developing a number of joint-venture proposals designed to replace contract research and increase the proportion of funding through the collection of royalty payments. These proposals include studies of coal dewatering by Aquaterre Pty Ltd, a company set up by CSIRO in partnership with Davy McKee Pacific Pty Ltd and Mawson Consolidated, and the establishment of Coal Processing Consultants (CPC), a 50/50 joint venture with ACIRL designed to combine their resources to produce a problem-solving facility for the coal industry.

Another project being conducted by CSIRO aims to reduce coal mineral matter content to less than one percent. A pilot plant is planned to produce a fuel-oil substitute in the form of a pulverised coal/liquid mixture, at a cost of around one third that of conventional fuel oil.

The Standing Committee on Coalfield Geology of NSW is working on systems to facilitate the exchange of encoded coal geological data and on preparing guidelines for the geological investigations required for the introduction of longwall mining units. Extensive coal-measure correlation studies are also in progress.

In Victoria, brown coal industrial developments conducted by the Coal Corporation of Victoria include construction of a coal-to-oil plant at Morwell at a cost of around $4 million. Intensive research is being conducted into the handling and industrial processing of brown coal products. Significantly, the Coal Corporation is developing a number of new export markets, principally in Europe.

In response to a request from the Australian Minerals and Energy Council (AMEC) in 1984 for the development of a national approach to the reporting of coal resources and reserves, a new code was developed and ratified in 1986. This code outlines general concepts of reporting identified coal resources and reserves and it is specifically designed to allow for the wide range and variety of coal deposits found in Australia.

Notable publications in preparation in the coal geoscience area include a bicentennial volume on the geology of Australian coal resources (coordinated by the Geological Society of Australia Coal Geology Group and the Bureau of Mineral Resources), a monograph on the chemistry of Victorian brown coal, and a Bulletin of the geology and coal resources of the Gunnedah Basin in NSW.

Economic geography

The fundamental change which has taken place over the past five years has been a shift from microeconomic issues to macroeconomic issues. This has come about in response to the rise of global forces which have become the key factors in shaping economic growth.

The self-containedness of geographical areas—be they cities or regions or nations—has been weakened by the array of forces that basically know no boundaries. Communications, transport and finance are good examples. Production systems are organised across space and time in such a fashion that the label designating the final product is often quite misleading in terms of the location and stages of the production process. Global manufacturing, global marketing, and global financing form the backbone of today's geographic systems.

Geographers first shifted to the macro level in studying manufacturing change. Initially this was an attempt to understand the growth of transnational corporations, and then to find explanations for the decline of manufacturing in the old industrial heartland. The old tools of location theory proved inadequate to this task and much broader economic frameworks replaced them.

Geographers have been slow to study service-sector growth in the modern era even though it has become the predominant area of employment and GDP growth. In particular, areas such as the finance industry have been relatively neglected. At the other end of the spectrum, geographers have not developed the study of commodity systems very well. At every level geographers have been slow to move into policy areas.

The changes which have been thrust on to the study of economic geography have challenged some of the old categories around which the discipline has been organised. Fields such as rural and agricultural geography or urban geography are no longer the simple and useful categories that they were in the past. A new economic geography is emerging which has much to say about 'the wealth of nations', and this has enhanced both geography's standing and usefulness to the community.

Enhanced oil recovery research

During the period 1985-1987, research on enhanced oil recovery (EOR) was carried out at the Bureau of Mineral Resources, at the Universities of Melbourne, New South Wales and Sydney, and at the Australian National University; all of this research was funded by NERDDC. The aim of the research was to increase the recovery of oil from subsurface reservoirs.

At BMR, a collaborative project between CSIRO and BMR (through the Baas Becking Geobiological Laboratory) has resulted in the development of a new process for EOR using microbiological means. This process makes use of bacteria which produce detergent-like compounds, gas, and viscosifiers when injected into the reservoir. It is hoped that this process will improve displacement of residual oil in subsurface reservoirs. In a joint venture agreement, industry and government funding has been combined to further develop this process in a field trial in the Alton oil field in the Surat Basin commencing in 1988.

In 1987, BMR commenced a study of the potential for application of EOR in Australian oil fields. This study aims to provide estimates of additional oil which could be economically produced under various oil-price scenarios using enhanced recovery methods.

Research has continued at the University of New South Wales into miscible gas flooding using CO_2, ethane, and LPG-enriched gas. In cooperation with operating oil companies, investigation of the behaviour of several Australian crudes in contact with CO_2 has been carried out. Research continued on measurement of minimum miscibility pressures, phase studies of gas-liquid systems, core-flood tests, and related reservoir-fluid analysis.

In addition, the development of computer-simulation models at the University of New South Wales has enabled methods to be derived to greatly reduce numerical-diffusion and

grid-orientation effects. These methods are now being used by an operating oil company to upgrade its compositional simulation model. Further work is planned to investigate the miscibility of CO_2 and various hydrocarbon gases with Australian crudes from the Amadeus, Cooper and Gippsland Basins. The effect of formation wettability on miscible displacement behaviour will also be investigated.

Until mid-1987, the University of Sydney participated in this program and conducted slim-tube misciblity studies on carbon dioxide/oil systems.

Fundamental research has been carried out at the Australian National University on the measurement of capillary forces in oil/water systems, microviscosities, and forces affecting clay swelling. It has been found that the behaviour of some crude oils in small pores is unlike that of pure hydrocarbons because of the effect of adsorption of certain petroleum compounds onto the pore surfaces. These effects will be further investigated in future research.

Research into simulated reservoir surface forces and fingering phenomena at the University of Melbourne continues.

In March 1985, Australia was elected as a full member of the International Energy Agency collaborative group on enhanced-oil-recovery research. In September 1987, Australia hosted the annual IEA-EOR Workshop and Symposium on EOR in Sydney; it was attended by 25 overseas delegates as well as representatives of Australian industry, academia and government.

Environmental and engineering geology

Issues which continue to attract the attention of those involved with environmental and engineering geology have been, to an increasing degree, water resources management and environmental problems related to mining and agriculture.

These issues were highlighted by an international conference *Groundwater Systems Under Stress* held in Brisbane in May 1986 under the sponsorship of the Australian Water Resources Council. The problem of groundwater salinity was one of the major issues discussed. The keynote address by Prof. E. Mazor from Israel discussed the use of isotope for solving groundwater problems.

To facilitate and coordinate research and education in groundwater in Australia, schools specialising in groundwater studies have been established at the University of New South Wales and Flinders University.

In 1987, Dr Bob Schuster of the Geological Risk Assessment Branch of the United States Geological Survey, Denver, Colorado, visited Australia as a Fullbright Scholar giving lectures in several States and attending the *Fifth International Conference and Workshop on Landslides.*

In most States, re-organisation and reassessment of government departments has resulted in changes to staffing levels in the areas of environmental and engineering geology. In New South Wales for example, the Department of Public Works is now responsible for the investigation and design of all major dam projects, and the Department of Water Resources is responsible for the assessment and management of the State's groundwater resources.

In the past several years, major civil engineering projects in the Sydney region have required considerable input from environmental and engineering geologists. These projects include the Ocean Outfalls Project, Sydney Harbour Tunnel, Darling Harbour Redevelopment, and remedial works at Warragamba Dam.

In Victoria, the Geological Survey has completed a 1:25 000-scale engineering geological map of the Melton area using innovative computer techniques. The Rural Water Commission has recently completed two reservoir enlargement projects—Lance Creek Reservoir and Merrimu Stage 3—and has made major groundwater salinity investigations.

In South Australia, the Department of Mines & Energy is investigating the hydrogeology of: the metropolitan parts of the St Vincents Basin; the artesian springs of the southwest part of the Great Artesian Basin; and parts of Eyre Peninsula.

In recent years, considerable activity has taken place in Australia and the Pacific Region in the development of major gold mines. These have required detailed groundwater, slope stability and environmental studies. This activity is expected to continue as deposits are developed and brought into production.

Exploration Geophysics

Activity in general during the period was strongly affected by economic factors, including the drop in oil prices and more recently the stock market crash. One commodity—gold—has benefited greatly from the decision not to impose a gold tax, and activity in the search for gold has boomed.

As magnetic surveying is a viable technique in the search for gold, particularly in the mapping of structure and in the direct detection of epithermal deposits, airborne magnetic activity has remained strong.

Ground geophysical surveying activity for non-petroleum applications increased during the period. The most commonly-employed methods were induced polarisation (IP), magnetics, and electromagnetics (EM). These all tended to emphasise the mapping of associated geology in the search for gold. Gravity surveys were used to explore for oil and diamonds. For the regional placement of gravity stations, inertial navigation with helicopters continued to be the most accurate and widely-used positioning system.

Base-metal exploration generally declined during the period with the exception of associated lead-zinc deposits. The electromagnetic method remains the one that is used most successfully for these types of targets. Electromagnetic methods are being increasingly applied in groundwater studies including the detection of contamination by natural and man-made causes.

In the search for oil and gas, rationalisations in both the service and user sectors, both onshore and offshore, were an inevitable consequence of the oil-price collapse during the reporting period. However, technological advances ensured that the efficiency and quality of the seismic method continued to improve.

In the offshore sector, improvements in air-gun sources and streamer design led to significant improvements in seismic data quality, especially in the difficult (but highly prospective) Timor Sea area. The requirement for improved definition of smaller and more structurally-complex subsurface features also led to rapidly-increasing use of 3-D and pseudo 3-D data-collection methods, and corresponding advanced data-processing, presentation and interpretation techniques.

In the onshore sector, the Vibroseis source maintained its dominance, and land air-guns were introduced for the first time in Australia. Shot-hole crews continued to dominate in the Surat basin, arguably Australia's most mature exploration province. Telemetric recording systems gained greater

acceptance, and in-field processing systems became almost standard (at least for Vibroseis crews). Australia's indigenous seismic contractors were responsible for novel developments in geophone-spread checking, common-mode attenuation, and telemetric recording techniques. Unfortunately one of these contractors was a victim of industry rationalisation in late 1987.

In data processing and interpretation, continuing improvements in noise rejection and structural/stratigraphic resolution greatly increased the scope for the integration of geological and geophysical data, especially in development situations. Specialised techniques including forward and inverse modelling, data inversion, amplitude versus offset studies, vertical profile data, time-to-depth conversion, and map migration, had a clear impact on exploration and development successes.

Exploration geophysical research in Australia has taken a significant swing towards seismology since the last report. New seismic research projects are under way on 3-D data acquisition and on noise reduction and data processing, and there is ongoing work on tomography and imaging. Seismic imaging is being used successfully between bore holes and for metallic mineral deposits, in addition to its (now standard) in-seam coal application.

Magnetotelluric (MT) research is now underway at three universities, with projects involving geological mapping and noise statistics. Given the major advances in treating MT static problems recently, some very useful new results and reinterpretation of old data can be expected.

Geochemistry

Inorganic geochemistry

Gold continued to be the main target of private-sector mineral exploration programs during 1985-87. Interest and expertise in geochemical prospecting techniques for gold deposits continued to grow and was reflected by a number of significant new gold discoveries in Queensland and Western Australia. Moreover a number of conferences and symposiums of international standing were held and are being planned, especially for 1988, in which gold geochemistry and exploration are major topics. These conferences include *Pac Rim*, *Gold 88* and the *Second International Conference on Prospecting in Arid Terrain.*

The direct analysis of trace concentrations of gold to ppb and sub-ppb levels in soils, stream sediments, laterites, rocks and other naturally-occurring sample materials, are now widely applied in mineral exploration programs throughout Australia. Concurrently, understanding of the mechanisms and factors controlling the dispersion of gold and platinum-group elements during weathering is being increased by studies carried out by CSIRO and the University of Queensland.

Continuing research involving fluid-inclusion and isotope studies have provided more detailed knowledge of the conditions under which gold deposits have formed, contributing to the refinement of genetic models and hence to geochemical search technology. The application of the phenomenon of thermoluminescence in gold exploration has also been advocated.

Geochemical exploration for deposits of base metals, tin, tungsten and molybdenum continued in many parts of Australia, but at very low levels reflecting depressed world markets for these commodities. However, research aimed at optimising geochemical exploration programs is continuing in many centres. Work included detailed studies of the relationships between mineralogy and trace-element chemistry in weathering profiles over base-metal mineralisation (University of Western Australia); studies of lead isotopes in gossans, soils and vegetation by CSIRO in an attempt to detect the presence of concealed base-metal mineralisation; and lithogeochemical and electrogeochemical studies by the University of New South Wales which have yielded encouraging results over massive sulphide deposits in deeply-weathered arid terrain in New South Wales.

In the analytical field, advances have been made in the commercialisation of the measurement of minute amounts of gold, arsenic and base metals in naturally-occurring waters, leading to the possibility of effective hydrogeochemical exploration for gold deposits. Work continues on the development of the inductively-coupled plasma-emission spectrograph (ICP) as a means of providing cost-effective, multi-element analyses for geochemical exploration.

Research in advanced data-processing techniques for geochemical exploration continued at the University of New South Wales.

More fundamental studies of the geochemistry of granitoids and volcanics (Australian National University and Latrobe University) and precious metals (University of Melbourne) are continuing.

Organic Geochemistry

Organic geochemistry is now an established part of the academic, industrial and research scene in Australia. A regular workshop on organic geochemistry is held but most new work is presented at interdisciplinary meetings on coal, petroleum or oil shale, or at broader energy-related conferences.

The coal industry is keen to use chemical characteristics, or properties based on geological history, to promote new products or to assist in marketing Australian coals. Transmission electron microscopy has highlighted the consequences of coal biodegradation during which humic matter is altered and many fine lipid bodies are formed. Computerised infrared characterisation of materials (CIRCOM) has been applied to brown coals with promising correlations with physico-chemical and petrographic information. Selective reductive alkylation has proved valuable in deriving geochemical parameters (such as biomarkers). The technique is best-suited to higher rank Australian coals.

More small oil discoveries in the Cooper Basin and overlying Eromanaga Basin have attracted the attention of organic geochemists. Recent work has shown that alginite in the very large volumes of inertinite-rich coal in the Cooper Basin is an adequate source for all the oil, even without a contribution from dispersed organic matter. Other biomarker studies indicate two types of Eromanga Basin oils, one of Permian origin and the other sourced from Jurassic sediments.

The possibility of Proterozoic petroleum is of particular importance in the Australian context. In the McArthur Basin, research has identified five potential source rocks at various stages of maturity.

Much remains to be understood about the organic geochemistry of Australian oil shales. Despite lower oil prices in recent years, the Tertiary deposits of Queensland have been the subject of detailed studies. Eight repetitively occurring facies are recognisable in the Rundle Formation at Rundle. A molecular model of representative organic matter in Rundle Ramsay Crossing shale has been derived

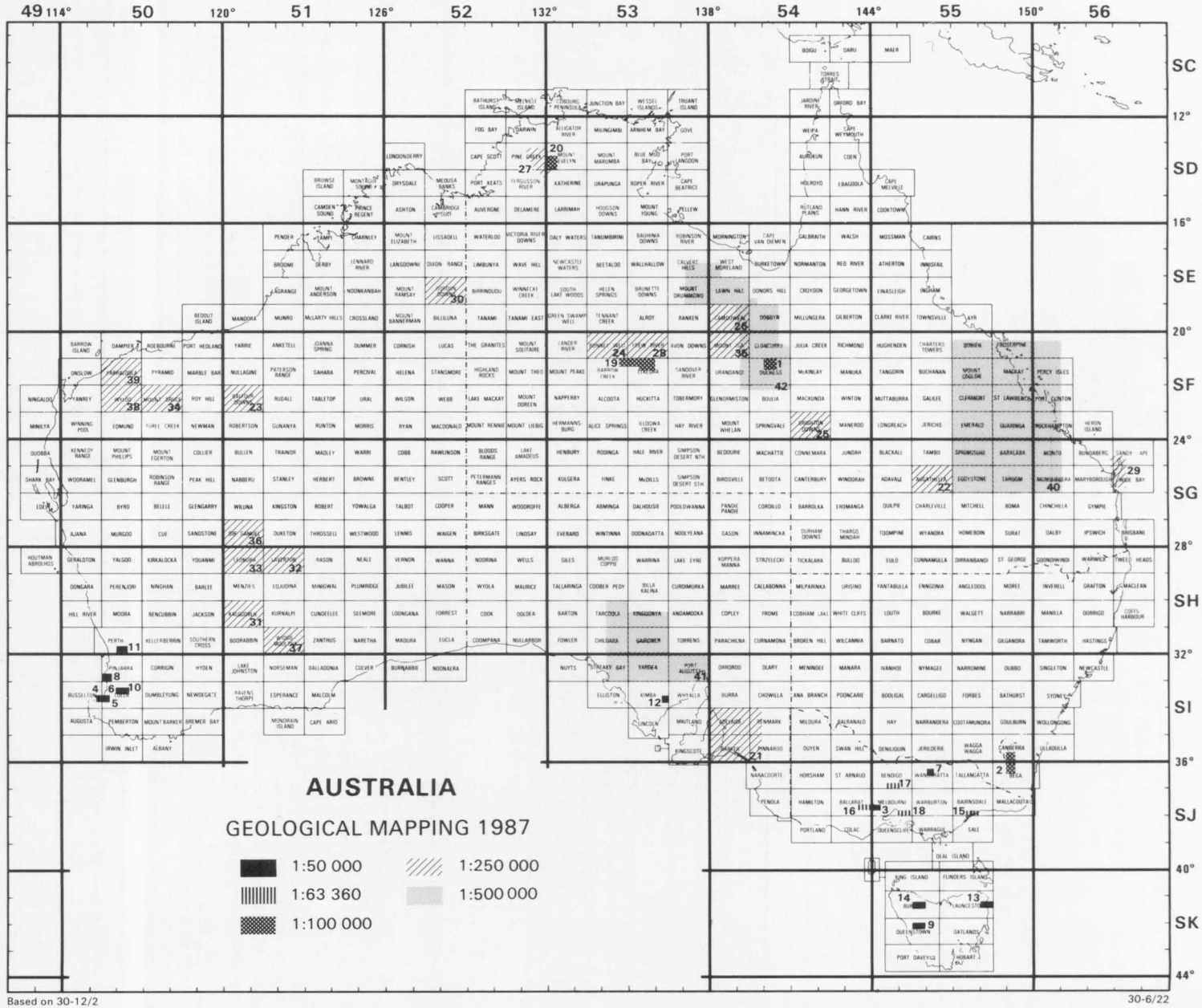


Fig. 1. Geological mapping in Australia, 1987.

PRELIMINARY EDITION

1 : 100 000

1 Malbon (QLD)
2 Michelago-Cooma Area, Late Silurian (BMR)

COLOUR EDITION

1 : 50 000

3 Ballan (VIC)
4 Busselton (WA)
5 Capel (WA)
6 Collie (WA)
7 Glenrowan (VIC)
8 Lake Clifton-Hamel (WA)
9 Lyell (TAS)
10 Muja (WA)
11 Mundaring (WA)
12 Rudall (SA)
13 St Helens (TAS)
14 St Valentines (TAS)

1 : 63 360

15 Bairnsdale (VIC) reprint
16 Ballarat (VIC) reprint
17 Heathcote (VIC) reprint
18 Ringwood (VIC) reprint

1 : 100 000

19 Elkedra Region (BMR)
20 Ranford Hill (BMR)

1 : 250 000

21 Adelaide Region Palaeosols (SA)
22 Augathella (QLD) reprint
23 Balfour Downs (WA) 2nd Ed
24 Bonney Well (NT)
25 Brighton Downs (QLD) reprint
26 Camooweal (QLD) reprint
27 Cullen Mineral Field (BMR)
28 Frew River (NT)
29 Fraser Island Special (QLD)
30 Gordon Downs (WA) reprint
31 Kalgoorlie (WA) reprint
32 Laverton (WA) reprint
33 Leonora (WA) reprint
34 Mt Bruce (WA) reprint
35 Mt Isa (QLD) 2nd Ed
36 Sir Samuel (WA) reprint
37 Widgiemooltha (WA) 2nd Ed
38 Wyloo (WA) 2nd Ed
39 Yarraloola (WA) reprint

1 : 500 000

40 Bowen Basin Solid Geology (QLD) 2 sheets
41 Gawler Range Volcanics (SA)
42 Mt Isa Inlier (BMR)

1 : 5 000 000

43 Hydrogeology of Australia

from chemical derivatives with isotopically-labelled reagents and characterisation by mass spectrometry and nuclear magnetic resonance spectroscopy. Attempts to quantify and explain differences between the upper and lower oil-shale units at Duaringa have been made using solvent extraction, pyrolysis and organic petrology.

Geochronology and isotope geology

Isotopic analysis for geochronology has been applied to various problems. Neodymium analysis in particular continued to provide clearer insights into the older cratonic regions of Australia and parts of Antarctica. The ion microprobe at the Australian National University—SHRIMP—sustained its revolutionary promise, particularly with U-Th-Pb dating of zircons. It confirmed the oldest-known crustal remmants (close to 4300 Ma) through zircons in Archaean sediments in the Yilgarn block. The ion microprobe has emphasised the relatively common occurrence of multiple zircon ages in the same rock—providing, for example, four different ages from one polymetamorphic rock from Enderby Land, Antarctica.

Fission-track studies continued to be applied in basin maturation studies, uplift and tectonic histories, and in heavy-mineral provenance. Thermal-annealing work and the analysis of fission-track lengths have made new contributions to the interpretation of mixed ages. The thermal evolution of rifted margins such as southeast Australia has been clarified using track lengths.

K-Ar age determinations were applied in a variety of geological situations. When used to date Cainozoic basalts, this method has been very effective in establishing long-term landform evolution and erosion, and whether uplift or stability has characterised parts of the older Great Divide in southern New South Wales and its more-recently active extension in parts of north Queensland. The Ar-Ar technique has been used in alkali feldspars in relation to argon diffusion and the temperature history of rocks. Stable and unstable isotope studies continue to be important in understanding a variety of mineral deposits and their environments. Papers on the isotopic aspects of diamondiferous eruptives were well represented at the *Fourth International Kimberlite Conference* in Perth in August 1986.

Geomathematics

The period 1985-1987 has witnessed a perceptible increase of activity compared with the relatively quiet levels of previous years. The main reasons for this are: the increased pressure on academic and other scientific institutions to pay greater attention to the needs of industry, and the dramatic increase in computing capabilities. The latter cause is particularly significant. On the one hand, the increased availability of raw computing power is making it possible to attack larger and larger problems, or alternatively, to use computer-intensive procedures on relatively simply-posed but difficult-to-solve problems. On the other hand, and at the other end of the hardware spectrum, microcomputers and packages are delivering to the individual scientist sophisticated techniques combined with display facilities previously only available in a substantial computing installation.

The area of image processing provides a good example of how the microcomputer is being used. Software packages have now been developed in Australia to perform a range of functions on multi-channel, remotely-sensed images, such as mapping, enhancement, and statistical classification. A few years ago, analysis of LANDSAT images was strictly a mainframe computer activity. On the subject of image analysis and processing, two aspects currently receiving attention are applications to seismic data processing, and the use of colours rather than the grey-scale.

Recent research in electromagnetic geophysical modelling has also been geared to the new generation of powerful microcomputers, with emphasis on implementation of compact finite-element methods and boundary-element methods.

Geostatistical research in Australia over the last three years has taken on an increasingly interdisciplinary character, with contributions from mainstream statisticians and soil scientists as well as geostatisticians. A successful workshop was held at the University of Adelaide in May 1986; this brought together scientists with different perspectives and led to some worthwhile collaborations. A clear trend in modern statistical science which is now affecting the development of geostatistics is the move away from a rigid dependence on particular models towards careful scrutiny of the model and the available data, thus reducing the dependence on the model where possible. Current research is addressing such problems as study design, use of interlaboratory trial information in ore reserve estimation, examination of stationarity assumptions, and the application of geostatistical techniques in sampling from a continuous stream.

A noteworthy initiative over the last few years has been the Mathematics in Industry Study Group (MISG), organised by the CSIRO Division of Mathematics and Statistics. The aims of MISG include: providing Australian industry with high-level mathematical advice on challenging scientific problems; stimulating greater awareness in Australian industry of the need for and role of mathematics; and establishing better links between industry and academic mathematicians.

Four meetings of MISG have been held to date. A number of problems are sought from industry for each meeting, then representatives from the companies providing the problems meet for a week with mathematicians for an intensive attack on the problems. Among the wide range of problems so far considered are a number from the geoscience area, for example: modelling the collapse of a mining bench by explosives (which has led to the development of a software package to simulate blasting of benches); modelling the crumbling of rock under tension; and scheduling of mining operations.

Geomechanics

The Australian Geomechanics Society (AGS) has the role of promoting the science and practice of geomechanics in Australia. The AGS is jointly sponsored by the Institution of Engineers, Australia, and the Australasian Institute of Mining and Metallurgy. The AGS has experienced a period of growth in membership over the past three years, and now has nearly 6000 individual members and 16 firms and organisations that are supporting members.

One of the many purposes of the AGS is to promote geomechanics by means of conferences, seminars or symposia. The Specialty Geomechanics Symposium—*Interpretation of Field Testing for Design Parameters*—was held in Adelaide in August 1986, and attracted 107 registrations of which 14 were from overseas. Members have been involved in the organisation of a proposed International Conference on Calcareous Sediments planned for Perth,

and an Australian-New Zealand Regional Conference planned for Sydney in August 1988.

The 19-page booklet *Guidelines for the provision of geotechnical information in construction contracts* was published in 1987. In order to help minimise the future occurence of problems experienced in recent litigation, the AGS also endorsed the document *Guidelines for members reviewing the work of other engineers for the purposes of litigation.* The AGS published a Commemorative Volume for the Golden Jubilee of the International Society for Soil Mechanics and Foundation Engineering in 1985. This contained a selection of 22 noteworthy papers written by Australian authors over the past 50 years.

The AGS is affiliated with the International Society of Soil Mechanics and Foundation Engineering, the International Society of Rock Mechanics, and the International Association of Engineering Geology, and has provided Australian representation on various technical committees and commissions of these organisations. In particular, the AGS spearheaded the Subcommittee on Undisturbed Sampling and Laboratory Testing of Soft Rocks and Indurated Soils; a 73-page report has been produced.

The AGS introduced the D.H. Trollope Award to honour a man who was one of the pioneers of geomechanics in Australia. The Award is for an outstanding doctoral thesis in geomechanics. The newsletter of the Society, *Australian Geomechanics*, now has subscriptions from many parts of the world. The AGS coordinated the visit to Australia by Prof. K. Kovari from Switzerland to speak to the State branches of the AGS and to meet local engineers involved in geomechanics.

Looking to the future, the AGS hopes to continue to encourage engineers and engineering geologists to publish their experiences, to maintain at a high level the AGS image with geomechanics communities in other countries, to encourage younger engineers, and to make submissions and respond to enquiries on technical matters related to geomechanics.

Geomorphology

Geomorphology in Australia in the last four years has become more tightly focussed on three main themes: longevity of landforms, Quaternary evolution of depositional landforms, and short-term variability in processes and morphologies. Continued development and application of new techniques for interpreting evidence, together with increased data availability, has made possible new insights into the behaviour of Australian landforms in time and space.

The three themes are represented in two books published in Australia by Academic Press. The first on *Coastal Geomorphology in Australia* (edited by B.G. Thom) appeared in late 1984 ; the second on *Fluvial Geomorphology in Australia* (edited by R.F. Warner) will be published in 1988. These two major areas of geomorphology have dominated and continue to dominate so much of our work and these books illustrate the active involvement of Australian geomorphologists in these areas at different spatial and temporal scales.

Of special mention is the recognition of the impact on landforms of changing climatic regimes at the decadal time scale. This work has recognised flood-dominated and drought-dominated regimes as applied to rivers, and accretion-dominated and erosion-dominated regimes as applied to coasts. In both cases there has been increased study of the human impacts on landform as well as modelling and prediction studies of the geomorphic change caused by human disturbance of Australian environments.

In addition to work on coasts and river systems, there has been a growing awareness of the Quaternary history of landscapes in semi-arid and arid regions. The SLEADS project based at the Australian National University has led to further understanding of salt-lake basins and aeolian deposits. The link between sedimentation processes (including those associated with fluctuating groundwater regimes) and sediment types in semi-arid environments has developed particularly as a result of work in western Victoria, southwest New South Wales and South Australia.

Australian geomorphologists have participated in several international conferences in recent years including the *First World Geomorphology Conference* in Manchester in 1986, The *International Sedimentological Congress* in Canberra in 1986, and *INQUA* in Ottawa in 1987.

A new program sponsored by the Academy of Science is the multidisciplinary International Geosphere Biosphere Program (IGBP) to be undertaken in the 1990s; the inaugural Australian meeting in Canberra in February 1988 was well attended by geomorphologists. They clearly stated what they felt was their role in such a program including participation in establishing and operating geosphere-biosphere observatories designed to monitor environmental change and to provide localities for experimental studies.

Groundwater

The first hydrogeological map of Australia, together with explanatory notes on the major sedimentary basins and fractured-rock provinces, was published in 1987. A unified system of symbols is expected to stimulate further mapping of groundwater in Australia. Other maps published during the period included the Groundwater Resources of Queensland and 1:250 000-scale maps of parts of New South Wales and Victoria.

Commonwealth funding for exploratory drilling under the National Water Resources Assessment Program was terminated during the period and drilling for groundwater resources assessment is now being funded at a state level. An updated review of Australia's groundwater resources was completed for Review 85.

Drilling continued for town-water supply and to monitor salt-water intrusion and the increasing salinity in rivers. Progressive rehabilitation of flowing bores in the Great Artesian Basin is being carried out in order to reduce wastage and maintain pressures.

The current boom in gold mining has led to an expansion in the use of saline and hypersaline groundwater in the Eastern Goldfields of Western Australia where water of as much as 200 000 mg/l is used in carbon-in-pulp treatment plants. A new borefield has also been established in the Great Artesian Basin to pipe water to the Olympic Dam mine.

A major study of groundwater use and urbanisation in Perth was completed in 1987 involving the modelling of the effects of land-use changes, use of groundwater for public and private water supply, and variations in rainfall. Computer models are increasingly being used in the management of aquifers throughout Australia.

Management of groundwater was a theme of the conference on *Groundwater systems under stress* held in Brisbane in 1986, and of a workshop on groundwater allocation in Sydney in 1987.

Fig. 2. Geophysical mapping in Australia, 1987.

MAGNETIC

1 : 100 000

1 Britten Jones (NT)
2 Mulga Park (NT)
3 Sentinel Bore (NT)

1 : 250 000

4 Childara (BMR)
5 Cobar (BMR)
6 Cunnamulla (BMR)
7 Dampier (BMR)
8 Elkedra (BMR)
9 Eucla (BMR)
10 Eufo (BMR)
11 Gairdner (BMR)
12 Georgetown Region (BMR)
13 Glenormiston (BMR)
14 Kurnalpi (BMR)
15 Mornington (BMR)
16 Mt Drummond (BMR)
17 Mt Isa (BMR)
18 Northwest Tasmania (BMR)
19 Orroroo (BMR)
20 Pyramid (BMR)
21 Ranken (BMR)
22 Sandover River (BMR)
23 Tobermory (BMR)
24 Toompine (BMR)
25 Urandangi (BMR)
26 Widgiemooltha (BMR)
27 Wyandra (BMR)

1 : 1 000 000

28 Adelaide (BMR)
29 Alice Springs (BMR)
30 Armidale (BMR)
31 Bourke (BMR)
32 Cloncurry (BMR)
33 Meekatharra (BMR)
34 Melbourne (BMR)
35 Oakover River (BMR)
36 Tarcoola (BMR)
37 Townsville (BMR)
38 Wiluna (BMR)

RADIOMETRIC

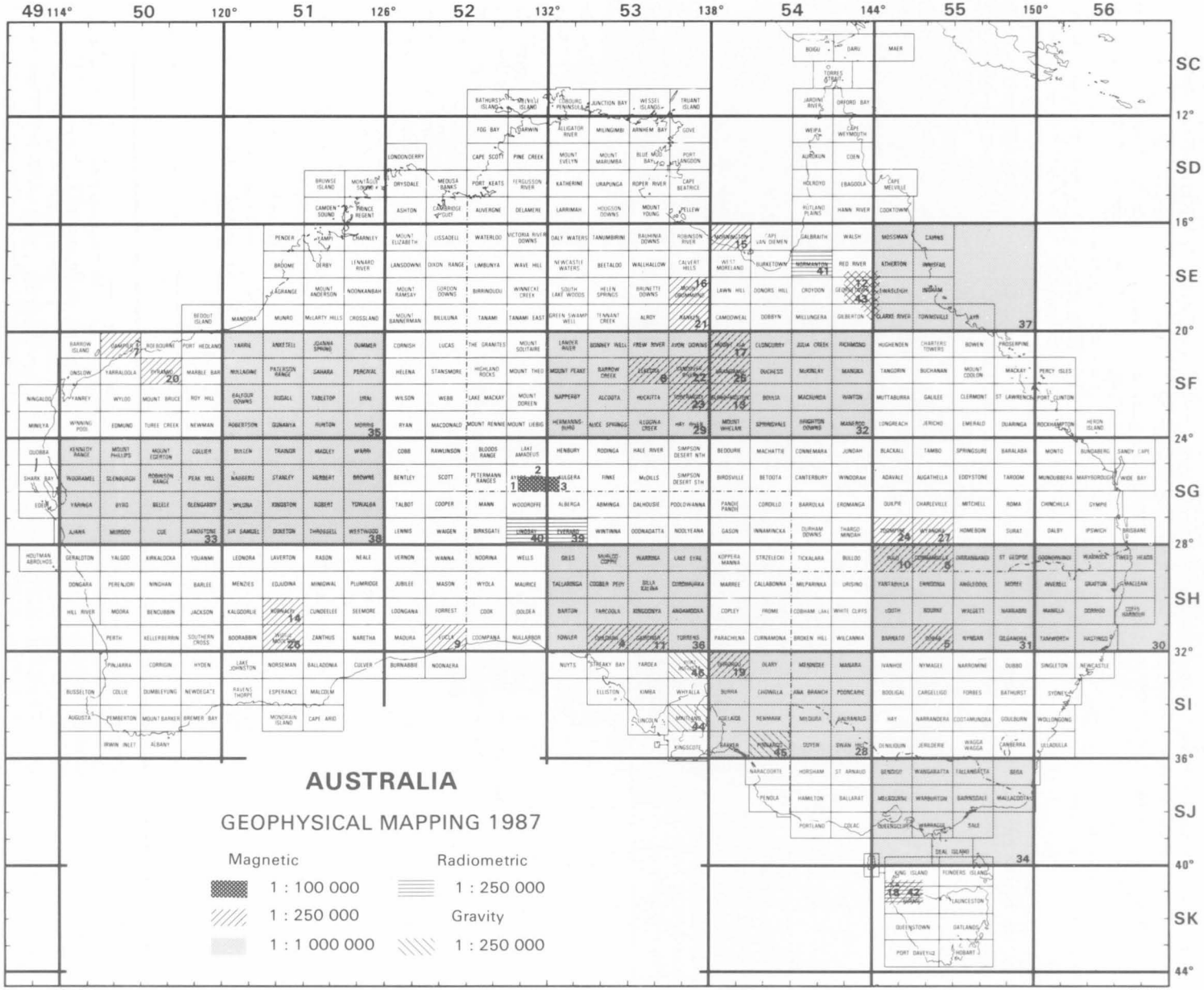
1 : 250 000

39 Everard (BMR)
40 Lindsay (BMR)
41 Normanton (BMR)
42 Northwest Tasmania (BMR)

GRAVITY

1 : 250 000

43 Georgetown Region (BMR)
44 Maitland (SA)
45 Pinnaroo (SA)
46 Port Augusta (SA)



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30-6/23

Increasing resources are being directed towards studies of land and stream salinisation; a major study of the Murray Basin and a number of investigations in southwestern Australia are being carried out.

A significant development in research has been the establishment of the Centre for Research into Groundwater Processes at the CSIRO Divisions of Water Resources Research and Soils and Flinders University in Adelaide, and the Centre for Groundwater Management and Hydrogeology at the University of New South Wales.

The Australian membership of the International Association of Hydrogeologists has grown to about 180 since the formation of the National Committee in 1983 and now represents a high proportion of the groundwater scientists in Australia.

History of the earth sciences

The Earth Sciences History Group (ESHG) of the Geological Society of Australia continues to be active. Membership has grown to about 100 scientists. The group has been honoured to welcome Dr Ann Moyal, a prominent historian of Australian science, as a subscriber to its regular newsletters. These newsletters report the Group's activities. Short articles on a variety of historical topics, notifications of meetings, book reviews, lists of newly-published historical papers, as well as stirring editorials and succinct state-of-the-art trends in Australian geoscience have been regular features. The ESHG executive has met with historians from CSIRO Archives and the Basser Library Archives.

A notable achievement of ESHG has been the assembling and editing of Australian papers contributed by many of its foundation members. The papers have been published in two issues of *Earth Sciences History* (Journal of the History of the Earth Sciences Society, based in the U.S.). Another contribution on Evan R. Stanley's pioneer mapping in Papua New Guinea was published in the *BMR Journal of Australian Geology and Geophysics* (Vol. 10, 153-177).

ESHG members have participated in well-attended symposia, such as the *International Sedimentological Congress* (Canberra, 1986) and the 9th *Australian Geological Convention* (Brisbane, 1988). At the latter, ESHG Vice-Chairman, Professor T. G. Vallance, delivered the principal address on the topic, 'Finding the way from scratch—opporunity and realisation in Australian geology over two centuries'.

Planning for a history of BMR up to 1979 has begun, and publication of a recently-completed autobiography by Emeritus-Professor A. H. Voisey is being contemplated by ESHG Executive. The manuscript covers the period from Edgeworth David's time to Esso-BHP's heyday.

There have been several other notable activities concerning the history of the geosciences. In May, the Edgeworth David Society of the University of Sydney held the first Edgeworth David Memorial Day Symposium. Melbourne University is currently compiling and editing a book of key papers to commemorate the career of the late Professor Edwin Sherbon Hills.

A paper entitled 'Evolution evolving' was delivered by Professor K. S. W. Campbell to a gathering at Armidale, NSW, for the 25th Anniversary of the New England Branch of the Royal Society of New South Wales. Professor Roy McLeod has edited a book, The Commonwealth of Science: ANZAAS and the Scientific Enterprise in Australasia 1888-1988, which coincided with the centenary celebrations of ANZAAS.

This year is the 200th anniversary of Johannes Menge's birth. Menge, one of the founders of South Australian geology, gained a lasting reputation for his early recognition of the State's mineral potential. Celebrations were held at his birthplace, Steinau in West Germany, including one attended by the Australian Ambassador. He was also remembered in Australia. The German Descendants Group of the South Australian German Association together with Orlando Wines Pty Ltd unveiled a plaque commemorating Menge's early recognition of the suitability of the Barossa Valley for producing wine. The gathering also inspected Menge Cave where he lived for a period in the 1840s. Menge was also remembered at the conference From Berlin to Burdekin held in Sydney.

These activities, and the recent formation of the Colonial Science Club based in Sydney, reflect the growing awareness being shown by Australian earth scientists in the history of their science in Australia.

Marine geoscience

The major Australian marine geoscience program is the Bureau of Mineral Resources Continental Margin Program, which commenced in 1985 using RV Rig Seismic. This program is designed primarily to study the geological framework and resource potential of offshore Australian basins as assistance to petroleum exploration. Up to the end of 1988, there have been 17 research projects involving 23 one-month research cruises, covering large parts of the Australian margin, the Lord Howe Rise and the Kerguelen Plateau. This is an ongoing program involving approximately six cruises each year.

Techniques used have included multichannel seismic reflection profiling; seismic refraction profiling; bathymetric, gravity and magnetic profiling; dredging and coring; and geochemical sampling. Scientists from Australian and overseas universities have collaborated with BMR on this program since 1987. The budget for BMR's marine research has been approximately $10m per annum.

As part of its program, BMR conducted site surveys for Ocean Drilling Program scientific drilling in Prydz Bay, the Kergeulen Plateau, the Exmouth Plateau, and the northeast Australian margin.

The RV *Franklin*, a national research facility operated by CSIRO which came into service in 1985, has been used as a platform for several marine geoscience investigations. The most notable are studies in eastern Bass Strait, investigation of the seamounts in the Tasman Sea, and two cruises in the western Woodlark Basin, PNG—Paclark I (1986) and Paclark II (1988)—mounted jointly by the CSIRO Division of Exploration Geoscience, the University of Toronto, Canada, and the Geological Survey of Papua New Guinea.

The Ocean Sciences Institute of the University of Sydney conducted 23 projects in marine geology, geophysics and geo-acoustics during the period 1985 to 1987; these are described in its biennial report. The projects included sedimentological and structural studies of the Eastern Australian margin and the Tasman Sea, petrological studies in the Tasman Sea, Tonga Arc, and North Fiji Basin, and 'Sea-Beam' mapping and geo-acoustic studies in the same areas. The Institute received $317 000 in grants and contracts for 1986 (including $184 000 from MST grants) and $236 000 in 1987 (including $13 6000 from MST grants).

The Marine Sciences and Technologies (MST) Grants Scheme provided the following sums for Australian continental shelf and margin studies, the percentages of total MST grant being given in brackets: 1985: $419 000 (10.9%); 1986: $494 641 (12.9%). Figures for 1987 are not available.

Australia continued its support of CCOP/SOPAC, the southwest Pacific regional marine geoscience organisation, and became a full member in 1986. Thirteen Australians from universities and BMR, including four co-chiefs, participated in five Tripartite II cruises supported by the Australian International Development Assistance Bureau on RV Moana Wave and RNZNS Tui. These cruises were carried out in the Solomon Islands, Manus Basin of PNG, Kiribati, Tuvalu, Cook Islands, Samoa, Tonga and the North Fiji Basin. Large-scale evaluation of earlier Tripartite cruise results continued. Direct and indirect Australian financial contributions to Tripartite II in 1985-87 amounted to about $600 000.

Australian observers continued to attend meetings of the Ocean Drilling Program Planning committee. The invitation to join ODP in a consortium with the European Science Foundation was declined due to lack of funding support. Subsequently an invitation was received to join Canada in a consortium membership, and this invitation was taken up in late 1988. Contributors to the annual membership fee of $US853 000 are the Australian Research Council, BMR, the Australian Vice-Chancellors' Committee, and the Antarctic Division of the federal Department of Arts, Sport, Environment, Tourism & Territories.

Limited participation by Australian scientists in ODP cruise legs commenced in January 1988 as the drill-ship began work in or adjacent to the Australian exclusive economic zone in areas where BMR had conducted site surveys.

The geoscience departments (both geology and geography) of many Australian universities continued inshore marine geoscience research during 1985-87. Several institutions and the BMR have worked in the Great Barrier Reef. Australia was represented by eight university and government marine geoscientists at the *CCOP/SOPAC Coastal Processes Workshop* in Lae PNG in 1987.

Scientists at several Australian higher-education institutions, including the University of Sydney and the Australian National University in particular, are engaged in 'blue-water' marine geoscience research. Much of this research is conducted under the aegis of the BMR Continental Margin Program, the Tripartite Marine Geoscience Research Program and the Marine Sciences and Technologies Grants Scheme.

Australian scientists have also joined foreign research cruises in the region, for example the 1986 Papatua Expedition on the RV *Thomas Washington* (Scripps Institution of Oceanography, USA).

Mineral resource classification and estimation

Highlights of the three-year period were the ratification by the Australian Minerals and Energy Council (AMEC) of an *Australian code for reporting identified coal resources and reserves,* and the distribution of a discussion draft report *Reporting of mineral resources and ore reserves* by the Joint Committee of the Australasian Institute of Mining and Metallurgy and Australian Mining Industry Council (AusIMM/AMIC).

In 1984, AMEC requested the Government Geologists Conference (GGC) to develop a national approach to the reporting of coal resources and reserves. A GGC subcommittee, with representatives from New South Wales and Queensland, used as a basis the fifth edition of the NSW *Code for calculating coal resources and reserves.* Modifications were made to meet the requirements of industry and governments in all of the states and BMR. The *Australian code for reporting identified coal resources and reserves* was ratified by the GGC and AMEC in 1986.

The code distinguishes between resources and reserves. Resources may be reclassified as reserves when a conceptual or detailed mine plan for a particular deposit has been formulated. Unlike the former NSW codes it does not permit the use of an 'assumed' category of resources, but has two levels of inferred resources based on the amount of information available.

Resource estimates using the new code have been prepared for Queensland by the Department of Mines.

The draft report of the AusIMM/AMIC Joint Committee extended the principles embodied in earlier guidelines by distinguishing between 'mineral resources' and 'ore reserves'. 'Resource' was used for *in situ* mineralisation from which valuable minerals might be recovered; three categories—inferred, indicated, and measured—denoted levels of increasing knowledge and confidence. As in the coal code, the term 'ore reserves' was to be applied only to that part of resources for which a study of technical and economic feasibility had been carried out.

A second draft, prepared in the light of comments on the first draft received by the committee, was discussed at the AusIMM *Ore Reserves Symposium* in November 1987. The Joint Committee submitted a revised report early in 1988 taking account of points raised at the symposium. The recommendations are expected to be published later in the year.

Mineralogy and crystallography

This biased review of current activities in mineralogy and crystallography is intended to be provocative, to stimulate discussion and to convey the excitment of the science.

It seems only 25 to 30 years ago that mineralogy was conservative and almost back in the Dark Ages. Now electron microprobes, X-ray diffractometers and innovation are essential tools for any research and for the applied mineralogist. One exciting development overseas has been the application of synchrotron radiation sources to mineralogy. These sources—there are none in Australia—generate an intense spectrum of high-energy X-rays that are tunable to any wavelength. The high intensities and energies permit the study of the processes of phase transformations; crystal structures at high pressures, and chemical analyses of fluids from individual fluid inclusions and down to the 1 to 10-ppm level in solids and the transient structures present in melts and electrolyte solutions. Given the diversity of applications, it is time for Australian mineralogists to join the agitation for such a synchrotron facility locally before any more of our bright young mineralogists leave these shores.

In clay mineralogy, modern analytical transmission electron microscopes (TEM) have permitted the development of petrological approaches down to the nanometer level. Techniques, including lattice imaging, have been useful in providing evidence, sometimes contradictory, relating to the reaction of smectite to illite in diagenesis, the possible development of mixed-layer illite/smectite phases, and the

'fundamental particle' hypothesis of mixed layering in clays. TEM studies have also demonstrated that in differing enviroments, both solution and reprecipitation and tranformation mechanisms occur in the smectite to illite reaction.

Australian contributions in the field of mineralogical TEM of phyllosilicates are noteworthy as are those in more conventional structural studies and applications of EM in weathered enviroments. More systematic investigations are needed in tropical regions where there are possibilities of an illite to smectite reaction and of an inherited structural crystallographic directional control during weathering transformations.

During 1987 the Australian scene was especially active in crystallographic electron microscopy with the International Union of Crystallography meeting in Perth and the *Validity of structures from electron microscopy* meeting in Melbourne. At present, TEM usage for structure determination is less strict and direct than XRD-based methods. The field is one of rapid advancement, and methods of direct structure analysis from TEM are progressing owing to greater control over instrumental variables such as accelerating voltage and beam tilt. When a direct method of structure determination from TEM is attained it will be of great importance to mineralogical crystallography.

Australian contributions to more conventional aspects of clay mineralogy have traditionally been significant. Recent studies include investigations of kaolinite intercalates using integrated crystallographic and solid-state NMR approaches. Another traditional area of Australian excellence has been in the study of high-pressure mineralogy which gives information concerning the nature of the mantle. These activities are continuing especially in the areas of phase transitions, the crystallographic effects of high pressure, and physical properties at high pressure.

Mineral exploration using remote-imaging spectrometry requires good 'ground truthing'. This is being attained by high-resolution, laboratory- acquired infra-red spectra and complementary field-based XRD information. Recently, good correlations between remote-sensing interpretations and real surface mineral distributions have been obtained in the weathered phyllosilicate alteration zones associated with North Queensland epithermal gold-bearing systems. Development of studies of this type between mineralogists and remote sensing experts are necessary if remote mineral-exploration techniques are to be successfully applied to arid, semi-arid and wet tropical areas.

For too long applied and industrial mineralogy have been neglected relatives of more traditional areas of mineral science. Hopefully, things are about to change if conference schedules for 1989 to 1990 are noted. Although the market has remained weak and oversupplied in 1987 for many industrial minerals, Australia has remained a major producer of iron ore (Western Australia) and bauxite and kaolinite (Weipa), and is potentially a large producer of the refractory mineral magnesite from Maryborough, Queensland. Additionally, Australia is the world's largest diamond producer with a production of 29 million carats in 1986. Only about 5% of the diamonds from the Argyle and associated deposits are of high gem quality; over half of the production is of industrial-grade diamonds.

Research in applied and industrial mineralogy is diverse. It includes the role of clays as barriers in the disposal of radioactive waste and artificial intercalation of clays to form 'pillared clays'. The latter are used as catalysts in which metal-hydroxyl 'pillars' open-up cavities resembling those of zeolites. Another area of Australian applied technological expertise and an excellent mineralogical pedigree is that of high-temperature semi-conductors whose structures resemble that of perovskite. It should be emphasised that the 1987 Nobel Prize in Physics (for research in high-temperature semi-conductors) was awarded to a scientist whose original training was in structural mineralogy and crystallography.

Palaeontology

At a time when much research in government and university is under pressure to be 'relevant', palaeontology shows an odd trend. While most palaeontology is for industry and geological surveys, the public sees relevance in what industry would see as irrelevant.

Vertebrate fossils have taken the limelight in recent years. The Riversleigh deposit in northern Queensland contains the most diverse and abundant Tertiary fauna in Australia. It has attracted much attention from the media in recent years. A Pliocene vertebrate locality near Australia's Davis Station in Antarctica also has promise as a major site; it is the only source of vertebrate fossils in the post-Eocene of Antarctica.

Australian dinosaurs have been given a great deal of recognition because of the opening of the new Queensland Museum and the popularity of *Muttaburrasaurus* through the availability of casts and an animated version at the National Science and Technology Centre in Canberra.

Australian palaeontologists have been involved in several legs of the Ocean Drilling Program in the Indian Ocean. This work was concerned with the origins of the Kerguelen and Exmouth Plateaus.

Creationism has been a matter demanding much otherwise useful time and energy. The discussion has received airing in the popular media and in geological news magazines where many prominent specialists have been very active.

Palaeontology is alive and well and is documenting the history of the Australian fauna and flora very actively. Numerous new types of discoveries, in addition to routine taxonomic studies, continues at an ever-increasing pace. The number of palaeontological meetings and publication lists is effective evidence that activity is of a high order.

Petrology

Aspects of current research were well summarised in abstracts for several conventions and conferences in Australia and New Zealand (*Eighth and Ninth Australian Geological Conventions*; *Fourth International Kimberlite Conference*; *International Volcanological Congress*; *Pacific Rim Congress*).

The Kimberlite Conference considered many details of igneous rocks associated with diamonds. Australian occurrences were given considerable prominence, including the Argyle lamproite and a number of other kimberlites and lamproites, lamprophyres and carbonatites.

Petrological studies of granites have focussed on their occurrence in different parts of the Tasman Zone in eastern Australia. In particular, work was carried out to determine the mineralisation controls that were associated only with certain regions. Work on plutonic rocks has also been carried out in the Precambrian regions of central and Western Australia. In some areas, the rocks are considered to be close to their source environments.

A major review has been undertaken of the Eastern Australian Cainozoic Volcanic Zone. This comprehensive study is being published in 1988. One new perspective about the mantle emphasises that the crust-mantle boundary does not generally coincide with the seismic Moho which probably reflects the spinel to garnet lherzolite transition.

Ocean-floor petrological investigations have been made in the Western Woodlark Basin (Papua New Guinea), including its potential analogue setting for volcanogenic massive-sulphide deposits. Studies in the Tasman Sea led to fuller understanding of its development, including details of the Tasmantid Seamount Chain, a convincing hot-spot trace.

High-pressure experimental work has included the role of variable C-H-O fluid compositions in mantle-derived magmas. The results have been integrated with regional studies and work on mafic volcanic rocks from Australia, Melanesia, Indonesia and other regions. Further experimental studies have involved the structural role of fluorine in magmatic systems, and the importance of amphibole in island-arc systems.

Other experimental work and modelling has examined geophysical fluid dynamics. This has concerned a number of aspects, including magma-chamber convection and mixing and its relevance to mineralisation such as nickel, platinoids and chromite.

The *International Volcanological Congress* in New Zealand included a number of Australian contributions. These included a special review of tectonic controls of magma chemistry.

An international conference on dyke swarms held in Canada included a review of Australian occurrences. The current IGCP project on this topic will be reported on at the second international conference to be held in Australia in 1990.

In metamorphic petrology, research in a number of recurrent themes is illustrated by the abstracts of the Eighth Australian Geological Convention (1986). Proterozoic and Archaean metamorphism, structure, tectonism and metallogeny have been the concern of many workers in Australia and Antarctica. The significance of P-T-t paths for deep crustal rocks was debated, and a new petrogenetic grid was proposed for silica-undersaturated granulites. Work on the high-temperature/low- pressure Proterozoic rocks included detailing of 'anticlockwise' P-T-t paths and the interpretation of scapolite and high-magnesium pelites in the Mount Isa Inlier as metamorphosed evaporite sequences. Australia's central role in microstructural studies, in particular interpretation of porpyroblast inclusion trails, has been maintained. Experimental results have involved completed work on the garnet-ilmenite geothermometer.

Fluids in the deep crust and upper mantle were considered at the *Conference on stable isotopes and fluid processes in mineralisation* held in Brisbane in 1985. Papers on deep crustal rocks in Antarctica and Western Australia were presented at the IGCP236 conference on *Precambrian events in Gondwana fragments* held in Sri Lanka in 1987.

Soil Science

Land degradation

The Australian Society of Soil Science responded to an invitation to make a submission on land degradation to the House of Representatives Standing Committee on Environment, Recreation and the Arts. The terms of reference of the inquiry included the causes of land degradation, the effectiveness of present policies to combat it, and future measures required.

The submission was prepared by Mr C.A. Hawkins following suggestions from branches. It listed the causes of land degradation and the social causes they stemmed from. The restricted progress resulting from past practices designed to alleviate erosion was emphasised. The submission concluded that emphasis should be placed on leadership, persuasion incentives and education.

The Society was represented at a public hearing in Sydney on 17 June by Mr Hawkins. Dr C. J. Chartres accompanied the Committee on a field trip to Wagga Wagga and Rutherglen.

National Soils Conference

The 1988 *National Soils Conference* was held from 9-12 May 1988 at the Australian National University, Canberra, and attracted over 300 participants. This was the third national conference to be organised by the Australian Society of Soil Science.

Most papers were presented as poster displays so as to avoid the problem of concurrent sessions which had been experienced at earlier conferences. Invited review papers and a selection of research papers dealt with topics in soil management including: chemical and physical degradation, applied pedology, fertility, hydrology, and reclamation of saline soils. A session was devoted to soils of tropical and sub-tropical regions. A panel discussion with contributions by B. R. Davidson, R. J. Gilkes, D. B. Smiles and P. J. Walker, under the chairmanship of J. P. Quirk, addressed the topic 'Australian soils—the next 200 years'. Although no consensus was reached on any issue, considerable concern was expressed on:

- the directions and funding of soils research;
- the economic assessment of land degradation; and
- the limited capacity of Australian universities to teach management-oriented topics in soil science.

Bicentennial reference soil sites

The Western Australian Branch of the Australian Society of Soil Science has received funding from the Australian Bicentennial Authority, under its heritage and environment program, to establish a system of well-documented reference soil sites in the agricultural regions of Western Australia.

Mr W. M. McArthur, formerly of CSIRO, will identify typical localities within the major soil and landscape associations that can be set aside permanently—primarily for educational purposes. The sites are intended for use by agricultural and earth scientists, secondary and tertiary students, and ecologists. Sites will be chosen on their historic, economic and scientific importance and will be in uncleared areas wherever possible.

The information is to be published as a booklet, and details for each site will be presented in a standard format which will include:

- precise location;
- economic, historic or scientific significance;
- morphology, and physical and chemical properties of the particular soil(s);
- colour photographs of the site and soil profile(s); and

- land-use aspects of the soils and their potential for growing particular crops, together with any associated problems and limitations.

NZSSS-ASSSI cooperation

The opportunity was taken during the National Conference for representatives of the Australian and New Zealand soil science societies to meet with the object of fostering closer cooperation and contact. It was agreed that a number of joint projects would be pursued. These included:

- a conference in the period to 1990 with soil science as one aspect of a wider theme, for example, soil science and future climate change;
- travel awards, to enable members to undertake lecture tours in each other's country;
- exchange or secondment schemes for visiting scientists for periods of 6-12 months;
- publications, for example, a tertiary textbook on soil science, and resource material for schools; and
- closer communication between or amalgamation of the Societies' newsletters.

Solid earth geophysics

Earthquake and nuclear detection seismology

Approximately 70 permanent seismographic stations operated on the Australian continent and in Antarctica in the period 1985-87. These were controlled by the Australian National University Research School of Earth Sciences ANU (RSES), BMR, Department of Works (WA), Phillip Institute of Technology, Geological Survey of Queensland, the University of Queensland, Flinders University, the University of Tasmania, and the Sutton Institute of Earthquake Physics.

Australian seismicity was dominated by the 1986 Marryat Creek earthquake and the foreshocks to the 1988 Tennant Creek earthquakes. The Marryat Creek event took place in the north of South Australia and had a magnitude of 6.0 on the Richter Scale. It produced a fault scarp approximately 13 km long with a maximum throw of about 0.6 m, and it occurred in an area where no previous earthquakes had been reported.

At Bream Creek (Tas.) and Tennant Creek (NT), the earthquake sequences were felt by the local inhabitants. The Tennant Creek sequence contained the largest event—ML 5.4—but this was only part of a series of foreshocks associated with the large January 1988 earthquakes which caused considerable damage in the vicinity of the town.

At BMR, new earthquake risk maps were produced which contained estimates of ground acceleration, velocity and Modified Mercalli intensity. These maps updated those that were published in 1979.

Seismicity studies of earthquakes in the New Guinea region have enabled the northern boundary of the Australian plate to be redefined.

At ANU (RSES) the main thrust of the seismological research program has been towards the delineation of the three-dimensional structures of the crust and upper mantle, particularly near the Tonga-Fiji subduction zone, and in south-eastern and central Australia.

A program to monitor nuclear explosions was started at BMR in 1984. The following statistics apply to the period 1985-1987:

Country	Number of nuclear explosions
USA	43
USSR	30
France	24
China	1
Total	98

It should be noted that from August 1985 through 1986 the Soviet Union had a moratorium on detonating nuclear explosions. In spite of this moratorium it can be seen that the total explosion rate averages nearly three per month over the three-year period.

Physical processes in the Earth

This research is concentrated in the universities, mainly at ANU (RSES), with additional work at Monash University and the University of Queensland. Research on tectonics includes studies of elastic flexure and faulting of the crust and lithosphere pertaining mainly to the formation of sedimentary basins.

Convection in the mantle and its effects on the lithosphere are studied with both numerical and laboratory models; these studies relate to basin formation, rifting and the formation of the earliest (Archaean) crust. Detailed numerical models of lithosphere faulting and rifting are made at Monash University.

Studies of temperatures and heat transport in the deep mantle and core are made at the University of Queensland. Laboratory models at ANU are used to study the behaviour of magmas in crustal magma chambers and during eruption.

Physical properties of rocks and minerals

Elasticity and ductility are studied at ANU (RSES) and at the CSIRO Division of Geomechanics in Melbourne. Elastic properties of rocks under pressure and temperature conditions appropriate to the crust and on mantle minerals at very high pressures and temperatures are measured for comparison with results from seisomology. Ductile behaviour under crustal and mantle conditions is studied with a view to unravelling the many microprocesses involved, so that more reliable extrapolations to realistic conditions will be possible.

Geomagnetism

Six magnetic observatories are operated by the Bureau of Mineral Resources (BMR): Canberra (ACT), Gnangara(WA), Charters Towers (QLD), Learmonth (WA), Macquarie Island, and Mawson (Antarctica) (Fig. 3). Learmonth is a new observatory and started producing data in January 1987. Toolangi has now been replaced by Canberra as the principal magnetic observatory in eastern Australia. Preparations are underway to upgrade the magnetic station at Alice Springs to a full observatory and the network will be completed eventually by the addition of an observatory at Darwin. A survey of 85 magnetic repeat stations was undertaken to provide a more detailed regional picture of the secular variation.

A prospective 'Australian Geomagnetic Reference Field' model of the regional magnetic field for 1985-1990 (AGRF 1985) has been produced by BMR as a software package and in the form of isomagnetic contour charts of the field elements. AGRF 1985 is the first step towards developing a set of prospective and retrospective field models for Australia.

A shipboard experiment was carried out in 1986 by BMR in cooperation with the Antarctic Division to relocate the South Magnetic Pole (the point where the Earth's magnetic field is vertically upwards). About 20 to 30 years ago the South Magnetic Pole drifted off the Antarctic continent into the Southern Ocean and is now about 240 km northwest of Commonwealth Bay. The mean position of the pole on 27-28 December 1986 was estimated to be 65°20'S, 138°10'E (Fig. 3). This experiment was the first shipboard direct determination of the position of either of the magnetic poles and achieved the closest-ever measured approach to the South Magnetic Pole—11.3 km on 6 January 1986.

Recording magnetometer array studies have been used not only for delineating crustal and upper mantle electrical conductivity structures, but also for providing information about mass transport in the oceans, and for evaluating the performance of aeromagnetic base-stations. Major new conductivity structures have been identified in the Eyre Peninsula, SA, and the Canning Basin, WA by Flinders

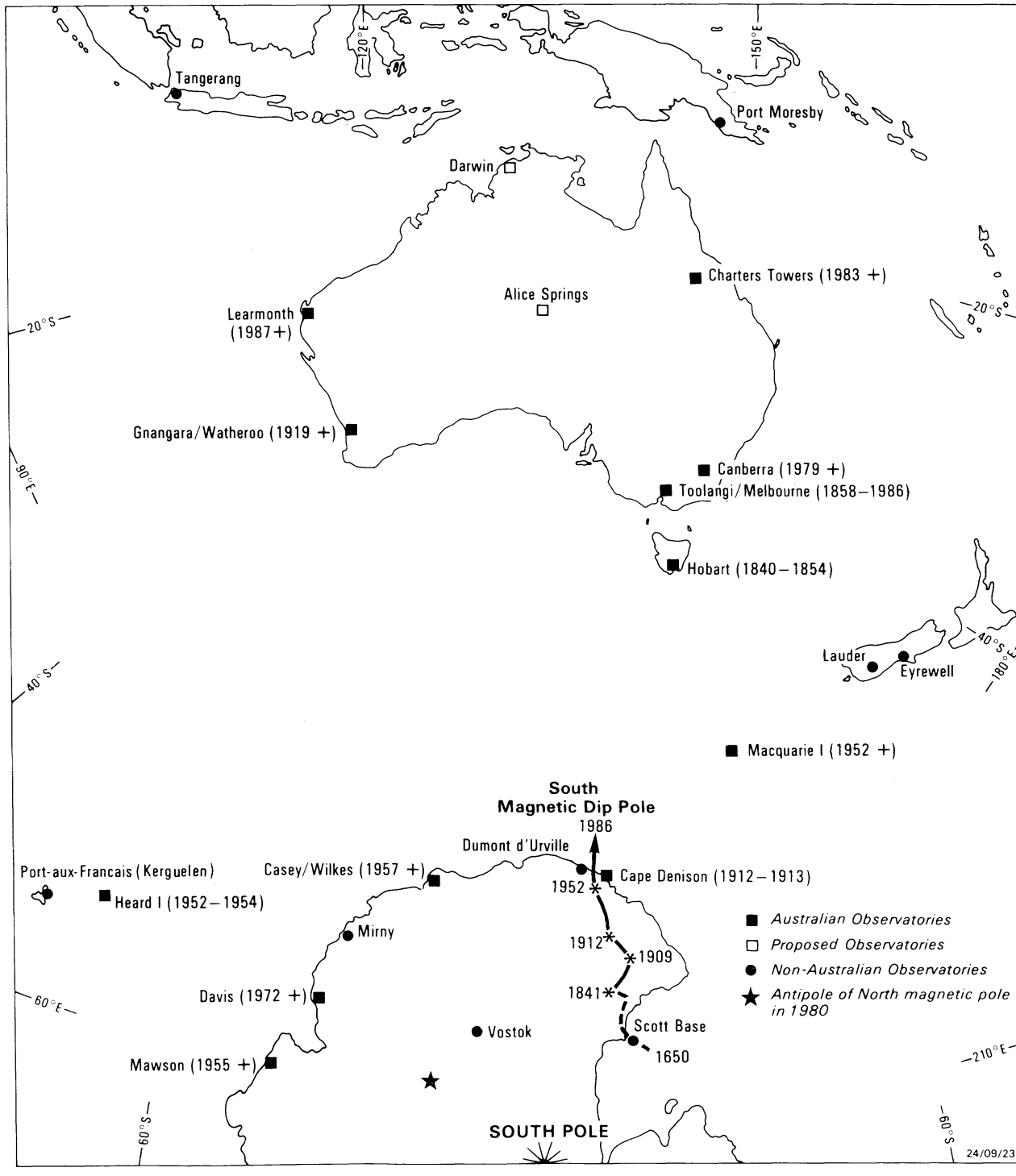

Fig. 3. Magnetic observatories and the path of the South Magnetic Dip Pole.

University, and in the Tamar Trough, Tasmania, by the University of Tasmania. The most ambitous study has been the Tasman Seafloor magnetotelluric project by the Australian National University and the Scripps Institution of Oceanography, California. This project involved the deployment of a line of instruments for recording magnetic and electric field fluctuations from near Ivanhoe, NSW, out into the middle of the Tasman Sea.

Modelling and interpretation of MAGSAT crustal magnetic anomaly data over the Australian region has given new insight into the large-scale geological structure of the region, particularly for the Broken Ridge off Western Australia, and for the Yilgarn Block. This work is being carried out by the National Science Foundation (USA), NASA, and BMR.

Robust analysis of the magnetic polarity timescale has demonstrated that: (1) the geomagnetic reversal process is essentially Poisson, which implies that the mechanism responsible for triggering reversals does not have a memory; (2) there is no discernible difference in stability between the normal and reverse polarity states of the geomagnetic field; and (3) the reversal rate has increased steadily from zero since 80 Ma and is now about four per million years. It has been shown that there are good reasons to suppose that seperate processes within the outer core (and its boundary conditions) are responsible for maintaining the geodynamo and for triggering reversals.

Transport geography

Transport geography as a subject of study has been an important part of the curriculum at the undergraduate, graduate diploma, and postgraduate level at various institutions in Australia both in geography and in town planning, civil engineering and applied science. There are three main thrusts that have become apparent during the last three years.

Firstly, interest in Australia at the micro-level has been both mode specific as well as multimodal. An examination of topics of dissertations at the bachelors and graduate levels shows that interests centre on the impact of pedestrial malls, public transport networks, travel behaviour and local area traffic management—themes investigated at the intra-urban and intra-metropolitan scale.

Secondly, also within the Australian context, multimodal investigations have been conducted on the impact of highway by-pass on towns, the commodity-transport infrastructure, travel behaviour, transport corridors and rural arterial transport strategies. A majority of these have been conducted within specific States.

Thirdly, on an international scale, the topics of theses have reflected similar interests, for example: public transport in the Philippines, and a study of the port of Singapore. In 1985, five out of the 154 theses submitted to Departments of Geography in Australia were based on a transport topic, while in 1986 the number was twelve out of 184 theses.

Research and publications in the area of transport geography have included public transport networks in Sydney; drink driving offenders and penalties in Hobart; vehicular and pedestrian interactions in suburban shopping strings along main roads; land-use activities and accessibility patterns in Sydney; Federal involvement in urban public transport and resource allocation; and accessibility in the metropolitan capital cities of selected southeast Asian countries.

Transport geographers have participated in various conferences including the *Australian Transport Research Forum* (ATRF), *Conference of Australian Institutes of Transport Research* (CAITR) and the Institution of Engineers Australia conference on *Developing Remote Regions*. The *International Geographical Congress* (IGC) is being held in Australia this year (1988). A study group on transport will conduct a workshop in Sydney and Canberra for participants at this Congress.

Continuing work in land-use activities and accessibility patterns in southeast Asia is continuing. In addition, interests are being expanded to include the development and evaluation of relevant computer software for teaching, research, and consultancy work.

STATUS OF AMF, BMR, GEOLOGICAL SURVEYS, AND CSIRO

Australian Mineral Foundation

Following the financial difficulties experienced in 1986, the AMF made good progress in 1987 through an increase in new member companies, revised membership rates and a contract for the training of staff from the Indonesian Department of Geology and Mineral Resources.

Highlights of the year included:

- transfer of the Australian Earth Sciences Information System (AESIS) database to CLIRS Information Service for on-line access;
- increase in AMF membership to 92 companies (as at early 1988);
- further development and expansion of the bookshop which now carries titles from 29 professional societies and organisations;
- completion of the first contract to train staff of the Indonesian Department of Geology and Mineral Resources in Australia, and commencement of the second contract.

Library

The library responded to over 4300 requests for documents during 1987, many generated from the two services: Earth Science and Related Information Selected Annotated Titles (ESRISAT) and AESIS Quarterly. Of these, 1027 came from ESRISAT, 527 from AESIS, and more than 1770 from other sources. Over 1000 were procured from other libraries. This inter-library loan process utilises the library's participation in the Australian Bibliographic Network (ABN) to great benefit.

Information searching is now conducted by the Library/ Information Services Section and 206 searches were conducted in 1987.

The library's book review program continues to be strongly supported by the world's earth science publishers. The publication of 136 reviews in 1987 remains a tribute to our reviewer for his dedication to the service.

Database

A major effort has involved relocation of AESIS on CLIRS and finalisation of direct access to the database through installation of a leased line to the CLIRS network. As at 1 May 1987, AESIS became available on CLIRS as the principal reference file in the Australian Resources Industry Database (ARID), which is a cluster of databases that relate to the earth sciences and the resource industries. Some 7460 new records were added to AESIS and ESRISAT during the year, making AESIS the world's largest database on Australian earth science and resource information. Total records in the AESIS public file on CLIRS as at 31 December 1987 was 56 396.

AESIS Special Lists continue to be in demand. The following updated or supplementary Special Lists were published during the year:

No. 2B/S4 Gold: July 1986-June 1987 (Supplements Lists Nos 2B, 2B/S1, 2B/S2 and 2B/S3)

No. 10B Hydrogeology: 1975-June 1987 (Incorporates List No. 10A)

No. 21A Platinum: 1975-June 1987 (Incorporates List No. 21)

No. 24 Gold Mining, Processing and Extractive Metallurgy: 1975-June

Other special compilations produced from AESIS for other organisations during the year were:

- The Aus IMM Publications Index, 1986
- Index to the Journal of the Geological Society of Australia, 1953-1985
- ASEG Publications Index 1970–1987

The 3rd edition of the *Australian Thesaurus of Earth Sciences and Related Terms* was published in December 1987. The publication of this 360-page document is a milestone in the development of one of the longest-running special projects undertaken by AMF on behalf of the mineral and petroleum industries and the earth science disciplines in Australia.

AMF Bookshop

The bookshop continues to expand its activities and now has some 29 agencies for Australian and overseas publishers. Sales continued to expand during 1987 under the concept of a one-stop book-ordering centre for the mining and petroleum industries.

Australian education

Twenty-six courses were held in 1987 with a total attendance of 498 participants. This compares with 48 courses and 740 participants in 1986. The courses spanned a broad range of subject areas including geoscience (8), mining and metallurgy (3), computer applications and statistics (2), petroleum production (5), mining and petroleum law (3), economics (1), and the environment (1). A seminar of the mining and petroleum industries for teachers was also held.

Overseas operations

Four courses were held in Indonesia and Malaysia during the latter part of 1987. Two contracts were arranged to provide training programs for employees of the Indonesian Department of Geology and Mineral Resources, with funding from an Asian Development Bank loan. These courses involved specialist English and report-writing courses, AMF workshop courses, and on-the-job training in various government departments and companies for the 20 Indonesians in each contract.

Bureau of Mineral Resources, Geology & Geophysics

BMR undertakes geoscience research into the geological framework of Australia and its territories and petroleum and minerals resource assessment, and is the primary national source of geoscience data. BMR has a total staff of about 595 including some 250 scientific staff. In 1987 BMR's projects were reorganised into six programs from eight in 1986: Fossil Fuels and Minerals Research; Groundwater Research and Assessment; National Geophysical Observatories and Antarctic Surveys; Petroleum and Minerals Resource Assessment; National Geoscience Databases; BMR Management and Information. Many of BMR's projects are of a multi-disciplinary and inter-divisional nature, and there is active cooperation with State and Territory Geological Surveys, Universities, other geoscience research organisations and exploration companies.

During 1987, the BMR Advisory Council met to advise the Minister and the Director, BMR, on BMR's research program. Members of the Council are Mr B. P. Webb (Chairman), Professor K. Lambeck, Professor D. H. Green, Mr R. J. Allen, Dr J. R. Ross, Mr V. G. Swindon, Mr B. Hill, Professor R. W. R. Rutland, and Dr H. L. Davies.

The emphasis in BMR's scientific program continues to be on energy research. During 1987, BMR continued its program of marine research cruises using the research vessel Rig Seismic. Successful cruises were carried out on the Otway Basin, Gippsland Basin, eastern Australian continental margin, Townsville Trough and Marion Plateau.

Brief reports from BMR's Divisions and Branches follow.

Division of Petrology and Geochemistry

During 1987, the Division's research scope was substantially increased by the transfer of the Explosion Seismology, Remote Sensing and Regolith groups from other Divisions within BMR. The latter two groups are small, and much of the remote-sensing applications research was already being carried out within the Division. The Remote Sensing group is concentrating on interpretation of the airborne multispectral data from the NASA Joint Scanner Project, working with geological teams from the Mount Isa and Pilbara provinces. Regolith studies are devoted to the 1:1 000 000-scale regolith terrain mapping program, commencing with Kalgoorlie sheet. High priority has been given to expanding the size and scope of these two groups.

The explosion seismology program has concentrated on interpretation of the eastern and central Australian crustal reflection and refraction data acquired in previous years, and on lead-up work for the Canning Basin acquisition program planned for 1989. Excellent results have been obtained from both eastern and central Australian seismic profiling experiments, providing key constraints on models for the evolution of the Mesozoic basins of eastern Australia and the Amadeus Basin. The only offshore seismic

acquisition program during 1987 was in the Tumut Trough of southern New South Wales where 45km of reflection data was collected under the Australian Continental Reflection Profiling Program (ACORP) in collaboration with the Australian National University.

In the field of mineral deposit and province studies, two new gold projects were commenced during 1987. The Division is collaborating with the Geological Survey of Western Australia in a project to determine the regional structural and tectonic controls on gold mineralisation in the Eastern Goldfields Province (Yilgarn Block, WA). This project will also produce a 1:1 000 000-scale geological map series, with BMR responsible for the Leonora and Minerie sheets.

In northeast Queensland, the Division is collaborating with BHP Minerals Pty Ltd in a regional study of the late Palaeozoic Bulgonunna Volcanics. This research will combine remote sensing, field mapping, regional geophysics and deposit studies to provide a basis for epithermal gold exploration throughout the region. The study of the Featherbed Volcanics in the same region has been completed. The study has demonstrated that there are two discrete periods of igneous activity, and that the bulk of the tin-tungsten mineralisation is associated with the first period, whereas gold mineralisation appears to be related to the second. During 1987, theoretical and experimental studies (in collaboration with DSIR, New Zealand) of the hydrothermal geochemistry of gold and platinum-group elements (PGEs) provided an improved basis for understanding metal transport, especially in lower-temperature, oxidised groundwater systems.

Regional research in the Mount Isa province continued to focus on an east-west structural transect, and significantly expanded the area of known extensional structures. Further refinement of the U/Pb zircon database provided a firm link between igneous history and tectonic setting. A major volume of papers on the Early to Middle Proterozoic of Australia was compiled and edited, and will be published in the journal *Precambrian Research* in mid-1988.

In the field of basin studies, the detachment models for continental extension continue to be refined and applied to sedimentary basins of Australia and its margin. During 1987, new extensional models were developed for the Canning Basin and the Southern Margin, and a synthesis of the Bass, Gippsland and Otway Basin tectonics was completed. Research in this field culminated in the

1987 BMR Symposium on Applied Extension Tectonics in November.

Division of Marine Geosciences and Petroleum Geology

BMR's geoscience research vessel *Rig Seismic* undertook five cruises on the Australian continental margin as part of BMR's Continental Margins Program. The vessel carried out multichannel seismic surveying and collected underway magnetic gradiometer and gravity data as well as obtaining *in situ* geological dredge and core samples, geochemical sampling and heatflow measurements. The vessel represents a unique, fully-integrated Australian geoscience capability. The data were obtained for basic scientific studies and for assessment of petroleum resources.

In 1987 the five Rig Seismic cruises dealt with five topics:

- Otway Basin and west Tasmanian continental slope geology and its relationship to resource potential; studies from geological sampling, and multichannel seismic, geochemical and heatflow data;
- structure, stratigraphy and resource potential of the deep-water Gippsland Basin, its northeast margin and the southern NSW margin, and correlation with similar structures on the Lord Howe Rise, utilising multichannel seismic reflection data;
- carbon accumulation and oxidation processes and development of Neogene to modern phosphorites on the eastern Australian continental margin, in cooperation with worldwide workers in this field;
- structural style and seismic stratigraphic framework of the Townsville Trough; and
- structural, sedimentological and subsidence history and resource potential of the Marion Plateau.

Cruises during 1987 were all successful in achieving their main objectives and obtained valuable regional multichannel seismic reflection data on the eastern Australian continental margin.

The pilot geochemical study carried out in the offshore Otway Basin was successful in indicating the presence of thermogenic hydrocarbons in the sediment column, emanating from mature source rocks at depth. Additional heatflow data, building on that obtained in previous *Rig Seismic* cruises, is continuing to increase that research database, which was very limited prior to the present program.

A number of projects associated with 1985 cruises were completed in 1987 and cruise reports and scientific papers giving important results of the studies were released. Processing of seismic, non-seismic and geological data at BMR continued in 1987 with public release of processed data sets, and preparation of other data sets for release in 1988.

Division of Geophysics

The Potential Fields Group continued its program of aeromagnetic and gamma-ray spectrometric surveys over the Australian continent. As at the end of 1987, about 90% of the continent had been covered by reconnaissance-level aeromagnetic data. It is expected that the whole continent will be covered by aeromagnetic surveys by 1992. A program of digitising and reprocessing old analogue aeromagnetic data is currently underway so that the entire database will be in digital form by 1992.

Three sets of new 1:1 000 000-scale aeromagnetic pixel maps are expected to be released in 1988. They will cover the Townsville, Melbourne and Esperance areas. A new series of interpretation maps taking into account long- and short-wavelength magnetic anomalies and gravity anomalies is being prepared. The first maps will include the Yilgarn Shield and Lachlan Fold Belt.

The Geomagnetism Group monitors variations of the Earth's magnetic field in the Australian region, produces numerical field models and magnetic charts, conducts research into the nature, origin and applications of geomagnetic variations, and provides advice and facilities as a national function. Four magnetic observatories are operated on the Australian continent, one on Macquarie Island and one at Mawson Station in Antarctica. A program of reoccupation of about 80 first-order repeat stations is maintained over a five-year cycle to measure the secular variation.

These data, together with additional survey information are incorporated into a regional field model called the 'Australian Geomagnetic Reference Field' (AGRF). The current model (AGRF1985) for the interval 1985-1990 is available

as a software package and in the form of isomagnetic charts for each field element. The Geomagnetism Group includes a Palaeomagnetic Section that conducts research into geological problems relating to tectonics, plate and continental reconstructions, and magnetostratigraphic correlation and dating.

The Australian Seismological Centre is part of the Division of Geophysics. Its role is to monitor earthquakes and nuclear explosions. During 1987, it reported 47 nuclear explosions detonated by the US, USSR, China and France. It operated a network of 24 seismic observatories and continued special studies of earthquakes which occur in the Southwest Seismic Zone of Western Australia and in the Daldon-Gunning region of New South Wales. No major earthquakes occurred in Australia during 1987 but foreshocks were reported from Tennant Creek, where a series of major earthquakes took place in January 1988.

Division of Continental Geology

Several major research projects are in the final phases of completion. The McArthur Basin project is essentially complete having made the exciting discovery of the world's oldest free oil and proving that this mid-Proterozoic basin is prospective for hydrocarbons. Significant advances have been made in understanding the environmental controls on source and reservoir distribution and the application of geochemical techniques to source rock and maturation assessment in proterozoic sequences.

The Baas Becking Geobiological Laboratory (BBGL) has completed research directed at understanding the origin and distribution of petroleum in late Proterozoic and Cambrian basins. This involved studies of Holocene sedimentary environments (eg Shark Bay) analogous to ancient environments of interest, and sedimentological, geochemical and palaeontological studies of key facies associations in Proterozoic and Cambrian basins.

A review of BBGL was commenced in June 1986 by a committee comprising representatives of the mineral and petroleum exploration industry and the Chiefs of the relevant CSIRO and BMR divisions.

The committee found that BBGL was undertaking work of a high scientific calibre but that its separate management structure had become redundant in view of the evolution that had occurred in both BMR and CSIRO. It recommended that it was now more appropriate for this work to be integrated with high-priority mainstream research in BMR and CSIRO. It was recommended that BBGL cease to function in its present form from 30 June 1987 and that its scientific facilities and research skills be deployed to BMR and CSIRO research teams working in such priority areas as petroleum geology and geochemistry, water resources, biotechnology, sedimentology, and ore deposit genesis.

These recommendations were accepted by the relevant Ministers on the advice of the management of the Institute of Energy and Earth Resources of CSIRO and of BMR. The most important elements of BBGL research will be retained as part of the wider strategic research programs of BMR's research divisions, especially the Division of Continental Geology.

In the Amadeus Basin, a new three-dimensional perspective of the basin based on analysis of sedimentary sequences has been completed and a thermomechanical model for the evolution of the basin and its relationship to deformational events has been developed. The development of a new biostratigraphic framework for the Cambro-Ordovician is progressing and detailed sedimentological studies of the late Proterozoic to Devonian formations are well advanced.

Distribution of Ordovician source rocks in the Amadeus and Canning Basins are associated with the occurrence of the microfossil *Gloecapsomorpha prisca* which has been linked to the unusual chemistry of Ordovician oils and source rocks.

In the Clarence-Morton Basin, seismic, structural and stratigraphic data have been integrated to produce a tectonic model of basin formation. A new stratigraphic framework has been developed which better reflects the sedimentation history and identifies the distribution of potential reservoir units. Source-rock investigations have defined new source-rock horizons and in conjunction with stratigraphic studies have allowed burial and maturation histories to be determined. Source-rock data from the Clarence-Morton Basin, in conjunction with studies of Permian to Tertiary coals and carbonaceous sediments, have enabled better definition of source-rock quality in non-marine sequences.

The first phase of the Palaeogeographic Map Project is essentially complete and has resulted in the production of 70 charts. All available petroleum source-rock data have been examined and summarised in well-data sheets and displayed as overlays to the palaeogeographic maps. Both maps and charts represent our state of knowledge of the Phanerozoic chronology and palaeogeographic evolution of the Australian continent and also the first systematic attempt to relate source-rock quality and type to depositional environment on a continent-wide basis.

A major effort has been devoted to studies of phosphate sediments both in ancient and recent environments. An international team of scientists in cooperation with BMR scientists has been examining the occurrence, geochemistry and age of phosphate in the Cambrian of the Georgina Basin, Tertiary of Victoria and New Zealand, and Neogene sediments of offshore eastern Australia.

The salinity problems in the Murray Basin are a matter of national concern and for this reason BMR is concentrating its groundwater research efforts in the Murray Basin. BMR coordinates a joint Commonwealth-State hydrogeological study of the basin. Significant progress has been made in the development of a geological synthesis, a hydrogeological database, and characterisation of the Gerra Clay aquitard. A 1:5 000 000-scale hydrogeological map of Australia was completed and published. It is an important contribution to the understanding of one of the nation's larger groundwater systems and is a guide to regional groundwater assessment.

Resource Assessment Division

The staff of this division are largely engaged in studies and activities designed to provide information on some 65 mineral commodities considered likely to be of economic or strategic importance in Australia. Greater emphasis is given to the study of energy minerals—in particular petroleum—because of their economic and strategic importance. Increased attention is being paid to some minor commodities, including rare earths and the 'electronic metals' such as gallium and germanium.

Most of the effort in resource assessment is directed towards the study of known mineral deposits because information about the quality, quantity, and availability of these resources is of prime importance to the Government and of major interest to industry and the public. Nevertheless

there is a growing demand for information about the petroleum and mineral potential of Australia and its territories as a basis for Government policy formulation and land-use planning. Assessments of the mineral potential of parts of north Queensland and Tasmania were prepared during the year.

The Division continued its well-established series of regular publications and information releases on the mineral and petroleum industries. Production of a series of reports summarising information on oil accumulations in sedimentary basins or regions of Australia continued. Reports 3 (Gippsland basin) and 4 (Adavale Basin) were published in 1987.

A new assessment of Australia's undiscovered condensate resources was published early in 1987. Research programs designed to improve the methodology for assessing undiscovered petroleum resources, and for estimating future supply from undiscovered crude oil resources, continued. Contributions on the petroleum potential of Australia's sedimentary basins for an Australian Petroleum Exploration Association Bicentenary publication on Australia's petroleum resources were completed.

In addition to the two principal activities of resource assessment and database development, the Division continued to coordinate Australian research on enhanced oil recovery (EOR) and a research project on Australia's EOR potential funded by the National Energy Research, Development and Demonstration Program (NERDDP). Divisional staff were responsible for organising the first meeting in Australia of the International Energy Agency EOR Group, held in Sydney in 1987.

A NERDDP grant continued to provide partial funding for the development of Petroleum Exploration Database (PEDIN). It is planned to release PEDIN about mid-1988. It will be made available to Commonwealth and State Government departments, petroleum exploration companies, contractors, consultants, academic institutions and others to facilitate exploration, research, and resource assessment studies, and as a source of information for administrative and legislative purposes.

An initial design for the BMR's mineral deposits database, MINDEP, was completed and implemented during the year. Data on 80 Western Australian gold deposits compiled earlier in the year were released in November 1987 as Resource Report No 3: *Gold deposits of Western Australia: BMR datafile (MINDEP).* The datafile contains information on the location and regional setting of the deposits; development history, including operating status of individual mines; mineral resources and production; deposit geology including brief descriptions of host rocks and their structures, metamorphism and alteration; genetic controls and proposed genetic models; ownership, geological setting, mineralogy and dimensions of orebodies; and bibliography.

A facility was established in the mineral prices (MINPRI) database to allow users to access the database and retrieve tabulated data.

The coal-seam database, COAL, was expanded to contain information on 160 seams in New South Wales, Queensland and South Australia. The database has information on stratigraphy, coal properties and, where available, resources and mine production.

Staff presented eight papers at the Petroleum and Minerals Review Conference in March 1987 and a paper on rare-earth resources at a multidisciplinary conference on rare earths.

The ORACLE relational database management system that was installed at the end of 1986 provided the impetus for considerable database development activity throughout BMR. Several pre-existing databases have been redesigned and new ones developed using the new software, The relational nature of the software allows the databases to be linked so that unnecessary duplication of data is avoided.

A Government Geoscience Database Policy Advisory Committee was established in 1987 to assist BMR in carrying out its responsibility to coordinate government geoscience database activity in Australia. This committee consists of representatives of the state geological surveys/mines departments and BMR.

BMR was also active in other national and international geoscience database organisations. These included the Australian Resources Industry Database Advisory Council, the International Consortium of Geological Surveys for Earth and Computer Sciences, and the IUGS Commission on Geological Documentation.

During 1987, BMR's Data General computer system was upgraded with additional memory and disk storage and a third tape drive was added. The local area network has been expanded to provide computing services to over 300 users distributed throughout the main BMR building and three other buildings in Canberra.

Special Projects & Geoscience Services Branch

In cooperation with the Specialist Group for Tectonics and Structural Geology of the Geological Society of Australia, compilation of a tectonic map of the Tasman Fold Belt Systen at a scale of 1:2 500 000 has been completed. Contributions have been prepared by State geological surveys and universities.

A bicentennial project that aims to publish two volumes on Australian geoscience for 1988 is being coordinated with scientists from BMR and other organisations. The volumes planned are the coals and coal basins of Australia, and the tectonics of the Tasman Fold Belt System (as a companion to the 1:2 500 000 map).

The main international map project during 1987 was on the Southwest Quadrant of the Circum-Pacific Map Project. The 1:10 000 000-scale geological map of the quadrant was published in 1987 and compilation of the 1:10 000 000 mineral resources map was completed. Compilation of the energy resources map continues.

The main BMR overseas project is the geological and geophysical mapping and training program by BMR personnel in Indonesia. This program is being carried out in cooperation with the Geological Research and Development Centre (GRDC) of the Indonesian Department of Mines & Energy and funded by the Australian International Development Assistance Bureau (AIDAB). Six Australian staff members in Bandung work in cooperation with Indonesian geologists and geophysicists in a helicopter-supported mapping project in Kalimantan.

As part of the training program during 1987, Indonesian geologists, geophysicists and draftsmen undertook three months of on-the-job training in Australia with State geological surveys (NT, Tas., SA and Qld) and BMR. In addition, seven geoscientists are enrolled at universities for MSc and PhD degrees. The project is due to finish in December 1988.

Notes to accompany the ten 1:250 000 maps that comprise the 1:1 million-scale map of Irian Jaya are being prepared.

BMR scientists continued to operate magnetic and seismological observatories in Antarctica through 1987 but there were no fieldwork activities. In the 1987 summer season, ANARE field operations were centred on Heard Island and on the Larsemann Hills in Prydz Bay and south west of Davis Station. The Larsemann Hills operation was in lieu of planned field activities in the Bunger Hills where access proved impossible because of severe sea ice. At the Larsemann Hills, Proterozoic gneisses of probable sedimentary origin are exposed and BMR scientists have already examined and reported upon them. Heard Island is the site of Australia's highest mountain and only active volcano. Geologists from the University of Tasmania and Monash University were landed by helicopter on the summit cone and sampled a flow which was erupted in late 1985.

In Canberra, laboratory and office studies were made of rock samples collected in the Bunger Hills in 1986. A preliminary account of the geology of this part of the East Antarctic metamorphic shield was presented at a meeting in Sri Lanka of IGCP Project 236 *Precambrian events in the Gondwana fragments.*

Northern Territory Geological Survey

The major field season for regional mapping was undertaken by three field parties throughout the Northern Territory. The biggest field party commenced on the East Arnhem Land Project and comprised five geologists and support staff. The base camp with all field facilities was located at Batten Creek some 70 kilometres southwest of Borroloola. The field work comprised the remapping of the second edition of the Bauhinia Downs 1:250 000 and the first edition of the Batten 1:100 000 map sheets.

A second party of three geologists and support staff were located at Kulgera and undertook field work on the Kulgera 1:250 000 map sheet. Comprehensive gravity surveys were undertaken on the Kulgera, Victory Downs and Sentinel Bore 1:100 000 map sheets. Mapping on the western extremity of the Sentinel Bore sheet identified a domain comprising a thick sequence of pseudotachylite (200 metres), ultramylonite (50 metres), and mylonite (3-4 km). This feature appears to be part of the Woodroffe Thrust and separates granulite-grade rocks to the South from amphibolite-grade units and Dean Quartzite to the North.

The thrust is a unique structure as the pseudotachylite zone ranges from 40 m of almost pure pseudotachylite in the Ayers Rock sheet to a 200-m-thick brecciated zone infilled by pseudotachylite veins up to 3 m wide. There are no comparable structures of this dimension anywhere else in the world. Similiar structural areas elsewhere contain pseudotachylite veins which rarely exceed a few centimetres.

The Dean Quartzite has been deformed by the Woodroffe Thrust (this can be shown structurally) and the thrust must therefore have been active at least during the Petermann Orogeny (600 Ma). However, an earlier history of thrusting cannot be precluded.

A third and a smaller field party has been finalising mapping of the Barrow Creek 1:250 000 sheet. Mapping has provided a new stratigraphy for the Central Mount Stuart Beds—a late Pre-Cambrian-Early Cambrian Sequence—previously correlated over a large area of the Alcoota and Mount Peake Sheets.

The pre-Central Mount Stuart surface is very irregular. In one locality, U-shaped valleys, possibly of glacial origin, are now being exhumed. Isolated outcrops of an unnamed tillite are located disconformably beneath the Central Mount Stuart Fomation near the western edge of the Barrow Creek sheet.

The Central Mount Stuart Formation (*sensu stricto*) was at least partly marine. This is reflected in the late Proterozoic soft-bodied Mount Skinner fauna and associated trace fossils which have been located at a number of new localities. On the Barrow Creek Sheet, the Central Mount Stuart Formation is disconformably overlain by a currently-unnamed sequence of white sandstone and quartzite probably of latest Proterozoic age. This is overlain disconformably by sandstone containing Early Cambrian formations separated by a disconformity. The other formation is disconformably overlain by an unfossiliferous white sandstone tentatively correlated with the Middle Cambrian Chabalowe Formation of the eastern part of the Barrow Creek sheet.

A 300-metre diameter circular structure has been located in almost flat-lying late Proterozoic sediments approximately 55 km southeast of Barrow Creek. This structure has a central area of disturbed strata samples of which show petrographic evidence of shock metamorphism consistent with the site being a deeply-eroded meteorite impact structure. The original crater was probably at least twice the size of the eroded remnant. There is evidence that the event pre-dates Tertiary silicification in the area.

Both the East Arnhem and Petermann-Musgrave Ranges Projects have purposely been commenced outside traditional Aboriginal Land to allow the geologists to familiarise themselves with the known rocks, and also to enable good relations to be established with the Aborigines. This will facilitate a smooth transition of the mapping parties onto the adjacent Aboriginal Lands.

The Litchfield mapping project entered its final phase with several of the 1:100 000 maps being submitted for publication. Production of the Tipperary 1:100 000 map sheet continued and detailed basin studies were undertaken. Ongoing studies by Dr P. D. Kruse have indicated a large number of unrecorded fossil species. Samples from surface outcrops and NTGS stratigraphic drill holes have provided a very comprehensive coverage of the Northern Daly Basin. Material from existing collections at BMR and the Geological Survey of Western Australia have also been reviewed.

The greatest known thickness—708.5 m—of the Daly River Group (Tindall Limestone, Jinduckin Formation, Oolloo Dolostone) occurs in NTGS drill hole 86/1 and serves as a stratotype for the constituent formations. General lithological trends and fossiliferous intervals within these units are now known, and environmental interpretations have been made. The Tindall Limestone is a unit of open-shelf mixed carbonate-siliciclastic marine deposition, and the Jinduckin Formation and Oolloo Dolostone are both peritidal units, the former mainly of low-energy siliciclastics, the latter of higher-energy ooid shoals. Only the Tindall Limestone has yielded biostratigraphically-useful fossils not already adequately treated in the modern literature.

Palaeontological studies have therefore concentrated exclusively on Tindall Limestone Faunas and have included work on trilobites, brachiopods, hyoliths, molluscs, sponges and bradoriides. As little systematic work has been done on Daly Basin faunas, most species are new. The few described forms (hyolith, Biconulites Hardmani—(Etheridge in Foord, 1890) and ptychopariid trilobites of Gatehouse (1968)), will be fully characterised and their nomenclature updated. The sponge fauna has already been

documented in an external publication (Kruse, 1987); the two new genera recognised are among the earliest known sphinctozoan sponges (Fig. 4). The remaining fauna will be published as an NTGS Report to appear later in 1988.

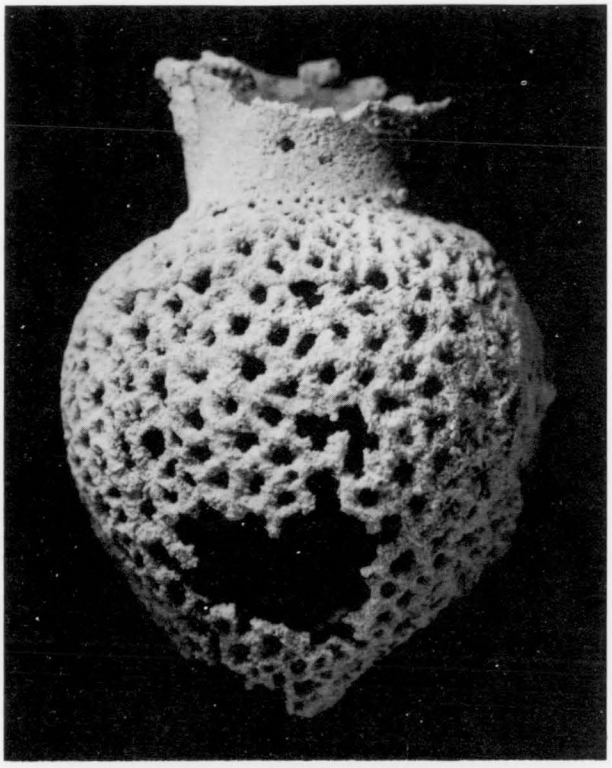

Fig. 4. *Jawonya gurumal* Kruse 1987—a Middle Cambrian sphinctozoan sponge from the Tindall Limestone, Daly Basin, Northern Territory (natural size).

The Frew River and Bonney Well 1:250 000-scale maps were released to the general public. An airborne geophysical survey was conducted of three 1:100 000 map sheets (Imbumbunna, Olia Chain and Butler Dome) as part of the Petermann/Musgrave Ranges Project. Image processing of the radiometrics and magnetics for the Petermann 1:100 000 sheet has produced a number of very useful multicolour interpretations.

The Metalliferous Unit commenced a detailed study of known mineral occurrences and mine sites in the Pine Creek 1:250 000 sheet as a prelude to the preparation of a metallogenic map of the area. Some 250 different localities were sampled and many specimens were selected for further microscopic work. This project is designed to understand the genesis and controls of gold, tin, base-metal and uranium mineralisation in the area by the use of fluid-inclusion, stable-isotope and wall-rock-alteration studies.

Queensland Department of Mines

The organisational review of the Department of Mines during 1986-87 led to the introduction of program management. Ten programs which reflect the Department's service delivery were established.

Under the previous Divisional Structure all geologists and geophysicists were included within the Geological Survey of Queensland. Reorganisation has resulted in the deployment of geoscientifically-qualified staff to six of the ten programs. Primary responsibility for geological and geophysical investigations was allocated to two programs: Geological Survey-Regional Investigations and Geological Survey-Services.

The coal, oil shale, and petroleum functions of the Fossil Fuels Branch of the Geological Survey of Queensland were transferred to the Energy Resources Development and Utilisation Program. The economic minerals, extractive materials and land-use planning components of the Metalliferous and Geological Services Branch were assigned to the Mineral Resources Development Program. The Computer Services and Publication Services Sections were integrated with the Corporate Services and Information Services Program respectively.

The Geological Survey-Regional Investigations Program which comprise the Geological Mapping, Basin Studies, Metallogenic Studies and Biostratigraphy Subprograms, also administers the District Office at Charters Towers.

During 1987, the Regional Geological Mapping Subprogram (RGMP) concentrated on the revision of regional map coverage of mineralised provinces in north Queensland. Two field parties operated from bases at Charters Towers and Collingwood near Cooktown. Recording of field data on a computer-based system (REGMAP) was adopted as standard practice.

Mapping of the extensive Palaeozoic Hodgkinson Province continued. Field work in the Mossman 1:250 000 sheet area has been completed and pre-release compilation sheets issued. Two reports on the Proterozoic rocks of the Eastern Georgetown Inlier, where field work was completed in 1984, were finalised and submitted for publication. Cartographic work on the 2nd edition Einasleigh 1:250 000 sheet has commenced.

Results of geological investigations of the Broken River Province, where field work was essentially completed in 1986, were disseminated at a field conference conducted in conjunction with the Australian Sedimentologists Group of the Geological Society of Australia. Pre-release compilation sheets for most of the Clarke River 1:250 000 sheet were released. Cartographic work commenced on a 1:100 000-scale Broken River special geological map of the Graveyard Creek Subprovince.

Field work continued on the Burdekin Basin and the Lolworth-Ravenswood Block within the Charters Towers and Townsville 1:250 000 sheet areas. Several pre-release compilation sheets were issued. Compilation sheets for the Mount Coolon 1:250 000 sheet were also released and the 2nd edition map was in preparation. The 1:50 0000-scale solid geology map of the Bowen Basin was in press.

In southeast Queensland the 1st Edition Fraser Island Special 1:250 000 sheet was published and cartographic work commenced on the revised edition of the Maryborough 1:250 000 sheet. In northwest Queensland the second edition of the Mount Isa 1:250 000 sheet area was published. Preparation of reports and 1:100 000 scale geological maps of city and provincial areas continued. The map commentary for the Caboolture 1:100 000 sheet was published. Cartographic work continued on the Cairns and Gladstone sheets.

The Metallogenic Studies Subprogram continued mapping mineral occurrences within the Atherton 1:250 000 sheet area. Mineral occurrences were plotted by computer on constituent 1:100 000 map sheets and details of each locality summarised in the standard format adopted for

the Mineral Occurrence Data Management System (MINOCC). A report on mineral occurrences in the Mungana

1:100 000 sheet area was issued and reports on the Bullock Creek and Chillagoe areas were nearing completion. Investigations in the Lyndbrook sheet area were completed and were in progress in the Atherton and Ravenshoe areas.

Investigations by the Basin Studies Subprogram concentrated on the subsurface geology of the Eromanga and Surat Basins and their potential for petroleum and groundwater resources. In the Eromanga Basin, the deep stratigraphic drilling program in the southeastern sector was completed with the drilling of four holes totalling 5062 m: GSQ Jundah 1, GSQ Connemara 1, GSQ Machattie 1 and GSQ Thargomindah.3. Reports on GSQ Jundah1 and GSQ Connemara 1 were issued and reporting on the remaining boreholes was in progress.

The NERDDP Project 914 continued to assess the hydrocarbon generation potential of the southern Eromanga Basin in Queensland. Progress results of this work were issued together with compilations of source-rock data. Investigations of the hydrogeology of the Eromanga and Surat Basins continued.

The Biostratigraphy Subprogram continued to provide a biostratigraphic framework for mapping projects in the Hodgkinson and Broken River Provinces and in the Burdekin Basin. Conodont studies revealed hitherto unrecognised repetitions of geological sequences in the Mungana area of the Chillagoe Subprovince. Studies of Devonian-Carboniferous invertebrates of the Burdekin Basin commenced.

Foraminiferal research was applied to the Permian stratigraphy of the Gympie Basin to assist gold exploration. Repetition by faulting was demonstrated and correlation with Bowen Basin sequences more firmly established. Palynological work centred upon the documentation of the microfloral succession in the Jurassic of the Surat Basin.

The Geological Survey-Services Program comprises the Geophysical Services, Geotechnical Services, Marine and Coastal Investigations, and Drilling and Field Services Subprograms.

Geophysical Services Subprogram undertook projects concerned with the management of geophysical data lodged as a requirement of petroleum and mineral exploration title. Inventories of seismic and other geophysical data were reviewed and computer retrieval systems enhanced or planned. Monitoring of seismic activity in the vicinity of major damsites continued.

Results of geophysical surveys in support of mineral and coal resource assessment projects were published. Regional geophysical investigations were undertaken in support of geological mapping programs in North Queensland. Seismic refraction profiling was conducted at several proposed damsites on behalf of the Queensland Water Resources Commission and local authorities.

Following restructuring of the Department, the Geotechnical Services Subprogram assumed responsibility for engineering geological projects undertaken on behalf of governmental, semi-governmental and local authorities.

Work the Baroon Pocket Dam and Blackall Range tunnel continued. Reports were prepared on the Cooktown and Gladstone water supply projects and on the Noosa sewerage effluent disposal scheme.

Results of rock-stress measurements at the Burdekin Falls Damsite (undertaken in collaboration with James Cook University and the CSIRO Division of Geomechanics) were prepared for publication. Technical and advisory services of this subprogram were subject to review.

Marine and Coastal Investigations Subprogram continued research investigations and projects for Governmental clients. Investigations for the Beach Protection Authority into active sedimentary processes, sediment distribution and the evolutionary history of the Mackay coastline were completed. Similar studies of the Sunshine Coast and the Townsville to Cairns coastline are in progress. An offshore survey of the proposed port site at Cape Manifold was also completed.

Results of research on sedimentation in the Gulf of Carpentaria (in collaboration with the Australian National University) were published. Investigations of the controls on reef development in the Swain Reefs area continued.

During 1987, 21 holes were drilled in six areas as part of the coal drilling program: Burton Downs, Eaglefield, Sullivan Creek, Clermont North and Taroborah in the Bowen Basin, and Rosewood in the Moreton Basin. These holes totalled 3571 m. Ten of the holes were drilled for resource evaluation, seven for geological reconnaissance, and four to assist engineering studies. A brochure and display map illustrating the geological distribution of coal in the State was published. A reorientation of Departmental activities towards resource assessment, industry support, and development and project facilitation has signalled the suspension of the coal-drilling program

The Queensland mineral reserves and resources inventory was updated and preparations made for computerisation and release of the open-file component. Computerisation of databases of information on resources of construction materials and on mining projects continued.

Geological Survey of South Australia

Bulletin 53, *The Adelaide Geosyncline—Late Proterozoic stratigraphy, sedimentation, palaeontology and tectonics*, was published towards the end of 1987 and represents the culmination of over four decades of geological investigation. It is one of the most important geological publications ever to be produced by the Department and gives a detailed account of all rock groups down to member level. Geochronology, tectonics and palaeontology are reviewed while the final section reconstructs the Geosyncline's palaeogeographic evolution by means of 45 time-slice diagrams. This publication will provide a geological background to stimulate new concepts in mineral exploration.

A new map *Geological setting of the Gawler Range Volcanics* was published. The Middle Proterozoic Gawler Range Volcanics, which includes the huge Olympic Dam copper-gold-uranium orebody, form one of the largest acid volcanic provinces in the world. The new map provides an overview of the area of outcrop which should stimulate further exploration of its largely unrealised mineral potential.

Other geological maps published were the Tallaringa 1:250 000 and Rudall 1:250 000 sheets. The Yardea, Olary, Kimba and Elliston 1:250 000 and Gawler, Vincent and Tepko 1:50 000 sheets were made available in colour manuscript form.

Results of drilling programs near Ooldea and Darke Peake on Eyre Peninsula were released.

Papers were contributed to a Geological Society of Australia Memorial Volume (in press) to the late Dr Brian Daily. The papers include an overview of the Adelaide Geosyncline, and papers on volcanics and gold potential in the Burra Group and on the stratigraphy and sedimentology of the Normanville and Kanmantoo Groups. Several papers on mineralisation in various South Australian geological provinces were prepared for a bicentennial volume on Australian mineral deposits being published by the Australasian Institute of Mining & Metallurgy.

Preliminary palynological studies have been made on a suite of dredge samples of Mesozoic and early Tertiary sediments from the Great Australian Bight Basin and the continental slope off Kangaroo Island. These samples were taken by the Bureau of Mineral Resources vessel *Rig Seismic*. Reports have been prepared on biostratigraphic aspects of the Eucla, Eromanga, Lake Eyre, St Vincent and Murray Basins.

Definitive compilations on various South Australian chronostratigraphic units were prepared for the Geological Society of Australia Stratigraphic Nomenclature Committee.

The petrophysical data in a large core-plug database have been used to calibrate downhole logs from Cooper and Eromanga Basin oil and gas wells. This has enabled constraints to be placed on parameters used in log analysis equations so that realistic in-place oil and gas reserves can be calculated.

A handbook entitled *Environmental planning techniques* has been prepared for the Australian coal, mineral and petroleum industries, and an *Atlas of geophysical and related data* has also been produced.

New seismograph stations have been installed at Arkaroola and Mount Gambier.

Tenders have been let for a 57 000-kilometre aeromagnetic, multichannel radiometric, and electromagnetic survey over Eyre Peninsula.

Storage capacity of the Data General MV/20 000 computer has been doubled, mainly to cater for rapid evaluation of South Australian coal deposits for the next electric power station. A total of 16 NEC micro-computers have been acquired; these will also act as graphics terminals to the main computer.

The Lead-Zinc Task Force has completed a review of existing data and has compiled over 250 summary sheets form Departmental and company reports. Reports have been prepared on mineralisation in the Kanmantoo Trough, Gawler Craton, Willyama Inlier-Curnamona Cratonic Nucleus, and Adelaide Geosyncline. Localities where exploration should be directed have been outlined within each of these areas.

Investigation and documentation of gold deposits and occurrences has continued in many areas of the State. Surface and underground mapping, rock-chip sampling, and sampling for fluid inclusion and isotope studies is in progress at Earea Dam, Glenloth and Tarcoola (Gawler Craton), and at Mongolata, Nillinghoo, Wadnaminga and Mannahill (Adelaide Geosyncline). Reports have been prepared on geological investigations at Waukaringa, Teetulpa, Mount Grainger and Mittopitta goldfields. Core from drillholes at the Kanmantoo copper mine has been sampled and found to contain up to 5.10 g/t Au and investigation of other copper mines is continuing.

A program of testing commercially-available South Australian building stone was completed. This is the most comprehensive program yet undertaken in the State to test properties such as compressive strength, flexural strength, modulus of rupture, dimensional stability and resistance to salt crystallisation. Thirty oriented samples were tested in accordance with draft Australian Standards.

Regional assessment of groundwater resources continues in the Tatiara proclaimed Region, Murray Basin and Great Artesian Basin. A major investigation has commenced in the Willunga Basin and Naracoorte Ranges in the southeast of the state. A slim-line, down-hole hydraulic water pump was constructed to collect water samples inside 80-mm diameter wells up to a depth of 75 m.

The SAMREF computerised bibliography is now available for public access on the Australian Resources Industry Database (ARID) through the commercially-operated CLIRS network. The network is available Australia-wide and can be accessed on-line by computer terminal.

Geological Survey of Tasmania

The Geological Survey Division of the Tasmanian Department of Mines is organised into three operational Branches and two Sections.

- Regional Geology Branch
- Engineering Geology Branch
- Economic Geology Branch
- Geophysics Section
- Petroleum Exploration and Marine Geology Section

Regional Geology Branch

Regional geological mapping for the 1:50 000 *Geological Atlas Series* continued as a major effort. During the summer field season, mapping continued in the Macquarie, Montgomery and Corinna areas of western Tasmania and in the Ben Lomond area in eastern Tasmania.

In the winter season, mapping continued in the Woolnorth and Trowutta areas in the far northwest of the State, in the Alberton and Snow Hill areas in northeast Tasmania, and at Dover in the south. Mapping was completed in the Ben Lomond region.

During the year the Lyell and St Helens sheets were published, and the Montgomery and Ben Lomond sheets compiled for drafting.

Engineering Geology Branch

This Branch provides and accumulates geological information which assists in the design and construction of engineering works and buildings, and in the provision of groundwater supplies. Specialised topics presently being pursued include the monitoring of groundwater pollution in the vicinity of sanitary land fills, methods and sites for the disposal of toxic wastes, and the development of a design for a landslide-resistant house.

A pilot study on the incorporation of geological, geohydrological and geotechnical information into a Geographic Information System (GIS) is being done jointly with other Departments and the University of Tasmania.

The urban soil mapping plans for greater Hobart are proceeding, and groundwater drilling continued in the Lower Midlands and the Sheffield area in northwest Tasmania. Long-term monitoring continues in basalt-aquifer irrigation areas, and a study of recharge in these and other areas is proposed.

Economic Geology Branch

The main emphasis in this Branch's programs was the continuing Mount Read Volcanics project—an integrated project aimed at providing industry with the basic information required for exploration planning. The components of the project are geological mapping, soil and water geochemistry, geophysics, alteration and isotope studies, lineament analysis and remote sensing, metallogenic mapping, and production of mineral deposit maps. Results are available for all components of the study.

The entire exploration report library has been indexed and a computerised database established. Microfilm copies of open-file reports are now available for purchase.

Geological maps at 1:25 000-scale have been produced for the Mount Murchison and Tyndall Range areas in 1987, in addition to the Mount Charter-Hellyer, Rosebery-Mount Read areas which were produced in 1986. Mineral deposit maps at 1:50 000 scale are available for the Andrew, Queenstown, Tullah, Rosebery, Ulverstone and Cethana areas. Maps in preparation are Elliott Bay and Loongana.

An extensive area of Tertiary basalt in northwest Tasmania has been drilled to provide information on basement lithologies prospective for base- and precious-metal and tin-tungsten deposits. Associated geophysical logging has provided physical-property data on the cover and basement rocks and is refining geophysical exploration in this environment.

Geophysical Section

The Mount Read Volcanics project has continued to be the dominant activity of the Section. Major reports prepared include the interpretation of the aeromagnetic data over northwest and central-northern Tasmania and a combined gravity and magnetic interpretation of west and northwest Tasmania to study the relationships of the Precambrian and lower Palaeozoic elements and the granitoids.

All publicly-available onshore gravity data for the State has now been corrected for terrain and checked, and a 1:500 000 Bouguer anomaly map of the State has been produced.

Petroleum Section

Research continued into Eocene sedimentology of the Bass Basin. The work has utilised detailed core analysis, wireline-log analysis, and coal-maceral studies, together with palynology and geochemistry. The research has indicated that throughout most of the Eocene, lower delta plain (and, in particular, tidal flat and marsh) environments persisted in the basin. A major transgression, probably occurring at 38 Ma, resulted in the development of excellent reservoir rocks at the top of the Eastern View Group, particularly in the northwest sector of the basin.

Geochemical studies were commenced on Bass Basin petroleum and coals and Permian sedimentary sequences.

Geological Survey of Victoria

The Geological Survey of Victoria has for the past five years channelled much of its investigative works through its Groundwater and Salinity and Pollution Sections. The groundwater function is in the process of transfer to the Water Sector of Government, namely the Department of Water Resources. Many of the research-oriented projects associated with salinisation of the Riverine Plain, the Mallee and Wimmera regions, and the basaltic plains of the Western District will henceforth be continued in that Department.

In addition, studies of the Westernport groundwater systems and the Barwon Valley supply and recharge experiments for Geelong's water supply will be continued under the auspices of the Department of Water Resources and the Rural Water commission.

Liaison with the Bureau of Mineral Resources has been maintained for the production of the Victorian portion of the 1:1 000 000 map of the Murray Basin.

Modelling studies of groundwater balance and migration for the Riverine Plain of the Murray system has progressed to an advanced stage. This will be completed under the new management of the Department of Water Resources.

A soils map of the Riverine Plain in Victoria was compiled by the Geological Survey during the salinity studies. This map will be published during 1988.

Other research-oriented activities included geological mapping studies leading to the completion of the first of three 1:10 000 map sheet areas of the Bendigo Goldfield. This work is a compilation of biostratigraphic, structural, and gold mineralisation data for the classic areas currently being further explored for gold by Western Mining Corporation Ltd.

Other active mapping investigations include the East Gippsland mapping project in the Murrindal and Bendoc 1:100 000 sheet areas. The project has reached the field-data-compilation and report-preparation stage. It is scheduled for completion in June 1988.

Engineering geological studies of the Melton development area were finalised in 1987 but no new project of this type will be undertaken owing to staff constraints.

No marine or coastal studies are currently being undertaken within the Geological Survey.

Geological Survey of Western Australia

One of the main aims of the 1987 program was to clear the backlog of partly-completed projects. This was largely achieved and some 41 projects have been completed. While the aim of a 30% increase in field work in 1987 was not met, the average number of days spent in the field increased from 17 in 1986 to 19 in 1987 (a 12% increase), arresting the steady decline which started in 1982.

Geological maps compiled during the year included four 1:250 000 sheets (Newman, Robertson, Balfour Downs and Widgiemooltha) and four 1:100 000 sheets (Bardoc, Lake Lefroy, Yilmia and Cowan). A revised edition of the State geological map at 1:2 500 000 has been prepared for drafting, and the Albany 1:1 000 000 map sheet has been compiled from the existing 1:250 000 sheets. In response to industry demand, sepias and dyeline prints of the map compilation sheets are now released in a freehand draft form so that the results of geological mapping can be made available rapidly.

Major projects on the Ashburton Fold Belt and the alkali granites of the Eastern Goldfields were completed during the year. The first geophysical standard map sheet to be produced by the Geological Survey—the gravity map of the Bridgetown 1:100 000 sheet—was also completed.

A wide range of isotope geochronology is undertaken on behalf of the Geological Survey in association with Curtin University of Technology, Australian National University, and the University of Western Australia. A lead isotope

study of gold mineralisation in the Yilgarn Block was completed, and work on the Sm-Nd characteristics of the Narryer gneiss and Jimberlana Dyke was published.

Analytical work on Rb-Sr isotope studies of rocks from the Pilbara, Sylvania Dome, Murchison and Harvey areas was completed during 1987. The tritium and carbon-14 laboratory was moved from the Curtin University of Technology to the Chemistry Centre (a division of the Mines Department) during the year and should be fully operational in the early part of 1988.

The Eastern Goldfields study is continuing, and a report on the structure of the Golden Mile has been submitted for publication. Another major project, the Murchison metallogenic project, is nearing completion and is scheduled to be finished in early 1988. Reports have been written on the potential of the Kimberley and Pilbara regions for hosting platinum-group elements, and work was completed on gold mineralisation in the Bullfinch-Forrestania area and the Nanutarra tungsten deposits. Routine inspections of mines (mainly gold mines) in the Kalgoorlie area and Southern Cross belt were made throughout the year.

During 1987, regional maps of the Carnarvon Basin and the onshore Bonaparte and Ord Basins were issued, and a bulletin on the Carnarvon Basin, representing the culmination of some 20 person-years of work, was published. The hydrogeological program of drilling shallow and deep aquifers in the Perth Basin continued. Reports were completed on the shallow aquifers in the Busselton area and the deep aquifers along the Gillingarra line of bores in the northern Perth Basin.

Monitoring of exploration activity and evaluation of reports submitted to the department under the various legislative requirements is an ongoing activity. Some 2600 mineral exploration and 300 petroleum exploration reports were received and accessioned in 1987.

The monitoring of exploration has been greatly facilitated by the installation of INFOPAC, a commercially-available information package of all minerals and petroleum exploration data reported to Australian stock exchanges. A review of the State's published gold resources and a report on the limestone and limesand resources between Lancelin and Bunbury were released during the year.

Engineering geology investigations were undertaken at a number of damsites. The largest project has been the Harris River damsite although work has also been done on the North Dandalup and Big Brook damsites and on the Ord Dam spillway. In addition, investigations have been carried out in the eastern urban corridor.

During the year, environmental geological mapping of six 1:50 000 sheets was completed and two sheets were published. The Broome and Perenjori 1:250 000 hydrogeological maps were compiled and are awaiting publication. Drilling in support of investigations of town water supplies for the Carnarvon and Derby regions was carried out; additional drilling was done in the latter area to provide data for hydrogeological mapping of the Derby 1:250 000 sheet.

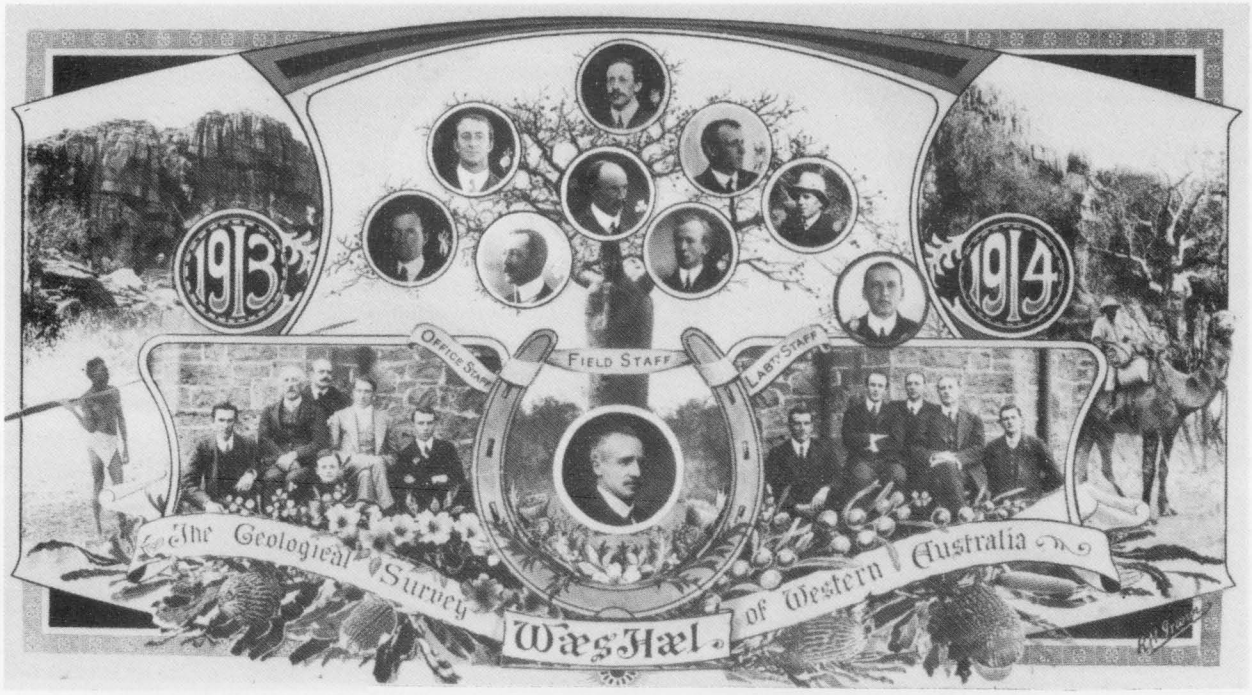

Fig. 5. A greeting card prepared for the 25th anniversary of the Geological Survey of Western Australia during its early heyday under A. Gibb Maitland (bottom, centre). Other geologists shown are (clockwise from far left): R.A. Farquharson, C.S. Honman, F.R. Feldtmann, E. de C. Clarke, J.T. Jutson, E.S. Simpson (far right), T. Blatchford, H.W.B. Talbot (centre), and H.P. Woodward. This card was reproduced on the 1988 calendar of the Mines Department to commemorate the centennial of the Geological Survey.

Much effort has been directed towards writing Memoir 3 which will summarize the geology and mineral resources of the State, and about half the geoscientific staff have been involved in producing this major review.

A major achievement during 1987 was that of eliminating the backlog of M-series mineral exploration reports requiring microfilming. This was completed on schedule. Routine microfilming of open-file mineral and petroleum exploration reports continued throughout the year. About 3000 reports comprising over 10 000 microfiche were added to the open-file database in 1987.

The Geological Survey maintains a number of geoscientific databases, and work continued on updating WAMEX (mineral exploration data), MININFORM (resources and reserves of Western Australian minerals), and the petrological and geophysical databases. During the year, plans were finalised for the WAPEX (petroleum exploration data) and SWRIS (water resources data) database systems, and data-capture projects for these systems were initiated.

Work continued on systematically documenting the fossils in the State; reports were produced on Cambrian, Ordovician and Devonian fossils.

Geophysical well-logging equipment was upgraded and modified during the year and arrangements were made to drill a borehole to enable some of the logging tools to be calibrated. Support services were supplied on a routine basis by the petrological, geophysical, palaeontological and geochemical sections to the other sections of the Geological Survey. Advice to other divisions of the Department on legislative, geoscientific of geotechnical matters was given as required.

The year 1988 marks the centennial of the Geological Survey of Western Australia. The first permanent Government Geologist, H. P. Woodward, was appointed in January 1888, following a resolution of the Legislative Council in 1886 to establish a Geological Survey for the colony. This decision was made because of the discovery of the colony's first payable gold field (at Hall's Creek) in 1885, largely through the work of the previous temporary Government Geologist, E. T. Hardman.

The Geological Survey is organising a number of events and special publications to mark this important occasion. These will include: a centennial dinner; a series of postcards illustrating aspects of the geology of the State; a centennial lecture series; centennial publications comprising Memoir 3, The Geology and Mineral Resources of Western Australia, new editions of the State geological and mineral resources maps, and the first hydrogeological map of the State; and centennial field excursions to Rottnest Island and the Murchison area. The Mines Department's calendar for 1988 commemerated the centennial by featuring a greetings card first produced for the 25th anniversary of the Geological Survey (Fig. 5).

Table 1. Geological maps published in 1987

1:250 000	
Colour	
SG50-8	Peak Hill (2nd edition)
SH50-15	Kellerberrin
SG50-15	Cue (2nd edition)
SI50-3	Corrigin
SF50-10	Wyloo (2nd edition)
SF51-9	Balfour Downs (2nd edition)
Line compilations (black and white)	
SH51-13	Boorabbin (2nd edition)
SH51-14	Widgiemooltha (2nd edition)
SE51-13	Robertson (2nd edition)
1:100 000	
Line compilations (black and white)	
3234	Cowan
3136	Kalgoorlie
3235	Lake Lefroy
3135	Yilmia
1:50 000	
Environmental Geology (colour)	
2131-3	Collie
2131-2	Muja
2134-2,3	Mundaring
2032-2,3	Lake Clifton-Hamel
1930-1	Busselton
2030-4	Capel

Commonwealth Scientific and Industrial Research Organisation

Centre for Environmental Mechanics

Research in the CSIRO Centre for Environmental Mechanics aims to achieve a quantitative understanding of mass and energy transfer in the environment. Highlights in 1987 include the development of improved field probes for the determination of soil-water content and electrical conductivity using TDR (time-domain reflectometry) and the design and construction of a non-contact laser system for measuring soil-surface topography.

TDR is a rapid, non-disturbing technique for measuring soil-water content and soil electrical conductivity, but use of the parallel-wire or two-wire transmission line TDR probes currently in field use results in unwanted noise and information loss owing to impedance mismatch between the probe and the coaxial connecting cable. Scientists at the Centre have developed symmetric, multi-wire probes designed to minimise these problems. Analysis of the electric field distributions around these new probes shows that they emulate the electric field around a coaxial transmission line; these fields differ substantially from those of a two-wire probe. Signals from the new probes are superior to those of the two-wire probe, even with balancing transformer, and this permits more reliable and accurate water-content and conductivity measurements. The enhanced signal clarity of the new probes extends to sample diameters of at least 0.2 m with better-defined sampled soil volume because of coaxial emulation.

Scientists at the Centre have also developed an optical non-contact system for measuring soil-surface topography. Soil elevation is measured by projecting a laser beam onto the surface and detecting the position of the interception point. The optical axis of the detection system is oriented at a small angle to the incident beam. A low-power HeNe laser is used as the laser source, a photodiode array is used as the laser-image detector and an ordinary 35-mm SLR camera provides the optical system to focus the laser image onto the diode array. A wide spectrum of measurement ranges (R) and resolutions are selectable from 1 mm to 1 m. These are determined by the laser-camera distance and angle, the focal length of the lens, the sensing length of the diode array and the number of elements (N) con-

tained in the array. The resolution of the system is approximately R/2N.

In the configuration selected for testing, elevation changes of 0.16 mm could be detected over a surface elevation range of 87 mm. The sampling rate of the system is 1000 Hz, which permits soil surfaces to be measured at speeds of up to 1 m/s with measurements taken at 1 mm spacing. Measurements of individual raindrop impacts on the soil and of soil surfaces before and after rain have shown the versatility of the laser surface profiler which has applications in studies of erosion processes, surface storage and soil trafficability.

Division of Fuel Technology

The Division of Fuel Technology (formerly Energy Chemistry, and renamed as from 1 January 1988 following the recent restructuring of CSIRO) is based at the Lucas Heights Research Laboratories and has 85 staff including approximately 45 professional scientists (mostly chemists) and engineers.

Its terms of reference are to undertake research directed towards developing new or improved processes and equipment for the production of liquid and gaseous fuels and their alternatives in order to maintain the maximum economic level of Australian production and self-sufficiency. It also provides specialist expertise in chemical analysis aimed at improving environmental water monitoring, occupational hygiene and exploration techniques. Major emphasis is therefore placed on process research. However, earth-science-related projects comprise about 10% of the research program and include applications of neutron activation analysis (NAA) in geology and geochemistry, and geochemical, mineralogical and trace-element studies on oil shale and coal.

Despite intense competition from non-nuclear instrumental analytical techniques, neutron activation analysis continues to find wide application in determining many elements in a variety of geological materials. In recent collaborative studies with overseas organisations, universities and industry the Division has assisted in the characterisation of ore bodies for mineral prospecting in Papua New Guinea; examined the geochemistry of Palaeozoic fore-arc volcanism in the southern New England fold belt of New South Wales; and measured the distribution of rare earths in the Brockman prospect of Western Australia and an allanite prospect near Alice Springs.

The distribution of trace elements in coals and oil shales and their fate during processing and combustion is also being investigated. A combination of X-ray diffraction, inter-element correlation techniques, selective-leaching procedures and electron microprobe analysis is used to establish specific mineralogical residences of the important trace elements. The geochemistry and mineralogy of Tertiary oil shales from Queensland have been examined as part of the characterisation of these resources. Most of the minerals are decomposed during oil-shale processing and studies are underway on several of these mineral reactions.

The mineralogy of coals and related geological strata is being investigated using X-ray diffraction and fourier-transform infrared spectrophotometry. These data are being used in studies of the ash-fusion characteristics of low-quality coals. The mineralogical residences of trace elements in coals are also being studied in relation to their partitioning during coal proparation and combustion.

Division of Mineral Physics and Mineralogy

At the end of 1987, the Division of Mineral Physics and Mineralogy was amalgamated with part of the CSIRO Division of Minerals and Geochemistry, and from the beginning of 1988 the new Division will be known as the Division of Exploration Geoscience. The Chief of the Division, DrBrianEmbleton, is located in Perth.

Highlights of 1987 were:

- Formation of the WA Remote Sensing Group, which concentrated all of CSIRO's Western Australian researchers in this field into one group.
- Successful construction of a prototype laser for active remote sensing by aircraft.
- Completion of a study of magnetic properties of rocks and geology in a number of areas of high interest for exploration (Hamersley Basin, Tennant Creek and Broken Hill).
- Completion of a study which demonstrates the feasibility of using lead-isotope data to delineate gold deposits in north Queensland.

New CO_2 laser system. A prototype rapidly-tuned CO_2 laser has successfully been constructed. It was designed to be carried in CSIRO's Fokker F27 aircraft, and to generate spectra at 500m above the ground.

This is the first Australian active remote sensing system in the mid-infrared region. It has the advantage of providing greater resolution than existing systems as it effectively

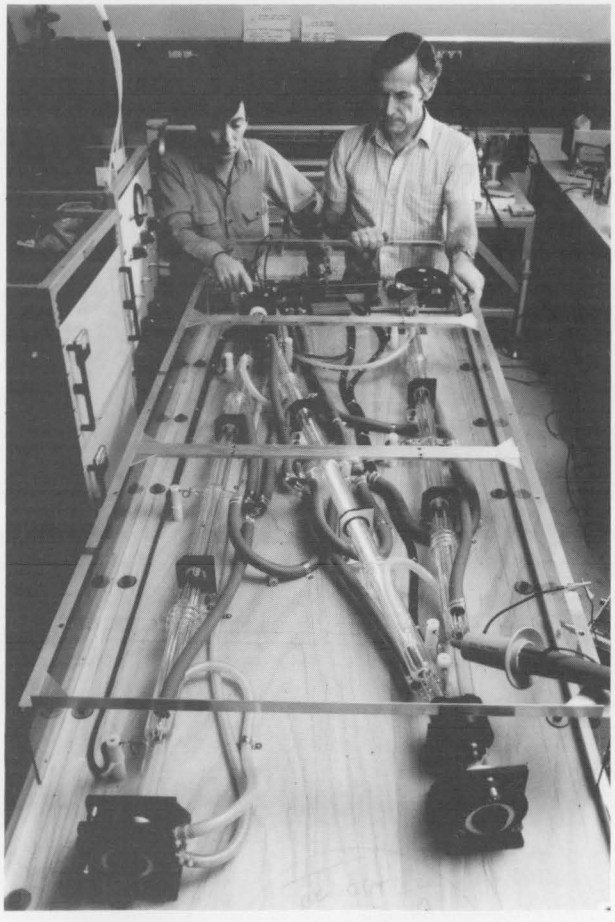

Fig. 6. Dr Lew Whitbourn and Mr Dick Phillips with the prototype CO_2 laser which will be flown in 1988.

splits the wavelength region between 9-11μm into 100 bands by tuning the laser through 100 discrete wavelengths in 3 milliseconds.

This new scanner should allow geologists to distinguish between the silicates of different elements, and between minerals with similar spectra in the visible and near-infrared. Test sites are being flown during 1988 and the results assessed (Fig. 6).

Lead isotopes for gold exploration in northeast Queensland. Target Pb-isotope ratios have been successfully defined for several styles of gold mineralisation in the Charters Towers and Georgetown Provinces. In both provinces the discrimination between Devonian orogenic quartz veins (with limited bulk tonnage potential) and Permo-Carboniferous prophyry-related quartz veins (with good bulk tonnage potential) is an important guide to exploration. It was found that both provinces have distinctly different Pb-isotope signatures for Devonian and Permo-Carboniferous gold mineralisation.

Ore signatures can also be recognised in weathered exploration samples. For example, the Pb-isotope compositions of soils with anomalous Au and relatively low Pb from across the Mount Success deposit have the Permo-Carboniferous ore signature.

Magnetic studies. In this just-completed AMIRA-sponsored project, the magnetic properties of surface and underground samples and drill core were measured and the properties of surface and underground samples and drill-core were measured and the properties of the rock units were characterised. This information was integrated with magnetic survey data of the areas to define the relationship between magnetic anomalies, lithology, structure, metamorphic grade, alteration, thermal history and mineralogy to improve the magnetic interpretation. The project concentrated on areas of high exploration potential. Some of the most interesting and significant results were achieved in the Hamersley Basin where:

(i) the bulk remanence of the banded iron formations, uncontaminated by surface effects, was determined for the first time by using orientable drill-core samples;

(ii) unusual magnetic signatures over the Turner syncline were explained, opening the way to reliable modelling of the Basin's geological structure; and

(iii) the age and duration of iron-ore formation was found to vary significantly across the Basin on the basis of the palaeomagnetism of the Paraburdoo, Tom Price and Mount Newman deposits.

WA Remote Sensing Group. This new team is actively pursuing research projects relevant to both the minerals exploration industry and to the management of natural resources. Natural resource projects include:

(i) assessing the usefulness of satellite data to pinpoint new offshore areas which might host natural pearl oyster stock. This is economically significant as pearling grounds near Broome are showing a decline in oyster stocks. Satellite data from three instruments will be assessed during the project;

(ii) a survey of Western Australian rain forests in the Kimberley region in order to document for the first time the extent and diversity of tropical rainforest in this region (in conjunction with the State Department of Conservation and Land Management);

(iii) monitoring the movement of phosphate into groundwater, by detecting vegetation with high phosphorus concentrations. Eutrophication of estuaries may be resulting from fertiliser seeping into groundwater systems on the Swan coastal plain; and

(iv) assessing the use of satellite data to reconstruct palaeodrainage and regional geological structures in that part of the Great Sandy Desert in the Canning Basin which is prospective for petroleum.

The Group has also initiated a new AMIRA project—'Remote sensing for gold exploration in Western Australia'. The purpose of this project is to develop and demonstrate practical remote sensing exploration techniques suited to the deeply-weathered gold-bearing environments of Western Australia.

Division of Mineral and Process Engineering

Within the last twelve months, this Division has undergone some minor administrative changes, one being the re-naming of the Division to reflect current and proposed research projects in many aspects of process engineering including instrumentation and control.

The reorganisation of Divisional research projects has seen two projects—borehole logging and acoustic emission—being transferred to the Division of Geomechanics from 1 January 1988.

The present thrust in research activities sees the Division working closely with Australia's mineral and fossil-fuel industries in developing technologies required to compete in international markets.

Research has been continuing in three areas of particular relevance to geoscience:

- metal refining by crystallisation with reflux
- SIROSMELT for non-ferrous metals
- high-intensity smelting techniques for iron and steelmaking.

Metal refining by crystallisation with reflux. Metals can be refined by fractional solidification to form purer, solid crystals surrounded by impure liquid into which the impurities are rejected. This operation forms the basis of the process of continuous refining by crystallisation with reflux which originated in this Division.

The process is being developed to the commercial scale for the production of high-purity aluminium. An acceptable high-purity product has been made at a rate of 12kg/h in a 100-mm-diameter refining column, and further scale-up and development of the technology is being attempted in collaboration with industry.

The Division's research includes the development of:

- materials of construction;
- methods of crystallisation; and
- methods for transport and separation of crystals.

A physical model constructed of steel and containing a lead alloy is used for studying and improving the mechanical operation of the refining equipment. A mathematical model which accurately simulates the operation is used for prediction of optimum operating parameters.

SIROSMELT for non-ferrous metals. SIROSMELT is an intense smelting process for non-ferrous metals which was developed in the Division in the late 1970s and commercialised during the past five years. Two small plants now operate at Mount Isa as supplements to the lead and

copper circuits, and another plant is soon to be commissioned at the zinc smelter at the Cockle Creek works of Sulphide Corporation.

Divisional research and development on SIROSMELT has continued up to the present. A large effort has recently gone into developing phenomonological mathematical models of the lance and mixing of the bath which can be used for design and scaling-up purposes. The models are being validated by comparing their predictions against the results of pilot-plant tests as well as (in the case of bath mixing) by injecting air into water baths under a wide range of conditions.

High-intensity smelting techniques for iron and steelmaking. The Division is participating in a collaborative project with CRA Ltd to develop a new iron and steelmaking process using high-intensity smelting techniques. The process has significant advantages over conventional blast-furnace/ basic-oxygen-furnace steelmaking as it will:

- avoid agglomeration of iron ores;
- replace comparatively costly blast-furnace coke with cheaper fuels;
- have less harmful environmental effects; and
- be economic in the range 0.5-1.0Mt/y.

The direct-smelting process employs a turbulent, gas-stirred iron/carbon bath as a heat and mass transfer medium for the smelting reactions. Powdered coal is injected into the bath where it dissolves and forms a strongly reducing medium. The carbon is simultaneously oxidised by oxygen which is also injected into the bath. The exothermic reaction between the oxygen and the dissolved carbon provides the process heat. Iron ore, or partially-reduced iron ore, is added to the bath where it is reduced and melted to form the product=hot metal.

In late 1982, CRA Ltd, together with a West German steel company, Kloeckner Stahlforschung GmbH, built a pilot plant in Germany to test the process. CSIRO, through the Division of Mineral and Process Engineering was commissioned to provide theoretical and practical support to develop the process. Work at the Division includes laboratory-scale experimentation, physical and mathematical modelling, process flowsheeting and process control.

Division of Oceanography

The field phase of a major 18-month study of the Leeuwin Current off Western Australia was completed during 1987. The Leeuwin is the only current on the eastern side of an ocean that carries water poleward, resulting in a significantly less fertile marine habitat than other eastern oceanic eastern boundaries.

Among the aims of the Leeuwin Current Interdisciplinary Experiment (LUCIE) is a better understanding of the current and the processes governing its seasonal flow, and of its influence on the life cycles of a number of commercially-important marine species, including western rock lobster and southern bluefin tuna. Several Australian and overseas institutions participated in the study. The Divisions's involvement included a series of cruises by RV Franklin, and use of moored instruments, drifting buoys, satellite imagery, and the first operational deployment of the new advanced-technology 'BUNYIP' towed microstructure vehicle.

Other Divisional research off Western Australia during the year included physical and chemical oceanographic studies of the Northwest Shelf and Slope, and a search for evidence of Pacific-Indian Ocean throughflow along a line from North West Cape to Christmas Island.

Increasing interest was shown in application of the Division's organic geochemical techniques to petroleum exploration, particularly in relation to identifying petroleum hydrocarbons in the marine environment. This included a contract from an exploration company to provide information on possible oil seeps in Tasmanian waters, and assistance to scientists at AMDEL in Adelaide in their study of the geochemistry of bitumens washed up on South Australian beaches. This latter work showed that the bitumens originated from off-shore oil seeps. Further work with the Bureau of Mineral Resources in Canberra has exploited new GC-MS-MS methods for identifying 4-methyl steranes in crude oils, and a joint project is underway on the organic geochemistry of phosphorites off the east Australian coast.

Close ties established with the Geology Department of the University of Tasmania include lectures in organic geochemistry, co-supervision of student research projects, and studies of the organic geochemistry of Tasmanian tasmanite oil shales.

The Western Equatorial Pacific Ocean Circulation Study (WEPOCS) revealed a number of new features of regional circulation. WEPOCS is designed to examine the origins of disturbances in the equatorial Pacific which may account for the early stages of the El Nino Southern Oscillation phenomenon. Two new ocean currents—the New Guinea Coastal Current and the Pacific Equatorial Monsoon Jet—were named and studied. The ocean mixed layer in the region was found to be substatially shallower than previously thought with the result that significant change may be needed to current estimates of the upper-ocean heat budget in the region. It was also found that the deep circulation of the Solomon Sea involves the interaction of the two deep-water masses from the East Australia and Central Pacific Basins.

The Ocean Modelling group, responsible for development and application of numerical models, experienced growing commercial interest in its services. Examples of the group's projects include modelling studies of the cyclone-driven circulation on the North West Shelf; circulation and transport of scallop larvae in Bass Strait and Great Oyster Bay, Tasmania; circulation and water quality of Jervis Bay, NSW; and ocean wave power studies.

In Chemical Oceanography, a collaborative project commenced with the CSIRO Division of Fisheries Research to determine the concentrations of essential fatty acids in the microalgae used in mariculture. Also during the year, a procedure for solid-phase preconcentration of arsenic species from natural waters was developed, and new systems for continuous underway measurement of pH and fluorescence, and depth-profiling of fluorescence, pH and turbidity were implemented on RV *Franklin.*

Technology transfer was accelerated. Expressions of interest were sought from industry for the further development and/or commercial marketing of a number of Divisional developments. These include a new type of wave-measuring buoy, an aluminium discus buoy, a UHF satellite antenna, and a fast data ingest system for remote-sensing applications.

Division of Soils

Soil structure management. A project, partly funded through the Cotton Research Council, is investigating the decline of soil structure under irrigated cotton.

Heavy clay soils used for cotton production under irrigation are often damaged by the heavy vehicles used in the industry. The project has shown that, in these often near-saturated soils, damage results from shearing the soil. Previously, damage was attributed to compaction, that is, density increase. This finding is being used to draw up management guidelines for controlling structural damage to soils.

Geostatistical survey. The Brisbane group of the Division has completed the initial phases of a geostatistical soil survey of the Edgeroi 1:50 000 sheet in the Namoi Valley, NSW. This has entailed field sampling and description of soils to 3-m depth and recording of surface conditions at each site. Chemical and physical data have been included in the *Empress* relational database to assist with characterisations of soils for agricultural management.

Land disposal of sewage sludge and ash. The Division of Soils has nearly completed a study of land disposal of Canberra's lime-treated sewage sludge and its incinerated ash. Both materials are sources of lime and the sludge is also a source of nitrogen and phosphorus. The effect of the application of sludge to pasture and the accessions of nitrogen and phosphorus to surface and ground waters were also determined. Sludge disposal has not yet been adopted, but the ash is being used as a source of lime for acidic soils.

Mineralogy. Structure analysis of the intercalate formed between 1,4 diazabico[2,2,2] octane and vermiculite has been completed. The work has shown that the organic cations are not symmetrically positioned between the silicate layers, as assumed by other workers. However, a network of inorganic cations and water molecules is present and controls the interlayer separation. The results are important as earlier work implied that the intercalate was a swelling-resistant molecular sieve. Structural studies of lithium-containing mica with weak X-ray diffraction reflections similar to those in ephesite were completed.

Studies relating to landscape evolution have continued. PhD programs dealing with a reappraisal of the 'laterite' concept and with the nature and distribution of calcareous palaeosols in the region south of Adelaide are substantially completed. Work on silica accumulations and red-brown hardpans in the arid zones of northern South Australia has continued. Reconnaissance field and laboratory studies of arid-zone soils between Port Augusta and Andamooka were completed.

Investigations directed towards rehabilitation strategies have continued in collaboration with Ranger Uranium Mines Pty Ltd in the Ranger Project area, near Jabiru, NT. These include work on the waste-rock dumps to characterise the series of minesoils that have formed rapidly in the tropical monsoonal climate; studies of the consolidation characteristics of tailings; and measurements of nutrients and contaminate elements in leaves or trees in the native forest and in experimental plantations on the waste dumps.

Software designed to run and control X-ray power diffractometers (including a new Philips PW1800-series instrument) in central laboratories from remote locations has been developed on IBM-compatible PCs. The software includes facilities for the remote user to collect, analyse and print the diffraction data, as well as to make comparisons with patterns from the JCPDS powder diffraction file. In conjunction with these developments, a database incorporating the mineralogical composition of some 3500 clay fraction samples of Australian soils has been established on IBM-compatible PCs.

The development of X-ray fluorescence spectrometric techniques as a standard method for the analysis of iron ores and heavy-mineral sands continues.

A project on the convergent-beam electron diffraction of clay minerals is in progress with collaborators at Latrobe University and the University of Melbourne. This work aims to obtain three-dimensional structural information from CBED patterns of sheet silicates lying on their [001] faces.

Studies of the synthesis and characterisations of fine-grained magnetites were completed. These studies demonstrated that the superparamagnetic-single grain particle size range found for magnetite in some soils can be produced by direct precipitation under pedogenic conditions.

Acidification. A project on the acidification of southeastern wheatbelt soils was begun in 1987 in collaboration with the New South Wales and Victorian State Departments of Agriculture and the New South Wales Soil Conservation Service. This project aims to develop farm-management strategies for counteracting soil acidification under crop and pasture. Soil surveys and initial field trials and chemical analyses have been completed. Funding for the project is largely from the National Soil Conservation Program.

Division of Water Resources

CSIRO's major reorganisation of water research evolved further during 1987; the Division of Water Resources was established on January 1 1988 with Dr G. B. Allison as Chief. The Division has 16 research scientists in Perth (HQ), 20 in Canberra, 13 in Griffith, four in Adelaide and two in Albury. In addition to strategic and applied research into water resources, the Division will assist in communication with the 60 or so government departments and agencies with an interest in water resources in Australia.

The main applications of the Division's strategic research will be in the areas of:

- Specific policy and management systems
- Efficient irrigation practices
- Catchment management models for specific purposes
- Methods for the monitoring and control of water contamination by sediments, salt and other pollutants of water resources which arise from agriculture, mining and urban waste disposal
- Monitoring systems for large river basins (recharge, evapotranspiration, etc.)
- Water resource assessment models
- Specific advice and consultation

Some important achievements during 1987 were:

- A system for in-situ measurement of both dissolved oxygen and the concentration of oxygen in gas. It can be used for many purposes, including measuring the uptake of oxygen from groundwater by phreatophytic vegetation, and monitoring the oxygen status of sulphur-containing mine wastes (Dr C. Barber)
- The application of transient electromagnetic (TEM) and DC-resistivity soundings for monitoring the spread of low-level pollution from urban waste sites. This technique obviates the drilling of numerous boreholes (Dr C. Barber)

- A model for the leaching of nitrogen from a diffuse agricultural source to groundwater near Mount Gambier (Dr P. Dillon)
- Establishment of a national interactive database (NATCOM) on the interests of personnel in the water resource sector to promote communication (P. Martin)
- Establishment of a low-infrastructure, cost-effective consulting and measuring service in evapotranspiration and salinity (Dr E. Greenwood)
- Total annual evaporation by banksia open woodland on the Gnangara groundwater mound. It amounted to 77% of the rainfall and over half of the evaporation came from the ground vegetation (Dr P. Farrington)
- Use of aquatic macrophytes for wastewater treatment to pilot stage with Shire Councils (Peter Breen).
- A gypsum slotter for soil amelioration—commercial development to joint-venture company stage (John Blackwell)
- Production of *The Australian Greenhouse Handbook* (Keith Garzoli)
- A resource competition model (RESCOMP) which computes spatial interactions between individual plants for rainfall, light, nutrients and energy and provides estimates of plant growth and cover. It is event driven and predicts the effect of short- and long-term changes in vegetation cover on the hydrologic and erosional behaviour of catchments (J. Walker)

NOTEWORTHY MINERAL AND HYDROCARBON DISCOVERIES 1987

Minerals and petroleum are non-renewable resources. As the known deposits are consumed, it is necessary to discover new sources of supply to maintain Australia's resource inventory at a satisfactory level, thus providing a sound basis for long-term planning for both national development and export markets.

The accompanying tables list noteworthy discoveries made during 1987. Many discoveries must be regarded as long-term resources until development work determines that they are economically amenable to exploitation.

The data were prepared and compiled by officers of the Resource Assessment Division, Bureau of Mineral Resources.

Resource Assessment Division
Bureau of Mineral Resources

Table 2. Noteworthy mineral discoveries—1987

Name	Companies	Location	Type of deposit	Grades & resources
Admiral Bay	CRA	140km S of Broome, WA	carbonate-hosted lead-zinc	not detailed
Bayfield	Strategic Minerals/ RZ Mines	75km NE of Rockhampton, Qld	Dune field	2.4Gt at 1.14% heavy mineral
Dry River South	MIM/Metall-gesellschaft	230km WNW of Townsville Qld	Massive volcano-genic sulphide base metals	not detailed
Goodall	WMC/W.R. Grace Australia	30km E of Adelaide River, NT	Gold in quartz veins and stockworks	not detailed
Hedges	Alcoa of Australia	120km SE of Perth, WA	Gold in laterite	8Mt at 2.1g/t Au
Reward	City Resources/ Norgold/North Queensland Resources	32km S of Charters Towers, Qld	Massive volcano-genic sulphide base metals	not detailed
WIMI50	CRA	20km S of Horsham, Vic.	Marginal marine	1 Gt at 3% mineral, containing 3.4Mt rutile and anatase 4.6Mt leucoxene, 12.5Mt ilmenite, 5.1Mt zircon, 0.58Mt monazite, 0.17Mt xenotime

Table 3. Noteworthy hydrocarbon discoveries—1987 (a)

Basin	State	Field Name	Company (Operator)	Type of Discovery
Bowen/Surat	Qld	Borah Creek*	Hartogen	o
Bowen/Surat	Qld	Caneon	CSR	g
Bowen/Surat	Qld	Harbour	Sydney	o
Bowen/Surat	Qld	Kanaloo	Hartogen	g
Bowen/Surat	Qld	Kungarri	Hartogen	g
Bowen/Surat	Qld	McWhirter East	Sydney	o
Bowen/Surat	Qld	Merroombil	Bridge	g/c
Bowen/Surat	Qld	Mindagabie	Sydney	o
Bowen/Surat	Qld	North Colgoon	Hartogen	g
Bowen/Surat	Qld	Rednook	Crusader	o/g/c
Bowen/Surat	Qld	Wingnut	CSR	g
Bowen/Surat	Qld	Yarrabend*	Bridge	g
Bowen/Surat	Qld	Yellowbank Creek Nth	Sydney	o
Bowen/Surat	Qld	Yuranigh	Hartogen	g
Canning	WA	Janpam Nth	Home	o
Canning	WA	Lloyd	Home	o
Carnarvon	WA	Rosette	Bond	o
Carnarvon	WA	Parrot Hill	Ampol	o
Cooper/Eromanga	SA	Balcaminga	Santos	g
Cooper/Eromanga	SA	Bungee	Santos	g
Cooper/Eromanga	Qld	Challum*	Delhi	o/g
Cooper/Eromanga	Qld	Chookoo*	Delhi	o/g
Cooper/Eromanga	SA	Cowralli*	Santos	g
Cooper/Eromanga	Qld	Cranston	Hartogen	o
Cooper/Eromanga	SA	Deina	Santos	g/c
Cooper/Eromanga	Qld	Dingera	Delhi	o/g
Cooper/Eromanga	SA	Gidgealpa*	Delhi	o/g
Cooper/Eromanga	Qld	Jackson South*	Delhi	o
Cooper/Eromanga	Qld	Judga	Delhi	g/c
Cooper/Eromanga	Qld	Karmona East	Delhi	g
Cooper/Eromanga	Qld	Karri	Delhi	o/g/c
Cooper/Eromanga	SA	Keena	Delhi	g
Cooper/Eromanga	SA	Kerna*	Delhi	g/c
Cooper/Eromanga	SA	Kurunda	Delhi	g/c
Cooper/Eromanga	SA	Lake MacMillan	Delhi	g/c
Cooper/Eromanga	Qld	Marengo	Delhi	o/g
Cooper/Eromanga	SA	Mawson	Delhi	o/g/c
Cooper/Eromanga	Qld	Maxwell	Pancon	o
Cooper/Eromanga	Qld	Monler	Hartogen	o
Cooper/Eromanga	Qld	Naccowlah Sth	Delhi	o
Cooper/Eromanga	SA	Pelican	Santos	o/g
Cooper/Eromanga	SA	Pintari Nth	Santos	o
Cooper/Eromanga	SA	Pirraminta	Santos	g
Cooper/Eromanga	SA	Taylor Sth	Santos	g/c
Cooper/Eromanga	Qld	Tickalara*	Delhi	o
Cooper/Eromanga	Qld	Toby	Delhi	o/g
Cooper/Eromanga	SA	Toolachee*	Santos	g
Cooper/Eromanga	SA	Waukatanna	Santos	g
Otway	SA	Katnook	Ultramar	g
Otway	Vic	Windermere	Minora	o
Gippsland	Vic	Patricia	Lasmo	g

(a) Completed or cased and suspended for future production.
* New pool discoveries
o oil
g gas
c condensate

THE GEOSCIENTIST AND THE ENVIRONMENT:
Planning from the ground down or science in the service of society?

Graeme McIlveen[1]

Let us begin by examining a fundamental proposition. An understanding of the distribution and behaviour of the materials that form the Earth's surface—rock, soil and water—should play an integral part in making decisions on any use of land. If this knowledge is not applied effectively the community may pay more for that use because of characteristics not perceived by the community. The extra cost may result either from the disequilibrium brought about by the change in use, or from a failure to recognise the dynamic nature of the environment itself.

Environmental Planning

People continue to build on flood plains. This suggests, by example, that commercial criteria for development in the physical environment are unlikely to change efficiently or rapidly in response to constraints imposed by natural systems, nor are commercial criteria alone enough to resolve land-use conflicts in more than the short-term.

On the other hand comprehensive environmental planning, according to McHarg (1969, 1970), takes into account:

1. natural physical constraints;
2. long-term economic criteria, in particular the conservation of resources (for example, in being aware of the sterilisation of extractive resources by urban development); and
3. non-commercial criteria.

1. Geological Survvey of New South Wales

It can do this by comprehensive assessment of environment impacts and by deliberate preservation of features of the natural environment, or of the unnatural historical environment.

The perceptions that geoscientists offer

An understanding of processes in the physical environment and of the distribution of earth materials is 'geoscience', and so 'geoscience' here must encompass geomorphology, geology, geomechanics, soil science, hydrogeology, hydrology, and glaciology. Luttig (1975) proposed a 'prospective geoscience' which should precede economic planning if we are to plan adequately for the future.

There are some distinctive features of geoscience which in effect are perceptions about the environment that geoscientists can offer to the community.

1. First, (and fundamentally) geoscientists recognise variations in the surface and beneath the surface of the earth—something taken for granted by geoscientists but not readily perceived by many in the community (e.g. geoscientists can recognise the existence of talus slopes or ancient mudslides and the dangers they pose for urban settlement).
2. Geoscientists recognise that the environment itself is dynamic; that it was not always, and will not be, as it is now. It changes over time as earth processes take place at various scales and rates (an important corollary

of this is that not all changes are induced by human activity) (see, for example, Wasson and Clark, 1987).

Some examples of the dynamism of nature are:

(a) major crustal processes such as movement of continents leading to earthquakes and volcanism. Some people in the community will be familiar with apparent changes in sea-level, or rather subsidence, that has caused, for example, the drowning of ancient cities beneath the sea in the Mediterranean;

(b) major climatic change leading in the long-term to rises and falls in sea-level and in the short-term to coastal erosion such as is occurring along the New South Wales coast;

(c) fluctuations in river flows and channel shape.

3. As a corollary of this awareness of dynamism, geoscientists recognise both the presence and the importance of infrequent but catastrophic events in changing the landscape (e.g. floods, landslides).
4. Geoscientists may help to recognise the fragility of particular landscapes, e.g. arid land.

Mackenzie (1987) writes generally on the nature of geoscience and the attributes of geoscientists.

Environmental geoscience: planning from the ground down

It is interesting at this point to look at the debate in the 1970s about the discipline of 'environmental geology'. Legget (1971) counselled against using such a title on the grounds that all geology dealt with 'the environment' and 'environmental' was therefore redundant. This has not prevented use of the term. Hofman (1974, 1975) has proposed that the discipline now encompasses the geological factors influencing both environmental impact assessment and land-use planning.

A definition is proposed here which has been found useful (and brief):

'*Environmental geology is that interpretation of geological data used to plan for (i.e. to predict and to design for) the physical impacts of land use.*

This particularly includes changes in land use'.

This definition is examined in more depth in McIlveen (1988).

Let us look then at a geoscientific view of the physical impacts of land use for the major uses of land.

Agriculture

Grazing and cropping would surely be responsible for the most dramatic changes made to land in human history. Geoscientists would recognise (and can measure) the following impacts induced by various agricultural uses:

(a) erosion and soil loss (especially in marginal lands, and of friable and non-cohesive soils);

(b) pollution of streams by eroded soil and by chemicals, and changes in stream flow;

(c) transport and re-deposition of eroded sediment;

(d) overuse of groundwater;

(e) salinisation of groundwater, surface water and soil; and

(f) such other related changes as 'desertification' and deforestation, and their effect on run-off and groundwater.

However geoscientists generally have made something of a 'Cinderella' contribution to wise agricultural land use, with the outstanding exception of soil conservationists and physical geographers in some developed countries (see, for example, the review by McDonald, 1988). This lack possibly mirrors the community's perception of agriculture as a benign land-use.

In Australia, New Zealand, South Africa and Papua New Guinea at least, there is some tradition of geology, geography and soil science jointly exciting the interest of well-known geoscientists (e.g. Cotton, Langford-Smith, Ollier). Twidale (1988) reviewed the development of geomorphology in Australia.

Urban development

Urban development is another land use perceived by the community as benign, in that the changes it brings about are accepted and the activity in itself is seen as a desirable one. Very little work has been done, again with the exception of that done by soil conservationists, on impacts such as erosion and siltation owing to changed run-off.

Rather, in the work that has been done, geoscientists have placed emphasis on appraising geological hazards, foundation conditions and stability, and on conservation of construction materials; indeed the term 'urban geology' was coined in the 1970s.

Geoscience for urban development has also included that type of geoscience required to ensure essential services such as water, energy transport, and waste disposal.

This field has matured so that the aims now are to provide interpretations of geological data which can be clearly understood and used by regional and local planners in making decisions about land zoning. Nevertheless some effort is still needed to persuade planners to use these interpretations.

'Urban geoscience' could however increasingly move geoscientists into the minefield of the short-term commercial pressures of land development. The professional aspects of this change may warrant care in the future.

Mineral Resources

The impacts of mining as a land-use, unlike those of agriculture and urban development, are seen as being greater and as less acceptable by the community.

Those aspects of mining as a land use which are familiar to geoscientists include:

1. finding a resource, finding out how much of it there is, and making sure that it is not wasted or covered over by mistake
2. Helping engineers to work out the best way to get the resource out of the ground
3. determining how water, exposed minerals and broken waste rock, can interact to cause pollution; and
4. helping soil scientists determine how the broken rock and soil will affect rehabilitation (exemplified by collecting data on the weathering characteristics of overburden).

Geoscientists are in an ideal position to make contributions to land-use planning in recognising the potential presence of minerals and in assessing the environmental impacts of their extraction (or non-extraction).

Geoscience should be used to examine the conservation of resources and their demand and supply, the options available in planning for other land uses which might prohibit their extraction and for alternative deposits of the resource.

From any objective point of view, failure to conserve resources has an environmental impact for which proposals for any change in land use (or status) should be assessed. This includes particularly urban and agricultural development and wilderness preservation. The preservation of wilderness does have physical impacts, but that is a separate issue not examined here.

The mining method determines the environmental impacts. The form of the resource in turn determines the mining method. So exploration geologists have the opportunity to collect, and should collect, environmental data. They should recognize that these environmental data are not different data but are in fact data which may be used directly in environmentally (and economically) sound mine design (McIlveen 1983). A simple example is recording standing water levels in reconnaissance drill holes.

The geoscience that is presented in environmental impact statements for most developments is poor, inadequate or non-existent; only in a few mining proposals has it been found to be comprehensive and thorough. This again warrants further professional examination.

If urban geology brings geoscience near commercial development minefields, environmental impact assessment brings it near conservation and resident action group firing lines.

The community's perception of, and acceptance of, the physical impacts of agricultural and urban uses contrasts with its response to planning and impact assessment for mining development. This may in part reflect some unique features of mining as a land use (see also Nicholson (1978)):

1. The long chain between the activity itself and the community's use of the end-product; in some cases the community has not recognised the differences between local, regional and national well-being, nor the relationship between the desire it has for goods and services and the necessary impacts of their production.
2. As a general rule (in Australia), the 'developer' does not own the land in which the resource occurs, and must obtain authority to enter on it.
3. As a general rule (in Australia), the 'developer' does not own the resource; again an authority is needed to remove it.
4. The development can only occur where the resource occurs. Even where alternative deposits can be considered, in market economies competition between alternative sources of supplies has to be allowed if unfair monopolies are not to be artificially created.
5. The occurrence of mineral resources is much less easily recognised than the other characteristics of land.
6. The community's perception of the environmental impacts of mining may be distorted; for some people there may be an exaggerated notion of the area occupied, the duration of the activity, and the degree of impact (e.g. comparing dust from mining operations with dust from cars on dirt roads or from ploughing).

Perhaps as a consequence, the community's responses to many environmental issues such as mining, have relied heavily on conflict, agitation and 'political' action, rather than on more objective analysis. The closest approach to objective analysis has been the judical inquiry or the traditional adversarial courtroom procedure—an area of difficulty for 'expert witnesses' which is already familiar to engineering geologists.

One other situation where mineral resource conservation differs from other land-use planning is the relative absence of powers to reserve mineral resources or prospective terrains. This is in marked contrast to the powers available to preserve land for forests, National Parks and water storage catchments. A solution to this difficulty may become available through land-use zonings (for example, for extractive industry around Sydney).

A particular problem here for scientists and engineers is the unscientific nature of the practice of reversing the onus of 'proof', a common practice where science is drawn into contentious public arenas. 'Proof' is demanded that a particular (undesirable) impact will not be caused by the development.

That is, the scientist must '*prove*' that a certain outcome will *not* eventuate). This, of course cannot be 'promised' in the scientific sense.

A familiar example would be the demand made on the proponent for 'proof' that extraction of marine sand on the continental shelf near Broken Bay would not lead to erosion of Palm Beach; this outcome (i.e. no erosion) cannot of course be 'guaranteed'; it can only be said to be most unlikely.

Contrary to a subjective approach, the scientific approach is that the onus should be to establish the likelihood of the (undesirable) outcome, if the activity takes place. There is indeed a recent trend in environmental impact assessment towards 'risk analysis', a statistical field already developed for engineering purposes.

Thus there is a role for geoscientists to assist the community to appraise mining as a land use more objectively.

Conclusion: geoscience in the service of society

The basic proposition advanced here is that geoscience must be used as a major input to plan wisely and objectively for the impacts of all changes in land use and this must include wilderness preservation and agriculture. All land users should have to place themselves equally under environmental planning and impact assessment procedures, avail themselves of geoscientific advice, and take the community into their confidence at an early point in site selection and design (i.e. before controversy arises). They could then reasonably expect an unbiassed outcome, and the proponent and the community will know that the long-term financial cost and environmental impact are acceptable.

Such is not the case at present. Graetz & Tongway (1979) quote ProfessorT. W. Box of Utah State University on the contrast between public reaction to the effects of mining and the general tolerance of farmland erosion:

> As we react with more force to a ghastly wound than to a lingering illness, said Professor Box, so we tolerate the erosion brought about by farming. Although the end result may be disastrous, the process is slow and gradual. With mining, huge machines open the earth and rearrange the landscape in days or weeks. The trauma of seeing the land change before our very eyes pricks the conscience and sets in motion reactions that slower and often more damaging activities fail to activate.

Graetz & Tongway (1979) saw the obstacles to rehabilitation of farmland as being primarily political, as farming cannot be regulated in the way that mining can:

> 'Even the most optimistic', they said, 'would concede that there would appear few, if any, ways of changing or affecting part or all of the management of agricultural or pastoral lands. The land has always been, and remains, the political sacred cow; and this in our opinion is the main reason for the disgraceful state of our nation's soil resources'.

Perhaps this view is changing at last; Australian soil conservation authorities have declared soil loss as the major cost facing Australia's land and water resources. The soil authorities are now beginning to receive stronger government support to survey critically affected areas such as salting in the Murray Basin. On the minus side, however, CSIRO work on land research has been wound down.

Perhaps the immediate need is for geoscientists themselves to recognise and promote the value of their own work as input to land-use planning and environmental impact assessment. Initially this responsibility must fall on geologists in the exploration and mining industries but, increasingly, geologists (whatever their job classification might be) in land-use and planning authorities have an important part to play.

Engineering geology was traditionally described as 'geology in the service of man'. Flawn (1975) defined environmental geology as 'geology for the public purpose', but this could now be taken further to see geoscience and the environment as being 'geoscience in the service of society's relationship with the Earth'.

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THE GLOBAL SEDIMENTARY GEOLOGY PROGRAM

Keith Crook [1]

In 1987, the International Union of Geological Sciences(IUGS) launched the Global Sedimentary Geology Program (GSGP) as a new IUGS Commission. The program of GSGP is being developed by a committee comprising R.N. Ginsburg (University of Miami) as Chairman and members from six other nations, including Dr K.A.W. Crook (ANU).

The goals of GSGP are:

1. To extend understanding of the history of the Earth, surficial processes, the evolution of life, and the biotic influences on Earth processes through global-scale research on sediments, sedimentary rocks and their contained organisms and remains.
2. To improve man's ability to find, produce and husband natural resources in sedimentary deposits—water, hydrocarbons, minerals, ores, building materials.
3. To expand and enhance the practice of sedimentary geology through training, exchanges, and cooperative research.

To realize these goals, two principal activities are envisioned: 1) research projects involving international and multi-disciplinary participation; and 2) training of scientists

1. Department of Geology, Australian National University, Canberra

from developing countries and exchanges between national groups.

The first project being conducted under the aegis of GSGP was announced late in 1987: Cretaceous resources, events and rhythms (CRER)—global processes and their sedimentary records. This project is being developed by five Working Groups:

WG-1 Sequence stratigraphy and sea-level changes

WG-2 Sedimentation in oxygen-deficient oceans

WG-3 Cyclostratigraphy

WG-4 Development and demise of carbonate platforms

WG-5 Palaeogeography, palaeoclimatology and sediment flux

Professor L.A. Frakes (University of Adelaide) is a co-covenor of WG-5. The Working Groups are assisted by two coordinating committees: CC1 Geochronology and CC2 Data management.

At the 9th Australian Geological Convention (Brisbane, February 1988) the nucleus of an Australian Cretaceous Working Group convened and selected Dr Marita Bradshaw as its Convenor. This Working Group aims to promote Australian involvement in CRER, including participation in the meeting of Working Groups to be held Digne, France, in September 1988. Coordination with relevant IGCP projects in Australia will also be sought.

The Geological Society of Australia has moved to establish an Australian Committee for GSGP. Dr K.A.W. Crook will serve as Convenor. This Committee will be broadly representative of geoscience disciplines relevant to GSGP.

ENGINEERING GEOLOGY AND COAL GEOLOGY IN NEW SOUTH WALES

This article was contributed by the NSW Committee for the Coordination of Government Geological Programs, a committee comprising representatives of all state and federal agencies that carry out geological work in New South Wales.

Engineering geology

Investigations in this field are fragmented in NSW amongst the various state governmental construction authorities. In addition, a large number of private engineering consulting groups are extensively involved in this field. There is also an Engineering Geology Specialist Group of the Geological Society ofAustralia and the Austyralian Geomechanics Society—a society which is jointly sponsored by the Institution of Engineers Australia and the Australasian Institute of Mining and Metallurgy. These organisations are involved in engineering geology on a national basis.

Currently the NSW Geological Survey does not carry out any activity in this field of geological study, nor does it perform any overview, review, coordination, or data storage function.

All investigations and data gathering are left to the individual specialist organisations and groups and any special task, such as an overview (e.g. of a region or of a parameter) would require a commissioned study. No systematic or state-wide database or register of NSW data exists, other than the limited bibliographic listings in the ARID public-access database.

Major research and development activities in the State during the past year have centred on the evaluation of finite-element modelling of surface subsidence effects due to underground coal extraction and the evaluation of insitu regional (?residual) stress fields and their impact on deep excavations, particularly cuts and tunnels. In addition, seepage and stability analyses, mostly of dams, using finite-element methods, and groundwater monitoring and hydrogeological appraisal of rock strata above underground coal mines has continued.

With the increasing resort to machines for rock cutting, extensive monitoring of the machinability of strata, particularly for predictive and contract purposes (e.g. in tunnels) is being undertaken.

Coal geology

Investigations in this field are also fragmented in NSW amongst the various state and federal governmental and private organisations and also a joint federal-state government organisation. In addition, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Coal Geology Specialist Group of the Geological Society of Australia also cover this field on a national basis.

While such diversity provides for a wide variety of research and development, it does introduce a major problem of information availability and distribution.

Major research activities in the last year have centred on drilling for further categorisation and quantification of coal resources for future planning. These efforts have encompassed the less-developed or undeveloped coalfields of the Oaklands, Western (Rylstone-Ulan), and Gunnedah Basins (Narrabri) and to a lesser extent, the Gloucester and Clarence-Moreton Basins. They have also included the Upper Hunter Coalfield, the Central Coast Coalfield, and the Robertson area of the Southern Coalfield.

Drill cores from the Parkville area (north of Scone) have revealed conglomeratic units—which at times are virtually a volcanic breccia—in beds up to several tens of metres thick. Their position in the stratigraphy has yet to be determined.

A geological model has been developed for Newcastle Coalfield seams and inter-burden, based on sedimentary depositional facies. The model has applications for the prediction of roof and floor conditions in underground mines and for the precise correlation of strata.

Most organisations have installed computer systems to manage and processgeological data.

One recent investigation has been that involving geological and geotechnical investigation of the various alternative routes for the F3 Freeway west of Newcastle. It was recognised that extensive sections of the Newcastle Coal Measures would be exposed and excavated during the course of freeway construction in the many road cuts. It was envisaged that it may be possible to recover potentially useable coal which was to be exposed and use it benificially rather than abandon it. In the 29 major road cuttings along the various alternate routes, a total of 335 boreholes have been drilled in an attempt to determine the location, quality and quantity of coal. Some 28 seam sections have been identified and analysed and are now being assessed to determine whether the coal can be recovered.

GEOSCIENCE, SOCIAL SCIENCE AND THE COMMUNITY

Elspeth Young [1]

In the 1986/87 report of the Australian Geoscience Council (AGC,1987), the President pinpoints three major areas in which the Council should be actively angaged. One of these is 'the role and contribution of geoscience to the economy and thus to the community'.

Such a role can be primarily interpreted as how geoscience aids the economy through channels such as the discovery of commercially-viable mineral resources and assistance in the devlopment of technology to exploit these; how the technical knowhow of soil scientists can contribute to enhanced agricultural production; or the generation of employment, either directly or indirectly, in geoscientific activities.

But the interaction and mutual understanding between geoscientists and the community could go further. Almost all geoscientific research has an influence on humans and their use of the environment, and conversely human activities may influence geoscientific enquiry. It is therefore important that understanding between members of the human community and geoscientists be as strong as possible. Social scientists can play an important role in building up such lines of communication.

Lines of enquiry in which geoscientific skills might be complemented by the work of social scientists include the development of minerals and sources of energy. Tailing wastes may affect water supplies needed for human use; and the same population groups may, because of anxiety over the effects of such activity attempt to hinder the development of such resources. This type of confrontation can easily become an important political issue. But the situation might well have been defused at an earlier stage through proper communication between the two groups, a process in which social scientists could make important contributions. Similarly a large part of the conflict between Aboriginal land rights interests and those of mining companies reflects lack of understanding.

Mining companies in such a situation need the advice not only of geologists and ecologists but also of anthropologists, human geographers and others whohave worked in the communities concerned. Also an understanding of the human anxieties related to mineral development is needed not only in cross-cultural situations concerning groups like Aborigines or Inuit but also where those involved belong to the same type of society. Miners, their wives and children in remote resource towns face many social pressures which are not only disruptive of family life but which may also inhibit their economic productivity. The mineral industry is not the only sphere in which the skills and knowledge of geoscientists and social scientists can usefully complement each other. Current concern with the greenhouse effect and resultant rise in global mean temperature brings many human issues into focus. Of major importance will be the flooding of estuarine and coastal areas through rise in sea level, a phenomenon which will have a major impact on many large cities. Here in Australia, where our population is heavily concentrated into coastal metropolitan centres this becomes a vital area for geoscientists and social scientists to collaborate. Such lines of investigation, discussed at the recent Australian Academy of Science conference on global change, seem likely to play an important part in the International Geosphere Biosphere Program.

Social scientists and geoscientists should take up that challenge together.

1. Australian Defence Force Academy, Canberra

Reference:

Australian Geoscience Council, 1987—*Australian Geoscience 1986-87* Bureau of Mineral Resources, Geology and Geophysics, Report 282, AGPS, Canberra

AUSTRALIAN GEOSCIENCE COUNCIL EXECUTIVE 1987-88

President	Dr P.J. Cook Bureau of Mineral Resources GPO Box 378 CANBERRA ACT 2601 (062) 499111
Past President	Dr D.H. Mackenzie CRA Exploration Pty Ltd PO Box 656 FYSHWICK ACT 2609 (062) 805665
Vice-President	Professor K.S.W. Campbell Department of Geology Australian National University GPO Box 4 CANBERRA ACT 2601 (062) 492061
Secretary	Mr T.G. Birtles School of Applied Science Canberra College of Advanced Education PO Box 1 BELCONNEN ACT 2616
Treasurer	Dr G.J. Burch Assistant Director Bureau of Rural Resources GPO Box 858 CANBERRA ACT 2601 (062) 716461
Executive Member	Professor B.G. Thom Professor of Geography University of Sydney SYDNEY NSW 2006 (02) 6922886
Editor	Mr E.P. Shelley Bureau of Mineral Resources GPO Box 378 CANBERRA ACT 2601 (062) 499111

PRESIDENT'S REPORT

I believe that the past year has been a busy year for the Geoscience Council. Whether we have also been effective remains to be seen in that a number of programs which we have implemented may take some time to bear fruit.

In making this comment I am thinking especially of our response to the Dawkins 'Green paper' on tertiary education. This is obviously a matter of particular concern to the profession and one which we must continue to be involved in. Clearly there is no one view regarding the future of tertiary geoscience education in Australia, and therefore I believe that Professor Ken Campbell has done an excellent job in bringing together the disparate views in a document which I believe all members of the Geoscience Council can readily accept.

It may be that in the future there will be opportunities for the Geoscience Council to provide more detailed input, particularly if there is a specific review of geoscience education. I have the impression that there is a common view in the geoscience community that the Oxburgh review is not the way we would wish to go in Australia. Therefore we must be alert to opportunities to provide our views to the Department of Employment, Education & Training on how any such review should be undertaken. Our efforts to find out where the geosciences stood in any future review process was unsuccessful—perhaps because at present that Department has no more idea than we have on the future course of events.

Related to the question of education is of course the general question of informing the community about geoscience and its national importance. I commend the Geoscience Awareness Program (GAP) to you, and Professor Bob Carter's initiative in getting this program up and running. It is my feeling that much of what GAP is attempting to achieve is covered in the Terms of Reference of the Geoscience Council but this is not to say that we have been putting a great deal of effort into this area. My view is that the Geoscience Council and GAP should in some way join forces, whether through GAP coming under the AGC umbrella or perhaps by some other mechanism which Council may be able to develop. I also believe that the Geoscience Awareness Program is one that would warrant the expenditure of Council's funds. Indeed, it should perhaps be viewed as the priority for the Council in the coming year.

As President of the AGC I participated in the panel discussion on *The future of geoscience* arranged at the 9th Australian Geological Convention in Brisbane in February 1988. I thought this was a very useful exercise. There was clearly a considerable amount of interest by the audience. The panel discussion lasted for over an hour and there were still many people attempting to have their say at that stage. This is something which we should be associated with in the future.

I also participated in the ANZAAS symposium entitled *The Contribution of Geoscience to the National Economy*. A series of excellent papers were presented at this symposium but the pity of it was that, as in most other geoscientific events at ANZAAS, the audience was small—a maximum of 20 people. The effort put into the occasion by the speakers clearly was not warranted in view of the size of the audience, and I would suggest that in future the Geoscience Council declines to be associated with ANZAAS unless it is in some other type of symposium which will clearly reach a very wide, multi-disciplinary audience. My perception is that, as ANZAAS presently stands, its emphasis is moving more and more into populist topics, particularly those relating to the social sciences. This is not to denigrate ANZAAS but rather to point out that we no longer readily fit into that forum.

One of the very valuable papers presented at ANZAAS was by Graeme McIlveen of the NSW Department of Mineral Resources on *The Geoscientist and the Environment*. This paper is published in this issue of the Council's Annual Report and I commend it to readers.

In contrast to ANZAAS, I would say that our involvement in the Murray Basin Conference was a great success. The Conference brought together people in a large number of disciplines represented by the Council as well as in many other disciplines with which we normally have fewer interactions, such as agriculturalists, economists and engineers. The Conference also received a considerable amount of media attention and I believe there were a number of very positive outcomes in terms of attracting community attention to particular geoscientific issues related to the geology and hydrogeology of the basin. I would strongly recommend to the Council that it is associated with similar meetings in the future which have as their particular aim the presentation of geoscientific issues to the community and demonstration to the community of the relevance of geoscience to major problems.

The association of AGC with FASTS is something which I know concerns a number of member societies of the Council. On balance I am persuaded that we should continue to be members of FASTS for the present. I take this view because I see it as part of our broader responsibilities to science in general and because of my feeling that geoscience should not be left out of this broader framework. However I believe that the Council should continue to monitor the value of its FASTS membership, for I know that, in some people's view, it would not take very much to tip the balance in favour of withdrawal from FASTS in view of the significant cost involved.

One matter which the Council has not so far considered, but which I would bring to your attention, is the question of the amount of research funding for the geosciences when compared with other areas. There are few reliable figures available on this, but the figures which we have seen suggest that the geosciences get a rather small level of funding for research compared to the amount of national and export income generated by the mineral and energy industries. Again this is something the incoming Council may wish to consider in the coming year.

In summary I believe that a number of things have been achieved in the past year (though inevitably not as many as I would have hoped), and I would particularly recommend that we continue to focus our attention on geoscience awareness in the community, geoscience education, and sponsoring symposia of broad community interest.

Finally, I should like to thank the Committee of the Geoscience Council for their support during the past year. I would like to record my particular thanks to the Secretary, Terry Birtles, for his support and for the workload he has had to bear over the year.

Peter J. Cook
President

SECRETARY'S REPORT

The Council

The Council consists of the Member Societies, whose nominated representatives elect at least six of their number to form the Executive Committee. In addition, related geoscience organisations who are not full members may be invited to join the Council as non-voting Associate Members or Observers.

Membership of the Council at the end of the session 1987-88 was as follows:

Members

Association of Exploration Geochemists (AEG)

Australasian Institute of Mining and Metallurgy (AusIMM)

Australian Geomechanics Society (AGS)

Australian Institute of Geoscientists (AIG)

Australian Society of Exploration Geophysicists (ASEG)

Australian Society of Soil Science Inc. (ASSS)

Geological Society of Australia Inc. (GSA)

Institute of Australian Geographers (IAG)

Associate Members

Australian Council of Chairmen of Earth Science Departments (ACCESD)

Australian Geoscience Information Association (AGIA)

Australian Mineral Foundation Inc. (AMF)

Australian Mining and Petroleum Law Association Ltd (AMPLA)

Bureau of Mineral Resources, Geology and Geophysics (BMR)

Commonwealth Scientific and Industrial Research Organisation (CSIRO)

Consortium for Ocean Geosciences (COGS)

Government Geologists' Conference (GGC)

International Association of Hydrogeologists (IAH)

New South Wales Committee for the Coordination of Government Geological Programmes

Soil Conservation Service of New South Wales

Statistical Society of Australia

Observers

Australasian Quaternary Association

Australian Academy of Science

Australian Academy of Technological Sciences

Australian Mineral Industries Research Association

Australian Mining Industry Council (AMIC)

Federation of Australian Scientific and Technological Societies (FASTS)

New South Wales Committee for the Coordination of Government Geological Programs is a a newcomer to the Council this year and as well the Australasian Quaternary Association has indicated its wish to accept an invitation to associate membership.

The Council meet at CSIRO Headquarters, Canberra on 26 June and 27 November 1987. Permission to use this venue was kindly given by Dr A. F. Reid, Director of the Institute of Energy and Earth Resources, and appreciation is recorded.

The Executive

The Executive elected on 26 June 1987 was as follows:

President,	Dr P. J. Cook
Past President	Dr D. H. Mackenzie
Vice President	Professor K. S. M. Campbell
Secretary	Mr T. G. Birtles
Treasurer	Dr G. J. Burch
Editor	Mr E. P. Shelley
Executive Member	Professor B. G. Thom
Public Officer	Dr P. F. Walker

Dr J. Truswell was appointed as the AGC representative on FASTS and appreciation was recorded of the previous contribution by Dr C. D. Branch who served as the foundation secretary of FASTS as well as AGC representative. Professor Campbell was appointed as AGC representative to FASTS standing committee on education.

The Executive met at BMR on 14 August, 2 October, 6 November and 10 December 1987, and on 22 February and 19 April 1988.

Activities

The Annual Report continues to serve as a vehicle for communicating matters of common interest representative of Australian geoscience and circulation has been broadened through distribution at national and international conferences.

A highlight of the year was a conference and workshop *Murray Basin '88: Geology, Groundwater and Salinity Management* held in Canberra from 23-26 May 1988. It was co-sponsored by the Council in association with the Groundwater Working Group of the Murray-Darling Ministerial Council. Much initiative was provided by the President. DrBurch represented the Council on the Conference Committee.

The Council also supported the 1988 ANZAAS Congress in Sydney through the organisation of a symposium entitled *The Contribution of Geoscience to the National Economy* under the chairmanship of Dr N. Markham.

Professor Campbell has led considerable Council activity concerning tertiary geoscience education. This included correspondence and meetings with representatives of the Minister for Education and the Commonwealth Tertiary Education Commission, formation of an AGC geoscience education committee, organisation of a workshop on the Green Paper at the Brisbane conference of Geological Society of Australia, and preparation of a formal AGC response to the Green Paper. The Executive has noted its appreciation of the enormous value of Professor Campbell's work.

The Executive has noted the important initiative provided by Professor R. Carter and Ms R. Stutchbury through the Geoscience Awareness Programme and has recommended that the Council develops a close supporting link. Dr Stutchbury was invited as guest speaker to the 1988 annual general meeting.

Although the Council has not maintained a seat on the executive of FASTS, Dr J. Truswell has kindly represented the AGC with considerable dedication to demonstrate the

Council's support of the work of FASTS. Dr D. Widdup, Executive Director of FASTS, addressed the Council at its November meeting. He reminded members that, as the representative of some 60 000 scientists and technologists, FASTS provides a significant lobby concerned with the rundown of government expenditure on science education and, also the concerns within the industry of the need for greater industrial support from government policies. FASTS issues monthly news bulletins and has now set up five policy committees to focus its action. The AGC has declared its support of both FASTS and AMIC in the promotion of geoscience issues in Australian schools.

The Secretary has endeavoured to advise members at least quarterly on such matters as forthcoming conferences, information concerning fellowships and initiatives taken by the Executive. Events of significance include correspondence to the Australian Research Council in support of a proposed ocean science drilling project, the Global Sedimentology Geology Program and geoscience representation on Australian Water Research Advisory Council.

Terry G. Birtles
Secretary

TREASURERS REPORT

This is the last report presented by the outgoing Treasurer, and it is with gratitude that all our member societies are acknowledged for their sustained financial support of Council during the past several years.

This year has seen the consolidation of the Federation of Australian Scientific and Technological Societies (FASTS). Several members of Council have made major contributions to the establishment and organisation of the Federation, particularly Dr C. D. Branch in his role as Federation Secretary. The Federation has adopted much of the AGC's constitution and benefited from the experience of Council as the coordinating body for its member societies.

Some members of Council have expressed concern regarding AGC membership of FASTS and the financial commitment it involves. There have been other concerns that Council needs to retain its important role as the peak organisation representing the geosciences. Undoubtedly some tensions have arisen as FASTS established its mandate and AGC adapted to this new arrangement. However, representatives of all member societies have had the opportunity to consider AGC membership of FASTS at several successive Council meetings and a unanimous decision was reached on each occasion supporting the existing membership arrangement.

A strong partisan association has now developed between FASTS and AGC, with both organisations benefiting from the complementary roles and activities that each is now pursuing. For example, the plan to reorganise higher education in Australia by Mr Dawkins, Minister for Employment, Education & Training, resulted in the preparation of coordinated but separate submissions by both AGC and FASTS. AGC was able to address specific geoscience aspects in great detail in the knowledge that the broader science policy aspects were being properly addressed by FASTS.

Coordinated promotion of science and industry needs for the geoscience community is now able to proceed with greater vigour as AGC identifies issues and then uses its own constituency as well as the weight of FASTS representation to pursue these issues. A good example of this was Council's sponsorship of the national conference on environmental and resource issues within the Murray Basin—*Murray Basin 88*—convened by the Bureau of Mineral Resources and held in Canberra on 23-26 May 1988. The conference was attended by over 200 delegates and received national coverage in press, television and radio reports.

The final cash balance for 1987 of $7976 represents continued strong financial support by member societies and State Geological Surveys. In addition, the continued assistance of the Bureau of Mineral Resources in publishing *Australian Geoscience* each year has significantly reduced the costs of producing this important publication.

Sponsorship of the *Murray Basin 88* conference incurred a cost of $2000, but this will be recovered when the finances for the conference have been finalised. No other major items of expenditure were incurred during 1987.

Auditors for the Council are Price Waterhouse, Chartered Accountants. The Canberra office of Price Waterhouse have audited Council accounts free-of-charge. This is gratefully acknowledged.

Financial Statement

Receipts		$
Bank Interest		845.00
		845.00
Expenses		
Meetings		35.00
Bank Charges		4.00
Conferences		2000.00
		2039.00
Balance brought forward	(31.12.86)	9170.00
Cash balance	(31.12.87)	7976.00

The financial statement for 1987 represents a change in arrangements for collecting membership subscriptions and in the payment of AGC membership fees to FASTS. These transactions will take place between January and June in future years.

Gordon J. Burch
Hon. Treasurer

APPENDIX

DATA ON MEMBER SOCIETIES, 1988

ASSOCIATION OF EXPLORATION GEOCHEMISTS (AEG)

Address:

PO Box 523
Rexdale, Ontario
M9W 5L4, Canada

Western Regional Councillor
9 Langdale Street
WEMBLEY DOWNS WA 6019

Eastern Regional Councillor
CSIRO Division of Exploration Geoscience
PO Box 136
NORTH RYDE NSW 2113

Membership:

Voting	474
Affiliate	354
Student	68
Honorary	3

Worldwide Membership over 800 in 60 nations

Objectives

To represent the professional interests of persons specialising in exploration geochemistry; to advance mineral exploration applications of geochemistry; to disseminate geochemical information and ideas among professional geochemists.

Meetings, activities:

- 12th International Geochemical Exploration Symposium, and 4th Symposium on Methods of Geochemical Prospecting, Orleans, France, April 1987.
- Regional Meetings in Vancouver, and Greece.
- Regular council meetings.

Committees:

Admissions; Bibliography; Case Histories; Geochemical Analysis; Membership; Publications; Research and Education; Student Prize; Symposium.

Publications:

- *Journal of Geochemical Exploration*, Elsevier (6 issues/yr)
- Quarterly Newsletter *Explore*
- *Exploration Geochemistry Bibliography*, AEG, updated periodically
- *Handbook of Exploration Geochemistry*, Volumes 1, 2, 3, Elsevier
- Geochemical Exploration Series from AEG-sponsored conferences

Awards:

- Honorary Membership.
- Annual Student Prize.

Association with other organisations:

- Australian Geoscience Council
- Canadian Geoscience Council
- International Union of Geological Sciences
- United States National Committee for Geochemistry

Other Information:

AEG was founded in 1970 in Toronto as an international organisation. Australia has the third largest membership after the United States and Canada. The office bearers consist of a five-person Executive and 12 ordinary Councillors, all of whom are normally resident in North America, together with six regional Councillors representing Australia (2), Europe, Northern Countries (Scandinavia), Southern Africa and Brazil.

THE AUSTRALASIAN INSTITUTE OF MINING AND METALLURGY (The AusIMM)

Address:

Clunies Ross House
191 Royal Parade
Parkville VIC 3052

Membership:

Honorary Members	18
Members	1931
Associate Members	2856
Company Members	168
Affiliate	232
Junior	1022
Student	643
Unknown	1
TOTAL	6871

Objectives:

The objectives and purposes of the Institute are to promote and advance the science and profession of engineering with special reference to mining, including geology and metallurgy in all its branches. The Institute is both a professional body and a learned society. It serves the interests of geologists (including geophysicists), metallurgists and mining engineers as well as persons in other disciplines of science and engineering associated with the mineral industry. The institute provides affiliate membership for persons working in responsible positions in the mineral industry and who are qualified in other professional fields.

Meetings, activities:

- Annual Meeting
- Annual Conference
- Specialist Symposia and Conferences
- International Conferences.

Committees:

Membership; Publications; Education and Accreditation; Awards; Mineral Heritage; Program; Public Relations; Long-range Planning and Strategy; Membership Extension; Ore Reserves; Also Mineral Industry Consultants Association; Australasian Mineral Heritage Trust.

Publications:

- The AusIMM Bulletin and Proceedings
- Annual Conference Volume
- Symposium Volumes
- International Conference Proceedings

Awards:

- The Institute Medal
- Honorary Membership
- President's Award
- Students Essay Prize
- O'Malley Medal
- Operating Technique Award

Association with other organisations:

- Australian Geoscience Council
- Australian Geomechanics Society (Joint technical unit with the institution of Engineers, Australia)
- Council of Mining and Metallurgy Institutions
- Australian Underground Construction and Tunnelling Association

Other Information:

The Institute has 35 branches in capital cities and major mining centres in Australia, New Zealand, Papua New Guinea and Fiji.

AUSTRALIAN GEOMECHANICS SOCIETY (AGS)

Address:

Mr Roy Bushnell
Society Secretary
c/- The Institution of Engineers, Australia
11 National Circuit
Barton ACT 2600

Membership:

Financial Membership 599

Objectives:

To promote and advance the science and practice of geomechanics.

Meetings, activities:

- Australia-NZ Conference on Geomechanics held every four years
- Each of the State groups meets approximately nine times per year for technical sessions
- Each of the State groups holds technical seminars to meet specific requirements
- National Committee meets twice yearly (usually Canberra, Sydney or Melbourne)

Publications:

- *Australian Geomechanics* published twice yearly
- *Australasian Geomechanics Computing Newsletter*, an occasional series

Awards:

- *The John Jaeger Memorial Medal.* Awarded on the recommendation of the judging panel to an individual, considered to have made a significant contribution to Australian geomechanics over recent years. Awarded every four years to coincide with each Australian-NZ Conference
- *The E.H. Davis Memorial Lecture.* The lecturer is selected by an AGS panel every two years for distinguished recent contributions to the theory and practice of geomechanics in Australia
- The D. H. Trollope Medal. Awarded every two years to the author of the most outstanding doctoral thesis accepted by an Australian university during the previous five years in the broad field of geomechanics

Association with other organisations:

- AGS is sponsored by IE Aust and The AusIMM. Each member of the society shall, upon payment of annual subscriptions become affiliated with one or more of the International Society of Soil Mechanics and Foundation Engineering, the International Society of Rock Mechanics, and the International Association of Engineering Geologists
- Australian Geoscience Council
- New Zealand Geomechanics Society
- The Australian Underground Construction and Tunnelling Association

Other Information:

The objectives of AGS are carried out by organising technical conferences, symposiums and meetings; by promoting research and development and improved practice; by cooperating with appropriate bodies outside the sponsoring societies both within Australia and overseas; and by means of publications.

AUSTRALIAN INSTITUTE OF GEOSCIENTISTS (AIG)

Address:

C/- Geological Society of Australia
Suite 1001, Challis House
10 Martin Place
Sydney NSW 2000

Membership:

600

Objectives:

To advance the professional status and practice of geoscience in Australia and to act as a professional institute of geoscientists concerned primarily with technical and ethical standards, patterns and conditions of employment, training and supply of qualified geoscientists and to improve the understanding of geoscience in the wider community.

Meetings, activities:

- Annual General Meeting.
- Monthly Council Meetings.
- State Branch Meetings.
- Seminars.

Publications:

- Special publication of Seminars.
- Guidelines/Handbooks on professional matters.
- Quarterly Newsletter.

Association with other organisations:

- Australian Geoscience Council
- Australian Society of Exploration Geophysicists
- Geological Society of Australia
- Petroleum Exploration Society of Australia.

Other Information:

Founded in October 1981 following the report of GSA committee which recommended that geoscientists required a professional body to represent them. This was supported by PESA and ASEG.

AUSTRALIAN SOCIETY OF EXPLORATION GEOPHYSICISTS (ASEG)

Address:

7th Floor
12 St George's Terrace
Perth WA 6000

Membership:

Active and Associate	652
Student	45
Honorary	6
Corporate	29
TOTAL	832

Objectives:

To promote:

- the science of geophysics especially as applied to exploration;
- fellowship and cooperation;
- good standing of the geophysical profession;
- close cooperation and understanding between all earth sciences.

To assist in:

- the design and teaching of geophysics courses;
- formation of local branches.

Meetings, activities:

- 1989—Melbourne (24-29 September)
- 1991—Sydney (March—date to be confirmed)
- Annual General Meeting—February each year

Publications:

- *Exploration Geophysics*: The Bulletin of the Australian Society of Exploration Geophysicists, four issues per year.
- Preview bimonthly newsletter

Awards:

- Graeme Sands Award—for excellence in geoscience Larry Hawkins Award—awarded for paper presented at the ASEG Conference showing the most innovative use of geophysics
- Honorary Membership.
- ASEG Medal.

Association with other organisations:

- Society of Exploration Geophysicists.
- European Association of Exploration Geophysicists
- Australian Geoscience Council.

AUSTRALIAN SOCIETY OF SOIL SCIENCE INC. (ASSS)

Address:

C/- J.C. Dixon
Resource Management Division
Western Australia Department of Agriculture
Baron-Hay Court
South Perth WA 6151

Membership:

Ordinary	748
Honorary	7
	755

Objectives:

To advance soil science. To provide a link between soil scientists and members of kindred bodies within Australia and other countries.

Meetings, activities:

- Meetings at approximately monthly intervals of branches in ACT, WA, SA, Vic., Qld, NSW and Riverina.
- National Soils Conference is being organised for 1992 in Adelaide.
- Federal Council Meetings—four per year.

Publications:

- No formal journal, although ASSS has a representative on the Advisory Committee of the *Australian Journal of Soil Research*.
- Occational publications produced on specific topics, eg soil classification, soil conservation, hydrogeology, soil analysis and interpretation.
- *Soils News* (quarterly) includes summaries of talks and newsletter material.

Awards: (1988)

- J.A. Prescott Medal of Soil Science—P. Walker.
- ASSSI Publication Medal - no award
- JohnK.Taylor, OBE, Gold Medal in Soil Science—N.J. Barrow.
- National Soils Conference Student Travel Awards - R. Hook, C, Grant, N. Menzies, R. Harper.

Association with other organisations:

- International Society of Soil Science.
- Australian Geoscience Council.

Other information:

ASSS was formed in 1956. It is a federation of seven Branches. The Executive moves from Branch to Branch every two years.

GEOLOGICAL SOCIETY OF AUSTRALIA INC. (GSA)

Address:

The Business Manager
Geological Society of Australia
Room 1001, Challis House
10 Martin Place
Sydney. NSW 2000

Membership:

Ordinary	2789
Associate	232
Student	211
Honorary	15
Retired	31
Company	30
TOTAL	3308

Objectives:

To advance the geological sciences in Australia.

Meetings, activities:

- Australian Geological Convention held approximately every two years, hosted by Divisions on a national roster
- National and regional thematic symposiums sponsored by the Society and run by Divisions, Branches or Specialist Groups at frequent intervals, as opportunity exists
- Division and Branch monthly meetings

Committees:

Stratigraphic Nomenclature; Geological Monuments; Education; Public Affairs; Australian Committee for Global Sedimentary Geology Program

Publications:

- *Australian Journal of Earth Sciences*, published quarterly
- Special Publications usually major thematic publications (latest release, No.12, 1986).
- *Australian Geologist*, a newsletter published quarterly
- *Alcheringa*, an Australasian journal of palaeontology
- Specialist Groups produce publications and newsletters from time to time
- Thematic maps—eg Geotectonic Map of Australia and New Guinea 1971.
- Excursion Guides
- Abstract Series

Awards:

- *W.R. Browne Medal* awarded by each Executive to a person distinguished in the geological sciences through research, education or administration.
- *F.H. Stillwell Award*, awarded annually for the best paper in the *Australian Journal of Earth Sciences*
- Some Divisions offer prizes for outstanding tertiary and secondary students in earth science.
- Honorary Memberships

Association with other organisations:

- Australian Geoscience Council
- Australian Academy of Science National Committee for Solid Earth Sciences
- International Union of Geological Sciences
- Fostered the foundation of the Australian Institute of Geoscientists
- Joint meetings with The AusIMM are commonly held at Division level
- Active scientific liaison is maintained between Australian earth scientists and overseas working groups, in part through collaboration in the International Geological Correlation Program

Other information:

- Founded in 1951. GSA has a code of ethics which members must endorse

- GSA is composed of six State Divisions, one Territories Division, two Branches, and nine Specialist Groups; and representatives of these bodies constitute the Council
- The Executive moves from one Division to another on a national roster, and consists of eight members, under the chairmanship of the President, who are elected by Council
- Executive term, and the interval between Council Meetings, is about two years
- GSA welcomes overseas members
- Sale of publications is through the Business Manager

INSTITUTE OF AUSTRALIAN GEOGRAPHERS (IAG)

Address:

C/- Dr G. Cho
Hon. Secretary IAG
School of Applied Science
Canberra College of Advanced Education
PO Box 1
Belconnen ACT 2616

Objectives:

The promotion of the study and discussion of geography in Australia, especially by the holding of meetings at which the results of research may be presented and discussed. The advancement of geography in Australia, and the representation and advancement of Australian geography internationally. Co-operation with other organisations with kindred purposes.

Meetings, activities;

- IAG Meeting every 12 months.
- Meetings of study groups.

Publications:

- Australian Geographical Studies published twice yearly.
- IAG Newsletter, two issues per year.

Awards:

- IAG Honours Award, for a paper based on honours research at an Australian tertiary institution.
- Griffith Taylor Medal for distinguished contributions, to professional geography in Australia in tertiary level teaching and/or applied geography. One award per every four year period.
- Fellowship of IAG for distinguished service to the Institute. One award per every three year period.
- Professional Service Commendation in recognition of distinguished professional service in applied geography in Australian tertiary institutions or for an outstanding record of service in teaching secondary school geography in Australia. Maximum of three awards annually.

Association with other organisations:

- Australian Geoscience Council.
- International Geographic Union.
- International Geographical Congress, 1988.

Other Information:

IAG was founded in 1958. Membership is by one to the following:

- Honours or higher degree in geography; membership of a Geography department or section in a tertiary institution;
- Contribution to geographical research;
- Engaged in work (recognised by IAG Council) as a professional geographer;
- By invitation.

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AUSTRALIAN GEOSCIENCE 1988

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