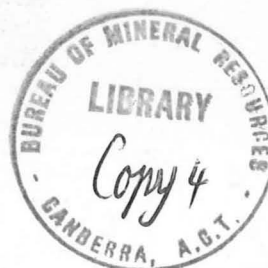


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**BUREAU OF MINERAL
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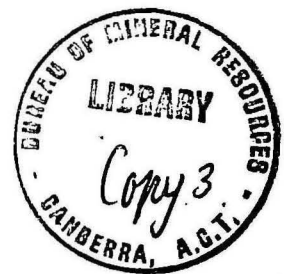
RECENT DEVELOPMENTS IN GEOPHYSICS IN AUSTRALIA

by

**M.G. Allen, N.G. Chamberlain, J.C. Dooley, E.C.E. Sedmik,
and A. Turpie**

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INTRODUCTION

The following brief statement on recent activity and new techniques in geophysics has been prepared for presentation at the meeting of Australian Commonwealth and State Government Geologists to be held at Perth in May 1972.

New exploration techniques

The heavy demands on geophysical exploration services during the mining boom of 1970 and the first half of 1971 stimulated efforts to improve the performance of geophysical prospecting methods. Emphasis was placed on the introduction and testing of techniques designed for use in difficult environments such as deep surface weathering and high surface conductivity.

New electromagnetic techniques were introduced to Australia by Seigel Associates Australasia Pty Ltd. The Turair system developed by Scintrex Ltd of Canada is a semi-airborne technique which combines some of the advantages of both ground and airborne surveying. The system uses a large transmitting loop on the ground as a primary source. Gradients of phase and amplitude are measured by means of two coils mounted in a 'bird' towed from a helicopter. Claimed useful penetration is as much as 200 m. The system seems ideal for reconnaissance surveys.

For Turam surveys in areas with highly conducting overburden, Scintrex has developed the Turam SE-75 system which operates within a frequency range of 45-60 Hz and uses a phaselock device for compensation. This system was tested in Western Australia using 50-Hz power lines as energizing source.

A new development in the field of induced polarization techniques - magnetic induced polarization (MIP) - was recently announced by Scintrex Ltd. In this method, energizing current is passed galvanically through the ground and the horizontal component of the magnetic fields due to current passage in the ground is measured. Advantages claimed for the method are: less attenuation with depth than is the case with other electrical methods; enhancement of polarization effects in conducting bodies; and ability to detect IP effects arising from below conductive overburden. The method has been tested in Canada and U.S.A. and it is expected that experimental surveys will be conducted in Australia in 1972.

Another new electromagnetic technique recently introduced to Australia is the one-loop transient equipment MPPO-1 developed in the U.S.S.R. A square loop is laid on the ground and current pulses are sent

through it. If conductors are present in the vicinity, eddy currents are induced in them. In the intervals between primary current pulses, the electromagnetic field caused by the decaying of the eddy currents is measured. It is claimed that such measurements allow discrimination between conductive overburden and a conducting orebody at depth. The method has been used with some success in difficult areas in Western Australia where other geophysical methods have failed.

Interest has developed in Australia in the use of down-hole geophysical measurements to explore the ground in the vicinity of drill holes, such as IP logging, magnetic susceptibility measurements, and *mise-à-la masse*, (or applied potential) technique in which a mineralized body is energized and its extent traced by surface measurements.

In ground magnetic surveys the measurement of magnetic gradients by taking readings with a magnetometer at two different heights above the surface has been found to assist in the interpretation of anomalies.

The increased activity in uranium exploration has been accompanied by greater use of gamma-ray spectrometers in airborne and ground surveys and for laboratory assaying of radioactive materials. Soil radon surveys by measurement of alpha particle activity in auger holes were conducted by BMR in the Rum Jungle region but the method proved to have no advantages over gamma-ray surveys.

Airborne surveys

BMR's regional aeromagnetic coverage was extended by surveys principally in the Yilgarn Block (WA), Eucla Basin (SA), and in East Papua; in addition, detailed airborne surveys were conducted in the Cloncurry (Qld) and Tottenham (NSW) areas. Experimental aerial photography of irrigation areas in northern Victoria demonstrated the value of colour infra-red photography for investigating water seepage and salinity problems.

BMR's DC.3 aircraft was replaced by Twin Otter VH-BMG, equipped with fluxgate magnetometer of advanced design, gamma-ray spectrometer, and navigation equipment including a Marconi doppler navigator. A digital acquisition system incorporating a small computer provides for digital recording of all geophysical and navigational data on magnetic tape in a form suitable for subsequent computer processing and presentation in profile or contour form.

Seismic surveys

An experimental airborne seismic refraction and reflection survey was carried out in the Ramu-Sepik plains area of northern New Guinea in an attempt to develop a method of seismic exploration using telemetered signals in inaccessible areas such as swamps and rain forest.

The eastern margin of the Galilee Basin, Queensland, was investigated by a seismic survey which indicated that a 4 600-m thickness of Galilee Basin and older sediments is separated from outcrops of the Drummond Basin sediments to the east by an abrupt and complex faulted zone. Drummond Basin sediments probably extend less than 20 km west of this zone.

BMR and some State authorities have been interested in the problems of high-resolution shallow seismic profiling both on inland or estuarine waters and on shallow offshore areas. BMR has tried a number of experimental arrangements and developed a simple method for suppressing the bubble pulse for a sparker element. The element is operated within a short open length of rubber hose of appropriate diameter. Experimental work by BMR is continuing.

In 1970, BMR, in co-operation with Queensland Mines Department, carried out some experimental geophysical work at Moura Coalfield in order to investigate the structure of coal seams which lie within 300 m of the surface. Encouraging results were obtained from seismic reflection work. The uppermost economic coal seam was mapped to within 100 m of the surface, and areas of faulting could be deduced from time differences and lack of continuity in reflections. Faults with throws as small as 6 m could be inferred in areas where good-quality reflections were obtained from the coal seams. Since 1970 several high-resolution shallow reflection surveys of this type have been conducted by private companies in the Queensland coalfields.

Gravity surveys

The helicopter gravity reconnaissance of Australia was continued in South Australia in 1970 and Western Australia in 1971-72. It is planned to complete the coverage of Australia in 1973 although some delay may occur in Tasmania because of lack of suitable photography. Further coverage was obtained in the New Guinea Highlands.

Detailed gravity surveys were carried out as a follow-up to the helicopter survey in the south of Western Australia and in conjunction with the Galilee Basin seismic survey.

Marine surveys

A marine geophysical survey was carried out in New Guinea waters during the last three months of 1970. This comprised mainly north-south lines at 32-km spacing in the Bismarck Sea and east-west lines at 16-km spacing in the Gulf of Papua.

Continuing on from the above survey a reconnaissance of the Australian continental slope at 32 km line spacing has progressed to cover areas off the east coast and south of Tasmania.

On these surveys seismic, gravity, and magnetic measurements have been made, and navigation has been mainly by satellite doppler and sonar doppler. Digital data acquisition and processing systems both on board and on shore have been and are being developed.

Crustal studies

The tectonics of New Britain and surrounding areas is becoming understood better as the result of deep seismic, gravity, and magnetic surveys by BMR, Hawaiian Institute of Geophysics, and University of Queensland, and of studies of locations and directions of first motions of earthquakes. Rabaul appears to be situated near an unstable quadruple plate junction, with a sinistral transform fault cutting east-west through the Bismarck Sea. Milsom has suggested that the Solomon Sea is another minor plate, but this needs confirmation. The whole area is very complex, and further investigations are in progress. Seismic waves were recorded at distances to about 20° from two large quarry explosions in 1970 and 1971 (about 500 tonne) near the Ord River damsite. The effect of these was equivalent to an earthquake of magnitude $4\frac{1}{2}$, and P and S wave velocities were measured to a depth of 160 km in the mantle.

Reflection seismic surveys for deep crustal investigation were conducted in five areas of the Geo-Traversal in Western Australia with supplementary refraction recording between Kalgoorlie and Mundaring.

Analysis of the seismic and gravity data indicates that the crust under the south-west Australia shield undergoes a transition from a normal continental type at Kalgoorlie to an abnormally thick crust towards the Perth Basin, owing to the presence of an extra basal layer of velocity 7.41 km/s.

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Regional gravity measurements

An Australian long-range calibration line for gravity meters, extending from Hobart to Laiagam in the New Guinea Highlands, was established by a battery of nine gravity meters transported by light aircraft; this was related to the world gravity network as some of the meters had been used on the Western Pacific Calibration Line in 1969. Local calibration ranges were measured during the survey to establish their values in relation to the Australian Calibration Line.

BMR is redesigning pendulum equipment for use with blunt knife-edge pendulums developed by National Standards Laboratory (N S.L.) in Sydney. It is hoped to achieve substantial improvement in accuracy over conventional pendulum equipment.

N.S.L. has completed an absolute determination of gravity at Sydney, confirming overseas results that the standard Potsdam value was too high by about 13.8 mgal.

The geoid surface and deflections of the vertical for Australia have been determined from Australian gravity and geodetic survey data, together with satellite data. Solutions have been published by Mather (University of NSW) and Grushinski (USSR).

Regional magnetic measurements

A first-order magnetic repeat survey to determine secular variation over Australia and PNG has been completed, and maps showing 1970 values of the field are available. A third-order survey, showing relatively local variations in more detail, has been completed for the eastern states and about half of Western Australia.

Australian National University's Department of Geophysics & Geochemistry investigated the conductivity of the upper mantle under central Australia, using an array of 25 magnetometers and earth current recorders spread over about 400 000 km² for several months. This showed higher conductivity, and hence higher temperatures, at a depth of 100 km or so in the eastern part of the area (east of about 140°E longitude).

Measurement of earth movements

An earth-tidal observatory has been established by University of New England, in the Cooney mining tunnel, about 50 km east of Armidale. The University is installing tensioned wire quartz, and laser strain meters, and BMR is installing horizontal pendulum tiltmeters.

Queensland University has used a differential proton magnetometer for detection of a magnetic effect due to changes in pressure preceding volcanic eruptions in New Zealand. It is also proposed to try to detect whether a seismo-magnetic effect will accompany the filling of Talbingo Dam in the Snowy Mountains. Earth strain meters with short base-lines (about 1 m), and using a differential capacitance bridge for measuring small movements, have been developed and are currently in use in Hawaii; also a displacement meter has been used for laboratory measurements of rock anelasticity.

The Division of National Mapping and BMR are planning direct measurements of relative movements of land masses, with a laser geodimeter, across the Ramu-Markham fault zone in New Guinea, and also between New Britain and New Ireland. Accurate distance measurements will be repeated at intervals of a few years.

Observatories

Seismology. New seismographs were established at Island Lagoon (SA), Alice Springs (NT), Karratha (WA), Kavieng and Pomio (PNG). A vault has been constructed at Manton Dam to house the equipment now at Darwin. An improved site was selected at Macquarie Island, with telemetered recording. Installations are planned at four more sites in PNG. Temporary seismographs have been set up to record after-shocks following large earthquakes in PNG and WA. The number of stations currently operated by Australian institutions is 63-40 on the mainland, 20 in PNG, two in Antarctica, and one at Norfolk island.

Sixteen strong-motion accelerographs have been set up in PNG, and seven in Australia. A strong-motion data centre has been established in Canberra by BMR to collate and analyse the records from these. Also an earthquake data file, listing all known events in the Australian region, is now operating.

Geomagnetism. An automatic digital recording magnetometer is under development, and some test recordings have been made. Digital clocks have been developed for observatory operation.

In co-operation with USSR scientists, simultaneous records of magnetic variations and ionospheric movements are being undertaken by BMR and Ionospheric Prediction Service at Canberra. This is geomagnetically conjugate to Petropavlovsk.