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RECENT DEVELOPMENTS IN GEOPHYSICAL PROSPECTING IN AUSTRALIA

by

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Introduction

At the regular meetings of Australian Commonwealth and State Government Geologists it is customary to present a brief statement of recent activity and new techniques in geophysical prospecting. The following statement was prepared for the last meeting, held at Hobart in March 1966.

Perhaps the most significant advance in Geophysical Prospecting in Australia during the last two years has been the increase in surveys over ocean covered areas in the search for oil. Sophisticated techniques in seismic, gravity, and aeromagnetic methods have been used.

Companies servicing oil prospecting equipment carry a wide range of cost and repair services. Contractors are offering the newest of equipment and techniques. The greatest departure from older established techniques has occurred in the western half of the continent, where West Australian Petroleum Pty Ltd, Continental Oil Company of Australia Ltd, and Hunt Oil Company have been employing an array of "Vibroseis", Weight Dropping, and Digital Recording seismic parties on land and sea.

The multiple coverage seismic technique has been increasingly used throughout the country, particularly in offshore operations, where with conventional explosive charge shooting it is now the accepted minimum effort. Three- and six-fold coverage are common at sea and six- and twelve-fold coverage on land.

Great demands for data processing follow from the multiple coverage seismic technique, and there are now at least five analogue-type processing centres distributed between Perth and Brisbane. Digital processing is currently being done in the United States. The leading company in the application of digital methods is self sufficient, with integrated equipment ranging from field recording to computer in a format of its own and its own library of programmes. There is now, however, a flood of equipments employing an I.B.M. format on the market, and the computer companies are developing independent libraries of programmes which undoubtedly will be widely available in Australia. The advantages of digital techniques lie in the flexibility of processing the data. However, to realise the advantages at present more expensive equipment, extremely careful field procedures, and more highly skilled and trained operators than are generally available are required, and all factors add to costs. Nevertheless, the use of both digital recording and processing is spreading.

The shipborne continuous-recording gravity meter and low-energy continuous seismic profiler were introduced in combination to Australia by the Bureau of Mineral Resources in 1965. A 14,000-joule

spark was used as the source transducer. An array of transducers is currently appearing on the market, including improved spark types, electrically powered repulsion plates, confined explosions of the gas and solid explosive types, and the compressed air gun. About 80,000 joules is the order of energy now being generally aimed at. However, the Bureau's operation was extremely successful and some 4000 miles of traverse was completed in the Bonaparte Gulf area with a gravity accuracy of the order of $\pm$ 2 milligals and seismic penetration of the order of 7000 feet. The continuous seismic profiler, using a low-energy source, can be applied to harbour and bridge site foundation problems.

In helicopter gravity survey operations the Polaroid camera is being used to aid positive identification of stations on air photographs, and experiments are in progress on the use of three-point control to determine barometric gradients in the area of operations, with the aim of reducing the need for multiple reading of stations by the traversing barometer. It is the barometric requirement that currently prevents advantage being taken of low-drift gravity meters of the La Coste type.

The reconnaissance gravity coverage of Australia is now well advanced. A Bouguer anomaly map is being prepared on the 40 mile to 1 inch Australian base, incorporating most of the gravity data available at November 1965. This has gone a long way towards correcting discrepancies between different surveys of the past, and will facilitate the integration of future surveys.

Magnetometers using the "optical pumping" principle have now been developed to a stage suitable for practical application in geophysical exploration. Three types - caesium vapour, rubidium vapour, and metastable helium - are currently in use for aeromagnetic surveying. In addition to extremely high sensitivity, these magnetometers have the advantages of being free from drift and of providing absolute field measurements. Also, the data are obtained in digital form and are therefore readily amenable to processing by electronic computers.

The capabilities of the caesium magnetometer have been demonstrated by the recent Timor Sea aeromagnetic survey. Although much of the survey showed only very low-amplitude anomalies, these were recorded with sufficient accuracy to allow satisfactory basement depth estimates to be made. The possibility of improved interpretation afforded by this type of magnetometer indicates that it could probably be used to advantage over the Australian sedimentary basins already flown with conventional magnetometers, as well as over the continental shelf.

A recent overseas development in magnetic surveying has been the use of electronic magnetometers, i.e. proton precession and fluxgate instruments, for measurement of the vertical gradient of the magnetic field, to supplement the normal total field measurement. The gradient measurements do not require correction for diurnal variation and provide additional information, which is obtained at little extra cost and is a valuable aid to the interpretation.

The use of induced polarisation in Australia has continued to increase; the method is now regarded as an essential, and in some cases the most important, method for major metalliferous exploration programmes. Although the equipment available has been improved, there still remains scope for fuller understanding of the basic phenomena involved and improvement in interpretation techniques. To a large extent interpretation has been based on rather limited empirical

information derived from the testing of actual survey results. A sounder basis for interpretation should result from the research programme currently being carried out by McPhar Geophysics Ltd of Toronto, Canada, with financial support from several Australian and overseas mining companies and the Bureau of Mineral Resources. The work aims to determine the induced polarisation effects to be expected from given sources. In the first stage, the results of which have now been issued, this was accomplished by calculations using an electronic computer. The second stage will deal with more complex types of source, using laboratory scale model experiments.

The problem of interpretation in conventional electromagnetic methods has been given attention in the Bureau in recent years. The problem in general is too complex to admit of mathematical treatment and the approach has been to use model experiments. Work carried out with both the Turam and Slingram methods on scale models has given results which have been of considerable assistance in interpreting electromagnetic data from field surveys.

The AFMAG method, which was tried in Tasmania for ground surveys some years ago, is being used again in that State as an airborne technique by one of the mining companies. The method claims to overcome the depth limitation of the normal electromagnetic methods. The present installation is in a helicopter.

A continuous velocity logger suitable for recording longitudinal and transverse velocities and pulse amplitudes in holes of less than two inches diameter has been developed by Schlumberger and will be brought to Australia. The sonic-amplitude log has successfully located and estimated the degree of jointing in the side of the hole. Several factors influence the results, and corrections have to be applied for centring of the tool in the hole, ellipticity and caving of the hole, difference in mud consistency, angle of the joint to the axis of the hole, material filling the joints, etc. Several methods are available to evaluate the corrections.

Velocity of flow of underground water, and permeability and porosity in the aquifer, have been calculated by the Bureau from the distribution of iodine-131 and tritium introduced with a carrier in closed holes under conditions of free natural flow and forced flow when pumping for irrigation. Laboratory investigation on the detection of flow patterns by means of radioactive isotopes is also in progress in conjunction with the Australian Atomic Energy Commission.