DEPARTMENT OF
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Record 1976/70

FUTURE ROLE OF PALAEOMAGNETISM IN THE BMR

Report by a BMR Committee on Palaeomagnetism

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Committee Members:
M. Idnurm (Chairman)
M.J.R. Robertson (Secretary)
P.J. Cook (until 9 June)
W.B. Dallwitz
J.C. Dooley
J.W.G. Giddings
H. Jones (from 9 June)
M. Walter

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SUMMARY AND RECOMMENDATIONS

The Committee considers that a need exists in the Bureau for palaeomagnetic work on a continuous basis, somewhat on the lines of the United States and Canadian Geological Surveys. Although several other organizations in Australia already have palaeomagnetic commitments, the emphasis is either mainly academic research or development of new techniques. This leaves a serious need for systematic application of existing techniques to areas of concern to the Bureau. It is unlikely that the other organizations would be prepared to provide results where needed on a service basis.

The main application of palaeomagnetism for the Bureau is considered to be magnetostratigraphic correlation, extending from studies of individual basins to continent-wide correlations. It is noted that a group of mining geologists has recently called on the Bureau to provide a framework of regional correlations for assistance in future metallogenic studies*. Magnetostratigraphy could also be effectively used in the "Period Studies" program at present being examined in the Bureau. Other applications besides magnetostratigraphy where palaeomagnetism could usefully contribute to the Bureau's work include age determination, ore body studies and tectonics.

With the above considerations in mind, the Committee recommends the setting up of a palaeomagnetic group comprising initially two professional officers and a technical assistant (part-time). This group should work within the Rock Measurements Group of Geophysical Services, and maintain close contact with the activities of the Geological Branch. Concerning equipment and laboratory space, there is currently a proposal under discussion to establish a joint palaeomagnetic laboratory, incorporating the latest measurement techniques, between ANU, BMR and CSIRO. Under this scheme the Bureau would be expected to provide the following items:

Item	Estimated Cost	Date
Minicomputer with a terminal and printout	$12,500	Mid 1977
Magnetic tape console for minicomputer	$10,000	1978-79
Helium recycling equipment	$10,000	1977-78
Liquid helium dewars	$ 2,000	1977-78
Nonmagnetic fittings for BMR drilling rigs	$ 1,000	1978-79

* A letter from CRA geologists, dated 27 May 1976.

The total BMR expenditure would be $35,500. In addition to capital items, each organization is expected to provide annually up to $5,000 towards the running costs of the joint laboratory.

The Committee recommends that the Bureau enter this cooperative scheme to avoid duplication of expensive facilities, and that formal negotiations be opened immediately with the other organizations concerned.

INTRODUCTION

At the request of the Heads of Branches a committee was convened on 12 May 1976 to determine the future application of palaeomagnetism and associated techniques in the Bureau of Mineral Resources. The Committee examined the existing palaeomagnetic program; estimated, by calling for submissions from project leaders, the future need for palaeomagnetic work; and determined the type of facilities, their cost, and the manpower needed to carry out the future program. This report presents its findings.

Two factors favour an increased palaeomagnetic involvement by the Bureau at the present time. The first is the recent advance in magnetometers arising from the introduction of cryogenic techniques. This has resulted in orders-of-magnitude improvements in both the sensitivity and the speed of measurement. Consequently, almost any rock type can now be considered for palaeomagnetic measurements, provided the magnetization is stable, and its origin can be defined. The increased speed makes it practicable to carry out measurements on the large collections of samples that are necessary for detailed investigations. These advances extend palaeomagnetic application into new fields such as correlation of sedimentary sequences.

The second factor is a proposal to establish between ANU, BMR and CSIRO a joint palaeomagnetic laboratory based on a cryogenic SQUID-type magnetometer. The proposed co-operative scheme would eliminate a large amount of duplication in equipment and buildings, and, by pooling resources, allow a higher standard of facilities than the organisations could afford individually. An additional benefit would be the exchange of information and ideas, particularly with the ANU group which has attained a world-wide reputation. However, in view of the serious need for palaeomagnetic studies within the Bureau, consideration should be given to upgrading the present palaeomagnetic program and to acquisition of facilities for detailed work should the joint laboratory not eventuate.

The Committee thanks all those who have contributed to its work by submission of project proposals or through discussions and criticism. It thanks particularly Dr. M. McElhinny of the Research School of Earch Sciences, ANU, for presenting a talk on magnetostratigraphy as part of the background information for discussions, and for opening the Black Mountain Laboratory for inspection.

APPLICATIONS OF PALAEOMAGNETISM

Palaeomagnetic applications may be divided into four categories:

1. Resolution of structural problems
2. Age determination
3. Correlations
4. Miscellaneous applications

1. Structural Problems

Besides the well-known large-scale tectonic applications - continental drift and seafloor spreading - palaeomagnetic techniques may be used to investigate relative movements of smaller crustal units. The method is limited primarily to rotational movements. Examples of its use are peninsulas (van der Voo et al., 1969; van den Berg et al., 1975), island arcs (Kawai et al., 1969), oroclines (Watkins, 1964; Kotasek and Krs, 1965), and tectonic blocks within continental assemblages (MacDonald and Opdyke, 1972; Embleton et al., 1974). Local examples where the method has been used are Yorke Peninsula in S.A. (Giddings and Embleton, 1974), Papua New Guinea (Manwaring, 1974), the Canberra-Molong High (Embleton et al., 1974) and the Kempsey Block in N.S.W. (Idnurm and Scheibner, 1974).

On a smaller scale, palaeomagnetic methods may be used to determine the structures of ore bodies (Sopher, 1963) and to unravel fold patterns in massive rocks generally (Idnurm and Embleton, 1977).

2. Age Determination

Palaeontological dating of poorly fossiliferous sediments (e.g. Precambrian sediments) or of sediments that lack diagnostic fossils, presents difficulties, while isotopic dating is restricted to igneous rocks and some sediments. Therefore, in some instances palaeomagnetism may provide the only method of determining age. However, even where one or other of the traditional dating methods is applicable, uncertainties in those methods, such as the loss of the argon-40 isotope, or the interpreted age of a faunal assemblage, may make it desirable to attempt independent verification by palaeomagnetism. It should be noted here that palaeomagnetic measurements are equally subject to restrictions, such as remagnetization by metamorphism. However, in some instances the primary magnetization directions are recoverable after low grade metamorphism (Ade-Hall et al., 1971; McWilliams and Dunlop, 1975).

A palaeomagnetic age may be obtained in two ways - first, by determining the pole position of the rock unit and fitting this pole to the apparent polar wander curve. Examples where this method has been used are Precambrian iron ore bodies, in S.A. and W.A. (Giddings, 1975), and weathering profiles in S.W. Qld. (Idnurm and Senior, 1977). The precision in the age estimate depends on the rate of polar wander and on how accurately the polar wander path is defined. For a well defined path precisions are unlikely to be better than 10 m.y.

The second method of dating is by polarity reversals. An example is the fixing of the time scale of a 100-km wide sequence of stranded beach deposits near Naracoorte, S.A. The age of the deposits increases with distance from the coast, and the 700 000 year B.P. Brunhes-Matuyama polarity reversal boundary was established near Naracoorte. Although this method gives a high precision*, it has the disadvantage that only discrete intervals within a rock sequence may be dated. The lower limit of dating is the most recent reversal, at 700 000 years.

It should be noted that palaeo-secular variations provide in principle a third method of dating, which would be particularly attractive for Quaternary deposits. These variations are, however, not sufficiently well defined at present to be useful for dating purposes.

3. Correlations

Rock units from different regions may be correlated by their magnetic characteristics. Several methods are possible.

The first method is based on reversals in the magnetization directions and is applicable to continuous sequences of sediment or continuous successions of lava flows (Pickard, 1964; Reeve and Helsley, 1972; Steiner and Helsley, 1975; Steiner and Helsley, 1976). It appears particularly suitable for stratigraphic work. The patterns of normal and reversed polarity are determined for stratigraphic sections from different parts of the same basin or from different basins, and the sections are correlated by matching their polarity patterns. It should be noted that, since polarity reversals are synchronous everywhere, this method does not suffer from the time-transgression problem of lithofacies. Unless the polarity patterns are complete, correlations are difficult to establish. This work therefore requires a magnetometer with sufficient sensitivity to measure all rock types encountered during sampling. The cryogenic magnetometer is at present the only instrument that fulfils this requirement.

* The accuracy is limited by the accuracies of the other methods used for determining the reversal boundaries, and by the uncertainity of the time of magnetization.

For discontinuous rock sequences correlations may be established by remanence directions. Remanence directions could be used for example to check that widely separated outcrops represent the same lithological marker bed, or to correlate intrusives associated with the same phase of magmatic activity (Jones and McElhinny, 1966).

Neither of the above methods is completely satisfactory for Quaternary correlations where the number of reversals is small, and polar wander insignificant. There, however, secular variations could be used effectively (Wilson, 1970). The feasibility of intracontinental palaeosecular correlations in Australia is at present being studied at the Research School of Earth Sciences, ANU.

4. Miscellaneous Applications

Applications which do not fall into the above categories include studies of ore genesis (Gross and Strangway, 1961; Symons, 1967; Hanus and Krs, 1968); determination of chilled margins between igneous bodies by remanence/susceptibility measurements (Hatherton, 1954); determination of palaeocurrent directions from susceptibility anisotropy (Rees, 1965; Aziz-ur-Rahman, et al., 1975); differentiaton between the fluid flow and plastic flow modes of emplacement of plutonic bodies by magnetic fabric analysis (Duff, 1975); differentiation between tectonic and slump origins of folds in sediments by susceptibility anisotropy; and the measurement of remanence and susceptibility for the interpretion of magnetic anomalies (Young, 1972).

THE PRESENT PALAEOMAGNETIC PROGRAM

Since 1972 a number of small palaeomagnetic investigations have been carried out in the Bureau. B.A. Duff, working in conjunction with ANU, has determined three Precambrian pole positions from intrusives of the Mount Isa region. Considering the preliminary state of the Australian Precambrian polar wander curve, this represents a significant contribution. The Rock Measurements Group projects have included the reconnaissance survey of Kempsey Block rotation, Tuggeranong and Pine Ridge Silurian pole determinations, Eromanga Basin deep weathering age determination, and, recently, fixing the time scale of the S.A. beach deposit sequence west of Naracoorte.

The present program provides for measurements on an ad hoc basis, and as time permits. The emphasis necessarily has to be on small projects, particularly those that do not need to meet urgent deadlines. Examples of the work tentatively planned are reconnaissance measurements in the Carpentaria Basin, on Christmas Island, and in Antarctica, a more exhaustive sampling of the Naracoorte dune sequence, and confirmation of the rotation of the southern part of the Canberra-Molong High.

All palaeomagnetic measurements to date have been carried out using the facilities of the Research School of Earth Sciences laboratory at Black Mountain. In recent years, however, palaeomagnetic activity in the Research School has intensified to a point where it is increasingly difficult to fit in the Bureau's measurements. A decision was therefore made to set up a small palaeomagnetic laboratory within the Bureau which can meet most of the Bureau's foreseeable needs under the existing program, and act at the same time as the nucleus for the growth of palaeomagnetic activities. As a first step, a Princeton Applied Research spinner magnetometer has been recently purchased from ANU*. Secondly, an alternating field demagnetiser is currently under construction, and is expected to be in service within the next two months. Thirdly, a site has been assigned within the proposed Kowen Forest Magnetic Observatory for a small palaeomagnetic building. Plans for this building have been drawn up by the Department of Construction. Fourthly, it is planned to construct a thermal demagnetizer which will be installed on completion of the palaeomagnetic building. These facilities would be adequate for the measurement of most igneous, and the more magnetized sedimentary rocks. The co-operation of the Research School of Earth Sciences is, however, still required for the magnetically weaker rocks.

A BASIS FOR A FUTURE BMR PALAEOMAGNETIC PROGRAM

In view of the recent advances in magnetometer design, certain current and projected programs of the BMR would now benefit from the application of magnetic remanence studies. The Committee has received 16 written submissions from Bureau officers suggesting projects (see Appendix 3) and from these and the numerous oral submissions and discussions the following notes have been compiled. Many of the submissions have been combined and are described below as "Period Studies"; these are of broad significance. Others relate to local geological problems and are named where appropriate.

1. Magnetostratigraphic Studies

A magnetostratigraphic study involves the determination of the magnetic polarity pattern preserved by a rock unit during its formation and, where the time of formation is sufficiently long, the path of apparent polar wander. It is evident from the use of these two sets of data for different rock units of similar age, that in the magnetostratigraphic method, one has a potentially powerful tool for correlation of rock units - of intrabasin, interbasin and intercontinental extent - particularly because the method is independent of facies changes. In addition, once the apparent polar wander curve for a plate is well established, apparent pole positions can be used to date rock bodies. To do this the poles are plotted on the polar wander curve, thus relating the rock body to others used in constructing the curve.

It is important to note that there are very significant by-products of magnetostratigraphic studies. Firstly, they lead to a continuing refinement of the apparent polar wander curve, which thereby becomes more useful for dating, and for studying plate movements. Secondly, magnetostratigraphic studies provide the palaeolatitude information necessary for palaeogeographic reconstructions and palaeoenvironmental interpretations.

Magnetostratigraphy will become an important part of the "Period Studies" now under consideration. In these studies all available techniques of correlation and dating will be employed. Period Studies given particular emphasis below are those for the Carpentarian, Adelaidean-Early Cambrian, Cambrian-Early Ordovician, Permian and Tertiary. Already within the Bureau there are extensive studies that could be integrated under these headings, and many of the proposals we received relate to these time intervals. The particular uses of magnetostratigraphy in this context are the correlation of rock facies with few or no fossils in common (many fossils are restricted to particular rock types), the correlation of unfossiliferous rock units, and use in combination with fossils and other dating methods where these provide only broad correlations (especially in Precambrian rocks at the present stage of knowledge).

(i) Tertiary and Quaternary: A project is currently being considered which would collate all data of value in dating and correlating Australian Tertiary sediments. This would include the dating of weathering events (particularly silcrete, laterite and bauxite formation) which have already been the subject of preliminary palaeomagnetic studies. Tertiary and Quaternary marine sediments can be readily dated palaeontologically, though even there problems occur, but it is particularly difficult to date the widespread non-marine sediments. This is because many lack spores and pollen as a result of weathering during or after sedimentation. Magnetostratigraphic studies may aid correlation of the marine and non-marine sequences and thus allow a comprehensive analysis of the Tertiary and Quaternary history of the continent. This will be important in understanding ore deposits such as bauxite, weathered iron-formations, heavy mineral sands and sedimentary uranium.

(ii) Permian: Rocks of the Sydney Basin provide the opportunity to establish a magnetostratigraphic standard for the correlation of Permian sediments. If such a standard can be established it would help resolve correlation problems resulting from the provincialism of many Australian Permian faunas. Here, as in other basins, the magnetostratigraphic work must be integrated with palaeontological and isotopic studies.

(iii) Middle Cambrian - Early Ordovician: Magnetostratigraphy could play a vital role in solving stratigraphic problems in the Georgina Basin, and would be of immediate use in the current Georgina Basin Project. Submissions have been received which involve particularly the Cambrian and Ordovician stratigraphy of the basin. For instance, the Ninmaroo Formation has been shown to be time-transgressive, but correlation of many sections of the formation within the basin is impossible because of the very restricted distribution of the faunas. Therefore it is not possible to make precise palaeoenvironmental reconstructions. Such reconstructions are essential, not only for obtaining a general understanding of the basin, but also for understanding the genesis of the base metals within the carbonates of the formation. Dolomites are abundant in the Georgina Basin. They are difficult to interrelate because of poor palaeontological control. Magnetostratigraphic studies could help here and may provide the key which allows basin syntheses.

(iv) Adelaidean-Early Cambrian: Sediments deposited in the time interval 1000 m.y. to Early Cambrian are widespread in Australia and form a distinct sedimentary-tectonic unit (e.g. Adelaide Geosyncline, Amadeus Basin, basal Georgina Basin, Ngalia Basin, Kimberley region). A widespread break in sedimentation occurred in about Ordian (late Early Cambrian) time. Sediments older than this are very difficult to date and correlate because of the endemic or long ranging nature of the fossils and the weathered condition of the volcanics. Bureau projects currently concerned with these sediments are the Georgina Basin Project and the Precambrian Fossils Project. Submissions have been received concerning correlation of the widespread Early Cambrian (?) volcanics (e.g. Antrim Plateau Volcanics) with the late Adelaidean to Early Cambrian sediments of the Georgina Basin, and correlation of sediments of this age within, or below, the Georgina Basin, with those of the Amadeus Basin. Such correlations are essential if the tectonic and sedimentary history of central Australia is to be understood. They are basic to understanding the development and evolution of the Georgina Basin. Every practicable method of correlation is being used and present indications are that magnetostratigraphy will play a vital role. Magnetostratigraphic studies of the late Adelaidean-Early Cambrian red beds of the Amadeus and Georgina Basins have already indicated the feasibility and potential value of this method, and provide a firm basis for future work.

(v) Carpentarian: Rocks of this age are economically important - e.g., Broken Hill, Mount Isa and McArthur River base metal ore bodies. Correlation within and between the McArthur Basin and Mount Isa region present problems which greatly restrict possible studies of ore genesis. Thus correlations between the eastern and western troughs of the Mount Isa Orogenic Zone are tenuous and correlations within the McArthur Basin from the Batten Trough to the surrounding shelves are very difficult. Consequently it is not known whether the major ore bodies are of the same age. A prerequisite for understanding the interrelationships of the ore bodies will be a reliable knowledge of the palaeogeography of the basins.

(vi) Other geological problems: Several submissions were received concerning dating and correlation problems in the Pine Creek Geosyncline and the Arunta Complex. In both these units a framework of isotopic datings is already available and magnetostratigraphic techniques may be applicable to solving problems that have proven intractable using other methods. Refer to submissions 3.3, 3.4 and 3.5. Similarly it may be possible to obtain new information that will facilitate correlations between the various Archaean greenstone belts in Western Australia. Such correlations are presently very difficult, dubious or impossible.

Magnetostratigraphic correlations could be used to solve problems for which the time scale involved is comparable to the uncertainty in isotopic age. Such a project concerns the Newcastle Range Volcanics in Queensland (Submission 3.8) where outcrops of the volcanics are separated by fault zones which prevent direct correlation.

The establishment of a soil stratigraphy in the Canberra area is important for engineering geology. The present stratigraphic schemes are controversial. Magnetostratigraphic methods may aid in the solution of soil correlation and dating problems.

2. <u>Dating of Ore Bodies/Ore genesis studies</u>

Most ores should possess a magnetic remanence. This will arise if the ore is of a magnetic compound - e.g., iron ore, nickel ore, chromite - or if a non-magnetic host ore contains trace amounts of magnetic minerals - e.g., magnetite, hematite and pyrrhotite. Remanence studies on ores could be used for their dating and for studies of their genesis - e.g. whether an ore is syngenetic or epigenetic, whether mineralization in a structure was pre- or post-folding, whether it was related to local igneous intrusion. Little work has been done so far on ores other than of iron, but the area is one of promise. Particular problems to which attention could be directed immediately are the dating and genesis of the McArthur River, Mount Isa and Broken Hill ore bodies, of the secondary iron ores of the Hamersley Basin, of the widespread bauxites, and of the uranium ores of the Northern Territory.

3. <u>General dating/Correlation of igneous rocks</u>

A better defined apparent polar wander path for Australia will, in the long term, be an important by-product of magnetostratigraphic studies. As a result, the palaeomagnetic technique will act as an additional method of dating rocks and may succeed where isotopic techniques fail owing to metamorphism. Remanence directions would also provide a rapid method for separating apparently similar igneous rocks into different igneous events. Any project in which igneous rocks are involved would profit from such studies (e.g. see Pine Creek Geosyncline, Submission 3.3).

4. <u>Tectonics</u>

Large-scale relative motions between cratons and local-scale rotations of small blocks are potentially detectable palaeomagnetically. Palaeomagnetic data derived from studies as in (1) and (3) would play an essential part in solving tectonic problems involving large-scale relative motions. Problems of this nature are the evolution of the Australian continent (important background knowledge when considering the distribution in space and time of mineralization), the relationship of Antarctica to Australia in the Precambrian (whether there is likely to be a counterpart of the economically important Yilgarn Block in that part of Antarctica which was adjacent to it before the Tertiary separation) the tectonic history of New Guinea and the Lachlan scale rotations of small blocks are potentially detectable palaeomagnetically. Palaeomagnetic data derived from studies as in (1) and (3) would play an essential part in solving tectonic problems involving large-scale relative motions. Problems of this nature are the evolution of the Australian continent (important background knowledge when considering the distribution in space and time of mineralization), the relationship of Antarctica to Australia in the Precambrian (whether there is likely to be a counterpart of the economically important Yilgarn Block in that part of Antarctica which was adjacent to it before the Tertiary separation) the tectonic history of New Guinea and the Lachlan Geosyncline (demonstration of the applicability of plate tectonic models would be significant in terms of metallogenesis because of the connection between certain types of mineralization and plate margins - e.g. base metal sulphides, chromite, asbestos).

Particular attention should be given to Antarctica because its positioning in relation to Australia is of broad significance. The collecting of samples for palaeomagnetic studies would be a small addition to the Bureau's current program on that continent.

AVENUES OF CO-OPERATION BETWEEN BMR, ANU, AND CSIRO

1. Roles of each institution

Broadly speaking the roles of the separate institutions fall naturally under the following headings.

ANU - a global approach; establishing and improving the polar wander path for Australia; investigations of continental drift. Also, the Economic Geology Department would use palaeomagnetism in elucidating history of formation of ore bodies.

CSIRO - their policy is that their work should be of assistance to the mining industry. They propose development of techniques, and investigation and demonstration of the feasibility of application of the techniques under various geological environments, particularly in sedimentary basins.

BMR - would apply palaeomagnetism - probably mainly magnetostratigraphy - in solving problems arising during the study of geological provinces where palaeontological methods and isotopic dating do not give the answers, or where palaeomagnetism would give useful additional information.

Thus the three organisations would have complementary roles; however, these are not intended to be mutually exclusive, and overlap is inevitable; for example, BMR's magnetostratigraphic work in the Precambrian could well contribute to establishing a polar wander curve for that period.

2. Existing facilities

ANU has a long-established palaeomagnetic laboratory at Black Mountain; it contains spinner magnetometers, sample preparation equipment, and AF and thermal demagnetizing apparatus. At present they have on loan a SQUID magnetometer, to be returned to USA in August 1976.

CSIRO has a spinner magnetometer and AF demagnetizing equipment at the Mineral Physics Laboratories, North Ryde, Sydney. It also has facilities for helium liquefaction.

BMR has a high-speed spinner magnetometer, sample preparation facilities, and drilling equipment.

3. Requirements for a co-operative facility

The main requirement is for a SQUID magnetometer to be available for use by the three institutions, for the reasons set out above (vastly improved sensitivity and speed of operation).

In order to take full advantage of the potentialities of this equipment, and to reduce the costs to any one institution, it is evident that co-operation in acquiring and using the equipment is highly desirable.

Subsidiary to the SQUID magnetometer, the following are required: housing, ancilliary computing facilities, increased facilities for sample preparation and demagnetizing to handle the large number of samples envisaged, helium recycling facilities, non-magnetic drilling bits, rods, and core barrels to avoid artificial magnetization of the samples, provision of on-site staff to maintain equipment, and to ensure proper operation; allocation of professional and/or technical staff by each co-operating institution to manage its own program, prepare samples, carry out measurements, analyze results, and report on them.

4. Potential contributions by the co-operating institutions

CSIRO has $25,000 for a SQUID on 76/77 estimates, and expects to go ahead with purchase shortly.

ANU can readily provide housing facilities. As they have managed to accommodate a SQUID in their existing building, this is obviously feasible; however, to accommodate the extra personnel from BMR and CSIRO an extension of about 3 squares is desirable. They believe they could finance this for about $10,000, which they should be able to find. They can also readily improve their magnetic "washing" facilities using their own workshop time and only minor expenditure. They could also provide the staff for routine maintenance and operation. They have temporarily arranged a computer interface for the SQUID magnetometer on loan; the results of preliminary processing of the measurements are output onto paper tape in a format ready to feed into the main ANU computer. However, an additional computer is required, as the existing one is required for its previous work; the additional computer would avoid the need to transfer tapes to the main university computer.

CSIRO can provide helium liquefaction facilities at Sydney, and would be prepared to move their palaeomagnetic laboratory and staff to Canberra to take part in the joint program. Provision of liquefaction facilities at Canberra is considered too expensive at present (in excess of $50,000); however, recycling equipment costing about $10,000 would greatly facilitate handling and transport.

BMR could provide drilling facilities, and comparatively minor expenditure would be involved in acquiring the necessary non-magnetic components. In view of the wide deployment of field parties, BMR would be able to collect oriented samples (subject to suitable training of field officers) for its own program, and possibly to some extent for other participants. BMR could offer to provide camping and logistic support for officers of the co-operating institutions wishing to collect their own samples in areas where field parties are working.

It is proposed that major equipment to be provided by BMR should comprise the computer and helium recycling equipment. Both items to be purchased during the 1977/78 financial year. However there is a possibility that a superseded computer from Marine Geophysics might be available; this depends on the relative priorities of other potential users in BMR.

A detailed list of equipment required, and a proposed purchasing program until 1980 by the three co-operating institutions, are set out in Appendix 2. The only equipment purchase proposed for BMR in 1976/77 is two portable drills for about $2,000.

Other possibilities for a BMR contribution considered by the Committee are as follows:

(a) BMR has a Works project for construction of a geomagnetic observatory, including a palaeomagnetic hut, at East Kowen Forest site. The possibility was considered that the funds for this hut could be diverted to extending the facilities at Black Mountain. However, the following objections arose:

(i) Administrative difficulties in varying a plan already drawn up, and the possibility that the building as planned would be unsuitable for the new site.

(ii) Arrangements for a BMR building on a site leased by ANU.

(iii) Current uncertainty whether the East Kowen project will be included in the final 76/77 Works estimates.

(b) Offer for housing the SQUID in the proposed palaeomagnetic hut at East Kowen, at least on a temporary basis. However, the other participants did not seem to be keen on this idea, mainly because of the distance to be travelled, and the necessity of having auxiliary facilities nearby.

(c) Share in purchase of the major equipment with CSIRO and/or ANU. The feeling of the Committee and of some people in BMR, was against sharing expenses in any component item needed for the co-operative project, but this alternative still warrants consideration if other proposals for contributions fall through.

(d) Pay a rental contribution annually to ANU/CSIRO for use of facilities. Dr McElhinny estimates the present running costs of the A.N.U. Black Mountain Laboratory at $10,400, the major item being electric power. Other items include provision of cleaning staff (one morning each week), and the maintenance of buildings and access road. If a consortium were to use the laboratory the running costs would increase considerably. McElhinny suggested that each partner contribute an amount such as $5000 annually towards the running expenses.

The Committee generally felt that the contribution towards the running costs was reasonable.

The sub-committee recommends that a financial contribution be made by way of equipment purchase as set out in Appendix 2, with minor contributions in providing drilling and logistic facilities for both our own program and those of the other participants, that at least 2 professionals and one technical assistant be provided initially; and possibly an annual contribution be made towards running costs of the laboratory.

Further, if we do not make our contribution now, we may miss out on an opportunity of participation in a program with good potential for improving our geological knowledge and solving problems which arise continually during geological investigations. However, BMR should not be involved in the project unless it can make a significant financial contribution and provide adequate staff to ensure real participation with benefits to BMR.

COST ESTIMATES AND STAFF REQUIREMENTS

During two meetings between ANU, BMR and CSIRO representatives held on 24 May and 11 June 1976, a tentative list of equipment and space requirements was drawn up for the proposed joint palaeomagnetic laboratory. The BMR contribution towards this laboratory was suggested as $35,500, with $24,500 to be committed in 1977-78, and $11,000 in 1978-79. Appendix 2 itemizes the laboratory requirements and shows the breakdown of costs between the three organizations. In addition to the items listed, the Bureau requires two portable coring drills for sample collection at approximately $1000 each.

One of the main BMR commitments towards the joint laboratory would be the provision of a minicomputer and associated hardware. It may be noted in this connection that the Marine Geophysical Section is at present proposing to replace its HP 2116 computer. The mainframe of the HP 2116 is suitable for palaeomagnetic computations, and this could significantly reduce the BMR expenditure.

Besides capital items, each organization would be expected to pay a portion of the running costs of the joint laboratory. At present the annual running costs of the Black Mountain laboratory are $10,400, the main expenditures being power, maintenance of the buildings and access road, and the salaries of cleaning staff (half day per week). Additional use of the laboratory will inevitably increase the costs, and therefore contributions of up to $5000 per annum may be expected from each organization. This amount would be subject to annual review.

Palaeomagnetic work would involve sampling, specimen preparation, measurements, analysis of results, organization of laboratory facilities, liaison with project leaders within the Bureau and with other organizations, and detailed planning of programs. It is estimated that a viable palaeomagnetic program in the Bureau requires a group comprising a minimum of two professional officers and a technical assistant (part-time).

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APPENDIX 1
NOTES ON PALAEOMAGNETIC TECHNIQUES

1. Sampling

Samples collected in the field are in the form of oriented blocks or, preferably, drill cores, the orienting instrument being normally a sun compass. The drillcores are obtained with a hand-operated portable coring drill giving cores of 2.5 cm diameter. The size of the collection depends on the nature of the project: the average project would require some 100 samples.

2. Laboratory Measurement

Remanent magnetisations are generally measured with a spinner magnetometer. To assess magnetic stability and to remove secondary components, the samples are subjected to demagnetization in steps. This involves either treatment in alternating magnetic fields (up to 200 mT) or heating in a field-free space (up to 690°C), though other methods such as chemical leaching (dil. hydrochloric acid) and low temperature demagnetization (to liquid nitrogen temperatures) are occasionally used as well.

Other measurements that may be required in the course of a palaeomagnetic investigation include magnetic susceptibility and Curie temperature.

An average project involving 100 samples takes approximately 4 weeks to complete.

3. Data Reduction

Data reduction includes conversion of remanence directions between the different reference systems (sample reference, geomagnetic reference and palaeo pole positions), the conversion of sun azimuth angles to geographic co-ordinates, and various corrections such as tilts of beds. The data are analyzed using Fisher's statistics for the distribution of points on a sphere.

For occasional, small-scale projects a desk top calculator, though very time consuming, is adequate. For work on a continuous basis access to a computer terminal is indispensable.

APPENDIX 2

EQUIPMENT ESTIMATES FOR A JOINT ANU, BMR, CSIRO PALAEOMAGNETIC LABORATORY

The following equipment list is based on discussions with ANU and CSIRO representatives.

1. SQUID magnetometer.
2. A minicomputer for the SQUID magnetometer. This computer is also intended for general palaeomagnetic data reduction at present handled by UNIVAC at the ANU Computer Centre. It is to comprise:
   (i) basic computer with printer (thermal)
   (ii) magnetic tape console and associated hardware.
3. Helium recycling equipment.
4. Liquid helium dewars.
5. Large (50 sample) AF demagnetizer.
6. Large (100 sample) AF demagnetizer.
7. Curie Balance.
8. Mumetal trolley.
9. Mumetal storage containers.
10. Mumetal shielded room.
11. Continuous core 3-component magnetometer.
12. Nonmagnetic fittings for drilling rigs.
13. Extensions to the present ANU Black Mountain Laboratory.

The laboratory is to be set up in three stages.

Stage 1

Item	Date	Estimated Cost	Suggested Contributor
Building extensions	1977-78	$10,000	ANU
SQUID magnetometer	1976-77	$30,000	CSIRO
Computer and printer	Mid 1977	$12,500	BMR
Helium recycling equipment	1977-78	$10,000	BMR
Liquid helium dewars	1977-78	$ 2,000	BMR
Large AF demagnetizer) Large thermal demagnetizer) Curie balance)	1977	$5,000*	ANU
Mumetal trolley) Mumetal storage containers)	1977	$ 2,000	ANU

* Includes cost of components only

During Stage 1 the laboratory will become operational for high sensitivity measurements.

Stage 2

Item	Date	Estimated Cost	Suggested Contributor
Magnetic tape transport for computer	1978-79	$10,000	BMR
Nonmagnetic fittings for BMR drilling rigs	1978-79	$ 1,000	BMR

Stage 3

Development of three-axis SQUID magnetometer for continuous core measurement	1980	$ 5,000*	CSIRO
Mumetal shielded room	1980	$30,000	ANU
TOTAL COST		$112,500	

The total cost would be shared as follows:

BMR	$35,500
CSIRO	$30,000
ANU	$47,000

It should be noted that the figures for ANU and CSIRO do not include development costs. The true costs would therefore considerably exceed those shown.

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* Includes cost of components only

APPENDIX 3
PROJECT SUBMISSIONS

List of Projects:

3.1 Mount Isa Geosyncline
3.2 Western Pine Creek Geosyncline
3.3 Eastern Pine Creek Geosyncline
3.4 Arunta Block
3.5 Arunta Block
3.6 Central Australian Sedimentary Basins
3.7 McArthur Basin
3.8 Newcastle Range, Queensland
3.9 Dating of Laterites
3.10 Georgina Basin
3.11 Antarctica
3.12 Sydney Basin
3.13 Correlations within the Ninmaroo Formation
3.14 Problems of Engineering Geology in the Canberra Region
3.15 Hydrological Problems
3.16 Importance of Phanerozoic Palaeomagnetic Studies

3.1 Mount Isa Geosyncline

It seems that considerable use can be made of the palaeomagnetic method in the Mount Isa region. Some of the potential uses are listed below.

(i) Intra- and interbasin correlations:

At present intrabasin correlations are made across the median tectonic ridge, using sedimentary patterns and periods of tectonism as markers. Magnetostratigraphy could play a role in confirming these correlations. Rock types involved are ferruginous sands, calcareous/dolomitic sands, and impure dolomites, all of about Mount Isa Group age.

Concerning interbasin correlations, some interest has been shown recently in the correlations between Broken Hill and the eastern part of the Cloncurry Complex. The suggestion is that these areas may have been much closer in the Proterozoic than they are at present. Available palaeomagnetic data, presented by Giddings, suggests that no movement has occurred, but at this stage the data are too few for a reliable conclusion. Palaeomagnetic verification of intercratonic separation combined with magnetostratigraphic correlations could have some impact on the methods of exploration for Broken Hill-type orebodies.

Similar, but less specific, problems could exist between the Mount Isa region and the McArthur Basin to the north-west.

(ii) Application to orebodies:

The Committee should provide some guidance as to how the palaeomagnetic method may be applied to orebodies. It would appear that remanence studies on orebodies and the enclosing country rocks may indicate whether or not mineralization is epigenetic or syngenetic. One example for consideration might be the Mammoth orebody, north of Mount Isa. Host rocks are the Myally Subgroup, but the deposit is highly brecciated, and lies near the unconformity with the overlying Gunpowder Creek Formation, about 100 m.y. younger than the Myally Subgroup. Certain geologists hold that this deposit does not necessarily increase the potential of the Myally Subgroup as an exploration target, and they suggest that diagnetic and post-depositional leaching of metals from both older and younger sequences may have occurred, followed by deposition in favourable structural sites. Can the Committee indicate whether palaeomagnetic methods could elucidate this problem?

(iii) General dating/Refinement of apparent polar wander curve

The Mount Isa region contains numerous rock types probably suitable for palaeomagnetic methods. Apart from dolerites of various ages and degrees of preservation/alteration, there are magnetite-bearing porphyries, belts of folded greenstone/metabasalt, magnetite-rich metasediments, and certain heavy mineral-banded sediments. Metamorphic magnetite masses abound, and skarn mineralization is common near some plutons. Considerable potential therefore exists for the refinement of the apparent polar wander curve particularly as we already have, and expect further refinement of, some isotopic ages.

A better defined apparent polar wander curve could prove useful for palaeomagnetic dating of metamorphic events in the region and for the studies concerning intercratonic motion mentioned in (i) above.

Finally, the recent circulation of explanatory notes on the subject of palaeomagnetism was most welcome, and I am convinced that the method will increase rapidly in importance as a tool in the understanding of earth science. It behoves the Committee, and/or experts in this field, to continually bring to the user's attention all relevant developments and applications of palaeomagnetism, so that the most efficient use can be made of the vast storehouse of geological information contained in the various projects under way in this Branch.

G.M. Derrick

3.2 Western Pine Creek Geosyncline

(i) To correlate ironstone marker beds in the Rum Jungle Area within the Golden Dyke Formation with ironstone beds in the same formation in the Burnside and Mt Bundey areas.

(ii) When the apparent polar wander curve has been reasonably well defined, palaeomagnetism may provide useful additional information concerning the ages of the Burnside, Margaret and Fenton Granites and the amphibolites intruded into the Golden Dyke formation in the Batchelor/Tipperary 1:100 000 sheet areas.

I.H. Crick

3.3 Eastern Pine Creek Geosyncline

Palaeomagnetic studies could prove useful in the Pine Creek Geosyncline. Semi-detailed mapping is under way, and geological knowledge of the area is good. A framework of Rb-Sr ages is available for parts of the region, especially in the Alligator Rivers uranium field.

Potential for the technique falls into 2 main categories:

(i) Filling in gaps in the Rb-Sr framework - e.g., dating of the Carpentarian sandstone and interbedded altered basic volcanics and granites not possible by Rb-Sr dating. The same applies to unfossiliferous Mesozoic rocks. The Carpentarian in the area is the base of the Australian Carpentarian sequence, and dating would therefore be important. Dates on the Lower Proterozoic metasediments of the geosyncline could perhaps also be obtained.

(ii) Correlation of units by magnetostratigraphy - e.g., between volcanics of Carpentarian age in separate basins not correlatable even on petrographic grounds; correlation of the Carpentarian sandstone of the Arnhem Land Plateau, the Tabletop Range, and intervening basins. Correlation of metasediments in the geosyncline would facilitate palaeoenvironment reconstructions and would provide a check on our ideas of correlations of units with associated uranium mineralization in the Rum Jungle (central basin), South Alligator River valley, and Alligator Rivers parts of the geosyncline.

Other possibilities include distinguishing between Oenpelli Dolerite and Zamu Complex dolerite in the southern half of the Mt Evelyn Sheet area, where, on field examination, the two can be indistinguishable in spite of an age difference of at least 120 m.y.

This work could tie in well with any similar studies in the adjacent McArthur Basin.

R.S. Needham

3.4 Arunta Block

The original sedimentary and volcanic rocks of the Arunta Block are everywhere metamorphosed to various degrees, ranging from greenschist to granulite facies. Isotopic dates so far obtained date only the time(s) of regional metamorphism, or of granite crystallization. In order to try to obtain an idea of the time of deposition of the Arunta sediments, we propose a preliminary palaeomagnetic study of the Lander Rock Beds, which are a widespread unit of slate, metasandstone, and minor amphibolite at or near the base of the Arunta sequence. The rocks are metamorphosed to the greenschist facies. The proposal is to collect, during the 1976 field season, four batches of oriented samples, ten in each batch, at each of three localities about 10 km apart in the Lander Rock Beds, making a total of about 120 samples. The samples will be taken from opposite limbs of folds of known geometry and orientation, so as to enable the reconstruction of the undisturbed rocks. Details of sampling procedure have already been discussed with Dr J. Giddings. Analysis of the samples should tell us (1) whether the rocks have retained their original magnetisation, so that they may then be fitted into a curve of apparent polar wander, and thus give an approximate date of deposition when the curve is fully calibrated, or (2) whether the rocks have acquired a new magnetic fabric during the low-grade regional metamorphism, so that their time of deposition cannot be determined. If the rocks do prove to be suitable, we should then consider a larger-scale sampling programme in order to test our correlation of the Lander Rock Beds with certain other units in the Arunta Block, and with the Warramunga Group of the Tennant Creek Block and with the Tanami Complex of the Granites-Tanami Block.

A.J. Stewart

3.5 Arunta Block

Rb-Sr work in the Arunta enables us to determine ages of metamorphism and intrusion only. However, we are also interested in determining the original ages of the various rock units - e.g., Lower Proterozoic Reynolds Range Group. Could you date samples of hematite-quartzite from the Mt Thomas Quartzite member? The rock is weakly foliated and metamorphosed to greenschist facies. There is a strong aeromagnetic anomaly along one side of the outcrop of the quartzite. It may be too strong to be accounted for by hematite: magnetite may be present at depth.

Could you date fine-grained magnetite in Mud Tank Carbonatite? So far we have isotopic ages, ranging from 1150 m.y. to 300 m.y. by various methods; none is conclusive.

A.J. Stewart

3.6 Central Australian sedimentary basins

There are several potentially rewarding projects. Probably the more important are -

(i) Dating and magnetostratigraphy of the Precambrian-Cambrian boundary in the Arumbera Sandstone (this is being attempted on a small scale by the Research School of Earth Sciences, A.N.U.).

(ii) Dating of the onset of sedimentation in the Ngalia and Amadeus Basins, and resolving the postulated contemporaneity of the Heavitree and Vaughan Springs Quartzites. The Vaughan Springs Quartzite has been dated at 1280 m.y. (glauconite age), but migmatisation dates in Arunta suggest that the Heavitree Quartzite is younger than 1070 m.y.

(iii) Dating and magnetostratigraphy of Precambrian sections in both the Ngalia and Amadeus Basins to establish correlations.

A.T. Wells

3.7 McArthur Basin

A major program of detailed studies and remapping in the McArthur Basin (N.T.) is scheduled to start in 1977; the aims and objectives of the project are discussed in some detail in a draft proposal that is available in the Geological Branch (K.A. Plumb). Although not specifically mentioned in that proposal, I submit that the Committee should consider including palaeomagnetic studies in the McArthur Basin in any future BMR program in palaeomagnetism.

At this early stage it is inappropriate to attempt to formulate a detailed program of likely requirements for palaeomagnetism. More detailed planning could take place once field operations have commenced, and requirements are better understood (late 1977 onwards).

In general, palaeomagnetic studies could provide information on:

(i) Large-scale tectonic and structural problems

(ii) Ages of rock formations

(iii) Interbasin and intrabasin correlations, particularly of the carbonates of the ore-bearing McArthur Group.

The results could be of great benefit in determining the palaeogeography and tectonic evolution of this part of Northern Australia.

M.J. Jackson

3.8 Newcastle Range, Queensland

The Newcastle Range Volcanics are a suite of late Palaeozoic (Carboniferous) continental volcanic rocks in the central Georgetown Inlier, northeastern Queensland. Rhyolitic (rhyodacitic) ignimbrites dominate the unit, and are preserved in several structures which have some similarities to cauldron-subsidence areas.

Systematic semi-detailed mapping of the Newcastle Range Volcanics will be completed during the coming (1976) field season. It is anticipated that the data collected, when synthesised, will enable the Volcanics to be used as a "model" for better understanding of similar ignimbrite-dominated sequences which are common in northeastern Queensland.

Now that the structure and stratigraphy of the Volcanics are known in fair detail, it is apparent that two separate stratigraphic sequences are present. The most extensive of these sequences is in the main part of the Newcastle Range; it is separated from a second sequence in the eastern part of the range by a zone of high-angle faults and dykes. One unit may be common to both sequences, but it is the highest preserved, and lies unconformably on older units in both parts of the range. Preliminary analytical results indicate that rocks in the two sequences had different initial $^{87}Sr/^{86}Sr$ ratios, suggesting the presence of two separate magma sources. Preliminary total rock Rb-Sr isotopic data indicate that the two sequences do not have statistically different ages - i.e., the age differences are in the order of only a few million years at most, probably not resolvable by isotopic methods.

Magnetostratigraphy appears potentially capable of solving the problem of the respective ages of the main and eastern range sequences of the Newcastle Range Volcanics. By next (1977) field season it will be clear whether or not isotopic methods can solve the problem, and that would be an appropriate time to collect samples for palaeomagnetic investigation.

B.S. Oversby

3.9 Dating of Laterites

Dating of laterites, etc., by palaeomagnetic methods has already proved useful in the Eromanga Basin, where it has provided a significant advance in Cainozoic stratigraphy.

The method could be used in parts of the Otway and Murray Basins, where detailed Cainozoic stratigraphy is available from a knowledge of fossils, superposition, pedology, and geomorphology.

The method would be particularly useful in other parts of Australia where Cainozoic successions are poorly fossiliferous - e.g., in the Karumba Basin (Gulf of Carpentaria drainage basin). In such cases palaeomagnetics offer the best hope of dating the successions.

H.F. Doutch

3.10 Georgina Basin

The following studies relating to the Georgina Basin are proposed:

(i) Extension of work undertaken by J.L. Kirschvinck in the Ross River and Central Mount Stuart areas to the Huckitta region of the southern Georgina Basin.

(ii) Having established a reference framework in these areas, assess the relationships of:

(a) the dolomites within the Mount Baldwin Formation to the Camooweal Dolomite and Thorntonia Limestone;

(b) the volcanics (Colless) of supposed Early Cambrian age which crop out along the northern margin of the Georgina Basin to the Antrim Plateau/Nutwood Downs Volcanics, and the siliciclastics of the southern and eastern margins of the Georgina Basin (Mount Baldwin Formation and correlatives).

These studies will specifically aid the understanding and definition of the base of the Georgina Basin.

(iii) Extend the reference framework of magnetic events into the Middle Ordovician of the Georgina Basin, using Middle Cambrian to Lower Ordovician carbonate sequences in the Burke River area and Lower to Middle Ordovician siliciclastics in the Toko Range. It would be interesting to note any magnetic change occurring at or near the bases of the Templetonian and Idamean Stages as these represent major faunal reorganisations of global significance. As this sequence is presently being subdivided by biostratigraphical criteria with a fine degree of precision, the value of any magnetic datum discovered should be greatly enhanced.

J.H. Shergold

3.11 Antarctica

Palaeomagnetic studies in Antarctica are desirable because so few have been undertaken in that continent. Its polar wander path is consequently very poorly defined. A refined path would have three important uses:

(i) It could be used as a supplementary dating technique

(ii) It is a prerequisite for projects in which the relationship of Antarctica to Australia figures prominently

(iii) It would provide additional control in magnetostratigraphic studies.

BMR activities in the Enderby Land and the Lambert Glacier-Prince Charles Mountains areas place it in an excellent position to attempt to remedy the paucity of palaeomagnetic information. The most favourable accessible area is the Vestfold Hills where an extensive suite of unaltered dolerite dykes of about 1400 m.y. age is exposed. It has already been sampled and examined on an exploratory basis by Arriens & Embleton (1973), and Arriens' presence in the area this year should lead to further sampling. There are however, unaltered dykes and flows in other areas. In the current work area, Enderby Land, unaltered dolerite dykes are known at a number of localities. Palaeomagnetic work done here, in conjunction with isotopic age determinations, may yield a number of dated pole positions. The Permian sedimentary sequence at Beaver Lake may also provide useful information.

In summary, the chief need for Antarctic palaeomagnetic work lies in the paucity of present data; the opportunity for fieldwork is provided by logistic support for other field programs. If the maximum scientific benefit is to be derived from the logistic dollars, then palaeomagnetic studies in Antarctica clearly warrant serious consideration. Furthermore such studies formed part of the recommendations of the Advisory Committee on Antarctica Geoscience programs of the Geological Society of Australia.

R.J. Tingey

3.12 Sydney Basin

The Sydney Basin offers an opportunity for investigating palaeolatitude changes and magnetic reversal patterns for the time span Carboniferous to Triassic. The continuous nature of the succession would enable it to be used as a magnetostratigraphic standard against which other sections of similar age could be compared - e.g., Bowen Basin.

Palaeomagnetism may help to resolve correlation problems resulting from the provincialism of many Australian Permian faunas.

J.M. Dickins

3.13 Correlations within the Ninmaroo Formation

The Ninmaroo Formation is a sequence of interbedded limestone and siltstone of Upper Cambrian to Lower Ordovician age.

The formation is extensively exposed in the south-eastern part of the Georgina Basin where the diachronous nature of this unit has been established from conodont biostratigraphy. The Ninmaroo formation youngs to the south-east.

Because of the abundance of restricted marine carbonates-faunas are sparse or non-existent in many areas where time correlation is desirable for palaeogeographic reconstructions. Magnetostratigraphic studies could provide the key to correlation of the carbonates on a regional scale.

Ninmaroo sections which currently require correlation (no or limited fauna for biostratigraphy) are in the Linda Downs, Alderley, Glenormiston-Mt Whelan, and Toomba Fault areas.

It may be possible to relate the magnetic zonation with biostratigraphic zones. This could be best achieved at the Black Mountain section, east of Boulia, Qld, where a well exposed sequence of Upper Cambrian to Lower Ordovician carbonates has already been biostratigraphically zoned.

B.M. Radke

3.14 Problems of Engineering Geology in the Canberra Region

(i) Drillcore Correlation:

The sedimentary sequence in Canberra is extensively faulted. This creates problems of correlation between drillcores from different sections.

Can the drillcores be correlated magnetostratigraphically?

At present we have:

(a) 165 m of unoriented core from southern margin of Black Mountain in the State Circle Shale (Lower Silurian).

(b) 300 m of unoriented core from Canberra Group Middle Silurian comprising calcareous mudstone, sandstone, and some limestone. The material has been partly reconstituted to greenschist facies.

Further cores will become available in the future.

(ii) Soils of Canberra

The soils of Canberra range from present-day back to Miocene. A soil stratigraphic column based on van Dyk's work is of considerable use to engineering geology; however, the ages of the various soils are a source of controversy.

The soils can be readily exposed by digging pits, or can be cored as required.

Is there a possibility that a dating of soils from palaeomagnetism could provide a more acceptable method of age determination than the current geomorphic hypothesis?

E.G. Wilson

3.15 Hydrological Problems

Following are some examples showing how palaeomagnetism may be applied to hydrological problems.

1. The Murray Valley contains unconsolidated Quaternary sediments increasing in thickness from 30 m near Albury to 300 m near Mildura. The sediments contain a complex of relic stream channels which govern the groundwater flow. For a hydrological interpretation of the valley the relic channels need to be traced. Augering would provide a suitable method, but there is at present no way of deciding on the channels to which auger samples should be assigned. Since the relic stream channels have different ages, palaeomagnetism may be used as a correlation tool for this purpose.

2. A groundwater problem, common to the east coast of Australia, concerns dune complexes. Old land surfaces within the dune complex act as bases for perched water tables. To understand the groundwater flow, the continuity of these surfaces needs to be determined by examination of widely separated stratigraphic sections. The land surfaces are of different ages, and palaeomagnetism may consequently again be used for correlation. A particular example of this type of problem is to be found on Stradbroke Island which is planned as a future Brisbane water supply.

3. The Burdekin delta investigation suggests the existence of old impermeable levee banks which interfere with the recharge. This would be probably the cheapest area to test the use of palaeomagnetism for hydrological problems.

E.J. Polak

3:16 Importance of Phanerozoic Palaeomagnetic Studies

The applications of palaeomagnetic work have been looked at with interest in the Petroleum Exploration Branch and it is generally agreed that BMR's activity in this field should be expanded as it should be a very useful technique in adding to our knowledge of the geological history of Australia.

The determination of polar wander curves and hence the relative movement of plates and also palaeo-depositional environments can make an important contribution to assessing the petroleum potential of sedimentary basins. I am therefore disappointed that the BMR program appears to be orientated more towards the Precambrian rather than the Phanerozoic. I would like to suggest that BMR should initiate a program aimed at defining the polar wander curve better, especially for the Palaeozoic, so that more detailed work could be planned either side of suspected plate boundaries and strike-slip faults within the continent to see if any relative movement can be detected.

Our Core and Cuttings Laboratory has a large collection of cores and cuttings from petroleum exploration wells. The cores, of course, are not orientated, but it may be possible in some cases to use the dipmeter log to determine the orientation of the core. I know Dr McElhinny stated that it was not possible to use material from wells drilled with steel pipe and bits, but my impression was that he was speaking of diamond core drilling and that the heat generated caused the problem. It may be that in rotary holes the cooling effect of the mud may protect the material from any magnetic change. It would be a great pity not to make use of the vast amount of material we have for palaeomagnetic measurements if it were at all possible.

With regard to BMR's contribution to the joint exercise with CSIRO and ANU I support the purchase of the magnetometer by BMR.

Summarising, the Petroleum Exploration Branch supports the Committee in its efforts to implement a more significant palaeomagnetic program within BMR, but would like more effort directed to the Palaeozoic era.

E.R. Smith