THE PRINCIPLES & PRACTICE OF GEOPHYSICAL PROSPECTING

AUSTRALIA

Areas investigated by the Imperial Geophysical Experimental Survey

(G1) Gravimetric Survey No. 1
(E6) Electrical ,, No. 6
(S2) Seismic ,, No. 2
(M3) Magnetic ,, No. 3

Compiled by D. F. McGregor

THE PRINCIPLES & PRACTICE OF GEOPHYSICAL PROSPECTING

BEING THE

REPORT

OF THE

IMPERIAL GEOPHYSICAL EXPERIMENTAL SURVEY

Edited by

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PREFACE

The work which is recorded in these pages was carried out under the joint auspices of the British Empire Marketing Board and the Commonwealth Government, each contributing £16,000 towards its cost. The object was not to prospect for minerals but to test the applicability of various geophysical methods under field conditions in Australia which, it was considered, might be regarded as fairly characteristic of considerable portions of the British Empire.

The Executive Committee, which undertook responsibility in Australia for the work, included Mr H. W. Gepp (with whom the whole idea of the Survey originated in 1927), representing the Development and Migration Commission, Mr W. E. Wainwright, representing the Australasian Institute of Mining and Metallurgy, Mr E. C. Andrews (N.S.W.) and Dr L. Keith Ward (S.A.), representing the several States, and Professor T. H. Laby of the University of Melbourne, with Mr G. A. Cook as Secretary. To these gentlemen the Survey is under deep obligation. Early in 1929 the Geophysical Survey Research Committee was formed in London through the Department of Scientific and Industrial Research and direct contact was effected by a visit from one of its members, Professor A. O. Rankine: also an officer of the Department was attached to the Survey during the second year. The Australian Committee desires to express its appreciation of the ready advice and assistance thus provided. The lines followed by the Survey have developed from those broadly suggested by the Geophysical Sub-Committee of the Committee of Civil Research, whose report was published for the Empire Marketing Board by H.M. Stationery Office in 1927.

Under the title of the Imperial Geophysical Experimental Survey, field parties have worked in selected, widely separated areas in the six Australian States. Everywhere they have been accorded assistance by the State Departments of Mines and to these the Survey is indebted for the carrying out of confirmatory work by drilling and shaft sinking, without which the value of the geophysical observations and predictions could not have been assessed accurately. The Universities, particularly those of Sydney and Melbourne, have helped in many ways. In the Physics Department of the University of Melbourne, laboratory and workshop facilities have been generously provided throughout the investigations.

To the Director of the Survey, Mr A. Broughton Edge, and his enthusiastic staff, the Executive Committee offers its warm thanks and congratulations. Their keenness has never flagged, even in circumstances often somewhat trying. The death of the brilliant Deputy-Director, Dr E. S. Bieler, of McGill University, Canada, in July 1929, was a serious blow to the investigation. In particular, the preparation of the electromagnetic sections of this Report has been severely handicapped, since this branch of the investigation was one to which Dr Bieler had brought special knowledge and for the exposition of which he was exceptionally well qualified. In this emergency Professor Laby, at the request of the Australian Committee, came to the aid of the Survey, placing his personal services as consulting physicist unreservedly at its disposal.

It is hoped and believed that the results now made public will be considered to provide justification for the enterprise. Electrical, gravimetric, magnetic, and to a limited extent, seismic, methods have been examined in country carrying sulphide and other ores, brown coal, graphite, saline waters, etc. Apart from the general report upon the field work, full descriptions have been given of the instruments used by the Survey and of the field procedure that has been followed. Accounts of the principles upon which the several geophysical methods are based have also been included and these may be welcomed by students of practical geophysics.

The several sections of the Report have been submitted for comment to leading authorities in Britain nominated by the Department of Scientific and Industrial Research. While the Editors take full responsibility for any errors which may be found in the work as now presented, both they and the Australian Committee gratefully acknowledge the value of the constructive criticism given by:

S. BUTTERWORTH, Esq., M.Sc., Admiralty Research Laboratory, Teddington (Electrical section);

A. F. HALLIMOND, Esq., M.A., Geological Survey of Great Britain (Magnetic section);

H. L. P. JOLLY, Esq., M.A., Ordnance Survey Department (Magnetic section);

E. LANCASTER JONES, Esq., M.A., Science Museum, South Kensington (Electrical section);

Dr W. MCLINTOCK, F.R.S.E., F.G.S., Curator, Museum of Practical Geology (Gravimetric section);

Dr H. MOORE, F.Inst.P., Asst.-Director of Research, British Scientific Instrument Research Association (All sections);

Professor A. O. RANKINE, O.B.E., D.Sc., Department of Physics, Imperial College of Science and Technology, South Kensington (Seismic section); and

Capt. H. SHAW, M.Sc., Science Museum, South Kensington (Gravimetric section).

In some cases the referees' comments have been added as footnotes to the text.

The help of officers of the Empire Marketing Board in completing arrangements for publication is also cordially acknowledged.

That there is ample opportunity within the Empire for the co-operation of physicists and geologists in the search for ore-bodies and the determination of earth structure is fully recognized to-day. A more general realization of the limitations of geophysical methods may also be desirable in those parts where their exploitation by untrained people is not unknown. This report should lead to a more accurate estimation of the present possibilities of applied geophysics.

A. C. D. RIVETT
Chairman of the Australian Geophysical Executive Committee

Council for Scientific and Industrial Research
May 1931 MELBOURNE

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J. McG. Bruckshaw[k], M.Sc. For the Department of Scientific and Industrial Research, London.
J. M. Rayner[l], B.Sc. For the Department of Mines, New South Wales.

TEMPORARY ASSISTANTS (one month or less)

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[a] Died in Australia 25. 7. 29. [b] Resigned 16. 10. 29. [c] Appointed 30. 9. 29.
[d] Appointed 17. 6. 29. [e] Served 14. 1. 29 until 31. 3. 29 and 1. 6. 29 until 15. 2. 30.
[f] Appointed 30. 10. 29. [g] Appointed 16. 1. 29. [h] Assistants provided by other sections as required.
[i] Served 27. 1. 29 until 8. 3. 29. [k] Attached 1. 1. 29. [l] Attached 21. 1. 29.

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The Chairman

THE GEOPHYSICAL EXECUTIVE COMMITTEE

MELBOURNE, AUSTRALIA

Sir,

This final Report of the Imperial Geophysical Experimental Survey, which I now have the honour to submit to the Geophysical Executive Committee, includes a full account of the activities and findings of the Survey, from the date of its inception in London in February 1928, until its close in February 1930; after having completed eighteen months of field work in Australia.

The Report has been prepared in two parts in the belief that by adopting this arrangement the work will prove of value to a wider range of readers than might otherwise be the case. In Part I the field investigations made by the Survey, together with elementary expositions of the different geophysical methods employed, are given in such a manner that they may be followed without serious difficulty, whether the reader be physicist, geologist, or mining engineer. Part II, on the other hand, is devoted to the more detailed explanations of field procedure, design of apparatus, interpretation of results and such theoretical considerations as are necessary for a more complete understanding of the principles upon which the methods are based. Since much of the information regarding electrical instruments has never before been made public it is confidently hoped that this section of the Report will prove of material assistance to those who may contemplate the application of electrical methods of prospecting.

The large proportion of space which has been allocated to the electrical and electromagnetic methods may occasion some comment, but it is thought that this course is fully justified in view of the paucity of information of any practical value which is available regarding these methods, and the fact that the procedure and theory of gravimetric and magnetic investigations are already well established. The position is clearly expressed by the Sub-Committee of the Committee of Civil Research in its Report on Geophysical Surveying[a]. On page 15 of this Report the following statement is made:

> In particular, the electrical method has throughout been treated, by the companies employing it, as a jealously-guarded secret trade process. In the result, little information is available to the general scientific world regarding the methods employed...the apparatus required, the field operations, or the interpretation of results. We believe that...a full disclosure of the scientific facts would tend, more than anything else, to stimulate the natural development of this method of geophysical surveying, by placing it on a scientific footing, similar to that of the gravimetric method.

In submitting this Report it is necessary for me to refer to the serious loss sustained by the Survey in the death of Dr E. S. Bieler, which took place with such tragic suddenness in July, 1929, exactly a year after his arrival in Australia as Deputy-Director of the

[a] *Geophysical Surveying. Report of Sub-Committee of the Committee of Civil Research.* H.M. Stationery Office, London, November, 1927.

Survey. From the inception of the Survey it was realized that the services of a senior physicist of considerable experience were required and the Survey could not have been more fortunate than it was, when Dr Bieler was induced to obtain temporary leave from his post as Associate Professor of Physics at McGill University, in order that he might fill this position. Quite apart from his able guidance in physical matters, his services as Deputy-Director of the Survey were of the greatest value—particularly so during the period of my own absence from Australia, when the technical administration of the Survey was left entirely in his hands.

During the twelve months which preceded his death, Dr Bieler had devoted a large amount of his time and attention to the testing and further development of electromagnetic methods of prospecting; with which he had considerable experience prior to his leaving Canada. Much of this work, and the theoretical aspects of it in particular, had not been formulated in such a manner as to permit publication but, fortunately, it has been possible for Mr J. M. Rayner, who had taken part in the field tests, to prepare an account of the work which Dr Bieler had initiated, and to interpret, to some extent, the rather disconnected series of notes and calculations which were found amongst his papers.

The effects of Dr Bieler's death were serious; particularly so since, in his capacity of senior physicist, he had accepted responsibility for a large proportion of the theoretical aspects of the Survey's investigations. His services during the preparation of the final report had been regarded as indispensable, as there were certain features with which he alone was fully competent to deal. To fill his place during the few months that remained was quite impracticable but, very fortunately, the Geophysical Executive Committee was able to prevail upon Professor Laby of Melbourne University to act as consultant physicist to the Survey until its conclusion. As a member of the Executive Committee, Professor Laby had followed the work of the Survey with great interest and he had already proved an unfailing source of help on many occasions, and since Dr Bieler's death, and during the preparation of this report in particular, his services have been invaluable. Not only has he devoted a large part of his time to advising the several writers on the physical aspects of their subjects, but he has taken an active part in editing the work and in arranging for its publication.

I must also draw attention to the generous assistance and exceptional facilities that have been afforded to the Survey in the many parts of Australia that have been visited. This co-operation and help has been given by so great a number of government departments, mining companies, and other bodies, that to make individual acknowledgments is hardly possible. It is necessary, however, to make special mention of the services rendered by the several State Mines Departments and Geological Surveys, and also by the individual State Geologists and the Geological Adviser to the Federal Government from whom the officers of the Survey have sought advice on so many occasions. Geophysical investigations have been carried out in each of the six States, and in every instance the closest co-operation has been experienced. Guarantees were given by the Departments of Mines that any important results obtained would be followed up and

tested by drilling operations and in many cases the field parties were provided with camp equipment, transport, etc.

The Survey also owes a great debt of gratitude to the Chancellor and Council of Melbourne University for the special facilities that have been put at the disposal of the Survey. Not only have the laboratories and workshop of the Natural Philosophy Department been made fully available for purposes of testing instruments, and effecting repairs, but the preparation of this Report was largely carried out within the University buildings.

In conclusion I should mention that, owing to the immediate dispersal of the personnel of the Survey at the close of the work in Australia, it has been impossible for several of the contributors to this report to receive and correct proofs of their work. The completion of the report and its preparation for publication have been carried out at Australia House (London) where accommodation and every facility have been provided. In this connection I particularly wish to acknowledge the generous help given to me by Mr F. L. McDougall, C.M.G., Mr A. W. Stuart Smith and Dr A. S. Fitzpatrick, and in proof reading by Captain H. Shaw, Mr S. H. Shaw and Mr J. McG. Bruckshaw. An expression of gratitude is also due to the Cambridge University Press for the ready assistance and advice it has given during the final stages of this work.

I am, Sir,

Yours faithfully,

(Signed) A. BROUGHTON EDGE
DIRECTOR
Imperial Geophysical Experimental Survey

Australia House
LONDON
May 1931