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BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD 1961 No. 58

A REVIEW OF GEOPHYSICAL EXPLORATION FOR METALS IN AUSTRALIA

by

J. Daly

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* Imperial Geophysical Experimental Survey
* Aerial Geological and Geophysical Survey of Northern Australia
* Bureau of Mineral Resources, Geology and Geophysics

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PLATE 1 Locality map of metalliferous surveys (G350-26)

PLATE 2 Locality map of aeromagnetic surveys (G350-23)

ABSTRACT

This Record concerns geophysical surveys for deposits of metallic minerals. Part I is a list of official publications containing the results of such geophysical surveys made in Australia and New Guinea by Commonwealth Government organisations. Part II gives comments on some of the broader applications of geophysical methods to metalliferous prospecting, and describes the results that have been obtained in the different States of Australia.

INTRODUCTION

The status of geophysical exploration for oil in Australia has been reviewed in a recent publication (Chamberlain and Maddern, 1959). It is considered that similar reviews of exploration for other mineral deposits would be of interest, and the present review is accordingly devoted to exploration for deposits of metallic minerals. It includes a list of relevant official literature and some comments on topics of general interest, based on the results of previous geophysical surveys.

Attention is confined to surveys conducted by Commonwealth of Australia authorities, the results of which are on file in the Bureau of Mineral Resources, Geology and Geophysics. For this reason, the review can only be an incomplete one. Although a considerable number of geophysical surveys have been done by State Government authorities and by mining companies, the results of the great majority of these surveys have not been published. This review is therefore confined to ground geophysical surveys made by (1) Imperial Geophysical Experimental Survey, (2) Aerial, Geological and Geophysical Survey of Northern Australia, and (3) Bureau of Mineral Resources, Geology and Geophysics and to aeromagnetic surveys made by the Bureau of Mineral Resources.

The choice of surveys referred to is to some extent arbitrary; as a survey intended primarily for one particular purpose may provide information that is valuable for other purposes. The following types of survey have not been included -

(1) surveys for coal. The extent of the work done, and the importance of the results, justify the treatment of the exploration for coal in a separate review.

(2) surveys for radiometric minerals, using only radiometric measuring equipment. However, surveys for radioactive minerals using the standard geophysical methods, and surveys for non-radioactive minerals using radiometric equipment, have been included.

(3) surveys in the search for oil.

All areas surveyed by the aeromagnetic method by the Bureau are shown on Plate 1. In accordance with (2) above, surveys using only the scintillograph are not shown. Many of the aeromagnetic surveys were designed originally to assist the search for oil. However, portions of most surveys have a possible bearing on the search for metallic minerals, and for this reason the map showing the locations of aeromagnetic survey has been included in this review.

Plate 2 shows the locations of all geophysical surveys listed in Part I, below. For convenience of reference, the reports listed in Part I have been divided into groups according to the States and Territories in which the surveys were made.

The list of references at the end of the Record shows only the publications that are referred to in the text.

1. LIST OF I.G.E.S.* REPORTS

All the I.G.E.S. surveys are described in "The Principles and Practice of Geophysical Prospecting, being the Report of the Imperial Geophysical Experimental Survey", edited by A. B. Broughton Edge and T. H. Laby (Cambridge University Press, 1931).

2. LIST OF A.G.G.S.N.A.* REPORTS

In addition to half-yearly reports issued between June 1935 and June 1940, the following detailed reports were published :

Queensland

Report No. 4	Geophysical report on the Soldiers Cap area, Cloncurry district, by J.M. Rayner and P. B. Nye.
No. 5	Geophysical report on the Trekelano area, Cloncurry district, by J. M. Rayner and P. B. Nye.
No. 6	Geophysical report on the Dobbyn area, Cloncurry district, by J. M. Rayner and P. B. Nye.
No. 7	Geophysical report on the Dugald River silver-lead lodes, Cloncurry district, by J. M. Rayner and P. B. Nye.
No. 9	Geophysical report on the Croydon-Golden Gate area, Croydon gold and mineral field, by J. M. Rayner and P. B. Nye.
No. 11	Geophysical report on the Silver Ridge auriferous lodes, Cloncurry district, by J. M. Rayner and P. B. Nye.
No. 13	Geophysical report on the Iron Range area, Claudie River gold and mineral field, by C.A. Jarman, J. M. Rayner, and P. B. Nye.
No. 17	Second geophysical report on the Trekelano area, Cloncurry district, by R. F. Thyer, J. M. Rayner, and P. B. Nye. (Unpublished).
No. 24	Geophysical report on the Lolworth area, Charters Towers district, by R. F. Thyer, J. M. Rayner, and P. B. Nye.

* Imperial Geophysical Experimental Survey

* Aerial Geological and Geophysical Survey of Northern Australia

Queensland (Cont.)

Report No. 36	Geophysical report of the area south-east of Mount Coolon gold mine, by B.P. Oakes, J. M. Rayner, and P. B. Nye.
No. 41	Geophysical report on the Herberton Deep Lead, Herberton district, by R. F. Thyer, J. M. Rayner, and P. B. Nye (Unpublished).
No. 42	Geophysical report on the Herberton tin lodes, Herberton district, by R. F. Thyer, J. M. Rayner, and P. B. Nye. (Unpublished).
No. 43	Geophysical report on the United North Australian group of mines, Watsonville, Herbertson district, by R. F. Thyer, J. M. Rayner, and P. B. Nye. (Unpublished).
No. 44	Geophysical report on the Croydon-Golden Gate area, Croydon gold and mineral field, by L. A. Richardson, J. M. Rayner, and P. B. Nye, (Unpublished).
No. 54a.	Geophysical report on supposed True Blue deep lead, Croydon gold field, by R. F. Thyer, J. M. Rayner, and P. B. Nye. (Unpublished).
b.	Geophysical report on potential ratio survey in the Croydon gold field by R. F. Thyer, J. M. Rayner, and P. B. Nye (Unpublished).
No. 55	Second geophysical report on Lolworth area, Charters Towers district, by R. F. Thyer and J. M. Rayner (Unpublished).

Western Australia

No. 35	Geophysical report on the Kookynie area, North Coolgardie gold field, by E. L. Blazey, J. M. Rayner, and P. B. Nye.
No. 36	Geophysical report on the Wiluna area, Wiluna (Part 1, Electromagnetic Surveys) by E. L. Blazey, J. M. Rayner, and P. B. Nye.
No. 37b.	Geophysical report on the Big Bell area, by E. L. Blazey, J. M. Rayner, and P. B. Nye.
No. 38	Geophysical report on the Norseman area, Norseman, by E. L. Blazey, J. M. Rayner, and P. B. Nye.
No. 39	Geophysical report on the Bamboo Creek area, Pilbara gold field, by E. L. Blazey, J. M. Rayner, and P. B. Nye.
No. 64	Geophysical report on the Wiluna area, Wiluna (Part 2, Magnetic Surveys), by L. A. Richardson, J. M. Rayner, and P. B. Nye.

Northern Territory

Report No. 4	Magnetic prospecting at Tennant Creek, by J. M. Rayner and P. B. Nye.
No. 6	Geophysical report on the Mount Todd auriferous area, Pine Creek district, by J. M. Rayner and P. B. Nye.
No. 7	Geophysical report on the Fountain Head area, Pine Creek district, by J. M. Rayner and P. B. Nye.
No. 9	Geophysical report on the Yam Creek area, Pine Creek district, by J. M. Rayner and P. B. Nye.
No. 11	Geophysical report on the Woolwonga area, Pine Creek district, by J. M. Rayner and P. B. Nye.
No. 13	Geophysical report on the Iron Blow area, Pine Creek district, by J. M. Rayner and P. B. Nye.
No. 15a.	Geophysical test surveys on the Britannia, Zapopan, and Mount Wells area, Pine Creek district, by J. M. Rayner and P. B. Nye.
No. 16	Geophysical report on the Hercules gold mine, Pine Creek district, by J. M. Rayner and P. B. Nye.
No. 23	Second report on magnetic prospecting at Tennant Creek (1936) by L.A. Richardson, J. M. Rayner, and P. B. Nye.
No. 25	The southern extension of the Pine Creek gold field, Pine Creek district, geophysical report by J. M. Rayner and P. B. Nye.
No. 26b.	The Evelyn Silver-lead Gold Mine, Pine Creek district, geophysical report by J. M. Rayner and P. B. Nye.
No. 34	Geophysical report on the Wolfram Hill area, Pine Creek district, by R. F. Thyer, J. M. Rayner, and P. B. Nye.
No. 36	Geophysical report on the Maranboy tinfield, Pine Creek district, by R. F. Thyer, J. M. Rayner, and P. B. Nye. (Unpublished).
No. 41	Third report on magnetic prospecting at Tennant Creek (1937) by L. A. Richardson and J. M. Rayner (issued as Bureau of Mineral Resources Bulletin No. 44).
No. 48	Geophysical report on the Granites gold field, Central Australia, by R. F. Thyer, J. M. Rayner, and P. B. Nye (Unpublished).
No. 51	Geophysical report on the Redbank (or Wollogorang) copper field by R. F. Thyer, and J. M. Rayner (Unpublished).

3. LIST OF B.M.R.G.G.* REPORTS

A few printed publications are available for sale to the general public. They are :-

Bulletin	No. 35	The investigation of deep leads by the seismic refraction method, by D.F. Urquhart; describing surveys at Kalgoorlie, W.A., Ardlethan, N.S.W., and Wellington, N.S.W.
	No. 43	Geophysical survey of the Renison Bell tinfield, Tasmania, by R. J. Davidson, L. W. Williams, R. P. Loh, J. Horvath, and O. Keunecke.
	No. 44	Magnetic prospecting at Tennant Creek, N.T., 1935-7, by J. Daly.
Report	No. 36	Geophysical survey of the Rye Park scheelite deposit, N.S.W., by J. Horvath and R. J. Davidson.

Most reports of surveys, however, are not available for general distribution. These are stencilled "Records" which are prepared by the Bureau in connexion with special investigations. In general, the geophysical surveys described in these Records were made on behalf of mining companies, and the results are not made available to other interests without the permission of those primarily concerned.

Papua and New Guinea

Record	No. 1950/54	First progress report on the geophysical survey of the Astrolabe mineral field, Papua, by Hugh Oldham.
	No. 1951/29	Final report on the geophysical survey of the Astrolabe mineral field, Papua, by K. H. Tate.
	No. 1951/30	Magnetic survey of alluvial gold deposits at Kuta, New Guinea, by N. G. Chamberlain.

Queensland

Record	No. 1949/101	Geophysical surveys at Mount Morgan, Queensland. First progress report, by L. A. Richardson.
	No. 1953/15	Geophysical test survey of Liontown near Charters Towers, Queensland, by J. Horvath.

* Bureau of Mineral Resources, Geology and Geophysics.

Queensland (Cont.)

Record No. 1954/2	Geophysical survey at Labour Victory mine, near Selwyn, Q'ld., by J. Horvath and K. H. Tate.
No. 1956/118	Geophysical survey of the Northern Prospect, (Tombstone Hill area), Mt. Isa, Q'ld., by J. Horvath and W. J. Langron.
No. 1956/119	Geophysical survey of the Southern Prospect (Mt. Novit area), Mt. Isa, Q'ld., by W. J. Langron.
No. 1956/151	Geophysical test survey at Greta and Corella prospects, Cloncurry mineral field, Q'ld., by W. J. Langron and J. Horvath.
No. 1957/99	Geophysical survey in the Chillagoe-Mungana district, Q'ld., 1949, by W. J. Langron.
No. 1959/57	Preliminary report of the geophysical survey at the Gray Creek chromite prospect near Greenvale Station, by K. H. Tate.
No. 1959/124	Preliminary report on a geophysical survey at Ruddygore copper deposit, Chillagoe, North Q'ld., by J. Horvath.
No. 1959/135	Radioactive investigations at Wolfram Camp, Q'ld., by J. Daly.

New South Wales

No. 1943/13	Report on geophysical survey of Chilcot copper mine (Cadia, N.S.W.), by L. A. Richardson.
No. 1946/19	Geophysical survey of Baryulgil asbestos deposits, N.S.W., by R. F. Thyer and J. C. Dooley.
No. 1947/60	Preliminary report, geophysical survey at Cobar, N.S.W., by L. A. Richardson and W. D. Keating.
No. 1948/43	Cobar geophysical survey second progress report, by L. A. Richardson.
No. 1948/51	Cobar geophysical survey, third progress report, by L. A. Richardson.
No. 1949/73	Shuttleton geophysical survey, first progress report, by L. A. Richardson.
No. 1949/80	Cobar geophysical survey, fifth progress report, by L. A. Richardson.
No. 1949/90	Cobar geophysical survey, sixth progress report, by L. A. Richardson.

New South Wales (Cont.)

Record No. 1950/25	Geophysical surveys at Hermidale and Girilambone, N.S.W., by A. J. Barlow.
No. 1951/12	Report on geophysical surveys at Mount Hope, N.S.W., by H. A. Doyle.
No. 1952/36	Geophysical survey of the Rye Park Scheelite deposit, by J. Horvath.
No. 1952/86	Preliminary report on magnetite deposit, Gulgong, N.S.W., by J. Horvath.
No. 1953/13	Geophysical investigation at the Commonwealth mine, Wellington, N.S.W., by O. Keunecke.
No. 1953/63	Geophysical survey of magnetite deposits near Gulgong, N.S.W., by K. H. Tate.
No. 1954/3	Geophysical survey at Silver Valley, Copeton, N.S.W., by K. H. Tate.
No. 1954/4	Geophysical survey at Tallawang magnetite deposit, Gulgong, N.S.W., second report, by K. H. Tate.
No. 1955/16	Geophysical test survey at Mt. Galena mine, Wellingrove, N.S.W., by K. H. Tate.
No. 1955/78	Preliminary notes on results of geophysical survey at Carcoar, N.S.W., by J. Daly.
No. 1955/88	Geophysical survey at Mount Brown copper mine, Karangi, N.S.W., by D. L. Rowston.
No. 1956/125	Geophysical survey at the Conrad mine, Howell, N.S.W., by K. H. Tate.
No. 1956/153	Geophysical test survey of Torrington wolfram deposits, N.S.W., by K. H. Tate.
No. 1957/4	Geophysical survey at Cobalt Workings, Carcoar, N.S.W., by J. Horvath and D. L. Rowston.
No. 1958/71	Geophysical survey at the Yithan alluvial tin mine, Ardlethan, N.S.W., by M. J. O'Connor.
No. 1959/1	Geophysical survey of Nymagee copper field, N.S.W., by W.H. Oldham.
No. 1959/44	Geophysical Survey at Blackfellows Dam uranium prospect, Condoblin district, by O. Keunecke.
No. 1959/142	Geophysical survey at the Yithan alluvial tin mine, Ardlethan, N.S.W., by M. J. O'Connor.
No. 1959/152	Geophysical surveys at Shuttleton and Cunbelego, N.S.W., by W.D. Keating and J. Daly.

Victoria

Record No. 1942/14A	Boolarra Bauxite test surveys, by L. A. Richardson.
No. 1942/19A	Report on Boolarra geophysical test surveys, by L. A. Richardson.
No. 1956/76	Magnetic survey of the Seven Mile and adjacent iron ore deposits near Nowa Nowa, East Gippsland, by O. Keunecke.
No. 1959/150	Geophysical survey of the Black Snake copper mine, Tubbut, Victoria, by K. H. Tate.

Tasmania

No. 1944/29	Report on geophysical survey of King Island scheelite mine, by L. A. Richardson.
No. 1949/28	Geophysical surveys at Mt. Lyell, carried out by G. Douglas on behalf of Mt. Lyell Co., by L. A. Richardson.
No. 1949/29	Geophysical surveys at Mt. Lyell, progress report No. 1, by L. A. Richardson.
No. 1950/41	Progress report of the geophysical survey of Renison Bell tin field, Tas., by L. W. Williams.
No. 1951/42	Second progress report of the geophysical survey of Renison Bell tin field, Tas., by R. P. Loh.
No. 1953/53	Third progress report of the geophysical survey of the Renison Bell tin field, Tas., by J. Horvath and O. Keunecke.
No. 1953/82	Geophysical investigation of the Copper-Nickel deposits, North Dundas field, near Zeehan, Tas., by O. Keunecke.
No. 1954/7	Geophysical investigations at Mount Cleveland mine, Waratah, Tas., by O. Keunecke.
No. 1955/24	Magnetic survey of the Hampshire magnetite deposit, Tas., by K. H. Tate.
No. 1956/70	Preliminary report on a geophysical survey at Mt. Lyell (Corridor area), Queenstown, Tas., by D. L. Rowston.
No. 1957/5	Geophysical survey at the Endurance tin mine, South Mount Cameron, Tas., by O. Keunecke.
No. 1957/63	Preliminary report on a geophysical survey of the Mount Farrell mine, Tullah, Tas., by K. H. Tate.
No. 1958/15	Geophysical investigation (1956-57) at Copper-Nickel deposits, North Dundas field, Tas., by J. Horvath and M. J. O'Connor.

Tasmania (Cont.)

Record No. 1958/35	Geophysical survey at the Mount Farrell mine, Tullah, Tas., by K. H. Tate.
No. 1958/39	Magnetic survey of the Savage River iron-ore deposits, North-western Tas., by O. Keunecke.
No. 1958/111	Geophysical survey at Mt. Lyell, Queenstown, Tas., 1948-9 by J. E. Webb.
No. 1959/11	Magnetic survey of the Natone, Blythe River-Cuprona, and Highclere iron ore deposits, North-western Tasmania, by O. Keunecke.
No. 1959/36	Geophysical survey of the Great Lyell, East Darwin, and Comstock areas, Queenstown, Tasmania, by D. L. Rowston.
No. 1960/111	Cypress Creek and Moores Valley geophysical survey, Tasmania 1959, by D. L. Rowston.

South Australia

No. 1942/4A	Report on geophysical test survey, Burra copper mine, S.A., by R. F. Thyer.
No. 1942/4B	Report on the geophysical test surveys, Moonta-Wallaroo copper field, S.A., by R. F. Thyer.
No. 1942/12B	Geophysical test surveys at Moonta, S.A., by R. F. Thyer.
No. 1942/26	Review of geophysical surveys in the Wallaroo-Moonta district, S.A. during 1942, by J. M. Rayner.
No. 1943/19	Report on the geophysical surveys, Moonta-Wallaroo copper field, S.A., by R. F. Thyer.
No. 1946/23	First report on geophysical survey operations at Ediacara, S.A., by L. A. Richardson.

Western Australia

No. 1947/3	A geophysical survey of the Copperlead mine area, Bullfinch, W.A., by L. A. Richardson.
No. 1947/9	Geophysical survey of Hampton Plains area, Coolgardie, W.A., by J. C. Dooley, W. A. L. Forsyth, and L. A. Richardson.
No. 1956/74	Geophysical survey in the Protheroe area, Northampton mineral field, W.A., by O. Keunecke.

Northern Territory

Record No. 1953/93	A reconnaissance magnetic survey of an area southwest of Brown's workings, Rum Jungle, N.T., by J. Daly.
No. 1956/24	Geophysical survey in the Manton Dam catchment area, N.T., by A. J. Barlow.
No. 1956/41	Geophysical test survey of copper deposits, Waterhouse Range, N.T., by J. Horvath.
No. 1956/43	Geophysical survey in the Rum Jungle area, N.T., by W. J. Langron.
No.C1957/7	Detailed magnetic survey of an area southwest of Brown's workings, N.T., by J. Daly (Confidential).
No. 1957/101	Geophysical survey at the Evelyn Mine, Pine Creek district, N.T., by D. L. Rowston.
No. 1958/33	Geophysical test survey at the Plenty River mica field, N.T., by K. H. Tate.
No. 1958/81	Geophysical survey, Waterhouse No. 1 uranium prospect, N.T. (1957), by J. Daly and K. H. Tate.
No. 1958/109	Reconnaissance ground magnetic survey over Olive Wood area, Tennant Creek (1958), by M. J. O'Connor and J. Daly.
No. 1959/14	Progress report on geophysical survey at Tennant Creek, 1957, by M. J. O'Connor, R. J. Goodchild, and J. Daly.
No. 1959/45	Recommendations for diamond drilling at Tennant Creek, N.T., by J. Daly.
No. 1959/54	Preliminary report on a geophysical survey at the Reward Lease, McArthur River, N.T., by J. Horvath.
No. 1959/72	Report of a reconnaissance gravity survey in the Darwin-Katherine area, N.T., 1955-57, by P.M. Stott and W. J. Langron.
No. 1959/111	Notes on ground magnetic survey at New Hope area, Tennant Creek, N.T., by J. Daly.
No. 1960/109	Waterhouse Nos. 2, 3, and 4 Prospects, geophysical surveys, N.T., 1957, by J. Daly and K. H. Tate.
No. 1961/33	Koolpin Creek and El Sherana geophysical surveys, South Alligator River, N.T. 1960, by D.L. Rowston.

PART II

4. DESCRIPTIONS OF THE GEOPHYSICAL METHODS

Before proceeding to any discussion of the use of geophysical surveys, it is desirable to describe briefly the methods generally employed, with brief comments on the factors governing their application. Detailed discussion of the various methods may be found in text books on geophysical prospecting.

(1) Electrical Methods

These methods all depend on measuring the electrical resistivity of the ground and are particularly suited to the search for ore-bodies whose resistivity is either much greater or much less than that of the neighbouring geological formations.

In the Resistivity Method, the resistance between two electrodes driven into the ground is measured directly. The observed resistance is an average value for the ground, to a depth which depends on the distance between the electrodes. By varying this distance, the resistivity of the ground can be explored to different depths. This method is particularly useful when the surface is underlain by geological formations lying almost horizontally. As ore-bodies tend to occur in regions of disturbed geology, the resistivity method does not have a wide application to prospecting for mineral deposits, but can sometimes be usefully employed in deep lead problems.

A.C. Methods depend on the application of a low-frequency electro-magnetic field to the ground and the measurement of the resulting distribution of electric potential. The presence of a formation whose resistivity is markedly different from that of the surrounding rocks, will cause an anomaly in the field. Various forms of the method can be used, such as the potential-drop-ratio method, which is considered to be particularly useful for detecting poor conductors (e.g. quartz reefs) and the electromagnetic method, which is most useful for detecting good conductors such as bodies of sulphide minerals. The electromagnetic method is the one most generally useful in prospecting for base metal deposits, but it has the limitation that it cannot explore the ground to a very great depth.

The Self-potential Method depends on measuring the natural potential distribution in the ground. An irregular potential distribution may be due to a number of causes which are very imperfectly understood. However, it is found empirically that a body of sulphide minerals which lies partly above and partly below water level is often associated with an anomaly of characteristic form. The practical use of the method is restricted to deposits of this type.

(2) Magnetic Method

This method involves detailed measurements of the Earth's magnetic field over the area of interest, made with sensitive instruments. The Earth's normal field is practically uniform over small areas, but will be locally disturbed if there are geological formations containing magnetic materials such as magnetite or pyrrhotite. The magnetic method is one of the most generally useful geophysical methods, as it can give valuable structural information and is also applicable to the direct detection of ore-bodies containing magnetic minerals.

(3) Gravity Method

This method uses detailed measurements of the Earth's gravity field, which may be locally disturbed by the presence of geological formations of higher density than the surrounding rocks. It is mainly applicable to structural problems, as ore-bodies generally are not large enough to cause measurable gravity anomalies. However, very large bodies such as certain iron ore-bodies may be directly detectable by this method. The method also has an important application in deep lead problems.

(4) Radiometric Method

This method uses measurements of gamma-ray intensity at the surface. It is found that many geological formations, and some ore-bodies, contain sufficient radioactive minerals to produce measurable gamma radiation. Measurements of this radiation are sometimes valuable aids in geological mapping. The value of the method is limited because the radiation is absorbed by a small thickness of soil or rock, so that measurements can only be made over outcropping rock.

(5) Seismic Method

This method measures the velocity of propagation of elastic waves in the various formations in the ground. Its effective use is restricted to areas in which the various geological formations do not dip steeply;it cannot be applied where dips are steep or the geology is complicated. Practically its only application in prospecting for metallic mineral deposits is to deep lead problems. As the depths involved are shallow the refraction seismic method is used.

5. APPLICATION OF GEOPHYSICAL SURVEYS TO MINING

The application of geophysics to mineral prospecting in Australia is far less than is warranted. This has been due not only to a lack of information on the technical possibilities of the various methods, but also to a lack of appreciation of the proper position of geophysical surveys in an exploration programme. Before proceeding to a discussion of detailed possibilities, it is desirable to devote some attention to the above-named general matters. The following remarks apply particularly to the use of geophysical methods for direct detection of possible ore-bodies. This aspect is of most immediate interest to mining companies, but it must be remembered that geophysical surveys can be at least equally valuable when applied to structural problems. It is convenient to discuss hard rock mining and alluvial mining separately, as they present somewhat different practical problems.

As regards hard rock mining, a revolutionary change in the organisation of exploration programmes for mineral deposits has been brought about by the introduction of the diamond drill. It is now possible to consider the evaluation and exploitation of a mineral deposit as consisting of three distinct stages :-

(a) exploration, involving location of a prospect and testing, usually by diamond drilling, to a stage at which an assessment of probable ore reserves can be made. At this stage, a decision is made as to whether mining will be undertaken, and on what scale.

(b) development, involving provision of surface and underground workings, construction of treatment plant, etc., in preparation for extraction of ore.

(c) mining, involving extraction and treatment of ore.

The purpose of the present Record does not call for discussion of mining economics. However, the following fundamental principles may be stated, both because they have an indirect bearing on the application of geophysical methods, and because the history of Australian mining shows many examples of ventures on which they have been disregarded, usually with fatal results to the mines concerned.

(a) the exploration and development stages involve heavy expense, with practically no return. It is only in the mining stage that any profit can be made.

(b) considerable time is required for exploration and development. The time varies with the size of the deposit, but may be as much as several years.

(c) To ensure the continued life of a mining company, or the complete exploitation of a mineral deposit, it is essential that exploration be kept ahead of development, and development ahead of mining, by a sufficient number of years.

It is of interest to consider the older methods of exploration and development in the light of present practice, because the situation is not the simple one of a procedure rendered obsolete by later discoveries. In the early days of mining in Australia, all deposits were prospected by surface and underground workings. This had the general effect of combining the exploration and development stages to some extent into one. Such a procedure has very considerable advantages. It provides good rock exposures which greatly facilitate detailed geological mapping. Also it enables detailed and precise sampling of an ore-body. The prospecting workings form part of the development, and are available for mining. However, it involves disadvantages owing to the fact that workings are very costly. It is impossible to keep exploration and development as far ahead of mining as is desirable, without disproportionate expenditure. There is a strong bias in favour of using existing workings, when fresh ones would be desirable in the interests of efficient mining. Also, a very heavy responsibility is placed on the management, which is constantly in the position of having to make decisions which may vitally affect the whole future of the mine.

As against this, the modern approach outlined earlier enables long term planning of an orderly and complete exploitation of a mineral deposit. Unfortunately, there is a common and important class of deposit to which the modern methods cannot be applied. Important production has been obtained in the past from ore-bodies which are narrow, irregularly mineralised, disturbed by geological conditions such as faulting, and individually not persistent in depth. Where any of these conditions is present, diamond drilling is a very expensive and inefficient method of exploration. A glance at published descriptions of some of the most important Victorian goldfields, such as Ballarat (Baragwanath, 1953), Bendigo (Thomas, 1957), or Clunes (Coldham, 1953), will illustrate this statement. Such deposits can be effectively explored only by means of workings.

As regards direct detection of possible ore-bodies, geophysical surveys can be of great assistance in the exploration stage. Their purpose is essentially to cut down the cost of exploration by limiting diamond drilling to the most favourable targets. Geological surveys may identify a favourable structure or geological horizon, but this may be so large as to require an extensive drilling programme to prospect it completely. The result of a successful geophysical survey is a target, precisely located, which can be tested by a small number of drill holes.

The application of geophysical surveys to the investigation of mineral deposits is a very large subject and, as almost every deposit has some peculiar features, a full discussion on general principles would require a considerable volume. However, it is desirable to state such principles as are of general application. Although the cost of a geophysical survey is generally small in comparison with the cost of an extended drilling programme, it is not negligible. As well as encouraging the use of geophysical surveys in general, the principles listed below may serve a useful purpose in discouraging unreasonable hopes or attempts at applying geophysical methods where there is little chance of useful results. The following considerations are relevant to almost all geophysical surveys :-

(a) no geophysical survey can give results of the type commonly claimed for the divining rod. A favourable indication obtained by means of a geophysical survey has no economic value until it has been tested, usually by diamond drilling. If it is properly established that the ore-body sought will be of a type unsuited to testing by diamond drilling, there is little advantage to be gained by using a geophysical survey to obtain evidence of its presence.

(b) certain geophysical methods can explore the ground to a limited depth only. Thus, the depth at which electromagnetic methods will detect conducting bodies seldom exceeds 300-500 feet.

(c) it is generally in the primary zone that the physical properties of mineralised bodies are best suited for investigation by geophysical methods. Thus bodies carrying sulphide minerals are usually good electrical conductors, but their weathered portions containing secondary minerals are not. For this reason, geophysical surveys over a large class of deposits are most likely to provide useful information only on the primary zone. This limitation is not generally serious under Australian conditions. Most known Australian mining fields have been well explored in the secondary zone, and in many cases important production of secondary ore has resulted. It is generally agreed that re-establishment of mining on these fields depends on the discovery of adequate reserves of primary ore, in the search for which geophysical methods are quite often particularly well suited to assist.

The attempt to use geophysical surveys at too late a stage of the mining process, (e.g. in the development or mining stages) is generally not to be recommended. In a properly organised operation this is not likely to happen. However, the situation arises sometimes that owing to unsound planning of operations a mine is faced with closure unless fresh ore can be found urgently. A mine in this condition is unlikely to be saved by the results of a geophysical survey; it generally cannot afford the expenditure and time required to develop a completely new ore-body, unless the ore can be easily reached from existing workings. Unfortunately, there are considerable difficulties in making geophysical surveys near working mines. The layout of the survey may be hindered, or even made impossib e, by the disposition of mine buildings, power lines, etc, The results are likely to be greatly disturbed by the consequences of previous mining operations, such as filled stopes and abandoned rails. Also, if the mine has been properly prospected from the upper levels, it is likely that any ore-body which remains to be discovered will be too deep to be detected by the most suitable geophysical methods. Under such conditions, useful results can hardly be expected.

With regard to alluvial mining, the discussion can be rather simpler. In the search for dredging ground, where it is desirable that mineralisation of economic grade be fairly uniformly distributed through alluvium to a considerable depth, it is not likely that the results of geophysical surveys will assist in locating mineralised zones. With deep leads, the position is different. These are channels in the bedrock in which heavy minerals such as gold or cassiterite have been concentrated by alluvial action. The channels have been later filled with unconsolidated material. In such leads, where the minerals of economic interest are concentrated into small sections, geophysical surveys can be of great assistance in exploration. In general, observations on the surface give little or no indication on the course of these channels. Prospecting by shaft sinking is a very expensive method of locating the course of a channel which may be only narrow, although when the position of the lead is known, a shaft enables it to be sampled most reliably. The usual method of finding the position of such a lead is by pattern boring. This is expensive when the course of the lead is completely unknown, and is also far more difficult than might at first appear. Only very experienced drillers can obtain reliable information, and the results of a particular bore can be completely misleading if the drill should happen to strike a large enough boulder. Moreover, even minor details and sudden small bends of the course of the lead may be of great importance in mining, and it is quite impossible to bore enough holes to map this detail.

It is a great advantage in the exploration and development of a deposit of this type if the course and depth of the lead are known in full detail before exploration by boring or shaft sinking is commenced. It cannot be stated definitely that this information will always be obtained from a geophysical survey, but experience shows that valuable information can often be obtained. This information must always be checked, but in favourable cases the exploration programme may be reduced to a restricted drilling campaign to check the geophysical information, and a few shafts to sample the mineral content of the lead. On the basis of the geophysical results, these shafts may be sunk in the most suitable positions for efficient exploration.

Summarising the above discussion, the application of geophysical surveys by appropriate methods should be considered at a very early stage in the exploration of any mineral deposit. Except for a few types of deposit, which are generally easily recognized, the cost of geophysical surveys will generally be more than recouped in savings in exploration costs, by limiting drilling to the most favourable targets. Each particular deposit will present its own problems, and the application of geophysical surveys to these must be considered each on its own merits. In general, however, the following could safely be considered as routine procedures :-

(a) if the deposit contains sulphide minerals it should be surveyed using electrical methods.

(b) if it contains magnetic minerals, the magnetic method should be used.

(c) if it is a deep lead, reconnaissance gravity surveys should be used, followed by the use of the refraction seismic method in key areas.

6. COMMENTS ON THE RESULTS OF GEOPHYSICAL SURVEYS

After what has been said, there is no need to stress the point that the application of geophysical surveys to the prospecting of any particular deposit is worthy of consideration, and that it is very likely that such surveys will be economically justifiable. Fairly extensive geophysical surveys have been made in some Australian mining fields, and the results in some cases are worthy of general comment, either because certain methods have a special application to the problems of a particular field, or because the results raise problems to which solutions are not yet available. Certain other fields have not been prospected by geophysical methods, but the nature of their geology suggests that particular methods offer good chances of results of considerable economic interest.

The mining fields discussed below are intended to give some examples of considerations which would certainly apply in many other mining fields. They are listed under the various States.

QUEENSLAND

Cloncurry-Mt. Isa

It is not proposed to suggest any targets for large scale exploration in the Cloncurry-Mt. Isa region, as the aeromagnetic surveys in this district have been made by private companies, and the results have not been published. However, the district appears to offer exceptionally good prospects for discoveries by electrical methods of survey.

A convenient review of the production from copper mines in the Cloncurry region is given by Nye and Rayner (1940). Approximately 500 copper prospects have been recorded as having produced some ore. Excluding the major deposits of Mt. Isa, four of these prospects have produced between 100,000 and 300,000 tons of ore, and eight others have produced between 10,000 and 100,000 tons. All the others have produced less than 10,000 tons. Most of the mines and prospects produced oxidised ore only and it is certain that few, if any, of the small producers have been examined in the primary zone. There is, therefore, great scope for geophysical surveys over many of these as well as all mineralised areas for non-outcropping deposits. These surveys would aim at the discovery of bodies of primary sulphide ore, and it seems a reasonable supposition that some deposits as large as the major producers remain to be discovered.

A detailed discussion of the possibilities of some mines in the region is given by Horvath (1952).

NEW SOUTH WALES

Carcoar

In the Carcoar area, geophysical surveys have given results which warrant some testing. If this testing indicates mineralisation of value, the results would provide a basis for recommending exploration of a structure of considerable size.

The geology of the Carcoar area is described by Rayner and Relph (1954). The area of interest is close to the south-western corner of a large body of granite. The corner of the granite is surrounded by hornblende dorite, which separates the granite from a suite of sediments and volcanics (andesites) considered to be of Lower Palaeozoic age. Close to the western edge of the diorite outcrop these Palaeozoic rocks contain a persistent zone of shearing, consisting of many short shears with a general northerly strike. On one of these shears occurs the Coombing Park iron ore deposit, from which 5,000,000 tons of ore have been mined and which contains further reserves.

The Bureau's investigations were concerned with small deposits of cobalt and uranium ores which occur in the sediments close to the southern edge of the diorite. Geophysical surveys show that these deposits also are associated with shears with a general northerly trend, although in detail the pattern is rather more complex than for the iron ore deposit. The results suggest that the shears may contain mineralised bodies considerably more important than would be expected from the very small size of the known deposits. These results have not yet been tested. If testing should disclose mineralisation of importance, it would suggest that a comprehensive geophysical survey covering the whole area around the diorite would reveal a shear pattern which would be well worthy of systematic testing.

Cobar

In this connexion, Cobar includes the main mining centre of Cobar and also the copper-producing region of central western New South Wales, lying between Cobar, Mt. Hope, and Girilambone, and including important mines at Shuttleton, Nymagee, and Hermidale. The status of exploration as regards the Cobar centre itself is reviewed by Thomson (1953), based on work done by the Bureau and by Zinc Corporation Ltd. Results of geophysical surveys by the Bureau over other mines in the region have the same general character as in the Cobar centre, though of course it would be unwise to assume that geological conditions remain uniform over the whole region.

In this region, geophysical methods may be useful in two ways. Firstly, in prospecting for ore-bodies. The ore-bodies generally contain some pyrrhotite; they are therefore associated with magnetic anomalies, and under suitable conditions, self-potential anomalies also. Secondly, there is some evidence that the region contains magnetic rocks which do not appear in outcrop. It may be hoped that the general aeromagnetic survey of the field, of which the results are not yet available, will suggest broad structural features which could not be discovered in any other way.

Ardlethan

The geological setting of the exploration problem in the Ardlethan area is relatively simple. There is a small area of outcropping granite which carries tin mineralisation. Tin ore has been profitably mined from high grade portions of the outcrop, and the possibility of treating the granite on a large scale has been considered. The granite outcrop is completely surrounded by soil cover. Alluvial tin ore has been concentrated in channels eroded in the bedrock, and the infilled valleys form deep leads; they occur under the soil cover. One such lead is now being worked, and though not large, the working of it has proved highly profitable.

The refraction seismic method has been successfully used to obtain detailed information on the course of this lead. However, of more general interest is the fact that gravity surveys have given results closely agreeing with those obtained from the seismic surveys. There is a reasonable possibility that other similar leads exist around the granite outcrop. The seismic method is expensive and inconvenient to use as a reconnaissance tool to prospect for such leads, but the gravity method is much cheaper and quicker in operation. A reconnaissance gravity survey around the Ardlethan granite, followed by a small amount of refraction seismic work in areas chosen on the basis of the gravity work, could well lead to the discovery of significant alluvial tin deposits.

Other Fields in which deep leads may be present

There are possibilities of extending such work to other regions. Considering New South Wales alone, alluvial tin deposits very similar to those at Ardlethan are known at Kikoira and Mt. Tallebung. There could also be opportunities for work of this type in the West Darling, Gulgong, and Wyalong goldfields, and no doubt a more complete study of mining records would suggest many other areas.

VICTORIA

In Victoria, gold mining has been much more important than base metal mining, and the main question of interest in the present discussion is the possibility of applying geophysical methods in the search for gold deposits.

In general, the prospects cannot be viewed with great confidence. A large portion of the production of gold which made Victoria famous came from surface gravels and shallow leads. It is probable that there is scope for the use of the gravity and seismic techniques tested successfully at Ardlethan, but prospecting in Victoria in the early days of gold mining was so intense that it is not likely that large scale deposits of this type remain to be discovered.

As regards deep leads, the position is complicated by the basalts which cover a large area of potentially gold-bearing country. Attempts to use electrical geophysical methods to prospect for basalt-covered leads were made by a private company many years ago without success. Further tests have been made by the Bureau, and though it may be said that the results are not unpromising, much more testing is required. If this problem can be solved, there would be great scope for such geophysical surveys in Victoria, and results of economic importance might well result.

In prospecting the auriferous quartz deposits of Victoria, it cannot be expected that geophysical methods would be of much service. Very few of these deposits could be called even reasonably large, by modern standards. Also, as mentioned in a previous section, many of the most important fields are totally unsuited to prospecting by the diamond drill. Such fields can only be explored by geological mapping using the controls established by the classical geological work of the Victorian Department of Mines. However, mapping in the finest detail is involved and this can only be done if mine openings are available. In the simplest possible case, in which the deposit sought is a steeply dipping tabular quartz reef, it is possible that geophysical surveys might give useful results. Although the possibilities have not been tested, it seems likely that such a reef could be detected by such methods as the potential-drop-ratio method. However, it is necessary that the reef be capable of testing by diamond drilling, which would require that it be more uniformly mineralised than is usual with Victorian quartz reefs. A useful test could possibly be made in the district between Scarsdale, Berringa, and the Staffordshire Reef, in which records suggest that some at least of the reefs carry uniform gold values to considerable depths.

An exception to this generally unfavourable judgement may be made for a class of primary gold deposits in eastern Victoria. These have the following characteristics in common : the shoots of ore are of stoping width, and extend to depths of 1000 feet or more; gold contents are high, of the order of 1 oz per ton; the ore is highly mineralised with sulphides, and by the standard of metallurgical practice of last century, difficult to treat.

It may be expected that advances in metallurgical practice have simplified the treatment problem. However, the necessary plant would involve considerable capital expenditure, and reasonably large reserves would therefore have to be proved. Deposits of this type are known in the Cassilis, Bethanga, Dark River, and Gibbo River areas.

Cassilis and Bethanga areas have been mined to a fairly large extent, and there is no doubt that primary sulphide ore exists. There appears to be a reasonably good chance of discovering further reserves. Some geophysical tests have been made, and have given encouraging results (Blazey and Rose, 1933). These two areas appear to offer good prospects. The other two areas are difficult of access, and have not been prospected to the same extent. All that can be said of them is that they have possibilities and that geophysical surveys could possibly be an important aid in the prospecting.

TASMANIA

Renison Bell

The Renison Bell tin field is an example of an area which is ideally suited to the application of geophysical methods. The tin ore or mineral is associated with pyrite and pyrrhotite, and the ore-bodies give rise to very strong magnetic and self-potential anomalies. Although geophysical surveys have not covered a very large area, many anomalies which may prove to be associated with ore-bodies have been discovered. It is considered that the prospects of locating other ore-bodies and possibly developing considerable reserves of tin ore are bright. The field is now receiving proper attention.

North-eastern Tasmania

The tin-bearing area of north-easterm Tasmania appears to offer opportunities for prospecting for alluvial deposits. The gravity and seismic methods as applied at Ardlethan could be used in many places with prospects of useful discoveries.

A problem of special interest, on account of its possibilities, is the location of the Ringarooma main lead. The geological basis of the problem is described by Nye (1925). Briefly, the original drainage system of the Ringarooma district consisted of the Ringarooma River, with an almost northerly course, and several short tributaries, draining tin-bearing granite country. The valleys of this system were filled with later sediments, and the main valley covered by basalt for a length of several miles. The present course of the Ringarooma River generally follows the original valley between Ringarooma and Derby but along or near its eastern margin. Down-stream from Derby it was diverted to the east of its former valley and follows a completely different course from the old valley.

The tributary valleys of the original drainage pattern are occupied by deep leads. Several of these have been mined for some distance, and some, such as the Cascade and Pioneer leads, have been of high grade. However, none has been followed to its junction with the deep lead of the main stream, which has not been seen at any point. There can be no doubt that this lead exists, and it may contain large quantities of tin. The problem of locating its course under the basalt cannot be approached with any great confidence, but it would be possible to select test areas which are free from basalt. A brief gravity and seismic survey in such areas would enable the course and depth of the lead to be determined, and its economic possibilities could then be checked by a boring campaign. It is possible, of course, that the lead may be so deep as to render mining it a very difficult matter.

SOUTH AUSTRALIA

Wallaroo-Moonta

The main comment to be made about exploration in the Wallaroo-Moonta area is that it presents a problem which has not yet been solved. The present position in this field has been reviewed by Dickinson (1953). Bedrock crops out only in a restricted area around the lodes, and the remainder of the field is covered by rock waste and travertine which completely mask the underlying bedrock. The production from the known lodes has been so important that there is every incentive to search for similar occurrences in the neighbourhood. However, the use of electrical methods is severely hampered, if not rendered impossible, by the conductive nature of the travertine overburden. Aeromagnetic surveys have given a very clear pattern of strong anomalies, but it has not yet been possible to relate this pattern directly to the mineralisation. Because of the importance of the target, and the fact that absence of outcrop renders geological mapping practically impossible, it is to be expected that further tests of geophysical methods will be made, but results so far have been disappointing.

WESTERN AUSTRALIA

The Goldfields Area

Interesting possibilities with regard to prospecting in the goldfields of central Western Australia are indicated by the results of aeromagnetic surveys. Banded iron formations, many of which are strongly magnetic, occur very commonly in the "greenstone" areas of Western Australia. These provide important structural markers in areas which are generally devoid of outcrop, but may also be directly connected with deposits of gold and iron ore. The significance of the formations is discussed by Miles (1953). The aeromagnetic surveys already made have provided much information on these magnetic formations, and it may be expected that study of the results will suggest many possibilities of further exploration. Similar formations have been found also in large areas outside the known goldfields, and it is possible that the results of aeromagnetic surveys over them will lead to further exploration in these areas also.

Northampton

The interest of the results obtained in the Northampton field is that they strongly suggest the need for development of improved geophysical methods in order to prospect it economically. As the field is relatively flat and covered mainly with soil and scrub, outcrops of bedrock are scarce. Over a considerable area the prevailing rock type is granitic gneiss. The field contains small but high-grade lead and copper ore-bodies which are considered to be localised on short shears arranged en echelon. The area in which such ore-bodies may occur is quite large.

In order to prospect the field, the first essential is to map or outline the shear pattern. Results of previous geophysical surveys have shown that the shears can be detected by ground electrical methods of prospecting. However, these methods would be very expensive to use over such a large area. What is required is a more mobile form of electrical equipment, either vehicle-borne or airborne. Airborne electromagnetic equipment has been used with success in Canada, and some tests have been made in Australia but with less success. However, the Northampton field would present a more difficult problem for this equipment than any in which it has been used successfully. Further development of the methods will be necessary before their use in this field can be recommended.

NORTHERN TERRITORY

Rum Jungle and Brocks Creek

These two areas are the main mineralised areas in the Northern Territory, and are geologically very similar. In each area the structure is a dome with a central granite core exposed. Around this core are rocks of the Golden Dyke Formation of the Brocks Creek Group, including rocks given the field name of "amphibolites". The amphibolites give rise to strong and persistent magnetic anomalies. Close to the amphibolites are graphitic schists containing very extensive sulphide mineralisation. The possible significance of the magnetic anomalies is discussed by Daly (1957). Attention has been drawn to the possibilities of the sulphide mineralisation in the Brocks Creek area by Sullivan and Iten (1952).

There are differences in detail between the two areas. In the Rum Jungle area the soil cover is deeper; the amphibolites do not crop out and their presence and position can be determined only by magnetic surveys. The sulphide mineralisation is not represented at the surface by gossans. The magnetic structure is relatively simple, consisting of a single ring of anomalies around the granite, with a tail extending south-westerly from the southern part of the ring and passing close to the Waterhouse uranium prospects.

Around the Brocks Creek granite, outcrops of bedrock are generally more abundant. Rocks mapped as amphibolite or diorite crop out and their positions correspond in general with the magnetic structure, though there are differences in detail which are worthy of further study. The sulphide mineralisation is represented at the surface by very persistent gossans. The magnetic structure is not quite so simple as at Rum Jungle. There appear to be two concentric rings of magnetic anomalies, and there are complications at the southern part of the outer ring which could be resolved only by ground magnetic surveys.

It is considered that these areas are amongst the best prospects for exploration in Australia. The structures are well defined, there is no doubt of the presence of sulphide mineralisation over long distances, and tests at several points on each structure indicate that the sulphide mineralisation can be located easily and precisely by electrical surveys. The following projects suggest themselves :

(i) large-scale electrical surveys around the magnetic structures, to discover sulphide mineralisation.

(ii) detailed geological and geophysical study of the "amphibolites" to see if any precise connexion between them and the mineralisation can be discovered. A broad general connexion is obvious, but it is not known at present if a more detailed correlation is possible; such a correlation would assist in exploration.

(iii) detailed ground magnetic and electrical surveys in the complicated area at the southern part of the Brocks

Creek structure, to discover whether the structure in this area can be mapped in more detail and whether further sulphide mineralisation similar to the primary ore of the Cosmopolitan Howley gold mine can be discovered. The ore is of high grade but as it is difficult to treat, the establishment of mining operations would be dependent on the proving of considerable reserves.

In regard to the exploration of these areas it must be pointed out that previous testing has established that the sulphide mineralisation is predominantly pyritic, and that lead and copper mineralisation of econoic value is confined to limited sections. Geophysical surveys will indicate the presence of sulphide mineralisation, but not the metals present; these can be discovered only by actual testing.

Tennant Creek

This is an example of a field in which exploration at present is mainly dependent on geophysical work. Ore is associated with pipe-like bodies composed mainly of haematite in the oxidised zone, and magnetite in the primary zone (these bodies will be referred to as "Ironstone" bodies). In the primary zone at least, these bodies can be easily and accurately located by magnetic surveys. The main problems awaiting solution at present are the following :-

(i) is the association of ore with ironstone bodies the dominant feature of the field, or are other structural features such as shears, fault zones, favourable beds, etc. of significance with regard to the location of ore?

(ii) very few of the ironstone bodies so far examined contain mineralisation of economic grade. Can any criteria be established whereby the possible value of a particular ironstone body can be estimated without actual testing?

These problems are essentially geological ones. Steady progress is being made in the collection of geological knowledge, and it is to be expected that more accurate criteria to guide exploration will be available in the future. The work has been slow, because geological mapping is very difficult owing to deep weathering and scarcity of outcrop, and because only one or two of the many prospects that have been opened have been extended into the primary zone.

7. A NOTE ON THE PRECAMBRIAN

The Bureau's aeromagnetic surveys have now covered substantial regions of Australia occupied by Precambrian rocks. The results show that certain major rock units have a consistent magnetic character over very large areas. When (if ever) the coverage approaches completeness, the results will provide the basis for a very interesting study which may prove of value in geological correlation.

The following general characteristics are already apparent.

(1) Western Australia

Over very large areas, the "greenstones" have consistent magnetic character. They show large persistent magnetic anomalies arising from the banded iron formations in them. Nothing similar has been observed elsewhere in Australia.

(2) Northern Territory

Three areas have been examined, each of which has distinct characteristics. Rocks of the Brooks Creek Group are almost completely non-magnetic, except in the areas around the Rum Jungle and Brocks Creek granites referred to in Chapter 6. The Warramunga rocks at Tennant Creek are generally weakly magnetic. They show relatively weak but very persistent anomalies, with a few strong anomalies, of small extent, due to the small pipe-like magnetic bodies which are a feature of the Tennant Creek field. The rocks of Davenport Range (probably to be correlated with the Ashburton sandstone north of Tennant Creek) are magnetically disturbed, with many sharp anomalies of a type which could be due to relatively short basic dykes.

(3) South Australia

The main features in the results of the surveys over the rocks of Eyre Peninsula are several circular anomalies which are probably due to fairly large pipe-like bodies composed of basic rocks.

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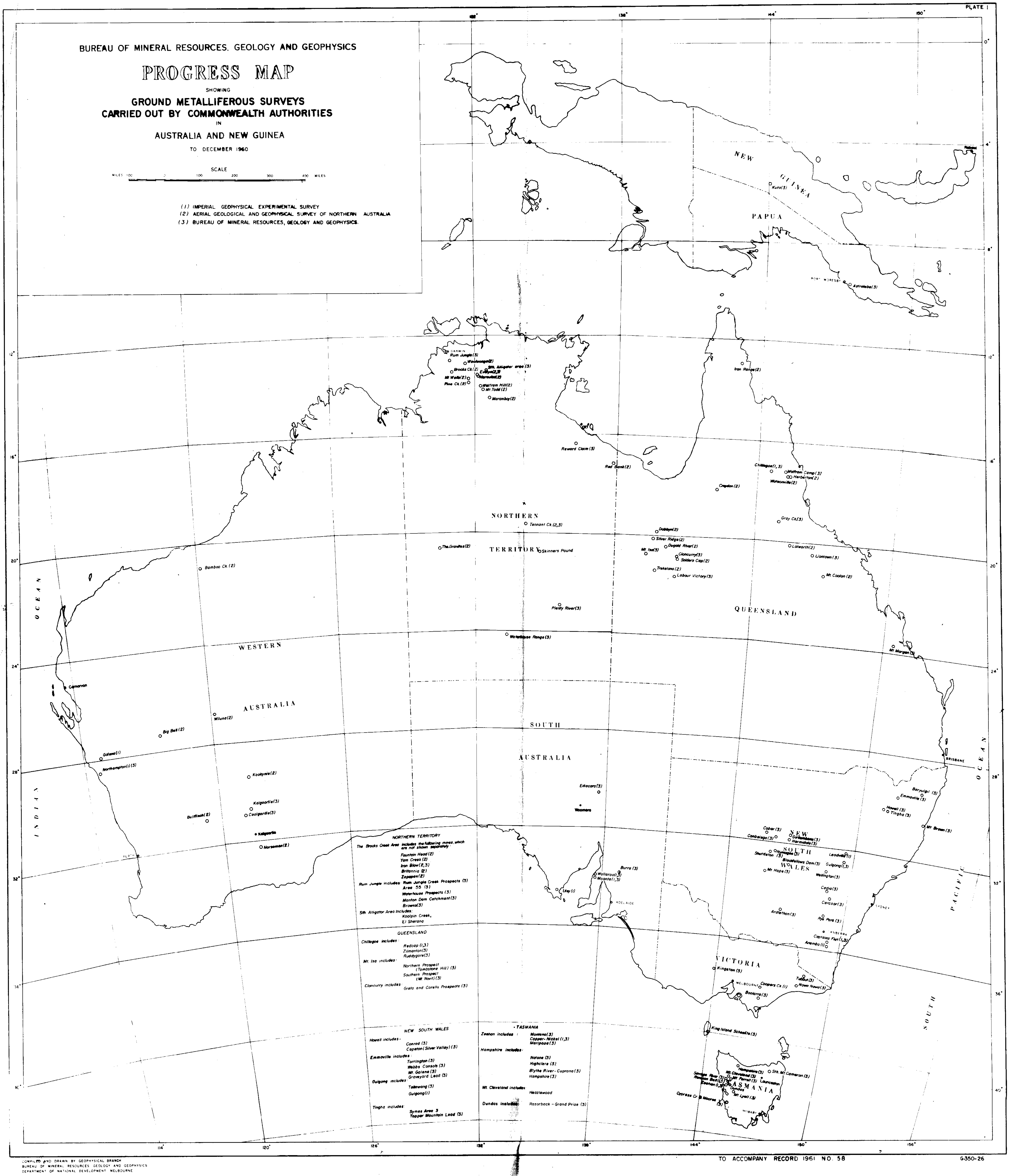
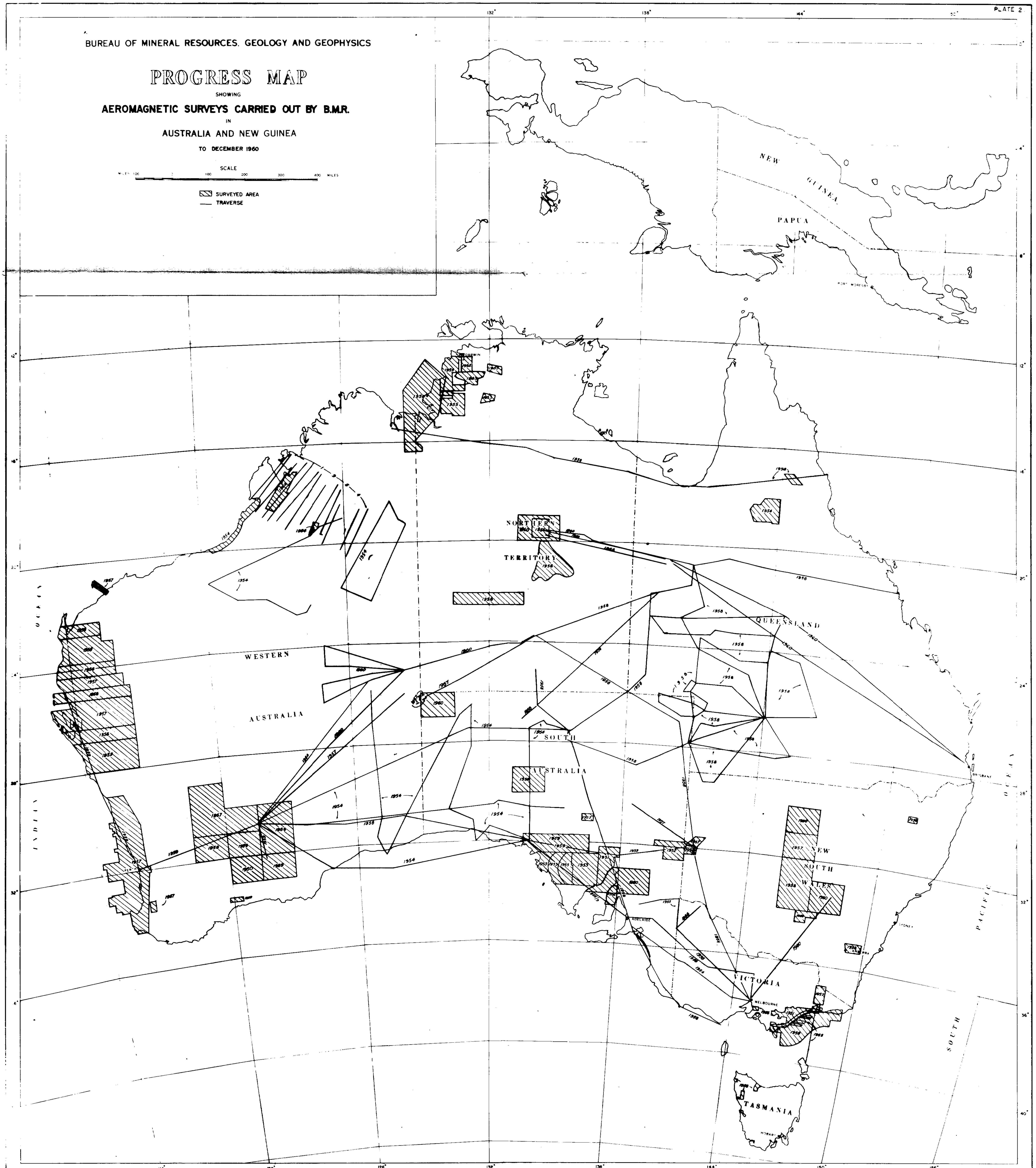


PLATE I
BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS
PROGRESS MAP
SHOWING
GROUND METALLIFEROUS SURVEYS
CARRIED OUT BY COMMONWEALTH AUTHORITIES
IN
AUSTRALIA AND NEW GUINEA
TO DECEMBER 1960
SCALE
MILES 100 0 100 200 300 400 MILES
(1) IMPERIAL GEOPHYSICAL EXPERIMENTAL SURVEY
(2) AERIAL GEOLOGICAL AND GEOPHYSICAL SURVEY OF NORTHERN AUSTRALIA
(3) BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS
NEW GUINEA
PAPUA
NORTHERN TERRITORY
WESTERN AUSTRALIA
SOUTH AUSTRALIA
QUEENSLAND
NEW SOUTH WALES
VICTORIA
TASMANIA
INDIAN OCEAN
PACIFIC OCEAN
NORTHERN TERRITORY
The Brocks Creek Area includes the following mines, which are not shown separately:
Fountain Head (2)
Yam Creek (2)
Iron Blow (2,3)
Britannia (2)
Zapopan (2)
Rum Jungle includes: Rum Jungle Creek Prospects (3)
Area 55 (3)
Waterhouse Prospects (3)
Manton Dam Catchment (3)
Browns (3)
Sth. Alligator Area Includes:
Koolpin Creek,
El Sherana
QUEENSLAND
Chillagoe includes:
Redcap (1,3)
Zilmanton (3)
Ruddygore (3)
Mt. Isa includes:
Northern Prospect (Tombstone Hill) (3)
Southern Prospect (Mt. Novit) (3)
Cloncurry includes: Greta and Corella Prospects (3)
NEW SOUTH WALES
Howell includes:
Conrad (3)
Copeton (Silver Valley) (3)
Emmaville includes:
Torrington (3)
Webbs Consols (3)
Mt. Galena (3)
Graveyard Lead (3)
Gulgong includes:
Tallawang (3)
Gulgong (1)
Tingha includes:
Symes Area 3
Topper Mountain Lead (3)
TASMANIA
Zeehan includes: Montana (3)
Copper-Nickel (1,3)
Mariposa (3)
Hampshire includes:
Natone (3)
Highclere (3)
Blythe River-Cuprona (3)
Hampshire (3)
Mt. Cleveland includes: Heazlewood
Dundas includes: Razorback – Grand Prize (3)
COMPILED AND DRAWN BY GEOPHYSICAL BRANCH
BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS
DEPARTMENT OF NATIONAL DEVELOPMENT, MELBOURNE
TO ACCOMPANY RECORD 1961 NO. 58
G350-26


BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS
PROGRESS MAP
SHOWING
AEROMAGNETIC SURVEYS CARRIED OUT BY B.M.R.
IN
AUSTRALIA AND NEW GUINEA
TO DECEMBER 1960
SCALE
SURVEYED AREA
TRAVERSE
NEW GUINEA
PAPUA
PORT MORESBY
DARWIN
NORTHERN TERRITORY
QUEENSLAND
WESTERN AUSTRALIA
SOUTH AUSTRALIA
NEW SOUTH WALES
VICTORIA
TASMANIA
ADELAIDE
MELBOURNE
SYDNEY
BRISBANE
HOBART
INDIAN OCEAN
PACIFIC OCEAN
SOUTH

G 350-23