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COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORDS 1956, No. 41

GEOPHYSICAL TEST SURVEY OF COPPER DEPOSITS, WATERHOUSE RANGE, NORTHERN TERRITORY

by

J. HORVATH

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A B S T R A C T.

This report describes a geophysical test survey which was made in the Waterhouse Range, near Alice Springs, where the Titanium Alloy Manufacturing Company is prospecting for possible syngenetic copper deposits in transition beds between Cambrian and Ordovician rocks. Self-potential, electromagnetic and magnetic methods were used along four traverses, each about 1200 ft. long.

The electromagnetic survey, in which SLINGRAM equipment was used, located some well-defined zones of varying electrical conductivity. The strength and character of the indications, however, were not such as would be expected from highly-mineralised beds. It is considered that the indications originate from either weakly-mineralised beds or from porous strata containing electrically conductive water. It is believed that this method might be able to locate, by systematic search, areas of high conductivity corresponding to any beds more highly mineralised than those at present known.

The self-potential and magnetic methods did not yield any results which would encourage their further use in this area.

1. INTRODUCTION.

An application was received by the Bureau of Mineral Resources, in March, 1954, from Mr. J. Ivanac (on behalf of Titanium Alloy Manufacturing Company), for a geophysical survey to be made over some syngenetic copper deposits in the Waterhouse Range, about 45 miles south-west of Alice Springs, Northern Territory (Plate 1). Consequent on this application, the area was visited by the author in company with Mr. Ivanac.

The deposits have not been worked, and lie in an uninhabited area, but the company had made a track from the main road and had established a small camp on the site. The area of main interest was being mapped by two geologists. Systematic investigations by geochemical methods have revealed large areas showing high copper and lead values. A "Failing" drill was being used for diamond drilling.

The visit showed the prospecting campaign to be an ambitious, far-reaching and systematic investigation which, if successful, could be of national importance. The application for a geophysical survey was therefore agreed to by the Bureau.

The survey was made between 2nd and 5th November, 1954, using electromagnetic, magnetic and self-potential equipment. The geophysical party consisted of Dr. J. Horvath (party leader) and Mr. D. Smellie. The company supplied the necessary field assistants, pegged and levelled the traverses, and provided camping facilities for the party.

2. GEOLOGY.

Geological information on the area was supplied by the geologists of the company.

The syngenetic copper deposits of the Waterhouse Range occur in transition beds between Cambrian and Ordovician rocks. The copper-bearing beds extend over a large area and had been traced mainly by geochemical methods. The transition beds are about 1,000 ft. thick and consist mainly of sandstones of varying composition (partly felspathic and partly glauconitic), shales and argillites. The transition beds are underlain by Cambrian limestones and overlain by Ordovician quartzites. The copper-bearing beds occupy part of a large domal structure and, in the area surveyed, dip to the north at about 45°.

Maps of the two areas of main interest, showing the topography and geology, were compiled by the Company from the results of a plane table survey made by the Company's geologists. Copies of these maps, showing also the geophysical traverses, were supplied to the Bureau to assist in the interpretation of the geophysical results. These maps are reproduced as Plates 5 and 6.

Prior to the geophysical survey, four diamond drill holes had been drilled by the Company and these provided useful information on the stratigraphy and mineralisation, which is confined to the transition beds. Three of the drill holes lie within the areas of the geophysical survey. No mineralisation of ore grade has yet been disclosed, but the boreholes have shown that lead, as well as copper, is present in the transition beds.

A geochemical soil survey was made by the Company while the geological mapping was being done, the dithizone method being used to determine copper values of the soil samples in parts per million. Extensive indications of copper were obtained, and these were used as a guide in selecting drilling sites. Some of the values are shown on Plate 6. As in other areas containing copper deposits, it was found that the copper migrates very freely, causing wide-spread anomalies.

3. SELECTION OF GEOPHYSICAL METHODS.

On the assumption that large, but low-grade, deposits of copper sulphides conforming with the transition beds might be present, electrical methods were considered to be the most suitable for the geophysical survey. Two electrical methods were used, namely the self-potential and the Slingram electromagnetic method.

In the self-potential method, measurements are made of the natural electrical potential on the surface to determine its distribution over the area being investigated. Anomalies in the potential distribution arise whenever different parts of a conductive body are immersed in electrolytic solutions of different concentrations or compositions. Sulphide bodies undergoing oxidation are commonly the source of large self-potential anomalies. Anomalies may, however, be due to various causes, such as the presence of graphite or other conducting zones. Therefore, the geological interpretation of self-potential results must be made with caution. A sulphide body, portion of which is undergoing oxidation, commonly produces a self-potential anomaly of a characteristic type. The occurrence of such an anomaly may be taken as indicating the possible presence of a sulphide body.

In the electromagnetic method, a primary alternating current is applied to the ground, and the resulting field measured and compared with its theoretical value. Anomalies in the resulting field are caused by the presence of secondary fields induced in formations whose electrical conductivity is greater than that of the surrounding rocks. These anomalies, therefore, indicate the presence of good conductors, which may be correlated with geological formations and ore-bodies.

With the Slingram equipment used in this survey, the primary field is produced by an alternating current delivered from a tube oscillator and passed through a transmitting coil held in a horizontal position. The distance between transmitting and receiving apparatus is maintained constant (200 ft. for this survey) and the whole equipment is moved along the traverses. Observations are taken at regular intervals (25 ft. in this survey). The observation equipment consists of a compensator unit and a search coil of several hundred turns of fine copper wire which is mounted on a frame and is also held in a horizontal position.

The compensator is so constructed that it gives two components of the electromagnetic field. The real component is in phase with the primary current in the transmitter coil and the instrument is so calibrated that the strength of the real component is expressed as a percentage of the primary field, where the field at the selected distance between transmitter and receiver coil over uniform non-conducting ground is called 100%. The imaginary component is 90° out of phase with the primary current. The dial for measuring this imaginary component is calibrated in degrees of phase displacement between transmitted and received signal, the phase displacement being practically zero over uniform non-conducting ground.

Although the rock types in the area were not considered very suitable for magnetic measurements, readings were taken over some of the traverses with an Askania vertical magnetometer. Large variations in magnetic susceptibility were not expected, but the high sensitivity of the instrument allowed slight variations, of the order of tens of gammas, to be measured.

4. RESULTS OF SURVEY.

(a) Self-Potential method

Four traverses, each about 1,200 feet in length, across the strike of the beds, were pegged for the test survey by geologists of the Titanium Alloy Manufacturing Company. The traverses extended from the Ordovician to the Cambrian rocks, and covered mainly the transition beds. To reduce topographic effects to a minimum, the traverses were laid out so that they covered relatively flat country. In most routine self-potential surveys the traverses are close enough together for one base station to suffice for the whole area surveyed. In the present survey, however, the traverses were more than 1,000 ft. apart and it was necessary to have a separate base station for each traverse.

The results of the self-potential survey are shown on Plate 2 as profiles along each traverse. The variations in the values recorded were quite insignificant as they rarely exceeded 20 millivolts and showed no definite trends. This irregularity in the profiles is probably due largely to variations in permeability and capillary action at the surface. The part of traverse G4 between 200N and 800N is typical of this irregular behaviour. Only at the northernmost end of traverse G4, where some weak negative anomalies were recorded (e.g. at 850N and 1050N), does the profile show any features of interest. In general, however, the four self-potential profiles do not show any significant anomalies which could be correlated with sulphide mineralisation. However, the amount of sulphides disclosed by the diamond drill holes in the surveyed area was very low; probably too low to give rise to significant self-potential anomalies. The self-potential method can therefore be considered as inconclusive for the investigation of deposits of the type tested but if much greater concentrations of sulphide minerals are present elsewhere in the area it is possible that they will give rise to self-potential anomalies.

(b) Electromagnetic method

Three of the four traverses, G1, G2 and G4, were surveyed using the Slingram equipment. Traverse G3 could not be surveyed because of an equipment breakdown which could not be repaired on the site.

Profiles of the real and imaginary components of the electromagnetic field are shown on Plate 3. The secondary and primary fields which comprise the real component are opposed to each other at the receiving coil. Therefore, assuming 100 per cent. to be the field strength over uniform, nonconducting ground, a field of considerably less than 100 per cent. indicates the presence of a good conductor. Negative values of the imaginary component also indicate good conductivity.

Vector diagrams of the results obtained along the three traverses are plotted on Plate 4. These diagrams are used to obtain additional information concerning the character of the conductor, and are plotted with the real component as the ordinate and the imaginary component as the abscissa of a rectangular co-ordinate system. The shape of the curve obtained by plotting successive readings along each traverse is indicative of the size and conductivity of the conductor.

The vector diagram of traverse G4 is a good example, as it shows two well-defined conductors of fair conductivity at 250N and 850N. The conductivity can be judged by the slope of the axis of the indication on the vector diagram. A very good conductor gives a real component of large amplitude but a relatively small imaginary component (measured by phase difference). The slope of the axis of the indication produced by a good conductor is, therefore, more nearly vertical. For a poor conductor it is more nearly horizontal.

The profiles of the real and imaginary components have also been plotted on the geological maps of the area (Plates 5 and 6) in order to permit a direct comparison between the geological and electromagnetic data.

Summing up the electromagnetic results, it may be claimed that the Slingram method gave fairly well-defined, but not strong, indications of the presence of conductors. Zones of fairly high conductivity were recorded on traverse G1 at 425S and 975S, on traverse G2 at 450S, and on traverse G4 at 850N and 250N. Less pronounced conductivity was recorded on traverse G4 near 500N and 1100N. Zones of extremely low conductivity were recorded on traverse G1 at 625S, on traverse G2 at 250S, and on traverse G4 at 100N, 650N, 950N and 1200N.

The dry, weathered formations near the surface do not usually show such pronounced differences in electrical conductivity as the lower strata. The electromagnetic anomalies will, therefore, be displaced to the hanging-wall side from the outcropping portion of the bed causing the anomalies. In the surveyed areas, the beds which lie stratigraphically immediately below Bed "A" (see Plate 5), appear to give the most prominent indication of a good conducting zone, and near traverse G4 also these beds appear to contain the highest copper values. The anomalies would, however, be more pronounced and indicate higher conductivity if they originated from highly mineralised beds. In the present instance of syngenetic deposits it might be expected that the quality of the anomalies would be, to some extent, indicative of the extent of the mineralisation. The anomalies can, however, even under favourable circumstances, be taken only as a rough guide to the degree of mineralisation, because the permeability of the beds and the pH value of the water in the beds also influence the conductivity.

The zones of low conductivity probably correspond to zones of non-mineralised, highly impermeable beds of quartzite or limestone. For example, the well-defined, rather narrow bed of low conductivity at 625S on traverse G1 can probably be correlated with a narrow limestone bed mapped in this part of the area.

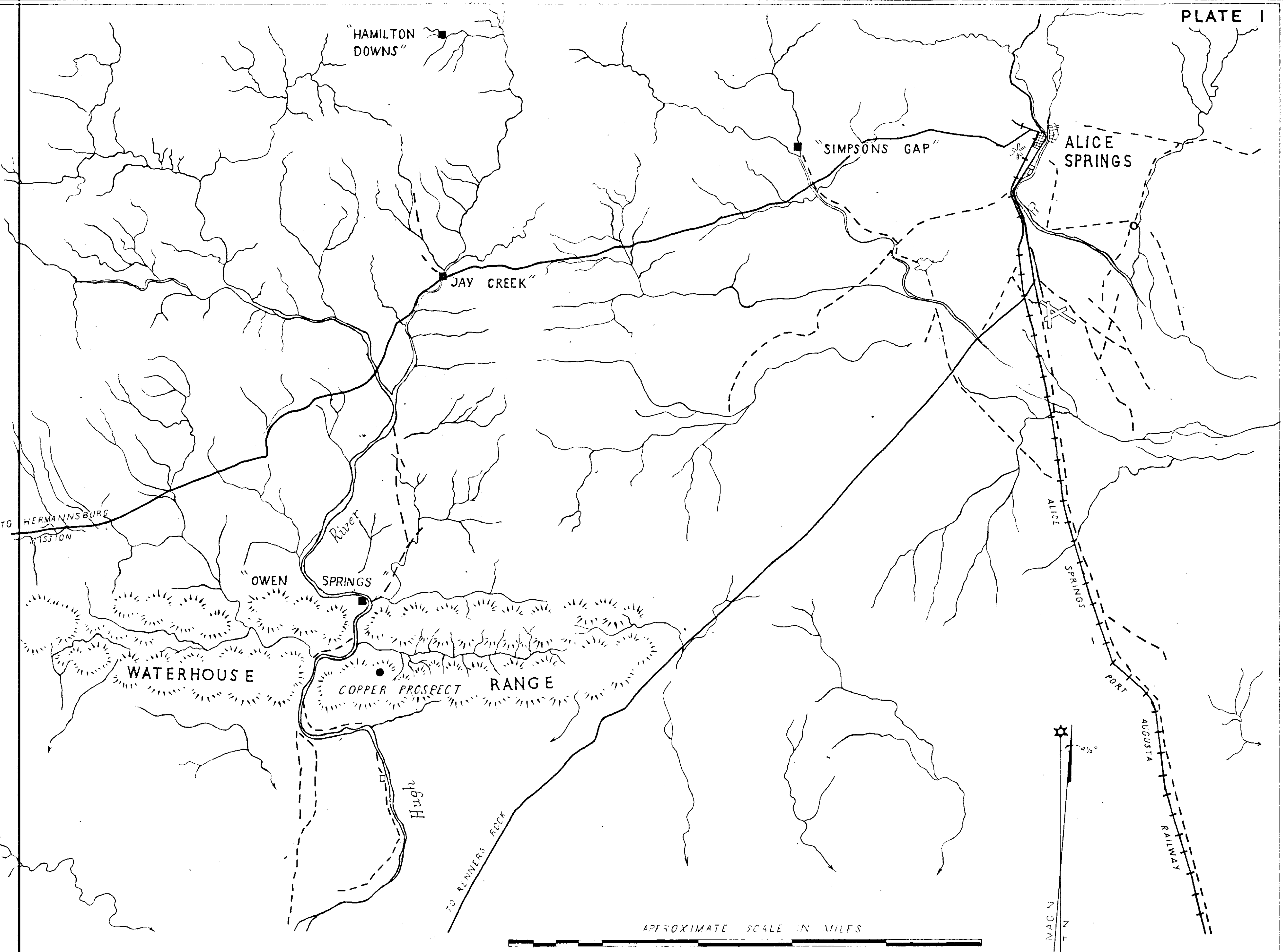
(c) <u>Magnetic method</u>

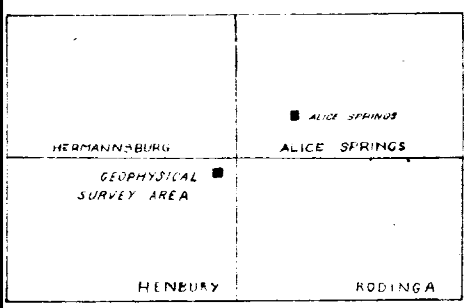
Although the rock types in the area did not appear to be conducive to the magnetic method of survey, it was considered worth while making a quick magnetic investigation along the surveyed traverses. The instrument used was an Askania vertical force magnetometer with a scale value of 30 gammas per division. The only indication of note was at 650S on traverse G1 (Plate 7), where a weak magnetic anomaly of about 50 gammas was obtained; it can probably be correlated with some limonite capping which was mapped nearby. Generally, however, the magnetic anomalies were so small, irregular and difficult to correlate with any known geological features, that the test proved fairly conclusively that the magnetic method is of little use in the search for this type of copper deposit.

5. CONCLUSIONS.

The results of the survey indicate that magnetic and self-potential measurements are not likely to be of any value in investigating weakly mineralised deposits such as were tested in this area. If much greater concentrations of sulphide minerals occur elsewhere in the area it is possible that they would give rise to self-potential anomalies. The results obtained by the electromagnetic method appear to be capable of satisfactory correlation with the geological features. It is considered that, if the copper bodies contain ore of economic grade, they could be traced reliably by this method.

PLATE 1





REFERENCE TO 4-MILE MILITARY MAP SERIES (UNPUBLISHED AT FEB. 55)

GEOPHYSICAL TEST SURVEY OF COPPER DEPOSITS, WATERHOUSE RANGE, NORTHERN TERRITORY.

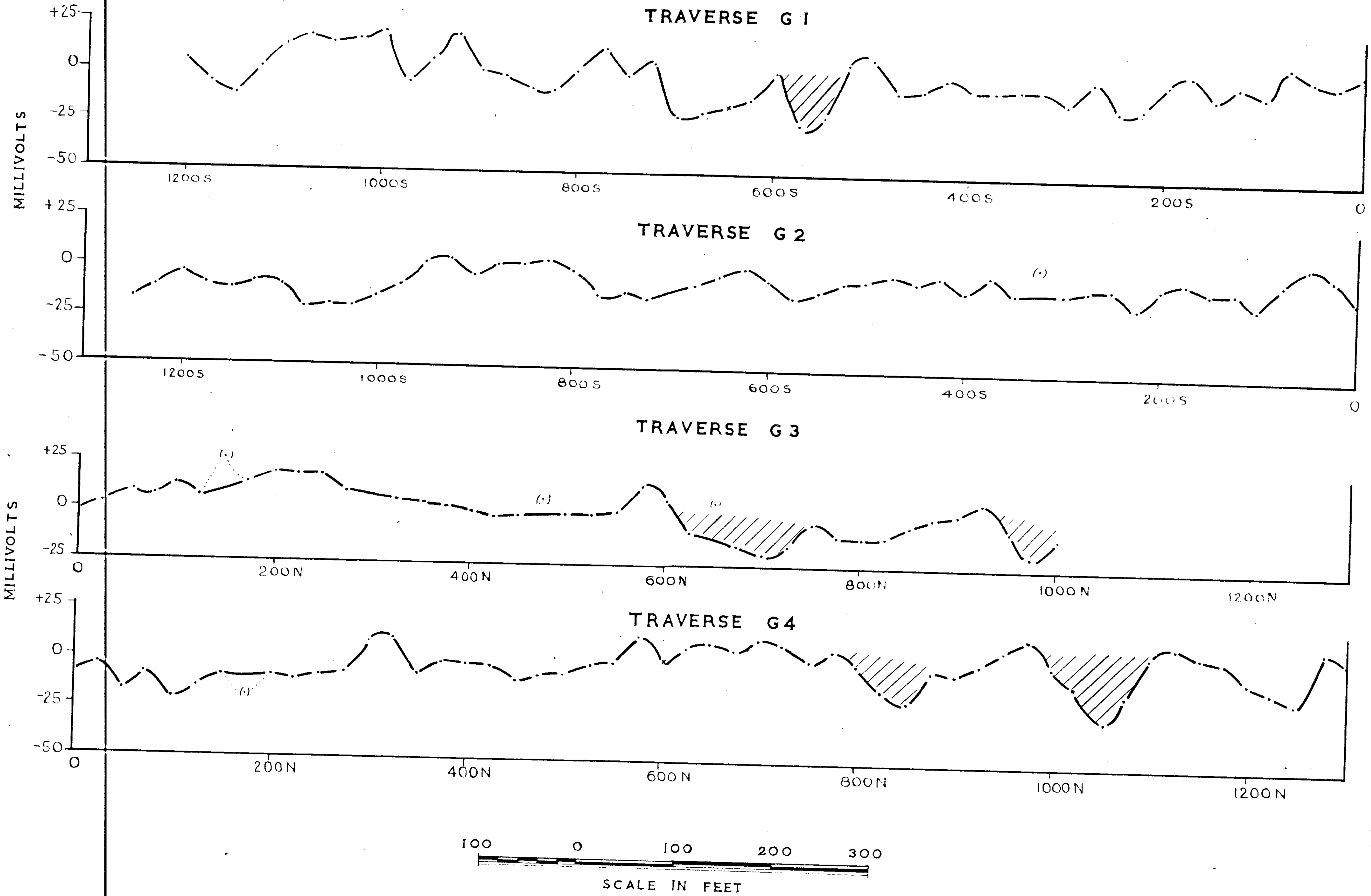
LOCALITY MAP.

TRACED FROM HERMANNSBURG, ALICE SPRINGS, HENBURY & RODINGA 4 MILE MOSAICS.

GEOPHYSICAL SECTION, BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS.

G 186-1

PLATE 2



GEOPHYSICAL TEST SURVEY OF COPPER DEPOSITS,
WATERHOUSE RANGE, NORTHERN TERRITORY

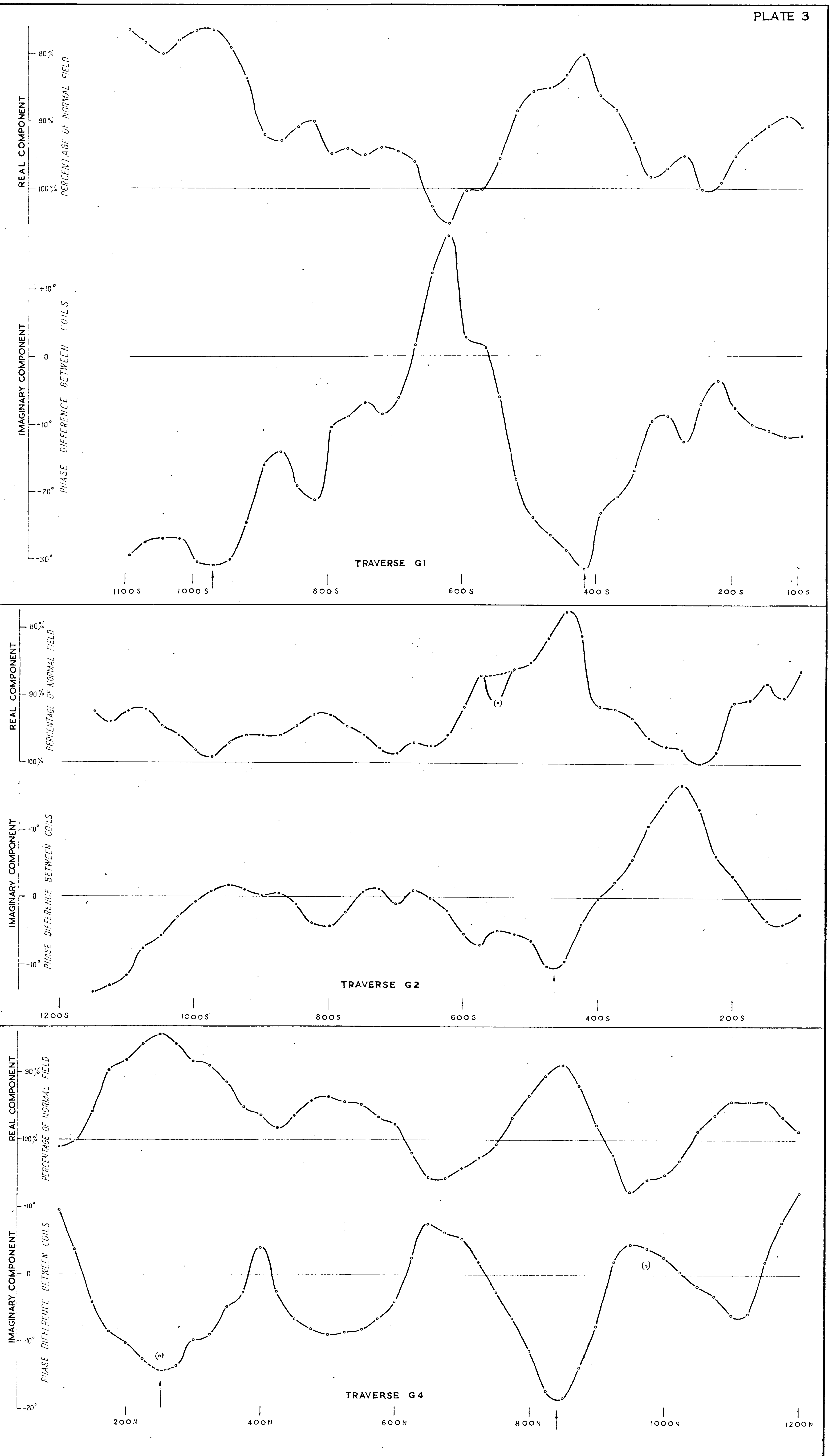
SELF–POTENTIAL PROFILES

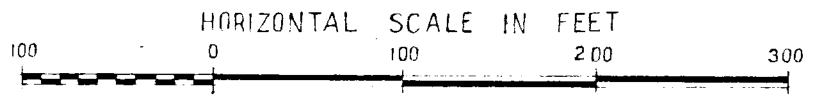
GEOPHYSICIST

Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics

G 186–2

PLATE 3





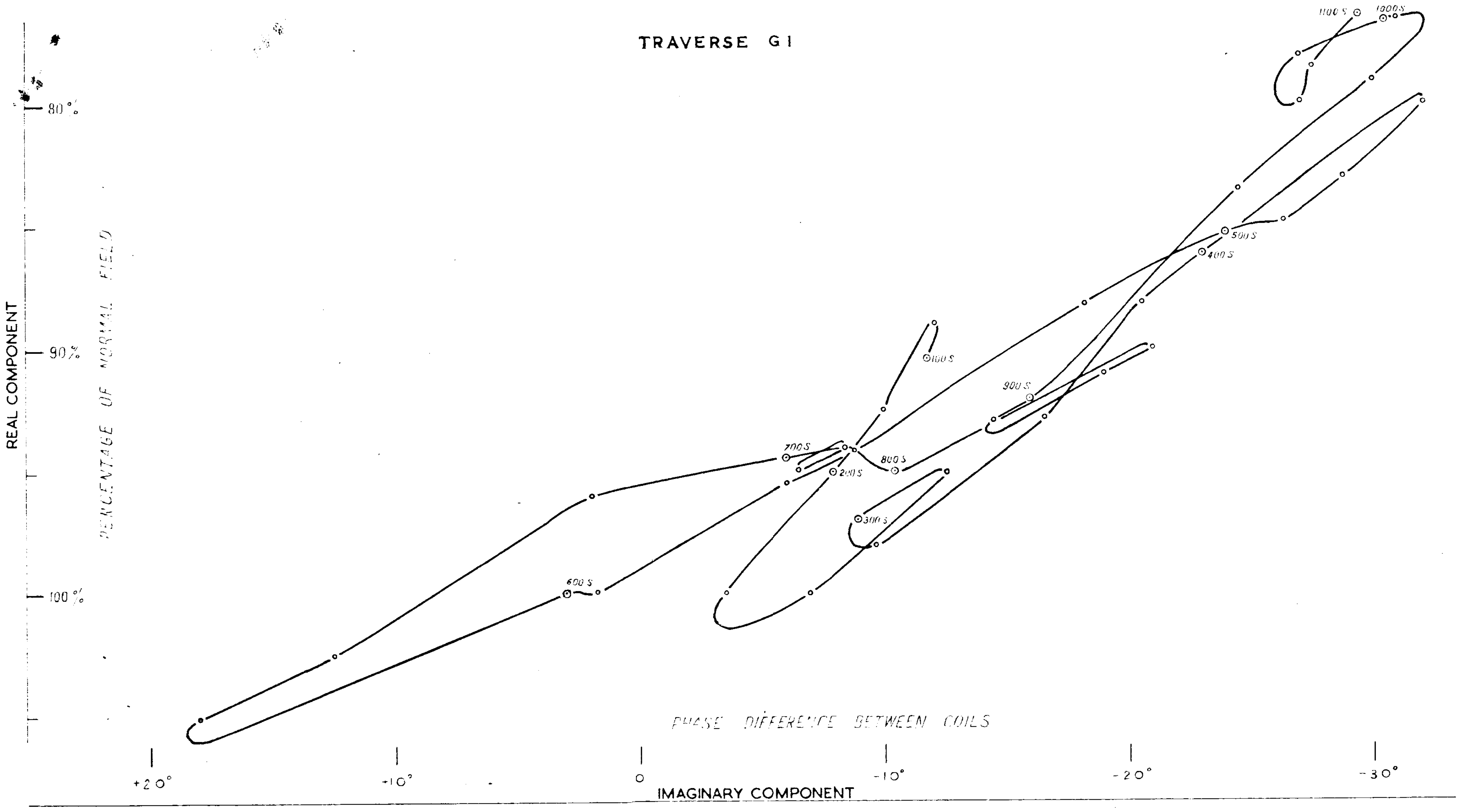
GEOPHYSICAL TEST SURVEY OF COPPER DEPOSITS
WATERHOUSE RANGE, NORTHERN TERRITORY

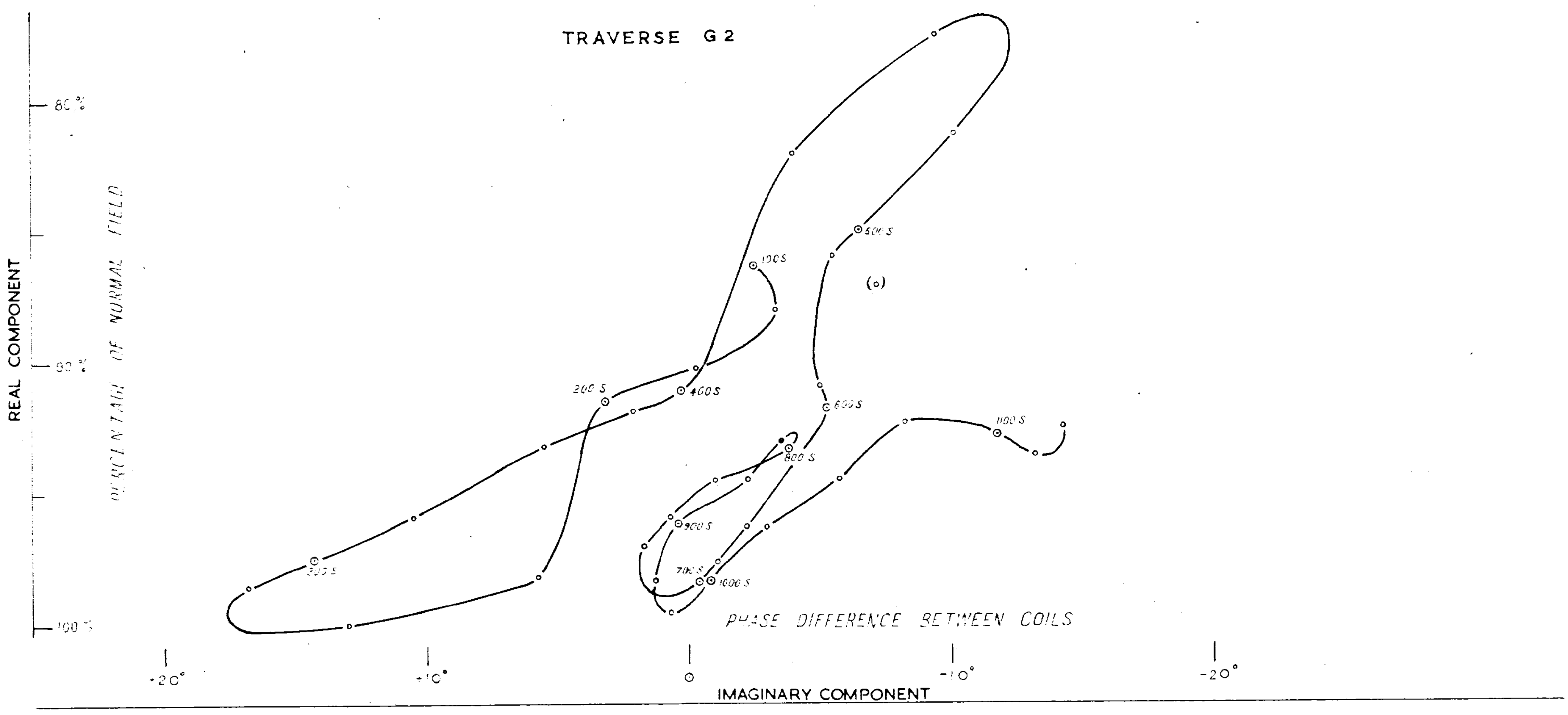
ELECTROMAGNETIC PROFILES

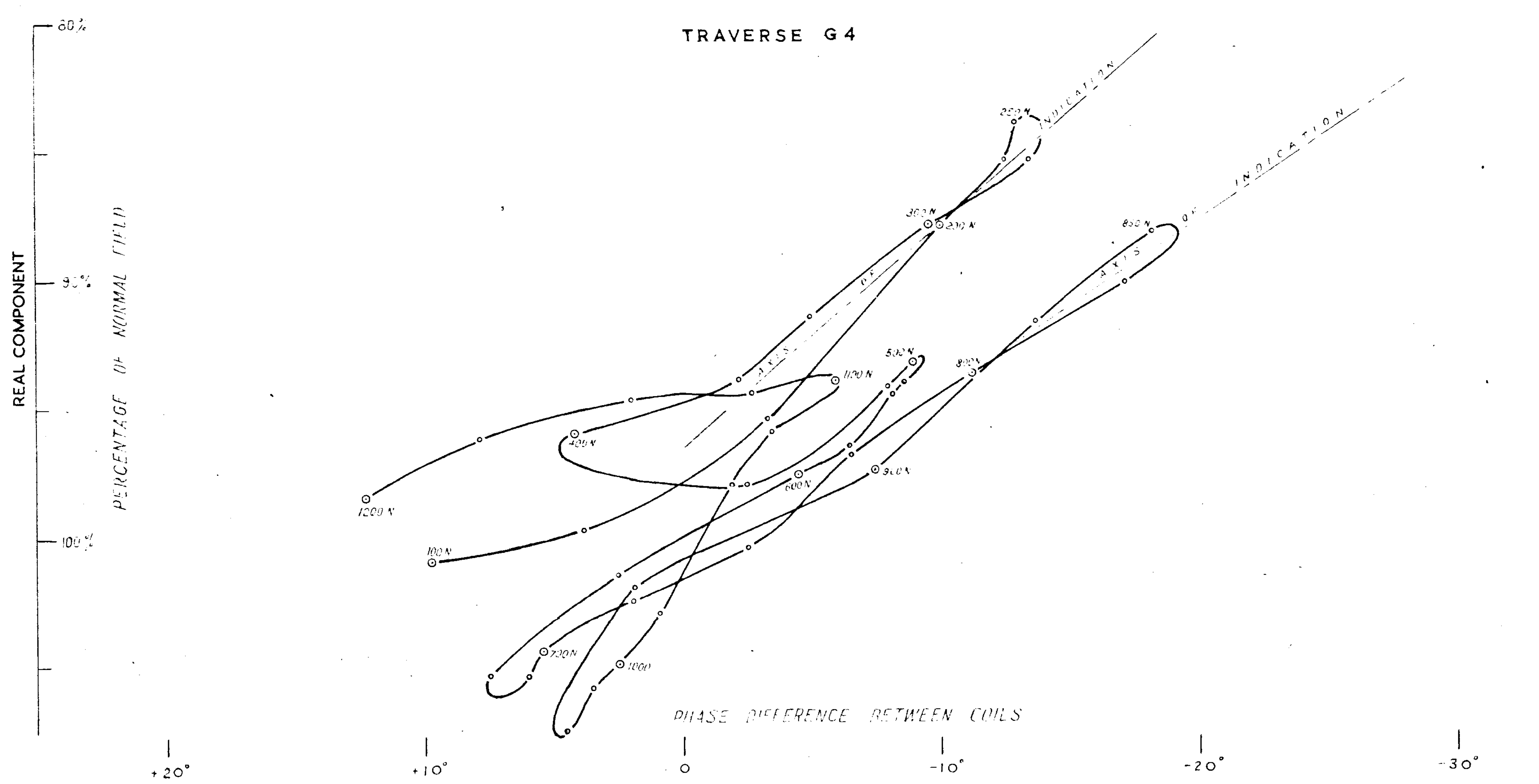
GEOPHYSICIST

Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics. G 186-3

PLATE 4





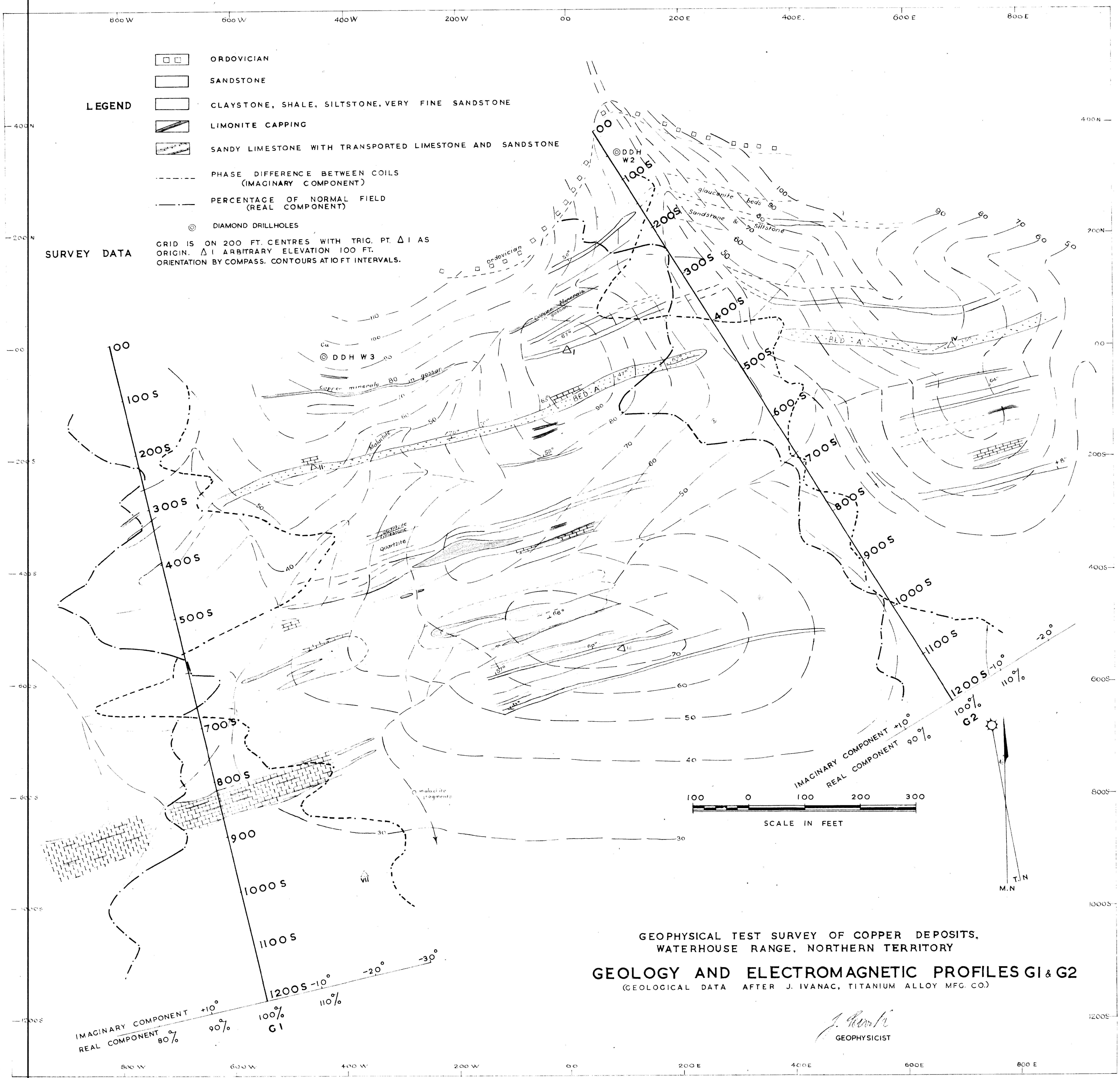


GEOPHYSICAL TEST SURVEY OF COPPER DEPOSITS
WATERHOUSE RANGE, NORTHERN TERRITORY

ELECTROMAGNETIC VECTOR DIAGRAMS

GEOPHYSICIST

Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics. G186-4

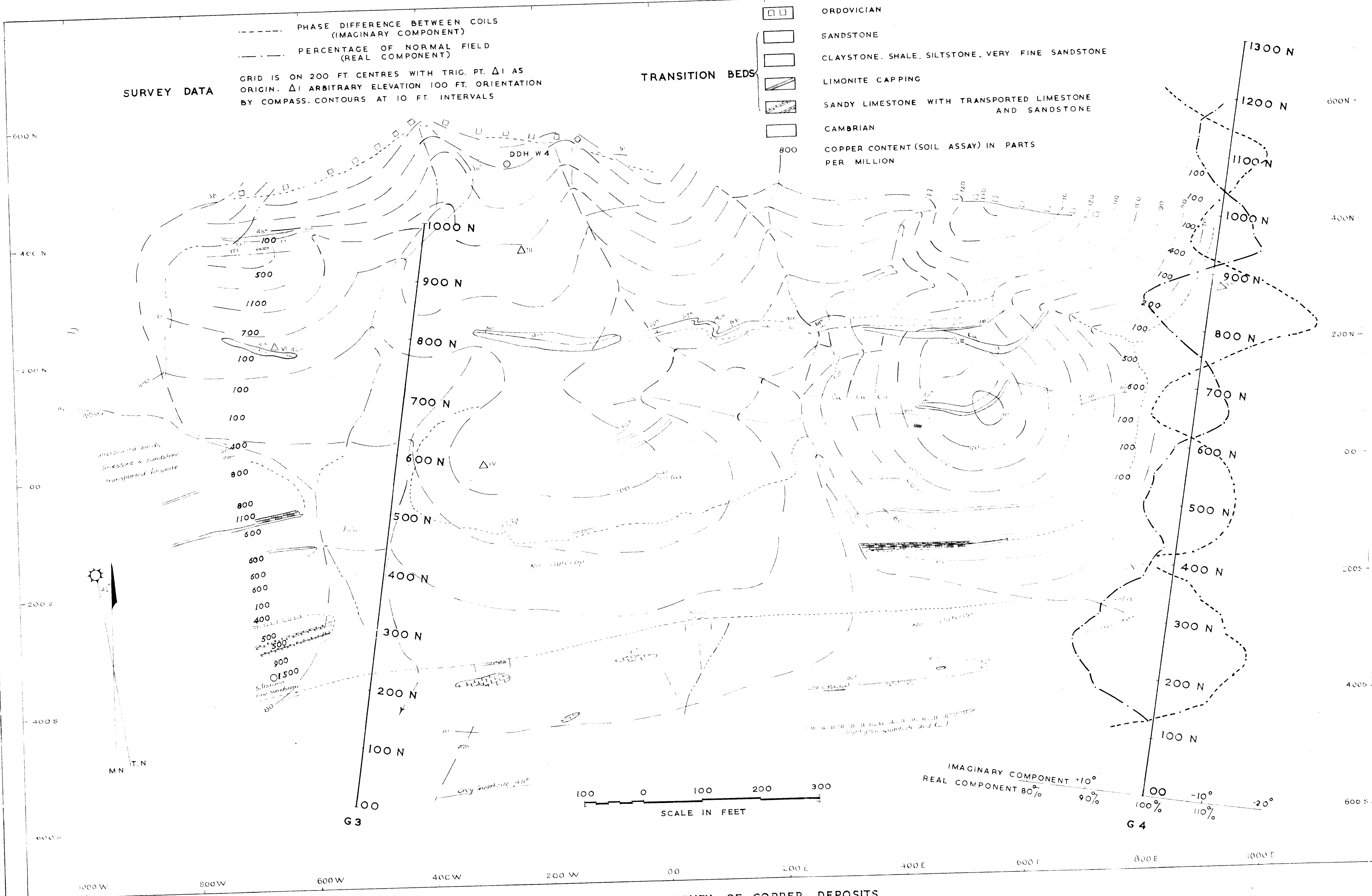


GEOPHYSICAL TEST SURVEY OF COPPER DEPOSITS, WATERHOUSE RANGE, NORTHERN TERRITORY

GEOLOGY AND ELECTROMAGNETIC PROFILES G1 & G2

(GEOLOGICAL DATA AFTER J. IVANAC, TITANIUM ALLOY MFG. CO.)

GEOPHYSICIST



GEOPHYSICAL TEST SURVEY OF COPPER DEPOSITS
WATERHOUSE RANGE, NORTHERN TERRITORY

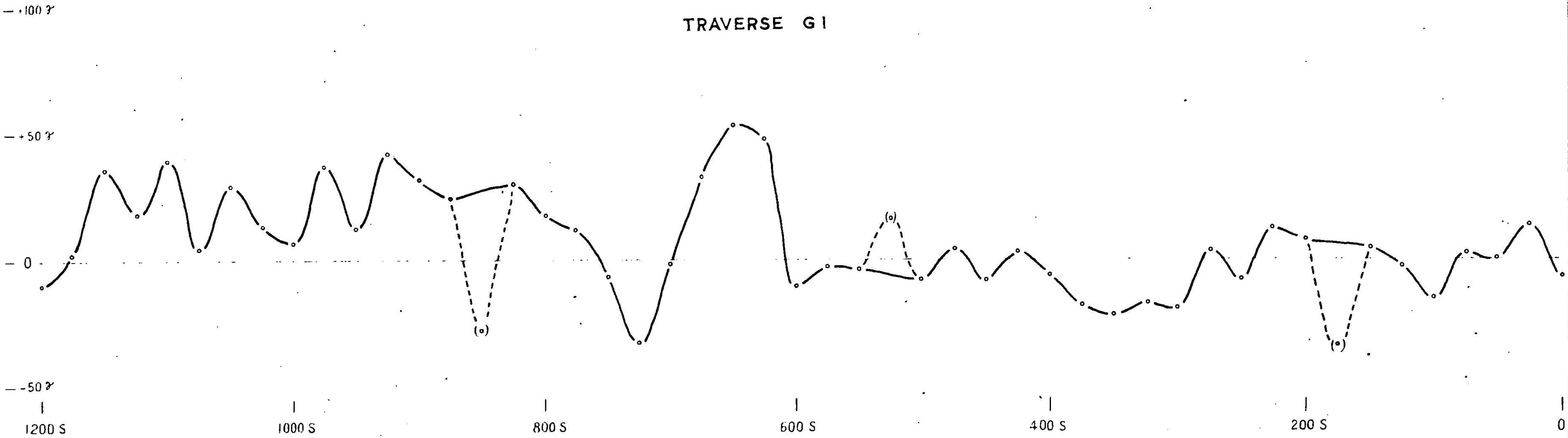
GEOLOGY AND ELECTROMAGNETIC PROFILE G4

(GEOLOGICAL DATA AFTER J. IVANAC, TITANIUM ALLOY MFG. CO.)

J. Carter
GEOPHYSICIST

Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics

G 186-6



HORIZONTAL SCALE IN FEET

100 0 100 200 300

J. Horvath
GEOPHYSICIST

GEOPHYSICAL TEST SURVEY OF COPPER DEPOSITS
WATERHOUSE RANGE, NORTHERN TERRITORY

VERTICAL MAGNETIC INTENSITY PROFILE

PLATE 7

Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics. G 186-7