COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORDS 1956, No. 74

GEOPHYSICAL SURVEY IN THE PROTHEROE AREA, NORTHAMPTON MINERAL FIELD, WESTERN AUSTRALIA

by

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ABSTRACT

The Northampton Mineral Field has been the largest producer of lead ores in Western Australia. Five main mines have each produced tonnages of ore of the order of 100,000 tons. At the time of the survey none of the mines was working, but Anglo-Westralian Mining Pty. Ltd. was considering re-opening the Protheroe Mine. At the request of the Company and the Department of Mines, Perth, a geophysical test survey was made in 1953 over an area of about one-half square mile, south-west of the Protheroe Mine, to search for indications of further mineralisation.

The electromagnetic method was used over the whole grid, and the magnetic method over certain selected traverses. Several indications were found, which appear favourably disposed with regard to the main structural features in the area. Locations are given for eight drill holes to test the most promising anomalies.

1. INTRODUCTION

The Northampton Mineral Field is situated north of Geraldton, Western Australia, and covers an area of about 1,500 square miles. Northampton, the largest town in the Field is about 35 miles north of Geraldton, which itself is about 310 miles north of Perth. The Field has three main areas of mineralisation, namely, Protheroe, Northampton and Galena, (Plate 1). Sixteen lead mines, eleven of which are smaller than the other five, have been worked; the oldest mine in the field was worked 100 years ago. The larger mines have produced ore tonnages ranging from 75,000 to 140,000, and with the lead content ranging from 9 to 20 per cent. Production from the smaller mines has ranged from 4,000 to 22,000 tons of ore, with a lead content of 6 to 13 per cent.

The Protheroe area is about 15 miles south-east of Northampton and 20 miles north-east of Geraldton. The area is undulating and is partly covered with bush. The area contains two of the five larger ore bodies, namely the Protheroe Lead Mine and the Narra Tarra Lead-Copper Mine, together with several smaller workings. None of the mines was producing at the time of the survey, but the Protheroe Mine was re-opened in November 1954.

The workings in the Protheroe area follow three, almost parallel, lines of mineralisation (Plate 2). The length of each of the workings is limited to several hundred feet. The Protheroe Lead Mine occurs on the centre line of mineralisation (Middle Lode), along which also other mine workings can be found, extending over a length of 4,500 feet. The former Narra Tarra Lead-Copper Mine workings are on a second line of mineralisation (West Lode) about 1,000 feet further west. The mine has been one of the largest producers in the area and was most intensively worked in the 1920's to a depth of 550 feet. The Narra Tarra workings extend over a length of 800 feet. The third line of mineralisation (East Lode) is about 800 feet east of the central line (Plate 2), but shows only smaller scattered workings over a length of nearly 3,000 feet.

In general, all the previous activities have been undertaken on a fairly small scale by individual prospectors who did not carry out any extensive exploration work. It is only in recent years that exploration on a larger scale has been undertaken by the Anglo-Westralian Mining Pty. Ltd., who made a geological survey and have re-opened the Protheroe Lead Mine. In May, 1953, a request was made by the company to the Mines Department, Western Australia, for a preliminary geophysical survey to be made to investigate the possibilities of locating further mineralisation in the area. This request was passed on to the Commonwealth Bureau of Mineral Resources, who subsequently carried out the test survey described in this report. The work was done from October to December, 1953, by Dr. O. Keunecke, geophysicist of the Bureau, and covered an area of 7,500 feet by 1,500 feet, surrounding the Protheroe Lead Mine.

The Imperial Geophysical Experimental Survey made electrical test surveys over the Wheel Ellen and Baddera mine areas near Northampton and over Block 7, Mary Springs and South Geraldine mine areas near Galena in 1929, but the limited amount of testing that followed gave no evidence of mineralisation associated with the electrical indications tested (Edge and Laby, 1931).

2. GEOLOGY

Investigation of the geology of the Northampton Field is difficult, because the rocks are mostly covered by a deep layer of soil, and very detailed examination has been necessary to establish the main structural features. The most complete geological study of the field is that by Campbell (1952). The following notes are based on Campbell's report.

The country rock is pre-Cambrian granitic gneiss, which is traversed by a series of persistent dolerite dykes striking roughly north-east. Some minor ore shoots are adjacent to these dykes, and it was thought at one time that they were the main control of mineralisation. Later investigation has proved that this is not so. The major ore bodies are associated with localised shears, which strike north-east (parallel to the dykes), but have no direct connection with basic rocks.

Campbell considers that the tectonic sequence has been, essentially, as follows:-

(i) Fracturing of certain areas by stresses, which have produced extensive shears, striking north-east and dipping generally north-west at about 65°.

(ii) Injection of these fractures with basic magma to form persistent dolerite dykes ranging from a few feet to 150 feet in width.

(iii) Development of steeply-dipping fault zones striking north-west.

(iv) Development of localised shearing in the gneiss between the dykes, and sometimes at the end of the dykes. This shearing, in general, strikes north-east and dips north-west at 60° to 70°. Occasional south-east dips at this angle have been observed.

(v) Formation of ore shoots by alteration and mineralisation of the localised shear zones.

According to Campbell, the ore deposits are critically controlled by the form of shearing. Favourable structures are considered to be either -

(a) Where the shears are split due to changes in rock type in the path of the shear; the ore bodies occurring in lenses of rock created by the splitting and rejoining of the shears.

(b) Sheared and brecciated links between shears.

A factor common to both types of structures is that ore bodies occur at places where the strike of the shear changes from a simple linear pattern to a more complex pattern.

It has been noted by Campbell that the majority of oreshoots occur in north-easterly striking shears where they are intersected by north-westerly striking faults and fractured zones. Strong alteration of the surrounding wall rocks by kaolinisation is a common feature of all ore deposits; the kaolinisation associated with the copper deposits being generally less than for the lead ore bodies. The ore bodies are limited in depth and workings have not exceeded 500 feet deep. Where the bottom of a shoot has been observed, the cut-off of the ore is due to structural causes. The field has not been prospected for possible repetition of ore shoots at depth.

In the Protheroe area, the West Lode dips 70° to the south-east; the Middle Lode, which contains the Protheroe Lead Mine, dips 65° to the north-west, and the East Lode dips 70° to the northwest. The West Lode on one side, and the Middle and East Lodes on the other, therefore dip towards each other. If the dips persist in depth, the West and Protheroe shears should intersect at a depth of about 1,000 feet and the West and East shears should intersect at about 2,600 feet.

The Protheroe and Narra Tarra ore shoots are each about 800 feet long. The ore contains 9 to 20 per cent lead (mainly galena), and minute quantities of zinc. The East and West Lodes also contain copper mineralisation and copper ore has been mined in the Narra Tarra Mine on the West Lode. Results of drilling have proved that the ore bodies are lenticular. The Anglo-Westralian Pty. Ltd. sank two drill holes on the Protheroe ore body, one 150 feet north, and the other 900 feet south, of the main shaft. Underground mining had reached the end of economic mineralisation at these distances in the various levels down to 425 feet. Both drill holes intersected the shear at vertical depths of 580 feet and 520 feet respectively, without striking any mineralisation of value. A third drill hole tested the East Lode near traverse 2600S, and at a vertical depth of about 210 feet struck galena showing an average of 14 per cent lead.

Another drill hole, sunk by a previous company, in the southern extension of the middle shear near 2,000S/600E reached a depth of about 200 feet without striking ore, but it is not certain that this hole actually reached the shear zone.

3. SELECTION AND APPLICABILITY OF GEOPHYSICAL METHODS

In order to verify that the geophysical methods chosen are suitable, the work should begin over a section of known geology. The results of this preliminary work will also show what kind of anomaly or indication can be expected, thus making more certain the geological interpretation of results obtained in adjacent areas.

In areas such as this, where sulphide deposits are associated with shears, geophysical methods can be of assistance, if the shears are sufficiently conductive to be detected, even though not mineralised to any significant extent. The facts that -

(a) the ore deposits are invariably accompanied by strong alteration by kaolinisation of the surrounding wall rocks, which could result in increased conductivity due to increased content of conductive water,

(b) the ore deposits occur where the normal linear course of the shears is interrupted or changed,

suggest that, even if the sulphide deposits cannot be detected directly, it would be possible to map the shear pattern and thus indicate those places along the course of the shears where favourable changes in strike occur and perhaps where alteration of the rocks is most intense.

Experience has shown that electrical methods, and in particular the inductive electromagnetic method, are the most suitable for the exploration of sulphide ore deposits. Magnetic and self-potential methods often provide useful additional information to assist in the interpretation of results.

4. ELECTROMAGNETIC SURVEY

(a) Method and equipment.

Inductive electromagnetic measurements utilise the fact that most sulphide minerals possess high electrical conductivity.

Although many variations of the method have been developed during the past 30 years, the basic principles underlying these methods are the same.

By passing an alternating current through a cable (usually in the form of a loop) laid out on the earth's surface, an electromagnetic field is set up around the cable. This field induces a current in any good conductor lying below the surface, this secondary current in turn setting up a secondary electromagnetic field. By measuring the total electromagnetic field at selected points along the traverses, and subtracting the known primary field, the effect of any good conductor is obtained.

In the method used in the present survey a primary current of 500 c/s from a transportable generator is passed through a rectangular loop of cable measuring 4,000 feet by 2,000 feet. At observation points on traverses at right angles to the longer side of the loop a search coil is set up, first vertically, with the plane of the coil perpendicular to the traverse, to measure the horizontal component of the electromagnetic field, and then horizontally to measure the vertical component. The current induced in the search coil is measured on an alternating co-ordinate potentiometer which determines the value of the component in-phase with the primary current (real component) and of the component 90° out-of-phase with the primary current (imaginary component). In all therefore, four components are measured at each observation point, namely the real and imaginary horizontal components and the real and imaginary vertical components.

(b) Work done and results obtained.

When surveying by the inductive electromagnetic method, it is advisable to have the source of the primary field on the footwall side of a deposit. The base line for the survey was accordingly located about 500 feet south-east of, and parallel to, the Middle Lode. In the southern area it was considered advisable to move the cable about 300 feet to the south-east so that the East Lode could also be investigated. Due to the south-easterly dip of the West Lode, the lay-out was not suitably placed for testing this formation.

The pegging and levelling of traverses was done by a surveyor of the Department of Interior, Perth. The traverses were 200 feet apart, 1500 feet long, and at right angles to the base line. Observation points were pegged at 50 feet intervals along each traverse. Traverse 00 corresponds to mine co-ordinate 500S, as it is 500 feet south of the Protheroe main shaft, which is the centre of the mine co-ordinates.

The geophysical survey started from the Protheroe Mine, but an area on both sides of the main shaft was not surveyed because of the presence there of buildings such as the power house, workshops, stores, etc. The first loop of 4,000 feet by 2,000 feet was laid out on the footwall side of the Middle Lode and an area south-west of the mine (traverses 00 to 2400S) was surveyed. By laying a second loop to the north-east, traverses 725N to 1525N were surveyed and finally, with a third loop to the extreme south-west, traverses 2400S to 4800S were surveyed.

The results of the electromagnetic survey are shown on Plates 2 to 5 inclusive. Plate 2 shows the location of the main geophysical indications, recommended drilling targets and known lodes. Plate 3 shows profiles of the imaginary horizontal component along all traverses and Plate 4 the real and imaginary horizontal components along traverses 00, 400S and 2600S, together with the geological information obtained from diamond drilling and underground development in these parts. Electromagnetic vector diagrams for several selected traverses are reproduced on Plate 5.

(c) <u>Discussion of results</u>.

Plate 2 shows that electrical indications occur north and south of the Protheroe Mine. In general, these indications are in the direction of continuation of the lodes, and have the same directions of strike, but are somewhat displaced from the outcropping lodes in the direction of dip. The indications are well pronounced on traverse 00 (Plates 3, 4 and 5), which crosses the mine area where underground mining has developed economic ore - see geological cross-section on Plate 4. The profile of this traverse shows the type and magnitude of the electrical indications over known mineralisation as disclosed in the area by mining operations.

There are practically no indications between traverses 200S and 800S to the immediate south of the Protheroe ore body. Diamond Drill Hole No.1 (traverse 400S, 1000W), intersected the lode shear at a vertical depth of about 580 feet, but struck no ore.

Further south, on traverses 1000S and 1200S there are indications of medium strength in the direction of continuation of the Middle Lode. These indications are interrupted on traverse 1400S which shows only a weak indication at 300W, which is outside the line of the Middle Lode. From traverse 1600S to traverse 2990S, however, there is a line of indications of varying strength which appears to be related to the Middle Lode shear. These indications are of medium strength on traverses 2000S, 2400S and 2600S and terminate on 2990S.

Two other lines of indications are shown on Plate 2 in the southern area, one between traverses 2400S and 3200S, and another between traverses 3200S and 4000S. Because the indications overlap to some extent on traverses 2400S to 3200S, there is some doubt about the way the individual anomalies should be connected between the traverses. The connections shown are believed to be the most likely on the available evidence. The two lines of indications appear to be related to the East Lode shear. The first of these is of medium strength between 2600S/25W and 2990S/200W, while the other is of medium strength at 3400S/150W, 3600S/225W and 4000S/275W. The occurrence of ore has been proved on the first of these lines of indications, D.D.H. No.3 having struck ore containing 14 per cent lead near traverse 2600S, at a vertical depth of 210 feet (see Plate 4).

In addition to the main indications already discussed, several smaller indications were recorded. The strongest of these is between 1800S/900W and 2200S/950W, and shows medium strength on traverse 2000S.

In the area north of the Protheroe Mine, the only indications are along the continuation of the Middle Lode, as far as traverse 1525N. These indications are generally weak, however, reaching medium strength only on traverse 1125N.

Tables 1 and 2 give a brief summary of the electromagnetic indications south and north of the Protheroe Mine respectively. The centre and strength of each indication is shown, together with recommendations for drill holes. It cannot be expected that these indications are all due to sulphide mineralisation. They probably show mainly the shear zones. The high electrical conductivity is probably caused by slight mineralisation and acid water in the shear. The vector diagrams show that the highest electrical conductivity is found on traverse 00, corresponding to payable lead values. By determining the electrical conductivity it might be possible to distinguish between better and less mineralised portions of the lode.

TABLE 1

ELECTROMAGNETIC INDICATIONS SOUTH OF THE PROTHEROE MINE

Traverse	Position of Indication	Strength of Indication	Drilling Recommendation
00	625W	Strong	
1000S	560W	Medium	D.D.H."A"
1200S	550W	"	
1400S	300W	Weak	
1600S	450W	"	
	700W	Very weak	
1800S	475W	" "	
	900W	Weak	
2000S	350W	"	
	500W	Medium	D.D.H."G"
	950W	"	D.D.H."E"
2200S	400W	Very weak	
	550W	Weak	D.D.H."C"
	950W	"	
2400S	75E	"	
	75W	Very weak	
	550W	Medium	
	800W	Weak	
2600S	25W	Medium	D.D.H."B"
	550W	"	
2800S	110W	"	D.D.H."D"
	250W	Weak	
	400W	"	
	600W	"	
2990S	200W	Medium	
	350W	Weak	
	550W	Very weak	
3200S	100W	Weak	
	275W	"	
3400S	150W	Medium	D.D.H."F"
3600S	225W	"	
3800S	250W	Very weak	
4000S	275W	Medium	

TABLE 2

ELECTROMAGNETIC INDICATIONS NORTH OF THE PROTHEROE MINE

Traverse	Position of Indication	Strength of Indication	Drilling Recommendation
725N	225W	Weak	
	525W	Very weak	
925N	475W	Weak	
1125N	470W	Medium	D.D.H."H"
	1450W	Weak	
1325N	450W	Very weak	
	675W	Weak	
1525N	450W	Very weak	

5. MAGNETIC TESTS

(a) Introduction.

A small amount of magnetic testing, using a Watts vertical variometer, was carried out, to determine whether the magnetic method would give any useful results. Readings were taken along traverse 2325N (not shown on Plate 2), and along traverses 2600S, 3400S and 3600S. The profiles obtained are shown on Plate 6.

(b) Discussion of results.

Anomalies of small magnitude, although reasonably well defined, are present on some of the traverses. The anomaly centred at 250W on traverse 2325N can be correlated with a dolerite dyke. A broad anomaly centred at 50W occurs on traverse 2600S, coinciding with an electromagnetic indication of medium strength. On traverses 3400S and 3600S, no definite magnetic indications were observed over the electromagnetic indications, which were also of medium strength, but definite anomalies are present at about 325E on each traverse.

Due to the limited amount of magnetic work performed, these indications cannot be interpreted with certainty, but it is reasonable to suppose that they indicate the presence of dolerite. As mentioned in section 2, geological information suggests that the dolerite has no necessary connection with mineralisation.

6. CONCLUSIONS AND RECOMMENDATIONS

It is concluded that the distribution of electromagnetic indications, as shown on Plate 2, shows the general pattern of shearing in the area surveyed. The pattern consists of several minor shears, roughly parallel, with lengths up to 800 feet. These shears occur more frequently, and are spaced closer together, towards the southern end of the area. The strength of the indications varies from weak to medium. Although the only indication which is classed as "strong" occurs on traverse zero, in a position where minable ore has been proved in the Protheroe workings, there is no reason to suppose that the intensity of the indications is related entirely to the degree of mineralisation of the shears. The strength of the indications depends mainly on the conductivity and dimensions of the bodies causing them and factors that effect the conductivity are the degree of sulphide mineralisation, and the amount and conductivity of the water present in the body. Where the amount of water in the body is low, the amount of sulphide mineralisation present is the principal factor. In this area, however, where considerable alteration by kaolinisation is known to be a feature of the mineralised shears, it is likely that the water content of the shears is relatively high and saline and may contribute largely to their conductivity. However, the extent of this alteration is greatest near the ore shoots, and high conductivity, no matter what its cause, may indicate those places in the shears most likely to be mineralised. Some testing therefore, purely on the basis of high conductivity, appears to be warranted.

In Tables 1 and 2, sites are shown for eight drill holes, which it is considered would adequately test the indications. These drill holes should be collared north-west of the lines of electromagnetic indications, and drilled in a south-easterly direction, depressed so as to reach the sites of the indications at a depth of 200 feet.

If the exploration work recommended should prove any ore shoots of economic value, a considerable extension of the geophysical survey would be warranted. Obvious directions for further work would be to extend the survey to the south-west, to test the East and West Lodes, and to extend to the north-east if indications appear to warrant this.

7. REFERENCES

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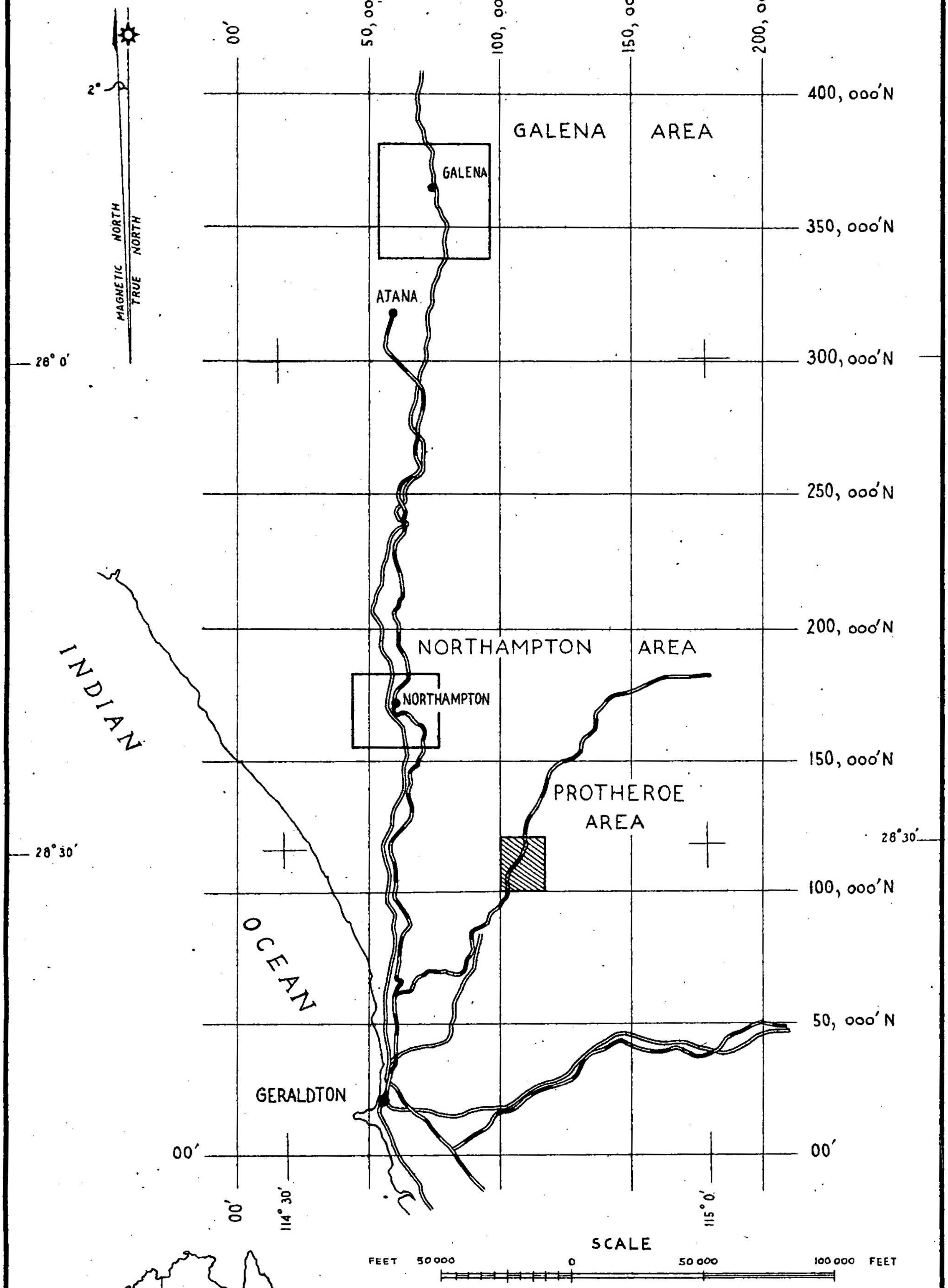
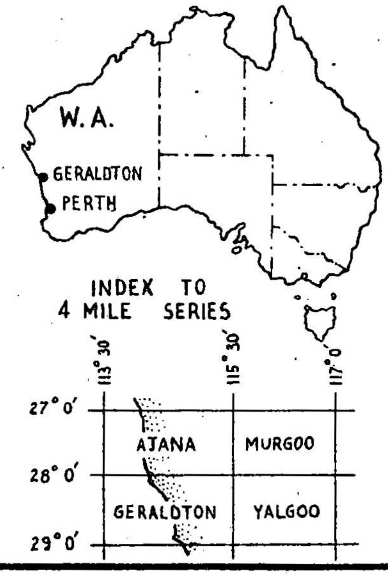
Wilson, R.C. - The Northampton Mineral Field, Dept. Mines W.A.

PLATE 1





LOCALITY MAP

GEOPHYSICAL INVESTIGATION OF THE PROTHEROE AREA

NORTHAMPTON MINERAL FIELD, W.A.

Geophysical Section,
Bureau of Mineral Resources. Geology and Geophysics.

G 154 – 3

GEOPHYSICAL INVESTIGATION OF THE PROTHEROE AREA, NORTHAMPTON MINERAL FIELD, W.A.

SURFACE FEATURES, KNOWN LODES, GEOPHYSICAL GRID AND INDICATIONS WITH DRILLING RECOMMENDATIONS

GEOPHYSICIST

Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics

G 154—4

PLATE 3

GEOPHYSICAL INVESTIGATION OF THE PROTHEROE AREA

NORTHAMPTON MINERAL FIELD, W.A.

PROFILES OF IMAGINARY HORIZONTAL COMPONENTS OF ELECTROMAGNETIC FIELD

Kenworthy
GEOPHYSICIST

Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics G 154-5

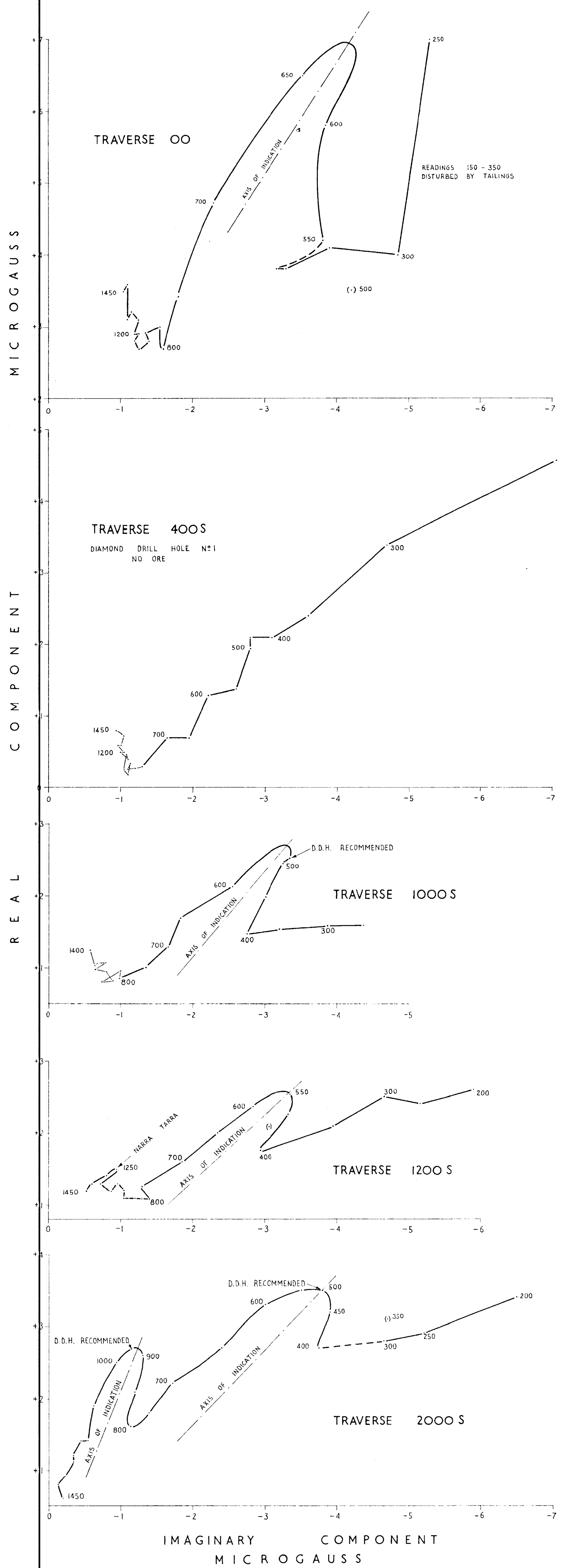
PLATE 4

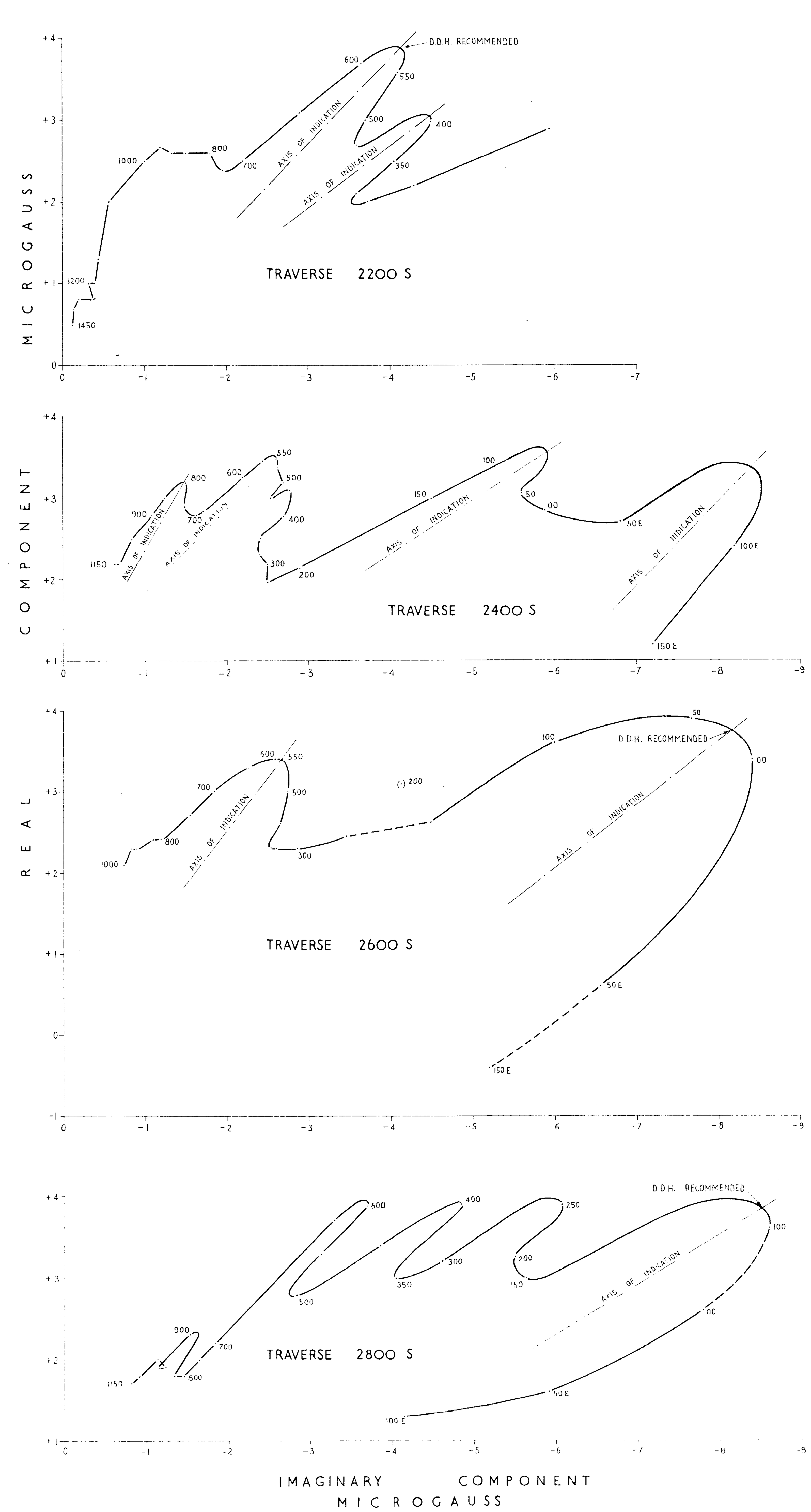
GEOPHYSICAL INVESTIGATION OF THE PROTHEROE AREA

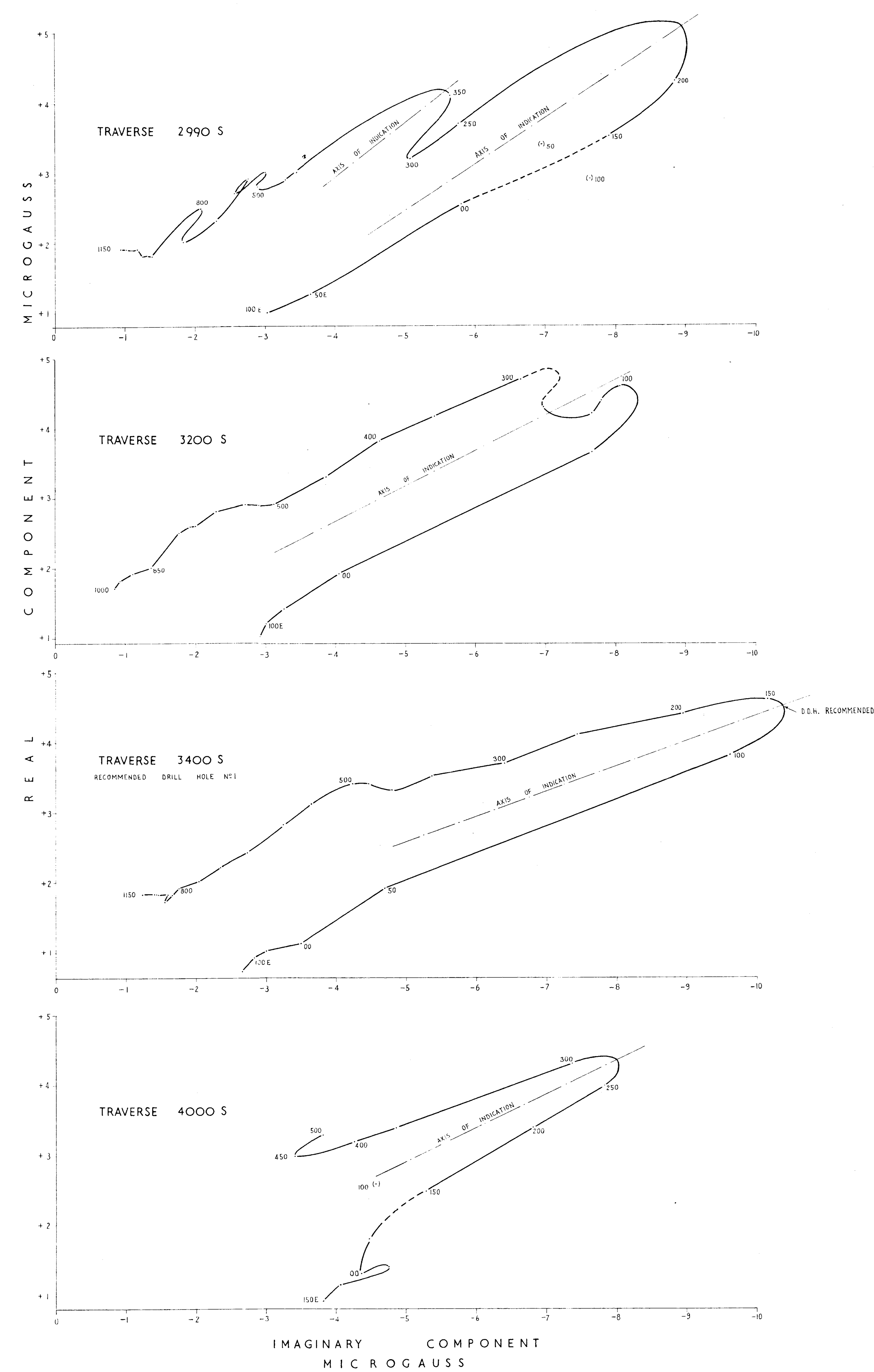
NORTHAMPTON MINERAL FIELD, W. A.

PROFILES OF REAL AND IMAGINARY HORIZONTAL COMPONENTS OF ELECTROMAGNETIC FIELD

Kenwerky
GEOPHYSICIST







GEOPHYSICAL INVESTIGATION OF THE PROTHEROE AREA, NORTHAMPTON MINERAL FIELD, W.A.

VECTOR DIAGRAMS OF HORIZONTAL COMPONENT OF ELECTROMAGNETIC FIELD

HORIZONTAL AND VERTICAL SCALE

MICROGAUSS 1 0 1 2 3 MICROGAUSS

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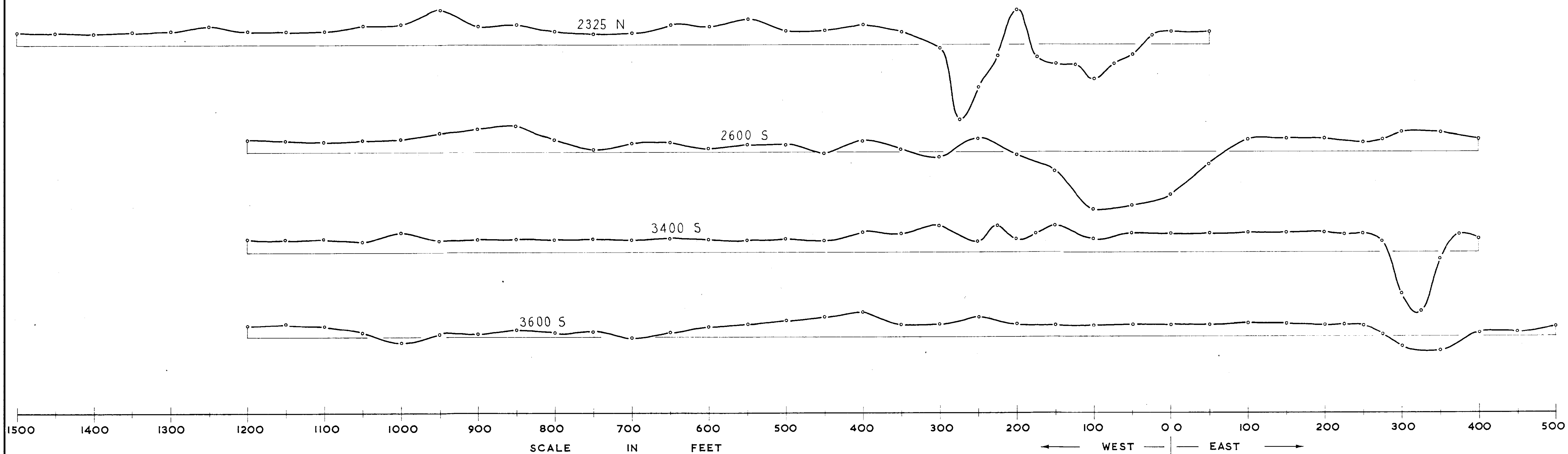
PLATE 6



SCALES

HORIZONTAL 100 0 100 200 300 400 FEET

VERTICAL 100 0 100 200 300 400 GAMMAS

GEOPHYSICAL INVESTIGATION OF THE PROTHEROE AREA

NORTHAMPTON MINERAL FIELD, W. A.

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PROFILES OF VERTICAL MAGNETIC INTENSITY

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