Copy 3.

COMMONWEALTH OF AUSTRALIA
DEPARTMENT OF NATIONAL DEVELOPMENT
BUREAU OF MINERAL RESOURCES,
GEOLOGY AND GEOPHYSICS

RECORDS 1957, No. 4

GEOPHYSICAL SURVEY AT COBALT WORKINGS, CARCOAR, N.S.W.

by

J. HORVATH and D. L. ROWSTON

COMMONWEALTH OF AUSTRALIA
DEPARTMENT OF NATIONAL DEVELOPMENT
BUREAU OF MINERAL RESOURCES,
GEOLOGY AND GEOPHYSICS

RECORDS 1957, No. 4

GEOPHYSICAL SURVEY AT COBALT WORKINGS, CARCOAR, N.S.W.

by

J. HORVATH and D. L. ROWSTON

CONTENTS

		Page
	ABSTRACT.	(iii)
1.	INTRODUCTION.	1
2.	HISTORY AND PREVIOUS SURVEYS.	1
3.	GEOLOGY.	1
4.	FIELD OPERATIONS.	2
5.	SELECTION AND APPLICABILITY OF METHODS.	2
	(a) Magnetic	2
	(b) Self-potential	2
	(c) Electromagnetic	3
	(d) Geochemical	4
6.	DISCUSSION OF RESULTS.	4
	(a) Magnetic	4
	(b) Electromagnetic	5
	(c) Geochemical	6
7.	CONCLUSIONS AND RECOMMENDATIONS.	6
8.	ACKNOWLEDGEMENTS.	7
9.	REFERENCES.	7

Table 1 - Geochemical Assays of Soil Samples.

ILLUSTRATIONS

Plate 1. Locality map and regional geology.
2. Geological map.
3. Topography and geophysical grid.
4. Vertical magnetic force contours.
5. Turam ratio contours.
6. Typical geophysical and terrain profiles.
7. Turam ratio profiles.
8. Geophysical indications.
9. Geochemical results.

ABSTRACT

A geophysical investigation was undertaken by the Bureau of Mineral Resources between April and June, 1955 at the Carcoar cobalt deposits, N.S.W. The survey was made in order to augment previous geological and radiometric work over the cobalt-uranium workings. The Department of Mines, N.S.W., as the result of a geological report by I. O. Rayner and R. Ralph (1954) advocated the geophysical survey.

Magnetic, self-potential and electromagnetic methods were used, and some geochemical sampling was also done.

The magnetic method was successful in outlining the extent of the main diorite intrusive. Main occurrences of cobalt-uranium mineralisation appear to be concentrated along the slate/diorite contact over a belt approximately 700 feet wide. Continuation of radiometric prospecting is recommended along this boundary to the north-east and south-west. Some magnetic anomalies in the central southern section cannot at present be correlated with mineralisation.

Electromagnetic methods gave a series of indications varying from very weak to strong and which are believed to delineate a shear system in the area. Varying conductivity along the shears and the results of geochemical assays indicate local mineralisation in the shear system. The indications show two main directions of strike, those trending N30E having some control of uranium concentrations because radioactive anomalies appear to strike parallel to these and are confined to the margins of, and between zones of, high electrical conductivity.

Self-potential observations gave no useful results over some test traverses and were discontinued.

Some samples were tested geochemically for copper, cobalt and uranium, and gave positive analyses for copper over some electro-magnetic anomalies. Copper assays showed well pronounced maxima practically coinciding with the electromagnetic indications. Uranium assays did not show such good agreement.

Exploration of the deposits should be started by trenching. This should be followed by diamond drilling, subject to study of the information obtained from the trenches. Locations for twelve trenches are suggested.

1. INTRODUCTION

The Carcoar cobalt workings are situated about one mile south of Carcoar township, which is some 40 miles south-west of Bathurst, New South Wales (Plate 1). The geophysical survey described in this report was made between April and June, 1955, by the Bureau of Mineral Resources as a result of a request by the N.S.W. Department of Mines. This request was based mainly on the results of a geological investigation made by Rayner and Ralph (1954). The survey was made with the object of augmenting the geological and radiometric data already obtained, and planning a development programme. Geophysical work was done in sections of Portions 1, 2, 3, 7, 8 and 9, Parish of Shaw, County of Bathurst.

A preliminary report on the results of the geophysical survey (Daly, 1955) was issued in September, 1955.

The mineral leases are held by a syndicate, and uranium minerals are known near old cobalt and copper workings. The area is accessible to vehicles, and the moderate topography and open grazing country are suitable for geophysical prospecting methods.

2. HISTORY AND PREVIOUS SURVEYS.

Torbernite, closely associated with cobalt, was first recorded in the area by G. W. Card (1894) and autunite was confirmed in a sample from the cobalt workings in 1916. The area was worked for cobalt from 1891 to 1895 for a total production of about 110 tons of cobalt ore.

During an examination of museum mineral specimens for radioactivity, it was found that samples of molybdenite and cobalt ore from Carcoar were strongly radioactive. After this, radiometric investigations were made in the Carcoar area by the Bureau of Mineral Resources in 1950/51 (Daly, Dyson and Pearce, 1951).

The geology of the area has been reported on by Matheson (1952), a previous survey by Bruce and Langley (1949) supplying regional data.

An airborne scintillometer survey by the Bureau (Daly, 1953) indicated small anomalies over and near the cobalt deposits.

A detailed ground radiometric survey was made over a larger area by officers of the N.S.W. Department of Mines (Rayner and Ralph, 1954).

3. GEOLOGY

The following geological description is based mainly on the report by Matheson (1952), and the results of his detailed survey are reproduced as Plate 2.

The cobalt-uranium deposits occur in a narrow belt along the southern limits of a hornblende-diorite body, which forms the nose of a south-pitching regional anticline. Granite forms the core of this structure and is thought to be the origin of the mineralising solutions. An area of silicified Silurian slates abuts the diorite and is terminated in the south-east by a suite of crushed andesites and tuffs. Both slates and volcanics are intruded by diorite sills and dykes and the area is crossed by a well-developed shear system.

Radioactive minerals are associated with cobalt minerals and molybdenite, the latter occurring mainly in the north-eastern workings. Mineralisation in the form of small lenses, is confined to a zone in the slates along the contact of the main diorite mass, and is controlled to some degree by the shearing. Matheson records two main directions of shearing, one striking approximately north and one N.30°E. Copper occurrences in the area are attributed to the same mineralisation period concomitant with the Blayney granite.

Two narrow silicified zones occur on a north-easterly strike, parallel with the slate bedding. Their abrupt termination and other geological and geophysical evidence suggest the existence of a fault plane striking N.20°W, linking with the shear outcrop shown on Plate 2.

4. FIELD OPERATIONS.

In April 1955, J. Daly, supervising geophysicist, accompanied by D. L. Rowston, party leader, made an inspection of the area and decided upon the orientation of the grid. After the arrival of P. Legge-Wilkinson, surveyor, from the Department of the Interior, Canberra, a traverse (10N) was pegged and all geophysical methods tested. Upon the successful completion of these preliminary tests the complete grid (Plate 3) was laid out and the geophysical investigation commenced.

After the return of J. Daly to Melbourne, J. Horvath (senior geophysicist) visited the area and was present during the early stages of the field work. R. Griffin of the N.S.W. Department of Mines assisted in the survey as observer for a few days, and P. M. Stott, geophysicist, assisted in the latter part of the survey.

5. SELECTION AND APPLICABILITY OF METHODS.

The following geophysical methods were used :-

(a) Magnetic.

(b) Self-potential.

(c) Electromagnetic.

(d) Geochemical.

(a) Magnetic.

Vertical magnetic force observations were made, as it was considered possible that magnetic intensity variations would occur near the slate/diorite contact and over the cobalt workings. Two Watts Vertical Force Variometers (Nos. 61319 and 63107) were used, each with a sensitivity of about 30 gammas per scale division. Readings were made at intervals of 25 feet or 50 feet, according to gradient, along the traverses shown on Plate 4. Traverses were 100 feet apart. Observations were corrected, reduced to an arbitrary zero, i.e. the value at base station 800 E on 10 N and plotted as profiles. A contour map of the results is shown on Plate 4.

(b) Self-potential.

Because of the occurrence of copper minerals and pyrite in quartz outcrops, measurements were made of natural earth potentials, which may be caused by chemical reactions during active oxidation of sulphide bodies above the ground-water table. However, readings with a Cambridge pH and S.P. meter indicated only normal surface fluctuations over selected test traverses 10N to 15N and 8S, and the S.P. measurements were therefore discontinued.

(c) Electromagnetic.

Two electromagnetic prospecting instruments were used in the survey, namely:-

(i) Turam.

(ii) Slingram.

In electromagnetic work an alternating primary field is set up in the area under investigation. If, within the limits of this field, there are zones of relatively high conductivity, secondary currents are formed in the subsurface and are apparent at the surface as secondary fields. The product of the primary and secondary fields results in an ellipse of polarisation. Determination of the components of this ellipse in amplitude and phase, and subtraction of the effects of the primary field, reveals the presence of any conductive bodies.

Sulphide mineralisation, graphitic schists, shearing and faulting are among the possible causes of such secondary fields.

Many parameters, such as the size, dispositon and continuity of ore bodies, exciting frequency, conductivity of soil cover and the relative conductivity of lode and country rock make mathematical treatment difficult. As the interpretation depends upon several variable factors, all geological information available must be taken into consideration.

The Turam and Slingram equipments, although employing the same principles of field excitation and observation, differ in the means of providing the primary field and in the presentation of results.

In the Turam method the primary field is provided by an audio-frequency motor generator which supplies current through a long insulated cable. Best results are obtained if the cable is oriented parallel to the strike of the mineralisation and earthed by ground spikes at both ends. Traverses are pegged at right angles to the cable.

The field distribution is observed by two electrically identical coils, a complex resistance bridge and null point indication device. The equipment measures the ratio of intensities and the phase difference between the two coils, which are kept at a constant separation.

Traverses were 100 feet apart with observation points every 25 feet along each traverse. The coils were 100 feet apart and the frequency of the primary field was 440 c.p.s.

The primary cable was laid along the baseline (00) and extended from 30N to 30S. To obtain complete coverage of the area to be surveyed it was later relaid along 700W. It was found that observations within 200 feet of fences were useless because of the disturbed fields, and these areas had to be omitted. Two additional traverses, 13.5N and 14.5N, were surveyed to give greater detail over the main anomaly. Elevation difference between the coils were small and terrain corrections were not necessary for Turam reductions. Observed ratios were corrected for primary field and the reduced ratios

-4

and phase differences were plotted as profiles and contours (Plates 5, 6 and 7).

The Slingram instrument consists of two coils, an alternating-current bridge amplifier and head phones. One coil acts as a transmitter and is excited by a battery-driven tube oscillator. The transmitter coil provides the primary field and the search coil is used for observing the field variations. The coils are kept at a constant distance apart. Greater mobility of the equipment results from not being bound to any fixed primary lay out. Observations are made with respect to a reference proportion of the primary field and are read directly as percentages of real and imaginary components, taking a normal field distribution as 100 per cent. The levels of all stations observed are required, as terrain corrections must be made.

In both instruments the coils are held in a horizontal plane controlled by water levels, and only the vertical component of the field is observed.

The area shown on Plate 5 was surveyed with the Turam equipment, the Slingram being used only on several test traverses to compare results.

(d) Geochemical.

If soil samples are taken at some depth below surface (usually about 2 feet) it is found that the soil contains an appreciably higher amount of metal near a vein than further away from it. The U.S. Bureau of Mines has developed some very sensitive and rapid colorimetric methods for the determination of small amounts of metal in the soil. Dithizone, which assumes certain shades of colours in the presence of very small amounts of copper, lead or zinc, is the organic reagent used. A weighed quantum of soil is dissolved in boiling nitric acid and the solution is treated with dithizone. The colour of the dissolved sample is compared with the colour of samples prepared from known standard solutions. In this way, the metal content of the soil at the various sample points can be estimated.

The soil samples were taken by a new sampling device consisting of a hard metal drilling bit driven from the Land Rover motor through a flexible drive. Only 30 samples were taken - mainly on traverses 14N and 16N - because the equipment broke down and could not be repaired before the end of the survey.

6. DISCUSSION OF RESULTS.

(a) Magnetic.

Results of the magnetic survey are shown as contours on Plates 4 and 8 and magnetic profiles along two selected traverses (4S and 15N) are shown on Plate 6 for comparison with topographic and electromagnetic profiles.

The outstanding feature of the magnetic observations is the division of the area into two zones, one of high magnetic intensity and the other comparatively undisturbed.

The highly magnetic zone in the north-west, with intensities ranging from 250 to 2,000 gammas, may reasonably be attributed to the hornblende-diorite. Diorite specimens from outcrops on traverse 20N exhibited strong magnetic properties when tested in the field.

Radioactivity appears to be concentrated along the slate/diorite contact. This assumed contact, approximately marked by the 250 gamma contour, does not coincide with the mapped geological boundary, but may be more sharply defined during development work.

Radiometric indications are largely absent, however, from the areas of high magnetic intensity i.e. the diorite. Some exceptions are probably due to leaching and migration of the uranium.

The main diorite mass is crossed by two parallel troughs of low magnetic intensity striking N20W. One of these, from 500 E/12N to 300E/20N coincides approximately with a weak electromagnetic indication and the geologically-mapped shear outcrop at 300E/18N. The other trough is narrower, and runs from 00/6N to 500W/20N. These troughs may outline major shears parallel with those to the west of Carcoar.

The area south of the diorite contact is magnetically uniform except for some small anomalies of unknown geological cause. These anomalies, which are of the order of 300 gammas, strike generally north-east and occur over soil-covered slates. They terminate abruptly in the north-east near the electromagnetic indication south of the G workings.

The diorite dykes crossing the area show no appreciable magnetic influence.

(b) <u>Electromagnetic</u>.

Electromagnetic results are shown as Turam ratio contours (Plate 5), profiles (Plate 7) and as lines of indications (Plate 8). Selected Turam, Slingram and magnetic profiles are shown on Plate 6.

Contours above 1.00 delineate zones of higher conductivity and on Plate 8 the axes of these zones have been classified as very weak, weak, medium and strong. They are attributed to a system of shears, as they conform with the direction of shears as reported by Matheson (1952). Increased values of electrical conductivity could be attributed to an increase in the amount of mineralisation within the shear zone. Coincidence of electrical indications and high copper values in the geochemical soil samples supports this assumption.

The indications, which have been numbered 1 to 10 for discussion purposes, show trends in two main directions, namely N.30°E and N.20°W to N. Indications in the first group are parallel to the slate bedding and the general strike of the diorite dykes. Indications in the second group show slight variations in strike, with the direction N20°W predominating. They cut right through the slates, dykes and main diorite.

Radiometric anomalies do not coincide directly with the electromagnetic indications but they appear to be controlled by them. Indications 3, 4 5 and 6, striking N.30°E, are the most important in this respect and are also within a few hundred feet of the slate/diorite contact.

The highest Turam ratios occur over indication 2, and this location, with its apparent high conductivity and higher copper values in the soil samples, should be tested by initial trenching and then by diamond drilling.

A continuous indication tending to link with the shear outcrop at 300W on 18N is outlined by anomalies 1 and 10. This indication appears to indicate a major structural feature parallel to the shear system west of Carcoar (Plate 1). The highly silicified (felsite) bands crossing the leases terminate abruptly on this indication. If the indication is due to a fault then not only can the pre-fault felsite be regarded as one continuous bed, but also all the cobalt-copper-uranium workings would form a line of lenses between the diorite and felsite. This assumption, if proved, could aid materially in the investigation of the extent of the mineralisation.

Indications 7, 8 and 9 form a smaller shear pattern in the central southern section. One strong indication (No. 9) is centred at 250E on 4S. Mineralisation is not known in this locality but further examination is warranted.

(c) Geochemical.

The results of the geochemical copper assays on soil samples, using the dithizone method, are shown on Plate 9, together with the Turam ratios. The copper values are plotted in parts per million and show a well-defined curve which is in good agreement with the electromagnetic results. The soil cover in the area sampled is rather deep and no outcrops were found in the neighbourhood. The soil samples were also assayed radiometrically for uranium and the results are shown on the same plate, also in parts per million but on a larger scale. Although the uranium assays also show a tendency to increase in a similar manner, the agreement is not quite as good as in the case of the copper assays.

The results of the geochemical assays are encouraging and the sampling should be continued and extended. The assaying was carried out in the Bureau's laboratory at Melbourne. The copper assays were done by A. Nicholson and J. Horvath, and the uranium assays by D. Urquhart and W. Langron. Tabulated results of the geochemical assays are given at the end of this report.

7. CONCLUSIONS AND RECOMMENDATIONS.

Magnetic and electromagnetic methods were successful in the area, and several well-defined anomalies were observed. The self-potential measurements were not successful and were discontinued after preliminary tests had been made.

Radioactivity, in the main, is confined to slates within a few hundred feet of the contact with the diorite. The diorite/slate contact appears to coincide roughly with the 250 gamma contour. There is no known radioactivity over the diorite mass in the magnetically disturbed area to the north-west, but the two areas of low intensity and the basin structure centred on 800E/18N should be investigated for radioactivity. No rock type has been found to account for the rather weak magnetic anomaly in the southern section. No indications of radioactivity have been observed in this area and no other mineralisation is at present known.

Further exploration should be carried out along the slate/diorite contact to the north-east and south-west.

Electromagnetic observations gave a series of indications which are considered to be due to shears. The location of the indications is consistent with geological evidence of shearing. The variation in electrical conductivity of these indications is probably due to some degree of mineralisation. There is a strong possibility that Indication No. 2 coincides with good mineralisation, as it shows high

-7

uranium ratios and high copper assays in soil samples.

Geochemical assays of soil samples for copper show very close agreement with the electromagnetic results. On the two traverses sampled (14N and 16N), the electromagnetic indication and the highest copper values coincide closely. The uranium assays do not show such close agreement with the electromagnetic indication and are relatively low and more erratic.

Two main directions of shearing are outlined, the shears striking N.30E being the most important. Radiometric anomalies are roughly parallel to this direction and between, or along the margins of, the electromagnetic indications.

Exploration should be started with trenching and detailed geological and radiometric investigation as trenching proceeds. Trenching should disclose and prove the geological cause of the geophysical indications and facilitate a more detailed interpretation. Soil samples for geochemical analyses should be taken over a larger area, especially between traverses 8N and 20N.

Sites for twelve trenches to test the electromagnetic indications are shown on Plate 8.

8. ACKNOWLEDGMENTS.

The writers wish to thank Messrs. F. Legge-Wilkinson and B. Courtney, surveyors from the Department of the Interior, Canberra, for their co-operation during the survey. The assistance given by Mr. N. Wilson of the lease-holding syndicate is also appreciated.

9. REFERENCES.

Bruce, J. and Langley, J.M. 1949 - The General Geology of the Mandurama District. University of Sydney, Honours Thesis.

Card, G.W. 1894 - Mineralogical and Petrological Notes No. 2. Rec.Geol.Surv.N.S.W., 1894, IV, 20.

Daly, J. 1953 - Radioactive Surveying from a Helicopter. Bur.Min.Res.Geol. and Geophys., Records 1953, No. 106.

Daly, J. 1955 - Preliminary Notes on Results of a Geophysical Survey at Carcoar, N.S.W. Bur.Min.Res. Geol. and Geophys., Records 1955, No. 78.

Daly, J., Dyson, D.F. and Pearce, J.W., 1951 - Report on Radiometric Investigations at Carcoar, N.S.W. Bur.Min.Res.Geol. and Geophys., Records 1951, No. 47.

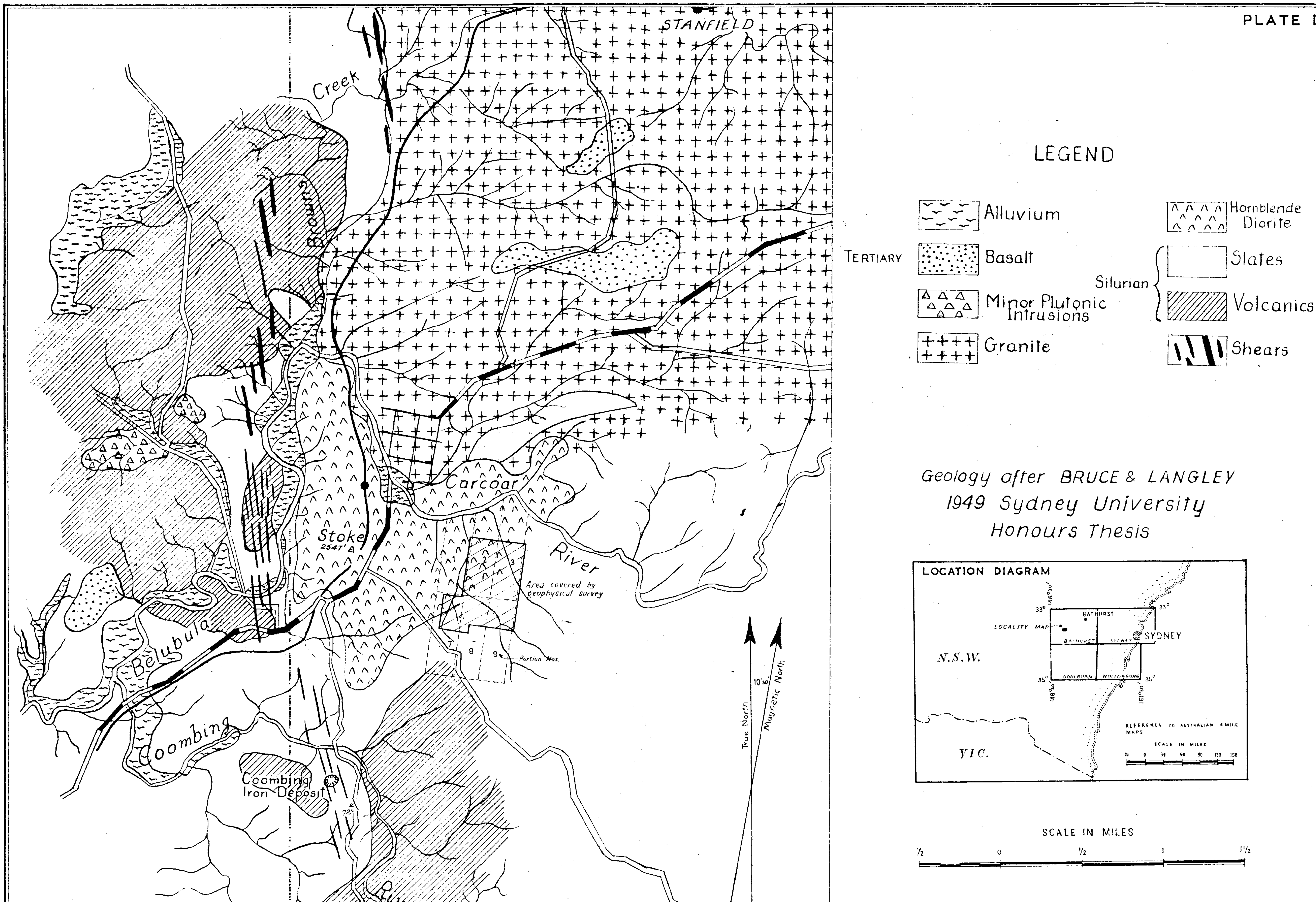
Matheson, R.S. 1952 - Radioactive Deposits, Carcoar, N.S.W. Bur.Min.Res.Geol. and Geophys., Records 1952, No. 65.

Rayner, E.O. and Ralph, R. 1954 - Uranium-Cobalt Deposits at Carcoar, N.S.W. Geol.Surv. N.S.W.

TABLE 1.

GEOCHEMICAL ASSAYS OF SOIL SAMPLES.

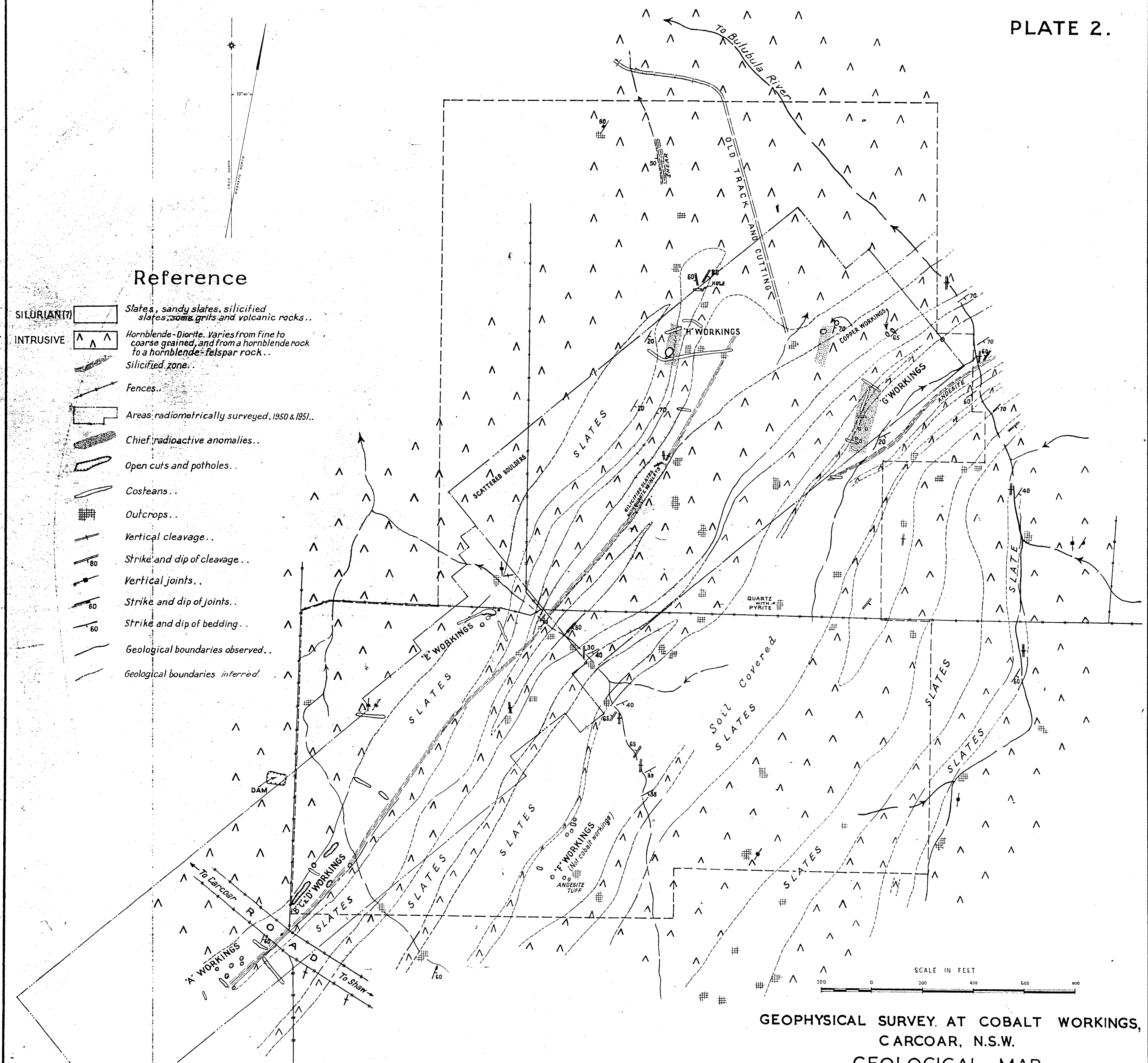
Sample No.	Location	Cu(p.p.m).	Co(p.p.m).	U_3O_8(p.p.m).
		Traverse 14N		
1	250E	187	10	6
2	275	63	-	7
3	300	-	10	-
4	425	-	20	6
5	450	-	20	6
6	475	-	25	-
7	500	?	33	12
8	900	-	50	50
9	925	-	58	35
10	950	31	20	3
11	975	125	25	10
12	1000	250	60	-
13	1050	312	-	26
14	1075	750	33	29
15	1125E	187	50	9
		Traverse 16N		
17	850E	-	50	25
18	875	-	50	-
19	900	-	75	3
20	925 2'depth	62	62	3
21	925 4' "	30	33	1
22	950	562	20	15
23	975	562	10	5
24	1000E	125	-	-
		Traverse 8N		
25	1075E 2'	62	62	15
26	1075 4'	187	33	6
27	1050	200	10	3
28	1025	750	-	2
29	1000	310	-	17
30	975E	62	10	-



GEOPHYSICAL SURVEY AT COBALT WORKINGS, CARCOAR, N.S.W.

LOCALITY MAP AND REGIONAL GEOLOGY

PLATE 2.



GEOPHYSICAL SURVEY AT COBALT WORKINGS, CARCOAR, N.S.W.

GEOLOGICAL MAP

Geology by R.S. Matheson & D. Smith

Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics G 41-17

PLATE 3.

SCALE IN FEET

200 0 200 400 600

CONTOUR INTERVAL 10 FEET

GEOPHYSICAL SURVEY AT COBALT WORKINGS, CARCOAR, N.S.W.

TOPOGRAPHY AND GEOPHYSICAL GRID

[signature]
GEOPHYSICIST

GEOPHYSICAL SECTION BUREAU OF MINERAL RESOURCES GEOLOGY & GEOPHYSICS G 41-18

GEOPHYSICAL SURVEY AT COBALT WORKINGS, CARCOAR, N.S.W.

VERTICAL MAGNETIC FORCE CONTOURS

CONTOUR INTERVAL AS SHOWN

[signature]
GEOPHYSICIST

GEOPHYSICAL SECTION, BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

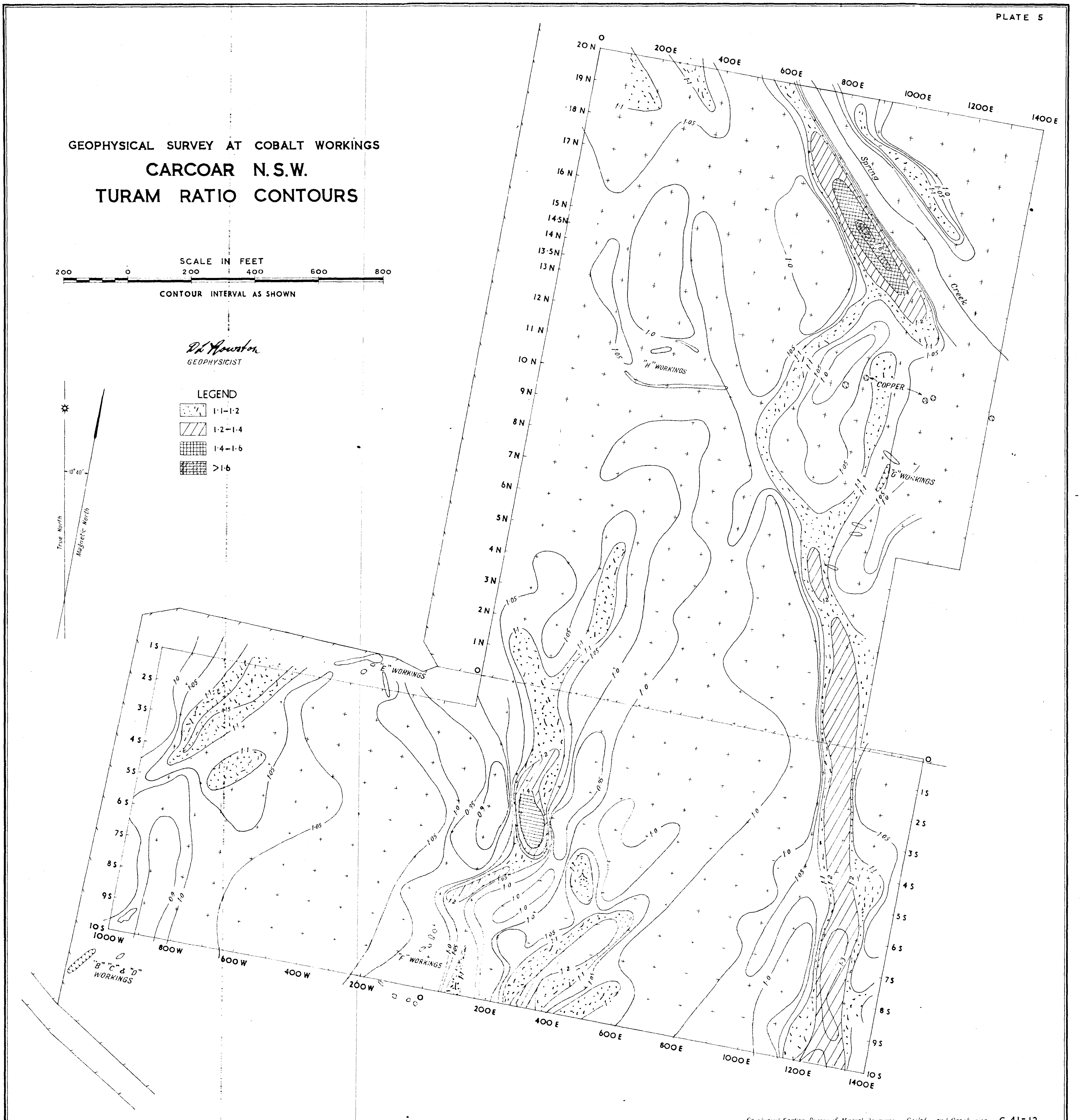
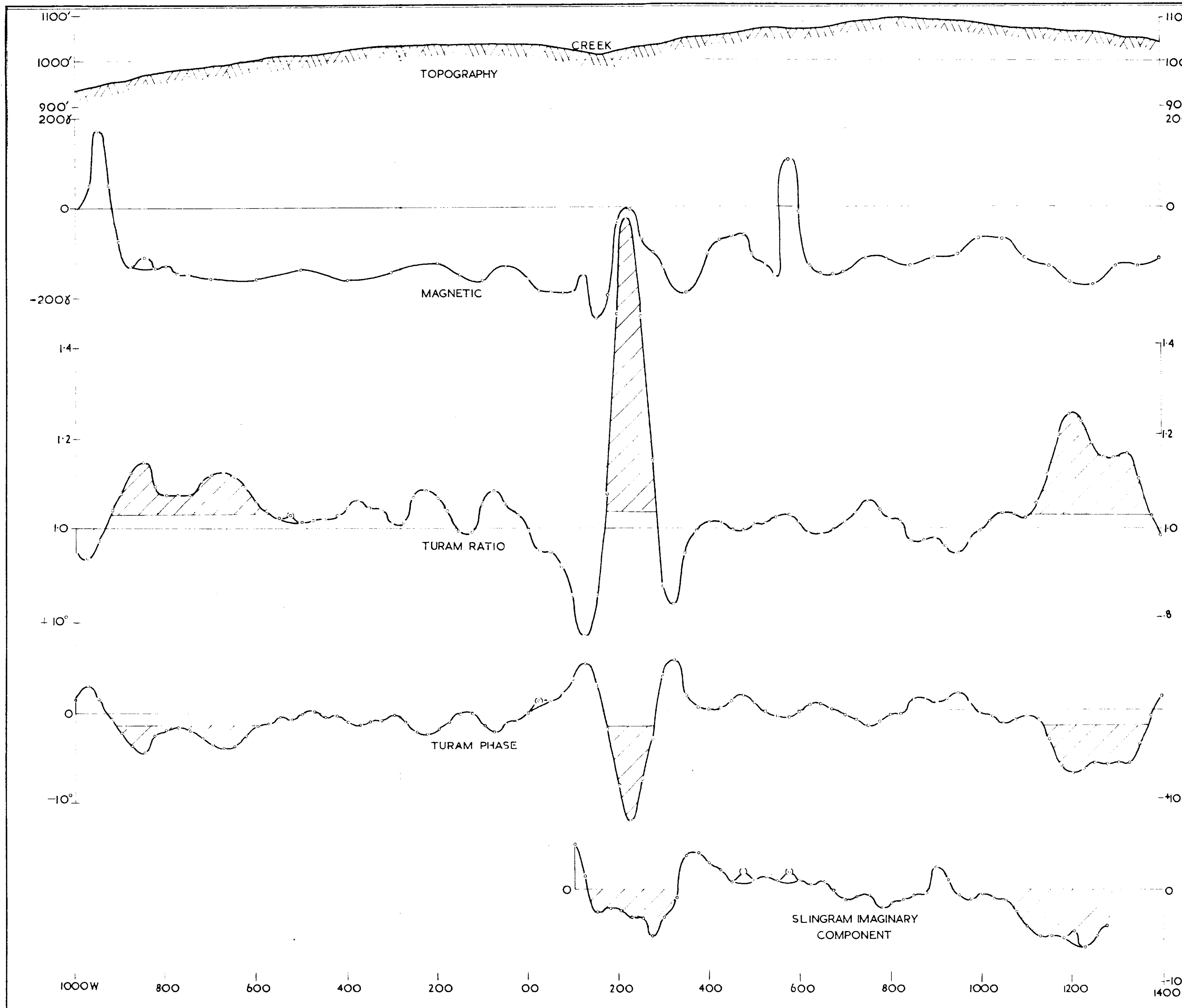
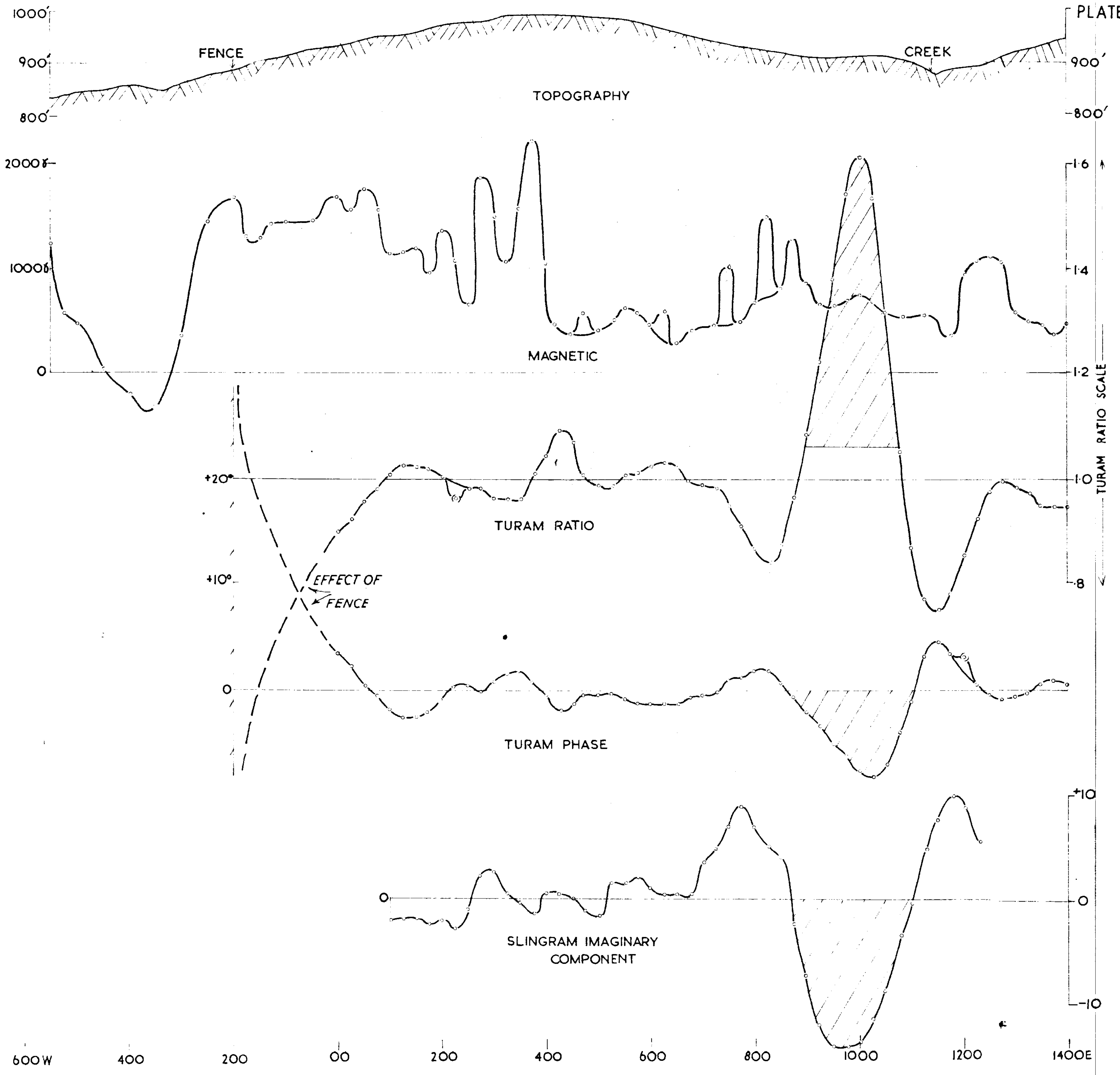


PLATE 5
GEOPHYSICAL SURVEY AT COBALT WORKINGS
CARCOAR N.S.W.
TURAM RATIO CONTOURS
SCALE IN FEET
200 0 200 400 600 800
CONTOUR INTERVAL AS SHOWN
D.L. Rowston
GEOPHYSICIST
LEGEND
1·1–1·2
1·2–1·4
1·4–1·6
>1·6
True North
Magnetic North
10°40'
Spring Creek
"H" WORKINGS
COPPER
"G" WORKINGS
"E" WORKINGS
"F" WORKINGS
"B" "C" & "D" WORKINGS
Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics G 41-12



TRAVERSE 4S



TRAVERSE 15N

GEOPHYSICAL SURVEY AT COBALT WORKINGS,

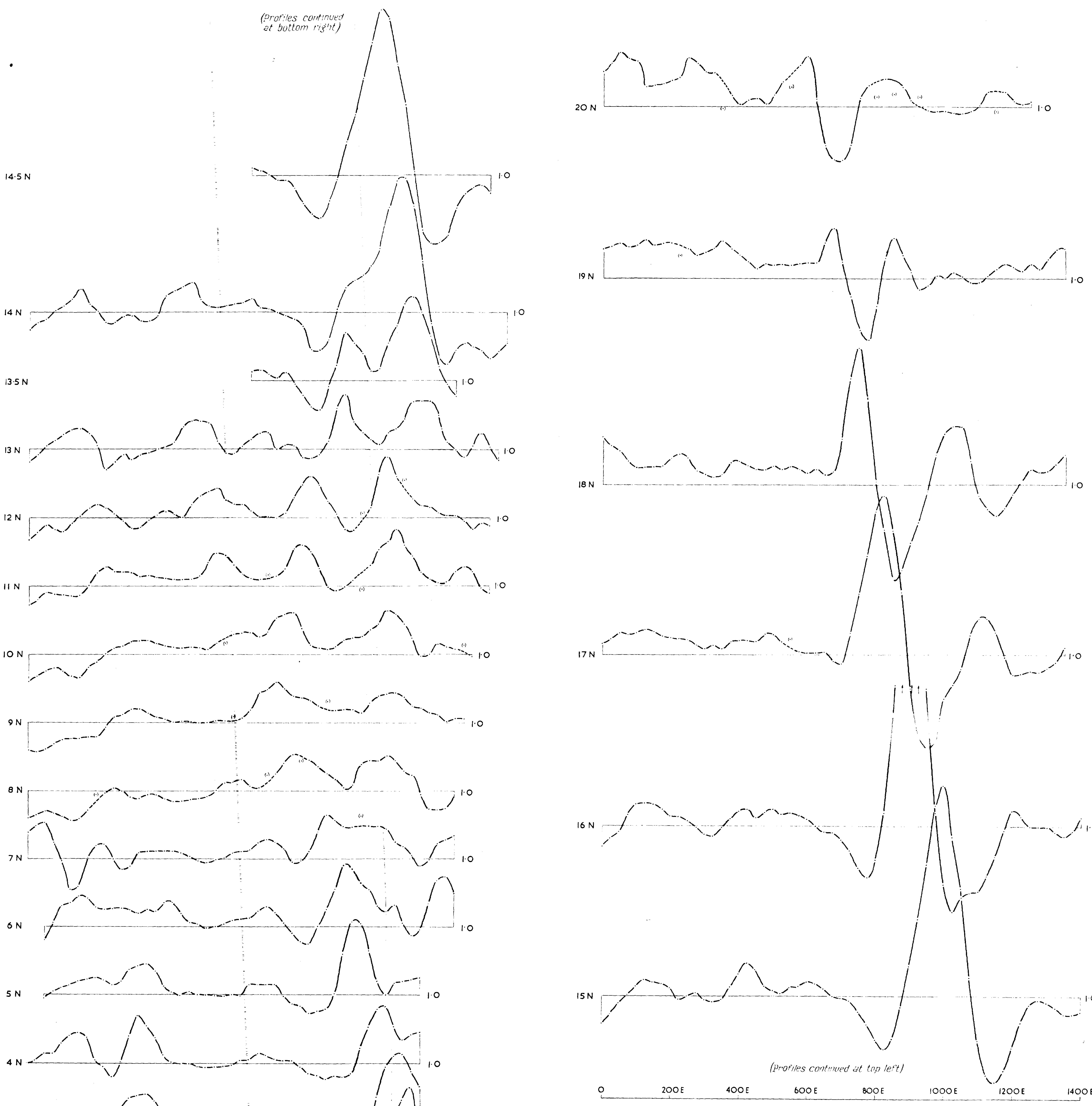
CARCOAR, N. S. W.

TYPICAL GEOPHYSICAL AND TERRAIN PROFILES

GEOPHYSICIST: D. Rowston

G41-15

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



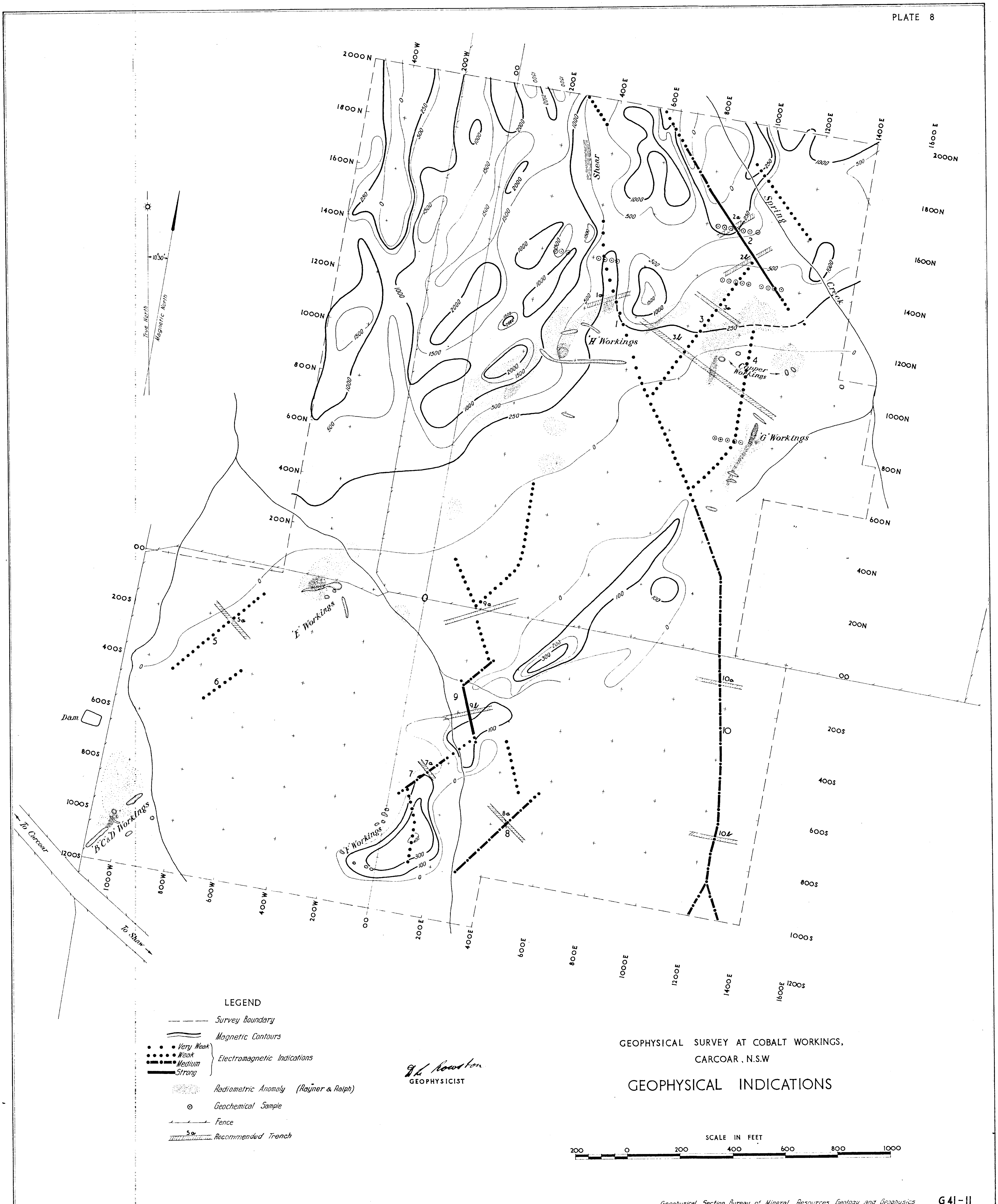
GEOPHYSICAL SURVEY AT COBALT WORKINGS, CARCOAR, N.S.W.

TURAM RATIO PROFILES

SCALES

HORIZONTAL 200 0 200 400 600 800 FEET
VERTICAL 0·2 0 0·2 0·4 0·6 0·8

GEOPHYSICIST

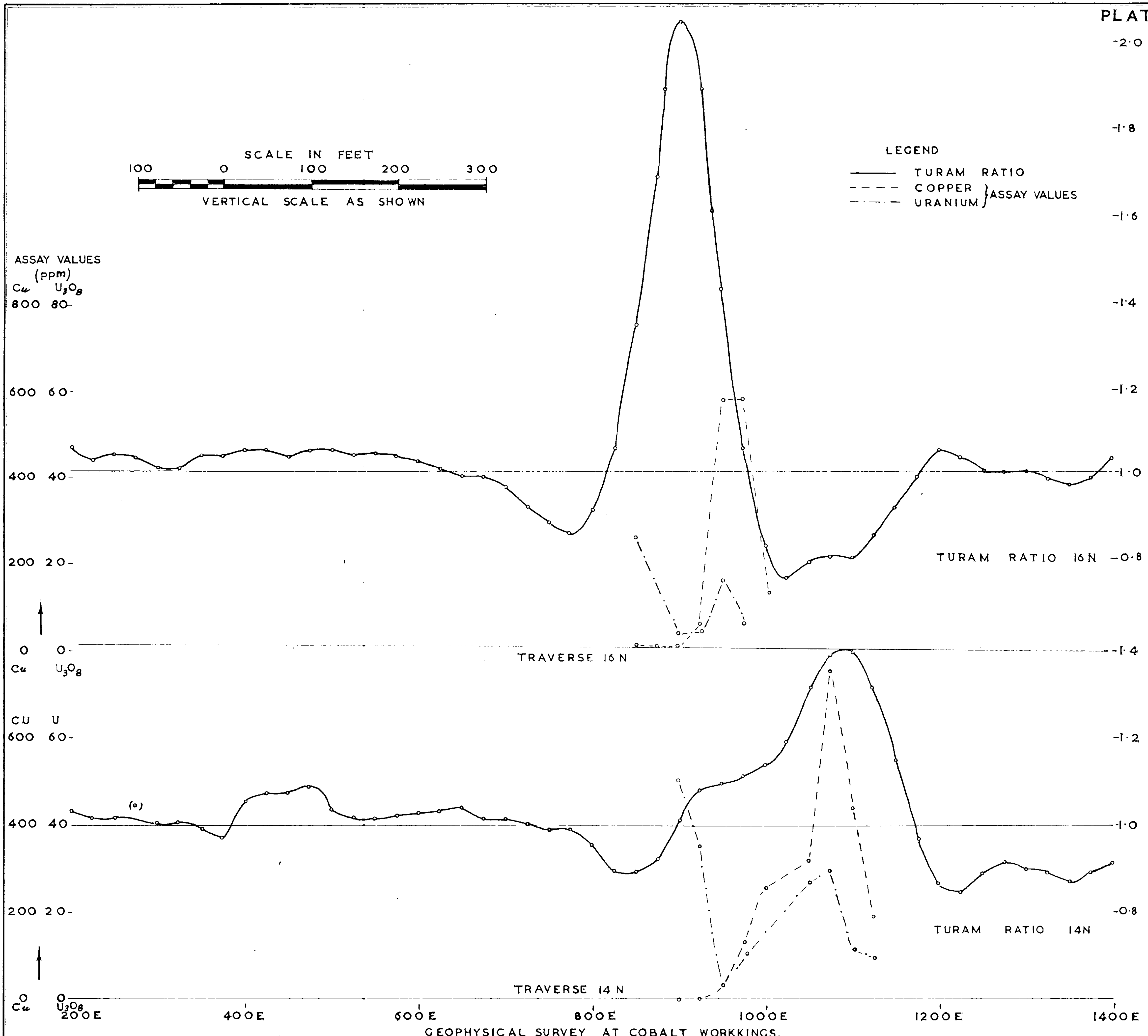


GEOPHYSICIST

GEOPHYSICAL SURVEY AT COBALT WORKINGS, CARCOAR, N.S.W

GEOPHYSICAL INDICATIONS

PLATE 9



GEOPHYSICIST

GEOPHYSICAL SURVEY AT COBALT WORKINGS, CARCOAR, N.S.W.

GEOCHEMICAL RESULTS

Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics

G 41-14