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COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD No. 1962/146

BROWNS DEPOSIT GEOPHYSICAL SURVEY,

RUM JUNGLE, N.T. 1957

by

J. DALY, J. HORVATH and K. H. TATE

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SUMMARY

A geophysical survey was made at Browns prospect in the Rum Jungle area to study a large low-grade sulphide orebody known by drilling, and to search for new orebodies on its western extension. Electromagnetic, magnetic, self-potential, and gravity methods were used. Electromagnetic results confirmed the earlier work done in 1950 and 1953 and showed that a large additional area is worthy of close investigation. Test drilling of several electromagnetic anomalies is recommended.

The results of magnetic work of various earlier surveys are summarised. Additional gravity work is described.

1. INTRODUCTION

The Rum Jungle mining district is about 70 miles south of Darwin. The name of Browns deposit is given to one area in which sulphide minerals containing lead and copper, occur on a large scale. As the area in general has had a great deal of geological and geophysical attention, it is convenient to mention the relevant operations in historical sequence.

Lead and copper mineralisation in the area has been known for many years and some drilling was done by Northern Territory Administration about 1920. In 1949 the only evidence of previous exploration was two shafts; one in the area now known as Whites and the other about one mile west where secondary lead minerals occurred in outcrop. This locality is known as Browns.

Since 1949, when J. White, a local prospector, discovered secondary uranium minerals in a trench near the first mentioned shaft, many geophysical surveys have been made in the adjacent Browns area. A brief resume of the surveys is given below in chronological order.

The Bureau of Mineral Resources commenced investigation of the uranium deposits in 1949 and made a geophysical survey that was designed to determine if the surface showings of radioactive minerals were associated with sulphide minerals (Allen, 1951). Self-potential and potential-drop-ratio methods were used. Self-potential anomalies of a favourable type were detected at Browns area and two diamond-drill holes were put down by the Bureau to test them. On the basis of the results of this drilling, it was considered that the self-potential anomalies were not a reliable indication of the presence of sulphide minerals. Later developments have shown that this conclusion involved a radical mis-interpretation of the drilling data.

In 1952, airborne survey methods were applied by the Bureau in the Rum Jungle area. As a preliminary, ground magnetic tests were made in order to discover whether there was sufficient magnetic relief in the area to justify the use of aeromagnetic methods. Strong and persistent magnetic anomalies were measured, and the test survey was extended to a large area at reconnaissance scale. The results of this work are described by Daly (1953). The results of a detailed ground survey over a small area are described by Daly (1957). Results of the airborne radiometric and magnetic survey are briefly discussed by Wood and McCarthy (1952).

At the end of 1952, the development of the radioactive deposits of the Rum Jungle area was taken over on behalf of the Commonwealth Government by Consolidated Zinc Pty Ltd, through a subsidiary company (Territory Enterprises Pty Ltd). This company re-examined Browns area on the surface and by diamond drilling. The first tests showed that base-metal minerals were present on a scale sufficient to warrant detailed investigation and subsequent work was undertaken by a second subsidiary company (Australian Mining and Smelting Co. Pty Ltd).

By 1954, exploration had revealed, and largely outlined, the dimensions of a base-metal orebody of considerable size. In discussions between officers of the Bureau and geologists of Consolidated Zinc Pty Ltd, it was agreed that the known orebody, which had not been disturbed by mining operations, offered a unique opportunity for testing the applicability of various geophysical methods in this area. A survey using electromagnetic (Slingram), self-potential, and gravity methods was made in 1954. The results, described by Langron (1956), were favourable and indicated that a search for possible extensions of the orebodies at Browns by geophysical methods was warranted.

This follow-up geophysical survey was made during September and October 1957, by a party comprising K.H. Tate (party leader) and M.B. McGirr and P.M. Stott (geophysicists). Electromagnetic, self-potential, gravity, and magnetic methods were employed. Surveying was done by staff of the Surveyor-General's Section, Department of the Interior. This geophysical survey and the relevant portions of earlier investigations are discussed in this Record.

In addition to the work described above, geological mapping and radiometric surveying have been done by staff of the Bureau, Consolidated Zinc Pty Ltd, and allied companies almost continuously since the original discovery of radioactive minerals in 1949. Some reference is made below to geology but the radiometric work is not discussed because no significant radioactivity has been detected in Browns area, except from a small showing of radioactive minerals in the old shaft.

2. GEOLOGY

The regional geology of the northern part of the Northern Territory has been well established by the mapping done by the Bureau of Mineral Resources. The conclusions regarding the Darwin/Adelaide River area are summarised by Malone (1958) and the following notes are based on his report.

The dominant structural feature in the area is a dome, the core of which is the Rum Jungle Granite. This dome is reflected through more than 8000 ft of sediments, which are considered to be of Lower Proterozoic age. At the southern boundary of the granite, where the known deposits of uranium and base metals occur, the stratigraphic succession of the formations affected by the doming is as follows (beginning with the oldest):

Batchelor Group

Beestons Creek Formation, consisting of arkose and arkosic conglomerate, quartz greywacke, sandstone, and siltstone. The thickness of the formation is estimated at about 1000 ft.

Celia Creek Dolomite, about 1000 ft thick.

Crater Formation, consisting of greywacke, arkose, quartz-pebble and fine conglomerate, about 2000 ft thick.

Coomalie Dolomite about 1000 ft thick.

Golden Dyke Formation

This consists of interbedded quartz and carbonaceous siltstone, greywacke siltstone, chert, silicified dolomite and marl, and is about 6000 ft thick south-east of Batchelor. It includes a rock type that has little outcrop, but causes strong and persistent magnetic anomalies. This rock has been intersected in drill holes, and is called by the field name of 'amphibolite'.

Contacts between the various formations are generally conformable. Most formations are lenticular in habit, so that the succession may vary in different areas. The Crater Formation includes two distinctive marker beds, viz. a silicified, pyritic, carbonaceous, dolomitic shale with chert lenses and nodules, referred to in early mapping as 'Haematite Boulder Conglomerate', and a thin lenticular bed of quartz-pebble conglomerate, which is slightly radioactive, owing to a small thorium content.

The granite and surrounding rocks are intersected by a major fault, the Giants Reef Fault. This strikes north-east and has a horizontal displacement of about three miles, the west block moving north. The vertical displacement appears to be small. The fault can be traced for many miles, and has associated with it a number of faults and shears of lesser importance. Owing to the movement on the Giants Reef Fault, there is an area of sediments re-entrant into the granite at its south-east corner. This is known as the Embayment area.

Mineralisation of economic value occurs only in the carbonaceous siltstone of the Golden Dyke Formation. The known deposits occur in the Embayment area and it seems likely that the disposition of the mineralisation is controlled by minor features such as faults and shears. However, such features are difficult to map, owing to soil cover and lack of outcrop. In the absence of more precise indications, the carbonaceous siltstones of the Golden Dyke Formation in the neighbourhood of the Rum Jungle and Waterhouse Granites must be ranked as generally favourable for sulphide mineralisation, and all the area occupied by these rocks is worthy of investigation.

3. GEOPHYSICAL METHODS

At various times electromagnetic, self-potential, potential-drop-ratio, magnetic, and gravity methods have been used in the Browns area. Notes on the methods, together with remarks on their application to the various problems encountered in this area, are given below.

Electrical

Potential-drop-ratio. The use of the potential-drop-ratio method was confined to a brief test survey by Allen (1951). As the results were inconclusive and no further use was made of this method, further discussion is unnecessary.

Electromagnetic. The electromagnetic method depends on the establishment of a primary alternating electromagnetic field at the surface of the ground. If the conductivity of the ground is uniform, this field will be undisturbed, except for attenuation by a factor that is dependant on the distance from the source of the field. If a geological feature whose conductivity is significantly higher than that of the surrounding material is sufficiently close to the surface, currents will be induced in it. These currents will produce a secondary electromagnetic field, which will be detected at the surface as an anomaly in the primary field.

The Slingram and Turam electromagnetic prospecting techniques were used in Browns area.

In the Slingram method the primary field is produced by a small oscillator and a horizontal coil of relatively small dimensions. Frequencies of 500 and 1500 c/s are available. A second coil and an AC bridge form the detector which is kept at a constant distance from the transmitter. Measurements of the magnitude and phase of the total vertical field with reference to the primary field are made at each observation point. Because no primary layout is required, this method is convenient for reconnaissance, but has several features which limit its applicability :

(a) the depth penetration of the method is limited by the power output of the transmitter,

(b) the distance and elevation difference between the coils is critical and in rough terrain levelling of observation points may be necessary.

The Turam method uses a primary field that is applied to the ground, either by a long cable which is earthed at the ends and carries a constant current or inductively by passing a constant current through a large rectangular insulated loop laid on the ground. The current is supplied by a motor-generator set at a frequency of 440 or 880 c/s. The detecting system consists of two horizontal coils, kept at a constant separation, and an AC bridge which measures the phase difference and the ratio of amplitudes of the fields induced in the coils. If no secondary fields are present, the amplitude ratio and the phase difference depend only on the distance of the coils from the primary cable, and can be calculated. Any departures from the calculated values indicate the presence of secondary fields. The Turam system has the advantages over the Slingram method that (a) its depth penetration is greater, owing to the energy of the primary field being much higher, and (b) that the corrections for differences in elevation of the coils can be neglected, except in areas of very rough topography.

Electromagnetic methods are especially suitable for detecting features of high conductivity. The sulphides, which are the primary minerals at Browns, occur in carbonaceous shales, and it would therefore be expected that orebodies would be very good conductors. If the carbon in the shales is present in the form of graphite, it is possible that the shale itself could be a good conductor even without sulphide minerals and it is therefore possible that strong indications obtained by electromagnetic methods might be due to unmineralised graphitic shales.

Self-potential. The self-potential method involves measurement of naturally occurring potentials in the ground. Although the mechanism for generating such potentials is very imperfectly understood, the observed potential distribution can frequently be related to geological conditions. It has been established that a body of sulphide minerals reaching as high as groundwater level frequently gives rise to a characteristic potential distribution, with a negative centre above the body. Similar anomalies may be obtained over carbonaceous/graphitic rocks.

The theory of the generation of self-potentials in general is in an extremely unsatisfactory state. The problem has been reviewed for sulphide and graphitic bodies by Sato and Mooney (1960) who have suggested an electro-chemical mechanism that agrees with most of the established data on such bodies. The mechanism is necessarily far from simple, and will require a great deal of control of observations on actual orebodies. However, it applies only to a relatively small class of anomalies and often anomalies of very large magnitude cannot be explained theoretically.

Magnetic

The Golden Dyke Formation, which contains the orebodies of the Rum Jungle district, includes a rock type that causes strong magnetic anomalies. The magnetic method has been used to locate the position of this magnetic bed. There is no evidence that any magnetic anomaly is directly related to an orebody; and therefore, there has been no systematic coverage of the area by the magnetic method.

Gravity

Sulphide orebodies of the dimensions to be expected in the Rum Jungle area would not give rise to detectable gravity anomalies, so that an attempt to use the gravity method for the direct detection of orebodies would not be warranted. The use of the method has been confined to a few traverses to obtain information on the structure of portions of the mineralised area.

4. RESULTS

The area covered by the survey is shown in Plate 1. The area from Traverse 6800W to Traverse 10,700W has been tested by drilling done by Australian Mining and Smelting Co. Pty Ltd and information supplied by the company is the basis of correlation and interpretation of geophysical results over the whole area.

In general, the results obtained using different methods refer to distinct geological problems, so that it is convenient to discuss the different methods separately.

Electromagnetic

The electromagnetic quantities actually measured were the ratio of amplitudes and the phase differences of the fields at points equally spaced on each side of the measuring point.

The most direct method of plotting the results is as profiles or contours of ratio and of phase difference. However, this method of presentation is misleading in some respects, as it may give the impression that these two parameters of the secondary field give independent information on the body causing the field. Ratio and phase difference are sufficient to specify the secondary field completely, and are the quantities measured by an AC bridge, but both quantities depend on all the parameters of the conducting body. To obtain a correct impression of the anomalous field, a single presentation of the results is required that takes account of ratio and phase measurements simultaneously.

One method of presenting the results is to plot ratio and phase readings for each observation point as ordinate and abscissa in a system of rectangular co-ordinates, and to join the points representing consecutive observation points. If no anomaly is present, the points will tend to cluster in the neighbourhood of the point representing ratio 1.0, phase 0 degrees, and will cover only a small area of the diagram. If anomalies are recorded, the travel of the curve from the original point will be greater, and the individual anomalies will appear as loops. This method of presentation has the advantages that it takes account of ratio and phase measurements simultaneously, and that it gives a visual indication of the strength of an anomaly. It has the disadvantage that, if several anomalies occur on one traverse, the loops representing them will tend to fall in the same region of the diagram, and the curve will become difficult to follow.

The results of the following electromagnetic surveys have been used :

(a) a Turam survey covering the whole of the layout shown in Plate 1. Primary field loops, a coil spacing of 50 ft, and a frequency of 440 c/s were used during the survey. Tests made on a few traverses showed that there was no significant difference between results obtained using frequencies of 440 and 880 c/s,

(b) the Slingram survey made by Langron (1956) with a coil spacing of 200 ft and a frequency of 1500 c/s. It covered the area between Traverses 7600W and 10,400W on the 1957 layout,

(c) two traverses (8000W and 10,400W) surveyed with the Slingram method, using a coil separation of 150 ft and a frequency of 500 c/s. The traverses were covered twice, with the transmitting coil north and south of the receiving coil separately,

(d) two long traverses (9800W and 12,000W) surveyed with the Slingram method, using a coil separation of 150 ft and a frequency of 500 c/s. The results of this work are discussed on Page 12.

Discussion of results: Before discussing the results it is convenient to mention briefly the comparison of results obtained by the different electromagnetic methods. Information bearing on this point is shown in Plate 12.

On Traverse 8000W, where a strong anomaly is associated with the orebody, the profiles obtained by the various methods are closely similar. On Traverse 10,400W, where the anomaly is weak, the agreement is satisfactory although there is some variation in minor detail. The anomaly on this traverse has not been tested by drilling.

The results of the Turam survey (Plates 2 and 3) show a number of anomalies of different magnitudes. Plate 4 shows examples of selected profiles as ratio/phase diagrams. The positions and strengths of the various anomalies, estimated on the basis of diagrams of this type, are shown on Plate 1. A continuous zone of anomalies extends the full length of the surveyed area, with a strike generally parallel to the baseline. Between Traverses 7600W and 10,800W, the anomalies are numerous and generally strong. From Traverse 10,800W to Traverse 13,600W, only one line of weak anomalies is present. West of Traverse 13,600W, the anomalies increase in number and strength to the end of the surveyed area.

Between Traverses 7600W and 10,700W, the orebody has been proved by drilling, and several geological cross-sections have been supplied by Australian Mining and Smelting Co. Pty Ltd. For the purpose of this Record, the cross-sections are shown only to a depth of 500ft. Comparisons of these cross-sections with the survey results are presented in Plates 5 to 11 to demonstrate the significance of the indications. Additional information bearing on certain factors that may affect the electrical properties of the orebody has been supplied by geologists of Consolidated Zinc Pty Ltd. The following points are relevant :

(a) on the most easterly Traverses (7800W and 8000W) the profiles show two strong anomalies. One of these corresponds in position to the orebody. The other one is located at about the zero peg on each traverse, and geological Cross-sections 6 and 8 (Plates 5 & 6) show no features that would account for this anomaly. The reason for this lack of geological information is that most of the early holes were non-coring in this region. Later core-drilling has established that this anomaly is associated with some bedded seams of pyrite in the slates; these bedded seams have high conductivity because of their sheet-like continuity for a considerable distance,

(b) the nature of the mineralisation changes along the orebody. From east to west the general tendency is for the copper content to decrease and the zinc content to increase,

(c) the mineralisation beneath Traverse 10,300W (Cross-section 14) and Traverse 10,700W (Cross-section 15) is well below economic grade,

(d) the depth of weathering is not constant over the orebody. It ranges between about 70 ft and 120 ft, decreasing both east and west of Traverse 10,000W where the maximum is attained.

Inspection of Plates 5 to 11 shows no close relation between the nature of the anomalies and the dimensions and aspect of the orebody. The main features of the anomalies are that going west there is a fairly consistent increase in width and a decrease in intensity. However, as the size and aspect of the orebody change quite irregularly, there seems little prospect of using the results of the electromagnetic survey to draw any conclusions about the shape of the orebody. A correlation of possible value is that between the strength of the anomaly and the intensity of mineralisation. The strength of the anomalies decreases to the west, and the weakest mineralisation in the orebody occurs on the most westerly portion. No anomaly can safely be neglected, but the most favourable place to test any particular anomaly is at its strongest point.

Plate 1 shows the positions and strengths of the anomalies, together with recommended targets for drilling. These targets have been divided into two classes, called first and second priority. The first-priority targets are those for which it is considered the results justify a definite recommendation for testing. The second-priority ones are considered worthy of some investigation, on the argument that no well-defined indication in this area should be neglected. However, further geological or geophysical investigation may produce more evidence for, or against, testing them.

The general pattern of the anomalies is consistent with the presence of a favourable zone, such as a major shear, striking almost parallel to the baseline, disturbed at several points by minor cross-faults, and mineralised to different extents in different portions. The individual anomalies are designated by the letters A to J. Anomalies A and C are due to the orebody that has been explored by drilling. The results suggest the possibility of a cross-fault at about 8800W. Anomaly B is strong, but does not persist very far in length. As mentioned previously, a small number of cored drill-holes, which have tested the ground under this anomaly, suggest that the anomaly is caused by a pyritic zone that does not contain mineralisation of economic value.

Anomaly D is short and is the only moderately-strong anomaly east of Traverse 10,700W that has not been investigated. It should be drilled to complete the testing of this area. A second-priority drilling target is shown.

The remaining anomalies are west of the area on which drilling information is available. Three main anomalies are visible, and have been designated G, E, and F. However, it seems possible that they should be considered as due to a single conducting zone, which has been displaced by a minor cross-fault at about 11,500W, and which splits into two at about 14,400W. This zone is worthy of testing, both because of its persistence in length, and because of the strength of the anomalies at the western end. Four first-priority targets have been specified; four second-priority targets, to be drilled if encouraging results are obtained on any of the first-priority targets, are also given.

Two other anomalies, shown as H and J, have been identified at the western end of the layout. Anomaly H is short and very weak, and although a target is shown, it cannot be given a high priority. Anomaly J is stronger and persists for a considerable length. One first-priority and two second-priority targets are specified on this anomaly.

It is very desirable that the survey be extended farther west. Apart from the fact that strong anomalies were obtained towards the western end of the present layout, a relatively short westward extension would approach the area in which the regional strike swings north, following the margin of the granite outcrop. It would be of great interest to discover whether the zone of electromagnetic anomalies also swings north, or continues on its general south-westerly strike.

Magnetic

The results of the following surveys have been used :

(a) a reconnaissance survey made in 1951. This survey covered an area extending westerly from the original Browns workings to a little beyond the railway line. Traverses were generally 800 ft apart, and stations were at 200-ft intervals. Traverses and stations were located by compass and pacing. The results have been described by Daly (1953),

(b) a detailed survey in 1954 covering the area between Traverses 10,000W and 11,100W. The purpose of this survey was to explore the anomaly in detail at a position where it was strongest, so that drilling targets could be selected if investigation by drilling were thought desirable. The survey was made by I.A. Mumme. The results are described by Daly (1957),

(c) a detailed survey made by I.A. Mumme, covering the whole of the Rum Jungle uranium field as known in 1952. In the area under discussion, the survey extended from Traverse 7000W to Traverse 8300W. The south-western corner of the area was not covered owing to the presence of buildings.

The areas covered by the various surveys are shown on Plate 13. Magnetic work done on the 1957 survey was restricted to a few traverses required to connect the results of previous surveys, and two long traverses (9800W and 12,000W). The results obtained on the long traverses are discussed on Page 12.

Plate 13 shows a contour plan extending from 7000W to 15,000W based on the results of previous surveys and reduced to a common datum. The contour interval is 1000 gammas; it was considered that use of a smaller interval was unwarranted, owing to the lack of accurate survey control in the reconnaissance survey. However, the profiles over the anomaly are so smooth that, on a survey with proper control, a contour interval of 50 gammas or even less could safely be used. Plate 13 also shows the contours at the eastern end of the anomaly, using a contour interval of 100 gammas. A geological cross-section along Traverse 8100W is also shown.

Discussion of results

The large scale (1 in. = 1000 ft) contour plan in Plate 13 shows that the orebody lies north of the magnetic anomaly and has a strike roughly parallel to it. As shown by the cross-sections in Plates 10 and 11, the orebody is very narrow at Traverses 10,300W and 10,700W. As the magnetic anomaly attains its highest value about this region, there is no apparent connexion between the intensity of the magnetic anomaly and the dimensions or degree of mineralisation of the orebody.

The drilling has not been extended sufficiently far south to explore in detail the body causing the magnetic anomaly. However, it is apparent that the anomaly is associated with the rocks described as 'amphibolite'. The drilling information now available shows that the suggestions made by Daly (1957) concerning the nature of the magnetic body require revision. At the time when these suggestions were made, there was no direct information on the cause of the anomaly. The suggestions were based on the assumption that the anomaly was caused by a body whose magnetic susceptibility was reasonably constant along its length. If this assumption is made, it follows that a profile such as that along Traverse 8100W (shown in Plate 13 together with the geological cross-section) indicates that the body is at considerable depth; a profile such as that along Traverse 10,700W, where the anomaly is much stronger and has two well-defined maxima, must indicate that the cause of the anomaly is much closer to the surface, and must be either two separate magnetic bodies or a single folded body. However, on the drilling evidence, the basic assumption on which these conclusions rest can no longer be accepted. All the available geological cross-sections now show a large mass of 'amphibolite' very close to the surface. The only possible conclusion at the present stage is that the anomaly is due to the 'amphibolite', and that the changes in intensity and shape are due to changes in the magnetic susceptibility of the 'amphibolite'.

As pointed out previously, 'amphibolite' in this connexion is a field term, and the rocks so designated have not been studied petrologically. It is possible that such a study would give an accurate classification of the rocks and any differentiation might be correlated with variations in magnetic properties. The magnetic anomalies might then provide a basis for conclusions as to structure.

Minor features of possible interest appear in the small-scale (1 in. = 200 ft) contour plan shown in Plate 13. These are small, but well-defined, discontinuities in the contour lines on the northern side of the anomaly. They cannot be attributed to discontinuities in the main body of 'amphibolite', and the most-likely cause appears to be narrow near-surface bodies that are weakly magnetic and persist over lengths of a few hundred feet with a general northerly strike. There is no information on the nature of such bodies but it is possible that they are associated with minor cross-faulting, which is known to affect the orebody. This could perhaps be checked by geological mapping. If such features have any significance they could be located by detailed magnetic surveys.

Self-potential

The following self-potential surveys have been made in Browns area :

(a) a survey made in 1950 covering the area between Traverses 7000W and 10,600W. The results have been described by Allen (1951),

(b) a survey made in 1954 which extended from Traverse 4400W to Traverse 8400W, and thus did not add any information to Allen's work concerning the area of interest in the present Record. The results are described by Langron (1956).

It had been intended that the 1957 survey would include a complete coverage by the self-potential method but it was found that the dry conditions were unfavourable for accurate measurements. Watering of the observation points did not improve the erratic readings and a complete survey was therefore not justified. As a check on the effect of different climatic conditions, it was arranged that three traverses (9200W, 9600W, and 9800W) on which measurements had been made by Allen in 1950 and Tate in 1957, should be remeasured during the wet season. This was done in 1958 by geophysicist B.J. Bamber of the Bureau's Darwin office. The results of the three sets of measurements are shown in Plate 14.

Discussion of results. Within the limits of accuracy attained, the results of the 1950 work were in agreement with the results of the electromagnetic survey; self-potential anomalies were generally obtained close to the electromagnetic anomalies. However, the profiles shown in Plate 14 demonstrate that a detailed interpretation of the results would be difficult. On Traverse 9200W, where a strong anomaly is shown by all three observers, the profile by Tate could be used with very minor smoothing. However, on Traverse 9800W, Allen and Bamber agree in showing fairly smooth profiles, but Tate's profile shows large variations that could not be smoothed out.

The information shown in Plate 14, together with other evidence obtained in the Rum Jungle district (Daly, 1962), shows that climatic conditions in this area can influence self-potential measurements in two ways. After a sufficiently long period of dry weather, the readings show what may be called parasitic anomalies of considerable magnitude and of unknown origin. After heavy rain these potentials disappear and reliable observations of the main anomalies are possible. Furthermore, it has been established that prolonged rain, which causes complete saturation of the ground, can reduce the amplitude of well-marked anomalies and even lead to their complete disappearance. There is no doubt that the self-potential method can give valuable information on the sulphide bodies that occur in the Rum Jungle area, but to obtain the best results, it should be used only under favourable climatic conditions.

Exploratory Slingram and magnetic traverses

Two long traverses were surveyed using magnetic and Slingram methods to test the suitability of these methods for large-scale reconnaissance surveys. Traverse 9800W was surveyed from about 3000S to 7000N, using both methods. Traverse 12,000W was surveyed by the magnetic method from 5000S to 7000N, and by the Slingram method from 5000S and 8000N. The results are shown as profiles in Plate 15.

Discussion of results. The results give useful information on the general applicability of the methods in this area. The magnetic profiles show clearly the major anomalies that are due to the 'amphibolite'. The profiles also show strong and erratic anomalies due to magnetic material very close to the surface. If these anomalies were smoothed out, the profiles would be practically flat. This supports the conclusion arrived at on the basis of extensive aeromagnetic surveys, viz. that the Precambrian rocks of the Darwin/Katherine area are remarkably free from major magnetic anomalies, except in the immediate neighbourhood of the Rum Jungle and Brocks Creek Granites. The strongest shallow anomalies are confined to relatively narrow zones on each profile, a fact which may have some geological significance. At the northern end, where the profiles cross the granite, each profile becomes practically featureless.

The Slingram results show no anomalies worthy of further investigation, except for the imaginary-component anomaly centred at about 3000S on Traverse 12,000W. This anomaly is south of the 'amphibolite' (as shown by the magnetic profile) in an area that has not been prospected. It is considered that it should be investigated in the first instance by geochemical testing and possibly by trenching. If favourable results are obtained, a survey by the Turam method would be warranted in this area.

Gravity

The following results of gravity surveys have been used :

(a) measurements made by Langron in 1954 along Traverses 7800W and 9800W. These results are described by Langron (1956),

(b) measurements made by P.M. Stott during the 1957 survey along Traverses 9800W, 10,400W, and 12,000W.

Stations were spaced generally at intervals of 200 ft, although 100-ft intervals were used along portion of Traverse 9800W. The readings have been tied to the Bureau pendulum station at Darwin. Reductions for level have been made using a density of 2.8 g/cm^3. The results are shown in Plate 16 as contours of Bouguer anomaly with reference to an arbitrary datum; to reduce these values to absolute Bouguer anomaly values, +10.38 mgal should be added to the values shown.

<u>Discussion of results.</u> An orebody of the dimensions of the known orebody at Browns would not be expected to cause a measurable gravity anomaly. The main interest of the gravity results lies in the possibility of drawing conclusions from them regarding geological structure. Plates 17 to 20 show some attempts at reconciling such conclusions with currently-known geology, but it cannot be claimed that the results are altogether satisfactory.

Plate 17 shows the gravity profiles along Traverse 7800W compared with a geological cross-section supplied by Territory Enterprises Pty Ltd in 1955. It is included merely for completeness, as geological and drilling information obtained since that date has invalidated the cross-section in several respects. The comparison of observed and calculated profiles is very poor. Plate 18 shows an alternative cross-section that was derived by Langron and based on the same surface geological information, but which enabled quite a close fit to be obtained between observed and calculated gravity profiles. Plates 19 and 20 show profiles along Traverse 9100W. These profiles were derived from the contour plan and are compared with a geological cross-section supplied by Australian Mining and Smelting Co. Pty Ltd. Plate 19 uses the geological cross-section as supplied by the company and Plate 20 uses that cross-section as modified in detail by the Bureau in an endeavour to improve the fit.

The general conclusion may be put in the form of a prediction, <u>viz.</u> that as more geological data becomes available, the geological cross-section of the embayment will be altered towards conformity with the cross-section used in Plate 18. However, the following points, which make it desirable that such a prediction should be made with caution, must be borne in mind :

(a) in Plates 17 and 18, allowance has been made for an assumed regional gradient or trend. It is very difficult to define such a term in the Darwin/Katherine area, as any regional trend that may exist is obscured by the numerous and strong gravity anomalies that are present all over the area (Stott and Langron, 1959),

(b) all the interpretations assume that the gravity profile is to be accounted for by a synclinal structure with a granitic basement of uniform density, the shape of the profile being due to the disposition of sediments of different densities in the syncline. On the basis of the survey described by Stott and Langron (<u>op.cit.</u>), it may be doubted that such a simple interpretation can be generally applied. If the profiles contain effects due to geological features below the bottom of the syncline, the whole basis of the interpretation is invalidated,

(c) the densities used for the various rock types are based on measurements on surface samples described by Langron (1956) and Stott & Langron (1959), and on measurements on core samples. The density values are fair averages of the measurements made and are reasonable for the rock types involved. However, as the total range in densities is not large, and considerable masses of rock are involved, relatively small changes in the values used could lead to important changes in the calculated profiles.

5. CONCLUSIONS AND RECOMMENDATIONS

Some detailed conclusions relating to the functioning of the various methods have been given in previous sections, and there is no purpose in repeating them. With regard to further exploration for possible mineral deposits of economic value, the following recommended drilling targets (shown in Plate 1) are justified by the results of the geophysical surveys :

(a) first-priority targets

12,400W/170S
14,200W/325S
14,600W/370S
14,700W/360S
14,900W/830S

(b) second-priority targets

10,500W/ 30N
11,200W/370S
13,600W/300S
13,800W/330S
14,100W/650S
14,300W/200N
14,400W/720S
14,600W/200S

All targets should be intersected at a depth of 200 ft. The location of collars and depression of holes should be decided using available information as to dip of the geological formations,

(c) the survey should be extended west, using electromagnetic methods.

6. ACKNOWLEDGEMENTS

It is desired to acknowledge the assistance received from officers of Consolidated Zinc Pty Ltd and subsidiary companies both in facilitating the work of the geophysical party in the field, and in supplying geological information to assist in interpreting the results.

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MALONE, E.J.	1958	Geology of the Darwin-Adelaide River area, Northern Territory; *Bur. Min. Resour. Aust. Rec.* 1958/96 (unpubl.).
SATO, M. and MOONEY, H.M.	1960	The electrochemical mechanism of sulphide self-potentials. *Geophysics* 25 (1), 226-249.
STOTT, P.M. and LANGRON, W.J.	1959	Report of a reconnaissance gravity survey in the Darwin-Katherine area, NT 1955-57. *Bur. Min. Resour. Aust. Rec.* 1959/72 (unpubl.).
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PLATE 1

LOOP Nº 1
LOOP Nº 2
LOOP Nº 3
LOCATION DIAGRAM
REFERENCE TO AUSTRALIAN STANDARD MAP SERIES: PINE CREEK
NT
Turam 'A'
Turam 'B'
Turam 'C'
Turam 'D'
Turam 'E'
Turam 'F'
Turam 'G'
Turam 'H'
Turam 'J'
BASE LINE FOR RUM JUNGLE MINE SURVEY
66° 07' 00" TRUE
64° 30' 00" MAGNETIC
66° 06' 46" TRUE
To Rum Jungle Mine
To Batchelor
Overland Telegraph Line
Railway
LEGEND
GEOPHYSICAL TRAVERSE
COSTEAN
BOREHOLE
ANOMALIES
VERY WEAK
WEAK
MODERATELY STRONG
STRONG
DRILLING TARGETS (1st Priority)
" " (2nd ")
Drill hole intersections which are at
50 FEET BELOW SURFACE
100 " "
200 " " "
GEOPHYSICAL SURVEY AT BROWNS PROSPECT
RUM JUNGLE, N.T.
GEOPHYSICAL GRID, EXPLORATION WORK,
ELECTROMAGNETIC ANOMALIES AND RECOMMENDED DRILLING TARGETS
SCALE IN FEET
200 150 100 50 0 200 400 600 800 1000
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To accompany Record No. 1962/146

To accompany Record No. 1962/146

GEOPHYSICAL SURVEY AT BROWN'S PROSPECT, RUM JUNGLE, N.T

TURAM PHASE CONTOURS

440 cycles/sec

CONTOUR INTERVAL 2° — COIL SEPARATION 50 FEET

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics D52/B7-24

To accompany Record No. 1962/146

PLATE 4

GEOPHYSICAL SURVEY AT BROWNS PROSPECT,
RUM JUNGLE, N T

TURAM RATIO-PHASE DIAGRAMS OF SELECTED PROFILES

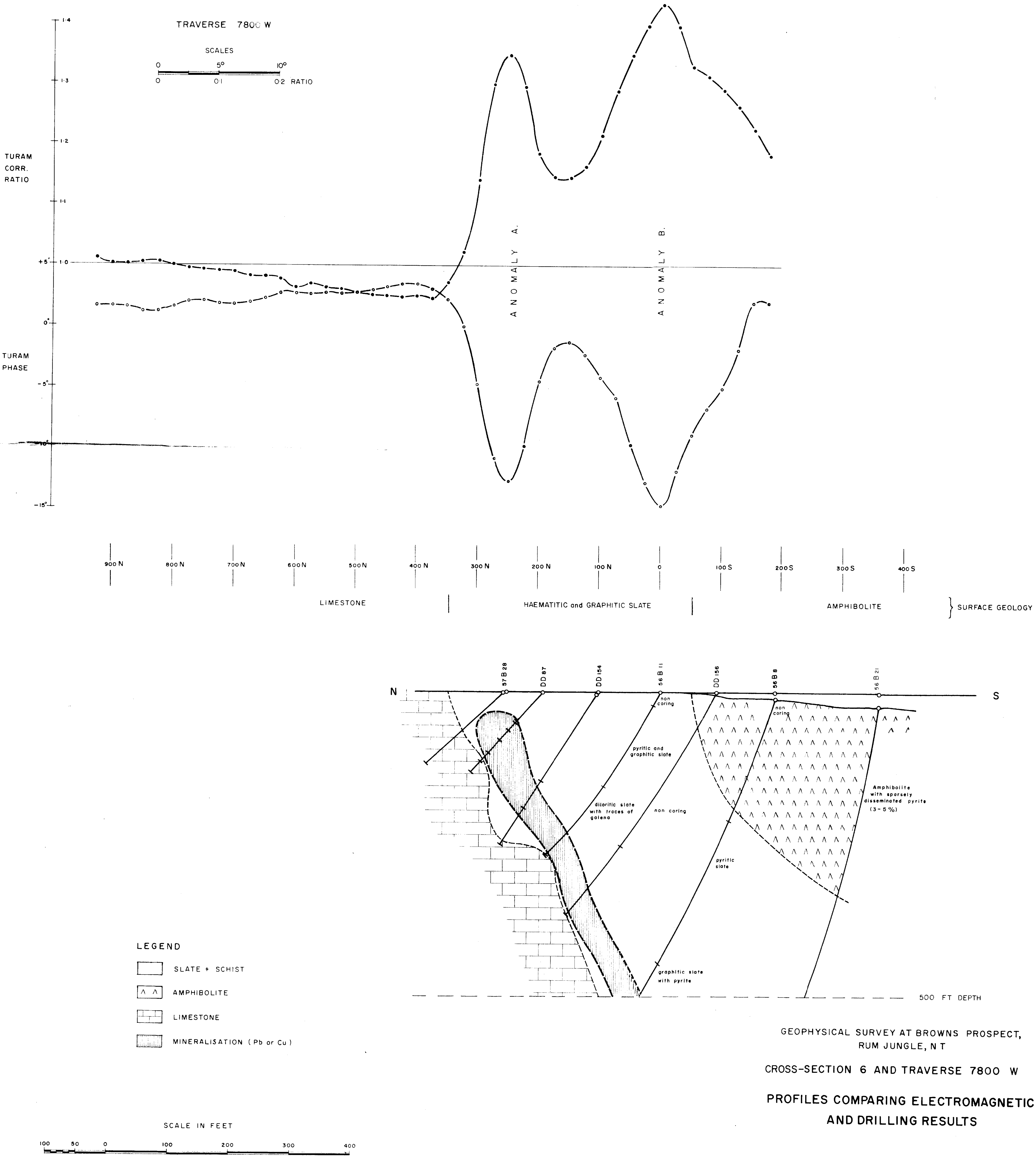
FREQUENCY 440 CYCLES/SEC — COIL SEPARATION 50 FEET

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

D52/B7-25

To accompany Record No 1962/146

PLATE 5

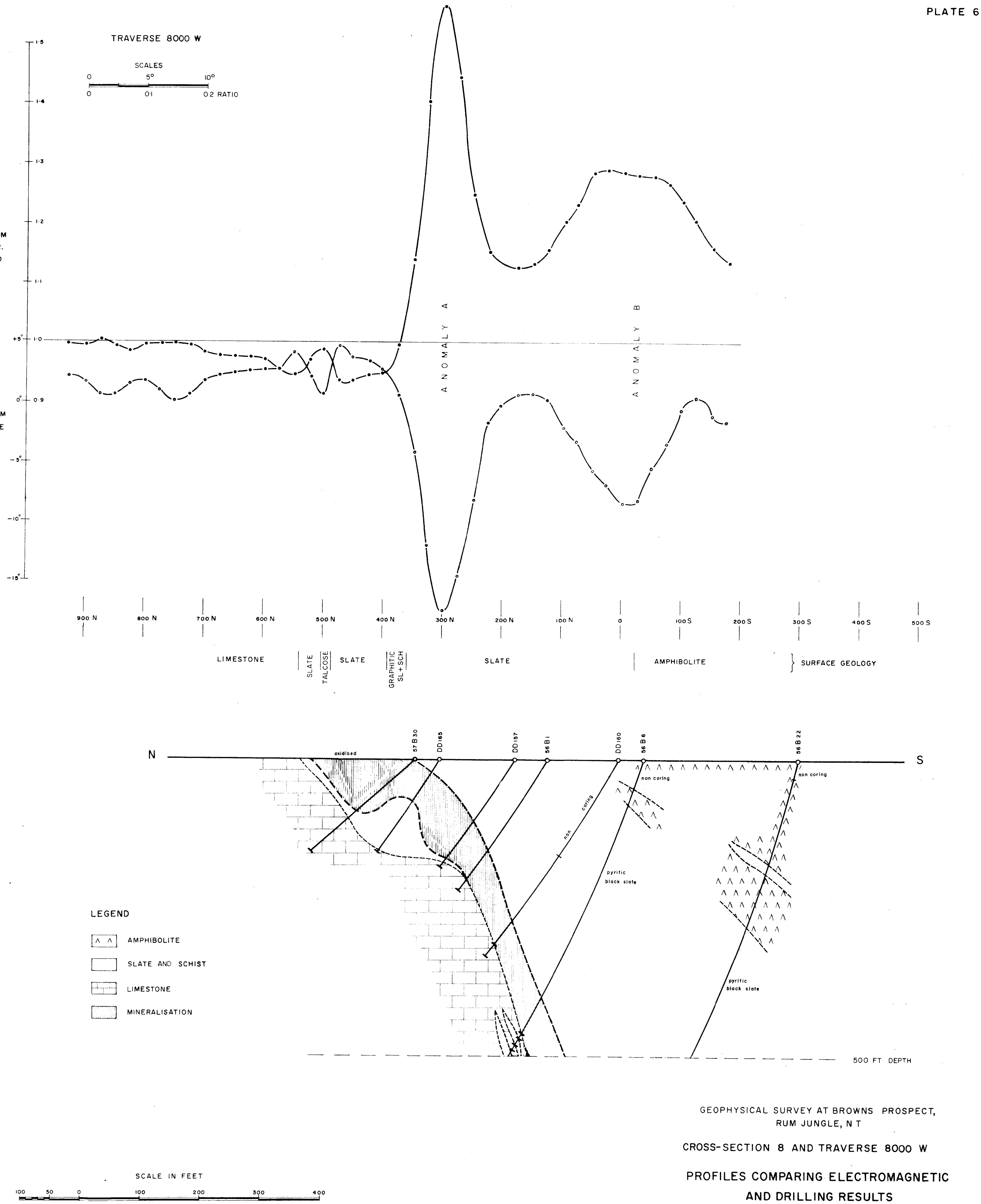


GEOPHYSICAL SURVEY AT BROWNS PROSPECT, RUM JUNGLE, N T

CROSS-SECTION 6 AND TRAVERSE 7800 W

PROFILES COMPARING ELECTROMAGNETIC AND DRILLING RESULTS

PLATE 6



GEOPHYSICAL SURVEY AT BROWNS PROSPECT,
RUM JUNGLE, N T

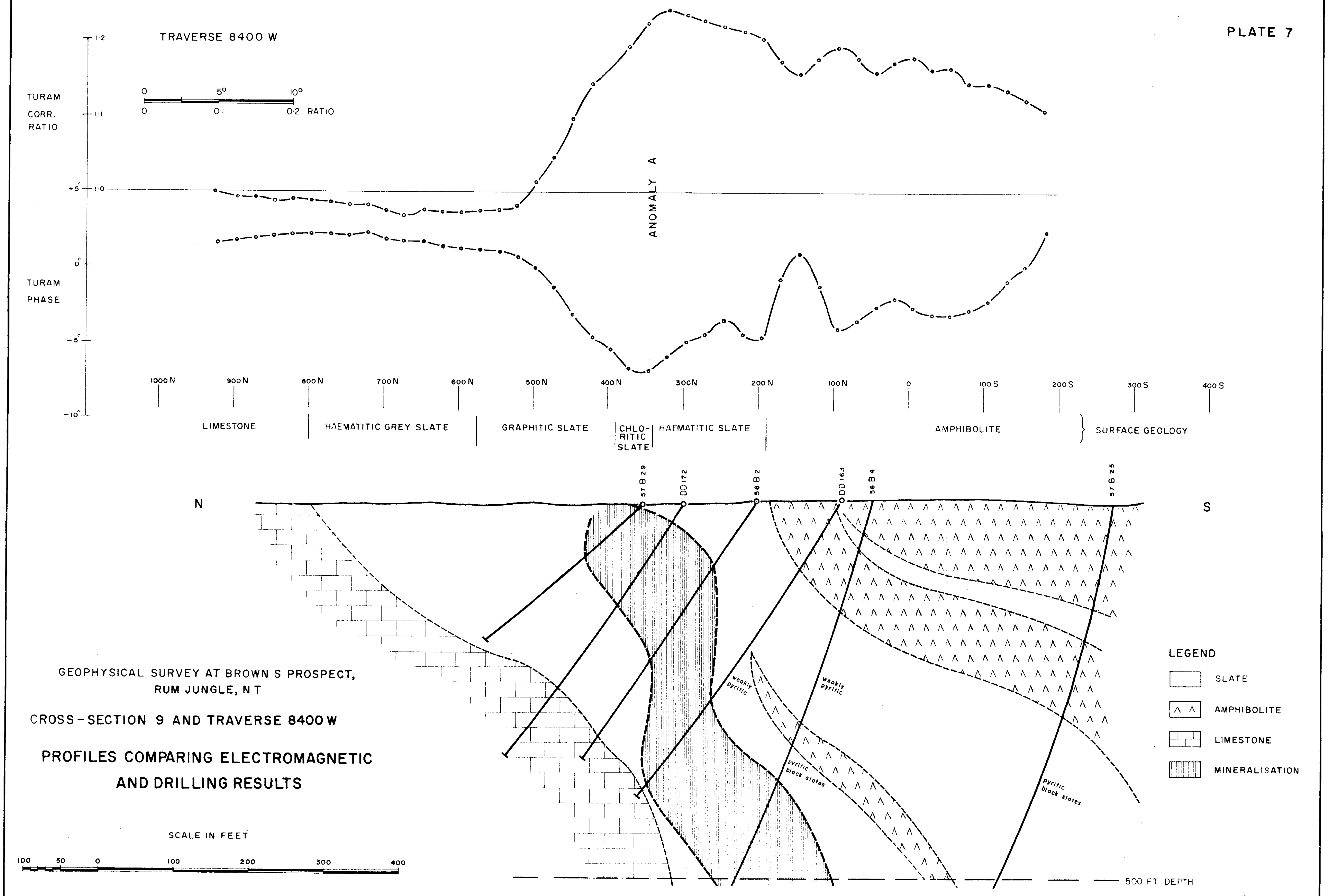
CROSS-SECTION 8 AND TRAVERSE 8000 W

PROFILES COMPARING ELECTROMAGNETIC
AND DRILLING RESULTS

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics D52/B7-27

To accompany Record No. 1962/146

PLATE 7



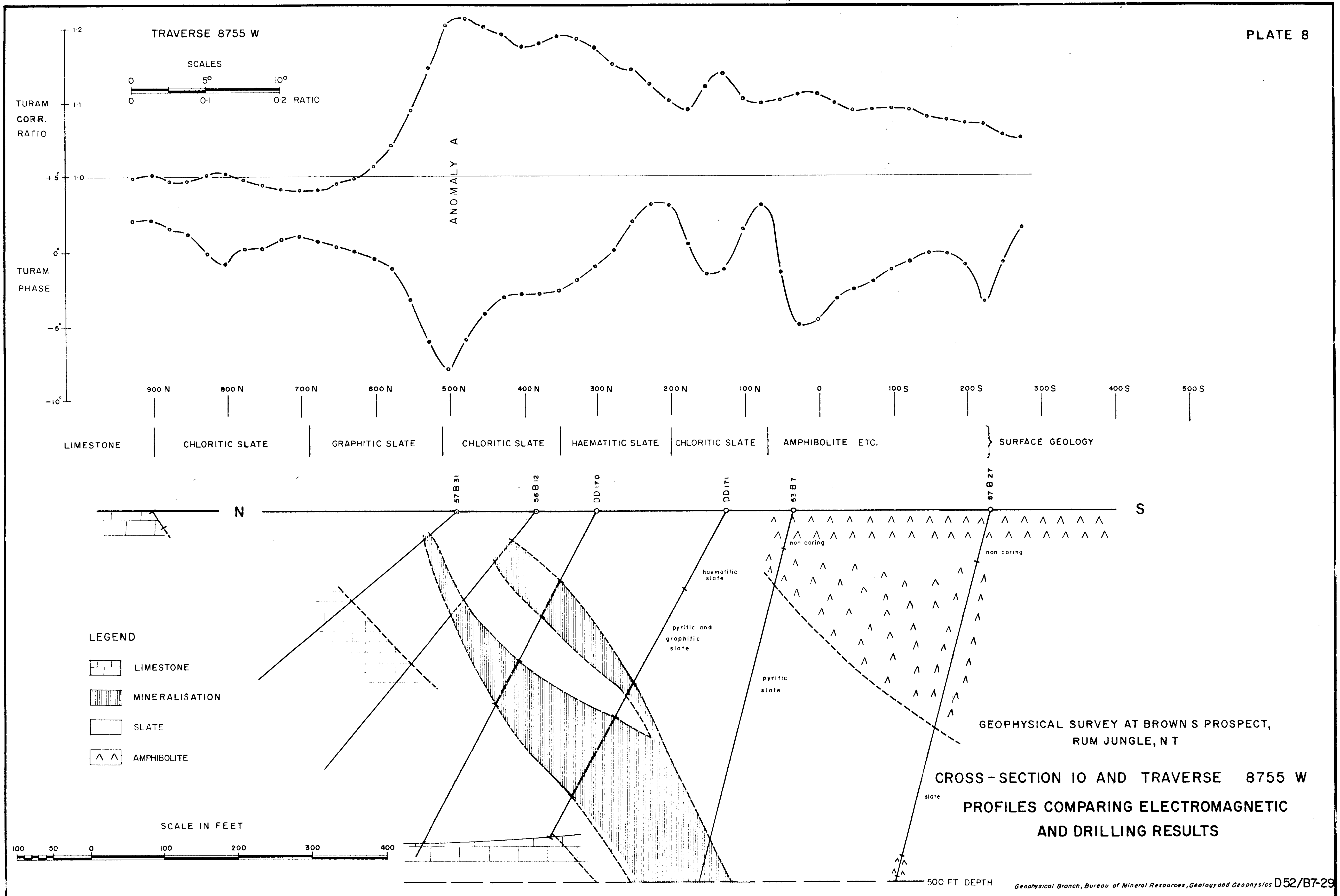
GEOPHYSICAL SURVEY AT BROWN S PROSPECT, RUM JUNGLE, N T

CROSS-SECTION 9 AND TRAVERSE 8400 W

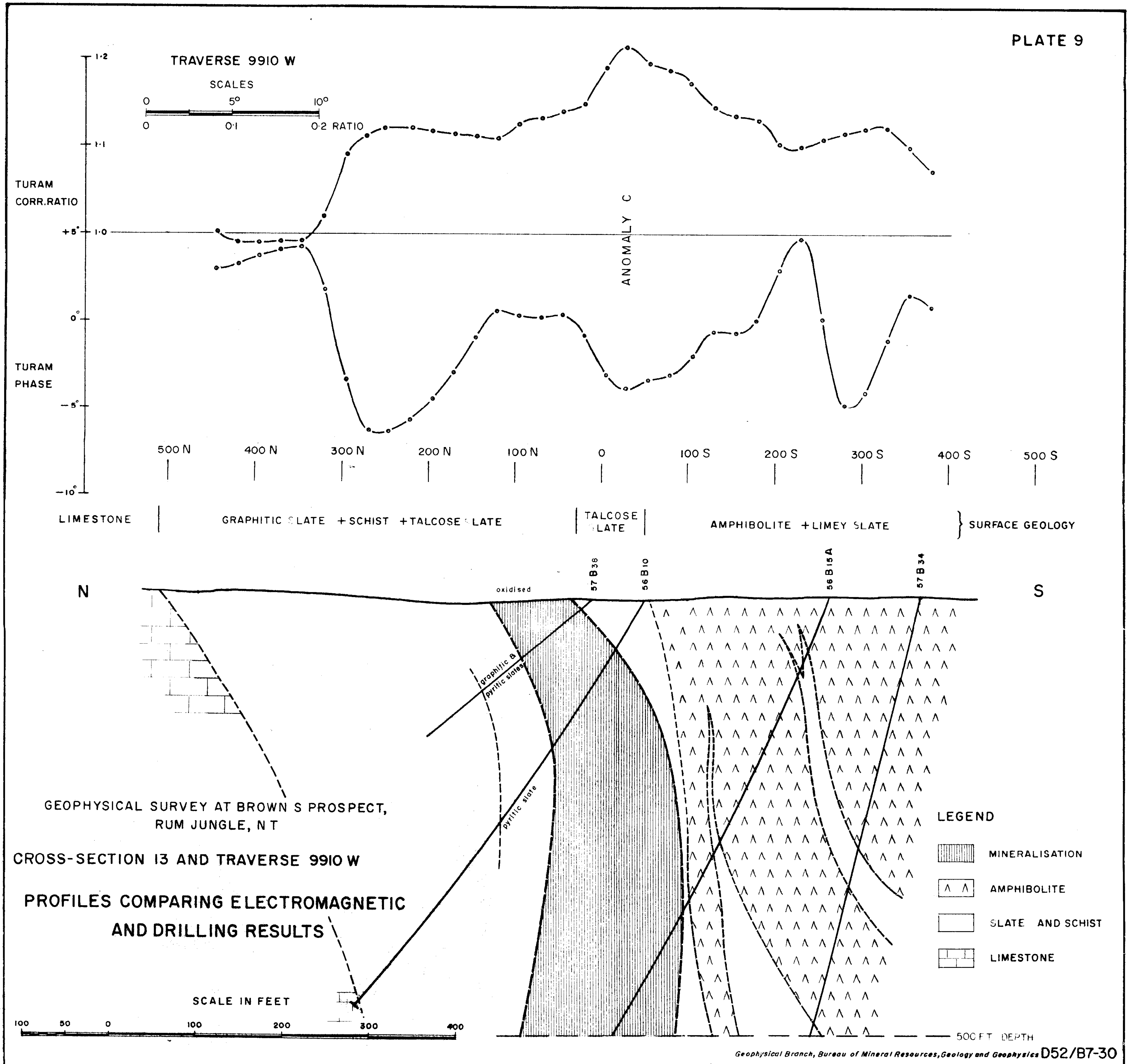
PROFILES COMPARING ELECTROMAGNETIC AND DRILLING RESULTS

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics D52/B7-28

To accompany Record No. 1962/146

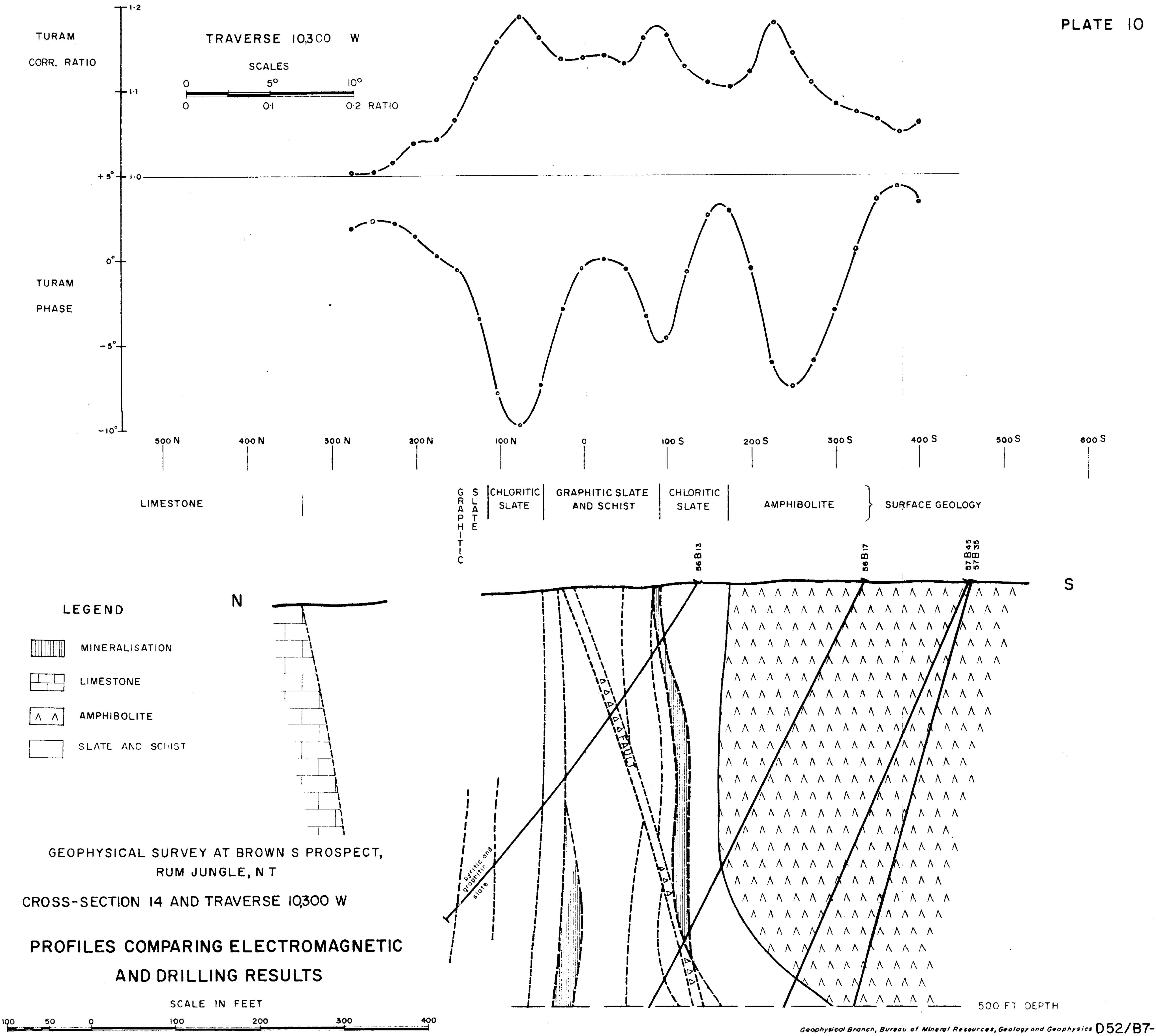


To accompany Record No. 1962/146



To accompany Record No. 1962/146

PLATE 10



GEOPHYSICAL SURVEY AT BROWN S PROSPECT, RUM JUNGLE, N T

CROSS-SECTION 14 AND TRAVERSE 10,300 W

PROFILES COMPARING ELECTROMAGNETIC AND DRILLING RESULTS

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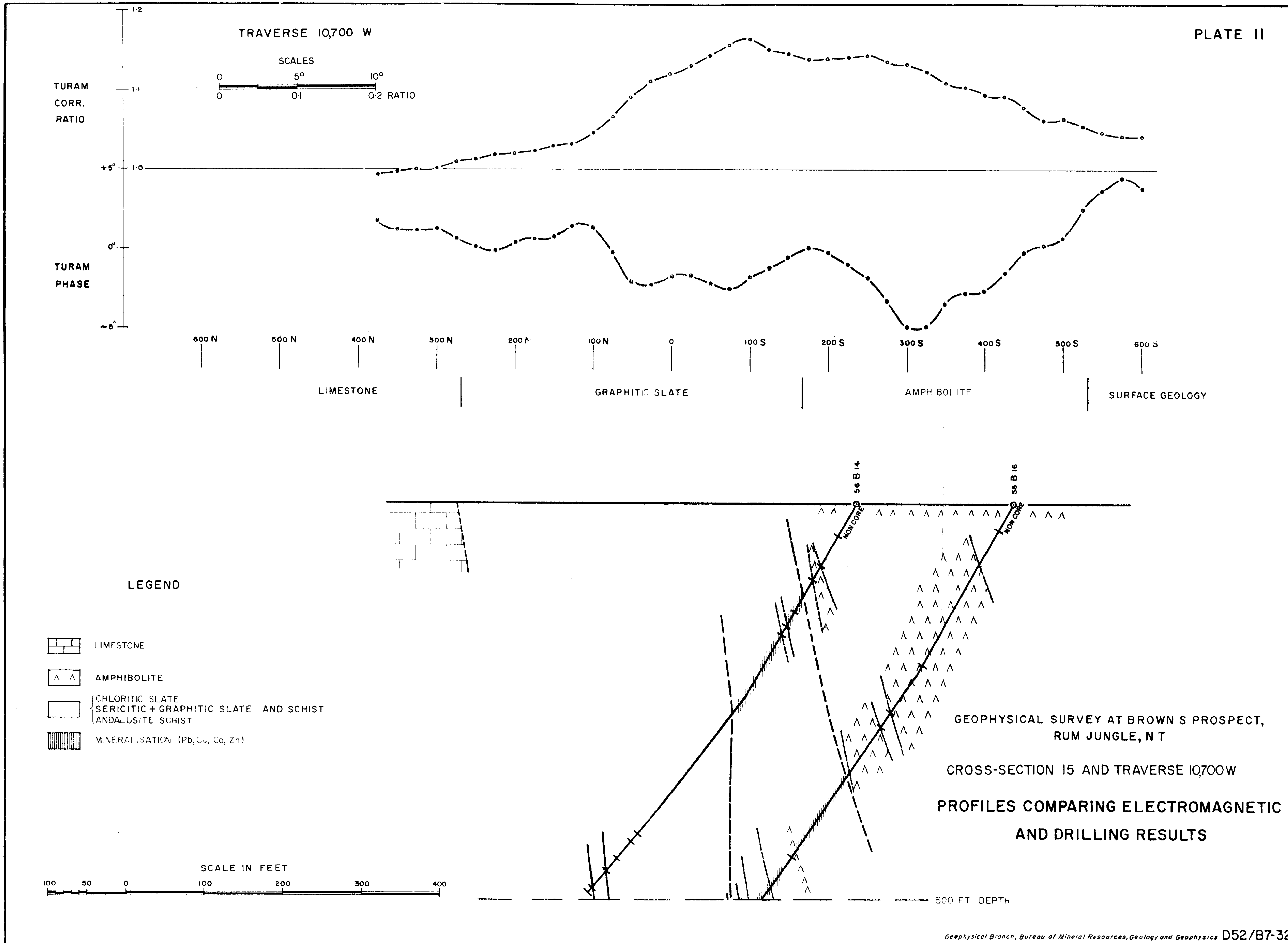
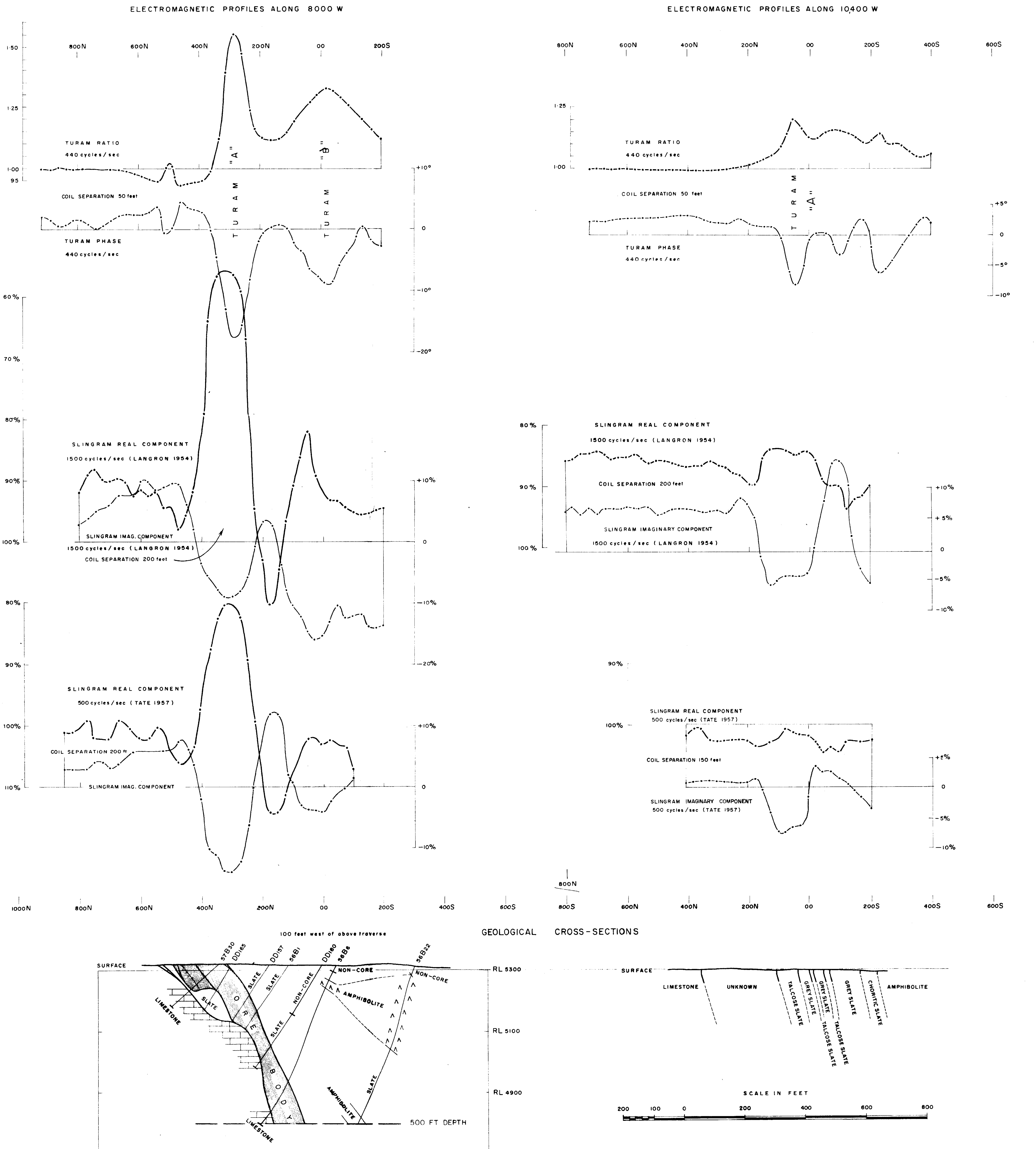
TO ACCOMPANY RECORD No 1962/146



TO ACCOMPANY RECORD No. 1962/146



GEOPHYSICAL SURVEY AT BROWN S PROSPECT

RUM JUNGLE N T

SELECTED PROFILES SHOWING COMPARISON OF SLINGRAM RESULTS (LANGRON 1954) AND TURAM RESULTS (TATE 1957) WITH GEOLOGICAL CROSS-SECTIONS SUPPLIED BY AM AND S

D52/B7-33

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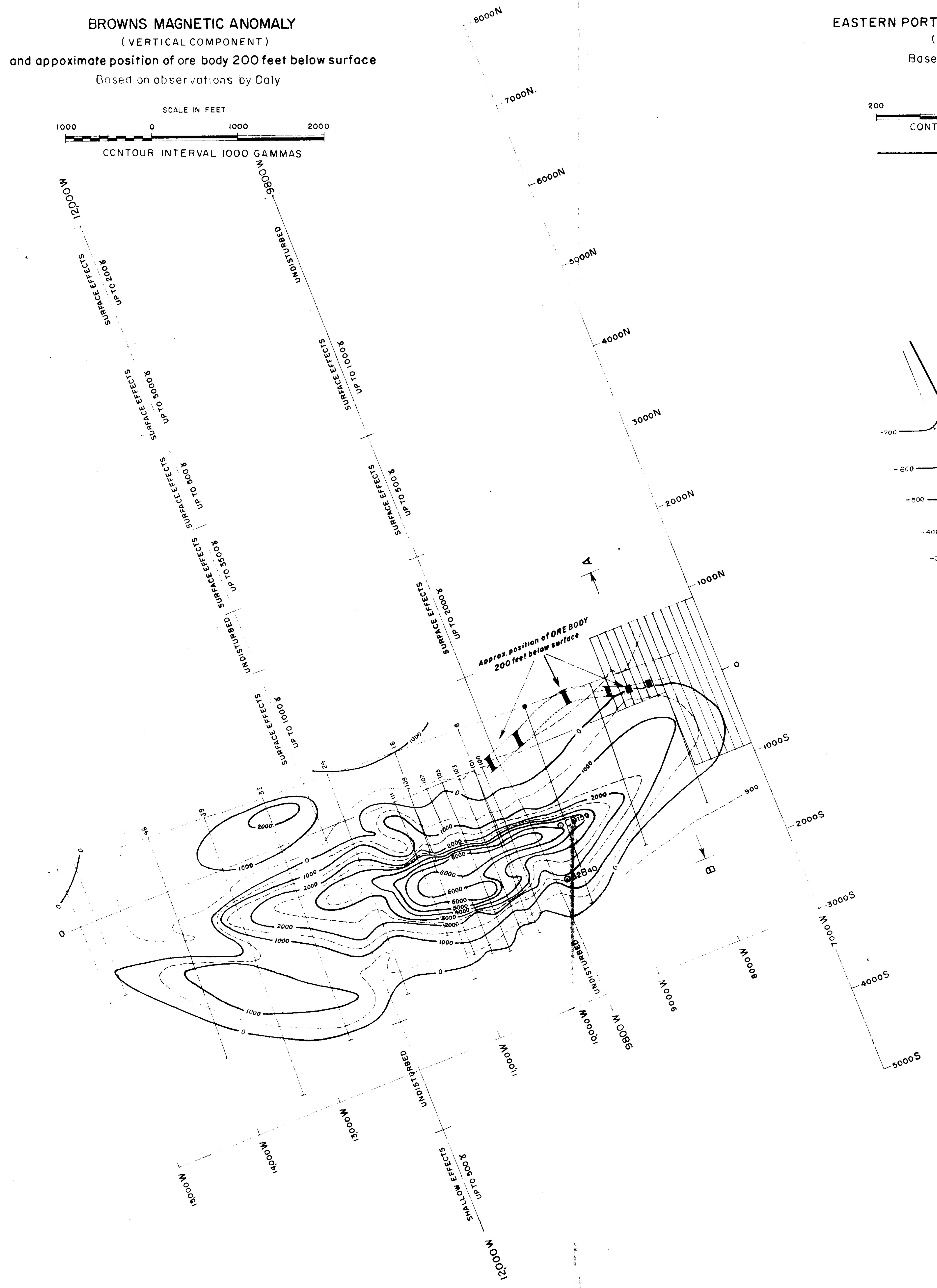
To Accompany Record No. 1962/146

PLATE 13

BROWNS MAGNETIC ANOMALY
(VERTICAL COMPONENT)
and appoximate position of ore body 200 feet below surface
Based on observations by Daly

SCALE IN FEET 1000 0 1000 2000

CONTOUR INTERVAL 1000 GAMMAS

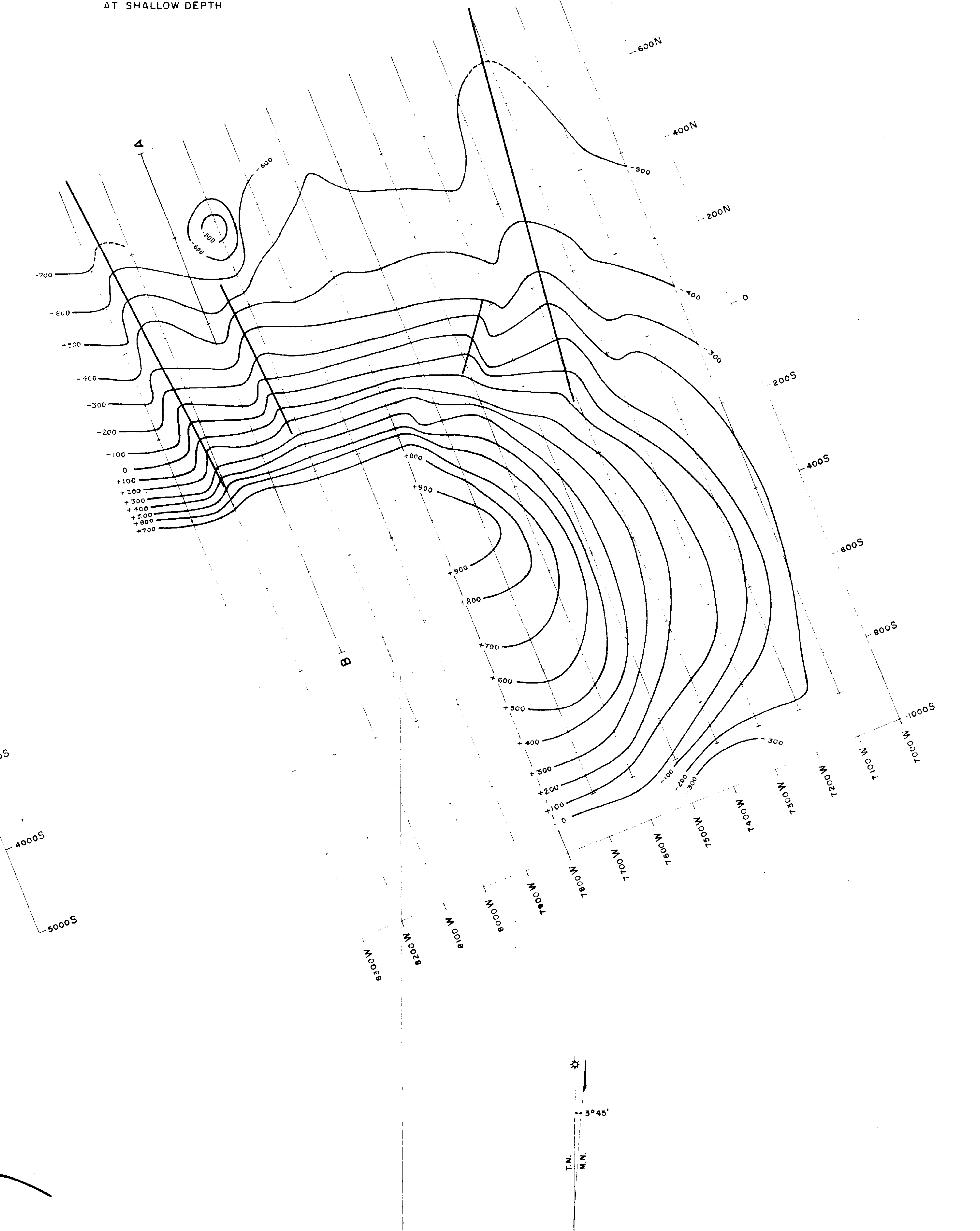


EASTERN PORTION OF BROWNS MAGNETIC ANOMALY
(VERTICAL COMPONENT)
Based on observations by Mumme

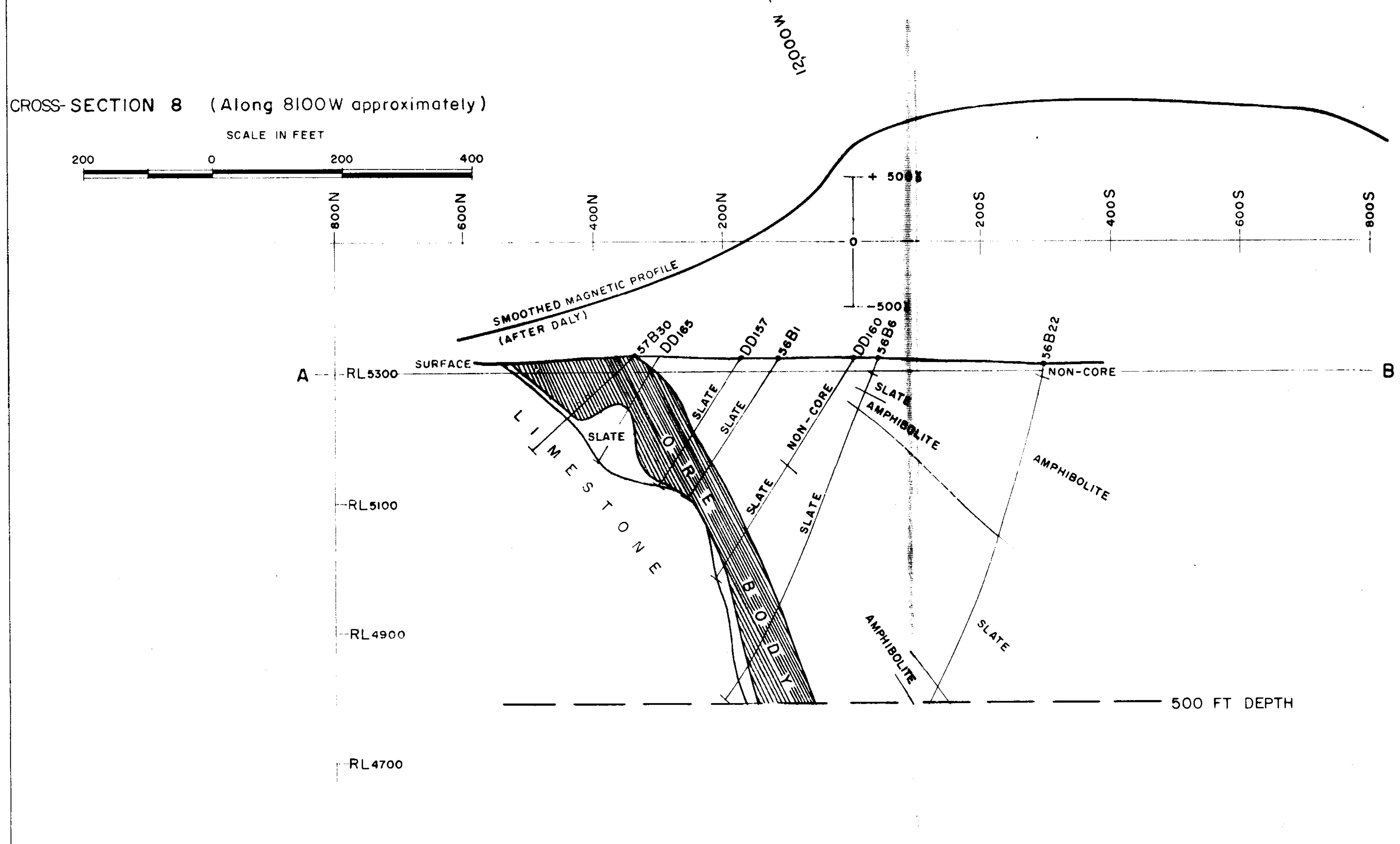
SCALE IN FEET 200 0 200 400

CONTOUR INTERVAL 100 GAMMAS

SMALL MAGNETIC BODY (POSTULATED) AT SHALLOW DEPTH



CROSS-SECTION 8 (Along 8100W approximately)



MAGNETIC VERTICAL FORCE CONTOURS
AND
GEOLOGICAL CROSS-SECTION ALONG TRAVERSE 8100 W

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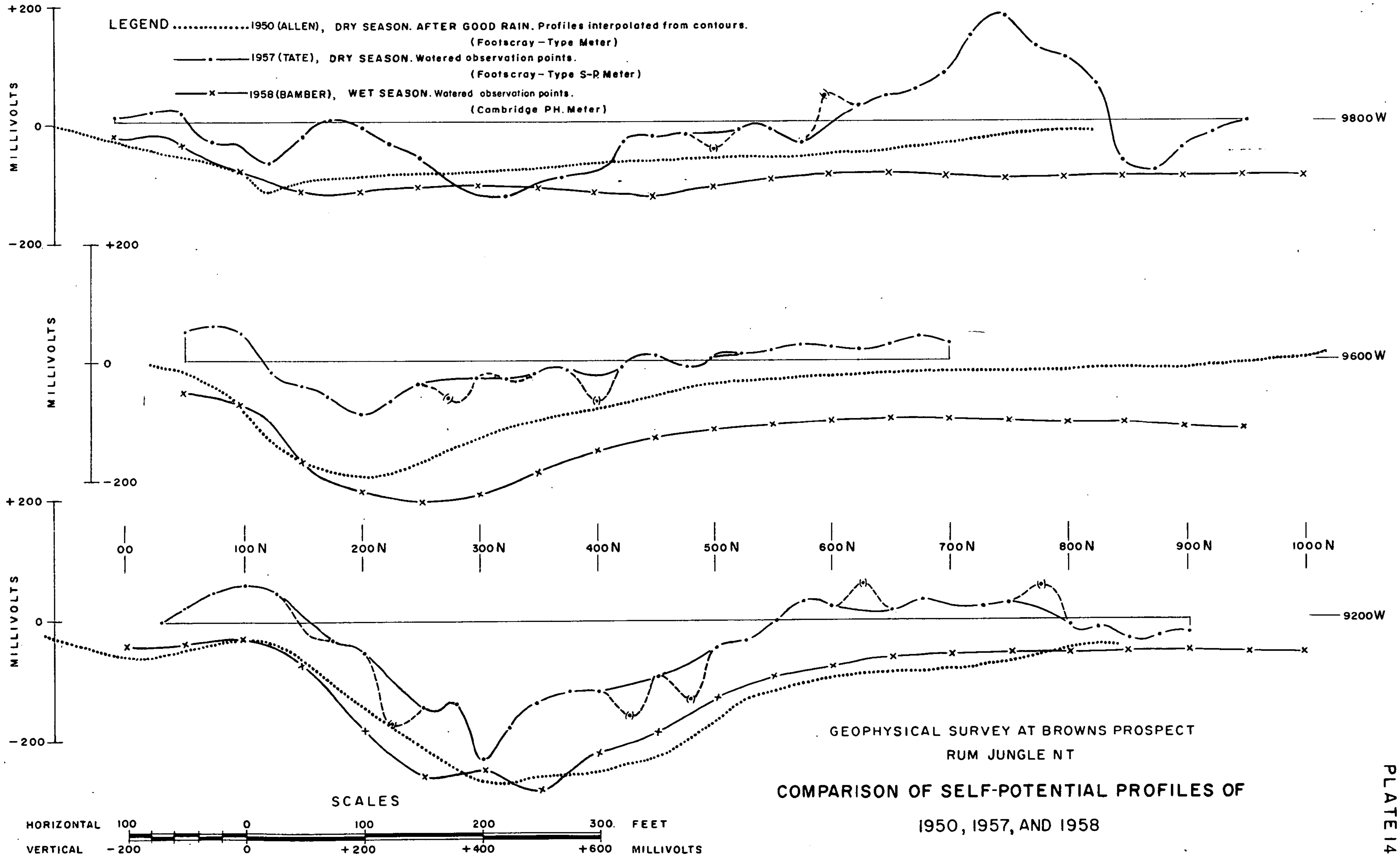
TO ACCOMPANY RECORD No 1962/146



GEOPHYSICAL SURVEY AT BROWNS PROSPECT

RUM JUNGLE N T

COMPARISON OF SELF-POTENTIAL PROFILES OF

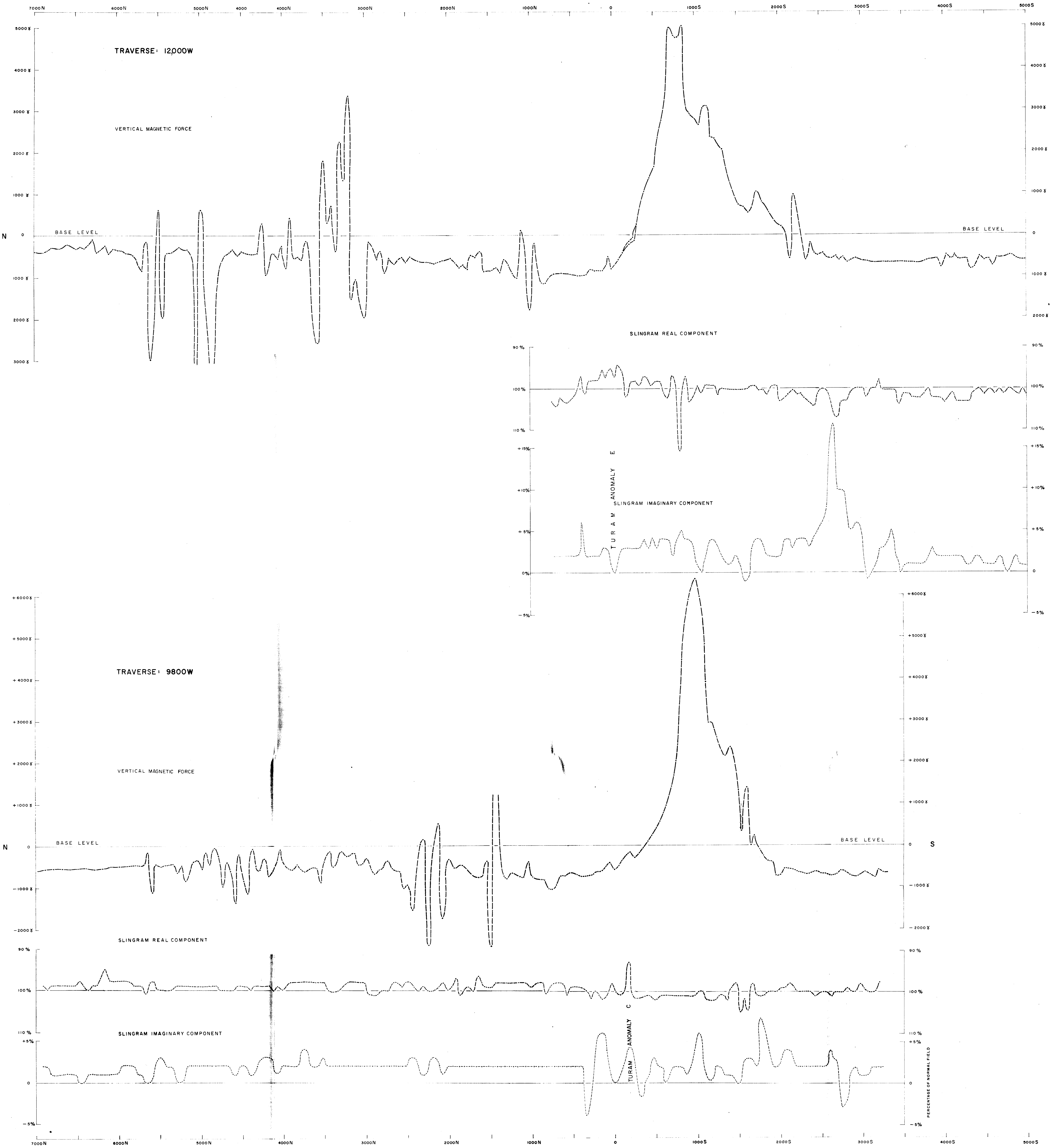
1950, 1957, AND 1958

PLATE 14

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics D52/B7-35

To accompany Record No. 1962/146

PLATE 15



GEOPHYSICAL SURVEY AT BROWN S PROSPECT,
RUM JUNGLE, N T

EXPLORATORY SLINGRAM (500 C/S) PROFILES, COIL SEPARATION 150 FT
AND
VERTICAL MAGNETIC FORCE PROFILES

HORIZONTAL SCALE IN FEET

500 250 0 500 1000 1500 2000

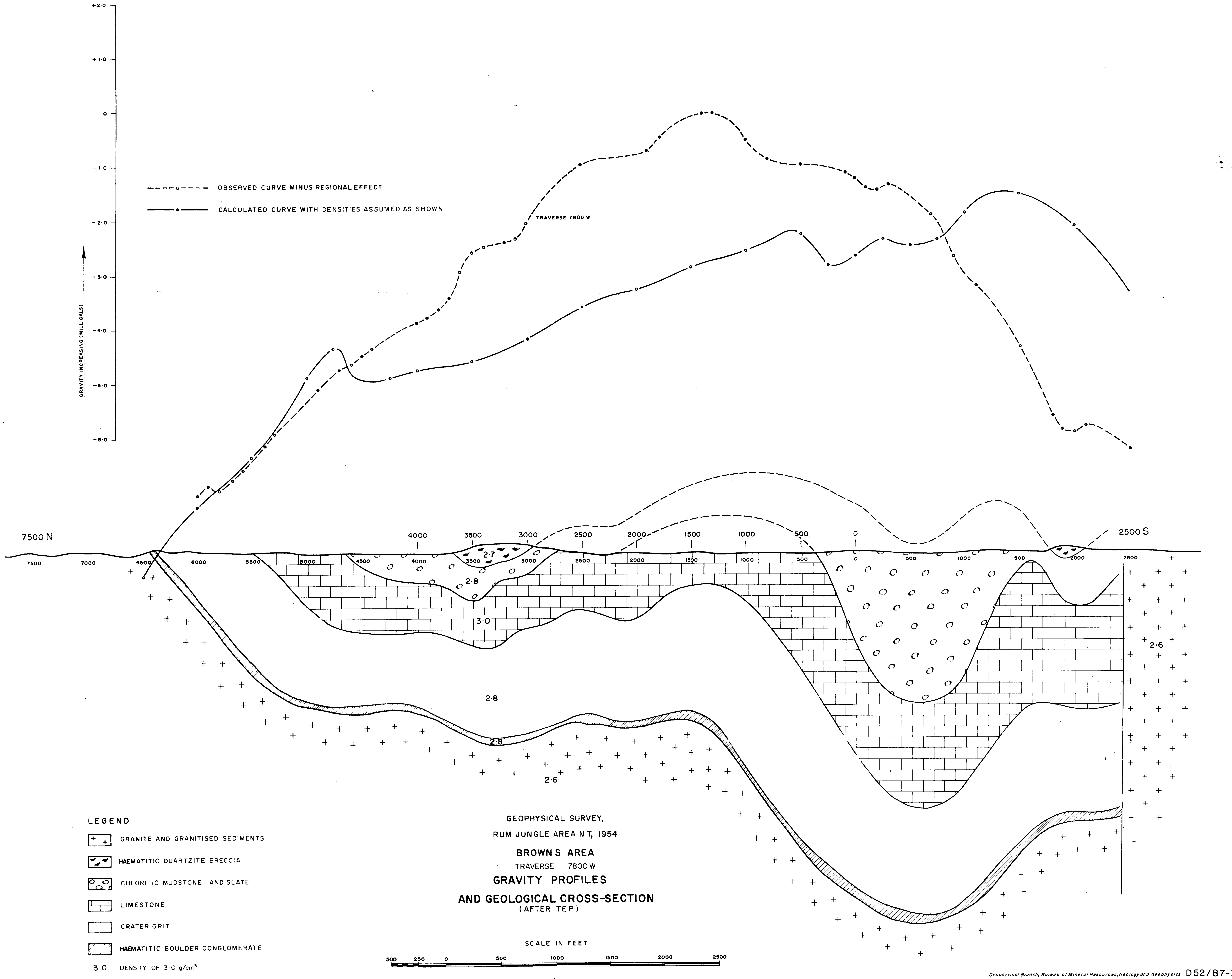
Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics D52/B7-36
To accompany Record No. 1962/146

PLATE 16

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics D52/B7-37

To accompany Record No. 1962/146.

PLATE 17



GEOPHYSICAL SURVEY,
RUM JUNGLE AREA N T, 1954

BROWNS AREA

TRAVERSE 7800 W

GRAVITY PROFILES

AND GEOLOGICAL CROSS-SECTION

(AFTER TEP)

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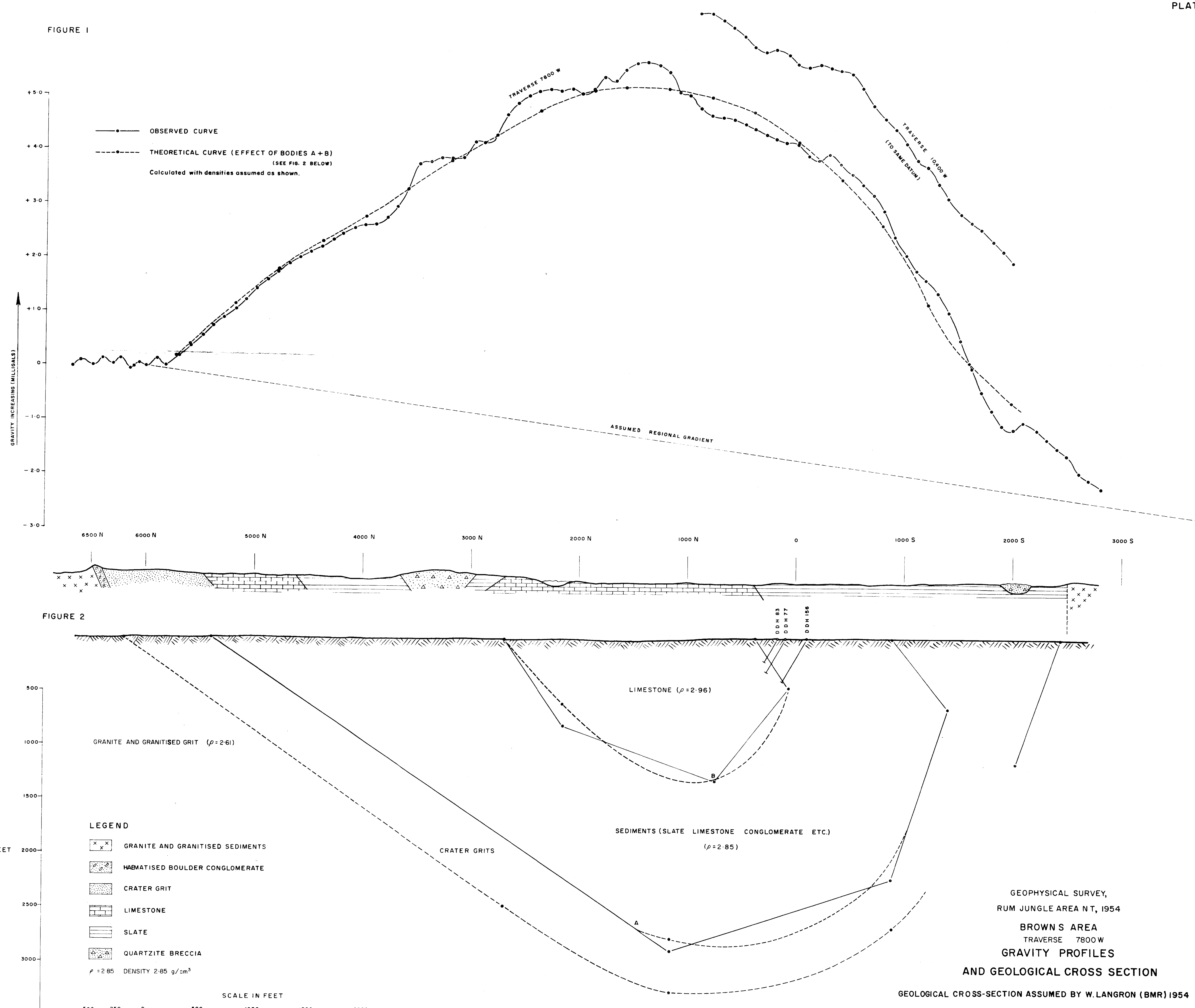
To accompany Record No. 1962/146



GEOPHYSICAL SURVEY,
RUM JUNGLE AREA N T, 1954

BROWN S AREA
TRAVERSE 7800 W

GRAVITY PROFILES
AND GEOLOGICAL CROSS SECTION

GEOLOGICAL CROSS-SECTION ASSUMED BY W. LANGRON (BMR) 1954

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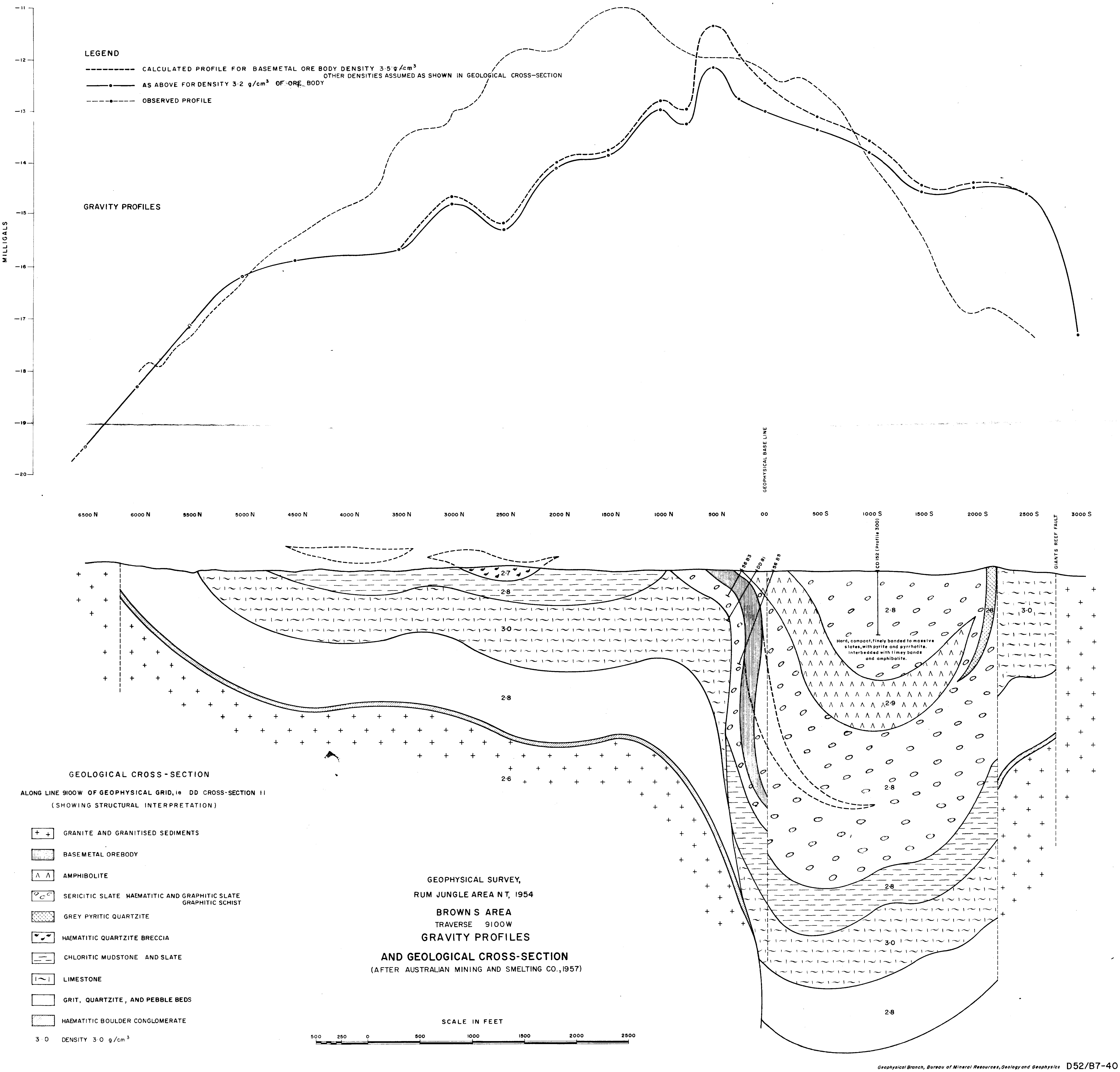
To accompany Record No. 1962/146

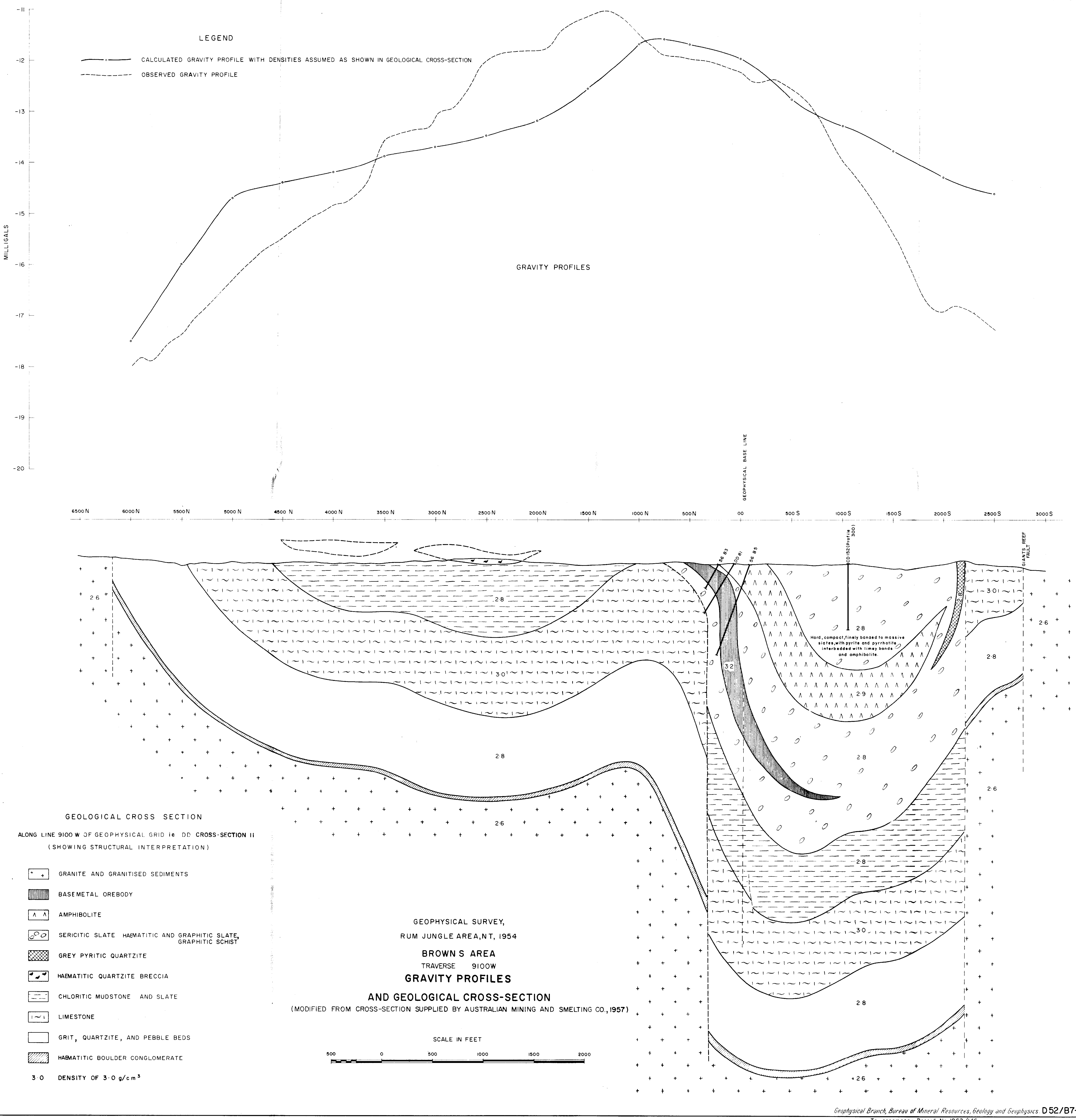


GEOPHYSICAL SURVEY,
RUM JUNGLE AREA N.T. 1954

BROWN S AREA
TRAVERSE 9100W

GRAVITY PROFILES AND GEOLOGICAL CROSS-SECTION
(AFTER AUSTRALIAN MINING AND SMELTING CO., 1957)

PLATE 20



Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics D52/B7-41

To accompany Record No. 1962/146