COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

REPORT No. 96

Captains Flat Metalliferous Geophysical Survey, N.S.W. 1960

BY

E. C. E. SEDMIK

Complimentary

Issued under the Authority of the Hon. David Fairbairn
Minister for National Development
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MINISTER: THE HON. DAVID FAIRBAIRN, D.F.C., M.P.

SECRETARY: R. W. BOSWELL

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SUMMARY

Geophysical surveys, using principally electromagnetic, self-potential, and gravity methods, were conducted over several areas in the vicinity of Captains Flat, New South Wales.

In the South Keatings area, only very weak electromagnetic anomalies were observed and these were not confirmed by the self-potential results.

In the Gourlay-Hickey and Golf Course areas, four electromagnetic anomalies were observed. The strongest of these extends over a length of 2000 ft and is situated close to the contact of volcanics with phyllite, quartzite, and slate. The self-potential survey and geochemical tests carried out by the Lake George Mines staff tend to confirm the presence of sulphide mineralisation at that place. The second anomaly also extends over a considerable length. It is accompanied by a self-potential anomaly and a weak geochemical anomaly but is considered to be caused mainly by graphitic slate. The remaining two anomalies are weak and are not confirmed by the self-potential results.

The gravity survey failed to show distinct gravity anomalies that could be definitely associated with any of the electromagnetic anomalies. This suggests that any mineralisation that might be associated with the anomalies would not represent large ore reserves.

Gravity traverses across the orebodies of the present mine showed a pronounced fault-type anomaly, which appears to be associated with the main lode shear in which the orebodies occur.

In the Bollard area, three electromagnetic anomalies were observed. They are accompanied by self-potential anomalies, but show no correlation with the results of previous geochemical tests in the area, and are considered to be primarily due to graphitic slate.

Recommendations are given for testing the more favourable results of the geophysical surveys.

1. INTRODUCTION

In June 1960, Lake George Mines Pty Ltd made representations to the New South Wales Department of Mines and the Commonwealth Department of National Development, expressing grave concern over the future of the mine at Captains Flat. The ore reserves there were likely to be exhausted in about two years and a recent exploration campaign had failed to prove any substantial additional reserves of ore.

Following these representations, a conference was held between representatives of Lake George Mines, the New South Wales Department of Mines, and the Bureau of Mineral Resources to consider measures that might be taken to assist in the search for additional ore reserves in the Captains Flat area. At this conference it was generally agreed that there was scope for both geological and geophysical investigations; it was decided that the Bureau should carry out a geophysical survey, using electromagnetic and other methods, across the trend of the mine shales south of the mine in areas known as the South Keatings, Golf Course, and Gourlay-Hickey areas. Later, another area farther south known as the Bollard area, where the Company had found some promising geochemical anomalies, was included in the geophysical programme.

The geophysical survey of the above-mentioned areas is the subject of the present Report. The Department of Mines carried out detailed geological mapping over the same areas and the results were made available for use in this Report.

The geophysical field work commenced on 29th August and was completed on 30th November 1960. The survey party consisted of Bureau geophysicists E.C.E. Sedmik (Party Leader) and R. C. Stubbs, and three field assistants. Clearing and surveying of the traverse lines were performed by surveyors of Lake George Mines.

The township of Captains Flat is situated on the Great Dividing Range, some 206 miles by rail south-south-west of Sydney. Access is provided by a branch line from the main Sydney-to-Cooma railway line and by an all-weather road from Queanbeyan.

Plate 1 shows the general location of the survey areas in relation to the mine and to other areas previously surveyed. The geophysical survey was commenced in the South Keatings area where an earlier diamond-drill hole, T47, intersected some weak lead-zinc mineralisation. The survey was extended south for about 1.6 miles over the Golf Course and Gourlay-Hickey areas. In addition the Bollard area, approximately three-quarters of a mile long and half a mile wide and situated about 5 miles south of the mine, was surveyed. Previous geophysical surveys in the Captains Flat area were carried out by the New South Wales Department of Mines (Conaghan & Foskett, 1949) using the self-potential and magnetic methods.

2. GEOLOGY

The following brief account of the geology of the Captains Flat area is based mainly on the report by the geological staff of Lake George Mines Ltd (1953) and on work by Kenny and Mulholland (1941), with attention to Tyler (1947), Glasson (1952), and Conolly (1953).

The geological information presented in Plates 17 and 22 was provided by the New South Wales Department of Mines from detailed mapping carried out in the areas of the geophysical survey during the latter half of 1960.

Economic geology

Auriferous gossans were discovered in the Captains Flat area by Wright in 1874, but actual mining did not commence until 1882. Early mining was carried out by two mining companies, known as Kohinoor and Commodore Vanderbilt, which later amalgamated under the name of Lake George United Mining and Smelting Company. Over 200,000 tons of ore was mined up to 1900, when production ceased. Work was not recommenced until Lake George Mines Pty Ltd started operations in 1937. Up to 1960 over three million tons of ore was removed at an average rate of 16,000 tons per month and with grades of 5.7% Pb, 9.9% Zn, 0.6% Cu, 1.4 oz Ag and 1.0 dwt Au.

The orebodies at Captains Flat strike meridionally. The main bodies are known as Elliot's and Keating's. Gossan occurs over a length of 9000 ft but the actual ore runs for only 4200 ft with 500 ft separation between the two orebodies, the gossan extending considerably beyond the economic mineralisation. Oxidation occurs to a depth of over 100 ft. The orebodies are sulphide deposits of galena, sphalerite, pyrite, and some chalcopyrite, with a quartz, dolomite, and chert gangue, replacing shears within favourable shale beds.

Elliot's orebody consists of three separate sections: a northern section about 400 ft long and up to 40 ft wide, a central section about 1000 ft long and 6 to 18 ft wide, and a southern section about 580 ft long, very narrow but of high grade.

Keating's orebody consists of two lenses: the northern or hangingwall lens and the southern or footwall lens. In both lenses the footwall is sharply defined; in many places it is marked by a zone of pug and dolomitic material up to two feet wide. The highest mineral values are found on the footwall side, decreasing gradually from east to west.

Regional geology

The Captains Flat area is part of a broad north-south syncline located between the Great Dividing Range and a steep western rise. The Molonglo River has dissected the area, resulting in a youthful topography in the vicinity of the mine.

The stratigraphy consists of sediments, probably of Silurian age, comprising shale and sandstone with minor conglomerate and limestone. Volcanics, mainly tuff, form the eastern and western limbs of the syncline. Regional metamorphism has indurated the sediments to slate, phyllite, phyllonite, cleaved sandstone, quartzite, and semi-schist. Both the sediments and volcanics have been intruded subsequently (probably in the Tertiary period) by dykes of dolerite. Since then, geological action has been limited to the deposition of alluvium along the Molonglo River. On the western side of the Narongo Fault the rocks are semi-schist and phyllite probably of Ordovician age.

The sediments and associated volcanics have been folded and sheared along north-south axes. The pitch of the folds is northerly. The strongest zone of shearing, with which the orebodies are associated, divides the field into two structural units: the western or hangingwall unit, which is a complex closely-folded anticline, and the eastern or footwall unit, which is a more gently folded syncline.

It is considered that the orebodies have been formed by replacement of intersecting shears within a favourable shale bed. It is probable that the deposition of lead and zinc minerals was influenced by the presence of impure limestone or other calcareous material. As the shear has provided the means of access for the ore-forming solutions, the shape of the bodies is largely dependent upon it. Hence they form lenses which strike north, dip west at 80 to 85 degrees, and pitch steeply north.

Following the ore deposition several transverse faults, the most important of which is the Molonglo Fault, displaced both ore and associated rocks but had no influence on ore formation.

Local geology

During the course of the geophysical survey, the areas under investigation were mapped in detail by geologists of the New South Wales Department of Mines. The geological map of the Gourlay-Hickey and Golf Course areas, based on this work and also on subsequent petrological studies, has been made available for comparison with the geophysical results, and this is reproduced in Plate 17.

The geology of the Bollard area (Plate 22) consists of a succession of sandstones (in places quartzite), cleaved sandstone, black slate, and sheared silicified volcanics. The age of these is at present unknown and the presence of inliers, together with some lensing, obscures the sequence. The strike of the rocks is approximately north. Three major faults intersect the area; two of them strike east and the third north-north-west. The last-mentioned fault has iron-staining and brecciation associated with it.

3. GEOPHYSICAL METHODS

Four geophysical methods were used during the survey: electromagnetic, self-potential, magnetic, and gravity. In addition, geochemical tests were carried out by the staff of Lake George Mines under the direction of Messrs Paine and Roach over areas where electromagnetic anaomalies were recorded.

Electromagnetic method

This method is used for detecting zones of good electrical conductivity, which are often associated with mineralisation. Of the more common ore minerals, chalcopyrite has the highest conductivity; then come pyrrhotite, pyrite, and galena in decreasing order. Sphalerite is rarely a good conductor. The conductivity of an orebody also depends on the mode of occurrence of the minerals, being higher for massive than for disseminated mineralisation, and is influenced also by the porosity and moisture content of the lode material.

However, good electrical conductivity does not necessarily imply the presence of mineralisation. Rocks such as graphitic schist, and shear zones containing mineralised waters, may also act as good electrical conductors, and the presence of these frequently complicates the interpretation of electromagnetic measurements.

In the Turam method used at Captains Flat, the primary field was applied to the ground by passing an alternating current through an insulated cable laid on the surface and arranged in the form of a large rectangular loop, about 2000 ft by 4600 ft. Measurements were made of the amplitude ratios and phase difference of the vertical fields detected by two horizontal coils, which were moved along traverses at a constant separation of 100 ft. Frequencies of 880 and 440 cycles per second were used.

The results of the Turam survey are presented as separate maps showing contours of ratio and phase difference, both of which are used in the interpretation. In general, an anomaly due to a conducting body appears as a maximum in the ratios and a large negative value in the phase differences. As the ratio contours give a better indication of the conductivity of the conducting bodies, they are therefore more important in the search for minerals than the phase contours.

Another method of presenting the Turam results is to plot the ratios and phase differences measured along a traverse in the form of ratio-phase diagrams, examples of which are given in Plate 12. The ratio-phase diagram is useful for locating the exact position of an anomaly. Qualitative information on the conductivity of the conducting body is given by the slope of the axis of the anomaly as shown in the diagram; a steeper slope corresponds to a higher conductivity.

Self-potential method

In this method the naturally-occurring earth potentials are detected and their distribution at the ground surface is measured. A negative anomaly is commonly associated with a sulphide body undergoing oxidation.

Self-potential measurements were made in all areas where significant electromagnetic anomalies were observed. The instrument used was a transistorised S-P. meter designed and constructed in the Geophysical Laboratory of the Bureau.

Magnetic method

The magnetic survey was limited to a few test traverses. The variations in the vertical component of the magnetic field were measured using an Askania torsion magnetometer (No. 581649). As the profiles showed no features that could be correlated with the geology, the survey was not continued.

Gravity method

The gravity method can be used for the detection of lead-zinc orebodies only where the lode is shallow and of considerable width and where there is a marked density difference between the ore and the surrounding country rock. An orebody of economic size close to the surface could be expected to produce a positive gravity anomaly of about 0.1 to 0.5 milligal. As this is a very small anomaly, extremely high accuracy is required when using the gravity method in the search for orebodies. In general, a gravity survey will provide information on the geological structure of an area, and this may indirectly assist in the search for orebodies where, as at Captains Flat, structure has been a controlling factor in ore deposition.

The gravity observations were made with a Worden meter (No. 61), capable of measuring differences of gravity of about 0.01 milligal. The calibration factor of the meter was 0.09015 milligal per dial division. Gravity traverses were surveyed over the more important electromagnetic anomalies and over the known orebodies.

4. OPERATIONS AND RESULTS

The following discussion of the surveys in South Keatings, Golf Course, and Gourlay-Hickey areas is mainly concerned with the electromagnetic and self-potential results. Some reference is made to the gravity results, but a fuller account of the gravity survey is given in a later section.

South Keatings area

The field work commenced with the laying-out of a geophysical grid having its origin corresponding to mine co-ordinates 7001S/388.4E. This origin was called 7000S/00 and a baseline was surveyed through it in a north-south direction. Owing to a small surveying error, the geophysical baseline is not parallel to the mine grid but is inclined to it at an angle of $1^{\circ}27'$. Traverses at 200-ft separations were laid out west of the baseline and at right angles to it. The surveyed area extended from 7000S to 10,000S. Observations were made every 25 ft along traverses.

The Turam survey disclosed only three lines of very weak anomalies, which occur at about 1600W, 1200W, and 700W, as shown in Plate 17. No phase or ratio contour plans are presented as the results are not considered to be of any significance.

Diamond-drill hole T47, which was previously drilled near the north-eastern corner of the area, intersected some very weak mineralisation at depth. In the phase profiles the Turam results show a broad, very weak minimum, which is considered to be due to this mineralisation, but there is no evidence of any well-defined lode channel.

Golf Course area

The area is situated south-east of South Keatings area and extends from 9400S to 12,600S and from 300W to 1000E. A Turam survey was made over the whole area, but self-potential and gravity readings were made only on Traverse 10,000S.

The Turam results, which are presented as phase contours and ratio contours in Plates 2 and 3 respectively, show only two electromagnetic anomalies worthy of mention. The positions of these anomalies are shown in Plate 17. One of them, located between Traverses 11,400S and 12,200S at about 50W, is very weak and is unlikely to be associated with mineralisation of any importance. The second, referred to as Anomaly D, is located between 10,000S/25W and 9400S/150E. The Turam profiles along Traverse 10,000S are shown in Plate 7, together with the self-potential and gravity profiles.

Anomaly D is best defined on Traverse 10,000S and appears to be caused by a moderately good conductor at a depth of about 100 ft. It is situated close to the contact of two different types of volcanics and could possibly be caused by disseminated mineralisation or by a shear. The self-potential profile along 10,000S shows only minor variations and provides no confirmation of the Turam results. The gravity profile shows a well-defined positive anomaly, but as its maximum is about 175 ft east of the axis of the electromagnetic anomaly, it cannot be assumed that the same body is responsible for both the gravity anomaly and the good conductivity indicated by the Turam results. From the geological information available, the gravity anomaly appears to be caused by a formation of feldspathic volcanics of slightly higher density than the surrounding rocks.

Gourlay-Hickey area

This area is situated south of South Keatings area and extends from 10,000S to 15,400S. Observation points were pegged at intervals of 25 ft along the traverses. The original traverses were at separations of 200 ft but additional intermediate traverses were surveyed at places where the results appeared to warrant more-detailed investigation. The Turam, self-potential, magnetic, and gravity methods were used in this area.

The Turam survey of the entire area required a total of four separate cable layouts. The results are shown as phase contours and ratio contours in Plates 4 and 5, respectively.

The self-potential contours are shown in Plate 6. Profiles showing the Turam, self-potential, and gravity results in relation to the known geology along selected traverses are given in Plates 8 to 11. The plan of the area (Plate 17) shows the locations of the principal geophysical features.

The Turam survey indicated three main conducting zones which are referred to as Anomalies A, B, and C. Anomaly A extends over a length of approximately 2000 ft from Traverse 11,000S to Traverse 13,000S at about 2200W. It may be continuous with another anomaly (A') farther south between Traverses 14,000S and 14,600S at about 2400W.

Anomaly A is characterised by medium to strong phase anomalies (up to -25°) and high ratio anomalies (up to 1.440) and is situated in phyllite, sandstone, and siltstone close to their contact with volcanics to the west. The shape of the ratio and phase profiles indicates that the conductor is generally close to the surface and has a steep westerly dip. The indication is confirmed by a self-potential anomaly of about -300 millivolts. The axis of the self-potential anomaly is about 25 ft east of the corresponding Turam anomaly, thus confirming a steep westerly dip. A good correlation was found between the Turam anomaly and the lead and copper content of geochemical anomalies (up to 240 p.p.m. Pb and Cu) found by Messrs Paine and Roach of Lake George Mines in a geochemical survey carried out to check the geophysical results.

Anomaly B extends over a length of approximately 2200 ft from Traverse 12,100S to Traverse 14,200S and strikes roughly south at about 1800W. It is characterised by medium phase anomalies (up to -15°) and low to medium ratio anomalies (up to 1.280). It suggests only medium conductivity and is considered to be caused by the graphitic slate which occurs between quartzite and sandstone in the west and phyllite in the east. Only very weak geochemical anomalies (up to 60 p.p.m. Pb and Cu) accompany this anomaly.

The self-potential anomaly along Turam Anomaly B is generally much stronger (up to 600 millivolts) than that associated with Anomaly A. Strong self-potential anomalies are commonly found in connexion with graphite, and the self-potential results tend to confirm the conclusions drawn from the Turam results.

Anomaly C, a rather weak anomaly extending over a length of approximately 2600 ft from 11,000S/1600W to 13,600S/1200W, is characterised by weak to medium phase anomalies (up to -10°) and low to very low ratio anomalies (up to 1.060). It appears to be due to relatively low conductivity, suggesting shearing or disseminated mineralisation. From the geological information available on the area, it is considered that Anomaly C is connected with the presence of some quartz dolerite outcrops, which contain desseminated pyrite. No self-potential anomalies accompany Anomaly C but there is a distinct gravity anomaly roughly parallel to it and about 200 ft to the west.

A selection of the ratio-phase diagrams from the Turam survey of the Gourlay-Hickey area is shown in Plate 12. The diagrams show that Anomaly A is very weak on Traverse 11,000S but increases to the south and reaches a maximum on Traverse 12,200S. However, the slope of the axis of the anomaly suggests that the highest conductivity is at Traverse 12,700S. The characteristics of Anomaly A′ are similar to those of A. Anomaly A′ is best defined on Traverse 14,200S. Anomaly B is best defined on Traverse 13,200S, but in general it is much less pronounced than either A or A′. Anomaly C appears on the diagrams for Traverses 12,000S and 12,200S, but it is not well defined and suggests relatively low conductivity.

Gravity survey

The gravity method was applied during the Captains Flat survey, in the hope that it would help to show whether the various electromagnetic anomalies are associated with economic mineralisation. Electromagnetic anomalies accompanied by positive gravity anomalies would be considered more favourable drilling targets than those that were not. It was also considered that the gravity survey might provide information on the structural geology of the area.

Gravity measurements were made at about 625 stations. Ten traverses were selected for gravity work to cover the most important electromagnetic anomalies in the Gourlay-Hickey area. Two traverses were surveyed over known orebodies to determine whether these orebodies produce any gravity anomalies. These traverses were oriented east-west and were situated at 1403S and 5335S (mine co-ordinates). The first crossed Elliot's orebody (the main orebody of the present mine) and the second crossed South Keatings orebody. Another traverse was surveyed over Roach's area between mine co-ordinates 13,440S/8250 E and 13,440S/6750E. Previous investigation of this area by the New South Wales Department of Mines (Conaghan & Foskett, 1949) showed a pronounced self-potential anomaly associated with a north-south shear zone, but geochemical tests showed no copper or lead and only very low zinc values. The gravity results along this traverse showed no features of any interest and the profile has therefore not been presented in this Report.

All gravity readings were referred to a base station at 12,200S/1400W and levels were referred to a bench-mark near the base station. The elevation of the bench-mark was arbitrarily taken as 500.00 ft. Levels were determined with an accuracy of ± 0.1 ft and the procedure adopted for the gravity readings was such as to give a check on instrumental drift and on the accuracy of the measurements.

A latitude correction of 1.214 milligals per mile was used. Terrain corrections could not be applied to most of the gravity readings, as no suitable topographical map of the surrounding country was available.

Elevation corrections (combining the Bouguer and free-air corrections) were applied to reduce the gravity values to a reference level of 450.00 ft. As the Bouguer correction depends on the density of the rocks between the surface and the reference level, a careful assessment of the rock densities in this range was necessary. Preliminary reduction of the gravity data was carried out using an elevation correction corresponding to a density of 2.65 g/cm^3. This figure was based on density determinations of surface rock samples collected from the area covered by the gravity survey. However, the resulting gravity profiles, when plotted, showed correlation with the topography, indicating that the assumed density value was too high in places.

Other methods were investigated in order to determine a more appropriate average density. One of these was the method of density profiles (Nettleton, 1940), in which different densities are used in the reduction of the gravity data and the proper density for the area is that which gives a profile showing minimum correlation with the topography. This method, when applied to traverse 15,400S, yielded a density of 2.25 g/cm^3, a value considerably less than the average density value determined from the surface samples.

A third method of finding the density was used, in which all the observed gravity values (corrected only for instrumental drift) were plotted on a graph versus the elevations. The slope of the graph should give the elevation correction factor. The results of this investigation are shown in Plate 13. The graphs for Traverses 10,000S and 15,400S indicate densitites of 2.65 and 2.25 g/cm^3 respectively. The combined graph as presented in Plate 13 has an average slope corresponding to a density of 2.4 g/cm^3. It was concluded that the average density of the surface rocks (above R.L. 450.0 ft) decreases from north to south, and in calculating the elevation corrections the density values assumed were as follows: 2.65 for Traverse 10,000S; 2.40 for Traverses 11,600S, 12,200S, 12,600S, 12,800S, 13,000S, 14,000S, 14,200S and 14,4000S; 2.25 for Traverse 15,400S.

The gravity results corrected for instrumental drift, latitude, and elevation are shown as individual profiles in Plates 14 and 15. A gravity contour plan of the Gourlay-Hickey area is shown in Plate 16.

Plate 14 shows the gravity profiles along Traverses 1403S, 5335S, and 10,000S with corresponding geological cross-sections. The cross-sections for Traverses 1403S and 5335S were supplied by the Mine staff, while that for Traverse 10,000S is based on the recent geological map prepared by the New South Wales Department of Mines.

Traverse 1403S was selected to cross the nearly worked-out Elliot's orebody of the present mine and was extended for 3200 ft west of the mine grid 00 to cross the Copper Creek Shales and the Narongo Fault. The geology is known from drilling information and underground mining development. The main feature on the gravity profile is a gravity "low" of about two milligals east of Elliot's lode, where the outcropping rocks are acid tuff, shale, and sandy tuff. The shape of the profile suggests a major north-south fault with considerable vertical movement and downthrow on the east side. The fault appears to be associated with the main lode shear, in which the orebody occurs. It is considered that the fault is connected with the mineralisation and probably provided the channel by which the ore-forming solutions entered the lode area.

The shape of the profile between 800W and 2000W is probably caused by a dense body of considerable vertical extent. The Narongo Fault, west of the basal conglomerate at about 2250W, does not produce a distinct gravity feature.

Traverse 5335S, about three-quarters of a mile south of Elliot's traverse, crosses South Keatings area where appreciable quantities of pyrite and lead-zinc ore are known to exist. The gravity readings started from the edge of the Molonglo Dam in the east, crossed the gossaniferous outcrop of the lode shear at about 650W and finished in carbonaceous shale (probably Copper Creek Shales) at 1950W.

The gravity profile shows a "low" at the eastern end, which is probably caused by the Molonglo Dam. The gravity anomaly of about one milligal between 00 and 1200W is probably caused by the presence of relatively low-density rocks such as shale, sandy tuff, and coarse acid tuff; it appears to be a continuation of the prominent anomaly on the eastern part of Traverse 1403S. The presence of a fault is suggested by the steep rise of gravity values between 800N and 1200W. The magnitude of the anomaly is considerably less than on Traverse 1403S, probably indicating that between this traverse and 5335S the vertical throw of the fault decreases and the shear tends to die out. This interpretation would be consistent with the northerly pitch of Keating's and Elliot's orebodies that has been observed in the Lake George Mine.

The small positive anomaly near the centre of the gravity "low" could be caused by the pyritic orebody at 650W, which comes relatively close to the surface. The gravity "high" between 1200W and 1950W corresponds to dacitic tuff and carbonaceous shale.

The third gravity profile in Plate 14 is along Traverse 10,000S, which is situated near the northern end of the Gourlay-Hickey and Golf Course areas. The profile shows only small variations. The small "low" between 1400W and 1900W is probably caused by increase of soil thickness in a "button grass" area. The gravity "high" between 00 and 400E is considered to be caused by volcanics of a denser type (with potassic feldspar).

The gravity profiles shown in Plate 14 indicate that the gravity anomaly that appears to be associated with the lode shear is very well pronounced on Traverse 1403S, becomes less pronounced on Traverse 5335S, and practically disappears on Traverse 10,000S. The results suggest that the gravity method could provide useful information on the structural geology of the area. However, considerably more gravity surveying would be required to show whether the gravity method would be likely to assist in selecting locations structurally favourable for ore occurrence.

Plate 15 shows the individual gravity profiles of the ten traverses observed in the Golf Course and Gourlay-Hickey areas and includes Traverse 10,000S which has already been discussed. The results are also presented in the form of contours in Plate 16. Traverses 11,600S to 15,400S all show a gravity "low" corresponding to the relatively low-density phyllite, phyllonite, quartzite, sandstone, and siltstone, but the "low" appears to be dying out at 15,400S.

There is a small positive gravity anomaly at 11,600S/1200W, but it cannot be correlated with any known geological feature. The gravity "lows" on Traverses 12,200S, 12,600S, 12,800S, and 13,000S each show a distinct positive anomaly of about 0.1 to 0.3 milligal between 1800W and 1200W. This gravity feature shows continuity at least over these four traverses, but its full extent to the south has not been determined. The size of this anomaly suggests the possibility of its being caused by mineralisation, but its position, between two electromagnetic anomalies (as shown in Plate 17), makes this possibility rather remote.

The gravity results in the Gourlay-Hickey and Golf Course areas do not appear to provide any information as to the probable cause of the electromagnetic anomalies.

Bollard area

The geophysical survey of this area was done at the request of Lake George Mines Pty Ltd, which had previously investigated the area by geochemical methods and found some promising lead and copper anomalies. Very little was known of the geology of the area at the time the geophysical survey was initated, and no geological or topographical maps were available. The geophysical baseline was surveyed parallel to the general strike of the geochemical contour lines, and the grid was arranged so that its centre corresponded to the maximum geochemical anomalies.

The origin (0/0) of the geophysical grid was at mine co-ordinates 23,008S and 4745E. The baseline was surveyed through this point with a bearing of 160°00'. Sixteen traverses at 200-ft spacing were laid out east of the baseline, and the surveyed area extended from 200E to 2200E and from 800S to 3800S. Observations were taken every 25 ft along traverses. The geophysical survey progressed slowly because of the rugged topography and difficult access.

The results of the electromagnetic survey are shown by the Turam phase contours in Plate 18 and ratio contours in Plate 19. Three electromagnetic anomalies, marked A, B, and C, were revealed. They occur in parts of the area where black slate crops out. It was not possible, within the time available, to trace Anomaly B to its northern limit.

Self-potential readings were made along alternate traverses. The results confirmed the electromagnetic anomalies. Self-potential and Turam profiles along selected traverses are shown in Plates 20 and 21. The electromagnetic and self-potential anomalies could not be correlated with the strong geochemical anomalies found by Lake George Mines at about 2300S/800E. Turam Anomalies A and C are similar in showing low ratio values for corresponding high phase values. Anomaly A appears to be terminated at its southern end and C at its northern end by a major east-west fault. Anomaly C extends southwards beyond the limit of the slate outcrop, but it is probable that the slate also continues farther south under cover of scree material. The conductors causing A and C are considered to be graphite in the slate, and are hence of no economic interest.

Anomaly B differs from the other two in showing higher ratio values; these could be caused by higher conductivity or, alternatively, by greater thickness of the conductor. The anomaly may be associated with either the black slate outcrop or the north-north-west fault, or both. It terminates at the major east-west fault. Two possibilities exist:

(a) That graphite has been formed in the slate during the process of faulting, or

(b) That mineralisation has been introduced along the fault. As the sharpness of the anomaly suggests a near-surface conductor, trenching would probably reveal which possibility is correct.

5. CONCLUSIONS AND RECOMMENDATIONS

The Turam electromagnetic survey revealed several anomalies in the Golf Course and Gourlay-Hickey areas. The ratio and phase characteristics of at least four of these indicate the presence of good conductors. The locations of these anomalies (A, B, C, and D) in relation to the geophysical grid and geological environment are shown in Plate 17.

Anomaly A is considered to be the most favourable electromagnetic anomaly. Subsequent self-potential and geochemical work tend to confirm it and suggest that the conductivity could be due to sulphide mineralisation.

Anomaly B, although confirmed by the self-potential method and associated with a rather weak geochemical anomaly, appears to be connected with the occurrence of black slate (Copper Creek Slates), which could account for the anomaly. The geochemical anomaly suggests that the black slate is slightly mineralised, but the anomaly is too weak to suggest economic mineralisation.

Anomalies C and D were not confirmed by the self-potential method, suggesting that the conductors responsible for them are of a different type from those causing Anomalies A and B. A small positive gravity anomaly associated with Anomaly D is believed to be caused by feldspathic volcanics of a slightly higher density than the surrounding rocks, as the boundary of this formation agrees fairly well with the extent of the anomaly. Geochemical tests gave no confirmation of Anomaly D. However, the possibility that Anomalies C and D are associated with disseminated mineralisation cannot be ruled out, and some testing is considered warranted to investigate this possibility.

The small amount of gravity work included in the present survey failed to show any distinct anomalies that could be associated definitely with the electromagnetic anomalies. This points to the conclusion that any economic mineralisation that may be associated with the electromagnetic anomalies must be in the form of narrow lodes, and would not constitute large ore reserves.

Further investigation of the geophysical results in the Golf Course and Gourlay-Hickey areas by diamond drilling is considered desirable. It is recommended that Anomaly A should be tested by the following drill holes in order of preference:

Drill Site No.	Position	Direction	Angle of depression	Approximate length
D.D.H. 1	12,300S/2300W	East in direction of traverse	45^{o}	250 ft
D.D.H. 2	12,700S/2400W	East in direction of traverse	45^{o}	250 ft
D.D.H. 3	11,600S/2250W	10^{o} N of E	45^{o}	300 ft

Testing of Anomaly A', which appears to be a continuation of A, would be recommended if the above three holes show promising results. To test A', a drill hole D.D.H. 6 should be drilled at about 14,200S/2450W, towards the east in the direction of the traverse and at an angle of depression of 45^{o}. The length of the hole should be about 250 ft. It is considered that Anomaly C should be tested initially by trenching, to provide more-detailed information on the geological environment. Trenching along Traverse 12,800S from 1250W to 1500W and geochemical tests along the traverse between 600W and 1600W are recommended. Should favourable results be obtained from the trenching and geochemical tests, then a drill hole D.D.H. 4 at 12,800S/1150W is recommended. This hole should be about 350 ft long and at an angle of depression of about 45^{o}. The proposed direction of the hole, viz. to the west, assumes an easterly dip of the formations. This assumption should be confirmed by trenching before the position and direction of the hole are finally determined.

Anomaly D in the Golf Course area should be tested initially by trenching along Traverse 10,000S between 50W and 100E. Should the results be favourable, it is recommended that a hole D.D.H. 5 should be drilled at 10,000S/200W, towards the east in the direction of the traverse. The hole should be about 450 ft long and at an angle of depression of 45^{o}.

The electromagnetic and self-potential anomalies in the Bollard area are believed to be caused by the black slate, and cannot be correlated with the previous geochemical results. The only additional investigation that might be warranted in this area is trenching to determine the nature of the shallow conductor associated with electromagnetic Anomaly B.

6. ACKNOWLEDGEMENTS

The author wishes to acknowledge the assistance and co-operation given by the management and staff of Lake George Mines Pty Ltd during this survey, and in particular the help and information provided by the Chief Surveyor, Mr S. Bannerman, and the Mine Geologist, Mr V. Paine.

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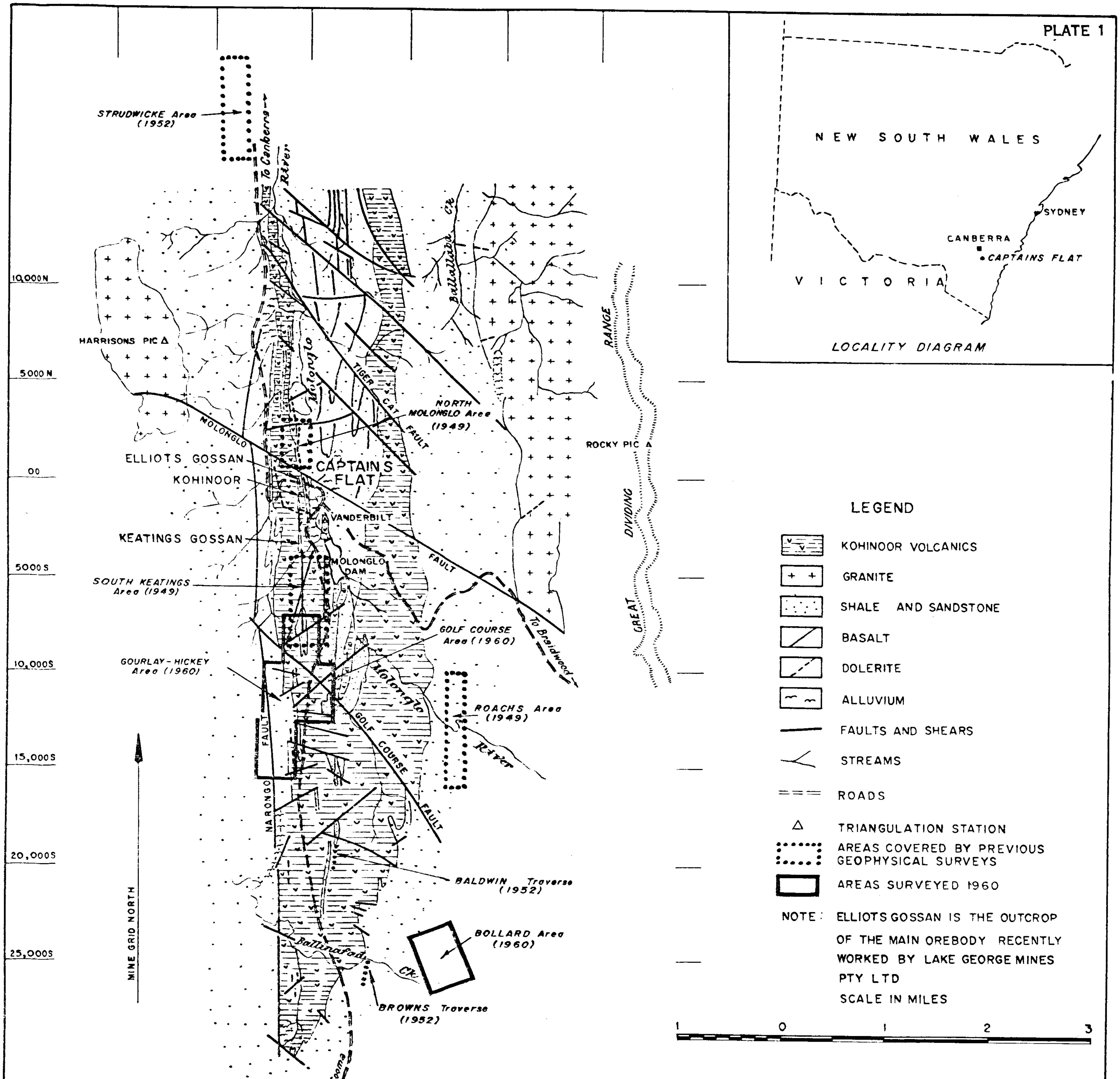
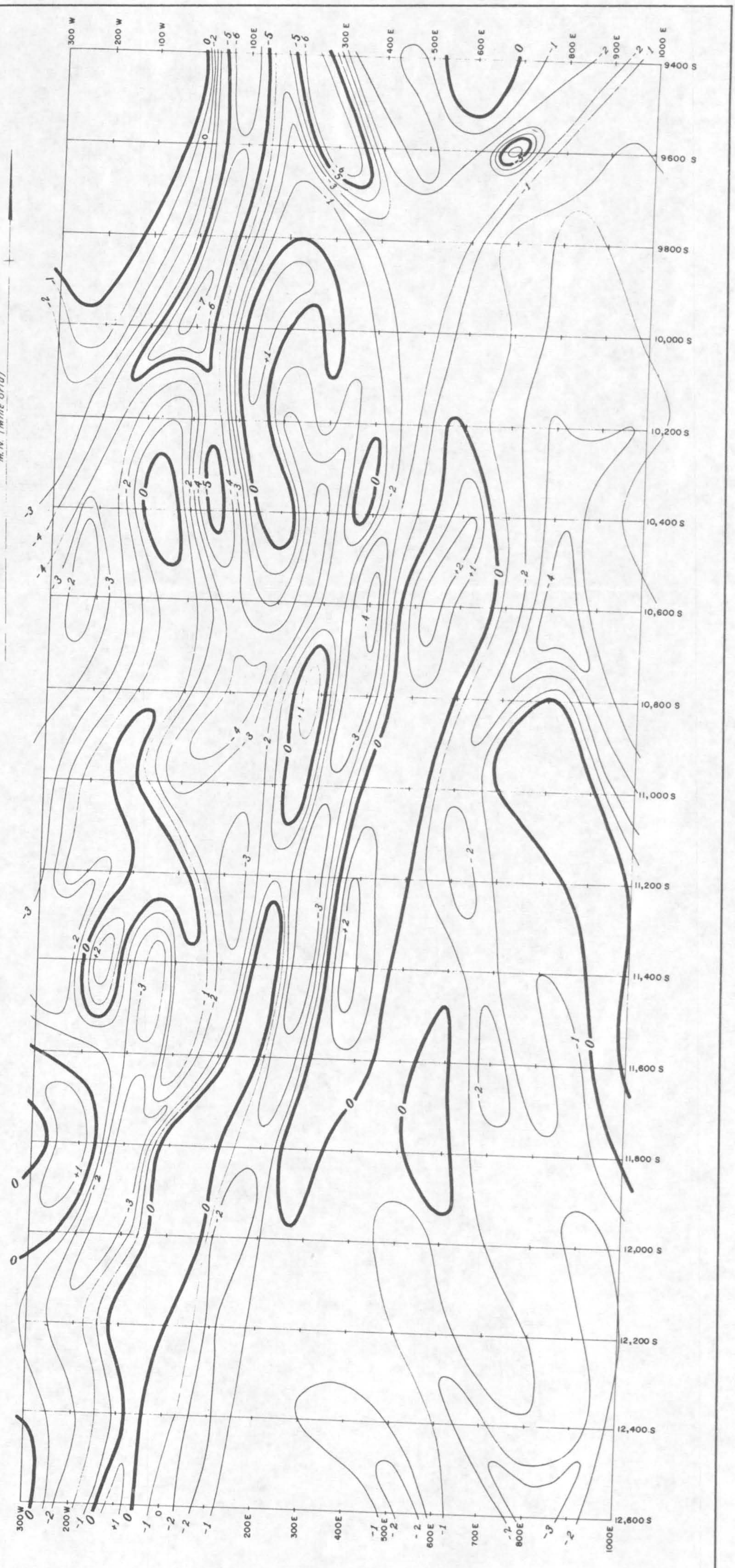


CAPTAINS FLAT N.S.W
LOCALITY MAP

GEOLOGY AFTER "GEOLOGY OF AUSTRALIAN ORE DEPOSITS" (VOL. I. 1953)

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics I55/B1-21

PLATE 1

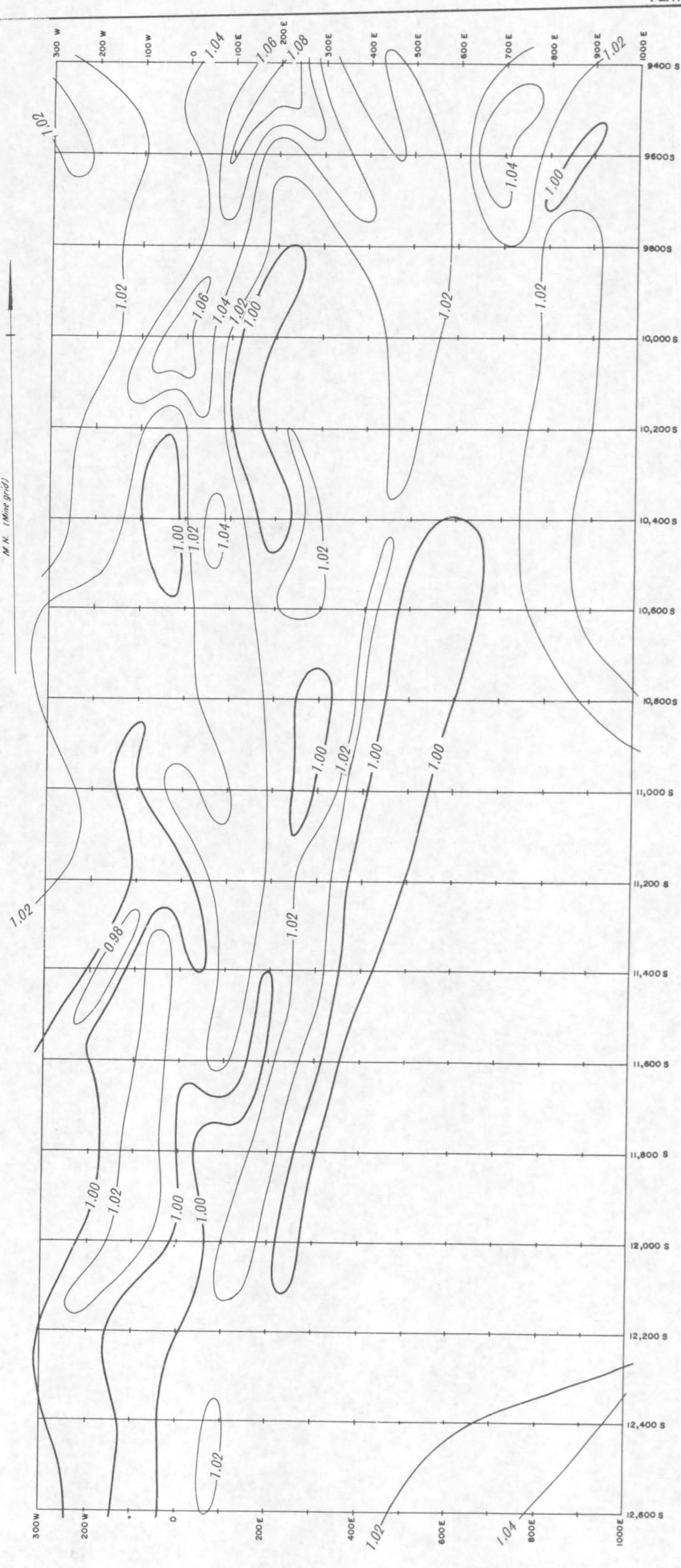


GOLF COURSE AREA
TURAM PHASE CONTOURS

FEET
200 0 200 400 600
CONTOUR INTERVAL 1°

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics 155/B7-25

PLATE 2



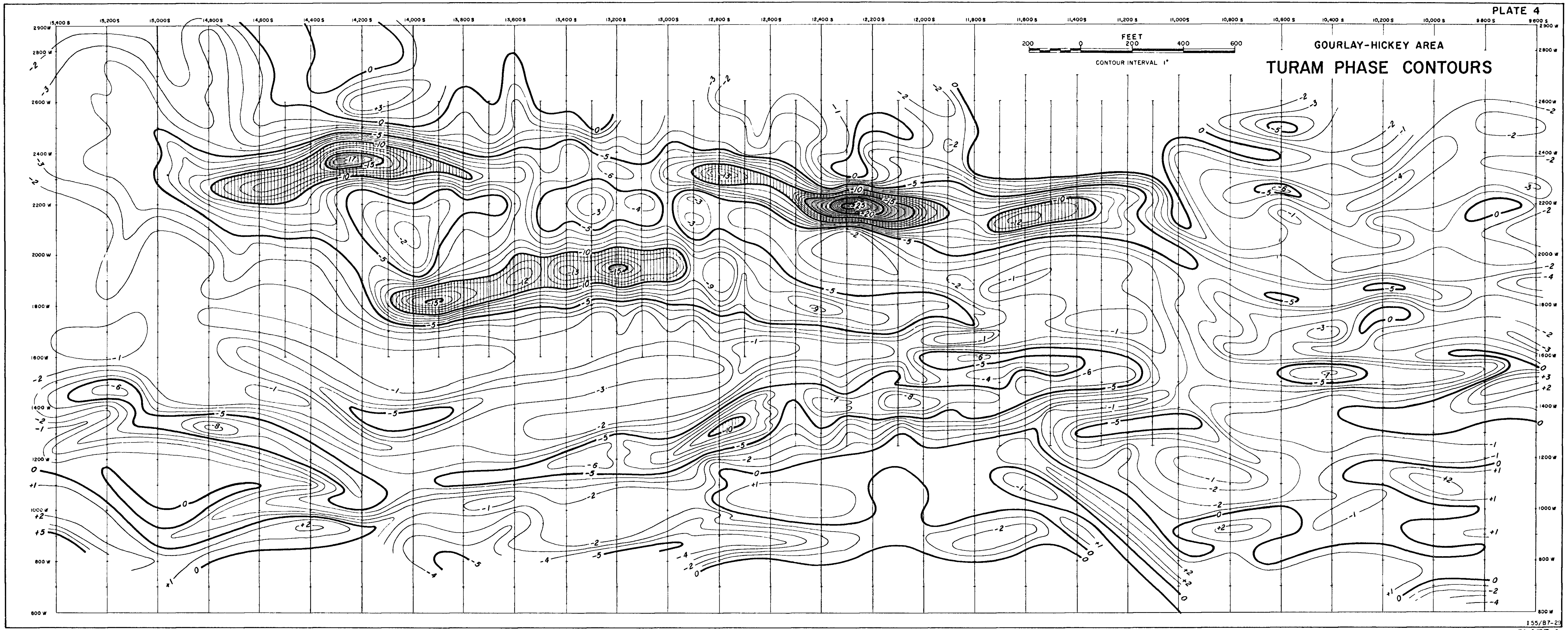
GOLF COURSE AREA
TURAM RATIO CONTOURS

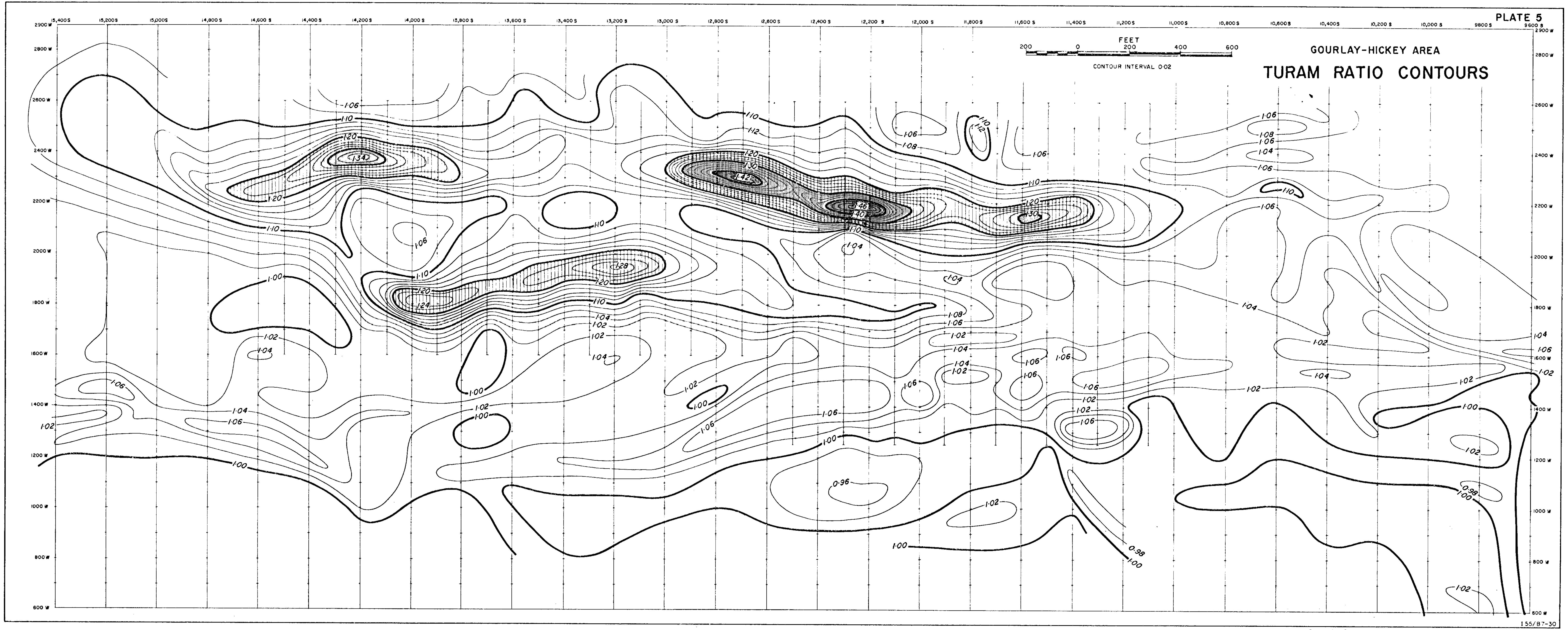
SCALE IN FEET
200 0 200 400 600

CONTOUR INTERVAL 0·02

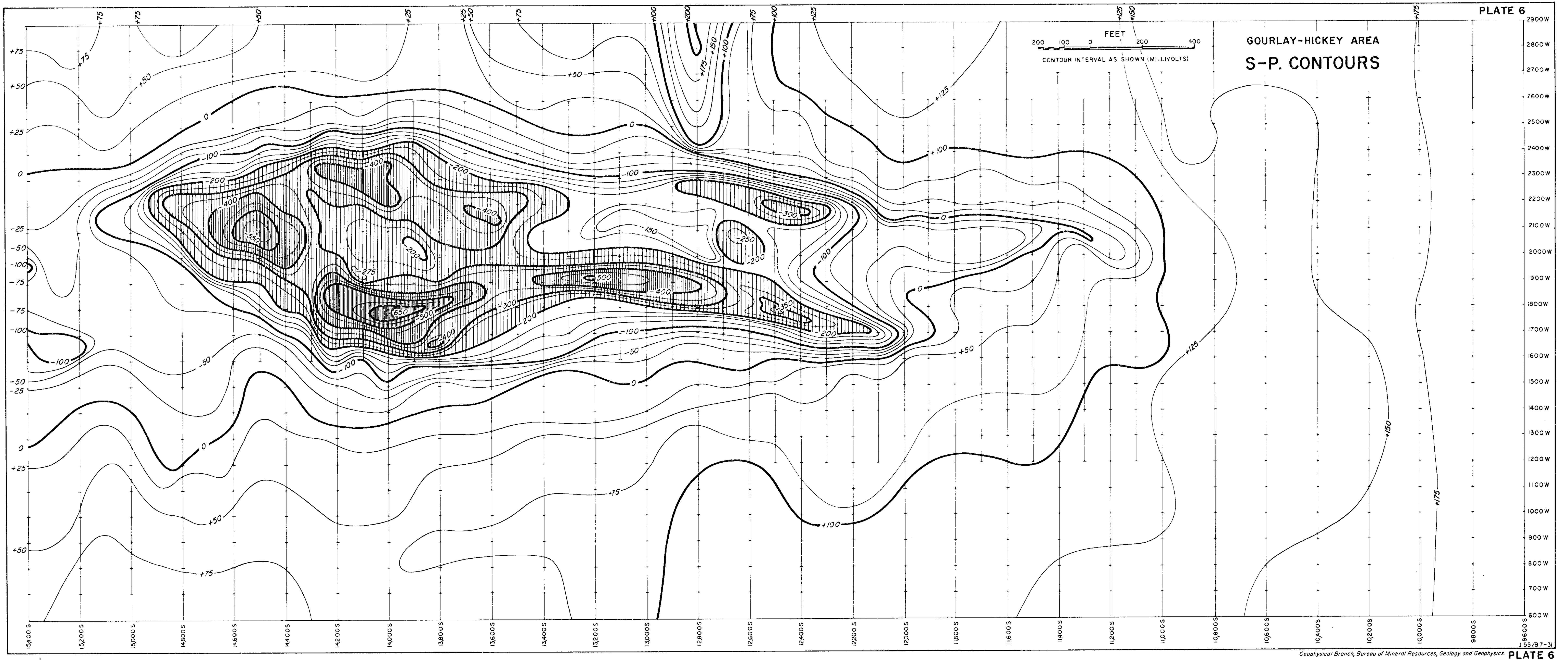
Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics I 55/B7-26

PLATE 3

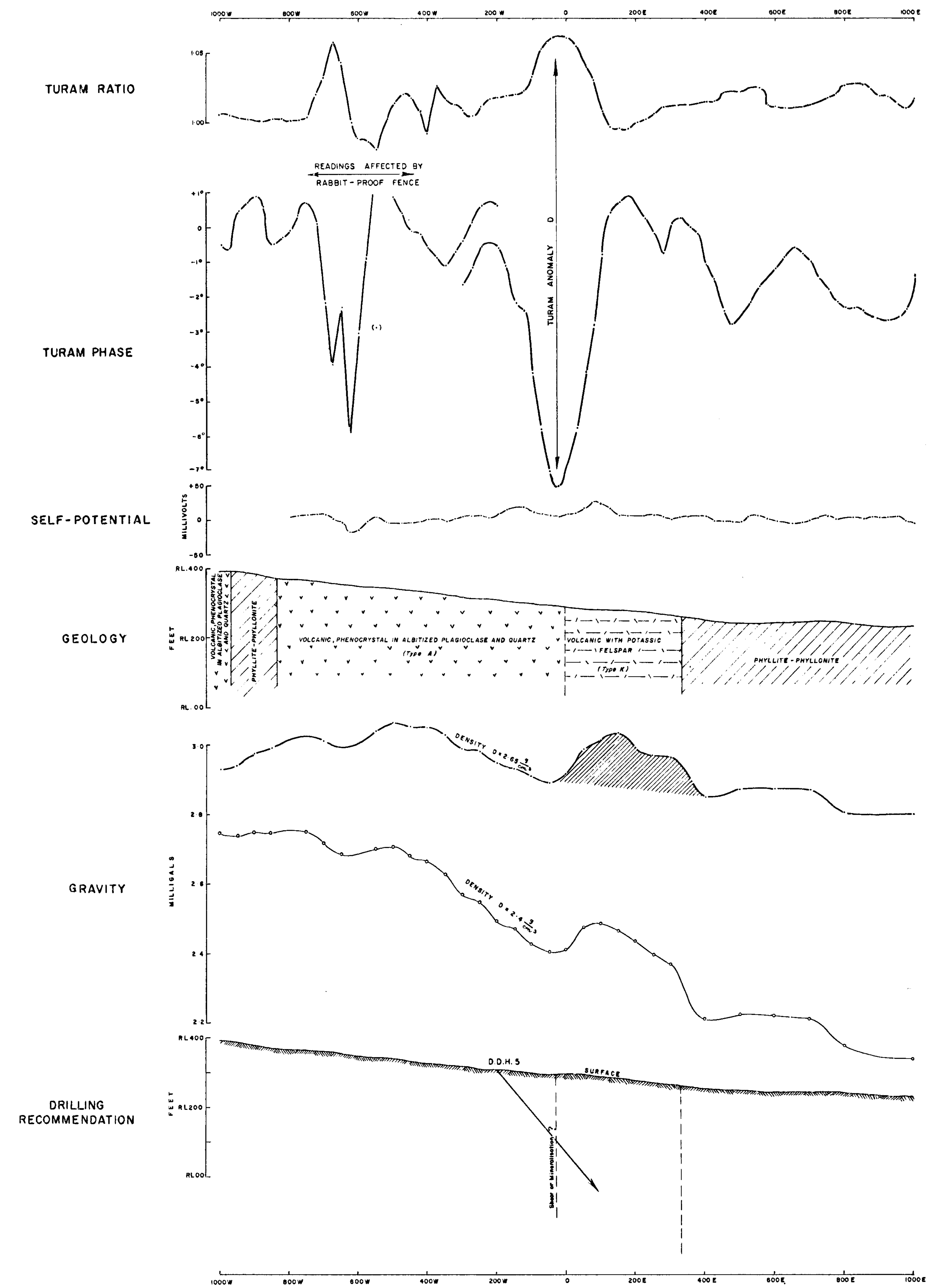

GOURLAY-HICKEY AREA
TURAM PHASE CONTOURS
FEET
200 0 200 400 600
CONTOUR INTERVAL 1°
I 55/B7-29



Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics PLATE 5



Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. PLATE 6

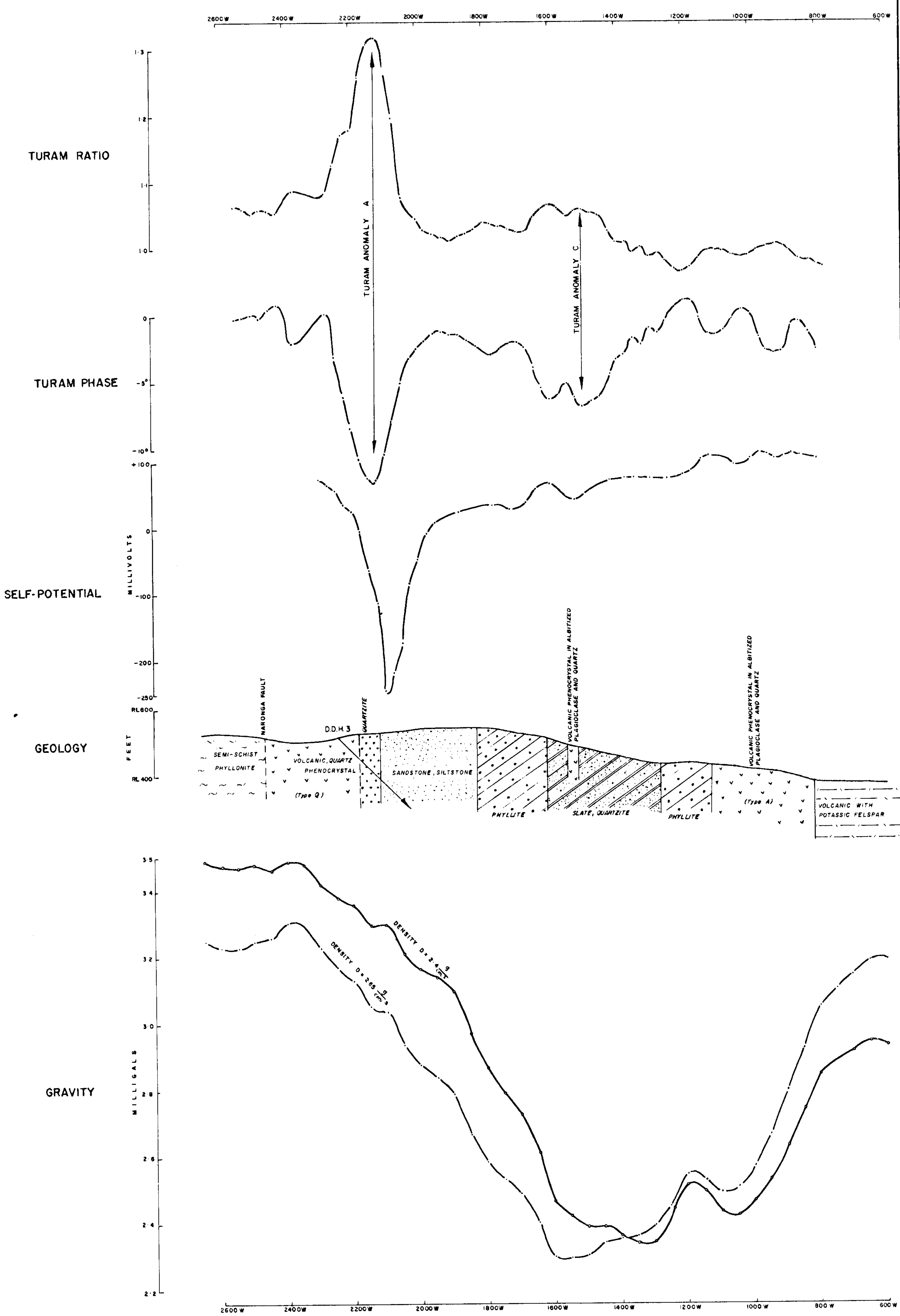


GOLF COURSE AREA
TURAM, S-P. GEOLOGY, GRAVITY PROFILES,
AND RECOMMENDED DRILL HOLE
TRAVERSE 10,000 S.

FEET
200 0 200 400 600 800 1000

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics I55/B7-37

PLATE 8



GOURLAY — HICKEY AREA

TURAM, S-P, GEOLOGY, GRAVITY PROFILES, AND RECOMMENDED DRILL HOLE

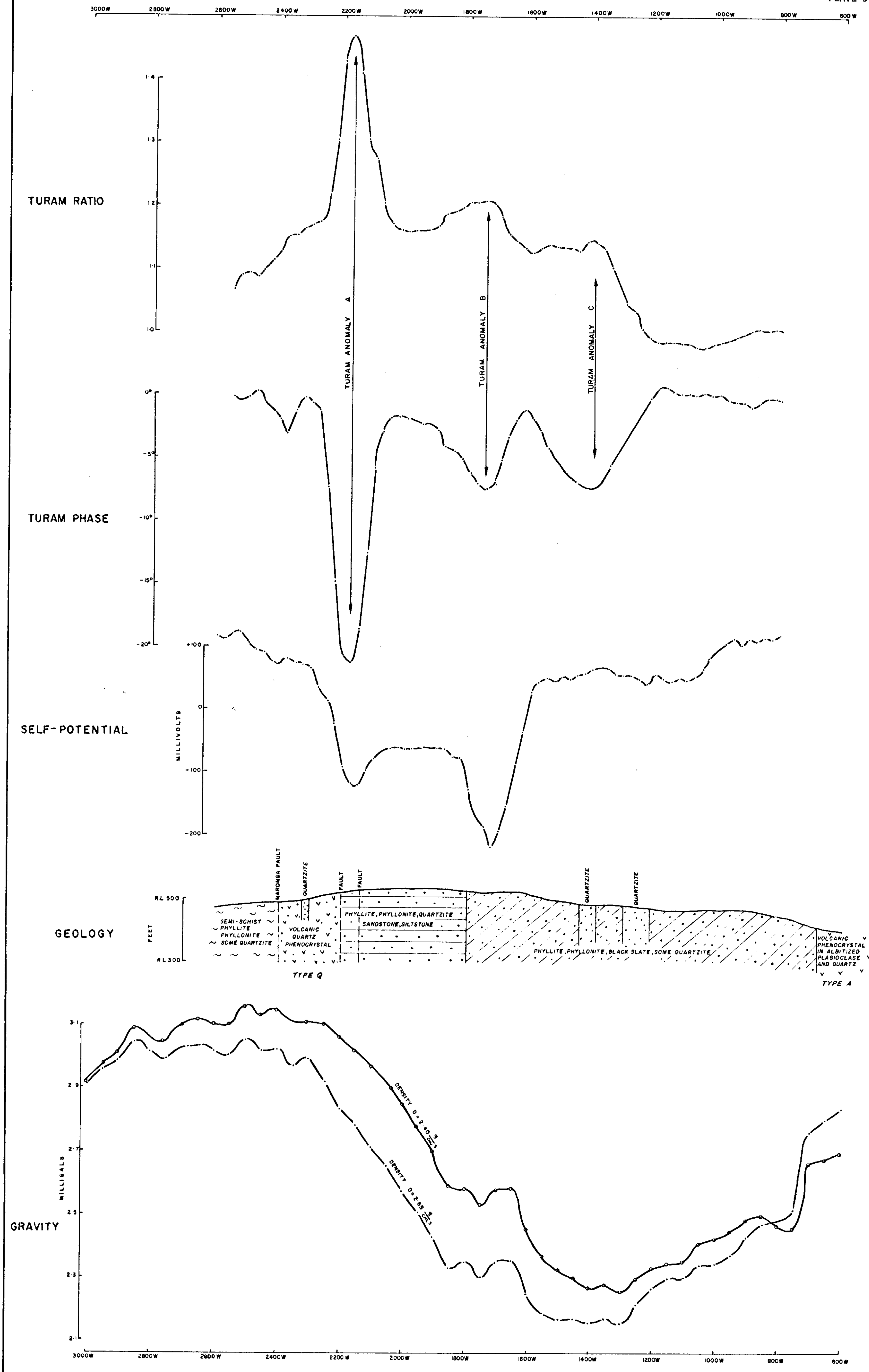
TRAVERSE 11,600 S.

FEET

200 0 200 400 600 800 1000

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics I55/B7-40

PLATE 8



GOURLAY — HICKEY AREA

TURAM, S-P., GEOLOGY, AND GRAVITY PROFILES

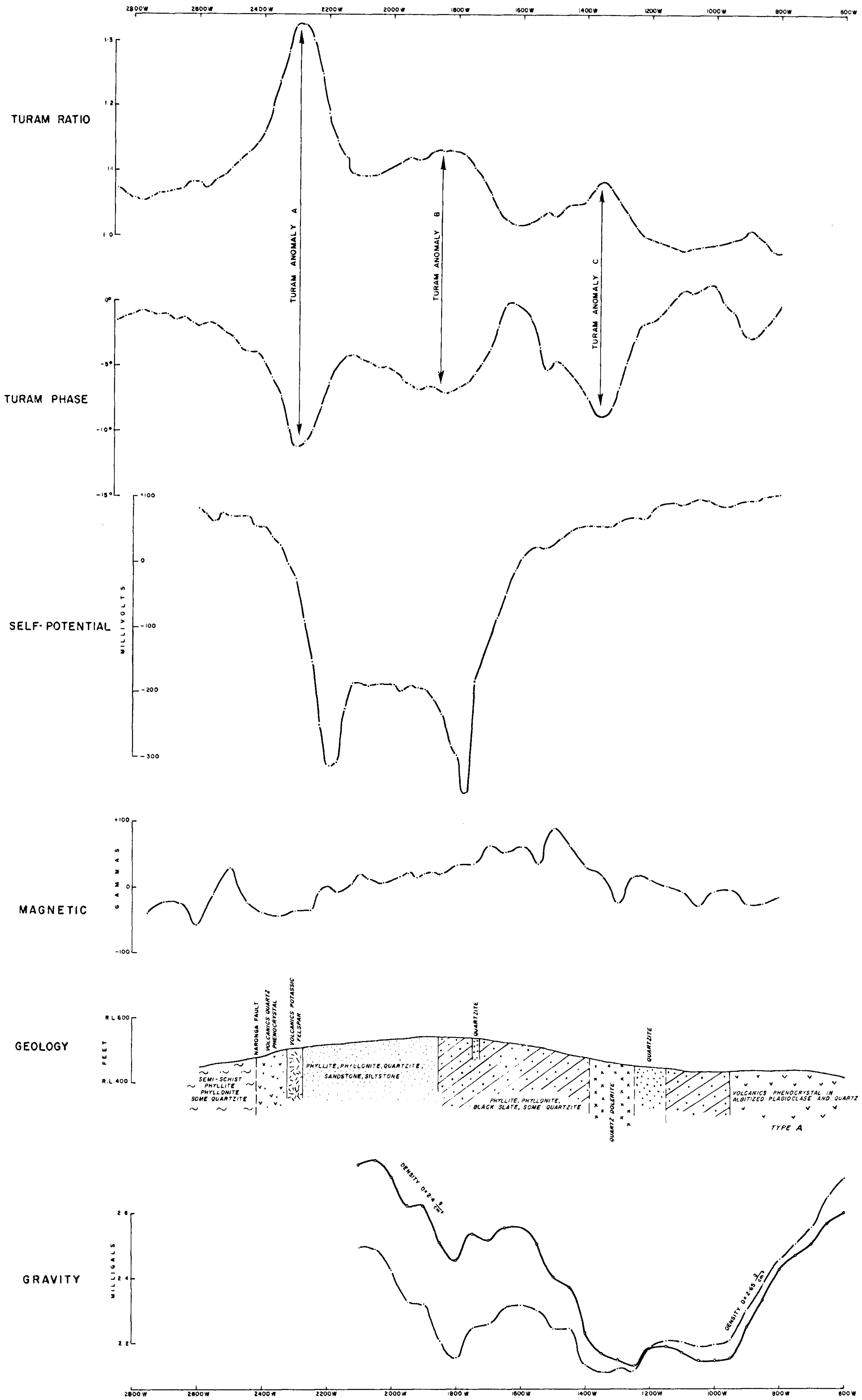
TRAVERSE 12,200 S.

SCALE IN FEET

200 0 200 400 600 800

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics I55/B7-41

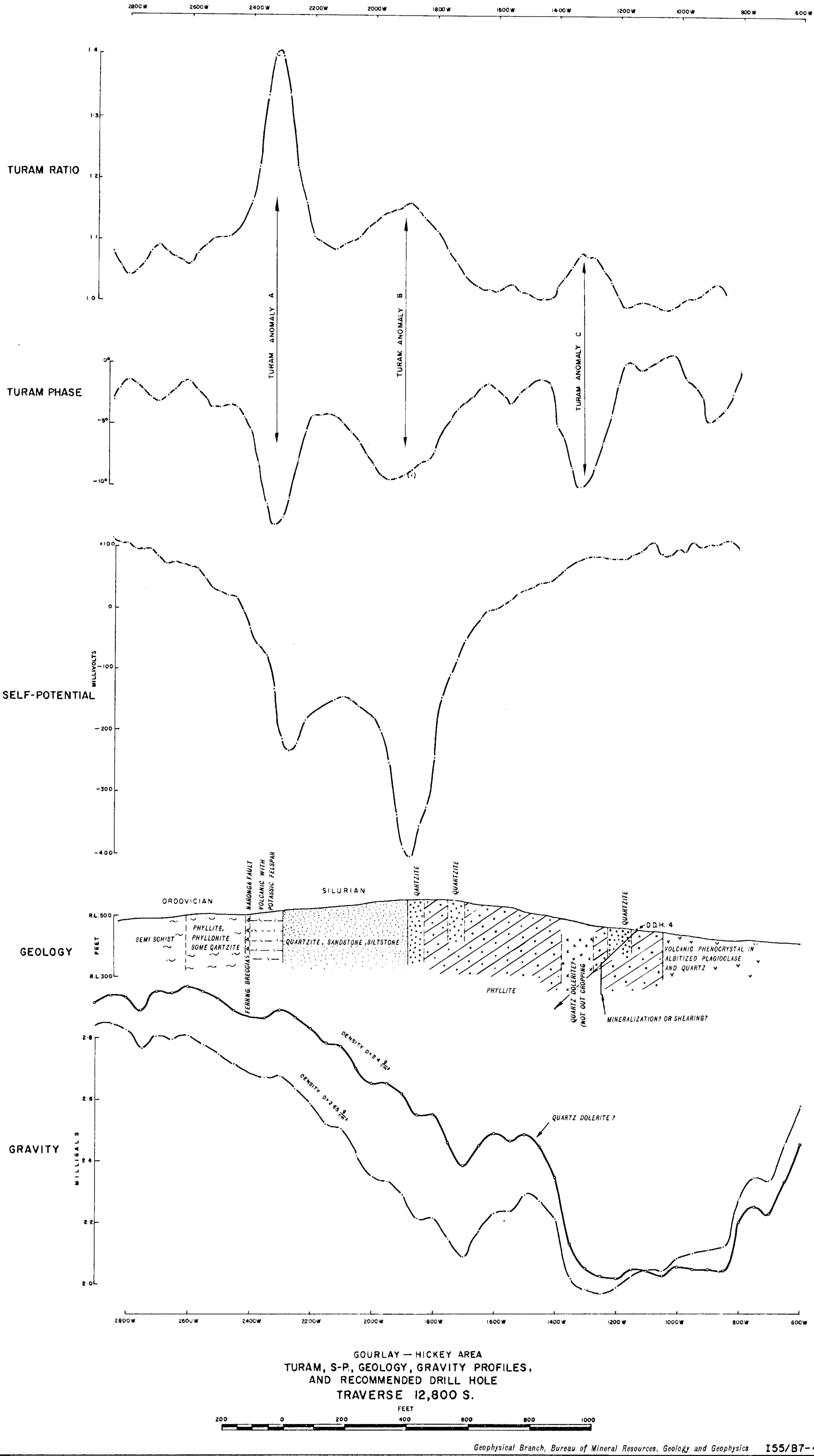
PLATE 9



GOURLAY - HICKEY AREA
TURAM, S-P, MAGNETIC, GEOLOGY, AND
GRAVITY PROFILES
TRAVERSE 12,600 S.

SCALE IN FEET
200 0 200 400 600 800 1000

PLATE 11



GOURLAY — HICKEY AREA

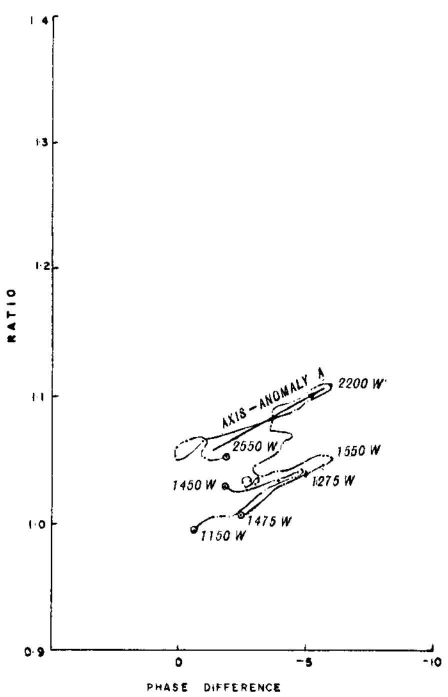
TURAM, S-P., GEOLOGY, GRAVITY PROFILES, AND RECOMMENDED DRILL HOLE

TRAVERSE 12,800 S.

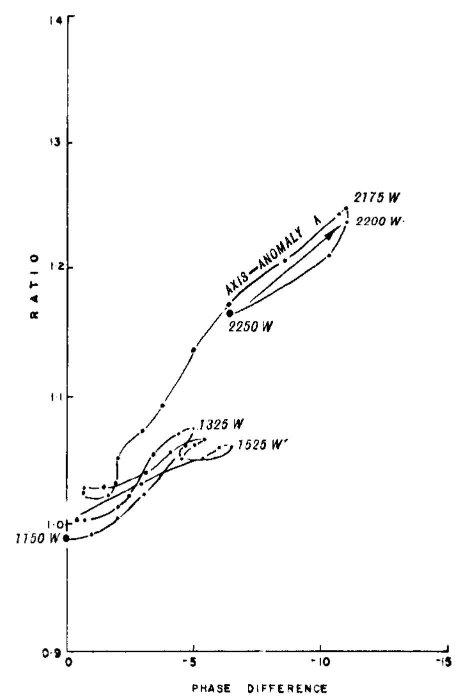
FEET
200 0 200 400 600 800 1000

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics I55/B7-43

PLATE 11



TRAVERSE 11,000 S.



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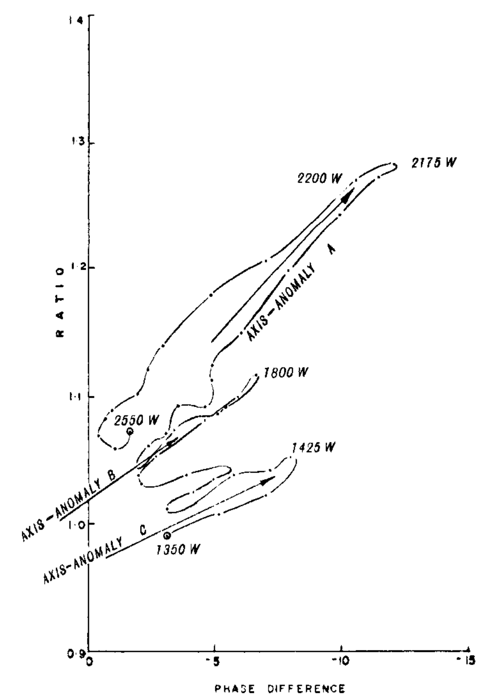

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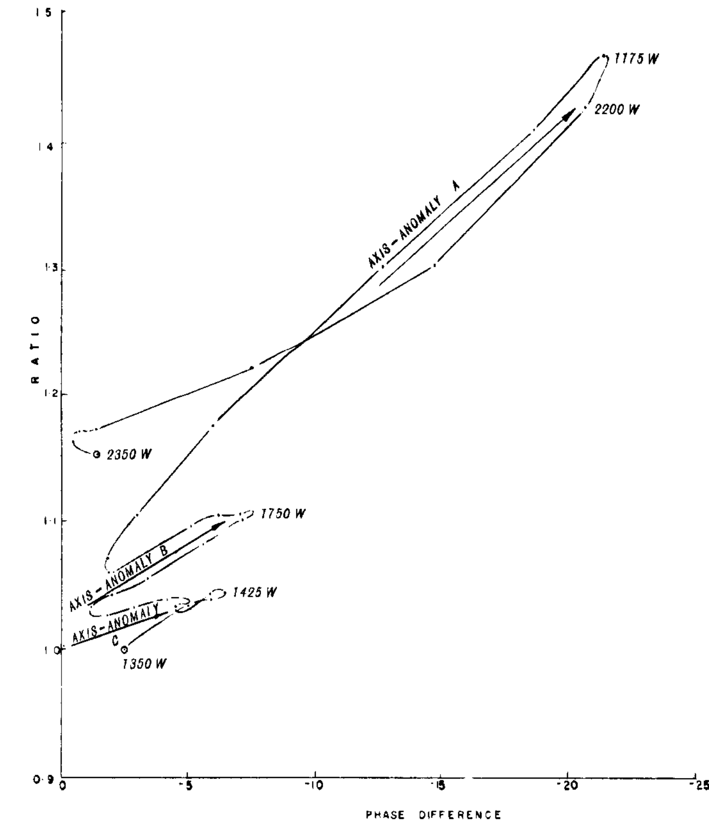

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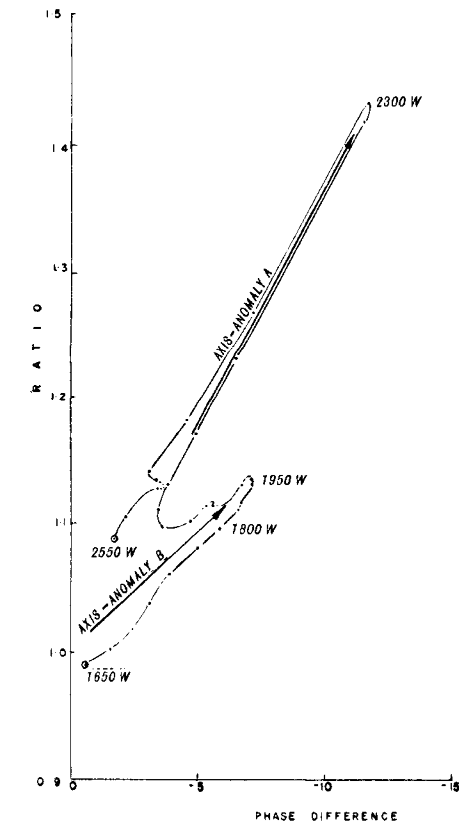
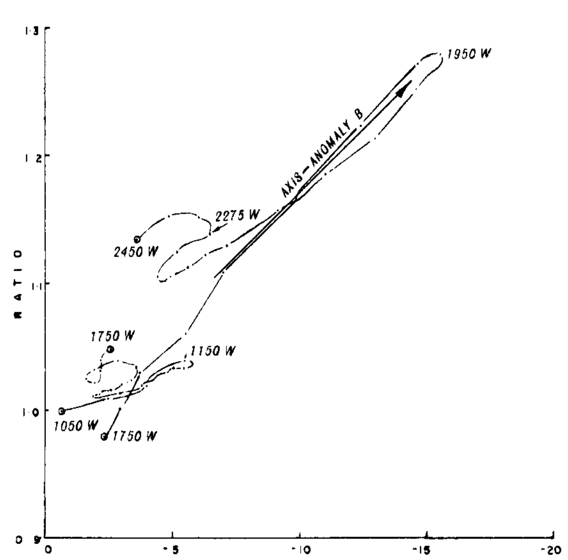


TRAVERSE 12,700 S.



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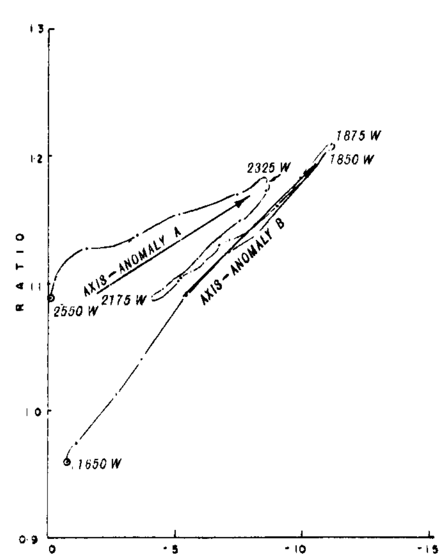

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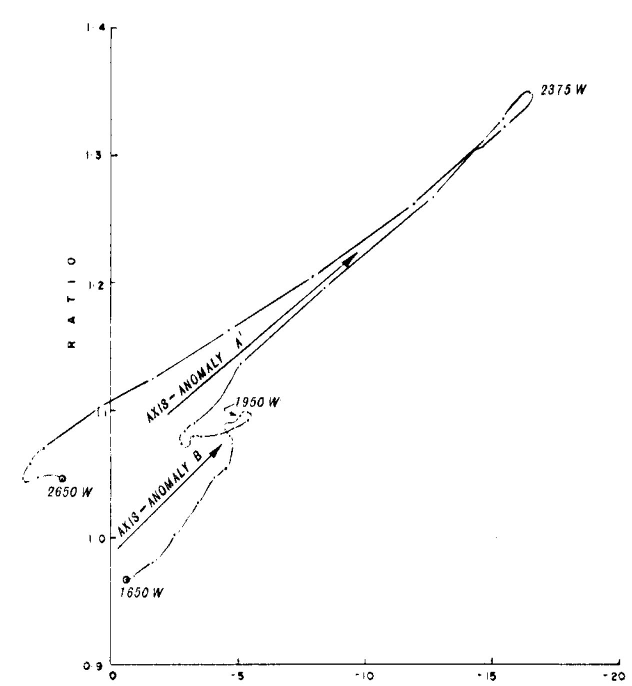
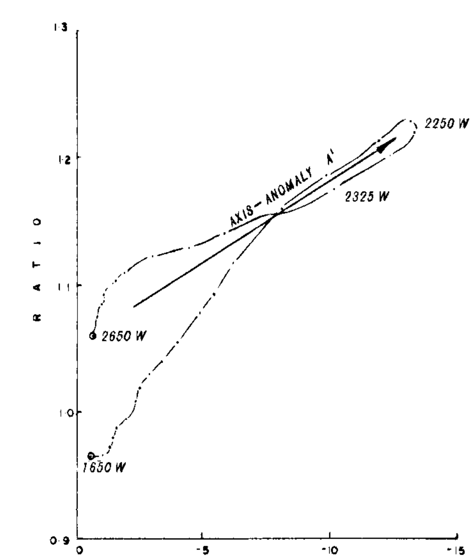


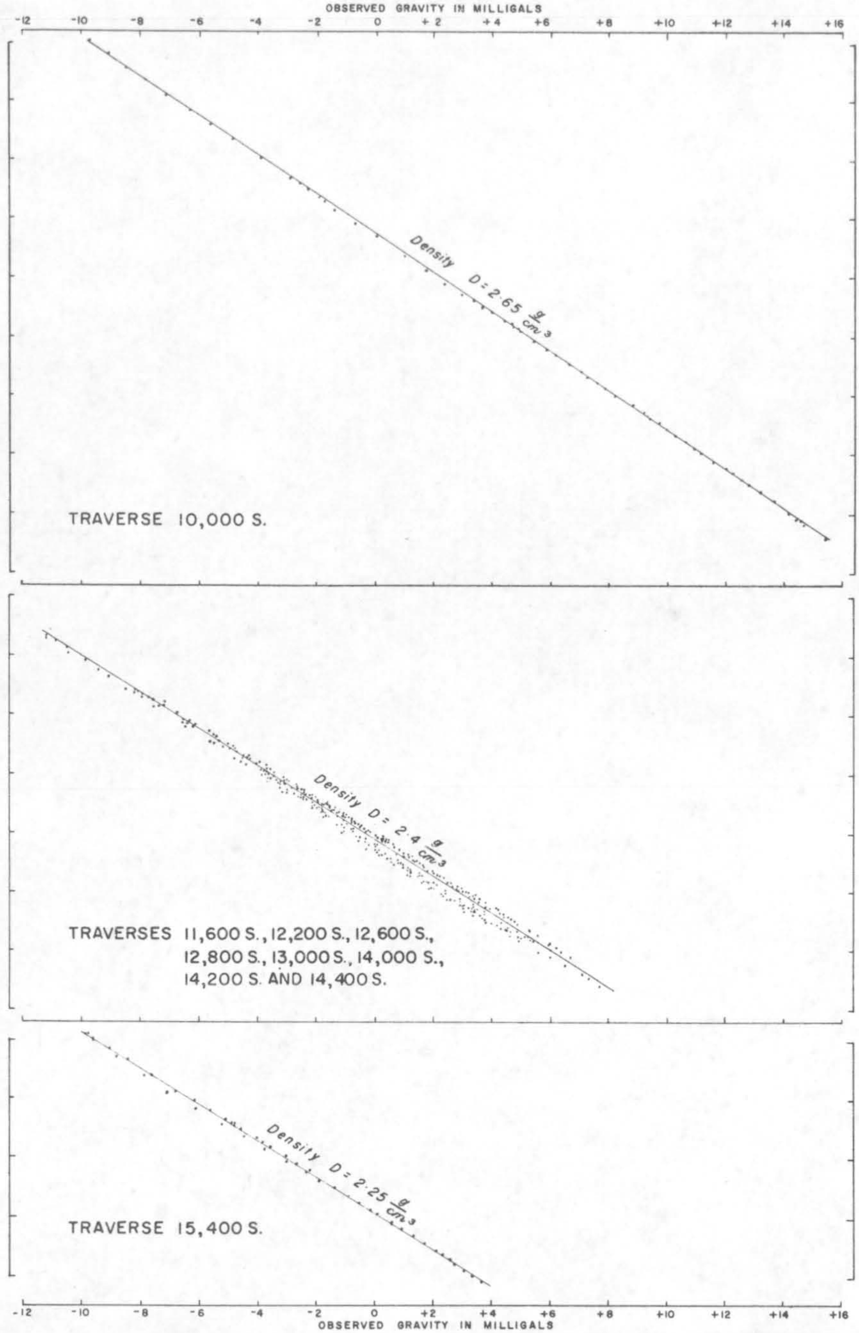
TRAVERSE 14,200 S.



TRAVERSE 14,600 S.

GOURLAY — HICKEY AREA
SELECTED RATIO — PHASE DIAGRAMS

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics I55/B7-32

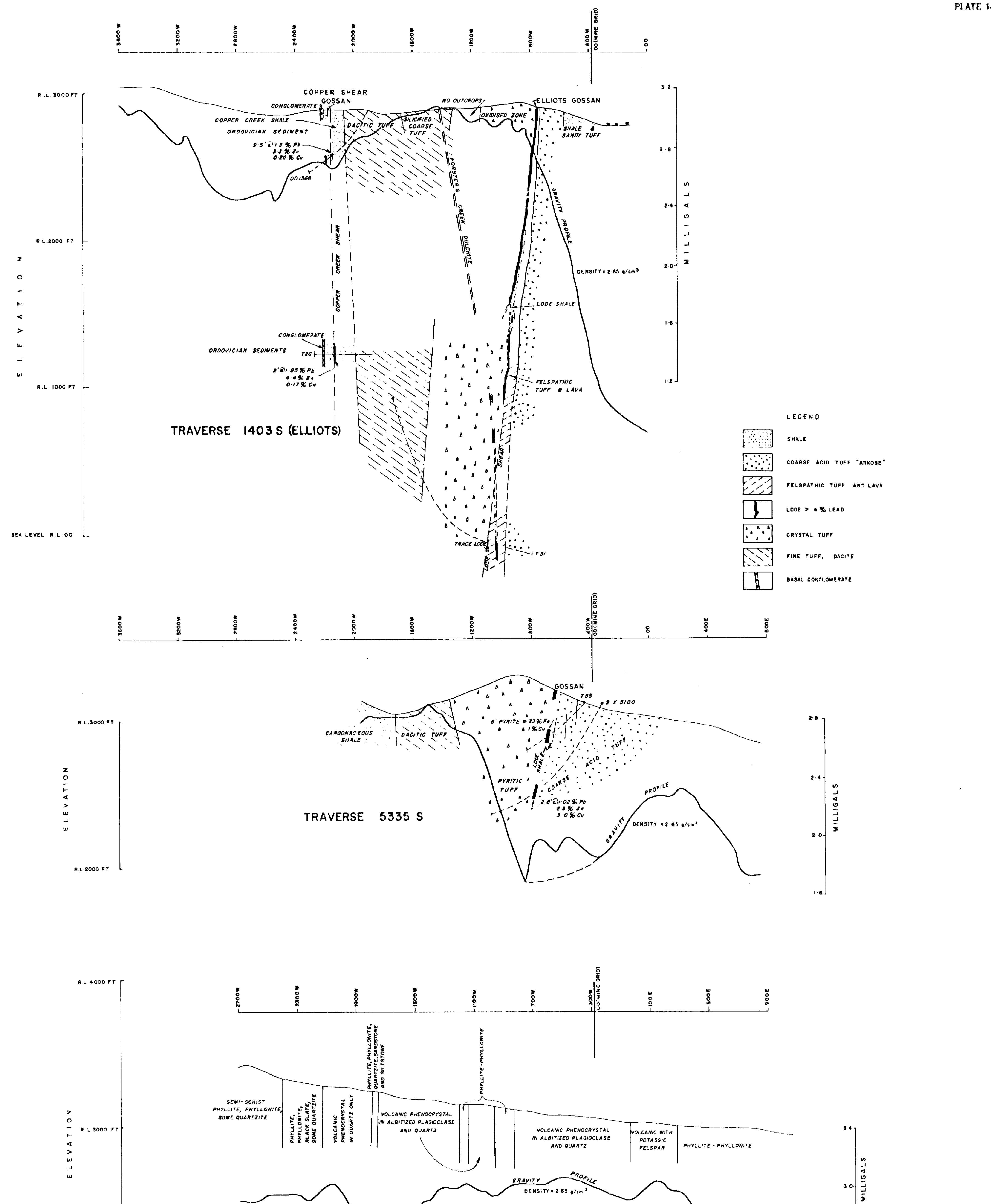


GOLF COURSE AND GOURLAY — HICKEY AREAS

GRAPHS USED FOR DENSITY DETERMINATION BETWEEN TRAV. 10,000 S. AND TRAV. 15,400 S.

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics 155/B7-36

PLATE 13

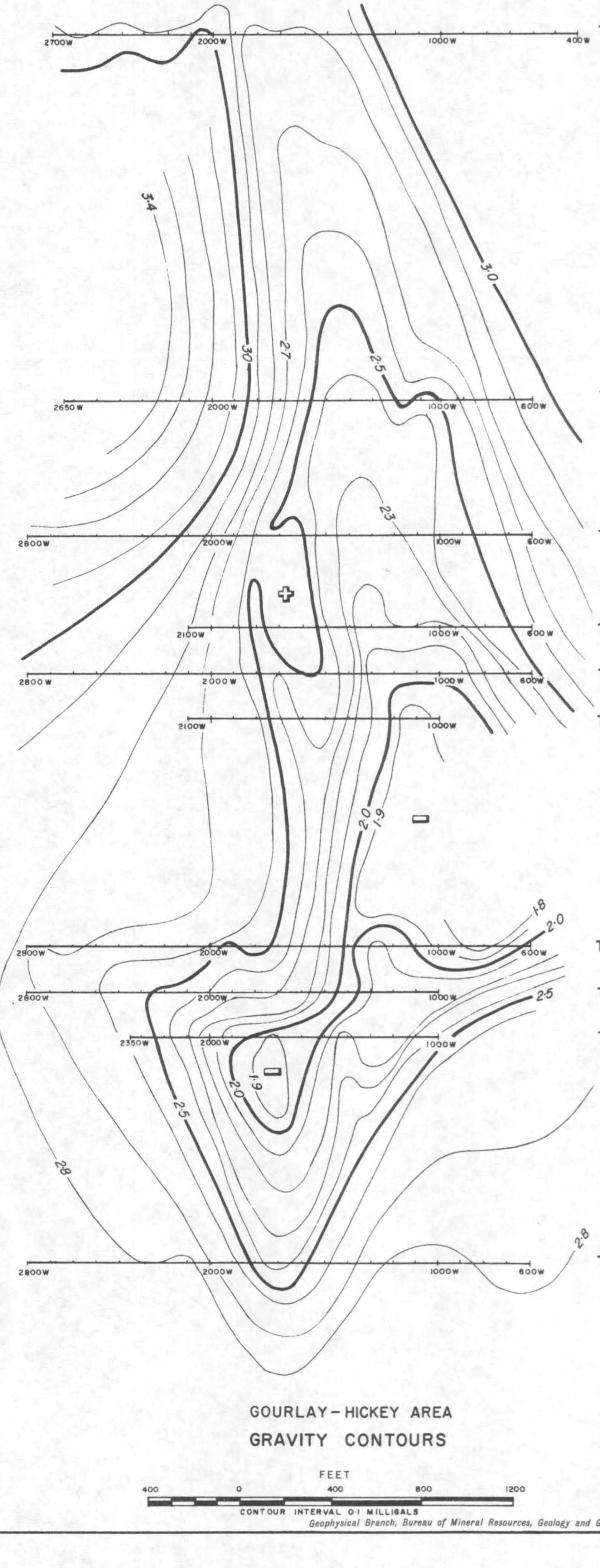


TRAVERSES 1403 S, 5335 S, AND 10,000 S
GRAVITY PROFILES
AND
GEOLOGICAL CROSS-SECTIONS

SCALES

HORIZONTAL 400 0 400 800 1200 1600 FEET
VERTICAL 0·4 0 0·4 0·8 1·2 1·6 MILLIGALS

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics I55/B7-33



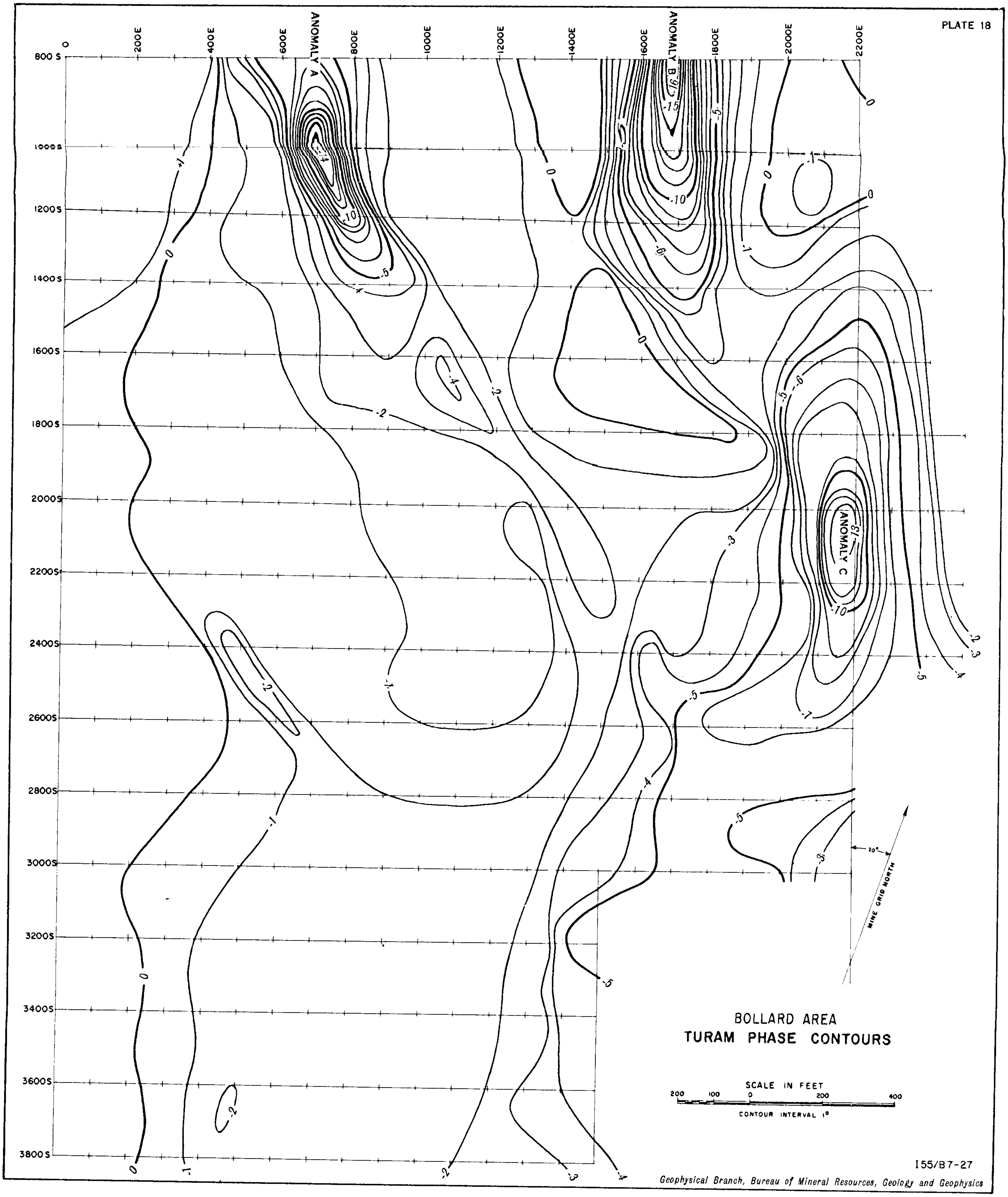
GOURLAY - HICKEY AREA
GRAVITY CONTOURS

CONTOUR INTERVAL 0·1 MILLIGALS

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics I55/B7-35

NARONGO FAULT
ANOMALY A
ANOMALY B
ANOMALY C
ANOMALY D
D.D.H. 1
D.D.H. 2
D.D.H. 3
D.D.H. 5
D.D.H. 6
D.H. T 47
RECOMMENDED TRENCHING
GOURLAY – HICKEY AREA
SOUTH KEATINGS AREA
GOLF COURSE AREA
TO COOMA
TO CAPTAINS FLAT
BASE LINE
MINE GRID NORTH
EQUALS MINE COORDINATES: 7001 S 388·4 E
AXES OF ANOMALIES
VERY WEAK
WEAK
MEDIUM
STRONG
TURAM
VERY STRONG
MEDIUM
WEAK
SELF-POTENTIAL
GRAVITY-ANOMALY
LEGEND
ROAD
FENCE
TRENCHING
RECOM DRILL HOLE
EXISTING DRILL HOLE
GEOLOGY
SILURIAN ?
Phyllite, phyllonite, black slate, some quartzite
Quartzite
Phyllite, phyllonite, quartzite, sandstone, siltstone
Phyllite, phyllonite
ORDOVICIAN ?
Semi-schist, phyllite, phyllonite, some quartzite
SILURIAN ?
Volcanic; phenocrystal in quartz only
Volcanic; phenocrystal in albitized plagioclase and quartz
Volcanic; with potassic felspar and with or without albite
TERTIARY ?
Quartz dolerite
GEOL. BOUNDARIES
Position accurate
Position approximate
Inferred
FAULTS
Position accurate, showing movement
Position approximate
Inferred
Shear
BEDDING
Measured, showing magnetic direction of strike and dip, with direction of dip
Showing vertical dip
Direction of strike only
Direction of plunge
CLEAVAGE
Strike and dip
Strike, and dip vertical
Strike ~ dip not determined
SOUTH KEATINGS, GOURLAY-HICKEY, AND GOLF COURSE AREAS
TRAVERSES, GEOLOGY, GEOPHYSICAL ANOMALIES AND RECOMMENDED DRILL HOLES
SCALE IN FEET
200 0 200 400 600
GEOLOGY AFTER R.E. RELPH & M.B. COLEMAN - GEOLOGICAL SURVEY OF DEPT. OF MINES, N.S.W.
MAP 8425
Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. 155 B7-44

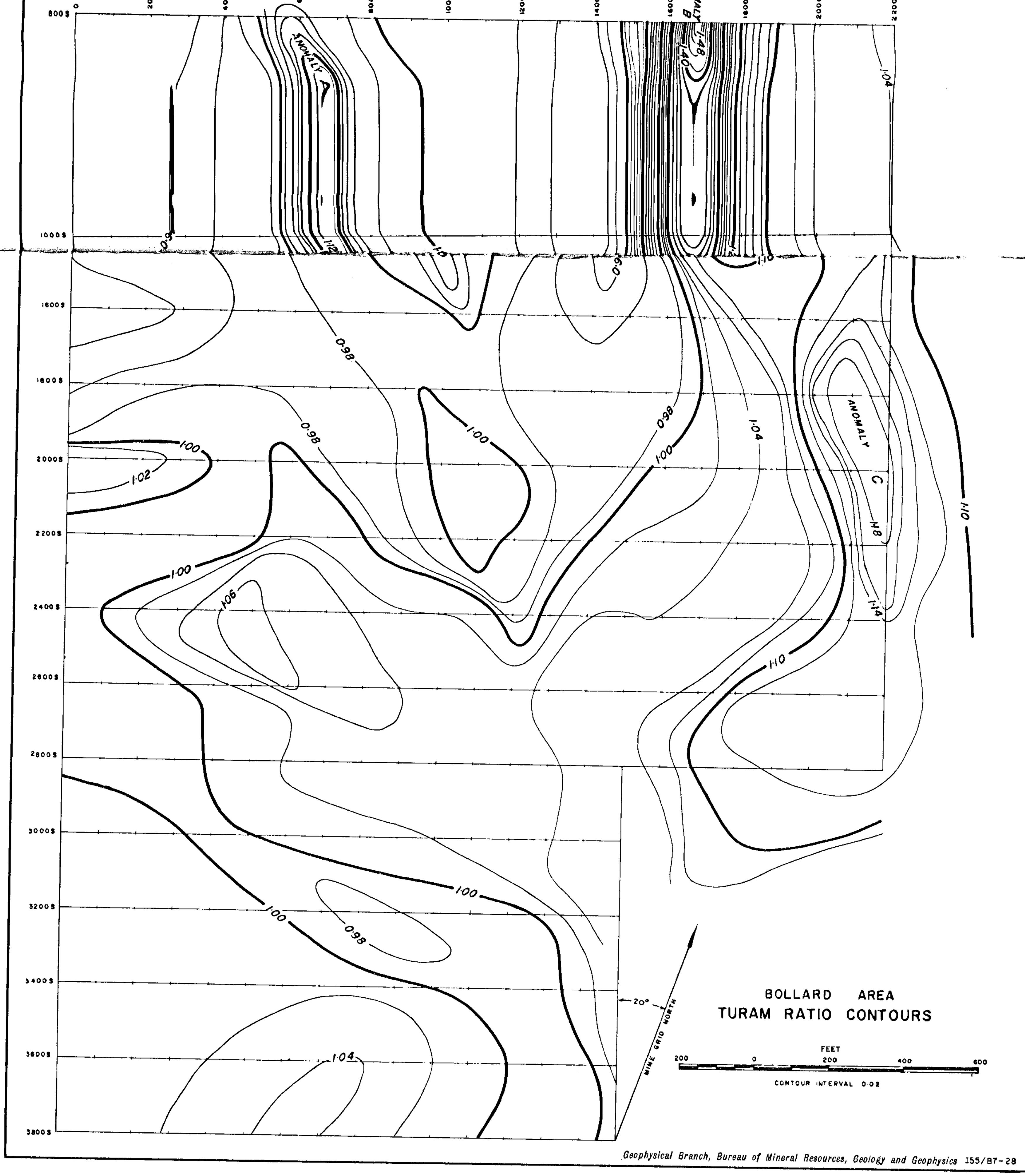
PLATE 18



I55/B7-27

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

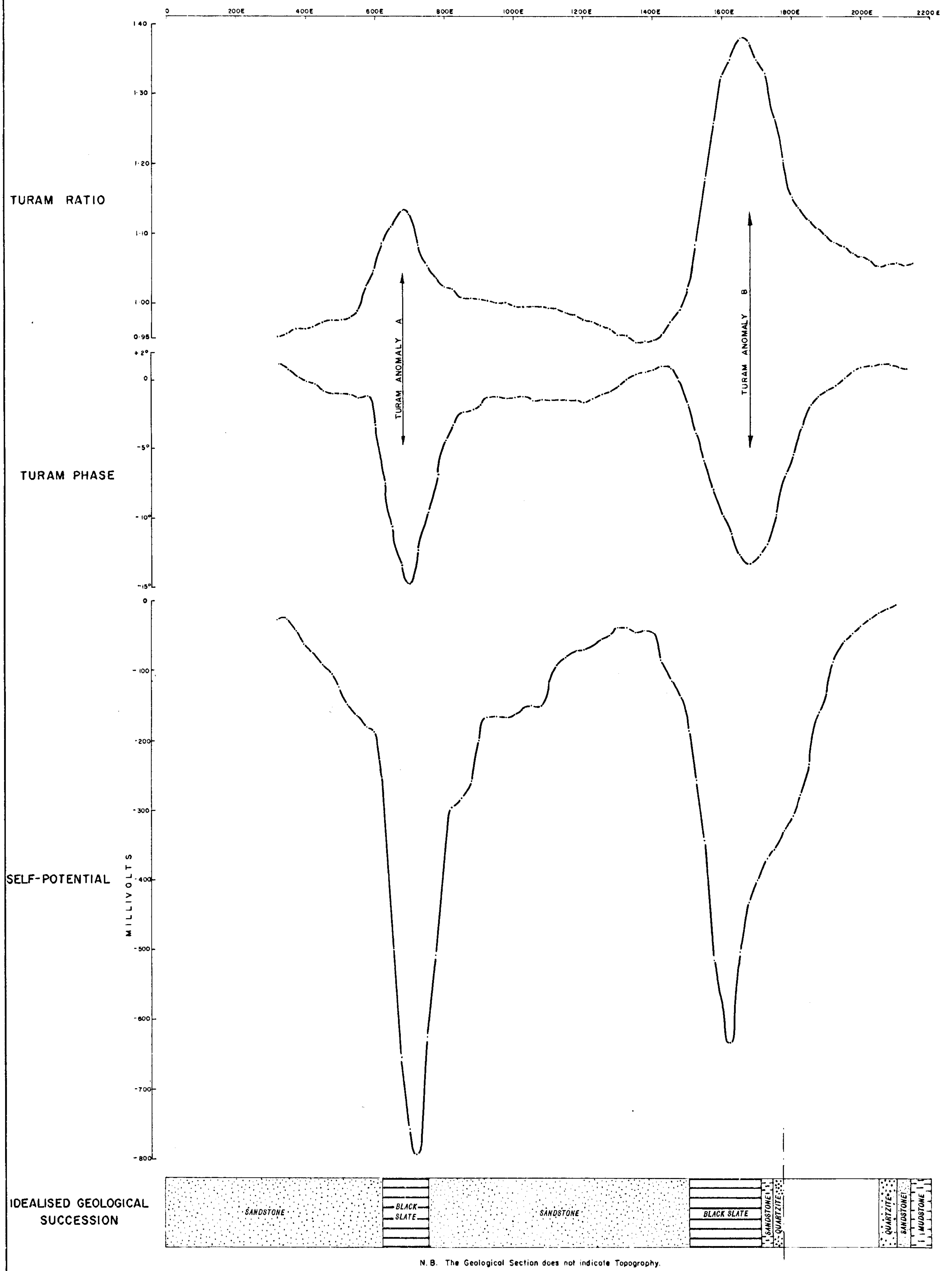
PLATE 18



Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics I55/B7-28

PLATE 19

PLATE 20

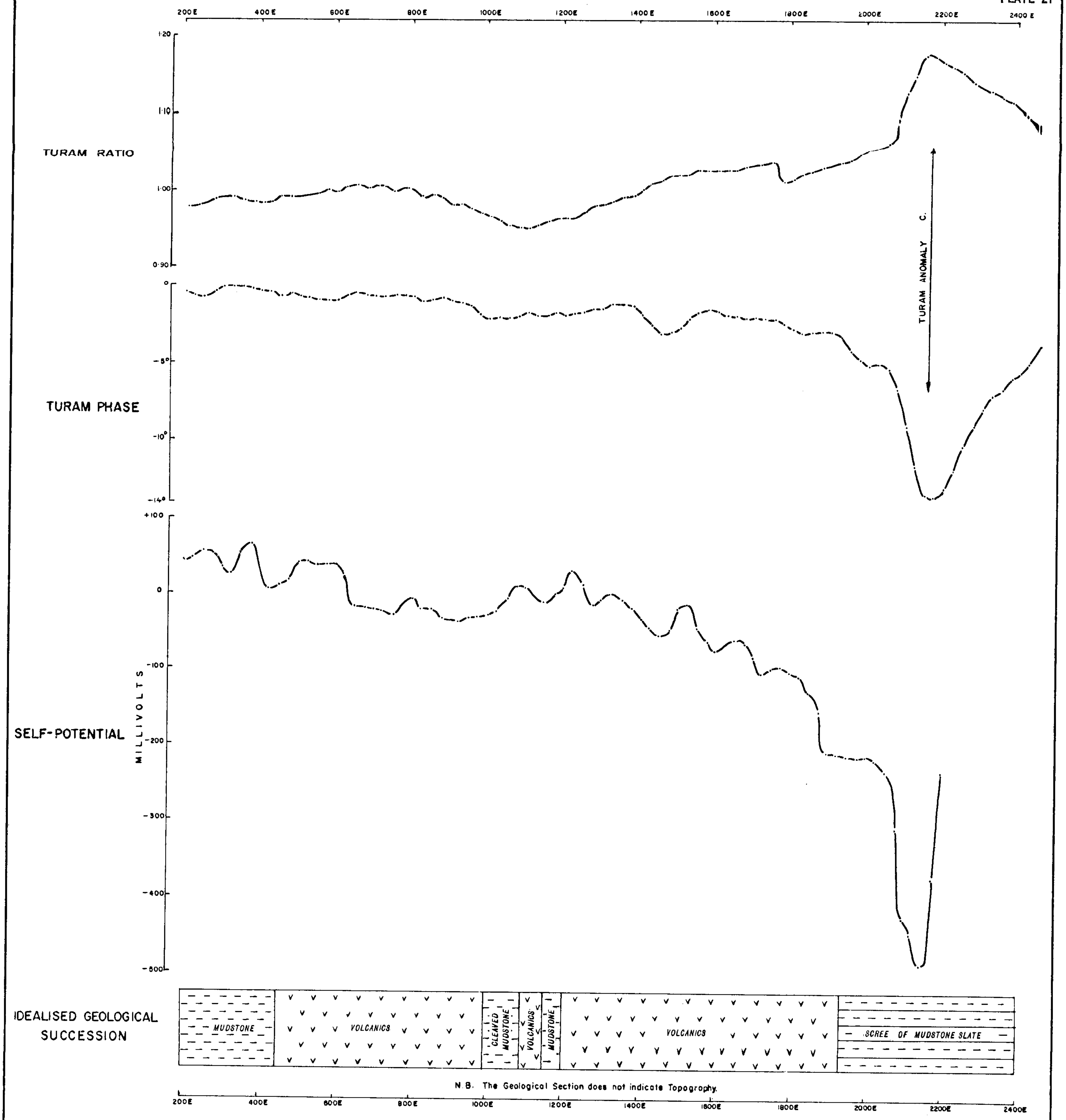


BOLLARD AREA
TURAM, S-P. and GEOLOGY PROFILES
TRAVERSE 1000 S.

FEET
200 0 200 400 600 800

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics 155/B7-38

PLATE 20



BOLLARD AREA

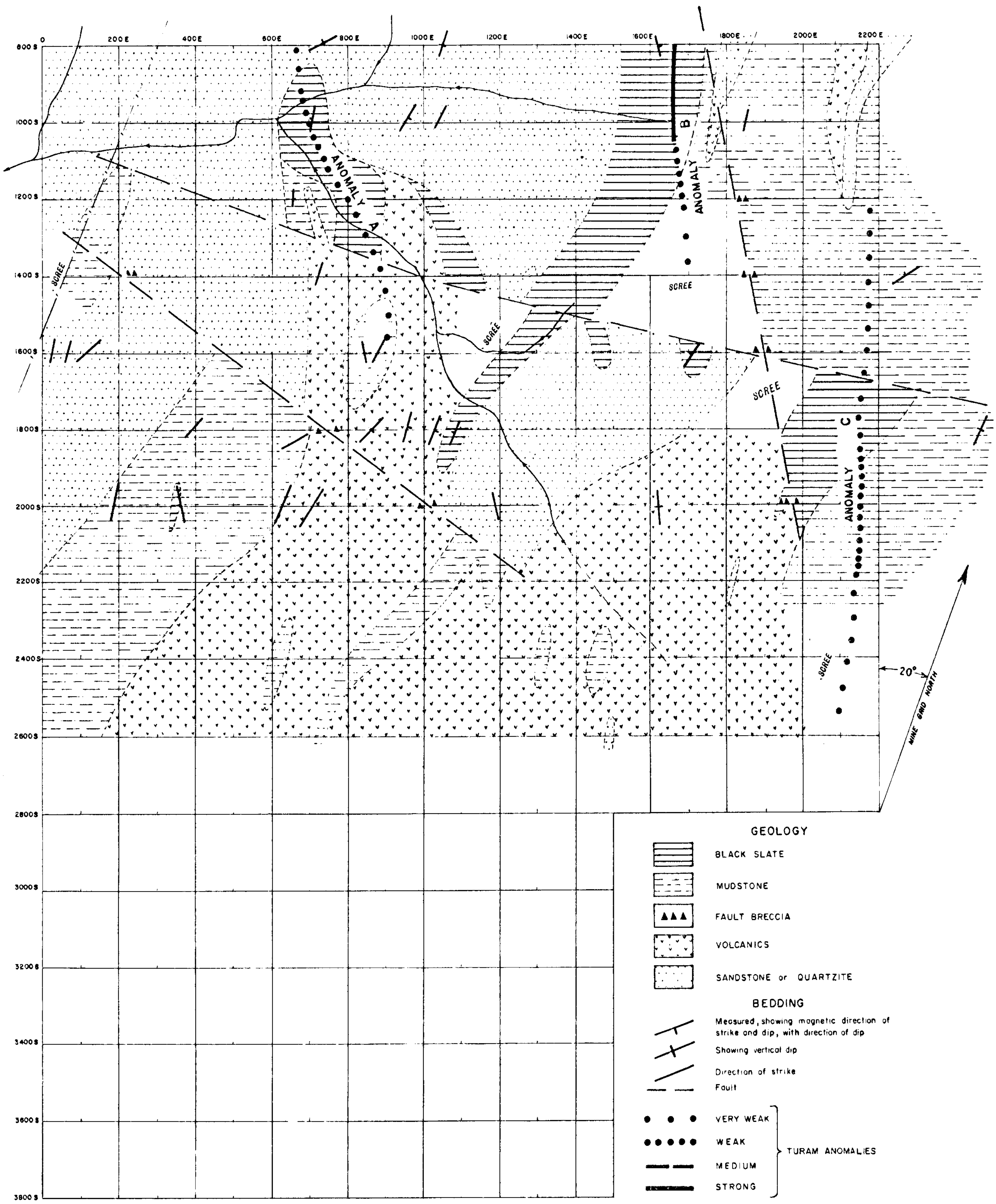
TURAM, S-P. and GEOLOGY PROFILES

TRAVERSE 2200 S.

FEET

200 0 200 400 600 800

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics I55/B7-39



BOLLARD AREA

GEOLOGY, GEOPHYSICAL GRID, AND ANOMALIES

Geology After M B COLEMAN – GEOLOGICAL SURVEY N.S.W Dept of MINES