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DOBBYN GRAVITY RECONNAISSANCE SURVEY,

QUEENSLAND 1963-1964

by

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SUMMARY

A reconnaissance gravity survey was made in the Dobbyn area of North Queensland between 28th May and 3rd August 1963 and extended between 2nd September and 24th September 1964. The aim of the survey was to study the main structural features in order to aid the search for copper.

Several interesting structural features were revealed and favourable areas for future geophysical work were selected. The value of the gravity method as a means of detecting changes in bedrock density (and hence composition) was revealed by the large anomalies and steep gradients encountered.

1. INTRODUCTION

From 28th May to 3rd August, 1963, a gravity reconnaissance survey was made in the Dobbyn area of North Queensland by the Bureau of Mineral Resources (BMR). The area covered was approximately 50 miles long (from Kajabbi in the south to Kamileroi in the north) and 30 miles wide (see Plate 1); it was surveyed with stations approximately half a mile apart along a network of traverses.

The aim of the survey was to study the major structural features, with particular emphasis on the fault zones where mineralisation has been found to occur (Carter, Brooks, & Walker, 1961, p.207). The gravity reconnaissance survey supplemented the aeromagnetic work done over the major part of the area in 1963 (Dockery & Tipper, 1964) and the detailed gravity, magnetic, self-potential, electromagnetic, and induced polarisation work done over selected areas in 1963 (Gardener, 1964) and 1964 (Gardener, 1965). No previous gravity work had been done in the area and the geological structure, particularly in the north where outcrops are scarce, was not well known. It was hoped that the gravity work would help to outline areas of interest for further geophysical work with the other methods available.

The 1963 geophysical party consisted of R.J. Smith and J.E. Haigh, geophysicists, a cook, mechanic, and field-hand. The Department of the Interior, Canberra, supplied two contract surveyors, J. Dwyer and R. Skett, who, with four chainmen, levelled all of the gravity stations and located many of them. The surveying in 1963 was not completed until several months after the gravity work and while drawing the contour maps it was found necessary to add approximately 160 gravity stations to fill in gaps in the gravity network. This additional gravity work was done between 2nd September and 24th September, 1964, by R.J. Smith while he was attached to a geophysical party camped in the area and led by J. Gardener. The additional gravity stations were levelled by a contract surveyor, J. Bates, supplied by the Department of the Interior.

Some geological mapping was done in selected areas by D.O. Zimmerman (1963) and W. Dallwitz (1964) of the Geological Branch of the BMR and samples were collected and identified for density determinations. The major part of the area was covered by airphotos taken during the 1963 survey by the BMR aeromagnetic party.

2. GEOLOGY

The geology of the area surveyed is shown in Plate 2.

The strike throughout the area is generally north-south with some local variations. There are two main anticlines with meridional axes, one east and one west of the Leichhardt River. Kalkadoon Granite occurs within the western anticline and Naraku Granite in the eastern one; both are mineralised but the more important mines - Dobbyn, Orphan, Crusader, Mount Cuthbert, and Kalkadoon - are all in the western anticline.

The main copper mineralisation occurs in the Leichhardt Metamorphics and Argylla Formation and to a lesser degree in the Corella Formation, so these are the most interesting parts of the area. The Naraku and Kalkadoon Granites occur as large masses probably related to the ore genesis and are therefore important in the gravity interpretation. The younger metadolerite and gabbroic intrusives have few surface exposures whereas the metadolertie dykes and sills are common in the Leichhardt Metamorphics and Argylla Formation and apparently have a significant effect on the observed gravity. The effect of the Tambo Formation on the observed gravity is uncertain and must be considered although it is not connected with the mineralisation. The Surprise Creek Beds and Myally Beds are only encountered on the western margin of the surveyed area; they are not considered to be important in the search for mineralisation and they have not been studied in any detail.

The following summary of the lithology of the various formations is based mainly on Carter, Brooks, and Walker (1961).

Tambo Formation

Lower Cretaceous siltstone, silty greywacke, and limestone with belemnites. Mainly occurs as small isolated outcrops, particularly along watercourses; the largest outcrop was observed near Kamileroi. May be up to 2000 feet thick.

Metadolertie and gabbro intrusives

Dolerite or microgabbro dykes and stocks, some metamorphosed, intrude folds and faults.

Surprise Creek Beds

Quartzite, sandstone, siltstone, shale or slate (generally sandy), impure dolomite, conglomerate, carbonaceous slate, and carbonaceous siltstone. Conformably underlain by Myally Beds and in places unconformably underlain by Argylla Formation.

Myally Beds

Essentially quartz arenite, generally medium-grained to coarse-grained sandstone and quartzite, with conglomerate and pebble beds near the base. The top of the succession includes several hundred feet of acidic and basic volcanics. Unconformably underlain by Leichhardt Metamorphics and Argylla Formation.

Corella Formation

Thin bedded (less than one foot) fine- to coarse-grained calc-silicate hornfels, gneiss, and granulite, with thinly interbedded pelitic and psammitic rocks. Quartz is very common in the Dobbyn area, more so than elsewhere in the Corella Formation. Beds are highly distorted by faulting and folding and are underlain at least disconformably by the Argylla Formation. East of the Leichhardt River the formation mapped as Corella Formation contains considerable amounts of basic igneous rock, either intrusive or laid down as basic volcanics.

Metadolerite dykes and sills

Metamorphosed dolerite without any obvious relation to regional structure. Most of the dykes form impressive swarms in the Leichhardt Metamorphics and Argylla Formation.

Argylla Formation

Metamorphosed rhyolite and metadacite with smaller quantities of metabasalt, tuff, and agglomerate; quartzite, arkose, calc-silicate rocks, conglomerate, slate, schist, and gneiss. The grade and type of metamorphism varies considerably. The Argylla Formation is underlain conformably by Leichhardt Metamorphics.

Leichhardt Metamorphics

Generally highly to moderately metamorphosed acid lavas, with some metamorphosed sediments, metabasalt, and rare tuff. Occasionally migmatite, gneiss, mica schist, quartzite, calc-silicate rocks, and hornblende schists and amphibolites which were probably originally basic igneous intrusives.

Naraku Granite

Occurs in the north-south line of hills east of the Leichhardt River from Kajabbi to Kamileroi and consists of fine-grained quartz, biotite, and pink felspar; the constituents are variable but probably best described as a micro-adamellite.

Kalkadoon Granite

Crops out in the Leichhardt Metamorphics immediately west of Dobbyn and extends from about ten miles north of Dobbyn to well south of the survey area. Consists mainly of granodiorite (plagioclase, oligoclase, biotite, and quartz) and minor intrusions of granite, adamellite, microadamellite, potash rich microgranite, pegmatite, aplite, and albitite.

Mineralisation

Copper deposits occur, and have been mined, to a lesser degree in the Corella Formation, but mainly in the Argylla Formation and also in the Leichhardt Metamorphics. The distinction between stratigraphical units, particularly the Argylla Formation and Leichhardt Metamorphics, is not well defined and the ore controls appear to be lithological and structural rather than stratigraphical.

Acid lavas (rhyolite, dacite, and metamorphic derivatives) and quartzite appear to be unfavourable hosts for ore deposition. Copper deposits in the Leichhardt Metamorphics and Argylla Formation are generally related to structural deformations near or in basic igneous rocks or schists, for example, in the Crusader (Searl, 1952), Orphan, Dobbyn, Mount Cuthbert, and Kohinoor (Carter, 1959) mines. Quartzite is an unfavourable host but is sometimes associated with ore as a hangingwall or footwall. Arenaceous formations, such as the Surprise Creek Beds and the Myally Beds, are generally poor prospects. In the Corella Formation, calc-silicate rocks appear to be generally unfavourable; calcite bodies seem more favourable and ore deposits in the Corella Formation are usually associated with calcite.

The relation between copper deposition and granite is uncertain, but most copper deposits seem to be near granite intrusions. Some of the copper mineralisation occurs in the Kalkadoon Granite and is evidently younger than it, but there is the possibility that there were several periods of granite activity and several sequences of copper deposition.

The most favourable areas for copper mineralisation are in basic igneous rocks (and their metamorphic derivatives) in fractured and deformed areas or at a contact with less competent rocks near granite intrusions. Many of these copper deposits have been mined and several mines are still operating on a small scale. Most mines have only operated in the secondary zone, where small high-grade enrichments have been rapidly worked out, but the possibility of larger, low-grade, primary deposits still exists and has to be probed by geophysical methods and by drilling.

Elsewhere in the Cloncurry district, the Hampden and Mount Elliot mines have orebodies on the amphibolite/slate contact, and gravity test traverses have been made at the Hampden mine (Horvath, 1952), which showed appreciable anomalies (about 1.4 milligals) over a band of amphibolite. This indicates that the bands of basic igneous rocks and their contact with the less competent slates and quartzites can be detected by gravity work. Thus, gravity work over a large area should, at least, indicate likely areas for a more detailed study.

The geological mapping carried out during the survey by D.O Zimmerman and W. Dallwitz - in particular along traverse OO (Plate 4) and traverse 400N (Gardener, 1964) - showed that the Leichhardt Metamorphics and Argylla Formation are very hard to distinguish from each other and from the Corella Formation. On traverses 00 and 400N, the areas mapped as Leichhardt Metamorphics and Argylla Formation appear to be mainly metamorphosed acid volcanics (rhyolite and dacite) interspersed with bands of amphibolite and heavily weathered basic igneous rocks. Possibly a gradational change in the degree of metamorphism exists but this is difficult to recognize. Further east, quartzites and calc-silicate rocks become more frequent in the Corella Formation. The whole sequence - Leichhardt Metamorphics, Argylla Formation, and Corella Formation - appears gradational and no sharp boundaries or changes in composition were observed.

3. METHODS, INSTRUMENTS, AND REDUCTION

The gravity readings were made with a Sharpe gravity meter (No. 145) during 1963 and a Worden gravity meter (W 140) during 1964. The instruments generally showed good drift characteristics despite a wide range of temperatures and the rugged terrain over which they had to be transported. Gravity stations were situated approximately 0.5 mile apart along roads, tracks, and fencelines throughout the area. Whenever possible, the gravity traverses formed closed loops and generally the closures were within the range of reading error. All gravity observations were connected to a concrete benchmark in the Kajabbi railway yard (gravity station KO) and reduced relative to this point.

As it was impracticable to return to Kajabbi every hour, a series of auxiliary bases were set up for drift control; for example, starting from the main base at Kajabbi (station KO), readings along traverse K would follow aregular pattern: KO, K1, K2, K3, K4, K5, K1, K5,.........K10, K5, K10,...... In this way, every fifth station becomes a base and the bases are checked by closing the loop. In some areas of rugged terrain or where steep gravity gradients were observed, bases were set up at every third station or stations were situated 0.3 mile apart according to the observer's discretion. As no detailed topographical maps of the area were available, terrain corrections could not be made, so terrain effects were kept to a minimum. This was achieved by care in selecting sites for gravity stations, and generally it was not difficult to avoid significant terrain effects.

The gravity field work was always performed using a Landrover for transport, the gravity measurements usually preceding the surveying and levelling. The observer used the Landrover speedometer to locate stations approximately 0.5 mile apart; these were marked and later levelled by the surveyor. Finally, the main loops were located accurately by stadia and chaining and intermediate stations were located on the new airphotos supplied during the survey. Two of the traverses (00 and 800N) on the geophysical grid were surveyed at 100-ft intervals for 10 miles along each traverse to gain more detailed knowledge of the gravity (Gardener, 1964).

Although the initial gravity observations were completed by 3rd August 1963, the surveying, levelling, and locating of stations on airphotos were not completed until 9th November. The additional gravity stations surveyed during 1964 were added in the same way and all stations were accurately levelled by the surveyor. Those stations that appeared on the airphotos were located on them and the remainder were located by stadia and chaining. The Department of the Interior, Canberra, combined the surveyed gravity stations with the airphotos to produce a final map showing all gravity stations.

The gravity observations were corrected for drift, elevation, and latitude in the standard way. Initially all elevation corrections were made using a density of 2.67 g/cm^3 for all material above the reference level but a section of one of the detailed traverses was used to plot a 'density profile' (Plate 3) in order to determine the best density to use (Nettleton, 1939). A value of 2.2 g/cm^3 was chosen as it appeared to give the least correlation between Bouguer anomaly and surface topography. The final results were reduced using a density of 2.2 g/cm^3. Latitude corrections were made relative to a central point (station 0 on traverse 0) using the international formula. Thefinal gravity results, tied in to a local base (station KO) at Kajabbi, corrected for latitude relative to a central point, and corrected for elevation relative to a convenient reference level (300 feet, which was approximately the lowest level encountered in the area) were contoured (Plate 5). The gravity survey was connected to the national network by connecting station KO at Kajabbi with Cloncurry, but only values relative to the local bases are used in this record.

D.O. Zimmerman spent some time in the area during 1963 collecting samples and mapping the geology on the ground and from the air. W. Dallwitz extended this work during 1964, but most of the mapping was confined to the detailed geophysical grid and was only of limited assistance in interpreting the gravity results. Density determinations were made on all samples taken and the results were used in the interpretation of the gravity results. A summary of the densities of the various rock types encountered is included in Table 1.

TABLE 1

Densities of rock samples

Description of rock	Number of samples	Mean density (g/cm^3)
Naraku Granite including associated aplites and pegmatites, all slightly weathered	11	2.58
Kalkadoon Granite including granodiorites and associated pegmatites, all slightly weathered	14	2.64
Quartzite and siliceous metamorphic rocks	8	2.66
Acid volcanics - rhyolite, dacite, etc.	11	2.65
Calc-silicate rock, some hornfels	15	2.72
Basic igneous rock, dolerite, gabbro, etc.	16	2.98
Amphibolite, sheared basic volcanics	14	2.94
Cretaceous limestone with belemnites (often porous)	6	2.60

4. INTERPRETATION

It has been noted (Carter, Brooks, & Walker, 1961, p.207; Carter, 1959; Searl, 1952) that mineralisation in the Cloncurry - Mount Isa - Dobbyn areas is generally associated with zones of shearing especially in basic igneous rocks. An inspection of the BMR 1:500,000 gravity maps of the Duchess and Cloncurry areas shows a series of very steep, north-striking, gravity gradients that coincide with major shear zones. The most important mineralised areas (Duchess, Trekelano, Selwyn, Kuridala, and Ballara) fall on or near these steep gradients, but since gravity stations in the regional survey were approximately four miles apart along traverses approximately ten miles apart, it is difficult to correlate the mineralisation and gravity gradients exactly.

Some detailed gravity work has been done across the mineralisation at Kuridala and Duchess (Horvath, 1952) and this shows a small but definite gravity gradient across the amphibolite/slate boundary, which coincides with the mineralisation. It has been shown (Horvath, 1952) that the gravity method is unlikely to detect mineralisation directly, but it may be useful in studying the geological structure and thus help to determine favourable areas for future work.

Before attempting to interpret the gravity results from Dobbyn it is necessary to study the densities of the rocks encountered (see Table 1). All rock samples were slightly weathered but, with the possible exception of the Naraku Granite and the limestone, this should not be enough to affect the measured densities significantly. The Naraku Granite, Kalkadoon Granite, acid volcanics, quartzite, and other siliceous rocks all have densities between 2.60 and 2.70 g/cm^3. The basic igneous rocks and amphibolites have densities grouped between 2.90 and 3.00 g/cm^3 - a density contrast of approximately 0.3 g/cm^3 existing between them and the acidic rocks. The calc-silicate, hornfels, etc. that have been observed in the Corella Formation have an intermediate density between the acidic and basic rocks.

As the Leichhardt Metamorphics and Argylla Formation are composed of relatively narrow bands of alternating acidic and basic igneous rocks and as these grade into the Corella Formation, it would be unreasonable to expect the gravity survey to distinguish these stratigraphical units. The large density contrast between the acidic and basic rocks should be sufficient to cause significant gravity anomalies if they occurred as large, discrete masses but this is not the case. As the amphibolites often occur as narrow bands (about 5 feet wide) within the acid volcanics and quartzites, it is extremely unlikely that individual bands would affect the observed gravity when measured at 100-ft intervals. It is reasonable, however, to expect that clusters of amphibolite bands or bands as broad as 200 or 300 feet could be detected by the gravity measurements.

Plate 4 shows the Bouguer anomaly profile along traverse 00 compared with the surface topography and geological notes prepared by D.O. Zimmerman. A qualitative comparison of geology with the Bouguer anomaly profile shows a good correlation; generally, groups of amphibolite bands and large amphibolite bodies coincide with gravity 'highs'.

The major features of this traverse are the two gravity peaks, each about 3 milligals high centred at 4500E and 12,900E. The first of these, extending from about 2700E to about 6400E, coincides with a concentrated group of amphibolite bands alternating with rhyolite; the second one, which is a much sharper and more regular peak, coincides with an area extending from 11,540E to 13,850E, which is mapped as amphibolite, basic rubble, and soil, with no apparent acid volcanics. Several other basic bands or groups coincide with small peaks in the gravity profile at 9000W, 1000W, 16,000E, 17,700E, 22,000E, 22,700E, 24,000E, and 31,000E. These peaks rise above some rather level portions of the gravity profile that correspond to about 9 to 10 milligals and coincide with more acidic sediments and volcanics. A zone mapped as calc-silicate hornfels (density 2.72 g/cm^3) from 33,600E to 35,000E also coincides with a small peak in the gravity profile. Although the density of the Kalkadoon Granite has been measured to be 2.64 g/cm^3, which is only very slightly less than that of the rhyolite and quartzite, granite apparently causes gravity depressions. Granite has been mapped from 7800W to 8780W, which coincides with a depression in the gravity profile; scattered granite outcrops between 16,000E and 22,000E coincide with a generally low part of the gravity profile.

The major fault zone at about 35,300E coincides with only a local small gravity 'low', but, as there is no marked change in rock type on both sides of the fault, this is to be expected. The steep downward trend at the eastern end of the traverse is on the western edge of a very large gravity depression between the two anticlines in the area. This gravity depression can be traced throughout the surveyed area running in an approximately north-south direction. The depression evidently coincides with a trough in the bedrock filled with less dense alluvial deposits and will be discussed in more detail later.

An inspection of Plate 4 shows a close correlation between rock type and the Bouguer anomaly values and this can be extended to explain many of the features shown by the Bouguer anomaly contours in Plate 5. The north-south strike of the formations in the area results in a general aligning of the gravity contours in this direction, particularly at the western and eastern edges of the surveyed area, where the gravity contours are quite regular and parallel. In the centre of the area, north and south of Dobbyn, the gravity contours appear more disturbed and this has become more apparent by the closer traverses and more detailed observations.

The main features of the gravity contour map (Plate 5) are as follows:

1. The two relatively high 'plateaux' east of the Leichhardt River and the north-south line of steep gravity gradient on their western edge.

2. The high local anomaly near Kamileroi.

3. The decreasing gravity values at the eastern and western edges of the area.

4. The 'trough' extending continuously from K15 in the south to H17 in the north.

5. The apparently disturbed area west of the Leichhardt River, centred about Dobbyn and enclosing all the major copper mines in the area (see Plate 8). The proximity of the known copper mines to north-south striking, major or minor gravity 'highs' is well illustrated in this area.

The two gravity 'plateaux' east of the Leichhardt River coincide with the eastern anticline that has been mapped as Corella Formation and Naraku Granite with some metadolerite and gabbro intrusives. Neither the Corella Formation nor the Naraku Granite have a sufficiently high density to cause the high gravity values observed, although the presence of calc-silicate rocks in the Corella Formation could be contributing factor. It seems likely that much more basic rock is present than appears on the geological map and this has been confirmed by field observations. A large body of metadolerite and gabbroic intrusives has been mapped in the north between H30 and H31 nearly coinciding with the peak of the gravity anomaly. This suggests that a large mass of basic rock is responsible for the gravity anomaly and that it is more extensive than it appears on the geological map. In particular, it probably extends further east than previously supposed but, as it does not necessarily crop out, it has escaped notice.

No outcrops have been mapped near the gravity 'high' centred at F20 on the southern gravity 'plateau'. However, between F3 and F14, both Corella Formation and Naraku Granite are mapped. Some basic intrusions and calc-silicate rocks have been observed, particularly on traverse K23 between stations K23E2 and K23E10, and the Naraku Granite outcrop is certainly not as extensive as the geological map indicates. It seems likely that this southern gravity 'plateau' is also due to the presence of basic igneous and calc-silicate rocks in sufficient concentration to raise the average density significantly (see later). The only gravity traverse that apparently crossed extensive outcrops of Naraku Granite was traverse X. Between stations X14 and X19, the geophysical party and W. Dallwitz were able to identify granitic and pegmatitic rocks, and the large mass of Naraku Granite mapped between traverse F and traverse V evidently corresponds with this. The gravity depression between the two gravity 'plateaux' corresponds with the main mass of Naraku Granite, which is less dense than the calc-silicate and basic rocks in the Corella Formation.

The steep gravity gradient on the western edge of this anticline, particularly noticeable on traverses K23, F, X, and V, is probably due to a steeply dipping fault. To the east along the above traverses, the first outcrops are observed at K23E3, F6, X7, and V12 corresponding closely with the eastern edge of the steep gravity gradient. West of the suspected fault, there is a depression (feature 4) which coincides with the Leichhardt River valley. Gravity observations over the Corella Formation west of the Leichhardt River valley are approximately 14 milligals lower than over the eastern Corella Formation, so there is evidently a difference in the average density of the two formations. This change in density could simply be due to a lateral change in the composition of the Corella Formation but it appears likely that a large fault has raised the denser, underlying Argylla Formation and Leichhardt Metamorphics near to the surface in the east.

The prominent gravity 'high' near Kamileroi cannot be explained by the known geology. Three Mile Bore, which is quite close to the anomaly, has been drilled to 590 feet without intersecting bedrock, and White Wood Bore, about five miles east, has reached bedrock at 732 feet. Such a large anomaly seems unlikely to be caused by changes in the overburden (Cretaceous and alluvium), so the cause must be looked for mainly in the bedrock at least 600 to 700 feet below the surface.

A magnetic anomaly was detected in the same place as the gravity anomaly, on traverses 104 and 105 of the aeromagnetic survey (Dockery & Tipper, 1964), and depth calculations using Peters' half-slope method (Peters, 1949) yield a depth to the top of the body causing the anomaly of 1300 $\pm$ 450 feet (Dockery, pers. comm.). This would certainly put the source in the bedrock and probably near the top of it. A similar, narrow, steep-sided magnetic anomaly was detected on traverse 101 (close to station K101 on the gravity traverse plan, Plate 5), and depth calculations on this anomaly place the source at a depth of 800 $\pm$ 350 feet (Dockery, pers. comm.).

A section (Plate 6) has been drawn across the gravity anomaly along line AB (see Plate 5) and approximate depth calculations using the method of Skeels (Skeels, 1963) have been made. The main difficulty is the choice of the zero base line for the anomaly and several different values have been tried. Using different values for the zero base line and different density contrasts, several vertical-sided prisms have been computed, the depth to the top generally being about 3000 feet. Since the depth to the top of a vertical-sided prism is the maximum depth for any probable shape, the depth to the top of the body causing the anomaly is probably much less and could easily agree with the magnetic calculations. The anomaly is slightly asymmetrical and, if the half- and three-quarter-widths are determined from the steeper side, the maximum depth is reduced considerably (e.g., if the density contrast is 0.4 g/cm^3, the maximum depth is 2160 feet). The theoretical body and computed anomaly, illustrated in Plate 6, have been obtained using the average half- and three-quarter-widths and give a reasonable overall fit. They are only intended to illustrate one example of the type of body that causes such an anomaly. The density contrast used (0.4 g/cm^3) could represent the contrast between acidic and basic to ultrabasic rocks but the body is only one of many possible solutions; in this case it is the deepest, vertical-sided prism that gives a reasonable fit with the observed data.

Since the body causing the anomaly is more dense than the surrounding material, which has a density of 2.70 g/cm^3, and since it also causes a magnetic anomaly, it is probably a body of basic or ultrabasic igneous rock. Similar gravity values have been observed further east on traverse H (near H35) and these have been attributed to the metadolerite and gabbroic intrusives mapped nearby. Although the area around H35 is magnetically disturbed, there is no clearly defined magnetic anomaly similar to that observed near H3 and it seems most unlikely that the two similar gravity anomalies have an exactly similar cause.

Both the eastern and western edges of the surveyed area exhibit decreasing gravity values. In the east this is easy to understand as the outcropping Corella Formation and Naraku Granite disappear beneath a blanket of less dense Cainozoic alluvium. West of Dobbyn, a steady decrease in gravity values is observed as one approaches the main body of Kalkadoon Granite. Even small granite outcrops can be correlated with gravity 'lows' (see 8000W on traverse 00, Plate 4) and the large mass of Kalkadoon Granite is evidently sufficient to cause a general decline in gravity values. West of the Kalkadoon Granite, the Myally Beds evidently have a sufficiently low density to continue this trend. As the geology west of Dobbyn becomes more complex and gravity observations are widely spaced, very little interpretation can be done.

Plate 7 illustrates a section along line CD (see Plate 5) compared with a calculated gravity profile based on the geological section shown. The observed gravity profile crosses gravity features 1, 3, 4, and 5 (see page 7) and is typical of them.

The first feature, the region of high gravity values east of the Leichhardt River with a steep western edge, is clearly illustrated but artificially smoothed as the section has been drawn from contour intersections and not from actual observations. The anomaly is evidently caused by a large mass of rock of average density higher than that of the surrounding formations. The shape suggests a zone of higher density near the centre of the mass (near longitude 140° 15') but otherwise the average density seems fairly uniform. The most surprising feature is the absence of a gravity depression coinciding with the position of the Naraku Granite (see Plate 2), which suggests much less granite than is shown on the geological map. No Naraku Granite has been included in the theoretical cross-section.

Feature number three, the decreasing gravity values at the eastern and western margins, is clearly illustrated at the western end of the profiles. The steep decrease in gravity values to the west coincides with the transition from Kalkadoon Granite to the less dense Myally Beds.

Feature number four, the trough near the Leichhardt River, coincides with the alluvium-filled river valley. The results of water bores in the area indicate maximum depth to bedrock of 600 to 700 feet but the bedrock encountered is not well defined. The theoretical cross-section (Plate 7) assumes a much greater depth to the Corella Formation, with the material above the Corella Formation consisting of recent sediments or Cretaceous limestone of the Tambo Formation. The aeromagnetic survey (Dockery & Tipper, 1964) indicates that the Corella Formation must be very deep if it underlies this region, and the gravity results confirm a much greater thickness of low density material than the water bores would suggest.

Feature five, the disturbed area around Dobbyn, is economically the most interesting. It is best studied by reference to the enlarged contour map (Plate 8). Closer traverses have contributed greater detail here and the general structure is clearly outlined. The formations present in outcrop are Corella Formation immediately west of the river, then Argylla Formation, Leichhardt Metamorphics, and Kalkadoon Granite. The two detailed traverses (traverse 00 and traverse 800N) with 100-ft station separation and detailed geological mapping have revealed the close correlation between rock composition and observed gravity (see Plate 4) and this can be extended to help understand the rest of the area.

All the main copper deposits that have been mined in the area (e.g., Dobbyn, Orphan, Crusader, Dinkum Digger, and Kohinoor mines) are close to or on gravity 'highs'. This is in accordance with the geological prediction that sheared basic rocks (which have been shown to cause gravity 'highs') are favourable areas for ore deposition. To the south, the Mount Cuthbert and Kalkadoon mines are very close to another gravity 'high' (see Plate 5) and there is insufficient gravity data near the Little Wonder and Mighty Atom group of mines to say whether this holds true there also. The north-south gravity ridge centred at station AD9 is apparently due to basic rock. It starts near the Orphan Mine and appears to continue to the south-east along traverse AC through the Crusader and Dinkum Digger mines. A similar ridge to the west extends north from the Dobbyn mine past the Kohinoor and Kohinoor North mines to station L52E4. Basic rock has been observed near stations KQ17, KQ16, KQ15, KQ13, QL9, and L58 (Dallwitz, pers. comm.), all of them stations with high observed gravity. The gravity 'high' near stations QL9 and L58 appears to be separated from the main ridge by a trough extending from station QL6 to station L52E3 and possibly represents a fault displacement of the basic material or a completely separate body.

Another parallel ridge appears near station KQ10, and may represent an extension of the Dobbyn - Kohinoor ridge displaced by faulting or a continuation of the ridge observed near the Orphan mine. By analogy with the gravity ridge to the west, the ridge near station KQ10 is probably caused by basic rock underlying the Cainozoic alluvium. In view of the number of ore deposits associated with similar features to the south, this would be a worthwhile area for further exploration. As outcrops are scarce, geophysics, particularly electromagnetic or induced polarisation work, would be required in the search for orebodies in this area.

East from station AD9 is a relatively uninteresting area with low gravity relief and no significant mineralisation until the Mount Richie mine is reached near station BD8. This mine does not correlate with a gravity 'high' but as it is only a small deposit and gravity traverses are widely spaced, this is not considered significant. Near 34,000E on traverse 00, a small gravity 'high' occurs, which appears to be continuous with a string of 'highs' extending north through stations B12, BK4, C1, and K65 to K70. On traverse 00, this 'high' appears to be due to a calc-silicate hornfels (see Plate 4), which would therefore be expected to continue to the north. An isolated sample of suspected calc-silicate rock has been observed near station C8 (Dallwitz, pers. comm.) but the absence of sufficient outcrops makes further geological mapping difficult. There is no evidence to suggest that this gravity ridge (B12 to K70) is of economic interest, and its distance from the Kalkadoon Granite is a possible reason. No mineralisation has been found in this area and calc-silicate rocks are expected to be unfavourable hosts (Carter, Brooks, & Walker, 1961, p.206). If further geological mapping located basic volcanic rock along this gravity ridge, the area would be much more interesting as a possible mineralised zone.

North of traverse KD, west of the Leichhardt River, outcrops are scarce and there are no gravity features considered worth further investigation. The few outcrops observed (e.g., near station L105W7) are mainly quartzites or altered sediments and there is no reason to expect mineralisation. South of Dobbyn, im the area bounded by traverses A, K, and L, there is an area of rugged terrain where gravity observations were very limited. The presence of the Little Wonder - Mighty Atom group of mines in the area makes it interesting but, as there is little or no alluvial cover, gravity work would probably not contribute much that could not be deduced from geological mapping. West of traverse L, the gravity survey is not sufficiently detailed to suggest areas for further work, but the presence of several known deposits (e.g., Wary Castle, Mount Cuthbert, and Kalkadoon)indicates the possiblity of locatingnew ones.

5. CONCLUSIONS AND RECOMMENDATIONS

The main aim of the survey was to study the major structural features in the Dobbyn area, particularly in relation to shear zones that appear to be related to mineralisation. It appears that the actual shear zones themselves do not affect the observed gravity significantly, but the variations in rock composition are shown up clearly. Since mineralisation appears to occur only in certain host rocks, the gravity results can indicate areas of suitable host rocks for further exploration. As described earlier, the area north of Kohinoor mine appears suitable and further exploration is recommended in the area bounded by stations L60 and KL4 and latitude 19°45'S. In particular in the area near station KQ11, a possible sheared zone between the two gravity 'highs' appears particularly favourable. The line of gravity 'highs' extending from station B12 to station K70 does not appear favourable as it is probably due to the presence of calc-silicate rock. More detailed geological mapping could possibly confirm this, but it is doubtful whether sufficient outcrops occur.

In the east, the gravity survey has indicated much more dense (probably basic) rock than was previously supposed. This is bounded on the west by a steep gravity gradient, which may be due to a major fault. Several mines have been worked in this region although no major ore deposits have been found and the favourable environment (sheared basic rock) suggests the possibility of finding more orebodies in the future.

The large positive gravity anomaly near Kamileroi is probably due to a mass of basic rock in the bedrock, several hundred feet below the surface. The anomaly appears to be still increasing to the north and further gravity and magnetic work to the north would be necessary in order to assess it properly.

Electromagnetic, self-potential, and induced polarisation methods have been used in the area (Rayner & Nye, 1936; Gardener, 1964 & 1965) with some success and further work north of Kohinoor mine is recommended. Further geophysical work in the sheared basic rocks east of the Leichhardt River could be useful but a great deal of more-detailed geological mapping would be necessary in order to select suitable areas and interpret the results from them. In any case, future geophysical surveys would need to be accompanied or preceded by detailed geological mapping in order to make full use of the results.

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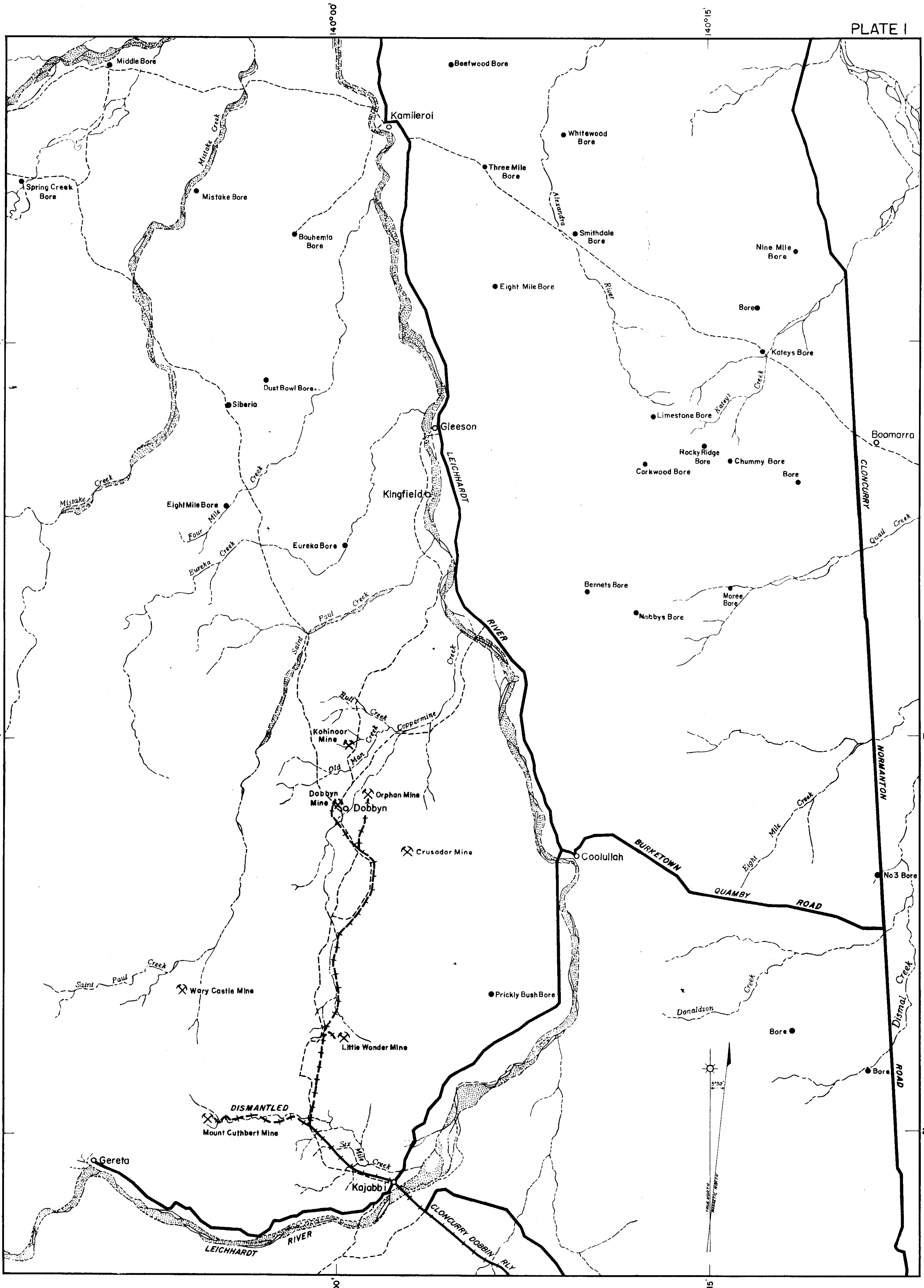
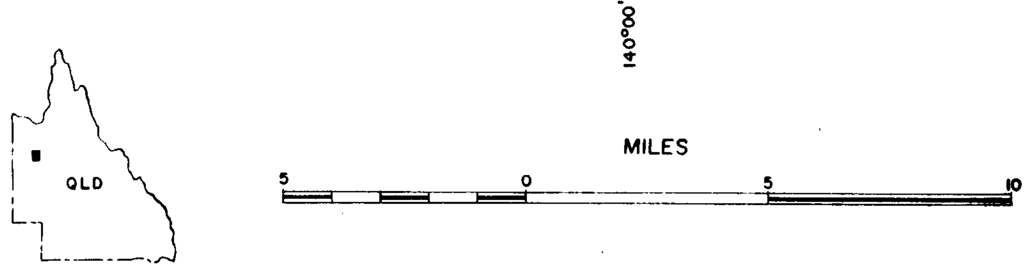
PLATE I





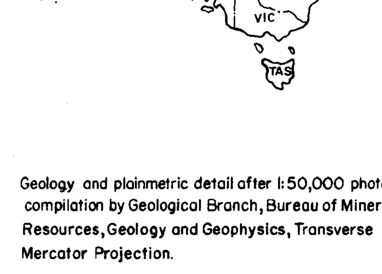
DOBBYN GRAVITY RECONNAISSANCE SURVEY, QUEENSLAND 1963-1964

LOCALITY MAP

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. E54/B7-40

TO ACCOMPANY RECORD No.1966/41

PLATE 2



Geology and plainmetric detail after 1:50,000 photo-scale compilation by Geological Branch, Bureau of Mineral Resources, Geology and Geophysics, Transverse Mercator Projection.

LEGEND

CAINOZOIC		Cza	SOIL AND ALLUVIUM
MESOZOIC	LOWER CRETACEOUS	Klt	TAMBO FORMATION
		M	TERRESTRIAL SEDIMENTS
LOWER PROTEROZOIC		dl	METADOLERITE AND GABBROIC INTRUSIVES
		Pl	STRATIGRAPHIC POSITION UNKNOWN
		Plu	SURPRISE CREEK BEDS
		Ply	MYALLY BEDS
		Plk	KNAPDALE QUARTZITE
		Plc	CORELLA FORMATION
			METADOLERITE SILLS
		db	ALTERED DOLERITE DYKES AND BASALT
		Pln	ARGYLLA FORMATION
ARCHAEAN		p€l	LEICHHARDT METAMORPHICS

Pgu	NARAKU GRANITE
Pge	EWEN GRANITE
Pgw	WONGA GRANITE
p€k	KALKADOON GRANITE
	GEOLOGICAL BOUNDARY
	FAULT
	RIVER OR CREEK
	RAILWAY
	NAMED PLACE
	HOMESTEAD
	MINE OR QUARRY
	TRAVERSE

TRUE NORTH
MAGNETIC NORTH
5°50'

GEOLOGY AND GRAVITY TRAVERSES
DOBBYN AREA

MILES

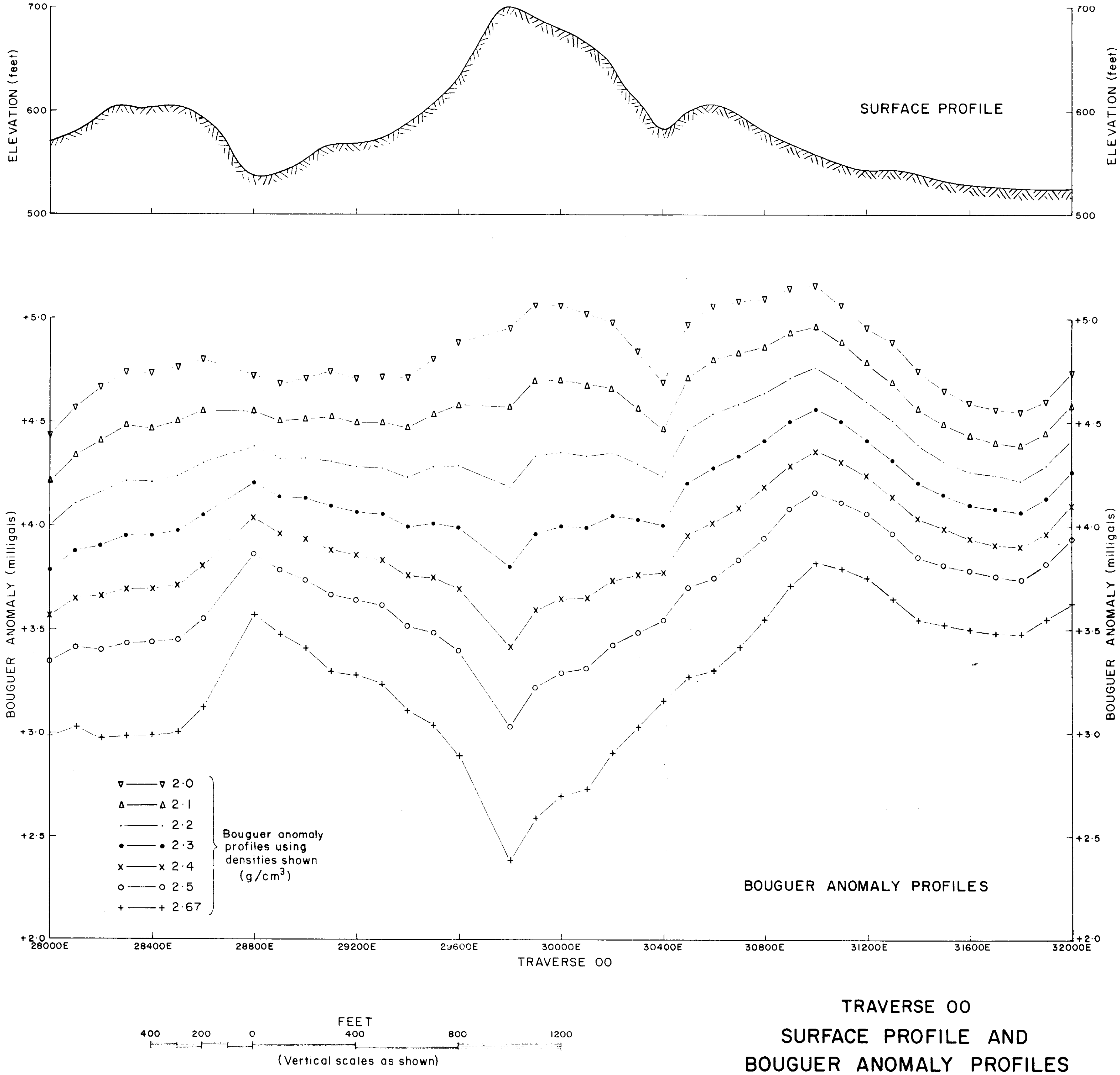
2 1 0 2 4 6 8 10

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

E54/B7-44

TO ACCOMPANY RECORD No. 1966/41

PLATE 3



TRAVERSE OO

SURFACE PROFILE AND

BOUGUER ANOMALY PROFILES

FOR DIFFERENT DENSITIES

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS E54/B7-39

TO ACCOMPANY RECORD No.1966/41

Dobbyn, Qld, 1963

PLATE 4

FEET

1000 500 0 1000 2000 3000

(Vertical scales as shown)

TRAVERSE OO

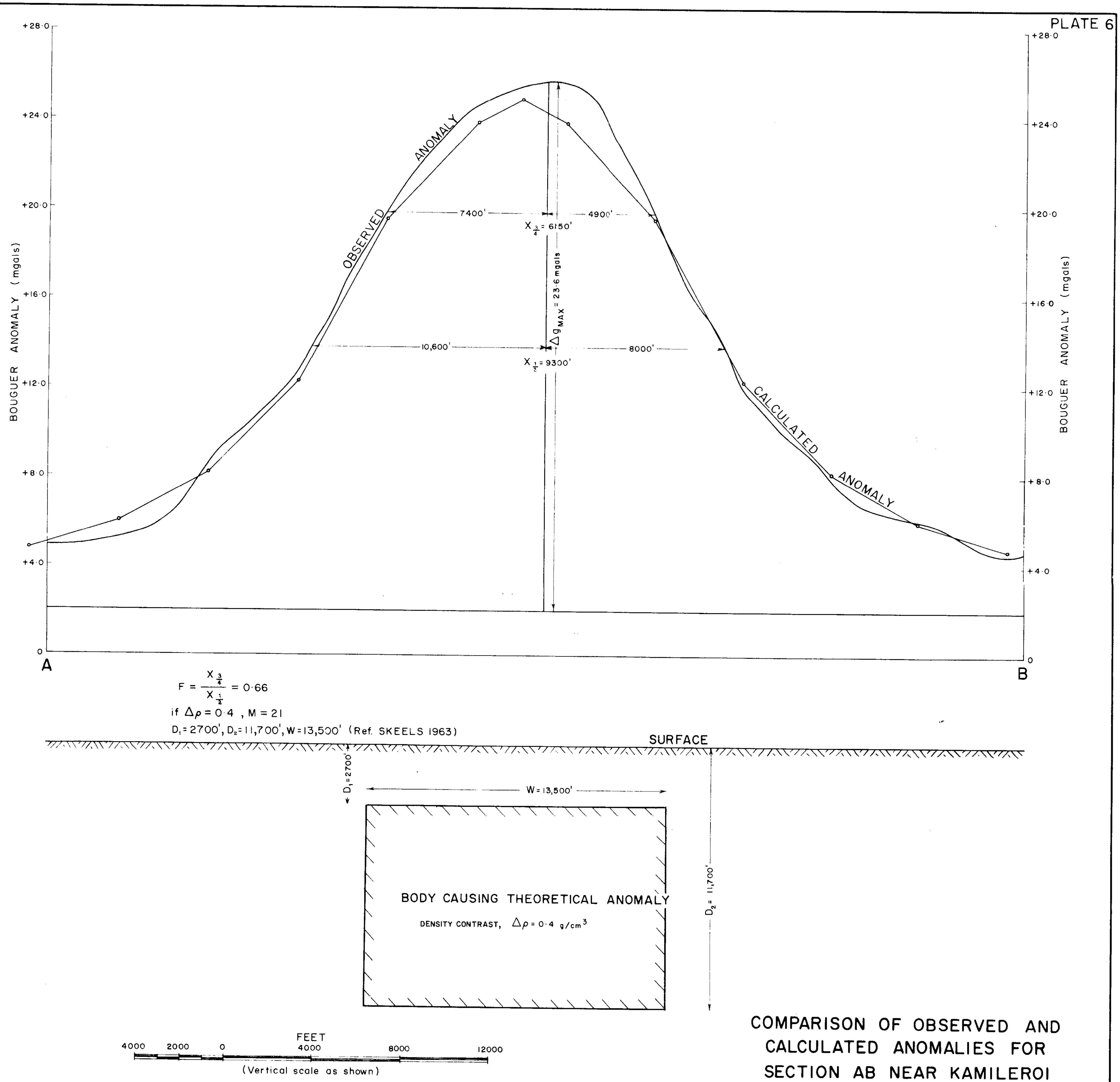
SURFACE AND BOUGUER ANOMALY PROFILES, AND GEOLOGY

Geology (after ZIMMERMAN 1963)

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS E54/B7-42

TO ACCOMPANY RECORD No 1966/41

TO ACCOMPANY RECORD No. 1966/41



COMPARISON OF OBSERVED AND CALCULATED ANOMALIES FOR SECTION AB NEAR KAMILEROI

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS E54/B7-38

TO ACCOMPANY RECORD No. 1966/41

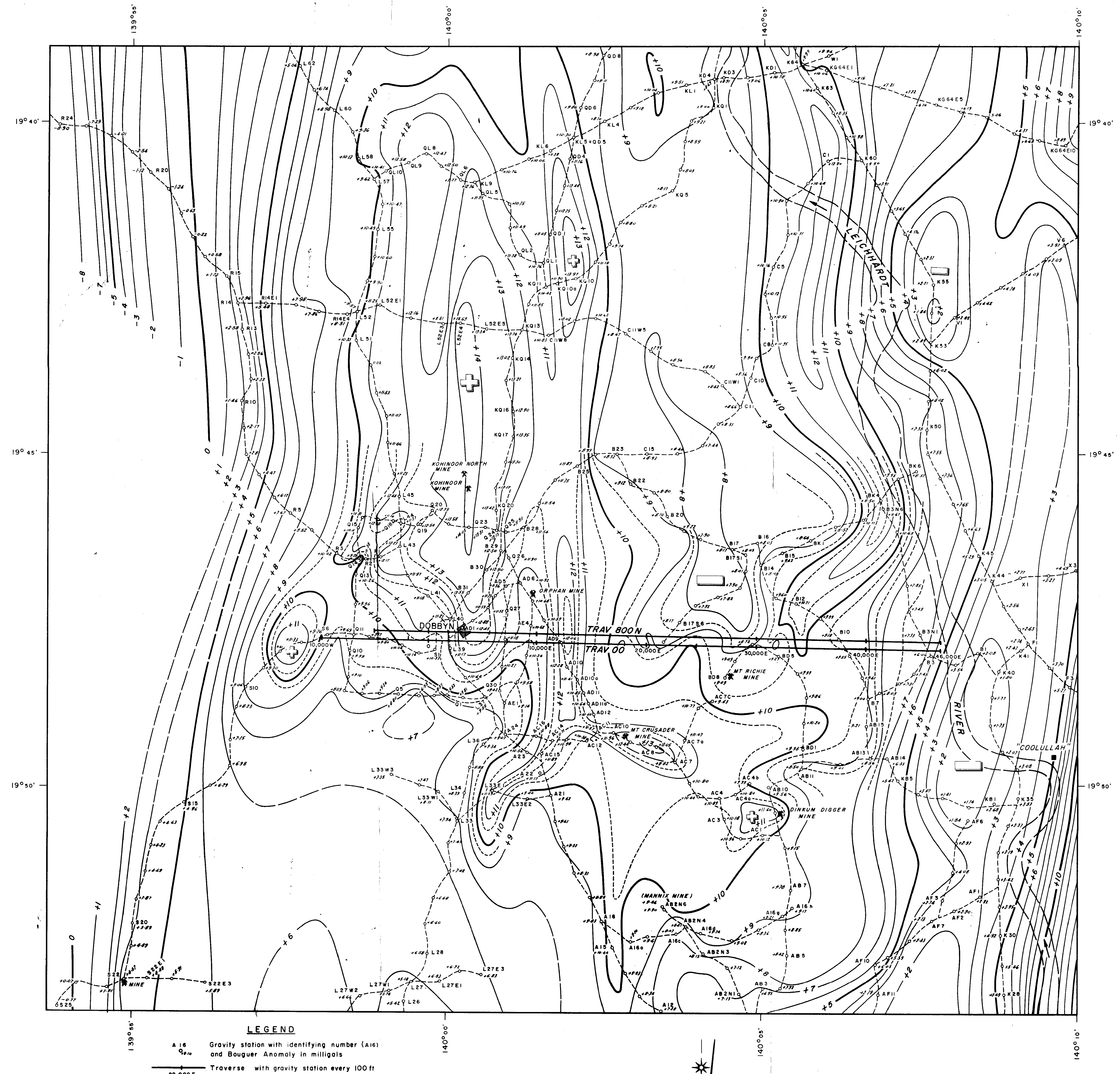
Dobbyn, Qld, 1963

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

E54/B7-46

TO ACCOMPANY RECORD No. 1966/41

PLATE 8



LEGEND

A 16 — Gravity station with identifying number (A16) and Bouguer Anomaly in milligals

20,000 E — Traverse with gravity station every 100 ft

Copper mine (not necessarily active)

+5 — Isogal

Isogal doubtful due to insufficient observations

Isogal at 0·5 mgal interval. (Only shown in areas of detailed observations)

'High' anomaly

'Low' anomaly

DETAILED BOUGUER ANOMALIES FOR THE CENTRAL AREA

MILE

1 0 1 2 3 4

(Contour interval 1 milligal)

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

E 54/B7-45

TO ACCOMPANY RECORD No. 1966/41