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DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD No. 1966/50

MOUNT ISA GRAVITY TEST SURVEY,

QUEENSLAND 1963-1964

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CONTENTS

ILLUSTRATIONS

SUMMARY

A test gravity survey was made in the Mount Isa area during 1963 and extended during 1964. The survey consisted of a series of traverses, crossing the full geological sequence encountered in the district, over areas where drilling had given some sub-surface information.

Surface mapping and drilling information were used to construct geological cross-sections, and gravity profiles were computed for comparison with the observed gravity. It was hoped that the gravity work might prove useful in studying the general geology of the area and also aid the detection, directly or indirectly, of mineralisation.

The results showed an interesting correlation between the observed gravity and surface geology, particularly in relation to the Eastern Creek Volcanics. Several interesting anomalies were encountered which suggest that gravity surveys could help indirectly in the search for copper mineralisation.

1. INTRODUCTION

During 1963, Mount Isa Mines Ltd requested the Bureau of Mineral Resources (BMR) to carry out a gravity test survey on their leases in order to show whether or not the gravity method could be applied to advantage in the area. Three pairs of traverses were proposed, the total length being about 17 miles. The traverses selected were in three areas (Plates 1 and 2).

A. North of Mount Isa near Tombstone Hill.
B. South of Mount Isa mine near Bernborough Hill.
C. At the Native Bee copper prospect.

These areas were chosen because they contained mineralisation, and geological information was available from surface mapping and drilling results.

E.M. Bennett (Chief Geologist, Mount Isa Mines Ltd) had explained (pers. comm.) that plans for downward extension of the workings at the Mount Isa mines would be greatly assisted by a knowledge of the depth to and configuration of the basement. Recent drilling had suggested that the basement rocks were greenstones similar to the Eastern Creek Volcanics and probably much denser than the shales and siltstones of the Mount Isa Group. The aim of the survey was to test whether the gravity method could be used to determine the configuration of the shale-greenstone boundary and possibly to detect mineralisation either directly or indirectly.

The initial gravity work was done between 17th August and 26th September 1963 by R.J. Smith, geophysicist, and one field-hand supplied by Mount Isa Mines Ltd. Interpretation of these results showed that some extensions to the traverses were needed and these were surveyed between 28th September and 5th October 1964 using large station separations (about 2000 feet) to collect more information on the regional background. All the surveying and levelling was done by surveyors provided by Mount Isa Mines Ltd.

2. GEOLOGY

Regional geology

The regional geology of the Mount Isa district has been described by Carter, Brooks, and Walker (1961), Knight (1953), and Cordwell, Wilson, and Lord (1963).

Plate 1 shows the regional geology, and the approximate positions of the traverses. The deposits occur in a corridor of sedimentary and volcanic rocks between two large granite masses. From east to west, the main geological sequence is:

Kalkadoon Granite. Mainly granodiorite, with some granite, adamellite, pegmatite, and aplite.

Mt. Guide Quartzite. Quartzite with some felspar, arkose, conglomerate, and metabasalt.

Eastern Creek Volcanics. Interbedded metabasalt and metasediments with some intermediate and acid lavas.

Myally Beds. Medium- to coarse-grained sandstone and quartzite with some siltstone, shale, and felspathic sediments.

Mount Isa Group. Shales and siltstones.

Judenan Beds. Quartzite, sandstone, siltstone, shale, pebble beds, and conglomerates, with some rhyolite and basalt. The Judenan and Myally Beds are similar in composition, and may be contemporaneous.

Sybella Granite. A granite of normal composition, but much weathered and silicified in outcrop.

The units are generally conformable, with a northerly strike and a dip to the west of 60° to 80°. The area is much disturbed by faulting. Blocks of Eastern Creek Volcanics have been faulted into the Mount Isa Group. The contact between the Mount Isa Group and the Judenan Beds is along a major fault, the Mount Isa Fault, a high-angle reverse fault, with considerable oblique movement, dipping west at about 65°. It is a bedding plane fault with the Judenan Beds overturned at the contact. Movement along the strike has apparently caused the drag folding in the Magazine Shale near Traverse B (see Plate 2) which has been correlated with a gravity anomaly (see page 9). Knight (1953) states that strike faults of large throw occur in the Mount Isa Group. As such faults are very difficult to recognise in these rocks, he considers it likely that strike faults of large dimensions are present, which have not yet been recognised.

Detailed geology

The detailed geology of the mine area has been discussed by Blanchard and Hall (1942), Murray (1961), and Carter (1958). Plate 2 is a detailed geological map, supplied by Mount Isa Mines Ltd, on which the positions of the gravity traverses are shown more accurately.

Additional to the regional description, the following geological details are relevant to the gravity survey :

(1) On the eastern side of the Mount Isa Fault, between the Mount Isa Group and the Judenan Beds, there is a discontinuous outcrop of volcanics, shown on the map as undifferentiated volcanics, and informally known as the 'Western Greenstone'. These are similar in composition to the Eastern Creek Volcanics and may be related to them.

(2) Within the Eastern Creek Volcanics, a formation known as the Lena Quartzite has been mapped. This consists of relatively narrow bands of quartzite interbedded with the volcanics, generally near the top of the sequence.

(3) Rocks mapped as undifferentiated quartzites and schists occur between the western outcrop of the Eastern Creek Volcanics and the Sybella Granite.

(4) The Mount Isa Group has been subdivided. Detailed investigation is still proceeding, but at present, the following seven formations have been distinguished and described by Battey (in preparation). (The boundaries of these formations are not shown in Plate 2).

Moondarra Siltstone. A thin-bedded, black (weathering to dark brown) dolomite and siltstone. The rocks are mainly composed of dolomite and quartz with some clay minerals and mica. Sericite, microcline, and carbonaceous material occur as accessory minerals. The Moondarra Siltstone overlies the Myally Beds. They are generally conformable but some local unconformities exist.

Breakaway Shale. A fine-grained, thin-bedded, light-grey shale with some siltstones, usually deeply weathered. The rock is mainly composed of quartz and sericite with tourmaline, rutile, limonite, albite, oligoclase, apatite, and zircon as accessory minerals.

Native Bee Siltstone. A dolomitic siltstone with variable composition. Principally composed of detrital and secondary dolomite, biotite, muscovite, sericite, and quartz in thin, well defined bedding.

Urquhart Shale. Outcrops as a thin-bedded sericitic shale with cream, red, and brown beds containing hematite and limonite. Weathering has removed carbonate minerals to a depth of about 200 feet. The unoxidised Urquhart Shale is dark grey, fine-grained, interbedded dolomitic and pyritic shale. Composed of detrital quartz, sericite, plagioclase felspar, carbonaceous material, and tourmaline crystals with some muscovite, biotite, chlorite, and abundant pyrite. Most of the mineralisation in the Mount Isa area, including the main economic deposits, occurs within this formation.

Spear Siltstone. A fine-grained dolomitic interbedded siltstone and shale with very variable carbonate content.

Kennedy Siltstone. A light-grey, massive, dolomitic siltstone, varying to a silty dolomite with occasional narrow bands rich in sericite. Bedding is very difficult to distinguish. Composed of dolomite, detrital quartz, and plagioclase with some zircon, tourmaline, biotite, rutile, isolated crystals of pyrite, pyrrhotite, and chalcopyrite.

Magazine Shale. Crops out as a weathered, light-grey to brown and red sericitic shale. The unoxidised Magazine Shale is a dark grey to black, thin-bedded, calcareous, sericitic shale with variable concentrations of carbonaceous material and detrital quartz and some pyrite and fine-grained biotite. The Magazine Shale conformably overlies the Kennedy Siltstone and underlies undifferentiated volcanics whose relationship is unknown. The undifferentiated volcanics known as 'Western Greenstone' have a similar composition to the Eastern Creek Volcanics and may be closely related to them.

Mineralisation. The main economic deposits, copper and lead-zinc, occur within the Urquhart Shale. Details of their mode of occurrence have been described by several authors (Blanchard & Hall, 1942; Carter, 1953; Carter, 1958; Murray, 1961; and Cordwell, Wilson, & Lord, 1963). The lead-zinc mineralisation that was discovered and mined originally, occurs in the Urquhart Shale conforming to the bedding planes. The copper mineralisation occurs mainly in a different host rock, the 'silica-dolomites', described in detail by Murray (1961). Broadly, this consists of sheared, brecciated shale that has later been silicified or dolomitized or both. It is generally surrounded by Urquhart Shale and was almost certainly derived from it. The chalcopyrite 'silica-dolomite' orebodies are separate from the lead-zinc orebodies although they occur close together, and in many cases are associated with the same shear zones.

The area of outcrop of the Mount Isa Group is a wide flat valley. The more resistant rocks on each side form hilly country, which in some cases (particularly in the Judenan Beds) is so rough as to necessitate terrain corrections.

3. METHODS AND REDUCTION

A Sharpe gravity meter (No. 145) was used for the gravity field work during 1963 and a Worden meter (No. 140) during 1964. Both instruments were satisfactory and showed reasonable drift throughout the survey. The Worden meter generally had a steeper drift than the Sharpe but both were regular and the errors caused by drift should be negligible. Both gravity meters were calibrated during the field season. The Sharpe meter was calibrated in Melbourne in April 1963 and at Townsville, Brisbane, and Sydney in November 1963, and the Worden was calibrated at Brisbane in August 1964 and Melbourne in October 1964.

The six detailed traverses were in the form of three pairs of parallel lines about 200 feet apart. Each pair of lines was connected by gravity measurements at both ends and at intermediate points to form closed loops. Observation points along the traverses were 100 feet apart even over very rugged terrain on the sides of the valley. The later extensions were surveyed to measure the regional gravity effects and were surveyed with station separations of 500 feet (Traverse B South, 1W to 14W) and 2000 feet.

The traverses were referred to as A Main, A South, B Main, B South etc., where A, B, and C refer to the three areas. As the lines were severl miles long it was found inconvenient to use one base for the whole of each set of traverses. To overcome this, bases were set up approximately every 1500 feet in the following manner. Starting at A1 the reading sequence would be A1, A2,...A14, A15, A1, A15, A16...A29, A30, A15, A30..... In this way, every fifteenth station became a base and the two lines, A Main and A South, formed a closed loop. In the more rugged parts of the traverses the spacing of bases was varied depending on accessibility, and where a larger station separation was used (500 feet or 2000 feet) every fifth station became a base. Generally it was possible to read the instrument at a base approximately every hour.

When extended, Traverses B and C crossed Eastern Creek Volcanics on both sides of the valley, but the extensions to Traverse A did not achieve this. Rock samples and drill cores were collected and described by G.C. Battey and W.D. Smith, geologists of Mount Isa Mines Ltd, who also assisted in the interpretation of the results by mapping and preparing geological sections along the traverses. Measurements have been made of the densities of the rock samples (Table 1) and these densities have been used in the interpretation.

The gravity results were reduced in the standard way, correcting for drift, elevation, latitude, and terrain. As the three pairs of traverses were tied in to each other, a central point (120 on Traverse B Main) was used as the gravity datum for the whole area and all latitude corrections were made relative to this point, using the international formula. The elevation correction contained both the free-air correction and the Bouguer correction. Results were reduced to a datum of 1200 feet above sea level, which is approximately the level of the lowest stations. A density of 2.5 g/cm^3 was used in the Bouguer correction as this was probably close to the average density of all rocks (weathered and unweathered) above 1200 feet.

Finally, a 'two-dimensional' terrain correction was applied in the more rugged parts of the area. This correction is an approximation based on the assumption that all topographic features are elongated perpendicular to the gravity traverses and can therefore be considered as infinite prisms. Generally, this condition is satisfied in the Mount Isa area, but many topographical features cannot be accounted for in this way and their effects have not been properly corrected. Without much more extensive mapping and accurate levelling throughout the area, the more correct three-dimensional terrain corrections (e.g. Hammer, 1939) cannot be made.

The 'two-dimensional' terrain corrections illustrated by Hubbert (1948) were computed in this case by a mechanical integrator (Olbrich, 1966) normally used for computing vertical sections. The levels of the gravity stations were used to draw topographical sections on a natural scale (1inch = 100 feet horizontally and vertically). These sections were then traced by the integrator, and terrain corrections as large as 1 milligal were obtained. Generally, the terrain corrections tended to smooth out the irregular parts of the gravity profiles and raise their average level. The terrain corrections are important only in limited areas (e.g. in areas where the Judenan Beds drop out) and do not seriously affect the flat parts of the traverses crossing the mineralisation, so they have no serious effect on the interpretation of the gravity results.

TABLE 1

Densities of rock samples from the Mount Isa area

Rock type	Average density of weathered samples	No. of Samples	Average density of unweathered samples	No. of Samples
Magazine Shale	2.39	7	2.68	3
Spear Kennedy Siltstone	2.67	6	2.74	9
Urquhart Shale	2.26	10	2.81	10
Native Bee Siltstone	2.56	5	2.79	10
Breakaway Shale	2.40	8	2.61	5
Moondarra Siltstone	2.80	5		
Black carbonaceous shale from boreholes PE36 & P29S	PE36 P29S		2.68 2.77	6 4
Judenan Beds	2.64	9		
Myally Beds	2.49	6		
Sybella Granite	2.61	6		
Kalkadoon Granite	2.62	7		
Schist (mapped as Kalkadoon Granite on Traverse C)	2.94 (Not representative of Kalkadoon Granite)	3		
Mount Guide Quartzite	2.62	5		
Silica-dolomite (density varies widely with sulphide content)			2.91	11
Eastern Creek Volcanics	2.92	10	2.85	10
	Samples probably contain basic intrusions. Samples collected at the surface, east and west of Mount Isa. Weathering is apparently very slight.		Samples from boreholes near mineralised 'silica-dolomites' excluding some shallow samples that appeared silicified.	

The regional extensions to the gravity traverses were not corrected for terrain effect. Stations were chosen to avoid rugged terrain as far as possible and any remaining terrain effects were expected to be insignificant.

The final gravity results, corrected for drift, latitude, elevation, and terrain were plotted as profiles on two different scales (1 inch = 4000 feet and 1000 feet horizontally and 1 inch = 2 milligals and 0.5 milligal vertically) for interpretation. The detailed gravity traverses were read in pairs to check that variations along the strike were small. As the results showed that this was so, only one gravity profile from each pair is included in this record.

The co-ordinates shown on the geological map (Plate 2) and used on the gravity profiles are local Mount Isa co-ordinates. These have been used throughout for consistency. The relation between the Mount Isa meridian and the true meridian is shown in Plate 2, where the 139°30' meridian has been inserted.

4. INTERPRETATION

The initial interpretation of the gravity results was carried out on the small scale (1 inch = 4000 feet and 1 inch = 2 milligals) profiles (see Plates 3, 5, and 7) using the geology as shown in Plate 1 as a starting point. Geological sections were drawn along Traverses B and C, incorporating only the major features (e.g. the Mount Isa Group was not split into its individual components). These sections were drawn from the western boundary of the Sybella Granite to the eastern boundary of the Kalkadoon Granite and extend to a depth of 20,000 feet.

Any changes in rock density beyond the eastern and western margins of these sections can safely be ignored as their contribution to the observed gravity would be insignificant. Lateral changes in rock density below 20,000 feet could cause significant changes in the observed gravity but, as this section is only meant to show one possible interpretation, there seems little point in trying to draw the section any deeper than 20,000 feet.

The anomalies due to these theoretical sections were computed on the mechanical integrator and compared with the observed gravity profiles. The method of computation using this integrator assumes that all geological features are infinitely long in a direction perpendicular to the section; however, this is not always a good approximation. The six surveyed traverses were approximately perpendicular to the general strike of the area and most of the formations involved were long enough to approximate to infinite prisms. The few cases where this condition is not satisfied will be mentioned later and the errors introduced will be taken into consideration.

After comparison of the calculated and observed gravity profiles, several modifications were made to the shape of the sections and to the rock densities involved. As Traverses B and C were close together and crossed a similar sequence of beds, care was taken to ensure that the densities, dips, and general features of the geological cross-section used on Traverse B were consistent with those used on Traverse C. As discussed later, a similar process could not be applied to Traverse A.

The densities used in the interpretation are not generally the actual determinations and some explanation is necessary. No fresh samples of Sybella Granite or Kalkadoon Granite were available but the densities of the samples suggest that the Kalkadoon Granite has a higher density than the Sybella Granite. This is consistent with the composition, as the Kalkadoon Granite is mainly a granodiorite and therefore should be more dense than the

Sybella Granite, which has a normal granite composition (Carter, et al., 1961). A density of 2.70 g/cm^3 has been assigned to the Sybella Granite on Traverse B as this should be a typical value for a granite; a density of 2.80 g/cm^3 has been used for the Kalkadoon Granite and this value gives an acceptable agreement between the observed and the computed Bouguer anomaly profile on Traverse C.

No samples of unweathered Mount Guide Quartzite could be obtained but samples of relatively fresh material were collected on the surface. The mean of five density measurements gave a value of 2.62 g/cm^3 and, allowing for some slight decrease of density owing to weathering, a value of 2.70 g/cm^3 was used in the calculations. A comparison of observed and calculated profiles on Traverse B suggests that a slightly higher density might give a better agreement.

Several samples of unweathered Eastern Greek Volcanics have been obtained from boreholes, and density measurements have been made on them. All of the boreholes were in the mineralised area in the Mount Isa Group but they all bottomed in 'greenstone', which is presumed to be Eastern Creek Volcanics. The mean of ten density measurements gives a value of 2.85 g/cm^3, which has been used in the detailed sections. The large mass of Eastern Creek Volcanics east of Mount Isa contains several basic intrusions of dolerite and micro gabbro (probable density about 3.0 g/cm^3) and frequent conformable beds of Lena Quartzite (probable density about 2.70 g/cm^3). Some samples of slightly weathered material collected on the surface have had densities as high as 3.1 g/cm^3. Because of these variations in composition it is very difficult to estimate the average density of the Eastern Creek Volcanics from density determinations of isolated samples. From a consideration of the measured values and a rough visual estimate of the average composition, it seems likely that the average density lies between 2.85 and 2.95 g/cm^3. A density of 2.90 g/cm^3 was used in the computed sections and this seems to give a satisfactory agreement. The Eastern Creek Volcanics west of Mount Isa are more highly metamorphosed and the surface is quite weathered. No fresh samples were obtainable, so a density of 2.90 g/cm^3 was used as in the eastern part of the formation.

A density of 2.75 g/cm^3 has been used for the Mount Isa Group in the regional section. This value is close to the mean of the densities of the components of the Group obtained by measurements on a wide range of samples. The wide range of values obtained, even for a certain shale or siltstone (components of the Mount Isa Group), owing to the different compositions and weathering characteristics of individual beds, makes the estimation of an average density difficult and the final result can only be regarded as approximate. The density value chosen, 2.75 g/cm^3 is consistent with the results of the density determinations carried out on the samples, the geological descriptions supplied by Battey (1963), and the observed gravity profile.

The Judenan Beds have been assigned the same density as the Mount Isa Group (2.75 g/cm^3) on Traverse C, but a slightly lower density (2.73 g/cm^3) on Traverse B. No unweathered samples were available for density determinations, but the composition suggests a density similar to that of the Mount Isa Group. The difference between the densities used on Traverses B and C was necessary in order to get a reasonable fit with the assumed geological configuration. Such a difference in density can easily be explained by slight variations in composition. In any case, the large terrain effects in the Judenan Beds introduce errors that cannot be completely accounted for, and a perfect fit is unlikely.

There is no information available on the density of the undifferentiated schist between the Eastern Creek Volcanics and the Sybella Granite on Traverse B. The undifferentiated schist has been given the same density as the Eastern Creek Volcanics (2.90 g/cm^3).

The Sybella Granite has been assigned a density of 2.72 g/cm^3 on Traverse C compared with 2.70 g/cm^3 on Traverse B. This difference was necessary in order to get a reasonable agreement between calculated and observed gravity profiles. Such a difference in density is quite possible within the granite.

The geological section on Traverse B (Plate 3) is considered first. Both the Sybella and Kalkadoon Granites are considered to be large batholiths whose width increases with depth. In the absence of any evidence to the contrary, this seems a reasonable supposition and, in any case, variations in dip of the sides of the batholith would need to be pronounced before they became important. The Mount Isa Group, Eastern Creek Volcanics, and Mount Guide Quartzite all have regular dips to the west; these dips have been observed in many places and have been continued down to 20,000 feet. West of the Mount Isa Fault, it has been assumed that the Eastern Creek Volcanics extend under the Judenan Beds, as the Judenan Beds are considered to be overturned (Carter et al, 1961 p.188). The undifferentiated schist bounded by the Eastern Creek Volcanics and the Sybella Granite is not an important component and no information on it other than surface mapping is available. Drilling has shown the presence of greenstone (probably Eastern Creek Volcanics) at a depth of approximately 2000 feet in the Mount Isa Group (suspected to be a faulted continuation of the Native Bee - Crystallena Block), but in order to get reasonable agreement between calculated and observed gravity, it is necessary to assume that this is an isolated block and it has been entirely omitted from the regional geological picture. The Native-Bee - Crystallena Block is discussed in detail by Cordwell, Wilson, and Lord (1963).

Plate 5 illustrates the effect of a block of Eastern Creek Volcanics similar to the one that exists on Traverse B. There is an appreciable density contrast (0.15 g/cm^3) between the Mount Isa Group and the Eastern Creek Volcanics and this presumably extends downwards several thousand feet to a depth (H) where this density contrast disappears. This depth (H) has been varied and the resulting gravity profiles have been computed.

The computed gravity profiles illustrated in Plate 5 show that H must be approximately 20,000 feet if the density contrast is 0.15 g/cm^3. Even if the density contrast were increased to 0.20 g/cm^3 (an extreme geological possibility), H would still need to be nearly 10,000 feet to produce the observed gravity profile. At about 4000E, greenstone, apparently Eastern Creek Volcanics, has been detected by drilling at a depth of approximately 2000 feet. As it has just been shown that the Eastern Creek Volcanics must plunge deeper than 2000 feet, the body detected below 4000E is either an isolated block or connected, at a depth of at least 10,000 feet, with the large mass of Eastern Creek Volcanics that crops out at 15,000E. If the body below 4000E were connected at depth, it would be a large mass itself and would significantly affect the gravity profile. It therefore seems probable that the greenstone detected at 4000E is part of an isolated block, not connected with the main Eastern Creek Volcanics, although possibly derived from it. This is in accordance with the ideas presented by Cordwell et al (1963) from a study of the geology of the area.

The regional geological section on Traverse C (Plate 6) was constructed similarly but with a few differences in the width of the formations. On the eastern end of Traverse C, 'two-dimensional' assumptions are not correct (see Plate 2) and good agreement between the observed and calculated profiles cannot be expected. The depth of the Judenan Beds assumed in this section is much less than that for Traverse B. This difference was necessary in order to get agreement between calculated and observed profiles, but there is no other evidence to support it. The presence of a block of Eastern Creek Volcanics in the Mount Isa Group has been omitted from this section as for the section on Traverse B, It is considered to be an isolated block of relatively small dimensions and it is sufficient to introduce it in the detailed section.

Plates 3 and 6 compare observed and calculated gravity values on Traverses B and C and show generally a good agreement except for a few discrepancies, particularly near the ends of the traverses, where the geological information is less detailed. The discrepancy at the eastern end of Traverse C is to be expected as the area mapped as Kalkadoon Granite is known to include other rock types and the 'two-dimensional' simplification is not strictly satisfied.

After reasonable agreement was obtained on the regional profiles, the centre portion of each was studied in detail. On Traverse B, a rectangular block extending from 3000W to 15,000E and 7000 feet deep, and on Traverse C, a rectangular block extending from 2100W to 11,900E and 10,600 feet deep were expanded and drawn in greater detail. The individual components of the Mount Isa Group were separated and a block of Eastern Creek Volcanics was added to each cross-section. These sections were then used to compute a more detailed gravity profile (using the mechanical integrator), the regional gradient being taken from the calculated regional profiles (Plates 3 and 6). The results were plotted on a scale of 1 inch = 0.5 milligal and 1 inch = 1000 feet (Plates 4 and 7).

Plate 4 shows the central portion of the observed gravity profile on Traverse B compared with a calculated profile obtained using the cross-section shown. The geology known or inferred from surface mapping and boreholes is also illustrated. This shows how much of the cross-section is based on observations. The rest is unsupported and represents only one of many possible interpretations. None of the boreholes shown was drilled on the traverse and all the subsurface information has been projected (up to 2700 feet) on to the traverse.

The agreement between the observed and calculated gravity profiles on Traverse B is not good near the ends of the detailed part of the traverse, but the main trends are consistent. The fit can easily be improved by further work by modifying the density or shape of the Judenan Beds, Breakaway Shale, and possibley the Eastern Creek Volcanics. The section has been left in its present form for consistency with Traverse C. Without more detailed geological mapping and density sampling outside the mineralised area, it seems pointless to try to get a perfect fit.

There are three main negative anomalies on the observed gravity profile - at station numbers 70S, 111S, and 193S. These anomalies are all steep sided and are therefore caused by near-surface features. The first anomaly, at station 70S, coincides with the distortion of the Magazine Shale and the Kennedy Fault (Plate 2). The Magazine Shale (density 2.60 g/cm^3) has evidently been drag-folded by strike movement on the Mount Isa Fault (Cordwell et al, 1963), near Traverse B; the strike of the Shale is irregular and the approximation to an infinite prism is certainly not satisfied as there is no Magazine Shale south of Traverse B. It has been considered sufficient to correlate this anomaly with the Magazine Shale and Kennedy Fault and no quantitative interpretation has been done on it.

The second anomaly, at 111S, occurs in the Urquhart Shale (density 2.80g/cm^3) over known mineralisation. 'Silica-dolomite' with disseminated sulphides has been detected in several boreholes (e.g., P29 South) approximately 1500 feet down-dip from the anomaly. If the 'silica-dolomite', with its sheared, brecciated, and folded zones (Murray, 1961) reaches close enough to the surface to be affected by oxidation and leaching, these processes could be responsible for the anomaly. It seems possible, particularly since sulphides are present, that leaching of the 'silica-dolomite' body could produce a low density mass extending down from the surface to the enriched zone. Such a mass, in an idealized form, has been sketched on the cross-section in Plate 4, and the anomaly due to it has been calculated and plotted on the gravity profile using a density contrast of 0.3 g/cm^3 between the leached zone and the surrounding shale.

Depth calculations have been made on this anomaly using the method described by Skeels (1963). If the body causing the anomaly is assumed to be an infinite rectangular prism with a density contrast of 0.3 g/cm^3, the maximum depth to the top of the prism is approximately 10 feet. If the density contrast is increased to 0.5g/cm^3, the depth to the top of the prism is increased to 50 feet. In any case, it is clear from the observed profile that the cause of the anomaly is a large mass of unusually low density close to the surface. If this is a leached zone connected with mineralisation, it can easily be traced with a gravitymeter, and the results would help in the search for copper.

The third anomaly, at point 193S, is not connected with any known mineralisation and its cause is unknown. It occurs in the Moondarra Siltstone and is also a near-surface feature. Possibly, a bed or a series of beds has weathered much more readily than its neighbours for some reason as yet unknown. The possibility of mineralised 'silica-dolomite' similar to that detected by boreholes in the Urquhart Shale cannot be discounted.

Plate 7 illustrates similar work carried out on Traverse C, which lies very close to the southern edge of the Native Bee - Crystallena Block of the Eastern Creek Volcanics. Unfortunately the proximity of this Block affects the observed gravity significantly and the computations (which assume 'two-dimensional' conditions cannot take it into account. A more detailed picture of the complex fault pattern near the southern end of the Block is given by Cordwell et al (1963) and this picture was used in the construction of the cross-section.

The cross-section was constructed by simply continuing the geological contacts mapped at the surface downwards with a constant dip. The position of the top of the block of Eastern Creek Volcanics was guided partly by the dip of the Native Bee Fault (Cordwell et al, 1963). The bottom of the block could be quite shallow, as on Traverse B, because the effect of the outcropping volcanics to the north, which has not been taken into account, would raise the computed gravity values considerably. In the absence of a simple method to account for the effect of the outcropping block, a deep block beneath Traverse C has been used in order to improve the agreement with observed gravity. The position of the faults, their dip, and movement have been deduced from the geological cross-section supplied by Mount Isa Mines Ltd and also from a geological plan of the area (Cordwell, et al, 1963, figure 4).

The computed profile does not agree well with the observed profile in detail, but once again the main trends are followed reasonably well. The two peaks at stations 55S and 70S are probably connected with the Native Bee-Crystallena Block of Eastern Creek Volcanics that crops out immediately north of the traverse. The three, steep-sided, gravity 'lows' centred at stations 28S, 63S, and 87S are the major features of this profile. The 'lows' coincide with three outcrops of Native Bee Siltstone repeated by faulting, and their steep sides indicate that the sources lie close to the surface. At least one borehole (Biotite No. 2 DDH) has detected copper mineralisation in the Native Bee Siltstone, 200 feet south of the traverse and close to the gravity 'low' at station 63S. These steep-sided gravity 'lows' seem to characterise mineralised 'silica-dolomite' as a similar 'low' was observed near station 111S on Traverse B (described earlier) over mineralised Urquhart Shale, but not over the Native Bee Siltstone on Traverse B, which is not expected to be mineralised. Since the three gravity 'lows' on Traverse C are all over Native Bee Siltstone it is likely that they have a common cause, possibly leaching in mineralised 'silica-dolomite'. It has not yet been established that preferential leaching in mineralised 'silica-dolomite' causes such anomalies, and deep weathering could simply be typical of the Native Bee Siltstone on Traverse C. Of the four gravity depressions studied (one on Traverse B and three on Traverse C), two are known to be over mineralisation and the other two are over similar formations that could be mineralised. Further work, particularly the drilling of the mineralised 'silica-dolomite' on Traverse B, should help to show definitely whether the gravity depressions correspond with leached zones.

Three low density bodies similar to the one postulated on Traverse B have been drawn on Traverse C and the resulting anomalies have been computed and illustrated. Using low density masses that start from the surface and extend down with a density contrast of 0.4 g/cm^3, it is difficult to obtain sufficiently steep sides. This could be overcome by using a higher density contrast and smaller masses or a group of narrow low density beds alternating with normal Native Bee Siltstone. The aim of the computations was to show that such a leached body with the density contrast shown could cause the observed anomalies, and there seems little point in spending more time to obtain a perfect fit.

Traverse A was originally short but was subsequently extended with 2000-ft spacing between observation points. The presence of several faulted blocks of Eastern Creek Volcanics close to the traverse makes the use of the mechanical integrator impractical as the 'two-dimensional' approxmation breaks down badly. Profiles (Plates 8 & 9) have been drawn at the two scales used for Traverse B and Traverse C, but no attempt has been made to interpret them quantitatively.

Plate 8 shows some correlation between the geology and observed gravity. The steep negative anomaly at about station 20 coincides with a steep hill and rugged terrain in the Judenan Beds. The terrain is not properly accounted for by a 'two-dimensional' cross-section and the terrain corrections applied are therefore inadequate. It seems likely that the relatively weak anomaly can be accounted for in this way and it is not regarded as very important.

The main depression centred about station 53 is in the Mount Isa Group and appears similar to the negative anomalies found on Traverses B and C. It is better illustrated on the larger scale (Plate 9) and will be discussed later.

The gravity 'high' near the centre of the traverse and the upward trend at the eastern end coincide with Eastern Creek Volcanics. The depression at about 24,000E coincides with the position of the Spillway Fault and is close to the mineralised "Stone Axe" area.

Plate 9 shows in greater detail the main gravity depression over the Urquhart Shale and Native Bee Siltstone. This depression is centred east of the known mineralisation and does not appear to be connected with it. The known mineralisation on Traverse A is lead and zinc, but that on Traverses B and C that coincides with gravity minima was copper. As there is no obvious cause for the gravity minimum on Traverse A, it is tempting to connect it with a mineralised zone (possibly copper) and its associated deeper leaching and weathering. If the gravity 'low' is due to a mineralised zone, it must lie east of the presently known deposits, probably in Native Bee Siltstone. The gravity depression is very pronounced and its steep sides indicate that the cause lies near the surface. It is similar to the anomalies observed on Traverse B and C and occurs in the same formations.

5. CONCLUSIONS AND RECOMMENDATIONS

The regional gravity profiles (Plates 3, 6, and 8) show a good correlation with the surface geology. This suggests that a more comprehensive gravity survey could be helpful in mapping the geology of the area. The complex structure and the apparent variations in density of the components of the Mount Isa Group make it difficult to map the Eastern Creek Volcanics beneath the surface but some useful information can be gained. For example, the greenstone detected by drilling near Traverse B is unlikely to extend at the same depth to where the Eastern Creek Volcanics crop out in the east.

The most interesting feature of the gravity results and possibly the most useful is the presence of the pronounced gravity depressions close to mineralised 'silica-dolomite'. This feature does not appear to be repeated over lead-zinc mineralisation, which does not occur in the 'silica-dolomite' bodies, gravity could be a very quick, economical, and efficient way to explore the district.

From the results of the present survey it appears that the usefulness of the gravity method for mapping the shale-greenstone boundary will be limited. The complicated structure and variable densities in the shale make it difficult to reach definite conclusions. The possibility of detecting mineralisation indirectly via leached, sheared zones seems promising. Comparison of future drilling results and results of other geophysical methods with the gravity profiles, should enable a firm conclusion to be drawn on the connection between the gravity depressions and mineralisation. If a connection can be established, further gravity work would be most useful and the results would be of immediate interest.

6. ACKNOWLEDGEMENTS

It is desired to acknowledge the ready assistance given by geologists of Mount Isa Mines Limited and the personal interest shown by the Chief Geologist, E.M. Bennett. In particular, G.C. Battey and W.D. Smith constructed geological sections along the traverses, supplied numerous rock samples with geological descriptions, and participated in many discussions, which were of great assistance in the gravity interpretation.

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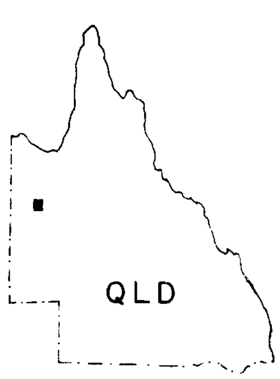


LEGEND

Lower Proterozoic:
- Mt Isa Group
- Judenan Beds
- Myally Beds
- Eastern Creek Volcanics
- Mount Guide Quartzite

- Sybella Granite
- Kalkadoon Granite
- Fault
- Geological boundary

Gravity traverses
- DETAILED
- REGIONAL

LOCALITY MAP AND REGIONAL GEOLOGY

(Geology after Carter, Brooks, & Walker, 1961)

MILES

4 0 4 8 12

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS **F54/B7-2**

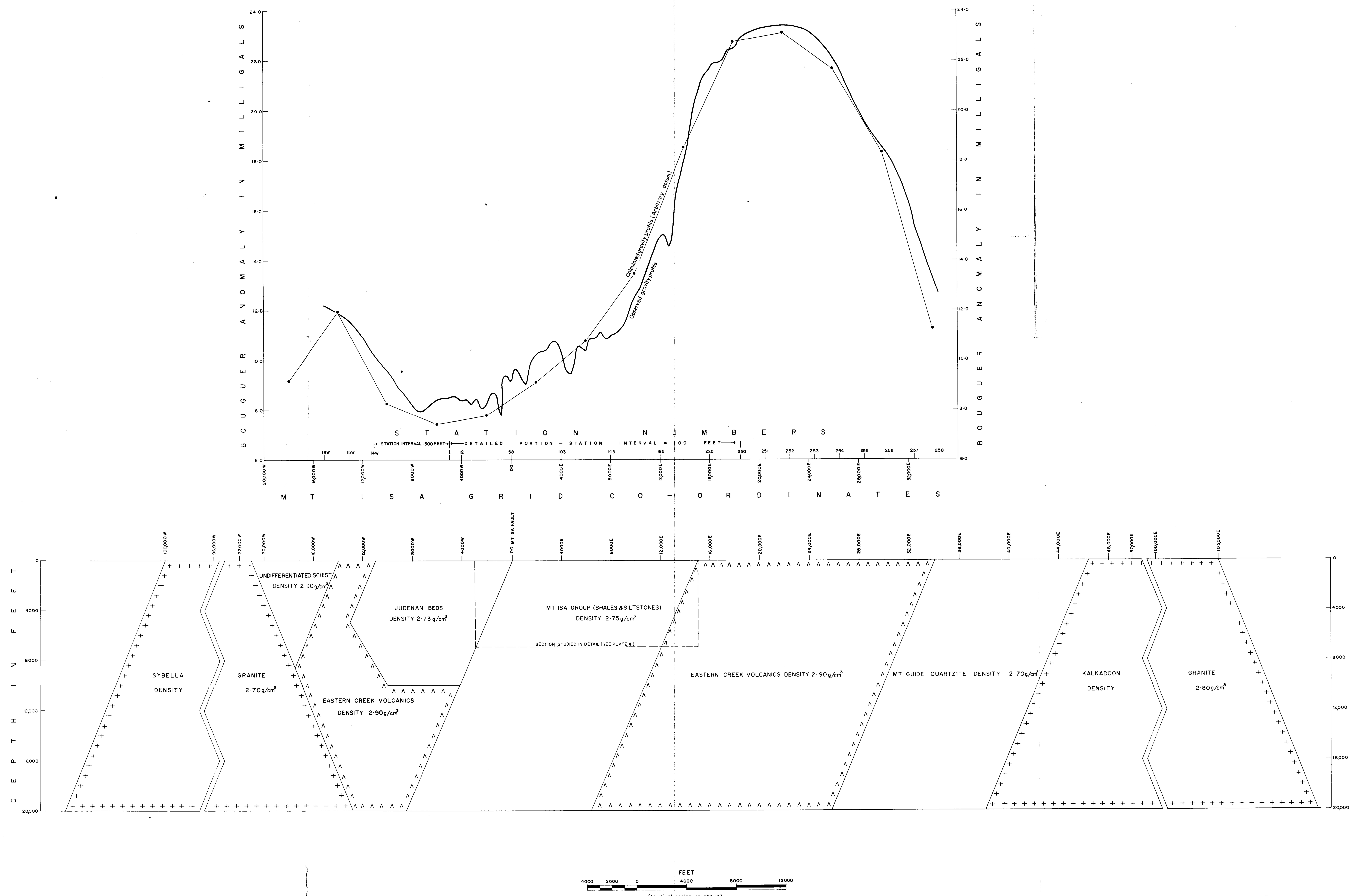
To Accompany Record No. 1966/50

PLATE 2

To Accompany Record No. 1966/50

F54/B7-4

PLATE 3



REGIONAL GRAVITY PROFILE, TRAVERSE B

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F54/B7-9

DETAILED GRAVITY, TRAVERSE B

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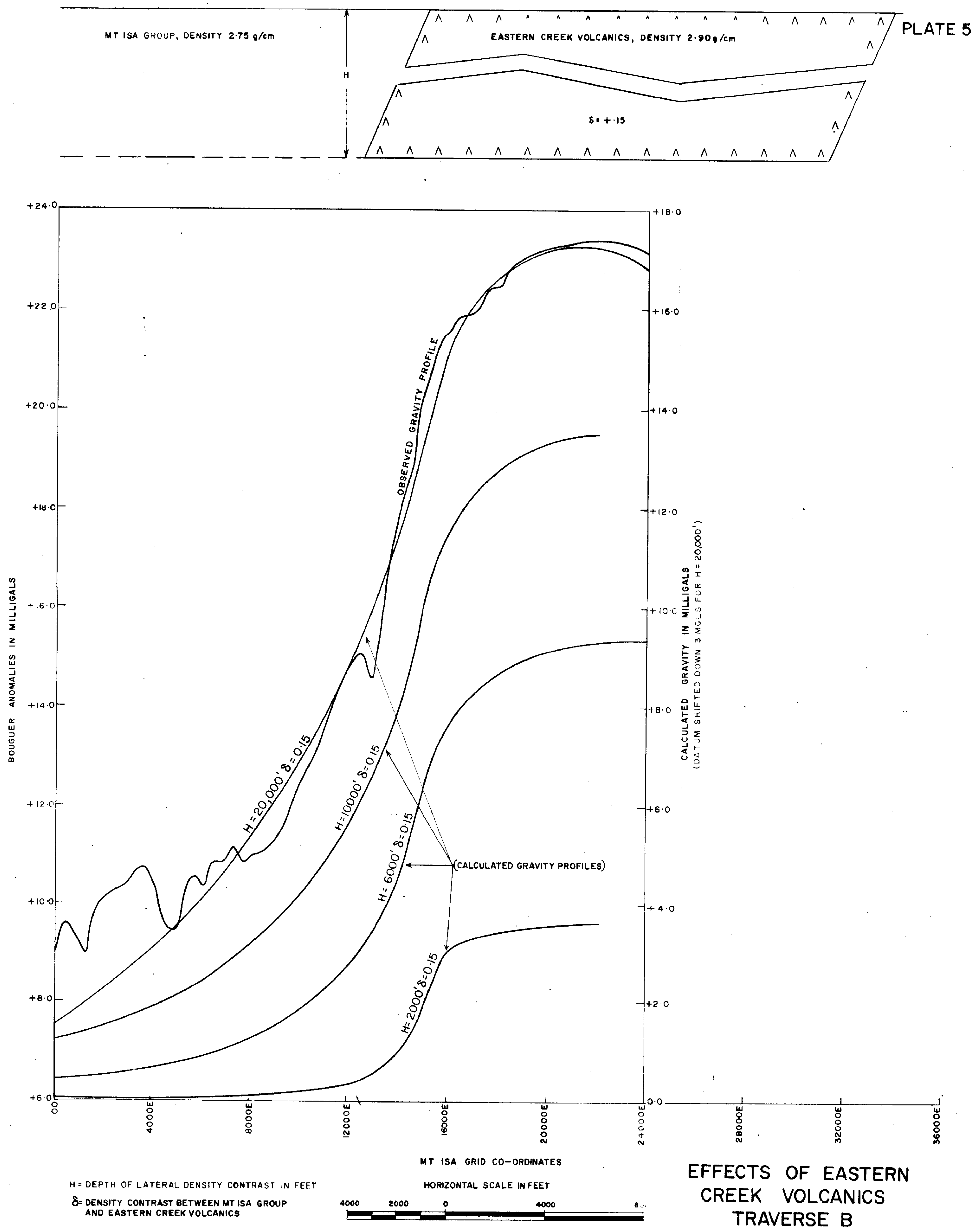
F54/B7-11



EFFECTS OF EASTERN CREEK VOLCANICS TRAVERSE B

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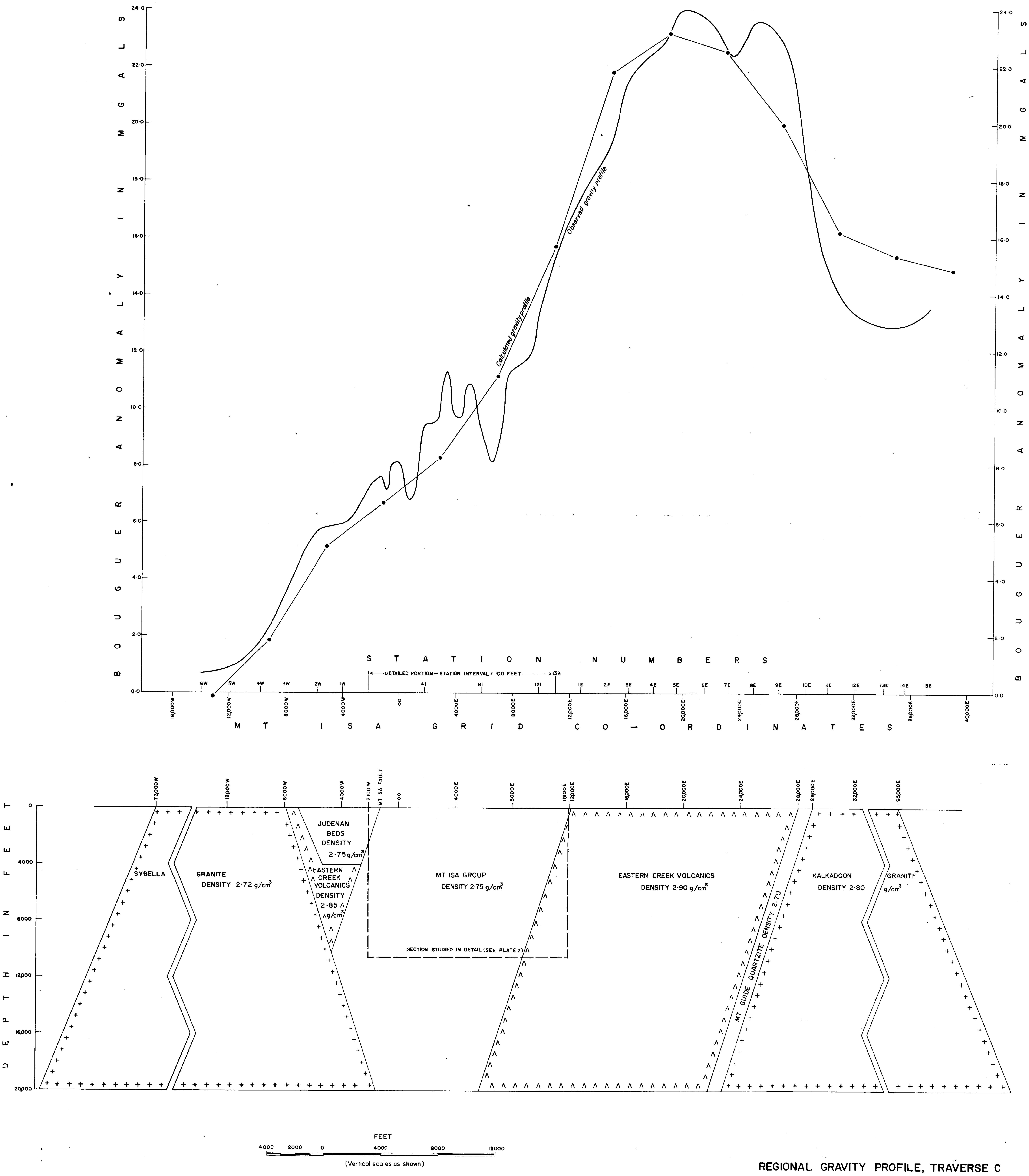
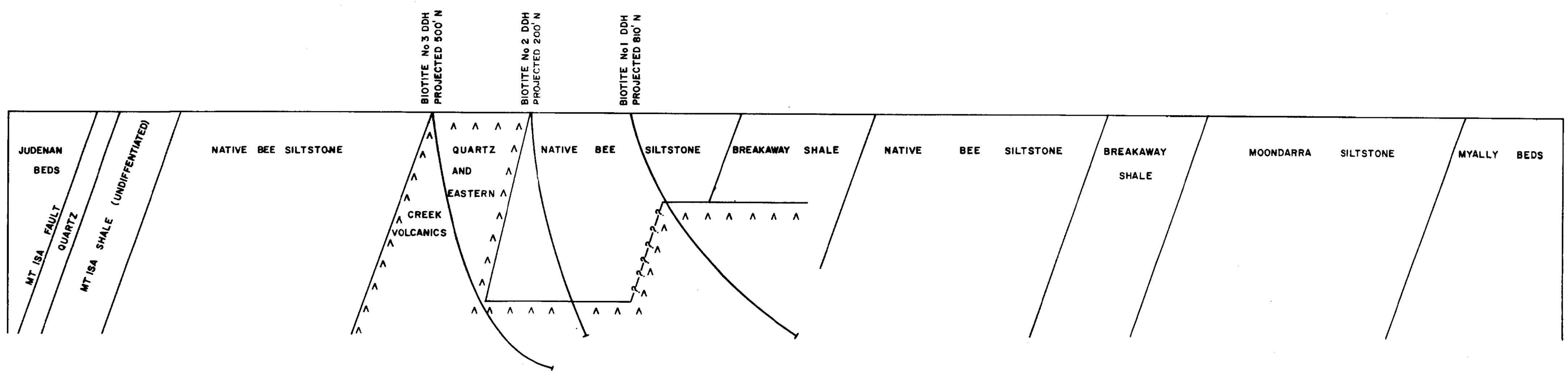
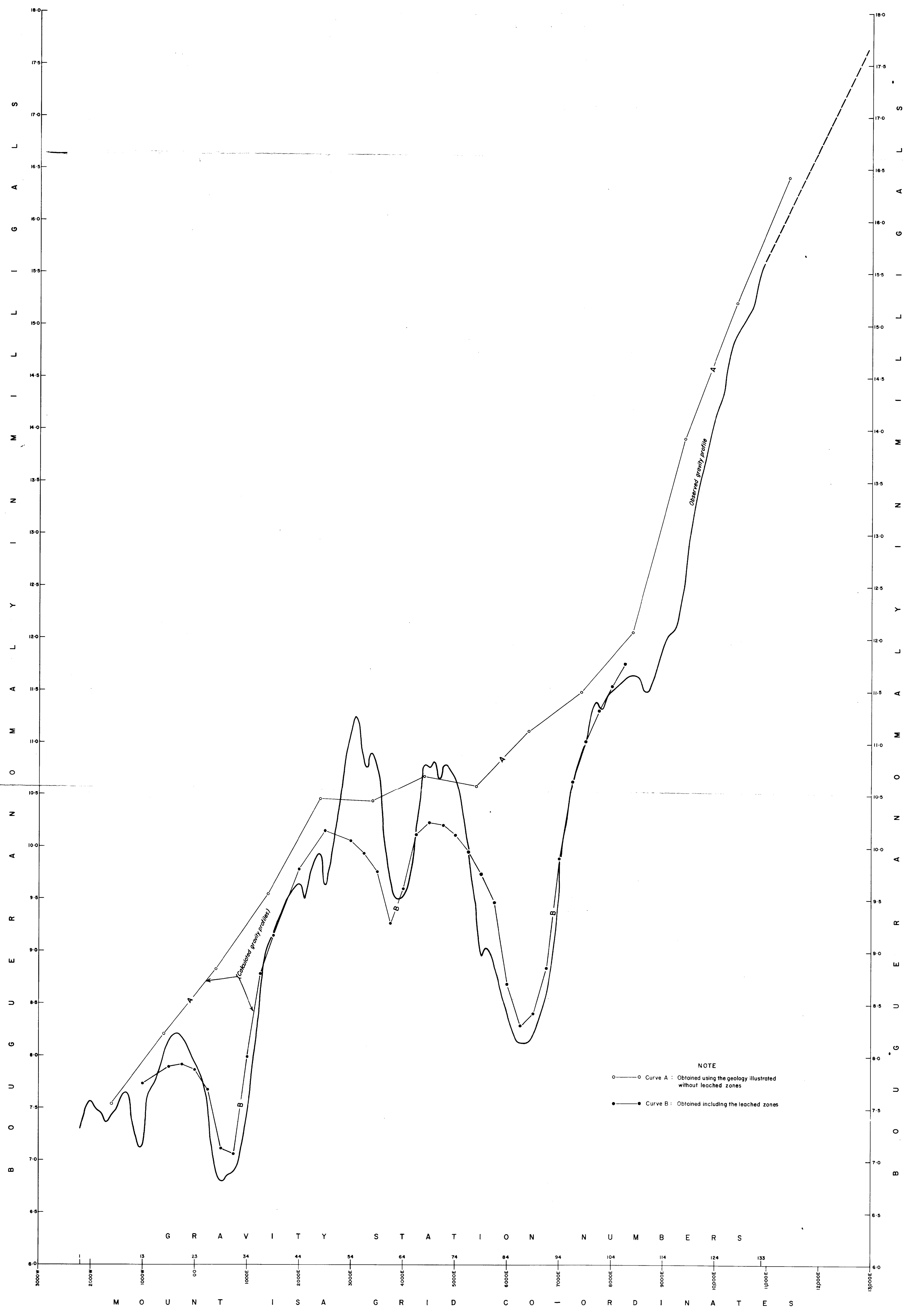
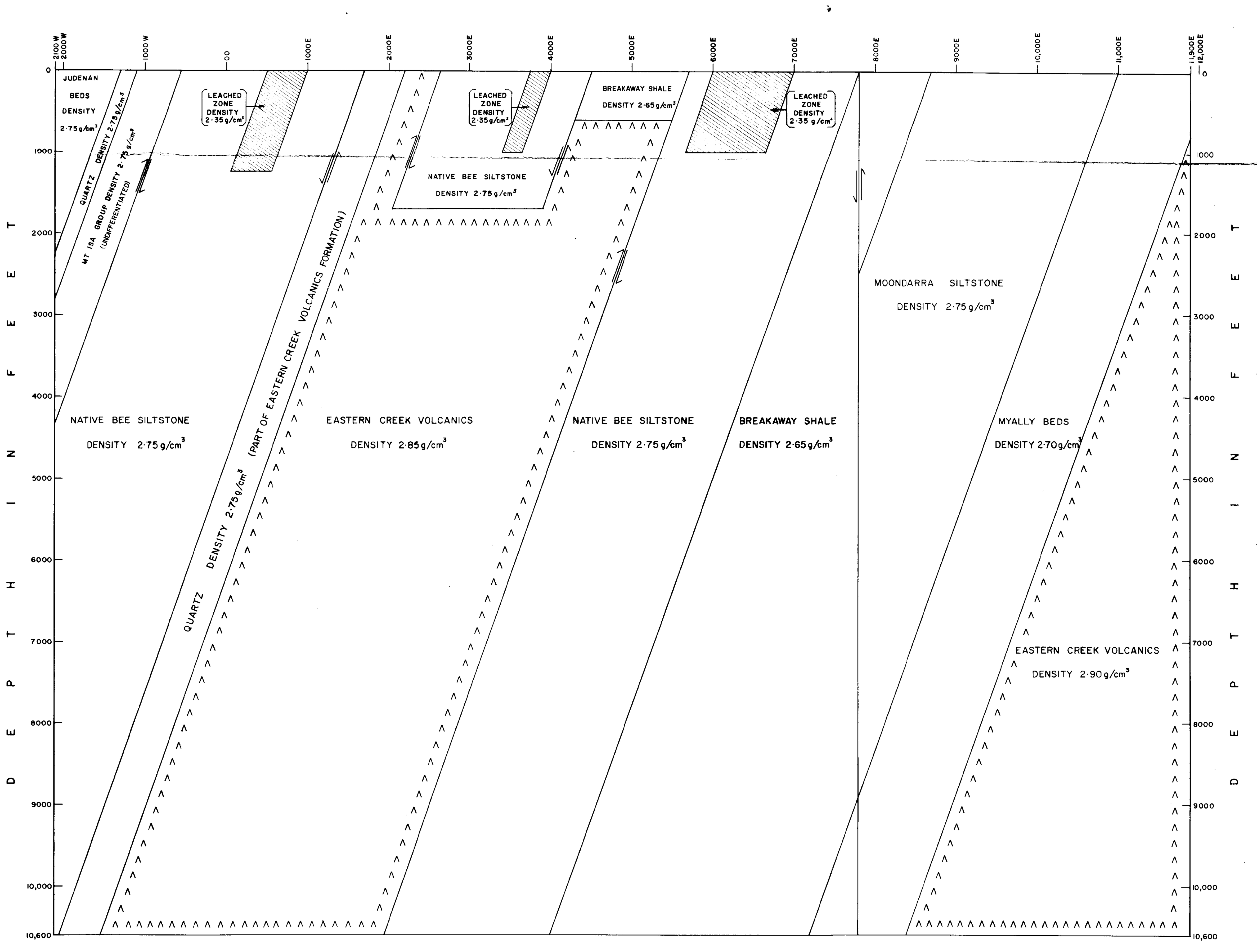


REGIONAL GRAVITY PROFILE, TRAVERSE C



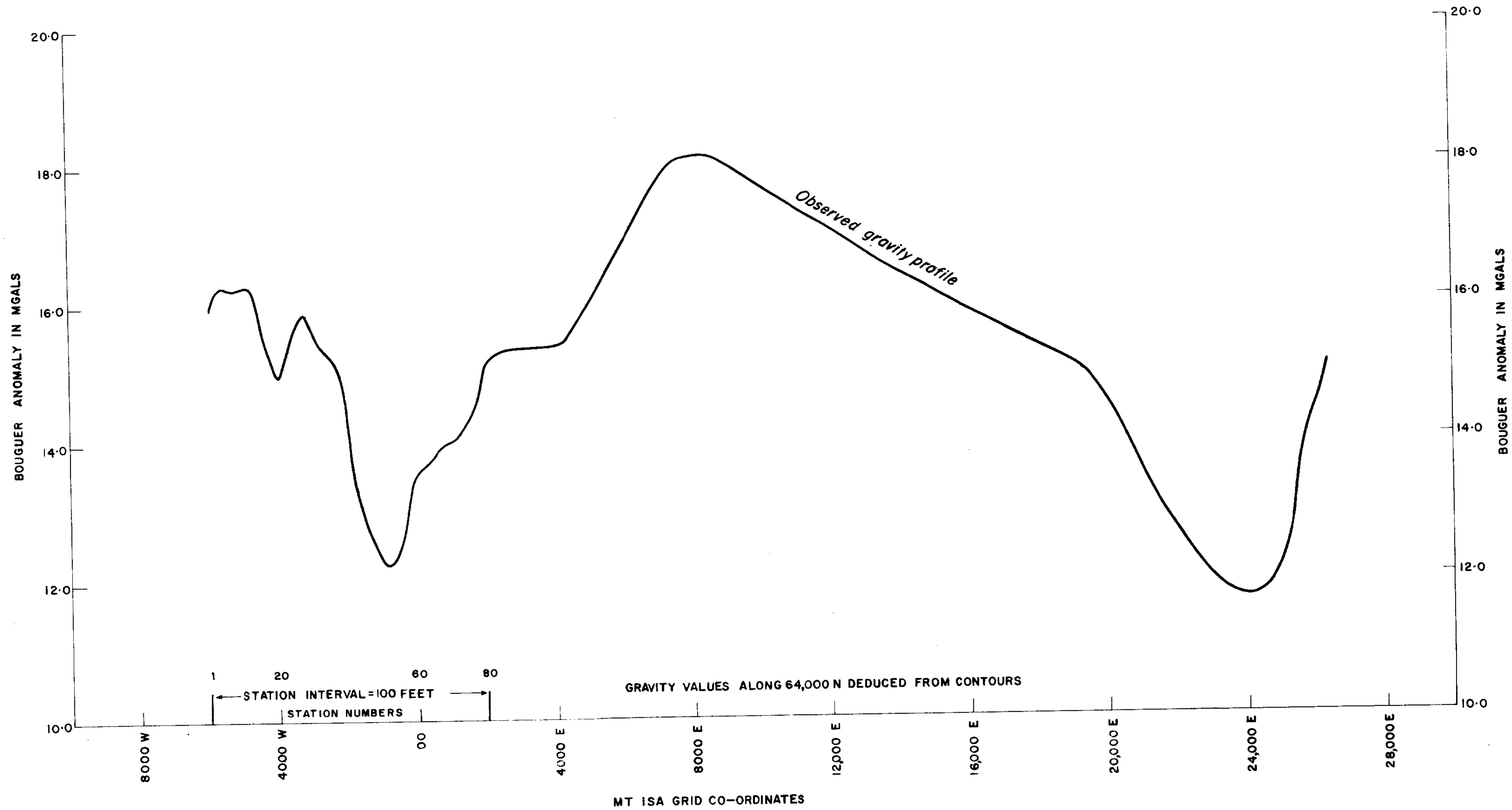
GEOLOGICAL SECTION FROM SURFACE MAPPING AND DRILLING



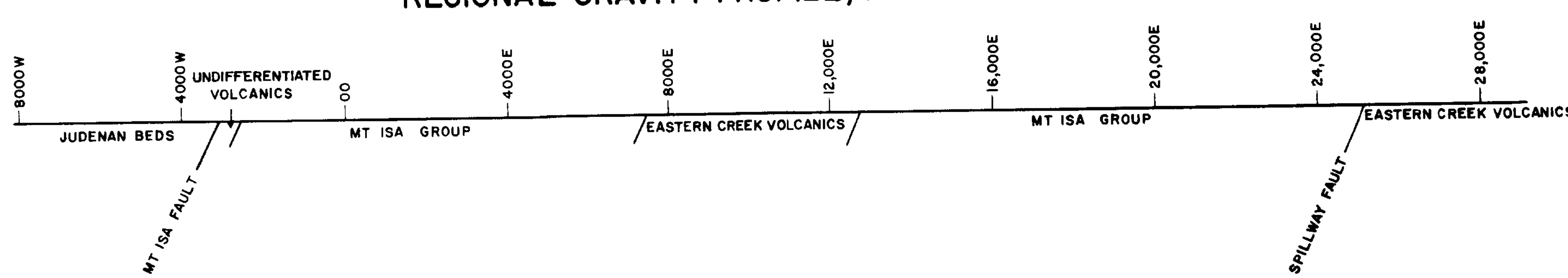


FEET
1000 0 1000 2000 3000
(VERTICAL SCALES AS SHOWN)

DETAILED GRAVITY, TRAVERSE C



REGIONAL GRAVITY PROFILE, TRAVERSE A



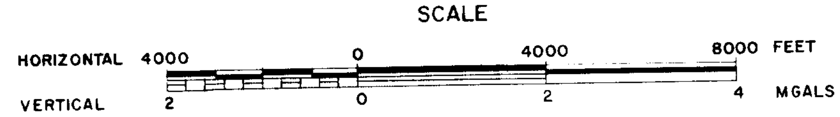
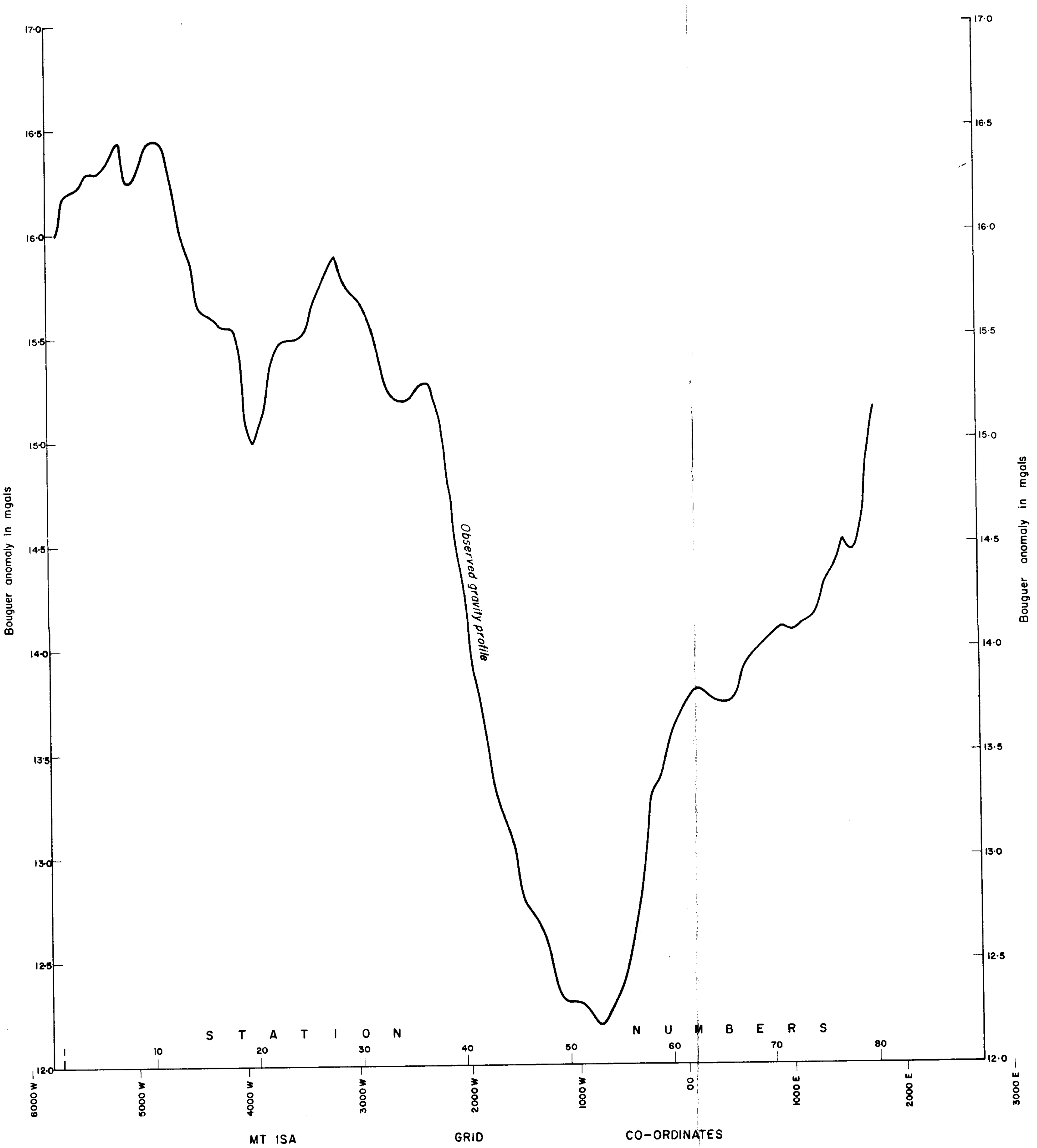
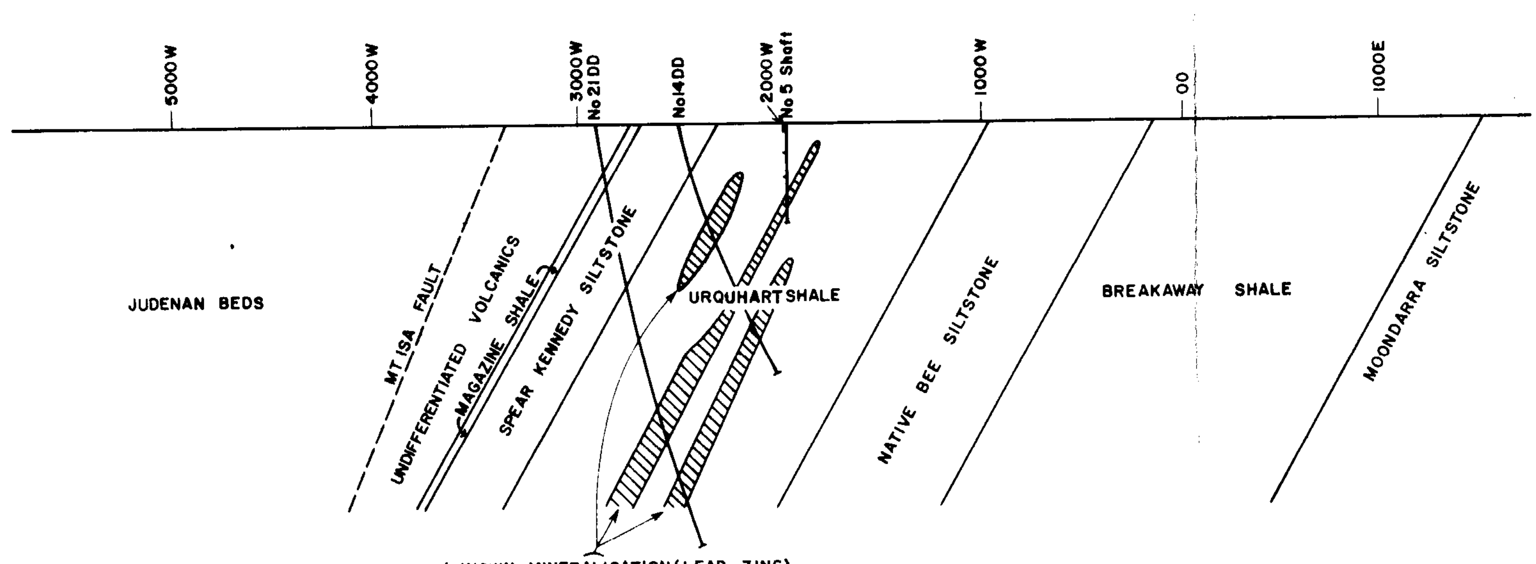


PLATE 9





NOTE

Bouguer anomaly profile plotted with stations 100' apart
MT ISA Co-ords projected onto section line

Geology after MT ISA Mines Ltd.

DETAILED GRAVITY, TRAVERSE A

SCALE

HORIZONTAL 1000 0 1000 2000 FEET
VERTICAL 0·5 0 0·5 1·0 MGALS

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F54/B7-7