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MELBOURNE AREA GRAVITY SURVEY, 1975

by

I. Zadoroznyj & P.J. Gunn*

* Formerly with the Geological Survey of Victoria, now with Australian Aquitaine Pty Ltd.

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CONTENTS

PLATES

SUMMARY

The Bureau of Mineral Resources carried out a detailed gravity survey of Melbourne and its surrounds in February and March 1975. Most of the 1247 gravity stations established on roads and tracks in the area are on an approximate 1.6 km grid, the remainder being at 300 or 480 m intervals on four detailed traverses. Rock samples, for density measurements to assist in the interpretation, were collected and processed by the Geological Survey of Victoria.

The western part of the survey area is dominated by a strong gravity low attributed to a large granite body. The low has strong gradients on two flanks, one corresponding with the Rowsley Fault and the other with the course of the Werribee River. A ridge within the low indicates a denser rock or structure within the granite. Smaller lows in the north of the survey area can be associated with the Bulla and Morang Granites.

A monocline complementary to the Beaumaris Monocline is weakly suggested in the gravity data. Between these features is a fairly pronounced gravity high, indicating a body of dense rocks of unknown composition. The gradient along the line of the postulated Anonyma Flexure supports the existence of this structural feature.

The sediment-filled valley along the Patterson River outlined by earlier gravity work was confirmed by the new data. The positions of basalt-filled valleys have been weakly indicated. Small isolated gravity highs have been attributed to igneous centres. A gravity high corresponds with the hill of basalt due to the Mount Cotteril volcanic centre. Small lows are attributed to sedimentary troughs. One such low may be due to a thicker coal seam.

The detailed profiles across the basalt showed many small anomalies which may be due to local variations in basalt thickness or composition.

INTRODUCTION

The Bureau of Mineral Resources (BMR) made a gravity survey of the Melbourne metropolitan and surrounding areas, extending to Frankston in the southeast, Bacchus Marsh in the west, and as far as the northern outskirts of Geelong in the southwest (Pl. 1), between 10 February and 27 March 1975. The survey was made at the request of the Geological Survey of Victoria (GSV) to assist generally in defining the near-surface structure of the area, and particularly in groundwater studies.

The survey party used cars for transport to establish 1247 new gravity stations; 467 were barometrically levelled and the remainder were at optically levelled benchmarks. Most stations were on a grid with the spacing between stations approximately 1.6 km; however, stations were read on some detailed traverses with 300 or 480 m between stations. In the western part of the survey area, gaps in the coverage were caused by difficulties in negotiating wet tracks. Some stations were established on the shores of Port Phillip Bay.

The main part of the survey was made in the built-up suburbs around Melbourne; open country was encountered at the extremities of the suburbs and generally in the western part of the survey area. The terrain was generally flat to gently undulating, apart from the You Yangs and isolated hills in the western part.

This report gives a brief description of the geology and previous geophysics of the area and a qualitative interpretation of the gravity features. To assist in the interpretation, samples of the various rock types occurring in the area were collected and their densities measured by the GSV. The result of this work is also discussed in the report. The survey details are listed in an appendix.

GEOLOGY

The geology of the survey area is shown in Plate 1. Specific geological descriptions have been given by Keble (1950) for the Mornington Peninsula, the Geological Survey of Victoria (1967) for the Melbourne area, and by Abele (1970) and Ripper (1975) for the Melbourne-Bacchus Marsh-Geelong area.

Basement rocks in the Melbourne area are Silurian sediments which occur in synclinoria deformed by concertina-type folding. The Silurian rocks overlie Middle-Upper Ordovician sediments northwest of Melbourne, and Lower Ordovician sediments in the Mornington Peninsula. The whole area is probably underlain by Cambrian greenstones which outcrop to the east and west.

Melbourne-Port Phillip Bay is a graben generally referred to as the Port Phillip Sunklands. The gravity survey covers the northern limits of this feature where it is bounded by the Rowsley Fault system to the west, Selwyn Fault and the Dandenong Ranges to the east, and by a general basement rise to the Great Dividing Range in the north. Depression of the Silurian rocks has allowed deposition of Cainozoic sediments which are known to be 250 m thick in bores west of Melbourne. No Mesozoic rocks are known north of the Bellarine Peninsula.

Devonian granites crop out in areas shown in Plate 1 and granite has been encountered in bores in the Melbourne metropolitan area, notably at South Yarra, Toorak, St Kilda-Prahran, and at Clayton and Clayton South (Kenley, in Geological Survey of Victoria (1967), p.53).

The plain west and northwest of Melbourne is covered by Pliocene-Pleistocene basalt flows from eruptions in a number of different places; some extinct volcanoes remain as elevated topographic features. As relatively few boreholes have been drilled through the basalt in the area, the sub-basaltic structure is largely unknown.

The distribution of the Tertiary sediments appears to be partly controlled by structural features including the Melbourne Warp, Beaumaris Monocline, Anonyma Flexure (Kenley, in Geological Survey of Victoria, 1967), and Selwyn Fault (Whiting, in Geological Survey of Victoria, 1967).

Fault movements in the area have caused rapid changes in the base level of erosion; this has resulted in parts of the present and previous drainage systems being deeply incised into the underlying rock. Some of the stream systems have been filled and covered by later deposition of sediments and lava flows. The geological map of Melbourne and Suburbs published at 1:31 680 scale by Geological Survey of Victoria (1967) shows the interpreted positions of some of the older stream systems. Little is known of the extent of similar systems in other parts of the survey area.

ROCK DENSITIES

Density measurements of the rocks likely to affect the gravity survey results are presented in Plate 2. Repeatability tests indicate that the measurements are accurate to $\pm$ 0.01 t m^{-3}.

Collecting sites were mainly located in the survey area; if this was not possible the nearest appropriate outcrop was sampled. The rock samples were collected from road cuttings, building excavation sites, and quarries, and were relatively unweathered. They were also generally saturated with water and thus the measured densities should approximate the in situ densities of the rocks. Densities increase with depth owing to compaction, consequently the average values of densities estimated from the results of density determinations shown in Plate 2 may underestimate the densities of rocks at depth.

The sampling program was designed to collect representative rock specimens. Approximately 5 samples were collected at each site and for each site rocks of different lithology (if this was applicable) were selected.

A compensated formation density log from the offshore Nerita No. 1 well (Shell Development (Aust) Ltd, 1967), which is located 100 km southwest of Melbourne, provides estimates of the densities of the Lower Tertiary and Cretaceous formations.

Previous density measurements by McInerney (1929) on the densities of Victorian igneous rocks have been included in the compilation, for comparison.

Cainozoic sediments

These were collected at Bacchus Marsh, in the Geelong area, and in cliff sections along Port Phillip Bay.

The wide range of densities measured for the Cainozoic sediments reflects the extreme variability of the constituent sand, clay, silt, marl, limestone, sandstone, and brown coal. The average value of 2.20 t m^{-3} appears to be a realistic estimate of the average density of the Tertiary sedimentary section. A Bouguer density of 2.20 t m^{-3} has been used to produce the Bouguer anomaly map (Pl. 3).

The results of drilling by the Victorian Mines Department, as summarized on the geological section in the 1:250 000 Geological Map of Melbourne, shows that the Werribee Formation, consisting of quartz sand, interbedded with clay, carbonaceous clay, grit, and gravel and the overlying Newport Formation comprising micaceous silt, marl, and minor limestone form the main part of the Cainozoic sedimentary section west of Melbourne. Although a detailed breakdown of the measured densities relative to lithological subdivisions has not been attempted, the density logs from Nerita No. 1 well suggest that these formations have densities in the range 2.10-2.25 t m^{-3}.

The discontinuous Brighton Group sediments, which consist of redbed formations and ferruginous sands, account for some of the higher density values which have been measured. Surficial Quaternary deposits and weathered samples of older rocks account for many of the measured density values less than 2.00 t m^{-3}. Brown coal has a density of approximately 0.70 t m^{-3}.

Mesozoic sediments

No outcrops of Mesozoic sediments are expected in the survey area but they are known to occur on the Bellarine Peninsula and probably occur at depth under the southern part of Port Phillip Bay. The density logs from Nerita No. 1 well indicate that the Cretaceous sediments (mainly shale and sandstone) have densities in the range 2.30-2.50 t m^{-3} and thus a density contrast exists between these rocks and the younger Tertiary sediments.

Palaeozoic sediments

Permian rock samples were collected near Bacchus Marsh. Permian tillite appears to be preserved in a graben structure near Bacchus Marsh and may possibly occur in similar structures beneath the basalt plains.

Measured densities for the tillite are in the range 2.20-2.35 t m^{-3}. The density contrast between these rocks and the Tertiary sediments is generally insufficient to allow them to be distinguished by the gravity method in areas of Tertiary cover. The solitary density value greater than 2.5 t m^{-3} for the tillite was for a specimen which contained a pebble of igneous rock.

Devonian samples were collected in road cuttings along the Hume Highway. Devonian siltstone and sandstone conformably overlie the Silurian rocks north and west of Melbourne. The densities of these rocks (Pl. 2) are similar to those of the Silurian sediments and hence for gravity interpretation the Siluro-Devonian basement of the survey area can be considered as homogeneous.

Silurian samples were collected from excavations in the Melbourne metropolitan area. Silurian mudstone, sandstone, shale, and greywacke form the basement to the survey area. The histogram of density results indicates problems in estimating an average density as weathering and drying out may cause a low density bias. The range of density values between 2.40 and 2.50 t m^{-3} probably reflects a deviation from a true average density value of 2.50 t m^{-3} or an even higher value suggested by the small peak of values at 2.60 t m^{-3}. An estimated average of 2.50 t m^{-3} appears to be a reasonable compromise.

Middle and Upper Ordovician samples were collected in the Woodend area. Difficulty was encountered in finding fresh outcrops of Middle and Upper Ordovician shale and sandstone. These rocks underlie the Silurian rocks west of Melbourne and probably continue at depth beneath the Melbourne area. The measured density values almost certainly are less than the true density values of the in situ rocks at depth because of weathering. The rocks probably have an average density close to that of the Silurian and Devonian rocks, viz. 2.50 t m^{-3}.

Lower Ordovician samples were collected on the Mornington Peninsula. The Lower Ordovician shale and sandstone which crop out on the Mornington Peninsula appears to have an average density of 2.60 t m^{-3}.

Cambrian greenstones were collected at Mount William. The Cambrian greenstones which crop out in the Heathcote area and the Barrabool Hills area west of Melbourne and in the Mount Wellington area east of Melbourne probably underlie the Lower Ordovician sediments. They appear to have an average density of 3.07 t m^{-3}.

Basalts

Basalt of two ages occurs in the survey area. The older basalts of Eocene age crop out in river valleys in the Melbourne area, and the newer basalts of Pliocene-Pleistocene age cover most of the area north and west of Melbourne. Histograms of density measurements of samples taken from various holes drilled by the Victorian Mines Department show the variability induced by weathering, fracturing, and vesicles. Samples of newer basalt collected at Werribee give a cluster of density values around 2.59 t m^{-3} and densities of samples of fresh older basalt collected at Cape Schanck (outside the survey area) clustered around 2.80 t m^{-3}. Thus there is some suggestion that basalt density may be constant for a particular lava flow or a particular area but may vary between such situations. The histogram for the basalt samples collected randomly shows the basalt density to be generally in the range 2.60 to 2.80 t m^{-3}.

Granites

Density measurements show that each granite body in the survey area has a distinct average density and apart from some spread towards lower density values due to weathering the density variation appears to be small for each granite. Different granites have different average densities. Estimates of average densities (based on the modes of the histograms) are:

Dromana Granite	2.58 t m^{-3}
Bulla Granite	2.67 t m^{-3}
You Yangs Granite	2.66 t m^{-3}
Mount Martha-Mount Eliza Granite	2.62 t m^{-3}
Mount Dandenong Granite	2.70 t m^{-3}

Granite densities published by McInerney (1929) are:

Harcourt	2.68 t m^{-3}
Wangaratta	2.61 t m^{-3}
Cape Woolamia	2.64 t m^{-3}
Gabo I.	2.64 t m^{-3}
Orbost	2.80 t m^{-3}
Trawool	2.67 t m^{-3}
Dromana	2.61 t m^{-3}
Colquhuon	2.62 t m^{-3}
Tynong	2.63 t m^{-3}

Conclusions on densities

Application of statistical techniques to estimate average densities from the histograms does not appear warranted in view of the variability in the results. The subjective estimates of average densities made in the discussion above are adequate for qualitative interpretation of the gravity results and they may be used in quantitative studies as a first approximation if necessary. Table 1 summarises these estimates.

TABLE 1 ESTIMATED AVERAGE ROCK DENSITIES

Cainozoic sediments	2.20 t m^{-3}
Mesozoic sediments	2.30-2.50 t m^{-3}
Permian tillite	2.20-2.35 t m^{-3}
Devonian sediments	2.50 t m^{-3}
Silurian sediments	2.50 t m^{-3}
Middle-Upper Ordovician sediments	2.50 t m^{-3}
Lower Ordovician sediments	2.60 t m^{-3}
Cambrian greenstones	3.07 t m^{-3}
Basalt	2.60-2.80 t m^{-3}
Granites	2.58-2.68 t m^{-3}

PREVIOUS GEOPHYSICS

Several gravity surveys have been conducted within or near the survey area. These are BMR's recent reconnaissance gravity survey (Zadoroznyj, 1975), BMR gravity surveys of Port Phillip Bay and adjacent areas (Gunson & Williams, 1965), a detailed gravity survey of the Westernport area conducted by Melbourne University in 1974 (Isles, 1974), a subsidized survey carried out near Geelong in 1971 (Shell Development, 1971) and an unsubsidized survey in the northwestern part of Port Phillip Bay (Victoria Refining & Smelting, 1971). Data from these surveys have been considered in the interpretation of the results of the present survey.

The area has not been surveyed magnetically on a systematic areal basis. A subsidized aeromagnetic survey was carried out near Geelong (Shell Development, 1970), and several single aeromagnetic traverses have been recorded across a small part of it, north of Essendon airport, by BMR survey aircraft. An examination of the magnetic profiles along the BMR traverses did not reveal any obvious correlation of the magnetic data with either the gravity data or geology.

No major seismic survey has been made in the survey area. Several engineering seismic surveys made to assist in site investigations for bridges, tunnels, etc, provide insufficient information to give an overall appreciation of the geological structure throughout the area.

DESCRIPTION OF GRAVITY FEATURES

The Bouguer anomaly contours for the survey area and part of the surrounding area are presented on Plate 3. A Bouguer density of 2.20 t m^{-3} was used for corrections.

A broad area of low gravity values from -4 to -16mGal, covering much of the western part of the survey area (Pl. 3, Feature 1), is the most prominent gravity feature in the survey area. The Port Phillip Bay survey (Gunson & Williams, 1965) shows that this low extends southwards and reaches a minimum value of about -25 mGal, 10 km southeast of Geelong. Within the survey area the low is bounded by fairly strong gravity gradients on its western and northeastern flanks. The gradient on the western side roughly corresponds with the Rowsley Fault, whilst the gradient on the eastern side, which occurs over a basalt-covered area, corresponds fairly closely with the course of the Werribee River.

A gravity ridge, Feature 2, trending northwesterly then northerly farther westward, extends from Port Phillip Bay into the low partly dividing it into two units: the larger, western unit trends northerly and extends from Geelong to Bacchus Marsh, and the smaller eastern unit, which is oval in shape, trends northwesterly.

A northwest-trending gravity shelf, Feature 3, extends from east of the City of Melbourne to the northwest corner of the survey area. The anomalies within this region are of small amplitude of 1 to 2 mGal. A gentle gradient bounds the shelf to the north, and a fairly pronounced, oval-shaped gravity high (Feature 4) occurs at the southeastern end.

A small gravity trough (Feature 5) and a gradient trending to high gravity values (Feature 6) are present in the southeastern part of the survey area.

A number of smaller features including isolated highs, lows, ridges, and troughs can be seen on the Bouguer anomaly map. Some of these are discussed in the section on interpretation.

INTERPRETATION OF BOUGUER GRAVITY FEATURES

Plate 4 shows gravity features which have been numbered on the Bouguer anomaly contour map to assist in the following discussion.

Features related to granites

The extensive gravity low (1) which is prominent in the western half of the survey area has been attributed to subsurface extensions of the granites which crop out in the You Yangs, the Anakies, and in the area west of Geelong. Although the granite density of 2.66 t m^{-3} is greater than that of the Tertiary and Palaeozoic sedimentary rocks (2.20-2.60 t m^{-3}) the roots of the granites, which characteristically extend for several kilometres down into the deep, denser crustal layers, are considered to be the main cause of the negative Bouguer anomalies.

The gravity ridge (2) extending across part of the low is also a prominent feature. Neither the gravity effect of a 200-m thick granite ridge under the area, which would give an anomaly of approximately 4 mGal, nor the gravity effect of the 70 m of basalt shown on the section of Plate 5, which would give an anomaly of approximately 1.5 mGal, is sufficient to account for the 16-mGal gravity ridge of feature (2). Therefore to explain fully the gravity ridge (2) it is necessary to assume that either the granite is thinner under this feature or that there are denser rocks within or underlying the granite.

The ambiguity as to whether structure or density variation within the granite is responsible for the gravity ridge, and the large amplitudes of the anomalies in this area prevent the immediate use of these gravity data for mapping features in the overlying Tertiary rocks. Such features could probably be outlined in a residual anomaly map of the area computed by removing the total gravity field from a suitable regional field. The major difficulty would be in computing the regional field, which would largely comprise the effect of the granite, in such a way that no fictitious features are generated.

Gravity lows (3 and 4), associated with the Bulla and Morang Granites respectively, suggest that the decrease in gravity northeastward from Melbourne may be due to an extensive underlying granite.

As mentioned in the chapter on geology, granite has been encountered in excavations in the Melbourne metropolitan area, but the gravity map does not show any anomalies which can be definitely related to these occurrences of granite.

Features related to faults and monoclines

Gunson & Williams (1965) noted that the Selwyn Fault has a strong gravity expression south of Frankston but not north of Frankston. The data of the present survey show that tracing the fault north of Frankston is extremely difficult using gravity information, probably because similar thicknesses of rocks of similar lithologies occur on either side of the fault in this area.

The Beaumaris Monocline appears from the gravity results to extend farther to the northeast than previously suspected.

A complementary fault or monocline (5) parallelling the Beaumaris Monocline is tentatively suggested by the gravity contours to run northeast from the Silurian inlier at St Kilda.

The gravity relief, 5 mGal, of the positive gravity area bounded by the above two features is greater than would be expected to be caused by the structural effect of the Beaumaris Monocline, which is 30 m according to Kenley (Pl. 2 in Geological Survey of Victoria, 1967). Thus this area appears to be underlain by anomalously dense rocks relative to adjacent areas.

Gravity gradients suggest a thickening of Tertiary sediments or a fault along the line of the postulated Anonyma Flexure.

The Melbourne Warp has no obvious gravity expression.

Gravity and aeromagnetic data (Shell Development, 1970) suggest the north-eastward continuation of the Bellarine Ridge (6) and its flanking Bellarine Fault.

Gravity data in the centre of Port Phillip Bay suggest a major northwest fault (7) has allowed subsidence of the southern half of the Bay area between the Selwyn Fault and the Bellarine Fault (Gunson & Williams, 1965). Depth estimates by Shell Development (1970), using aeromagnetic data, suggest that at least 2 km of post-Palaeozoic sediments occur in this trough.

The course of the Werribee River coincides roughly with the strong gradient marking the eastern limit of the large gravity low (1), which has been interpreted as being mainly due to granite. Although drilling results presented in Plate 5 do not suggest a major fault along this boundary some minor fault movement or differential compaction of sediments must have occurred for the effect of the edge of the granite to show through 250 m of sediments.

South of the survey area a major east-west dislocation is suggested from the gravity contours in the Geelong area (8). The existence of a fault in this area is supported by the existence of the Curlewis Monocline, the Newton Fault, and the Barrabool Fault which have been mapped along this line, and a distinctive magnetic lineation which occurs in magnetic data presented by Shell Development (1970).

The gravity gradient which has been interpreted as due to the western margin of the You Yangs Granite coincides with the Rowsley Fault.

Buried valley type features

The sinuous gravity low (9) terminating at the fault bounding the graben at the south end of Port Phillip Bay (10) is thought to be caused by low-density sediments filling an erosional valley feature caused by sudden downfaulting of the graben.

The sinuous gravity low in the Carrum area (Feature 11), which extends beneath the Bay, is thought to be due to another buried valley. Both features were noted by Gunson & Williams (1965). The sea floor of Port Phillip Bay is flat in the area of these postulated buried valleys, so the gravity features are not due to present-day sea floor topography.

Basalt flow features

Several continuous, narrow, gravity highs and lows can be traced in the area covered by the newer basalts. Some of these can be related to known features, others cannot.

The elongate gravity high marked as Feature (12) corresponds with the basalt-filled valley shown on the geological map of Melbourne in Geological Survey of Victoria (1967). Features (13) and (15) also correspond to mapped basalt-filled valleys but they show only a questionable correlation with gravity highs. This could be due to the sparse gravity station coverage in the area. The cause of Features (15), (16), (17), (18), and (19) is not obvious. Profile studies, (Pls. 5 and 6), especially the detailed profile across Feature (15), offer no suggestions as to the cause of these 1-2 mGal features. They may reflect density variations between individual basalt flows.

Isolated small gravity highs and lows

Gravity highs (20), (21), and (22) could possibly be due to small igneous intrusions; so could gravity highs (23) and (24), which occur over a synclinal pile of Upper Silurian rock; alternatively, they may be related to this structural feature. Gravity high (25) corresponds with the hill of basalt due to the Mount Cotteril volcanic centre. As shown in Plate 5 (Profile AB), gravity low (26) overlies a thick brown coal seam which thins to the east and west. The thickness of brown coal is sufficient to account for the gravity low. Possibly gravity low (27) is due to similar coal accumulations. Gravity low (28) indicates a sedimentary trough in the Hobson Bay area. The small elongate low (29) possibly indicates a sediment filled trough.

INTERPRETATION OF GRAVITY PROFILES

Profile AB indicates mainly the large gravity lows due to granite. Drilling results from Woornyalook No. 6 and 7, Bulban No. 1, and Mamborin No. 1 bores indicate a flat granite basement, which suggests that the gravity high over this area is due to a zone of dense rocks within or beneath the granite. The Lovely Banks Monocline does not have any obvious gravity expression.

The gravity low over the Truganina No. 3 bore can be explained as being due to the extra thickness of brown coal encountered there. It is difficult to relate variations in gravity to basalt thicknesses and the deepening of the Silurian sediments at the eastern end of the profile.

Profile CD consists of optically levelled gravity stations spaced at 300 m intervals. Plate 4 shows the location of this profile. Plate 5 shows a correlation of the gravity results with Geological Survey of Victoria drilling results. The bores show that the basalt base dips fairly uniformly on the western 27 km of the profile, thus the minor 1 mGal anomalies which have widths of approximately 1 km must relate to local thickening of basalt not encountered by the drilling or to density changes in the basalt or bedrock. A basalt flow between gravity stations 8101 and 8113 appears to correlate with a 1 mGal positive anomaly. The drilling provides no evidence as to the origin of the broad gravity low centred on gravity station 8020, and thus this feature must be related to topography at the base of the underlying formation or a density decrease in the basalt or bedrock.

The gravity low centred on gravity station 8092 is probably related to thinning of the basalt in the Maribyrnong River Valley.

Profile EF was surveyed at barometrically levelled station which are approximately 480 m apart. Most of the traverse is over Quaternary basalt and the small-amplitude gravity features probably represent minor variations in thickness and composition of the basalt. The eastern end of the traverse is over various rock types in the Maribyrnong Valley; gravity stations 2114 and 2119 are located on Tertiary basalt and have high gravity values relative to adjacent stations, which are on Tertiary or Quaternary sediments.

Profiles GH and IJ were also barometrically levelled with stations about 480 m apart. These profiles cross the Silurian inlier at St Kilda with gravity stations 3005, 3006, 3014, and 3015 on the Silurian rock outcrops.

The Bouguer anomaly amplitude increases easterly in Profile GH which extends across part of the high marked as Feature 4 in Plate 3. The small anomalies revealed probably reflect minor variations in composition or thicknesses of the Tertiary sediments.

In Profile IJ the low centred on gravity station 283 is due to the sedimentary trough noted as Feature 28 in Plate 4. It seems likely that the high between stations 780 and 3006 is due to near-surface Silurian rocks, suggesting a steep northerly flank and a gentle southerly flank for the inlier.

CONCLUSIONS

The general objective of the survey of helping to define the near-surface structure of the area was achieved in some measure. This is illustrated by the outlining of the large granitic mass, sediment-filled troughs, basalt-filled valleys, basalt hills, and the possible fault along the course of the Werribee River. Several of the particular survey objectives, viz -

(a) definition of the Selwyn Fault north of Frankston,
(b) indication of a suspected fault between Footscray, and Altona,
(c) delineation of the western extension of the Melbourne Warp,
(d) indication of possible extension of the Studley Park Fault Zone,
(e) indication of sediment thickness in the Werribee area,

were not achieved, either because the features did not have a gravity effect of sufficient wavelength and amplitude to be detected, or else the effect of the feature was masked by stronger gravity effects, e.g. the granite mass masking the effect of the sediments. Where a postulated geological feature has no gravity effect it may be that the feature does not exist.

Particular conclusions drawn from a qualitative analysis of the gravity data are:

1. Low gravity values suggest that granite underlies the area bounded by the Rowsley Fault and the Werribee River. A gravity ridge intruding into the low suggests that either the granite is thinner in this part or else a significant mass of denser rocks lies within or below the granite. The strong gradient marking the western boundary of the granite appears to be related to the Rowsley Fault. The similar gradient along the Werribee River suggests a fault beneath the overlying basalt.

2. High gravity values between the Beaumaris Monocline and the Melbourne Warp indicates a body of dense rocks in this area.

3. A sediment-filled trough is indicated to lie along the course of the Patterson River near Carrum. This was earlier noted by Gunson & Williams (1965).

4. The gravity expression of the Selwyn Fault appears to end about 8 km north of Frankston, which was also noted earlier by Gunson & Williams (op. cit.).

5. A gravity high corresponds with the hill of basalt due to the Mount Cotteril volcanic centre.

6. A coal seam may have been outlined east of Mount Cotteril.

7. The positions of basalt-filled valleys have been weakly indicated.

8. The detailed profiles reveal small anomalies which may be related to basalt thickness.

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APPENDIX I: OPERATIONAL DETAILS

1. The survey was carried out using the 'cell method' of traversing (Hastie & Walker, 1962) modified to suit the operational requirements of the survey. Most stations were spaced on a 1.6 km grid except in the western part where difficulty was experienced in negotiating wet tracks. Stations were also established on detailed traverses with 300 and 480 m spacing.

2. The survey commenced on 10 February 1975 and was completed on 27 March 1975.

3. A total of 1247 new stations was established, 467 of which were barometrically levelled using Mechanism microbarometers.

4. Station positions were marked on 1:63:60 topographic maps which provided horizontal control.

5. Ties were made to the following Isogal stations (Wellman, 1975):- Moorabbin (7090.9401), Footscray (6491.0501), Essendon (6491.0101), Tullamarine (7213.0101), Melbourne City (6491.0401). Ties were also made to five old BMR stations, viz: 5203.0043; 5203.0063; 5609.0003; 5609.0007; and 5809.0014.

6. The gravity meter used was LaCoste & Romberg No. G132. The meter was run over the Melbourne calibration range on 11 February 1975 and 25 March 1975. The meter calibration factor supplied by the manufacturer was accepted.

7. A density of 2.20 t m^{-3} was adopted to make Bouguer corrections.

8. The 'survey numbers' for the survey in the BMR National Gravity Repository are 7501 and 7502.

9. Staff

J.C. Allen	Party Leader/Technical Officer
O. Terron (10/2-28/2)	Technical Officer
J. Price (3/3-27/3)	Trainee Technical Officer

10. Data reduction

The data were reduced by computer using standard BMR programs. The computing procedure is outlined in Allen & Waldron (1974). The internal and external network adjustments are given in the table below:

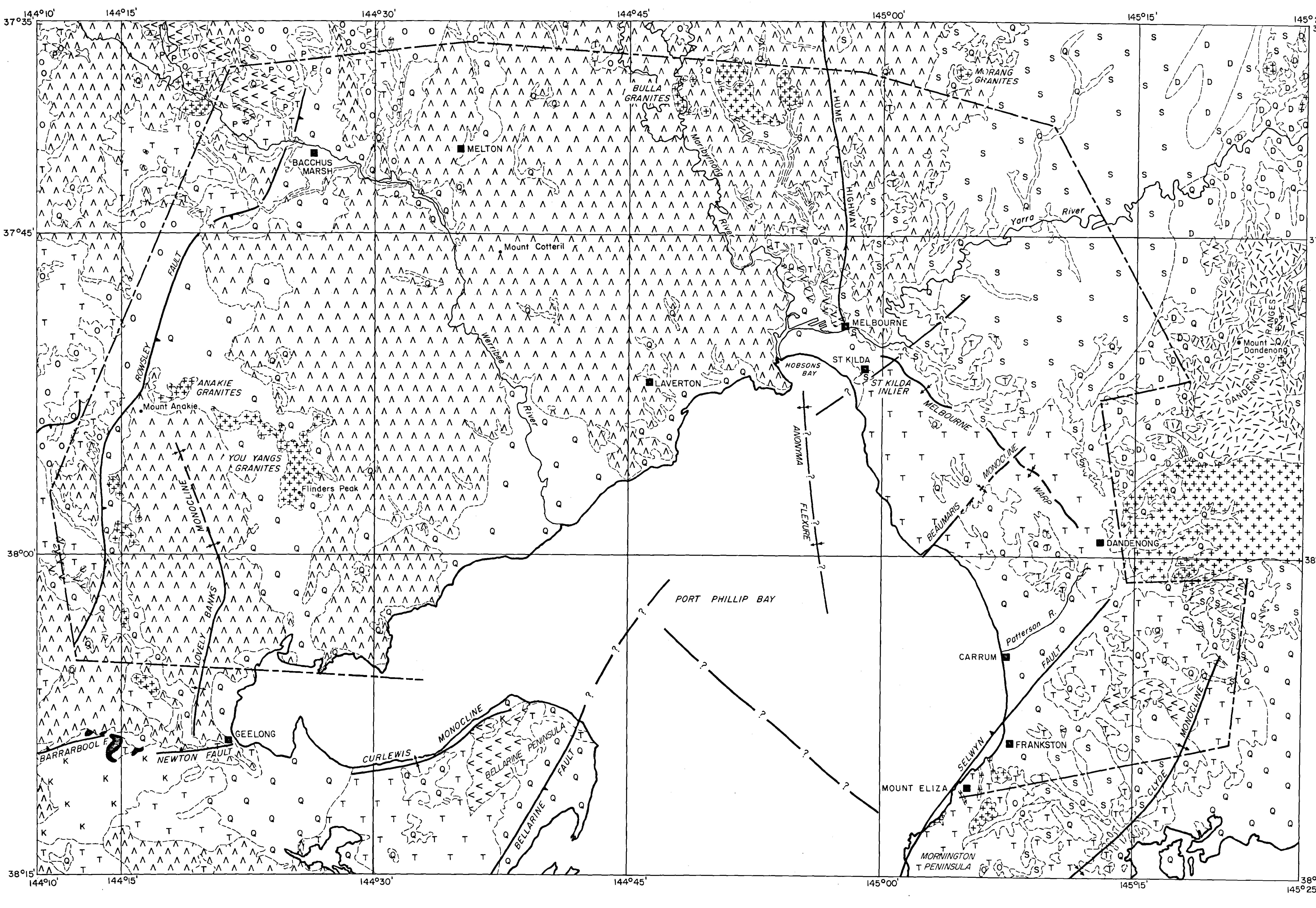
	Internal Network		External Network	
	S.D.	M.A.	S.D.	M.A.
Gravity (mGal)	0.01	0.03	0.01	0.04
Elevation (m)	1.81	4.42	1.96	4.98

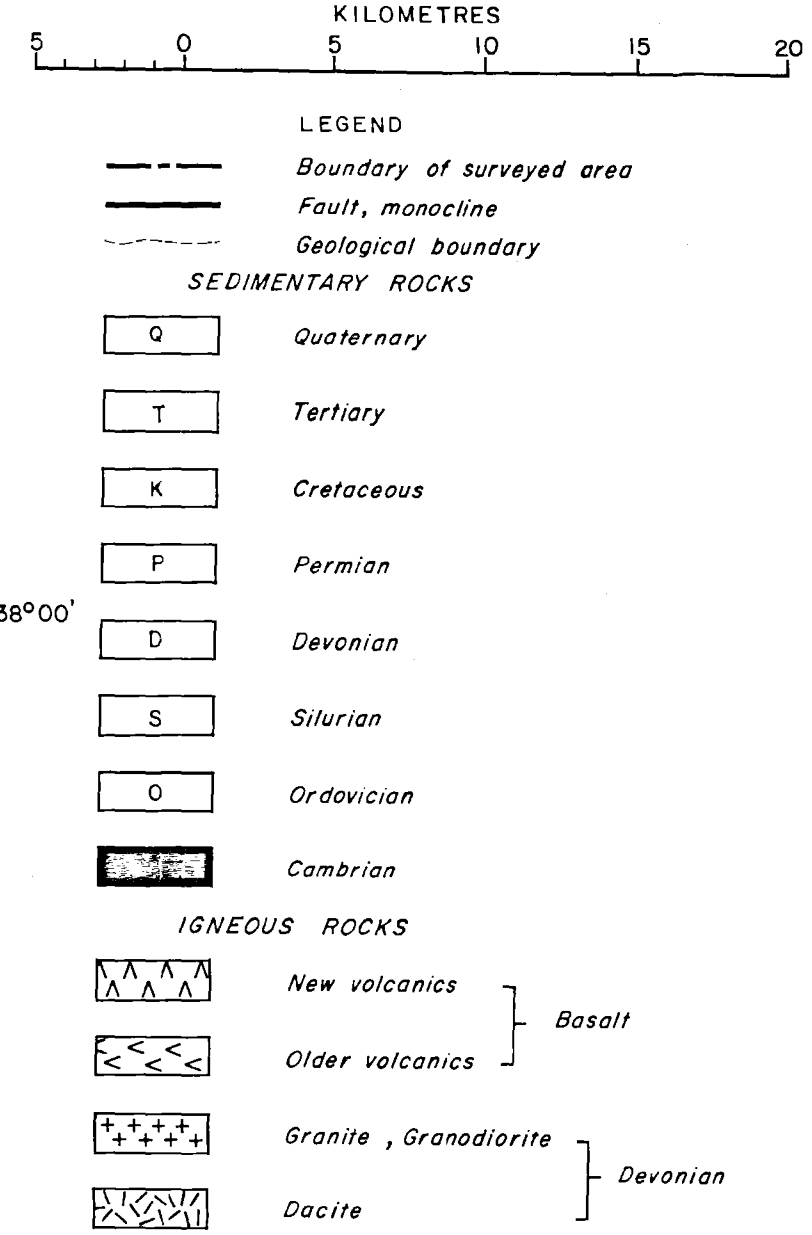
where S.D. = standard deviation and M.A. = maximum adjustment.

The elevation standard deviation for the external network, 1.96 m, indicates that Bouguer anomalies at most of the barometrically determined stations are accurate to about 0.4 mGal. Anomalies of amplitude less than about 0.5 mGal and defined by a few barometrically levelled stations are questionable.

PLATE I

GEOLOGY OF THE MELBOURNE AREA

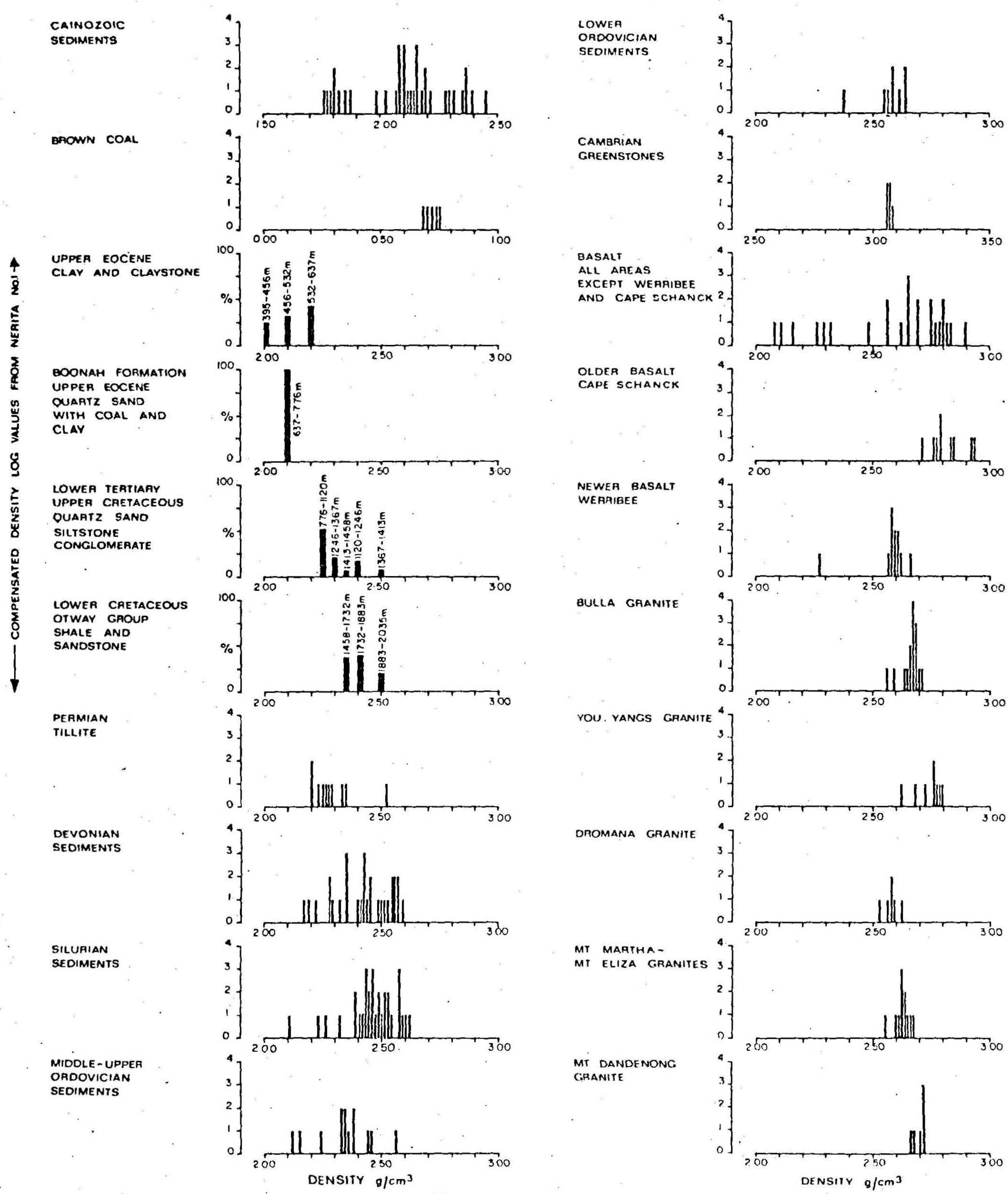




Record No. 1977/2

J55/B2-134

PLATE 2

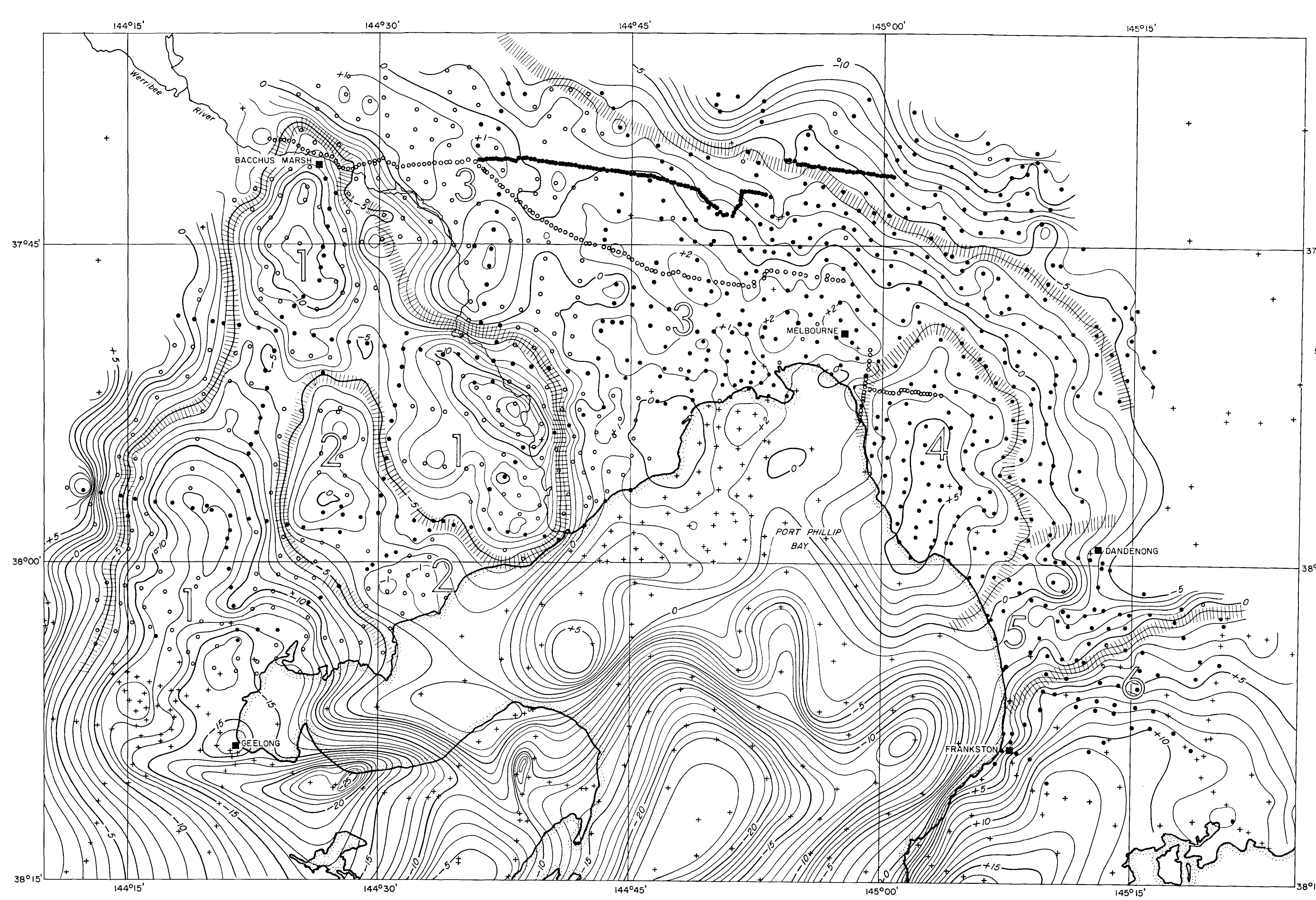


DENSITY HISTOGRAMS

VERTICAL AXES GIVE DENSITY FREQUENCY
DENSITY FREQUENCY IS EXPRESSED AS A PERCENTAGE OF THE FORMATION THICKNESS FOR THE DENSITY LOG RESULTS.

PLATE 3

BOUGUER ANOMALY CONTOURS AND GRAVITY FEATURES



KILOMETRES
5 0 5 10 15 20

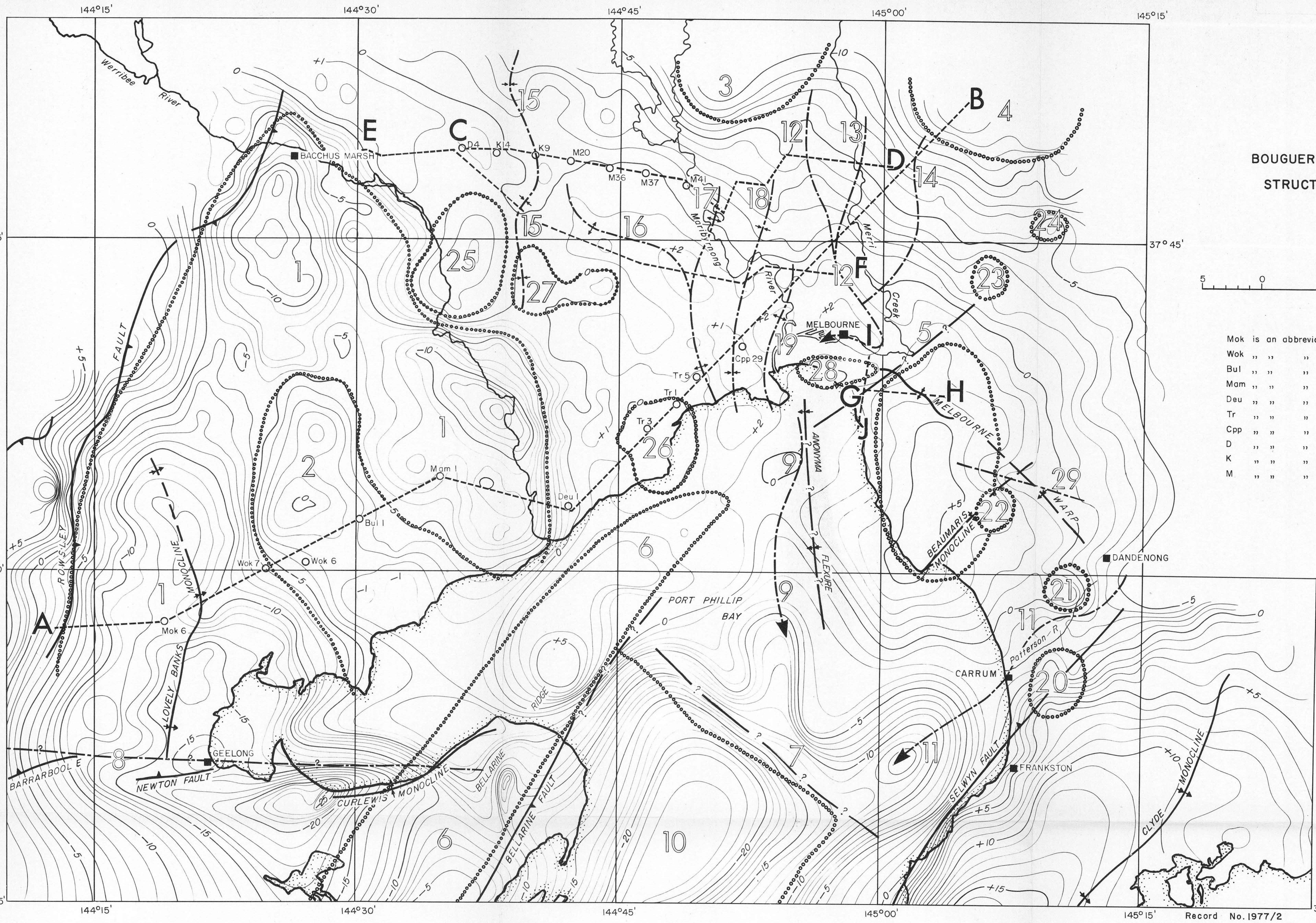
1 *Low*
2 *Ridge*
3 *Shelf*
4 *High*
5 *Trough*
6 *Gradient*

• *1975 Survey station - optically levelled*
○ *1975 Survey station - barometrically levelled*
\+ *Other Gravity stations - other surveys*
||||||| *Feature boundary*

Rock density 2·2 g/cm³

Record No. 1977/2 J55/B2-129

BOUGUER ANOMALIES AND STRUCTURAL FEATURES



KILOMETRES

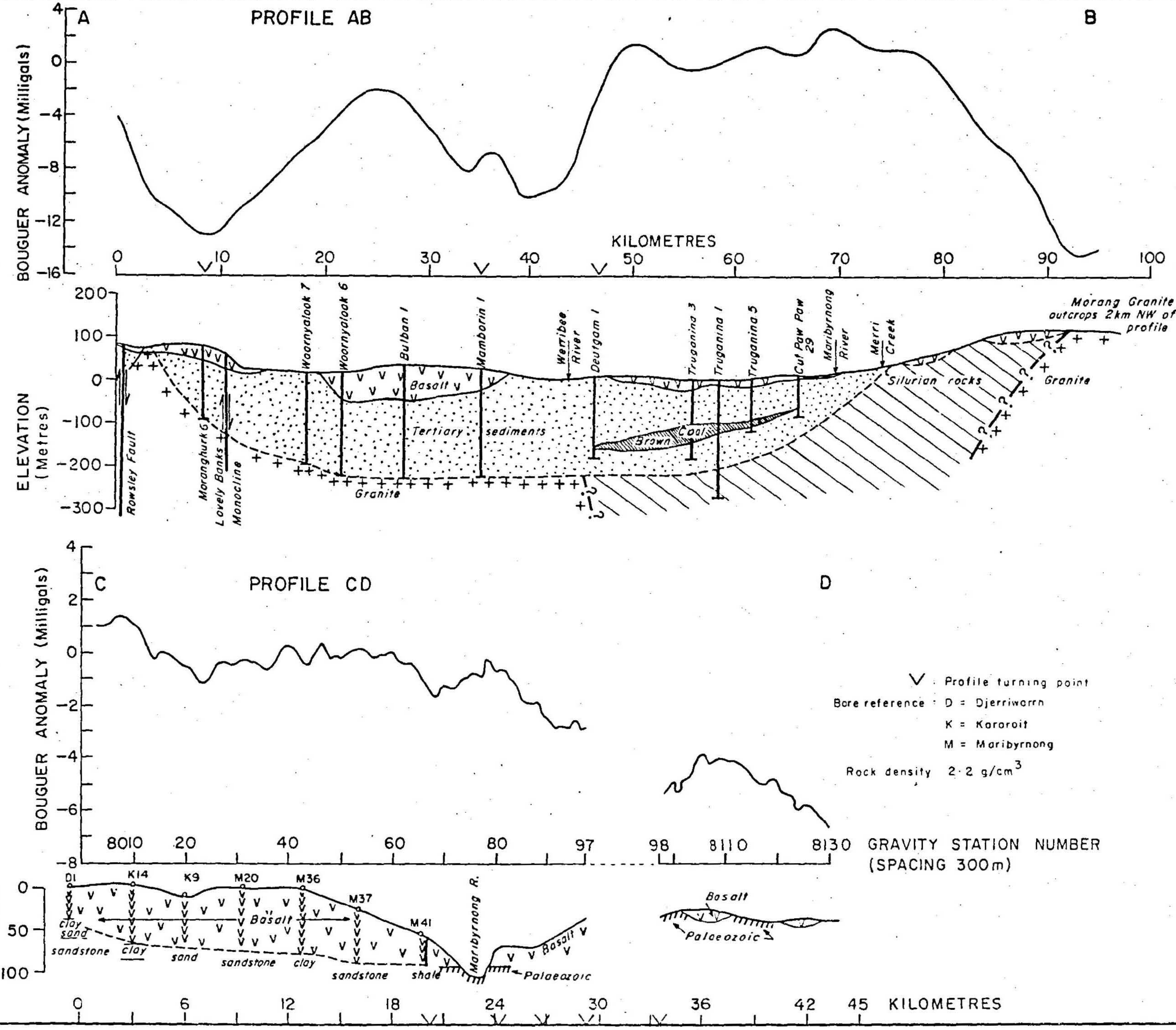
5 0 5 10 15 20

Mok	is an abbreviation for	Moranghurk	(Parish of)
Wok	,, ,, ,, ,,	Woornyalook	(,, ,,)
Bul	,, ,, ,, ,,	Bulban	(,, ,,)
Mam	,, ,, ,, ,,	Mamborin	(,, ,,)
Deu	,, ,, ,, ,,	Deutgam	(,, ,,)
Tr	,, ,, ,, ,,	Truganina	(,, ,,)
Cpp	,, ,, ,, ,,	Cut Paw Paw	(,, ,,)
D	,, ,, ,, ,,	Djerriwarrh	(,, ,,)
K	,, ,, ,, ,,	Kororoit	(,, ,,)
M	,, ,, ,, ,,	Maribyrnong	(,, ,,)

- O G.S.V. bore
- Fault, monocline
- Lineaments
- Feature boundary
- 6 Feature number
- A - - - Section line

Record No. 1977/2

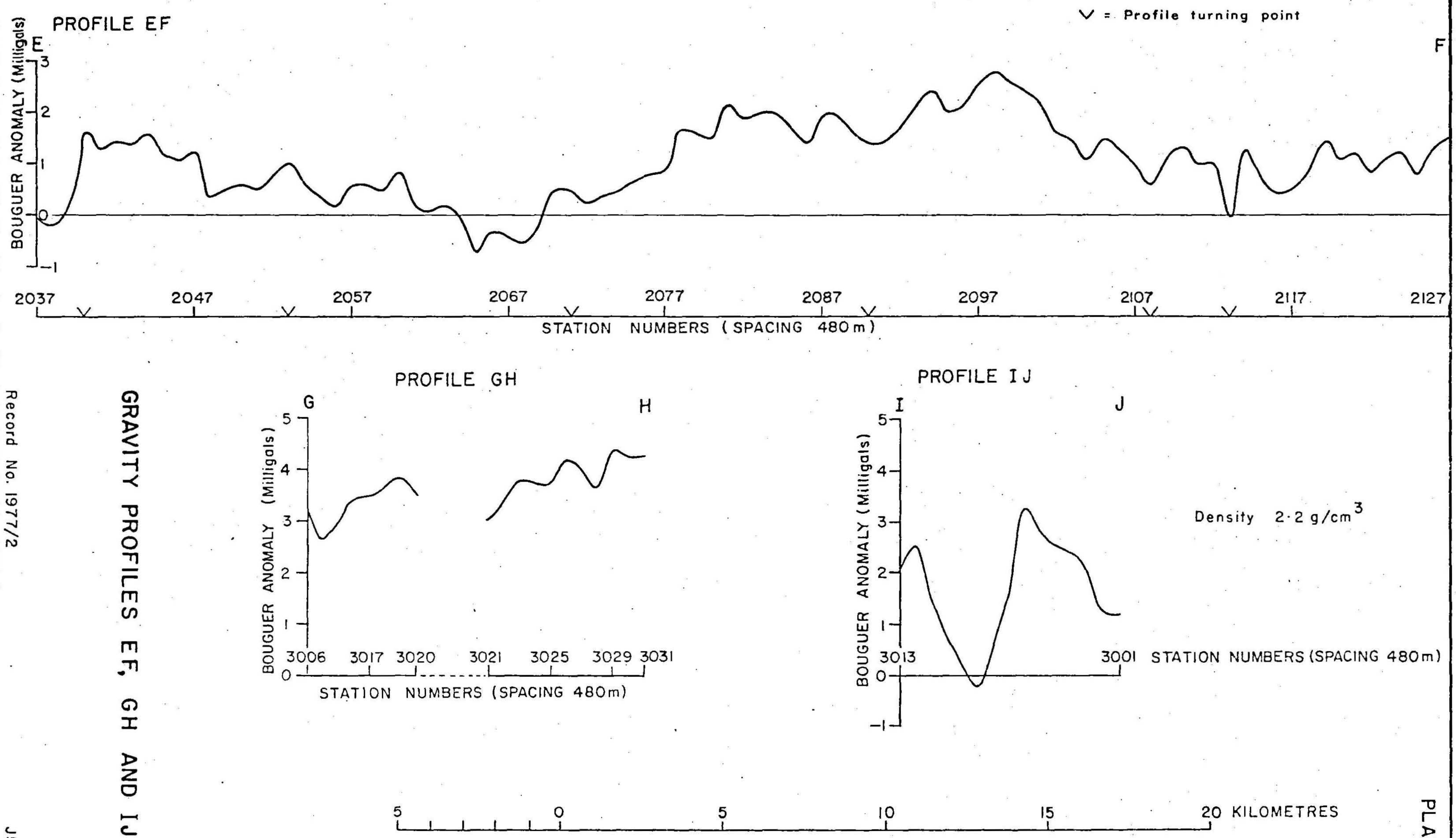
PROFILES AB AND CD



J55/B2-131A

PLATE 5

GRAVITY PROFILES EF, GH AND IJ



Record No. 1977/2

J55/B2-132A

PLATE 6