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Results of a gravity survey in the Kuala Lumpur area

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Abstract: A Bouguer gravity map is presented of the region around Kuala Lumpur. The dominant feature is a variation of c.40 milligals with a decrease from SW to NE at a rate of roughly 1 milligal/km. The trend of this variation is roughly parallel to that of the Main-Range Granite. When this regional variation is removed a number of mostly positive local anomalies of up to 7 milligals are revealed, mostly over areas of known limestone bedrock. The larger local anomalies are matched with 2-dimensional modelling.

INTRODUCTION

A gravity survey of the Kuala Lumpur Area (1:63,360 scale topographic map. 94) was conducted to investigate the variation in Bouguer gravity values across the western margin of the Main-Range Granite and over more local geological features. Regional E-W profiles along lines shown in figure 1 had previously been measured by Ryall (1982) and Loke (1981) which established an E-W gradient in the Bouguer gravity field with a variation of over 40 milligals across the area, but because of poor areal coverage and wide station spacing the effects of local geological features were undefined. In this survey measurements were made at almost 500 stations covering an area of approximately 1400 sq kms at an average density of one station every 3 sq kms or a linear station spacing of just less than 2 kms. Measurements were reduced using an IGSN'71 station established in the University of Malaya which is central to the area. Measurements were taken with a Worden Prospector Meter mostly at benchmarks and spot-heights, but approximately one third of the measurements were constrained with elevation control from repeat measurements with a pressure-sensitive altimeter with estimated accuracy to better than one metre (Foss, 1986).

SURVEY RESULTS

The station coverage and the contoured Bouguer gravity map are shown in figure 2. The stations are well distributed throughout the area mostly on a network of metalled roads, but the spacing is inhomogeneous on a small scale with stations mostly at 1 km intervals along the roads, but with some regions of difficult access of up to 5 kms radius completely unsampled.

The dominant feature of the Bouguer gravity map obtained is the regional variation of over 40 milligals which is essentially identical to Loke's regional determination as mapped in figure 1. There are also however areas where the irregularity of the field suggests superimposed anomalies controlled by the local geology. Five gravity profiles are shown in figure 3 with accompanying geology taken from the geological map of Yin (1976). Profiles A, B and C are roughly perpendicular to the regional trend and have a slope of *c.* 1 milligal/km. This pattern is quite different to that of the profiles across the eastern margin of the Main-Range granite measured in

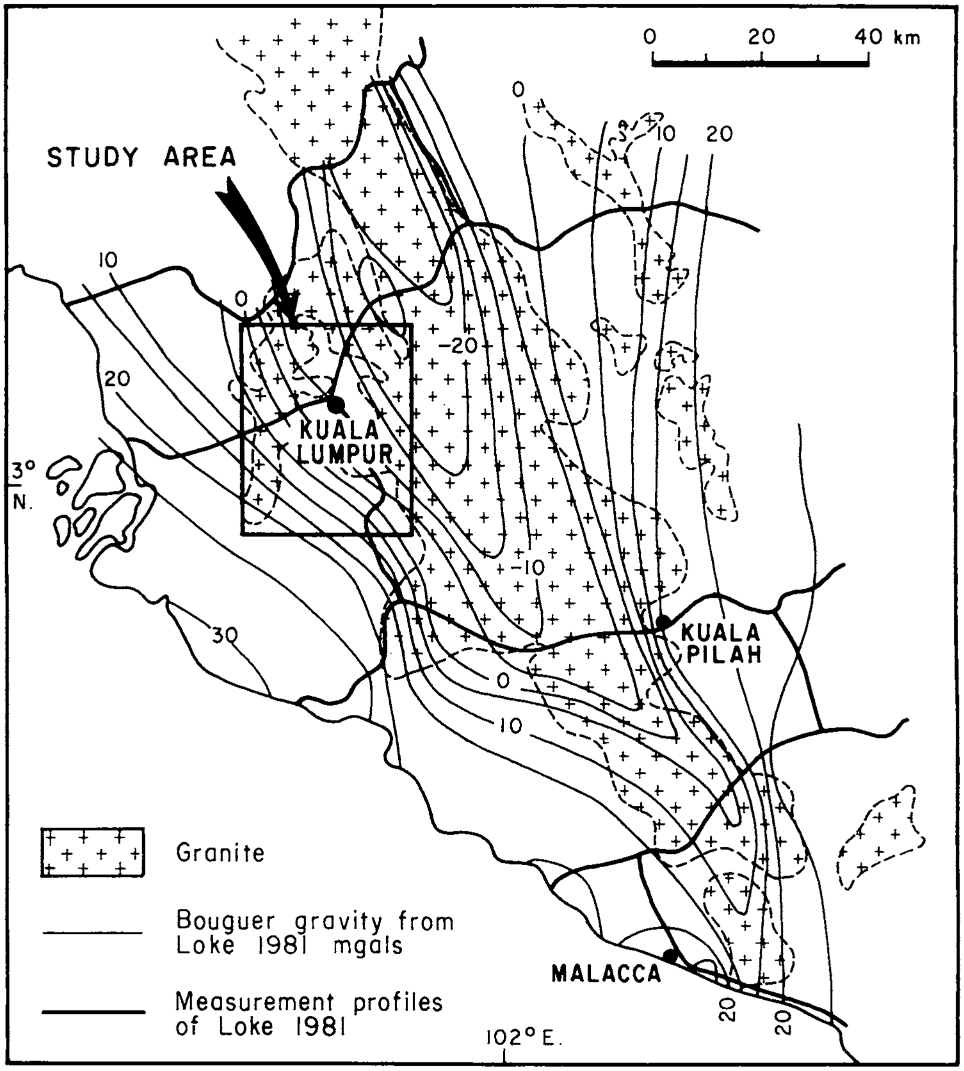

Fig. 1. Location of the study area.

the Kuala Pilah Area (Foss, 1986), one of which is shown for comparison with profile A-A in figure 4. Both profiles show a similar range in values of *c*. 40 milligals, but the one over the eastern margin is typical of a step change in density from which the location of the contact is easily determined, whereas profile A-A has no indication of any sharp near-surface density variation. Excessive weathering of the Kenny Hill and Kajang Formations precludes any reliable direct measurement of their densities, but the lack of sharp gravity changes across the contacts of these formations with the granite indicates that their densities are very close to that of the granite.

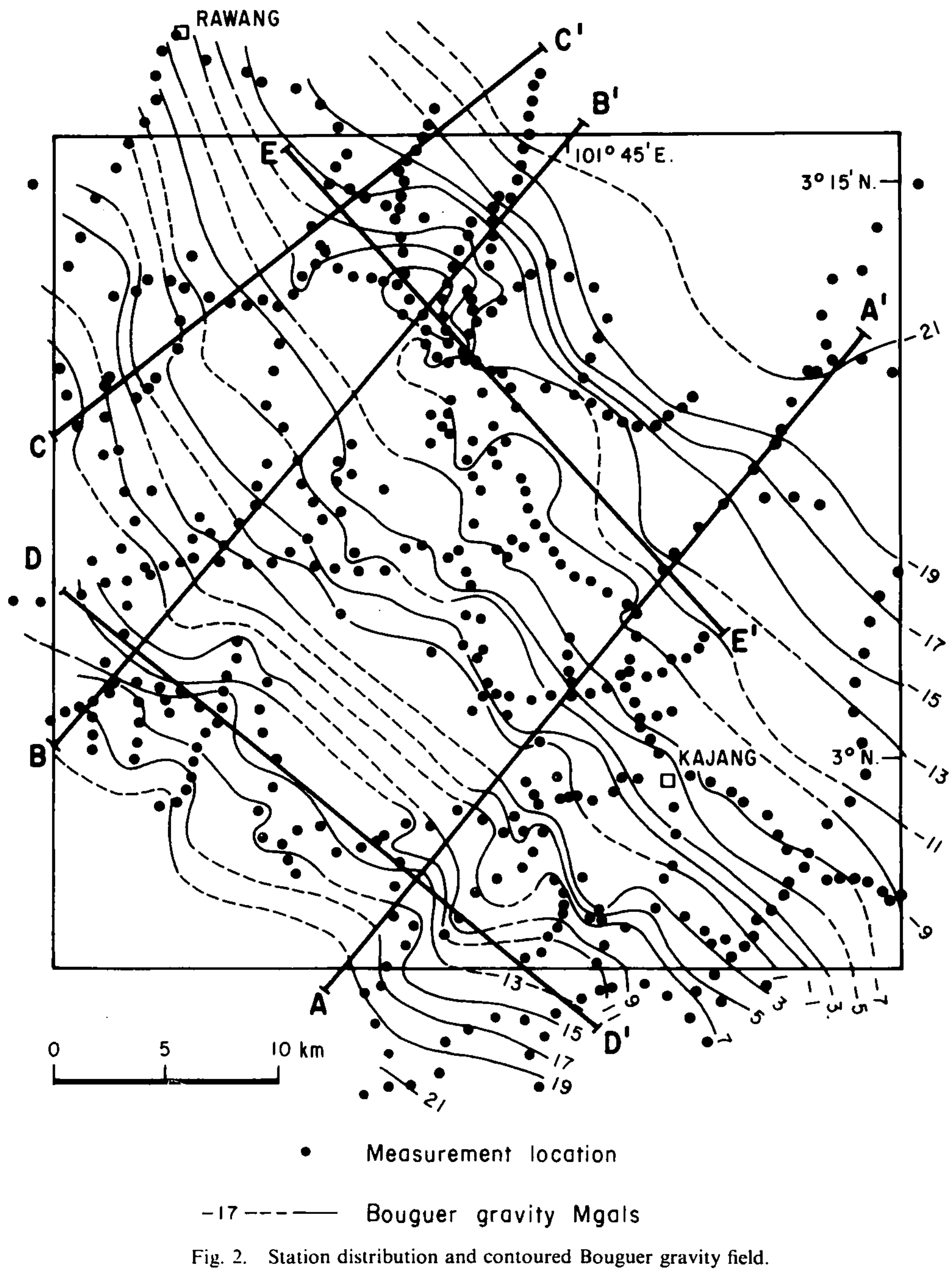

Fig. 2. Station distribution and contoured Bouguer gravity field.

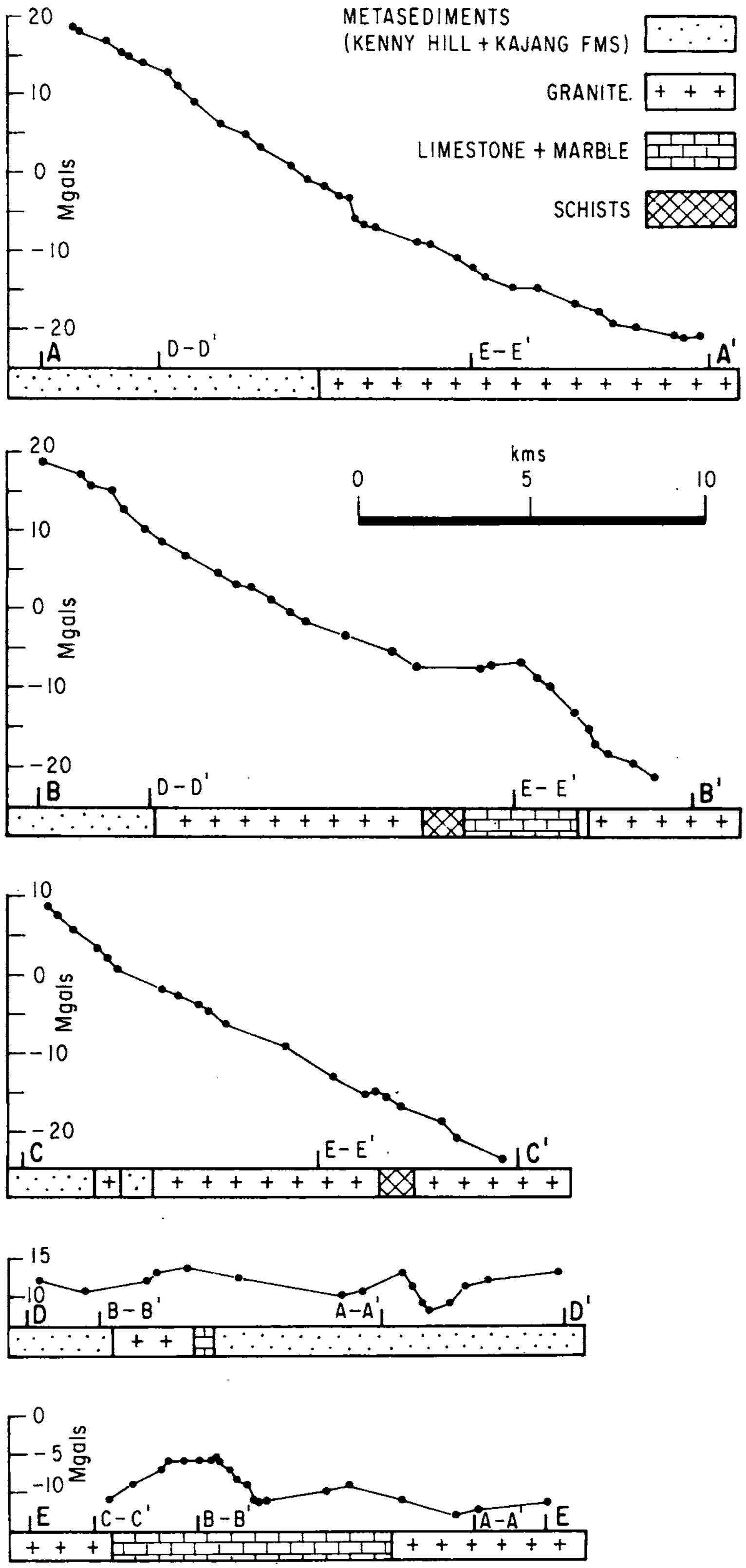

Fig. 3. Bouguer gravity profiles along the lines as located in figure 2.

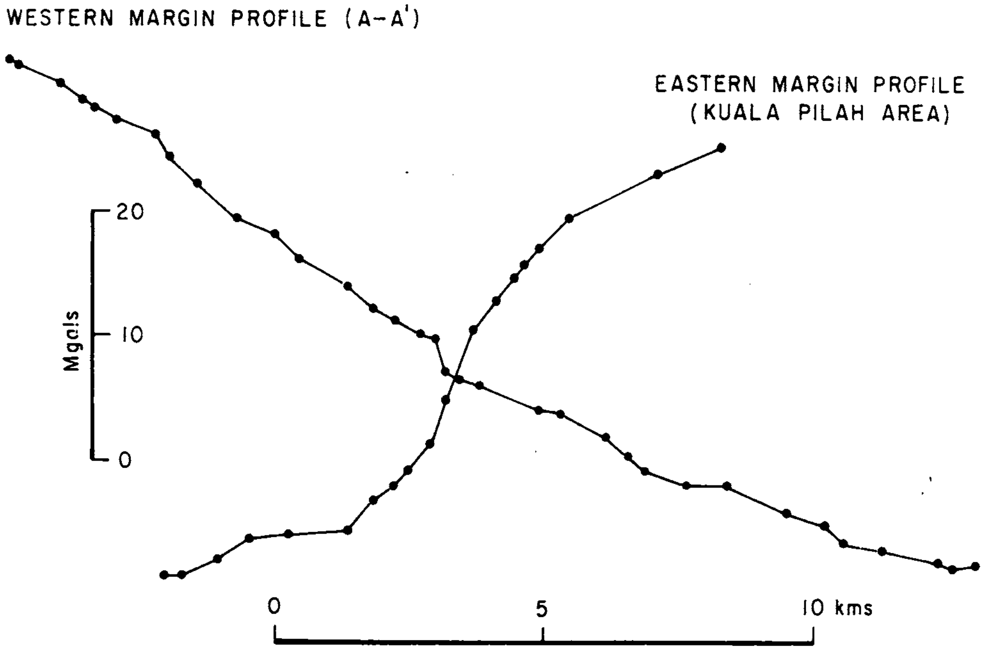

Fig. 4. Bouguer gravity profiles over the eastern margin of the Main Range Granite in the Kuala Pilah area (from Foss, 1985) compared with profile A-A from this study.

The most prominent local anomalies intersected by the profiles shown in figure 3 are over the Kuala Lumpur limestone which is expressed by the positive anomaly on profiles B and E, and closely spaced positive and negative anomalies in profile D which have no mapped geological expression despite the fact that the sharpness of the anomalies indicates sources very close to surface. Detailed analysis of the local anomalies requires removal of the dominant regional variation on which they are superimposed.

REGIONAL-RESIDUAL SEPARATION

Gravity maps generally represent superimposed variations due to several sources, and for a detailed interpretation of any one of them it is necessary to isolate that anomaly from the others. Various methods have been used to effect such separation, such as graphical methods, grid operators (Griffin, 1949), least squares methods (Coons *et al.,* 1967), spectral analysis (Gupta and Ramani, 1980), and differential methods (Clark, 1969). All these methods are based on the assumption that smooth variations across large areas are due to deep sources, whereas sharp localised variations are due to near-surface sources. The method used to define the regional in this survey was an interactive computer trial and error approach, with the best regional chosen as that which gave a geologically reasonable pattern for the remaining residual anomalies. This method is not as rigorous as the analytical techniques available, but is based on the same assumption regarding the nature of the regional and residual

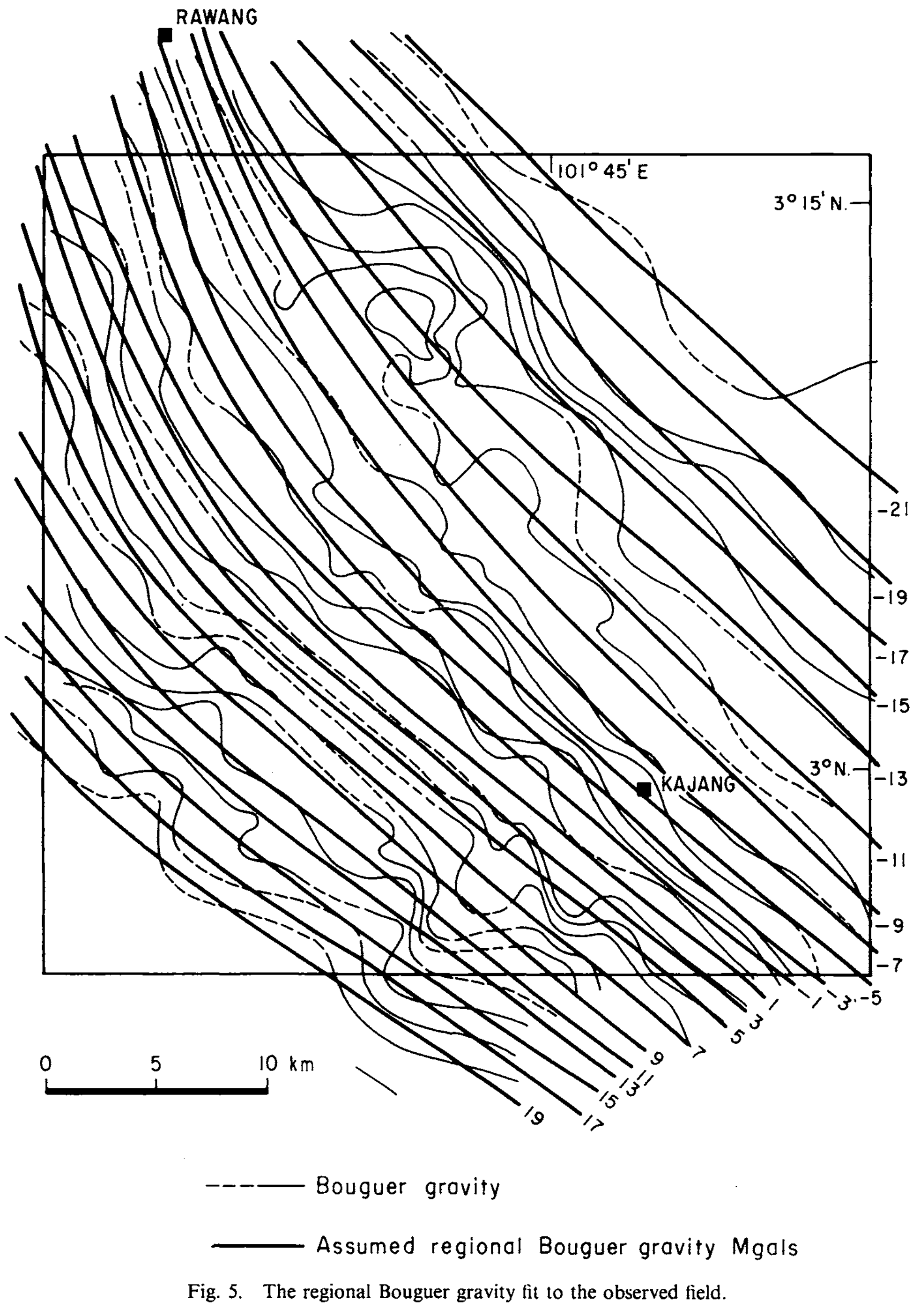

Fig. 5. The regional Bouguer gravity fit to the observed field.

anomalies. The analytical methods were not applied because they are best computed based on values defined over a regular grid, and there are considerable inaccuracies in surveys such as this where some of the grid nodes are far from any data points and require very poorly constrained interpolation.

The prominent regional variation is considered to be due to variation in the depth to the base of the granite (similar to the manner in which Ryall (1982) modelled it). That the granite underlies the coastal plain to the west is assumed from the fact that stocks of granite penetrate the rocks and alluvial cover in the plain and offshore, which are assumed to be offshoots from an extensive granite body. Lack of any sharp expression of the granite contact on the Bouguer gravity map presented here suggests a lack of any significant density contrast between the granite and the Kenny Hill or Kajang Formations and therefore the regional variation cannot be modelled by changing thickness of these metasediments overlying it to the West, but has to be ascribed to changing depths to the base of the granite where a density contrast is assumed. Although this regional variation is of value in studying the crustal structure (particularly with the recent exploration of the Malacca Straits for petroleum resources) is was not studied further because of the limited extent of this survey, which was designed to investigate the residual anomalies left on removal of this regional field.

INTERPRETATION OF THE RESIDUAL ANOMALIES

The residual anomalies left upon removal of the regional field are plotted in figure 6 on a geological basemap simplified from Yin (1976). The largest anomaly with a peak value of +7 milligals occurs over the Kuala Lumpur Limestone and merges with an anomaly of +3 milligals over the limestone at Ampang to the southeast. A +4 milligals anomaly occurs in the northwest corner of the map over a region of schists and metasediments. In the southern half of the map there are a number of anomalies of mixed sign of up to 3 milligals amplitude: to the northwest of Kajang there is a region of positive values near to the granite contact. Limestone is mapped in this region, which is probably the cause of the anomaly with imprecise removal of the regional field a possible explanation of the slight mismatch between the anomaly and the mapped geology. In the southwest quarter of the map there is another area of positive values which again roughly coincides with mapped limestone occurrences, although one of the local peak values occurs over a granite (Bukit Lanchong). The remaining anomalies for which there is no mapped geological expression occur to the southwest of Kajang in a pattern which appears to consist of a northwest trending positive anomaly cut by an east to northeast trending negative anomaly, although the pattern is highly dependant on the exact removal of the regional field.

Sections along lines B-B and E-E across the Kuala Lumpur Limestone were modelled 2-dimensionally using a programme developed from Talwani *et al.*, (1959). For line B-B a linear regional variation of 1 milligal/km was removed, but for line E-E which is parallel to the regional trend no correction was required. The anomalies were modelled with causative bodies of both 0.1 and 0.2 gm/cc density contrasts. Acceptable fits can be achieved for either density with the further constraint of matching depths for the point of intersection of both profiles. Maximum depths for the bodies are 4 and 2 kms for the smaller and larger density contrasts respectively, but because of the

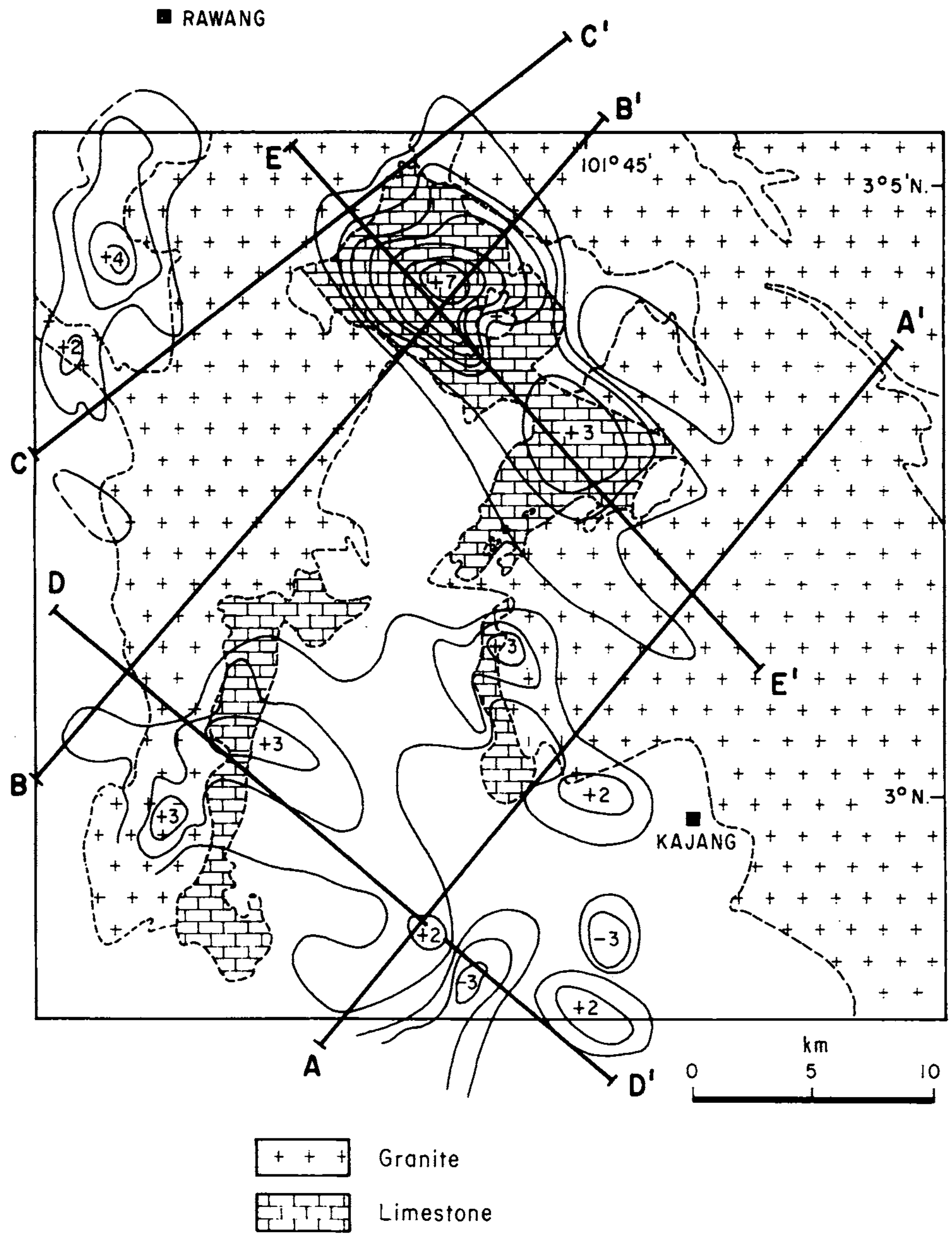

Fig. 6. Residual anomalies obtained on subtraction of the regional from the observed field. Geological map simplified from Yin (1976).

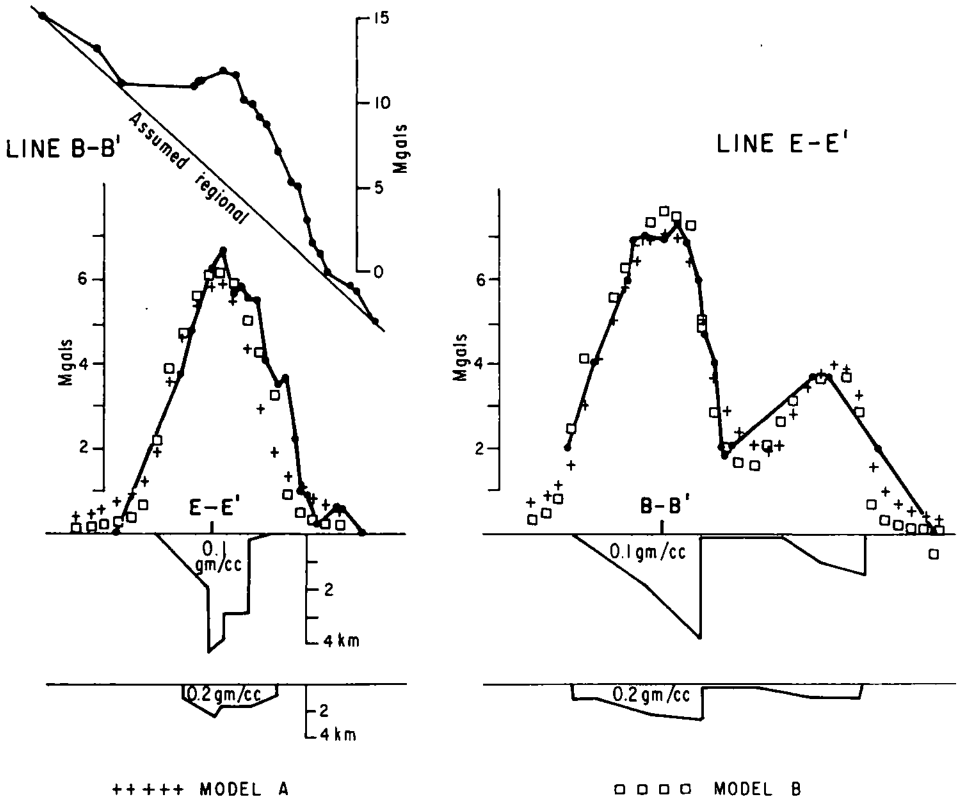

Fig. 7. Model fits to the anomaly over the Batu Cave Limestone.

indistinguishable densities of the granite and the Kenny Hill Formation it is not possible to suggest what underlies the limestone at its base. It is clear from the model fit to line E-E in figure 7 that there is little support from the gravity data for a continuous limestone body extending between Kuala Lumpur and Ampang, but because the measurement density is not sufficient to map these small areas in great detail, and because of some uncertainty in defining the regional field, the author chose to model the anomaly within the constraints of the existing geological map. Because of the excellent access and elevation control available over much of the Kuala Lumpur Limestone it would be quite feasible to produce a more detailed gravity map of that area, which could be modelled with greater confidence and could provide information which may be of value in engineering geology and groundwater hydrology studies pertinent to the continuing expansion of Kuala Lumpur.

CONCLUSIONS

Gravity mapping has enabled better resolution of individual anomalies in the Kuala Lumpur area than was possible with the previous studies made along profiles and with larger station spacings. The dominant feature on the gravity map is the regional field which produces a variation in excess of 40 milligals over the mapped area with a gradient of *c.* 1.0 milligals/km. The more prominent anomalies left on removal of the regional field have amplitudes of up to 7 milligals and are due to relatively high density limestone bodies. Although this survey has located and roughly delineated these anomalies, more detailed surveys over each one would be necessary to define them sufficiently well for reliable modelling. There is no indication on the gravity map of the location of the contact between the Kenny Hill or Kajang Formations and the granite, and this is taken to indicate that they have very similar densities. The regional variation is therefore interpreted as being due to density contrasts at the base rather than at the top of the Main Range and its assumed extension westward under the coastal plain.

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