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Interpretation of regional gravity and magnetic data in Peninsular Malaysia

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Abstract: A regional gravity survey covering the portion of Peninsular Malaysia between latitudes 2°N and 4°N was carried out to study the crustal structure. The total number of gravity stations obtained by Universiti Sains Malaysia is 450. Some aeromagnetic data covering mainly the southern half of the peninsula were also used in the interpretation.

In general, the gravity data reflect the regional geology of the area. A gravity maximum of up to 20 mgals, and a broad magnetic minimum with an amplitude of up to 30 gammas were obtained over the Central Belt. These anomalies may indicate a denser and more basic upper crust underlying the Central Belt. A gravity minimum, with an amplitude of up to 50 mgals, was observed over the Main Range. A smaller gravity minimum, with an amplitude of 20 to 25 mgals, was also observed over the Eastern Belt granites. These anomalies are probably caused by the granite batholiths in these areas which have lower densities than the surrounding rocks.

The gravity values on both coasts of the peninsula are roughly the same. This indicates that the gross tectonic structure beneath both coasts may be similar. The anomalies over the Main Range and the Central Belt taper off towards the south in Melaka and Johore. This implies that the Main Range granite batholiths and the denser (possibly oceanic) crust beneath the Central Belt do not continue farther south into Johore.

Most of these features seem to be best accounted for by the marginal basin tectonic model of Hutchison (1978), which postulates an oceanic crust underlying the Central Belt.

INTRODUCTION

Since 1976, the School of Physics of Universiti Sains Malaysia has carried out a series of gravity surveys in Peninsular Malaysia. The gravity traverses are shown in Figure 1. Profile 1 was obtained by Ryall (1976), and Profiles 2 to 7 were obtained by Loke (1981). Recently, a gravity profile from Penang to Bachok via the East-West Highway was obtained jointly by the Universiti Sains Malaysia and the Geological Survey of Malaysia. The interpretation of Profiles 1 to 7 (from a regional perspective) is given in this paper.

In addition, a considerable amount of aeromagnetic data have been available for about 20 years (Agocs and Paton, 1958, 1960) but have never been interpreted from this point of view. We consider this data as only a secondary source of information, because anomalies of near-surface origin often mask the more interesting but weaker anomalies arising at depth.

In contrast to the extensive geological investigations that have been made of Peninsular Malaysia, there have been very few geophysical studies on a regional scale. In recent years, several plate tectonic models (mainly based on the known surface geology) have been proposed to explain the tectonic history and present crustal structure of Peninsular Malaysia. The results from gravity surveys would provide a

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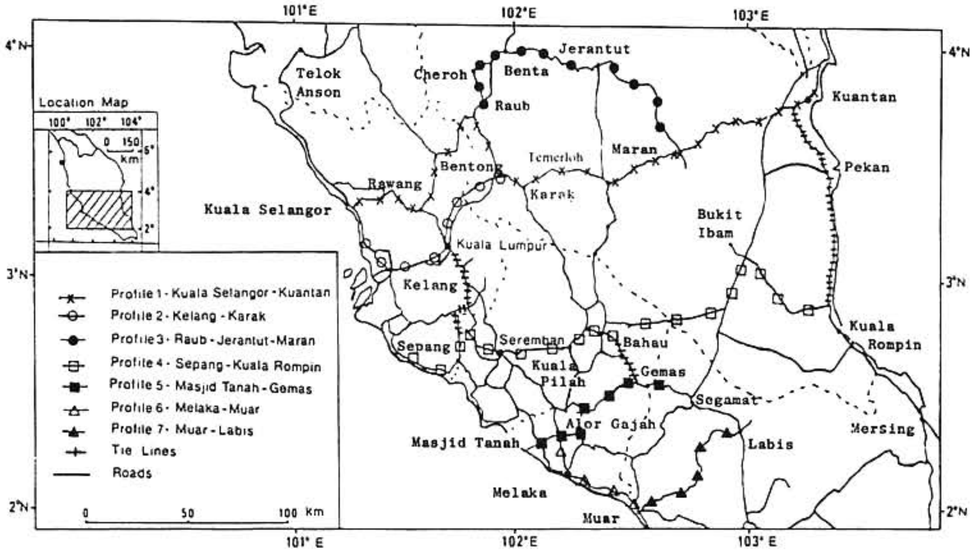

Fig. 1. Map showing the area covered by the gravity survey and the gravity traverses.

geophysical basis for determining the crustal structure of the peninsula. It would also help in testing the various tectonic models and selecting the plausible ones.

FIELD METHOD AND MODELLING

Gravity measurements were made along the available roads and highways with a Scintrex geodetic gravimeter. As the strike of the regional geology is roughly north-south, the major traverses were made in an approximately east-west direction. Along these traverses, the gravity station interval is about 1 to 2 miles. Along the north-south tie lines, the stations were placed 5 to 10 miles apart.

The elevations of the stations were obtained from a variety of sources such as benchmarks, spot heights, engineering road diagrams, altimeter readings and topographic map contours. Altogether, 450 stations were obtained, of which 112 were obtained earlier by Ryall (1976). The error in the elevation for 154 stations was less than 0.03 metre, it was about 0.3 to 0.6 metre for 173 stations, about 2 to 3 metres for 96 stations (from altimeter readings), and up to 15 metres for 27 stations where the elevations were estimated from topographic map contours.

Drift, latitude, free-air and Bouguer corrections were applied to the gravity readings. Terrain corrections up to Hammer (1939) zone L were also applied. A density of 2.65 gm/cc was used for the Bouguer and terrain corrections. The accuracy of the final calculated gravity anomaly values depend largely on the error in the elevation data. For about 73 percent of the total number of stations, where the elevation error is 0.6 metre or less, the expected error is less than 0.2 mgal (1 mgal = 10^{-3} cms^{-2}). For stations where the elevation error is between 2 to 3 metres (21 %), the error is between 0.4 to 0.6

mgal. For a regional gravity survey where the anomalies are of the order of 10 mgals, errors of this magnitude are acceptable.

The gravity stations along the traverses were projected onto profiles which were approximately perpendicular to the regional strike. The geological models by Bott (1961, 1971) and Mueller (1977) for a typical continuental crust were used in the interpretation. Two dimensional models for the profiles were obtained using a non-linear optimization computer program (al-Chalabi, 1971, van Klinken, 1976).

The gravity anomalies give information on density variations within the earth. It is well known that an infinite (but bounded) number of mass distributions can give rise to the same observed anomaly. Thus the models are non-unique. However, any geological model which does not agree with the observed data can be safely rejected.

BRIEF DESCRIPTION OF THE REGIONAL GEOLOGY

In almost all of the area covered by the gravity survey, geological mapping has been done to at least a 1:250,000 scale (Chung and Yin, 1978). Peninsular Malaysia is generally divided into 3 major belts (Fig. 2). The Western Belt is characterized by the Main Range granite batholiths flanked on both sides by Paleozoic metasediments. In general, schist is predominant near the Main Range while farther away the rock types include phyllites, quartzites, chert, conglomerates and marble.

The Central Belt is largely overlain by gently folded and generally un-metamorphosed Triassic sediments. The main rock types are shale and sandstone. Acid volcanics such as tuff are commonly distributed within the sedimentary formations. More strongly folded Permian sedimentary formations outcrop in north and central Pahang to the east of Temerloh. Closely associated with the Permian sedimentary rocks are lava flows and pyroclastic rocks of andesitic composition.

The major country rocks in the Eastern Belt are Permo-Carboniferous sedimentary formations into which numerous elongated granite plutons have intruded. In the northern part of the survey area, the country rocks are, in general, weakly to moderately metamorphosed with metamorphic aureoles near the granite contacts. In the southern half, the oldest rocks are the Permian Sawak metasediments which consists of regionally metamorphosed phyllites and schists.

The major geological units are the Palaeozoic metasediments, granite and the Triassic sediments. A density value of 2.74 gm/cc was used for the Palaaeozoic metasediments. This is an average from 10 different rock samples. For the Triassic sediments, an average value of 2.5 gm/cc was obtained from 5 samples. However, within these two geological units, there are large variations in the densities of the different rock types. Furthermore, there is only a rather small number of rock samples available. An average density of 2.65 gm/cc was used for the granite (from 15 samples).

INTERPRETATION OF THE GRAVITY DATA

A Bouguer gravity contour map, with highly simplified geology, of the survey area is shown in Figure 3. Figure 4 shows the gravity profiles stacked from north to south.

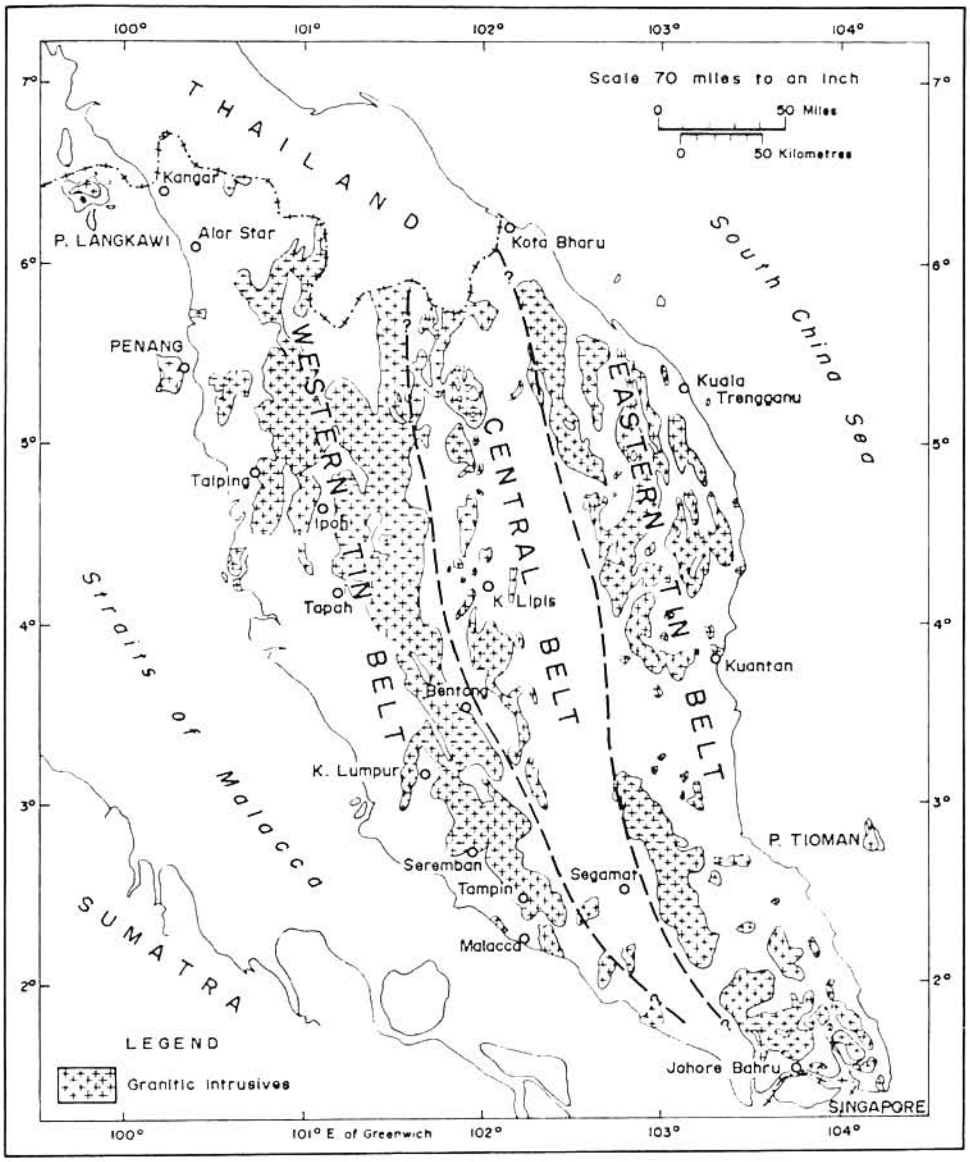

Fig. 2. The three major belts of Peninsular Malaysia (after Rajah and Chand, 1977).

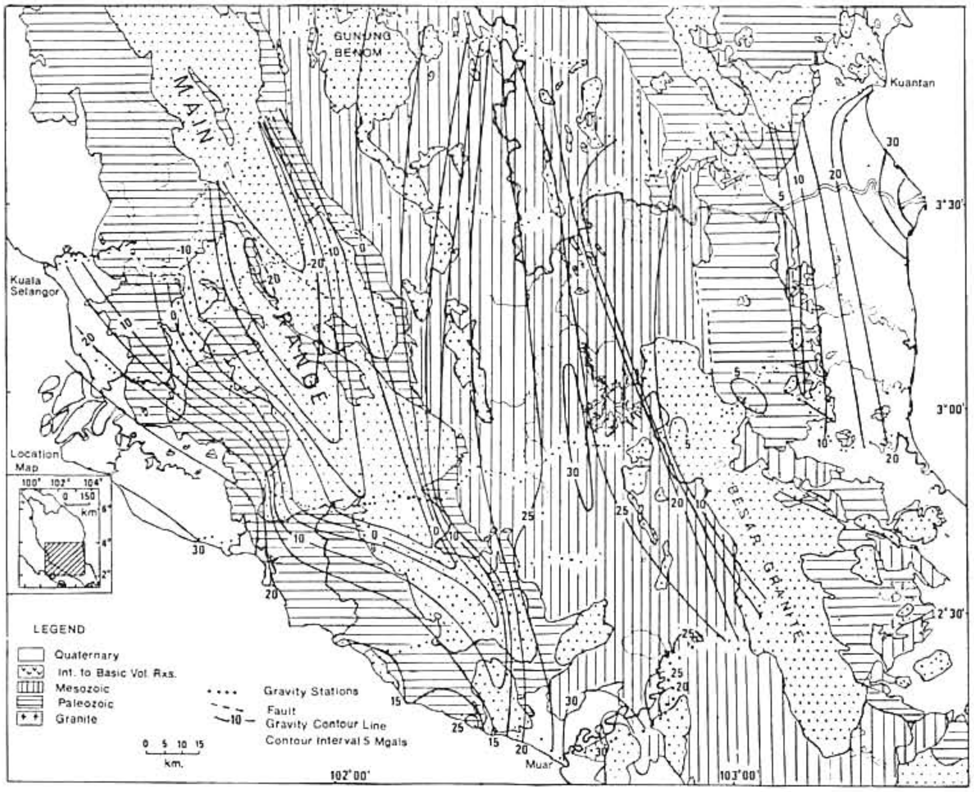

Fig. 3. Bouguer gravity contour map of South-Central Peninsular Malaysia.

Using the non-linear optimization program, a series of models (Fig. 5) was obtained for these profiles (Loke, 1981).

In general, the gravity contour map reflects the regional geology of the area. The contour lines tend to follow the strike of the regional geology. A notable exception is around the Gunung Benom Igneous Complex situated in the northern part of the survey area (Figure 3). The departure from the general trend is probably caused by the Gunung Benom granite batholith.

The gravity data show four main features. Firstly, there is a prominent gravity minimum centred over the Main Range. Here, the contour lines roughly follow the outline of the granite outcrops. The gravity minimum is obviously due to the Main Range granite batholiths which have a lower density than the surrounding rocks. Similar gravity minima are commonly observed over granite bodies in other parts of the world (Bott and Smithson, 1967). There is a change in the shape of this gravity minimum from north to south (Fig. 4), especially towards the southernmost profiles. The magnitude of this minimum decreases from about 50 mgals on Profiles 1 and 2, to about 40 mgals on Profile 4, to about 25 mgals on Profile 5 and to about 20 mgals at the

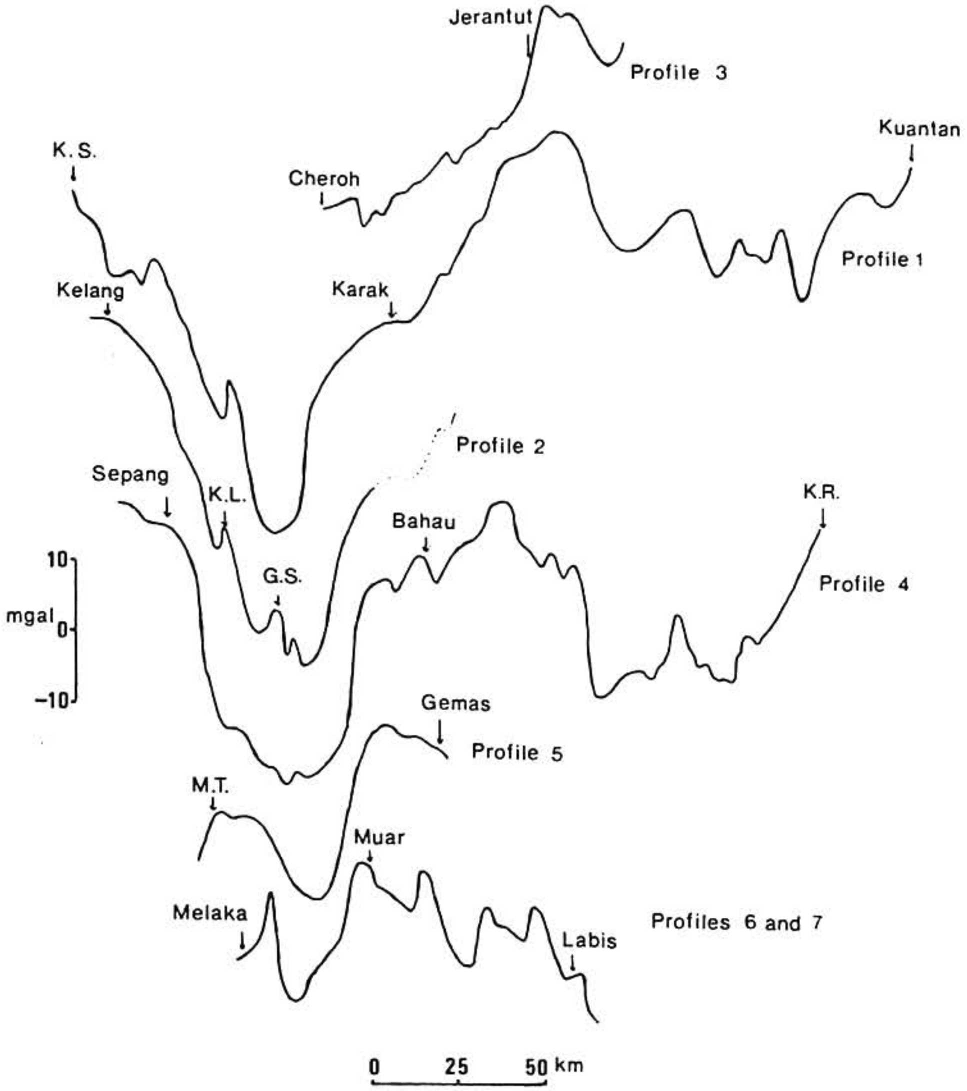

Fig. 4. Gravity profiles stacked from north to south (K.S. = Kuala Selangor, K.L. = Kuala Lumpur, G.S. = Genting Sempah, M.T. = Masjid Tanah, K.R. = Kuala Rompin).

southern end on Profile 6. The width of this anomaly also decreases appreciably towards the southernmost profiles.

Both these features are probably caused by the tapering and thinning of the Main Range granite batholiths towards the south. Another factor could be the proximity of the southern boundary of the Main Range. Also both the stacked profiles (especially Profiles 6 and 7) and the gravity contour map show that the Main Range granite batholiths continue beneath the Straits of Malacca, and are not contiguous with the minor granite bodies farther south to the east of Muar.

At the edges of the Main Range granite, there is a sharp increase in the gravity profiles. This is due to the higher density of the Paleozoic metasediments flanking the Main Range granite. In Figure 5, the gravity minimum is modelled by a thickening of the granite batholith beneath the Main Range. The sharp increase at the flanks of the gravity minimum is modelled by prisms of Paleozoic metasediments up to 5 kilometers thick.

The second major feature is the gravity maximum over the Central Belt. In Figure 3, this is indicated by the 25 mgal contour line between latitudes 2° 45′N and 3° 25′N. The gravity maximum is clearly shown on Profiles 1 and 3 (Fig. 4). It is still distinct, but less prominent on Profile 4. This gravity maximum is significant as the Central Belt is overlain by Mesozoic sediments which have a lower density than granite (2.5 compared with 2.65 gm/cc). This anomaly extends at least up to slightly east of Jerantut in the north, and to the east of Bahau in the south, a distance of 115 kilometres. The extent of this anomaly indicates that it is probably caused by a major crustal feature rather than by near-surface sources only.

The continuation of this maximum south of Profile 4 is rather uncertain, partly due to insufficient gravity data over the Central Belt in the south. Furthermore, the gravity contour pattern is further complicated by granite plutons to the east of Muar (which are not part of the Main Range). The higher gravity values around Muar could indicate a southward extension of the gravity maximum, but this is rather uncertain.

The half-width, and thus the limiting depth of the source (see e.g. Nettleton, 1976) of the gravity maximum on Profile 1 is about 15 kilometers. For Profile 4, the maximum possible depth of the source of this anomaly is about 10 kilometres. The stratigraphic thickness of the overlying Mesozoic sediments has been estimated to be more than 6 kilometres in the vicinity of Temerloh (Chow, 1974) on Profile 1 and at least 6 kilometres near Bahau (Ng, 1970) on Profile 4. The aeromagnetic data indicate that the thickness of these sediments is about 1 kilometre in Southern Pahang (Agocs and Paton, 1960). Thus the source of the gravity maximum must lie approximately between 1 and 10 kilometres deep, i.e. the upper crust. In Figure 5, the gravity maximum is modelled by a thinning of the granite layer beneath the Central Belt. Alternatively, an increase in the average density of the upper crust beneath the Central Belt would also produce the same anomaly.

The third major feature is a broad minimum over the Eastern Belt, which is probably caused by the granite batholiths there. This anomaly is clearly shown on Profiles 1 and

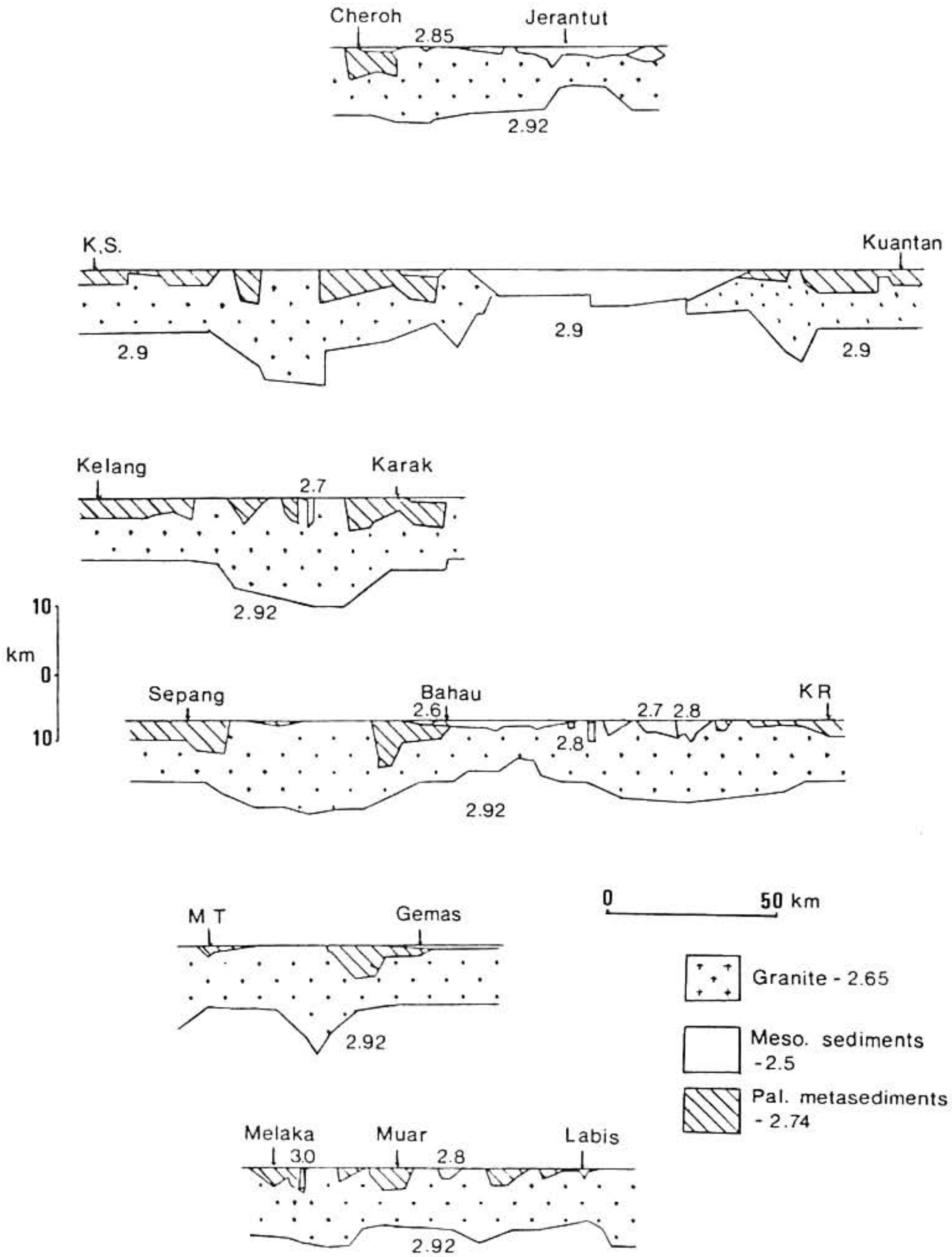

Fig. 5. Stacked crustal sections for gravity profiles. The model for Profile 1 was obtained by Ryall (1980). K.S. = Kuala Selangor, K.R. = Kuala Rompin, M.T. = Masjid Tanah.

4 (Fig. 4). On Profile 7, the decrease in the gravity values at the eastern end indicates the edge of this minimum here. This gravity minimum is modelled by a thickening of the granite batholiths in the Eastern Belt (Fig. 5).

On Profiles 1 and 4, the amplitude of the minimum over the Main Range is about twice that over the Eastern Belt. This indicates that the Main Range granite batholiths are thicker than those in the Western Belt. In the southern part of the survey area in Melaka and Johore (Profiles 6 and 7), where the Main Range granite batholiths taper off, the gravity minimum over the Eastern Belt is more prominent than that in the Western Belt.

The fourth major feature is the similarity of the gravity values (and thus the crustal structures) on both coasts of the peninsula (Ryall, 1976). This is shown by the gravity values at the ends of the 2 complete trans-peninsular profiles, i.e. Profiles 1 and 4. The gravity value at the western end of Profile 2 at Kelang (which is joined to Profile 1 at Karak) is the same as that at the eastern end of Profile 1 at Kuantan.

There is also a general increase in the gravity values towards the south in the western half of the peninsula. This is indicated by the 'V-shaped' contour pattern over the Main Range and the Central Belt. This is probably due to the decrease in the size of the Main Range granite batholiths, and/or a thinning of the crust (or an increase in its average density) towards the south.

INTERPRETATION OF MAGNETIC DATA IN SOUTHERN PAHANG

The areas covered by an old aeromagnetic survey (Agocs and Paton, 1958, 1960) in Peninsular Malaysia are shown in Figure 6. The only area covered by this survey where the gravity maximum in the Central Belt has been observed is in Area 3.

In the vicinity of Kampong Awah on Profile 1, there is an outcrop of andesitic agglomerate (Hutchison, 1973). As it has a higher density than the surrounding Mesozoic sediments, it was considered by Ryall (1976) as a possible major source of the gravity maximum here. Since the andesite has a higher magnetic susceptibility than the surrounding sediments, it gives rise to a prominent anomaly on the aeromagnetic contour map in this area (Agocs and Paton, 1960). An analysis of this anomaly shows that the andesitic agglomerate is limited in lateral extent to about 6 kilometres (Loke, 1981) and thus could not be the major source of the Central Belt gravity maximum.

Farther south in the vicinity of Profile 4, the Central Belt is relatively free of magnetic anomalies due to near-surface sources. Figure 7 shows four profiles (after correction for the geomagnetic field) which were extracted from the aeromagnetic contour map. The location of these profiles are shown in Figure 6. In each of these profiles, there is a broad magnetic minimum with an amplitude of about 20 to 40 gammas over the Central Belt. The half-width (and thus the maximum possible depth of its source) is about 10 kilometres, which is the same as that of the gravity maximum on Profile 4. The location of this magnetic minimum also coincides approximately with that of the

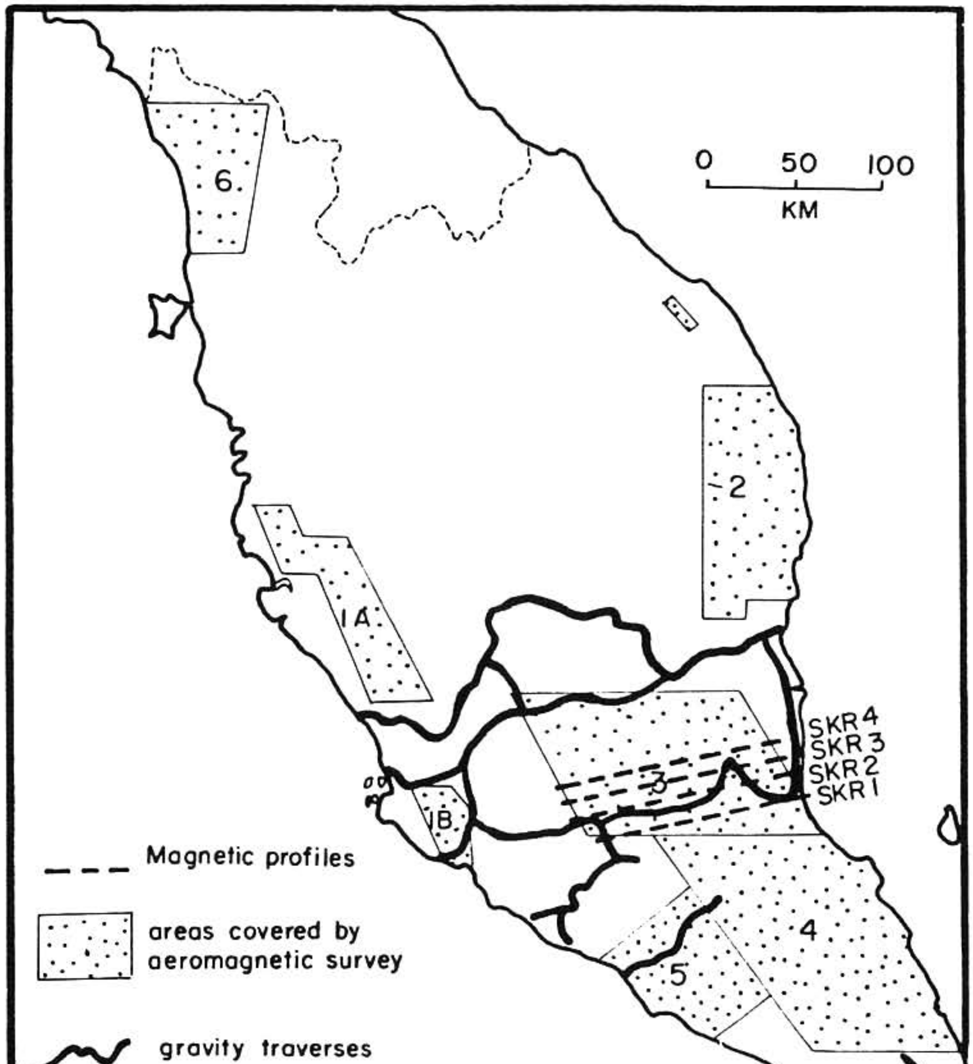

Fig. 6. Location of areas covered by aeromagnetic survey (Agocs and Paton, 1958) and the gravity traverses.

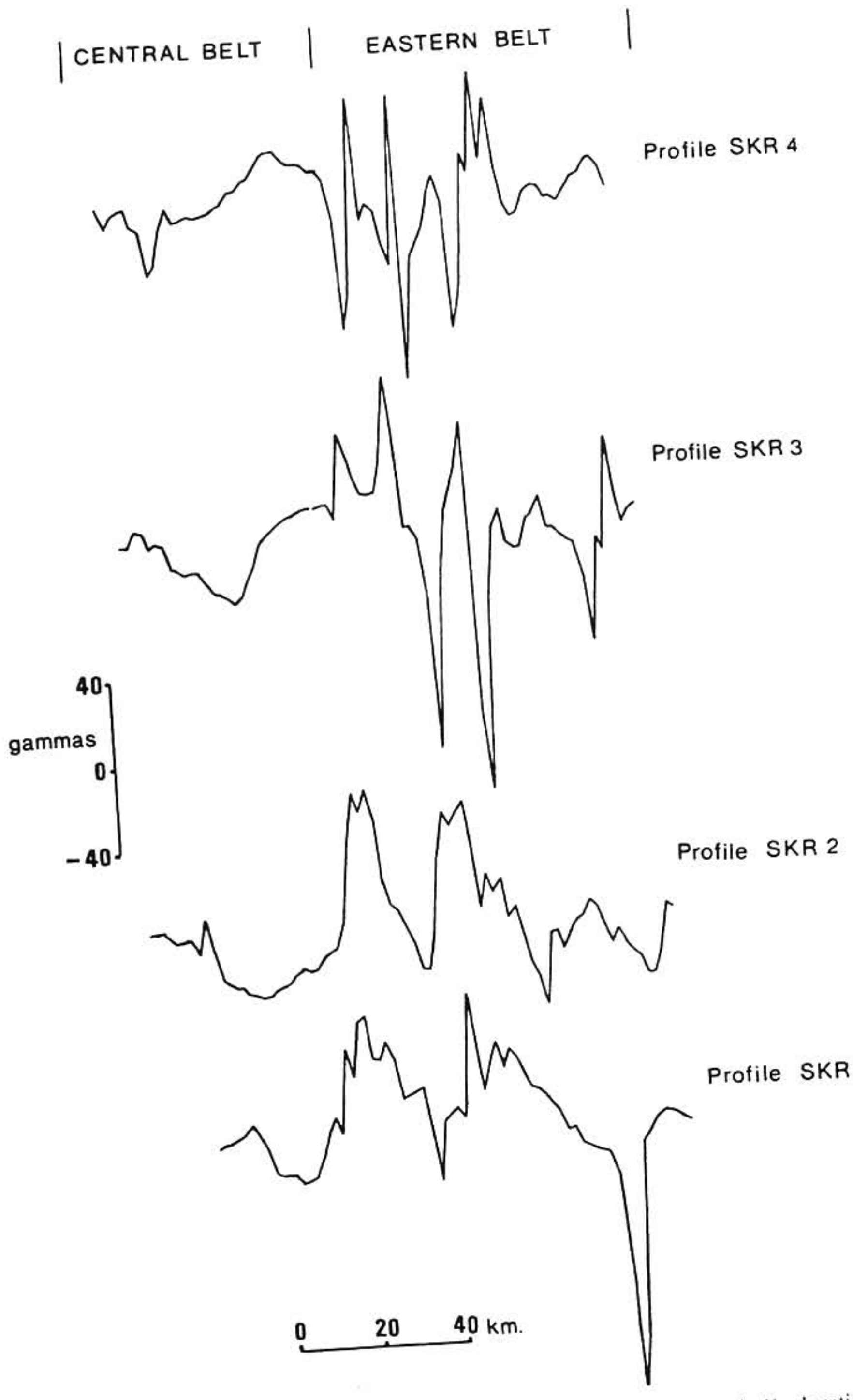

Fig. 7. Magnetic profiles across Southern Pahang stacked from north to south. For location of the profiles, see Figure 6.

gravity maximum. Taking both these two factors into consideration, both the magnetic and gravity anomalies could be due to the same source.

A possible cause of the magnetic minimum is a higher magnetic susceptibility (which in general implies a more basic composition) of the upper crust beneath the Central Belt. A model was obtained for the Central Belt magnetic minimum on Profile SKR 3 using the non-linear optimization computer program mentioned earlier. The mean depth of the model is about 5 kilometres, and the depth to the top of the model is about 3 kilometres. This model does show some gross similarities to the thinning of the granite layer in the Central Belt in the model for the gravity Profile 4 (Fig. 5).

Farther north of Profile SKR 4, the magnetic contours in the Central Belt are complicated by anomalies due to near-surface sources. No significant broad magnetic minimum over the Central Belt exists in this area.

SUMMARY OF THE CONSTRAINTS ON THE CRUSTAL STRUCTURE OBTAINED FROM THE GRAVITY AND MAGNETIC DATA

The gravity and magnetic data indicate that the composition of the upper crust beneath the Central Belt is different from that beneath the Western and Eastern Belts. The average density of the upper crust beneath the Central Belt must be higher (than in the other Belts) to account for the gravity maximum here. The magnetic minimum over the Central Belt discussed earlier could indicate a more basic upper crust beneath the Central Belt. Thus both the gravity and magnetic data seem to point to a more dense and basic upper crust for the Central Belt.

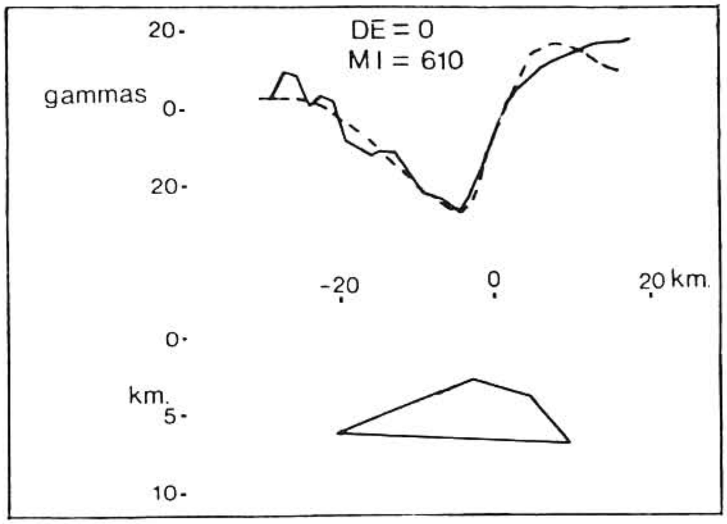

Fig. 8. Model for magnetic profile SKR 3. The calculated curve is shown by the broken line. DE is the direction of transverse magnetization in degrees and MI is the intensity of magnetization in 10^{-6} cgs units.

The similarity of the gravity values on both coasts of the peninsula indicates that the gross tectonic structure of the crusts beneath them are also similar. Assuming the average crustal density to be the same at both coasts, then the total crustal thicknesses must be the same.

In the northern two-thirds of the survey area, the Main Range granite batholiths are thicker than those in the Eastern Belt. Towards the south in Melaka, the major anomalies in the Western and Central Belt taper off. At the southern limit of the survey area in Johore, the dominent geological formations are the granite batholiths in the Eastern Belt. All these features point to a major change in the tectonic structure of the peninsula from the northern to the southern portion of the survey area.

COMPARISON WITH PROPOSED TECTONIC MODELS

In recent years, especially since the general acceptance of plate tectonics by earth scientists, a number of tectonic models have been proposed for the Malay Peninsula. Essentially, these models can be classified into three main types.

The first type by Hutchison (1977, 1978) involves a former marginal basin in the Central Belt. The second type by Tan (1976, 1981) involves an aborted rift zone. The third type by Mitchell (1977, 1979) was based on a subduction of continental crust from the west. The resultant crustal structures derived from these models are tested against the results obtained from the gravity survey.

a) The marginal basin model

In this model, rifting of the present day Eastern Belt from a stable continental craton to the west started in the Carboniferous. A marginal basin was formed in between and reached it's greatest extent in the Permian. Subduction of the marginal basin began in the Late Permian which ended with the collision of the Eastern Belt against the western continental craton. The present day Central Belt is postulated to be underlain by a remnant of the former marginal basin. A proposed crustal section of the Malay Peninsula (Hutchison, 1977) is shown in Figure 9.

As the results of the Kuala Selangor to Kuantan (Profile 1) gravity traverse were taken into consideration by Hutchison (1978) in constructing this model, it naturally does agree with the combined results of the present survey. The survey from the present survey tend to confirm that the major features found earlier by Ryall (1976) on Profile I are indeed regional in nature.

The source of the gravity maximum is explained by an oceanic crust underlying the Central Belt which is a remnant of the former marginal basin (see Fig. 9). As oceanic crust is more basic (as well as more dense) than continental crust, it could also be the source of the magnetic anomaly (a minimum) in the Central Belt.

The difference in the thicknesses of the granite batholiths in the Main Range and the Eastern Belt could be explained by the difference in the mechanisms of emplacement and sources of the granites. The deep seated anatectic Main Range granite was

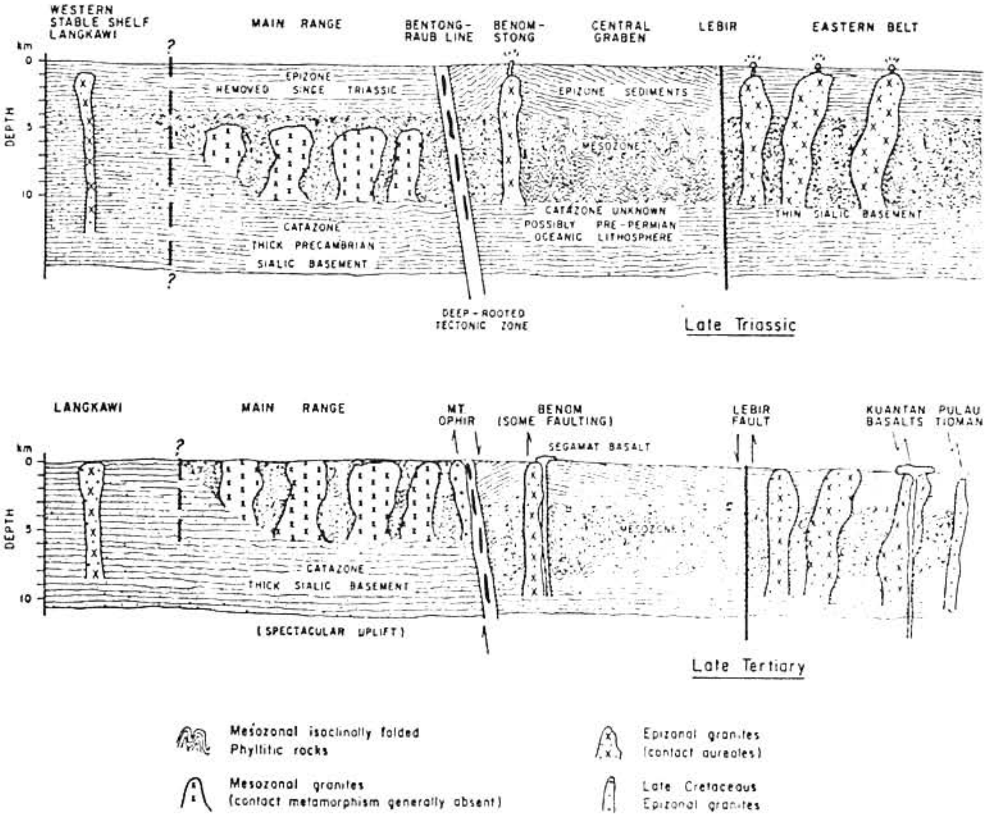

Fig. 9. Proposed crustal sections for the Malay Peninsula during the Late Triassic and Late Tertiary in the marginal basin model (after Hutchison, 1977).

postulated to have been caused by a temporary subduction of the western continental craton while the Eastern Belt granites originated from subduction of oceanic crust (Hutchison, 1978). This could conceivably result in a greater volume and thickness for the Main Range granite batholiths.

The gravity data tend to support the modified southward extension of the proposed Raub–Bentong ophiolite line (Fig. 10) by Hutchison and Taylor (1978) in Melaka. In this model, the Raub–Bentong line separates the Main Range Belt from the Central Belt. The gravity data show that the Main Range granite batholiths are not contiguous with the Bukit Pengkalan granite to the east of Muar. Also, if the higher gravity values near Muar are indeed a southward extension of the Central Belt gravity maximum to the north (Fig. 4), then the boundary between the Main Range Belt and the Central Belt must like to the west of Muar.

As noted earlier, the gravity anomalies (and presumably the geological structures causing them) in the Western Belt and particularly in the Central Belt taper off towards

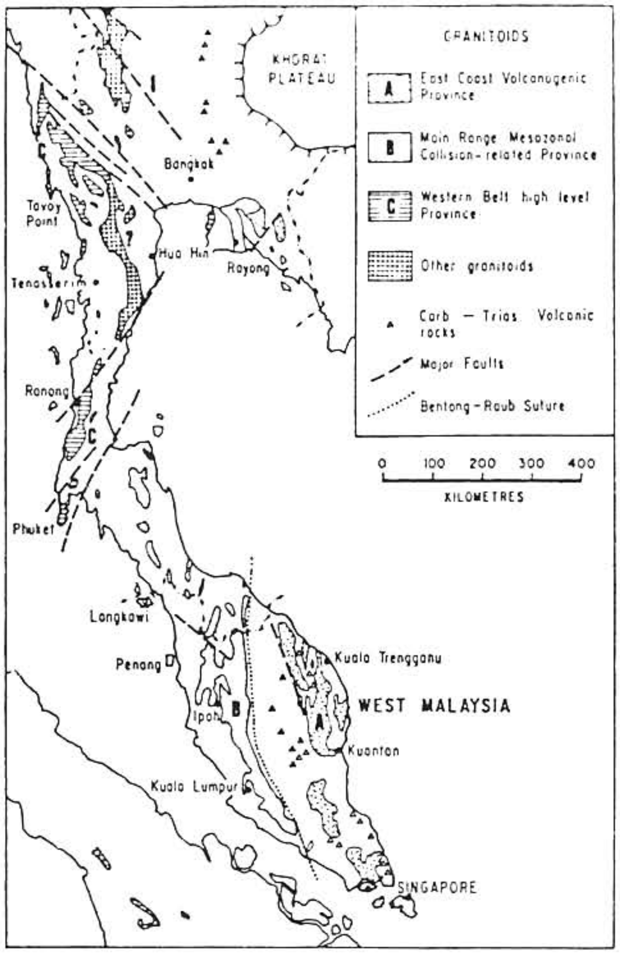

Fig. 10. Subdivision of the Malay Peninsula into tectonic zones (after Hutchison and Taylor, 1978).

the south in Melaka and Johore. This puts a southern limit on the extent of the Central Belt as a major tectonic zone, i.e. as the site of a former marginal basin with an oceanic crust. This also imposes a limit on the extension of the Main Range and Eastern Belt tectonic zones, as understood in this model, to as far south as the Indonesian islands of Bangka and Billiton (Hutchison, pers. comm.).

In Figure 9, the Western Belt is assumed to be underlain by a thicker continental crust than the Eastern Belt. Assuming a density contrast of 0.4 gm/cc between the continental crust and the mantle (Bott, 1971), a difference in the thickness of the continental crust of 1 kilometre would result in a gravity difference of 17 mgals (compared with a probable error of less than 0.3 mgal for this survey). Thus in this model, the gravity values at the west coast should be less than that on the east coast. However, the results for Profile 1 (and 2) and 4 show that the gravity values at both coasts are similar. Furthermore, preliminary results from the Penang to Bachok gravity traverse indicate that the gravity values at both coasts in the north are also similar (van Klinken, pers. comm.). Also, the results from an old marine geophysical survey (White *et al.*, 1964) passing through the Strait of Malacca show that the difference in the average gravity values in the vicinity of the Langkawi Islands and the southern part of the Strait of Malacca is less than 20 mgals. However, this survey has an error of up to 17 mgals. The School of Physics intends to extend the present survey to Kedah and Perlis, and the Thai Department of Mineral Resources has plans for a regional gravity survey in Southern Thailand from the Malaysian border to Phuket (Hasegawa, pers. comm.). The results from these forthcoming surveys would greatly help in establishing whether there is a significant difference in the crustal thickness in the Western and Eastern Belts.

b) The aborted rift model

In this model, the observed surface geology is explained in terms of an oborted rift zone centred beneath the Central Belt which was initiated sometime in the Upper Paleozoic (Tan, 1976). A proposed crustal section for the Malay Peninsula during the Late Mesozoic when the rifting ended is shown in Figure 11.

The thinner crust beneath the Central Belt in this model should result in a gravity maximum here (Fig. 11). However, the crustal thickness of Peninsular Malaysia is about 30 kilometres (Loke, 1981) and even assuming the crust beneath the Central Belt is only about 20 kilometres thick, the resulting anomaly would be much broader than that observed. As mentioned earlier, the gravity and magnetic data suggest that the source of the gravity maximum lies somewhere between 1 to 10 kilometres deep, i.e. somewhere in the upper crust rather than at the base of the crust. Nevertheless, in this model, widespread intrusions of ultrabasic and basic rocks could increase the average

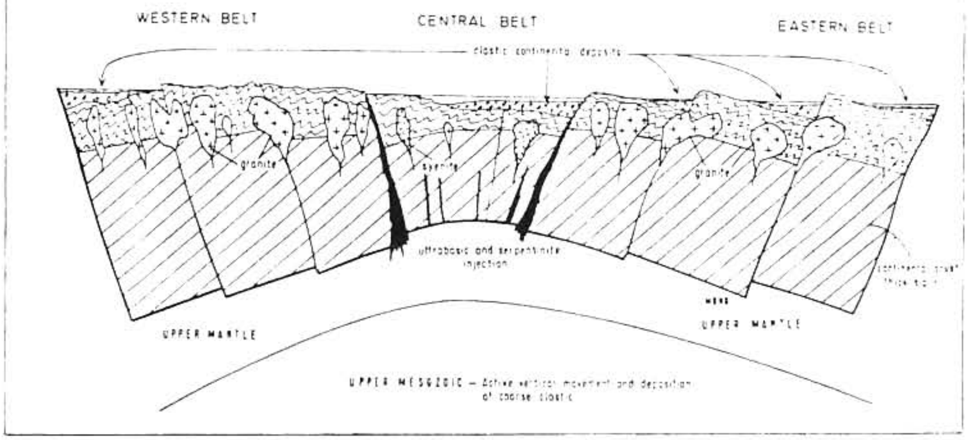

Fig. 11. Proposed crustal section for Peninsular Malaysia during the Late Mesozoic in the aborted rift model (Tan, 1976).

density of the upper crust below the Central Belt, resulting in the observed gravity and magnetic anomalies.

The similarity of the gravity values at both coasts of the peninsula is easily accounted for by this model. The similarity of the tectonic structure on both sides of the peninsula is a characteristic feature of this model.

The difference in the magnitudes of the gravity minima over the Main Range and Eastern Belt granite batholiths does not appear to be readily accounted for by this model. There does not appear to be any mechanism or feature in this model to account for the differences in the thickness of the granite batholiths in these two belts (at least for the northern two-thirds of the survey area). The gravity data, together with the geological data (Hutchison, 1977), show that the modes of emplacement and the sources of the Western and Eastern Belt granite batholiths are different.

Thus the main difficulty of this model is in explaining the difference in the sizes of the granite batholiths in the Western and Eastern Belts. However, it must be noted that there is nothing in this model to preclude the possibility of the granite batholiths having different sizes. Some modification or additions, such as different depths of emplacement, could be made to explain the difference.

c) The collision zone model

In this model, the regional geology and the distribution of tin deposits in the Malay Peninsula are explained in terms of a collision of two continental plates in the Western and Eastern Belts (Mitchell, 1977, 1979). A proposed crustal section for the Malay Peninsula (during the Early Eocene) is shown in Figure 12.

The main difficulty with this model is in explaining the gravity maximum over the Central Belt. Figure 12 seems to imply that underthrusting of the western continental plate continued beneath the present day central Belt and up to the granites of the

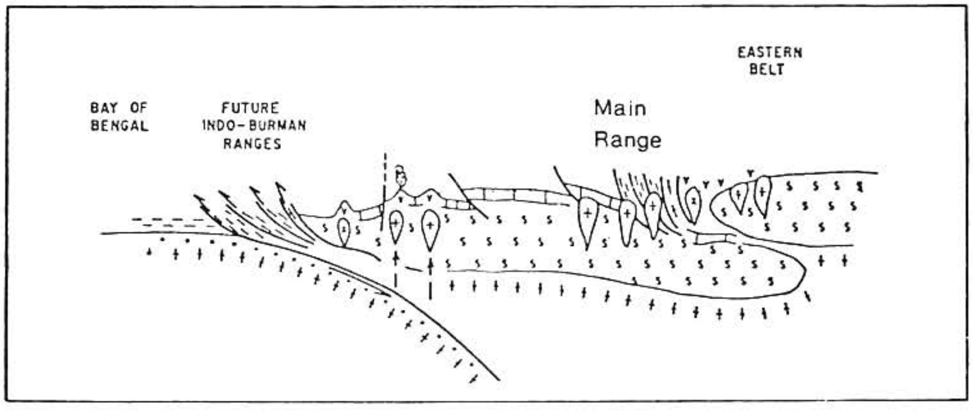

Fig. 12. Proposed crustal section for the Malay Peninsula during the early Eocene in the collision zone model (after Mitchell, 1977).

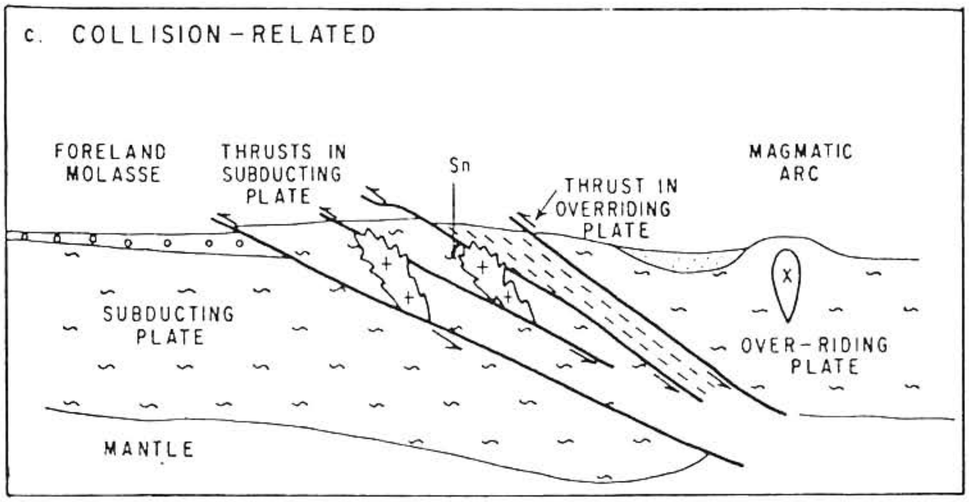

Fig. 13. Crustal section for the Malay Peninsula in the collision related model (after Mitchell, 1979).

Eastern Belt. This would result in thickening of the continental crust in these areas. Although isostatic uplift would reduce the increase in the thickness of the crust, there should be some residual increase in the crustal thickness as in the Himalayan (Mitchell, 1977) and Appalachian zones.

As noted earlier, an increase in the crustal thickness by 1 kilometre would result in a decrease of the gravity by approximately 17 mgals. Thus we would expect a very broad gravity minimum centred over the Central Belt. A later model (Mitchell, 1979) seems to imply that subduction of the western continental plate continued up to the eastern edge of the Central Belt only (Fig. 13). This would reduce the degree of crustal thickening (and thus the amplitude of the associated gravity minimum) somewhat, but it would certainly not produce a gravity maximum. Also, as Figure 13 seems to imply that the Central Belt is part of the western edge of the over-riding eastern continental plate, this would seem to rule out the presence of remnants of oceanic crust here.

Thus the results from the gravity survey seem to rule out this model.

CONCLUSIONS

There are three main results from the present gravity survey. Firstly, the tectonic structure on both sides of the peninsula are similar. Secondly, the Main Range granite batholiths are thicker than those in the Eastern Belt. Thirdly, the upper crust beneath the Central Belt is denser and possibly more basic (from the magnetic data) than that in the flanking belts.

The marginal basin model of Hutchison (1978) seems to be able to account for most of the results from the gravity (and the aeromagnetic) survey. The Central Belt is probably underlain by an oceanic crust which marks the location of a former marginal basin.

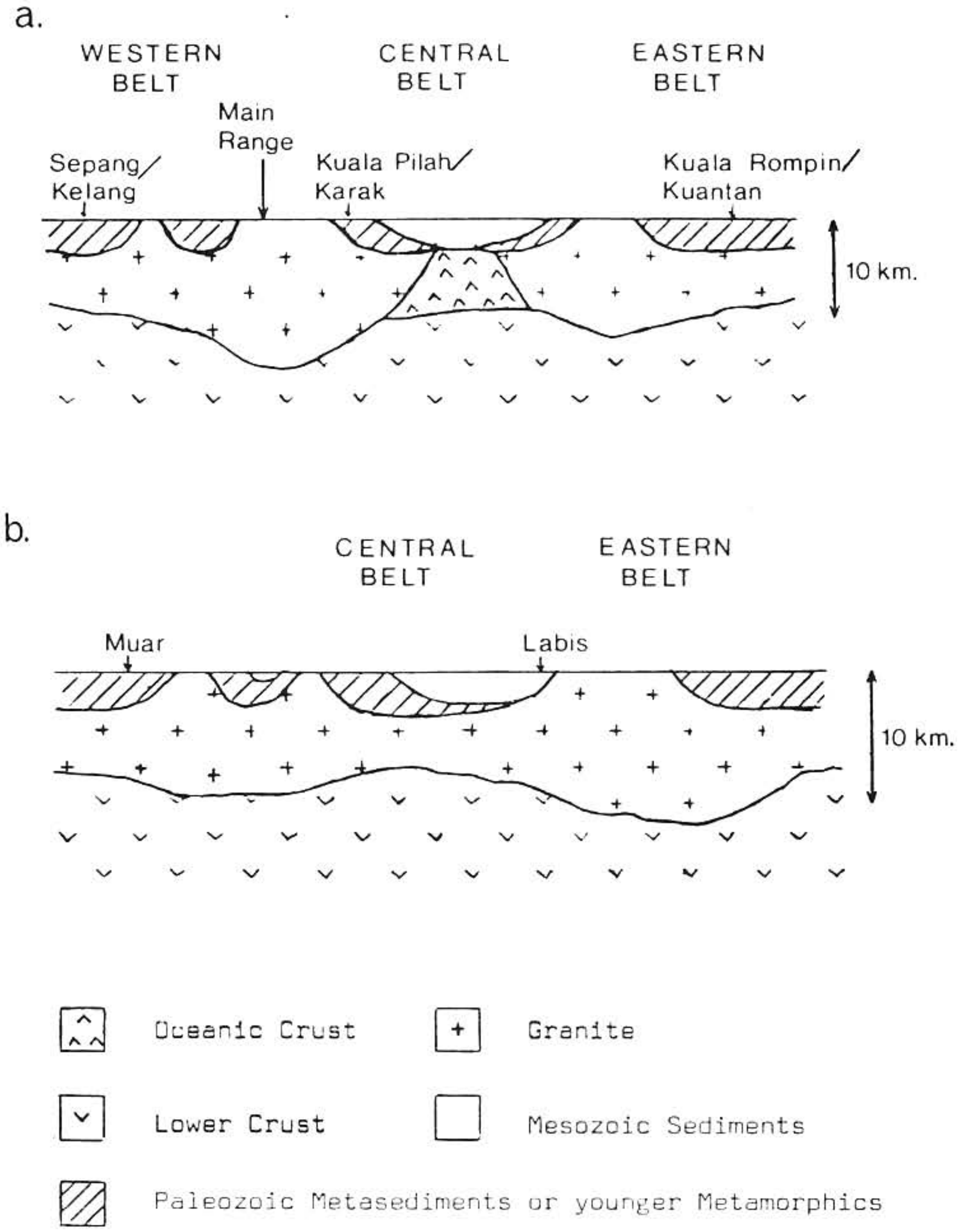

Fig. 14. Proposed east-west crustal sections for the (a) Central and (b) Southern portions of Peninsular Malaysia.

From the gravity and magnetic data available at present, a proposed crustal section for the northern two-thirds of the survey area is shown schematically in Figure 14a. For the southern portion of the peninsula in Johore, the results from the Muar to Labis (Profile 7) gravity traverse show that the crustal structure here is significantly different from that in the northern portion. A proposed crustal section is shown in Figure 14b. Here the Main Range granite batholiths and the oceanic crust beneath the Central Belt are absent, and the dominant geological feature is the Eastern Belt granite batholith.

Although the above geological sections best fit the available data, they are not unique due to ambiguity in gravity and magnetic interpretation. More extensive geophysical studies are necessary to confirm and extend the findings of the present survey. In particular, a magnetotelluric survey (e.g. Jupp *et al.*, 1979) could greatly reduce the ambiguity problem at moderate cost.

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