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The Magnetic Anomaly Across Peninsular Malaysia Between Muar and Endau

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Abstract

The aeromagnetic anomaly by Agocs and Paton (1959, 1966) between Muar and Endau has been studied. A major part of the anomalies form circular and linear features. The circular features are probably caused by isolated sources such as concentration of magnetic minerals in granite bodies. The linear features are caused by alignment of elongated magnetic anomalies. These are probably due to concentrations of magnetic minerals along fracture zones. Four sets of anomaly alignments are observed, which can be correlated to the major fracture system of Peninsular Malaysia between Endau and Muar.

Anomali Magnet Sepanjang Semenanjung Malaysia di antara Muar dan Endau

Abstrak

Anomali aeromagnet oleh Agocs dan Paton (1959, 1966) diantara Muar dan Endau telah dikaji. Sebahagian besar anomali membentuk fitur membulat dan linear. Fitur membulat kemungkinan disebabkan oleh sumber yang berasingan seperti konsentrasi mineral magnet dalam jasad granit. Fitur linear dibentuk oleh penjajaran anomali magnet. Ini mungkin disebabkan kepekatan mineral magnet sepanjang zon retakan. Empat set penjajaran anomali boleh dilihat dan dikorelasikan dengan sistem retakan utama Semenanjung Malaysia di antara Endau dan Muar.

INTRODUCTION

Magnetic anomalies are available for parts of Peninsular Malaysia in the form of maps such as the aeromagnetic maps of Agocs and Paton (1959, 1966). The interpretation, however, has been mainly targeted for locating mineralized areas and its relation to the granitic bodies. Therefore, there is a need for more detailed interpretation of the magnetic anomalies. A study has been carried out for selected areas and this study adds another dimension to the understanding of local and regional geological problems such as the tectonic setting, as well as the surface and basement features and structures.

One of the geological problems in Peninsular Malaysia is the varied geology across the peninsula from the South China Sea in the east to the Straits of Malacca in the west. This leads to different interpretations on problems such as the tectonic and structural setting across the peninsula. The dense vegetation and lack of fresh outcrops tend to cause concentrated study where outcrops can be found. Thus, interpretation which are mainly based on these studies may be best suited for localized geological problems but can cause contradiction when extended to regional interpretations. Observations from the aeromagnetic anomaly can be used to bridge the gap between local interpretations and regional problems.

A magnetic transect across Peninsular Malaysia is chosen for this purpose. One such east-west transect, which has complete magnetic data coverage is from Endau in the east to Muar in the west. This is an interesting transect because it passes through an area where the relationship between three major tectonic belts, refered to as the Western, Central and Eastern belts is rather vague and conflicting. The magnetic anomaly along this transect provides an additional perspective towards solving this problem.

THE MAGNETIC FIELD

The earth produces a magnetic field that is generally known as the main field. This is produced from within the deep interior of the earth (sometimes called the dipole field) and forms the major component of the magnetic field that surrounds the earth. Superimposed on this main field is the magnetic field from above the earth surface (referred to as the non-dipole field) and the magnetic field produced by magnetic material at the crust of the earth (the anomalous field). Together these magnetic fields form the total field, which is the measured field in any magnetic data acquisition survey. Removal of the dipole and non dipole fields from the measured field, results in the anomalous magnetic field that arises from the materials within the crust. Therefore, this residual component defines the crustal subsurface magnetic material distribution. In some cases these magnetic materials are assimilated in the rocks of the crust while in others the magnetic materials are formed in the plane of weakness such as faults, fracture zones and bedding.

THE DATA

The magnetic anomaly used in the study is from Area 4 and Area 5 of the Agocs and Paton (1959, 1966) aeromagnetic maps. To enable effective computer aided processing, the data has been digitized by the Minerals and Geoscience Department, formerly known as the Geological Survey Department of Malaysia. This data has been digitized along flight lines at 1 to 10 nanoTesla intervals depending on the gradient of the magnetic anomaly. In order to retain the exact anomaly, closer sampling has been carried out where the magnetic gradient is high. The flight line orientation for Areas 4 and 5 are different. Area 4 has a NE-SW orientation while Area 5 has an E-W orientation.

DATA PROCESSING AND INTERPRETATION PROCEDURE

The digitized data was processed using a personal computer with a Pentium III processor and a number of computer softwares. The softwares used include graphics software such as Surfer 7 (Golden Software, 1999) as well as spread sheets. The initial part of the work involved studying Agocs and Paton (1959, 1966) analogue magnetic maps and comparing them to the geological map of the study area. Due to the large area involved, the existing geological map of Peninsular Malaysia (GSD, 1988) has been used. Figure 1 shows the geological map of the southern part of Peninsular Malaysia and the location of the study area. Some geological field studies were also carried out.

Subsequent to this, the digitized data was contoured. The first step in contouring the data using Surfer 7 is to grid the digitized data into a regular rectangular grid data. Griding irregular data into the form of regular grid data requires interpolation. A number of interpolation methods are available in Surfer 7. Two interpolation methods have been used. They are the triangulation and kriging methods. The triangulation gridding method is good for evenly distributed data and is an exact interpolator. This method is fast and has been used to grid the data at close spacing for rapid results and interpretation. It takes a few minutes to grid the data at spacings of 50 m^2. Digitizing at this interval produces 57 megabytes of data. For larger spacing the kriging method, which expresses trends in the data has been used. This method can be both exact and smoothing depending on the variogram model used but is very slow. The final map presented here used the kriging method with 100 m^2 grid spacing, took 6.5 hours to grid using the Pentium III computer and the resultant data file occupies 14 megabytes of space.

Magnetic anomalies of large areas are commonly caused by different sources that produce anomalies of different wavelengths. Deep and large features generally cause long wavelength anomaly while the shorter wavelength anomalies are normally caused by shallower sources. Separation of the anomaly components using frequency filtering is desirable to isolate the different

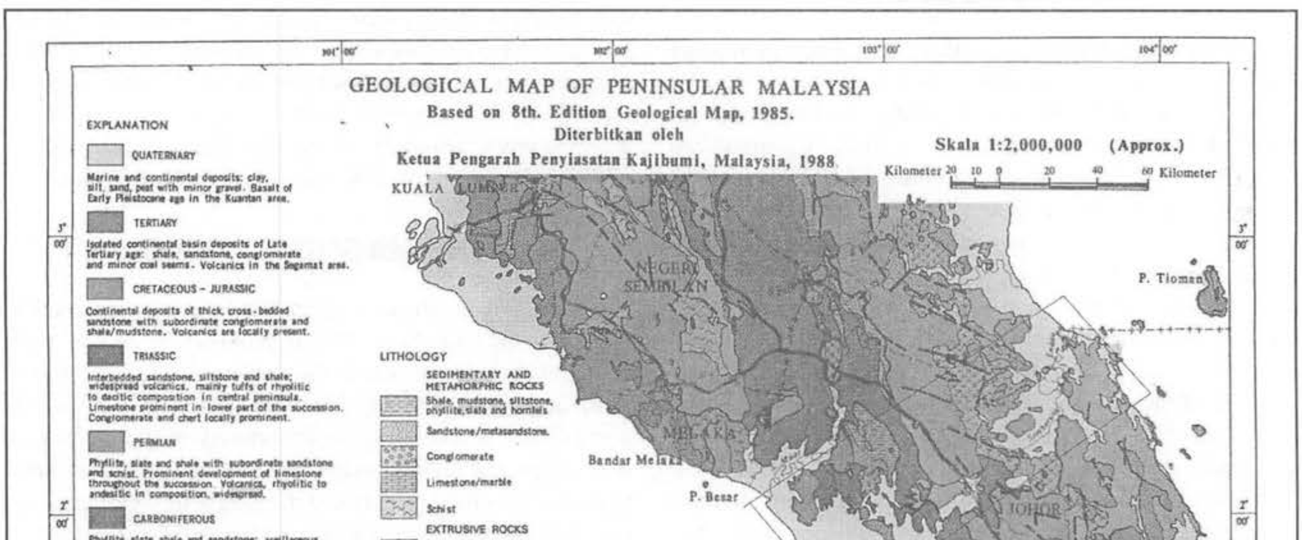

Figure 1: Geological map of the southern Peninsular Malaysia showing the study area (indicated by rectangle).

frequency components but in its absence, sampling at different intervals also achieves a similar effect. The magnetic maps given here have been sampled at different spacings. Figure 3 has been sampled at 4 km^2 spacing while Figure 2 and Figure 4 were sampled at 100 m^2 spacing.

Contouring of maps where lines of the same height are drawn has been conventionally used to express the changes in magnetic anomalies. This type of display is not able to show all the features, particularly the smaller features, due to constrain of drawing the contour lines. With the availability of high-resolution video display units and printers, a more effective method of display has been used. This method involves placing different colors or gray shades to different range of values, hence producing a more refined visual display of the variations. In addition the color or gray shades can be used to indicate the local orientation of the surface relative to a directed light source using its reflectance. Surface facing away from the source has lower reflectance. The map produced is called the shaded relief map shown in Figure 4.

THE ANOMALY

A typical magnetic anomaly away from the magnetic pole normally comprises a pair of high and low values. For Peninsular Malaysia where the magnetization direction is upward and towards the north, the low values are at the southern part while the high values are at the northern part. Most of the anomaly pairs observed within the study area have this typical character. In the case where the anomaly does not follow this character, possible reasons include the presence of remnant magnetization or the presence of multiple sources.

The magnetic anomalies observed within the area (Figure 2) form various shapes. Some form almost circular anomalies, such as the long wavelength anomalies in Bukit Pengkalan and Ayer Hitam, or relatively short wavelength almost circular anomalies seen all over the area. A series of short narrow elongated high amplitude short wavelength anomalies were also observed such as the anomalies in Bukit Kepong, while slightly broader anomalies with lower amplitude, were seen in Gunong Beremban. A very distinct feature of these elongated anomalies is that they often form

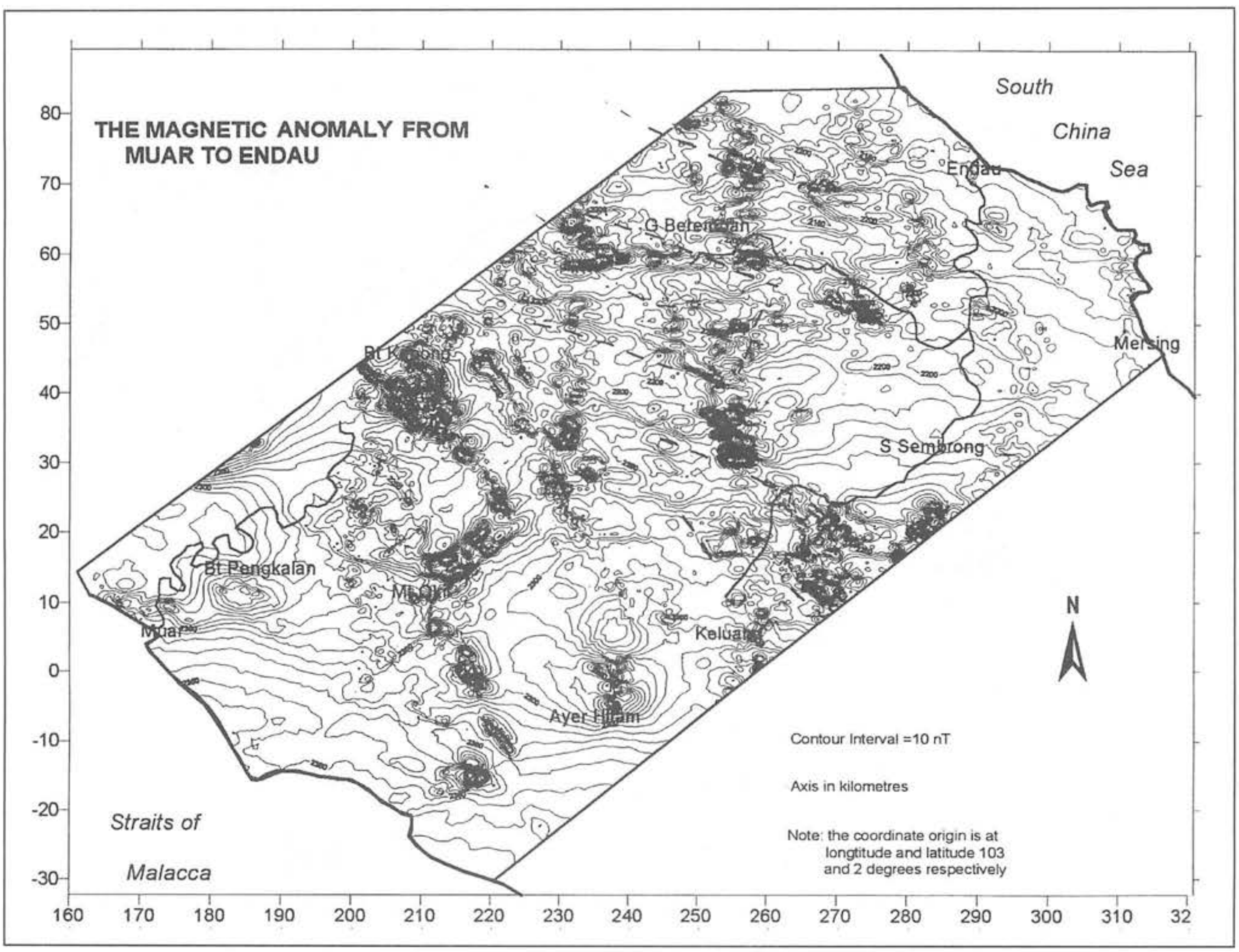

Figure 2: The magnetic anomaly from Muar to Endau.

a series of aligned anomalies. This alignment is especially observable in the shadow relief map (Figure 4).

Figure 4 shows that Peninsular Malaya is characterized by relatively large areas of quite magnetic zones and a larger area of magnetized zones.

The quite magnetic zones include the area between Muar and Batu Pahat (west of Ayer Hitam), the area north of Ayer Hitam, the area around the lower part of Sungai Semborong and the area between Endau and Mersing. Within these regions there are isolated anomalies such as the anomaly at Bukit Pengkalan.

The magnetized zones generally show distinct alignment of the elongated anomalies, and four clearly distinct alignments are observed (Figure 4).

In the western coast, to the east of the coastal quite magnetic zone, distinct northwest-southeast (strike angle 155^0) alignment (Bukit Kepong) together with a northeast-southwest (strike angle 55^0) alignment (Mount Okil) are seen. The two sets of alignments form a large step like pattern. The northwest-southeast alignment continues to the east of Bukit Kepong. Within this aligned magnetic anomalies smaller step like features having similar strike displacement to the large one can be observed.

The orientation of the aligned magnetic anomalies changes to a more easterly direction with a strike direction of about 110^0 further east (southwest of Gunong Beremban). This orientation can also be seen near the eastern coastal region, west of Endau.

The third distinct orientation is the almost easterly alignment of the magnetic anomalies around and south of Gunong Beremban.

The forth distinct orientation is the alignment of the magnetic anomalies in a northerly direction. Within this alignment the anomalies seem to form a series of step like features having the same orientation as the large step like feature in the west. These three alignments (110^0, easterly and northerly) are superimposed on each other.

INTERPRETATION OF THE MAGNETIC ANOMALIES

The quite magnetic zones occur mainly in areas underlain by Quaternary deposits. Presumably the Quaternary deposits in this region are thick to be able to mask the possible high amplitude magnetic anomalies from the rocks underlying the Quaternary sediments.

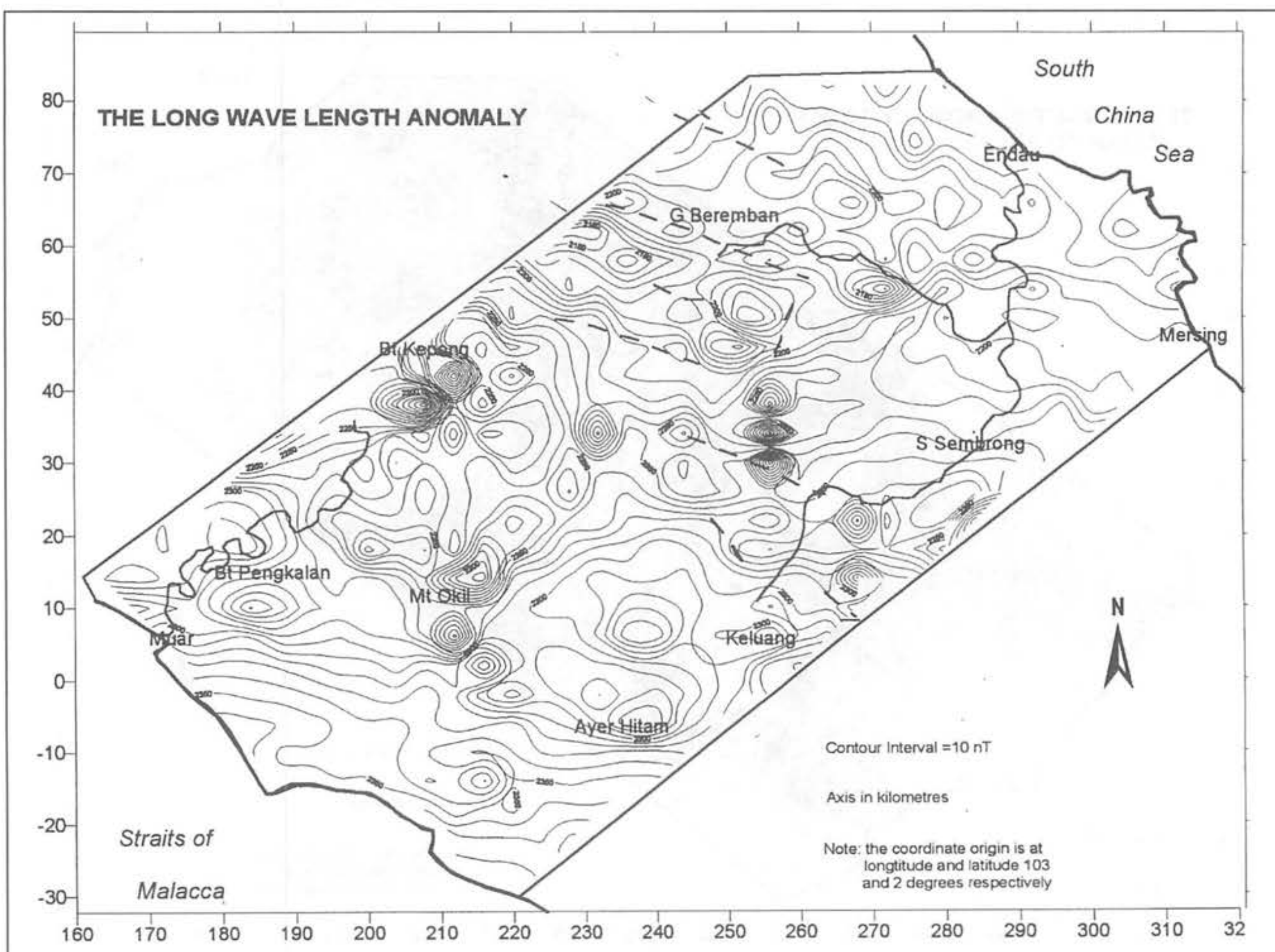

Figure 3: The long wave length anomaly.

The isolated and almost circular anomalies, particularly the large ones, are probably caused by a cluster of magnetized bodies or concentration of magnetic materials within the causative bodies. This is true of the anomalies at Batu Pahat where some parts of the granite have high concentrations of magnetite.

The anomalies that are aligned are mainly associated with concentrations of magnetic materials in linear structures. Among the structures are faults and fracture systems and bedding planes within sedimentary beds. The large scale nature of the alignment transgressing geological boundaries suggest that the linear features associated with them are mainly faults or fractures. In Bukit Kepong the magnetite are formed in sheared zones. Compared to the existing published fault and fracture systems, these orientations are similar to the known fault and fracture directions. But the magnetic anomalies indicate that most of the fault and fracture systems are much longer than have been indicated in the Peninsular Malaysia geological map (GSD, 1988).

The long wavelength magnetic anomaly (Figure 3) with a 4 square kilometer grid removes the high amplitude short wavelength anomalies. The long wavelength features such as the anomaly at Bukit Pengkalan is retained. The short wavelength high amplitude anomaly which forms linear features are almost absent in this map. Linear features such as those south of Bukit Kepong disappear. This suggest that some of the linear features only occur in the rock above the magnetic basement. While some of the long wavelength anomalies are caused by large near surface body such as that of Bukit Pengkalan, others are a reflection of the magnetic basement. The short wavelength anomalies forming an east-west alignment near Gunong Beremban is also reflected in the long wavelength anomaly map. Unlike the linear anomaly south of Bukit Kepong which occurs only within the rock underlying the area, this east-west fracture system occurs in the near surface rock and continues into the basement.

CONCLUSION

A number of deductions can be made based on the assumption that these orientations are closely related to the fault and fracture systems. They are as follows:

1. The step like structure indicates a right lateral movement in a northeast southwest orientation.

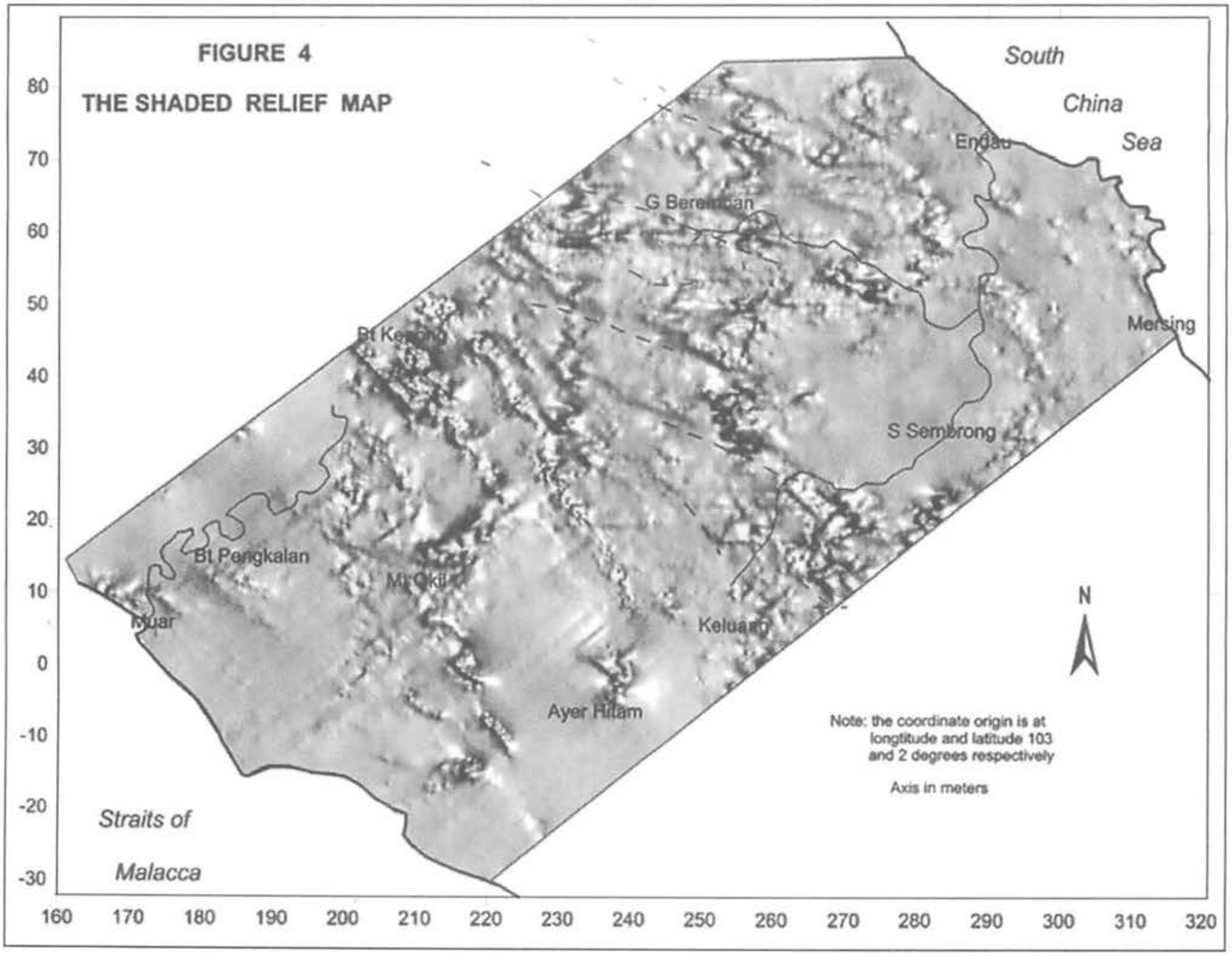

Figure 4: Shaded relief map of the study area.

2. The different orientations allows division of the area into two regions. The first is a region having a major magnetic alignment with a bearing of about 155° in the west, and the second is the eastern region having major magnetic anomalies aligned in the other directions as described earlier. The boundary is to the east of Bukit Kepong where the change in alignment is distinct. This may be correlated to the Central and the Eastern Belts.
3. The northerly alignment in the eastern region appears to cut the other alignments hence indicating that it is formed last suggesting that the northerly fracture system is the youngest.
4. The fracture system given in some of the existing maps are slightly displaced from the magnetic alignment and shorter. They may not havebeen mapped completely and accurately; and
5. Isolation of the anomalies into different frequency components helps to determine the level at which the anomaly originates.

With the above observation, the magnetic data should provide a good base for evaluating and solving regional problems. Detailed work is under way, including carrying out more field confirmation and computer modeling. This is anticipated to bridge the gap between isolated studies and increase understanding of the regional setting.

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