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Confirmation of the Yan Magnetic Anomaly by Gravity Data

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Abstract

The well-defined Yan aeromagnetic anomaly located north of Gunung Jerai in Kedah was investigated further by running a detailed gravity traverse over it in an approximately north-south direction. After the standard reductions to the raw gravity data were made, a Bouguer gravity profile was obtained. A clear regional trend, with gravity values decreasing uniformly towards the south, is apparent. This is attributed to the major granite intrusion centred at Gunung Jerai. Superimposed on this regional trend are two negative and one positive gravity anomalies. The middle anomaly with a magnitude of -1.2 mgal coincides with the Yan magnetic anomaly. Mathematical modelling indicates that the causative body is an igneous intrusion with its top at approximately 31 m below the surface. This gravity model is entirely consistent with the magnetic model based on detailed ground magnetic data of previous surveys.

Kehadiran Anomali Magnet Yan Berdasarkan Data Graviti

Abstrak

Takrifan terbaik anomali aeromagnetik Yan yang terletak di utara Gunung Jerai Kedah dikaji lebih lanjut dengan menjalankan kajian terperinci rentasan graviti pada arah lebih kurang utara-selatan. Selepas sahaja reduksi piawai dilakukan terhadap data graviti mentah, profil graviti Bouguer akan diperolehi. Tren rantau yang jelas, dengan penurunan nilai graviti secara seragam ke arah selatan dapat dilihat. Ini merupakan kesan intrusi granit utama di bahagian tengah Gunung Jerai. Pertindanan kawasan rantau ini memberikan dua anomali graviti negatif dan satu anomali positif. Anomali tengah dengan magnitud 1.2 mgal sama dengan anomali magnet Yan. Model matematik mencadangkan jasad penyebab adalah intrusi igneus dengan puncak lebih kurang 31m bawah permukaan. Model graviti ini berkadar terus dengan model magnetik berdasarkan data terperinci magnetik bumi yang telah dibuat dahulu.

INTRODUCTION

The interesting Yan magnetic anomaly is a prominent, well-defined, intense negative anomaly with its trough located at latitude 5° 51' 8" N and longitude 100° 21' 53" E, approximately 15 km north-northwest of Gunung Jerai in the Yan district of Kedah (Figure 1). In contrast to the numerous small, sharp and closely-spaced aeromagnetic anomalies located around Gunung Jerai (Agocs and Paton, 1958) which are associated with iron-ore deposits (Bean, 1969), the Yan anomaly is a broad, relatively smooth one suggesting a source which is of deeper origin and more regional in character. Its magnitude is of the order of -250 gammas with its complementary positive anomaly located approximately 14 km north of it. The source of the Yan anomaly was interpreted to be an igneous intrusion at a depth of the order of 100 feet (Agocs and Paton, 1958). Subsequently, Bradford (1972) postulated that the source is a subsurface extension of the Gunung Jerai granite.

More recent work involving regional gravity surveys lent support to the idea that underlying the alluvium in this area, at relatively shallow depths, are igneous intrusions closely associated with the granite of Gunung Jerai (Lee *et al.*, 1983; Burley and Jamaludin Othman, 1990). Lee *et al.* (1995) presented a magnetic model of a subsurface intrusion beneath the Yan anomaly. Its peak is within 100 m of the surface. An extension of this ground magnetic survey to the north to take into consideration the positive complement of the Yan anomaly yielded a more detailed, but essentially similar, model of the causative body (Phua, 1997; Tham, 1997; Tsen, 1997).

To further investigate the cause of the Yan anomaly a detailed gravity survey was conducted over the central portion of magnetic model (Swee, 1998; Yee, 1998).

GENERAL GEOLOGY

The area under investigation is covered almost completely by alluvium of Quaternary age (Bosch, 1988). The thickness is of the order of 30 m; locally the alluvium can be found much deeper, as indicated by the limited number of deep boreholes that have been drilled in the area.

The Sungai Patani Formation to the east of the study area consists of shale mudstone, sandstone and orthoquartzite. The Jerai Formation to the south is made up of schist, semi-schist, metaquartzite, granulite and grit. Granite and quartz porphyry are found in Gunung Jerai to the south (Bradford, 1972).

Although the bedrock beneath the alluvium is largely unknown, it is most likely some combination of rocks

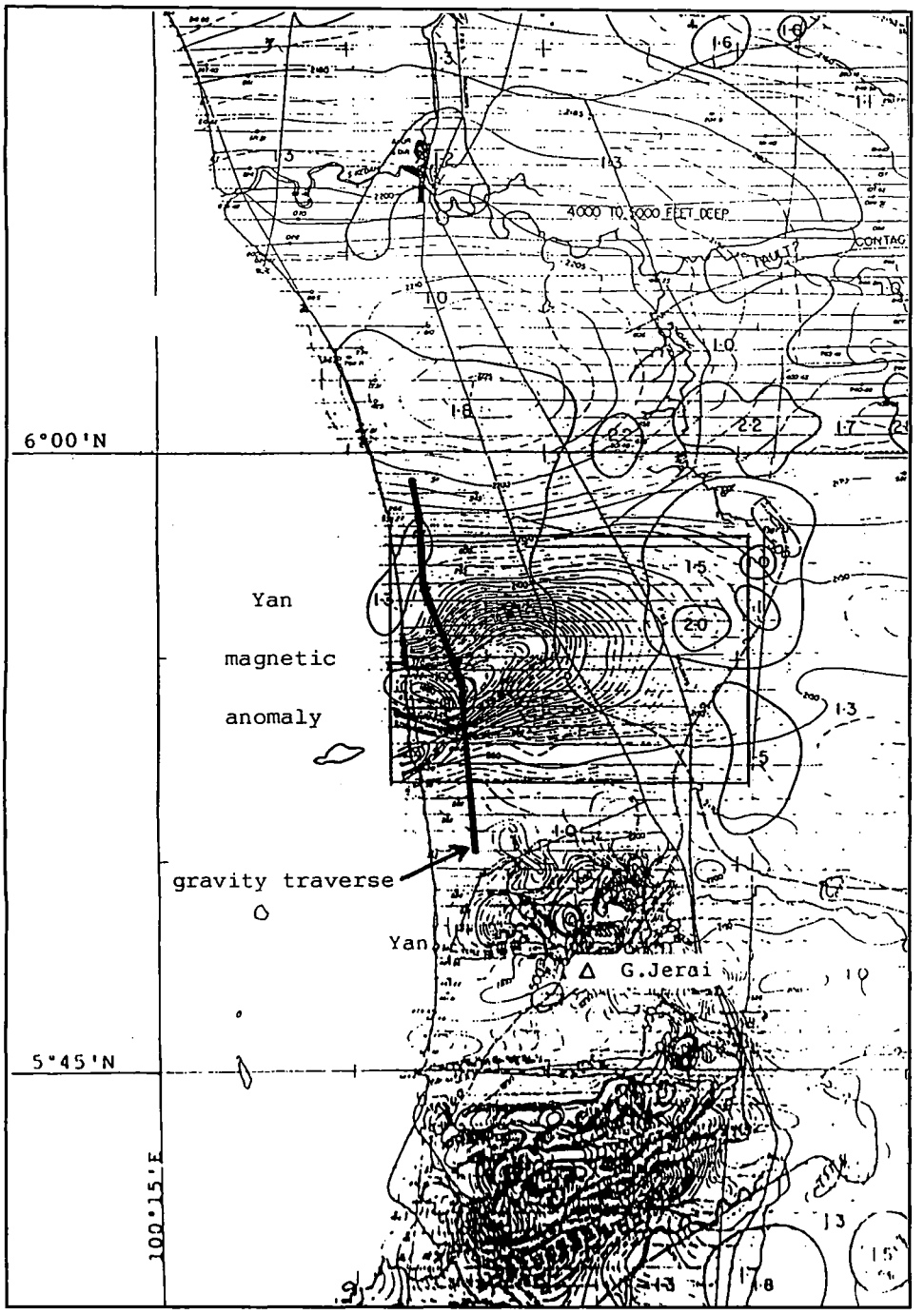

Figure 1: The Yan magnetic anomaly and the gravity traverse (extracted from Agocs and Paton, 1958).

belonging to these formations and the igneous complex closely associated with the granite, which forms the core of Gunung Jerai.

FIELD SURVEY

A gravity traverse more than 17 km in length was run in an approximately north-south direction over the centre of the Yan magnetic anomaly along a relatively quiet rural road (Figure 1). The surrounding areas consist of paddy fields, the condition of which was not conducive to off-road gravity surveys. The station spacing was approximately 50 m over the central portion of the anomaly but was increased to about 100 m beyond that region.

The expected magnitude of the gravity anomaly is of the order of only 1 mgal. Consequently a LaCoste-Romberg model G gravity meter with a sensitivity of 0.01 mgal was utilized for this survey. The locations and elevations of stations were surveyed with a theodolite to an accuracy of 0.1 m and better than 1 cm respectively. As the area was essentially flat, the theodolite survey was straightforward.

A reference gravity station was set up near the centre of the anomaly at Simpang Empat Sungai Limau. Its coordinates were 50° 54' 14" N and 100° 22' 41" E. Readings

were repeated at this station at appropriate times to determine the drift correction to be applied to the raw data.

DATA REDUCTION

The observed gravity data were corrected for drift and earth tides, latitude variation, free-air effect and the Bouguer effect using standard procedures.

For a LaCoste-Romberg gravity meter instrumental drift is extremely small; tidal effects of the order of 0.1 mgal constitute the main component of the drift correction. The latitude correction required is 0.1664 mgal per km north-south. For a profile approximately 17 km long with a generally north-south orientation, this correction is significant. Elevation differences along the profile are all within 2 m. With a free-air correction factor of 0.3086 mgal per m, this correction is of the order of 0.5 mgal. The Bouguer correction is of the order of 0.2 mgal with the Bouguer density taken as 2.69 g cm^{-3}.

GRAVITY INTERPRETATION

After reduction, the gravity values were plotted as a Bouguer gravity profile (Figure 2). A well-defined regional trend of gravity values decreasing progressively towards the south can be readily discerned from this profile.

Two pronounced negative Bouguer anomalies, labelled A and B, and a less well-defined positive Bouguer anomaly, labelled C, are superimposed on the regional gradient. Their magnitudes are -1.0 mgal, -1.2 mgal and +1.0 mgal respectively.

For comparison, the magnetic profile along the same

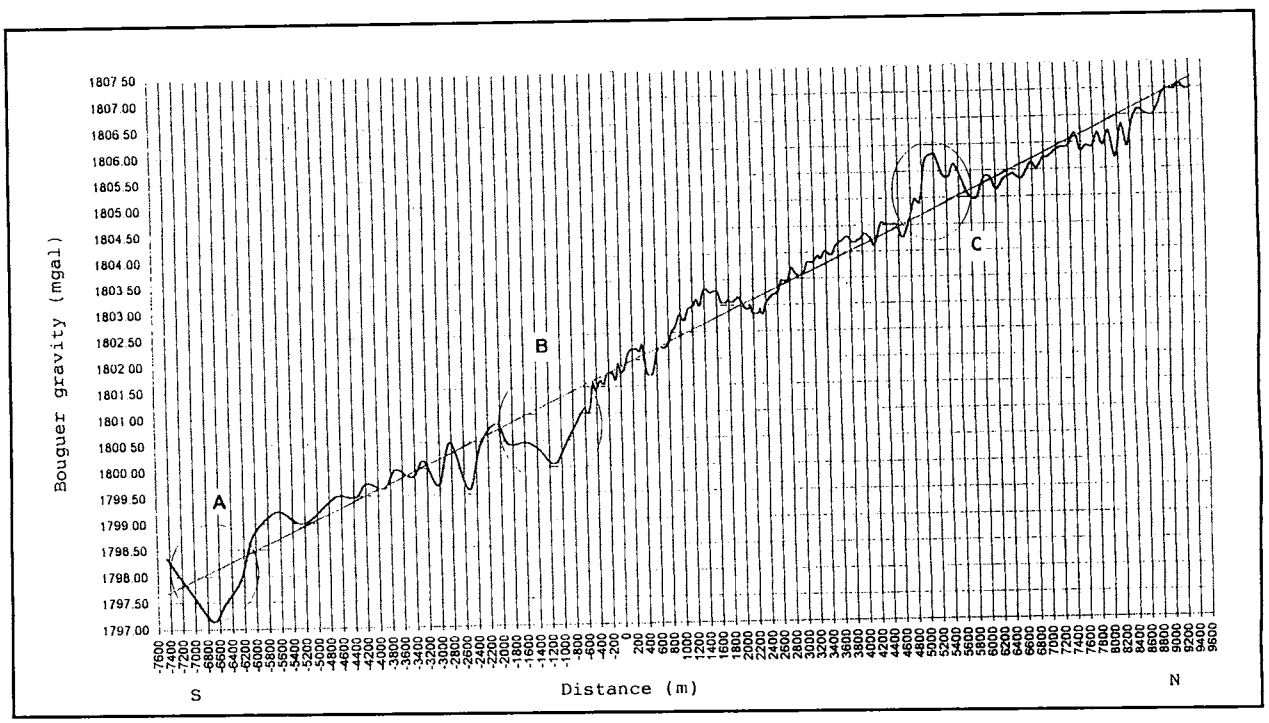

Figure 2: The Bouguer gravity profile.

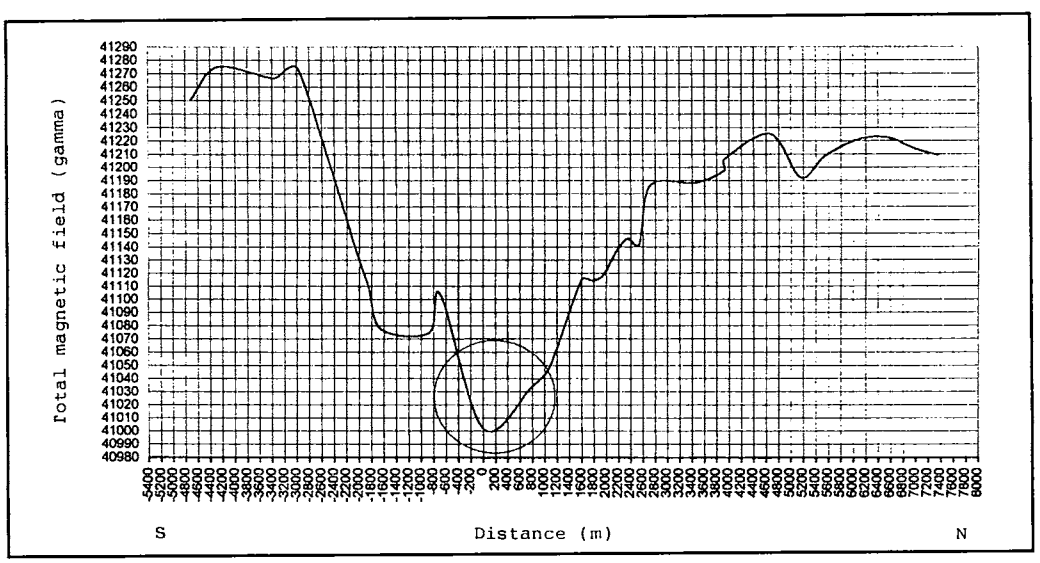

Figure 3: The coincident magnetic profile.

line was prepared using values interpolated from the data of Tan (1994) and Faridah Abdul Hamid (1994). This is presented as Figure 3. The pronounced negative is the Yan anomaly which is the object of this study. The Bouguer anomaly B roughly coincides with it.

A quantitative interpretation of these three gravity anomalies was carried out with two-dimensional mathematical modelling using polygonal bodies as sources. For the negative anomalies A and B a density contrast of -0.08 g cm^{-3} was used. This is based on a density of 2.66 g cm^{-3} for granite and 2.74 g cm^{-3} for metasedimentary rocks in this area (Lee *et al.*, 1983). A density contrast of +0.08 g cm^{-3} was used for the positive anomaly C.

The models obtained are shown as Figures 4, 5 and 6. The depths to the top of the causative bodies for anomalies A, B and C are 39 m, 31 m and 32 m respectively.

DISCUSSION AND CONCLUSION

The obvious regional gradient of decreasing Bouguer gravity values towards the south is consistent with the presence of the granite intrusion centred at Gunung Jerai. This trend was also evident in earlier gravity surveys in the area.

The original target of this survey was anomaly B which is located approximately where it was expected to be, based on earlier magnetic models. The depth of 31 m to the top of the body is fully consistent with the estimate from magnetic data. Its centre is, however, displaced approximately 1 km to the south vis-a-vis the magnetic model. This can be attributed to the fact that the magnetic anomalies are not due to granite per se, since granite is nonmagnetic, but to localized concentrations of magnetite such as those exposed in Gunung Jerai and its vicinity. Thus one would not expect the gravity and magnetic anomalies to be completely overlapping but their sources would, in this case, be closely related.

Anomaly A had not been detected in previous surveys. The causative body appears to be a similar granite intrusion at shallow depth. Although the sources of anomalies A and B have been mathematically modelled as separate distinct bodies, in reality they should be parts of the same subsurface igneous intrusion and linked at depth. This intrusion is likely to be an extension of the main igneous body in Gunung Jerai. The positive anomaly C is interpreted to be a block of denser metasediments lying on top of the less dense granite intrusion.

In conclusion, the recently acquired gravity data confirms the existence of a subsurface igneous intrusion in the vicinity of Simpang Empat Sungai Limau which is also the source of the prominent Yan magnetic anomaly. A more detailed gravity mapping of the area would enable a three-dimensional gravity model to be constructed. Ultimately, however, the only way to firmly establish the existence, nature and depth of this igneous intrusion is by drilling.

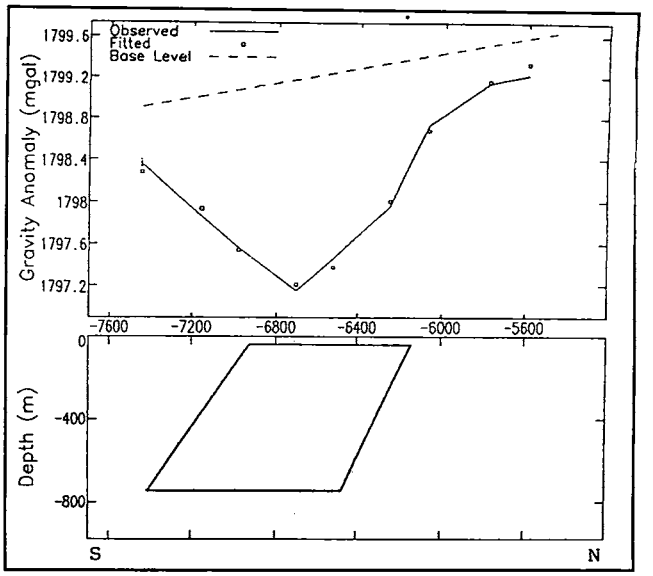

Figure 4: Gravity model of anomaly A.

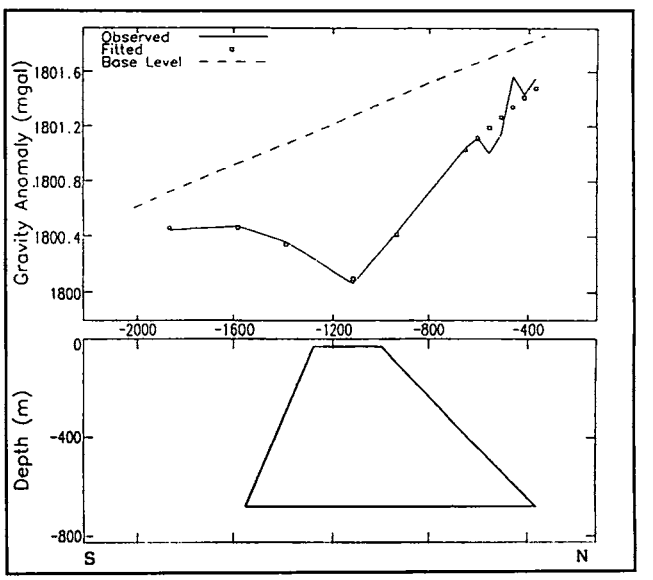

Figure 5: Gravity model of anomaly B.

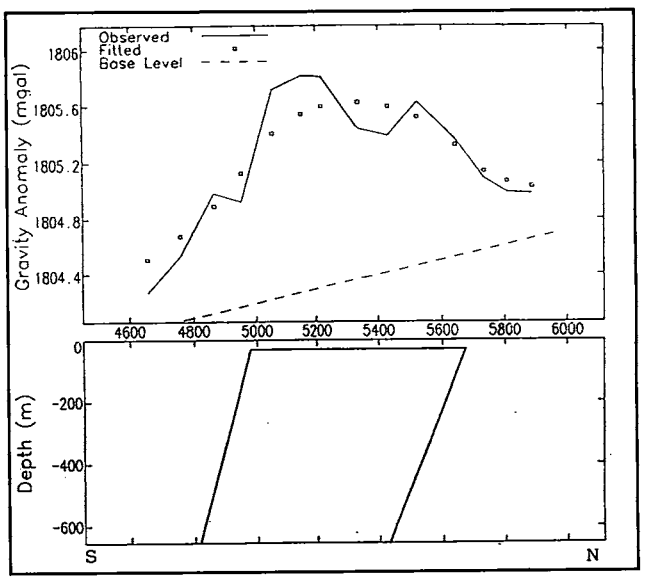

Figure 6: Gravity model of anomaly C.

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