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REGIONAL GRAVITY STUDY OF PERAK, MALAYSIA USING SATELLITE ACQUIRED DATA

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ABSTRACT

Gravity method is one of the methods in geophysics that involves measuring the earth's gravitational field at specific locations on the surface of the earth. It is used to determine the subsurface properties according to anomalies which indicate density variations. The main objective of this study is to determine subsurface geological properties in Perak, Malaysia using satellite acquired corrected gravity anomaly data obtained from Earth Gravitational Model 2008 (EGM2008). With the aid of Oasis Montaj, a software by Geosoft, the data from 296225 station points are used to produce Bouguer Anomaly map. By comparing the Bouguer Anomaly map produced with the geological map of Perak, three zones can be determined from the anomaly value which are high, intermediate and low. High anomaly zone (> 10 mGal) can be seen on Quaternary rocks due to the influence of high density oceanic crust. Intermediate anomaly zone (-10 to 10 mGal) can be seen on Palaeozoic rock formation. In this zone, low value can be seen on rocks closer to granite formation and higher towards oceanic crust. Low anomaly zone (<10 mGal) can be seen on areas with granitic body due to isostatic compensation. From the GYM-Sys filter of the Oasis Montaj software, two estimated two dimensional gravity model is produced from two lines (A-B) and (B-C) drawn on the Bouguer Anomaly map. These models were deduced based on the formation information provided by past researches.

Keywords: geophysics, gravity method, anomaly.

INTRODUCTION

Geophysical methods are a means to determine the physical characteristics of rocks as well as subsurface geological structure. The gravity method is a geophysical tool used for geological, engineering and environmental investigations where the detection of geological boundaries, cavities, subsurface karstic features, subsoil irregularities, or landfills is essential [1]. Gravity survey is one of the commonly used geophysical methods which is influenced by density. The difference in density of subsurface rocks will cause variations in gravity reading or also known as gravitational anomalies.

The general geology of Perak (Figure-1) can be divided into three groups of rock formation periods which are Palaeozoic, Mesozoic, and Cenozoic [2]. Palaeozoic rock formations of Perak consist of Papulut Quartzite and Grik Siltstone from Baling Group, Trolak Formation, Belata Formation, Lawin Tuff, Kinta Limestone, Salak Baharu Beds, and Kati Beds. Mesozoic rock formations in Perak only consist of Semanggol Formation while for Cenozoic rock formations consist of Enggor Coal Beds, Boulder Beds, Old Aluvium, Simpang Formation, Simpang Formation, Young Aluvium, Cula Formation, Lawin Basin Deposit, and Beruas Formation.

Papulut quartzite from north Perak is part of the Baling Group formed from Upper Cambrian to Upper Ordovician [3]. It is predominantly protoquartzite and subgreywacke, subsidiary greywacke and conglomerate with chert and quartzite pebbles. Another part of Baling Group distributed in Perak is the Grik Siltstone which contains carbonaceous siltstone aging from Upper Ordovician to Low Silurian. Trolak formation is located in south Perak aging from Ordovician to Silurian. It consists of major argillaceous facies with minor arenaceous and limestone facies [4]. Near it is the Belata Formation aging from Carboniferous to Permian also consists of argillaceous facies and a predominant arenaceous facies [4]. with Lawin Tuff from north Perak consist of rhyolitic to rhyodacitic tuff aging from Upper Ordovician to Lower Silurian. Distributed majorly in Kinta Valley, Kinta Limestone is a limestone facies formation aging from Lower Devonian to Middle Permian and can be correlated with Chemor Limestone [5]. Salak Baharu Beds consists mainly of quartz-mica schist, graphitic schist and quartzite aging from Devonian to Permian whereas Kati Beds consists of carbonaceous shales, siltstone, mudstone and rare red sandstone aging from Carboniferous to Permian.

Semanggol Formation from north Perak consist of chert, rhythmite and conglomerate aging from Lower Permian to Upper Triassic. It is intruded by upper Triassic granites in east. It is intruded by upper Triassic granites in east. Chert member (Lower Permian to Middle Triassic) consist of thinly bedded light to dark grey chert interbedded with mudstone, sandstone and limestone [6]. Rhythmite member (Middle to Upper Triassic) consist of interbedded sandstone and shale [7]. The sandstone is litharenite in composition grading to pebbly sandstone and conglomerate. Conglomerate member (Middle to Upper Triassic) consist of light grey conglomerate interbedded with sandstone and shale [7].

Enggor Coal Beds is one of the rock formation within Cenozoic period aged Tertiary. Named after Sg. Enggor, Perak, it consists of thick uppermost layer of sandy shale and sandstone followed by thinner zone of grey shale, the first coal seam, thin zone of shale, the second coal seam, black shale and calcareous shale [8]. In Kinta Valley, weathered limestone or Boulder Beds (Lower to Middle Pleistocene) underlie Old Aluvium

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(Lower to Middle Pleistocene) and at some localities Young Alluvium (Holocene) forms the overlying sediments with an unconformity contact [7, 9]. Lawin Basin deposits aged Pleistocene comprises of poorly graded sediments ranging through sand, grit, gravel, and boulder beds [3]. Simpang Formation (Pleistocene) in Taiping is made up predominantly of clay, silt and sand with subordinate amounts of gravel towards the lower part of the succession. The sediments are usually mixtures of gravel, sand, silt, and clay with presence of peat and peaty clay [10]. Gula Formation (Holocene) is underlain by the Simpang Formation and is mainly made up of clay and silt, minor gravels and the presence of organic matter [10]. Conformably overlying the Simpang Formation and Gula Formation is the Beruas Formation of Holocene age which is generally made up of clay, peat, sandy clay, and minor sand and gravels [10].

This study will be focusing on the satellite acquired gravity anomaly data of Perak, Malaysia. It involves 296225 station points of corrected satellite gravity anomaly data obtained from Earth Gravitational Model 2008 (EGM2008). The analysis of the data is conducted using Oasis Montaj software by Geosoft. The objective of this study is to observe gravity response to geological variations in Perak, Malaysia.

METHODOLOGY

This study is conducted on three levels from literature review, data processing and finally interpretation of results. Literature review is done to extract information done by past researches on the study area to be used and compared with the results of the gravity anomaly data analysis. Data processing involves 296225 station points of corrected satellite gravity anomaly data obtained from EGM2008 analysed using Oasis Montaj software to produce Bouguer Anomaly map. The general geology of Perak can be divided into groups of rock formation periods which are Quaternary, Tertiary, Triassic, Carboniferous, Devonian, Silurian-Ordovician, and also granitic body [2, 4]. These groups are traced onto the Bouguer Anomaly map to observe the gravitational response for different geological formations (Figure-1).

Two dimensional gravity modelling is also conducted to estimate profile images on the subsurface structure of study area. To produce this, a cross section is taken from the Bouguer Anomaly map. The model requires input on the density of rocks within the chosen cross section. Using the Oasis Montaj software under the menu GYM-Sys, trial and error approach is used until it reaches minimum error.

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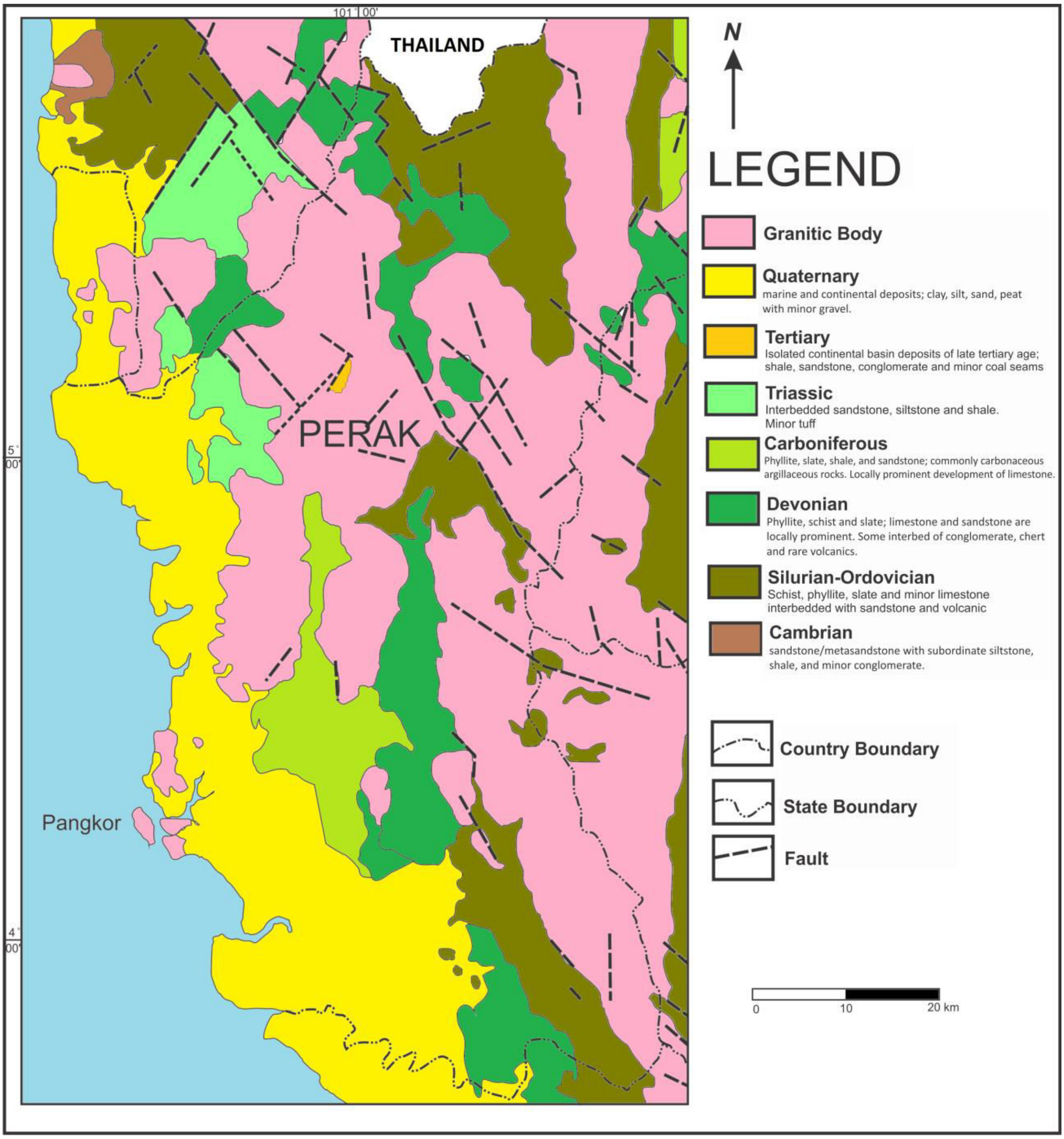

Figure-1. Geological map of Perak traced from Lee *et al*. [2]

RESULTS

Bouguer Anomaly Map

The Bouguer anomaly map produced (Figure-2) shows a minimum value of -72.719 mGal and a maximum value of 36.815 mGal gravity anomaly. The granitic body which is situated at the Perak-Pahang-Kelantan Boundary shows anomaly as low as -72.719 to -25.123 mGal. Other granitic body also shows low anomaly values ranging from -26.859 mGal to -6.049 mGal. The comparison between general geology and bouguer anomaly map shows these anomaly ranges for each age group formation; Quaternary: -8.745 to 36.815 mGal, Tertiary: -21.942 to -16.919 mGal, Triassic: -18.209 to 0.456 mGal, Carboniferous: -19.427 to 16.705 mGal, Devonian: -48.853 to 3.152 mGal, and Silurian-Ordovician: -72.719 to 0.456 mGal.

Two Dimensional (2-D) Gravity Model

Two profiles were made from Bouguer anomaly map which are A-B and C-D. These profiles were deduced based on the formation, main lithology and estimated formation density information provided by Gan [4], Lee *et al.* [2], and Meng *et al.* [11], as shown in Table-1.

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Table-1. Main lithology and estimated formation density information.

Formation	Main Lithology	Density (g/cm^3)
Kati	Interbedded sandstone and mudstone	2.58
Kinta Limestone	limestone	2.60
Main Range Granite	Granite	2.60
Belata	Metasediment	2.65
Trolak	Metasediment	2.65
Upper Crust	Sedimentary basin	2.70

The 2D gravity model for profile A-B (Figure-3) consists of four layers representing Main Range Granite, Kinta Limestone, Kati formation and Upper Crust. The Kati formation, aged Carboniferous, is placed above the older Kinta Limestone (Early Devonian to Mid Permian). The Main Range Granite is set on the east side of the profile where it was likely to intrude. The 2D gravity model for profile C-D (Figure-4) consists of 5 layers representing Quaternary layer, Belata formation, Trolak formation, Main Range Granite and Upper Crust. The youngest Quaternary layer is placed on top followed by Belata formation (Permian-Carboniferous) and Trolak formation (Silurian-Ordovician).

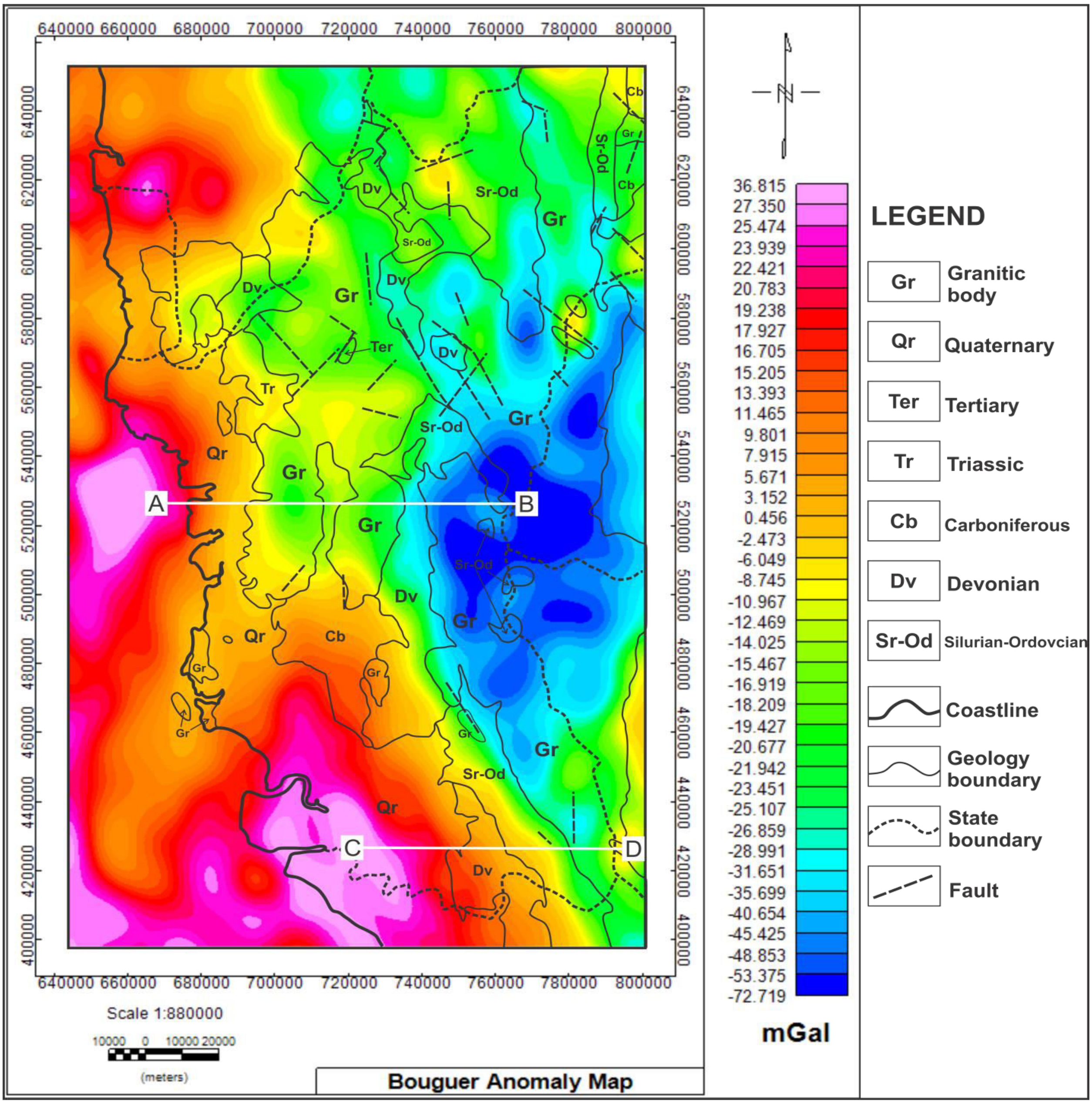

Figure-2. Bouguer Anomaly map of Perak with general geology traced from Lee et al. [2]. Line A-B and C-D is used to form 2-D gravity models.

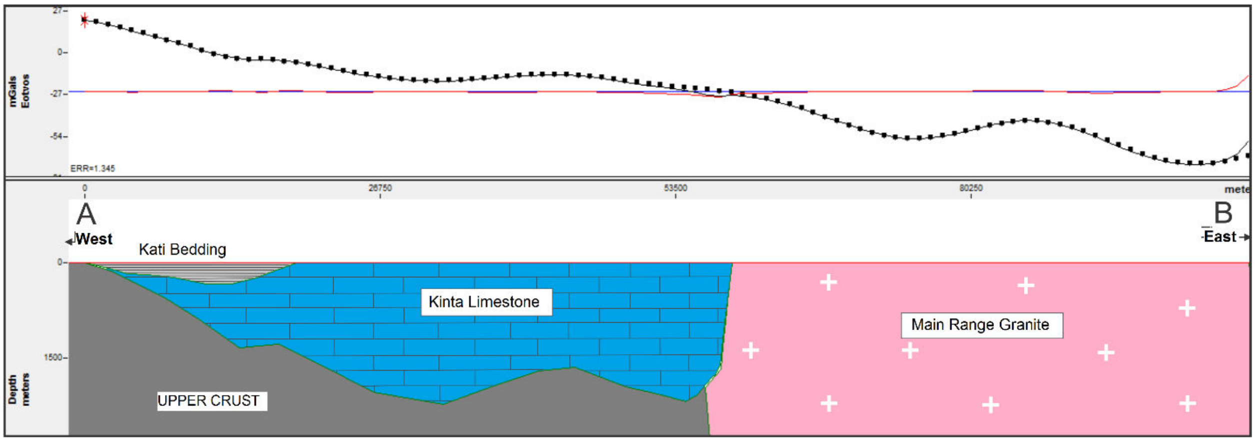

Figure-3. Two Dimensional gravity model of the line A-B showing a cross-section of estimated depth and structure of rock formations.

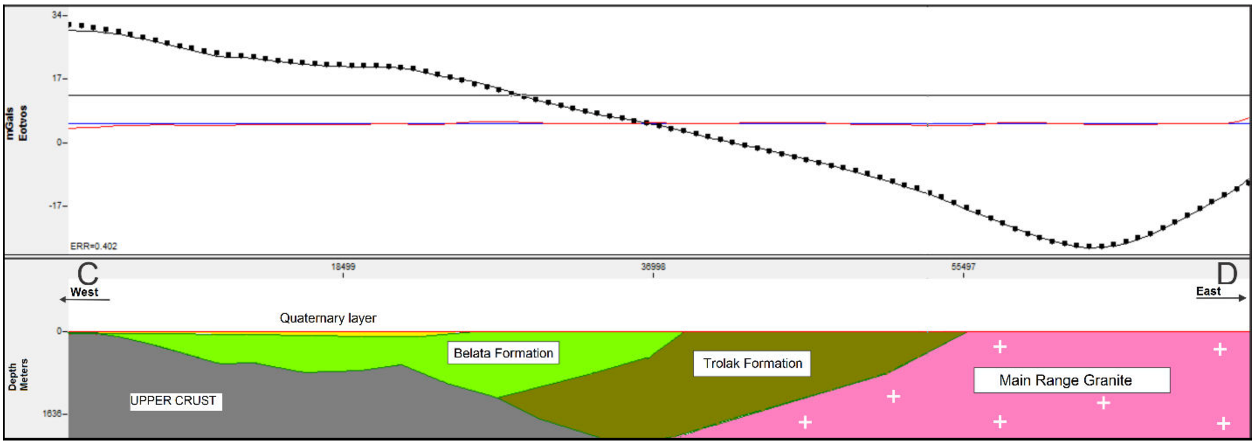

Figure-4. Two Dimensional gravity model of the line C-D showing a cross-section of estimated depth and structure of rock formations.

CONCLUSIONS

Based on the Bouguer Anomaly map, three zones can be determined from the anomaly value which are high, intermediate and low. High anomaly zone (> 10 mGal) can be seen on Quaternary rocks due to the influence of high density oceanic crust. Intermediate anomaly zone (-10 to 10 mGal) can be seen on Palaeozoic rock formation. In this zone, low value can be seen on rocks closer to granite formation and higher towards oceanic crust. Low anomaly zone (<10 mGal) can be seen on areas with granitic body due to isostatic compensation. Two dimensional gravity models from lines A-B and C-D were deduced based on the formation information from past researches

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