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DEEP CRUSTAL PROFILE ACROSS NW SABAH BASIN: INTEGRATED POTENTIAL FIELD DATA AND SEISMIC REFLECTION

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ABSTRACT

The crustal model has been created from the integration of potential field data and complemented by multichannel reflection seismic profiles, allowing the interpretation of five tectono-stratigraphy provinces of Deepwater Fold and Thrust Belt, Sabah Trough, Dangerous Grounds Province and Thrust Sheet Zone. The free-air and magnetic anomaly was published from satellite altimetry data. Seismic interpretation displays structural anticline that indicate fold and thrust zone as the Sabah Trough frontier to the southeast. The formation of half-grabens and normal faults was clearly indicated extension in the entire Dangerous Grounds which subducted beneath to the Sabah Trough. The crustal modelling was used to describe and determine the Moho thickness and the configuration of deeper crustal layer by using the GM-SYS Profile Modelling software. The range of Moho thickness shows slightly variable between 33 and 26 km across of the study area. Analytical signal analysis estimated the depth of magnetic source range between 26 and 33 km disclosed to upper crust. The high density surrounded by low density body at Thrust Sheet Zone interpreted as a thrust block built of Palaeogene Crocker sediment.

Keywords: crustal model, free-air gravity anomaly, magnetic anomaly, analytical signal, NW sabah basin.

INTRODUCTION

This paper demonstrates the large scale of integrated regional studies of NW Sabah basin and the value of interpretation of seismic reflection cooperated with potential field data. The integrated study allows us to present in the evaluation of crustal layer and propose the source of magnetic fields.

The NW Sabah Basin is located in the southern of South China Sea margin and the northwest of Borneo. Generally, the Borneo Island was surrounded by tectonics plate of South East Asia namely from the south is Indo-Australia Plate, Pacific Plate to the east, Philippines Plate to the northeast and to the north is the Eurasia Plate. There are still on-going actively plate in South East Asia. Indo-Australia Plate, Pacific Plate and Philippine Plate had subduction boundary between them and divert to the passive continental margin of Eurasia Plate with a relative velocity 6-8 cm/yr (Hamilton, 1979). According to Tongkul (1994), this divergent of tectonic plates are finally producing geological structure such as fold, normal and thrust faults and also shear zone to the NW Borneo margin.

The southern of South China Sea margin are divided by different morphology of West Baram Line. The sea floor spreading occurs along South China Sea Basin. The magnetic anomalies associate with the trend E-W indicate of sea floor spreading events during Middle Oligocene and ceased in Lower Miocene (32-17 Ma) (Brias *et al.* 1993). This event leads to several South China Sea micro-continents such as Reed Bank, Dangerous Grounds and Luconia Block drifted to the south and collides subducted beneath northern Borneo (Hall, 1996).

Hamilton (1979) and Hall (2002) suggested that the complex deformation belt take place at onshore Crocker-Rajang Belt formed as accretionary throughout the proto-South China Sea oceanic crust subduction striking to the south. The termination of proto South China Sea started during Upper Eocene (~44 Ma) occurred in Luconia Block (direction to the SW) and then during Early Miocene (~16 Ma) displayed progressively towards NE.

The NW Sabah Basin also referred as NW Borneo (Franke *et al.*, 2008), Baram-Balabac Basin (Cullen, 2010), Sabah Basin (PETRONAS, 1999), in the beginning interpreted as trench associated with basin and fore-arc basin (Levell, 1987). Based on the previous study which is related to the gravity, sequence stratigraphy and paleo-depositional, the basin was developed as foreland basin following by collision of continental fragments from South China Sea with North Sabah and also formed by thinned continental crust (Hazebroek *et al.*, 1993 and Milsom *et al.*, 1997).

The crustal model reported in this paper has been created from the the integration and interpretation of geophysical and geological data as: 2D multi-channels seismic reflection, free-air gravity anomaly data from the combined Earth Gravitational Model EGM2008 (Pavlis *et al.*, 2008), and magnetic anomaly data from the Earth Magnetic Model EMAG2 (Maus, 2009). The objective of the study is to construct a crustal structure and thickness underlying the NW Sabah Basin by integrating satellite derived gravity and magnetic data. Thus, the continuity of crustal structure across the northwestern margin of Borneo can be clarified.

The depth of Moho from previous studies

Milsom *et al.* (1995) evaluated qualitatively the crustal layer across NW Borneo based on free-air anomaly derived from Satellite ERS-1. The depth of Moho estimated around 24 km and which is compatible to the depth of continental crust.

Holt (1998) proposed the average depth of Moho along South China Sea indicated the depletion of continental crust estimated around 20-22 km. meanwhile in the centre of South China Sea Basin decrease in 14 km interpreted as oceanic crust and then increase toward NW Borneo around 20-25 km. His results based on shipborne gravity survey data.

Franke *et al.* (2008) produced a crustal profile across NW Sabah offshore based on combination of new refraction seismic data (P-wave) and gravity data. The cross section profile revealed that Dangerous Grounds continental crust fragment subducted to the NW Sabah margin and the Moho depth estimated around 22 km.

These previous studies provide guideline to us in building new crustal model from different geophysical method in the NW Sabah Basin.

Geological background of study area

The study area is located in continental margin in the northern part of the NW Borneo, divided by tectonics element and depositional history. The crustal modelling in this study covering the Dangerous grounds, the Sabah Trough, the Deepwater Fold and Thrust Belt and the Thrust Sheet Zone (Figure-1).

The Dangerous Grounds also referred as southern South China Sea Platform and NW Sabah Platform (PETRONAS, 1999) included Spratly Island, Reed Bank and northern Palawan. The structural classifications in this area consist of half-graben formation and tilted fault blocks. Beneath the Dangerous Grounds is thinned, rifted continental crust and has become part of continental margin of north Borneo occurred after rifting and spreading of South China Sea Basin events.

The Sabah Trough also referred as Nansha Trough, NW Borneo Trough, Borneo-Palawan Trough and NW Sabah Trough within the depths range between 2000-2900 m from mean sea level and 37 km wide. There are different interpretations about Sabah Trough from different researchers. Hamilton (1979) and Tan and Lamy (1990) interpreted Sabah Trough as seafloor expression of inactive development subduction trench during Paleocene (~44 Ma) along NW Sabah margin. Hinz and Schluter (1985) suggested as Sabah Trough not underlain by oceanic crust but the lower plate is similar to the continental crust part of Dangerous Grounds. Milsom et al. (1997) and Mazlan Madon (1999) proposed Sabah Trough as a sediment- starved foreland trough and it is not displayed as a subduction trench.

The Deepwater Fold and Thrust Belt dominated by formation of folded anticlinal structure with thrust fault shows a typical deepwater fold and thrust system. The fold and thrust belt made up thick wedges imbricated sediments (Franke *et al*. (2008). Tan and Lamy (1990) referred this region as Compressed Fold Belt of Baram Delta. Gee *et al*. (2007) suggested the folding and thrusting belt resulted from gravity driven tectonics by transporting onshore sediments slide outbound to the deepwater and dumped as mass flow deposits. Meanwhile, Ingram et al. (2004) was descripted this region as tectonic compression caused folding and thrusting activity which also supported by Hesse *et al*. (2010).

The Thrust Sheet Zone was interpreted as complexly deformed imbricated thrust fan of a huge thrust sheet (Hinz and Schluter 1985). The refraction seismic data recorded a high velocity body at the basinward edge of this feature (Franke *et al*. 2008), indicating the presence of a large carbonate body encased in siliciclastics, or a thrust block built of Palaeogene Crocker sediments.

METHODOLOGY AND RESULT

Seismic interpretation

The seismic interpretation was taken from a high quality migrated 2D seismic reflection profiles. A multi-channels seismic profile of deepwater portions of NW Sabah Basin was contributed by PETRONAS in the. Only four seismic profiles (LSA, LSD, LSH and LSL) were selected and interpreted.

There are three mega sequences were observed in the four selected seismic profiles. Due to the lack of deep well data provided we followed chronostratigraphic level defined by Ding *et al.* (2011) and Hutchison (2004) are used in this study. These mega sequences are namely Paleocene to Early Oligocene Sequence (SED.3), Oligocene to Early Miocene Sequence (SED.2) and Early Miocene to Recent (SED.1).

Paleocene to Early Oligocene Sequence referred as SED.3 unit (orange in the crustal model) was confined by the dark green horizon in the bottom and the yellow horizon at the top. Below the dark green horizon is corresponding to the basement (grey) in the crustal model. The basement is manifested by discontinuity and chaotic reflector pattern. These pattern are associated with the older rocks deposited earlier before rifting from South China Sea Basin. The dark green horizon correlated to the "Tg" reflector by Ding *et al.* (2011) and "Sequence A" horizon by Hutchison (2004) approximately equal to 65 Ma and 45 Ma respectively at that level. This sequence is interpreted as the pre-rift unit which is the extension of the rifted crust of Dangerous Grounds. Thus, we followed "Tg" horizon of Ding *et al*. (2011) which is nearly similar in description of seismic attributes compared to our dark green horizon. Consequently, the age of this horizon is approximately 65 Ma.

Oligocene to Early Miocene Sequence also designated as SED.2 unit (dark green in the crustal model) with the boundary interval between the yellow horizon at the bottom and the blue horizon at the top. This sequence

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exhibits moderate to sub-parallel seismic reflector continuity. The underlying of blue horizon was indicated as the limit of half-graben structures and normal faults. The fault dips beneath the fold and thrust belt and the thrust sheet zone. The yellow horizon correlates with "T70" by Ding *et al.* (2010) and Base Miocene Unconformity (BMU) by Hutchison (2004) with an age of approximately 30 Ma. This regional unconformity is considered as a syn-rift unit formed during the drifting period of South China Sea.

Early Miocene to Recent Sequence is identified as SED.1 unit (light green in the crustal model) served as a youngest sequence. Both horizons in this sequence divided clearly by seafloor topography and the blue horizon. The seismic attribute and configuration are highly continuous with high to moderate amplitude and show parallel to wavy reflection. Unclear and chaotic seismic facies are mapped beneath the blue horizon suggesting an acoustic substratum associated with complex half-grabens and tilted blocks system. The blue horizon easily traceable throughout the region and correlates with "T60" of Ding *et al.* (2010) and Middle Miocene Unconformity (MMU) of Hutchison (2004) has been dated approximately 16 Ma. The blue horizon classified as a major erosional events that formed the top of carbonates platform, extending from Dangerous Grounds to beneath NW Sabah Basin margin.

Gravity interpretation

The free-air anomaly map shown in Figure-2 was extracted from high resolution satellite altimetry and compiled with Geosat and ERS-1 to derive the EGM2008 map. The map indicates distribution of major positive and negative free-air gravity anomalies. The magnitude of anomaly ranges between -57 to 81 mGal corresponding to the variety of density bodies occurring in NW Sabah Basin. A prominent band of strongly positive gravity anomalies occurs from southwest to northeast of deepwater fold thrust belt and some part of Dangerous Grounds. The gravity values decrease toward the Sabah Trough. The negative free-air anomaly in the Sabah Trough correspond to the depressed rifted continental margin of the South China Sea and also possibly connected to the depression of lithosphere into the mantle attributed to the thrust loading as previously mentioned by Milsom *et al.* (1997).

Magnetic interpretation

The magnetic anomaly data were derived from Total Magnetic Intensity (TMI) Anomaly map of EMAG2. The magnetic intensity map was derived from the excellent satellite altimetry available from CHAMP mission. The satellite-derived magnetic field resolution is 2 arc-min-grid at 4km above geoid. The total magnetic intensity map is as shown in Figure-3.

The TMI map generated for the study area shows a range of magnetic intensity values between -90 to 64 nT and it can be divided into four main sections. The northern part of NW Sabah Basin was characterized by mixed high and low magnetic anomalies.

The obvious high and low magnetic anomalies situated across the Sabah Trough are probably associated with tectonic elements of Sabah Shear Zone which along N-NE lineament directions (Hutchison 2004). The central part was characterized by high surrounded by low magnetic anomalies. These features were probably associated with the seamount region located at the Sabah Trough. The seamount is part of South China Sea chain from Dangerous Grounds indicated extinct or relict spreading axis of South China Sea (Ding et al. 2010 and Franke *et al.* 2008) but Hutchison (2010) suggested seamounts occurred in the western part of Sabah Trough associated to accumulation of carbonate build-up. The southern part was characterized by high magnetic anomaly of fold and thrust belt due to accumulation of mass flow deposits sediments fill the top of deepwater fold and thrust belt of Baram Delta. The low magnetic anomaly along the SW-NE band in the west of northern part was characterized as The Sabah Trough represented by huge and deepest ponded strata of hemipelagic sediments accumulated and surrounded by continental shelf margin.

Analytical signal analysis

In the analytic signal method, it is assumed that the causative sources are magnetic contacts. The depth was estimated by determining the width of the analytic signal anomalies between inflection points Macleod *et al.* (1993). The analytic signal signature of the NW Sabah Basin area was calculated in the frequency domain using the fast Fourier transform technique Geosoft Reference Manual (2009). The analytical signal is calculated from the square root of the sum of the squares of each of the three directional first derivatives of the magnetic field as given in the following equation:

$$|A_m\,(x,y,z)| = \sqrt{\frac{dM^2}{dx}} + \sqrt{\frac{dM^2}{dy}} + \sqrt{\frac{dM^2}{dz}}$$

Where the A_m (x,y.z) is the analytical signal amplitude at the point of x, y, z and M is the magnetic field value.

The resulting shape of the analytic signal is independent of the orientation of the magnetization of the source and is centered on the causative body. This has the effect of transforming the shape of the magnetic anomaly from any magnetic inclination to one positive body centered anomaly. The analytic signal technique has merit at all magnetic latitudes, but the benefits are most appropriate near the magnetic equator.

There are two methods to determine the depth source of magnetic anomaly. Atchuta *et al.* (1981) and Roest *et al.* (1992) proposed the depth by calculate half of amplitude from anomaly width. This calculation was elaborated by Ian *et al.* (1999) produced the new equation

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which is inflection point method that differentiate between anomalies characterization as shown in Table-1.

Table-1. Characteristics of anomaly and equations to determine the magnetic source depth. (Ian *et al*. 1999).

Characteristic of anomaly	Equation
Contact (H1)	xi = 1.414 h
Sill/Dyke (H2)	xi = 1.155 h
Cylinder (H3)	xi = h

xi - distance between inflection points
h - depth of magnetic source

To estimate the depth of the source of magnetic anomaly from the analytical signal, ten profiles were selected over the regions where contrasts could be found as shown in Figure-4. The depth values of ten profiles shown in Table-2. The calculated depth match to the crustal model represents average depth which is referring to upper crust. We suggested the source of magnetic anomaly come from upper crust with best fit to dyke (H2).

Table-2. Estimated depth of magnetic anomaly source.

Line	Xi (km)	H1 (km)	H2 (km)	H3 (km)	GMSYS Profile
GA	15.6	11.1	13.5	15.6	Upper Crust
GB	17.2	12.2	14.9	17.2	Upper Crust
GE	17.5	12.4	15.2	17.5	Upper Crust
GF	29.5	20.9	25.5	29.5	Upper Crust
GH1	19.0	13.4	16.5	19.0	Upper Crust
GH2	30.4	21.2	25.9	30.4	Upper Crust
GHI	18.3	12.7	15.6	18.3	Upper Crust
GHJ	20.7	14.1	17.3	20	Upper Crust
GK	17.2	12.2	14.9	17.2	Upper Crust
GL	19.4	13.7	12.8	19.4	Upper Crust

Construction of Crustal model

The Crustal model was predicted with the integration of potential field data, seismic interpretation, free-air gravity and magnetic susceptibilities. The gravimetric data used for the modelling corresponds to the free-air anomaly of the Earth gravitational model EGM2008 (Pavlis *et al.*, 2008) and the magnetic data correspond to the total field anomaly from the earth magnetic model EMAG2 (Maus *et al.*, 2009).

Forward gravity modelling is carried out to define crustal layers from measured gravity field corresponding to variations in thickness and different density at every crustal unit. The depth estimations of shallower unit (SED.1, SED.2 and SED.3 unit) were obtained from seismic interpretation. The depth of deeper unit was obtained from spectral analysis and was compared to previous study as mentioned earlier. The variations of crustal units density were defined as follows; Seawater: 1.03 kg/m^3, SED.1: 2.35 kg/m^3, SED.2: 2.40 kg/m^3, Thrust Sheet: 2.45 kg/m^3 SED.3: 2.55 kg/m^3, Basement: 2.60 kg/m^3, Upper Crust: 2.70 kg/m^3, Lower Crust: 2.90 kg/m^3 and Upper Mantel: 3.35 kg/m^3.

The magnetic modelling was generated after the gravity modelling was correlated satisfactorily by having error below 5% which produce crustal depths equivalent to the depth interpreted by seismic section. The shallower unit assumed to be non-magnetic body (SI=0) while the added prismatic bodies (dark red) are assigned to be different in magnetic susceptibility but equal in density of the upper crust. However, several attempts has been made to determine magnetic susceptibility body through shallower unit but the variation between observed and calculated magnetic modelling curves were not successful as increasing variation error. The depth of prismatic body shows approximately parallel to the depth of calculated magnetic anomaly source by analytical signal. The magnetic filter that has been used in this study is Reduction to Equator (RTE) representing NW Sabah Basin located at low latitude (below 25^0). The geomagnetic field parameters in this area were defined as follows; Average Total Intensity: 40980 nT, Inclination (I): -7.95^0 and Declination (D): 0.4^0.

GM-SYS Program

GM-SYS is Interactive Gravity and Magnetics Modelling developed by Northwest Geophysical Associates (NGA). The forward modelling software package both gravity and magnetic data and is a program for interactive modelling of 2D or 2 ½ D geological cross sections constructed perpendicular to the strike of the body or structure, with the ability to calculate and display gravity and magnetic responses. Where modelled features have a limited strike length (y-direction), 2½ dimensional corrections are possible based on an algorithm of Rasmussen and Pederson (1979). Software is given in the GM-SYS Manual.

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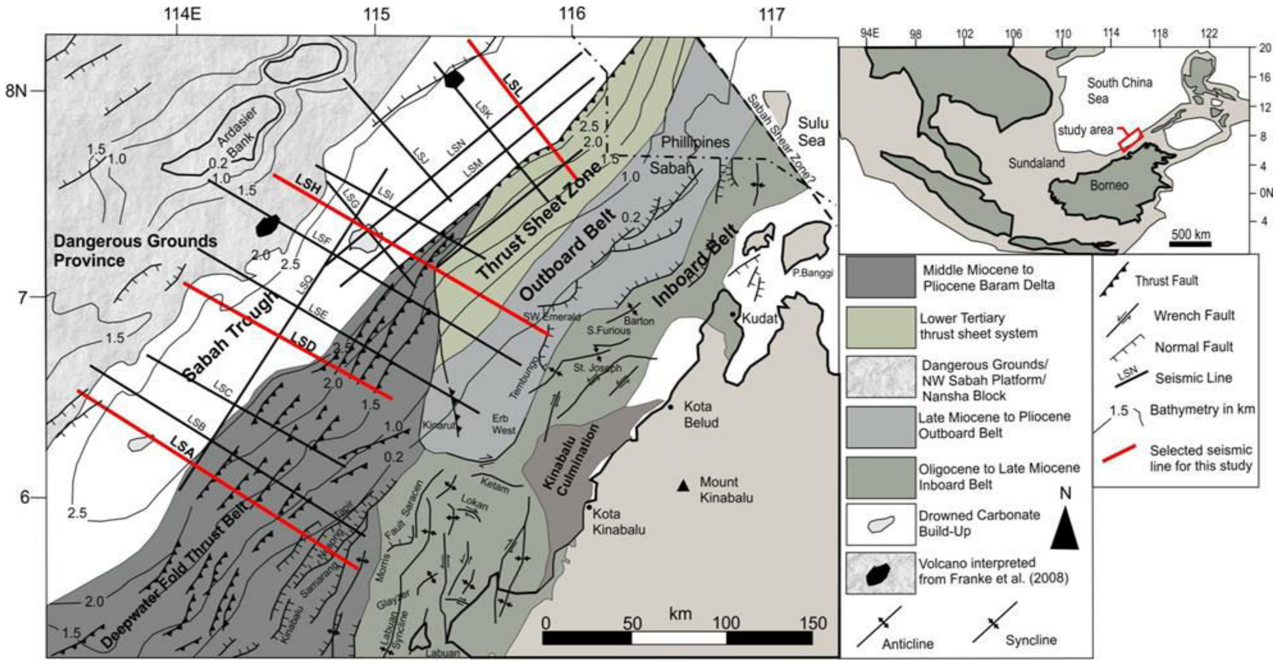

Figure-1. Location map of study area showing tectono-stratigraphy provinces, bathymetry and location of four selected 2D multi-channel seismic profiles (After Hutchison, 2004).

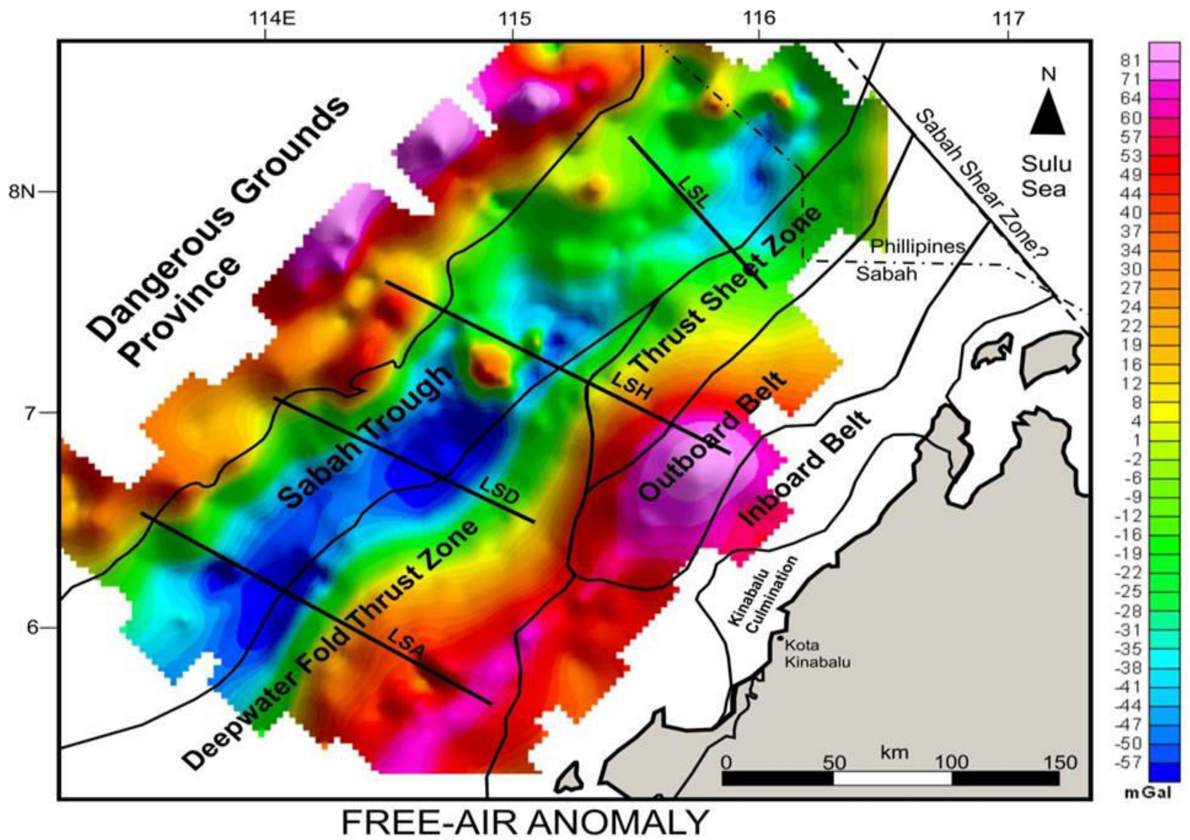

Figure-2. Free-air gravity anomaly map of NW Sabah Basin.

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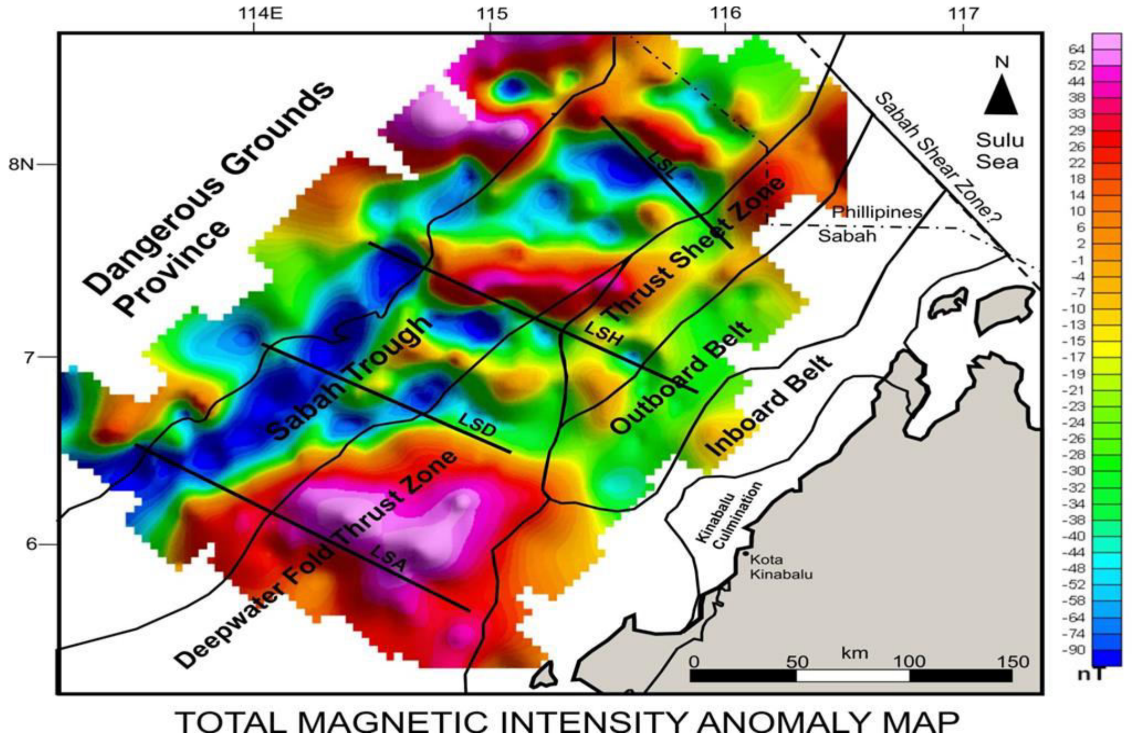

Figure-3. The total magnetic intensity map of NW Sabah Basin.

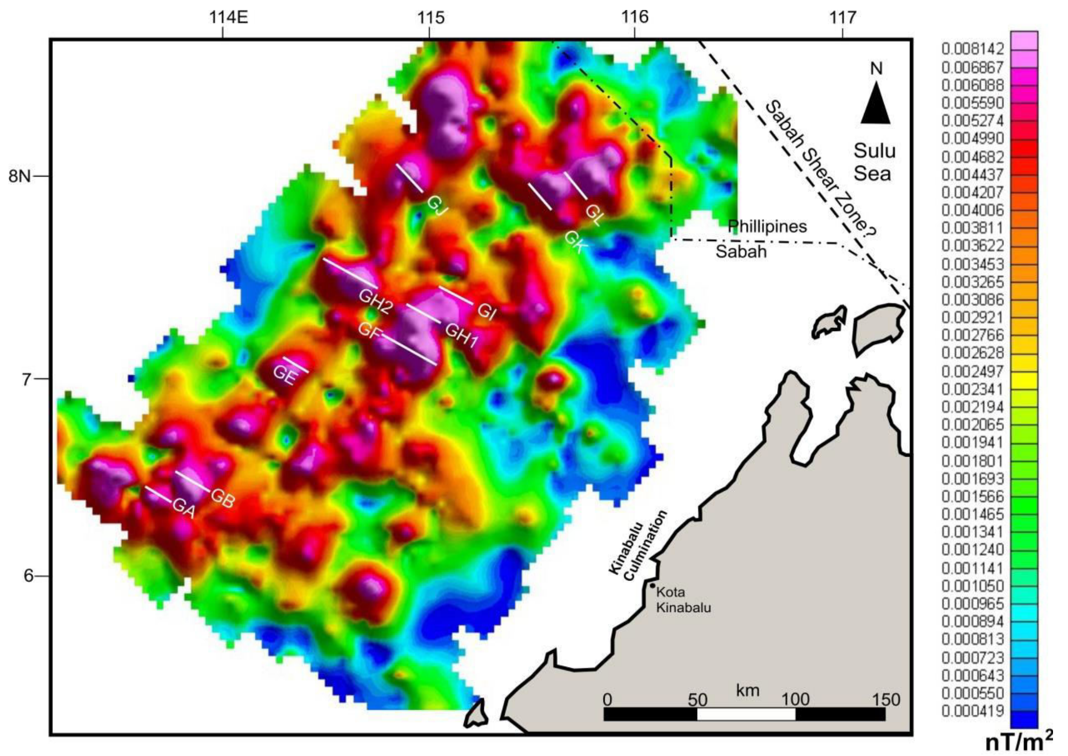

Figure-4. Analytical signal analysis of TMI map of the NW Sabah Basin. The profile lines (white) are selected profile were used to estimate depth from the analytical signal.

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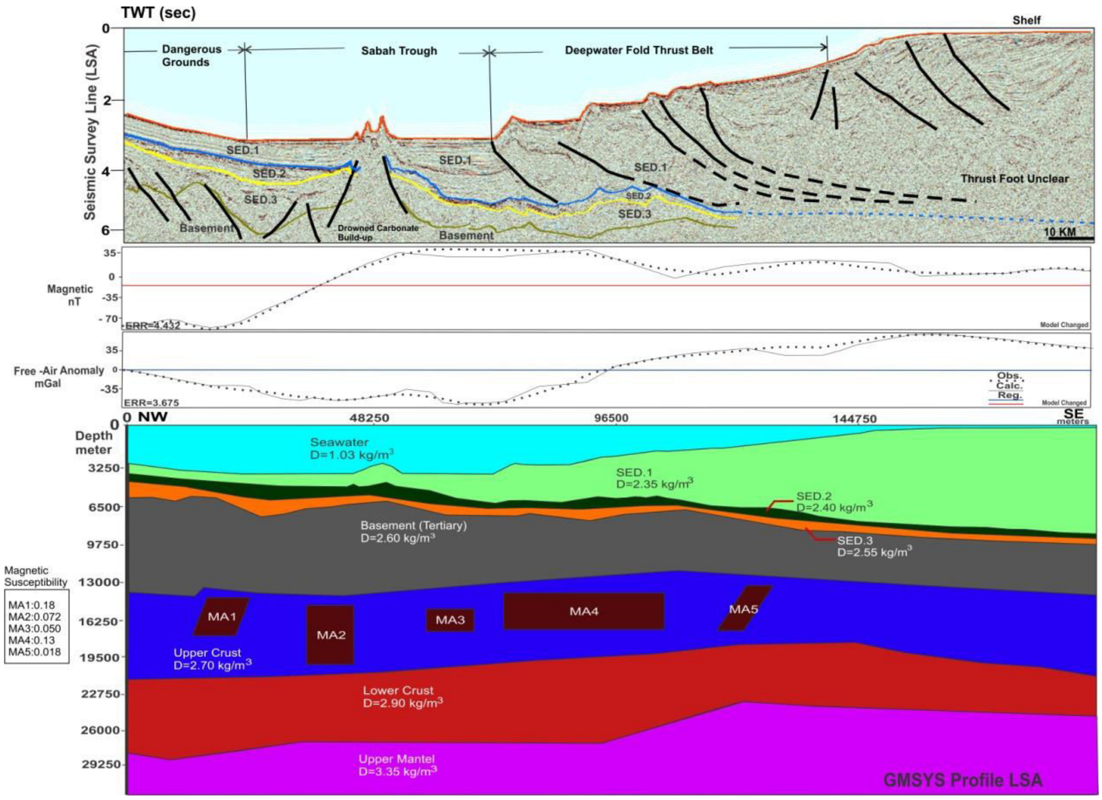

Figure-5. The Crustal model of LSA profile, the top profile shows seismic interpretation, the middle profile is magnetic and free-air gravity anomaly calculated and observed curves and the lower profile is modeled crustal unit constructed by GMSYS software.

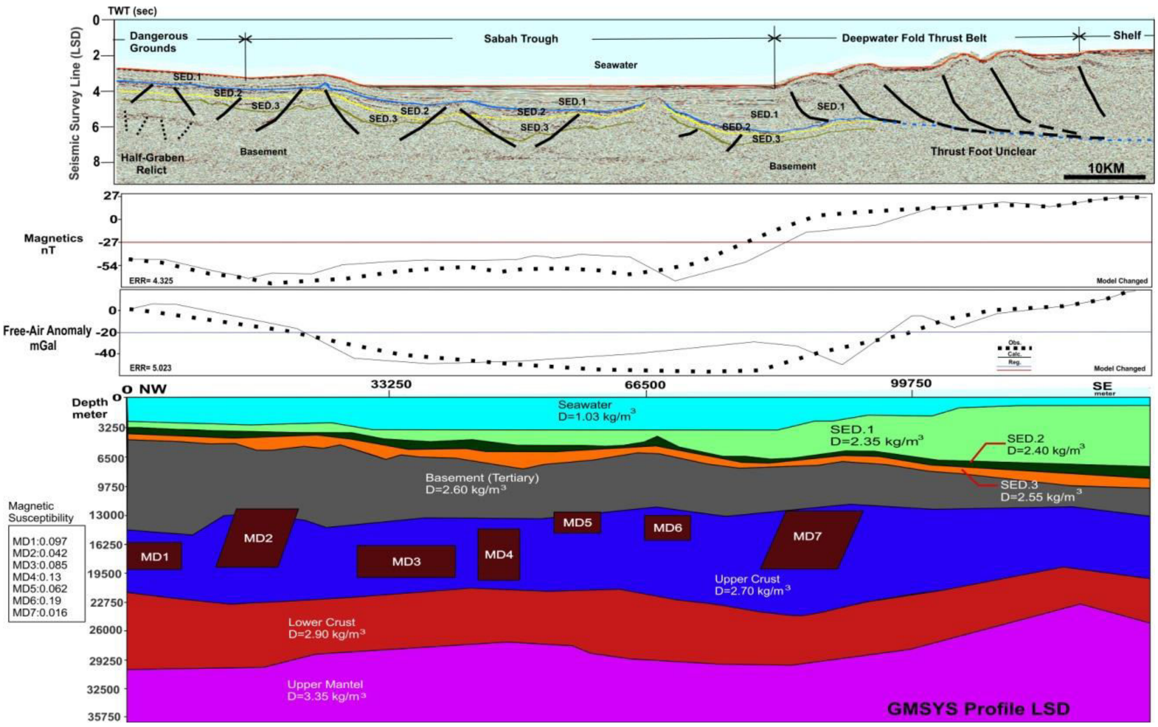

Figure-6. The Crustal model of LSD.

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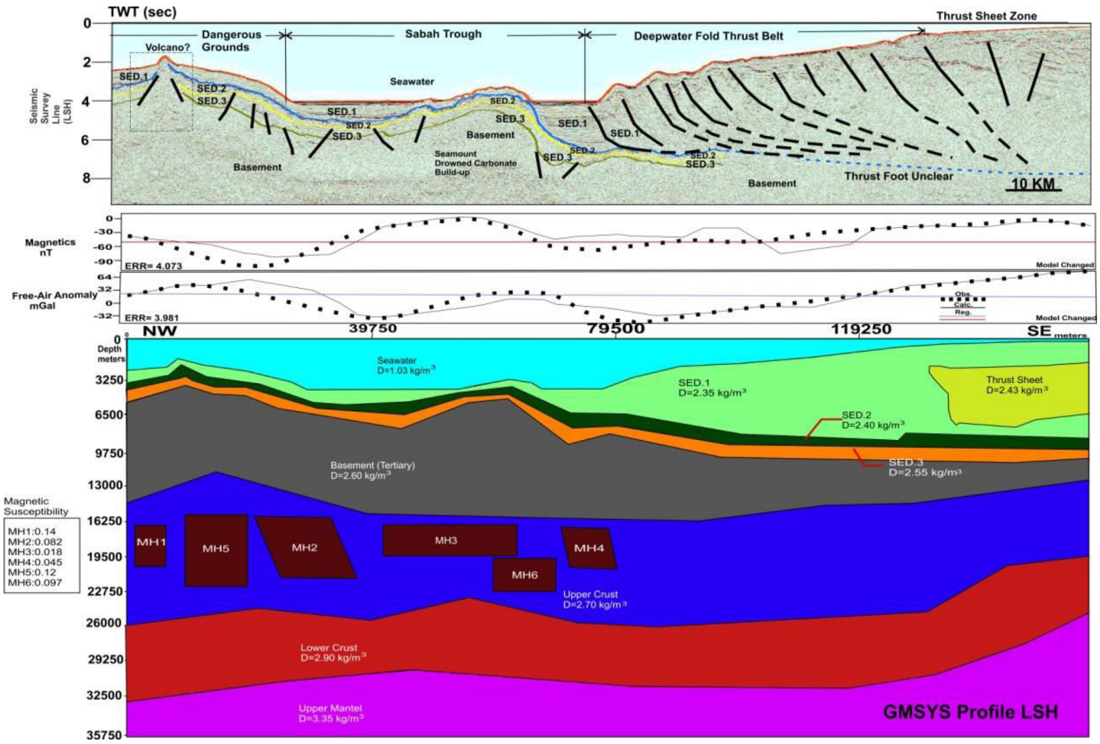

Figure-7. The Crustal model of LSH profile.

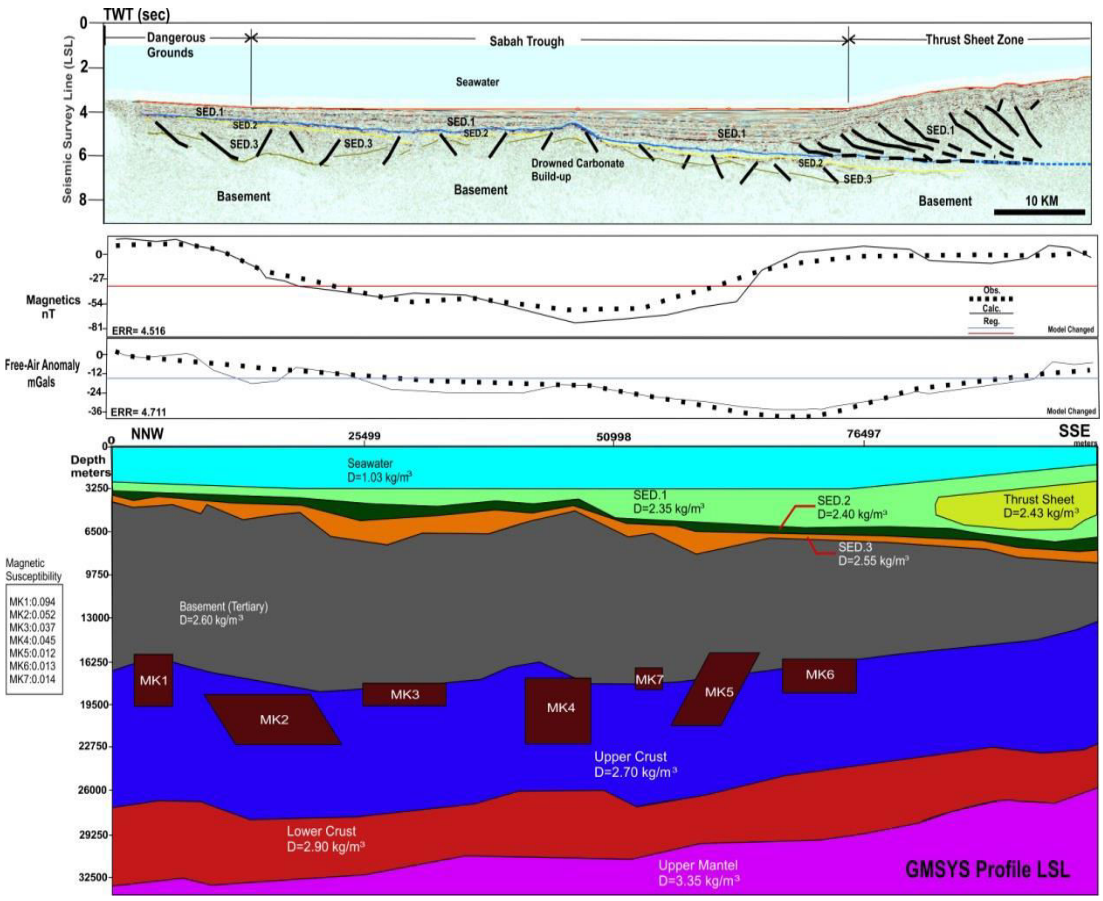

Figure-8. The Crustal model of LSL profile.

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DISCUSSIONS

Profile LSA Crustal model

The crustal model of LSA profile shows a northwest-southeast orientation and the length of 180 km (profile location in Figure-1). The seismic reflection profile in this model shows extending from Dangerous Grounds, across the Sabah Trough and off to the continental shelf of NW Sabah Basin. The crustal model conformable with seismic profile where both of the magnetic and gravity modelling error (correlation coefficient between calculated and observed gravity and magnetic curves) is 4.432% and 3.675%, respectively. The range between free-air gravity anomalies varies between 70 and -65 mgal. The gravity anomaly low in the area of Sabah Trough reached -65 mgal and increased gently to the Deepwater Fold and Thrust Belt and gradually to the continental shelf. The range of magnetic values gradually grew from Dangerous Grounds to Sabah Trough between -80 and 35 nT. There are five magnetic susceptibility index bodies encountered and related to the upper crust unit (Figure-5).

The crustal model in this profile shows continuous crust from Dangerous Grounds to continental shelf margin of the NW Sabah Basin. The Tertiary Basement (grey) narrowed beneath to the NW Sabah Basin. This might be indicating as continuation of rifted crust of the Dangerous Grounds beneath NW Sabah, which is support Hutchison (2004) interpretation about a part of Dangerous Grounds subducted southward beneath Sabah (North Borneo). The thickness of shallower unit increased to the south-eastward suggested as thickest sedimentary accumulation contains on the shelf and the continental margin. Generally, the depth of Moho of LSA Crustal Model from the Dangerous Grounds to the NW Sabah margin was decreased from 28 km to 26 km, respectively.

Profile LSD Crustal model

The Profile LSD presents northwest-southeast direction and the length of this profile is 163 km (Figure-6). The seismic profile shows several half-graben relicts probably related to deep extensional structures occurs during continental of South China Sea Basin start rifting period (~65 Ma). The overall magnetic and gravity modelling error is 4.325% and 5.023%. The observed free-air gravity anomaly ranges between -60 and 20 mgal. The gravity modelling shows slightly low correlation between calculated and observed curves and shows good matching parallel to the seafloor topography. The range of magnetic anomalies varies between -70 and 25 nT. The magnetic field strength have similar trend of observed curves to the gravity anomalies which is from Dangerous Grounds increased gradually to the NW Sabah continental shelf margin. Seven magnetic susceptibility bodies occur at the upper crust. The highest magnetic susceptibility located beneath the Sabah Trough appears to be same level with the base of Tertiary Basement. This probably indicates the pre-rift sequence of Dangerous Grounds sediment at the older section contains calcalkalic extrusive rocks and intermediate to acid intrusive rocks (Yan and Liu 2004). The depth of Moho from this model shows varies increased from northwest to southeast is 30 km and 28 km respectively.

Profile LSH Crustal model

The gravity and magnetic modelling of LSH profile shows northwest-southeast orientation and the section profile length is 173 km (Figure-7). The seismic section attached to this profile presents the thrust sheet body occurs at the southeast profile. Seismic interpretation shows frequency a thrusts fault increased through the northern area compared to the profile LSA and LSD. It can be suggested as presence of carbonate body or basement thrusting upward (Franke *et al.* 2008) that represented by the strong obstacle body during folding and thrusting episodes. The thrust sheet indicated a presence of huge allocthonous or melange mass of imbricated sediments with chaotic seismic facies. The crustal model error for both gravity and magnetic modelling is 3.981% and 4.073%, respectively. The gravity anomalies range fluctuated between 65 and -34 mgal. The calculated gravity modelling curves have slightly matched to the seafloor topography. Meanwhile, the magnetic anomalies range varies between -100 and -10 nT with six different magnetic susceptibility bodies. Magnetic anomaly gently changes up from the Dangerous Grounds to the Sabah Trough and highest magnetic susceptibility body occurs along seamount at the Dangerous Grounds may indicate the presence of magmatic body (volcano) as explained by Franke *et al.* (2008).

The thickness of Tertiary Basement unit thinned abruptly to the Thrust Sheet Zone probably indicates compression effect due to high loads of the thrust sheet body. This model shows a depth to the Moho from northwest to southeast gradually decreased between 33 km and 26 km, respectively.

Profile LSL Crustal model

The Crustal model of this profile shows north northwest - south southeast orientation and the length of this profile is 100 km. This profile is the most northern part of the study area. The modelled underground arrangement of density unit and probable location of magnetic susceptibility bodies along this profile is shown in Figure-8. The gravity and magnetic modelling errors shows almost equal curves with the value are 4.711% and 4.516% respectively. The free-air gravity variation along this profile indicated low at the Sabah Trough in front of the Thrust Sheet Zone approximately -40 mgal. The gravity modelling curves slightly matched to the seafloor topography. The magnetic model for this profile allowed a good correlation to the trend related with the modelled density units of observed gravity curves. The magnetic anomalies variations along this profile are surrounded by high anomaly approximately 10 nT at Dangerous Grounds and NW Sabah continental margin while low anomaly -60 nT occurs at the Sabah Trough.

The size of Thrust Sheet with dimension of ~15 km wide and ~ 5 km thick body in this profile relatively small compared to the Thrust Sheet body in the LSH profile. It can be suggested to the north of Sabah Basin, the contents of Palaeogene Crocker sediments decreased and bordered by the Sabah Shear Zone as accordance to earlier interpretations (Hinz *et al*., 1989; Hazebroek and Tan, 1993). The depth to the Moho in this profile shows decreased 33 km in the Dangerous Grounds and 28 km in the Thrust Sheet Zone.

CONCLUSIONS

The integration of free-air gravity and magnetic data allows us to determine Moho thickness and the arrangement of deeper crust layers. Seismic interpretation was used to define sedimentary columns by differentiate seismic attributes and facies. The depth of seismic profile could not reach to the deeper crust layer and the deeper crust beyond penetration of seismic data revealed by complementing gravity and magnetic modelling.

The modelled crustal shows the deeper crustal structures from seawater level to the upper mantel as a lowermost part. The crustal layers has been constructed from several density and distributed correspond to the free-air gravity calculated curves. A seismic event was picked to ensure the gravity modelling is the best fit to the geological condition. The magnetic modelling contributed as secondary data to gain confident during constructing model. Several magnetic susceptibility bodies attached to the upper crust unit to reduce magnetic calculated error curves. The depth of magnetic susceptibility was determined by analytical signal analysis and also described the depth of magnetic source.

The volcanic like structure (~20 km wide and thickness ~5 km) indicates in the LSH profile but the magnetic anomaly did not show any evidence of magmatic intrusion to the seafloor. The best way to determine this features by dredging or drilling works, so the plausible suggestion can be made. There are higher density body surrounded by low density unit in the Thrust Sheet Zone of the northern study area. It possibly interpreted as Palaeogene Crocker sediments cut off by ophiolites during Dangerous Grounds Block collide with the Borneo (Franke *et al*., 2008).

The Moho was uplifted from northwest to southeast and presented a typical behaviour of continental crust thinning and Sabah underlain by thick continental crust (Holt 1998). The overall Moho depths range between 33 km and 26 km which is the depth slightly similar to previous studies (Milsom *et al*. (1995), Holt (1998) and Franke *et al*. (2008). However, through this crustal model, we could not determine the event that subjected to the thinning process. Another researcher may come out with different shapes, sizes and styles of crustal model but it depends on their data and methods as long as relevance to the geological history of this area.

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