GEOTHERMAL POTENTIAL OF THE LOMBOK ISLAND
(NEW INSIGHTS FROM GEOMAGNETIC INVESTIGATIONS)

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ABSTRACT

The Lombok Island lies between zones characterized by the highest intensity geomagnetic anomalies of the Indonesian region. It is remarkable as one of the eight most important features provided on the 1st edition of World Digital Magnetic Anomaly Map. Geomagnetic surveys over this island have been carried out since 2004, and the new results from 2006 and 2007/2008 surveys are presented here. These new results agree with earlier ones obtained by satellite, aeromagnetic, and marine platforms; and provide a much more detailed picture of the strong anomalies on this island. They show the general pattern of contiguous negative-positive anomalies, revealing an active magmatic arc related to subduction region. Simultaneous magnetic anomalies and gravity models suggest geothermal and hydrocarbon potentials, as well as mineral resources of this region, which could be exposed by evaluating the modelled intrusions and subduction morphologies.

Key Words: geomagnetic field, magnetic anomaly, Lombok Island, Sunda-Banda arcs, Flores Thrust.

INTRODUCTION

The Lombok Island is a part of the Lesser Sunda Islands (LSI) region; a chain of small to medium size islands situated along the transitional region between the Sunda and Banda Arcs. There is a long history of geological and tectonic study of the LSI region and particularly the Lombok Island; however, the detailed morphologies are not fully understood so far, therefore further studies are needed to better understand several aspects of the regional geology.

Meanwhile, a geomagnetic lithospheric anomaly map obtained from 4 years (2004−2007) CHAMP satellite measurements (Maus et al., 2008) indicates that the Lombok Island (pointed out by black arrow of **Fig. 1**) lies between zones characterized by the highest intensity geomagnetic

anomalies of this region. It was described in detail by Zubaidah et al. (2010). Mandea and Thébault (2007) noted it as one of the eight most important geological features provided on the 1st edition of World Digital Magnetic Anomaly Map (Korhonen et al., 2007). The map of **Fig. 1** reveals that the subduction zone along the Sunda-Banda Arcs mainly coincides with an anomaly band of contiguous negative-positive pattern. Therefore such anomaly bands could indicate the presence of magmatic arcs related to subduction regions.

Here, we investigate the geomagnetic anomaly pattern obtained from ground surveys over the Lombok Island to reveal some new geological and tectonic insights of this island region, particularly focussing on the assessment of geothermal potentials as prospective alternative energy resource for this region.

METHODS

We have conducted several geomagnetic surveys over the Lombok Island in order to obtain a better understanding of the regional geological and tectonics by improving the quality of our surveys and data processing (Zubaidah et al., 2005; Zubaidah et al. 2010). From November 24th 2007 to April 3rd 2008, the new ground-based magnetic survey of total field intensity has been conducted at 177 stations, including measurements at 55 old stations which had been previously occupied in 2006. The detailed information of this geomagnetic survey can be found in Zubaidah (2010); here we only summarize some important aspects of the improved survey methodology and data processing.

During the new survey, a standard proton precession magnetometer (GSM-19T v6.0, GEM System) has been used at all stations, replacing the old manually operated one (ENVI PRO Proton Magnetic System, Scintrex). It measures the total magnetic fields ranged 10,000–120,000 nT with a resolution of 0.01 nT and an accuracy of ±1 nT. Since no dedicated local base station had been established, the measurements have been obtained every 60 seconds during 30–60 minutes, to compare and reduce the data using one-minute values of the nearest observatory (i.e. Kakadu/KDU in Australia). To schedule our geomagnetic surveys on the magnetically quietest time, we have used the forecast data from the weekly reports of the IPS (Ionospheric Prediction Service of the Australian Space Weather Agency). The 10th generation of IGRF values (IAGA WG V-MOD, 2005; Maus et al., 2005) for epoch 2008.08 (January 29th 2008) have been used to subtract the core field. Statistical evaluation applied to the new survey results shows that 99% of stations provided good quality data, which is much better than our previous survey in 2006 with only 75 % good data.

Thereafter, we have generated 2D as well as 3D maps of geomagnetic anomalies and developed new integrated magnetic-gravity models. The new models are obtained using the GM-SYS Profile Modeling, which can generate an integrated

model by using Talwani's algorithm (Talwani and Heirtzler, 1964). The models used local gravity data (Sukardi, 1979), constrained with the known geological (Mangga et al., 1994) and tectonic settings of this region (Kopp and Flueh, 2007; Silver et al., 1983; McCaffrey and Nabelek, 1984; Hall, 2002; Nugroho et al., 2009) as well as topography (Becker et al., 2009) and earthquake relocated hypocentres data (courtesy of Engdahl et al.).

RESULTS and DISCUSSIONS

The 2D geomagnetic anomaly map of **Fig. 2** depicts three strong dipolar magnetic anomaly structures (one in the southern part, and the other two in the northern part which are stronger). The map clearly underlines the pattern of repeated contiguous negative-positive anomalies, revealing magmatic arc. The negative anomaly which extends southward and the contiguous positive anomaly peaks over the northern end of the island suit the global geomagnetic anomaly pattern.

Modelling and analyzing over the second profile of strongest apparent dipolar structure in the north (**P2**) could be interpreted as induced and remanent magnetizations of several magmatic intrusions accompanied by several Tertiary and Quaternary lava layers. Considering the active subduction in the back arc of LSI, we infer geothermal potential in the north part of the Lombok Island (white circled area in **Fig. 2**).

Figure 3 shows our geothermal reservoir model, suggest that the geothermal system is in the old crater of Mt. Rinjani (about 5 km east of the new crater). The earlier estimates of reservoir depth (Sundhoro et al., 2000; Hadi et al., 2007a; Hadi et al., 2007b) can be confirmed further to some 800 – 2800 m depth with cap rocks are sediments of Quaternary lava with low resistivity. The modelled new subduction on the back arc region (**Fig. 4**) maintains the sustainability of the potential.

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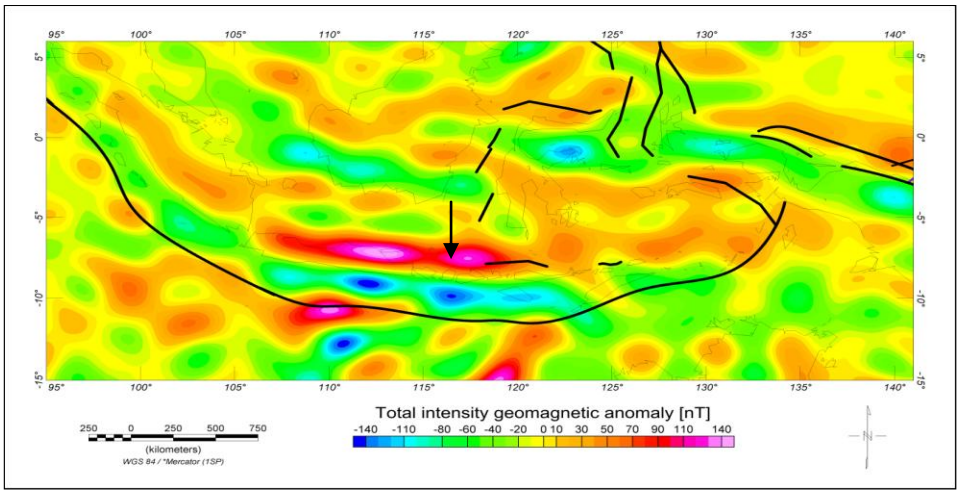

FIGURE 1: Map of the total component of the large-scale lithospheric anomaly field at geoid altitude for the Indonesian region obtained from the MF6 model (Maus et al., 2008). Plate boundaries and subduction zones are indicated as black lines. The Lombok Island (pointed out by a black arrow) lies between the extremities of geomagnetic anomalies in this region.

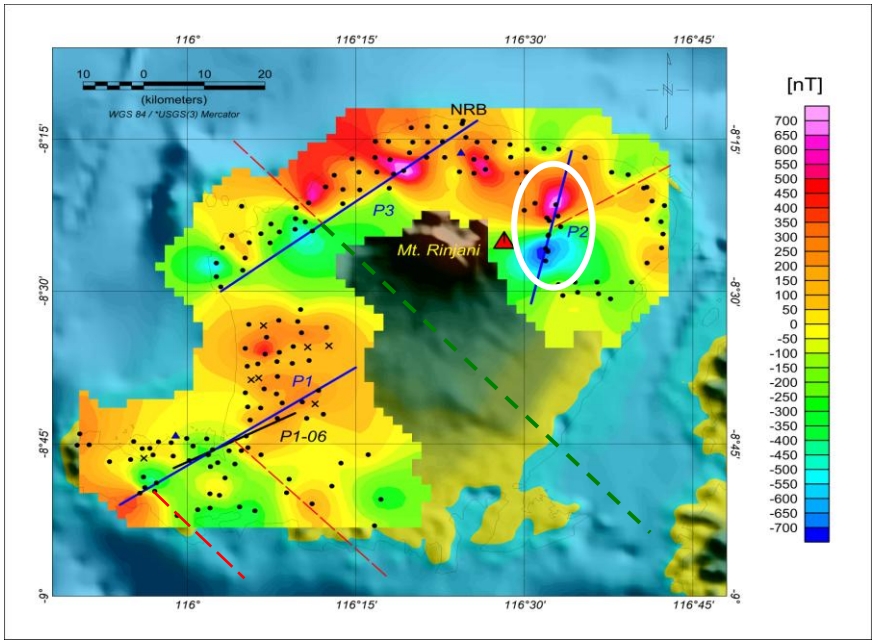

FIGURE 2: Map of the geomagnetic total field anomaly obtained from the new measurements in 2007/2008, plotted over a regional topographical map of SRTM30 Plus v4 (Becker et al., 2009). Only the most reliable data are used and interpolated over the surveyed area on the Lombok Island. The geomagnetic survey stations are shown, providing good quality (black points) and intermediate quality (blue triangles), while the black crosses represent the stations with large difference in anomaly value compared to that in 2006 (Diff. > 100 nT). The blue line represents the traces of the studied magnetic profiles (P1, P2, and P3), which connects the peaks of dipole magnetic anomalies; while the black line represents the trace of the magnetic profile (P1-06) that has been inferred from measurements in 2006. The red dashed lines are the modelled strike directions of the related profiles. The position of the summit of Mt. Rinjani is depicted with a red triangle, while NRB label is the location of "Nurul Bayan" station.

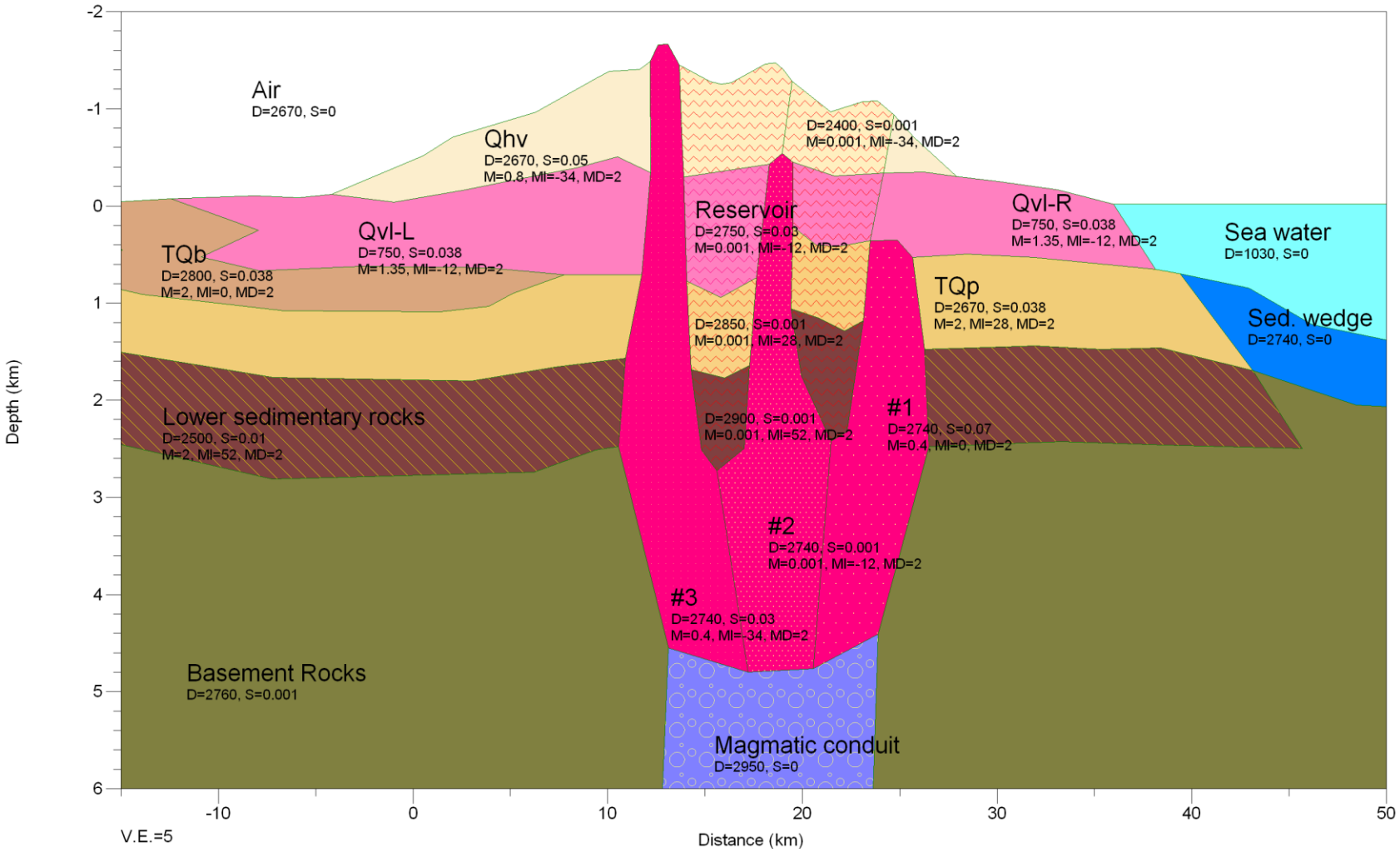

FIGURE 3: The details of stratigraphy and geothermal reservoir of the P2 model, accompanied by the gravity and magnetic properties of each layer.

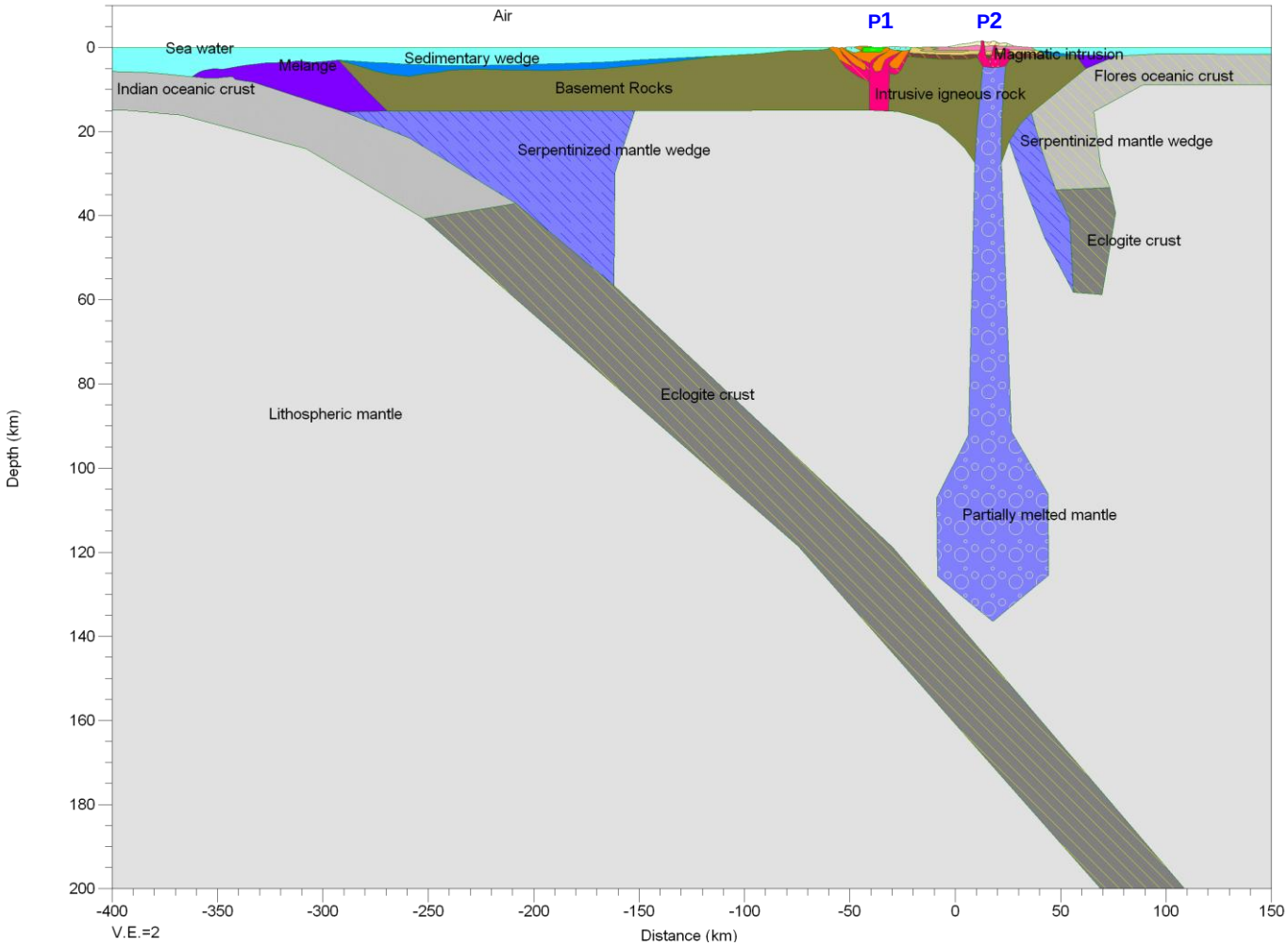

FIGURE 4: The overall model of the Lombok Island, representing the present day tectonic settings of this region. The magnetic and gravity anomalies over the southern area are caused by the Indian oceanic crust which is subducting at the Java Trench (315 km south of the main intrusion of P1) and leading to the formation of volcanic rocks as well as intrusions of igneous rock structures. From the opposite direction, the Flores oceanic crust is subducting at the Flores Thrust zone (about 60 km north of the main intrusion of P2). The two simultaneous opposite subductions cause the magnetic and gravity anomalies over the northern area by upwelling of partially melted mantle and forming some lava structures.