Analysis of The 3D Geothermal Reservoir Model from Anomaly Magnetic Data Using Mag3D

(Case Study: Rajabasa Geothermal field, Lampung Province, Indonesia)

Nandi Haerudin, Wahyudi, Wiwit Suryanto and Sarkowi

ABSTRACT - To get a description of reservoirs in the Rajabasa geothermal field, the geomagnetic research has been done. This area covered all geothermal manifestations spread around of Rajabasa Mount. It is about 156 km^2. The total magnetic anomalies directly was modelled using Mag3D software. A Low susceptibility anomaly that was considered as the main reservoir was located at 900 m to 3500 m depth. It's position is in the southern part of the Rajabasa peak and southwest of Balerang peak and covered three manifestations e.g. Cugung (Bulakan), Kunjir (Way Merak) and Pangkul. This Reservoir is suspected to be a source feeded the geothermal manifestations that appeared in the southern part of geothermal Rajabasa area.

Index Term: reservoir, Mag3D software, Rajabasa geothermal field

I. INTRODUCTION

Rajabasa geothermal field located on Rajabasa volcano near Sunda Strait in the south-southern tip of Sumatra Island, included into the South Lampung Regency, Lampung Province Indonesia (Figure 1). It is about 60 km of Bandar Lampung City as the capital city of Lampung Province.

Lampung fault, the shear fault trending northwest-southeast, is the subject controled Rajabasa geothermal system. It is estimated to control in the northern part of the geothermal system. In the southern part, the local normal fault drived an important role to control its system [1]. Rajabasa mountain have two peaks, namely Rajabasa and Balerang peaks. Volcanic activity of the both suspected as the heat source of this geothermal systems (figure 2). The Rajabasa volcanic eruptions result dominantly is lava basaltic to andesitic composition

The fist period of volcanism at Rajabasa volcano was the construction phase of Pre Rajabasa composite cone followed by stage crushing cone volcano. It formed the caldera Pre-Rajabasa with a diameter of 25 km. In the second development phase of the composite cone, Rajabasa volcano today, along with the slopes and volcanic eruptions monogenesis appeared in the Pre-caldera basin Rajabasa. Building blocks of pre Rajabasa and Rajabasa volcano consists of larva flows, pyroclastic breccias, and tuffs having andesit to basal in compotition as in [2].

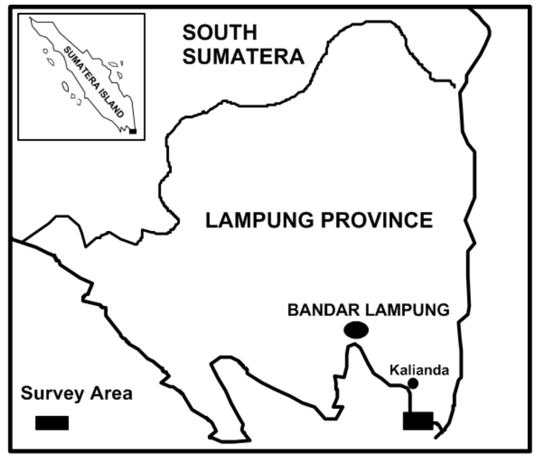

Figure 1. Lampung Province Map (inset Sumatera Island)

Historical eruptions G. Rajabasa was not recorded in volcano history and has never shown the eruption, nor an efution. Reference [3] stated that in April 1863 and May 1892, there was an increasing in volcanic activity but it has not happened eruption. Generally, there was not encountered geological hazards associated with aspects of volcanology [4].

Structural patterns developed in the Rajabasa complex were influenced by regional structures such as Lampung fault , closely associated with the Semangko shear fault as in [5].

There found several manifestations wich were devided into two groups. On the nortern part, there were three located of manifessatation i.e. Sukamandi hot spring, Maja hot spring and Simpur fomarole (Kedaton). The other on the southern part i.e. Kunjir (Way Merak) and Bulakan (Cugung) and Gunung Botak. The results of several geochemical investigations showed that the geothermal fluid type are sulfate type e.g. Simpur, Kunjir, Bulakan and Pangkul, whereas Kalianda and Maja are bicarbonate and last, Gunung Botak is chloride [6] [7] [8]. The potential power estimated 12.5 MW/km^2 and included medium reservoir as in [7].

Geophysiscs research has been started to study by resistivity method [9]. Then the Geological Agency (Badan Geologi) conducted preliminary simultanous geological survey for geothermal prospects in 2001. However, this study was not published and only in the form of project reports. In Reference [10], the research have been

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conducted by magnetic methods to investigate description of the major fault that occurred at G. Rajabasa. Then, studied about permeability reservoir geothermal system with the same data was conducted [11]. This study concentrated domanntly in the northern part of Mount Rajabasa but not cover the entire area of geothermal prospects Rajabasa especially in the south. Reference [12] showed a study have been conducted by measuring geomagnet field to complete the data from the Geological Agency. These combined data cover the entire region of G. Rajabasa. The results of the analysis of qualitative description of faults is found, confirm the geological interpretation have been done earlier geological researchers. The methods in the field of geothermal exploration is intended to determine the depth and reservoir boundaries (the prospect area) as a source of geothermal energy to be exploited. Accurate determining of subsurface reservoir location is required to achieve that goal. And the purpose of this study is to determine the position of geothermal reservoir as a three-dimensional model using Mag3D software.

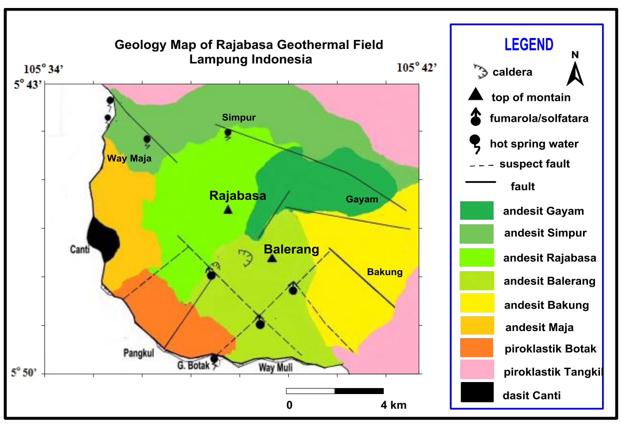

Fig. 2. Geology Map of Rajabasa Geothermal field (modified from Budiardjo, 1995)

II. METHODS

In this research, the analysed magnetic data covered the entire area of geothermal prospects Rajabasa. The used data is a combination of the secondary data from the Geological Agency of Indonesia (Badan Geologi), as many as 81 data and primary data were taken in 2011 as many as 77 data. Magnetic field data in the area of geothermal Rajabasa was taken using Scintrex PPM magnetometers to complete secondary data. In addition, There was also measured position using GPS (global positioning system) Garmin . The position data was used to determine the location of measurement points in the form of a map of the position. The measurement data was given the correction IGRF and daily variation correction to get the value of the total field magnetic anomalies. Position of research area is 0.5^{o} in declination and -30 in inclination. Data presented in a contour map. Then it is being input data for Mag3D program to model the Rajabasa geothermal structure. Then the modelling results was matched with detailed geological maps for The reservoir analysis.

III. RESULTS AND DISCUSSION

The observation data are presented in the form of total magnetic anomaly contour map. Figure 3 showed the contours map of position point data overlaid on the total magnetic anomalies. Values of positive and negative anomalies appeared is balanced at 900 nT and -900 nT.

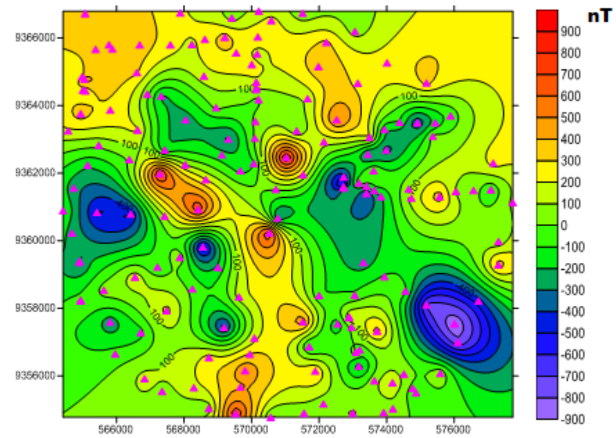

Fig. 3. Measurements Point Distribution on Contour Map of Total Magnetic Anomaly

Structural patterns that developed in the Rajabasa complex volcano influenced by lampung fault regional structures closely correlation with Semangko fault. It controled the emergence of minor faults in the vicinity of Rajabasa volcano which include Rajabasa shear fault, Balerang normal fault, Gunung Botak normal faults, Banding normal fault and Simpur normal fault. Shear Faults generally trending northwest - southeast and normal faults trending northeast - southwest (Figure 2). The patern picture of the total magnetic anomalies contours map correspond to geological description of the Rajabasa showed by Reference [4] and [5] that is visible the contours of geomagnetic total anomaly indicated major fault trend to northwest - southeast and other started from Gunung Botak to G. Balerang in the northeast direction [12] [13].

The magnetization of volcanic rocks can be significantly reduced by hydrothermal fluids seepage. Main magnetic minerals (magnetite and titomagnetit) replaced by alteration minerals such as pyrite or non magnetic hematite. So reservoir zones associated with low and negatif susceptibility zones. Figure 4 displayed results of general 3D modelling. We slice model from south to north inthe midle of study area. From this model, there are negatif susceptibility under Balerang peak. Figure 5 shows two diagonal slices in the study area. In the center below the Balerang peak seen negatif susceptibility zones that are considered Rajabasa geothermal reservoir. It was suspected as mayor reservoir of Rajabasa which is expected to andesitic rocks that have good agreement result with the statement as in [2].

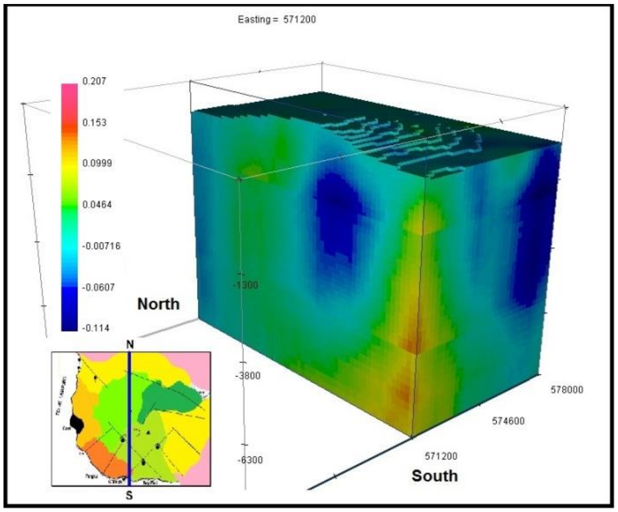

Fig. 4. The results of 3D modelling using Mag3D in the south to north crosssection

On either sides showed low susceptibility zones. But on the left side is an area without measurement data. On the real filed, the zones is actually a region of coastal waters. While the lower zone on the right side is less data. To be sure, it can be done magnetic measurements around this zone or be integrated with other methods.

The depth of the reservoir zone is estimated at depth of 1000 m (Figure 6). While we compare with the results of the power spectrum analysis obtained 1180 m depth of source anomalies in the northern part 2 km from Gunung Botak [14], this has resulted in the value of the adjacent. The magnitude depth is still within depth range of geothermal reservoir common in Indonesia i.e. 1000 m to 1500 m. Reservoir depth from Statistical data and temperature measurements in several drilling geothermal locations in Indonesia resulted the range of 1000 - 1500 m [8]. And the reservoir position is in UTM 9357850 - 9359375 N and 569500 - 571200 E (figure 7). The position of the reservoir area is between three manifestations Pangkul, Kunjir and Bulakan. This reinforces the analysis of geological stated that reservoirs are among fracture formed by a alignment connecting the Rajabasa and Balerang peak with a suspected fault conected Kunjir to Pangkul manifestations.

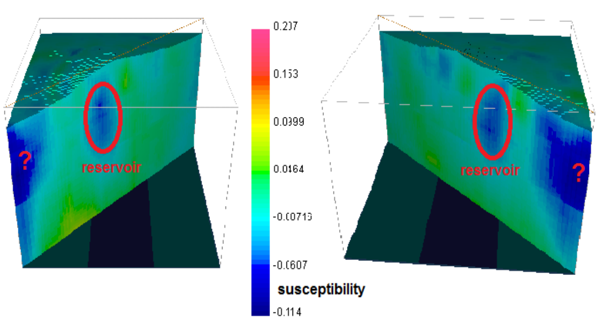

Fig. 5. The results of diagonal slices crosssection

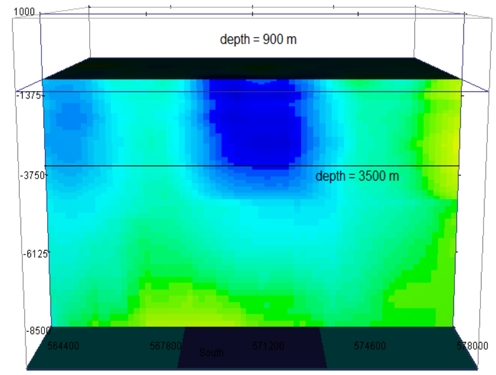

Fig. 6. Depth of Reservoir Based on Modelling

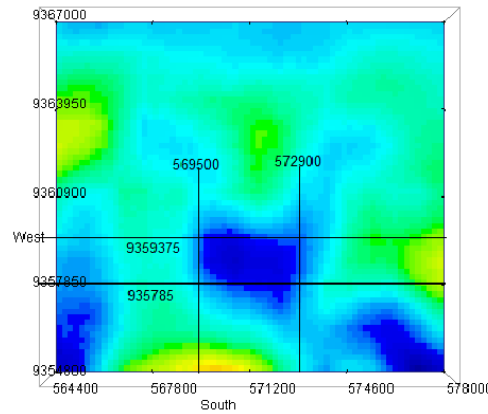

Fig. 7. Position of Reservoir Based on Modelling

IV. CONCLUSION

By Mag3D modelling, the position reservoir is located under G. Balerang among three manifestation i.e. Bulakan, Kunjir and Pangkul at 9357850-9359375 N; 569500-571200 E. Reservoir rock is estimated andesit.

ACKNOWLEDGEMENTS

1. We thanks to Djoko Santoso who has license Mag3D program in Indonesia for allowing the software.

2. We thanks to Indonesian Geological Agency (Badan geologi) for allowing the used data.

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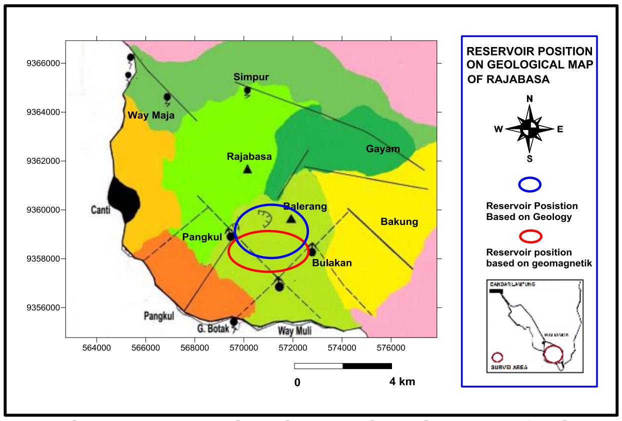

Fig. 8. The area is suspected Rajabasa Geothermal Reservoir (circle area)

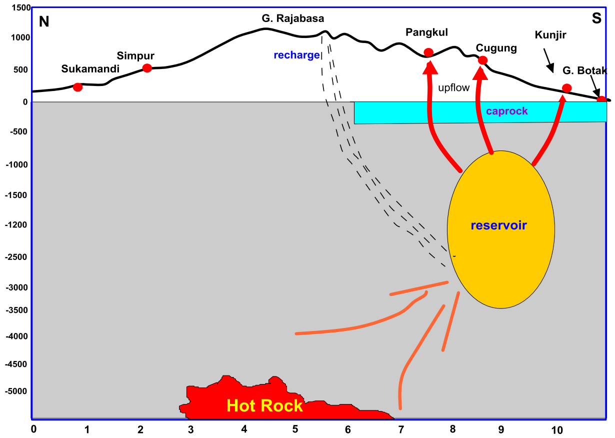

Fig. 9. Tentatif Model of Reservoir Rajabasa Geothermal Field

Development of Information Systems to Semeru Volcano Activity using SMS : In Study

Didik Yudianto, J.E. Istiyanto, K.S. Broto and Sismanto

Abstract - Semeru Volcano at East Java which have about 20 minutes eruptions' average repose time is suitable for an integrated sensor system experiment. A design of integrated seismic and infrasonic waves monitoring and recording system is going to be completed. Wireless sensor network is used for online data transmission, recording, processing, and decision support system. At the end of the process, level or state of volcanic activity will be sent by short message service (SMS) to public community.

Keywords: Wireless Sensor Network – Seismic – Infrasonic - SMS

I. INTRODUCTION

Semeru volcano is one of the volcanoes that are still active in the area of East Java, located between the administrative area Malang district and Lumajang district with geographical coordinates between 7° 51' - 8° 11' latitude of south and 112° 47' - 113° 10' longitude of east. With a height of 3,676 mdpl, position ourselves as the highest volcano in Java.

Semeru volcano activity is characterized by the release of energy each time duration of 20 - 45 minutes so that the condition makes the characteristic of Semeru volcano (Kusumadinata, 1979). Semeru volcano activity monitoring systems are still using methods of monitoring that is both conventional procedure and mono system that takes a long time at the time of delivery of information and required an analysis of the decision process, while the current requirement is to obtain information can be accessed remotely with easy.

Volcano monitoring system that will be developed in the study completed the doctoral program at UGM is a double systems integration consisting of a seismic sensor and infrasound sensor with bases wireless sensor network and SMS (be composed: sensing unit, telemetry unit and web server unit), used to recording , monitor and evaluate the status of Semeru volcano activity by online. So that the peoples around Semeru volcano can a request for that information directly from remotely by sending an SMS to a data processing center (server and a provider). In addition, monitoring station Semeru volcano activity and related parties can receive information and find out the time change Semeru volcano activity by online and up to date.

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II. RESEARCH METHODS

The system will be developed in the study, consisting of two parts: hardware unit (shown in the figure 1, 2, 3 and 4) and a software unit (shown in the figure 5, 6, and 7).

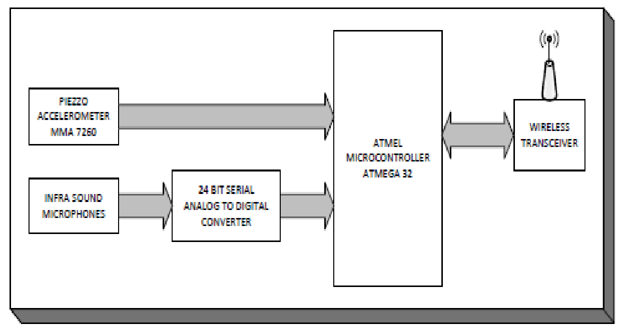

Fig. 1. Block diagram of the sensing unit

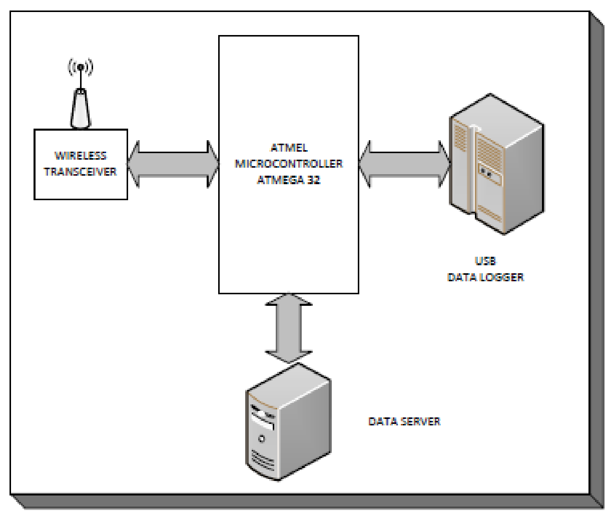

Fig. 2. Block diagram of a data logger unit