FAULT MODELLING BASED ON LOCAL MAGNETIC ANOMALY DATA IN GEOTHERMAL PROSPECT AREA RAJABASA LAMPUNG

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Abstract.
Two and half dimensions fault modelling was conducted based on Local Magnetic Anomaly Data in Mount Rajabasa site, Lampung. The research utilized total magnetic anomaly secondary data to perform quantitative interpretation. The total magnetic anomaly data was then transformed into flat field, reduced to a pole and carried upward continuation until at an altitude of 4000 MSL to separate local anomaly and regional anomaly. Based on the qualitative interpretation of the anomalous magnetic field, it indicates a normal fault with the direction of northeast – southwest and northwest – southeast. In the research, quantitative interpretation was done to local anomaly by selecting two locations that showed the presence of lineament patterns in the contour. Modelling was conducted by using *Mag2DC* software. By modelling those two sites, was obtained that fault model that is located in Mount Rajabasa area is a normal fault trending northwest – southeast with the value of magnetic susceptibility contrast of 0.004 and -0.015 in cgs units.

Keywords: fault modelling, local magnet anomaly, Rajabasa geothermal

Introduction

Background

Volcanic phenomena was open further horizons of human thought, that is under the earth's surface contained a source of energy that can be harnessed by humans other than fossil sources of energy in the form of geothermal energy. In general, geothermal field in Indonesia associated with magmatic and volcanic areas.

Indonesia was an archipelagic country which has many volcanoes. This condition was related with Indonesian archipelago position, located at the confluence of three plates regions of the world, the Indo-Australian Plate, the Eurasian Plate and the Pacific Plate. The process of plate collision produces magmatic paths along the islands and seas in its path, so there was appeared the volcanoes. Evidence of collision of Indo-Australian and the Eurasian Plate was appeared of a row of active volcanoes, including Rajabasa Kalianda mount South Lampung. Search of geothermal energy sources needed a survey methods, one of them was used geophysics methods that is magnetic method. This method could be done by measurement of magnetic field on the surface of geothermal energy area.

The geothermal presence was generally depends on the faults around the geothermal resource. The steam and hot water usually come out to the surface through fractures or faults. Rajabasa Mount geothermal systems conjecturable related with the fault in the geothermal resources area. Therefore it is necessary to study the existence of the faults and fault models in this geothermal systems area.

The study purpose for modeling the two and half dimensional (2.5 D) Rajabasa volcano Lampung and estimate the fault directions, the depth average, and the fault type. Based on the purpose above then the problem extent in this study was limited to a few things: The data used was the secondary data of total magnetic anomalies in Rajabasa volcanic Lampung regions which obtained from Bandung Geological Agency by Rahman et al in 1992 and Geophysics Unila by Haerudin et al in 2011. This data was used directly without any corrections to the modeling of magnetic anomalies and two and half dimensional modeling (2.5 D) of subsurface structure of the area carried out the alleged fault by local magnetic anomalies.

Geological Overview of Research Areas

The research area is administratively located in Desaru, South Lampung area, geographically located 5^0 50' 13.313" to 5o 43' 41.589" southern latitude and 105^0 34 '54.866" to 105^0 42' 7.380" longitude east (Figure 1).

Geology Structure

Structural patterns that developed in the Rajabasa mount complex influenced by regional structures such as Lampung Fault which closed related with Semangko horizontal section. According Suswati (2001), structural patterns controlling the faults around Rajabasa mount that is: Rajabasa horizontal fault, Balerang normal fault, Botak normal faults, Banding and Simpur normal faults. Generally, trending of Shear Fault are northwest-southeast and normal faults trend are northeast-southwest. The faults existences are closely related with the appearance of some craters in Rajabasa mount complex. There are four craters, the Balerang peak Crater, Rajabasa summit crater, Way Balerang and Simpur crater. Both craters are located on the slopes last. Besides the result to outcrop condition and influence the surround morphology pattern, the structure activity also triggers the emergence of several groups of hot springs around the Rajabasa mount complex

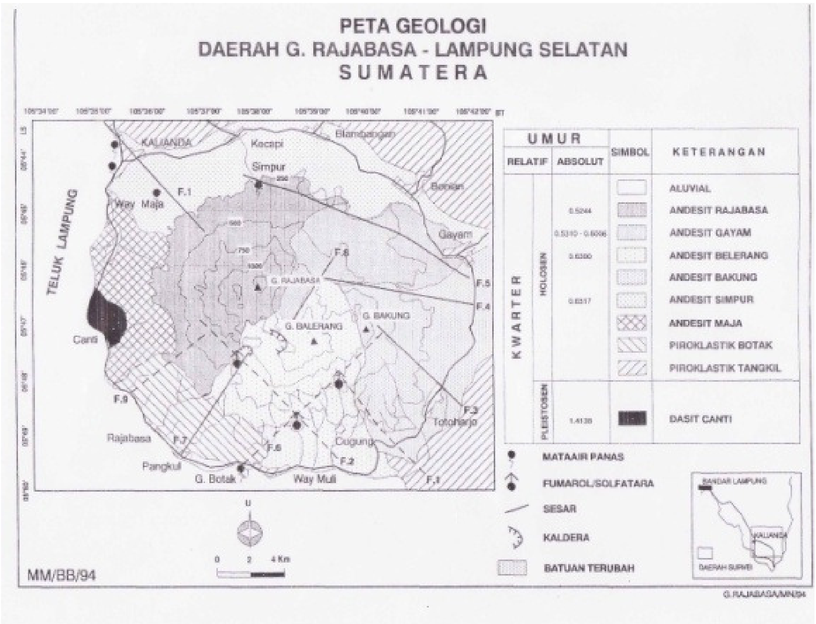


Figure 1: Geological Map of Rajabasa volcanic areas (modified from Budiardjo, 1995)

Geophysical Review

Magnetic method was a geophysical method that is often used to study of subsurface. Here, some of the last research on the Rajabasa volcano Lampung area which aimed for interpreting the subsurface geology of an area.

Harmadi (2007) was research with magnetic methods in Rajabasa Volcano. The result are the qualitative interpretation of magnetic anomalies indicate that there is a relatively low anomaly that extends trending northeast - southwest and northwest - southeast indicate a normal faults with northeast - southwest and northwest - southeast direction. While the modeling results obtained using the software Mag2DC, obtained rock models with 0.025 cgs susceptibility which is a basaltic andesite rock body with an average thickness of 0.6 km.

Rasimeng (2008) was analyzed Rajabasa Mount South Lampung faults as geothermal prospect area based on the total magnetic field anomaly data. Analysis of total magnetic field anomaly data in the study area was conducted for obtaining faults system figure. Based on total magnetic fields anomalies on flat contour map, shows rock anomalous response. The response indicates a fault with the southwest-southeast direction relative as geothermal fluid flow path to the surface of the earth.

Haerudin, et al (2008 and 2009) doing the geoelectric measurements in areas of geothermal manifestations Way Belerang and Kecapi (Simpur). Found a low anomalous dispersion pattern to limit geothermal reservoir located in the northern research area.

Meanwhile, according to Suharno, et al (2010) was analyzed the magnetic to determine the permeability of the geothermal reservoir with case studies of geothermal systems Rajabasa mountain. The results of this study indicate that the dominant negative anomalies in Rajabasa volcano geothermal systems.

Basic Theory

Magnetic field strength is the magnitude of magnetic field at a point in space that arises as a result of a polar m_1 that is as far r from that point. Magnetic field (**H**) is defined as a force per magnetic poles unit, can be written as:

$$\mathbf{H} = \frac{\mathbf{F}}{m_2} = \frac{m_1}{\mu r^2}\hat{\mathbf{r}} \qquad (1)$$

where **H** is the magnetic field strength with units of amperes / meter (Am^{-1}).

A magnetic material which placed in the external field **H** would produce an internal field **H** 'whose it magnitude is:

$$\mathbf{H}' = 4\pi\mathbf{M} \qquad (2)$$

The presence of internal field **H'** would be increase the magnetic field value of the material, so that the total magnetic field measured was the magnetic induction total $\mathbf{B_t}$:

$$\mathbf{B}_t = \mathbf{H} + \mathbf{H}' \qquad (3)$$

By inserting equation (2) and (3) obtained:

$$\mathbf{B}_t = \mu\mathbf{H} \qquad (4)$$

Total magnetic field measurements in the field were usually done in the field of uneven topography. To reduce the topography effect was done the reduction onto a flat surface at a certain height.

A method which could be used to carried the potential field observations data which was distributed in not horizontal area (example: topography areas) to the horizontal plane was through by Taylor series approximation. To calculate the potential field on a flat surface z_0 was continuation of the potential field that is on an uneven surface z (x, y) which given by the equation:

$$U(x,y,z_0) = U(x,y,z) - \sum_{n=1}^{\infty} \frac{(z-z_0)^n}{n!} \frac{\partial^n}{\partial z^n} U(x,y,z_0) \qquad (5)$$

Flow diagram of magnetic data processing methods can be drawn as follows:

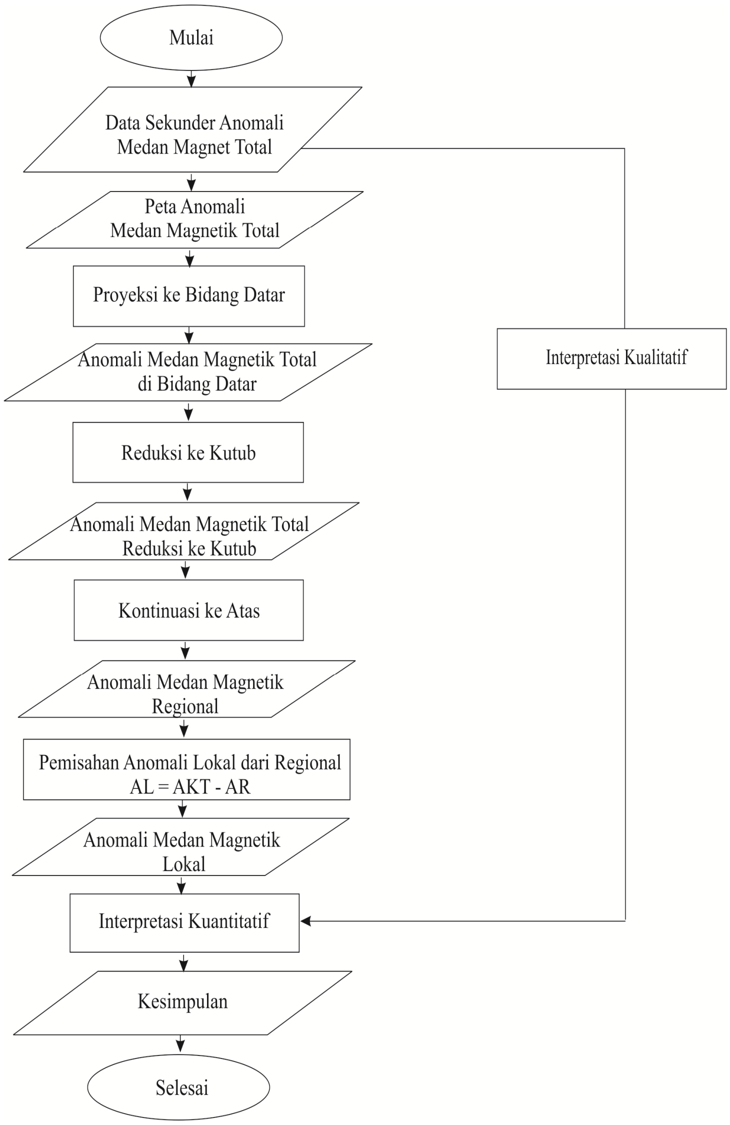
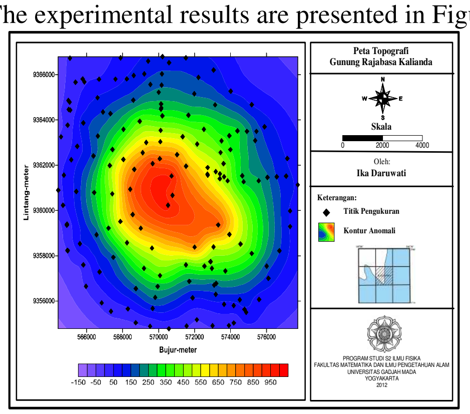


Figure 3: Flowchart of data processing

Results and Discussions

Data Processing Result

The experimental results are presented in Figures 4-10.



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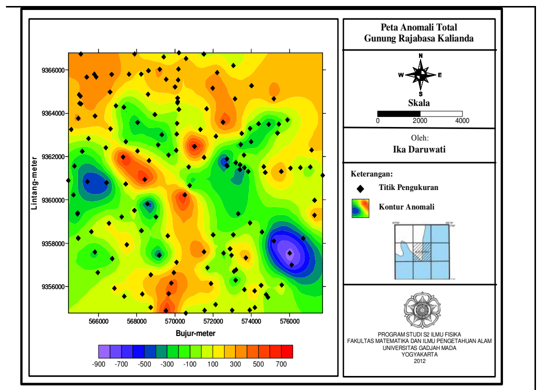

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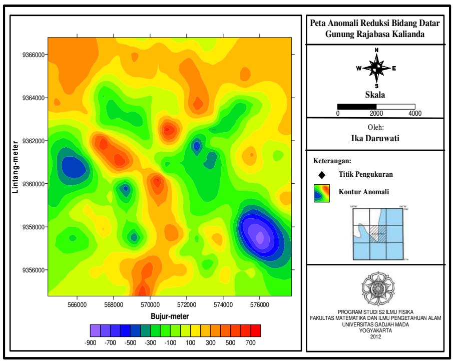

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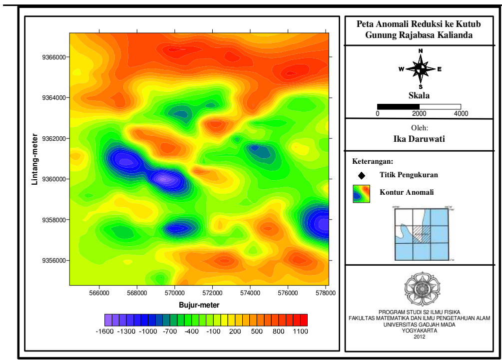

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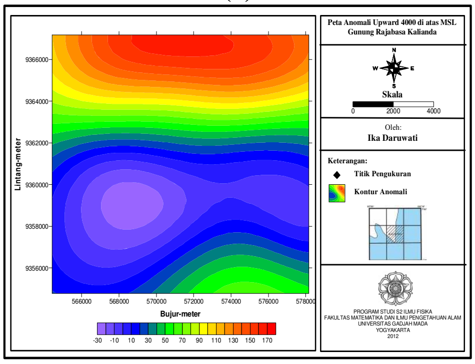

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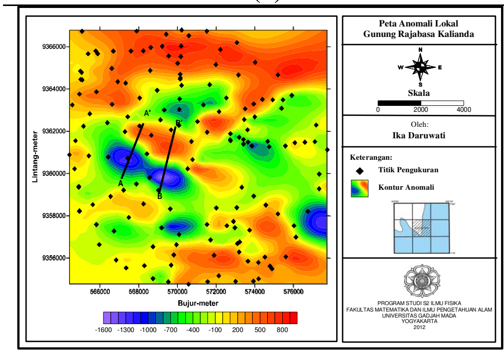
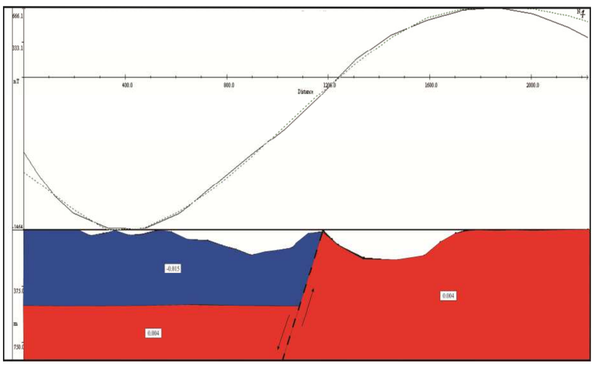


(9)

Figure (4): The topography contours and the distribution of the points total magnetic field measurement station in topography (5) The contours of the anomalies total magnetic field on the topography (6) Contours of anomalous magnetic field reduction to a flat surface (7) The contours of the anomalous magnetic field reduction to the pole (8) The contours of the anomalous continuation magnetic field upward 4000 above MSL (9) The contours of the local magnetic field anomalies

Modeling Results



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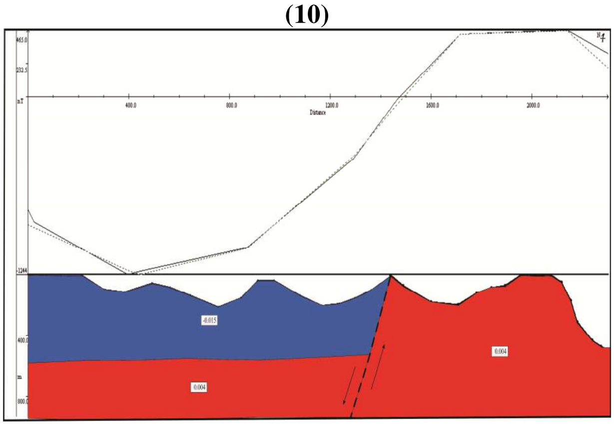

(11)

Figure 10. The results of modeling the trajectory slice AA' (11) The results of modeling the trajectory slice BB'

Discussion

Qualitative Interpretation

The results of the investigation described in the magnetic anomaly map of the local magnetic field (Figure 9). Magnetic anomalies are grouped into two groups, that is low magnetic anomalies and high magnetic anomalies which bounded by zero contour lines which showing the alignment patterns anomaly contour with Northeast - southwest and northwest – southeast directions.

The results also accordance with the Mount Rajabasa geological conditions proposed by Suswati et al that, the structure pattern which develops in the RajabasaMount complex area influenced by regional structures such as lampung faults closely related with Semangko fault. The pattern of this structure control the emergence of Rajabasa mount fault that is Rajabasa horizontal section, Balerang normal faults, normal faults of Botak Mount, normal faults and normal faults of Simpur. Fault shear generally trending northwest - southeast trending and normal faults and northeast - southwest. Besides it ensured with existing outcrop condition and the surrounding morphology pattern, structure activity also triggers the emergence of several groups of hot springs around the Rajabasa mountain complex.

Base on the total magnetic field anomaly contour (Figure 3) appear curved groove pattern and northeast-trending elongated shape straightness - southwest and northwest - southeast were interpreted as normal faults. In addition the negative anomaly contours are elongated relative trending northeast - southwest and northwest - southeast on the contour of the local magnetic field anomalies identified the direction of normal faults with northeast - southwest and northwest - southeast.

Quantitative interpretation

Quantitative interpretation of the data has been done by taking the path on the local magnetic field anomaly map as shown in figure 10. Body shape or geometry, position, depth, and contrast prices magnetic susceptibility (k) polygon models changed their shape resembles the shape of the profile observations. Changes in these parameters by taking into account the geological conditions of the study area, resulting in a realistic outcome.

The results of the model slice trajectory profile AA' contours of the local magnetic field anomalies are:
Magnetic intensity : 45 500 nT
Contrast susceptibility : 0.004 c.g.s
Depth body : 495 m
The results of the model slice trajectory profile BB 'local magnetic anomaly contours are:
Magnetic intensity : 45 500 nT
Contrast susceptibility : 0.004 c.g.s
Depth body : 527 m

From the results of modeling which has been done, gained some model parameters such as those listed above. Cross-section of both sites shows that two locations have the same price magnetic susceptibility, the susceptibility value 0.0197 and 0.0007 cgs cgs which is andesitic igneous and sedimentary rocks. Based on geological information Rajabasa Volcano volcanic rocks belonging to the type of young Rajabasa composed of andesitic lavas - basalts, breccias and tuffs. The results obtained from modeling faults was thought to be a buried fault and not the straightness of faults - faults that have been mapped. This indicates that the hot springs located in volcanic regions Rajabasa emergence in the field of fracture surface through igneous rock composed of andesite.

From the results of modeling that has been done, the second location of the slice appears that both sites are normal faults alleged to have prices similar magnetic susceptibility is the price of 0.049 cgs magnetic susceptibility which is an igneous rock andesite. This indicates that the hot springs located in volcanic regions Rajabasa emergence in the field of fracture surface through igneous rock composed of andesite.

Conclusion

Based on the results of the research, can be concluded that:

1. The results of the qualitative interpretation of magnetic anomalies indicate the presence of normal faults in the Bonian area, in north east - south-west direction and Way Maja with north west – south east direction.
2. From the model parameters which obtained, the cross section of the AA' path has a body depth of 495 m and a cross section of the track BB' has a body depth of 527 m. The results of the 3D model of merging trajectories cross section AA' to BB' has a dip for AA' 76^0 and BB ' 80^0.
3. Rocks models which obtained has 0.0197 c.g.s and 0.0007 c.g.s susceptibility that are andesite and sedimentary rocks such as sandstone which suspected as reservoir zones.
4. The obtained fault straightness a buried fault and not the all of faults that have been mapped.

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