Magnetic Survey within Penantian Geothermal Area in Pasema Air Keruh, South Sumatra

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Magnetic Survey within Penantian Geothermal Area in Pasema Air Keruh, South Sumatra

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Abstract— Magnetic survey has been conducted within Penantian geothermal area of Pasema Air Keruh, Empat Lawang District, South Sumatra Province. The purpose of the survey is to determine the subsurface geological structures that act as a migration path to the surface of the geothermal fluid. Total magnetic field anomaly data obtained is transformed into a flat surface, and reduced to the pole, then carried upward continuation. The result is a regional magnetic field anomaly, which describes the existence of subsurface geological structures in the Penantian geothermal area.

Keywords— Anomaly, geothermal, magnetic, structure.

I. Introduction

The research area is located in the Penantian village, Pasema Air Keruh Subdistrict, Empat Lawang District, South Sumatra. Geothermal manifestations such as hot springs, streaming ground and hot mud. They are located at 3°53'5" to 3°53'8, 2" South Latitude and 102° 47'45" to 102°47'47" East Longitude.

In general, the formation of the study area is shown in Figure 1. Formation consists of two main groups: the group is represented by Bengkulu Basin which is product of volcanism activity Barisan Mountains, that exist in Oligocene - Miocene to the Quaternary Period. Then the rock of South Sumatra Basin is represented by Gumai Formation as the product of exposure system passive margin sediments into the Fluvial, Deltaic to shallow marine.

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Stratigraphic sequence from old to young research areas are as follows: Hulusimpang andesitic-basaltic lava altered unit, Gumai sandstone unit, andesite intrusion and Quaternary volcanic andesite lava unit [1].

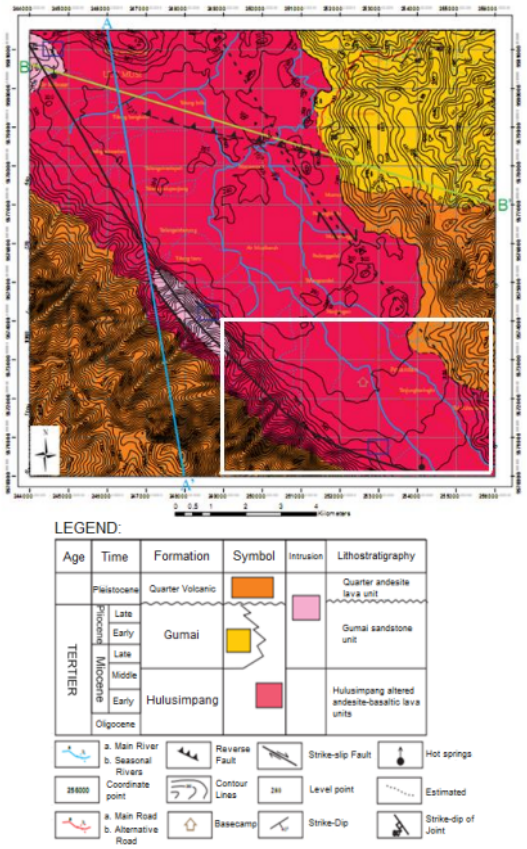

Figure 1. Pasema Air Keruh Geological Map. White box indicates magnetic survey area [1].

The geothermal manifestations are controlled by the fault as heat medium fluid flow to the surface. Area manifestation is near to Sumatra Fault System and Musi-Keruh Fault. However, whether these two major faults that control the presence of manifestations or minor faults that surround the two main fault is still not known.

One of the geophysical method that can explain the existence of faults in the subsurface is a magnetic method. This method is commonly used in geothermal exploration in determining weak zones / faults. In this zone, magnetic field anomaly value will be low, because the rocks has undergone demagnetization by hydrothermal alteration processes due to heat fluid from below the surface.

II. Basic Theory

Magnetic method in exploration of geothermal energy is used to study subsurface structures, alteration zones, the characteristics of the magnetic anomalies and the type of rock below the surface [2].

This method is basically used for the measurement of total magnetic field anomalies in the earth's surface by magnetic susceptibility contrast of rocks beneath the surface. By the contrast, it can be identified masses of igneous rocks that have a high concentration of magnetic minerals. Furthermore, the structure and rock formations below the surface can be determined. Suscepbilitas magnetic rocks are affected by a natural magnetic field, which is measured in nanotesla (1 gamma = 1 nT).

Susceptibility expressed as the level or degree of a magnetized object because of the influence of magnetic field, and is written as: [3]

$$k = \frac{M}{H} \quad (2.1)$$

Where k is the magnetic susceptibility, $\boldsymbol{H}$ is the earth magnetic field strength (Am^{-1}), and $\boldsymbol{M}$ is the magnetic intensity (Am^{-1}).

Magnetic anomaly is caused by the presence of local rocks that affect the earth's magnetic field. Local rock was dike, faults, folds, lava flows, massive intrusions, metamorphic rocks, and magnetite ore body. Illustration of normal earth's magnetic field and Earth's magnetic field is affected by magnetic anomalies can be seen in Figure 2 [4].

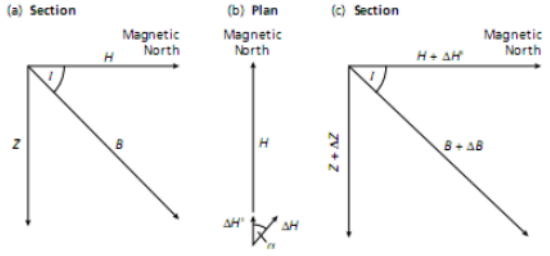

Figure 2. Vector representation of (a) normal earth's magnetic field (b) magnetic field (c) earth's magnetic field with superimposed magnetic by the anomaly [4].

The existence of magnetic anomalies caused total magnetic field vector $\boldsymbol{B}$ changes by $\Delta\boldsymbol{B}$, $\Delta\boldsymbol{Z}$ changes as the vertical component and a horizontal component changes by $\Delta\boldsymbol{H}$ '($\Delta\boldsymbol{H}$ projection to the horizontal component $\boldsymbol{H}$). Normal earth's magnetic field is given by equation (2.2) and the Earth's magnetic field is affected by the anomaly is given by equation (2.3):

$$\boldsymbol{B^2 = H^2 + Z^2} \quad (2.2)$$

$$\boldsymbol{\Delta B = \Delta Z \sin I + \Delta H \cos I \cos \alpha} \quad (2.3)$$

Where $\boldsymbol{I}$ is the angle of inclination of the earth's magnetic field.

III. Methodology

The first magnetic surveys carried out around the manifestation of the measurement points tighter around manifestations. The second, conducted by the pattern of spread in the Penantian village and surrounding. The area of the survey is about 6.5 km2, with 165 observation stations (Figure 1).

The measurement results corrected prior to the daily variation using Excel software to get the total value of the magnetic anomaly. Then, this value is plotted using Surfer software to get the contour patterns of total magnetic anomalies (Figure 2).

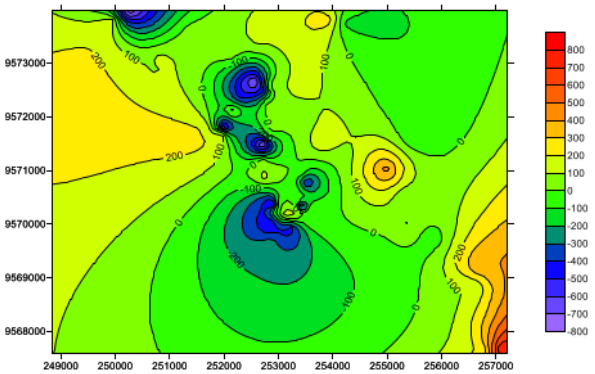

Figure 2. Total magnetic anomaly map of Penantian area.

The contour is transformed into a flat surface to eliminate the effects of topography, then reduced to the pole to eliminate the effect of a magnetic dipole. Furthermore, carried upward continuation to get regional magnetic anomalies (Figure 3).

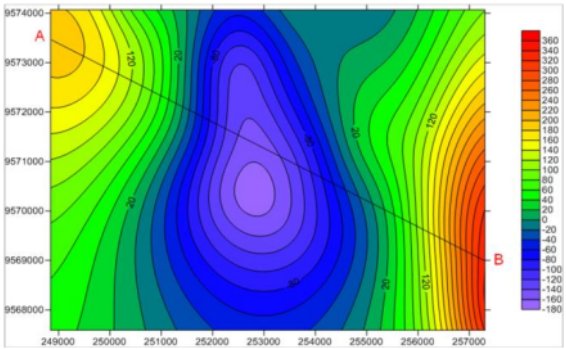

Figure 3. Regional magnetic anomaly map after carried upward continuation at an altitude of 1000 m above sea level. The line AB is the cross-section to be modeled.

Based on the contours of the regional magnetic field anomalies, can be further interpreted the presence and position of faults beneath the surface through 2-D modeling by using Mag2dc software.

IV. Discussion

From 2-D modeling has been conducted (Figure 4), it can be seen that there are two faults that surround the Penantian village. Then there are two rock formations with different susceptibility values, ie $k = 0.02$ and 0.0196.

Based on the local geology map, the value of $k = 0.02$ is a unit of andesitic lava of the Quaternary volcanic rock formations, while the value of $k = 0.0196$ is a unit of altered andesitic-basaltic lava of Hulusimpang rock formations. Meanwhile, the two faults identified above as Sumatra Fault Fault System and Musi-Keruh Fault.

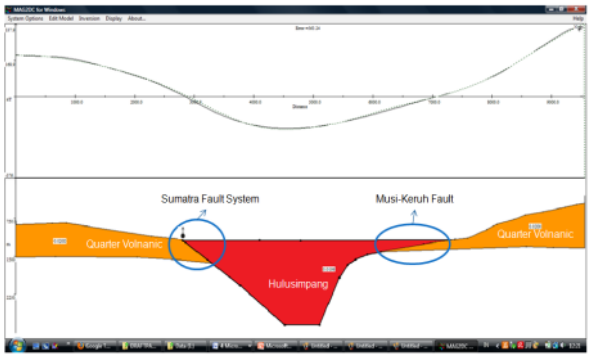

Figure 4. The result of 2-D modeling of AB section (Fig. 3). The value of $k = 0.02$ is a unit of andesitic lava of the Quaternary volcanic rock formations, while the value of $k = 0.0196$ is a unit of altered andesitic-basaltic lava of Hulusimpang rock formations.

According to the location and position of geothermal manifestations on geological maps, it can be estimated that the Sumatra Fault System is a fault that controls the existence of Penantian geothermal manifestations.

V. Conclusion

Sumatra Fault System is a fault that act as hot fluid migration path to the surface in the area of Penantian geothermal manifestations. Magnetic susceptibility values of Hulusimpang and Quarter Volcanic rock formations, respectively are is k = 0.0196 and 0.02.

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