Identification of Magnetic Anomaly at Geothermal Subsurface Area PLTP Sarulla Unit I Pahae Jae, North Sumatera, Indonesia

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Identification of Magnetic Anomaly at Geothermal Subsurface Area PLTP Sarulla Unit I Pahae Jae, North Sumatera, Indonesia

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Abstract. This research was done entitled Identification of Magnetic Anomalies at Geothermal Subsurface Area at PLTP Sarulla Unit I Pahae Jae, North Tapanuli. This research was conducted to find out the dispersion pattern of earth magnetic anomaly based on its magnetism and to know the rock structure based on susceptibility value in the geothermal area. The measurements of Total magnetic field using *Proton Precission Magnetometer* (PPM) Elsec 770 type, Global Position System (GPS) for positioning and geological compass for north direction orientation. The data were collected randomly with the number of points obtained as much as 50 measuring point, then data analysis was done by using surfer 11 to get contour map and Mag2DCfor windows maps to get the magnetic anomaly cross section. The results showed that the magnetic anomaly value had the lowest value of 34,4358 nT and the highest value 144,789 nT moving from North toward East. While the results of quantitative interpretation of A'A model show sedimentary rock with k value (0.0035 x 103, 00059 x 103, 00061 x 103), and esite lava with k value (0.0277 x 103, 0.0241 x 103) and basalt with k value (0.2437 x 103).

Keywords: *Magnetic method, GPS, Magnetic Anomaly, Susceptibility*

1. Introduction

Increasing of population makes the need for energy resources in Indonesia both in the community and industry field will also increase. Currently, the utilization of renewable energy and friendly for environment becomes very important; it is because decreasing of the availability of oil and gas energy sources in Indonesia.

One of the most potential energy to be utilized as an alternative energy is geothermal from an energy source which is friendly for environment contained in the heat of the Earth [1,2,3,4]. Heat energy comes to the surface will be collected in the earth crust which is composed of various types of rocks which has different melting point. Rocks that can not stand with high temperatures from earth's core will melt and become liquids called magma[5]. This energy is directly derived from a terrestrial heat source that is essentially endless under the earth's crust and does not depend on direct solar energy[6]. Temperature under the earth crust which relatively thin could reach 1300^0 C [7].

Sumatra Island is the province with the most geothermal potential of 1,857.00 MW located in six districts of Karo, Simalungun, North Tapanuli, South Tapanuli, Padang Lawas and Mandailing Natal [8]. One of the existing geothermal energy developments in North Sumatra is Sarulla geothermal (330 MW) located in North Tapanuli District,Pahae Jae Subdistrict, located in Silangkitang Village and Namora Village. Geographically this subdistrict is in position 10 20'- 20 41 'North Latitude and 980 05'- 990 16' East longitude which is an area with potential for promisingNatural Resources. This area is interesting for exploration, to see rock type beneath its surface.

In conducting geothermal exploration primarily to determine the geothermal area distribution and identify the anomalous type at subsurface geothermal area, Geomagnet Method can be utilized. This method utilizes the earth magnetic characteristics, based on the measurement of geomagnetic anomalies caused by differences in the susceptibility or magnetic permeability of surrounding areas [9].

Based on the description of some research above, the researcher is interested for doing research in PLTP Sarullaarea by using Geomagnet Method to identify some physical characteristics of subsurface geothermal area. In addition, this study was conducted because there has never been a researcher doing the research in this area. So by using geomagnet method, it is expected to provide more complete information for further researchers in the field of geothermal exploration of geothermal manifestation of PLTP Sarulla.

2. Research Method

2.1 Tools

In Identification of Magnetic Anomalies at Geothermal Subsurface Area, total magnetic field measurements at 50 point measurements were randomized and repeated three times using the Proton Precission Magnetometer (PPM) instrument type Elsec 770, positioning using Global Position System (GPS) and determination north orientation using geological compass.

2.2 Geomagnetic Data Analysis

The magnitude of the magnetic field measured at each station is essentially the contribution of the earth's main magnetic field, the outer magnetic field and the anomalous magnetic field. To obtain the anomalous magnetic field strength generated by the rock beneath each surface measurement point, it is necessary to make corrections to the main magnetic field and the external magnetic field measured by PPM. Corrections made include [10]:

1. Daily Correction

Correction is done to eliminate the effect of external magnetic field on the price of measurement result. This correction is made if there is a difference in the measurement of the earth's magnetic field at the base with the survey area. The price of such deviation is obtained by the interpolation equation as follows:

$$I_f = \left[\frac{t_f - t_1}{t_2 - t_1}\right] x\ (I_2 - I_1) \qquad (2.1)$$

The above equation is the measurement between t1 and t2 to I1 and I2. As for the daily correction is:

$$T_{vh} = I_1 \pm I_f \qquad (2.2)$$

2. Topographic Correction

Topographic correction is a correction performed to eliminatethe magnetic field effect generated by the magnetized hills towards the field price of observations. If the topography is considered not magnetized, then what is done is only the height correction, with reference to the vertical gradient price of the earth's magnetic field, namely: for the polar region around γ / m and for the equatorial region around γ / m.

Note :
where 1 γ = 1 nanotesla.

Because the research was done in aquator area, so the topographic correction is:

$$T_T = T_{vh} - (\Delta h * 0{,}015\,\gamma) \quad (2.3)$$

3. IGRF Correction

The main magnetic value is none other than the IGRF value. IGRF correction can be done by subtracting the IGRF value against the daily corrected total magnetic field value at each measurement point based on its geographic position. Correction equations are as follows:

$$\Delta H = H_{obs} \pm \Delta H_{harian} - H_0 \quad (2.4)$$

4. Anomaly Spreading Pattern

The magnetic field anomaly is the deviation of the average value of the earth's magnetic field, which is caused by the magnetic minerals found on earth surface. Daily correction data and IGRF correction are called earth magnetic field anomalies on topography, written on the following equation:

$$\Delta T = T_T - T_{IGRF} \quad (2.5)$$

And the anomaly spreading pattern will be shown incontour map by surfer 11 computer program.

5. Magnetic Susceptibility

Rocks susceptibility magnetic is a fundamental physical parameter in magnetic investigation, since it is a measure of the ability of a rock to receive magnetization from the Earth's magnetic field. To obtain a clear picture of the magnetism properties encountered in the study area, magnetic susceptibility measurements were made at each measurement point. Using the following equation [11]:

$$k = \frac{\vec{I}}{H} \quad (2.6)$$

6. *Interpretation*

In general, the interpretation of geomagnetic data is divided into two, namely the qualitative and quantitative interpretation. The qualitative interpretation is based on the magnetic field anomaly contour pattern derived from geomagnetic objects distribution or geological structures at earth subsurface by using surfer software 11. Quantitative data interpretation begins by making an incision profile on the anomaly magnetic field contour map. This incision profile can be interpreted directly to estimate the location based on existing geological information. Interpretation is not done directly by processing the profile of this incision with Mag2DC Software, but by creates a subsurface model that is adjusted with existing geological information. This quantitative interpretation creates additional information of the rock susceptibility value at the research location.

3. Result and Discussion

3.1 Magnetic EarthAnomaly Spreading Pattern

The magnetic field anomaly obtained from the calculation results is shown in the form of anomaly contour map by using surfer software 11. Based on the anomaly value and 3d map mensi anomalyobtained from each measurement, the pattern of spreading anomalies of the area can be seen in Figure 1 below.

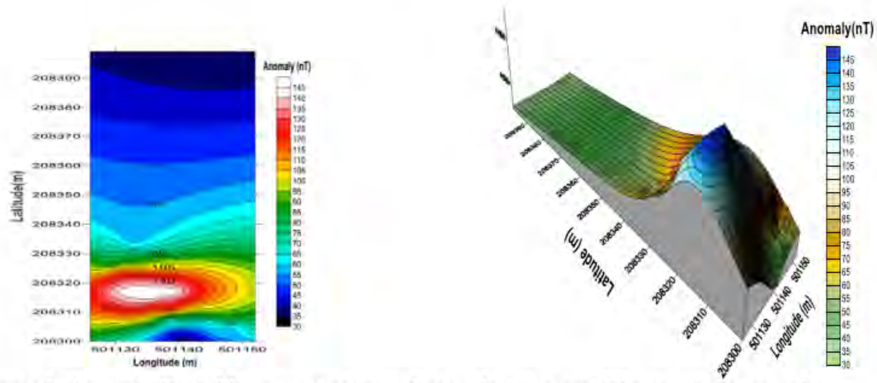

Figure 1. Anomaly Earth Magnetic contour at Survey location and 3d map mensi anomaly

Figure 1. It can be seen that the color difference is a magnetic intensity value that ranges from 30 nT to a minimum value of up to 145 nT for maximum value, the minimum value pattern tends toward the North. The magnetic anomaly values in the study area can be grouped into three groups of anomalies: low magnetic anomalies with values of 30 - 65 nT, medium magnetic anomalies with values of 60- 110 nT, and high magnetic anomalies with values more than 115 nT.

Based on the three groups of magnetic field anomaly values, research location is dominated by low magnetic field anomaly values which is scattered in Central longitudinal research area from North to East, West and South, medium magnetic anomalies scattered in Central research area, and high magnetic anomalies scattered in Central research area.

3.2 Rocks Susceptibility of Research Location

Based on susceptibility value from each measurement, so rocks susceptibility at the location and 3d map mensi Susceptibilitycan be seen in Figure 2 as follows:

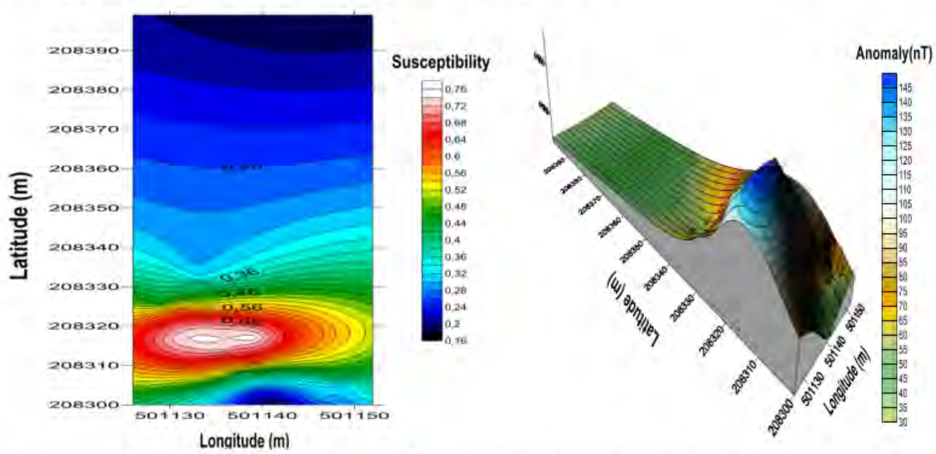

Figure 2. Susceptibility Contour Map at Research Locationand 3d map mensi Susceptibility

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From the calculation of susceptibility value, it is obtained that research area has susceptibility value from the lowest to the highest value, it is: 0,178617332 x 10^3 to 0,751016484 x 10^3 . The susceptibility which is obtained will be used to know the rock types at subsurface research location.

3.3 Magnetic Anomaly Model

Quantitative interpretation is needed to describe the subsurface structure of data measurement. Quantitative interpretation aims to determine the lithology of the research area. Interpretation is done to create a geomagnetic sectional model using Mag2DC software. In numerical modeling some geometric magnetic field parameters of the research location are required including IGRF value (41837.1 nT), declination angle (-0.2582 °), inclination angle (-13.0164 °), and some modeling parameters.

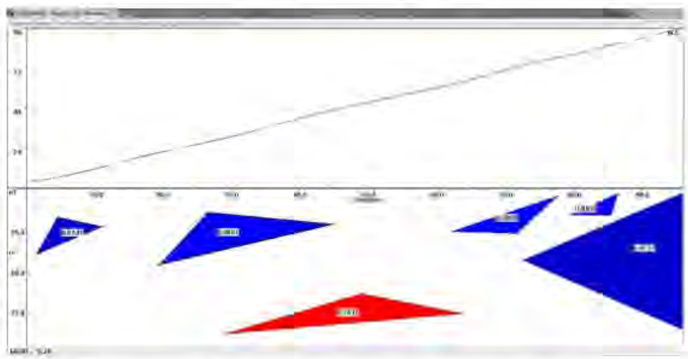

Figure3. Geomagnetic Sectional Model by using *softwareMag2DC*

Figure 3 shows the AA cross-sectional model, where are the x-axis denotes the length of the latitude, the positive y-axis represents the strenght value of magnetic anomally, field and the negative y-axis represent depth. The magnetic modeling results using the mag2dc software, so the anomaly body and magnetic susceptibility value are clearly illustrated. Where the magneticsusceptibility(k) is enough varied on its each body.

Top layer with value k = 0.0035 x 103 SI, 0.0059 x 103 SI, 0.0061 x 103 SI at depth ± 5 up to ± 40 meters. This body layer is defined as a type of pyroclastic species including sedimentary rocks from volcanic eruptions. The second layer consists of a body having k = 0.0277 x 103 SI, 0.0241 x 103 SI at a depth of ± 8 up to ± 85 meters, geologically this layer is identified as andesite lava rock which is a volcanic eruption product. This layer is a rock cap zone (supporters) that serves as a barrier to the loss of geothermal steam. While the third layer consists of a body with a value of k = 0.2437 x 103 SI at a depth of ± 65 to ± 90 meters, geologically this layer is identified as basalt rock.

The geomagnetic sectional value at (figure 3) is linked to rock type susceptibility values table by Thelfrod where the andesite rock susceptibility (0,0100-0,0500) and geological data of the research area to determine the subsurface rock structure. The value of the andesite's magnetic susceptibility is at 0.0200 -0.0400 [12].

4. Conclusion

1. The magnetic anomaly value in the survey area ranges from: 34.4358 nT at coordinates 501132 N and 208300 E to 144.789 nT at coordinates 501139 N and 208317 E, the magnetic field anomalies is caused by contact between several rock types in the research location.

2. Based on the susceptibility value obtained, the types of rocks found in this study area are sedimentary rocks with k values (0.0035 x 103, 0.0059 x 103, 0.0061 x 103), andesite lava with k values (0.0277 x 103, 0.0241 x 103) and basalt with the value of k (0.2437 x 103).

Suggestions

1. Further research should be conducted by expanding the data retrieval area, so that the spread of rock types can be seen both on the surface and below the surface.
2. 3D modeling should be done to get a picture below the surface of the research area in more detail.
3. This research can be continued with geophysical methods such as, gravity, geo electricity and others, as supporting components to obtain better results in interpretation.

References

[1] Axelsson, G., Stefansson, V., (2003), *"Sustainable Management of Geothermal Resources." International*

[2] Calvin, W. M., Coolbaugh, M., Kratt, C., Vaughan, R. G., Calvin, W. (2005), *Application Of Remote Sensing Technology To Geothermal Exploration. Nevada,* Us: Geological Survey Of Nevada; 1083–1089.

[3] Kunkel, T., Ghomshei, M & Ellis, R., (2012), *Geothermal Energy As An Indigenous Alternative Energysource In British Columbia.*Journal Of Ecosystems And Management 13(2):1–16.Lillesand, T.M., Dan F.W.

[4] Jina, T., Zahra, Z., Ali, H., (2015), Ultilization Of Geothermal Energy For Industrial Use In The World. Journal Of Applied And Basic Sciences. Vol. 9 (11): 2060-2064.

[5] Barbier, E. (2002), *Geothermal Energy Technology And Current Status: An Overview. Renewable And*

[6] Kolar, J.L. (2000), *Alternative Energy Technologies. Environmental Quality Management* 10(2):45–54.

[7] Ghomshei, M.M. (2010). *Canadian Geothermal Power Prospects. World Geothermal Congress 2010.* Bali,Indonesia

[8] Gunawan, H, (2013), Potensi panas Bumi di Samosir Siap Dilelang, *Tribunnews:* http://tribunnews.com accesed on14 November 2017.

[9] Broto, S., T. T, Putranto, (2011), *Aplikasi Metode Geomagnet Dalam Eksplorasi Panas Bumi.* Undip: Semarang.

[10] Tampubolon, T., Hutahean, J., Siregar, S., (2017), *Subsurface Structure Determination of Geotermal Area in Siogung-ogung Samosir District by Using Magnetic Method,* IOP Conf. Series: Journal of Physics: Conf. Series 970(2018) 012002.

[11] Awaliyatun, F. Z, (2015), *Penentuan Struktur Bawah Permukaan Tanah Daerah Potensi Panas Bumi Dengan Metode Geomagnet di Tinggi Raja Kabupaten Simalungun,* Skripsi, Fmipa, Universitas Negeri Medan (UNIMED), Medan.

[12] Lita, F., (2012), *Identifikasi Anomali Magnetik Di Daerah Prospek Panas bumi Arjuna-Welirang,* Skripsi, Fmipa, Universitas Indonesia (Ui), Depok.

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