Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol.6, No.6, 2016
www.iiste.org

Geothermal Fluid Determination and Geothermal Stones Mineral Identification at Geothermal Area Tinggi Raja Simalungun, North Sumatera, Indonesia using 2d Resistivity Imaging

Muhammad Kadri Rahmatsyah Togi Tampubolon
Physics Department, State University of Medan

Abstract

This reserach is done to determine the geothermal fluid flows beneath the ground by using 2D resistivity imaging and to identify the stones that compile the mineral by using XRD at geothermal Area Tinggi Raja Dolok Morawa Simalungun, North Sumatera Province. The area is located at 02º36'- 03º18' N and 98º32'- 99º35' E. The results from XRD by using difractometer Jeol-350 Shimadzu 6100 Show that the intensity from x ray difraction has the geothermal fluid spreads laterally to the geothermal manifestation. Three lines were surveyed by using 2d resistivity imaging for geothermal delineation purpose. At Tinggi Raja, the 2d resistivity imaging survey site shows the existence of geothermal fluid flows. The maximum depth of investigations for the surveys is 25 - 30 meters and 155 m of length of each line. The array used in this study are Schlumberger. In general the results show that the subsurface is made up of limestone (resistivity value of less 100 ohm-m) and clay with resistivity also less than 100 ohm-m in all the sections. XRD survey shows the mean mineral that compile the getothermal stones at Tinggi Raja are calsit ($CaCO_3$) with trigonal crystal system (hexagonal). This mineral is the mean mineral that compile the clay.

Keywords: resistivity method, XRD, clay and limestone

I. BACKGROUND

Energy is an absolute necessity that is needed in human life. The availability of the energy gives a large influences on the progress of development in this world. The more Increasing of human activity and also the demand of energy the more energy consumption. The most energy consumption in the wolrd especially in Indonesia is from fossil fuels. It makes the fossil is dwindling. makes the government saves fuel and energy continue to look for alternative energy sources to re-fulfill the growing need. One-air sum expected energy as an alternative energy is geothermal energy.

Geothermal energy is the energy that is located in the fluid and stones beneath of the earth surface. The potential of geothermal energy in Indonesia is reach almost 40% from the geothermal energy in the world or it is reach 28.000 MWe. But the use of geothermal energy for electricity energy only 3% from the total geothermal energy in Indonesia. It is caused the location of the geothermal energy is very relatively difficult to reach.

One of the potential location of geothermal energy is in Simalungun district. Simalungun is located between 02º36'-03º18' N and 98º32'-99º35' E and it is covered 4.386,60 km^2.

Based on geological map, Simalungun has potential geothermal energy area at Dolok Tinggi raja conservation. In order to to determine the potential geothermal area in Simalungun and to identify the stones that compile the mineral of geothermal 2d resistivity imaging and XRD are utililized.

The configuration array used in this survey is Schlumberger array. Schlumberger array is the common array that can be used to investigate the structure of layer beneath the earth surface especially to investigate the geothermal prospect areas. For the result of 2D Resistivity, the data is processing by using RES2DINV program in order to obtain a 2Dl cross-sectional model of the subsurface along the path where the resistance value types are distinguished by different colour. The accurate way to identify the mineral rocks that compiled geothermal stones by using the X-ray diffraction analysis (X-ray diffraction). XRD analysis is a method that can provide information about the types of minerals present in a rock. XRD results data is then analyzed to determine the characteristics of each mineral, mineral percentages, and the level of mineral crystallinity

II. RESEARCH METODOLGY

The research is done at Tinggi Raja conservation area, Dolok Morawa village, at Simalungun District. The reasearch is done for two weeks from 19 until 30 of June 2014.

Electrical Imaging system is now mainly carried out with a multi-electrode resistivity meter system.

Each survey use a line of 41 electrodes laid out in a straight line with a constant spacing. A computer controlled system is then used to automatically select the active electrodes for each measure. Throughout the survey conducted in the proposed site, the Schlumberger array have been used with the ABEM SAS 4000 system.

In this survey the 2D resistivity array is Schlumberger array, we need to move the two potential electrodes to obtain readings. This can significantly reduce the time required to acquire a sound. Because the electrode potential remains at a fixed location, the effects of near-surface lateral variations in custody deducted (Loke, 2004).

By applying the Schlumberger array (Figure 1) showed better resolution in the near surface layer. However, because of the potential electrode spacing smaller than the current electrode spacing, to a large current electrode spacing is very sensitive voltmeter is required. A location where the top layer is very non-homogeneous is not suitable for the central array. As a result, interpretations based on DC Soundings will be limited to simple, horizontally layered structure (Loke, 2004).

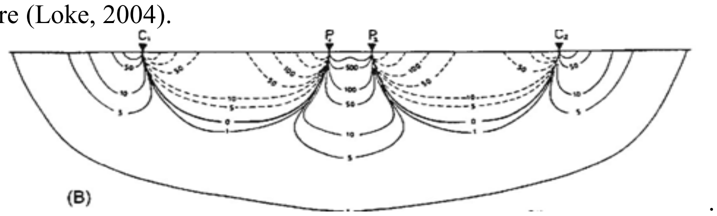

Figure 1. Schlumberger array sensitivity pattern plot

For XRD analysis, the samples were tested at static state. Data results of X-ray radiation in the form of a diffraction spectrum. X-rays detected by the detector is then recorded by a computer in the form of a graph of peak intensity, which further analyzed the distance between crystal lattice planes and compared with Bragg law on a computer using certain software in order to generate the data. The process of data interpretation is done by identifying the peaks of the XRD chart by matching the existing peak on the graph with the ICDD database. So that, refinement on the XRD data using the Match program. Through the refinement, content, and their phase structure and lattice parameters that exist in the sample is known.

III. RESULT AND DISCUSSION

III.1. Resistivity result

The length of line 1 is 155 meters. The maximum depth of investigations for the surveys is 30 meters. The location of the survey is shown in figure 2. A spacing of 5 meters using the Shclumberger array was used on the survey. The total length of the survey lines is 465 meters. In general the results show that the subsurface is made up of silt (resistivity value between 100 - 140 Ωm) and sandstones with resistivity from 100 to 600 Ωm. The high resistivity values of more than 600 Ωm near the surface is due limestone.

Based on the geological map sheet the area of Tinggi Raja, generally the location of research consists of limestone and has a fault.

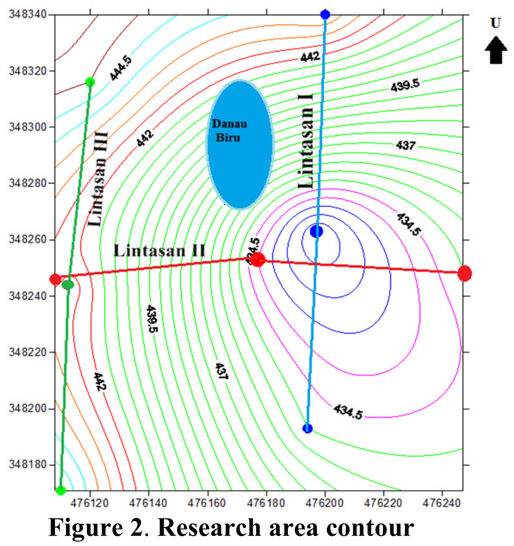

Figure 2. **Research area contour**

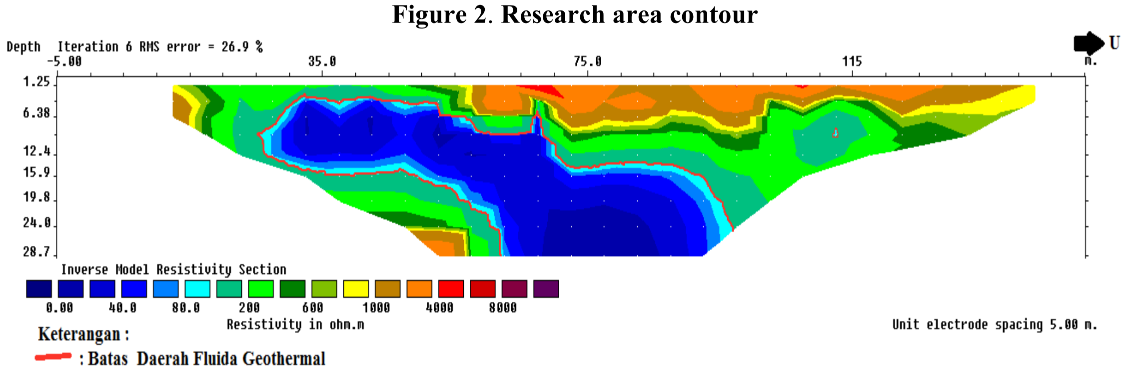

Figure 3. Resistivity section of line 1

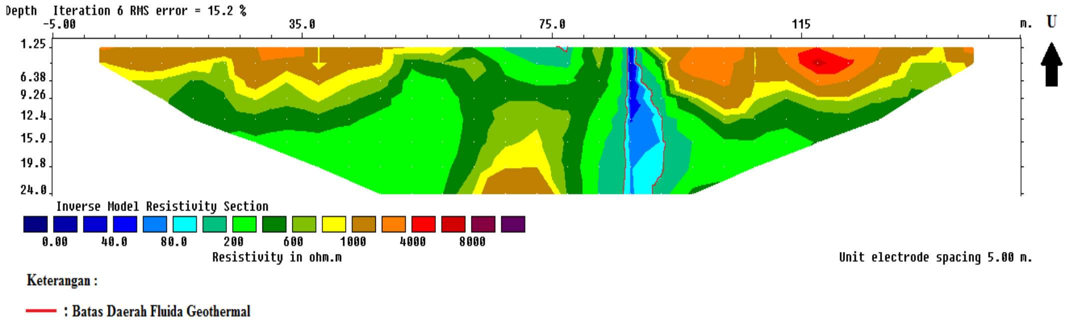

Figure 4. Resistivity section of line 2

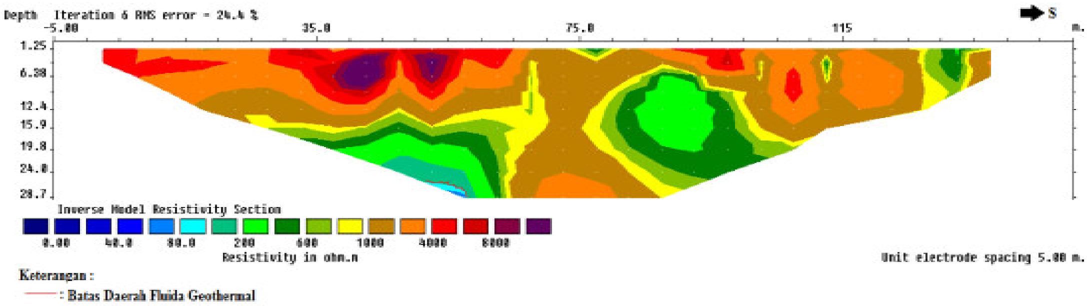

Figure 5.. Resistivity section of line 3

Generally the result of line 1 is dominating by the value of resistivity more than 600 Ωm.it can be interpreted as limestone.

For line 1 (Figure 3), the result shows the value of resistivity from 9.09 to 80 Ωm at the depth of 2.5 to 28.7 in the distance 25-92 m and 112-113 m, it can be interpreted as clay. At the depth depth of 1.25 to 28.7 m in the distance of 22 to 102.5 m the resistivity value from 140 – 200 Ωm. It can be interpreted as silt. at a depth of 1.25 to 2.87 m in the distance of 17 -137 m the resistivity value is from 106 to 600 Ωm it can be interpreted as sandstone. The value of resistivity is more than 600 Ωm is interpreted as limestone that lies at a depth of 1.28 to 28.7 m and the distance of between 7.5 to 144 m.

For line 2 (Figure 4), the result shows the value of resistivity from 7,89-80 Ωm at the depth of 1.25 to 24 in the distance 87-99 m, it can be interpreted as clay. At the depth depth of 1.25 to 24 m in the distance of 67 to 79 m and 83 – 97.5 m the resistivity value from 200 – 600 Ωm. It can be interpreted as sand. At a depth of 1.28 to 28 m in the distance of 2.5 -143 m the resistivity value is more than 600 Ωm it can be interpreted as limestone.

For line 3 (Figure 5), the result shows the value of resistivity from 40 to 80 Ωm at the depth of 26.35 to 28.7 in the distance 52 -59 m it can be interpreted as clay. At the depth depth of 20.85 to 28.7 m in the distance of 45 to 60 m the resistivity value from 140 – 200 Ωm. It can be interpreted as silt. at a depth of 1.25 to 2.87 m in the distance of 33-64 m and 76 – 79 m and 130 -135 m the resistivity value is from 200 to 600 Ωm it can be interpreted as sandstone. The value of resistivity is more than 600 Ωm is interpreted as limestone that lies at a depth of 1.28 to 28.7 m and the distance of between 3 to 138 m.

The contours of all the lines were analyzed using surfer8 (Figure 6). The Measurement points as much as 3 trajectory illustrates by the distribution of rock below the surface of the depth of 5m, 10m, 15m, 20m, 25m. Based on the figure 8, the deeper under the surface, the smaller the value of resistivity of rocks. So it can be interpreted to the greater spread of fluid to the subsurface.

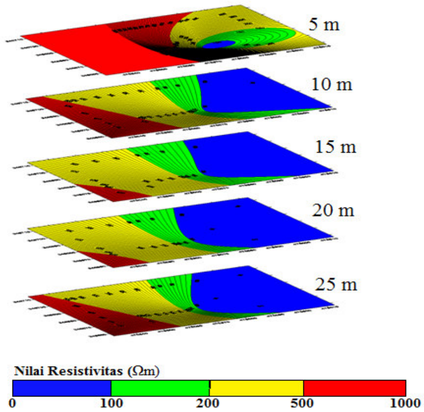

Figure 6. Depth Contour

III.2. XRD RESULT

- **SAMPLE A**

  The result of X ray diffraction patern using MATCH program shows in Figure 7.

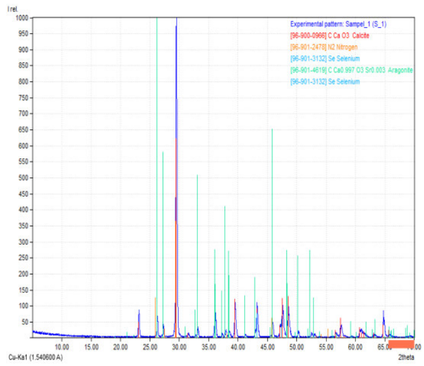

Figure 7. Difraktogram of Sample A

Analysis of the content of the mineral phase in sample A showed that the rock sample A is a crystalline material with the main content of calcite ($CaCO3$) and has a trigonal crystal system (hexagonal), the crystal size of a = 3.9670 Å AC = 17.0610. Mineral Calcite ($CaCO3$) has the highest peak in a row at an angle $2\theta = 29{,}51^{o}$; $47.58\ ^{o}$; $48.58\ ^{o}$, the intensity of (i) 621; 95.8; 89.0, Nitrogen (N_2) has the highest peak at an angle 2θ = 363.8 $29{,}51^{o}$ and Selenium at an angle 2θ = 47.32 58.2.

- **Sample B**

  The result of X ray difraction pattern for sample B using *Match* program can be shown in Figure 8.

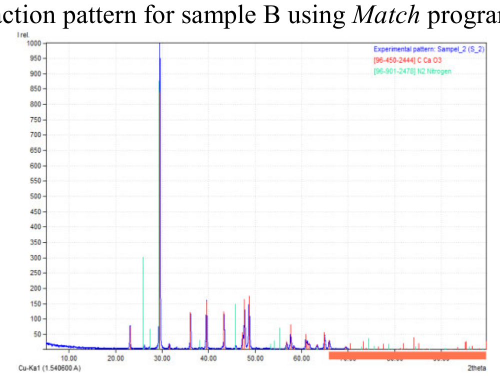

Figure 8. Difraktogram of Sample B

Analysis of the content of the mineral phase in sample B showed that the rock sample A is a crystalline material with the main content of calcite ($CaCO3$) and has a trigonal crystal system (hexagonal), the crystal size of a = 4.9758 Åc = 16.9921 Å. Mineral Calcite ($CaCO3$) has the highest peak in a row at an angle $2\theta = 29{,}51^{o}$; 39,55; ^{o} 48,70 the intensity of (i) 840,0 ; 158,3 ;156,6, Nitrogen (N_2) has the highest peak at an angle $2\theta = 29{,}51^{o}$ with the intensity 875,9. The number of the weight (%) of the mineral composition is shown in table 1.

Table 1. the composition of research result

Sample	Mineral content	weight (%)
A	calcit ($CaCO_3$)	59.5
	Nitrogen (N_2)	39.3
	Selenium (Se)	1.1
B	calcit ($CaCO_3$)	84.0
	Nitrogen (N_2)	16.0

Based on table 1, it is known that the composition of mineral stone of Tinggi Raja area is dominated by Calcite ($CaCO_3$). It is supporting the data from 2D resistivity imaging that the resistivity value of the survey area is dominated by limestone ($CaCO_3$) with resitivity value is more than 600 Ωm especially in the top soil area.

IV. CONCLUSION

From the study it can be concluded that the distribution patterns of geothermal fluid in the study area is spread laterally, leading to a geothermal manifestation. where the clay layer as conductive zone with resistivity value between 9.09 to 80 Ωm in the line 1, 7.89 to 80 Ωm in line 2 and 40-80 Ωm in line 3 . While the cover layer in line 3 is limestone with resistivity value is more 600 Ωm.

The main mineral constituent geothermal rocks in Tinggi Raja area is calcite (CaCO3) with a trigonal crystal system (hexagonal). Mineral is a major constituent mineral limestone.

It can be concluded also that the survey area of Tinggi Raja Simalungun North Sumatera Indonesia is very potential to more explored the geothermal resources energy.

V. SUGGESTION

From the research that has been obtained, the suggestions for further research are expanding research area to see the pattern of spread of the geothermal fluid in more detail using geophysical methods such as geomagnetic methods to corroborate the information about the pattern of spread of geothermal fluid in the area.

VI. ACKNOWLEGMENT

We appreciate the support from State University of Medan for the facilities and the geophysics instruments. We would also like to appreciate our laboratory members and the students of physics department, State University of Medan for the generous help.

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