Geothermal Fluid Identification at Geothermal Area Sorik Marapi using 2d Resistivity Imaging

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Abstract. This research is done to determine the geothermal fluid flows by using 2D resistivity imaging and to identify the stones that compile the mineral by using XRD at geothermal Area Sorik Marapi, North Sumatera Province. The area is located at 99º32'.050'' E - 0º41'193' N to 99º32.861'' E - 0º41'214'N. The results from XRD by using difractometer Jeol-350 Shimadzu 6100 Show that the intensity from x ray diffraction has the geothermal fluid spreads laterally to the geothermal manifestation. Four lines were surveyed by using 2d resistivity imaging for geothermal delineation purpose. The 2d resistivity imaging survey site shows the existence of geothermal fluid flows. The maximum depth of investigations for the surveys is 31,3 meters and 155 m of length of each line. The array used in this study are Wenner-Schlumberger. In general the results show that all the subsurface is made up of limestone (resistivity value of less than 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 get otheral stones at Sorik Marapi are Quartz (O2Si) and magnesium (Mg). This mineral is the mean mineral that compile the clay.

Keywords: resistivity method, XRD, Quartz (O2Si) and magnesium (Mg).

1. Introduction

Indonesia's geothermal energy potential which reaches 40 percent is the largest in the world. However, in terms of geothermal energy development, Indonesia is still ranked third after the United States and the Philippines (Christina, 2013). Considering that geothermal energy in Indonesia has quite a large potential, exploration is needed to maximize development and utilization.

Sumatra Island is one of the major islands in Indonesia which has considerable geothermal potential. On this island there are 84 geothermal locations with a total estimated geothermal energy of around 13,419 MWe (Status of Geothermal Potential in 2006).

Globally the availability of geothermal energy in Indonesia is associated with magmatic and volcanic regions as a source of heat. The Indonesian archipelago that located on a volcanic path is very potential area for geothermal energy formation. Along the west coast of Sumatra Island continues to south of Java, then to Bali and Nusa Tenggara, then turns north towards Sulawesi Island, Maluku Islands and the Philippines. The formation of volcanic arcs is the basis for the large geothermal potential contained in Indonesia. One of the potential area for geothermal resources in Sumatra is Sorik Marapi (99º32'.050'' E - 0º41'193' N to 99º32.861'' E - 0º41'214'N).

Based on geological map, Penen has potential geothermal energy. In order to determine the potential geothermal area in Simalungun and to identify the stones that compile the mineral of geothermal 2d resistivity imaging and geomanet are utilized.
2. Research Metodology
The research is done at Sorik Marapi. 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).

For XRD analysis, the samples were tested at static state (Rajagukguk et al. 2016). 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.

3. Result And Discussion

3.1. Resistivity results
The Resistivity configuration used is the Wenner Schlumberger configuration. The Resistivity research carried out in the Sorik Marapi area used 4 passes (Figure 2) with coordinate as shown in table 1.
Table 1. coordinate line of resistivity

| Line | electrode | E      | N      |
|------|-----------|--------|--------|
| Line 1 | first     | 99°32'35.67" | 0°44'38.84" |
|       | last      | 99°32'40.67" | 0°44'38.58" |
| Line 2 | First     | 99°32'36.17" | 0°44'38.24" |
|       | last      | 99°32'36.31" | 0°44'43.30" |
| Line 3 | first     | 99°32'39.92" | 0°44'37.89" |
|       | last      | 99°32'40.02" | 0°44'42.92" |
| Line 4 | first     | 99°32'35.44" | 0°44'42.77" |
|       | last      | 99°32'40.45" | 0°44'42.72" |

The length of the cable for line 1, 2, 3 and 4 is 155 meters, with the electrode spacing of 5 meters. The total electrodes are 32 electrodes. Data collection was carried out by spreading the cable along 155 meters where the cable starts from the point where the Resistivity device is placed. The tool used is a set of Multichannel and multielectrode resistivity Ip meters.

Figure 3. Line 1 of Sorik Marapi area

Figure 4. Line 1 of Sorik Marapi area

Line 3
The lines 1, 2, 3 and 4 shown in Figures 3, 4, 5 and 6 in this area show the inversion result of the Wenner Schlumberger configuration very low resistivity. In fact, all the results on this one line show that in general this area has a resistance of less than 100 Ωm. It should be assumed that this area is the distribution of hot water.

In general, all resistivity lines in the geothermal potential area in Sorik Merapi show low resistance values, namely between 0 ohm.m to 70 ohm.m. This indicates that this area is very likely an alluvium area that stores hot water. This water comes from a reservoir located below the surface which then appears on the surface. This is what then becomes the manifestation of hot springs in this area.

3.2. XRD Result
The sedimentary rock samples were tested using XRD Shimadzu 6100. Rock samples were taken from the research area in Aek Balerang, Roburan Dolok Village, Sorik Marapi. Rock samples were ground before the XRD test was carried out as shown in the figure 7.

From the test results using X-ray diffraction and data processing using Match software obtained images in graphical form and the output data in the table below.
Table 2. X-ray diffraction test data

| Chemical Formula | Mineral Name | Entry number   | Quant (weight %) |
|------------------|--------------|----------------|-----------------|
| O₂Si             | Quartz       | 96-901-0146    | 53.0            |
| Mg               | Magnesium    | 94-154-5543    | 37.7            |

Based on table 2 it is known that the rock mineral composition of the geothermal area of SorikMarapi, data collection point, is dominated by Quartz (O₂Si) and magnesium (Mg).

Table 3. XRD Test Results

| Peak No. | Angle 2θ | d (Å) | Intensity (I/I₀) |
|----------|----------|-------|------------------|
| 1        | 10,426   | 8.4783| 91               |
| 2        | 19,538   | 4.5399| 34               |
| 3        | 20,560   | 4.3164| 46               |
| 4        | 20,786   | 4.2699| 152              |
| 5        | 21,891   | 4.0569| 83               |
| 6        | 23,562   | 3.7727| 95               |
| 7        | 24,160   | 3.6808| 36               |
| 8        | 24,340   | 3.6539| 68               |
| 9        | 25,584   | 3.4790| 36               |
| 10       | 26,260   | 3.3909| 69               |
| 11       | 26,556   | 3.3538| 1022             |
| 12       | 26,840   | 3.3190| 45               |
| 13       | 27,061   | 3.2923| 41               |
| 14       | 27,320   | 3.2618| 55               |
| 15       | 27,684   | 3.2197| 439              |
| 16       | 27,940   | 3.1908| 145              |
| 17       | 28,260   | 3.1554| 77               |
| 18       | 28,460   | 3.1337| 116              |
| 19       | 29,634   | 3.0121| 57               |
| 20       | 30,268   | 2.9504| 68               |
| 21       | 31,348   | 2.8513| 50               |
| 22       | 32,913   | 2.7192| 75               |
| 23       | 35,408   | 2.5331| 135              |
| 24       | 36,432   | 2.4642| 36               |
| 25       | 38,489   | 2.3370| 50               |
| 26       | 39,317   | 2.2897| 47               |
| 27       | 42,120   | 2.1436| 41               |
| 28       | 42,300   | 2.1349| 42               |
| 29       | 45,580   | 1.9886| 33               |
| 30       | 45,470   | 1.9820| 31               |
| 31       | 50,032   | 1.8216| 77               |
| 32       | 54,783   | 1.6743| 73               |
| 33       | 59,836   | 1.5444| 65               |
| 34       | 64,633   | 1.4409| 35               |
| 35       | 67,730   | 1.3823| 56               |
| 36       | 68,063   | 1.3764| 84               |

From the table data above, research results are obtained such as the graph in Figure 5.30 below.
Table 3 and graph Figure 8 can be concluded that there are 6 of the 36 peaks containing the highest peak at the 11th peak with an intensity of 1022 in the corner of 26.5560.

Analysis of the mineral phase content obtained from rock samples shows that the rock is a crystalline material with mainly quartz (O2Si) and magnesium content. The quartz crystal system is trigonal (hexagonal axes) with a crystal size of 9,65267 Å. Mineral quartz has the highest peaks at an angle of $2\theta = 26.620$; 20,840; 50,080 intensity (i) 891.6; 177.4; 101.5. Magnesium mineral has the highest peak at an angle of $2\theta = 27,980$; 45,580; 30,300 intensity (i) 275,1; 116.0; 91.9.

From the results obtained, it is stated that the rock studied using xrd has a content consisting of quartz (O2Si) and magnesium.

4. 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.

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