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Mapping of rock resistivity value using geoelectrical method Schlumberger configuration in Solok Regency, West Sumatera

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Abstract: Mapping of rock resistivity value is useful for knowing the potential of the natural wealth contained in the earth. Investigation of resistivity value in Solok Regency is using 3 lines. The first line is at S 00055'0.7 "and E 100040'56.8" coordinates, the second line is located at S 00054'53.2 "and E 100041'00.9" coordinates, and the third line is coordinated by S 00055'20.5 "and E 100041'01.8". The method of mapping is using the Geoelectric method with Schlumberger Configuration and the Ares (Apparent Resistivity) tool. The data obtained is processed by using Res2Dinv software to be analyzed and interpreted. The results obtained on the first line have resistivity value of 3.95-641 Ωm which is interpreted by having a rock structure consisting of Groundwater, Clay, Dry Clay, Basalt and Andesite. Next on the second line, the resistivity values of 2.53-1560.5 Ωm are obtained consisting of layers of rock Groundwater, Clay, Dry Clay, Basalt, and Andesite. Finally on the third line have resistivity value about 6.85-113.5 Ωm having a Groundwater, Tuff, Sandstone, Clay, Dry Clay, Basalt, Andesite, and Lava rock structure. The Tuff rock layer is estimated as a geothermal reservoir because its resistivity value is 20.8-23.6 Ωm surrounded by more contrasting rock layers and is located between two solid rock layers.

Keywords: resistivity, geoelectrical method, Schlumberger Configuration

1. Introduction

The mapping of rock resistivity is the first step to know the rock structure in an area. The mapping is purpose to get information about the potential wealth of natural resources. Solok Regency is one of regency in West Sumatera and has not been known the rock structure, so that it can't be done the exploration of its natural resources. On the early survey the hot spring is founded on Lembang Jaya Distric. The Solok Regency that is indicated to have geothermal source energy. According to the local community, hot springs come from Talang Mountain. The mountain is still active and it is estimated to have geothermal energy resource. Conceptually, the geothermal model can be seen on Figure 1.

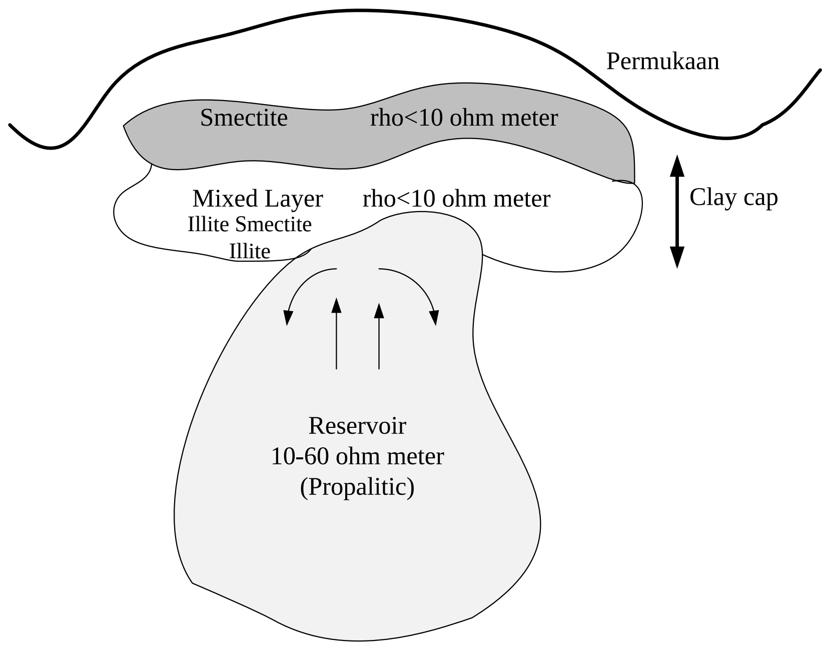

Figure 1. Conceptual model of geothermal (E.Ariani and W. Srigutomo, 2016)

The Figure 1 describe the formation of geothermal. The overburden layer has high resistivity value. Then, underneath is followed by smectite layer has low resistivity value < 10 Ωm. Next, illite smectite layer or mixed layer has low resistivity value 10 Ωm. There layer is called by clay cap and there is propylitic alteration layer under the clay cap that is geothermal reservoir layer. The layer has resistivity value about 10-60 Ωm (Pellerin, 1996).

Eysteinsson on his research said that the resistivity geothermal value in out active volcanic area is about 1-5 Ωm (Eysteinsson, 1994). Haerudin is also said that the potential rocks as geothermal source were volcanic and Tufan stone. They have 24-62.2 Ωm resistivity value and depth of 20 m (Haerudin, 2008). Talang Mountain has volcanic and Tuf stone, so that is estimated to have geothermal energy and another mineral.

2. Research Methods

Geoelectrical method is one of geophysics method to describe subsurface layer (M.H.Z. Abidin et al, 2010). Using this method, we can learn resistivity variation laterally and vertically (Tsepav, Mattew Tersoo, and Umar Mohammed Alhahi, 2016). This method utilize electricity of stone (Santoso, 2002). Every layers can be predicted its depth and thickness in subsurfaces. So, it will make easy to interprete this layer (A. Octova, A.S. Muji, M. Raeis, dan R.R Putra, 2019). Some scientist was using this method to investigate groundwater (G.R. Lashkaripour, 2003), and to explore geothermal reservoir distribution (Rahmi Hidayati, Sesri Santurima, Akmam, 2011). The work principle geoelectrical method is by doing injection an electric current inject to earth (Uros Stepisnik, 2008).

This research was using Schlumberger configuration. It is because the method could do far current penetration and could describe resistivity distribution model simply (Ugwu et al, 2016). This method was using 2 current electrode and 2 potential electrode with space potential electrode smaller than current electrode.

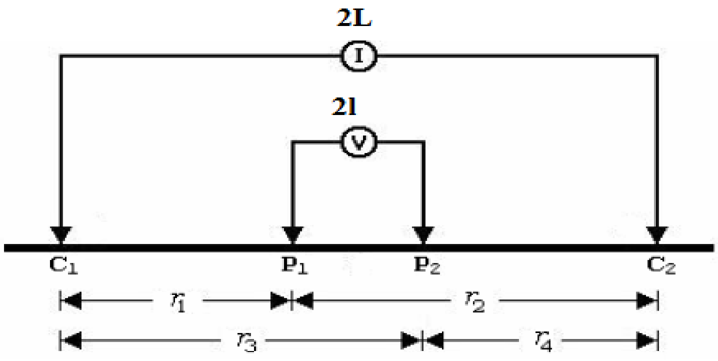

Figure 2. Schlumberger configuration (Teti, 2008)

Apparent resistivity value is determined by equation:

$$\rho_a = \frac{\Delta V}{I} K \quad (1)$$

With K is geometry factor that has value:

$$K = \left[\left(\frac{1}{r_1} - \frac{1}{r_2} \right) - \left(\frac{1}{r_3} - \frac{1}{r_4} \right) \right]^{-1} \quad (2)$$

2.1. Location

Lembang Jaya District, Solok Regency is a place for getting data. Survey use 3 lines. Based on geological map of Solok Regency, this area is compossed by Andesit, Basalt, Breccia, and it is estimated to have energy resource. Then Sediment and Malihan as Gamping, Sabak, and Filit stone are estimated to have mineral resource potential.

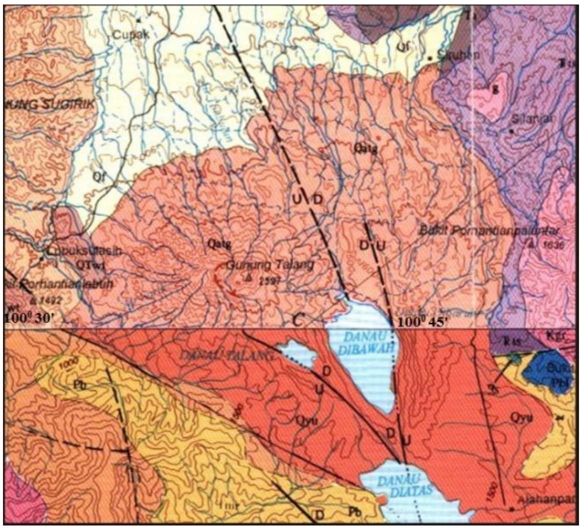

Figure 3. Geological map of Solok Regency (Kastowo, 1995)

Based on the Figure 3 the area is in around Talang Mountain is arranged Qatg stones that consist of Breccia stone, lava deposits, and Lapili that is included on Basalt and Andesite. The Basalt has resistivity value about 10- 1.3 x 10^7 Ωm, while the Andesite has resistivity value about 4.5 x 10^4- 1.7 x 10^2 Ωm (Telford, 2004). Another stone is Qtwt that fused Tuf, Qtau is volcanic, Ta is Andesite and Basalt, ect (Kastowo, 1995).

2.2. Tolls

Apparent Resistivity (Ares) was used to this research. It worked automatically and reached up to 155 m. Meanwhile manually, it could be used up to unlimited depend on ours cable. Principle of Ares took a data and saved automatically. Then data could be downloaded and was done to process by using Res2DInv software. The result gave the different colour on resistivity value. The last did to compare to geological map and get to image in each layer in subsurface.

3. Results

The research has been carried out by collecting data current, potential, apparent resitivity and standard deviation to each lines. The first line had length 155 m. The distribution of resistivity value was about 3.95- 641 Ωm. The depth was until 33.1 meter.

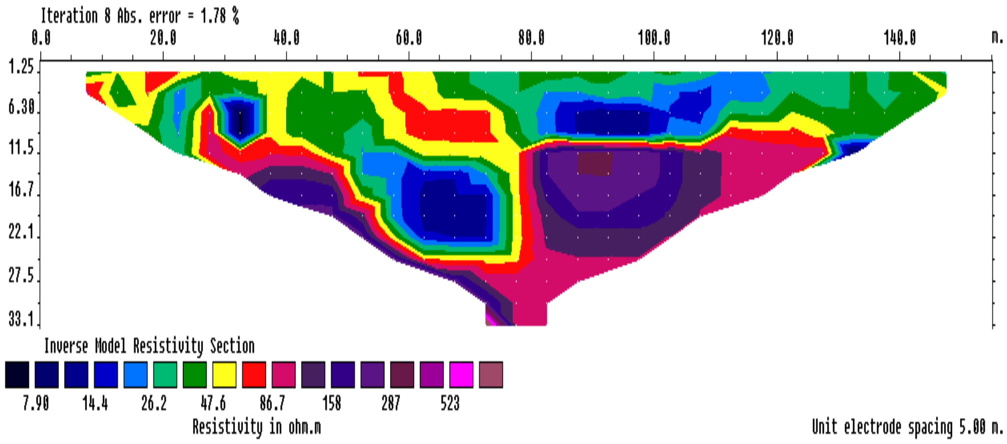

Figure 4. Distribution resistivity value section one

Based on Fig 4, we can make to category with colour and see Table 1:

Table 1. Apparent resistivity value, depth, thicknes, and rock type

Colour	Resistivity Value	Depth	Thickness	Rock Type
■■■■■	<26,2 Ωm	1,25-8,9 m 3,78-10,2 m 11,5-24,8 m	7,65 m 6,42 m 13,3 m	*Groundwater*
■■■	26,2-67,15 Ωm	Spread		*Clay*
■	67,15-86,7 Ωm	Spread		*Dry clay*
■■■■■	86,7-276 Ωm	11,5-24,8 m	13,3 m	Basalt
■■■	276-641 Ωm	30,3-33,1 m	2,8 m	Andesite

The resulted analyse and interprete from the section one is having the rock structure such as (1)The Groundwater has resistivity value about <26.2 Ωm at depth 1.25 meter until 24.8 meter with varies of thicknesses 6.42 meter until 13.3 meter, (2) The Clay has resistivity value 26.2- 67.15 Ωm with spread position, (3) The Dry Clay has resistivity value 67.15- 86 Ωm with spread position too, (4) The Basalt has resistivity value about 86.7- 276 Ωm at depth 11.5- 24.8 meter with thicknesses 13.3 meter, (5) The Andesite has resistivity value 276- 641 Ωm at depth 30.3 until 33.1 meter with thicknesses 2.8 meter.

Then, section two has length 440 m and depth 78.7 meter with resistivity value range 24.3- 1560.5 Ωm.

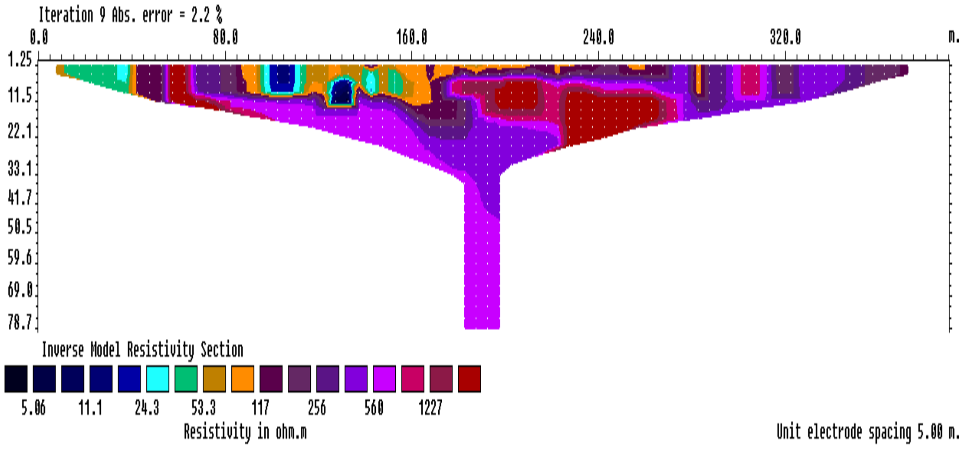

Figure 5. Distribution resistivity value section two

The grouping of type rock for section two:

Table 2. Resistivity value, depth, thickness, and type of rock to section two

Colour	Resistivity Value	Depth	Thickness	Rock Type
	<24.3 Ωm	1.25-8.93 meter	7.68 meter	*Groundwater*
	24.3-53.3 Ωm	Spread		*Clay*
	53.3-58.5 Ωm	Spread		*Dry Clay*
	58.5-280 Ωm	Spread		Basalt
	280-1560.5 Ωm	6.37-78.7 m and spread	21.23 m	Andesite

Based on the Table 2, we could estimated the rock type are (1) The Groundwater has resistivity value about <24.3 Ωm with depth 1.25- 8.93 meter and thicknesses 7.98 meter, (2) The Clay has resistivity value 24.3- 53.3 Ωm spread along the surface, (3) The Dry Clay has resistivity value 53.3- 58.5 Ωm and spread along surface too, (4) The Basalt has resistivity value about 58.5 -280 Ωm and spread in some point in layer, (5) The Andesite has resistivity value 280-1560.5 Ωm and spread until the depth 78.7 meter.

The last section, data has been taken automatically and manually with length 550 meter and the depth until 109.5 meter. The variation of resistivity value is about 20.8-113.5 Ωm. The Figure 6 is the section three:

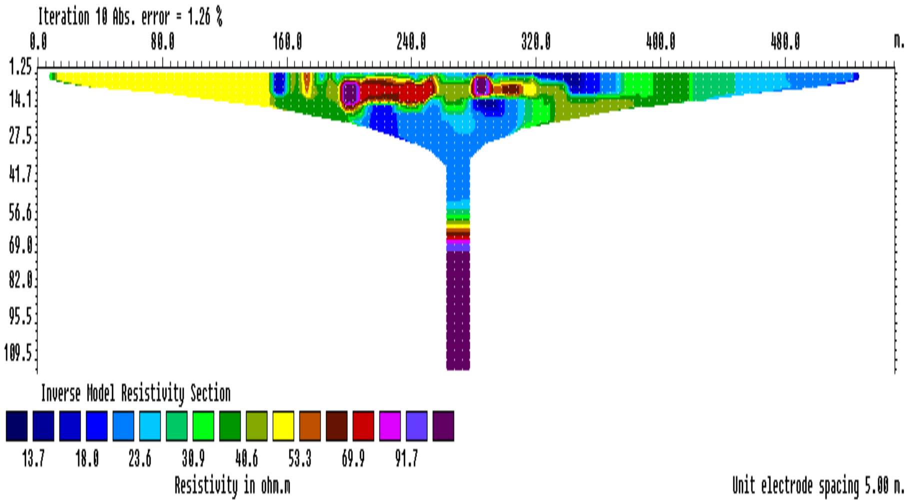

Figure 6. Distribution resistivity value section three

Based on the colour resistivity value, we can make some category for rock type:

Table 3. Resistivity value, depth, thickness, and type of rock the section three

Colour	Resistivity Value	Depth	Thickness	Rock Type
	<20,8 Ωm	1,25-8,9 meter	7,65 meter	*Groundwater*
	20,8-23,6 Ωm	8,9-50,64 meter	41,74 meter	*Tuff*
	23,6-27,25 Ωm	8,5-53,62 meter	45,12	*Sandstone*
	27,25-53,3 Ωm	53,62-56,6 meter dan menyebar	2,98 meter	*Clay*
	53,3-80,8 Ωm	56,6-59,08 meter	2,48 meter	*Dry Clay*
	80,8-91,7 Ωm	59,08-64,04 meter	4,96 meter	Basalt
	91,7-102,6 Ωm	64,04-69 meter	4,96 meter	Andesite
	102,6-113,5 Ωm	69-109,5 meter	40,5 meter	Lava

The section three is estimated to have of rock type are (1) The Groundwater has resistivity value <20.8 Ωm at the depth 1.25- 8.9 meter with thicknesses 7.65 meter, (2) The Tuff has resistivity value 20.8- 23.6 Ωm at the depth 8.9- 50.04 meter and thicknesses 41.74 meter, (3) The Sandstone has resistivity value 23.6- 27.25 Ωm at the depth 8.5- 53.62 meter and thicknesses 45.12 meter, (4) The Dry Clay has resistivity value 53.3- 80.8 Ωm at the depth 56.6- 59.08 meter and thicknesses 2.48 meter, (5) The Basalt has resistivity value 80.8- 91.7 Ωm the location is 59.08-64.04 meter and thicknesses 4.96 meter, (6) The Andesit has resistivity value about 91.7- 102.6 Ωm at the depth 64.04- 69 meter and thicknesses 4.96 meter, (7) The Lava stone has resistivity value 102.6- 113.5 Ωm at the depth 69- 109.5 meter dan thicknesses 40.5 meter.

The Tuff layer is estimated as geothermal reservoir source because it is located between the two the solid rock that are Basalt and Andesite. The founded support by Onodera's research that geothermal reservoir rock has resistivity value 20- 70 Ωm (Mardiana, 2007) and based on Haerudin's research resistivity geothermal value is about 24- 62.2 Ωm at the depth >20 meter (Haerudin, 2008)

4. Conclusion

Based on the results, we can make conclusion that the first line have the rock structure Groundwater, Clay Cap, Dry Clay, Basalt and Andesite, the second line have Groundwater, Clay, Dry Clay, Basalt, Andesite, and the third line have variation resistivity value with the rock type are Groundwater, Tuff, Sandstone, Clay, Dry Clay, Basalt, Andesite, and Lava. The Tuff stone is estimated as geothermal reservoir rock with resistivity value 20.8- 23.6 Ωm. It is located between two of rock solid.

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