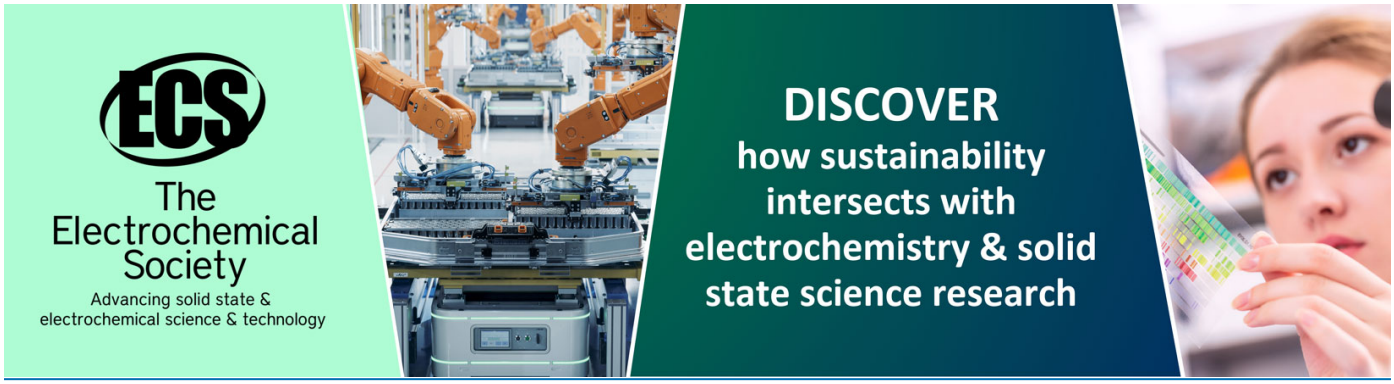
Identification of salty zone in Grabagan salt mine, Kradenan sub-district, Grobogan district, Central Java, Indonesia



Identification of salty zone in Grabagan salt mine, Kradenan sub-district, Grobogan district, Central Java, Indonesia

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Abstract. Grabagan Village is located to the southwest of Bledug Kuwu, the famous mud volcano in Central Java Province. In this area, there are surface manifestations such as mudflow and saltwater explosion. Mud volcano is a product of mountains that emit mud or clay onto the earth's surface.The aim of this research is to know the dispersion of salty zones in Grabagan mud volcano using 3D model. This research was done by geoelectric method using Sclumberger configuration with stretch of approximately 300 meters at 8 measurement points. Based on the resistivity value distribution, the research area is dominated by salty zone with resistivity values of 0.0851- 8.22 Ωm and at depth of 0.75-129 meters. The salty zone leads to the northeast direction. Two vertical columns were identified in southeast and southwest of the measured area.

1. Introduction

Mud volcano Grabagan is located in Grabagan Village, Kradenan Sub-District, Grobogan District, approximately 30 km from Purwodadi, and about 1 km away with Bledug Kuwu which is the largest mud volcano in the area. Mud volcano is result of migration of fluidized sediment along active faults due to overpressure [1]. Mud has compositions of various substances such as solids, liquids and gases that carrying out mud, sulfur, salt, and gaseous materials from inside forming vertical columns [2]. Based on the geological map of Ngawi sheet [3], the geological condition in the research area is dominated by alluvium formation. Alluvium formation is composed of clay, silt, sand and gravel.

The use of the resistivity method is particularly suitable because the sub-surface structure of mud volcano is consist of salt and hydrocarbon sources that have certain resistivity value. Salt is more easily flowing electric current because of its low resistivity value. In the other words, it is conductive. This conductive feature can be recognized as anomaly.

There are some resistivity methods, one of them is the geoelectric method. Geoelectric is one of the geophysical methods used to measure the potential difference response due to current injection to determine the nature of the subsurface rock flow. The principal of this method is injected electric current through two current electrodes, then measured the potential difference using two potential electrodes. From the results of this potential difference measurement can be used to determine the variation of the apparent resistivity value in the layer below the measurement point [4].

2. Experimental Methods

The research was conducted in mud volcano Grabagan Village, Kradenan Sub-District, Grobogan District. The study sites are in coordinate positions (07°06'51.66"- 07°07'03.87")S and (111°06'08.92"-111°06'17.41")E, as shown in the figure below:

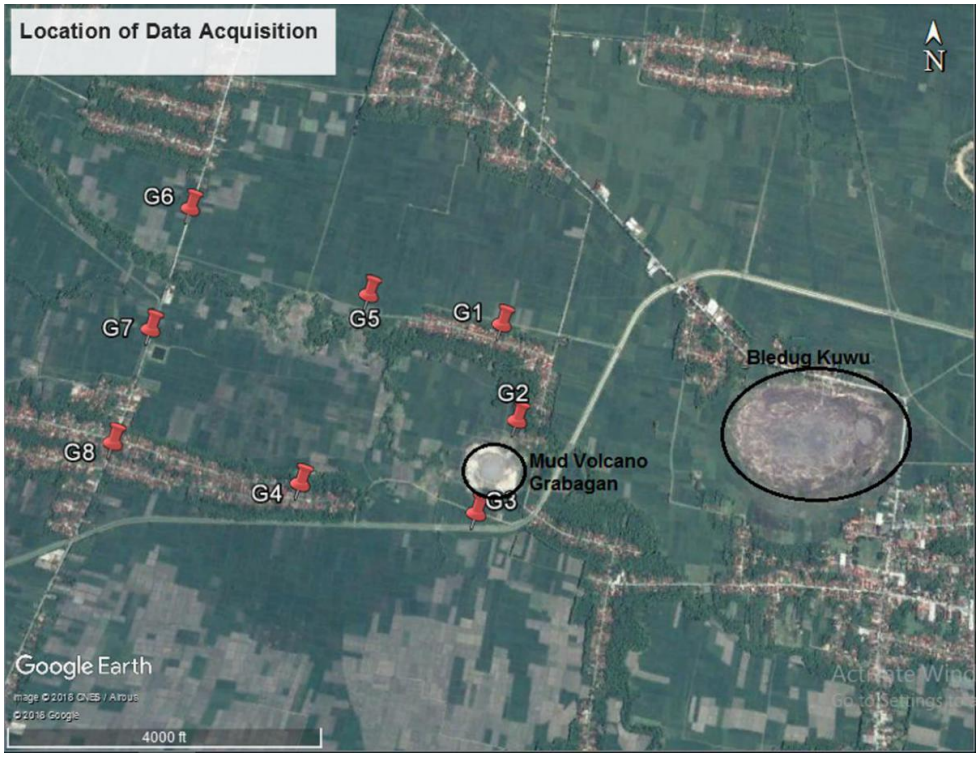

Figure 1. Location of data acquisition

The data acquisition was performed using the OYO McOHM El 2119C resistivitymeter at 8 measurement points. Each measurement point has its own line. The stretch used is 300 meters, but at the point G4 is used 400 meters.

The data acquisition using Schlumberger configuration. This configuration uses two current electrodes (C1 and C2) to inject the current and two potential electrodes (P1 and P2) to measure the potential difference[5]. The Schlumberger configuration is organized as shown below:

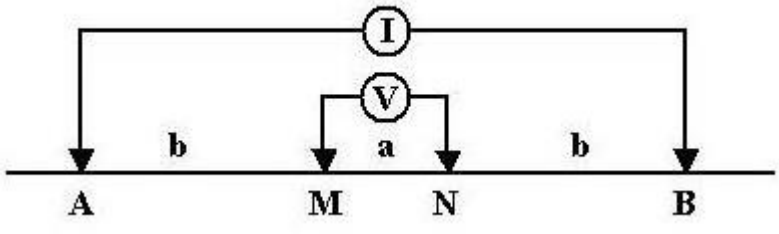

Figure 2. Schlumberger configuration of geoelectric methods

The potential difference between P1 (M) and P2 (N) can be written as follows:

$$\Delta V = \frac{I\rho}{2\pi}\left(\frac{1}{r1} - \frac{1}{r2} - \frac{1}{r3} + \frac{1}{r4}\right) \quad (1)$$

$$\text{If, } k = 2\pi\left(\frac{1}{r1} - \frac{1}{r2} - \frac{1}{r3} + \frac{1}{r4}\right)^{-1} \quad (2)$$

Then the equation can be written to be:

$$\rho = k\frac{\Delta V}{I} \quad (3)$$

The geometrical factor (k) for the Schlumberger configuration obtained the following equation:

$$k = \pi\left(\frac{a^2 - b^2}{2b}\right) \quad (4)$$

The output of the resistivitymeter will produce current value and potential differences, while geometry factor obtained according to equation (4). These three parameters are used to obtain the apparent resistivity value. Apparent resistivity value must be processed to obtain true resistivity value by matching curve using IP2WIN software. Matching curve is a process to match the observed curve with a calculated curve. The output of IP2WIN is used to be input on Rockwork15 software to be modeled in three dimensions.

3. Results and Discussion

Outputs from IP2WIN software are the layer thickness, layer depth, and true resistivity value of each sounding point. The result of one dimensional interpretation shows lithology of Grabagan mud volcano are salty mud with resistivity 0.0851 - 0.321 Ωm at depth between 3.74 - 33.1 meters, clay with resistivity between 0.566 - 4.42 Ωm and its depth ranges from 0.75 - 129 meters, clay sandstone with resistivity value 6.12 - 8.22 Ωm with depth between 1.23 - 84.5 meter, sand of clay with resistivity between 17.1 - 17.7 Ωm with depth between 2.5 - 43.4 meters, and sandstone with resistivity 24.6 - 62.2 Ωm at depths of 1.45 - 106 meters.

Sounding data is used as a three dimensional data processing input using Rockworks15 software, resulting in the picture below as follows:

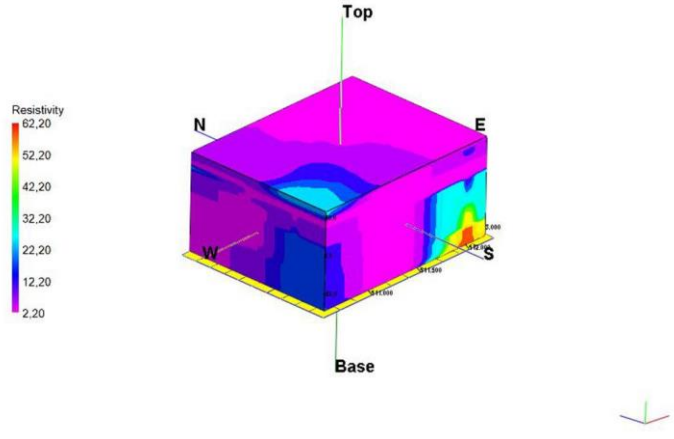

Figure 3. Three-dimensional processing results using Rockworks 15

Based on the interpolation of the sounding points that turn into a three-dimensional model, it shows that most of the measuring areas are salty zones. This zone consists of salty mud materials, clays and clay sandstones. This refers to the purple color having a resistivity value of 0.0851 - 8.22 Ωm. The dispersion of the salty zone is dominant in the middle area to the northeast, which leads to Bledug Kuwu, thus it makes presumption that there is a correlation between mud volcano Grabagan and Bledug Kuwu (see Figure 1). In Figure 4 we can see the 3D model without the salty zone, as follows:

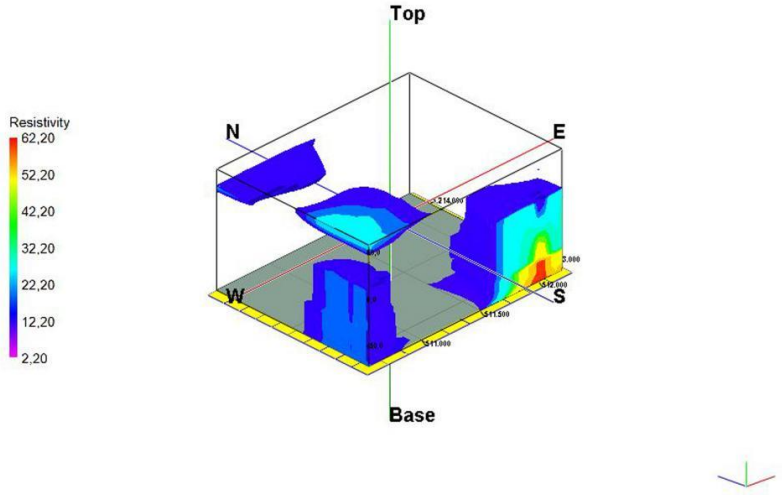

Figure 4. 3D processing results by filtering the salty zone

Based on the Figure 4, two vertical columns were identified in the measuring area. The first vertical column is in the southeast forming a mud volcano morphology-like pattern at a depth of 41.19 meters. This is because the southeast area (the point between G2 and G3) is an area beneath the surface of Grabagan mud volcano. The second vertical column is in the southwest with a pattern similar to that in the southeast at a depth of 46.4 meters, but only a small fraction. Both of these columns are suspected as a place of mud/shale eruption. The mud volcano morphology have some vents to emits any materials. Vertical column of the southeast area is suspected as main crater where salt infiltrated with the discharge of mud. While vertical column of the southwest area can be flank vent (secondary vent) or just another column which raises the notion of a location that emits salt water or mud. So it's need for further searches in the southwest area because we still have no idea whether there is correlation between those two columns or not.

4. Conclusion

In conclusion, salty zone dominates in the research area. This zone consists of salty mud, clay, and clay sandstone. This salty zone leads to the northeast which refers to Bledug Kuwu. So it is suspected there is still a correlation between Grabagan's mud volcano with Bledug Kuwu. A three-dimensional model indicates the presence of two vertical columns in the research area. In the southeast area, vertical column is suspected as main vent which salt appears along with mud as it is in Grabagan mud volcano. While in the southwest area is suspected as flank vent or just another column.

5. References

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