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Identification of Aquifer Layers Using Geoelectric Methods Based on Vertical Electrical Sounding (VES) in Dengkol Village

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Abstract. Dengkol Village, Malang Regency, East Java, is an area that is known to be difficult to get water sources or is a red zone for well drillers, because there are several excavation points that fail to get water. The depth of the existing well is close to 100m, dominated by hard rock, so drilling costs in this area are quite expensive. This research aims to determine the depth of the aquifer layer at the research location, so that it can be used as a reference in drilling wells at that location. This research was carried out using the geoelectric VES method with a schlumberger configuration and an electrode path length of 400 meters. The research results show that the subsurface lithology in Dengkol Village consists of clay rock, alluvium, tuff breccia at a depth of 0,7-4,24 m with rock resistivity value of 6892 Ωm and a depth of 30.5 – 46,3 m with a rock resistivity value of 521 Ωm, is a layer of hard rock. Sandstone rock at a depth of 46,3 – 167 m with a rock resistivity value of 3,95 Ωm is an aquifer layer.

Keywords: Aquifer Layer, Geoelectric, Vertical Electrical Sounding (Ves).

1. Introduction

Dengkol Village, Malang Regency, East Java, is an area that is known to be difficult to get water sources or is a red zone for well drillers, because there are several drilling points that have failed to get water. The depth of the existing well is close to 100m, so this research uses the geoelectric resistivity method with a measurement technique based on vertical electrical sounding so that the data obtained reaches that depth[1][2][3]. The geology of Malang district in its rock structure (stratigraphy) clearly shows clastic, epiclastic, pyroclastic and alluvium rocks, which are aged from the Early Pleistocene to the Recent. The research area is located in an area that has quaternary volcanic sedimentary rocks (Qvtm) or Malang tuff rock formations in the Solo Quaternary volcanic formation strip. The rocks that make it up are dominated by volcanic rocks, including: fine tuff, lapilli tuff, sandy tuff, pumice tuff and breccia. This is as shown in Figure 1.

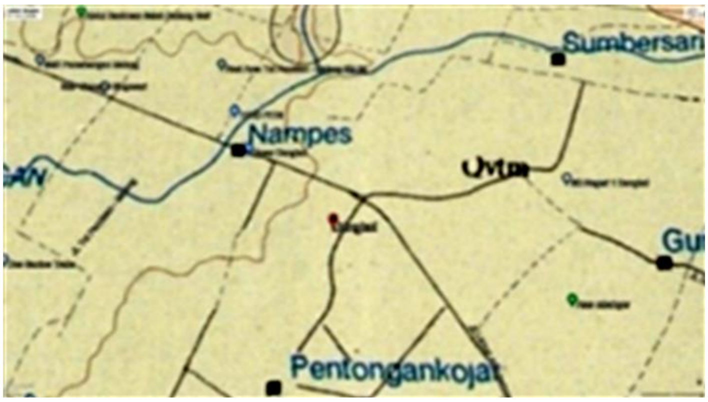

Figure 1. Map of research locations

There are two types of layers in the soil, namely the waterproof layer or what is known as the impermeable layer and also the non-waterproof layer or what can also be called the permeable layer. If groundwater can be used economically and its volume can meet human needs, then this condition is called an aquifer or water-bearing layer, whether in the form of rock, soil, or both. An aquifer is a permeable layer[4], such as sand, gravel, sandstone, or cracked limestone, which has the capacity to store and transmit large amounts of water[5][6]. Aquiclude, on the other hand, is a non-permeable or low-permeability layer such as clay, shale, fine tuff, or silt, which can hold water but does not drain it easily[7].

The geoelectric method is a method that can be used to study structures beneath the earth's surface that are sensitive to differences in rock resistivity. This method involves the flow of electric current through rocks below the surface, where the current flow is influenced by the conductivity properties of the rock and the presence of groundwater in the rock. As a result, the geoelectric method can be used to assess the condition of the underlying rock through resistivity analysis, which measures the ability of rock materials to conduct electricity. Therefore, the depth, thickness and distribution of water wells in the water-bearing layer can be determined using this method. The resistivity contrast in the aquifer layer can be determined using the geoelectric resistivity method [8][9][3]. So with this method the aquifer layer can be clearly identified. For this purpose, this research aims to determine the depth of the aquifer layer at the research location, so that it can be used as a reference in drilling wells at that location.

2. Material and Methods

The research location is in Lowok hamlet, Dengkol Singosari Village, Malang, with a stretch of track 400 m long. This research uses the geoelectric resistivity method with a measurement technique based on Vertical Electrical Sounding, a resistivity method that investigates vertical differences in the resistivity of rocks below the earth's surface. In this method, the distance between the electrodes is changed to measure the sounding point. Changes in electrode distance start from the smallest distance and gradually increase. The distance between electrodes is related to the depth of the rock layer detected. The electrode distance increases with increasing depth of the rock layer and vice versa. The location of the VES measurement points can be seen in Figure 2.

Figure 2. Research path length design

The data that has been obtained is processed using Ms. software. Excel to calculate apparent resistivity values. The resulting data is inverted and further processed in IP2Win software to obtain a 1D cross section. Then the data is processed using Rockworks software for 3D modeling.

Data processing uses IP2Win [10] and Rockwork software. The modeling results are then analyzed by grouping rocks based on rock resistivity values, then interpreted based on the geology of the research area. The rock resistivity values used as references can be seen in the table below:

Table 1. Rock Resistivity Values*

Rock	**Resistivitas (Ωm)**
Sandstone	1– 6.4 x 10^8
Sand	1 - 10^3
Marls	3– 70
Clay	1 – 100
Tuff	2 x 10^3 – 2 x 10^5
Lava	10^2 – 5 x 10^4
Alluvium	10 – 800
Breccia	75 – 200

* Telford, 1990

3. Result and Discussion

Based on the results of data processing using IP2WIN software, rock layering and resistivity information is produced as in Figure 3 below.

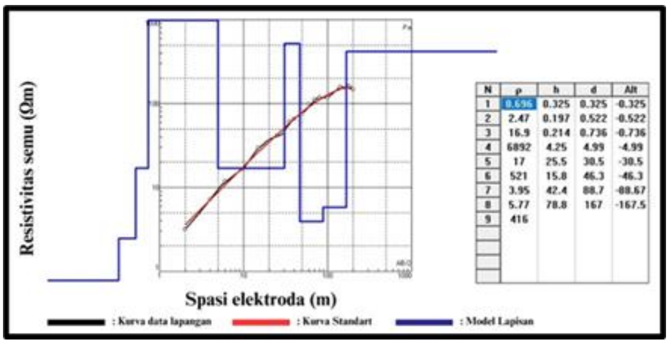

Figure 3. Data Processing Results

Based on Figure 3 above, it can be concluded that at the research location there are nine layers. An explanation of the rock resistivity values and rock depth can be shown in table 2 below.

Table 2. Rock Resistivity Values at the research location*

Track1 (Error: 7,34%)		
Depth(m)	**Resistivitas (Ωm)**	**Litologi**
0	0,696	Top Soil
0,325	2,47	Clay
0,522	16,9	Alluvium
0.736	6892	Breccia Tuff
4,99	17	Sand Tuff
30,5	521	Breccia Tuff
46,3	3,95	Sand
88,7	5,77	Sand
167	416	Breccia Tuff

*Self-supporting

Based on Table 2 above, it shows the results of resistivity measurements on Track 1 with an error of 7.34%. The results of data processing from IP2Win software are then processed further using Rockworks software to obtain a 3D model.

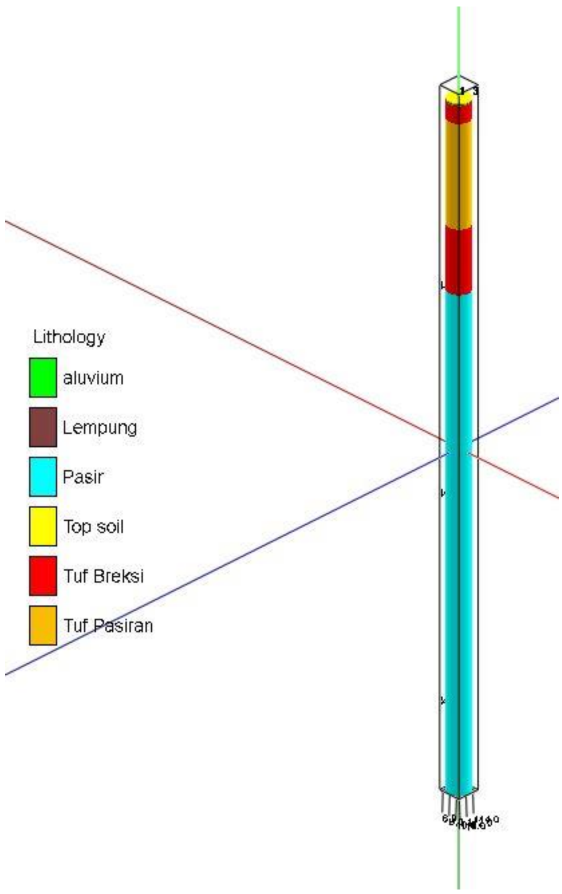

Figure 4. Cross-section of rock layers in 3D

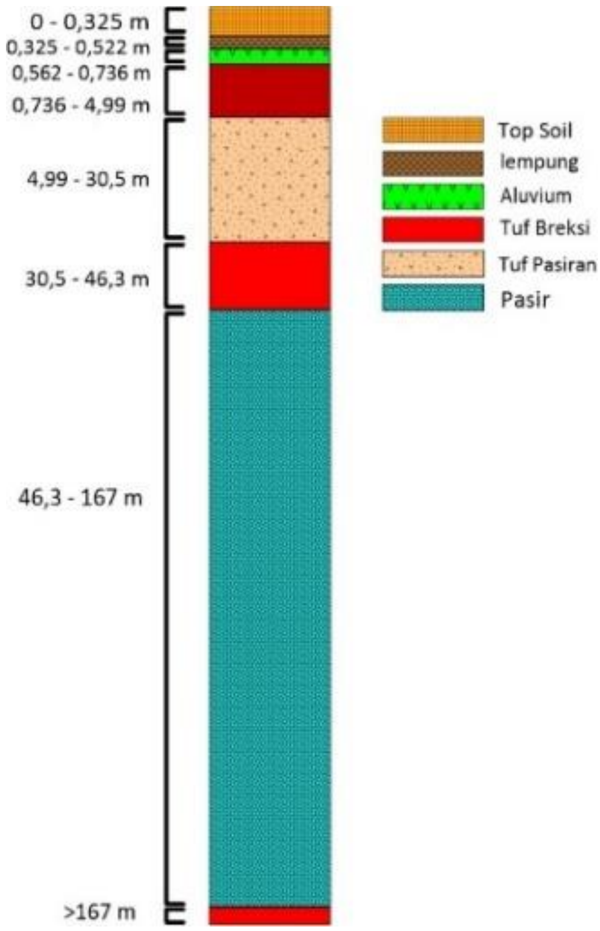

Figure 5. 2D cross-section of rock layers

Based on Figures 4 & 5 above, the research was conducted on a sugarcane plantation, where the soil here is alluvial soil. Alluvial soil itself is the result of alluvium deposits. Alluvium is a sediment deposit carried and deposited by river water. This alluvium is filled with various particles ranging from sand, fine gravel to clay and sandy rocks. Alluvium has high porosity and permeability properties, usually found on riverbanks or river deltas. This is in accordance with the results of data analysis on track 1 where measurements were taken through the River. Then at a depth of 0 m - 0.325 m, a resistivity of 0.696 Ωm indicates a topsoil layer. At a depth of 0.325 m-0.522 m, a rock resistivity of 2.47 Ωm indicates a clay layer. There is a hard layer of tuff breccia at a depth of 0.522 m - 0.736 m with a resistivity value of 6892 Ωm with a layer thickness of 4.2 m. Tuff breccia layer that has a resistivity value of 521 Ωm. This layer is at a depth of 30.5 - 46.3 m with a thickness of 15.8 m. Tuff breccia has coarse grains formed from cementation of coarse fragments. This tuff breccia is cloudy yellow, gray and brown, composed of andesite, sand to bomb grains, semi-rounded angles, has low permeability so that it is unable to store and drain water. At a depth of 46.3 - 167 m with a resistivity value of 3.95 Ωm - 5.77 Ωm as a sand layer and is an aquifer layer [11][12], where in figure 7 is marked in blue. The magnitude of the aquifer resistivity is 5-15 Ωm [13] and is a confined aquifer. Sand has large pores (porosity) and better water flow capacity (permeability)[14][15][16] compared to tuff and clay[17][18], so that the sand layer is considered an aquifer[19][20].

4. Conclusion

This study shows that the subsurface lithology conditions in the research area consist of clay, alluvium, tuff breccia, sandy tuff, and sandstone. Then an aquifer layer was found at a depth of more than 40m and under a very dense tuff breccia layer so that it is a confined aquifer. The aquifer layer is at a depth of 46.3m - 167 m with a resistivity value of 3.95 Ωm - 5.77 Ωm which is a sand layer.

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