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RESEARCH ARTICLE

Identification of Deep Groundwater Aquifer Zones with Geoelectrical Method in Sukadanaham Area Bandar Lampung, Indonesia

Nandi Haerudin[1, *], Aldika Rizkiano[1], Rahmi Mulyasari[1], Hesti[1]

[1] *Geophysical Engineering Department, Universitas Lampung, Jl. Prof. Soemantri Brojonegoro no.1, Bandar Lampung, Indonesia 35145.*

* Corresponding author : nandi.haerudin@eng.unila.ac.id
Tel.:+62-853-5767-2527
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Abstract

Research on groundwater aquifers using the geoelectric method has been carried out in the Sukadanaham area, Tanjung Karang Barat District, Bandar Lampung City. This Research Objectives This research aims to identify the lithology and depth of groundwater aquifer zones based on resistivity values and geological literature. Data acquisition was carried out using the Schlumberger configuration of 3 points in the young Betung volcanic formation (Qhvb). The data used is the resistivity value. Resistivity value data is modeled vertically with inverted results. The resistivity value of each point is adjusted and interpolated based on the literature on rock resistivity values. Based on the identification results, 4 types of subsurface rock lithology were found, namely top soil, tuff, breccia, and andesite. The lithology of the layers at point 1, point 2 and point 3 is dominated by tuff and breccia layers. The resistivity value of the andesite layer obtained has a high value, which is > 300 Ωm. The resistivity value of the tuff layer for the waterproof layer has a value of 200-250 Ωm. The breccia layer acts as a groundwater aquifer zone with a low resistivity value of 15-60 Ωm. The rock resistivity value with the lowest value is at a depth of 40-95 m which is a compressed aquifer layer with andesite and tuff layers as a waterproof layer above and below.

Keywords: Geoelectrical, Resistivity, Aquifer, Lithology

1. Introduction

1.1 Background of Research

The population level of the City of Bandar Lampung over the last twenty years has grown quite rapidly, thus encouraging an area to increase the need for water sources (Rustadi et al, 2022). Based on statistical data for the City of Bandar Lampung in 2022, Sukadanaham Village has a recorded population of 5,686 residents with water sources in the last three years, there are 3 types of water sources, namely refill water, metered piped water, and Artesian Well (Bandar Lampung City Central Statistics Agency, 2022). At one of the research well points in Sukadanaham, the community uses one well to meet the needs of 200 households, ideally a well can only meet the needs of 30 households (Mulyasari et al., 2022a). Due to the lack of information on subsurface water sources, it is necessary to carry out this research which is expected to be put to good use by the surrounding community. One of the efforts to increase the amount of water from water sources is by conducting exploration targeting the determination of potential zones of groundwater aquifers. Aquifer detection functions to determine the formation of a rock has the possibility of containing water and other secondary permeable water catchments with the potential to become quality aquifers. Aquifer detection can also be used to determine raw water production wells, to fulfill the clean water needs of the general public (Shantharam et al., 2018). Subsurface estimates related to the presence of groundwater are carried out using resistivity estimation techniques using the Vertical Electrical Sounding (VES) method (Falae et al., 2019; Mulyasari et al., 2022b). Subsurface thickness can be determined using Schlumberger vertical electrical sounding (VES) method (Sholichin et al., 2019).

To determine the potential zone of groundwater aquifers, the geoelectrical method can be used (Mulyasari et al., 2021; Arowoogun and Osinowo, 2022; Sastrawan et al., 2023; Antosia et al., 2023, Hasani et al., 2023). In this method an electric current is injected under the earth's surface through two current electrodes and a potential difference is measured through two potential electrodes, the result is a potential difference value which is a reference for determining the resistivity variation of each layer below the surface point.

1.2. Location

The location of this research is in Sukadanaham Village, West Tanjungkarang District, Bandar Lampung City. Located at elevation 270-300 m.

2. Regional Geology

This research area is located in Sukadanaham Village, West Tanjungkarang District, Bandar Lampung City which is in the Betung Volcano (BV) Young Volcano Deposit geomorphological unit (Mulyasari et al., 2019). Based on the geological map (Mangga et al., 1993), the research area is located in the Betung young volcanic deposit formation (Qhvb) which is composed of andesite-basalt rock, breccia and tuff. In Figure 1 is a geological map in the study area that uses the Tanjungkarang geological sheet as a reference in map modification. The young volcanic sediment formation (Qhv) and the Lampung formation (QTl) are the dominant part of the cover layer in the Lampung region (Rustadi et al., 2020). The subsurface stratigraphy in the Sukadanaham Village area is still included in the young Betung volcanic deposit formation (Qhvb) which is young, namely the Holocene Quaternary is in the upper formation layer, there is an older Pleistocene formation, namely the Lampung formation (QTl), there is an older formation compared to the Lampung formation which is Eocene old, namely the Tarahan formation (Tpot), in that area there is the Undifferentiated Gunung Kasih Complex formation (Pzg) which acts as the dominant basement of the oldest age, namely Paleozoic Pre-Tertiary (Rustadi et al., 2022).

According to (Zaenudin et al., 2020) there are rock layers and groundwater basin geometries located at a depth of 1 – 1.5 km in the Lampung formation (QTl) and young volcanic formations (Qhv). Found two basin structures composed of 4 rock layers namely andesite, sandy tuff, silty tuff, and lava (andesite-basalt) (Haerudin et al., 2022).

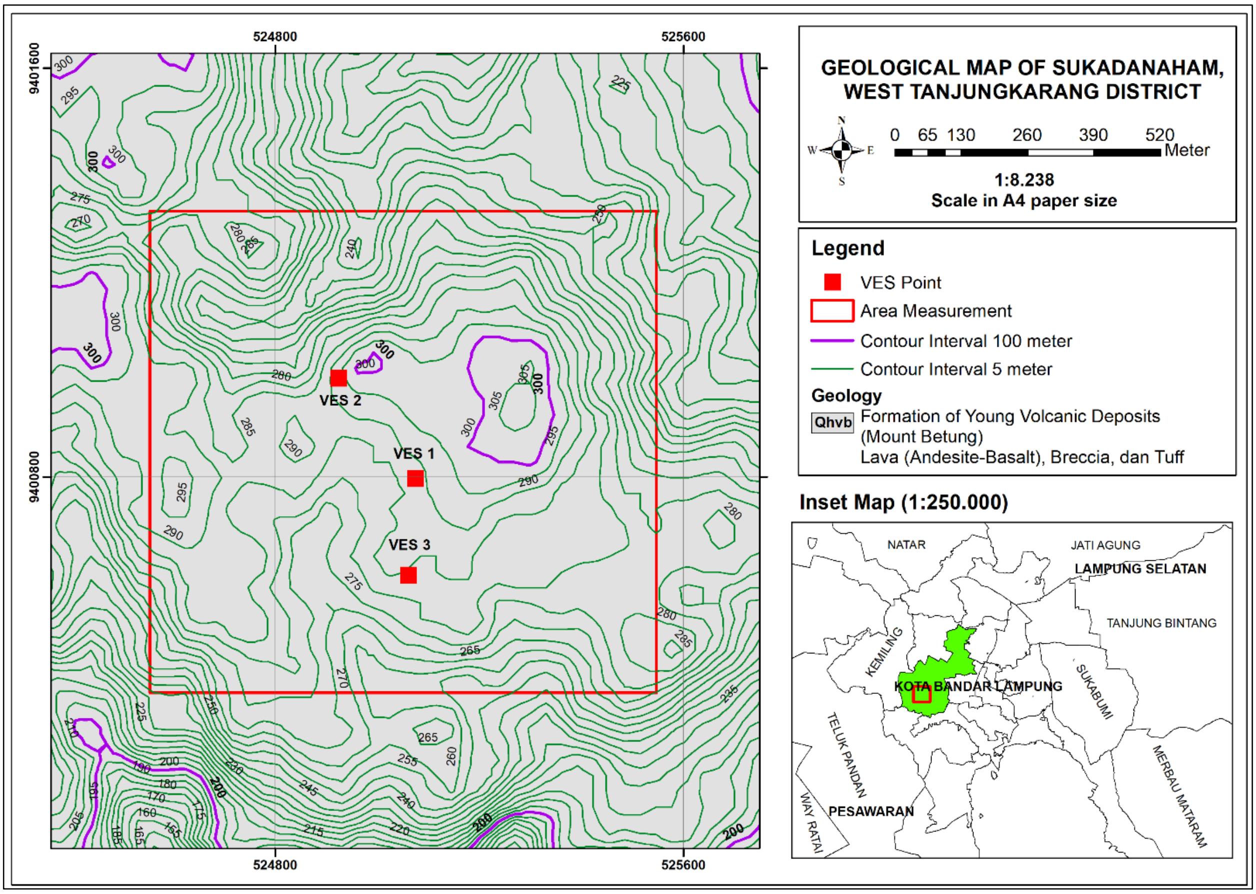

Fig 1. The research location at Sukadanaham, West TanjungKarang District (Adapted from Mangga et al, 1993).

3. Method

3.1 Geoelectric

The Schlumberger configuration is a configuration or arrangement of electrodes in the geoelectrical method that uses the C1-P1-P2-C2 arrangement, with the distance between the P1 and P2 electrodes tending to be constant. While the distance between P12 and C12 is changed according to a predetermined space (Loke, 2004)

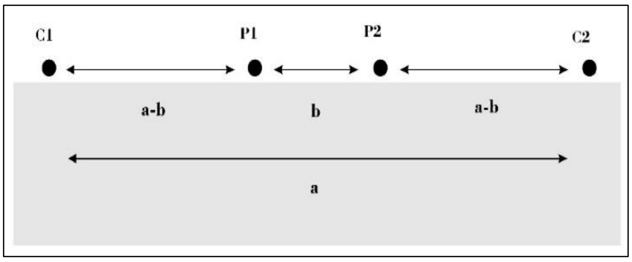

Fig 2. The arrangement of the current electrode (C) and the potential electrode in the Schlumberger configuration (Loke, 2004).

In the Schlumberger configuration ideally the distance between the potential electrodes P1 and P2 is made as small as possible, with changes in the distance between the potential electrodes not greater than 1/5 the distance between the current electrodes C1 and C2 (Kirsh, 2009). The formula used in the Schlumberger configuration is:

$$K = \frac{\pi(a^2-b^2)}{2b} \tag{1}$$

$$\rho = \frac{\pi(a^2-b^2)}{2b}\frac{\Delta V}{I} \tag{2}$$

Where K is the geometric factor of the Schlumberger configuration, a is the current electrode distance, b is the potential electrode distance, ρ is the resistivity, ΔV is the potential difference, and I is the current (Telford et al., 1990).

3.2 Table Resistivity

The reference for the resistivity value of the rock used is derived from research conducted by Rustadi et al., 2022 in the Mount Betung area with a similar formation, namely the Betung young volcanic deposit formation (Qhvb).

Table 1. Table Resistivity of Young Betung Volcanic Deposits Formation (Qhvb) (Rustadi et al, 2022).

Lithology	Resistivity (Ωm)
Andesite	> 300
Tuff	50 – 250
Breccias	15 – 60

3.3 Aquifer

An aquifer is a layer of rock that stores and distributes water in a certain amount. The amount of groundwater that can be obtained depends on the properties of the aquifer below. The types of aquifers based on their lithology are Unconfined Aquifer, Confined Aquifer, Semiconfined Aquifer, and Perched Aquifer (Asmaranto, 2012).

1. Unconfined Aquifer is groundwater in an aquifer covered with an impermeable layer and is an aquifer that has a groundwater table. Unconfined Aquifer is a water-saturated aquifer. Saturated aquifers are also known as phriatic aquifers, non-Ariesan aquifers or free aquifers
2. Confined Aquifer is an aquifer where the groundwater is located under an impermeable layer and has a pressure greater than the atmosphere. A confined aquifer is a water-saturated aquifer bounded by an upper and lower layer.
3. Semiconfined Aquifer is an aquifer where water is confined under a semi-permeable layer so that the aquifer here is located between free aquifer and confined aquifer.
4. Perched Aquifer is a type of aquifer that forms above an impermeable layer causing water to be trapped to form a water reservoir that is separate from the main aquifer below.

4. Results

In this study, processing was carried out to obtain the actual resistivity value so as to make it easier to determine the groundwater aquifer zone. The processing results for each VES point show variations in resistivity values with different depths, reaching 160 m for VES 1 point, 101 m for VES 2 point, and 105 m for VES 3 point. The processing also obtains a 1D curve comparison between AB/2 and the actual resistivity value which is complemented by the number of layers and the depth and thickness of the layers. In the 1D curve there is an RMS (Root Mean Square) error value which is used as a marker of compatibility between the 1D measurement curve and the inversion standard curve.

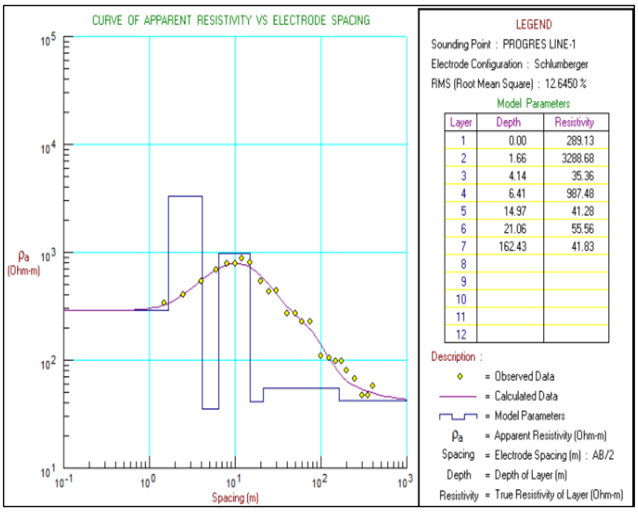

Fig 3. Curve VES 1.

Table 2. Lithology VES 1

Depth (m)	Lithology	Resistivity (Ωm)
0 – 1,66	Top soil	289,13
1,66 – 4,14	Andesite	3288,68
4,14 – 6,41	Breccias	35,36
6,41 – 14,97	Andesite	987,48
14,97 – 21,06	Breccias	41,28
21,06 – 162,43	Tuff	55,56
> 162,43	Breccias	41,83

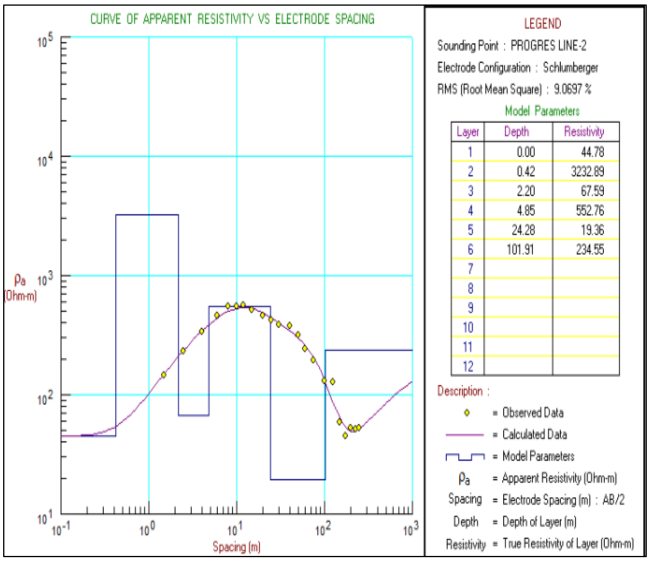

Fig 4. Curve VES 2.

Table 3. Lithology VES 2

Depth (m)	Lithology	Resistivity (Ωm)
0 – 1,66	Top soil	289,13
1,66 – 4,14	Andesite	3288,68
4,14 – 6,41	Breccias	35,36
6,41 – 14,97	Andesite	987,48
14,97 – 21,06	Breccias	41,28
21,06 – 162,43	Tuff	55,56
> 162,43	Breccias	41,83

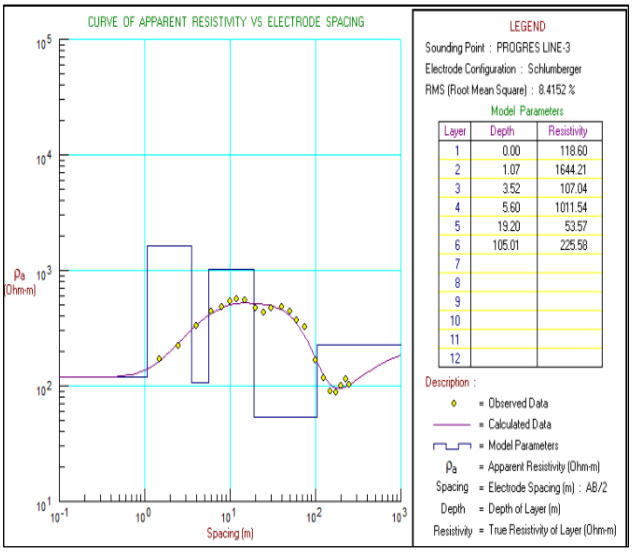

Fig 5. Curve VES 3.

Table 4. Lithology VES 3

Depth (m)	Lithology	Resistivity (Ωm)
0 – 1,66	Top soil	289,13
1,66 – 4,14	Andesite	3288,68
4,14 – 6,41	Breccias	35,36
6,41 – 14,97	Andesite	987,48
14,97 – 21,06	Breccias	41,28
21,06 – 162,43	Tuff	55,56
> 162,43	Breccias	41,83

Each of these VES points then produces a vertical model that adjusts to the depth and resistivity value of each point. This model will represent the subsurface rock lithology vertically based on resistivity values.

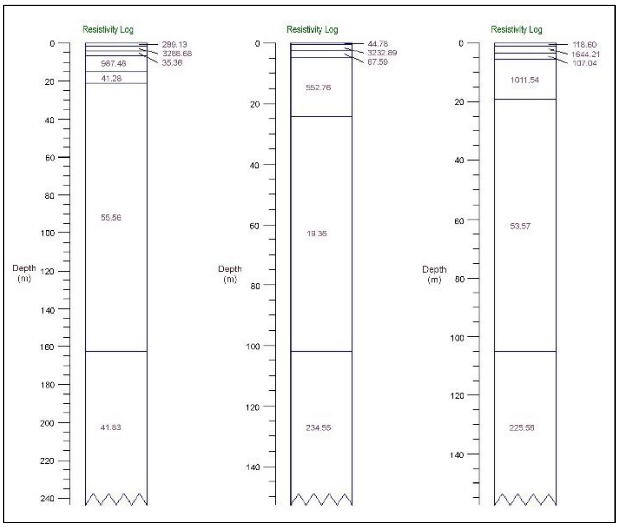

Fig 6. Vertical Model VES point.

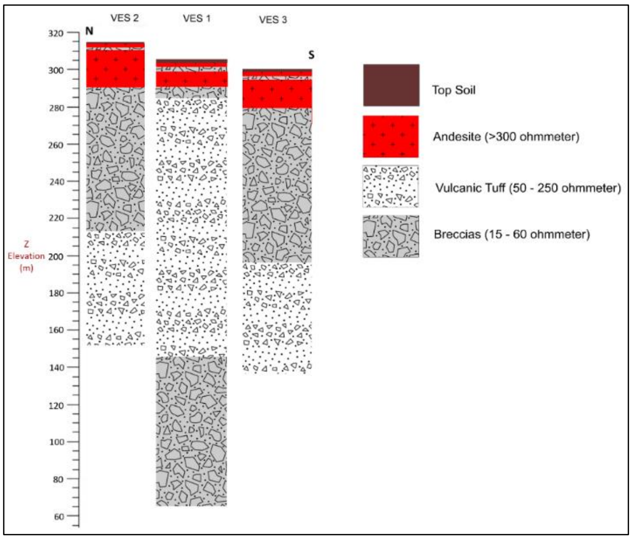

Fig 7. Lithology of each VES point.

The 1D curve from left to right is VES 1, VES 2, and VES 3. Then in the model lithology can be reconstructed with reference to the rock resistivity table and sorted according to the elevation and location according to the cardinal directions.

Furthermore, similar lithologies will be aligned. Alignment is done by adjusting to the VES 1 point which is a point with deeper penetration depth than the VES 2 and VES 3 points.

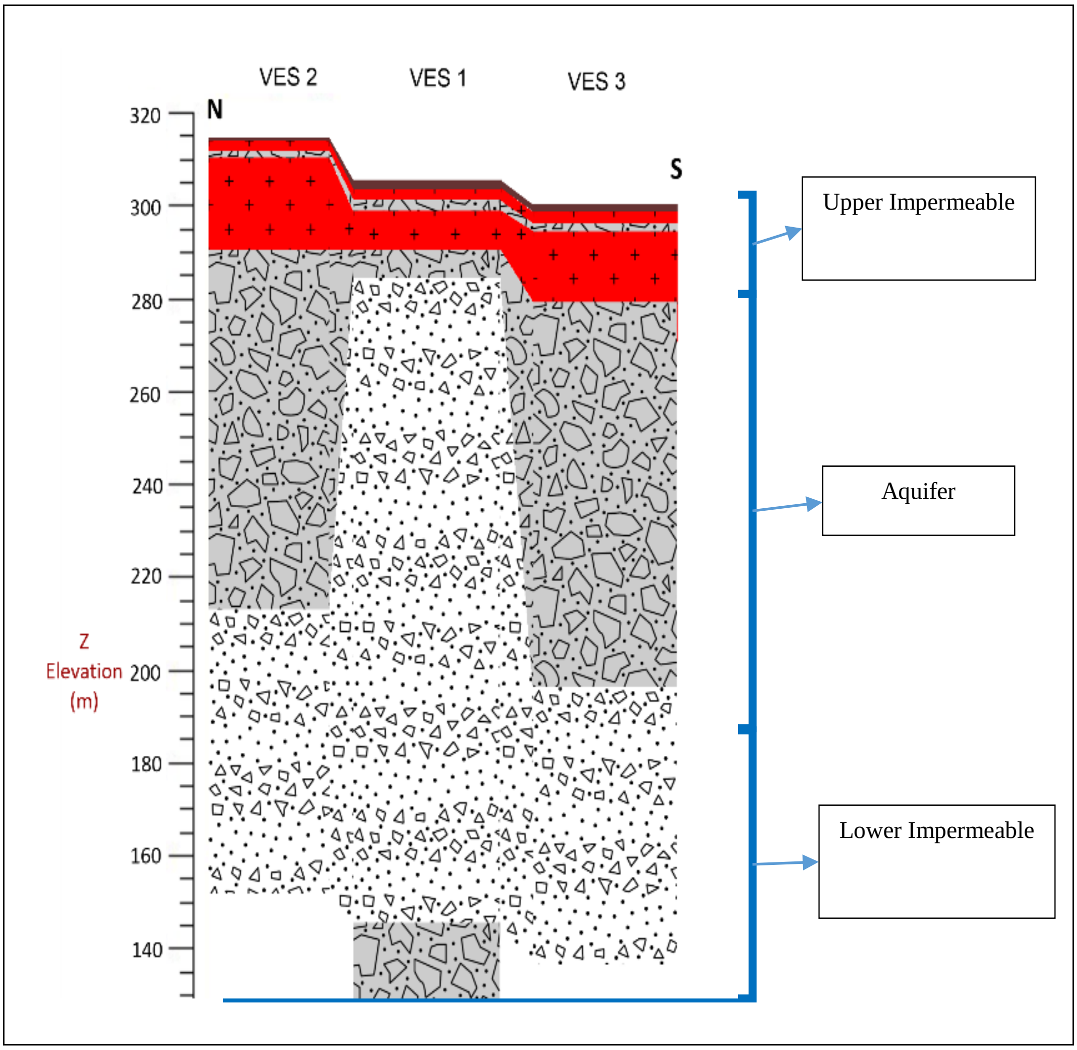

Fig. 8. Lithology aquifer of groundwater.

In the lithology of Figure 26, it is interpreted that there is a water-resistant layer characterized by a high resistivity value, while the aquifer layer is located in a breccia lithology with a low resistivity value at a depth of 40-95 m.

Based on information from residents' well points with a total of 5 well points, the depth of the groundwater table is estimated to be at a depth of 60-71 m from the surface. Point 1 has a groundwater level of 62 m, well point 2 has a groundwater level of 69 m, well point 3 has a groundwater level of 64 m, well point 4 has a groundwater level of 71 m, and well point 5 has a groundwater level of 64 meters. The well points that are close to the VES point are well point 1, well point 2, and well point 4.

4. Conclusions

At the sounding points that were measured, namely at VES 1, VES 2, and VES 3, and the geological literature and resistivity values, it was found that the lithology of the layers was dominated by the presence of tuff and breccia. The breccia layer acts as a groundwater aquifer zone with a relatively small range of resistivity values, namely with a resistivity value of 15-60 Ωm. As a result of the interpolation of the three sounding points that have been carried out by aligning the elevation and depth of each sounding point and lithology, the aquifer is confined to a depth of 40-95 m, with the upper impermeable layer composed of andesite and the lower impermeable layer composed of tuff layers.

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