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Study of Groundwater Types Using the Vertical Electrical Sounding (VES) Method in the 'Martani Field' Ngemplak District of Yogyakarta

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Abstract
Study of groundwater types using the Vertical Electrical Sounding (VES) method in 'Martani Field' Ngemplak District of Yogyakarta was done by carrying out eight measurement points to look for groundwater potential. This area is an area on the southern slopes of Mount Merapi which is included in the Yogyakarta Groundwater Basin. The type of lithology is identified based on the measurement of its resistivity value so that there are several types of lithology, namely Breccia (110-670 Ωm), Clay (1.99-10.12 Ωm), Sandstones (17.06-56.82 Ωm) and andesite lava (688-1657 Ωm). The bottom of the aquifer in this basin is composed of rock formations that are impermeable or semi impermeable which are non-aquifer, namely by Breccias, Clay and Andesite Lava. The existence of sandstones that act as aquifers is found near the surface at a depth of <25 m and at a depth of about 60-100 m below the surface so that it is divided into two categories, namely shallow groundwater and deep groundwater.

Keywords: Groundwater type, aquifer, vertical electrical sounding, Ngemplak District

1. Introduction

Water is a very important need for life, so the search for groundwater sources are continuously carried out as an effort to meet the needs of life, both during the dry season or during the rainy season, one of which is in the "Martani" Field, Ngemplak District, Sleman Regency, DI Yogyakarta Province, research area. This area is an area on the southern slopes of Mount Merapi which is included in the Yogyakarta Groundwater Basin.

Ngemplak district is one of the areas in Sleman Regency which has experienced quite rapid development in the industrial, agricultural and domestic sectors. This causes the need for groundwater to increase, causing degradation of its quality and quantity.

The aquifer base in the Yogyakarta-Sleman Groundwater Basin is composed of rock formations that are impermeable or semi impermeable or non-aquifer in nature. The spread of these rock formations, in the northern part, is composed of Old Merapi sediment in the form of breccias, lava and lava deposits which are very hard and compact (Figure 1). Whereas in the southern part of the Groundwater Basin, the non-aquifer rock formations are composed of the Sentolo Formation which is composed of claystone and limestone in the western part, and in the eastern part it is composed of the Semilir Formation and the Nglanggran Formation which consists of Tertiary volcanic rocks in the form of volcanic sandstones and breccias. volcano which is very loud and compact (Hendrayana & Putra, 1993; Raharjo *et al.,* 1995).

Groundwater is water that is below the ground surface and is contained in an aquifer layer. Groundwater has many types in geological formations known as aquifers (Kodoatie, 2021). An aquifer can be defined as a formation containing a saturated permeable material that generates a sufficient amount of water to form wells and springs. Rocks that are aquifer are capable of storing and transmitting water. Sand and unconsolidated gravel is a characteristic feature of aquifers (Todd & Mays, 2004).

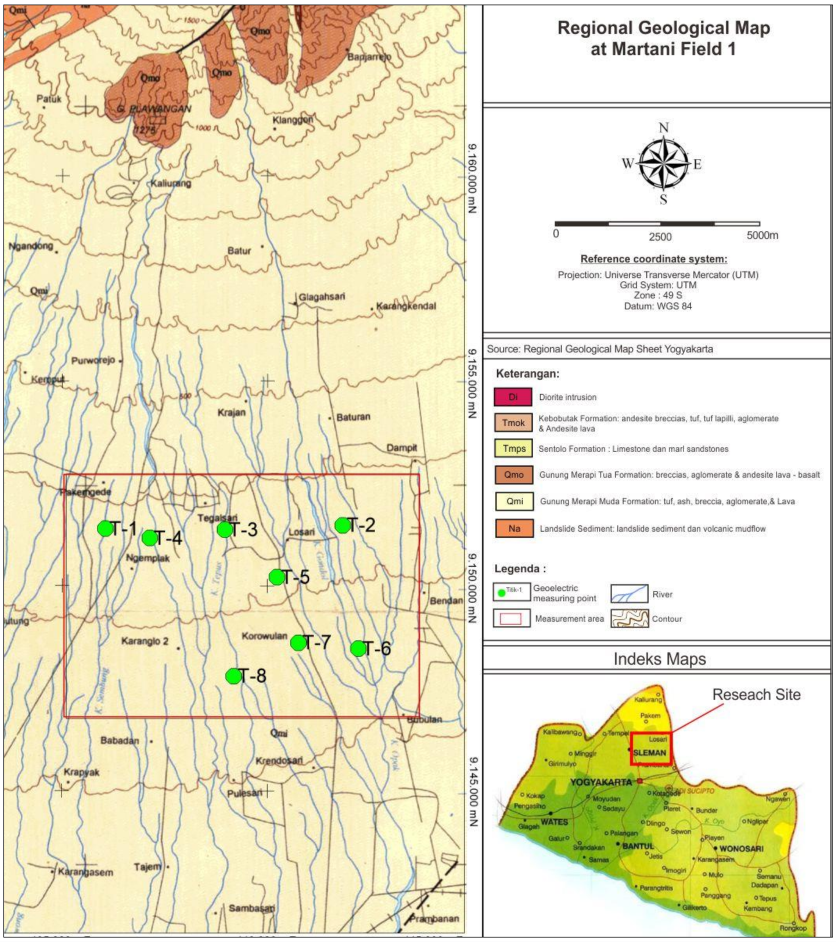

Figure 1. Regional Geological Map Sheet Yogyakarta along with the location of measurement points in the Martani field (modified from Raharjo *et al.,* 1995)

The existence of groundwater is searched by measuring using the Vertical Electrical Sounding (VES) method. The data from the resistivity method are modeled with a one-dimensional resistivity log. The resistivity value in each layer is used to estimate the type of rock and identify lithology and layer thickness at each measurement point. The rock type at each point is adjusted to the surface rock resistivity value which is supported by the local geological map of the study area so that the type of aquifer can be interpreted (Dzakiya *et al.,* 2019). Based on this background, the estimation of groundwater presence in Ngaglik District was studied by taking geophysical measurements using the Vertical Electrical Sounding (VES) method to obtain a geological model.

2. Methodology

The Vertical Electrical Sounding (VES) method is used in eight measurement points at the research location which are spread over several villages as shown in Figure 3 which are at different heights. The highest measuring point (point 1) is around 380 masl and the lowest (point 7) at 240 masl means that the topography is relatively moderate with relatively gentle topographic contours. The measuring points spread evenly on Ngemplak district by representing each sub-district.

This method is a geoelectric method that is often used for subsurface investigations. VES is able to describe subsurface models based on rock resistivity values with a vertical depth function. Based on these advantages, the VES method is often used to assess the potential presence of groundwater (Zakaria & Suyanto, 2020; Zakaria, 2019; Sutasoma *et al.,* 2018; Sutasoma *et al.,* 2018; Apriliawan *et al.,* 2017). In addition, based on the results of data processing, variations in rock layers will be obtained based on differences in resistivity values caused by differences in lithology. The maximum cable length used is 250 m.

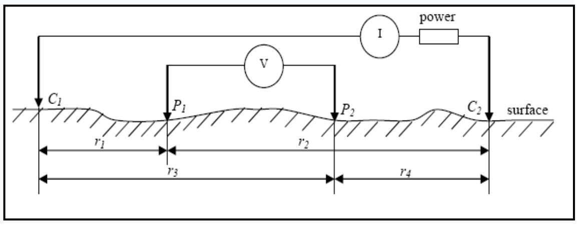

Fig. 2 Model of two current electrodes and two potential electrodes (Todd & Mays, 2004)

The principle of the geoelectric method is to inject an electric current through a pair of current electrodes C1 and C2 (Figure 2). Meanwhile, the voltage/potential values are measured by electrodes P1 and P2 (Telford *et al.,* 1990). The raw data retrieved from the field are current (I) and voltage (V). From these two parameters could calculate resistant (R) and Resistivity (Rho). The general VES method used for shallow exploration (less than 500 m), so it is often used for groundwater search both shallow and deep. In addition, it is able to distinguish differences in subsurface layers according to different types of lithology. The existence of aquifers is indicated by a lower resistivity value compared to the surrounding environment because aquifers contain water which is capable of conducting electricity, while earth's material is considered to be resistive or barrier to electric currents. Rock materials have different values for conducting electric current.

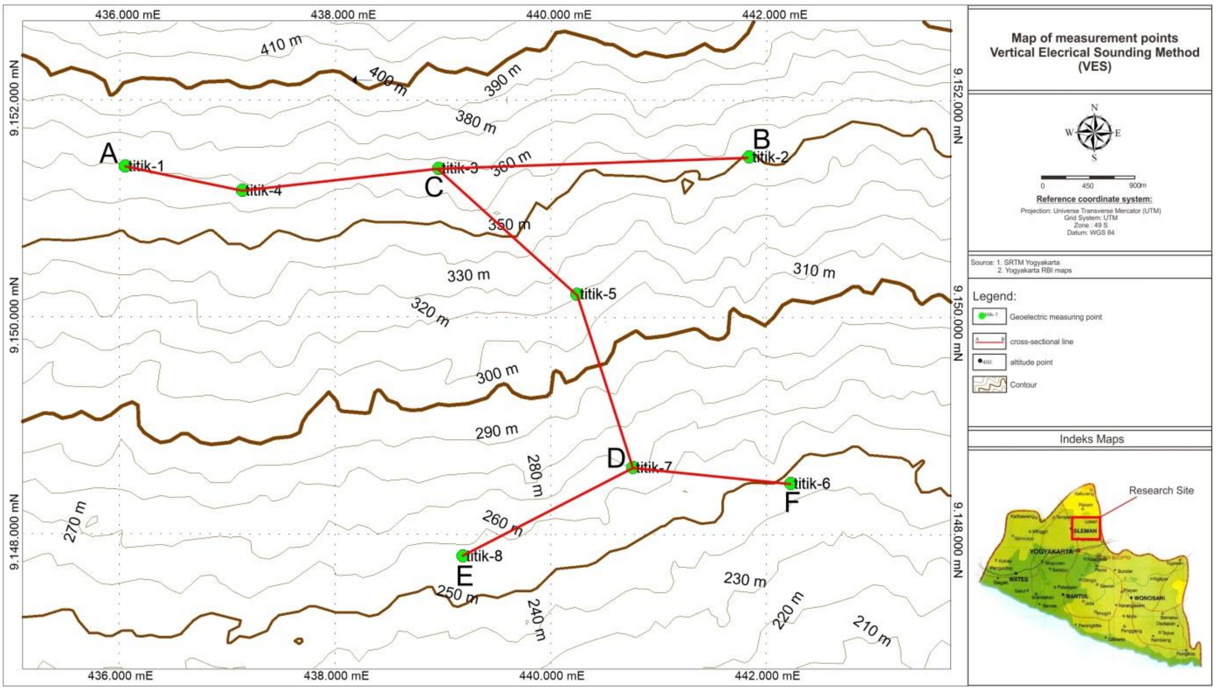

Figure 3. The distribution of measurement points in the eight research locations

3. Results and Discussion

The flow of the research process is in accordance with Figure 4. Data processing of the measurement results of the Vertical Electrical Sounding (VES) method in the Martani field, Ngemplak District, is processed using PROGRESS 3.0 software to produce several subsurface geological models in the form of log resistivity values. The value is modeled according to the geological conditions in the area. There are eight resisitivity logs in the 1D model which are divided into three sections with a depth function according to the location of the measurement points that are close together or relative to one path, namely Section A-C-B, Section C-D and Section E-D-F. This is to clarify the relationship between rock resistivity values between measurement points. The model is interpreted to obtain subsurface information and to determine rock types to find the presence and depth of the aquifer.

Based on the geological information of the research area, the locations of measurement points include the Yogyakarta-Sleman Groundwater Basin and are in the southern part of Mount Merapi. This area has a spread of rock formations that are impermeable or semi impermeable or non aquifer in nature. When linked with VES data, it is easier to interpret subsurface geological models. The measurement results of the resistivity value correlated with the surface regional geological data obtained by four types of lithology in the Martani field, namely Breccia (110-670 Ωm), Clay (1.99-10.12 Ωm), Sandstone (17.06-56.82 Ωm) and andesite lava (688-1657 Ωm). When viewed from the eight measurement point models from Figure 4, Figure 5 and Figure 6, there is an aquifer base composed of impermeable or semi-impermeable rock formations that are non-aquifer, namely breccias, andesite lava and clays. These lithologies are not able to store and transmit water so there is no groundwater.

In accordance with the definition of groundwater, namely water that is below the ground surface and is contained in an aquifer layer. Groundwater has many types in geological formations known as aquifers. An aquifer can be defined as a formation containing a saturated permeable material that generates a sufficient amount of water to form wells and springs. Rocks that are aquifer are capable of storing and transmitting water such as sandstones. The presumption of groundwater is based on sandstone lithology and the like. The existence of sandstones that act as aquifers is found near the surface at a depth of <25 m and at a depth of about 60-100 m below the surface so that it is divided into two categories, namely shallow groundwater and deep groundwater. From Figure 4, Figure 5, and Figure 6, it shows that both of the aquifer connected each other.

The spread of rock formations in the northern part is composed of Old Merapi Deposits in the form of breccias, lava deposits and very hard and compact lava. This is found at the 8th measuring point. Whereas in the southern part of the Groundwater Basin, the non-aquifer rock formations are composed of the Sentolo Formation which is composed of claystone and limestone in the west, and in the eastern part it is composed of the Semilir Formation and the Nglanggran Formation which consists of Tertiary volcanic rocks in the form of volcanic sandstones and breccias. volcanic which is very hard and compact which is almost found in all measurement point modeling results carried out in the field.

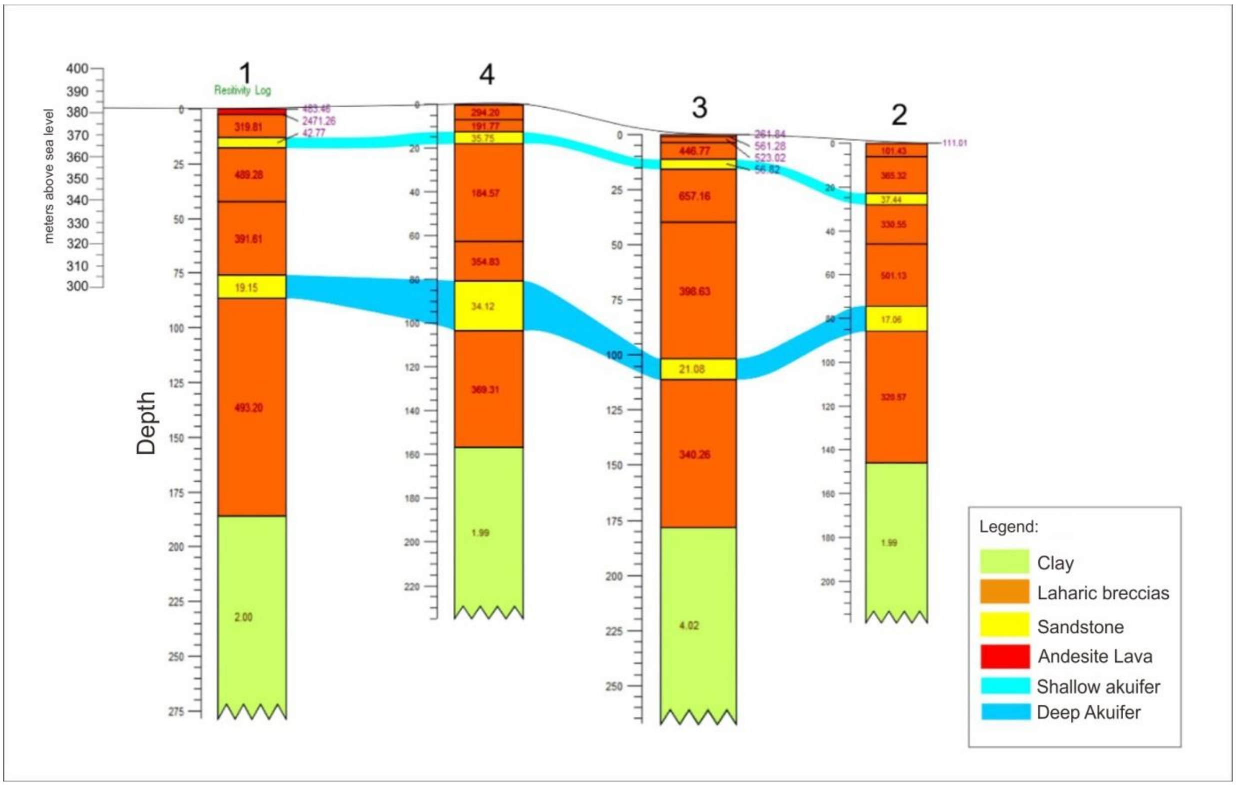

Figure 4. The results of the interpretation of the resistivity values of the rock at points 1, 2, 3 and 4 in section A-B

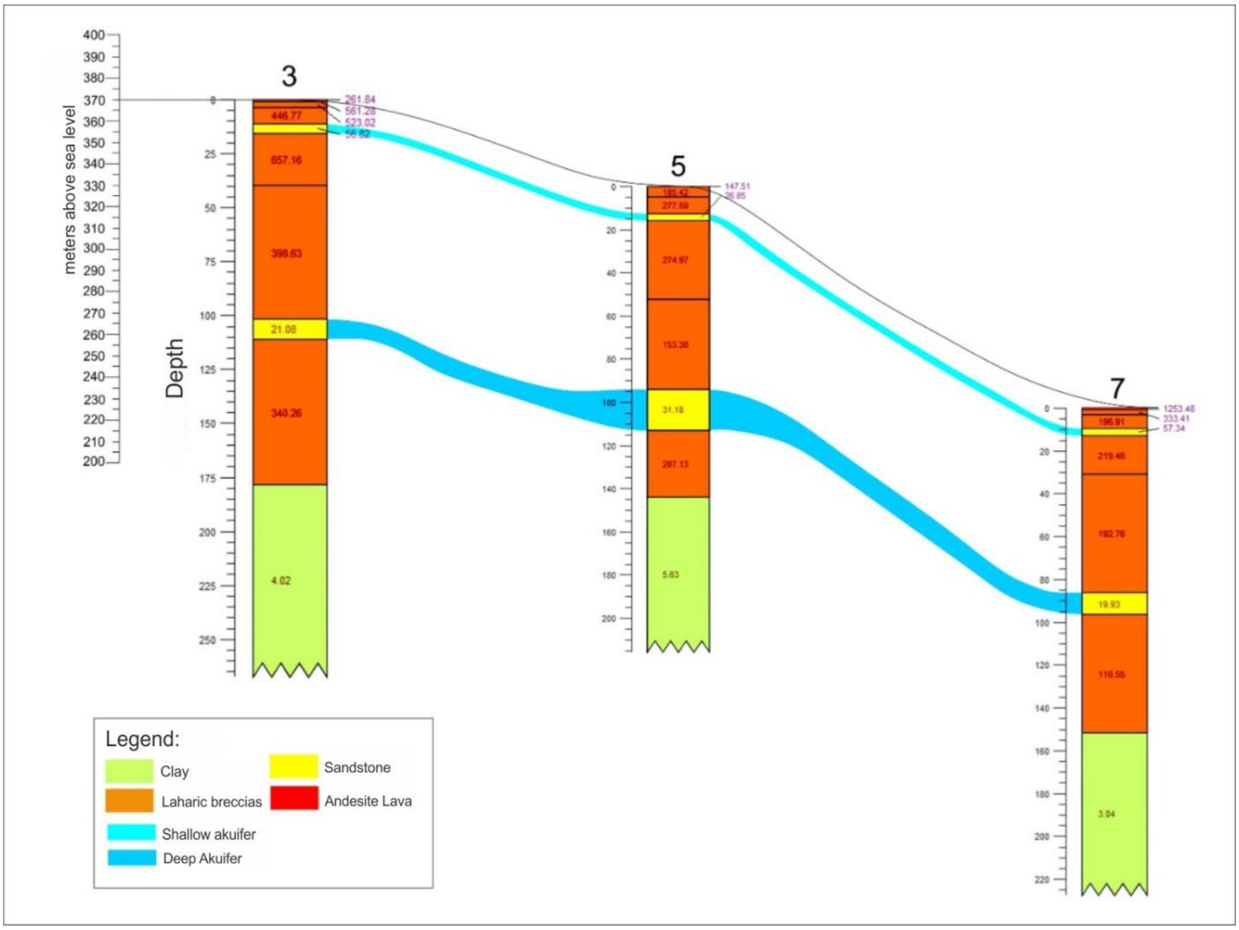

Figure 5. The results of the interpretation of the resistivity values of the rock at points 3, 5 and 7 in section C-D

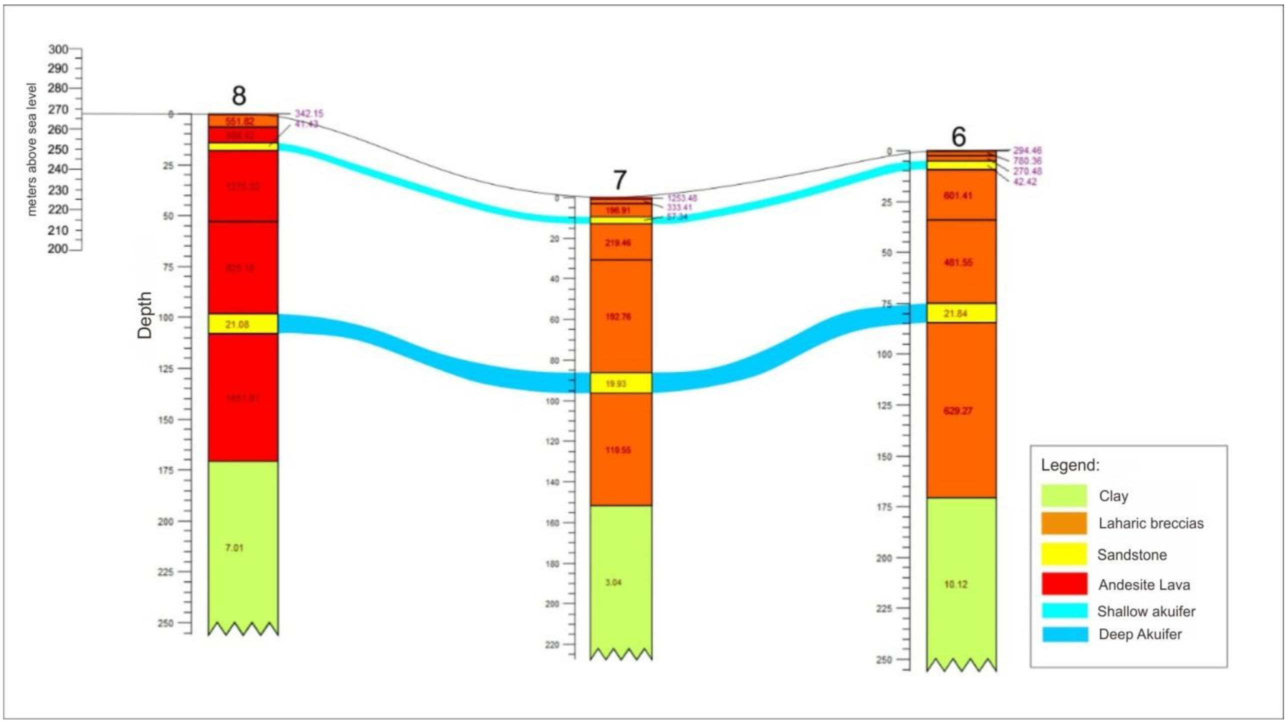

Figure 6. The results of the interpretation of the resistivity values of the rock at points 6, 7 and 8 in the E-D-F section

4. Conclusion

The Martani field in Ngemplak Subdistrict is a research area composed of impermeable or semi impermeable rock formations which are non-aquifer in the form of breccias, andesite lava and clay. These rocks are identified based on the measurement results of their resistivity values so that there are several types of lithology, namely four types of lithology, namely Breccia (110-670 Ωm), Clay (1.99-10.12 Ωm), Sandstones (17.06-56.82 Ωm) and andesite lava (688-1657 Ωm). The presumption of groundwater is based on sandstone lithology and the like. The existence of sandstones that act as aquifers is found near the surface at a depth of <25 m and at a depth of about 60-100 m below the surface so that it is divided into two categories, namely shallow groundwater and deep groundwater

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