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Research Paper

Fresh Water Exploration in Gunung Tunak, Lombok Island, Using Wenner Electrodes Configuration

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Abstract: Geoelectric is the most popular geophysical method for groundwater exploration. This method is based on measuring the electric current injected into the earth and measuring the potential generated at the surface. This research was carried out at Mount Tunak, on the island of Lombok, using the Wenner electrode configuration. The data is then processed using the Res2div software. The survey was conducted on two lines and obtained two parameters, namely the injection electric current measured at the current electrode and the potential generated at the surface measured through the potential electrode. The measurement results show the rock resistivity values between 0.053 to 194 Ohm-meters. The resistivity of the aquifer rock has a value of 1.67 to 4.25 Ohm-meter, which is a sandy claystone with an aquifer containing fresh water at the depth of about 20 meters below the surface. There is a presence of salty water below the fresh water with resistivity between 0.102-0.657 Ohm-m.

Keywords: Geoelectric; Schlumberger; Water Exploration.

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INTRODUCTION

Geophysics is the study of the earth using physical measurements on the surface or subsurface of the earth. Geoelectric method is one of the geophysical methods that stud electric properties of the earth and how to detect it on the earth's surface. This includes measuring potential and electric currents, both naturally and as a result of current injection in the earth. There are several kinds of rules/ electrode configurations for estimating the subsurface layer with this geoelectric, including: Wenner, Schlumberger, dipole-dipole and so on. The measurement procedure deepens on variation of resistivity with depth, namely the vertical direction (sounding) or horizontal direction (mapping). Geoelectric methods are usually also used for preliminary surveys before entire exploration is carried out.

This geoelectric survey was conducted in order to obtain an overview of the groundwater conditions at the survey site which will be used to meet the needs of fresh water due to the difficulty to determine fresh water location. The availability of groundwater is not evenly distributed and usually separated depending on the geological conditions of the subsurface or aquifer layers and the local area's geological conditions. To find out the existence of the groundwater layer, it is necessary to conduct a geophysical investigation using a geoelectric method.

The purpose of this research is to determine the rock layers containing groundwater or aquifers. The purpose of this study is to determine the depth and presence of water-bearing aquifers and to determine the properties of the carrier layer, to locate the potential for groundwater surveys in the area.

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The 2-dimensional geoelectrical data was taken by configuring 2-point Wenner electrodes configuration which were expected to describe the hydrological conditions of the local area. The next stage is the interpretation of the data using the Res2Div software. The results of this study are expected to provide geological information in the form of aquifers in a trajectory and obtain a 2-dimensional model from the Wenner configuration geoelectrical data, so that it can be used to build the location of the groundwater aquifer layer below the earth's surface.

Groundwater is water layer or lenses below the ground surface in aquifer rocks. The main characteristics that distinguish groundwater from surfacewater are its quiet slow movement and quiet long residence time. This duration of time can reach tens to hundreds of years. Groundwater can be divided into two types, ie. Free-ground water and compressed-groundwater. Free-groundwater is groundwater from the aquifer that is only partially filled with water, and is located on water tight bottom, with a free surface. Compressed-groundwater is groundwater from the aquifer that is completely water saturated, with the top of aquiver and bottom of it bounded by water tight layer (Efendy, 2011). Todd (1980) states that the aquifer comes from Latin, namely aqui from aqua which means water and ferre which means to carry, so the aquifer is a water-carrying layer.

Exploration of Groundwater using geoelectric method has been carried out by many previous researchers as a reliable method. Hasibuan et al. (2013), performed a study intrusion of seawater using the Wenner-Schlumber wire configuration of resistivity method. Asfiannisa et al. (2015), perform estimation of seawater intrusion due to preparation for deep well drilling using the Wenner electrode configuration. Irham et al. (2006), perform mapping the distribution of sea water intrusion in deep aquifers in the lower part of Semarang City. Husni and Roh, (2012), conducted study for prediction of seawater intrusion in South Tangerang City and the groundwater subsidence. Ratnakumari et al. (2012). Perform 2D mapping of the aquifer at the bottom of the Chandrabhaga river, Nagpur District, Maharashtar, India. Sadjab, et al (2012) perform mapping of groundwater aquifers with geoelectricity in Prambanan, Sleman, Yogyakarta Province. Sedana et al, (2015), perform mapping of groundwater aquifers using the geoelectric in Malendeng area. Meanwhile, Andriayani et al, (2010), used the geoelectric method to get image of geologic features with a dipole-dipole configuration to trace the underground river of Karst system in area of Pacitan, East Java. Zuhdi and Habiburrohman (2021) exploring fresh water around Gunung Tunak with Schlumberger electrodes configuration. Zuhdi et.al., (2022) using geoelectric to estimate discharge rate of water aquiver.

METHOD

Geoelectric is a geophysical method that aims to determine the electrical properties of rock layers below the ground surface by injecting electric current into the soil. Geoelectric is one of the active geophysical methods, because the electric current comes from outside the earth's rock system. The main purpose of this method is actually to find the resistivity of the rock. Resistivity is a quantity or parameter that indicates the level of resistance to electric current. Rocks that have a greater resistivity, indicate that the rock is difficult to flow by electric current. In addition to rock resistivity, geoelectrical methods can also be used to determine other electrical properties such as self-potential, miss a la masse and induced polarization.

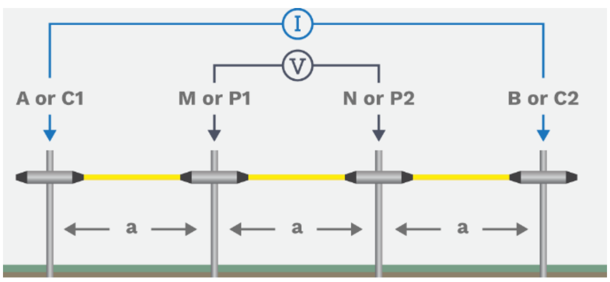

Figure 1. Wenner electrode configuration

Rock resistivity can be measured by inserting an electric current into the soil through 2 current electrode points on the ground surface and 2 potential electrode points to measure the potential difference on the surface. The results of geoelectric measurements can be in the form of a map of the distribution of resistivity either by type of mapping or horizontal or sounding or depth. The results of geoelectrical mapping and sounding measurements are adjusted to the needs of data acquisition and the type of configuration used. Apparent resistivity can be formulated as Formula 1:

$$\rho_a=K (\Delta V)/I \qquad (1)$$

where ρa is apparent resistivity, K is geometrical factor for Wenner electrode configuration, ΔV is measured potensial of M-N electrodes, and I is injected electric current through electrode A-B (Sheriff, 2002).

This measurement is carried out by placing the electrode points at the same distance from each other. Adjacent electrodes will be equidistant (AM = MN = NB = a), as shown in figure 1. This configuration has advantages in reading accuracy because it has an eccentricity value that is not too large or a value of arround 1/3. This method is also one of the methods with result a good signal. The weakness of this method is that it cannot detect the homogeneity of rocks near the surface which can affect the calculation results.

The resistivity (ρ) has a value that is inversely proportional to the conductivity. Conductivity is the ability of a material to conduct electric current which depends on the magnitude of the electric field and the current density. The unit of conductivity is siemen and the unit of resistivity is Ohm-meter. Rock is a material that has a certain electrical conductivity and resistivity value. The same rock does not necessarily have the same resistivity, because it still depends on the fluid that fills the pores of the rock. On the other hand, different rock types can have the same resistivity value, this happens because the resistivity value or rock type resistance has a range of values that can overlap each other. Table 1shows resistivity of some types of rocks according to Telford (2011).

Table 1. Resistivity of Rocks and minerals

Rock/Mineral	Resistivity (Ohm-meter)
Pyrite	0.01-100
Quartz	500-800000
Calcite	1×1012-1×1013
Rock Salt	30-1×1013
Granite	200-10000
Andesite	1.7×102-45×104
Basalt	200-100000
Limestones	500-10000
Sandstone	200-8000
Shales	20-2000
Sand	1-1000
Clay	1-100
Ground Water	0.5-300
Sea Water	0.2
Magnetite	0.01-1000
Dry Gravel	600-10000
Alluvium	10-800
Gravel	100-60

This geoelectric research was carried out at Mount Tunak, Mertak Village, Pujut District, Central Lombok on Sundays and Tuesdays, September 16th and 18th, 2018. Geological information of this area is taken from Wafid et. Al (2014). The electrode configuration used in this geoelectric survey is a 2-dimensional geoelectric Wenner configuration with a spacing of 5 meters and a line length of 200 m which was carried out at 2 survey locations to obtain current data (I) and voltage (V) which will then be processed to obtain the resistivity of each layer below the surface.

After the current (I) and voltage (ΔV) data are obtained, then the data is processed using the Res2div® software to get an overview of the surface material so that it can be determined whether there is a groundwater carrier layer (aquiver) at the survey location.

RESULT AND DISCUSSION

From the results of data taken from location as shown in figure 1, with coordinates shown in Table 2, than be processed using Res2Div on 2 measured lines, a cross-section of line 1 and 2 is obtained as shown in Figure 3 and Figure 4, then from the cross-sectional display the image can be interpreted according to the color scale.

Table 2. Geodetical position of survey location

Sounding	Coordinates (UTM)	Elevation (m)
Line 1	L1-1 (431342.9012708), L1-2 (431260.9012528)	33. 32
Line 2	L2-1 (431585.9013119), L2-2 (431432.9012996)	30. 27

Figure 2. Map of Survey Location

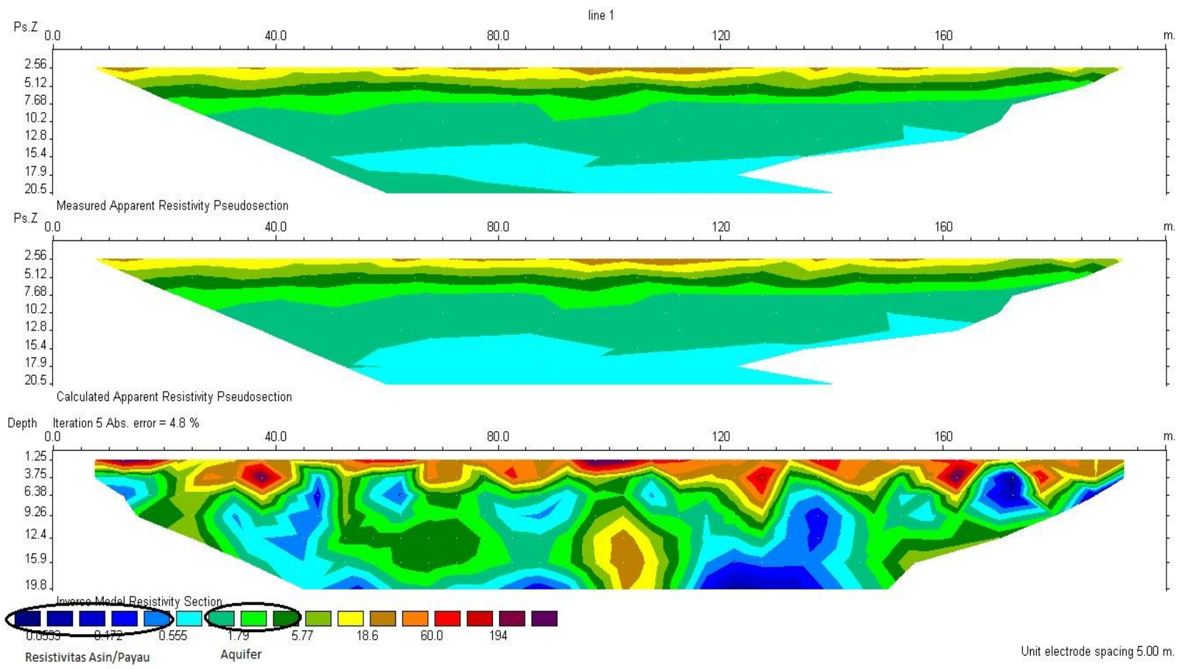

Figure 3. Res2Div Processing Results of Line 1

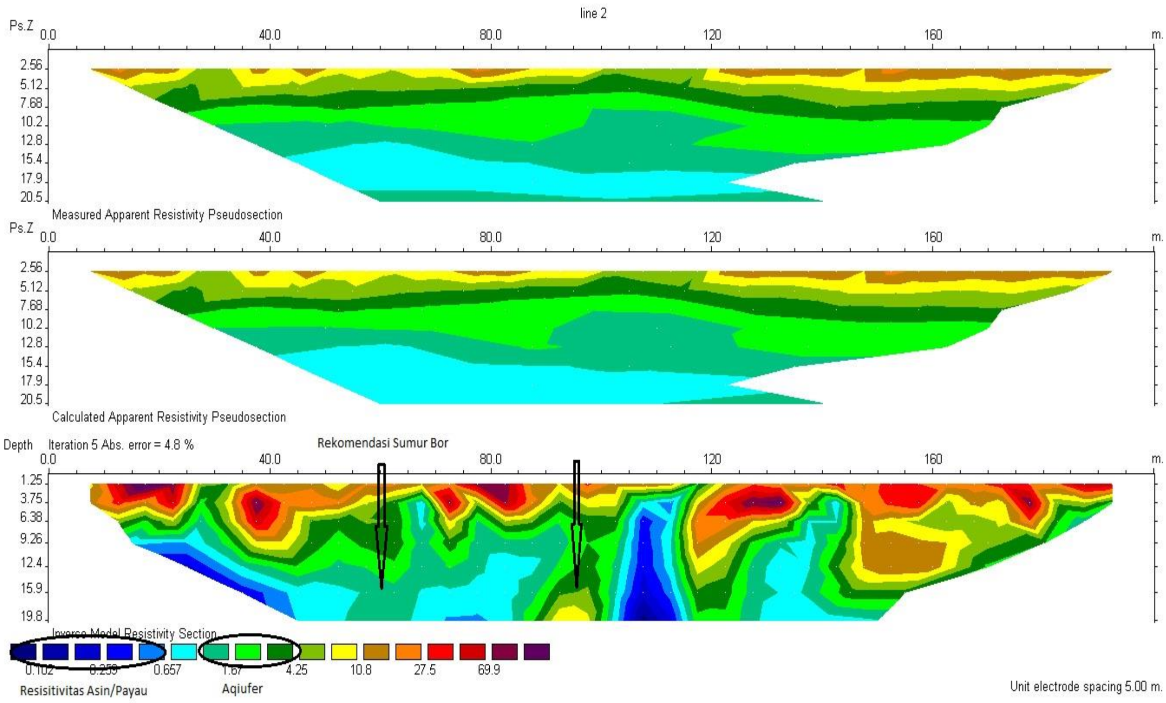

Figure 4. Res2Div Processing Results of Line 2

In Figure 3 the horizontal direction shows the electrode spacing which is 5 m apart while the vertical shows the depth of the subsurface. From the results of data processing, the distribution of rock resistivity values is 0.053 – 194 Ohm-m, in the figure it can be seen the distribution of rock resistivity values indicating a layer containing salty/brackish water with a resistivity value of 0.053-0.555 Ohm-m with the carrier layer interpreted as sand imaged in blue scattered throughout the line. The aquifer layer is indicated by a resistivity value of 1.79 - 5.77 Ohm-m with the carrier layer being clay sand, which is imaged in green at a position of 70 m from the line with a depth of about 15 m and below it is limited to a layer containing salt water.

Figure 4 shows the distribution of rock resistivity values on line 2 with a rock resistivity value of 0.053 – 194 Ohm-m, from the picture it can be interpreted that rocks containing salty/brackish water have a resistivity value of 0.102-0.657 Ohm-m with the carrier layer being sand with colored sand. Blue and the aquifer layer is interpreted as having a resistivity value of 1.67 - 4.25 ohm-m with the carrier layer being clay sand at a position 60 m and 95 m from the line with a depth of more than 20 m and not limited to a layer containing salt water underneath.

CONCLUSION

From the results of the geoelectric survey in the Gunung Tunak area, it can be concluded that: The distribution of resistivity value on line 1 is between 0.053 - 194 Ohm-m, and line 2 is between 0.102-69 Ohm-m. On line 1, the salty water carrier layer with resistivity between 0.053-0.555 Ohm-m is almost evenly distributed throughout the line and aquifer with resistivity between 1.79-5.77 Ohm-m is located at a position of 70 m from the line with a depth of 15 m and below that is a presence of salty water. On line 2, the salty water carrier layer with resistivity between 0.102-0.657 Ohm-m is almost evenly distributed throughout the line and aquifer with resistivity between 1.67-4.25 Ohm-m is found at positions 60 m and 95 m from the line with a depth of more than 20 meters and below there is no layer of salty water. To obtain more complete information about the presence of groundwater in the estimation area, it is necessary to continue with exploration drilling at the estimation location. If exploration is going to be carried out, it should be carried out on line 2 at a position of 60 m with a depth of about 20-25 m.

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