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Identification Of Liquefaction Slide Planes Using The Geoelectric Resistance Type Method In Balaroa Village

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ABSTRACT

Introduction: Research has been conducted with the title "Identification of Liquefaction Sliding Fields Using the Type Resistance Geoelectric Method in Balaroa Village". This study aims to determine the subsurface constituent rock layers and the position of the sliding plane based on the type resistance data. **Method**: This study consists of 6 measurement tracks with a track length of 150 meters using the *Vertical Electrical Sounding* (VES) method with the *Schlumberger* configuration. Data processing uses the *software* program Progress *version* 3.0 and *ipi2win*. **Results and Discussion**: The results obtained indicate the presence of subsurface constituent layers, namely: Passive clay, clay sand, and gravel, and the presence of an inclined plane of 25° to 55.5% with a steep slope. **Conclusion**: Based on data analysis and interpretation, it can be concluded that the rock lithology at the study site consists of passive clay, clay sand, and gravel, based on the value of specific resistance. The slope of the sliding plane layers that have the potential to trigger landslides and liquefaction at the site tends to be west-east with a slope angle of 25°, or 55.6%, which is included in the steep slope category

1. Introduction

The earthquake that occurred in Central Sulawesi on September 28, 2018, caused damage and other disasters such as tsunamis and liquefaction in several places in different regions [1]. The earthquake with a magnitude of 7.4 centered in Donggala Regency at a distance of 80,000 m, northwest of Palu City occurred due to tectonic activity of the Palu-Koro Fault. The activity is in the form of a change in the fault structure with a horizontal direction that causes a tsunami in Palu Bay and liquefaction in several places, one of which is in Balaroa Village [2]. The loss of strength in saturated or partially saturated soils caused by seismic vibrations or sudden shifts is known as liquefaction [3]. This situation is caused by cyclic loading so that the pore water pressure increases past the vertical stress [4]. The result of the liquefaction phenomenon is the movement of soil both vertically and horizontally which causes material losses, property, and casualties [2].

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The area that experienced liquefaction in Balaroa Village was ±345,000 m² [2]. The direction of land movement due to liquefaction was southwest and then changed to the south. Land movement caused by the instability of soil or rock that forms a slope, which causes the mass of soil, rock, or a combination of both, to move down or out of the slope after liquefaction occurs [4].

The area of liquefaction in Balaroa has 2,895 damaged and destroyed buildings caused by the ground movement that occurred [5]. The surface layer of the Balaroa Kelurahan area is composed of Alluvial fan deposits dominated by sandy material with igneous rock fragments, phyllites, and schists of pebble to boulder size. The resistance value of this type of Alluvial fan sediment varies, which is thought to be related to fragment size and water content. For this reason, it is necessary to make efforts to reduce disaster risk, one of which is knowing the point of the prone zone of land movement in the Kelurahan [6]. Factors that cause the occurrence of sliding fields can be identified by conducting detailed and thorough geophysical measurements. The resistivity geoelectric approach is one of the geophysical techniques that can be applied.

The geological condition of the research location plays an important role in estimating the subsurface conditions of the area under study. The research location is in Balaroa Village, West Palu Subdistrict, Palu City. The rock formations found in the research location are Mollasa Celebes Sarasin and Sarasin (*QTms*). This formation consists of conglomerate, sandstone, mudstone, sandstone, and marl [6].

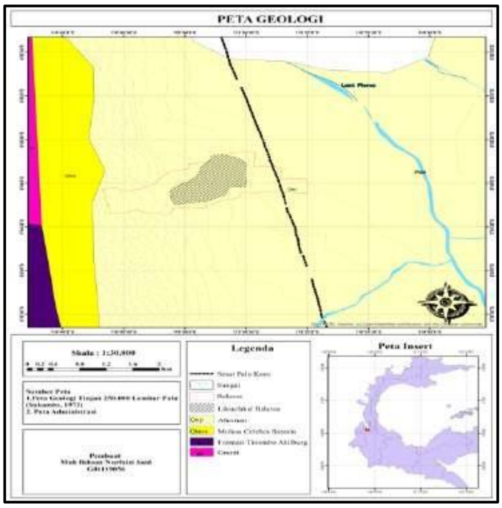

Fig. 1 Geologic map of the study area and its surroundings

The type resistance geoelectric method is one of the geoelectric methods used for subsurface investigations by utilizing the nature of electrical flow under the earth's surface and how to detect it on the earth's surface. The discussion of the earth's electricity, according to its nature, tends to discuss the electrical properties of the earth [7]. The type resistance method is also one of the best methods for determining the subsurface layer accurately at a low cost [8]. Each rock has different geological structures, lithology of rock types, different slopes that will affect the shear plane which causes landslides to occur later. In this case, the electrodes used are based on the configuration used in the field, the electrodes used as current and potential in this case are known several types of configurations including Schlumberger, Wenner, and Dipole-dipole configurations [9].

Geoelectric methods with *Sounding* or *Vertical Electrical Sounding* (VES) techniques are commonly used to study the value of subsurface-specific resistance *horizontally* [10]. The VES method is an effective 1-D geoelectric method to see the value of specific resistance and the depth of each layer vertically [11]. The advantage of this VES geoelectric method is to detect the presence of subsurface rock layers by comparing the value of specific resistance [12].

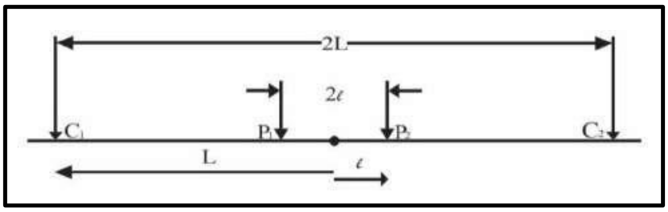

Fig 2. The Electrode Array Of Schlumberger Configuration

Referring to the distance between electrodes, the geometry factor in the Wenner-Schlumberger configuration can be formulated as follows [4]:

The geometry factor for the *Schlumberger* Configuration can be formulated:

$$K = \frac{p(L^2 - l^2)}{2l}$$

2. Research Method

The research site is located in Balaroa Village, West Palu Subdistrict, Palu City, Central Sulawesi Province located at position 119°50'0"-119°51'10" East 00°54'0" - 00°54'30" LS. To clearly see the condition of the research location, it can be seen in Figure 3.

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Fig 3. Map of the research site and its surroundings

The research is located in Balaroa Village, West Palu Subdistrict, Palu City, Central Sulawesi Province. Geo-electrical measurements of specific resistance were carried out to determine the image of the subsurface layer in the research area. Each track has a different stretch length according to the conditions in the field. Track 1 is 150 m long, track 4 is 125 m long, and tracks 2, 3, 5, and 6 are 100 m long. The position of track 1 is located in the Balaroa liquefaction area; tracks 2, and 4 are located near the highway; tracks 3 and 5 are located in the Residential Area.

3. Results and Discussion

The results of field observations and the geological conditions of the research area for the soil surface at the location are dominant clays which are in very dry conditions in the field and there is a swamp in the central area. In the central to eastern part of the study area, several points have puddles.

Based on the analysis of the type resistance value, it is interpreted that there are 3 types of rock lithologies that make up the research location with a type resistance value between 14 Ωm to 1347.46 Ωm. The three rock lithologies consist of; Passive clay, Sand clay, and *Gravel.*

The rock lithology in the Balaroa liquefaction area on the right is the lithology of the rocks that make up the research site, namely: Passive clay, clay sand, and Gravel or gravel, which are samples obtained in the research area. The results of the rock samples were obtained from research conducted by [13] The position of the drill point is in the west of the liquefaction area and the eastern part of the Balaroa liquefaction area and rock samples were obtained, namely in passive clay, namely clay sand and namely Gravel or gravel.

Table 1. Rock Lithology Based On Type Resistance Data

Material	Color	Specific Resistivity Value (Ωm)
Sandy Clay	Green	14 – 100
Loamy Sand	Yellow	100 – 500
Gravel	Orange	500 – 1400

1. West-East Lithologic Cross-Section of Barriers

West-East Lithologic Cross SectionThe west-east (B-T) cross-section in Figure 4 shows the correlation of 3 measurement points, namely: points L5, L1, and L6. The cross-section stretches from the west (B) of point L5 to the east (T) of point L6 (N 60°). Based on the visualization of the cross-section, 3 layers were obtained, composed of 3 rock lithologies, namely sandy clay, sandy clay, and gravel. at point L5, 2 layers with a measured height of 76 m were obtained, at point L1, 2 layers with a measured height of 33 m were obtained. At point L6 2 layers with a measured height of 24 m. Based on the visualization of the B-T cross section in the measurement, the direction of the layers follows the surface contours and tends from the west (B) of point L5 to the east (T) of point L6 (N 60°E). In the West-East cross-section, the lithology is arranged in harmony between sandy clay and clay sand and stops in the east where the presence of clay sand is replaced by Gravel at a depth of 100 meters. Where this slide field is known to be the value of the vertical distance of 110 m (depth), the horizontal distance is 178 m and the slope distance is 175 m, then the slope percentage is obtained which is 25 ° to 55.5% with the slope obtained being a steep slope. This is supported by the geological map of Palu, Central Sulawesi, scale 1:250,000."[6]

The geological map of Palu shows that the area is dominantly composed of Mollasa Celebes Sarasin and Sarasin rock formations (QTms). It is composed of Conglomerate, sandstone, mudstone, coral limestone, and marl. The ground surface condition at the site is very dry and dominated by Pasir loam. Based on Figure 4.8 and referring to (2.1) the equation in determining the slope of the slope [7].

In the western and eastern lithologic areas, the vertical distance is 67, the horizontal distance is 138 and the slope distance is 153, so based on these values, it can be known that the slope of the sliding plane is 25° to 55.5%. This slope according to Van Zuidam is included in the steep slope category.

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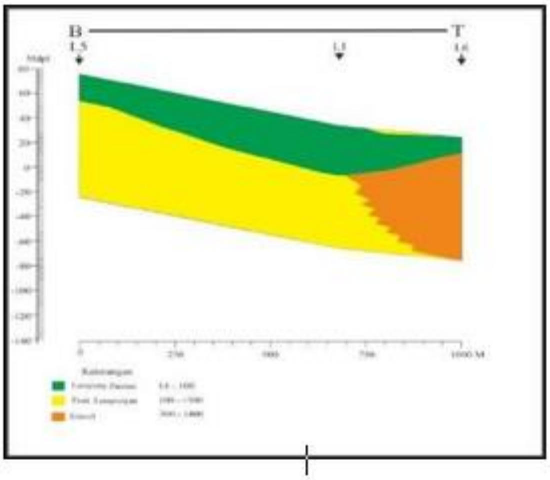

Fig 4. Cross Section Of Lithology In The Direction Of West-East

2. North-South Lithology Cross Section

The north-south cross section is composed of 2 rock lithologies, namely sandy clay and clay sand. In the North-South (U-S) cross-section, the lithology is composed of a mixture of sandy clay and clayey sand. There is no slope in the north-south cross-section.

The cross-section of the North-South modeled type resistance in Figure 4.9 shows the correlation of the 3 measuring points namely: L4, L1, and L3. The cross-section of the North-South (U-S) model type resistance stretches from the south (S) of point L4 to the north (U) of point L3 (N 10°E). Based on the visualization of the cross-section, 3 layers are obtained in the cross-section, the first layer is loamy sand, the second layer is passive clay, and the third layer obtained is clay sand. At point L4, 2 layers were obtained with a measured height of 23 m. At measuring point L1, 2 layers were obtained with a measured height of 33 m. At point L3, 2 layers were obtained with a measured height of 32 m. Where in the North-South cross-section, the sliding plane layer has not been seen in that direction due to the absence of granite or bedrock which is thought to be the carrier layer of the sliding plane. This is also seen by the topography of L4 23 m, L1 33 m, L3 32 m.

This assumption is supported by the geological map of Palu, Central Sulawesi, scale 1:250,000.[8] The geological map of Palu shows that this area is dominantly composed of Mollasa Celebes Sarasin and Sarasin rock formations (QTms) composed of Conglomerate, sandstone, mudstone, Coral limestone, and marl. The soil surface condition at the site is very dry and dominated by pair loam.

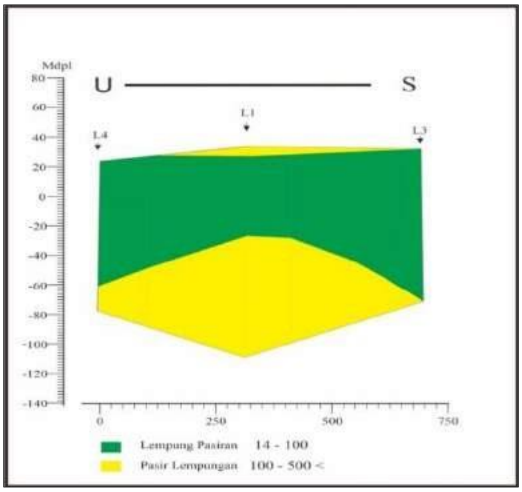

Fig 4. The Soil Surface Condition

4. Conclusion

Based on the results of the analysis and interpretation of research data, it can be concluded that based on the value of the type of resistance, it can be known that the rock lithology that composes the research location, namely; pasiran clay, clay sand, and gravel. The slope of the sliding plane layers that helped trigger landslides in the liquefaction event at the research location tends to be west-east with a slope of 25 ° or 55.6% with a steep slope category.

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