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DISCONTINUITY AND SLOPE STABILITY ANALYSIS BASED ON GEOLOGY STUDY AND ELECTRICAL RESISTIVITY MEASUREMENT

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ABSTRACT

Solok Regency is rich in natural resources, which is evident from the number of mining activities in this area (exploration and production). In Sub Sumiso district, an iron mining company has been has been in production stage for decades. The mining products are transported to ports using access point that is also used by public. This access point has a landslide risk. To prevent the landslide, there is a need to conduct a study to determine areas prone to landslides. Therefore, we conduct geological and geophysical studies in areas that potentially has weak planes and unstable slopes. The geophysical methods used in this study are electrical resistivity method with dipole-dipole electrodes configuration. The results from this study can be used by decision makers to improve safety along the areas used to transport mining products in Solok Regency.

Keywords: *Slope Stability, electrical resistivity, Safety Factor*

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INTRODUCTION

Assessing landslide risk is essential to improve road safety in transporting mining products from mining area to ports, where they will be delivered to clients. In this study, we conduct geological and geophysical analysis to comprehend the risk of landslide hazards in Solok Regency. The results of geological studies are useful to help analyse the results of electrical resistivity measurements.

The measurement results are illustrated in electrical resistivity cross-sections identified as line K to O. The electrical resistivity measurements were conducted using dipole-dipole electrode configuration with a total length of 1.5 km. This length was covered by 5 tracks with South to North direction. The location of tracks spanned from Rangkiang Luluih to PT. Darma Power Bersama site (Figure 1). In individual track, the electrode spacing varies from 5 m to 20 m with a total length of 300 m. The measurement geometry was also used by other studies [1] [2] [3] [4] [5].

METHODOLOGY

Electrical Resistivity Method

The electrical resistivity method is an active and non-destructive geophysical method used for shallow exploration and determining subsurface layers. Ohm's law is the basis of the resistivity method. The resistivity is calculated using Equation 1 below, assuming that the subsurface medium is homogeneous isotropic [6]

$$\rho_a = kR \qquad (1)$$

Where ρ_a indicates apparent resistivity of subsurface (ohm), k represents the geometric factor of the electrode configuration, and R is resistance of electrode to subsurface materials (Ω). Equation 1 can be modified by including the geometric factors of dipole-dipole electrode configuration.

$$\rho_a = 2\pi n(n+1)aR \qquad (2)$$

Where n is number of maximum separations between electrodes and a is electrode spacing (m). The apparent resistivity can be converted to the true resistivity of the subsurface using the inversion method. The electrode shape used in this study is peak electrode. It is assumed that the geometric characteristics of the electrodes has a minimum influence on the resistivity measurement [7].

Geology of Study Area

Regional geology of the study area is shown in Figure 1 [8], which indicates that the study area consists of several lithology types [9], from old to young:

a. Quartzite and quartz sandstones (Figure 2), shales, conglomerates, regionally, which are part of the Lower Formation Kuantan Perm.

b. Batusabak (slate), black shale silicified, phyllite (Figure 3), and thin layer greywacke metamorphic, which are included in the Formation Tuhur Trias.

c. Granite, structure (Figures 4-5) ranges from leucogranite to quartz monzonite, Triassic-aged, gray-green, massive structures, holokristalin, fanerik granular, subhedral, mineral composition of quartz, plagioclase, hornblende.

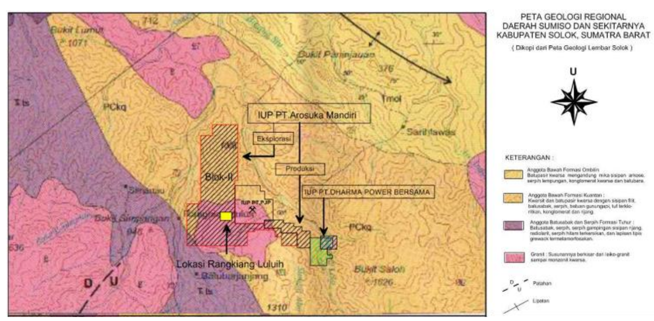

Figure 1. Regional geology map of Solok Regency, where landslide risk assessment was conducted [8]. Rangkiang Luluih and PT. Dharma Power Bersama is also shown by black arrows

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Figure 2. Quartzite Outcrop, which is covered by thick vegetation

Figure 3. Outcrop of Phyllite in Cliff Road Rangkiang Luluih. The outcrop is covered by vegetation.

In addition, apart from granite outcrop, we also found granite boulder, which are interpreted as a result of transportation and are expected not far from their original location because the boulder has an angular shape.

Figure 4. Iron Ore Boulder

Figure 5. Granite Boulder found on the surface in the study area

RESULT

Morphology

The morphology of the study area is shown by elevation map (Figure 6). This area includes the section of track Bukit Barisan Mountains of Sumatera extending Northwest-Southeast. The Bukit Barisan is formed old sedimentary rocks, metamorphic and granitic intrusive rocks. The elevation in this area ranges from 800 to 1100 masl and has a moderate to a steep sloping hills with a slope of more than 20° to 45°. This hilly area is formed by old sedimentary lithologies including quartz sandstone, mudstone, quartzite metamorphic rocks, phyllite, and granitic intrusive rocks.

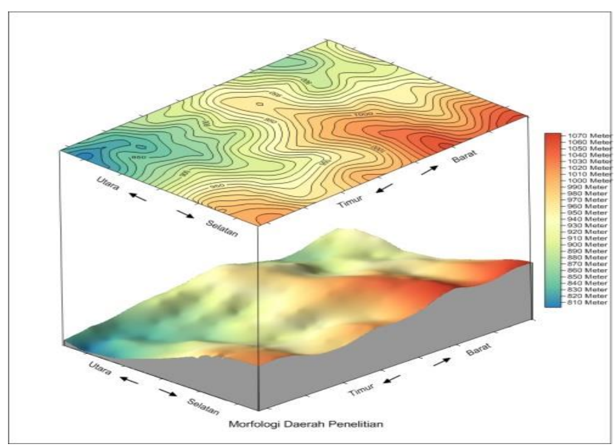

Figure 6. Elevation of the study area, which indicates a hilly area with elevation ranges from 800 to 1100 masl.

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Electrical Resistivity

The result of electrical resistivity measurement is shown in Figures 7-12. These sections show true resistivity of the subsurface, which will used to interpret rock type [10][11][12]. The geological information of the study area will also be used to validate the interpretation as many rock types have a similar resistivity values.

Line K

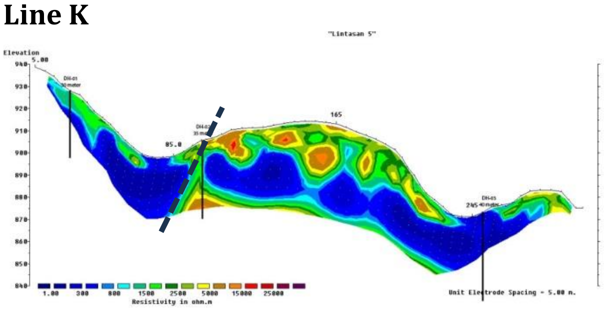

Figure 7. Resistivity of subsurface along Line K. The local fault is shown by diagonal black dashed line.

Line L

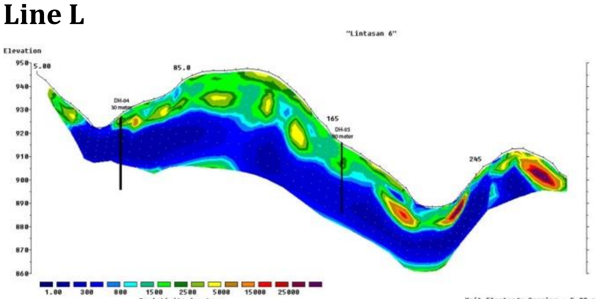

Figure 8. Resistivity of subsurface along Line L

Line M

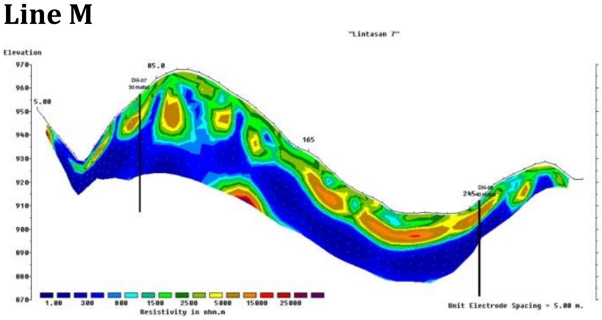

Figure 9. Resistivity of subsurface along Line M

Line O

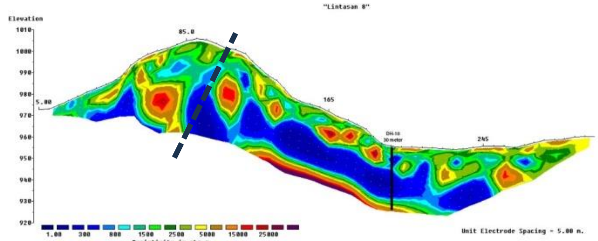

Figure 10. Resistivity of subsurface along Line N. The local fault is shown by diagonal black dashed line.

Line O

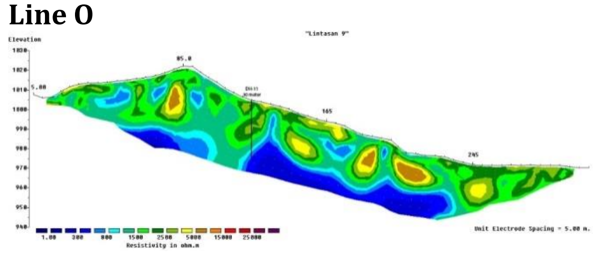

Figure 11. Resistivity of subsurface along Line O

All Lines

z

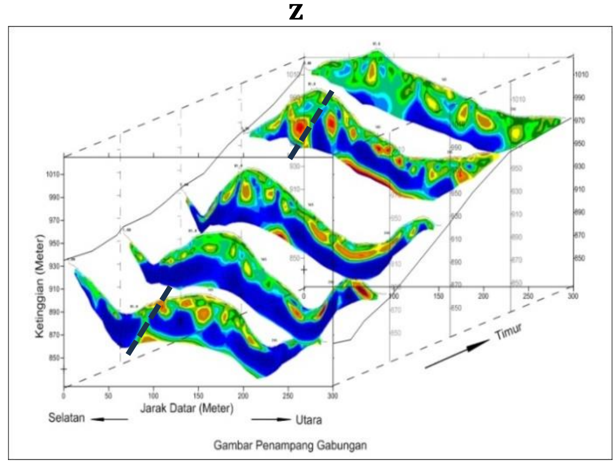

Figure 12. Resistivity cross sections for lines K-O. The local fault is shown by diagonal black dashed lines

The results show high resistivity anomaly near the surface in all lines (Figures 7-12), which is associated with hard rock type. Interpretation of the rock type indicates granite and quartzite rock, which is also found in the surface as granite boulder based on geological survey (Figure 6). In addition, we found a low resistivity anomaly

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below the granite layer, associated with soft sediment in all lines (Figures 7-12). Interpretation shows that this soft sediment is clay. This clay layer is thicker than granite layer.

We also found a local structure in lines K and N indicated by lateral discontinuity of the granite and clay layer (Figures 7 and 10). The local structure is extended towards the East (Figure 12). To improve the interpretation, borehole data is required in several areas along the lines. The rock sample from the borehole can be analyzed in the laboratory to determine the resistivity property of the rock in the study area. In addition, this information can also be used to calculate safety factor in the study area.

There are several factors that influence landslide, most notably are slope, lithology, and vegetation [13]. Although the slope in the study area can be considered as steep (> 30^0), this area is mainly covered by vegetation with strong trunks and roots. This indicates that water infiltration into the soil can be effectively absorbed by the vegetation, reducing over-saturated soil conditions that prone to landslide. In addition, the lithology of study area consists of hard rock that is not easy to move due to gravity. Therefore, we suggest that the study area has a low risk of landslide.

CONCLUSIONS

The geological studies and electrical resistivity measurement indicates that the study area has low risk of landslide. This is supported by the fact that the study area is mainly covered by thick vegetation that can acts as a barrier to potential landslides, despite the present of local fault and relatively steep slope of the study area.

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