

## Availability of the Sangatta Pelangi Hill Slide Using Geoelectric Correlation on the Borlog

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**Abstract:** The earth's surface moves downward from a point in a process known as land subsidence, which causes the elevation of the ground surface to drop or become lower than it was. The geoelectric technique is one way to investigate soil. Depending on the electrical characteristics of the rock, this technique is one of the geophysical exploration methods that can give a generalized (map) of a rock layer or formation and the depth of the rock layers. The goals of this study were to model landslide behavior and identify the soil layers using geoelectric data. The rock or hard soil zone has a high resistivity rating based on geoelectricity. As a result, evidence of topsoil to clay may be seen in Trace 1's rock or hard soil zones, which range in depth from 18.5 to 24.9 tie points and 40 to 120 tie points, respectively. The soil layer is unidirectional and uniform. This geoelectrical value is linear with the results of a soil survey performed using the drilling method, i.e., the soil properties are quite sturdy and strong at a depth of 10–20 meters, with NSPT at a depth of 10–17 and increases at that depth. than 20 m at NSPT 60, and because it has reached twice NSPT 60, this can be considered real rock.

**Keywords:** Geoelectricity, Subsoil, Rock, Geology, Geophysics

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## Introduction

Subsidence as a type of avalanche is a downward movement on the earth's surface from a point so that the elevation of the land surface decreases or becomes lower than before. The occurrence of subsidence is caused by several active and passive factors where these factors are dominated by geological, geomorphological, geohydrological and loading factors.

Seismic, magnetic, gravity, electric, and electromagnetic resistivity are the geophysical techniques that are often utilized in exploration. The geoelectric method is one of the geophysical exploration techniques that may be used to investigate a geothermal system's properties, determine the lithology of rock strata, locate reservoirs, analyze flow patterns, and map the distribution of geothermal fluids under the earth's surface (Efendi, 2022).

One method that can be used to investigate subsidence is the geoelectric method. This method is one of the geophysical exploration methods that can provide an overview (map) of a layer or rock formation and layer of the rock formation build upon the electrical for rock properties. In relation to subsidence, the geoelectric method can provide an overview of subsidence as a weak zone with electrical properties in the form of specific resistance and certain chargeability. (Broto, 2008; Musa & Murniasih, 2021; Riskawati & Abdullah, 2021).

In this research, soil type boundaries are identified at a certain depth by utilizing geoelectric as a tool to display the color of each layer of soil.

## Methods

Measurement of geoelectrical variable values of rock layers was carried out using the Schlumberger configuration geoelectric method using the Resistenza geoelectric tool, Resistivity Meter, Type Gliv-100. *Resistance, Resistivity Meter, Type Gliv-100* is a multichannel measuring instrument equipped with 48 electrodes. Measurements are carried out at each sounding point with a fixed potential electrode spacing and a maximum spacing of  $n$  times the magnification factor on each line.

After the measurement results (potential and electric current in rock) are obtained, calculations can be made to obtain the apparent resistivity and chargeability values for each measurement line using equations. Then, the calculated apparent resistivity value is processed using the `res2dinv` program to get an image (map)

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of the rock layers in a 2-D (two-dimensional) view. (Abdulaziz & Faid, 2017; Adeyemo et al., 2017; Broto, 2008; Musa & Murniasih, 2021; Riskawati & Abdullah, 2021).

This study uses the LEM (Limit Equilibrium Method) for analysis, it has been carried out since the mid-1930s. Since then, many boundary balance methods have been developed and some are still used in general. limit is the use of equilibrium conditions. Some conditions are satisfied for force balance and moment balance while other methods satisfy only one of them. In other words, some methods only take into account normal forces while other methods take into account normal forces, tangential forces and also inter-slice forces. Therefore only a few methods meet the actual conditions in the field. Bishop's method developed in the 1950s is based on moment equilibrium. This method is calculated by approaching the surface of the collapsing plane surface considered to be circular. Other methods such as the simplified Janbu method are based on force equilibrium conditions, this method is very suitable for layered soil conditions. (A. W. Efendi, 2022; Nasvi & Krishnya, 2019).

The balance method generally takes into account the balance of forces and the balance of moments, as well as the inter-slice forces (normal forces and tangential forces) that apply to all surfaces of the shear plane. Among all the slice methods the most common are the Morgenstern-Price method and the Janbu method. In this method all shear masses are divided by the number of slices and the inter-slice forces are calculated based on the assumption of a fungus relationship between the slices. The final calculation of the security number is calculated by iterating.

At this time, with the rapid advancement of computers, slope stability calculations can be done more easily using the finite element method (FEM). The use of the finite element method has been widely used in geotechnical engineering. In this study, the boundary balancing methods and the finite element method will be applied, and the results will be compared.

The most fundamental thing that distinguishes between the LEM and FEM methods is that in the LEM method many assumptions must be made such as the shape and location of the failure, the direction and force between the slices. Figure 1.1 shows the failure plane assumptions made in the equilibrium method (Carbonell et al., 2022, 2022; Dayarathne et al., 2022; Nasvi & Krishnya, 2019; Sasmal & Behera, 2018; Wang et al., 2022).

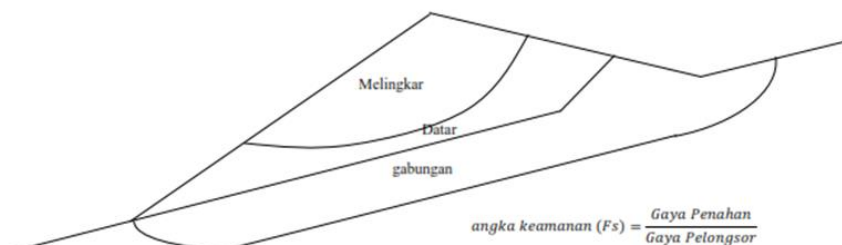


Figure 1. Surface Forms of Landslides

## Result and Discussion

Several methods, including the Boring method (SPT), the Sondir method (CPT), the geoelectric method, the Georadar method, and several methods using geophysical instruments, can be used to identify soil types and conduct soil investigations in accordance with previous studies and governmental regulations. One of the methods used to swiftly and instantly determine soil layers is geoelectrical. (Broto, 2008; A. E. W. A. W. Efendi, 2019; Musa & Murniasih, 2021).

The first step in exploration after determining the location of data collection is measuring the topographic profile along the measurement line and setting the electrode spacing. Topographic profile measurements were carried out on 150 meters, 150 meters and 20 meters long tracks using measuring instruments. point coordinates geoelectric trajectory is 0°32' 07.6" N; 117°36' 13.2" E.

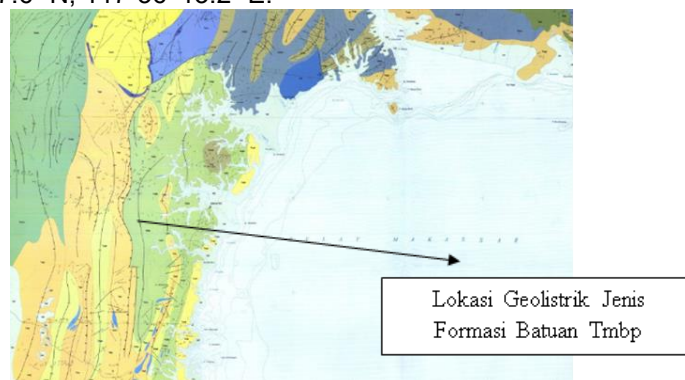


Figure 2. Geological Map of Sangatta

The Sangatta Rock Formation is a category of Balikpapan formation TMB consisting of jackstone, loam, alluvium, volcanic ash and coke. Alternately silica sand, loam and silt, it shows a traverse structure of silurs with waters. In the local area it contains coal inserts with a thickness of between 20 – 40 cm. gray clay, brittle, containing muscovite, bitumen and iron oxide. Fossil content consists of; annular ring, Cycloclypeus fossil other shellfish fossils. The thickness of formation is until 2000 meters with a deltaic plain depositional environment. This formation is overlapped in harmony with the Kampungbaru formation.

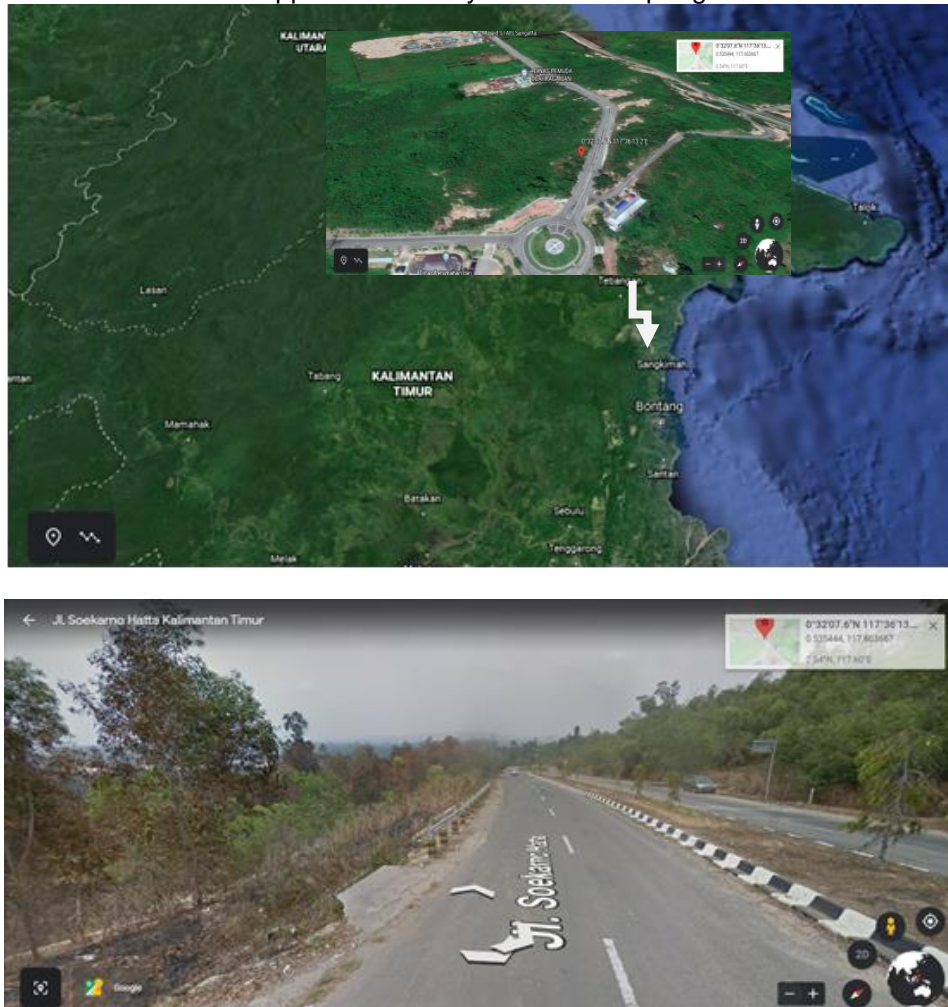


Figure 3. Geoelectric Location, Bukit Pelangi Sangatta

The soil investigation survey carried out is a soil investigation using boring and using geoelectricity, for boring with data using the B-02 borlog point where the location of the landslide safety building is placed.

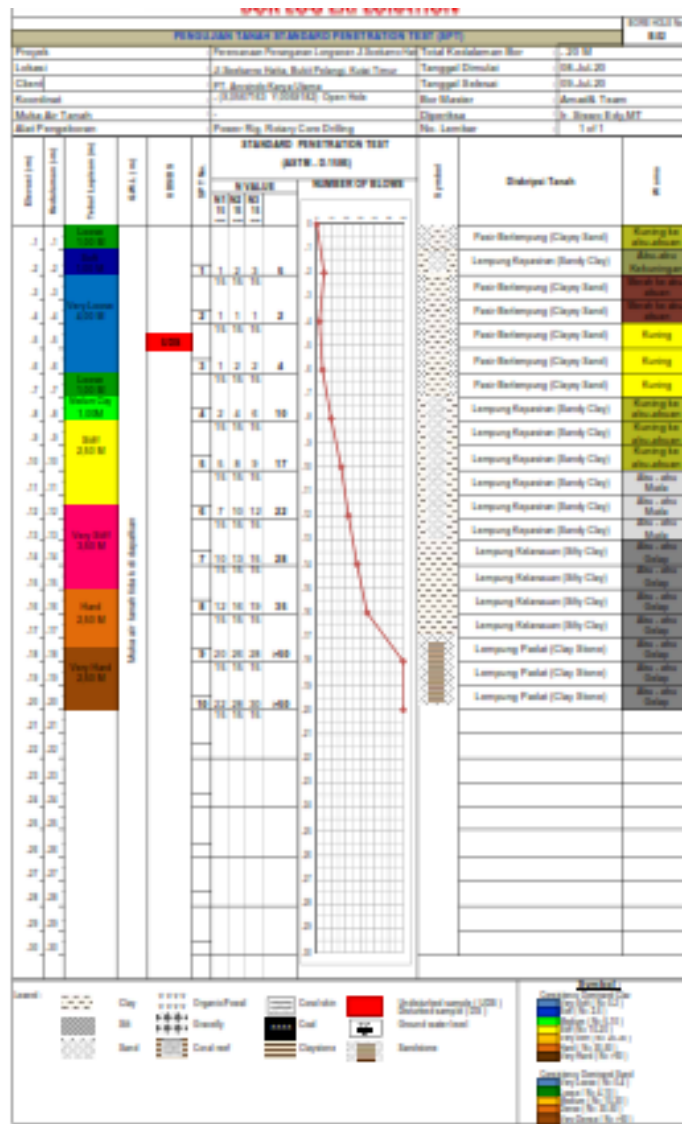


Figure 4. Borlog results from the boring method of soil investigation, the Bukit Pelangi Sangatta section

Table 1. Soil parameters as a result of the investigation of the boring method

Kedalaman (meter)	Jenis Tanah	Berat volume (kN/m <sup>3</sup> )	Nspt rata-rata	EFEKTIF STRESS		EFEKTIF STRESS	
				c=cu=4,5N (kN/m <sup>2</sup> )	phi (o)	c(kN/m <sup>2</sup> )	phi (o)
0	Pasir berlempung NSPT 2-4	16	4	18	0	20	20
6	Pasir berlempung NSPT 4-10	17	7	31.5	0	26	21
8	Lempung Kerasiran NSPT 10-22	18	17	76.5	0	44	25
12	Lempung Kelanauan NSPT 22-28	20	29	130.5	0	48	25
16	Lempung Padat NSPT >50	21	52	306.8	0	105	31
20							

**Inversion Modeling**

The values of apparent resistivity and apparent chargeability of rock layers are arranged based on the data format in the notpad program. The data format is opened and processed using the res2dinv program with the inversion modeling method. The results of the inversion modeling of each path are a description of the distribution of resistivity and chargeability values of rock layers in a two-dimensional (2-D) view as follows.

Weak Zone Analysis (Subsidence) I. Trajectory

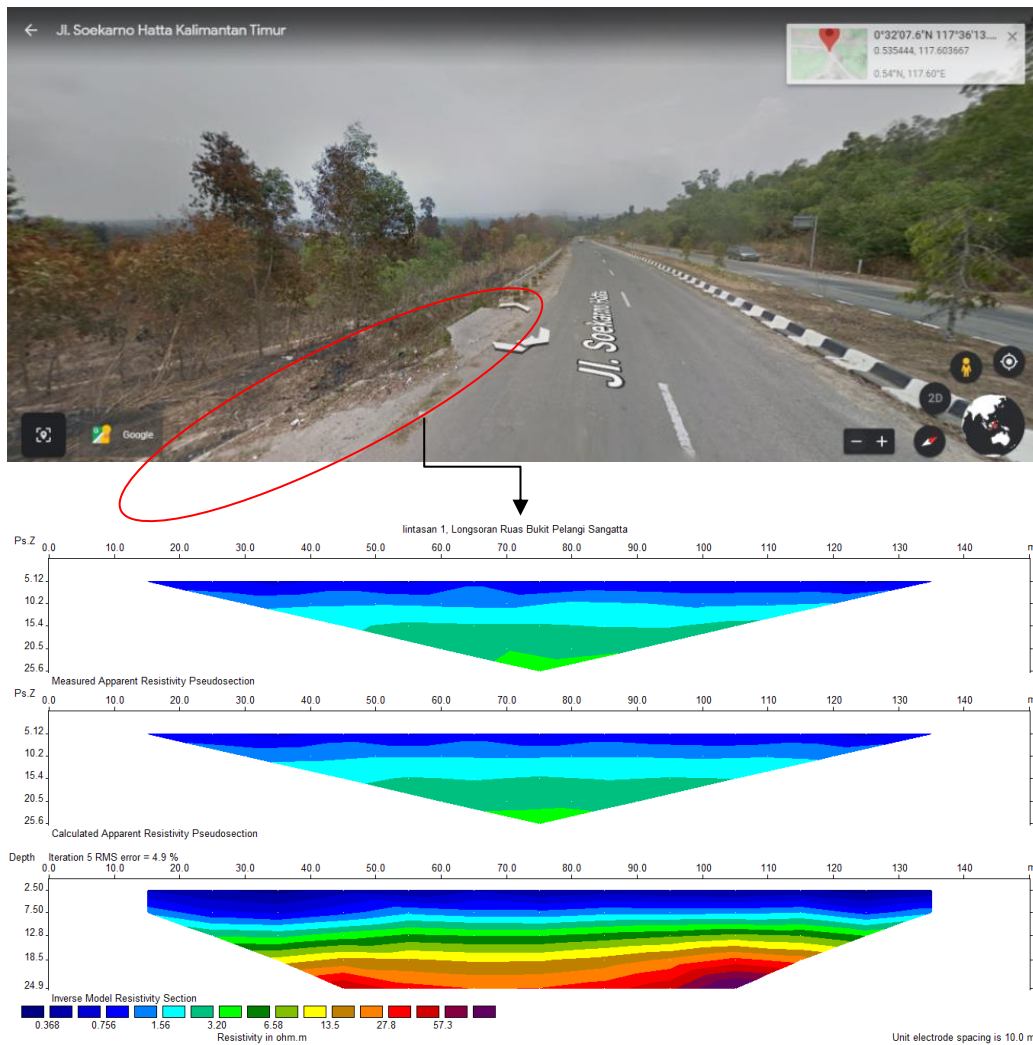


Figure 5. (a) Location of Track Zone I (b) Results of Track I. Analysis

Based on geo-resistant weak zone (subsidence) has a low resistivity value (<10 .m) and low chargeability (0-20 msec). Thus, the results of the analysis of the weak zone (subsidence) in each track 1 are weak soil/puddles/mud (salty) in the area of the 0-150 span point track 0 to 12.8 m depth.

Based on geo-resistant, hard rock or soil zone has a large resistivity value (> 57.3 .m). Thus, the results of the analysis of rock zones or hard soils on track 1 have Topsoil to clay indications in the 40-120 span point area, 18.5 to 24.9 depths. The soil layers are uniform and unidirectional.

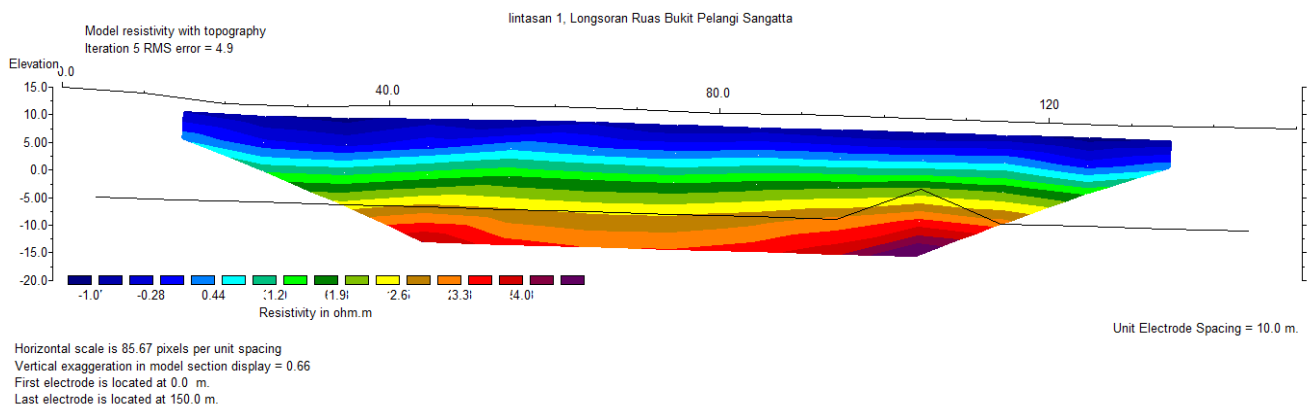


Figure 6. Hard Rock Zone I. Trajectory

Bedrock zoning on the 0-95 m path from -6.00 elevation on the 95-115 m path up from -6.00 to 0 elevation and down again at 6 elevations on the 120 m track.

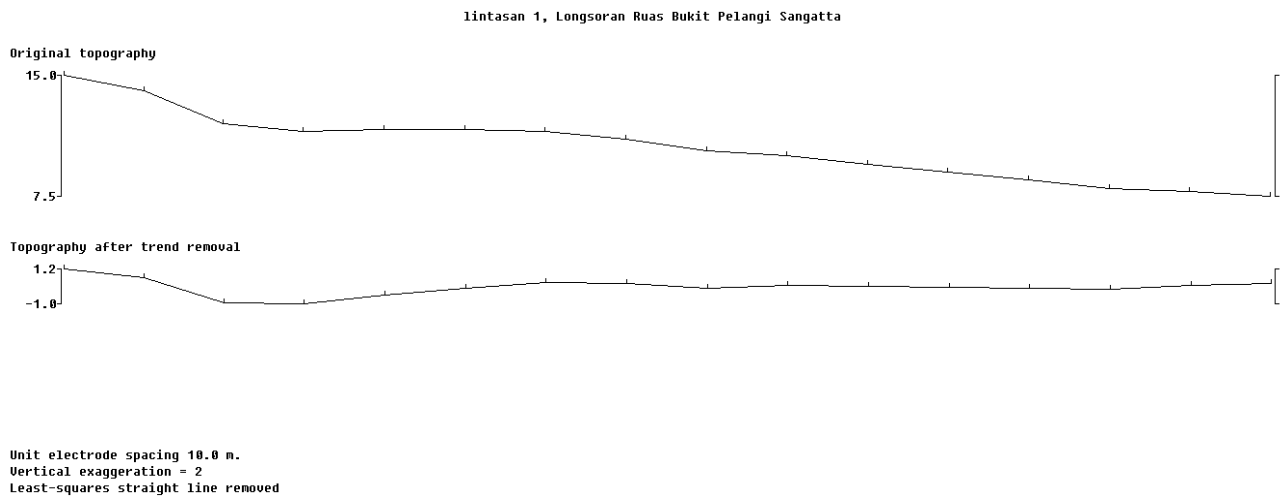


Figure 7. Topographic Flow of Path I

**Weak Zone Analysis (Subsidence) Track III**

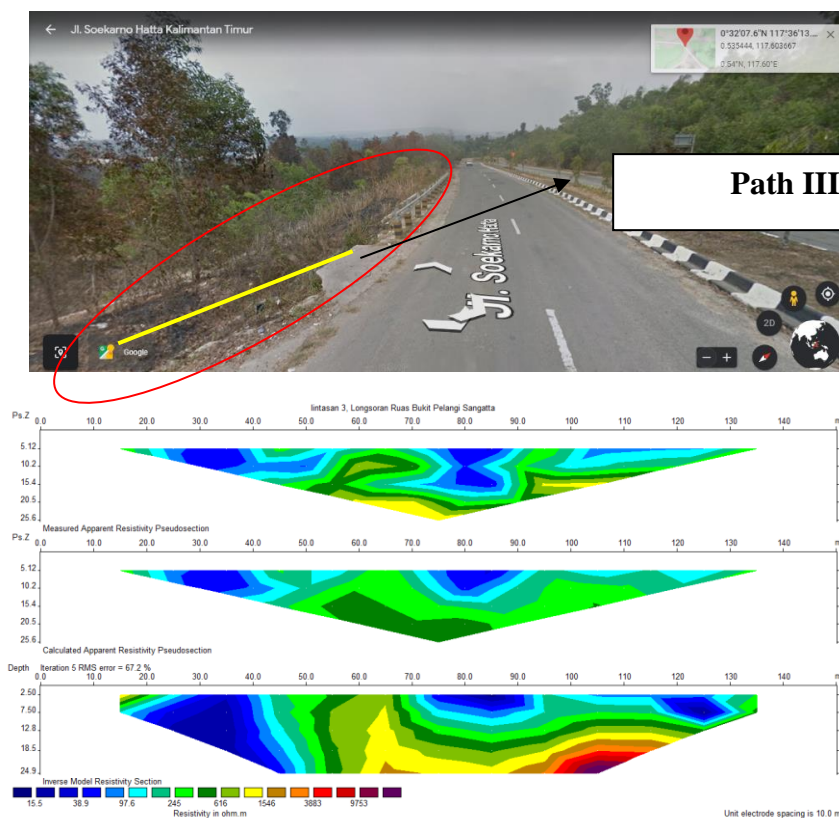


Figure 8. (a) Location of Track Zone III (b) Results of Track III Analysis

Based on geo resistant, weak zone (subsidence) has low resistivity value ( $< 10 .m$ ) and low chargeability (0-20 msec). Thus, the results of the analysis of the weak zone (subsidence) on each track 3 are weak soil/puddles/mud (salty) in the area of the 0-40 span point trajectory 0 to 24.9 m. In the track area the span point is 70-90, the depth is 0 to 7.5 m. And in the trajectory point spans 120-130 depth 0 to 12.8 m.

Based on geo-resistant, hard rock or soil zone has a large resistivity value ( $> 9753 .m$ ). Thus, the results of the analysis of rock zones or hard soils on track 3 contain Limestone to Greenstone indications in the 90-120 span point area with a depth of 18.5 to 24.9. The soil layers are varied and not in the same direction.

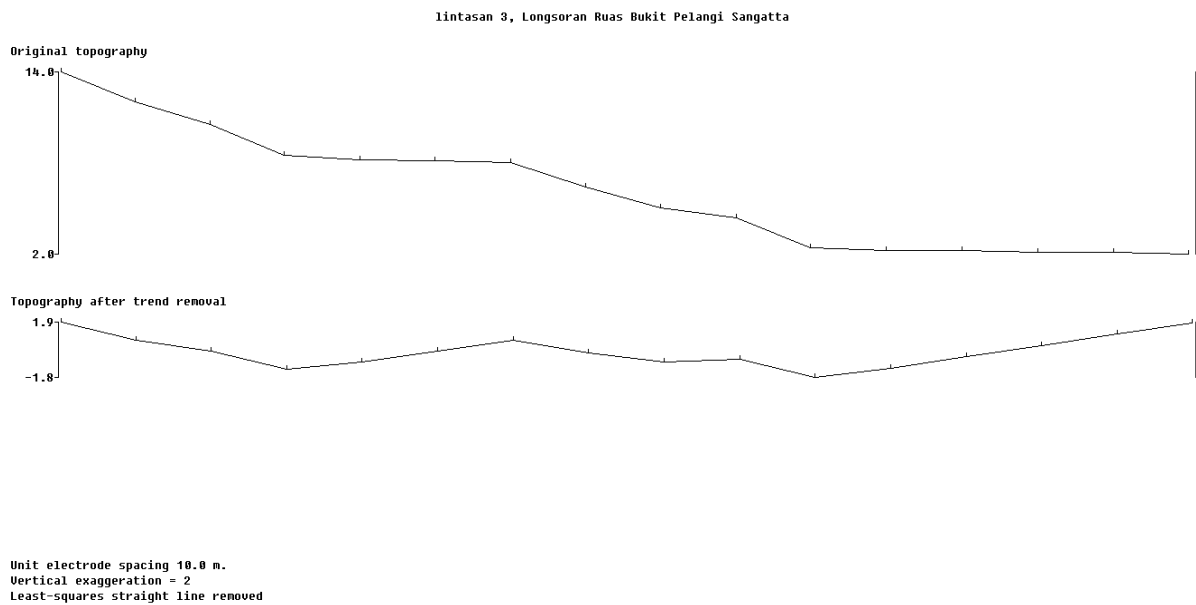
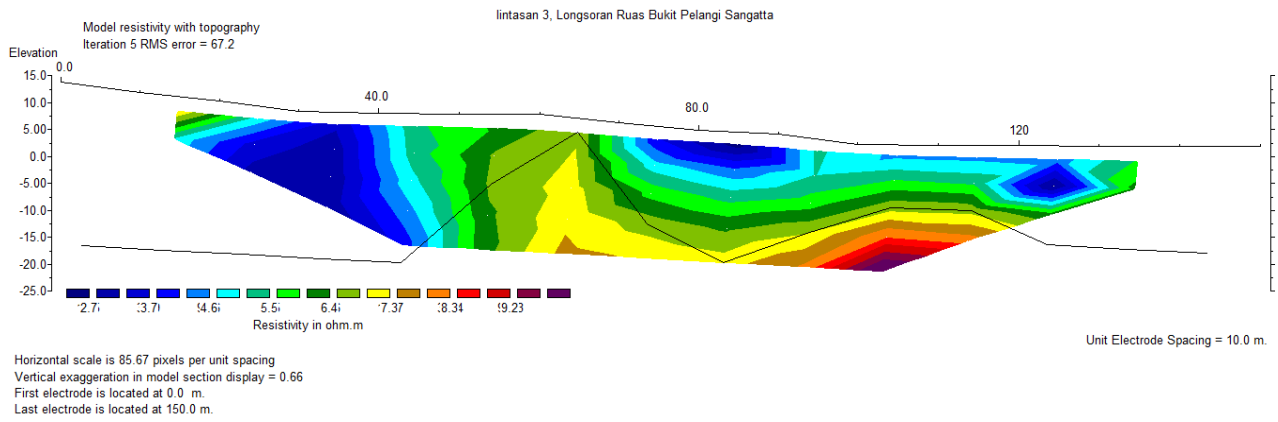


Figure 9. (a) Hard Rock Zone of Track III (b) Topographical Channel of Track III

**Modeling with LEM**

The use of LEM in landslide analysis in the Bukit Pelangi area uses the help of the LEM application using surface geometry data according to topographic results and soil layer geometry/soil stratigraphy using geoelectric results by conducting soil parameter data from correlation results with soil investigation results using boring which produces NSPT values for each subsoil.

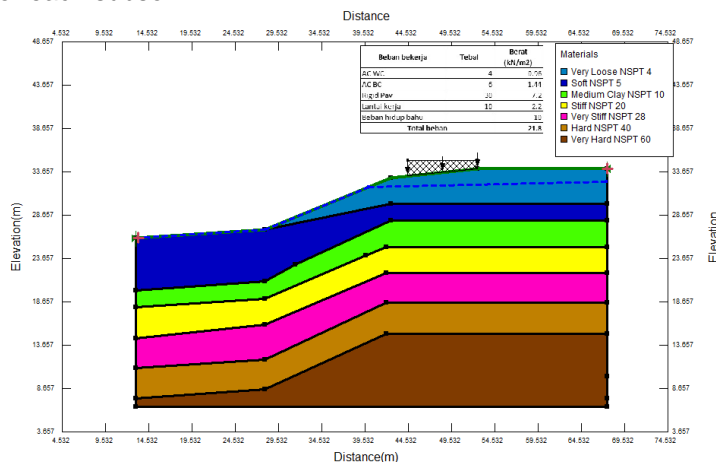


Figure 10. LEM modeling of the area under review

The load used is the standard load on the highway, which is 21.8 kN/m<sup>2</sup>. And the results obtained are the occurrence of ground movement in accordance with the results of the geoelectric analysis that there is a sliding area zoning.

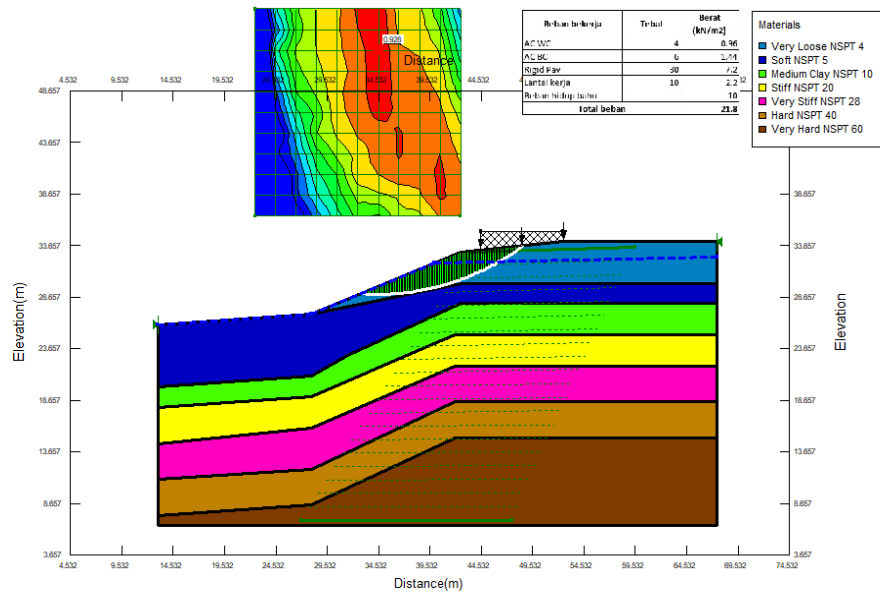


Figure 11. Results of analysis and zoning of sliding areas

## Conclusion

From the results of the borlog data of soil and geoelectric investigations, it can be concluded that there is a linear correlation between the results of the two soil investigation methods, where in the weak zone (subsidence) has a low resistivity value and low chargeability, the results of the analysis of the weak zone (subsidence) on each track 1 are found. weak soil/waterlogging/mud (salty) in the area of the track span point 0-150 depth 0 to 12.8 m. The value of this geoelectric result is linear with the results of soil investigations using the boring method, namely at a depth of 0 to 8 meters, the soil characteristics are quite weak where the NSPT is below the NSPT value of 10.

Based on geoelectricity, the zone of rock or hard soil has a large resistivity value. Thus, the results of the analysis of rock zones or hard soils on track 1 have Top Soil to clay indications in the 40-120 span point area, 18.5 to 24.9 depths. The soil layers are uniform and unidirectional. This geoelectric value is linear with the results of soil investigations using the boring method, namely at a depth of 10 to 20 meters, the soil characteristics are quite firm and strong where the NSPT is NSPT 17 at a depth of 10 and is getting bigger to a depth of 20 m at NSPT 60, this can be said to be the original rock because has reached 2 times the value of NSPT 60. And the results obtained are the occurrence of ground movement in accordance with the results of the geoelectric analysis that there is a sliding area zoning.

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