REKAYASA
Journal of Science and Technology
https://journal.trunojoyo.ac.id/rekayasa

Rekayasa, 2025; 18(1): 32-39
ISSN: 0216-9495 (Print)
ISSN: 2502-5325 (Online)

Analysis of Slip Plane Using Geoelectric Data in Pancor Dao Central Lombok

Syarifatul Ulfah[1]*, Agus Winardi[1]
[1]Teknik Sipil Fakultas Teknologi dan Sains Universitas Qamarul Huda Badaruddin
Jl H Badruddin Praya Lombok Tengah Nusa Tenggara Barat 83371
*E-mail Korespondensi : syarifa9296@gmail.com
DOI: https://doi.org/10.21107/rekayasa.v18i1.26538
Submitted July 15th 2024, Accepted March 3rd 2025, Published April 7th 2025

Abstrak

Longsor adalah salah satu bencana yang terjadi didaerah berlereng. Terjadinya sangat sering ketika intensitas curah hujan tinggi. Selain itu, terjadi bidang yang disebut sebagai bidang gelincir. Bidang gelincir itu sendiri berada pada kontras nilai resitivitas batuan. Penelitian ini bertujuan untuk mengetahui nilai resistivitas tanah yang terindikasi daerah longsor dengan menggunakan metode geolistrik konfigurasi dipol-dipol. Konfigurasi dipol-dipol digunakan untuk mendapatkan nilai penetrasi yang lebih dalam dibandingkan konfigurasi lainnya. Pengumpulan data lapangan dilakukan pada 3 lintasan dengan luas penelitian sekitar 1.000 m2. Berdasarkan hasil pengolahan data menggunakan inversi 2D Res2divn diperoleh nilai resistivitas tanah yang diindikasikan sebagai bidang gelincir. Nilai resistivitas tanah yang ditunjukkan sebagai bidang gelincir pada 3 jalur yaitu nilai resistivitas pada jalur 1 sebesar 973 Ωm - 2067 Ωm, jalur 2 sebesar 1202 Ωm - 3167 Ωm, jalur 3 sebesar 618 Ωm – 1391 Ωm yang tergolong dalam jenis tanah lempung lanau. Hasil penelitian menunjukkan bahwa kedalaman bidang gelincir pada garis ketiga lebih dalam dibandingkan dengan garis pertama dan kedua. Dari nilai resistivitas tanah mewakili bidang gelincir. Dan kedalaman bidang gelincir pada 3 jalur yaitu pada kedalaman 8,53 m – 12,7 m untuk jalur pertama, 5,13 – 16,3 m untuk jalur kedua, dan 1,71 – 17 m untuk jalur ketiga. Dan dikategorikan jenis bidang gelincir dangkal hingga dalam.

Kata Kunci: bencana, longsor, geolistrik, resistivitas, dipol, bidang gelincir

Abstract

Landslide are one of the disasters that occur in sloping areas. It occurs very often when the intensity of rainfall is high. Apart from that, it occurs in an area known as a slip area. The slip area is characterized by contrasting rock resistivity values. This research aims to determine the resistivity value of the soil indicated as a sliding area using the geoelectric method with a dipole-dipole configuration. A dipole-dipole configuration is used to get a deeper penetration value compared to other configurations. Field data collection was carried out on 3 tracks with a research area of around 1,000 m2. Based on the results of data processing using 2D Res2divn inversion, the soil resistivity value is obtained which is indicated as a slip plane. The soil resistivity value indicated as a slip plane on 3 line, namely resistivity value on line 1 of 973 Ωm - 2067 Ωm, line 2 of 1202 Ωm - 3167 Ωm, line 3 of 618 Ωm – 1391 Ωm which is classified as a type of silt clay soil. the results show that the depth of slip plane on the third line is deeper than the first line and second line. From the soil resistivity values, it represents the slip pla ne. And the depth of slip plane on 3 line, namely at a depth of 8.53 m - 12.7 m for the first line, 5.13 - 16.3 m for the second line, and 1.71 - 17 m for the third line. And categorized as shallow to deep slip plane types.

Key words: *disaster, landslide, geoelectic, resistivity, dipole, slip plane*

INTRODUCTION

Lombok Island is one of the halal tourist areas which is a destination for many people. The importance of knowing disaster-prone areas is a very important factor to do. Especially on these tourist routes. Pancordao is a hamlet located in the Central Lombok district in the Batukliang sub-district in Aik Dareq Village. This area is one of the routes that must be passed by tourists in the Batukliang area. Apart from that, this area is a transition area from the Batukliang and North Batukliang sub-districts. And at the end of 2023 from direct observations from the author. There was a sudden landslide which caused several road accesses to be closed caused of the disaster. So it is necessary to know the cause of the landslide.

The unexpected occurrence of landslides late last year, their surface extent, and the difficulty of predicting landslide activation have sparked great interest among geophysicists, geologists, and scientists. By identifying the causes of landslides, their efforts aim to minimize life-threatening and other losses (Šilhán et al., 2019). So it is very important to know many things about landslide disasters. both in the form of causes, prevention methods, and steps after the landslide disaster occurs.

According to the definition, a landslide is defined as a type of rock mass movement down or off a slope due to disruption of the stability of the slope (Yilmaz, 2011). The steepness of a slope greatly influences landslide susceptibility (Dzakiya et al., 2023). Steep slopes will have a greater potential for landslides (Fadillah et al., 2024). In general, land that experiences landslides moves on a slip plane (Arsyad et al., 2018). When it rains, the stability of the soil and slope-forming materials is affected by rainwater which seeps into the rock layers. The rock layer will become slippery so that the avalanche material will move down the slope.

This slippery area is called the slip area. Because one of the very influential factors causing landslides is the slip surface or shear surface. In general, land that experiences a landslide will move above the slip surface (Prastowo et al., 2021). Especially during the rainy season, the soil mass above the slip surface increases and the infiltration of rainwater into the soil becomes greater (Rhesdeantia et al., 2017). The effect of rainfall is difficult to measure because it depends on several factors (Peruccacci et al., 2017), including soil heterogeneity (strength and permeability properties) (Perrone et al., 2008), and regional climate (Hadmoko et al., 2017). It has been recognized in the literature that rainfall can be a predisposing factor in soil slip activation (Pratiwi et al., 2019). Slip fields can be investigated using a variety of geophysical methods. The resistivity geoelectric method is a geophysical method that is widely used to explore land surfaces that have the potential for landslides (Susilo et al., 2018). According to the definition, a landslide is defined as a type of rock mass movement down or off a slope due to disruption of the stability of the slope. The steepness of a slope greatly influences landslide susceptibility.

Steep slopes will have a greater potential for landslides. Based on direct observations in this research area, the slope conditions are categorized as quite steep (Hidayah & Dzakiya, 2018). Apart from that, in general the land that experiences landslides moves on the slip surface (Summa et al., 2015). Resistivity comparison, which shows a difference in texture and porosity, may be used to show the state of the foundation, the sliding plane, and the form of a landslide that may occur. Many factors that affect slope stability, such as hydrologic conditions, bedrock type, soil type, and soil thickness, also affect rock and soil electrical resistance (Sismanto & Nasharuddin, 2018). And on the slip surface when it rains, the stability of the soil and slope-forming materials is affected by rainwater which seeps into the rock layers (Bell et al., 2006). The rock layer will become slippery so that the avalanche material will move down the slope. The place where the landslide material moves is what acts as a slip plane, resulting in ground movement or landslides (Hendri et al., 2020).

The slip plane is the layer that is the plane of motion of the landslide material layer (Aliyatarrafiah, & Widada, 2014). The shape and structure of the slip surface will influence the movement pattern of the landslide material above it. The slip surface is one of the important factors in the occurrence of landslides (Susilo et al., 2018). Therefore, we need a method that can describe the depth of the landslide slip plane to avoid greater losses (Nordiana et al., 2018). Several researchers have conducted research related to the potential for landslides by sharing methods such as the geoelectric resistivity method (Karimah et al., 2022). Cause, The most appropriate way to analyze basic things that cause landslides below the surface is with the geoelectric method (Zakaria & Maisarah, 2020). Field landslides are a layer between rock strata that is light in weight and absorbs little water. The landslide area has an important role in determining the cause of the landslide or not (Agustina, 2014). Therefore, it is necessary to carry out this research to determine exactly the parts of the land that are susceptible to landslides through surface analysis of the slip plane using geoelectric method. The geoelectric method is a geophysical method for investigating subsurface conditions by studying the nature of DC electricity flow in rocks below the earth's surface and how to detect it on the earth's surface (Sugito et al., 2010). In the geoelectric method survey, potential difference values, current strength and rock resistivity values will be obtained (Mahmudi, 2018). This method is rarely used for hydrocarbon exploration, but is widely used in the field of geological engineering such as determining bedrock depth, searching for water reservoirs, geothermal exploration, and also for environmental geophysics (Suprianto, 2018). One of the geoelectric methods is the resistivity or resistivity method (Wardoyo, 2018). This resistivity method studies differences in rock resistivity by determining changes in resistivity with depth. The rock resistivity value obtained from field measurements is an apparent resistivity value which requires further data processing to obtain the actual resistivity value (Green, 1993).

Research on slip plane analysis using geoelectric data in the Pancor Dao area of Central Lombok has never been carried out. So, it is necessary to carry out this research to know the posistion of slip plane (_ et al., 2018). Carried out as a disaster mitigation step in tourist route areas which are still visited by local and foreign tourists. Later, from the information obtained from the results of this research, further studies will be carried out to create a landslide disaster vulnerability map for the tourist route area of Batukliang - North Batukliang District. So that it can be used as a reference for sustainable development in the Batukliang - North Batukliang, Central Lombok tourist route area.

Also, geoelectric resistivity is a method that is widely used by several researchers to identify landslide slip areas (Sismanto & Nasharuddin, 2018). One of them is the dipole-dipole configuration resistivity geoelectric method (Yatini & Suyanto, 2018) which can be applied for the purpose of obtaining subsurface images of objects whose penetration is relatively deeper compared to other sounding methods such as the Wenner configuration and Schlumberger configuration (Ulfah et al., 2021). So research on slip plane analysis using geoelectric data in Pancardao is very important to carry out as one of the initial efforts to mitigate disasters on the tourist route in Batukliang - North Batukliang, Central Lombok. Apart from that, in this research area also no one has ever conducted research related to analysis of slip plane using geoelectric data.

RESEARCH METHODS

Research on slip plane analysis using geoelectric data was carried out in Pancor Dao Hamlet, Aik Dareq Village, Batukliang District, Central Lombok Regency, West Nusa Tenggara Province. This research was carried out in March 2024. Using a Resistivity Meter with a research area of 10,000 m^2. Then the location and line design can be seen in Figure 1.

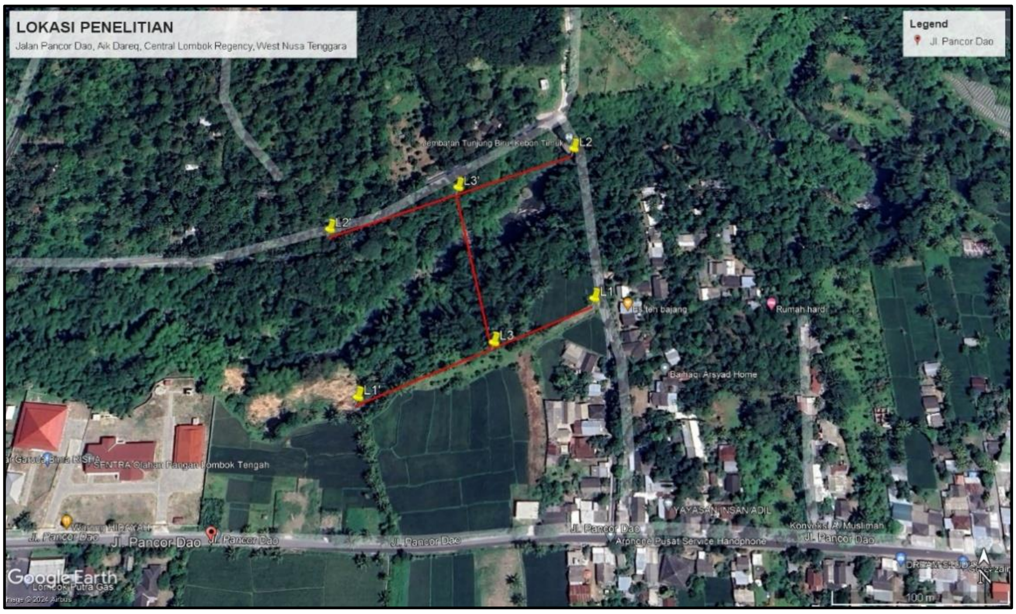

Figure 1. Research Location

Geoelectric Data Retrieval

This research used a 2D resistivity geoelectric method with a dipole-dipole configuration. In this study, 3 trajectories were used. 2 lines with a length of 200 m and 1 line with a length of 100 m. The distance between the lines is 10 m with a multiplier factor (n) 1, 2, 3, 4, 5, 6, and 7. The electrodes used are with a distance of a=10 m. On each line with AB, BM and MN spacing, the current electrodes (C_1 and C_2) and potential (P_1 and P_2) are connected to a resistivity meter. Then the current is injected into the earth through the current electrodes (C_1 and C_2). Note the magnitude of the current strength (I) and potential difference (V) measured on the resistivity meter for n=1. And move the potential electrode (fixed current electrode) at a predetermined 2nd distance. Then note (I) and (V) which are measured for n=2. These steps are carried out until the potential electrodes (P_1 and P^2) are at a distance of 90 m and 100 m. Record the measured (I) and (V) for n=3 to n=8. Move the current electrode to the 2nd position (towards the potential electrode) which has been determined with a fixed potential electrode. Record the measured (I) and (V). And move the potential electrode (fixed current electrode) closer to the current electrode according to a predetermined distance. Then do this step several times in sequence until the electrodes (C_1 and C_2) and (P_1 and P_2) are at a distance of 170 m, 180 m, 190 m, and 200 m and do this on line 1 and line 2. Then for line 3 also did the same thing. However, with a line length of 100 m. dipole - dipole configuration is shown in Figure 2.

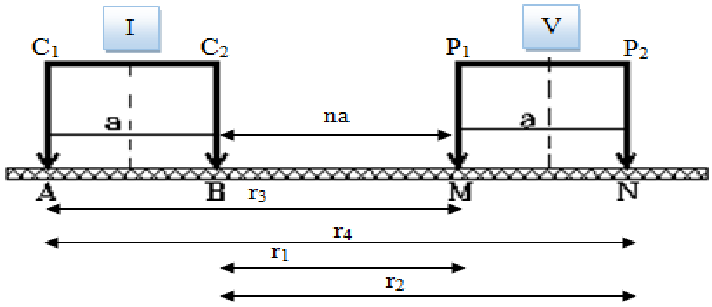

Figure 2. Dipole-Dipole Configuration Electrode Arrangement

In this configuration, current is injected through electrodes A and B. Meanwhile, the potential difference is measured through electrodes M and N, where the geometric factor value can be calculated using the following equation (Ewusi, 2006):

$$K \quad = 2\pi\left(\frac{1}{r1}-\frac{1}{r2}-\frac{1}{r3}+\frac{1}{r4}\right)^{-1}$$

$$= 2\pi\left(\frac{1}{na}-\frac{1}{a+na}-\frac{1}{a+na}+\frac{1}{2a+na}\right)^{-1}$$

$$= 2\pi\left(\frac{1}{na}-\frac{2}{a+na}-+\frac{1}{2a+na}\right)^{-1}$$

$$K = \pi an\ (1+n)(2+n) \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (1)$$

So resistivity can be calculated using the equation below (Khan et al., 2013):

$$\rho = K\frac{\Delta V}{I} \ldots \ldots \ldots \ldots \ldots \ldots . \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (2)$$

$$\rho_a = \pi an(1+n)(2+n)\frac{\Delta V}{I} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (3)$$

Geoelectric Data Processing

Based on the results obtained in the data collection process using a resistivity meter. Then the data is processed using Excel software first to get the calculated values which are then entered into the Re2div software for processing. So the resistivity results are obtained which are then interpreted to determine the slip plane.

RESULTS AND DISCUSSION

Based on the results of field data collection using the dipole-dipole configuration geoelectric method on 3 lines. For lines 1 to 2 with a length of 200 m and line 3 with a length of 100 m. The distance between electrodes is 10 m. From the results of geoelectrical data processing using Res2dinv software, results were obtained in the form of 2D cross-sections depicting variations in resistivity values laterally and vertically. The measurement results for paths 1 to 3 show anomaly values ranging from low to those marked with different colors.

For low and high anomaly values in the first pass interpretation results, they are shown with resistivity values of 47.8 Ωm and 9326 Ωm, in the second pass interpretation results are shown with resistivity values of 25.0 Ωm and 21,969 Ωm, low and high anomalies in the third pass measurements are carried out with resistivity values 24.1 Ωm and 7047 Ωm. Based on field measurement data which has been correlated with geological data from the research area, in general the research area is dominated by layers of sand clay, sand, silt clay and sandstone. And from the results of geoelectric data processing, the three measurement trajectories of the research area using res2div software are displayed as in Figure 3, Figure 4, and Figure 5.

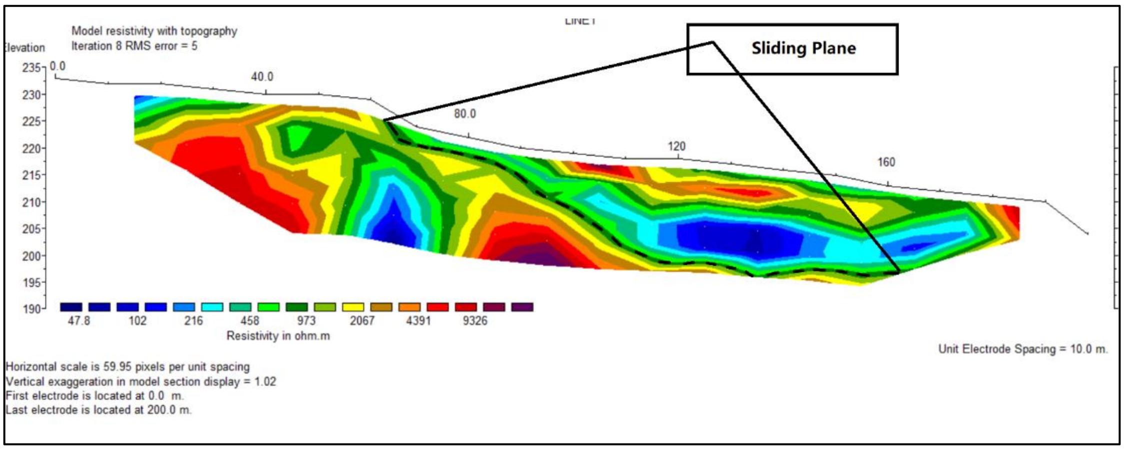

Figure 3. Results of Res2dinv Inversion with Topography on first line

Based on the results of 2D modeling Figure 3 , it appears that there are 4 types of soil that have been correlated with the geological data of the research area, characterized by different types of color from blue to purple. The first type of soil has a resistivity value range of 47.8 Ωm – 215 Ωm. This is predicted to be a type of sand clay. The second type of soil with a resistivity value range of 216 Ωm – 458 Ωm can be assumed to be sand. The third type of soil with a resistivity value range of 973 Ωm – 2067 Ωm, can be estimated as silt clay. And the fourth type of soil with a resistivity value range of 4391 Ωm – 9326 Ωm, can be estimated as sandstone. Based on the cross-sectional results from the first pass, it is known that there are very contrasting resistivity values between 973 Ωm - 2067 Ωm at a depth of 8.53 m - 12.7 m from the surface, at a distance of (60 - 170) m. This layer is thought to be a slip area on the first pass which could trigger a landslide disaster.

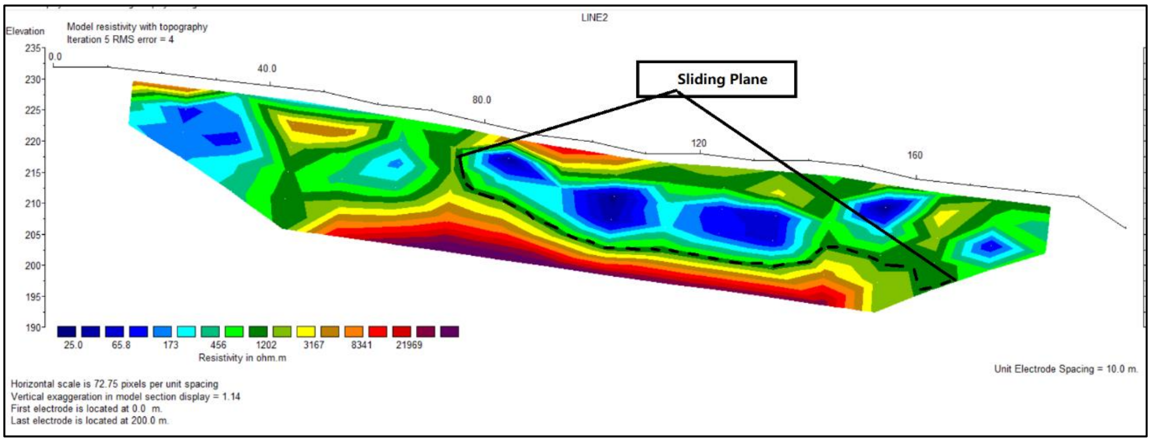

Figure 4. Results of Res2dinv Inversion with Topography on second line

Theoretical slip plane indications are obtained from contrasting resistivity values between two adjacent rocks. And for the second line also appears that there are 4 types of soil. With the first type of soil on the second line has a resistivity value range of 25 Ωm – 65.8 Ωm. This is predicted to be a sand clay soil type. The second type of soil with a resistivity value range of 173 Ωm – 456 Ωm can be assumed to be sand. The type of soil with the third range of resistivity values ranging from 1202 Ωm – 3167 Ωm, can be estimated as silt clay. And the fourth type of soil with a resistivity value range of 8341 Ωm – 21969 Ωm, can be estimated as sandstone. Based on the cross-section of the second line, it is known that there are very contrasting types of resistance values between 1202 Ωm - 3167 Ωm at a depth of 5.13 – 16,3 m from the surface, at a distance of (80 - 180) m. Same as the first line. In this second pass, the slip plane is also indicated on the layer (Figure 4). However, the depth is much deeper than first line.

Furthermore, for route 3, as with the first and second routes, 2D modeling results were obtained from the research area in the form of 4 types of soil. The first type of soil has a resistivity value range of 24.1 Ωm – 54.2 Ωm and is predicted to be a type of sandy clay soil. The second type of soil with a resistivity value range of 122 Ωm – 275 Ωm can be assumed to be sand. The third type of soil with a resistivity value range of 618 Ωm – 1391 Ωm, can be estimated as silt clay. And the fourth type of soil with a resistivity value range of 3131 Ωm - 7074 Ωm, can be estimated as sandstone. In this third pass, it is known that there is a very contrasting difference in resistivity values between 618 Ωm - 1391 Ωm at a depth of 1.71 - 17 m from the surface, found at a distance of (30 - 70) m and this layer is thought to be the slip plane (Look at Figure 5).

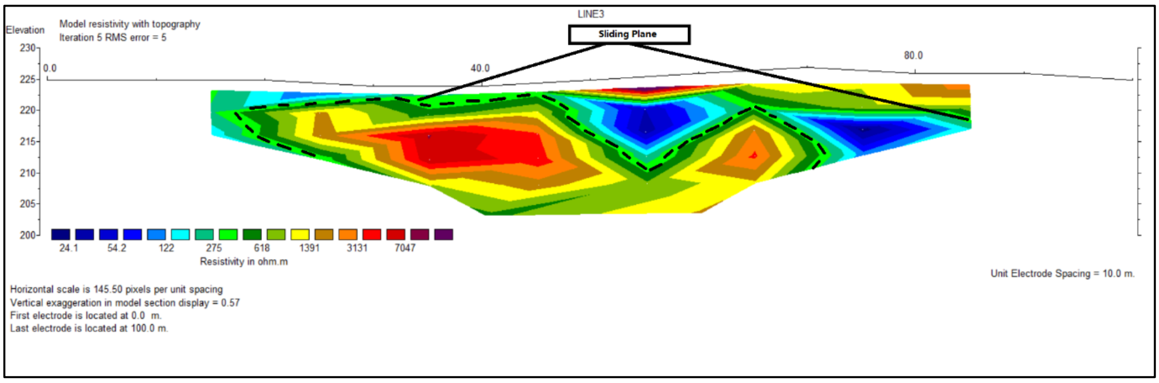

Figure 5. Results of Res2dinv Inversion with Topography on third line

So, from Figure 5 above, the results show that the depth of slip plane on the third line is deeper than the first line and second line. Theoretically, the slip plane category is divided into three types, namely shallow slip planes found at depths of 1.5 - 5 m, deep slip plane are found at depths between 5 - 20 m and very deep slip areas are found at depths between more than 20 m. The slip plane from the first line to the third line are in the shallow to deep slip plane category. The deeper of slip plane make the greater level of landslide danger. On the other hand, the shallower of slip plane make lower level of landslide danger.

From this research it was found that there are slip areas on each track with different slip plane depths. For Line 1, the slip surface is at a depth of 8.53 m – 12.7 m. Line 2, namely at a depth of 5.13 – 16.3 m. and on track 3 at a depth of 1.71 – 17 m. Based on theory, the research results in this area are categorized as slip areas ranging from shallow to deep. The depth of the slip area is important to know because it can determine how big the risk of landslides is. The deeper the slip area, the greater the level of landslide danger, conversely the shallower the slip area, the lower the level of landslide danger (Hajar Saleng et al., 2024).

CONCLUSIONS

Based on the results of data analysis and discussion which have been correlated with geological data, it is concluded that the soil resistivity value indicated as a slip plane on 3 line, namely resistivity value on line 1 of 973 Ωm - 2067 Ωm, line 2 of 1202 Ωm - 3167 Ωm, line 3 of 618 Ωm – 1391 Ωm which is classified as a type of silt clay soil. From the soil resistivity values, it represents the slip plane. And the depth of slip plane on 3 line, namely at a depth of 8.53 m - 12.7 m for the first line, 5.13 - 16.3 m for the second line, and 1.71 - 17 m for the third line. And categorized as shallow to deep slip plane types. urthermore, suggestions for further research include further research such as research on the permeability values of the research area. And there is socialization to the public of the results of this research to provide information and awareness among the public in this research area about the dangers that can arise from the slip plane.

REFERENCES

Agustina, E. (2014). Identifikasi Bidang Gelincir Zona Rawan Longsor dengan Metode Geolistrik Resistivitas Konfigurasi Dipole-Dipole Di Payung Kota Batu. In *Jurnal Fisika Universitas Negeri Malang*. Universitas Negeri Malang.

Aliyatarrafiah, & Widada, S. (2014). Identifikasi Bidang Gelincir Dengan Metode Tahanan Jenis Konfigurasi Dipole-Dipole Daerah Bambankerep Ngaliyan Semarang. *Youngster Physics Journal*, *3*(4), 291–298.

Arsyad, U., Barkey, R. A., Wahyuni, W., & Matandung, K. K. (2018). Karakteristik Tanah Longsor di Daerah Aliran Sungai Tangka. *Jurnal Hutan Dan Masyarakat*, 203. https://doi.org/10.24259/jhm.v0i0.3978

Bell, R., Kruse, J.-E., Garcia, A., Glade, T., & Hördt, A. (2006). Subsurface investigations of landslides using geophysical methods: geoelectrical applications in the Swabian Alb (Germany). *Geographica Helvetica*, *61*(3), 201–208. https://doi.org/10.5194/gh-61-201-2006

Dzakiya, N., Laksmana, R. B., & Hidayah, R. A. (2023). Identifying Probable Slip Surface in Wanurejo, Borobudur District, By Subsurface Analysis Utilizing the Dipole-Dipole Configuration of Resistivity Method. *Journal of Applied Geospatial Information*, *7*(1), 739–746. https://doi.org/10.30871/jagi.v7i1.5055

Ewusi, A. (2006). *Groundwater Exploration and Management using Geophysics: Northern Region of Ghana. November 2006*, 171.

Fadillah, R., Tjahjono, B., & Dwiyanti, F. G. (2024). Landslide Hazard Analysis Based on Geographic Information Systems in Sumedang Regency. *Jurnal Penelitian Pendidikan IPA*, *10*(SpecialIssue), 147–158. https://doi.org/10.29303/jppipa.v10ispecialissue.8354

Green, R. (1993). Applied geophysics. *Journal of Applied Geophysics*, *30*(4), 322–323. https://doi.org/10.1016/0926-9851(93)90043-x

Hadmoko, D. S., Lavigne, F., & Samodra, G. (2017). Application of a semiquantitative and GIS-based statistical model to landslide susceptibility zonation in Kayangan Catchment, Java, Indonesia. *Natural Hazards*, *87*(1), 437–468. https://doi.org/10.1007/s11069-017-2772-z

Hajar Saleng, R., Arbie, A., & Gede Eka, D. (2024). Simulasi Model Material Tanah Pada Bidang Gelincir Longsor Dengan Variasi Sudut Kemiringan (Studi Kasus Material Tanah di Daerah Kabupaten Gorontalo Utara). *Jurnal Teori Dan Aplikasi Fisika*, *12*(01), 29–38. https://doi.org/10.23960/jtaf.v12i1.3207

Hendri, H., Faryuni, I. D., & Zulfian, Z. (2020). Identifikasi Bidang Gelincir dan Tipe Tanah Longsor di Daerah Rawan Longsor Desa Bantai Menggunakan Metode Geolistrik. *Prisma Fisika*, *7*(3), 167. https://doi.org/10.26418/pf.v7i3.36329

Hidayah, R. A., & Dzakiya, N. (2018). Analysis Geological and Geophysical Data for Prediction Landslide Hazard Zone with Weight of Evidence Method in Pacitan District East Java. *Journal of Applied Geospatial Information*, *2*(1), 117–123. https://doi.org/10.30871/jagi.v2i1.830

Karimah, K., Susilo, A., Suryo, E. A., Rofiq, A., & Hasan, M. F. R. (2022). 3D Modelling of Geoelectrical Resistivity Data to Determine the Direction of Landslides in Kastoba Lake, Bawean Island, Indonesia. *Jurnal Penelitian Pendidikan IPA*, *8*(3), 1495–1502. https://doi.org/10.29303/jppipa.v8i3.1714

Khan, G. D., Waheedullah, & Bhatti, A. S. (2013). Groundwater Investigation by Using Resistivity Survey in Peshawar, pakistan. *Journal of Research Development and Management*, *2*, 9–20.

Mahmudi, A. K. (2018). Investigasi Keberadaan dan Arah dari Pipa Bawah Tanah dengan Metode Kelistrikan. *Rekayasa*, *1*, 1. https://doi.org/Agus Mahmudi, Kuspijani Kuspijani

Nordiana, M. M., Azwin, I. N., Nawawi, M. N. M., & Khalil, A. E. (2018). Slope failures evaluation and landslides investigation using 2-D resistivity method. *NRIAG Journal of Astronomy and Geophysics*, *7*(1), 84–89. https://doi.org/10.1016/j.nrjag.2017.12.003

Perrone, A., Vassallo, R., Lapenna, V., & Di Maio, C. (2008). Pore water pressures and slope stability: A joint geophysical and geotechnical analysis. *Journal of Geophysics and Engineering*, *5*(3), 323–337. https://doi.org/10.1088/1742-2132/5/3/008

Peruccacci, S., Brunetti, M. T., Gariano, S. L., Melillo, M., Rossi, M., & Guzzetti, F. (2017). Rainfall thresholds for possible landslide occurrence in Italy. *Geomorphology*, *290*, 39–57. https://doi.org/10.1016/j.geomorph.2017.03.031

Prastowo, R., Helmi, H., Trianda, O., & Umam, R. (2021). Identification of Slip Surfaces Using the Geoelectric Imaging Method in the Kalirejo Area, Kokap District, Yogyakarta, Indonesia. *JIPF (Jurnal Ilmu Pendidikan Fisika)*, *6*(3), 234. https://doi.org/10.26737/jipf.v6i3.2072

Pratiwi, E. S., Sartohadi, J., & Wahyudi. (2019). Geoelectrical Prediction for Sliding Plane Layers of Rotational Landslide at the Volcanic Transitional Landscapes in Indonesia. *IOP Conference Series: Earth and Environmental Science*, *286*(1), 0–9. https://doi.org/10.1088/1755-1315/286/1/012028

Rhesdeantia, Y., Darsono, T., & Khumaedi, K. (2017). Geo-Electric Resistivity Method of Dipole-Dipole Configuration For Cavities Model 2D in Karst Area of Temurejo Village Gubug Sub-district Central Java District. *Journal of Physics: Theories and Applications*, *1*(2), 167. https://doi.org/10.20961/jphystheor-appl.v1i2.19318

Šilhán, K., Tichavský, R., Fabiánová, A., Chalupa, V., Chalupová, O., Škarpich, V., & Tolasz, R. (2019). Understanding complex slope deformation through tree-ring analyses. *Science of the Total Environment*, *665*, 1083–1094. https://doi.org/10.1016/j.scitotenv.2019.02.195

Sismanto, & Nasharuddin. (2018). Landslide potential mapping in penggung purwosari village, district girimulyo, kulonprogo, yogyakarta province, Indonesia using dipole-dipole resistivity method. *International Journal of Civil Engineering and Technology*, *9*(6), 1141–1150.

Sugito, Irayani, Z., & Jari, I. P. (2010). Investigasi Bidang Gelincir Tanah Longsor Menggunakan Metode Geolistrik Tahanan Jenis di Desa Kebarongan Kec. Kemranjen Kab. Banyumas. *Berkala Fisika*, *13*(2), 49–54.

Summa, V., Margiotta, S., Colaiacovo, R., & Giannossi, M. L. (2015). The influence of the grain-size, mineralogical and geochemical composition on the Verdesca landslide. *Natural Hazards and Earth System Sciences*, *15*(1), 135–146. https://doi.org/10.5194/nhess-15-135-2015

Suprianto, A. (2018). Pencitraan Rembesan Limbah Menggunakan Metode Geolistrik Resistivity Konf igurasi Schlumberger 2-dimensi. *Rekayasa*, *1*(1), 7. https://doi.org/https://doi.org/10.21107/rekayasa.v1i1.2167

Susilo, A., Suryo, E. A., Fitriah, F., Sutasoma, M., & Bahtiar. (2018). Preliminary study of landslide in Sri Mulyo, Malang, Indonesia using resistivity method and drilling core data. *International Journal of GEOMATE*, *15*(48), 161–168. https://doi.org/10.21660/2018.48.59471

Ulfah, S., Marzuki, M., & Susilo, A. (2021). Analysis Vulnerability Disaster of Landslide in Lantan Village Using Geoelectric Data and Sentinel Image. *Jurnal Penelitian Pendidikan IPA*, *7*(4), 794–801. https://doi.org/10.29303/jppipa.v7i4.915

Wardoyo, T. M. A. (2018). Investigasi RembesanfKebocoran Dinding Suatu KanaVSungai yang Terkontaminasi dengan Metode Resistivitas. *Rekayasa*, *1*(1), 7. https://doi.org/https://doi.org/10.21107/rekayasa.v1i1.2163

Yatini, Y., & Suyanto, I. (2018). Identification of slip surface based on geoelectrical dipole-dipole in the landslides hazardous area of Gedangsari District, Gunungkidul Regency, Province of Daerah Istimewa Yogyakarta, Indonesia. *IOP Conference Series: Earth and Environmental Science*, *212*(1). https://doi.org/10.1088/1755-1315/212/1/012013

Yilmaz, S. (2011). A case study of the application of electrical resistivity imaging for investigation of a landslide along highway. *International Journal of Physical Sciences*, *6*(24), 5843–5849. https://doi.org/10.5897/IJPS11.564

Zakaria, M. F., & Maisarah, S. M. (2020). Identifikasi Bidang Gelincir Pada Daerah Rawan Longsor Desa Srimartani, Yogyakarta. *JGE (Jurnal Geofisika Eksplorasi)*, *5*(3), 214–222. https://doi.org/10.23960/jge.v5i3.36