# Lithological Identification using Geoelectric Method in Landslide Area in Bengle Village

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**Abstract**: Dlepih Village, specifically in Bengle Hamlet, is an area that experienced a landslide disaster on November 28, 2017. This landslide disaster occurred in a residential area, resulting in the death of 2 people, necessitating mitigation measures. One of the initial steps in mitigation is to identify the lithology in the landslide area. This study aims to determine the lithology in the landslide area using the Dipole-Dipole resistivity geoelectric method. The resistivity method is used to investigate the subsurface structure of the earth by measuring the resistivity of rock or soil. The mechanism of this method relies on the flow of electric current and the measurement of potential difference, and is calculated based on a certain electrode configuration to obtain a picture of underground resistivity. Data was acquired using a set of Naniura Resistivity Meter instruments on four measurement lines. The measurement paths are located in the Semilir Formation, which consists of sedimentary rocks. The research results show that the landslide area consists of soil layers with a resistivity value of 2.32 Ωm 6.69 Ωm and a thickness of 1.26 m - 11.39 m, claystone layers with a resistivity value of 6.69 Ωm - 160 Ωm and a thickness of 11 m - 40.5 m, and andesite rock layers with a resistivity value of more than 160 Ωm and a thickness of 5.25 m - 37.71 m.

Keywords: Landslide; Lithology; Geoelectric; Dipole-Dipole; Bengle

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## I. INTRODUCTION

Landslides are movements of soil and/or rock that descend slopes under the influence of gravity [1]. According to Thompson and Turk, landslides generally occur naturally in all hilly or mountainous areas with steep slopes [2]. Landslides that occur in Indonesia often result in land damage and hundreds of people dying each year. Based on data from the Central Bureau of Statistics (BPS), in 2017, Wonogiri Regency experienced landslide disasters 6 times, one of which occurred in Dusun Bengle, Desa Dlepih, Kecamatan Tirtomoyo [3]. The landslide incident caused severe damage to residents' houses and resulted in the deaths of 2 people. Christalianingsih state that the Tirtomoyo sub-district has steep slope inclinations, whereas the research area has steep slope inclinations [4].

There are two main factors that cause landslides, namely external factors such as rainfall, earthquake vibrations, and human activities. Then the internal factors include geomorphological conditions, geological structure conditions, and lithological conditions [5]. The two factors are interconnected, resulting in a significant impact on the occurrence of landslide disasters [6].

Pirenaningtyas et al in 2020 conducted research at the same location on slope engineering techniques for the management of soil mass movements using survey and field mapping methods. The result of their research is that the slope at the research location is included in the classification of unstable slopes. [7].

Based on this, it is necessary to take landslide disaster mitigation steps to minimize the adverse effects of the disaster. One of the steps for landslide disaster mitigation is by understanding the subsurface lithology. According to Fernania, lithology is a description of rocks based on their characteristics, such as color, mineral composition, and grain size [8]. The geophysical method that can be used to identify the subsurface lithology of the research area is the geoelectric method. The geoelectric method has many types of configurations, one of which is the dipole-dipole configuration.

## II. METHODOLOGY

The research area is located in Bengle Village, Tirtomoyo District, Wonogiri Regency with coordinates 111° 3'43.96" E to 111° 3'51.68" E and 7°5854.39 S to 7°58'45.76" S. The landslide area in the research area is shown in Fi. 1.

This research uses the dipole-dipole configuration geoelectric method, with four measurement lines in the landslide area. The geoelectric method is one of the geophysical methods that studies the characteristics of electric flow within the earth by detecting it on the earth's surface [10]. The dipole-dipole configuration has the advantage of sensitivity to lateral resistivity values and this configuration has deeper current penetration [11].

The dipole-dipole configuration was chosen in this study based on its superiority in detecting lateral variations in subsurface resistivity in more detail. This configuration is also


FIG. 1: Landslide Area [9]. (Orange line indicates landslide flow scar).

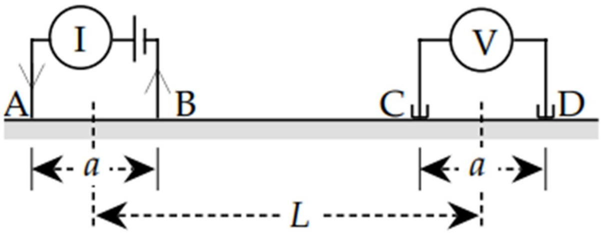


FIG. 2: Electrode arrangement in a dipole-dipole configuration [12].

very sensitive to horizontal changes making it ideal for use in areas that have the potential for layer shifts such as landslide-prone areas. In addition, the more flexible spacing between electrodes allows adjustment to difficult or restricted terrain. Fig. 2 shows the arrangement of current and potential electrodes in the dipole-dipole configuration.

In conducting geoelectric measurements, the tools used consist of the Naniura NRD-300 HF Resistivity Meter, current and potential electrodes, batteries, connecting cables, measuring tape, hammer, and log sheet. The measurement is conducted by injecting current into the ground through the current electrodes and measuring the potential difference through the potential electrodes. The arrangement of electrodes in the dipole-dipole configuration is AB used as the current electrode and CD used as the potential electrode. The distance between the two current electrodes and the potential electrode is a, and the distance from the midpoint between the current electrode and the midpoint of the potential electrode is L. The length of the measurement paths used varies, points AA' and DD' have a length of 160 meters, point CC' has a length of 200 meters, and point BB' has a length of 180 meters. Fig. 3 shows 4 measurement tracks.

In this geoelectric measurement, data in the form of current (I) and potential difference (V) values are obtained. From this data, calculations are performed using Microsoft Excel software to obtain the values of Resistance (R), Geometric Factor (K), and apparent Resistivity (a). To obtain those values, the following equations were used. Resistance value equation:

TABLE I: Resistivity Value [13].

| No | Lithology | Resistivity ($\Omega$m) |
|---|---|---|
| 1 | Clays | 1-100 |
| 2 | Andesite | 4,5 $\times 10^4$ 1,7 $\times 10^2$ |

$$R = \frac{V}{I} \tag{1}$$

F geometric factor for dipole-dipole configuration:

$$K = \pi an(n+1)(n+2) \tag{2}$$

Therefore, the value of the apparent resistivity is:

$$\rho_a = RK \tag{3}$$

After obtaining the values of R, K, and $\rho_a$, data processing was carried out using the Res2dinv software to produce a 2D cross-section model and the RockWork 16 software to generate a 3D stratigraphic model. The resistivity values from the 2D results were then interpreted based on Table 1 to be identified and classified and adjusted according to the Ponorogo geological map.

Resistivity values have a close relationship with geological conditions because the resistivity value of a subsurface material reflects the type of rock present. Therefore, by measuring resistivity in the field, changes in lithology can be identified as well as detecting the presence of subsurface structures that have the potential to become weak zones such as landslide-prone areas.

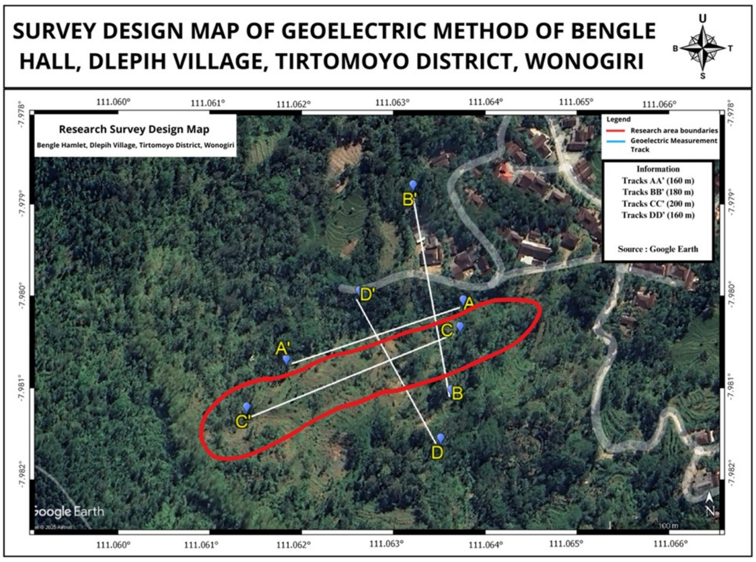


FIG. 3: Geoelectric Measurement Survey Design Map (Google Earth Pro, 2024).

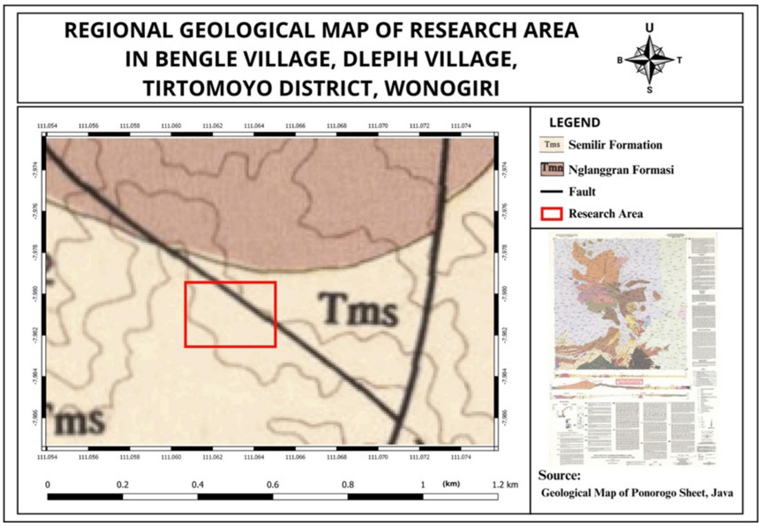


FIG. 4: Regional Geological Map of the Research Area (Sampurno dan Samodra, 1997).

## III. RESULT AND DISCUSSION

According to the geological map of the Ponorogo Sheet, Java (Sampurno, 1997), the research location, namely Bengle Village, is located in the Semilir Formation consisting of pumice breccia, pebble sandstone loops, sandstone, and clay as shown in Fig. 4.

The results of data processing using the Res2Dinv software yielded a resistivity model that can be seen in Fig. 5, 6, 7, and 8. Then, from these values, they were classified into several rock layers referring to the rock classification according to Telford et al. (1990) in Table 1 and adjusted to field conditions, so that a rock classification in the research area is produced, as shown in Table II.

Track 1 has a span direction from East to West with a track length of 160 meters. The processing results on line 1 yielded

TABLE II: Rock Classification from Research Results.

| Types of Rocks | Resistivity (Ω.m) | Color |
|---|---|---|
| Soil | $1 \leq \rho < 6.69$ | |
| Clays | $6.69 \leq \rho < 160$ | |
| Andesite | $\rho \geq 160$ | |

a depth of up to 43 meters with an error value of 23.1% (Fig. 5). The interpretation of the obtained resistivity values is that at points 43 to 52 m, a soil layer with a thickness of 1.26 m was found, extending to a depth of 6.26 m. This soil layer has a resistivity value of 2.32 Ωm to 6.69 Ωm. At points 40 to 135 m, a claystone layer was found with a thickness of 31.44

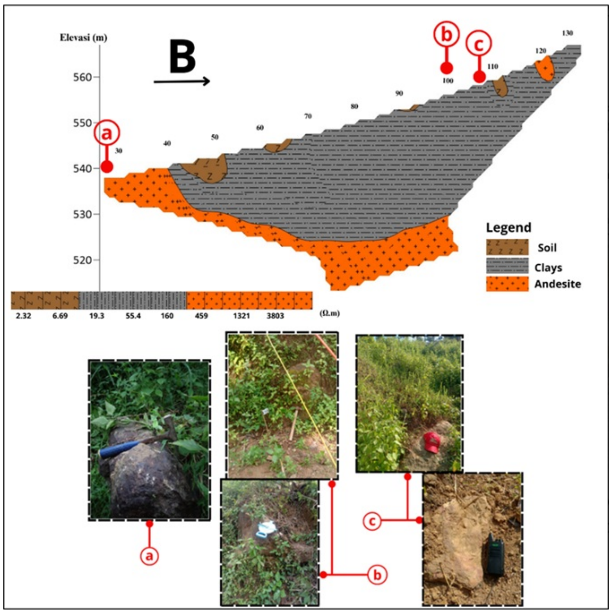


FIG. 5: 2D model of track 1 with topography and field validation.

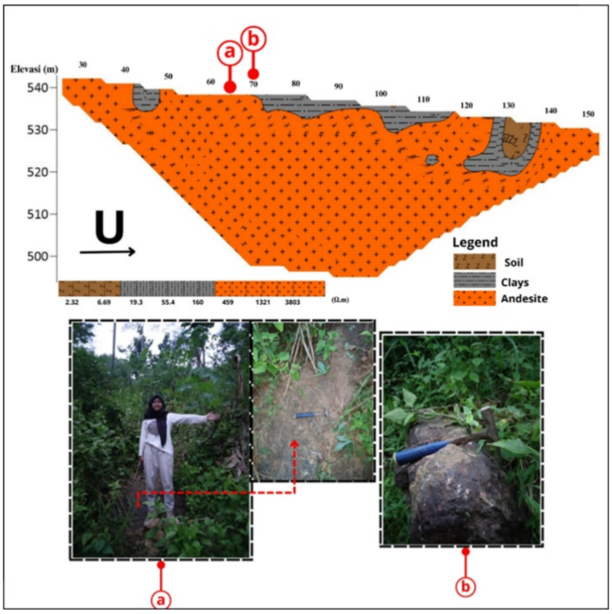


FIG. 6: 2D model of track 2 with topography and field validation.

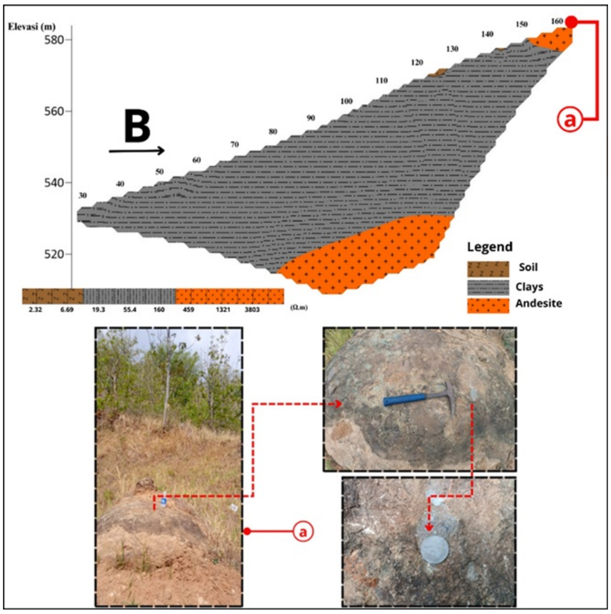


FIG. 7: 2D model of track 3 with topography and field validation.

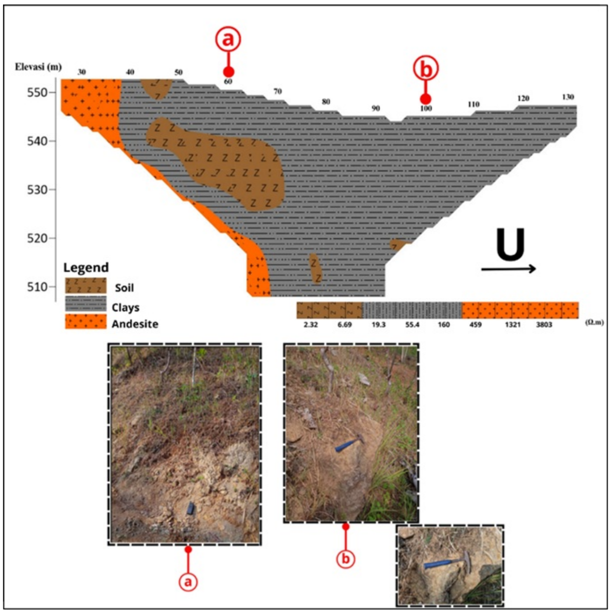


FIG. 8: 2D model of track 4 with topography and field validation.

m and a depth of up to 33.94 m. The claystone layer has a resistivity value ranging from 6.69 Ωm to 160 Ωm. Next, an andesite rock layer was found at a depth of 25 to 40 meters with a thickness of 13.5 meters and a depth of up to 43 meters. Andesite rock can be found at the surface at the 25-meter point as shown in Fig. 5(a).

Track 2 has a span direction from South to North with a track length of 180 meters. The processing results on line 1 yielded a depth of up to 43 meters with an error value of 27.3% (Fig. 6). The interpretation of the obtained resistivity values is that a soil layer was found at points 133 to 137 m with a layer thickness of 7.3 m and a depth of 9.8 m. This soil layer has a low resistivity value ranging from 2.32 to 6.69 Ωm. At the point from 70 to 140 m, a layer of claystone was found extending with a thickness of 11 m. This layer has a resistivity range of 6.69 to 160 Ωm. Track 2 is dominated by andesite rock with a resistivity value of more than 160 Ωm. This layer has a thickness of 37.71 m with a depth of 43 meters. Andesite rock can be found at the surface at points 65 meters and 70 meters, as shown in Fig. 6(a) and 6(b).

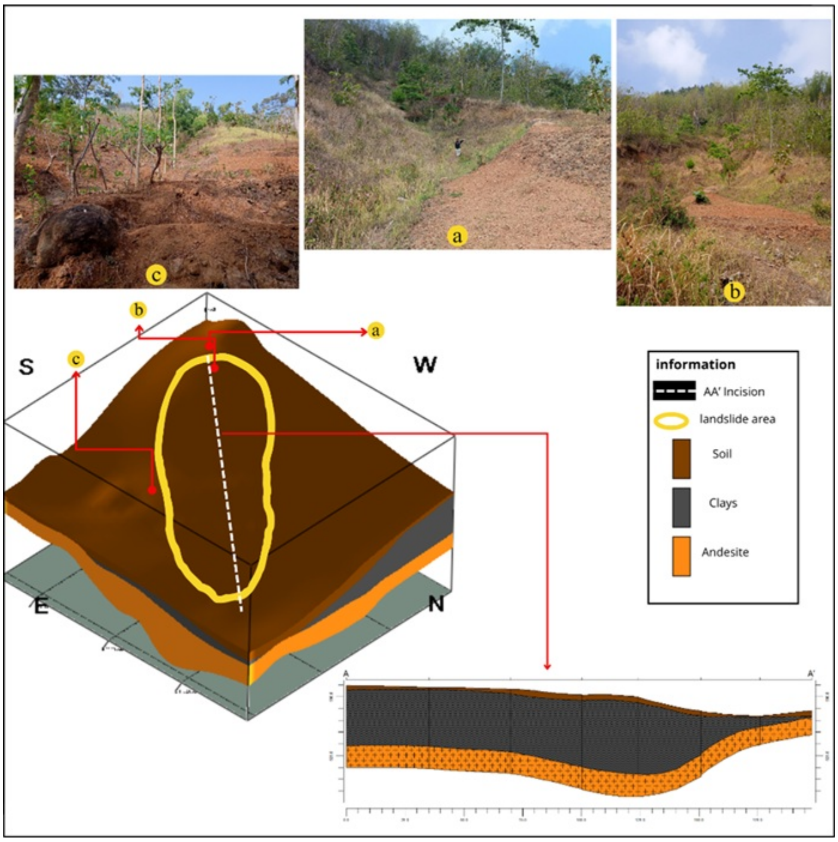


FIG. 9: 3D model of stratigraphic research area.

Track 3 has a span direction from East to North with a track length of 200 meters. The processing results of this track obtained a depth of up to 52.3 meters with an error value of 29.9% (Fig. 7). On this trajectory, it is dominated by a claystone layer that extends from point 25 m to point 150 m. The claystone layer has a resistivity value ranging from 6.69 to 160 Ωm with a thickness of up to 40 m. Meanwhile, the high resistivity values are interpreted as layers of andesite rock that can be found at the surface at a point 175 m, as shown in Fig. 7(a). This layer is also found at a depth of 34.6 m to 52.3 m.

Track 4 has a span direction from South to North with a track length of 160 meters. The results from the processing on this line obtained a depth of 43 meters with an error value of 14.1% (Fig. 8). The interpretation of the obtained resistivity values is that the soil layer extends to a depth of 23.66 m at points 42 m to 70 m with a thickness of 11.39 m. At points 40 m to 135 m, a claystone layer was found with a thickness of 40.5 m and a depth reaching 43 m. This layer was found at the surface at points 60 and 100 m, as shown in Fig. 8(a) and 8(b).

This research shows the dominance of lithology in the form of claystone and andesite rocks in the subsurface of the research area, with a fairly thick distribution of claystone and andesite layers that appear at depth and surface at certain points. These results are different from research conducted by Rahmawati, *et al.* (2024) in Kalongan Village, East Ungaran, where the subsurface lithology is dominated by tuffaceous sandstone, tuff, and lava flows with low resistivity values, and the presence of igneous rocks such as Andesite rocks is not found. This difference indicates that the geological conditions between the two locations have significantly different characteristics, both in terms of rock type, subsurface structure, and potential susceptibility to ground motion.

The results of the data interpretation conducted can produce a 3D model using RockWorks 16 software. The results of the 3D modeling of the resistivity values were presented with a stratigraphic model view shown in Fig. 9. In the 3D model, there are several stratigraphic layers consisting of soil, claystone, and Andesite rock. The soil layer indicated by the brown color has a resistivity value of 2.32 Ωm - 6.69 Ωm, located at a depth of 0 m-23.66 m with a thickness of 1.26 m-11.39 m. Claystone is shown in gray color with a resistivity value of 6.69 Ωm-160 Ωm, located at a depth of 0 m-43 m with a thickness of 11 m-40.5 m. Meanwhile, the andesite rock, marked in orange, has a resistivity value of more than 160 Ωm, located at a depth of 0 m-43 m with a thickness of 5.25 m-37.71 m.

3D stratigraphic modeling shows that the landslide occurring in the research area moves from the Southwest to the Northeast. In Fig. 9(a), the landslide crown area is shown on the southern side of the measurement area, and Fig. 9(b) shows the measurement path of track 3 located in the landslide crown area. Meanwhile, Fig. 9(c) shows the soil layer in the measurement area on track 4.

## IV. CONCLUSION

Based on the research that has been conducted, it can be concluded that the resistivity values on each line are different, allowing them to be classified into several types of rocks. The four measurement lines are composed of the same types of rocks, namely layers of soil with a resistivity value of 2.32 Ωm to 6.69 Ωm, the claystone with a resistivity value of 6.69 Ωm to 160 Ωm, and the andesite rock with a resistivity value of more than160 Ωm . The three layers are present in all four lines with varying thicknesses. The landslide disaster in Bengle Hamlet was triggered by the interaction between the steep slope, the presence of a water-saturated soil layer, and the underlying claystone which is impermeable and mechanically weak. These conditions cause the water pressure to increase and the shear force to exceed the retaining force of the slope, triggering the landslide. Research on the lithology in the study area needs to be conducted using other methods to obtain more accurate results.

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