Advance Sustainable Science, Engineering and Technology (ASSET)
Vol. 6, No.2, April 2024, pp. 0240208-01 ~ 0240208-08
ISSN: 2715-4211 DOI: https://doi.org/10.26877/asset.v6i2.18163

Identification of Landslide Prone Areas with Schlumberger Configuration Geoelectric Method, Kalongan Village, East Ungaran in 2023

Zeni Rahmawati[1*], Thaqibul Fikri Niyartama[1], Nugroho Budi Wibowo[1,2], Andi[1]

[1]Faculty of Science and Technology, Universitas Islam Negeri Sunan Kalijaga, Jl. Laksda Adisucipto, Papringan, Caturtunggal, Kec. Depok, Kabupaten Sleman, Daerah Istimewa Yogyakarta 55281

[2]BMKG, Stasiun Geofisika Sleman, D.I Yogyakarta

*zenirahmawati28@gmail.com

Abstract. Landslides are one of the natural disasters that occur in Semarang Regency. The landslide event in Kalongan Village, East Ungaran Subdistrict took place in 2022 to 2023. The dimension of the landslide is large and has the potential to cause damage to infrastructure and settlements, mitigation measures are needed. One of the mitigation measures is to identify the lithology of the landslide area and its surroundings. This study aims to determine the lithology of the landslide area and its surroundings using the Schlumberger configuration geoelectric method. Geoelectric acquisition using a set of naniura geoelectric, with a line variation of 120 to 300 meters. The number of measurement lines is 6 VES located in the landslide zone in the Kaligetas Formation. The results showed that the avalanche zone is composed of Tufan Sandstone with a resistivity of 0.17 Ωm to 334.9 Ωm, Tuff with a resistivity of 10.03 to 26.96 Ωm, and Lava Flow with a resistivity of 1161.91 Ωm to 3040.05 Ωm. Avalanche materials were identified to be associated with lithologies such as tufan sandstone and tuff with a thickness between 5 to 50 m.

Keywords: Lithology, Landslide, Geoelectric, Schlumberger Configuration, Ungaran.

(Received 2024-01-15, Accepted 2024-02-11, Available Online by 2024-03-08)

1. Introduction

Natural disasters are defined as disasters caused by natural events, such as tsunamis, volcanic eruptions, earthquakes, droughts, floods, hurricanes and landslides. One example of a natural disaster is a landslide. Landslide has a definition of moving rock, detritus, or soil caused by the force of gravity [1]. Landslides also have another definition which is the movement of soil or rock down a slope due to local geological factors, groundwater conditions, extreme weather, earthquakes, or other factors [2]. Factors affecting landslides consist of internal factors (slope building, rock lithology, geological structure, and sliding plane) and external factors (high rainfall and earthquakes). One of the factors that can determine the occurrence of landslides is the lithology of the area. Lithology is included in the characteristics or properties of rocks that consist of mineral composition, structure, and forming materials.

Based on data from the Regional Disaster Management Agency (BPBD) of Semarang Regency in 2022, the area of Semarang Regency is categorized as at risk of landslides with a total incidence of 108.The area includes Bringin Subdistrict, Banyubiru Subdistrict, Getasan Subdistrict, Sumowono Subdistrict, Suruh Subdistrict, Pringapus Subdistrict, West Ungaran Subdistrict, and East Ungaran Subdistrict [3]. Landslides that occurred in East Ungaran subtodistrict resulted in the disconnection of the connecting road between East Ungaran and Mranggen. Landslide movement continues to this day, oriented from the south to the north. Landslide movement has entered residential areas, this can be seen in **Figure 1**.

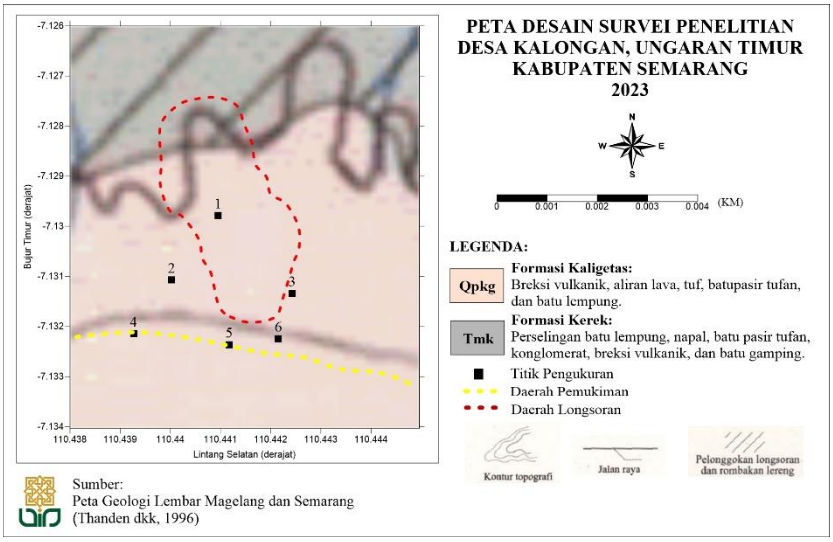
(**Figure 1.** Landslide Area)

Landslides can be minimized by mitigation. Mitigation has a definition of the stages of how to reduce disaster risk in terms of physical development or the ability to deal with disasters. One of the mitigations carried out to minimize damage and casualties is by using geoelectric methods. There are various types of geoelectric method configurations, one of which is the Schlumberger configuration. The Schlumberger configuration geoelectric method can be used to identify rock layers and layer thickness. This can be done because rocks have electrical properties that depend on the constituent minerals [4]. The Schlumberger configuration has the advantage of being able to detect the presence of inhomogeneous rock layers.

Research conducted in this area has been conducted by Lestari (2019) and Zulaikhah (2020) covering Semarang Regency using the Geographic Information System (GIS) method, and Vijaya (2022) covering Semarang Regency using the Fellinius method. There is no research in this area that uses geoelectric methods, lithological analysis, and research in Kalongan Village specifically. Thus, this study aims to identify lithology using geoelectric methods in Kalongan Village, East Ungaran. This research is important because the landslide area is densely populated and continues to experience movement.

2. Methods

The research was conducted in Kalongan Village, East Ungaran with the Schlumberger configuration geoelectric method. The Schlumberger configuration geoelectric method has advantages and disadvantages, one example of its advantage is that it can detect the non-homogeneity of rock layers on the surface by comparing resistivity values and its weakness is that it requires current sending equipment that has a very high direct current (DC) voltage to overcome small potential electrode voltage readings. This study used 6 VES located in the landslide area with varying line lengths, short lines of 120 m and 300 m. The varying track lengths are due to the different areas of the study where there is soil on the surface along the track. The data were collected using a set of naniura geoelectric tools. Data collection uses a set of naniura geoelectric tools. Data processing used Microsoft Excel software, Progress to display 2D modeling, and Rockwork 16 to display 3D modeling. The research survey design map can be seen in **Figure 2**.



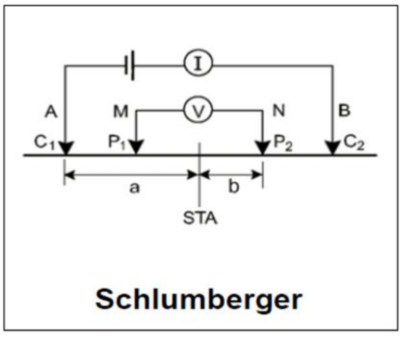
(**Figure 2.** Survey Design Map of Data Collection of Schlumberger Configuration Geoelectric Method with 6 VES)

2.1. Regional Geology

The study area is located in the kaligetas formation. This formation is composed of volcanic breccia, lava flows, tufan sandstone and claystone. Breccia flows and lava are interbedded with fine to coarse lava and tuff. The lower part is claystone that contains mollusks and tufan sandstone. Weathered volcanic rocks have a brown to reddish color by forming large chunks and a thickness of 50to200 m.

2.2. Geoelectric Method

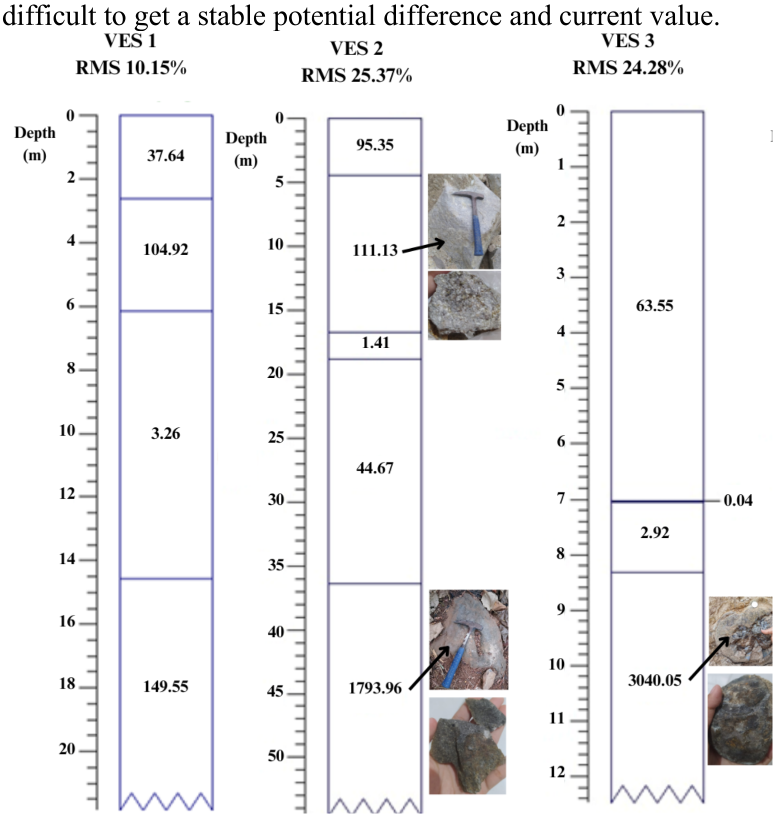
Geoelectric method is a geophysical method that studies the nature of electric currents in the earth and detects electric currents on the earth's surface. This method includes measurements of naturally occurring potentials and measurements of currents generated by the injection of electricity into the earth. There are various types of geoelectric methods, one of which is the resistivity geoelectric method. The type resistance method can describe the rocks below the ground surface. This can be seen by the difference in resistivity values in each rock. The working principle of the geoelectric method is by injecting electric current (I) into the subsurface of the earth using electrodes, so that it will produce a potential difference value (ΔV). Based on the survey objectives, the resistivity geoelectric method is divided into two, one of which is the sounding resistivity geoelectric method (Schlumberger configuration). The sounding resistivity geoelectric method is used to determine the variation of resistivity values vertically. The Schlumberger configuration uses four electrodes, two current electrodes and two potential electrodes. This can be shown in **Figure 3**.



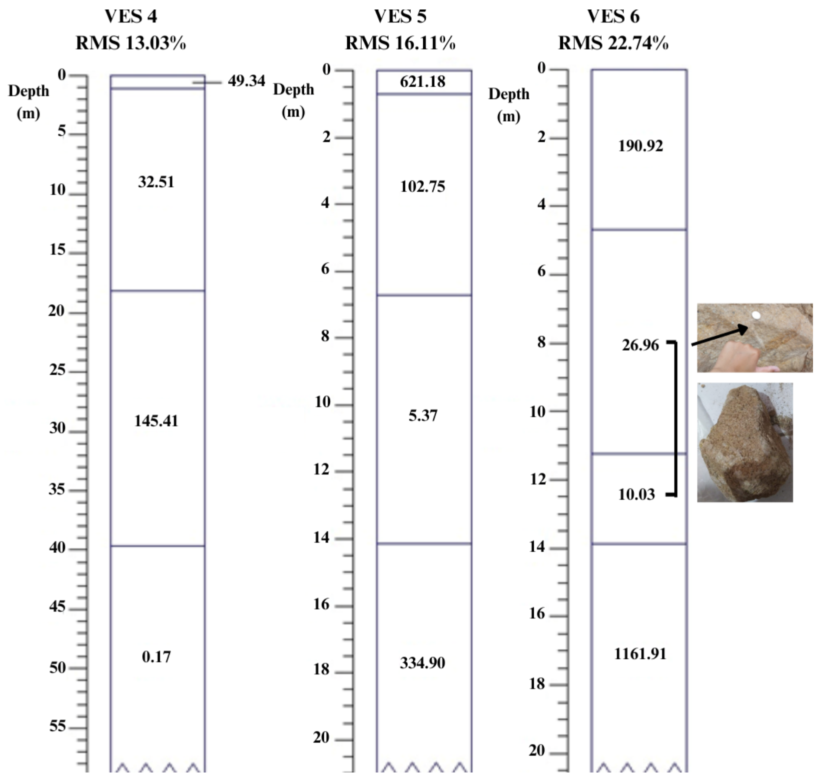
(**Figure 3.** Electrode arrangement of Schlumberger Configuration Geoelectric Method**)**

3. Results and Discussion

Measurements were taken in the landslide deposit area, the west, east and south sides of the landslide, as well as houses close to the landslide. The measurement location aims to determine whether the research area will continue to occur landslides by knowing the lithological constituents in the area. The results of data processing using progress software obtained resistivity value results that can be seen in **Figure 4** and **Figure 5**. VES 1 has a line length of 140 m with the measurement location right in the landslide sediment area. The results of the VES 1 data processing, getting a depth of 21.5 m with a resistivity value of 3.26 to 149.55 Ωm has an error of 10.15%. VES 2 has a line length of 300 m with the measurement location on the west side of the landslide. The results of the VES 2 data processing, getting a depth of 54 m with a resistivity value range of 1.41 to 1793.98 Ωm has an error of 25.37%. VES 3 line has a length of 240 m with the measurement location on the East side of the landslide. The results of the VES 3 data processing, getting a depth of 12.6 m with a resistivity value range of 0.04 to 3040.05 Ωm has an error of 24.28%. VES 4 has a line length of 300 m with the measurement location on the south side of the landslide close to residents' houses and road access. The results of the VES 4 data processing, getting a depth of 59 m with a resistivity value range of 0.17 to 145.41 Ωm has an error of 13.03%. VES 5 has a line length of 120 m with the measurement location on the south side close to residential houses. The results of the VES 5 data processing, getting a depth of 21 m with a resistivity value range of 5.37 to 621.18 Ωm has an error of 16.11%. VES 6 has a line length of 300 m with the measurement location on the south side of the landslide. The results of the VES 6 data processing, getting a depth of 20.5 m with a resistivity value range of 10.03 to 1161.91 Ωm has an error of 22.74%. The results of data processing that produce the smallest error are in VES 1 and the largest error in VES 2. This is because in VES 1 it is easier to stick the electrode because it is in the avalanche sediment area compared to VES 2 because it is in an area close to people's homes and access roads for pedestrians and motorbikes, so that the electrode that is stuck to the ground is difficult even though it has moved the electrode and it is difficult to get a stable potential difference and current value.



(**Figure 4.** Data Processing Results of VES 1 to 3 Resistivity Log Value and Depth)



(**Figure 5.** Data Processing Results of VES 4to 6 Resistivity Log Value and Depth)

The resulting resistivity value will be interpreted into several types of rocks. The resistivity value for rock interpretation refers to the 1990 Telford reference and field conditions. The resistivity value in the 1990 Telford reference can be seen in **Table 1** and the resistivity value of the research results can be seen briefly in **Table 2**.

Table 1. Resistivity values Telford, 1990.

No.	Litologi	Resistivitas (Ωm)
1	Batu Pasir	$1 - 6.4 \times 10^8$
2	Tuff	$2 \times 10^3 - 10^5$
3	Aliran Lava	$10^2 - 5 \times 10^4$

The interpretation of the data processing that has been done, obtained in VES 1 is represented by soil (49.34 Ωm) and tuff sandstone (104.92, 3.26 and 149.55 Ωm). The interpretation of VES 2 is soil (95.35 Ωm), tuff sandstone (111.13, 1.41 and 44.67 Ωm), and lava flow (1793.96 Ωm). The interpretation of VES 3 is soil (63.55, 0.04 and 2.92 Ωm) and lava flow (3040.05 Ωm). This line is thought to have rocks that absorb water, so that at a depth of 7 m has a low resistivity value. The interpretation of VES 4 is soil (49.34 and 32.51 Ωm) and tuff sandstone (145.41 and 0.17 Ωm). This line is suspected to have rocks that absorb water, so that at a depth of 45 to 59 m has a low resistivity value. The interpretation of VES 5 is soil (621.18, 102.75, 5.37 Ωm) and tuff sandstone (334.90 Ωm). The interpretation of VES 6 is soil (190.92 Ωm), tuff (26.96 and 10.03 Ωm), and lava flow (1161.91 Ωm). The results of data interpretation, obtained rocks that are almost found in all lines are tuff sandstone. While lava flows are only found in VES 2, VES 3, and VES 6. Meanwhile, tuff is only found in VES 6.

Table 2. Resistivity Value of Research Results

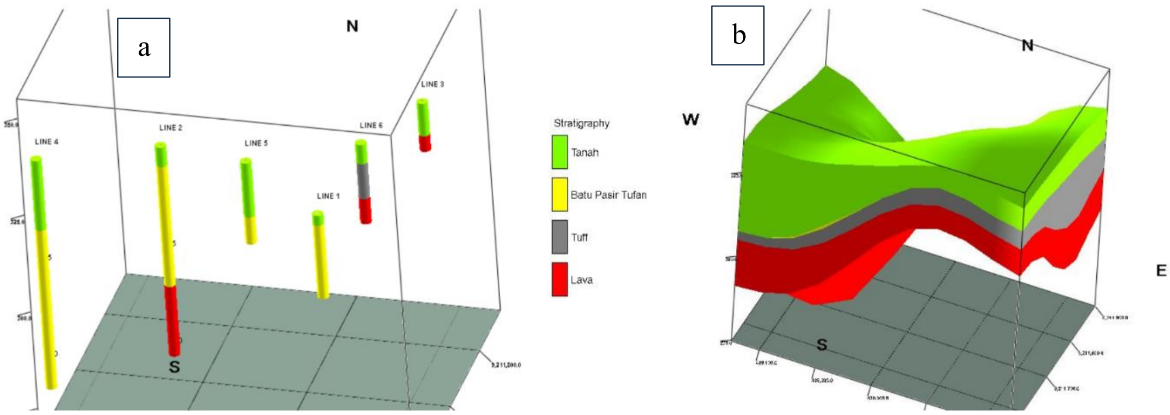
No.	Lithology	Resistivity (Ωm)
1	Top Soil	0.04 to 621.18
2	batu pasir tufan	0.17 to 334.9
3	tuff	10.03 to 26.96

4	lava	1161.91 to 3040.05

Lithologic conditions are one of the causes of landslides. One of the factors that can cause landslides is local groundwater, in the research area there is a water flow, this can be seen in **Figure 6**. Rocks that will experience landslides in this research area are tuff sandstone, claystone, and tuff. This is because tuff sandstone and tuff have low bearing capacity according to their grain size, if these rocks absorb water beyond their capacity, landslides will occur because the rocks are unable to withstand the water. Clay stones have impermeable properties and will expand when exposed to water, so clay stones are prone to landslides. Tuff sandstone, tuff, and claystone are included in sedimentary rocks. Sedimentary rocks generally have a lower resistivity value compared to igneous rocks, this is because each rock has different shape characteristics to absorb water.

(**Figure 6.** Puddles and Water Flow in the Avalanche Area)

The results of the data interpretation that has been done, can be produced 3D modeling using rockwork 16 software. The results of this modeling show the depth of each research line along with the depth of different rock types, so that it can be known visually the depth of the rock that has been interpreted. 3D modeling was made to show that each measured traverse consists of different rock layers. this can be seen in **Figure 7**. Multilog 3D modeling resulted in depths of less than 25 m at VES 1 and VES 5 not yet represented igneous rocks, namely lava flows. This is because the length of the measurement line is too short in the area. While on VES 3 and 6 with a depth of less than 25 m represented igneous rocks, namely lava flows, the short line length does not affect this area. The depth of VES 4 reaches 50 m, although this area has a deeper depth than the other lines. The measurement points in this area have not yet been represented by igneous rocks, thus requiring a longer measurement trajectory. The 3D stratigraphic modeling shows that the landslide that occurred in the study area moved from the south to the north. This can be seen in the first line measurement point which has a lower elevation than the other line measurement points. The East side of the avalanche has a higher elevation than the West and South sides of the avalanche, in this model the soil (top soil) is more than other rocks. Multilog 3D modeling can be a reference that the research area will be more prone to landslides seen from the interpreted rocks and stratigraphic 3D modeling that clearly shows the basin in the landslide area and the depth between rock layers.



(**Figure 7.** a.3D Multilog modeling, b.3D Stratigraphic modeling)

4. Conclusion

Based on the research that has been done, it can be concluded that the resistivity value in each track is different so that it can be interpreted into several types of rocks. VES 1, VES 4, and VES 5 are composed of the same rocks, namely soil (top soil) and tuffaceous sandstone. VES 2, VES 3, and VES 6 have the same rock composition, namely soil and lava flow, which distinguishes tuff in VES 6 and tuff sandstone in VES 2. The research conducted resulted in the research area being represented by dominant sedimentary rock, namely tuff sandstone. These rocks will be more easily weathered than igneous rocks, namely lava flows. Even this research area has a fairly heavy water flow in the rock layer on the South and East sides. This makes the area prone to landslides. The suggestion for research in Kalongan Village, East Ungaran is to use other methods to analyze the rock layers in the area to be more accurate.

References

[1] F. V. De Blasio, *Introduction to the physics of landslides: lecture notes on the dynamics of mass wasting*. Dordrecht ; New York: Springer, 2011.

[2] S. Szalai, K. Szokoli, M. Metwaly, Z. Gribovszki, dan E. Prácser, “Prediction of the location of future rupture surfaces of a slowly moving loess landslide by electrical resistivity tomography,” *Geophysical Prospecting*, vol. 65, no. 2, hlm. 596–616, Mar 2017, doi: 10.1111/1365-2478.12421.

[3] S. Lestari, A. L. Nugraha, dan H. S. Firdaus, “Jurnal Geodesi Undip,” vol. 8, no. 1, 2019.

[4] M. Farhati dan M. S. Rosid, “Identifikasi Bidang Gelincir dengan Metode Geolistrik Tahanan Jenis 2 Dimensi di Daerah Keranggan, Tangerang Selatan,” *Positron*, vol. 12, no. 1, hlm. 1, Mei 2022, doi: 10.26418/positron.v12i1.53584.

[5] “telford-geldart-sheriff-applied-geophysics.pdf.”

[6] F. Faizana, A. L. Nugraha, dan B. D. Yuwono, “Jurnal Geodesi Undip,” vol. 4, 2015.

[7] R. M. Vijaya dan B. A. Arizaky, “ANALISA STABILITAS LERENG LONGSOR DI UNGARAN TIMUR KABUPATEN SEMARANG”.

[8] V. Arsanti, R. S. Kharisma, dan S. Arfianto, “Analysis Spatial Pattern Garbage Bank using Web Geographic Information System in Yogyakarta City,” *ASSET*, vol. 5, no. 1, hlm. 0230102, Apr 2023, doi: 10.26877/asset.v5i1.15139.

[9] K. Tjandra, *Empat bencana geologi yang paling mematikan*, Cetakan pertama. Yogyakarta: Gadjah Mada University Press, 2017.

[10] “[Gary_Mavko,_Tapan_Mukerji,_Jack_Dvorkin]_The_Rock(Bookos.org).pdf.”

[11] B. Usman, R. H. Manrulu, A. Nurfalaq, dan E. Rohayu, “IDENTIFIKASI AKUIFER AIR TANAH KOTA PALOPO MENGGUNAKAN METODE GEOLISTRIK TAHANAN JENIS KONFIGURASI SCHLUMBERGER,” *FLUX*, vol. 14, no. 2, hlm. 65, Okt 2017, doi: 10.20527/flux.v14i2.4091.

[12] N. Muhlisah, R. A. Magfirah, I. N. Mutiah, dan A. Pratama, “Analisis Litologi Bawah Permukaan Teluk Liukang Menggunakan Metode Seismik Refraksi,” vol. 01, no. 01, 2020.
[13] E. S. Putriutami dan U. Harmoko, “INTERPRETASI LAPISAN BAWAH PERMUKAAN DI AREA PANAS BUMI GUNUNG TELOMOYO, KABUPATEN SEMARANG MENGGUNAKAN METODE GEOLISTRIK RESISTIVITY KONFIGURASI SCHLUMBERGER,” vol. 3, no. 2, 2014.
[14] D. D, B. Nurlaksito, dan B. Legowo, “Identifikasi Bidang Gelincir Pemicu Bencana Tanah Longsor Dengan Metode Resistivitas 2 Dimensi Di Desa Pablengan Kecamatan Matesih Kabupaten Karanganyar,” *Indonesian J Appl Phys*, vol. 2, no. 02, hlm. 51, Mei 2016, doi: 10.13057/ijap.v2i02.1292.
[15] A. Masyhuri, H. Purnaweni, A. R. Herawati, dan B. P. Priyadi, “Kolaborasi Antar Stakeholders Dalam Manajemen Bencana Tanah Longsor Di Kota Semarang,” *j.Educ.hum.soc.sciences*, vol. 4, no. 2, hlm. 854–862, Okt 2021, doi: 10.34007/jehss.v4i2.759.
[16] M. A. Syam, K. Sasmito, dan N. N. Adlina, “GEOLOGI DAN PENGARUH LITOLOGI TERHADAP BENTUK MORFOLOGI DAERAH BANGUN REJO KECAMATAN TENGGARONG SEBERANG KABUPATEN KUTAI KARTANEGARA,” vol. 1, no. 1, 2018.
[17] Y. Arman, “Identifikasi Struktur Bawah Tanah di Kelurahan Pangmilang Kecamatan Singkawang Selatan Menggunakan Metode Geolistrik Resistivitas dan Inversi Lavenberg - Marquardt,” *positron*, vol. 2, no. 1, Mei 2012, doi: 10.26418/positron.v2i1.2001.
[18] M. Kadri dan T. F. Sudarma, “Penentuan Struktur Bawah Permukaan Daerah Geothermal Menggunakan Metode Geolistrik di Desa Penen Kecamatan Biru Biru Kabupaten Deli Serdang,” *TGEO*, vol. 8, no. 1, hlm. 1, Nov 2019, doi: 10.24114/tgeo.v8i1.13914.
[19] D. Trisnawati, Najib, dan A. S. Hidayatillah, “The Relationship of Lithology with Landslide Occurrences in Banyumanik and Tembalang Districts, Semarang City,” *IOP Conf. Ser.: Earth Environ. Sci.*, vol. 1047, no. 1, hlm. 012026, Jul 2022, doi: 10.1088/1755-1315/1047/1/012026.
[20] M. I. R. Marani, N. Najib, dan R. K. Ali, “Penentuan Zona Gerakan Tanah dan Analisis Kemantapan Lereng di Kecamatan Klego, Kabupaten Boyolali, Jawa Tengah,” *Jurnal Geosains dan Teknologi*, vol. 1, no. 3, hlm. 89, Nov 2018, doi: 10.14710/jgt.1.3.2018.89-98.