Bedrock identification using resistivity method at campus II of Universitas Syiah Kuala, Banda Aceh

M Syukri¹,², A M Taib³*, Z Fadhli³
¹Physics Department, Universitas Syiah Kuala, Banda Aceh, Indonesia
²Program Study of Geophysical Engineering, Universitas Syiah Kuala, Banda Aceh, Indonesia

*E-mail: amsir@unsyiah.ac.id

Abstract. Research of resistivity method at campus II Universitas Syiah Kuala has been conducted with the SuperSting 68 instrument. There were three lines, each 330 meters long with a spacing of 6 meters. The purpose of the research was to determine the depth of the bedrock at campus II of Universitas Syiah Kuala. The results showed that there was a conductive and resistive coating with a resistivity value of between 2–1250 Ωm. The rock types were composed of water-saturated rocks, Tuffs sandstone, and andesite. The supposed bedrock rock is an andesite rock with a resistivity of 170–1250 Ωm with good density. In conclusion, the separation between the sediment and the bedrock was visible at a depth of up 10 meters across the measuring track.

1. Introduction
Universitas Syiah Kuala (UNSYIAH) is currently developing campus II in Neuheun village, Aceh Besar, to support Aceh’s higher educational activities further. The construction of Campus II UNSYIAH requires the construction plans to meet the development criteria and standards. These criteria help optimize buildings and physical infrastructures such as roads, pedestrian pavement, academic offices, lecturer buildings, laboratory, and garden. Thus, subsurface information is crucial. Subsurface information could be categorized as crucial information or data to optimize infrastructure construction, like Campus II development.

The condition of the rock structure is essential when planning the construction foundation. The type of rock and basement rock as supporting data help determine the characteristics and weight of the foundation that will be developed [1]. Bedrock information is vital subsurface data during the construction building. Furthermore, the foundation of a building is also crucial as the foundation continues the building load to the soil [2].

The resistivity method was applied in the western part of Campus II of UNSYIAH. The purpose of the research was to identify the subsurface based on the resistivity value. The result could help determine and describe the depth of bedrock and thickness of bedrock in Campus II of UNSYIAH. The resistivity method was historically used for these goals. It was able to determine and map the high resistivity value contrast between the conductive covering layer and the resistive bedrock [3], [4], [5], [6], [7]. This technique is non-invasive, rapid, and low-budget and can be efficiently executed in alluvial [8].
2. Methodology and Geology of the study area

The resistivity method is an efficient method in the geophysics survey to investigate the subsurface field based on the resistivity value of material in the subsurface [2]. Generally, the resistivity method was conducted by transmitting direct current (DC) into the ground surface as shown in Figure 2. Furthermore, the potential difference was measured at a different area on the ground surface [9]. The current can easily seep into a rock and soil, depending on the conductive properties of rock and soil.

The Schlumberger array was used as a type of electrode array in this research used four electrodes, including two current (C1 and C2) and two potential (P1 and P2) electrodes in a straight line. The Schlumberger array generally has better resolution, greater probing depth, and less time-consuming field deployment than another array such as Dipole-dipole, Pole-dipole, and Wenner array [10]. The Schlumberger array can be seen in Figure 1.

![Schlumberger array](image1.png)

**Figure 1.** Schlumberger array [10]

![Current Flow Distribution](image2.png)

**Figure 2.** Current Flow Distribution [11]

The research area is a proposed location of Campus II of Universitas Syiah Kuala, Banda Aceh. The site is located in Aceh Besar District and situated between 5°36'43.32" N and 95°25'6.36" E and 5°36'51.04" N and 95°25'13.74" E in the southern part of the main UNSYIAH campus. The geology of campus II of Unsyiah located in Neuheun village, Aceh Besar has been well described [12] and consists mainly of alluvium, gravel, sand, mud, and Lamteuba volcano rock. The geology of the field is presented in Figure 3.

![Geology map](image3.png)

**Figure 3.** Geology map of Neuheun village, Aceh Besar [12].

The research field is presented in Figure 4. There are three measurement lines, using SuperSting R8 electrical resistivity with 56 electrodes and 6 meters spacing between electrodes. The total length for
each measurement line is 330 meters. The resistivity measurement method conducted in the study is electrical resistivity imaging of Schlumberger array to identify bedrock zones; it will be interpreted into 2D cross-sections of the subsurface zones later on.

![Legend](image)

**Figure 4.** Measurement line of Campus II UNSYIAH

### 3. Results and discussion

The resistivity value for line 1 has a contrast between 2 - 1250 Ωm. The total length was 330 meters; the depth of investigation is about 63 meters (Figure 5). There are three different layers from the inversion resistivity value. The first layer contains sand showing a low resistivity value that ranges from 2 - 18 Ωm. The soil was located between andesite bumps at a depth of 20 - 40 meters with a thickness of approximately 4 - 20 meters. The resistivity value for the intermediate layer was 25 - 120 Ωm interpreted as the second layer and contains tuffaceous sandstone layers found in volcanic rock formations in Lam Teuba volcano with a thickness of approximately 0 - 60 meters. The third layer presented a high resistivity value (170 - 1250 Ωm) and was interpreted as an andesite rock. In this section, the bedrock appeared at a depth of 20 - 60 meters.

The hard/dense soil depth data can also be plotted in a base map, which is useful for knowing the position of each test point and the depth of stable soil at each location. Then an interpolation is made to determine the zoning of hard/dense depth, as shown in Figure 4. The zoning map shows that most of the tested locations have a stable soil depth of 10 meters below the existing ground surface. In certain places such as the area around Lambung, around Lamjame, around Neusu Aceh, around Lambaro Skep, around...
Jeulingke, around Doi, and around Kopelma Darussalam exhibited stable depth from 5 to 10 meters. The shallowest hard/dense soil depth is only found around Lamjame of Jaya Baru District.

![Figure 5. Inverted Resistivity value for line 1](image1.png)

The inversion result of the second line is presented in Figure 6. The length of this line is 330 meters, with a maximum depth of penetration of 67 meters. The lower resistivity with a value of 2 - 18 Ωm may be interpreted as water-saturated rocks at a depth of 0 - 30 meters in a distance of 70 - 160 meters. The second layers showed a low resistivity value of 25 - 120 Ωm and were presented as tuffaceous sandstone, which dominated this layer. The lowermost surface layer showed a relatively high resistivity value over 170 Ωm, which is bedrock at a depth of 10-60 meters in a distance of 50 - 200 meters.

![Figure 6. Inverted Resistivity value for line 2](image2.png)

The 2D inversion resistivity pseudosection of line 3 (Figure 7) trends from the Southwest to the northeast direction, the total length of the survey line was 330 meters. In comparison, the maximum depth of penetration was 67 meters, and the topography was approximately 70 meters high. In this section, the subsurface resistivity image along line 3 appears as an identical layer, where line 3 has three layers for low resistivity (2 - 18 Ωm) and is interpreted as a water-saturated rock with a value of 25 -
120 Ωm presented tuffaceous sandstone rock. The high resistivity value is shown in the third layer, which has a value up to 170 Ωm indicated as a bedrock at a depth of 10–45 meters.

![Diagram of inverted resistivity value](image)

**Figure 7.** Inverted Resistivity value for line 3

4. Conclusion
The research results indicate a complex subsurface profile in the area. The measurement result of 3 lines found that the hard layer is located at a depth up to 10 meters in lines 2 and 3, while line 1 found the hard layer at a depth of up to 20 meters. Furthermore, based on the resistivity value of the geology map, the research location is composed of andesite rock as bedrock with a high resistivity value of up 170 Ωm.

5. Acknowledgments
The authors would like to thank the Geophysics teams, students, and staff of the Geophysical Engineering Program, Earth Sciences Engineering Department, Engineering Department, Universitas Syiah Kuala Banda Aceh (Indonesia). Special thanks are extended to the Ministry of Education and Culture, Indonesia, for financial support in the scheme of PLK-PNBP Unsyiah 2020 Grant.

References
[1] Pazha H, Nasro M, Agustina R D 2019 *J. Phys. Conf. Ser.* **1175** 012014.
[2] Rizka R, Satiawan S 2019 *JSAT* **2** 281430.
[3] Hamilton W, Bachman S B 1982 *Fundamental of Geological Surface*. Birmingham: University of Birmingham.
[4] Bavitra A, Amir H 2015 *Pillar of Physics* **6** 1-8, (in Bahasa Indonesia).
[5] Aziz N A, Abdulrazzaq Z T, Alwan H A Z 2015 *Iraqi J. Sci. Technol.* **6** 83-88.
[6] Syukri M, Anda S T, Safitri R, Fadhli Z, Saad R 2020 *Int. J.* **18** 123-129.
[7] Syukri M, Saad R, Anda S T, Fadhli Z 2019 *Int. J.* **17** 133-143.
[8] Cardarelli E, De Donno G 2017 *J. Appl. Geophys.* **141** 77-87.
[9] Samouëlian A, Cousin I, Tabbagh A, Bruand A, Richard G 2005 *Soil Tillage Res.* **83** 173-193.
[10] Loke M H. 2000. *A Practical Guide to 2d and 3d Surveys*. California: Stanford University.
[11] Telford W M, Geldart L P, Sheriff R E, Keys D A. 1990. *Applied Geophysics* 2nd ed. New York: Cambridge University Press.
[12] Bennet J D, Bridge D M, Cameron N R, Djunuddin A, Ghazali S A, Jeffry D H, Kartawa W, Keats W, Rock N M S, Thomson S J, Whandoyo, R 1981 *Peta Geologi Lembar Banda Aceh, Sumatera, Skala 1:250.000. (in Bahasa Indonesia).*