Application of Electrical Resistivity Imaging (ERI) to analyse geological structure in Paloh, Gua Musang, Kelantan

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Abstract. This study is conducted in Paloh, Gua Musang district, Kelantan and focussed on Electrical Resistivity Imaging (ERI) method which was carried out to assess the subsurface geological structures of Paloh area, Gua Musang. Two survey lines of 200 m are conducted in the study area by using Gradient array. The data obtained from ERI is processed by using RES2DINV software to produce a pseudosection model. Variable resistivity values ranging from 1Ωm to >3000Ωm with a depth of investigation of approximately 40m showed in the pseudosection model. Based on the model, the structural analysis of the study area resulted in several fault lines occurring in the subsurface area. The fault line indicated the occurrence of subsurface movement. This study suggests further geophysical investigation (seismic survey) be carried out as it would be able to give the extent of information on subsurface geological structures for geoengineering study for site investigation.

1 Introduction

The uses of geophysical imaging of Electrical Resistivity Imaging (ERI) are well-known for its non-destructive, time-effective, and low-cost method that used high alternating current voltage, low current, and low power frequency to penetrate the ground and then produce a model of the subsurface region [1]. Specifically, the spatial distribution of the low-frequency resistive and capacitive characteristics of underground earth materials was imaged using electrical resistivity and IP imaging. [2][3]. A geological assessment is implemented in Paloh area to analyse the subsurface geological structure as the area is prone to landslides. According to [2], the investigation of detailed geological and geophysical to define the tectonic geological features (main faults) helped to better understand the subsurface geological conditions which able to prevent any severe consequences such as landslides that caused the destruction of the main road [4].

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Application of ERI for the detection of subsurface geological structural changes has been verified by [5] that resulted in the existence of conductive structures caused by weathered carbonate, as well as additional conductive and resistive anomalies caused by water-filled and dry cavities (cave), respectively. Another evidence of ERI application for geological structure analysis is proven by [6] which found three shear zones within the subsurface of a Wetland Area of Lagos, Nigeria by using this method.

1.1 Study Area

The study area is located in Paloh, Gua Musang as shown in Figure 1 within the main road to Kampung Paloh 3 and Lebir 1 (Figure 2). Generally, the geological setting of Paloh is made up of volcanic rocks and sedimentary rocks. The volcanic rocks are composed of pyroclastic; tuff, ignimbrite, volcanic sandstone and volcanic breccia. While, the sedimentary rocks are composed of sandstone, mudstone, carbonaceous mudstone and conglomerate.

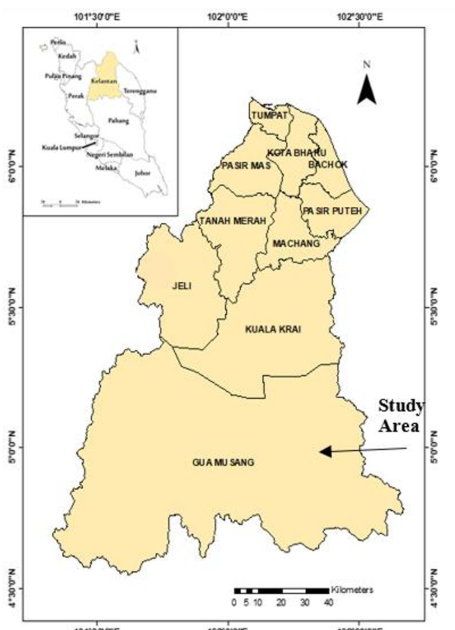

Fig 1. Location of study area.

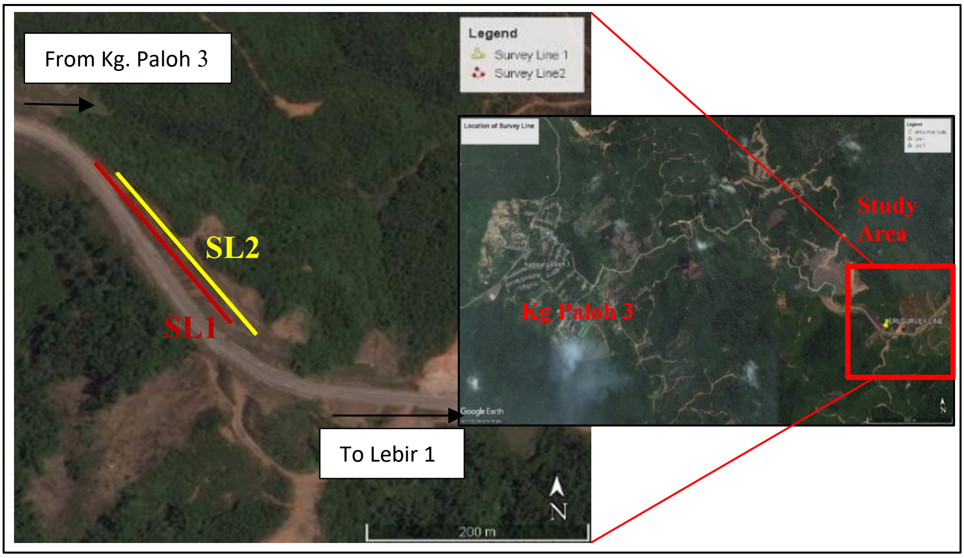

Fig 2. Location of survey lines.

2 Methodology

The method used to determine geological structure is electrical resistivity method. In the study area, two survey lines of 200m with 5m spacing between electrodes are carried out using an ABEM Terrameter LS. Gradient array configuration is ideal for locating sinkholes, fractures, geological changes, and cost and time-effective arrays.

Subsurface resistivity distributions are typically evaluated by passing an electrical current through the ground using two current electrodes. A pair of potential electrodes measures the potential differences induced by the flow of current between any two places in linear line with the current electrodes. The resistance at the chosen position in the subsurface can be calculated using the measured voltage (V) and current (I) values.

In this study, both survey lines are set up horizontally on the berm slope along the roadway as shown in Figure 3 and Figure 4.


Fig 3. Set up of survey line 1.

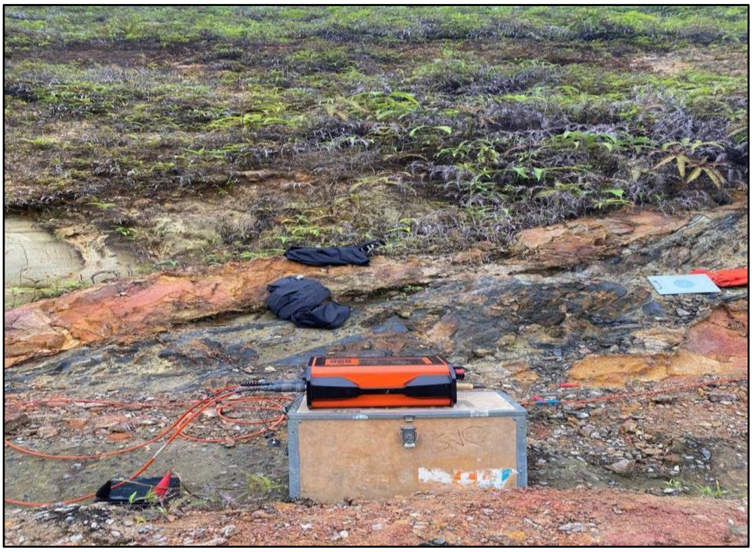

Fig 4. Set up of survey line 2.

The 2D resistivity inversion pseudo section model, which displays the resistivity values of the subsurface area, is created by processing raw field data using the RES2DINV software. Results of the inversion are generated with RMS error of less than 20%. The obtained result is then compared with the standard materials resistivity value determined by earlier research, as given in Table 1. The comparison is then used to interpret the results.

Table 1. Resistivity values of some common rocks, minerals and chemicals [7, 8].

Material	Resistivity (Ωm)
Toneous and Metamorphic Rocks	
Granite	5×10^3 - 10^6
Slate	10^3 - 10^6
Basalt	6×10^2 - 4×10^7
Marble	10^2 – 2.5×10^8
Quartzite	10^2 - 2×10^8
Sedimentary Rocks	
Sandstone	8 - 4×10^3
Shale	20 - 2×10^3
Limestone	50×10^2 - 4×10^2
Soils and waters	
Clay	1 - 100
Alluvium	10 - 800
Groundwater (fresh)	10 - 100
Sea water	0.2
Chemical	
Iron	9.074×10^8
0.01 M Potassium Chloride	0.078
0.01 M Sodium Chloride	0.843
0.01 M Acetic acid	6.13
Xylene	6.998×10^{16}

3 Result and Discussion

3.1 Survey Line 1

The result of pseudosection for Survey Line 1 is shown in Figure 5. The resistivity pseudosection root-mean-square (RMS) error is 6.4%. The obtained resistivity values of Survey Line 1 ranged from 38.2 Ωm to 1181 Ωm. Based on Figure 5, the area in orange to purple colour indicated a high resistivity value of > 700 Ωm, which is classified as moderately weathered to hard material zone. This high resistivity zone are expected consist of bedrock or dry material. This area is located at a depth between 10m to 30m below the subsurface.

The area in blue to brown colour with low resistivity value 166 Ωm to 700 Ωm is classified as a weak zone, which is composed of weak material or soil with high content of water. The weak zones are indicated a fractured area (fracture line) that allowed water to store within it. This zone is located at a depth between 5m to 10m. The area in dark blue colour with resistivity between 38.2 Ωm to 102 Ωm is classified as water saturated layer or layer with high content of clay material. These layer is located at surface to depth between 0m to 10 m.

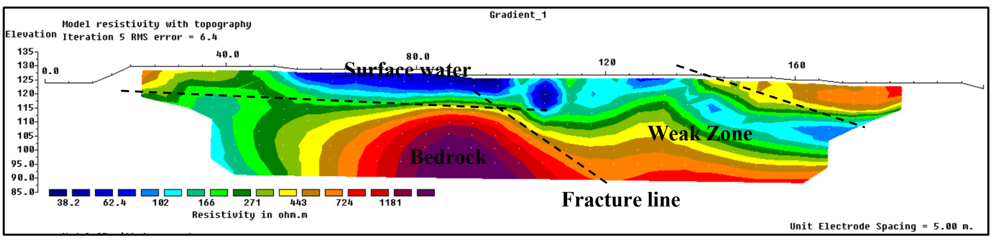

Fig 5. Survey Line 1.

3.2 Survey Line 2

Figure 6 shows the result of resistivity pseudosection for Survey Line 2. The resistivity pseudosection root-mean-square (RMS) error is 9.5%. The obtained resistivity values of Survey Line 2 ranged from 7 Ωm to >3000 Ωm. Based on Figure 6, the area in dark green to purple colour indicated a high resistivity value of > 700 Ωm, which is classified as moderately weathered to hard material zone. This high resistivity zone is interpreted consist of bedrock or dry material. The area located in the elevation between 95m to 65m below the subsurface is classified as bedrock, while the area in elevation from the surface to 90m is classified as boulder/dry material.

The area between elevation 65m and 105m with blue to green colour is classified as weak zone, which is composed of weak material or soil with high content of water. The weak zone also indicated a fractured area (fracture line) that allowed water to store within it. The area in dark blue colour with resistivity between 7Ωm to 200 Ωm is classified as water saturated layer or layer with high content of clay material and located at depth between 0m to 20 m.

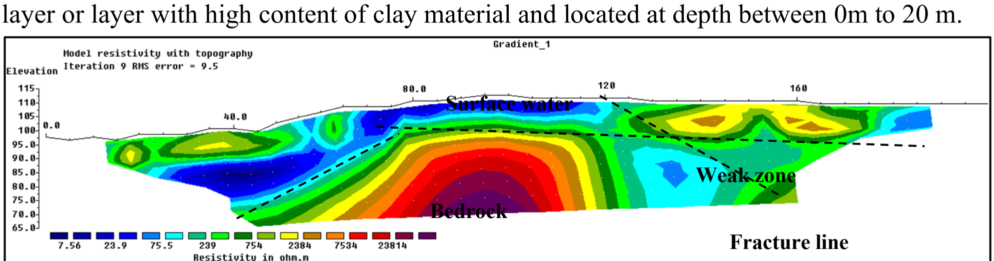

Fig 6. Survey Line 2.

4 Conclusion

The application of ERI in geological structure analysis is proven in this study. The pseudosection of both survey lines showed a geological structure of weak zone that indicated the occurrence of fractured zone in the subsurface. The fracture plane low angle (fracture line) is understood to be the outcome of thrust fault activity. Further geophysical investigation (seismic survey) need to be carried out as it would be able to give the extent of information on subsurface geological structures for the purpose of geoengineering study for site investigation.

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