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Groundwater Potential Using Electrical Resistivity Imaging In Batu Melintang, Jeli, Kelantan

M S Sulaiman[1]*, M A Khan[1], N Sulaiman[1], and W S Udin[1]

[1]Faculty of Earth Science, Universiti Malaysia Kelantan, 17600 Jeli, Malaysia
*E-mail: syakir.s@umk.edu.my

Abstract. The study is carried out in the northern Kelantan region, specifically at Batu Melintang, Jeli, across a distance of around 20 km^2. The study's main aim is to analyze groundwater potential that can be used for future mining or agricultural propose. Batu Melintang's lithology consists of slate, phyllite, schist, hornfels, metasiltstone and metasandstone with granitic intrusions. Sungai Pergau and Sungai Tadoh are the major rivers in the area fed by tributary drainages located in the gold mining zones. It is crucial to assess the groundwater potential for future usage as any disruption of the watershed drainage system, could interfere with the primary surface river system which will eventually hinder the importance of Batu Melintang as a gaining popularity geotourism site. This research is conducted by using geological mapping and resistivity surveys. Four survey lines of 200 m are conducted within the study area using the Wenner configuration. Resistivity data is processed using Res2Dinv software and result with RMS error lower than 20% were produced. Both pseudosection of lines L1 and L2 show the occurrence of fresh groundwater (1-100ohm.m) at a depth of 5 meters and below the surface. It also shows the activity of normal faulting that might produce the aquifer. In the cases of LS3 and LS4, potential groundwater found in the continuous low angle aquifer located deeper around 10m to 30m might also be produced by the activity of the thrust fault. The study also found that the best groundwater potential occurred in the zone within the fractured bedrock of metamorphic rock.

1. Introduction

In a major part of the world, groundwater is an essential resource for drinking and agricultural purposes, especially in the landscape's dominated sub-tropical to semi-arid climatic conditions [1]. However, low quality and low amounts of freshwater are significant problems in Kelantan. Assessing groundwater resources is essential as it can help solve this problem, especially in Kelantan. Groundwater usage in Kelantan is also high. In Kelantan, groundwater is the main source of drinking water for more than 70% of the population., including in the rural areas without access to piped water [2].

One of the widely used geophysical techniques is the electrical resistivity approach for detecting groundwater potential as it is an effective, non-destructive, and low-cost method that is proven to be able to locate potential groundwater sources [3]. This method is done by taking measurements on the surface for the subsurface resistivity data to understand better the subsurface characteristics, which help to accurately locate aquifers with high groundwater yield [4]. The application of the electrical resistivity method for groundwater potential has been portrayed by many authors [3,4,5]. Baharuddin [5] detected the thickness and location of the aquifer zone in North of Kelantan by using the electrical resistivity method, then proceeded to design a submersible pump and well screen after obtaining the data condition of the subsurface. Sulaiman and Saliman [6] also conducted five resistivity survey lines in Lojing, Gua Musang, Kelantan to identify whether groundwater potential might exist which then resulted in a high

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potential of groundwater accumulation in the study area. This study aims to analyze groundwater potential in Batu Melintang, Jeli, Kelantan that can be used for future mining or agricultural propose.

1.1. Geological Setting

Kelantan is located in the northeast of Peninsular Malaysia. The study is conducted within the area of approximately 20km^2 located in Batu Melintang which is in the western part of Jeli, Kelantan (Figure 1). Jeli has located about 92 km from Kota Bharu, bordered by the state of Perak to the west, Thailand to the north, Kuala Krai district to the south-east and Tanah Merah district to the northeast.

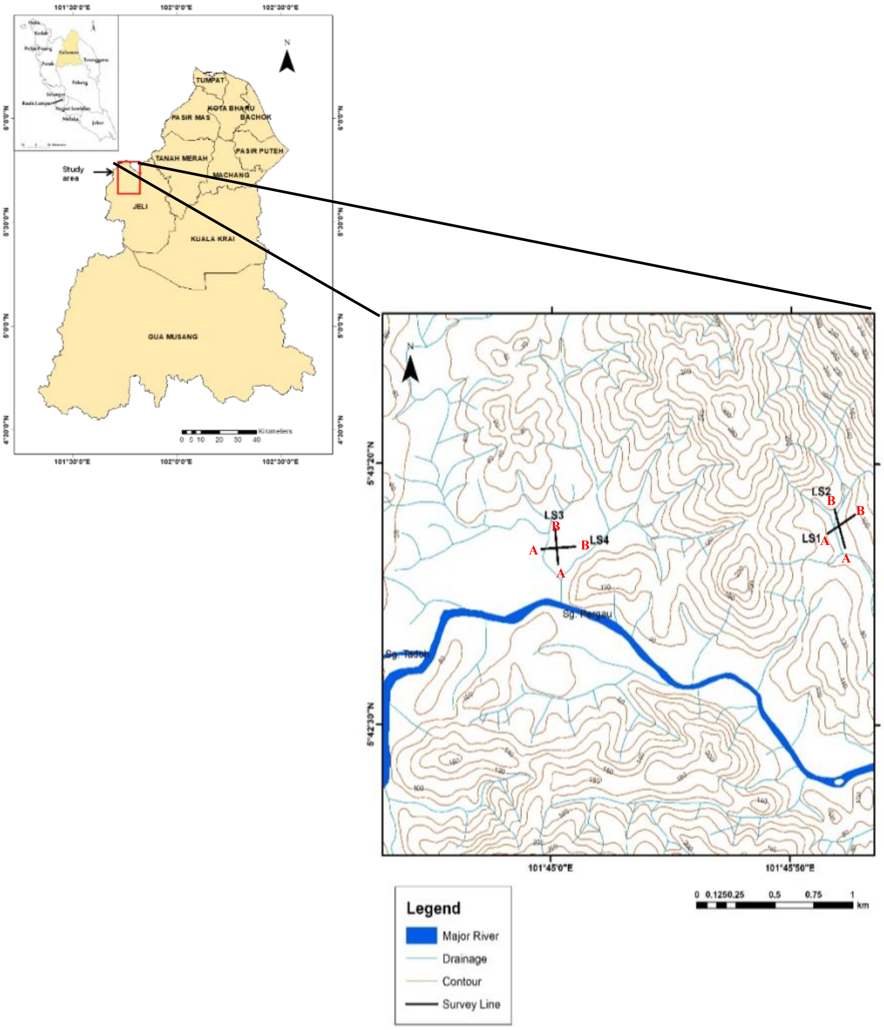

Figure 1. Map of the study area and survey line location of groundwater potential in Batu Melintang, Jeli.

Batu Melintang is part of the Bentong-Raub Suture and is in the Central Gold Belt of Peninsular Malaysia, which is also well-known for its gold occurrences with high potential for gold mining. The study area is predominantly comprised of two major rock units which are Mangga Formation and Telong Formation. The Mangga formation is made up of the low-grade metamorphic sequences of arenaceous, argillaceous, pyroclastic, and calcareous rocks. The Telong Formation is made-up of argillite, low-grade metasedimentary and metavolcanic rocks [7]. Generally, the lithology of Batu Melintang consists of slate, phyllite, schist, hornfels, limestone, metasiltstone and metasandstone with granitic intrusions of Lawar Granite (Figure 2).

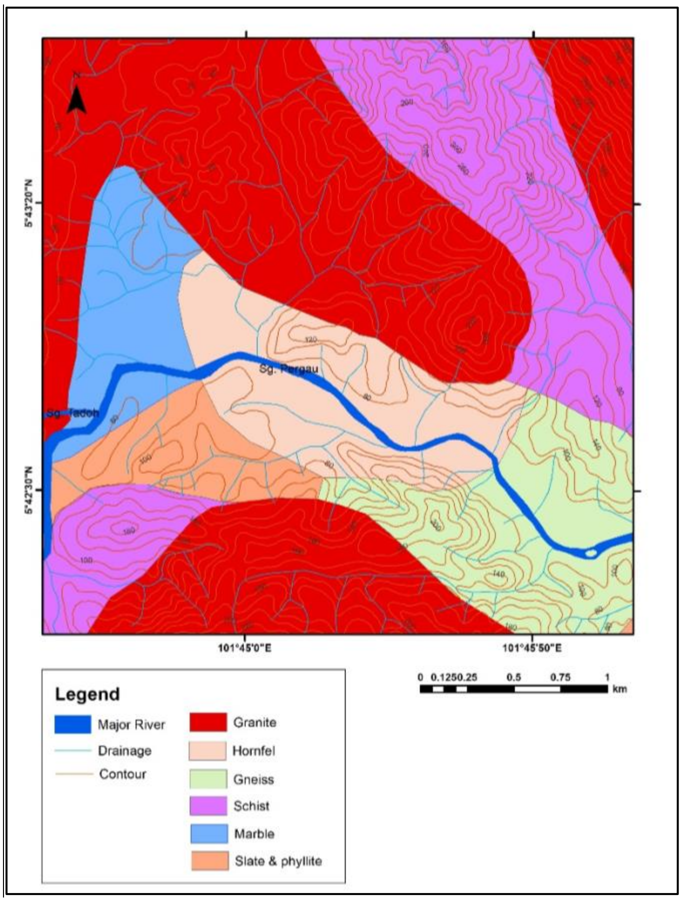

Figure 2. Geological map of the study area [8].

2. Methodology

2.1. Electrical Resistivity Imaging Survey and Data Processing

Analysis of groundwater potential is conducted by utilising the Electrical Resistivity Imaging (ERI) method. A total of four survey lines of 200 m length with 5 m electrode spacing are conducted by using the ABEM Terrameter LS. The Wenner array was used due to its high signal strength and good vertical resolution. Other than that, the advantage of the Wenner array is that it can calculate the apparent resistivity easily in the field, meaning a shorter survey time than different arrays [9]. The measurement of subsurface material's resistivity value is produced by putting current into the earth. Then, the reading is taken by ABEM Terrameter LS.

Res2DINV software is used to process the raw field data to obtain the 2-D resistivity inversion pseudosection model that shows the subsurface resistivity values. The inversion results with RMS errors lower than 20% are produced due to complex lithology. Then, the result is interpreted by comparing the obtained result with an expected value of resistivity material from previous research, as shown in Table 1.

Table 1. Resistivity values of some common rocks, minerals and chemicals [10,11].

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	$10^2 – 2.5\times 10^8$
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. Results and Discussion

The location of four survey lines conducted in the study area is shown in Figure 1. Survey Line 1 and Survey Line 2 are carried out further from Sungai Pergau and set up perpendicularly towards each other meaning the interpretations of these two survey lines are related to broader subsurface information. Both Survey Line 3 and Survey Line 4 are also arranged perpendicularly and carried out near Sungai Pergau. The results show that the maximum penetration depth for the subsurface imaging is 30 m. The RMS error produced for the pseudosection profile is lower than 20%. The resistivity value obtained for this study is ranged from 1ohm.m to 3000ohm.m.

3.1 Survey Line 1 and Survey Line 2

With a 10.2% of RMS error, the resistivity profile of line 1 in Figure 3, showed the high groundwater potential zone with a low resistivity value of less than 100 **Ω**m located at 5 m to 25 m depth with blue to green colour (cold colours). While the high resistivity area value of more than 800 **Ω**m with orange to red colour (warm colours) is classified as the outcrop that is located near the surface at 0m to 10m depth and bedrock, below the groundwater potential zone at depth of 25 m to 30 m depth.

A large aquifer with two groundwater potential zones is observed in this survey line with Zone B being slightly larger than Zone A. The fractured lines present in the pseudosection indicated a highly fractured area which enables water to store within it. These fracture structures may cause by localized tectonic activities activity or faulting.

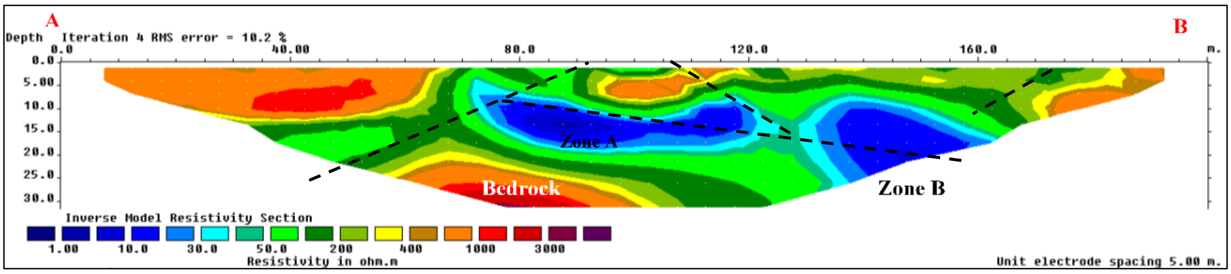

Figure 3. Pseudosection profile for survey line 1 (dashed line= fracture zones).

With a 12.9% of RMS error, the resistivity profile of line 2 in Figure 4 can be classified into 2 zones namely the high resistivity zone, HRZ (>400ohm.m) and the low resistivity zone, LRZ (<400 ohm.m). The HRZ and the LRZ are interpreted as bedrock located at 20 m to 30 m depth and fractured/water-saturated zone located at 5 m to 25 m depth, respectively.

The groundwater aquifer/fractured zone is extended along with the survey line survey with three high groundwater potentials in blue colour. This fracture zone is also having a low-angle fracture plane which indicated it occurred due to the effect of a thrust fault. The fractured lines found in the pseudosection represent a highly fractured area which enables water to store within it. Figure 5 showed a fence diagram of survey lines 1 and 2 to represent the correlation between both survey lines.

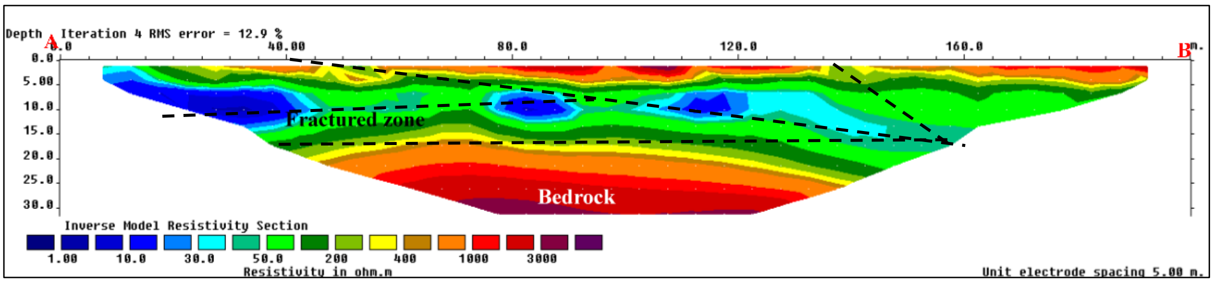

Figure 4. Pseudosection profile for survey line 2 (dashed line= fracture zones).

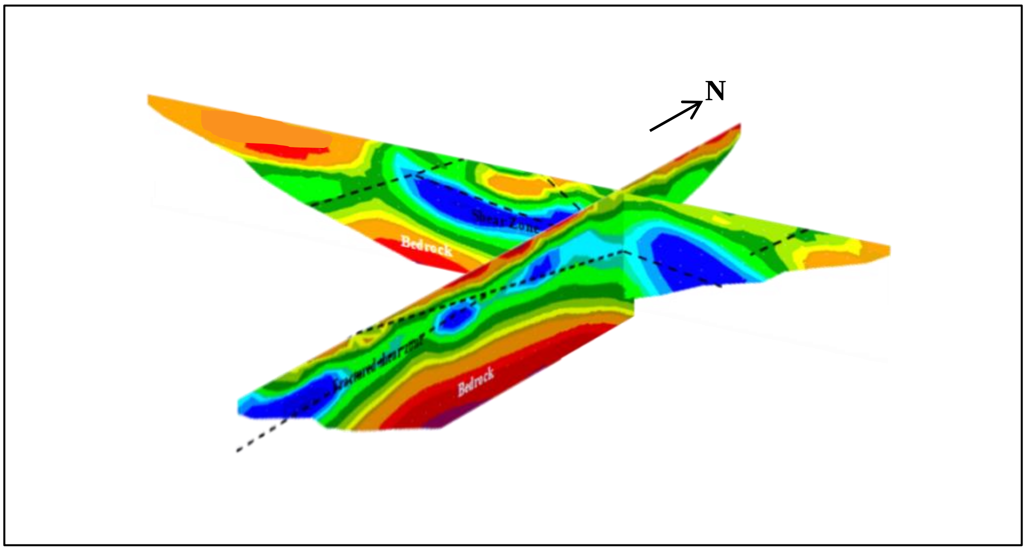

Figure 5. Fence diagram of survey lines 1 and 2.

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3.2 Survey Line 3 and Survey Line 4

In Figure 6, Survey Line 3 resulted in an 11.3% RMS error with resistivity values less than 800 Ωm is classified as fractured rock/fracture zone, while the high resistivity values area more than 800 Ωm is classified as bedrock. The fracture zone is located at 5 m to 25 m depth with a blue to green colour that extended along the survey line. The present bedrocks are located near the surface as outcropping bedrock and are also found at 25 m to 30 m depth.

The extensive fracture zone is displayed at the left part of pseudosection with the fractured lines representing the low angle of the fracture plane. The low angle fracture plane suggested that a thrust fault may have had some impact on the fracture. The presence of a large fracture zone indicated a high potential of groundwater aquifer according to its geological structure of fractured zone and affected by the activity of thrust fault.

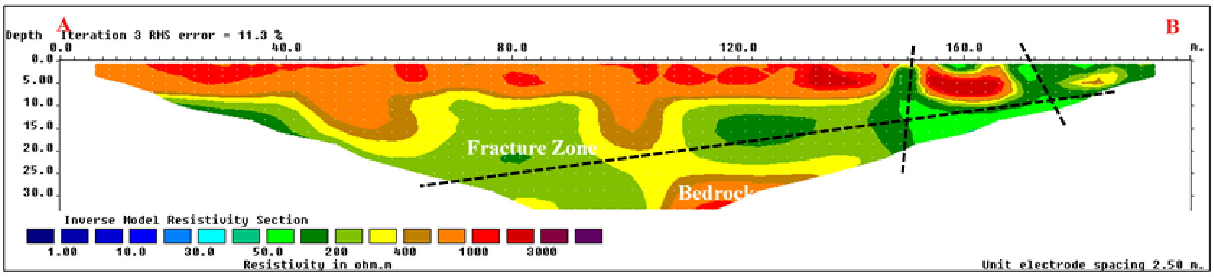

Figure 6. Pseudosection profile for survey line 3 (dashed line= fracture zones).

With a 3.5% of RMS error, the resistivity profile of line 4 in Figure 7, showed a geological structure of fracture zone and bedrock can be seen extended along the survey line. The low resistivity values area less than 800 Ωm is classified as a fracture zone, located at 5 m to 30 m depth in blue to green colour. The high resistivity area (more than 800 Ωm) is classified as bedrock/overburden in orange to red colour. The overburden is found near the surface at 0 m to 20 m depth, with the bedrock found below the fracture zone at 25 m to 30 m depth.

A low angle fracture plane can be observed (in dashed line) as shown in the pseudosection profile which might be affected by the thrust fault activity. This fracture zone indicated the potential of groundwater aquifer as groundwater may store in the fractured zone. The fence diagram in Figure 8 represents the correlation between survey line 3 and survey line 4 in the study area.

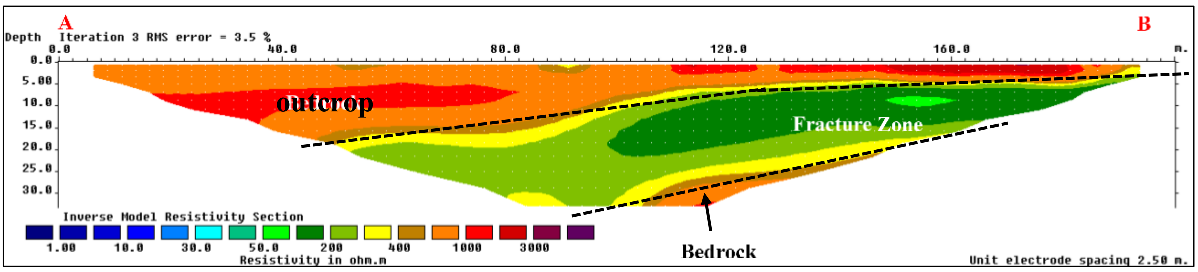

Figure 7. Pseudosection profile for survey line 4 (dashed line= fracture zones).

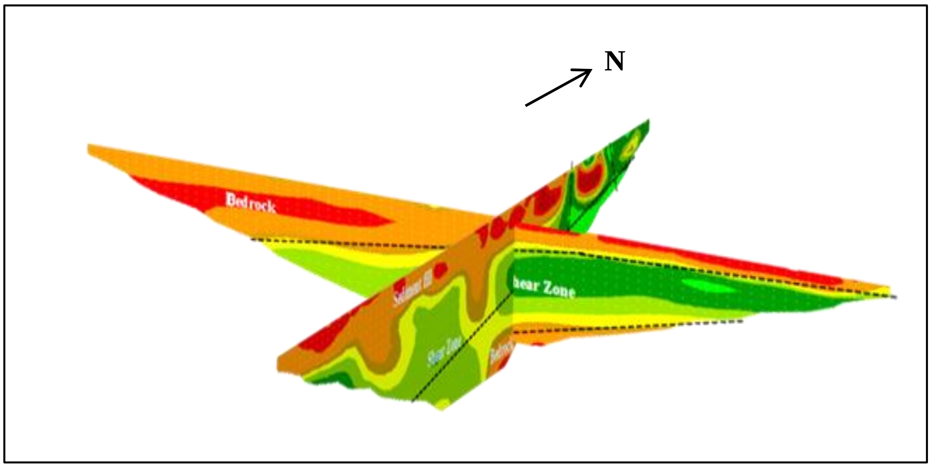

Figure 8. Fence diagram of survey lines 3 and 4.

4. Conclusion

Pseudosection of Survey Line 1, 2, 3 and 4 showed the high potential of groundwater occurrences based on the low resistivity values of the subsurface materials. Groundwater potential in the study area is observed to locate deeper than 5 m to 30 m in the subsurface. Lithology and structural geology are the two main factors that contribute to the accumulation of groundwater in the study area. The fractured zone in the bedrock plays a major role not just as a groundwater container but also works as a medium for groundwater migration and infiltration. The fracture zone is believed to result from the thrust fault activity based on the occurrence of a low-angle fracture plane in the resistivity profiles. Further study of the drilling method is recommended in the study area due to its high groundwater potential, also to verify this finding.

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