

Identification of potential groundwater sources using Electrical Resistivity Imaging (ERI) method in Jambu Lawar, Machang, Kelantan

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Abstract. The study area is primarily composed of volcanic rock and plain quaternary sediment. Extrusive and intrusive rocks are the two varieties of igneous rock that have been found. In the examined location, igneous intrusive rock, specifically biotite granite, makes up most of the rock formation. Grey to white colour, biotite granite has a phaneritic, coarse-grained texture. On the other hand, andesite, an igneous extrusive rock, makes up the minor rock formation. The study aims to identify the potential groundwater resources of the study area. Groundwater viability is examined using the Electrical Resistivity Imaging (ERI) method. Each of the survey lines extends over a length of 200 meters, incorporating 41 takeouts positioned at 5m spacing, and adopts the Schlumberger array electrode configuration. Both surface water and groundwater are essential resources in Kelantan for daily life; nevertheless, ongoing groundwater exploitation causes depletion. This potential is defined by low resistivity materials that can store large amounts of groundwater. As biotite granite is inherently unsuitable for groundwater collection between grains, possible fracture zones are highlighted as likely sites for groundwater presence. The 2D pseudosection results for all three survey lines emphasize a substantial accumulation of groundwater in a spatially expansive zone. This is because the resistivity value for all the survey lines is below 100 Ωm .

1 Introduction

Groundwater is a source of groundwater found in cracks and spaces in soil and rock. Groundwater resources should be relied upon more and more due to the world's rapid environmental change and population expansion [1]. Given the growing demand for water for agricultural, industrial, and residential use, groundwater has emerged as a significant supply [2]. Most people should be knowledgeable about groundwater and its many sources since it is one of the natural resources that are essential for the existence of living things. Along with a growth in both the overall population and the percentage of that population that utilises it for domestic purposes, the demand for freshwater somewhat increases. The freshwater supply may need to be extracted again because of this [3]. In Kelantan, which supplies more than 70% of the country's potable water supply, groundwater is prevalent. Due

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to the lower cost of groundwater supplies than establishing surface water sources, groundwater is crucial. In addition to being used for everyday needs, groundwater also contributes to the stabilization of the hydrological cycle. Water storage within limestone caves helps to maintain cavity pressure and ward against sinkholes [4].

Over the past few decades, the electric resistivity method's apparatus, data collection, and data inversion approaches have all seen significant advancements. Two-dimensional (2D) and three-dimensional (3D) resistivity surveys can more accurately scan complicated geological features because to the advent of multi-electrode and multi-channel systems [5]. Electrical Resistivity Imaging (ERI) method is one of the geophysical tools that offers very attractive technique for subsurface profile characterization in a larger area [6]. In order to achieve consistent, higher-resolution images during the acquisition of ERT data using a multielectrode cable system with fixed interelectrode spacing, pole-dipole configurations were chosen in order to capture the best anomaly data with appropriate depth coverage and a high signal-to-noise ratio by combining measurements from both forward and reverse [7]. Alluvial plains contain groundwater because of the groundwater's innate ability to replenish itself. A sizable tract of level ground created by the deposition of sediments like clay, silt, and sand is known as an alluvial plain. The sediments originate in the highlands that have weathered and eroded. Water then carries the sediments to the lowlands, where they are gradually deposited until the sediments build up and form alluvial soil. The geophysical method can be used to determine the potential groundwater sources such as resistivity method [8]. This study proposes to evaluate the potential of groundwater existence as a source of alternative freshwater using Electrical Resistivity Imaging (ERI) method.

2 Geological setting

The study area is in Jambu Lawar, Machang Kelantan (Figure 1). The lithology in this area is subdivided into three types of rock units consisting of plain quaternary sediment, andesite and biotite granite accordingly. The geographical location of Kelantan is in Peninsular Malaysia's northeastern section. The main river in the area is the Kelantan River. The river in issue may be found close to Kuala Krai, where the Galas and Lebir rivers meet. It travels in a round pattern through the coastal plain before emptying into the South China Sea. There are no similarities between the tectonic settings of Peninsular Malaysia and Sarawak, nor the stratigraphic composition of their rocks [9]. The Peninsula stretches further to the Indonesian island of Bangka, and in terms of the tectonic setting in which it was formed as well as the stratigraphy of its rock layers, the geology of Vietnam and Sarawak may be comparable. The western, eastern, and central bands each have their distinct stratigraphy [10]. Machang, which is located in North Kelantan, Malaysia, is the location of the region that is the subject of the inquiry. On top of the granite bedrock in North Kelantan is a layer of Quaternary sediments, which cover the plain. The drainage system is dendritic, and the principal river flows into the South China Sea. The granite went through four stages of structural deformation [11].

3 Methodology

Detecting groundwater presence in hard rock regions involves assessing the existence of water within the geological formations. In north Kelantan, an abundance of groundwater is attributed to the quaternary sediment landform, characterized by unconsolidated materials capable of retaining water. Monitoring groundwater involves utilizing the Electrical Resistivity Imaging (ERI) method. This technique determines subsurface conditions by analysing resistivity values, which vary among different materials. Over the research region, electrical resistivity measurements were taken along three survey lines. Each of the survey

lines extends over a length of 200 meters, incorporating 41 takeouts positioned at 5 meters spacing and adopts the Schlumberger array electrode configuration. The subsequent interpretation of the processed survey lines is a multifaceted process that entails a thorough examination and comparison of the obtained resistivity values with the established standard actual resistivity value. During setup, an electrode placed below the surface will introduce an electrical current from the ABEM into the earth [8]. The ABEM's display will show a subsurface resistivity reading. Because Schlumberger array could provide a dense near-surface resistivity data cover, it was used to gather the data. Large 2-D, 3-D, and even 4-D surveys may now be conducted effectively to resolve complicated geological features, something that was previously impossible with standard 1-D surveys thanks to the development of multi-electrode and multi-channel systems [12]. Inversion method Least-Square 2-D can be used to interpret the subsurface resistivity structure [13, 14, 15].

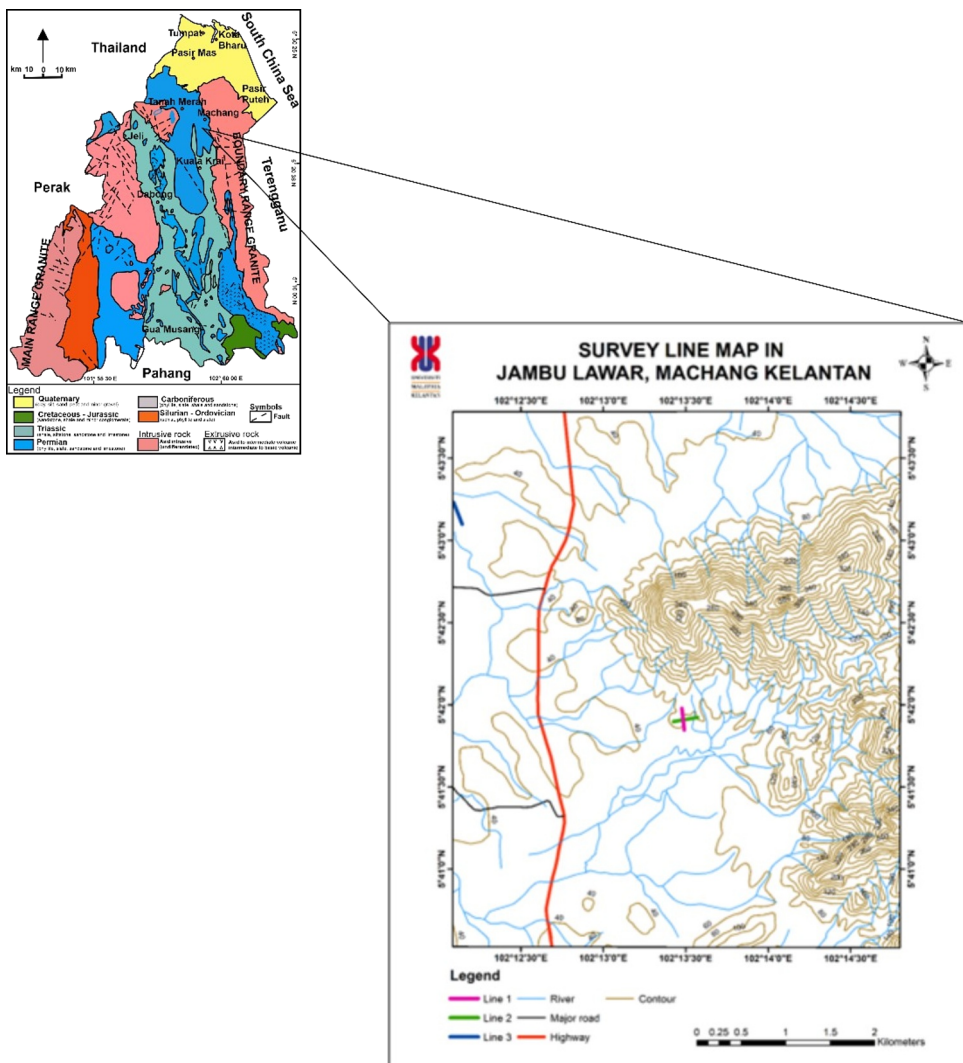


Figure 1. The basemap of study area indicates three survey lines at Jambu Lawar, Machang, Kelantan.

4 Results and Discussion

4.1 Survey Line 1

This survey line is oriented from South to North and employs the Schlumberger electrode configuration. Despite eliminating numerous unreliable data points, the total RMS error percentage for resistivity remains at 8.6%. In this survey, the resistivity values range from a minimum of 24.1 Ωm to a maximum of 700 Ωm at depths exceeding 30m. Figure 2 shows the 2-D pseudosection divided into three zones – Zone A, Zone B, and Zone C. Zone A indicates high groundwater potential with resistivity below 100 Ωm . Zone B encompasses resistivity values ranging from 100 Ωm to 385 Ωm , typical for silt or gravel. Zone C consists of materials with high resistivity (385 Ωm to 700 Ωm), suggesting hard substances like granite. Groundwater potential in this location is concentrated in sediments, and the top of the pseudosection (Zone A) features groundwater and topsoil with resistivity values ranging from 24.1 Ωm to 100 Ωm . The resistivity values from various lithological sections in the table confirm that potential groundwater typically exhibits resistivity values between 5 Ωm and 100 Ωm . Consequently, the observed resistivity for potential groundwater in Line 1 falls within the range of 24.1 Ωm to 100 Ωm .

4.2 Survey Line 2

The second survey line, positioned at a stream and coinciding with a lineament, intersects with survey line 1. This location was selected because streams associated with lineaments serve as potential groundwater recharge sources, increasing the likelihood of groundwater presence. The coordinates for this second location are 04° 42' 26.08" N and 101° 41' 27.56" E, with the survey line direction spanning from West to East. The electrode configuration for this line employs the Schlumberger array. Figure 3 illustrates a total RMS error percentage of 4.3%, with resistivity values ranging from 43.6 Ωm to 500 Ωm . The pseudosection is further segmented into three zones which are Zone A, B, and C. Zone A, situated at the top of the pseudosection, denotes a potential groundwater zone, likely characterized as shallow due to its proximity to the surface. The presence of a stream intersecting the survey line suggests a possible reason for the shallow groundwater, with the stream's surface water acting as a recharge source. Resistivity values for Zone A fall within the range of 43.6 Ωm to 100 Ωm . Zone B exhibits resistivity values between 100 Ωm and 255 Ωm , indicative of silt or gravel composition. Lastly, Zone C features resistivity values ranging from 255 Ωm to 500 Ωm , consistent with fractured granite, as supported by Srinivas et al. (2013), which notes resistivity values for fractured granite in the range of 60 Ωm to 500 Ωm . This reinforces the argument that groundwater in this line is concentrated in the region below 100 Ωm .

4.3 Survey Line 3

The third line is in proximity to the river at coordinates 05° 43' 10.07"N and 102° 12' 7.16"E. The selection of this fifth is based on the potential of the stream to serve as a recharge source for groundwater. The electrode configuration for this line is Schlumberger, and the survey line extends from south to north (S-N). Based on the analysis depicted in Figure 4, the investigation into depth of elevation reveals a range from -5m to 40.0 m. The inverse resistivity model exhibits a root mean-squares error of 7.0%. In survey line 3, resistivity values span from 20.2 Ωm to 1700 Ωm , with the highest resistivity values (500 Ωm – 1700

Ωm) concentrated in the lower section, denoted by colors ranging from orange to dark red, indicative of gravel or medium-grain sand.

Zone B was characterized by medium resistivity values (100 Ωm – 500 Ωm) highlighted in green, surrounding both lower and higher resistivity values, suggesting the presence of fine sand or silt. This observation aligns with the corresponding resistivity ranges for fine sand or silt, ranging from 5 Ωm to 500 Ωm . In Zone A, the section displays the lowest resistivity values (20.2 Ωm to 100 Ωm) with colors ranging from dark blue to light, extending from the centre to the right side. Identified as a groundwater potential zone due to its low resistivity, this conclusion finds support which provides resistivity values for distinct lithological sections. The elevation is approximately 25m with a width of around 100m, and the precise determination of water content remains elusive due to the constraints of the limited investigation.

5 Conclusion

The lithological composition of the study area mostly comprises igneous rock and plain quaternary sediment. Two types of igneous rock that have been discovered are intrusive rock (granite) and extrusive rock (andesite). Granite has a coarse-grained texture (phaneritic) with a grey to white colour. In contrast, the minor rock formation is composed of igneous extrusive rock, namely andesite. Andesite has a fine-grained texture (aphanitic) with a light to dark grey colour. Approximately half (50%) of the studied area consists of granite rock, while 42% is comprised of plain quaternary sediment, and the other 8% is composed of andesite. During the mapping process, geological structures such as minor faults, joints, and quartz veins were identified. The geomorphology of the region includes lowland, low-lying plain, low hills, and hill features. The drainage pattern observed within the studied region encompasses parallel, dendritic, contorted, and radial patterns. The variation in drainage patterns is determined by the topography and elevation of a certain region. Employing the Electrical Resistivity Imaging (ERI) method in the geophysical survey has revealed a considerable potential for groundwater within the study area. The 2-D pseudosection profile shows all survey lines emphasize a substantial accumulation of groundwater in a spatially expansive zone. This is due to the resistivity value and chargeability value corresponding to the value of water. The resistivity and chargeability values have ranged from 100 Ωm below and 0.01 msec.

The authors would like to thank Encik Mohd Khairul Aizuddin bin Razali for his technical assistance. Sincere gratitude should be conveyed to every research participant for their outstanding work and involvement.

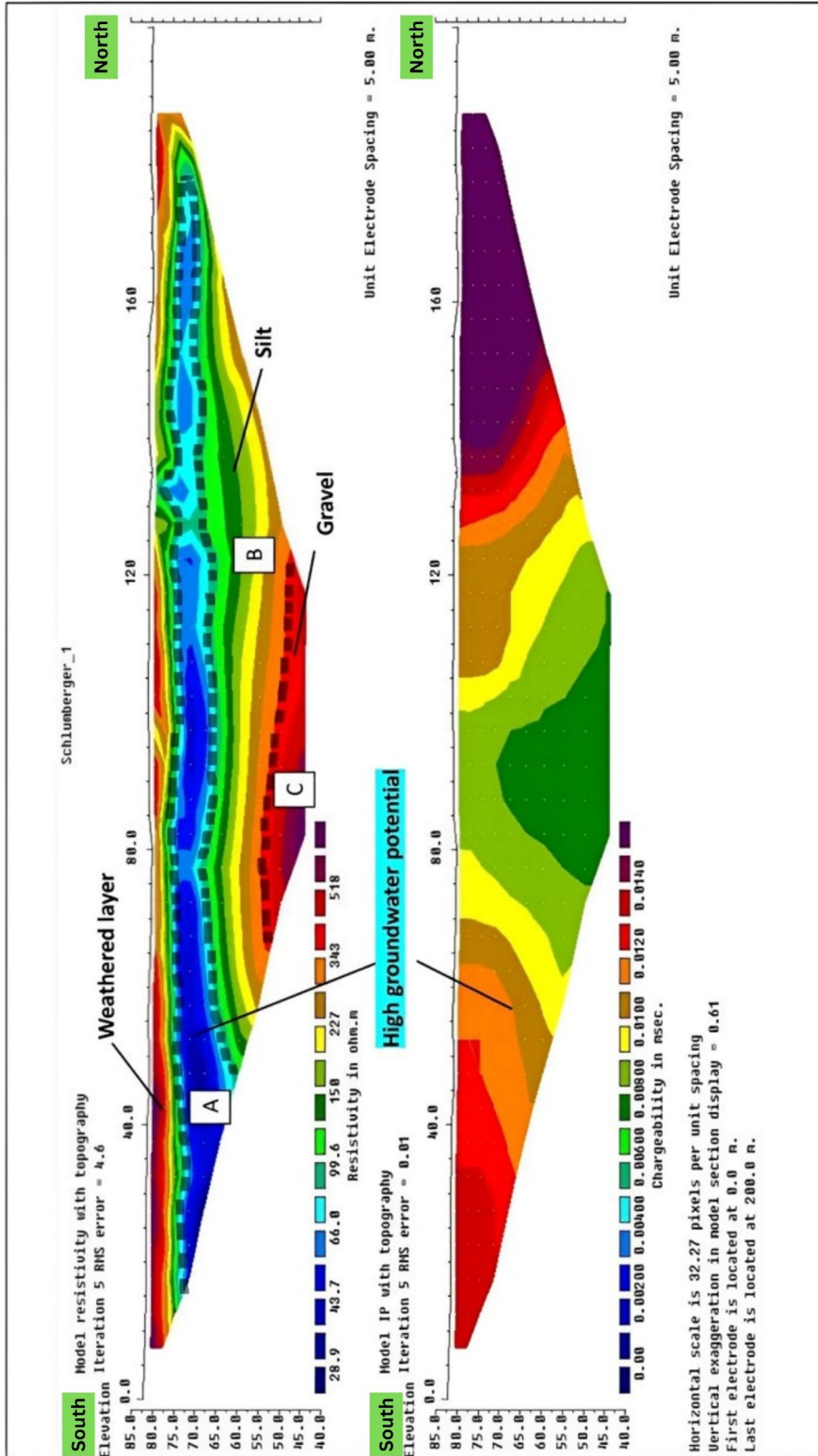


Figure 2. Pseudosection 2-D resistivity profile for Line 1.

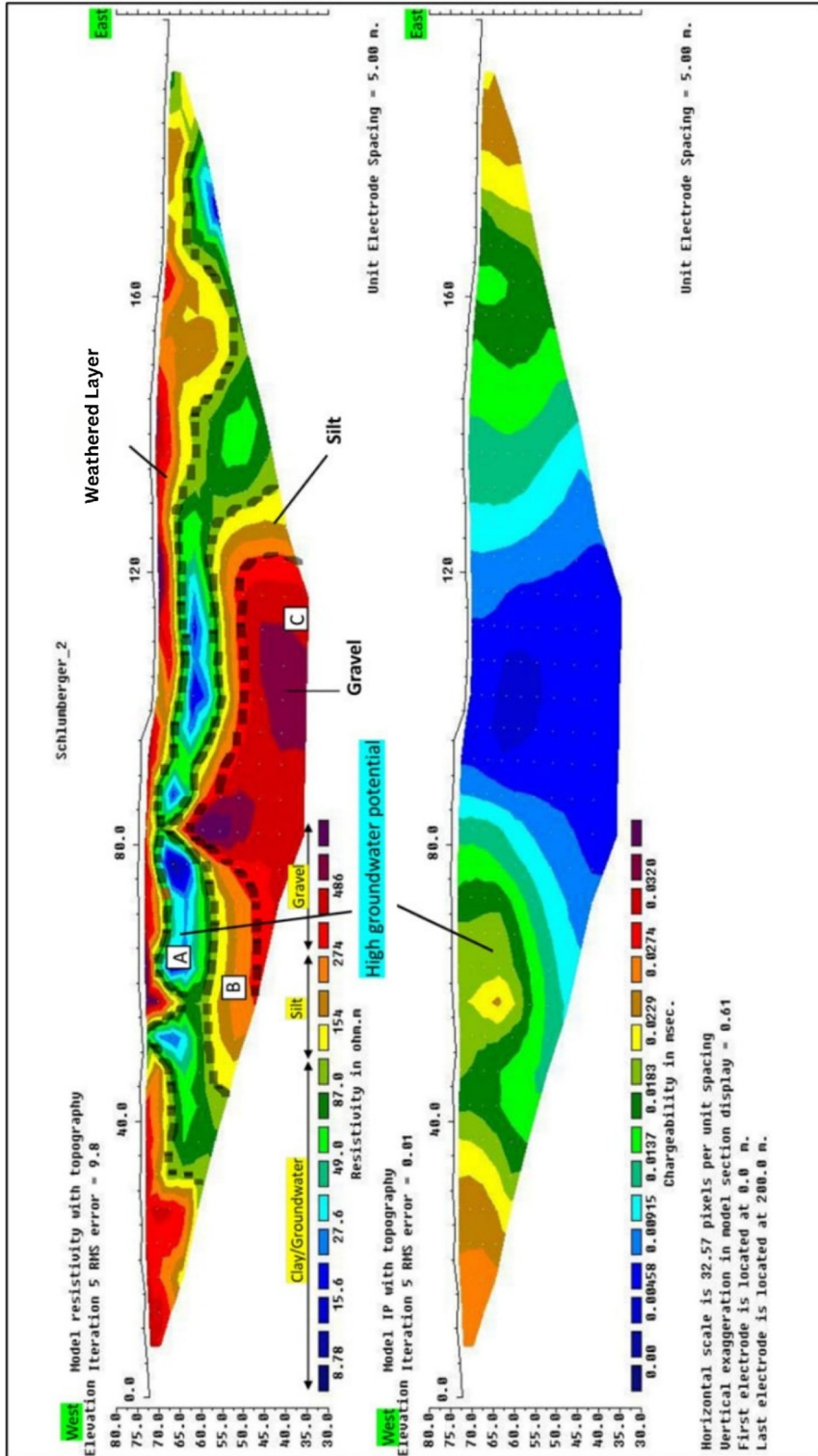


Figure 3. Pseudosection 2-D resistivity profile for Line 2.

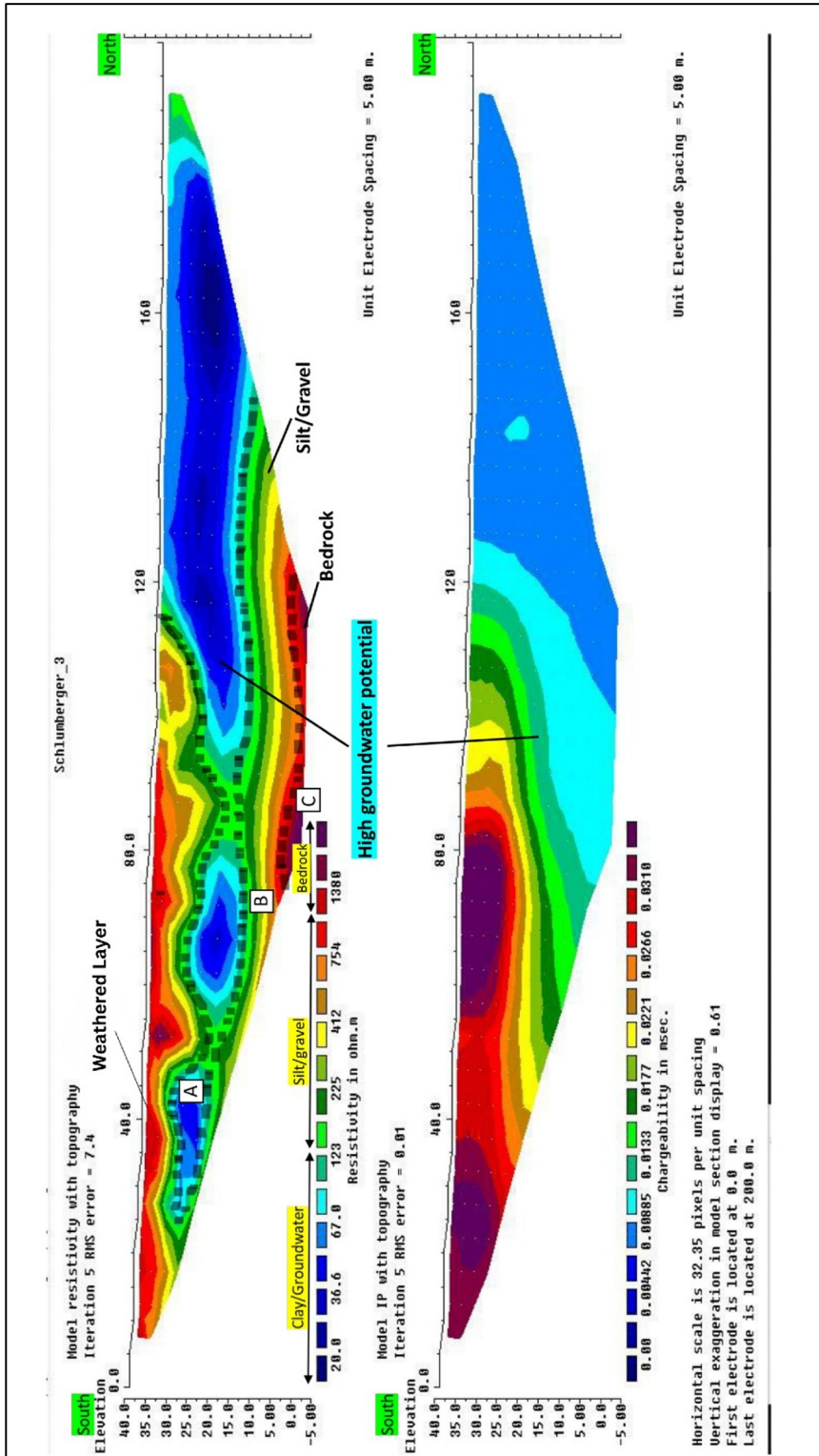


Figure 4. Pseudosection 2-D resistivity profile for Line 3.

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