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2-D Resistivity Imaging in Taiping, Perak, Malaysia

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Abstract – *Geoelectrical resistivity imaging is increasingly being applied in environmental, engineering and hydrological investigations on top of geothermal and mineral prospecting, where thorough knowledge of the subsurface is required. A survey at Taiping, Perak was conducted using Wenner-Schlumberger configuration. For field measurement, a set of ABEM Terrameter SAS 4000, switcher unit, electrodes and multicore-cable were used in this study. A resistivity line with length 400 meter and electrodes spacing 5 meter was proposed. Software RES2DINV was used to interpret and analyze resistivity data. The maximum depth in this study is 84.7m and the resistivity value obtained range from 1 to 370 Ωm. The result of resistivity value in range of 10 – 800 Ωm referring to a figure, it can be justified that the study area was under alluvium material. The aquifer identified had shown the resistivity value was range from 200Ωm to 370Ωm.*

Keywords: Electrical resistivity, 2-D resistivity, RES2DINV, Wenner-Schlumberger

1.0 INTRODUCTION

Geophysical study plays an important role in providing supported data in order to save cost and time. Geophysical methods can be used to solve engineering, geological, environmental and forensic problems such as determining depth of bedrock, nature of overburden materials and near surface structures such as sinkholes, cavities, voids, faults and boulders [1]. This paper aims to determine the groundwater potential zone based on the 2-D Geoelectrical Resistivity Imaging Technique.

In the past decades, ground resistivity survey methods have been widely applied in order to solve engineering, archaeology, environmental and geological problems [2-4]. Subsurface resistivity distributions are measured by resistivity surveying. Resistivity surveying investigates variations of electrical resistance by applying electrical current through the subsurface using wires (two current electrodes). The potential differences caused by the flow of current between any two points in linear line with the current electrodes are then measured by a pair of potential electrodes. For simplicity, all layers are assumed to be horizontal. An analogy is shown in Figure 1, to get water to circulate through the system, a push must be

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provided. Electricity acts in similar way, to get current to flow (the current), a push (potential difference or voltage) must be provided.

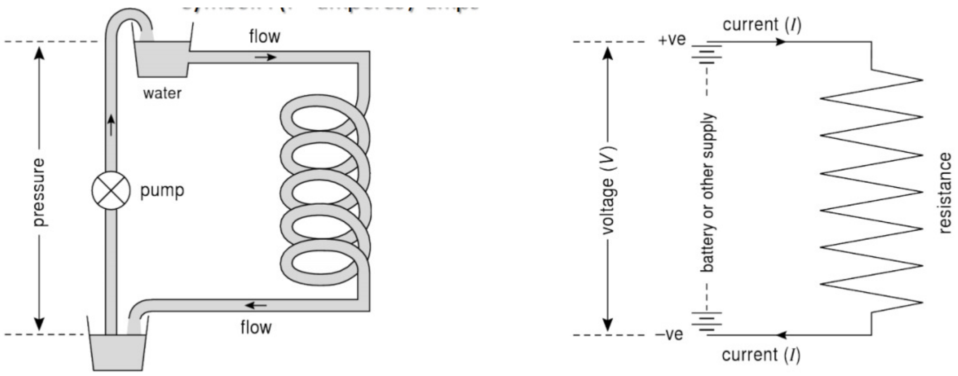

Figure 1: Analogy on current and potential difference

The resistance at the specified point in the subsurface can be determined from the measured voltage (V) and current (I) values. Penetration depth is directly proportional to electrodes spacing, and changing the electrode's separation gives information on sub surface's stratification in homogeneous ground [5]. For 2-D resistivity imaging, having a large set of data recorded along a survey line is vital to effectively map the complex resistivity distribution of subsurface structure. The most practical way to acquire such large amount of data is by using automated multi-electrode data acquisition system. The resistivity of a soil or rock is dependent on several factors that include amount total dissolved solid such as salts and mineral composition (clays), presence of contaminants and percentage of porosity and permeability. The 2-D resistivity method is described by [6-9].

It is important to differentiate between apparent resistivity and true resistivity in the interpretation of ground resistivity survey. Apparent resistivity can be defined as the volumetric average of a heterogeneous half-space, except for the averaging is not done arithmetically but by a complex weighing function dependent on electrode's configurations [10]. In a simple word, apparent resistivity is close to the resistivity of the upper layer at small spacing between electrodes. In resistivity survey, true resistivity can only be measured in ideal condition where the ground is homogenous, which is almost never is the case. Advancement in computer forward modelling software (e.g.: Res2DINV) have made it possible to calculate numerous amount of data obtained from 2D resistivity survey in a short amount of time, and minimized the different between true and apparent resistivity for subsurface earth material by subdividing the subsurface into small rectangular cells where each cell has resistivity value close to the true resistivity of subsurface material. Electrical resistivity value for different geological material was provided in Fig. 2 below.

2.0 STUDY AREA

A location was selected to carry on 2-D geoelectrical resistivity imaging study. A resistivity line was proposed with the length of 400m with a vertical depth of penetration to 84.7 m. Electrodes spacing of the line is 5m. The study was conducted on February 2016 at Taiping, Perak.

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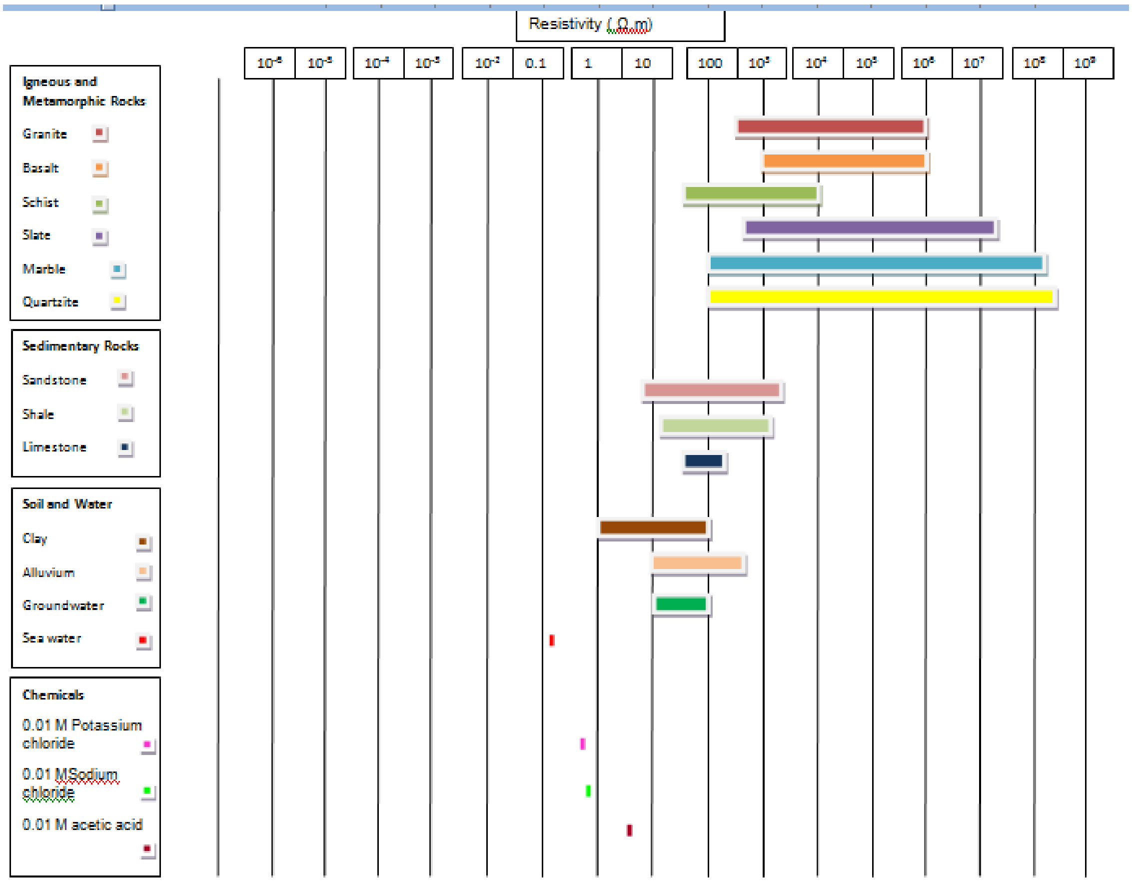

Figure 2: Resistivity and conductivity value of selected rocks, soil and water [14,15]

3.0 METHODOLOGY

3.1 Field Measurement

A set of ABEM Terrameter SAS 4000 (Fig. 4) and a switcher unit were used to control the induction of current and potential readings from electrodes linked by multicore-cable along the survey line. The length of the survey line, electrode spacing and the protocol file used in the survey effect the depth of the data obtained.

In this study, Wenner-Schlumberger protocol was preferred. For field measurement, the Wenner-Schlumberger protocol was selected as it provides reasonably good horizontal and vertical subsurface resistivity coverage [11]. Software RES2DINV was used to interpret and analyze resistivity data. In data interpretation, blocky constraint was used as it is the most appropriate inversion method when subsurface internal resistivity values are separated by sharp boundaries [16].

3.2 Wenner-Schlumberger Array

In electrical surveys, Wenner, Schlumberger and Dipole-Dipole configurations are commonly used. For environmental, archeological or landfill problem, Wenner and Dipole-Dipole configurations are usually applied. Whereas for groundwater exploration, Sclumberger configuration is commonly used (Telford et.al.,1990). Refer Figure 5 for the arrangement of those arrays. It shows also the uses of each array. In principle, sounding gives information on changes in resistivity with depth, whereas profiling gives information on lateral changes in resistivity.

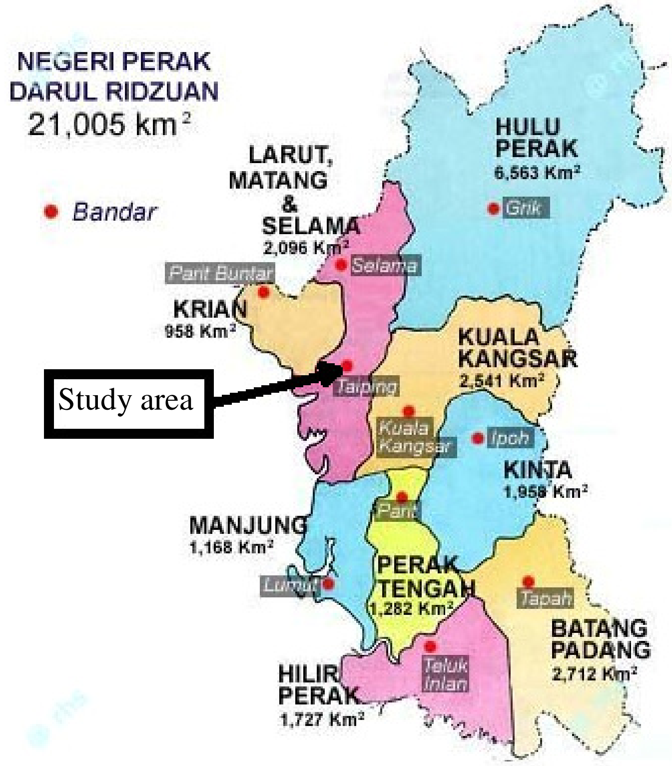

Figure 3: Study area

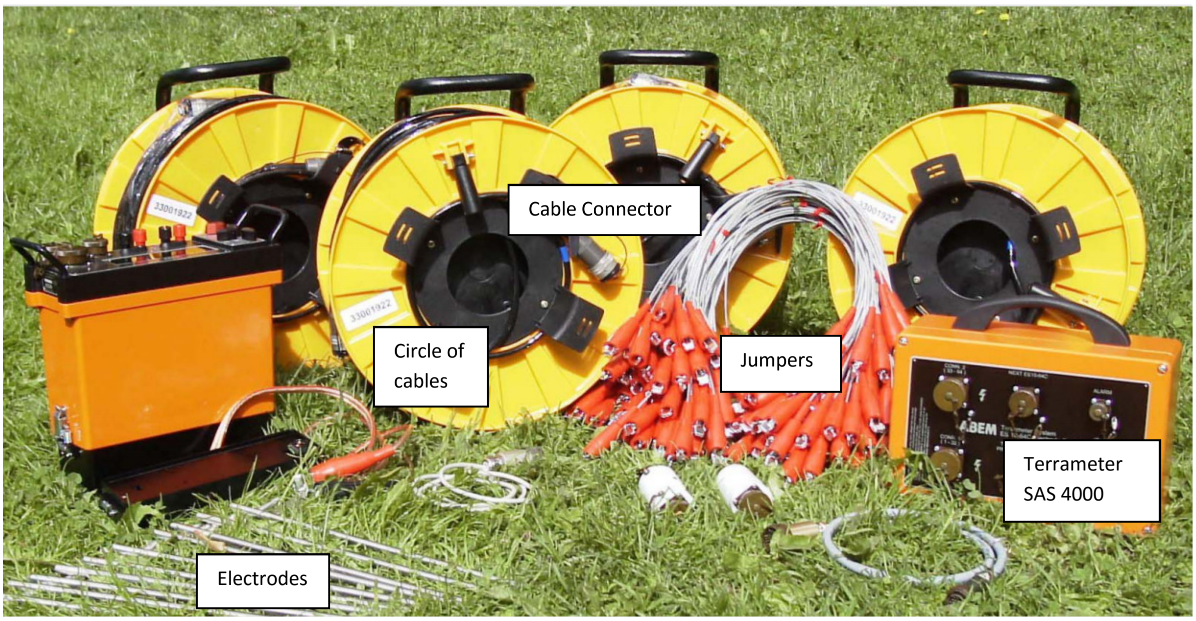

Figure 4: ABEM Resistivity set used in this survey

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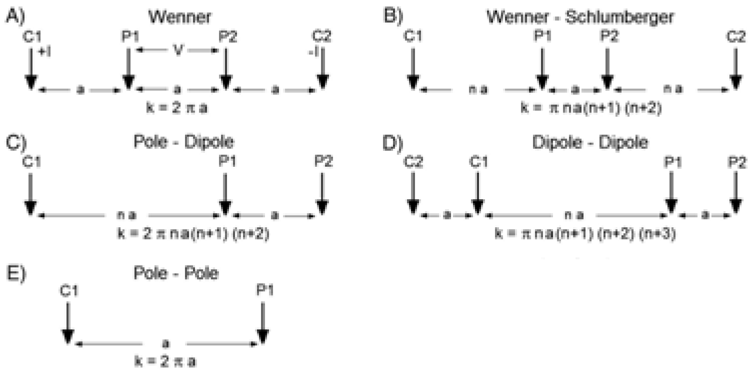

Figure 5: Common arrays used in resistivity surveys. Symbols: A, B, and C are current electrodes; M, N, and P are potential electrodes; V is voltage, I is current, a is electrode separation, n is an integer multiplier, and x is the separation distance.

Wenner-Schlumberger is a new hybrid which was created by integrating Wenner and Schlumberger arrays [11] for resistivity imaging (RI). Modification has been made on the classical Schlumberger array so that it can be used on a system with the electrodes arranged with a constant spacing. The arrangement of Wenner-Schlumberger array is same as Wenner array, C1, P1, P2 and C2.

The measurement of this array is same as the previous array where it consists of many sequences and each sequences has many subsequences with different steps. The properties of this array are almost in the medial point between Wenner and the dipole-dipole arrays. This array combines the advantages and disadvantages of the previous arrays. The imaging via Wenner-Schlumberger array for the horizontal and vertical structures is moderate and the median depth of investigation and the horizontal data coverage of Wenner array are smaller than this array. The signal strength of Wenner-Schlumberger is smaller than Wenner array, but higher than dipole-dipole array [12].

4.0 RESULT AND DISCUSSION

In general, the resistivity values obtained from this survey show wide range from 1 Ωm–3000 Ωm. There are four categories divided for the value interpretation depending on the material types as shown in Fig. 6 below. Crucial part in the shown table is the materials probably represented by the resistivity values. However, the resistivity values also can be change due to geological structure, ground and weather condition.

In this survey, the authors are focusing more on the contrast of the resistivity values which is probably reflected by the geological structures. Fig. 7 shows the result of the resistivity profile from the survey. The resistivity value obtained range from 1 to 370 Ωm. The depth covers up to 84.7 meters beneath ground surface. Based on the result of resistivity value in range of 10 – 800 Ωm (Refer to Fig. 2) from Fig. 6 above, it can be justified that the study area was under alluvium material. T. Suntharalingam, 1984 [17] has proved it through the analysis of the quaternary stratigraphy where the study area was classified under Simpang formation. The term Simpang Formation was a unit made of gravel, silt and clay overlying bedrock in the Taiping area. The formation is divided into two members i.e. the Lower Sand Member which consists of sand and gravel and the Upper Clay Member which is mainly clay. The illustration of the Simpang formation in Taiping area was shown in Fig. 8 below.

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JMG, 2010 [13] had published a geological map as in Fig. 10 showing that the study area is under the quaternary (alluvium) formation which contained of sand and gravel.

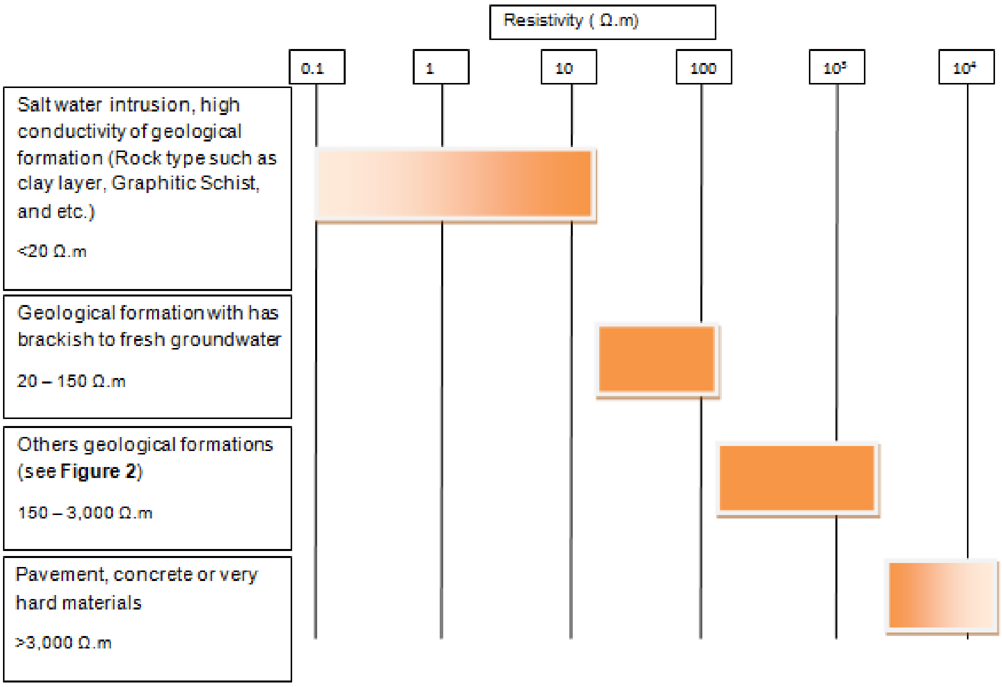

Figure 6: Resistivity values for the interpretation.

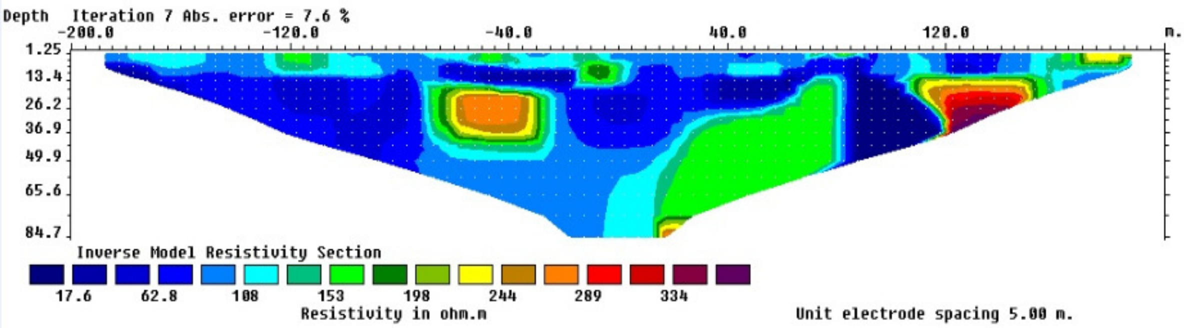

Figure 7: Resistivity Imaging Profile

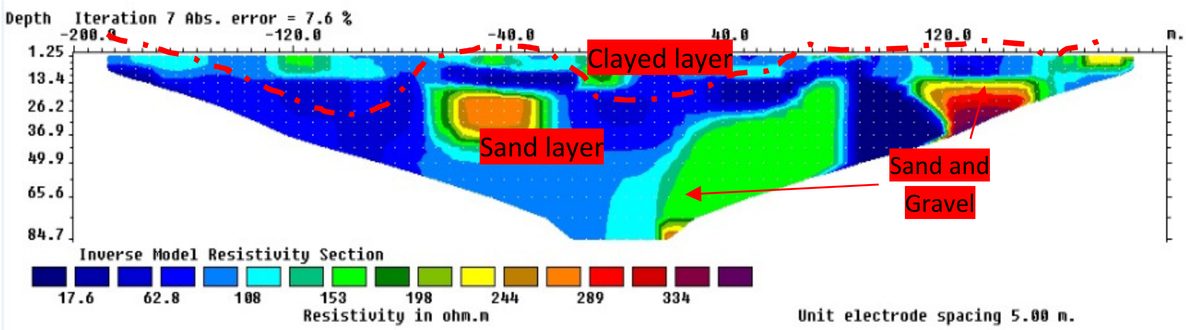

Figure 8: The illustration of Simpang formation in the study area.

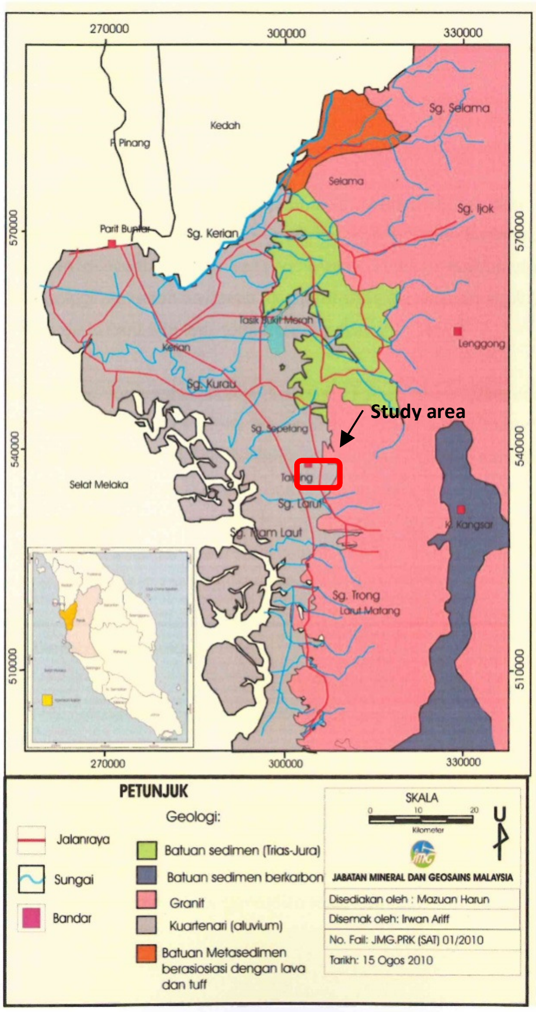

Figure 9: Geological map of the study area

Interpretations. Generally, this study area has associated with alluvium zone which was considered to be a good groundwater potential as shown in Figure 10. The aquifer identified had shown the resistivity value was range from 200Ωm to 370Ωm. However, borehole log (soil investigation) and groundwater pumping test analysis suggestion are the best way to prove the result of resistivity survey and express the aquifer as the good groundwater potential aquifer.

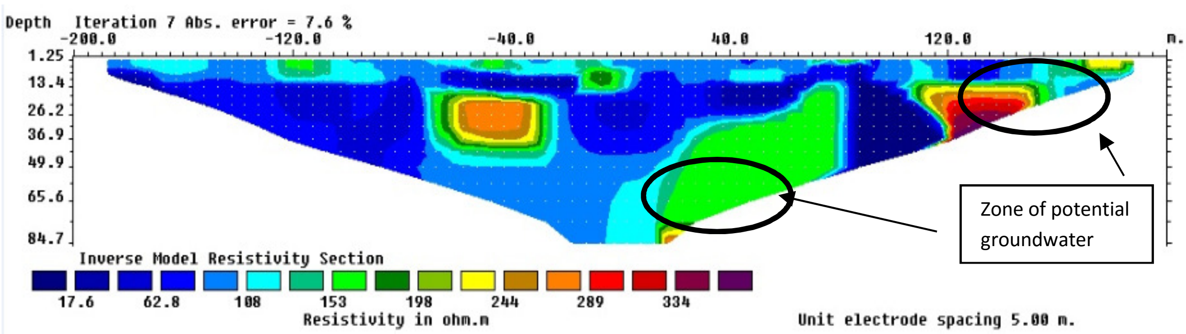

Figure 60: Suggestion of groundwater potential zone through the imaging profile

5.0 CONCLUSION

Based on regional characterization of the study areas, the 2-D resistivity imaging using Wenner-Schlumberger configuration has successfully been used to locate the groundwater potential in the study area. Through the analysis of the quaternary stratigraphy and geological map at the area, 2-D resistivity technique interpretation is supported. A further study using various configuration is suggested in the area to get the best and maximum depth.

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