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Electrical Resistivity Imaging (ERI) and Induced Polarization (IP) Survey to Solve Water Drought Problem at Alor Gajah, Melaka, Malaysia

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Abstract. Water drought become serious problem during dry season for rice field at Alor Gajah, Melaka, Malaysia. Electrical Resistivity Imaging (ERI) surveys have been conducted in order to locate and delineate groundwater resources by distribution of subsurface resistivity. The survey of ERI was carried out using ABEM Terrameter SAS 400 and ABEM Selector ES10-64 with pole-dipole configuration of electrode. At the same time, Induced Polarization (IP) survey also carried out to support the result of ERI. There are three line profiles with 400 m length and 5 m electrode spacing named PS1, KRBG2 and BB3. From three line profiles, two of them show that the distribution of low resistivity value (20 – 500 Ωm) are located at depth ranging from 20 to 70 m. The low resistivity values are associated with water saturated zone. This result was supported by IP's results that show at that particular depth the value of chargeability ranging 0 to 4 ms. Meanwhile, line profile BB3 indicate low resistivity value (0.5 – 500 Ωm) but the chargeability value are high (10 – 75 ms) interpreted as clay layer.

Keyword: Drought, Electrical Resistivity Imaging, Induced Polarization, Groundwater, Alor Gajah, Melaka

1. Introduction

Water is an essential need for earth life including human, animal and plant. Generally, water can be divided into two types they are surface water and groundwater. Every water on the surface is classified as surface water like water in a river, lake, wetland or ocean. It different with groundwater which present beneath earth's surface in pore space and in the fractures of rock formation. In comparison, groundwater is much better than surface water in quantity and quality. During dry season, surface drought usually occur at Alor Gajah, Melaka, Malaysia which is become serious problems for rice field. Groundwater become the best alternative as water resources when surface water is not sufficient to prevent agriculture failure [1].

Groundwater sources is trapping in aquifers that led to a need of intensive study to locate the aquifers. Electrical Resistivity Imaging (ERI) is widely used in groundwater exploration and environmental survey [2–8]. By using ERI, the distribution of resistivity value of subsurface can be determined to produce two-dimensional modelling. Besides that, IP method to measure chargeability of subsurface

layer become important to correlate with ERI. Correlation between ERI and IP raising the accuracy of aquifer layer interpretation.

Study area located at three irrigation scheme in Alor Gajah, Melaka, Malaysia that are irrigation scheme of Padang Sebak II Gadek, irrigation scheme of Lanjut Manis and irrigation scheme of Parit China (Figure 1). This study held to solve water drought problem during dry season. The aim of this study is to find aquifer layer as alternative water sources. From that aim, tubewell location and depth will propose to fulfill water needed at the study area.

Figure 1. Map of study area that show the location of survey line

2. Geology Regional

Generally, geology regional of study area and surrounding consist of intrusive granite as basement rock, metasediment and marine deposit with aged from Devonian to Ordovisian [9]. First location at irrigation scheme of Padang Sebak II Gadek consist of intrusive granite. Second location at irrigation scheme of Lanjut Manis composed of sandstone and mudstone that overlay graphitic schist and phyllite from howthorndern. At third location is irrigation scheme of Parit China consists of marine and continental deposits such as mudstone, siltstone, sandstone, peat and gravels. Geological maps of study area can be seen at Figure 2.
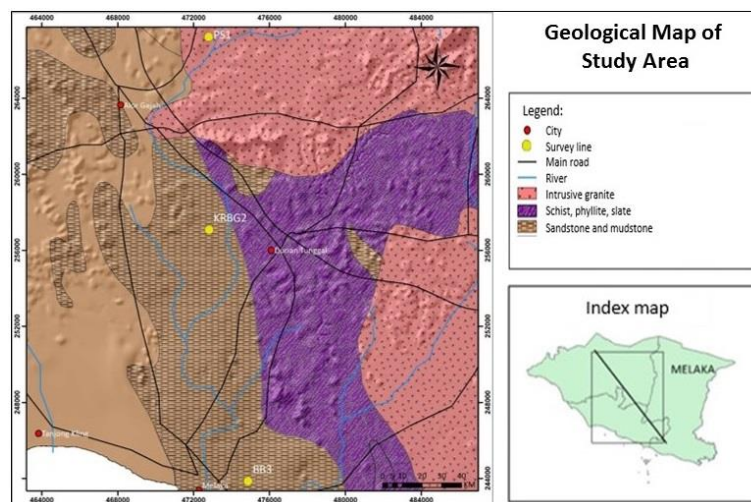

Figure 2. Geological map of study area

3. Material and Method

ERI and IP Survey was conducted using ABEM SAS 4000 terrameter and Lund electrode selector system ES10-64 (Figure 3). Basically, resistivity measured by using 4 electrodes whereas 2 current electrode and 2 potential electrode. Apparent resistivity (ρa) value can be calculate with equation between current (I) and voltage (V):

$$\rho a = k \, V / I$$

k is geometry factor that depend on configuration. In this study electrode configuration used is pole-dipole (Figure 3). For pole-dipole configuration factor geometry (k) calculate with formula below:

$$k = 2\pi \frac{b(a + b)}{a}$$

a is distance between P1 to P2; b is distance between C1 to P1.

In other hands, IP survey carry out with injecting current through electrode and potential difference (voltage) measured between potential electrodes. The voltage did not drop instantaneously to zero when the current was turned off. Instead, the potential difference dropped sharply at first, then gradually decay to zero after a given interval of time. From that chargeability can be calculate with formula:

$$Chargeability = V_t / V_0$$

Where V_t is voltage after interval time t and V_0 is voltage during current injecting.

Data collection taken by using multi-electrodes with 61 electrodes. Electrode spacing used is 5 meters with 400 m length of survey line in straight length arrangement. The electrode selector system automatically select the relevant four active electrode for each measurement of resistivity data. The data were processed by using inversion software RES2DINV [10,11] to produce two-dimensional model of resistivity value (ERI) and chargeability (IP).

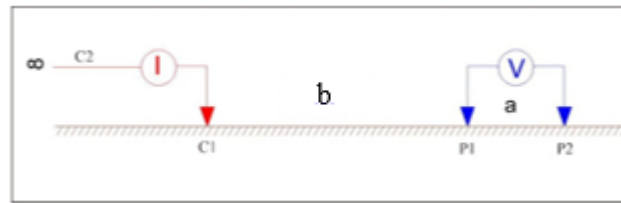
Figure 3. ERI Survey equipment

Figure 4. Pole-dipole electrode configuration

4. Result

Three survey lines has processed to produce inversion model of resistivity. The result is representing the true condition of subsurface with shown variation of resistivity value. The different of resistivity value indicate the different of subsurface material.

4.1. Survey line PS1

Survey line PS1 conducted at irrigation scheme of Padang Sebak II with line orientation $N30^0E$ - $N210^0E$. Based on the result of inversion model, the apparent resistivity (a) value ranging from 0.5 to 1000 Ωm. A large variation of apparent resistivity value indicating heterogeneous layer of subsurface. There are three layers interpreted from line PS1. The highest resistivity value (500 - 1000 Ωm) represented by red and purple in colour at depth more than 30 m interpreted as granite which is basement rock of study area. This layer is overlay by less resistive layer with resistivity value 30 – 500 Ωm (light green to orange in colour) from 100 m depth up to surface. This layer interpreted as sandstone. Another layer is located within sandstone layer that shown as low resistivity value ranging from 0.5 – 10 Ωm (dark blue to light blue) interpreted as Clay layer. Meanwhile, IP line PS1 also have chargeability value variation with the highest value is 75 msec and the lowest value is 0.00 msec. Low chargeability value found at depth 25 m and below has value at 0.00 – 2.00 msec (dark blue to blue), this value can be associated with aquifer, presented in Fig. 5.
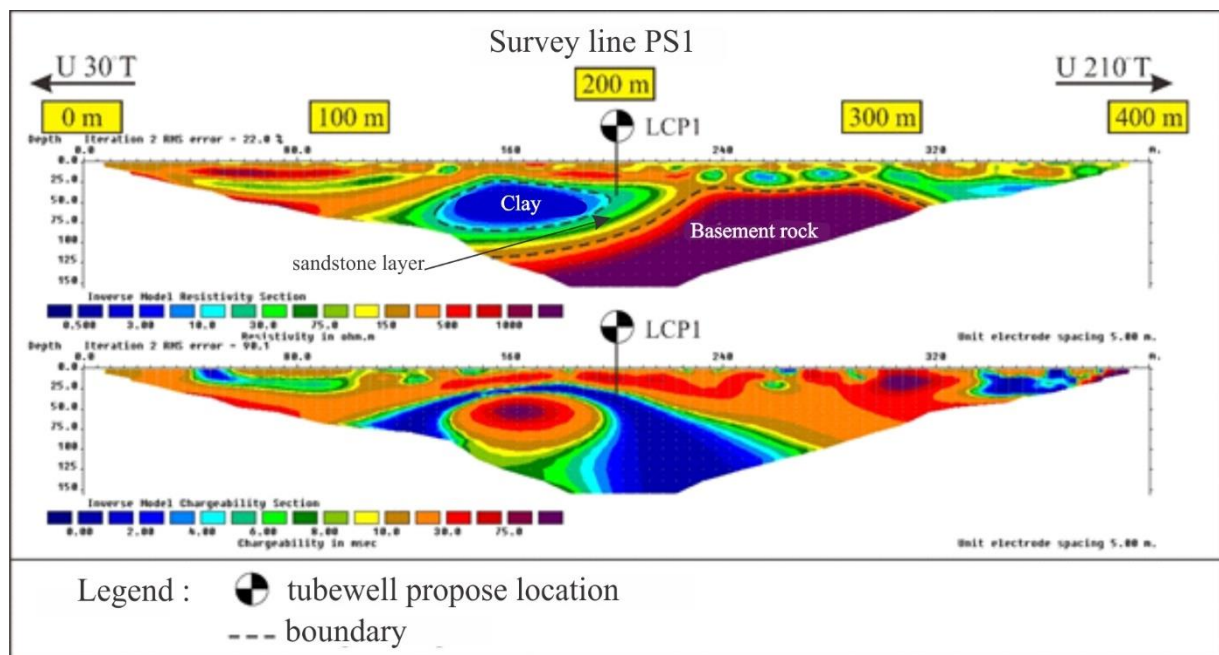

Figure 5. Inversion model of ERI and IP survey line PS1

4.2 Survey line KRBG2

This line survey conducted at irrigation scheme of Lanjut Manis Center of Melaka Area with line orientation N210^{0}E - N30^{0}E where at 0 to 80 m line survey is assigned at palm oil plantation with high topography. Apparent resistivity value that shown from inversion model has value with range 0.5 – 1000 Ωm. Based on large variation of apparent resistivity value, it divided into three layers. First layer is interpreted as granite as basement rock with high resistivity value 500 – 1000 Ωm (orange to purple) that shown at 25 m depth below. Second layer with resistivity value ranging from 30 – 500 Ωm (dark yellow to green) is interpreted as sandstone layer at near surface down to 100 m beneath earth. Third layer with lowest resistivity value 0.5 – 10 Ωm (dark blue to light blue) sandwich between sandstone layers is interpreted as clay layer. In other hand, chargeability value also have wide range from 0.00 – 75.00 msec. aquifer that indicated by low chargeability value (0.00 – 2.00 msec) with blue in colour shown at 25m as presented in Fig. 6 below.
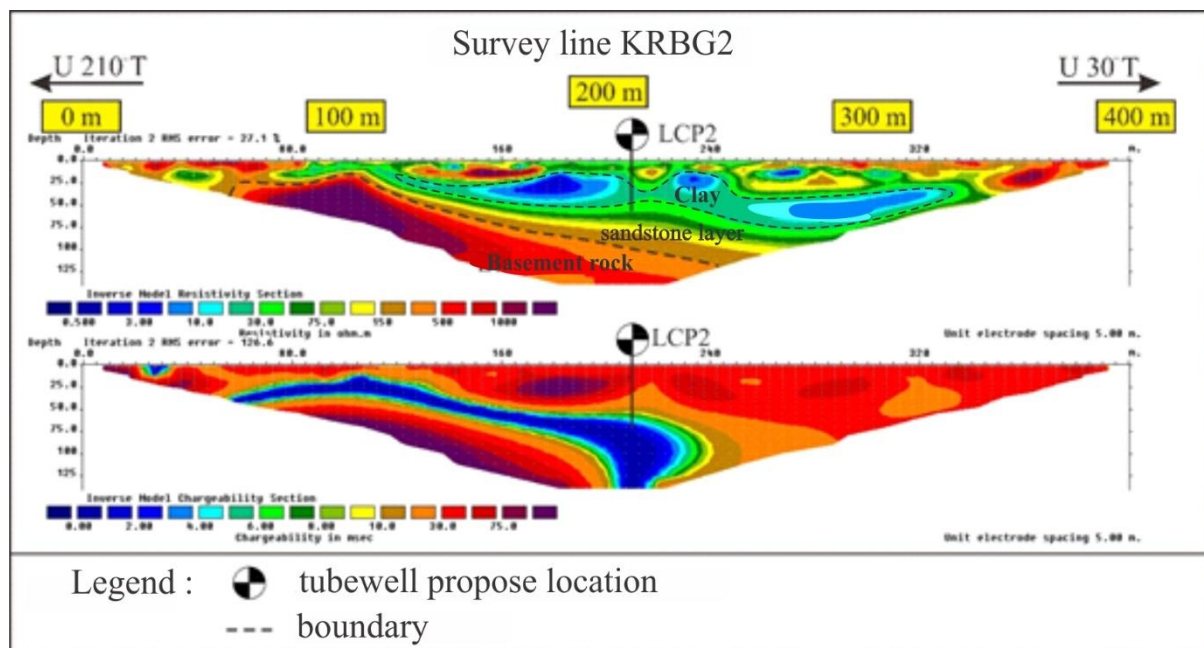

Figure 6. Inversion model of ERI and IP survey line KRBG2

4.3 Survey Line BB3

Survey line BB3 is located at irrigation scheme of Parit China area with line orientation N170^{0}E - N350^{0}E. The data collected at rice field with gentle topography. Result of inversion model shown that apparent resistivity value ranging from 0.5 up to 150 Ωm. it divided into two layers, first layer with resistivity value 30 – 150 Ωm (green to yellow) interpreted as weathered sandstone. This layer found at 50 m below surface. Another layer is interpreted as unconsolidated soil mostly clay layer with resistivity value 0.5 – 30 Ωm (dark blue to light blue) that show at surface to 150 m below. From the chargeability value there is no indicating for aquifer layer because mostly they have high chargeability value (30 – 75 msec), as shown in Fig. 7 and Table 1.
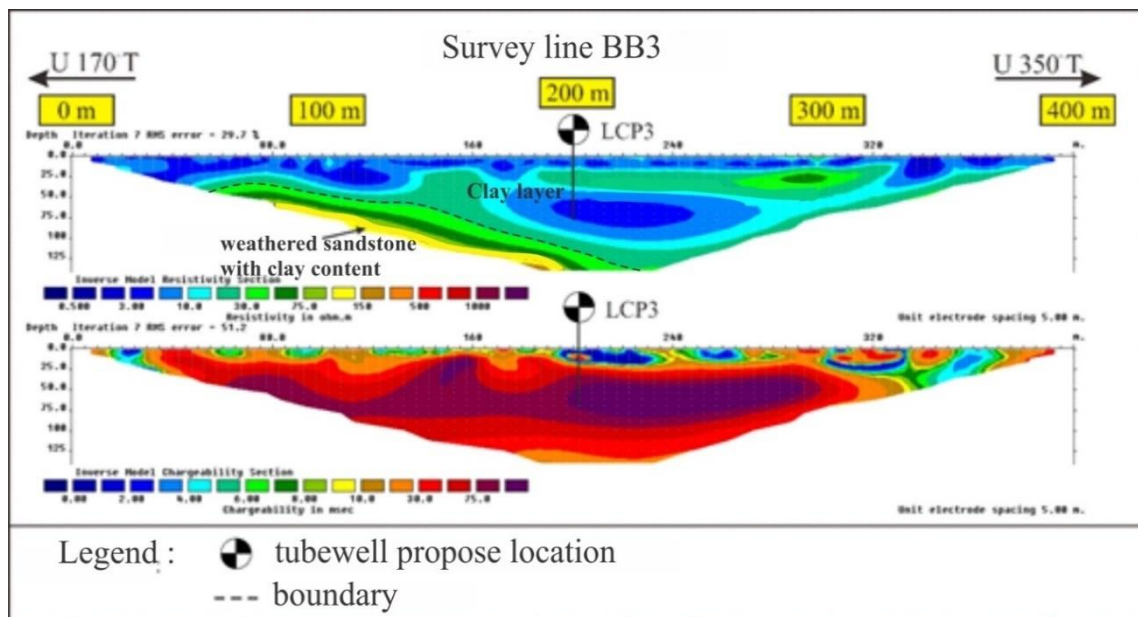
Figure 7. Inversion model of ERI and IP survey line BB3

Table 1. Interpretation of ERI and IP results

Survey line	Depth (m)	Resistivity value (Ωm)	Chargeability value (msec)	Interpretation
PS1	0 – 100	30 – 500	0 – 2	Sand, Sandstone layer
	25 – 75	0.5 – 10	30 – 75	Clay layer
	30 – 150	500 – 1000	0 – 20	Granite (basement rock)
KRBG2	0 – 100	30 – 500	0 – 6	Sand, sandstone layer
	15 – 50	0.5 – 10	30 – 75	Clay layer
	25 – 125	500 – 1000	30 – 75	Granite (basement rock)
BB3	0 – 125	0.5 – 30	6 – 75	Clay layer
	50 – 125	30 – 150	30 – 75	Weathered sandstone (high clays content)

5. Discussion

Based on the result of ERI and IP survey, location of aquifer layer can be predicted and suggestion for tube well location can be determined. At survey line PS1 and KRBG 2, layer with resistivity value 30 – 500 Ωm interpreted as aquifer (sandstone layer). This interpretation supported by low chargeability value (0.00 – 2.00 msec) that always associated with groundwater. For survey line BB3, there is low resistivity value (30 – 150 Ωm) that interpreted as weathered sandstone. But it's not an aquifer layer because that layer have high chargeability value (30 – 75 msec). High chargeability value at this layer interpreted as high clay content within weathered sandstone.

Location and depth of tube well can be suggest by ERI and IP result. For survey line PS1 at irrigation scheme of Padang Sebak II, tube well suggestion located at middle of survey line (200 m from first electrode) with 40 m minimum of depth. Tube well location for survey line KRBG2 at irrigation scheme of Lanjut Manis suggested at 210 m from first electrode with minimum depth is 75 m. While survey line BB3 doesn't have groundwater potential but if needed try to make tube well at 200 m from first electrode with more than 125 m of depth.

6. Conclusion
Electrical Resistivity Imaging (ERI) and Induced Polarization (IP) method in this study has been successfully used to locate groundwater as alternative water source to solve water drought during dry season at Alor Gajah, Melaka, Malaysia. Aquifer layer at study area characterized by resistivity value ranging from 30 up to 500 Ωm and supported with low chargeability value (0 – 2 msec) that interpreted as sandstone layer. The depth of aquifer layer are around 40 m to 75 as the suggestion to generate tube well at study area.

Acknowledgements

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