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Enhancement in resistivity resolution based on the data sets amalgamation technique at Bukit Bunuh, Perak, Malaysia

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Abstract. In this paper, we have carried out a study with the main objective to enhance the resolution of the electrical resistivity inversion model by introducing the data sets amalgamation technique to be used in the data processing stage. Based on the model resistivity with topography results, the data sets amalgamation technique for pole-dipole and wenner-schlumberger arrays are successful in identifying the boundary or interface of the overburden and weathered granite. Although the electrical resistivity method is well known, the proper selection of an array and appropriate inversion parameters setting such as damping factors are important in order to achieve the study objective and to image the target at the Earth's subsurface characterizations.

1. Introduction

In the past few years, significant effort has been done in developing in-field data acquisition technique in electrical resistivity method. This method work by measuring the potentials between two electrodes while injecting current into the ground at another electrode pair. The enhancement of model resolution in resistivity method is challenging in geophysical imaging in order to characterize the Earth's subsurface. In addition, the identification of the Earth's subsurface structures which is invisible materials or structures undersurface of the Earth such as bedrock and alluvium thickness. This is based on amplitude and geometry indicators obtained via this method, requires a good understanding about the electrical resistivity arrays and appropriate parameter settings selection.

The electrical resistivity method has been used worldwide in engineering and environmental study. This geophysical method has been used for a long time in the investigation of the Earth's subsurface. The electrical resistivity method is usually used in bedrock determination, overburden materials and subsurface structure such as cavities, boulders, faults and voids [1]. In environment study, there are many physical parameters can take into consideration before making an important decision in civil construction. These physical parameters play an important role in indicating their characterization which is due to time and condition changes [2]. The in-situ behaviour of soils is complex because it is

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heavily dependent upon numerous factors. To acquire appropriate understanding, it is necessary to analyze them not only through geophysics and geotechnical engineering methods, but also through other associated disciplines like geology, geomorphology, climatology and other earth and atmosphere related sciences [3]. Thus, the correlation of these technical methods of investigation of Earth subsurface is required by geoscientists and engineers. As no single geophysical method yields the optimal information about the Earth subsurface, it is better to combine the geophysical method such resistivity tomography, or seismic refraction tomography with geotechnical works which is in-situ measurements. The main objective of this study is to enhance the resolution in the inversion model in electrical resistivity method. The development of the technique are discussed in the next section.

2. Geological setting

Bukit Bunuh is located in the Malaysian most famous prehistoric valley, Lenggong Valley, Perak, Malaysia. Among the most notable of the excavations of Paleolithic period is located at the Paleolithic sites at Kota Tampan, Lawin, Bukit Jawa and Temelong [4]. These prehistoric archaeological sites classified as open sites, with the materials of quartzite and quartz. Bukit Bunuh was found at the end of 2001, which also an in-situ undisturbed open sites with the tool making workshop evidences [5]. At Bukit Bunuh, the quartz blocks can be classified as large to small fragments which forming suevite rocks.

3. Materials and methods

The electrical resistivity survey is a surveying technique for imaging the Earth's subsurface characterization including complex geology structure. In this study, we carried out an electrical resistivity survey using multi-electrode system. In this system, we are using 41 electrode number. The current and potential electrodes are changed automatically by Electrode-Selector (ES10-64), which is based on selected array for the resistivity survey. The minimum electrode spacing used in this study is 5 m spacing and the total length of straight survey line is 200 m. There are three different resistivity arrays used in this study, which is pole-dipole, dipole-dipole and wenner-schlumberger arrays. Each of this resistivity arrays has their own advantage and limitations in imaging the subsurface. Thus, the inversion model obtained using RES2DINV software is correlated with the borehole record which acts as geological reference. This will help in the interpretation work of the inversion resistivity models obtained to be more reliable and effective. In this study, we are studying three possible data sets amalgamation for three selected different types of resistivity arrays. Figure 1 shows the schematic diagram for possible combination of all three selected resistivity arrays. Simply codes were created by these possible data sets amalgamation technique are given as (P-D) for pole-dipole array, (D-D) for dipole-dipole array and lastly (W-S) for wenner-schlumberger array. The code combination used are (a) pole-dipole and dipole-dipole arrays (P-D and D-D), (b) dipole-dipole and wenner-schlumberger arrays (D-D and W-S) and (c) pole-dipole and wenner-schlumberger arrays (P-D and W-S).

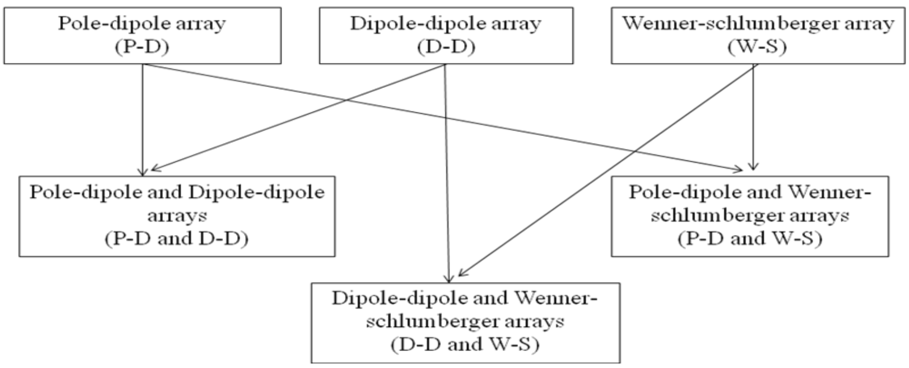

Figure 1: Schematic diagram for possible data sets amalgamation technique for three different resistivity arrays used in this study.

Dipole-dipole array was sensitive to horizontal changes however, lower signal strength compared with pole-dipole. Pole-dipole array has good depth of penetration among all arrays, but signal strength is lower compared to wenner-schlumberger. Signal strength for wenner-schlumberger array is twice than pole-dipole, however horizontal coverage is narrower than dipole-dipole. Wenner-schlumberger array is the amalgamation of wenner alpha array and schlumberger array. This is proven by data coverage is similar between wenner alpha and schlumberger arrays amalgamation with wenner-schlumberger array. Thus, this array can be considered as co-linear and asymmetric array. In this paper, we are also presenting the real datum points to show the development of the data sets amalgamation technique used in this study. Thus, we will show that this technique is able to give significant advantages compared using one single array in engineering and environmental investigation. Figure 2 shows the datum points for pole-dipole, dipole-dipole and wenner-schlumberger arrays used in this study. The maximum number of datum points for pole-dipole array is 1387, dipole-dipole array is 356 and wenner-schlumberger array is 665.

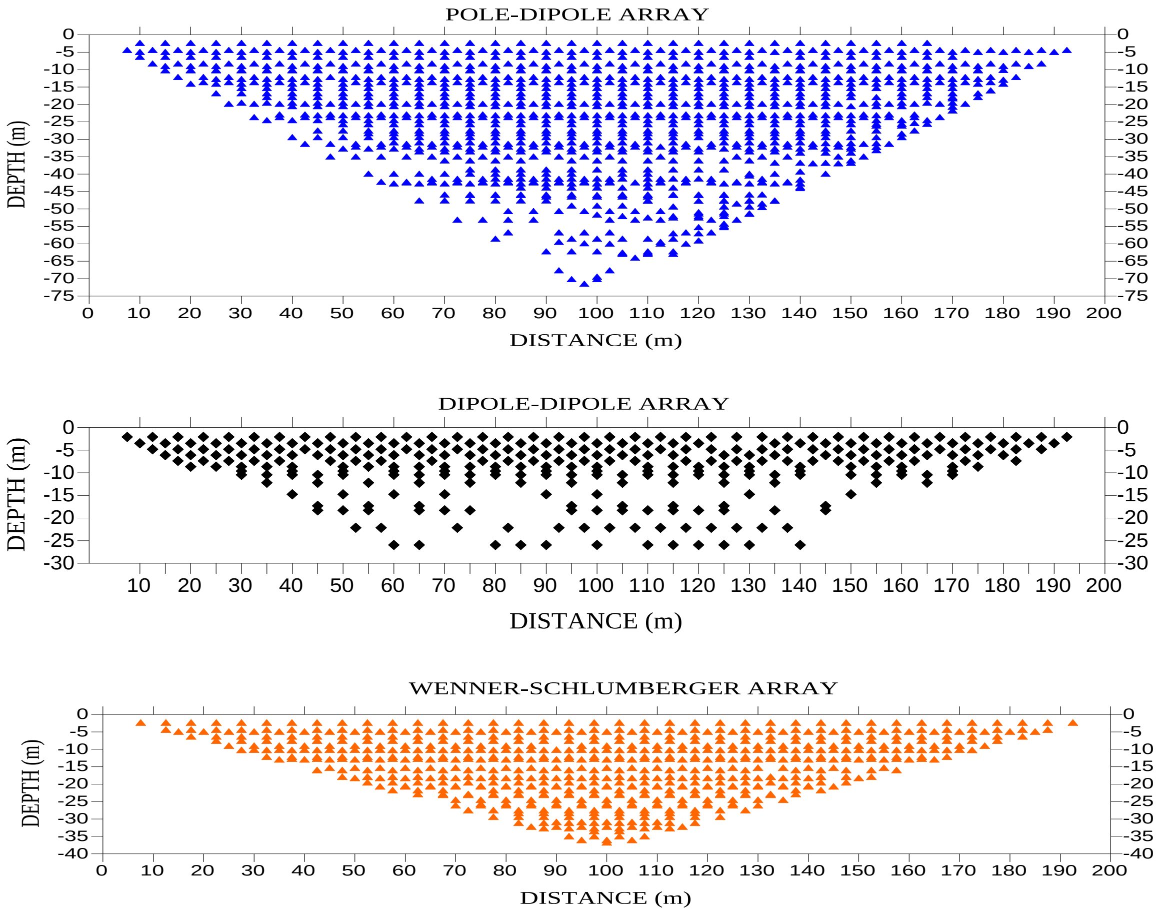

Figure 2: Three different resistivity arrays used in this study, which is pole-dipole array (above), dipole-dipole array (middle) and wenner-schlumberger array (bottom).

Meanwhile, Figure 3 shows the data sets amalgamation for all three different resistivity arrays used for inversion processing stage. By this technique, we have identified that there is an improvement in the maximum number of datum points used for 2-D inversion processing which is given by datum points summation of two different resistivity arrays. The maximum number of datum points identified in this study was (P-D and D-D) is 1743, (D-D and W-S) is 1021 and lastly (P-D and W-S) is 2052.

With this technique, it shows that the data levels of these two different arrays in the inversion models are improved better compared to one single array. Another term for this condition, we can consider that the enhancement in vertical resolution has occurred in inversion models. Moreover, the datum points in the horizontal section which is governed by electrode spacing is filled with other data sets of array. Thus, the horizontal resolution of the inversion model is enhanced using this technique.

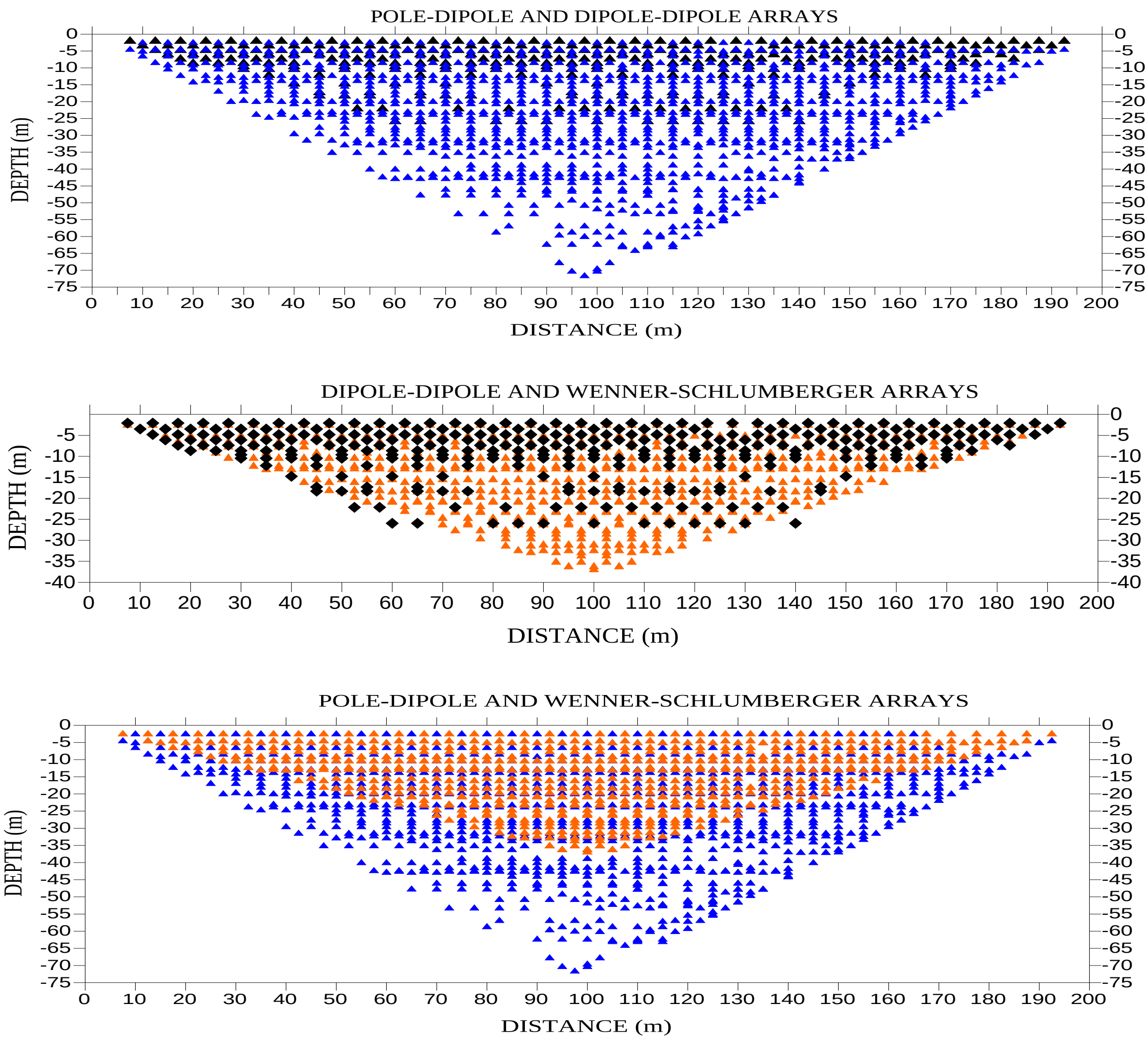

Figure 3: The data sets amalgamation from two different resistivity arrays used in this study. The data set used in the inversion models were (P-D and D-D) (above), (D-D and W-S)(middle) and (P-D and W-S)(bottom).

4. Results and discussions

In this paper, we present the results of the inversion resistivity model where the electrical resistivity survey was conducted in Bukit Bunuh, Perak, Malaysia. The electrical resistivity survey was conducted using appropriate survey setting which is same for all selected arrays. Figure 4 shows the resistivity model result using the data sets amalgamation technique for dipole-dipole and wenner-schlumberger arrays. Figure 5 shows the resistivity model result using the data sets amalgamation technique for pole-dipole and dipole-dipole arrays. Meanwhile, Figure 6 shows the resistivity model result using data sets amalgamation technique for pole-dipole and wenner-schlumberger arrays. All the resistivity model results are correlated with the in-line borehole record (BH-6). This borehole record is used in electrical resistivity model interpretation because this borehole record assists the interpreter to identify the Earth's subsurface lithology at one point only. However, the borehole record helps in the interpretation where this borehole record can acts as geological reference. In Figure 4, 5 and 6, the electrical resistivity model results were successful in imaging Bukit Bunuh subsurface. The overburden of the study site is classified as sandy silt and sandy materials. These two materials made up the overburden with thickness range from 10 m to 23 m. Figure 6 shows significant and reliable results where the boundary (black dash line) of the overburden and weathered granite using data sets amalgamation for pole-dipole (P-D) and wenner-schlumberger (W-S) arrays. However, this boundary is not significant and unclear for others as shown in Figure 4 and Figure 5.

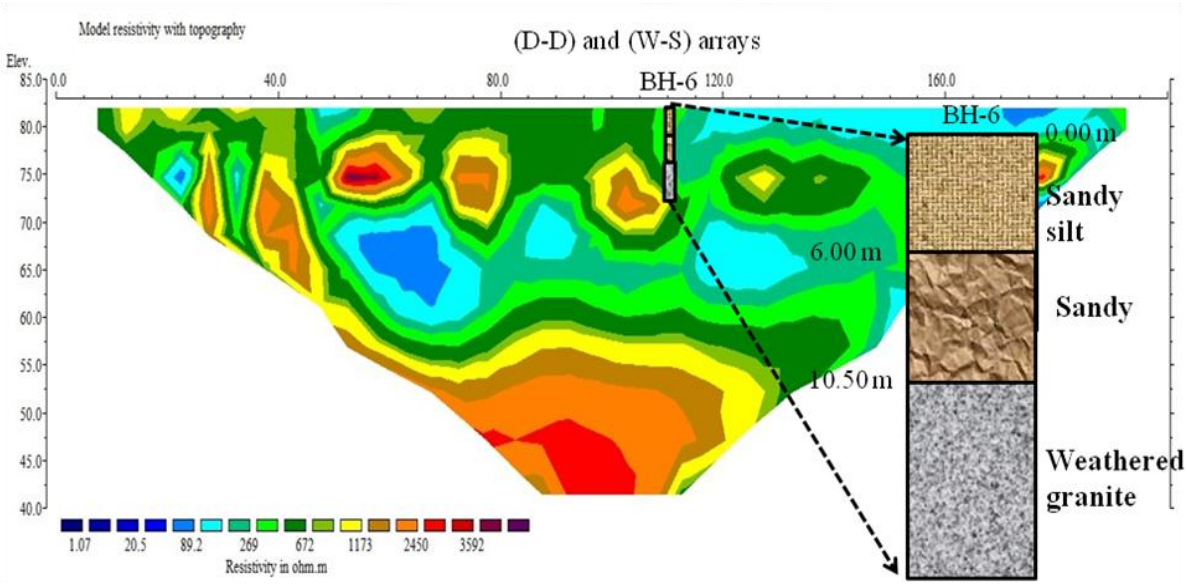

Figure 4: The model resistivity result for Bukit Bunuh subsurface characterization using (D-D) and (W-S) arrays along with geological reference (BH-6).

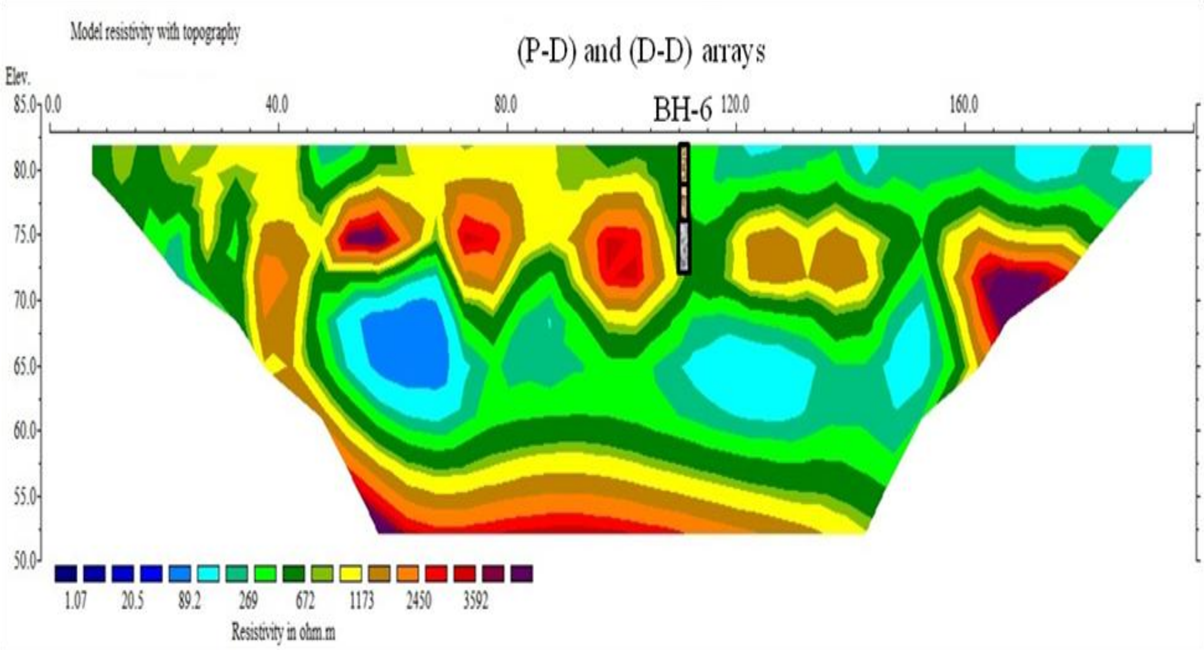

Figure 5: The model resistivity result for Bukit Bunuh area subsurface characterization using (P-D) and (D-D) arrays along with geological reference (BH-6).

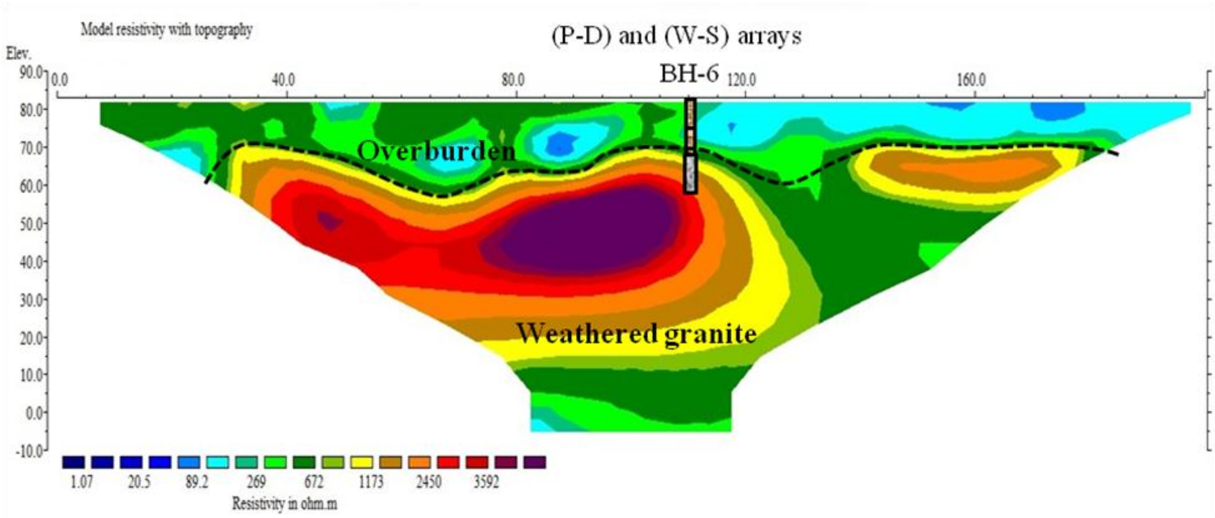

Figure 6: The model resistivity result for Bukit Bunuh subsurface characterization using (P-D) and (W-S) arrays along with geological reference (BH-6).

5. Conclusion

This electrical resistivity tomography method is a good geophysical tool for imaging the Earth's subsurface structure such as bedrock layer. In this study, we are successful achieved our objective to enhance the resolution in the resistivity model results using the data sets amalgamation technique. Although the time taken is twice in data acquisition works, it shows that this technique is applicable and has its technical merit in imaging the Earth's subsurface. Moreover, this study showed that this electrical resistivity resolution enhancement via this technique has covered both horizontal and vertical resolution in resistivity pseudo-section. To fully exploit the data, it is important for proper selection of an array and appropriate inversion parameters setting such as damping factors are used in this study.

6. References

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