Detection of Shallow Buried Archaeological Remains Structure using 2-D Resistivity Method at Sungai Batu, Lembah Bujang, Kedah

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Abstract. In an archaeological study, 2-D resistivity becomes important tools for the scientific investigation and also can be applied to map shallow subsurface structures at the archaeological site. The main purpose of the research is to locate the shallow buried archaeological remains structure in the area of Sungai Batu, Lembah Bujang, Kedah (Malaysia). Resistivity surveys have been applied using a Pole-dipole array with both 5 survey lines for SB1 and SB2 sites using 0.75 m electrode spacing. Both results revealed high resistivity zone with ≥ 3000 Ωm at a depth ranging from 0-1.5 m at the study area. SB1 site conducting an excavation to validate the result obtain while SB2 is not conducting any excavation. Besides that, the other characteristics of the buried archaeological remains are indicated as mound area and there is exposed remain found on top of the surface. Based on the archaeological evidence, the higher resistivity value indicates the interesting anomaly which is clay bricks for archaeological excavation.

1. Introduction

In recent decades, it is well reported that geophysical prospecting is increasingly used for detecting and mapping buried archaeological remains and standing monument. Geophysical methods are applied for conducting excavation and for analysing larger layout of a site by extending the mapping of ruins that have already been excavated [1]. 2-D resistivity, magnetics, and ground-penetrating radar (GPR) are the most commonly geophysical methods that were used [2].

Sungai Batu already provides the earliest evidence of archaeology in Southeast Asia. During a scientific paleoenvironmental reconstruction study, Sungai Batu complex was found and the discovery of this complex by the Centre for Global Archaeological Research, (CGAR) Universiti Sains Malaysia in 2007 mark a great significant in understanding the early civilizations in Malaysia.

This paper provides data from SB1 and SB2 site in Sungai Batu, Lembah Bujang, Kedah, Malaysia. At the chosen sites which are SB1 and SB2, its share the same characteristics mound area (Figure 1) and exposed clay bricks on the surface (Figure 2). In this work, the paper present a 2-D resistivity survey carried out in two mounds area SB1 and SB2 site, where SB1 is already excavated while SB2 is not conducting any excavation yet.
2. General Geology

Sungai Batu is located in Lembah Bujang along the road from Sungai Petani to Merbok in South Kedah near Gunung Jerai and Sungai Merbok area, mostly covers the coastal plain around Gunung Jerai (1,300 meters high) [3]. Most of Sungai Merbok area underlain by the Mahang Formation especially in eastern and southern part. This formation formed in Middle Ordovician to Early Devonian age [4]. The rock unit comprises shale, red slate, grey slate and black slate. Sungai Batu area are mostly composed of sandy clay covered with fine sand. The geomorphology of the Sungai Batu area mostly flat with oil palm and rubber trees fields and also covered with small stream, rivers and swampy area at eastern part of the study area. Figure 3 shows the geological map of Sungai Batu.

![Figure 1. Mound area at SB 2 site.](image1)
![Figure 2. Exposed clay bricks on the surface.](image2)

[Image 3. The geological map of Sungai Batu [5].](image3)
3. Study Area

The study location was at SB1 and SB2, Sungai Batu area which is in Lembah Bujang district. The location for SB1 site was from N 5.694935° E 100.450817° to N 5.694932° E 100.451088° and N 5.694858° E 100.450830° to N 5.694849° E 100.451098° meanwhile the location for SB2 site was from N 5.697810° E 100.453460° to N 5.697901° E 100.453721° and N 5.697971° E 100.453394° to N 5.698089° E 100.453635°. There were 5 survey lines of 2-D resistivity method for both SB1 site and SB2 site directed towards West-East (Figure 4).

![Survey lines of 2-D resistivity method at SB1 and SB2 site](image)

**Figure 4.** Survey lines of 2-D resistivity method at SB1 and SB2 site, Sungai Batu, Lembah Bujang, Kedah (Malaysia) [6].

4. Methodology

The geophysical method used in the survey area was 2-D resistivity method with pole-dipole electrode array (Figure 5). To achieve good result in an archaeological study, 2-D resistivity was designed with close line spacing in a grid manner. For SB1 site, the survey was conducted to cover the whole of the study area with 5 survey lines (L1-L5) using 0.75 m electrode spacing and 2 m interval line spacing. For SB2 site, the survey was conducted with 5 survey lines (L1-L5) using 0.75 m electrode spacing and interval between line is 5 m spacing. The survey used ABEM SAS 4000 and the data was processed using Res2DINV and Surfer 10 software.
5. Results and discussion

Figure 6 shows inversion model of 2-D resistivity for SB1 site from SB1L1-SB1L5 and Figure 9 shows inversion model of 2-D resistivity for SB2 site from SB2L1-SB2L5. The results show the potential for identifying shallow buried archaeological structures. SB1 and SB2 sites show the same characteristic which is mound and an alluvium area. At SB2 site, the clay bricks clearly can be seen on the top surface. Most inversion model of 2-D resistivity from Sungai Batu show high resistivity value up to ≥ 3000 Ωm out the surface and low resistivity value of ≤ 100 Ωm underlain at the second layer. Generally, the alluvium area have resistivity value of ≥ 50 Ωm and an interesting anomaly are identified on some survey lines from SB1 and SB2 at depth of 0-1.5 m with resistivity of ≥ 3500 Ωm.
From both figures, the presence of clay bricks are indicated by high resistivity values due to the extremely strong ceramic bonds formed by the effect of heat at high temperature. The excavation was already carried out in SB 1 site and discovered clay bricks as a structure composition of the floors (Figure 7). Normally, the excavation for shallow buried remain structures will be done less than 1 m below surface.

![Structure of the floor in the SB 1 site.](image1.jpg)

**Figure 7.** Structure of the floor in the SB 1 site.

While compared to both sites, SB 2 site has lower resistivity values compare to SB1 site which has higher resistivity values. It is most probably due to the structure found in SB 2 site is shallow than SB1 site. This low resistivity values also might be due to clay with high water content and soil of sedimentary origin. Near SB 2 site, there is small drain located along the oil palm field that also probably the other cause that may affect low resistivity value at SB2 site compare to SB 1 site (Figure 8).

![Small drain located near the SB 2 site.](image2.jpg)

**Figure 8.** Small drain located near the SB 2 site.
6. Conclusion
In this paper, the investigations are focused by using an archaeo-geophysics approach which is 2-D resistivity method to detect shallow buried remain structures located in the Sungai Batu, Lembah Bujang, Kedah, Malaysia. The presence of high resistivity values caused by clay bricks (archaeological structure) from the 2-D inversion model resistivity were presented and discussed. The results from the studies were very useful as a guiding for the excavation activities in SB 1 site. Perhaps, there is more surveys and excavation process at suspected area to detect the archaeological buried structures. For future research in an archaeological study, the results from the 2-D inversion model resistivity hopefully can be useful in order to detect the presence of other archaeological buried structure.

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