Stratigraphy Identification with Emphasis to Shells Layer using 2-D Electrical Resistivity Method at Guar Kepah, Penang

Najmiah Rosli¹, Hafizuddin Mansor¹, N A Ismail¹, S S K Masnan², M Saidin²

¹ Geophysics Section, School of Physics, Universiti Sains Malaysia, 11800 Penang, Malaysia.
² Centre for Global Archaeological Research, Universiti Sains Malaysia, 11800 Penang, Malaysia.

E-mail: najmiahrosli@gmail.com

Abstract. 2-D electrical resistivity method was done at an archaeological site in Guar Kepah, Penang, to determine its stratigraphy with emphasis to shells layer. This study aims to guide the archaeological studies where many prehistoric findings are related to shells and also for engineering purposes as an archaeological gallery is to be built there. Results show that the area is composed of three unconsolidated soil strata where the uppermost layer is sandy-clay, followed by shells layer, and lastly sandy layer. The shells layer is undulating with similar thickness throughout the site, but thickens at the northern part of the study area. The depth of the shells layer however, is different at different parts of the site.

1. Introduction
Guar Kepah is Peninsular Malaysia’s new archaeological site as recent excavations in this area have exposed the famous ‘Penang Woman’ skeleton. The skeleton was found buried in a thick layer of shells, a clear indication that this layer is associated to archaeological findings. An archaeological gallery is also to be built on this land. The aim of this study is to map the subsurface stratigraphy of the study area and delineate the resistivity values of each layer of soil. The results are used as a guide for subsequent excavation works and also for engineering purposes related to the construction of the gallery.

2. Study area
The study area is located at Guar Kepah in Seberang Perai, Penang, Malaysia. The area is in Kampung Guar Kepah and surrounded by paddy fields. The site is about 50 m from the main road and 8 km from the present coast line. There was a house overlying the site before being demolished for archaeological activities. Previous archaeological studies were also done here, known as Site C, has coordinates of 5° 33’ 29.2” N and 100° 25’ 32.3” E [1], shown in figure 1. The studies had recovered ceramic artefacts, “sumatralite” unifacial and bifacial pebble tools that indicate the site to belong in Early Neolithic period. Shell samples also suggest that Guar Kepah was inhabited about 5,000-6,000 years ago [2].
Geology
Guar Kepah is situated on a stranded beach ridges, deposited around mid-Holocene sea transgression, which is about 4,000-5,000 years ago [4]. Most of Seberang Perai area is underlain by pre-Quaternary granite and sedimentary rocks of Sungai Petani and Mahang Formations [5]. The coastal areas is underlain by Simpang Formation, Gula Formation and Beruas Formation of Quaternary age. The Simpang Formation is composed of gravel, sand, clay, silt and peat by terrestrial fluvial deposit. The Gula Formation is composed of silt, clay, sand, gravel, peat and often shell fragment deposited within an estuarine and shallow marine environment. The Beruas Formation consists of clay, silt, sand, gravel and occasional peat [6].

Methodology
Geophysical method employed for this study was 2-D electrical resistivity method. The survey used a multi-electrode resistivity meter system with a constant spacing of 1 m between electrodes, laid out in a straight line. Wenner-Schlumberger protocol was chosen. A computer-controlled system was then employed to automatically select the active electrodes for each measurement [7]. 15 parallel lines of 20 m length were carried out with a distance of 1 m between each survey lines as shown in figure 1. Interpretation of the obtained data was done using an inexpensive microcomputer with reference to table 1 which shows resistivity values of common soil [8]. The data was later confirmed by cross-referencing with exposed stratigraphy at the site due to construction works of the gallery.

| Soil        | Resistivity (Ωm) |
|-------------|------------------|
| Alluvium    | 10-800           |
| Clay        | 1-100            |
| Sand        | 60-1000          |
| Groundwater | 10-100           |
5. Results and discussion

Figure 2 shows resistivity profiles of Lines 13-15. Profiles of Line 6 and Lines 9-12 are shown in Appendix.

Based on the resistivity results of Lines 1-15, the area composes of three layers of unconsolidated soil with generally low resistivity values. The uppermost layer is sandy-clay with resistivity values of <40 Ωm, followed by shells layer of 40-70 Ωm, and sandy layer of >70 Ωm.

The thickness of shells layer is relatively similar throughout the site, ranging from 0.20-0.30 m, but thickens up to 0.72 at distance 7-11 m of Lines 14 and 15 as in figure 2. The shell layer is also undulating and has different depths, ranging from 0 m depth (at surface) until 1.5 m depth. Its depth tends to be shallower at the southern part of the site and deepens to the north.

The results are later confirmed when construction of the gallery started, exposing the stratigraphy as shown in figure 3. The range of resistivity values of each layer fit the actual stratigraphy. Figure 3A is situated in Line 15 at distance 2.3-9.7 m while figure 3B is cutting across perpendicularly between Lines 7-10, at distance 0 m. Figure 3B shows all three layers of soil and proves that resistivity method could resolve both stratigraphy contrast between layers and their dipping.
There is an abandoned concrete well of 1 m diameter and 2 m deep situated in Line 8 at distance of 10.8–11.8 m shown in figure 4. Previous construction of the well causes disturbance in the soil around it shown in both Lines 7 and 8, causing the area to have lower resistivity than the surrounding soil. Furthermore, concrete material tends to have low resistivity values.

**Figure 3.** Correlation between resistivity profiles and exposed stratigraphy. A) stratigraphy at Line 15, B) stratigraphy cutting across Lines 7–10 at distance 0 m and C) resistivity scale and legend used for A) and B).
Figure 4. Resistivity profiles of Lines 7 and 8 where there is a disturbance of soil due to presence of well, causing the area to have low resistivity values than surrounding soil.

6. Conclusion
The stratigraphy of the study area is composed of three layers of unconsolidated soil with low resistivity values. The uppermost layer is sandy-clay, followed by shells layer and sandy layer. Their resistivity values increases from top to bottom layers, with sandy-clay layer having the lowest resistivity (<40 Ωm), followed by shells layer (40-70 Ωm) and sandy layer with highest resistivity (>70 Ωm). The thickness of the shells layer is relatively similar throughout the site, but thickens at the middle of the northern part of the study area. The shell layer is also undulating with different depths, having a trend of shallowing at the southern part of the site and deepens to the north. Correlation between resistivity method and actual stratigraphy proves that this method is accurate in resolving stratigraphy contrast between layers and their dipping.

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Appendix

Figure A1. Resistivity profiles of Lines 1-5.
Figure B1. Resistivity profiles of Line 6 and Lines 9-12.
References

[1] Khairuddin A H 1994 Tapak Prasejarah Guar Kepah-Satu Catatan. Jurnal Arkeologi Malaysia 7 76-84
[2] Cullin E G and Zehnder W F 1905 The early history of Penang 1592-1827
[3] Google Earth Pro 2016
[4] Tjia H D 1987 Ancient shorelines in Peninsular Malaysia Paper presented at the SPAFA Final Report Seminar in Prehistory of Southeast Asia Thailand
[5] Courtier D B 1974 Geology and mineral resources of the neighbourhood of Kulim, Kedah 3 50
[6] Hassan K 1990 A summary of the Quaternary geology investigations in Seberang Prai, Pulau Pinang and Kuala Kurau Geological Society Malaysia Bulletin 26 47-53
[7] Griffiths D H and Barker R D 1993 Two-dimensional resistivity imaging and modelling in areas of complex geology Journal of Applied Geophysics 29(3) 211-226
[8] Keller G V and Frischknecht F C 1966 Electrical methods in geophysical prospecting