2012 International Conference on Geological and Environmental Sciences
IPCBEE vol.36(2012) © (2012)IACSIT Press, Singapoore

Archaeological Structure Detection Using 3D GPR Survey in Jeniang, Kedah, Malaysia

Norhidayahti Mohd. Muztaza[1+], M. Mokhtar Saidin[1], I.N. Azwin [2] and Rosli Saad[2]

[1] Centre for Global Archeological Research Malaysia, 11800 Universiti Sains Malaysia, Pulau Pinang, Malaysia

[2] Geophysics Section, School of Physics, 11800 Universiti Sains Malaysia, Pulau Pinang, Malaysia

Abstract. As a non-destructive method, geophysical techniques are very useful in archeology especially in detecting and mapping buried structures. Archaeological features could be acquired from different methods in geophysics depending on research objective. Beside its benefits to archaeology, the information from the geophysics data gives an advantage for archaeologist to plan for archeological research framework especially in optimizing the excavation work. Ground penetrating radar (GPR) is one of the geophysical methods that utilizes electromagnetic waves to record relative position and shape of archaeological features in 3D. This method was applied in detecting buried archaeological structure in Kampung Sungai Perahu Jeniang, Kedah. GPR with 3D interpretation managed to locate buried objects in KSP 1 study area at Jeniang, Kedah.

Keywords: Site KSP 1, Jeniang, 3D GPR survey, archaeological structure.

1. Introduction

Geophysical technique has commonly being used in archaeology as a non-destructive method. This method allow subsurface features to be located, mapped, and characterized by making measurements at the surface that respond to a physical, electrical or chemical property [1]. A variety of geophysical methods are applicable to the investigation of an archaeological site. Geophysical properties measurement of the ground surface produced images of subsurface that could be interpreted by the 'in-collaboration' of geophysicist and archaeologist in identifying subsurface features of cultural origin [2]. Ground Penetrating Radar (GPR) is a near surface geophysical technique that most effective with buried site existing artifacts and features of interest that are located within 2-3 meters from surface, also occasionally been used for more deeply buried site [3]. In 1990 and 1992, a discovery of an archaeological structure in the district of Jeniang was reported. The findings were informed by local resident of Kampung Mambung Bawah and Kampung Gading without any further archeological research of the structures [4]. Similar archaeological structures have been discovered by USM Centre for Global Archaeological Research (USM CGAR) in 2010 at Kampung Gading, Kampung Chemara and Kampung Sungai Perahu in Jeniang, Kedah. Two sites in Kampung Sungai Perahu have been indentified of having high potential for archaeological studies, with the upper part of the archaeological structures are visible on the ground surface which located in residential area. A careful and efficient archaeological excavation strategy needs to be planned without affecting any existing modern infrastructures on site.

2. Archaeological Structure of Jeniang

+ Corresponding author. Tel.: +6017-7175850 ; fax: +604-6573546.
E-mail address: mhidayahti@gmail.com

The archaeological structures discovered since 1990 in Jeniang are situated near the bank of Muda River. It is made of clay with a shape of an earthenware jar. Trace of combustion on the inner wall of the structures show that it may have been exposed by a high temperature of burning (Fig. 1). Excavation in 2010 by USM CGAR, discovered seven structures at Kampung Gading and four at Kampung Chemara with the measurement of 1.2 m height and 1 m diameter (Fig. 2). Studies about the site are still on going. Preliminary study on the archaeological structure shows that it may have functioned as furnace or kiln. Other artefacts found during excavation in Kampung Chemara and Kampung Gading is small quantity of broken pottery and other artifacts that resembles iron slag.

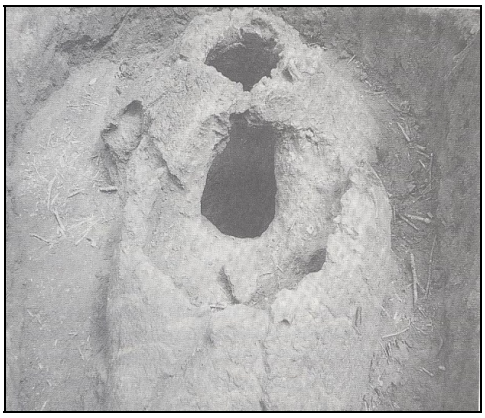

Fig. 1: Archaeological structures discovered at Kampung Mambung Bawah, Jeniang in 1990.

Fig. 2: Archaeological structures unearthed at Kampung Gading, Jeniang in 2010.

3. Ground Penetrating Radar (GPR)

GPR is a near-surface geophysical technique that allows archaeologists to discover and map buried archaeological features or landscape analysis, in ways not possible using traditional field method [5]. It provided high resolution imaging under the right conditions. The subsurface properties determined the depth of investigation, varies from less than a meter to over thousand meters [6]. The use of GPR in detecting archaeological remains has been used since 1970s. It was first used by the archaeologist in 1976 at Chaco Canyon, New Mexico to discover the location of walls covered by wind-blown sediment remains and has been successfully used in archaeological research framework [7]. GPR data are acquired by transmitting pulses of radar energy into a ground from a surface antenna, reflecting the energy of buried objects, features, or bedding contacts and then detecting the reflected waves on the ground surface with a receiving antenna. The receiving pulses will be amplified, processed and recorded to produce reflection profiles of the two-way travel time and amplitude of the reflected pulse (Fig. 3).

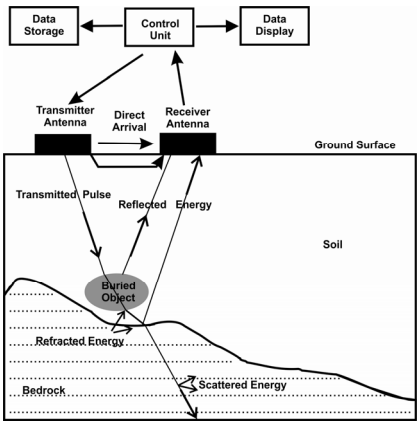

Fig. 3: GPR schematic [8].

4. Study Area

The study area is situated near Muda River, where the upstream flow comes from the mountainous area towards southern area of Kedah. The river changes it course at the downstream and flow towards west coast after passing the confluence of mainstream [9]. Jeniang area which is located near Sik in Kedah, is part of Sungai Petani Formation. Sungai Petani Formation consisting shale, siltstone, sandstone, orthoquartzite and homologous with Mahang Formation [10]. The soil type of the study area is fine sandy clay. Physical geography of Jeniang area is flat and hilly land planted with rubber tree with settlement in a form of villages, mostly nearby Muda River and channel stream. The research area is in district of Jeniang, Kedah. The archaeological structure is located in Kampung Sungai Perahu and labeled as KSP 1 (N 5º 47.648', E100 º 37.910') which situated near Muda River. The structure seemed to be distributed in a clustered form, with the upper part of the structures are visible and situated near to a resident.

5. Methodology

GPR method are employed using 250MHz shielded antenna to identify buried anomalies in individual transects that might represent features of interest. A total of 10 survey lines executed in East-West direction (L1-L10) and 7 survey lines (L11-L17) oriented almost North-South direction (Fig. 4).

Fig. 4: GPR survey lines at site KSP 1 in Kampung Sungai Perahu, Jeniang, Kedah.

6. Results and Discussions

Fig. 5 shows GPR cross section of East-West survey lines. Two anomalies are detected at L7 and L8 at 1.6-2.6m and 2.3-3.0m with depth of 0.24m and 0.3m respectively. The anomalies due to the occurrence of buried archaeological structure beneath the spotted location and supported by evidence of some surface findings (ruined structure) scattered at the surface.

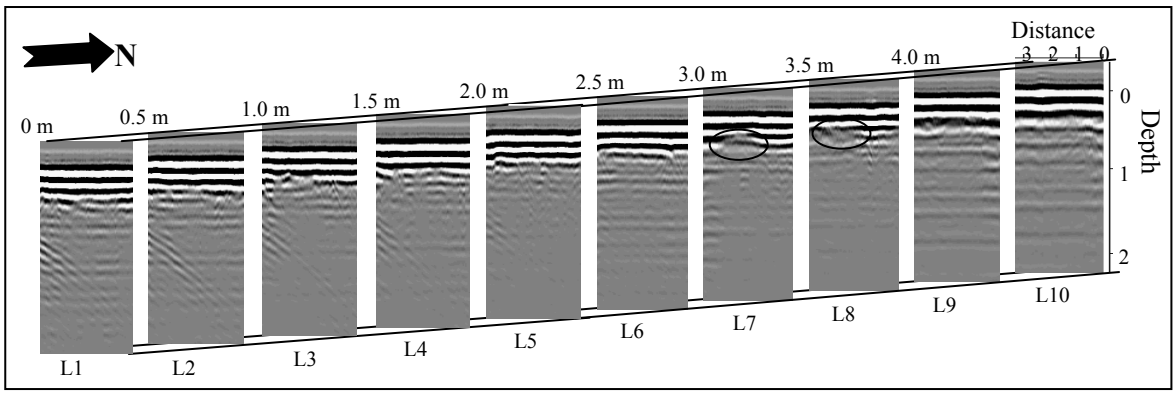

Fig. 5: Ten GPR cross sections for survey lines oriented in East-West direction.

Fig. 6 shows GPR section of North-South survey lines. Anomalies are detected at all survey lines except L16. L11 shows anomaly detected at 3.77-5.55m with depth of 0.3m, while L12 and L13 at 4.24-5.55m and 4.15-5.23m with depth of 0.3m respectively. There is also anomaly detected at 2.31-3.23m with depth of 0.34m at L12. For L14 and L15, two anomalies are detected at 1.96-2.95m and 3.64-4.65m with depth of 0.32m respectively. Following the anomaly flow patterns from L11-L13, the anomaly at 3.64-4.65m is believe to occur due to the diffraction from base of the expected furnace or kiln as the diameter is in average of 1m. While for survey line L17, anomaly at 3.42-4.12m may be due to the diffraction of buried archaeological structure located next to this line that can be seen at the surface.

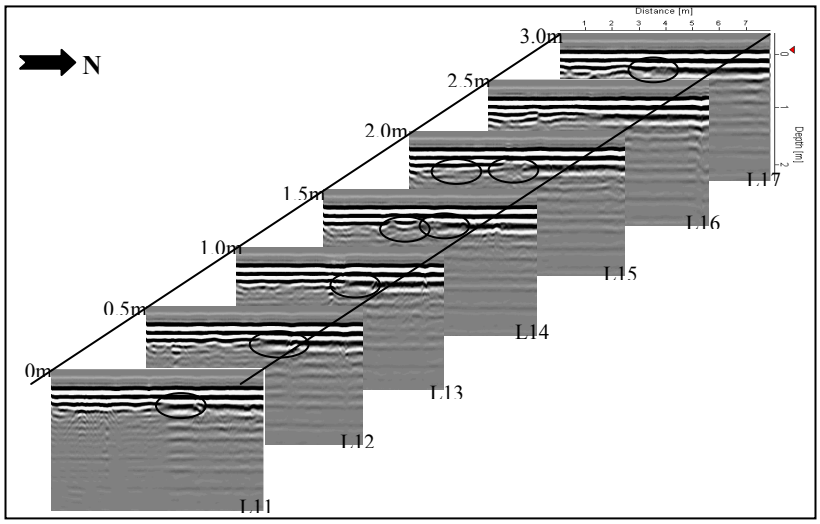

Fig. 6: Seven parallel GPR North-South survey lines. Locations of anomalies are marked with the circle.

The study area is presented in 3-D cube with top view, side view and front view. Results are cut at depth <0.3m for the top view which shows an anomaly distribution. The 3-D cube also cut at x=4.8m and y=1.5m distance in order to show better anomaly distribution. Fig. 7 shows the 3-D view of the study area in the North-South direction.

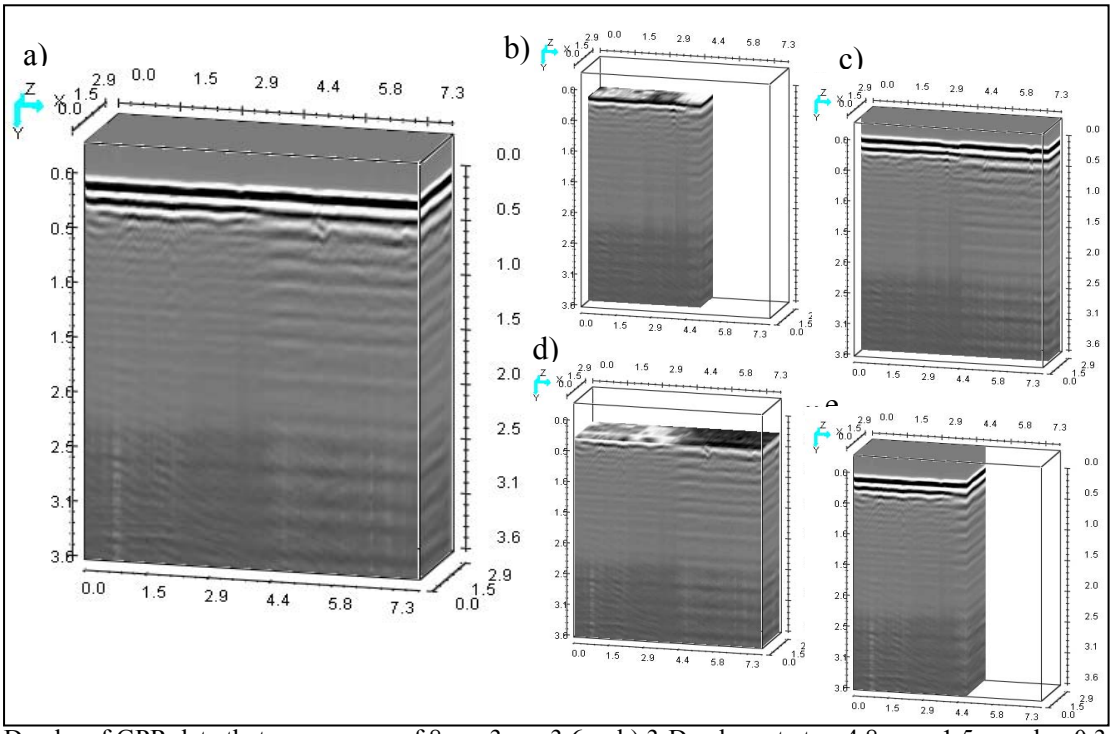

Fig. 7: a) 3-D cube of GPR data that covers area of 8m x 3m x 3.6m, b) 3-D cube cut at x=4.8m, y=1.5m and z=0.3m, c) front view cut at 1.5m, d) top view cut at 0.3m and e) side view cut at 4.8m.

7. Conclusion

GPR successfully detected a possible ancient furnace or kiln located at L11-L13 with depth of 0.3m, which is located almost the same distance with the existing furnace or kiln (surface finding). 3D views give clearer image of the subsurface over the survey area where the distributions of anomalies are well mapped. GPR is useful in mapping the subsurface for preliminary evaluation of any structure that favorable with archaeology.

8. Acknowledgements

Authors wish to express gratitude to USM Centre for Global Archaeological Research (CGAR) and USM Geophysics department for the support in this research.

9. References

[1] *Technos, Vol.1, Fall 2004.* 'Surface Geophysical Methods'. (Online). (Accessed 5th January 2012). Available from http://www.technos-inc.com/pdf/SurfaceTechnotes.pdf

[2] Johnson, W.J. and Johnson D.W .(June 2006).'Application of Geophysics to North American Prehistoric Sites'. *Archaeology Geophysics Feature,Vol.24.* (Online). (Accessed 5th January 2012). Available from http://www.dappolonia.com/pdfs/techpaper14.pdf

[3] Conyers, L.B. (2009). 'Ground Penetrating Radar for Landscape Archaeology: Method and Applications'. *Seeing the Unseen.* Taylor and Francis Group, London. (Online) . (Accessed 5th January 2012). Available from http://mysite.du.edu/~lconyer/landscape_archaeology.pdf

[4] Mohd. Zokhi Tahir. (1995). Laporan Penelitian Arkeologi di Kedah, in *Jurnal Arkeologi Malaysia*. Vol.8. pp 50-63.

[5] Conyers, L.B .(2007). 'Ground Penetrating Radar for Archaeological Mapping'. *Interdisciplinary Contributions to Archaeology: Remote Sensing In Archaeology.* New York: Springer.

[6] Olhoeft, G.R. (2000). 'Maximizing The Information Return From Ground Penetrating Radar'. *Journal of Applied Geophysics*. 43(2-4), 175-187.

[7] Conyers, L.B. (1998). 'Ground Penetrating Radar Techniques and Three-dimensional Computer Mapping in the American Southwest'. *Journal of Field Archaeology, Vol.25, No.4*, pp 417-430. (Online). (Accessed on 5th January 2012). Available from http://ncptt.nps.gov/pdf/1998-36.pdf

[8] Rittenhouse, J. (2008). Environmental Protection Agency, (Online). (Accessed 5th January 2012). Available from http://www.epa.gov/region5superfund/sfd_fss/gpr.html

[9] Aminuddin Ab. Ghani, Rabie Ali, Nor Azazi Zakaria, Zorkeflee Abu Hassan, Chun Kiat Chang, Mohd Sanusi Ahamad. (2010). 'A Temporal Change Study of the Muda River System Over 22 Years'. *Intl J. River Basin Management Vol.8, No.1*. International Association for Hydro Environment Engineering and Research. pp 25-37.

[10] Bradford, E.F. (1972). 'The Geology and Mineral Resources of the Gunong Jerai Area, Kedah: Geological Survey Malaysia'. *District Memoir* 13.