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

The Preliminary Study of Meteorite Impact Crater at Bukit Bunuh, Lenggong

A. H. A. Teh Saufia [1+], Rosli Saad [1], M. Mokhtar Saidin[2], M. M. Nordiana [1] and Nisa' Ali [1]

[1] Geophysics Section, School of Physics, Universiti Sains Malaysia, 11800 USM, Penang
[2] Centre for Global Archaelogical Research, Universiti Sains Malaysia, 11800 USM, Penang

Abstract. Bukit Bunuh, Lenggong has become one of the interesting places for archaeogeophysics study due to the discovery of scattered suevite rocks by Centre for Global Archaeological Research (CGAR), Universiti Sains Malaysia. The rock characteristic is commonly associated with meteorite impact. Therefore, a preliminary study using 2-D resistivity method was done at this area to map and understand the subsurface structure of Bukit Bunuh as well as to investigate any fractures or faults due to the meteorite impact. A South-West line with 1840m length was conducted using Pole-dipole array with 'roll-along' technique. The results show the variation of resistivity value and faults. Integration with boreholes data gives positive sequence to carry out details study at this area.

Keywords: archaeogeophysics, Bukit Bunuh, meteorite impact crater, resistivity,

1. Introduction

Generally, information related to meteorite impacts in South East Asia is limited and hardly recorded. One of the reasons is because of the lack of direct observation and identification of Earth's impact due to the erosion and weathering. However, Centre for Global Archaeological Research (CGAR), USM has presumed that Bukit Bunuh, Lenggong used to undergo a meteorite impact million years ago due to the findings of suevite rock which scattered on the subsurface during the excavation process. Suevite rock is commonly related with meteorite impact which also one of the essential characteristic that differentiate it from the volcanic explosion [1]. In conjunction to that, Geophysics Department, USM has come up with geophysical study in mapping and distinguish the subsurface characteristic of the area.

2. Study Area

This study was conducted at Bukit Bunuh, Lenggong which is located at northern part of Kota Tampan. It is located between two main ranges of Malaysia which is Bintang and Titiwangsa Range. Based on previous geological study, it believes that during Mesozoic era (Triassic age) which occurred about 200 million years ago, Malaysia has gone through granite intrusion all over the place [2]. Addition to that, the nearby area to the river is entirely covered by quaternary deposits such as clay and sand. A survey line of 1840m length was chosen with South-West. The coordinate of 0m distance is N5˚3'32.58" E100˚57'52.69" and 1840m distance is N5˚4'11.62" E100˚58'37.86". Generally, the area is undulating and rough with mixing of primary jungle and agricultural land (Figure 1).

[+] Corresponding author. Tel.: + (6013) 597 0895; fax: + (604) 657 9150
E-mail address: teh.saufia@gmail.com.

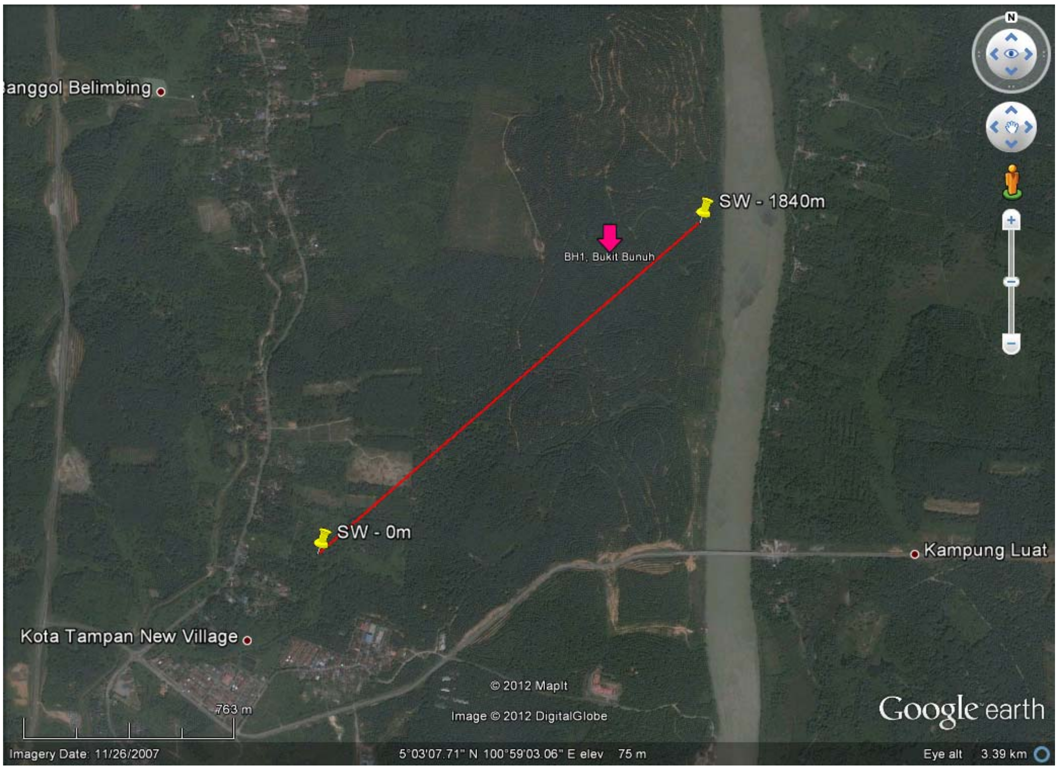

Fig. 1: The survey area at Bukit Bunuh, Lenggong

3. 2-D Resistivity

3.1. Theory

Resistivity method were developed in early 20th century but have been more widely used since 1970s. This method basically measures the resistivity distribution of the subsurface material. The practical usage of resistivity method is injecting a current into the ground by means of two electrodes (C_1 and C_2) and measures the potential between it using second pair of electrodes (P_1 and P_2).

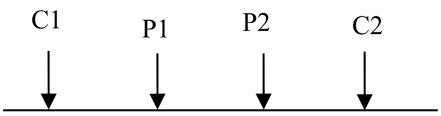

Fig. 2: Two current electrodes and two potential electrodes used in resistivity measurement

Resistivity method is strictly related to resistance, current flow and potentials, thus it is essential to know the basic electrical concepts. Based on the current (I) and voltage (V) obtained, apparent resistivity (ρ_α) can be calculated using equation 3.1.

$$\rho_\alpha = k\, V / I \qquad \text{(eq. 3.1)}$$

where,

k is the geometrical factor depending on the array used

However, the apparent resistivity has to undergo an inversion to obtain a true resistivity (Eq. 3.2).

$$\rho_\alpha = k\, R \qquad \text{(eq. 3.2)}$$

where,

R is the true resistivity value

In order to convert resistivity variation towards geological point of view, knowledge of typical resistivity value for different types of subsurface material and geology are important. It is because, the value of resistivity is depend much on various geological parameters such as porosity, mineral content, texture, moisture content, fissures and fracture of geological information [3]. Table 1 show the resistivity and conductivity values of some typical rocks and minerals [4].

Table 1: Resistivity values of some common rocks and minerals

MATERIAL	RESISTIVITY (Ω.m)	CONDUCTIVITY $(\Omega.m)^{-1}$
Igneous and Metamorphic rock		
Granite	$5x10^3 – 10^6$	$10^{-6} – 2x10^{-4}$
Basalt	$103 – 10^6$	$10^{-6} – 10^{-3}$
Slate	$6x10^2 – 4x10^6$	$2.5x10^{-8} – 1.7x10^{-3}$
Marble	$10^2 – 2.5x10^8$	$4x10^{-9} – 10^{-2}$
Quartzite	$10^2 – 2x10^8$	$5x10^{-9} – 10^{-2}$
Hornfels	$8x10^3 – 6x10^7$	$1.7x10^{-8} – 1.3x10^{-4}$
Sedimentary rock		
Sandstone	$8 – 4x10^3$	$2.5x10^{-4} – 0.125$
Shale	$20 – 2x10^3$	$5x10^{-4} – 0.05$
Marble	3 - 70	$1.4x10^{-2} – 0.3$
Limestone	$50 – 4x10^2$	$2.5x10^{-3} – 0.02$
Soil and Waters		
Clay	1 – 100	0.01 – 1
Alluvium	10 – 800	$1.25x10^3 – 0.1$
Groundwater	10 – 100	0.01 – 0.1
Sea water	0.15	6.7

3.2. Methodology

Prior to resistivity study, all previous data (geophysical, geological and borehole) were collected and analyzed to determine any significant resistivity between the stratigraphic units of the area. The success of geophysical methods largely relies on the presence of significant and detectable contrast in electrical earth physical properties. This method was chosen as it can map areas which have complex geological problems [5].

A preliminary study of South-West line consisting of eight survey lines of 405m length each was carried out. A Pole-dipole array was chosen as it produces good horizontal and vertical resolution. A designed procedure was planned to fit the 'roll-along' techniques, where 200m of resistivity section will be overlapped with the previous section. The computer software played an important role as it completely control the data acquisition, checking all the electrodes are properly connected and have a good contact with the ground before measurement starts. The survey was carried out using ABEM SAS400 system and the field data was then processed using RES2DINV software [6].

4. Results & Discussions

Fig. 3 shows the inversion results at all survey lines while Fig. 4 shows the inversion result of the combination of the eight lines. Basically, there are two main resistivity zones. The first zone with resistivity value of 1-800 Ωm, is believed to be an alluvium layer due to the quaternary sedimentation. The second zone is interpreted as granitic rock due to high resistivity value of >6000 Ωm. The result shows there were few faults and fissures which met with one of the characteristic where the crater should have many faults due to the great impact. Further information on subsurface geology can be achieved from nearby borehole data located at N5˚04.135' E100˚58.453' (Table 2).

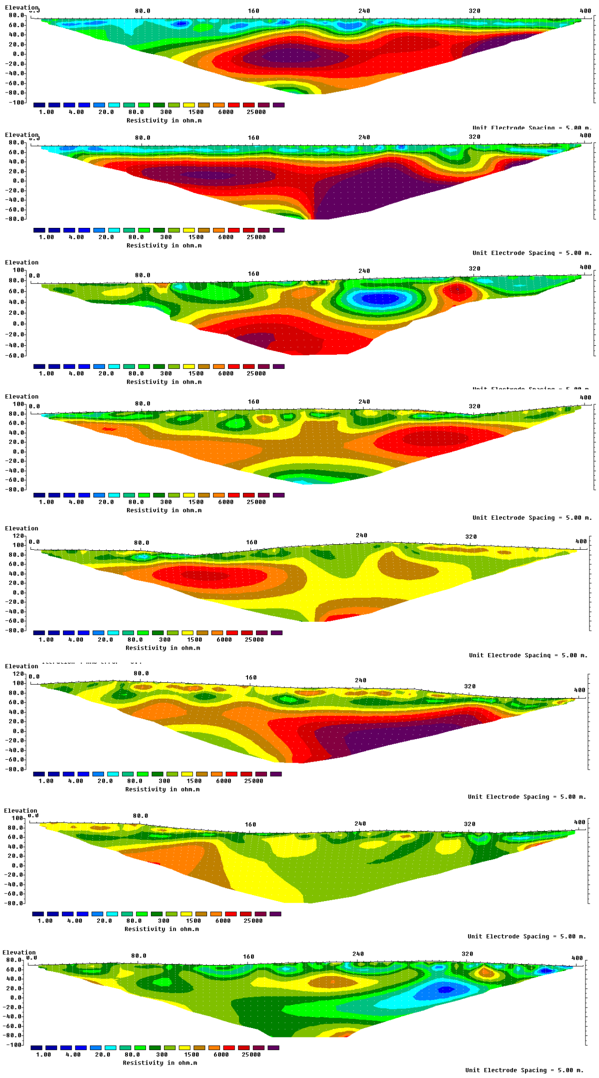

Fig. 3: Inverse model resistivity section.

Table 2: Borehole record (BH1)

Legend	Depth (m)	Lithology Description
	0.20	Suevite
	0.50	Sand and clay
	1.50	Coarse sand and silt
	3.00	Weathered granite
	4.50	Weathered granite
	6.00	Weathered granite
	7.50	Weathered granite
	9.00	Weathered granite
	10.50	Weathered granite
	12.00	Weathered granite
	12.50	Granite
	14.00	Granite
	15.00	Granite

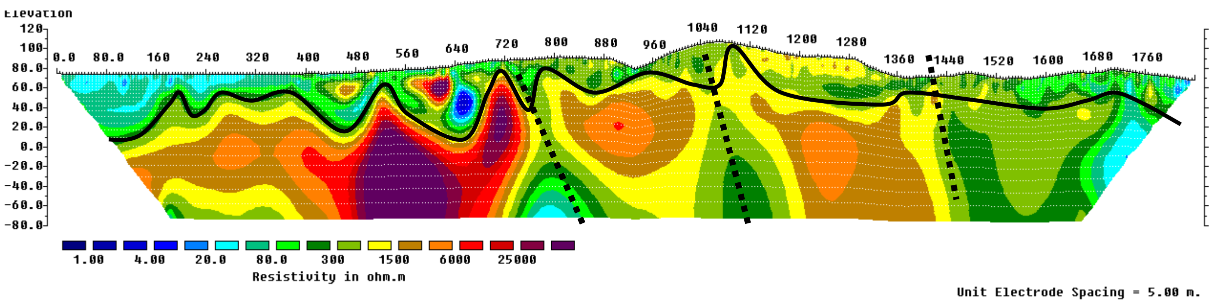

Fig. 4: A combined resistivity section.

5. Conclusion

The 2-D resistivity imaging is effective in defining the variation and dynamic of the subsurface. The interpretation clearly shows the existence of two major zones which are quaternary deposition and granite bedrock. Quaternary sedimentation such as clay and sand has a resistivity value of 1-800 Ωm and the granitic rock which has value of >6000 Ωm. Based on the results, faults and fractures were detected. In conclusion, this findings act as an indicator with some interest related to meteorite impact.

6. Acknowledgements

The authors would like to express their gratitude to Centre for Global Archaeological Research for their financial support throughout this study and thanks also to Geophysics laboratory assistants, undergraduates and postgraduate students for their help.

7. References

[1] Shoemaker, E. M., and E.C.T. Chao (1961), New Evidence for the Impact Origin of the Ries Basin, Bavaria, Germany, *J. Geophys Res. 66*(10), 3371-3378 doi:10.1029/JZ066i010p03371.

[2] Alexander, J.B. (1962). A short outline of the geology of Malaya with special reference to Mesozoic orogeny: Crust of the Pacific Basin. *Geophysical Monograph*, Vol. 6, pp 81-86.

[3] Raja, R.N. and Reddy, T.V.K. (1998). Fracture pattern and electrical resistivity studies for groundwater exploration. *Environmental Geology*, **34**, pp 175-182.

[4] Loke, M.H. (1996). The use of electrical imaging surveys for mapping subsurface pollution. *Seminar Geologi dan Sekitaran: Impak dan Pengauditan.* 6-8 December. pp 223-232

[5] Griffiths D.H. and Barker R.D., (1993). Two-dimesional resistivity imaging and modeling in areas of complex geology, *J. Geophys Res.***29**, pp 211-226

[6] Loke, M.H. and Barker R.D., (1996). Rapid least-squares inversion of apparent resistivity pseudosection using Quasi-Newton method. *Geophysical Prospecting,* **44**, pp 131-152.