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# GEOPHYSICAL SUBSURFACE STUDY AT GUA KAIN HITAM, NIAH, SARAWAK

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## INTRODUCTION

The subsurface is perhaps the most important geological layer of the earth's crust as it contains many natural resources. Additionally, through the study of rocks and unconsolidated sediment accumulations at or near the surface, soil scientist or geologist has discovered much about the earth's history and the behaviour of its dynamic landforms (Neal, 2004). For the geologist and engineering geologist, the subsurface are the underlying structures, spatial distribution of rock units, structures such as faults, folds and intrusive rocks and the depth of investigation may vary. While for the soil scientist, the subsurface are typical soil horizons and layers of classification up to bedrock (Agriculture handbook, 1999).

The shallow subsurface has become a major focus for geoscience research nowadays especially in developing countries as it is closely related to natural resources and humans. As human population increases and developing countries become more industrialised, the subsurface structures become important to study due to its geological behaviour that can pose hazards to human and sometimes help engineers in designing construction foundation and also in archaeological application especially in detecting buried objects.

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Niah is located within the Miri division, Sarawak which is well-known for its enormous caverns systems and important archaeological sites. The main cave, known as the Niah Great Cave is located on the northern edge of Gunung Subis, a limestone massive of the coastal plain of Sarawak in Northern Borneo (Wilford, 1964) which is made up of several voluminous, high-ceiling chambers (http://www.geographia.com/malaysia/niah.html).

In February 1958, an anatomically modern and young *Homo sapien* skull, radiocarbon dated around 40,000 years old, was unearthed by

Tom Harrisson, the curator of Sarawak Museum from 1947-1967, and his team at West Mouth of the Great Cave (Brothwell, 1960). As they excavated through the layers, coffins and urns appeared, along with grave goods such as pottery, textiles and ornaments, and glass and metal items that suggested a long period of settlement reaching back into the Palaeolithic era (Barker *et al.*, 2000). Anthropologist establishes that the Niahian lived in the caves from 40,000 BC right up to 1400 AD as there are large burial sites further into the mouth of the cave which had clearly been used from the Palaeolithic period right up to the modern era.

The other important archaeological site is Gua Kain Hitam or Painted Cave which contains ancient wall-paintings depicting the boat journey of the dead into the after-life. There are numerous death ships dated between 1AD and 780AD on the cave floor which are actually boat-shaped coffins containing the remains of the deceased and a selection of grave goods. Although the burial site at the Painted Cave is far more recent than those at the Great Cave, it is no less important as it offers a clear insight into the development of the traditional practices of Borneo. By using the geophysical methods, 2-D resistivity and Ground Penetrating Radar (GPR) in this study area, layers of overburden are detected which are favourable as a burial site or cultural layer. The study also indicated the possible depth of the cultural layers at the sites in study area.

## 2-D RESISTIVITY METHOD

The resistivity measurements are normally made by injecting current into the ground through two current electrodes, $C_1$ and $C_2$, and measuring the resulting voltage difference at two potential electrodes, $P_1$ and $P_2$ (Figs. 1 and 2). Electrical Imaging System is now mainly carried out with a multi-electrode resistivity meter system. Such surveys use a number of electrodes laid out in a straight line with a constant spacing. A computer-controlled system is then used to automatically select the active electrodes for each measure.

Resistivity method basically measures the resistivity distribution of the subsurface materials. Igneous and metamorphic rocks typically have higher resistivity values than sedimentary rocks. Clay has a significantly lower resistivity value than sand (Tables 1 and 2). The resistivity of soil or rock is dependent on several factors that include the amount of interconnected pore water, porosity, amount of total dissolved solids such as salts, and mineral composition such as clays (Zohdy *et al.*, 1974; Sumner, 1976; Reynolds, 1997; Rubin and Hubbard, 2006).

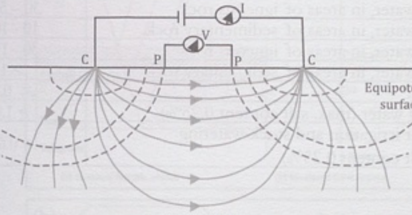


Fig. 1: Four-point electrode configuration in a two-layer model of resistivity, $P_1$ and $P_2$. I, current; V, voltage; C, current electrode; P, potential electrode (Reynolds, 1997).

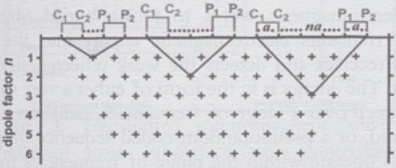


Fig. 2: Acquisition of a 2D apparent resistivity pseudosection using dipole–dipole array ($C_1$, $C_2$, $P_1$, $P_2$); C, current electrode; P, potential electrode; *a*, dipole spacing; *n*, dipole factor.

Table 1: Resistivity values of common rocks and soil materials.

| Material | Resistivity (ohm-m) |
|---|---|
| Alluvium | 10 to 800 |
| Sand | 60 to1000 |
| Clay | 1 to 100 |
| Groundwater (fresh) | 10 to 100 |
| Sandstone | $8 - 4 \times 10^3$ |
| Shale | $20 - 2 \times 10^3$ |
| Limestone | $50 – 4 \times 10^3$ |
| Granite | 5000 to 1,000,000 |

**Table 2**: Resistivity values of some types of waters.

| Type of water | Resistivity (ohm-m) |
|---|---|
| Precipitation | 30 - 1000 |
| Surface water, in areas of igneous rock | 30 – 500 |
| Surface water, in areas of sedimentary rock | 10 - 100 |
| Groundwater, in areas of igneous rock | 30 - 150 |
| Groundwater, in areas of sedimentary rock | > 1 |
| Sea water | ≈ 0.2 |
| Drinking water (max. salt content 0.25%) | > 1.8 |
| Water for irrigation and stock watering (max. salt content 0.25%) | > 0.65 |

## GROUND PENETRATING RADAR (GPR)

GPR is a non-destructive technique and it uses the high resolution electromagnetic technique that is designed primarily to investigate the earth's shallow subsurface, building materials, roads and bridges. It is commonly used for environmental, engineering, archaeological, and other shallow subsurface investigations. It uses the principle of scattering electromagnetic waves to locate buried objects (Jeffrey, 2000). GPR transmits electromagnetic energy into the material or ground, and receives and detects the weak reflected signal from the buried target. The energy is in the form of either a very short-duration impulse, a sweep over a range of frequencies, radiation of noise over a defined band, or a pseudorandom coded sequence of pulses. Most GPR systems operate within the range of frequencies from 10 MHz to 10 GHz and can have a bandwidth of several GHz. GPR system consists of four main elements which are the transmitter, receiver, control unit and display unit (Pettinelli and Barone, 2008). Fig. 3 shows an electromagnetic wave sent through transmitter antenna which had penetrated into ground, and reflected back to receiver antenna when an interface between materials of dissimilar dielectric constant is encountered (Al-Qadi and Lahouar, 2005). The propagation of electromagnetic waves depends on the dielectric and conductivity properties of the materials where electrical properties of geological materials are primarily controlled by water content.