COMPARISON OF SEDIMENTARY OUTCROP BETWEEN RESISTIVITY AND GROUND PENETRATING RADAR METHODS

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COMPARISON OF SEDIMENTARY OUTCROP BETWEEN RESISTIVITY AND GROUND PENETRATING RADAR METHODS

by

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LIST OF SYMBOLS

A	Area
c	Speed of light in free space
cm	Centimeter
d	Depth
f	Frequency
H	Magnetizing force
Hz	Hertz
I	Current
K	Permeability
km	Kilometer
L	Length
m	Meter
t	Time travel
V	Potential
ρ	True resistivity
σ	Electric conductivity
α	Radar wave attenuation
μ_r	Magnetic permeability
ε	Dielectric permeability
ε_r	Relative dielectric permeability
ε_o	Dielectric constant
Ωm	Ohm-meter
ϕ	Porosity
%	Percentage

LIST OF ABBREVIATION

a	Spacing
BC	Outcrop of Bukit Chondong
BK	Outcrop of Bukit Kukus
C	Current electrode
dB/m	Unit decibel per meter
E	Easting
EM	Electromagnetic
GJ	Outcrop of Guar Jentik
GPR	Ground Penetrating Radar
HBP	House, Building and Planning
JMG	Jabatan Mineral dan Geosains Malaysia
m/s	Unit meter per second
mS/m	Unit milli Siemens per meter
N	Northing
P	Potential electrode
RES2DINV	Resistivity 2-D Inversion software
Rx	Receiver
Tx	Transmitter
UA	Outcrop of Utan Aji
USM	Universiti Sains Malaysia
VES	Vertical Electrical Sounding
2-D	Two dimensional

PERBANDINGAN SINGKAPAN SEDIMEN ANTARA KAEDAH KEBERINTANGAN DAN RADAR TUSUKAN BUMI

ABSTRAK

Kajian mengenai singkapan kebanyakannya bergantung pada tafsiran dan pemerhatian di permukaan bumi. Penyelidikan sebelum ini telah mengaplikasi kaedah geofizik dan telah menghasilkan nilai julat standard yang digunakn secara am. Walau bagaimanapun, kekurangan nilai fizikal tertentu untuk jenis bahan boleh menyebabkan salah tafsiran data. Objektif penyelidikan ini adalah untuk mencirikan singkapan geologi dengan menggunakan kaedah keberintangan 2-D dan radar tusukan bumi (GPR) untuk menentukan parameter geofizik berkaitan dengan nilai keberitangan, ρ dan radar gelombang pengecilan, α, bersama ujian geoteknik dan analisis petrografi, dan akhir sekali untuk membandingkan nilai kekonduksian elektrik, σ menggunakan kaedah keberintangan 2-D dan radar tusukan bumi (GPR) untuk batu lumpur, batu pasir dan rijang di negeri barat laut Semenanjung Malaysia. Terdapat empat kawasan kajian dengan kemunculan singkapan, iaitu Bukit Chondong, Guar Jentik, Utan Aji dan Bukit Kukus. Dua kaedah geofizik yang berbeza telah digunakan, iaitu keberintangan 2-D dan GPR. Bagi kaedah keberintangan 2-D, susunatur konfigurasi yang digunakan adalah “Pole-dipole” manakala untuk kaedah GPR, frekuensi antena yang digunakan ialah 250 MHz. Hasil kajian menunjukkan keberintangan 2-D dan kaedah GPR telah dapat mencirikan singkapan geologi. Penyongsangan model keberintangan 2-D telah menunjukkan nilai aliran kontur yang sepadan dengan ciri-ciri geologi singkapan. Radargram daripada GPR boleh memetakan singkapan tetapi dengan beberapa batasan penembusan mendalam dan kehilangan isyarat. Sifat-sifat kebolehtelapan dan

keliangan batu telah ditentukan namun nilainya dibandingkan secara nisbah untuk sampel batu yang ada. Pemerhatian batu-batu daripada analisis petrografi hanya boleh dijelaskan separuh melalui tafsiran tekstur bijirin dan komposisi. Perbandingan parameter geofizik antara keberintangan 2-D dan kaedah GPR adalah satu kejayaan dimana nilai kekonduksian yang dikira GPR adalah hampir sama dangan nilai kekonduksian dari keberintangan 2-D bagi semua batu.

COMPARISON OF SEDIMENTARY OUTCROP BETWEEN RESISTIVITY AND GROUND PENETRATING RADAR METHODS

ABSTRACT

Studies of outcrop mostly depended on the interpretations and observations at the surface of the earth. Previous research had employed the applications of geophysical methods and had produce standard range values in general. However, lack of specific physical value for the type of materials can cause misinterpretation of data. The research objectives are to characterize the geological outcrop using 2-D resistivity and Ground Penetrating Radar (GPR) methods, to determine the geophysical parameters related to resistivity values, ρ and radar wave attenuation, α with geotechnical test and petrography analysis, and finally to compare electrical conductivity values, σ using 2-D resistivity and Ground Penetrating Radar (GPR) methods for mudstone, sandstone and chert at Northwestern state of Peninsular Malaysia. There are four study areas with the appearance of outcrops, which are Bukit Chondong, Guar Jentik, Utan Aji and Bukit Kukus. Two different geophysical methods were utilized, which are the 2-D resistivity and GPR. For 2-D resistivity method, the array configuration used is Pole-dipole while for GPR, the frequency of the antenna used is 250 MHz. The results show that 2-D resistivity and GPR methods has well characterize the geological features of outcrops. The inversion model of 2-D resistivity shows the trend of contouring resistivity value is successfully matched with the outcrops geological features. The radargram from the GPR can map the outcrop but with some limitations of depth penetration and signal loss. The properties of rock permeability and porosity were determined but the values were compared relatively for the available rock samples. The observation of the rocks from the

petrography analysis had partially explained the rock properties through the interpretation of grain texture and composition. The comparison of geophysical parameters between 2-D resistivity and GPR methods is a success as the calculated conductivity value of GPR is almost the same with the conductivity value from 2-D resistivity for all the materials.

CHAPTER 1

INTRODUCTION

1.0 Background

Outcrop or exposure is simply described as rocks that exposed at the earth's surface, which consist variety of different stratigraphy. Stratigraphy is the branch of geology concerned with the origin, composition, areal distribution and with the relationship to the geological time scale (Monroe and Wicander, 2006). Studies on outcrops have been done before by other previous researchers and has become enormous prominent that highly related with the environmental and engineering implications. The previous research established historically from the outcrops investigations are such as the understanding of the origins of geological structure, characterize the aquifer properties, role of ecological function in maintaining soil fertility, productivity and biodiversity, involvement in reservoir mapping and exploration, and review in basic properties of materials for building structure. A vital piece of information regarding with the outcrop profile can trigger appropriate action that could lead to any convenient interest towards the society or as the supportive component in certain collaborative ventures as the cross sections may indicate where an oil well should be drilled or where other resources may be present below the surface (Monroe and Wicander, 2006).

The importance of outcrops study is primarily related to two main groups of expertise, which are in the view of geology and geotechnical application. In terms of geology approach, the factor that contributing to the uncertainty of the origin of outcrop stratigraphy is the lack of understanding about particular rock properties and location of distribution. For example, geological map have been compose and distribute by previous geologists, which serve as guidance. Current tectonic activities that happen nowadays will affect the shape and structure of the subsurface details, thus some of the geological profiles might change. Frequent inspection and survey need to be conduct to provide the latest update.

In terms of geotechnical approach, recent and variety of outcrop studies can be a point to provide comparison within the type of materials that will further the understanding of the subsurface which can be link to several civil engineering works in Malaysia, such as in geotechnical engineering, rock mechanics and engineering geology, water and environmental engineering, and pavement engineering. The information gain will help to implement the preferred alternative purposes related with geological and soil resources. For example, rock engineer needs general information about the elevations and type of structures to locate the materials with which to build them. For reservoir engineers, the value of rock permeability and porosity is one of the factors and significant in characterizes the type of subsurface materials that have potential to conduct oil and gas extraction activity. The permeability and porosity of rocks related with the rock composition can be described through the arrangement of the grain texture.

Geophysics is a major discipline of earth sciences, which has to do with the physics of the earth and with the surrounding atmosphere by quantitative physical methods and numerical values (Telford et al., 1990). It uses the concept of non-destructive method which the result is interpreted by looking at the interior of the earth from the surface. Studies of the outcrops based from the geophysical methods represents the subsurface investigations that are non-invasive while develop knowledge and better understanding. The earth's internal structure can be described based on the composition and physical properties of the rock materials. Every geophysical methods measure physical phenomena due to the technique sensitivity to the subsurface physical properties.

Outcrop studies have a huge scope of interpretation view, which starts from the observation of the most obvious type and shape of the structure within the exposed profile to the smallest scale of grain texture and composition within the rock materials. The interpretation of the smallest grain of the rock materials can be obtained through the petrography analysis. The petrography analysis could also indicate as a part of outcrop studies but from the observation of microscopic view. The information obtain from the petrography analysis of the rock materials from the outcrops can be important as the knowledge could contribute mostly to the properties of reservoir rocks exploration or in a way of supportive available details obtained from the other method for outcrop research.

1.1 Problem statements

Most research on the geological outcrop has been depended on both experience of geologist's observations and interpretations, such as by Hassan (2013) had conducted studies on the geology at the area of Northwest Peninsular Malaysia which preserves an almost complete Paleozoic sedimentary succession. The geologists use traditional approach to study and characterize the outcrop which usually by hand measuring device. Boreholes records produce from drilling of the subsurface in geotechnical activities which mostly refer by the engineers help in validate the type of materials efficiently beneath the subsurface. However, the interpretations from the geologist depend on the visible geological formations from the surface only and geotechnical activities involve intrusive of the subsurface method plus with highly cost.

Previous research related with the outcrop studies have successfully established with various applications from geosciences methods, such as the resistivity values from Loke (1999) have been use as references by many researcher regarding with the resistivity values of the subsurface materials. Despite that, the information related with numerical values of the materials is general and in a very wide range.

The geophysical methods have become a reliable source of information to determine and characterize the subsurface materials. Misinterpretation of the data might happen when the result is only in the form of image of signal and no other geophysical method is applied at the same area for the comparison purpose. GPR method only produce image of amplitude signal through the radargram but not in the form of numerical values.

1.2 Research objectives

The objectives of this research are:

i. To characterize the geological outcrop using 2-D resistivity and Ground Penetrating Radar (GPR) methods.

ii. To determine the geophysical parameters related to resistivity values, ρ and radar wave attenuation, α with geotechnical test and petrography analysis.

iii. To compare electrical conductivity values, σ using 2-D resistivity and Ground Penetrating Radar (GPR) methods for mudstone, sandstone and chert at Northwestern state of Peninsular Malaysia.

1.3 Scope of study

The scope of this research is to study the sedimentary outcrop. The locations of the study area are mainly located at the Northwestern part of Peninsular Malaysia, which is in the state of Perlis and Kedah. In Perlis, the outcrops are at Bukit Chondong, Guar Jentik and Utan Aji, while in Kedah is at Bukit Kukus. The geologic age of all the outcrops at the study area is within the Paleozoic era.

Two different geophysical methods, which are 2-D resistivity and GPR methods with only one survey line was applied on top of the outcrop at each of the study area except for the outcrop at Utan Aji. The interpretation of the geophysical results is discussed based from the most obvious materials observes from the outcrops, such as the exposed at Bukit Chondong shows the interbedded of mudstone and sandstone, at Guar Jentik shows a complex structure of red mudstone and sandstone, at Utan Aji shows the bedding of red mudstone and grey mudstone and at Bukit Kukus shows a contact between chert and claystone. Only the parameter of conductivity values of each of the materials was calculated to show the correlation between the 2-D resistivity and GPR methods.

Rock samples were taken at each of the study area to study the rock properties. Most of the rock samples taken are from the type of detrital sedimentary rock. The study of the rock properties in this research are the rock permeability and porosity with the support information from the petrography analysis. The petrography analysis includes the observations of rocks through the hand specimen and thin section. The supportive details acquire from this method are the arrangement of the grain texture.

1.4 Significance of the study

The significance attain based from this study is the well characterizes of the geological outcrop with combination of two geophysical methods that give almost exact result when comparing with the outcrop features, especially from the 2-D resistivity method. The GPR method was used to determine the geological subsurface, but the depth of penetration is lower as radar wave is highly attenuate at the layer of high conductivity. This study also has established the detrital rock physical properties through the combination of geophysical methods, which are the value of resistivity and radar wave attenuation for the materials of mudstone, sandstone and chert at the region of Northwestern state of Peninsular Malaysia. The calculation of rock's permeability and porosity, and observation of grain's texture through petrography analysis was included but only for several rocks that available. Since this study is involving the characterizes of the subsurface materials from the outcrops, the results obtain not just solely through the interpretation of image but also produce numerical values that represent the subsurface materials and show the correlation between 2-D resistivity and GPR methods.

1.5 Layout of thesis

Generally, the contents of this dissertation are organized as follows;

In chapter 2, the theory of 2-D resistivity and GPR methods are described in this chapter. This includes the general theory of the 2-D resistivity, GPR methods and the general description of the rock properties. This chapter also includes the previous study relating with the correlation between the geophysical methods in the study of subsurface and the properties of rocks.

Chapter 3 discuss about the research methodology designed for this research. The early description is about the geological setting of the study area in Perlis and Kedah according to the formation and type of materials distributions. In Perlis, the outcrop is at Bukit Chondong, Guar Jentik, and Utan Aji while in Kedah, the outcrop is at Bukit Kukus. For the data acquisition, only one survey line was proposed on top of each of the outcrop from the study area except for Utan Aji together with the description of the data processing from the 2-D resistivity and GPR methods in this chapter. The equation in finding the value of rock conductivity, σ is stated in this chapter which is a part of the research objectives in showing the integration between the geophysical methods. This chapter also explains the lab procedure from the geotechnical test in obtaining the value of permeability and porosity of the rock sample and the observations of grain texture and composition for the petrography analysis from the hand specimen and thin section of the available rocks from each of the study area.

Chapter 4 presents all the results that arranged indirectly according to the flow of this research objectives. The interpretation of imaging results from the inversion of 2-D resistivity and the radargram of GPR is based from the observation of the outcrop profiles. The values obtain from the geotechnical test for the rock samples is present in table form followed by the description of the petrography analysis. The calculated conductivity values of the rock materials from GPR method is established and compare with the 2-D resistivity method to show the correlation between both of these methods.

Chapter 5 is the conclusion of the study of sedimentary outcrops using the 2-D resistivity and GPR methods with the descriptions of rocks properties. This chapter also includes some recommendations that suitable for further research in the future studies.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

The involvement of geophysics in civil engineering with reference of geology has become a promising approach due to the non-destructive mode of stratigraphy determination, cost effective and direct result. Geology and geotechnical share many common interests and concerns where both involve in investigations of ground profile, although from different perspectives. Since the study is involving with the geological of outcrops, other details of information related can be obtained which are the rock properties based from the rock composition and grain texture, besides the interpretation of only the obvious structure. The study of rock properties in details can extract variety of information as the relations in the sedimentary rocks are extremely useful that indirectly described the geological features of the outcrop where the variations in the elastic properties of rocks have been developed for determining structures associated with oil and gas, such as faults, anticlines, and synclines several kilometers below the surface (Telford et al., 1990). Sedimentary rock is any rock made up of consolidated sediment, where the term sediment refers to all solid particles of preexisting rocks yielded by weathering, mineral derivation from solution and organisms (Monroe and Wicander, 2006). This chapter will explain about the theory of the geophysics methods and the types of the analysis of the rock properties for the application in the studies of sedimentary outcrops.

2.1 Theory of 2-D resistivity

2-D resistivity method is the common electrical methods use in the exploration geophysics field. For this study, 2-D resistivity method was utilized for the data acquisition. In this sub-section will describe about the theory of 2-D resistivity method and the principles used in this study.

According to Ohm's Law, V=IR in an electrical circuit, where V and I are the potential differences across a resistor and the current passing through it respectively. Equation 2.1 shows the resistance, R is proportional to length, L divided by an area, A, and the constant proportionality can be written as in Equation 2.2 and ρ is the true resistivity (Reynolds, 1997).

$$R \alpha\ L/A \qquad (2.1)$$

$$R =\ \rho L/A \qquad (2.2)$$

2-D resistivity method generally injecting electric currents into the ground and the potential differences are produce and measured at the surface (Kearey et al., 2002). The resistivity method is more accurate model of the subsurface used in the study of horizontal and vertical anomalies along the survey line to determine the subsurface resistivity distribution. At the present time, this method is the most practical in economic compromise between obtaining very accurate results and lower the survey costs (Loke, 1999). 2-D resistivity method is often used for engineering and hydrogeological purpose and recently, it has been used for environmental surveys by making measurement on the shallow subsurface geology. The resistivity method works by utilize direct currents or low frequency alternating currents to probe the electrical properties of the subsurface. The SI unit of resistivity is the ohm-meter (ohm-m, Ωm) and the reciprocal of resistivity is conductivity with unit in Siemens per meter (S/m, σ), which are equivalent to per ohm per meter (Ω^{-1} m^{-1}) (Reynolds, 1997; Kearey et al., 2002). Current distribution in the ground flows away radially which is generally display in Figure 2.1 where the current is injected into the ground using two current electrodes of C1 and C2. The current flow effects are graphically illustrated by contours of the signal contributions that are made by each unit volume of ground to the measured potential difference and to the apparent resistivity value (Milsom, 2003).

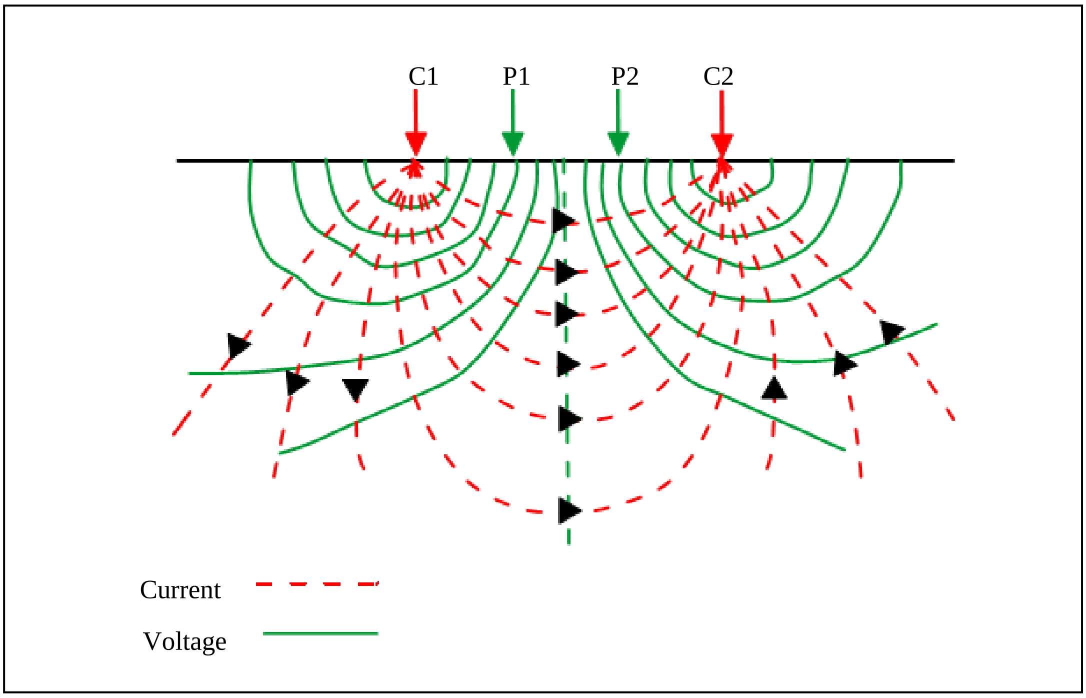

Figure 2.1: The flow of current when injected into the ground (Reynolds, 1997).

For the field survey, the techniques and equipments to carry out the 2-D resistivity method are fairly well developed. The 2-D resistivity method usually deploys a large number of electrodes that connected to a multi-core cable (Griffiths and Barker, 1993). The current will be injected into the ground through the two current electrodes of C1 and C2, and the resulting of potential difference will be measured through two electrodes of P1 and P2. The resistivity meter system work when the internal microprocessor controlled circuitry and electronic switching unit automatically select the relevant four electrodes for each measurement. The spacing between the electrodes is “a” and as the electrode spacing increases, the number of measurements decreases. The typical setup for a 2-D resistivity method is shown in Figure 2.2 with a number of electrodes along a straight line connected to a multi-core cable (Loke, 1999).

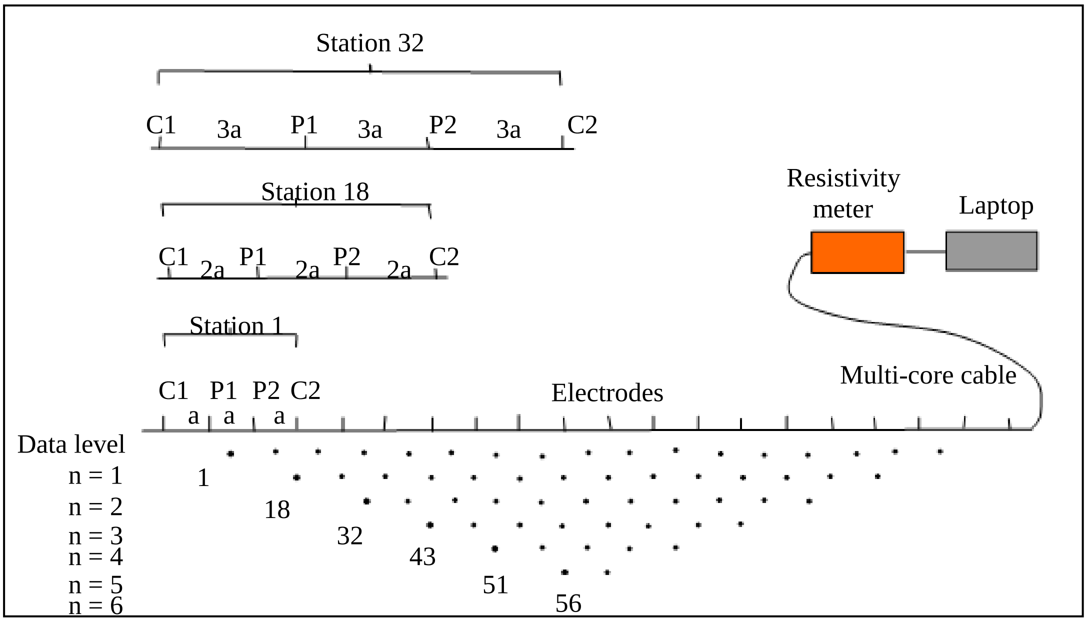

Figure 2.2: The setup of 2-D resistivity method and the sequence of measurement to produce a pseudosection (Loke, 1999).

To obtain a good model for interpretation, the data must be in good quality which is clear from noise. The noise will affect the apparent resistivity almost through the entire voltage measurement. Two categories of noise happen to give bad datum points, which are the systematic and random noise. Systematic noise usually caused during the survey and random noise caused by natural voltages includes effects such as the telluric current. To improve the signal is by increase the signal strength and avoid large separations or long cables (Loke, 1999 and Milsom, 2003).

The shape of the contours in the inversion results for over the same structure can be different if using the different type of arrays and the choice of the best arrays for a field survey depends on the type of structure of the survey area, the sensitivity of the resistivity meter and the background noise level (Loke, 1999). The characteristics that should be considered for the choice of array is include the depth of investigation, the sensitivity of the array to the horizontal and vertical changes in the subsurface resistivity, the horizontal data coverage and the signal strength.

The Pole-dipole array is a three point array where one of the current electrodes is fixed at a great distance from the other three and can have various spacing (Telford et al., 1990). The Pole-dipole array has good horizontal coverage with higher signal strength. The Pole-dipole array is an asymmetrical array which means that for over the symmetrical structures, the apparent resistivity anomalies in the pseudosection are asymmetrical and the sensitivity of the Pole-dipole array is more towards the vertical structures (Loke, 1999).

The current flows in the earth materials at shallow depth through electronic conduction and electrolytic conduction. Electronic conduction shows the current flow via free electrons, while electrolytic conduction shows the current flow via the movement of ions in groundwater. The electrolytic conduction is probably more common mechanism in environmental and engineering surveys as it is related with the present of conductive minerals (Loke, 1999).

The resistivity of sedimentary rocks normally has lower values range from 10 to 10000 Ωm. For unconsolidated sediments, the resistivity values normally lower than sedimentary rocks that ranging from about 10 to less than 1000 Ωm. The resistivity value is dependent on a number of factors such as the porosity of the rocks, degree of water saturation and the salinity of the contained water. The reference for this study regarding the values of resistivity for common rocks is shown in Figure 2.3 (Loke, 1999).

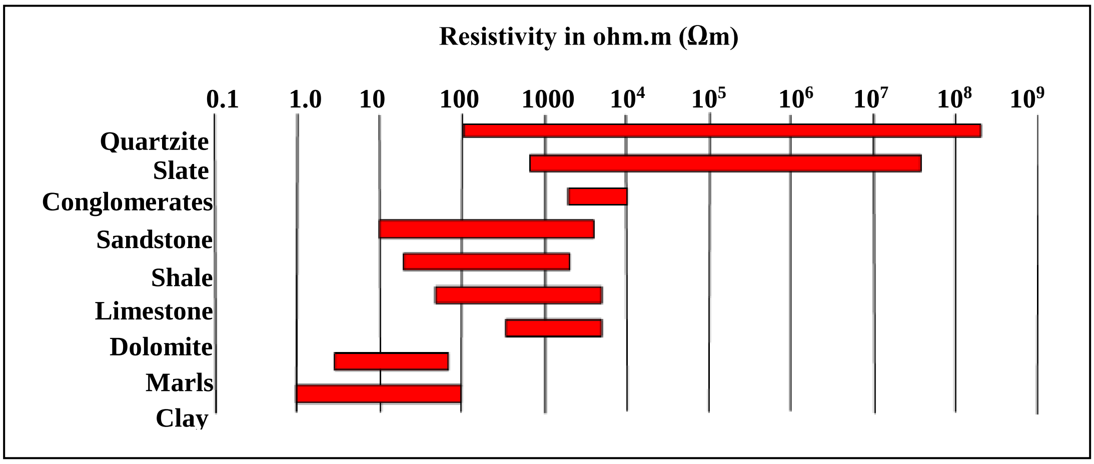

Figure 2.3: The resistivity values of common rocks (edited from Loke, 1999).

2.2 Theory of Ground Penetrating Radar (GPR)

The ground penetrating radar (GPR) works by use the response of the ground to the propagation of incident alternating electromagnetic (EM) waves into the subsurface, which are composed of an electric intensity (E) and magnetizing force (H) (Kearey et al., 2002). The EM method mainly involves the propagation and attenuation of electromagnetic waves (Telford et al., 1990).

Generally, a transmitter coil is used to generate the primary electromagnetic field to the receiver coil that propagates above and below ground. The general principle of the electromagnetic surveying is shown in Figure 2.4. There is no difference between the fields propagated above the surface and through the ground if the subsurface is homogenous, however if there is any presence of conducting medium within the ground, the magnetic component of the electromagnetic field that penetrating the ground will induces alternating currents (eddy currents) to flow in the conductor. The eddy currents then generate their own secondary electromagnetic field which detected by a receiver. The receiver also detects the primary field that travels through the air, thus the response of the receiver resultant of the combined both primary and secondary fields differ in both phase and amplitude from the response to the primary field alone. The differences between the transmitted and received electromagnetic fields show the presence of the conductor and can provide the information regarding the geometry and the electrical properties (Kearey et al., 2002; Reynolds, 1997).

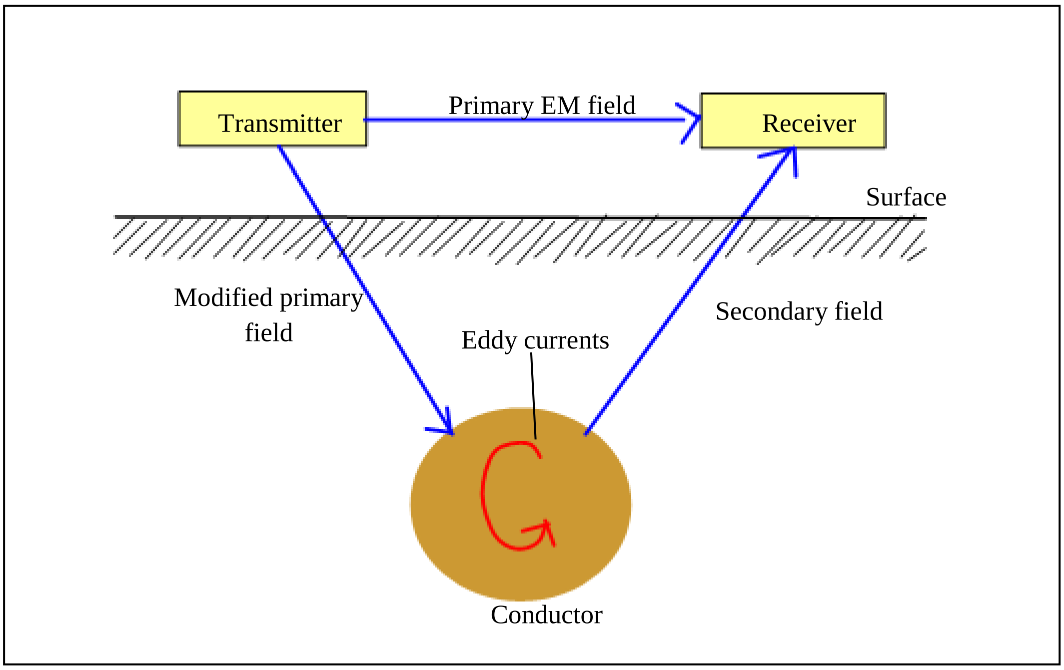

Figure 2.4: General principle of electromagnetic surveying (edited from Kearey et al., 2002).

The applications of GPR method have become much more heavily used, mostly in engineering and environmental geophysics purposes (Reynolds, 1997). According to Davis and Annan (1989), the function of GPR is defined as the uses of electromagnetic fields to study or examine the dielectric materials by reflection and transmission of wave to detect structures and changes of the material properties within the materials. Those materials usually involve the natural geologic materials such as depth of a glacier, groundwater investigation, landfill leachate migration and other environmental studies. Recently, the applications of this method have widespread for man-made composites such as concrete, asphalt and other construction materials (Annan, 2003).

The frequency and electrical conductivity of the medium are the factors that determine the depth of penetration of electromagnetic field propagation. The amplitude signal will decrease exponentially with depth and tends to make the electromagnetic fields attenuated during the passage through the ground. In other words, the depth of penetration will increase when both the frequency of the electromagnetic field and the conductivity of the ground decrease (Kearey et al., 2002). However, the relations need to be vice versa in order to obtain high resolution. The water content influence the measurement of the depth range of ground penetrating radar survey which depends on the composition of the material, sediment mineralogy and clay content in that material (Rehman and Abouelnaga, 2016).

The main separate section of GPR consists of an antenna that transmits and receives signals, a control unit to process signal and graphic screen to display data (Annan, 1992). Figure 2.5 shows the basic constituents of GPR system. The mechanical component of GPR works when the antenna transmits electromagnetic waves energy into the ground. The transmitter (Tx) will generate a pulse of radiowaves at a frequency which control by the type of antennae used. The receiver (Rx) is set to scan and the received signals are displayed as a function of two-way travel time on a screen in the form of radargram (Reynolds, 1997).

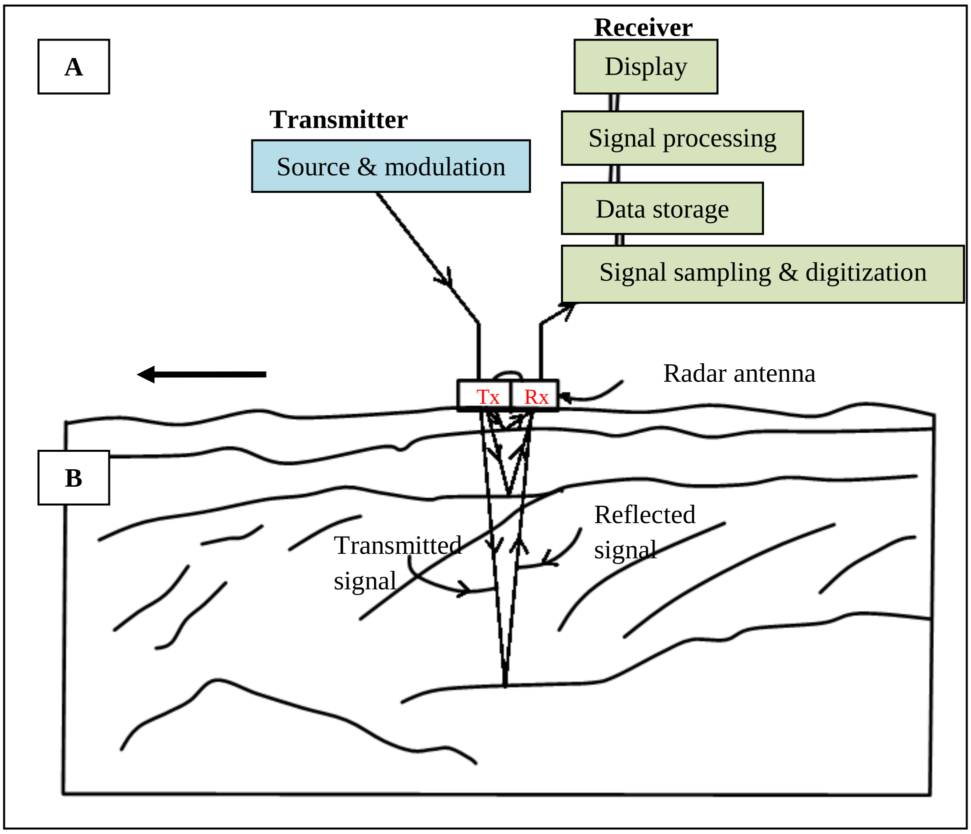

Figure 2.5: A) Components of radar system and B) Interpreted section (Reynolds, 1997).

Some of the energy is scattered and absorbed into the Earth material and some of the wave are reflected back to the antenna when the radiated energy hit an interface. The reflection and scattering of wave energy are caused by the difference in the electromagnetic properties of the materials related to the composition and water content of the medium that control the speed of radiowaves propagation also the attenuation of the electromagnetic waves (Reynolds, 1997). The parameters involve in this method are the travel time and amplitudes of reflected electromagnetic energy. The calculation of these parameters is dependent on the electrical and electromagnetic properties which are the dielectric constant, conductivity of the material and magnetic permeability of the medium (Rehman and Abouelnaga, 2016). The speed of radiowaves in any medium depends on the speed of light in free space (c = $3x10^8$ m/s), relative dielectric permeability (ε_r) and magnetic permeability (μ_r) but usually negligible (Reynolds, 1997).

There are many connections exist between the relations of parameters in this radar method. The apparent dielectric coefficient depends on the water content of the materials, where the water content depends on the texture of the material. As the GPR works by penetrate of radar wave through the subsurface depth (d) and reflected signal received as two way travel time (t), the velocity (V) can be measure that generally expressed as in Equation 2.3.

$$V = \frac{2d}{t} \tag{2.3}$$

The general term of attenuation is referring to any reduction in the strength of a signal, which sometimes called loss. Attenuation is actually a natural consequence of signal transmission occur each time the radiowaves pass through a boundary. A fundamental root of energy loss involves a complex function of dielectric and electrical properties through the radar travelling. The attenuation (α) is dependent on the electric conductivity (σ), magnetic permeability (μ) and dielectric properties (ε) of the material through the signal penetrate correlate with the frequency of the signal ($\omega = 2\pi f$). All these properties depend on the composition of the material and the electrical behavior on each constituent and generally exhibit some loss which is primarily contributed to electrical conductivity. Equation 2.4 shows that the attenuation is directly proportional to frequency as the higher the frequency, the higher the value of attenuation (Reynolds, 1997).

$$\alpha = \omega \left\{ \left(\frac{\mu\varepsilon}{2} \right) \left[\left(1 + \frac{\sigma^2}{\omega^2 \varepsilon^2} \right)^{1/2} - 1 \right] \right\}^{1/2} \quad (2.4)$$

Another equation of attenuation that related to conductivity is display in Equation 2.5 that usually quoted in decibels per meter (dB/m) and in the frequency range 100 to 1000 MHz (Davis and Annan, 1989).

$$\alpha = 1.69 * \frac{\sigma}{\sqrt{\varepsilon_r}} \quad (2.5)$$

Permittivity also known as dielectric constant was defined in terms of the ratio of the capacities or otherwise identical parallel-plate capacitors with vacuum or the type of material that fill the space between the plates (Milsom, 2003). The permittivity of free space, ε_o is equal to 8.85 x 10^{-12} F/m, the relative permittivity, ε_r can be calculated using Equation 2.6 and the permittivity, ε of the materials can be calculate using the Equation 2.7 (Leucci, 2008).

$$\varepsilon_r = \left(\frac{c}{v} \right)^2 \quad (2.6)$$

$$\varepsilon = \varepsilon_r \varepsilon_o \quad (2.7)$$

The more fine-grained of the materials means the higher water content, thus the higher value of attenuation due to higher apparent dielectric coefficient (Sutinen, 1992; Hänninen, 1997). Most materials made with complex mixture of components tend to have different electrical and dielectric properties. For geological materials, the grain size and even grain shape can affect the behavior of bulk electrical and dielectric. Most rocks contain a degree of moisture within pore spaces where the amount of water contain within the rock will affect the speed of propagation of the radiowaves (Reynolds, 1997).

2.3 Geological description of sedimentary outcrop

The huge scopes of outcrop studies have widespread recently due to several interests from the nature findings, which generally about the history of the area in the past, the occurrence of variety of natural resources such as the groundwater, petroleum and other entrenchment, and also include the numerous projects in geotechnical prospects. For sedimentary outcrop description, such details should be explore and acquired in order to gain the geological understanding, which comprise of the sedimentary structure and texture, the environment of deposition and the rock facies.

There are two types of sedimentary rocks, which are detrital and chemical sedimentary rocks (Monroe and Wicander, 2006). Most sedimentary rocks are formed and dependant from several stages which is the process of weathering and erosion, transportation, deposition and diagenesis (Nelson, 2013). Sedimentary rock refers to any rock that is made up of consolidated sediment (Monroe and Wicander, 2006). The textural interpretation of sedimentary rocks refers to the size, shape, sorting and arrangement of grains in a sedimentary rock. For most clastic sedimentary rocks, there are three textural components that have been classified which are clasts that refer to the larger grains in the rock, matrix means the fine grained material surrounding clasts and cement is the glue that holds the rocks