SCHOOL OF MATERIALS AND MINERAL RESOURCES ENGINEERING

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GROUNDWATER EXPLORATION BY USING ELECTRICAL RESISTIVITY SURVEY

By

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DECLARATION

I hereby declare that I have conducted, completed the research work and written the dissertation entitled **"Groundwater Exploration By Using Electrical Resistivity Survey".** I also declare that it has not been previously submitted for the award of any degree or diploma or other similar title of this for any other examining body or university.

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Date :

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ABBREVIATIONS

WA- Wenner Alpha

WS- Wenner Schlumberger

DD- Dipole- Dipole

PENENTUAN AIR BAWAH TANAH MENGGUNAKAN KAEDAH KAJIAN KEBERINTANGAN ELEKTRIK

ABSTRAK

Dalam projek ini, kaedah geofizik keberintangan elektrik digunakan untuk penentuan kewujudan air bawah tanah di Kilang Semen Lafarge, Langkawi, Kedah. Secara amnya, faktor geologi Langkawi terutamanya terdiri daripada batu kapur dan lapisan tanah tidak mampat. Projek ini dijalankan untuk menentukan kehadiran air bawah tanah supaya langkah pencegahan dapat diambil untuk mencegah bencana seperti lubang benam. Walau bagaimanapun, jika air bawah tanah diekstraksi secara berlebihan, ia akan menurunkan paras air dan menyebabkan lubang benam berlaku. Tiga susunan elektrod yang merupakan susunan Wenner Alpha, susunan Wenner Schlumberger dan susunan dipole-dipole telah digunakan. Semua kaedah mempunyai kelebihan dan kekurangannya. Terdapat enam garis yang terletak di titik kritikal kuari. Garisan 1 dan Garisan 2 mempunyai nilai keberintangan terendah pada sekitar 0.5Ω hingga 50Ω. Garisan 3 dan Garisan 4 memberikan nilai keberintangan yang agak tinggi pada sekitar 200Ω hingga 500Ω. Walaupun Garisan 5 memberikan nilai keberintangan tertinggi sekitar 5000Ω hingga 15000Ω. Garisan 6 yang terletak lebih jauh dari 5 garisan lain memberikan nilai sederhana pada hanya sekitar 500Ω hingga 1000Ω. Ini menyimpulkan bahawa kawasan yang mempunyai nilai kerintangan rendah adalah kawasan yang dilitupi atau tepu air tanah manakala kawasan keberintangan tinggi adalah kawasan yang terdiri daripada batu. Hasil dapatan kajian mendapati air bawah tanah dikesan pada kedalaman 10 meter dan kebawah. Terdapat masalah tertentu semasa projek dijalankan seperti kabel terputus dan kaedah keberintangan tidak dapat menunjukkan

sempadan yang jelas antara kawasan bertanah dan berbatu. Untuk cadangan, projek ini boleh dikaji dengan lebih lanjut dengan menggunakan seismik dan lubang bor untuk mendapatkan hasil yang lebih baik dan lebih tepat.

GROUNDWATER EXPLORATION BY USING ELECTRICAL RESISTIVITY SURVEY

ABSTRACT

In this project, geophysical method of electrical resistivity survey is used for subsurface groundwater mapping in Lafarge Cement Plant, Langkawi, Kedah. Generally, the geology of Langkawi is mainly overlying by limestone and unconsolidated soil. This project is conducted to determine the presence of the groundwater so that prevention step can be taken to prevent disasters such as sinkholes. Water is essentially important in human life. Groundwater is one of main water supply for drinking and industry. However, should the groundwater are excessively extracted, it will lower the water table and could cause sinkhole formation. Three different electrode array which are Wenner Alpha array, Wenner Schlumberger array and dipole-dipole array were used. All of the method have their advantages and disadvantages. Six survey line of interest which located at critical point of the quarry were established. Line 1 and Line 2 has the lowest resistivity values at just around 0.5Ω to 50Ω. Line 3 and Line 4 gives moderately high resistivity values at around 200Ω to 500Ω. While Line 5 exert the highest resistivity values which around 5000Ω to 15000Ω. Line 6 which located further from the other 5 lines exert moderate values within 500Ω to 1000Ω. This conclude that the area which convey low resistivity value are the zone that covered or has large quantity of water in the soil while the high resistivity area are the area underlain by limestones/ soil rocks. For this survey project, groundwater has been detected at depth below 10 meter level. There are specific drawback occur during the

project such as damaged cables and the method cannot show the clear image of boundaries of soil and rock zones. For recommendation, this project can be further enhanced by incorporating seismic refraction and borehole to get a better and more accurate result.

CHAPTER 1

INTRODUCTION

1.1 Research Background

There are several methods being used to determine the physical properties of sub-surface geology and condition from surface measurements. Most common method used are geophysical method. Distinct variable are measured by each geophysical technique depending on the physical properties. For examples, magnetic survey is carried out based on the magnetic susceptibility of the target, gravity survey measures the magnitude of gravitational field or density, and seismic survey relies on the properties of P-wave and S-wave velocity. Applications of geophysical methods include hydrocarbon exploration, mineral exploration, engineering site investigation, hydrogeological investigation, detection of cavities and mapping of leachate and contaminant plumes. The variation of physical properties influences the implementation of geophysical methods for a particular situation.

These techniques are non-destructive and do not cause disturbance of sub-surface materials. Other than that, they are rapid and cost-effective in covering a large study area. Two dimensional (2-D) methods measure geophysical properties along a surface survey line which will produce cross-section through subsurface. 3-D techniques determine those properties over an area. In this project, electrical methods which include 2-D self-potential

survey and earth resistivity survey are chosen for the purpose of groundwater survey. The study area is at Lafarge Langkawi, Kedah.

1.2 Problem Statement

The existence of underground water in aquifer can be useful as a resource for drinking, industrial use and agriculture especially for usage in quarries and mines operations. All they need to do is just pump out the water from the underground. However, the occurrence of groundwater could also lead to major problem such as sinkholes due to the formation of cavities. In order to minimize the failure, physical properties of the subsurface materials are fundamental because they are one of the aspects that can be used to determine the presence of underground water. Geophysical methods are applied to investigate subsurface geology and presence of highly water saturated zone, aquifer and formation of sinkholes.

The chosen method is electrical resistivity survey. Electrical resistivity technique is used to explore groundwater condition and to locate sub-surface cavities. Resistivity imaging can determine the structure of subsurface materials. electrical resistivity techniques are complementary for slope stability study.

1.3 Objectives

The objectives of this project are listed below:

1. To investigate the subsurface geology at quarry site
2. To explore the presence of likely groundwater and cavity/sinkholes using electrical resistivity survey

1.4 Geophysical Surveys Over Groundwater Determination Study

Electrical resistivity imaging surveys have been conducted in order to locate, delineate subsurface groundwater resource, quantity and likely presence of cavity/sinkholes features. The resistivity imaging surveys carried out basically measures and maps the resistivity of subsurface materials. Electrical imaging is an appropriate survey technique for areas with complex geology where the use of resistivity sounding and other techniques are unsuitable to provide detailed subsurface information. The purpose of electrical surveys is to determine the subsurface resistivity distribution by making measurements on the ground surface.

The increased interest in recent years in underground sources of water has led to a need for more intensive studies of the geometry and properties of aquifers. Geophysics has played a useful part in such investigations for many years and improvements in

instruments and the development of better methods is resulting in a widening of its applications. In groundwater exploration in hard rock media, it is very important to delineate structures such as geological contacts, faults and joints. Exploration of groundwater in hard rock terrain is a very challenging and difficult task when the promising groundwater zones are associated with fractured and fissured media. In this environment, the groundwater potentiality depends mainly on the thickness of the weathered/fractured layer overlying the basement.

The main use of geophysics in the geosciences is for hydrocarbon exploration typically at depths greater than 1000m. Significant technological advances have been made in this industry over the last thirty years especially with seismic reflection techniques. In contrast, near-surface geophysics for groundwater investigations is usually restricted to depths less than 250m below the surface and developments have not concentrated on one specific geophysical technique. Groundwater applications of near-surface geophysics include mapping the depth and thickness of aquifers, mapping aquitards or confining units, locating preferential fluid migration paths such as fractures and fault zones and mapping contamination to the groundwater such as that from saltwater intrusion.

Among the geophysical methods commonly employed in subsurface investigations is electrical resistivity method which has particular advantage in hydrogeology as it responds to variations in conductivity of the groundwater bearing formations. Electrical resistivity method has gained considerable importance in the field of groundwater

exploration because of its low cost, easy operation and efficacy to detect the water bearing formations. Resistivity of geological formations vary significantly between their dry and saturated states. Resistivity values of rocks are controlled by chemical composition of the minerals, density, porosity, water content, water quality and temperature.

1.4.1 Resistivity Surveys

Electrical resistivity survey is a geophysical method for imaging internal structure from resistivity (inverse of conductivity) measurement. This survey determines apparent resistance of ground to direct current flow. A display of tomographic inversion or resistivity imaging is one of the geophysical techniques employed to map subsurface structure which then can be used to investigate the occurrence of groundwater.

The measurements are made by penetrating steel electrodes in soil to allow direct current to pass through. The current and potential electrodes are moved along a profile with the spacing according to electrode arrays. Common electrode arrays are Wenner Alpha, Wenner Schlumberger and dipole-dipole. Each has its own advantages and disadvantages and some can be complementary with each other. Electrode configurations used for this resistivity survey are Wenner Alpha, Wenner Schlumberger and dipole-dipole.

1.5 Surface Location and Geology

Geophysical survey is carried out at Lafarge Cement Plant which is located at Langkawi, Kedah. Langkawi is an island which is situated in the northern region of peninsular Malaysia. Generally, the geological structure of this island is consist of complex composition of limestone. The Palaeozoic sedimentary rocks in Langkawi had been placed under four formations. They are, from the oldest to the youngest, the Machinchang, Setul, Singa, and Chuping formations (Jones, 1966). Their geological distribution and stratigraphic relationship are given in Figure 1.1. They are mostly comprise shallow marine shelf type deposits forming part of a belt that extends from south China down through Burma, Thailand, Northwest Peninsular Malaysia and north Sumatra. The rocks beneath the ground are impacted by weathering because of the hot and humid tropical climate in the Malay Peninsula where almost everywhere the granite mass is covered by soil and alluvium. According to geological map of Peninsular Malaysia (Appendix A), area of Langkawi comprised unconsolidated deposit of limestone and clay.

The study survey area is located within the crushing plant of the quarry. It is a wide area covered by tiny forest and ponds. This project is conducted for 5 days starting from 21st November 2017 until 25th November 2017. During this period of study, the weather at Lafarge Langkawi is bright and with only small amount of rainfall. Figure 1.2, Figure 1.3 and Figure 1.4 shows the location of geophysical survey located within the area of crushing plant, conveyer belt, and forest.

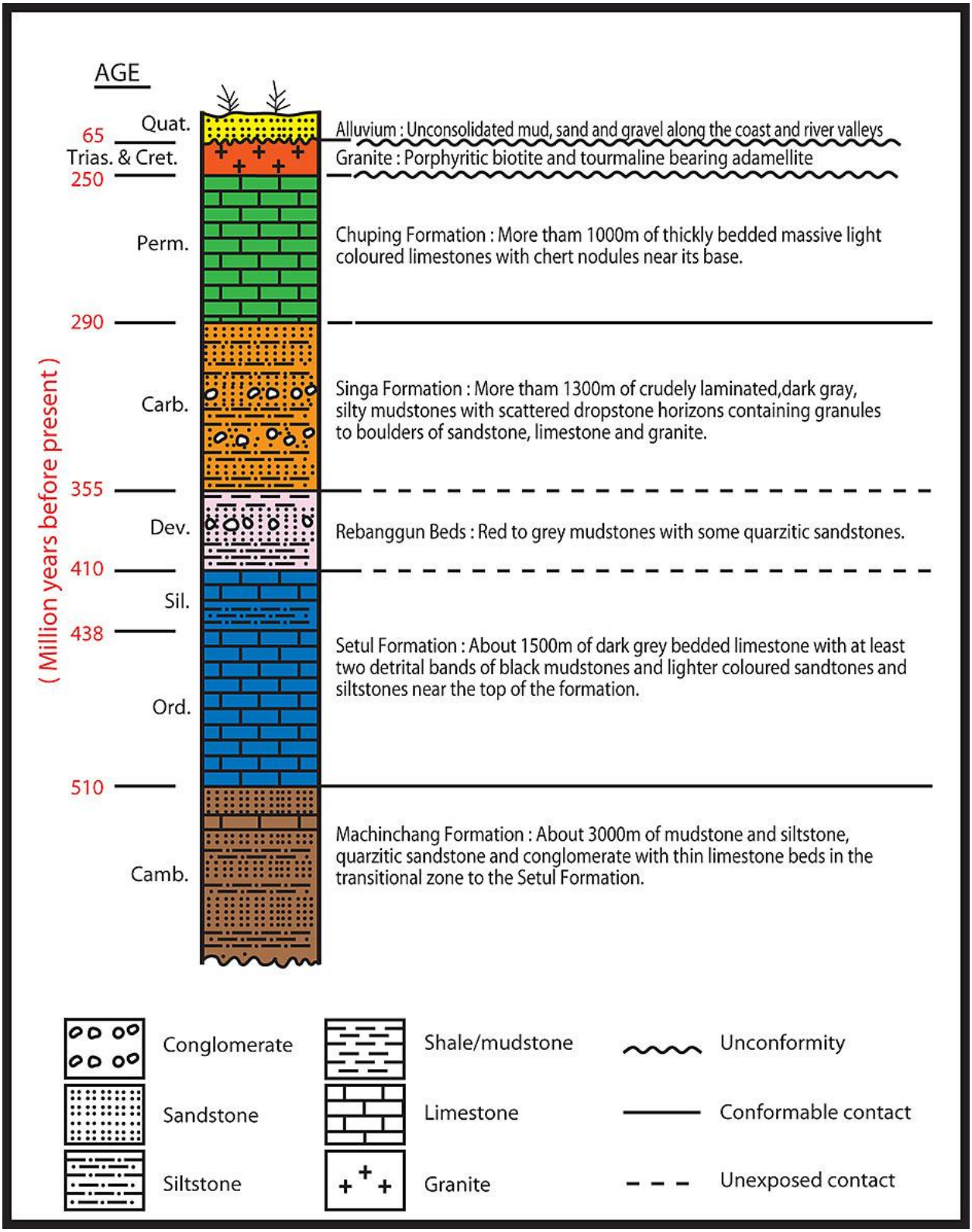

Figure 1.1 General Stratigraphy of Langkawi Islands (Geological Society of Malaysia)

Figure 1.2 Crushing Plant

Figure 1.3 Conveyer Belt Section

Figure 1.4 Resistivity Survey line within forest zone

Figure 1.5 Resistivity Survey lines field layout(line 1-6)

1.6 Scope of Work

After the approval of research proposal, the project was being held for about 1 weeks, starting from 21st November 2017 until 25th November 2017. The work outline and tasks had been carried out to achieve the above objectives. Firstly, basic knowledge is vital before proceeding to research work and it can be obtained from literature readings. Literature review is the assessment of available scholarly paper of the chosen research subject. It discusses and analyses the information gathered from published resources of that particular topic in a summary. This helps me to understand the concepts and theory related to my research of geophysical methods over groundwater determination study. Literature review serves as support and foundation of substantive findings as well as gives an overview to make this research possible.

To investigate groundwater, a survey must be conduct first. The hints or signs of occurrence of groundwater must be studied and take into account. Hence, a discussion must be made with the supervisor or manager of the plant before we proceed with the study. Ayer Hangat is a district in Langkawi which is located near to the ocean. This strengthen the theory that natural groundwater must be existed in that area. This site consists of forest mostly and also scattering housing areas. Since the slope condition is dangerous like some parts are too steep and covered with thick bushes, only a small specified area can be taken as study site. Then, information of that selected study site such as area, map and geology are gathered.

After getting adequate site information, investigation of the study area was carried out using proposed research methodology. For groundwater determination investigation, the methods used are geophysical techniques which is electrical resistivity survey. Data acquisition is performed during this stage considering all parameters setting that will affect the end results and interpretation. Electrical resistivity measures the resistivity along survey lines which is influenced by electrode array configuration.

The application of software such as Res2DINV is used to process the data display 2D/3D and interpreted. The results obtained are analysed and presented in a way that ensure the objectives of this research are satisfied. After all tasks are done, research conclusion has to be stated clearly by restating the argument and summarizing the results of investigations and conclusions. Recommendations are suggested to improve the study in future.

CHAPTER 2

LITERATURE REVIEW

2.1 Groundwater

In many developed and developing countries there is not only a heavy reliance on ground water as a primary drinking supply but also as a supply of water for both agriculture and industrial use. The reliance on groundwater is such that it is necessary to ensure that there are significant quantities of water and that the water is of a high quality.

2.5 litres of water needed by most humans everyday which justify the average amount of water used domestically each day by every person is around 190litres. One third of the public water supply are required by the industries, with the remainder being used in the home. Thus the total per capital day use is around 300litres per day. (Lateef, 2012)

Increased anthropogenic activities in combination with climate change affects the coastal groundwater throughout the world. Coastal groundwater system already threatened by high seawater level. (Esther et al, 2010)

Groundwater is considered as a preferable alternative solution to face the lack of freshwater problem. (Abdel Moneim, 2005)

Groundwater utilizations of close surface geophysics incorporate mapping the profundity and thickness of aquifers, mapping aquitards or keeping units, finding particular liquid relocation ways, for example, breaks and blame zones and mapping sullying to the groundwater, for example, that from saltwater interruption. The hypothetical and viable foundation to geophysics has been widely investigated and can be contemplated in standard content regarding the matter, for instance: (Kearey and Brooks, 1991; Telford et al, 1976; Parasnis, 1996; Dobrin, 1976; Grant and West, 1965).

Groundwater and near surface investigations in particular have been specifically covered in some detailed in recent text by (Reynolds, 1997; Milsom, 1996).

Groundwater exploration has produced general method of practices for geophysical techniques (Van Dongen et al, 1994)

Groundwater found almost wherever underneath the earth surface. It is water that fills the pore spaces between grains in shake or soil or fills cracks in the stone. The water table is the surface that isolates the soaked zone underneath, wherein all pore space is loaded with water from the unsaturated zone above. Changes in the level of the water table happen due changes in precipitation. The water table tends to ascend amid wet seasons when more water saturates the framework, and declines amid dry seasons when less water penetrates. Such changes in the level of the water table can have consequences for the variables examined above (Stephen, 2013).

The groundwater is altogether shielded from surface toxins as the earth media (made out of various subsurface layer) go about as a characteristic channel to invaded water. It once in a while less expensive to be created. Curiously, the volume of groundwater is impressive. Groundwater volume is 2000 times that of the volume of water at any given time in every one of world's streams (Olorunfemi et al,1999). Groundwater improvement in this way constitutes a practical alternative or supplement to the costly earth/solid dam arrangement of surface water supply, where potential groundwater is great.

The accessibility of potential assets has dependably been the essential worry of social orders in semi parched and dry locales, even in zones of more plenteous precipitation, the issue of getting satisfactory supply of value water is for the most part winding up more intense because of consistently expanding populace and industrialization. Subsequently, surface water can't be tried and true consistently, consequently, the need to search for different other options to supplement surface water. This influences the world to rely upon the biggest accessible wellspring of value new water which lies underground and this is alluded to as Groundwater. It is the water held in the subsurface inside the zone of immersion under hydrostatic weight beneath water table (Ariyo and Banjo., 2008).

Groundwater can be found in sedimentary territory where it is less hard to abuse with the exception of its synthetic arrangement. It can likewise be in the Basement Complex territory where it can be somewhat hard to find particularly in regions underlain by crystalline unfractured or unweathered rocks. The examination for groundwater today

has turned out to be fundamental, because of its relative minimal effort and its shot of getting quality water from the bedrock.

Consequently, the utilization of geophysics survey to the fruitful investigation of groundwater in sedimentary landscape requires an appropriate comprehension of its hydro-topographical trademark. Confirmation has demonstrated that geophysical techniques are the most solid and the most precise methods for all looking over strategy for subsurface auxiliary examinations and shake variety (Carruthers, 1985; Emenike, 2001).

Ajayi and Adegoke-Anthony (1987) researched groundwater prospect in the Basement Complex rocks of southwestern Nigeria. They inferred that nearby geographical condition assume a critical part in the yield of boreholes situated in the cellar complex region of southwestern Nigeria.

In the event that a groundwater is to be misused, it is basic that the whole undertaking be directed in most productive and financially savvy way imaginable. Racing into groundwater advancement program will likely outcome in the off base area of focuses, wasteful plan of the deliberation works. The achievability of utilizing the geo-electric strategy to decide resistivity, profundity and thickness of the model earth layers, estimation of the quantity of smooth and equality layers comparing to the quantity of model earth layers (stratigraphic connection) (Kunetz, 1966).

2.2 Geophysical Survey

Coordinate perception of the inward structure and testing of properties of soil or shake mass is constantly favored, however this requires boreholes or trenches that are frequently outlandish or too exorbitant to ever be made. Thus, geophysical techniques might be utilized with the end goal of incline dependability investigations (Robert Hack, 2001). Geophysical overviews react to the physical properties of subsurface materials. It can be ordered into two sorts :

a) Passive : Methods that distinguish varieties inside the regular field related with the Earth, for example, gravitational and attractive field.

b) Active : Such as those utilized as a part of investigation seismology, in which falsely created signals are transmitted into the ground, which at that point alters those flag in ways that are normal for materials through which they travel.

Each geophysical strategy measures a particular parameter, which relies upon at least one physical properties of the Earth. Since not every single physical property will shift in a specific circumstance, certain methods are not reasonable for all issues. Cases of geophysical reviewing with its particular physical properties to be estimated are appeared underneath :

• Gravity overview strategy relies upon thickness and extent of Earth's gravitational field.

• Magnetic overview estimation relies upon attractive weakness of subsurface materials.

• Electrical resistivity or actuated polarization overview procedure measures electrical conductivity or electrical capacitance.

• Seismic refraction study relies upon P wave and S wave speed.

Information of geophysical studying technique is normally prepared somehow after procurement. One of the benefits of this procedure is that it is non-damaging and makes no aggravation subsurface materials. Geophysical looking over is fast and practical in covering a substantial region and furthermore can gather properties of subsurface from surface estimations (John, 1997).

The primary use of geophysical strategies are hydrocarbon investigation, provincial geographical examinations, mineral store investigation, building site examination, recognition of subsurface cavities, mapping of leachate and contaminant tufts and area of covered metallic articles (Reynolds, 2000).

Geophysics is normally utilized as a part of one of two ways. It is possible that it is utilized to extend a translation of the topography and hydrogeology from boreholes and surface introduction into an arrangement or the geophysics is utilized as a part of a territory of obscure geography and hydrogeology with a specific end goal to better concentration the immediate testing program. For both of these kinds of utilization, if the geophysics is talked about right on time in the procedures then the most fitting methods can be found and utilized as a part of the most financially savvy way. A parallel for groundwater improvement can be found in the hydrocarbon world where the fruitful utilization of a coordinated geophysical program is seen at all phases of building up a hydrocarbon supply.

Initial a geophysical territorial recognizance consider is led with potential field strategies (gravity and magnetics). This is trailed by local seismic projects and investigation wells. In light of these outcomes, more point by point neighborhood 3D geophysical overviews are made and the surface geophysics is fixing to the subsurface topography by borehole geophysics.

Elements that prompt an effective review is picking the proper geophysical strategies and applying the techniques in a suitable way. Just once the goals have been unmistakably characterized and conceded to by both the customer and the temporary worker can the suitable geophysical strategies be picked. The off base decision of method and inadequately experienced work force directing the examination have been referred to as essential explanations behind the disappointment of numerous geophysical overviews (Darracott and McCann, 1986; MacDonald et al, 2001).

The effective utilization of each geophysical strategy is reliant not just on the cautious outline of the review yet in addition on the thought of various key geographical and social factors together with the geophysical information. These variables include:

a) Nature of the objective:

The objective geophysical mark must be distinctive to that of the foundation topography or hydrogeology.

b) Profundity of internment of target:

The profundity of internment of the element of premium is critical as various strategies have distinctive examination ranges. The profundity go is procedure dependant anyway there is dependably an exchange off between infiltration profundity and determination of the system regarding the component of intrigue. A method that will look profound into the earth for the most part has bring down determination than a strategy that is just hoping to shallow profundities

c) Target measure:

An estimation of the objective size is important preceding choosing fitting procedures. The objective size ought to be considered in conjunction with the profundity extend for singular strategies.

d) Estimation station interim:

This will rely upon the internment profundity, target size and procedure chose. Geophysical reviews have customarily been directed along line profiles or on frameworks and accordingly the station dividing along the lines must be figured together with the line detachment keeping in mind the end goal to not miss a specific target estimate or to bring about spatial associating the objective (Reynolds, 1997). An unpleasant general guideline is that a geophysical oddity will be roughly double the span of the question causing the peculiarity so this will give the greatest line and station separating.

e) Adjustment of the information:

The way to achievement of any geophysical review is the adjustment of the geophysical information with both hydrogeological and geographical ground truth data. Alignment information might be given by both down-gap geophysical logs in boreholes,

tests got from boreholes by ceaseless inspecting and through estimating the groundwater transition. (Peynolds,1997).

A few strategies utilized in groundwater investigation incorporate electrical resistivity, gravity, seismic, attractive, remote detecting, electromagnetic, among others, out of which the resistivity strategy is the best to locate beneficial well and the Vertical Electrical Sounding (VES) method can give data on the vertical variety in the resistivity of the ground with profundity and the Constant Separation Traversing (CST) gives a methods for deciding interim variety in the resistivity of the ground (Olayinka and Mbachi, 1992; Olorunniwo and Olorunfemi, 1987; Ariyo, 2003).

Brousse (1963) refered to the adequacy of the electrical resistivity technique in the examination for groundwater in complex stone territories. He utilized the technique to delineate, gorges gouge, and blames which go about as water stores.

A geophysical model made can be utilized to help different examinations which include, fundamentally one-, two-, and three-dimensional demonstrating. Resistivity imaging is one of the geophysical overviews which have been utilized to outline tainting and it is broadly utilized for natural reviews (Griffiths and Barker, 1993)

Electrical resistivity imaging was utilized as a part of this examination to explore the subsurface geographical attributes and groundwater condition in the investigation region. The resistivity strategy has its beginning in the 1920's because of crafted by the Schlumberger siblings. In the following 60 years, for quantitative understanding, traditional sounding overview was regularly utilized. In this technique, the inside purpose of the

terminal exhibit stays settled, yet the dividing between the cathodes is expanded to get more data on the more profound segments of the subsurface. The resistivity technique is the most mainstream of all the geophysical strategies to the extent groundwater investigations is concerned. Anyway the technique all things considered has not grown much over the most recent two decades (Barker, 1981).

Numerous investigations have been focused on the geometry assurance of the aquifers (Robain et al., 1995, 1996; Cherry et al., 1996). The electrical resistivity of an arrangement depends for the most part on the saltiness of its liquid substance, immersion, aquifer lithology and porosity (Shaaban, 2002). This procedure has been effectively utilized as a part of the world to investigate groundwater and its condition. The electrical resistivity method is generally utilized additionally to evaluate the profundity and the idea of the alluvium, aquifer limits and its area (Young et al, 1998, Lashkaripour et al, 2005; Al-Garni, 2004a, 2004b, 2005; Al-Garni et al, 2005 and 2006; Hassanein et al, 2007).

Numerous geophysical techniques (i.e. attractive, gravity, seismic and electrical techniques) have been utilized to find and outline subsurface water assets (Telford et al., 1976).

Investigation of groundwater in hard compacted landscape is an extremely difficult and troublesome undertaking when the promising groundwater zones are related with cracked and fissured media. In this condition, the groundwater possibility depends principally on the thickness of the weathered/cracked layer overlying the storm cellar.

Attractive materials inside the weathered zones are decreased because of the weathering forms amid the geographical time. Consequently, the exhaustion of the attractive materials in the modified zones would decrease the defenselessness, which is a measure of the degree to which a material might be polarized. Attractive overview has been broadly utilized as a part of groundwater investigation where outlining structures was the primary target (i.e. Al-Garni, 1996, 2004a, 2004b, 2005; Al-Garni et al., 2005 and 2006; Hassanein et al., 2007).

The resistivity estimations are regularly done with four anodes set equidistant along a line. The course of action of the four anodes, known as an exhibit, will influence the profundity of examination, affectability, determination and the joining of commotion into each evident resistivity estimation (Smith, 2006; Loke, 2001).

Geolectrical technique has been widely used in groundwater exploration to correlate between the electrical properties of the geologic formations and their fluid content (Flathe, 1955; Zohdy, 1969; Flathe, 1970; Ogilvy, 1970; Zohdy et al., 1974).

The electrical resistivity technique measures both parallel and vertical variety in ground resistivity from various focuses on the earth surface. The resistivity of the ground is estimated by sending current into the ground at the present terminals and the comparing potential contrast is estimated at the potential anodes, which is then changed over to evident resistivity esteem by duplicating with a fitting geometrical factor. Diverse components influence the resistivity in the subsurface (Telford et al, 1990).

The electrical resistivity overview includes electrical sounding utilizing schlumberger setup with ABEM WADI (SAS 300B) Terameter. The potential anodes stay settled and the present cathodes are extended all the while about the focal point of the spread. The separation between the terminals gets too expansive, it then obligatory to expand the separation between the potential cathodes to have a quantifiable potential contrast. The schlumberger exhibit utilized, with most extreme current cathode division of 100m-150m terminals are ordinarily organized along a straight line, with the potential anode set in the middle of the present cathodes. This arrangement is generally utilized as it would give subsurface data considering the profundity of infiltration which extends between 1/3 and ¼ of the aggregate current anode partition (David and Ofrey, 1989; Osemeikhian and Asokhia, 1994; Mallam and Ajayi,2000).

2.3 Resistivity Method

2.3.1 Concept

The 2D electrical resistivity technique is one of geophysical strategies utilized to delineate structure which can be utilized to screen incline disappointment. It gauges evident resistivity of the ground to coordinate current stream. The 2D electrical resistivity strategy gives an impression of inside structures (De Vita et al., 2006) which is a dynamic planned technique utilized for acquiring a high determination picture of subsurface examples.

Ohm's Law depicts electric current course through a resistive material. The fundamental idea of the law relates electric current (I) moving through a resistor to voltage

(V) connected over the resistor. The reverse amount of electrical conductance is electrical obstruction (R). For a uniform wire or solid shape, opposition is corresponding to the length and conversely relative to cross-segment territory. The steady of proportionality is called resistivity (ρ), estimated in ohm-m. Resistivity is the crucial physical property of the metal in the wire.

Resistivity technique is to a great extent connected for the examination of regions having complex topography (Perrone et al., 2004). It is a decent roundabout indicator of water content and is an intriguing instrument to evaluate the profundity of bedrock secured by shallow dirt stores or to decide the thickness of the last mentioned (Cosenza et al., 2006). Likewise it can be utilized as a part of zones that are loud or have low resistivity where seismic and GPR overviews can't be utilized. Cases of its utilization incorporate identification of depressions in limestone zones, bounders, channels, groundwater pollution and archeological studies (Loke and Zuhar, 2003).

Groundwater, through the different disintegrated salts it contains, is ionically conductive and empowers electric streams to stream into the ground. Thus, estimating the ground resistivity gives the likelihood to distinguish the nearness of water, taking in thought the accompanying properties:

• a hard shake without pores or crack and a dry sand without water or earth are extremely resistive: a few tens thousands ohm.m