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3D ELECTRICAL RESISTIVITY IMAGING FOR GROUNDWATER IN HARD ROCK AREA: A CASE STUDY OF NEW CAMPUS OF GOVT POLYTECHNIC, BHAGA (DHANBAD)

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ABSTRACT

Electrical resistivity imaging is a widely used tool in near surface geophysical surveys for investigation of groundwater exploration in hard rock terrain. In the present study, Electrical Resistivity Imaging (ERI) was conducted in the hard rock area, located in the campus of government polytechnic ,Bhaga .Present investigation is based on 2D and 3D resistivity imaging along seven imaging line using a Schlumberger configuration. Present study revealed the geometry and characteristics of the aquifer in the area of investigation. In addition, a 3-D synthetic resistivity modeling was carried out to know spatial pattern of water bearing rock in sub surface. Two boreholes were also drilled in the groundwater potential area, delineated by imaging of sub surface. Both the drilling and resistivity results indicated the presence of a confined aquifer in the site.

Keywords- *Electrical resistivity, groundwater, hard rock.*

I. INTRODUCTION

Two-dimension electrical resistivity imaging is widely used for mapping of an area having complex geology. Electrical resistivity imaging has been proved an excellent tool for identification of horizontal and vertical extension of buried litho- units. The electrical prospecting method consists of measuring the potential at the surface which results from a known current flowing into the ground[1]. A pair of current electrodes, A and B, and a pair of potential electrodes, M and N, are used. The apparent resistivity (ρ_a) is given by

$$\rho a = K \Delta V / I$$

Where, K denotes a geometric coefficient dependent upon the electrode array, ΔV denotes the measured potential difference and I denotes the current intensity. By expanding the current electrode array, the depth of investigation can be increased. Such a data set provides a vertical log of apparent resistivity called a vertical electrical sounding (VES). The sounding site is conventionally located at the centre between the inner electrodes. Electrical profiling is used for generation of electrical resistivity image. The electrode separation is kept constant and the electrode array is moved as a whole with the center of the configuration occupying successive points along a traverse in electrical profiling.

Three dimension (3D) electrical imaging are now widely used where conventional 1-D and 2D resistivity sounding surveys are inadequate to map subsurface object. One dimensional resistivity surveying is a point specific investigation that gives vertical information in terms of resistivity with depth of layers laying in sub -surface to that point. Therefore, No sub-surface information can be obtained by any shift or deviation from surveying point in 1-D resistivity survey. 2D electrical resistivity imaging the reveals the vertical cross section along line of imagining. Basically,2D Electrical Resistivity Image (ERI) is the final result of mathematical stitching of all 1-D. Similarly, 3D electrical resistivity is the clustering of all 2D data. Most popular method for electrical imaging of sub- surface object has been developed by Loke and Barker [2].

II. OBJECTIVE

Following are main objectives

1. Delineation of ground water potential zone in the hard rock terrain.
2. Scanning of subsurface for demarcation of 3D geometry of aquifer using resistivity imaging techniques.

The study area

The present study area is located in north eastern corner of BIT Campus in the Sindri Town of Dhanbad. This area enjoys cold season from December to February and is followed by the hot season which last till about the middle of the June. Mid June to September constitute the south west Monsoon season. The average annual rain fall in this district is 1200 mm. January is generally the coldest month. May is the hottest month of the year. The terrain of the study area is adulatory. Therefore most of rain water run off and drained through gullies and rivulets, which becomes dry after the rainy season

Geologically, area under investigation comprise of Chhotanagpur Gneissic Complex. These rocks are hard and compact in nature and devoid of any water bearing primary porosity. Upper portion of these rocks are weathered that form unconfined type of aquifer. Presences of fracture in deeper part of these gneissic complexes are the potential locality for

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accumulation ground water. Identification of such fracture in hard rock is possible through geophysical techniques especially for horizontal fracture. Among the Other techniques, remote sensing is mostly useful to identification such fracture that appears on surface and extended to deeper sub surface.

III. METHODOLOGY

Electrical resistivity survey was carried out at various sites in the study area, employing Schlumberger profiling techniques for creation of ERIT.

A D.C resistivity meter (SSR- MP-AT) was used to measure the apparent resistivity. This instrument has been fabricated by M/s integrated Geo-instrument and service private limited, Hyderabad. It measures the apparent resistivity directly in ohm – meter. In the presence of random (non-coherent) earth noise, the signal to noise ratio can be enhance by $\sqrt{N}$, where N is the number of stacked reading. SSR-MP-AT is a microprocessor based signal stacking resistivity meter in which running average of measurement [1,(1+2)/2,(1+2+3)/3.(1+2+3…+16)/16] up to the chosen stacks are displayed and the final average is stored automatically in memory. It has resolution of 10^{-5}. The SSR MP-AT contains mainly two parts viz. current unit and microprocessor based measuring unit built in single housing. The current unit sends bipolar signals into ground at a frequency of about 0.5 Hz. The receiver has 4.5 digital dual slope analog to digital converter unit which can measure the ground potential and current with resolution up to10 µV and10 µA respectively. The microprocessor controls the current unit, determines attenuation level for potential measurements, computes the resistance values, average the measured values, keeps the data in memory display and transfer the data to PC.

A switch box was used as an intermediate connecting device between resistivity meter and electrodes. All electrodes have been coded by a specific number and connected with same code number key of switch box. Apparent resistivity was converted into absolute resistivity of various layers using inverse slope software i.e. based on inverse slope principle proposed by Sankaranarayan and Ramanujachary [3]. Resistivity with thickness and depth of each layer has been also determined by using this software. Horizontal extension (i.e. surface distance,), vertical extension (i.e. depth) and resistivity of layers were placed in A, B, C column respectively in the worksheet of surfer software for generation of image. Thereafter, all the data were transferred in data modules for griding, which is important step before contouring. Finally, 2D image has been generated in form of coloured contour interval and pixel format

3D Electrical Resistivity Image of study area has been also generated using Voxler software by combining all VES data of various stations

IV. RESULTS & DISCUSSION

Two dimensional and three dimensional Electrical Resistivity Images (ERI) have been used to understand the geometry of aquifer in the study area. Electrode array on various image lines has been shown in figure 1. Sub surface geo electrical resistivity images along seven imaging lines were generated with 39 one dimensional VES points data

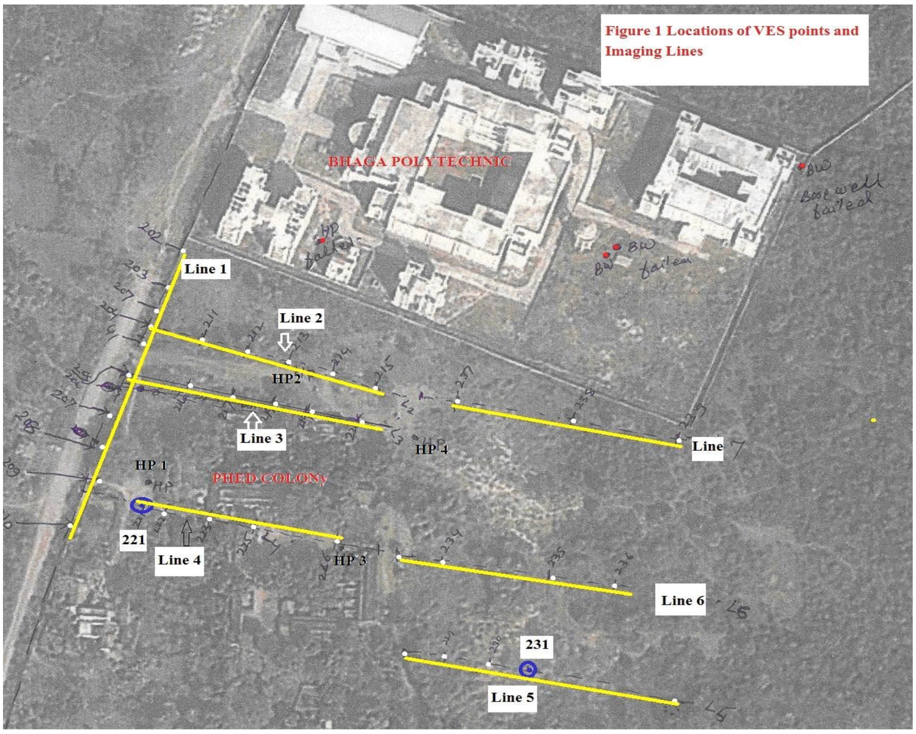

Figure 1 Locations of VES points and Imaging Lines

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Imaging line 1

Imaging line 1 was performed along the western boundary. Resistivity data of Point 201 to 210 were used as input for creating the ER image along line1. Length of line 1 was kept 117m on surface. Image of this line was created up to depth of 110 m in sub surface. The thickness of weathered horizon is varies in between 10 m to 30 m along this imaging Line. The hard rock encounter at depth of 35 m below sub surface has been extended up to depth of 110m. Two fractures, one at 70 to 80 m depth and other below 90 m depth are prominently present in hard rock but traces of water is not clearly identified in these fractures

Imaging Line 2

Imaging Line 2 is located at 30 m from southern boundary wall of polytechnic. The line 2 is roughly parallel to this boundary wall. Length of line on surface was kept 80. This line is oriented in WE direction. The total depth in sub surface is investigated up to 66 m along this line. Two Fractures having angle of inclination about 30 degree toward east noticed at depth of 21 m in electrical resistivity image. Both these fractures are parallel to each other up to depth of 56 m. After this depth lower fracture turned towards west direction. It is very difficult to trace out the water in this fracture on the basis of resistivity value. However water may be located in down side of inclination direction of fracture at deeper part of sub -surface. The verification of this fact is only possible through electrical tomography of concerned portion

Line 3

This image reveals that the upper portion of hard rock is weathered up to depth of 20 m from surface. Depth to weathered zone is increases toward east direction. Hard rock portion is free from water holding fracture is this image. Movement of groundwater may be east due to progressive increment of thickness of weathered rock

Line 4

The road passing from the PHED colony has been selected as site for image line 4 (fig1). This image line started from hand pump 1 to hand pump 3 in PHED colony. Length of this image line was Kept 90 m and scanned up to 100 m below surface. This image illustrates that a fracture constitutes synclinal structure in the deeper part of image. Fracture extends towards east direction and having angle of inclination about 30^0. Traces of water might be possible in this fracture. But it is very difficult to suggest the amount of water present in fracture. On the basis of inclination of fracture, greater amount of water might be possible in eastern side, where it will be traced out at deeper part of sub surface(figure2).

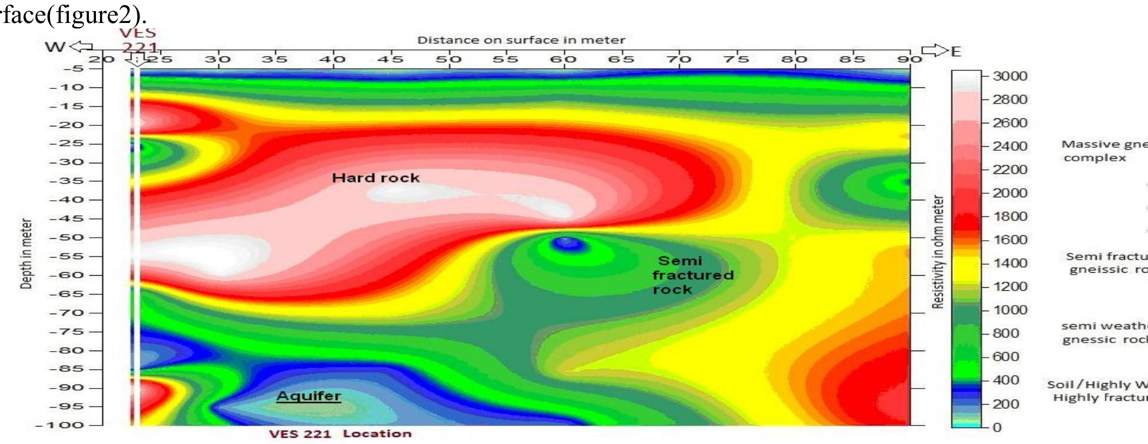
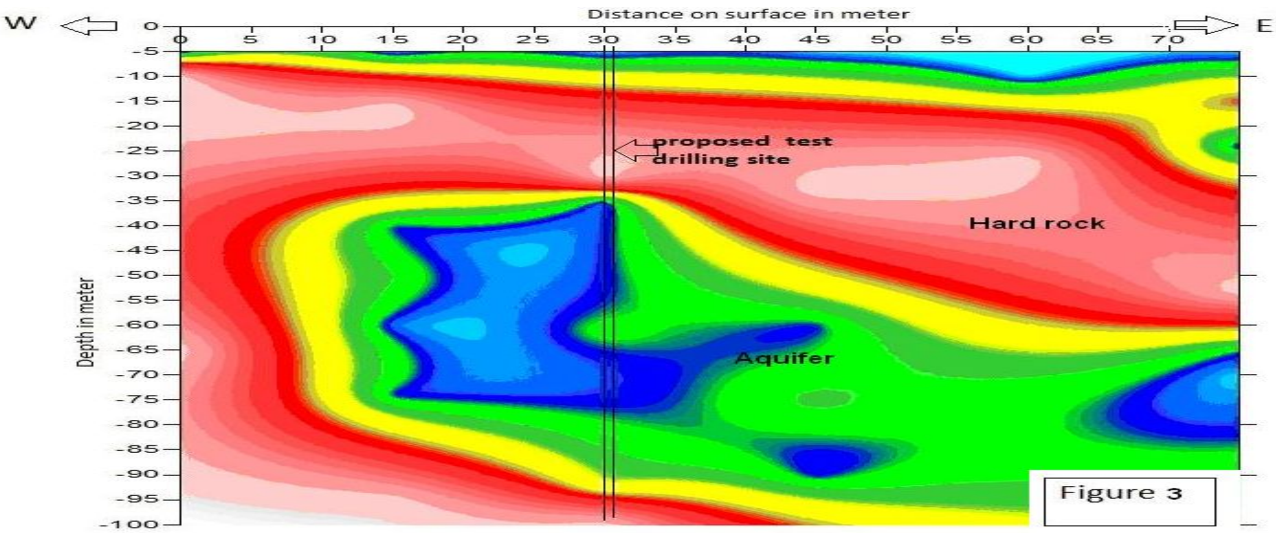


Figure 2

Line 5

This imaging line has been marked near a small culvert in the north of super phosphate colony. Sub surface geo electrical image at this site indicate the presence of wide fracture holding water. This fracture initiates at depth of 35 m near culvert and extends toward eastern side. Depth of weathering progressively found deeper in the eastern side indicates the flow direction of ground water in this upper unconfined aquifer. This site might be good for recharge as well as extraction of ground water (Figure3).



Line 6

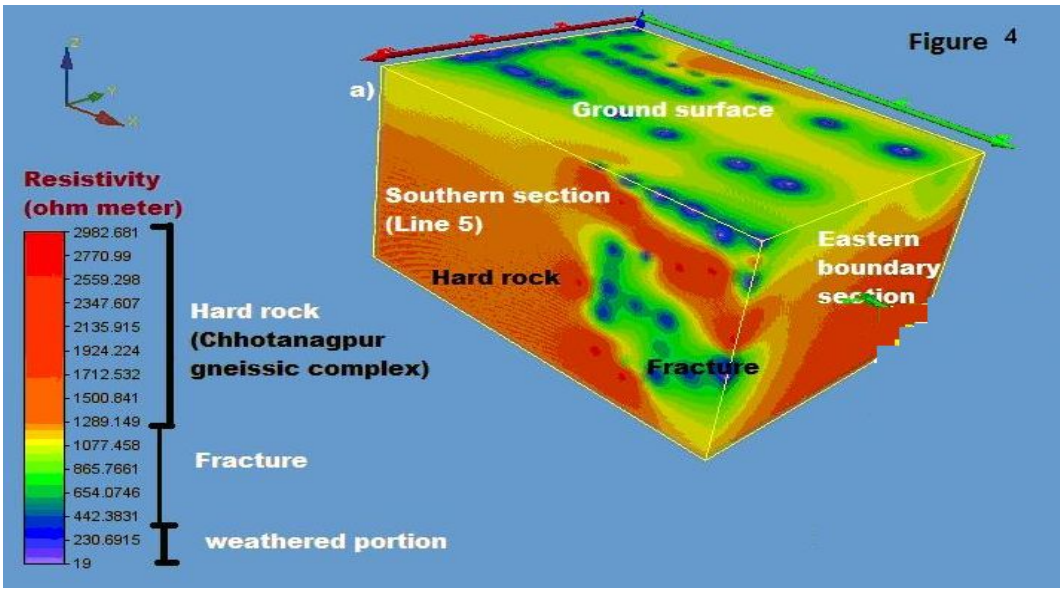
This image line is the eastern continuation of line 4. Upper part up to depth of 25 m to 70 m has been noticed highly weathered. Thickness of weathered layers increases toward eastern side in this image. Movement of groundwater might be also possible to ward eastern direction in this layer. Many small fractures without water has been also noticed in deeper past of image

Line 7

This imaging line is the eastern extension of line 2 and parallel to southern boundary of polytechnic campus. An unconfined aquifer is noticed in the upper part. The lower part of image indicates the presence of hard rock without any water bearing fracture

Three dimension geometry of aquifer

Three dimensional interpretations of resistivity data indicates that hard rock is not fractured near the polytechnic boundary. A linear fracture might be present along the road passing through PHED colony and extended upto Durga Mandir in eastern direction. Sub surface topography of hard rock has been generated using 1400 ohm meter resistivity value in order to identify the trend of fracture. Width of this fracture is very limited and subjected to detailed investigation (figure 4).



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V. CONCLUSION

Signatures of electrical images have made easy to take decision about sites for drilling for groundwater exploration. Location no 221 on line 4 and location 231 on Line 5 have been identified for favorable sites for drilling. Drilling has been performed at these suggested sites. These bore well have yielded adequate volume of water

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