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Identification of aquifer zones by VES method: A case study from Mangalore block, Tamil Nadu, S. India

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ABSTRACT

Aquifer zones are identified by the Geophysical Electrical Resistivity Survey method. This method is useful to delineate the subsurface formations, weathered zone, fracture pattern, etc. An attempt made to identify the subsurface lithology and aquifer zones by geoelectrical resistivity method in part of Mangalur block, Cuddalore District, Tamil Nadu, S.India. The study area consist of charnockite and charnockitic gneiss rocks. Electrical soundings have been conducted at every 2 Km intervals in grid pattern. Totally 36 VES were conducted, which have been qualitatively and quantitatively interpreted using software packages. Pseudosections have been generated by IPI 2 WIN ver.3.1 and isoresistivity maps were prepared. Geoelectrical parameter and sections have been prepared based on quantitative interpretation. Considering the hydrometeorological and hydrogeological conditions the VES interpretation was done. From the interpretation result the VES no. 21 (Alambadi) is a prospective zone for groundwater target.

Key words: Resistivity survey, quantitative and qualitative, interpretation, isoresistivity maps.

INTRODUCTION

Water is renewable resource occurs in three forms liquid, solid and gaseous. We known that the groundwater is essential for irrigation, industry and domestic purpose. Groundwater is the main source for potable water supply, domestic, industrial and agricultural uses. The scarcity of groundwater increases day by day due to rapid population, urbanization, industrial and agricultural related activities, natural calamities, and etc. the impact of trio on soil and groundwater is alarming with years of devastating effects on humans and the ecosystem [1]. Study of groundwater geology is much useful for all the activities of human life. Groundwater is more advantageous than the surface water. Water scarcity problem affects the human chain and other living things. To meet out the demand of water, people are depending more on aquifers. There are two end members in spectrum of types of aquifers; confined and unconfined (with semi confined aquifer being in between them) [3]. For identifying the ground water potential in the hard rock aquifer terrain the main target is fractured zone. The present study focuses on identification of fracture zone and its thickness by using geoelectrical resistivity method.

Location of the study area

The present study area has falls in Mangalore block of Cuddalore district, Tamil Nadu, S.India (Location map shown in Fig.1). The study area lies between the latitudes North 11°21'80" to 11°30'11" and the longitudes East 78°40'57" to 79°03'11" in the Survey of India Toposheet no. $58\frac{M}{3}$ & $58\frac{M}{15}$. The present study area occupies an areal extent of 100 sq.km and the relief ranges from 62 m to 121 m above MSL. The study area receives an average rainfall of 1100 mm with more than 80% of the rainfall received during the NE monsoon. The minimum and maximum temperature ranges between 20°C and 34°C in the month of January and May respectively. River Vellar flows in the southern part of the study area. Geomorphologically the area consists of old flood plains, pediments, duricrust and pediments covered by forest land [7].

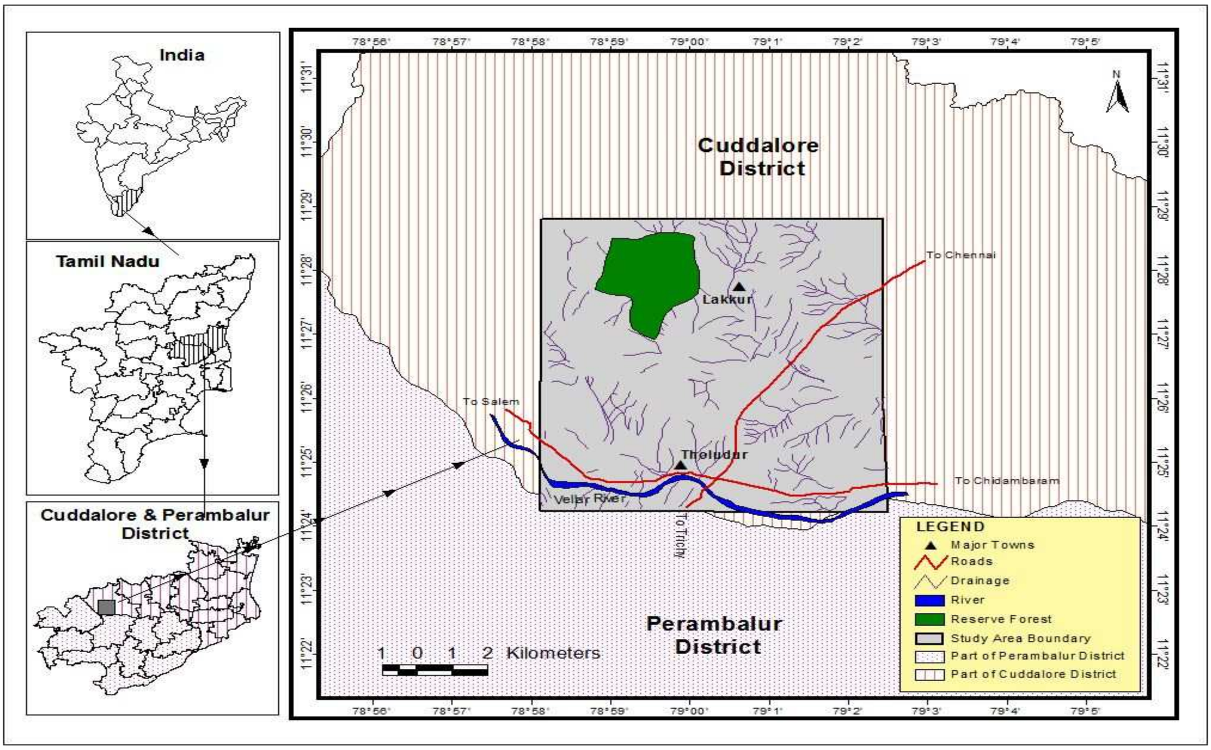


Fig.1. Location map of the study area

Geology and Hydrogeology

The study area rock types belong to early to mid Precambrian represented by charnockite and charnockitic gneiss, indicating the oldest and subjected to granulite facies of metamorphism. The charnockites are intermediate to acid in composition, coarse to medium grained and form the high land topography. The charnockitic rocks are massive to foliate and the foliations usually trending ENE – WSW with an average dip of 45° towards South. The charnockite shows different depth of weathered zone. In the study area groundwater occurs under water table conditions in the joints, fractures and weathered rocks. Generally, the charnockite of the study area is highly massive and compact and devoid of joints and fractures making it impervious, which in turn result in poor potential. The open wells give better yield than bore wells [8].

MATERIALS AND METHODS

Geophysical prospecting of groundwater comes under both surface and subsurface exploration. Under geophysical prospecting, one of the electrical methods is schlumberger array of electrical resistivity method. The schlumberger array was used to ensure deep penetration and for logistics of limited man power in the field [2]. Schlumberger configuration using Microprocessor based signal stacking digital resistivity meter of IGIS, Hyderabad make, Model – SSR-MP-AT-S. Both the survey procedures resistivity profiling and resistivity sounding (VES) have been carried out. Resistivity profiling has been conducted in a grid pattern. The total study area of 100 Sq.km. has been divided into square grids of 2.0 Sq.km and 6 resistivity profiles were conducted with a station interval of 2 Km. resistivity profiling with $AB/2$ 10, 20, 30, 40 & 50 m have been carried out. VES has been conducted at 36 locations with $AB/2$ 50 m. The resistivity data have been qualitatively and quantitatively interpreted and analyzed by software packages.

Resistivity Method

The electrical resistivity is the resistance offered by the opposite faces of a unit cube of material to direct current is called as resistivity. In geophysical literature the unit of resistivity is taken as the ohm. m. The resistance (R) of the material having a resistivity (ρ) over a length (L) and surface area of current flow (A) is given by

$$R = \rho \frac{L}{A}$$

This is governed by ohms law. The inverse of resistance is termed as conductance [5]. The resistivity of the geological formation is generally very high under dry conditions and decreases in clayey rock. The presence of water containing salt even in minor amounts, geological formations makes them relatively conductive and as the moisture increases the resistivity falls deeply. As the salinity of water increases the resistivity of the rock formation decreases substanceously.

Measurement of Resistivity

In general for measuring the resistivity of the sub surface formation four electrodes are required. The current of electrical intensity (I) is introduced between one pair of electrodes called current electrodes which can be identified as A & B. The potential difference produced as a result of current flow is measured with help of another pair of electrodes called potential electrodes represented as M & N. Let Δ^r represent the potential difference. The apparent resistivity measure is $K \times \frac{\Delta^v}{I}$, where K represents geometrical constant, which can be calculated if we know the electrode arrangements. The basic needs for the resistivity survey are the power source, meter to measure current and potential, electrodes and cables.

Schlumberger Configuration

In schlumberger configuration all the four electrodes are kept in a line similar to that of Wenner but the outer electrode spacing is kept large compared to inner electrode spacing usually more than five times. For each measurement only the current electrodes are moved keeping the potential electrodes at the same locations. The potential electrodes are moved only when the signal become too week to be measured. The apparent resistivity for this configuration is computed with the formula;

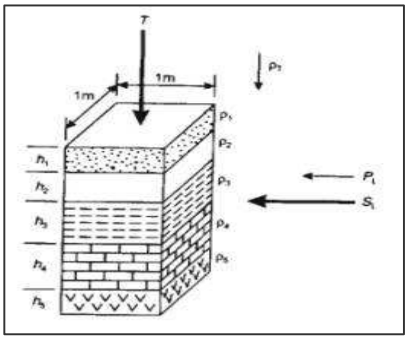
$$\rho a = \frac{\Pi\left[\left(\frac{AB}{2}\right)^2 - \left(\frac{MN}{2}\right)^2\right]R}{MN}$$

Vertical Electrical Sounding (VES)

A series of measurements of resistivity are made by increasing the electrode spacing in successive steps about a fixed point. This method of vertical exploration is known as the expanding electrode method, “Resistivity sounding” or “Depth probing” or vertical electrical sounding (VES). The apparent resistivity values obtained with increasing values of electrode separation are used to estimate the thickness and resistivities of the subsurface formations. VES mainly employed in groundwater exploration to determine the disposition of the aquifers.

Geoelectrical Parameters

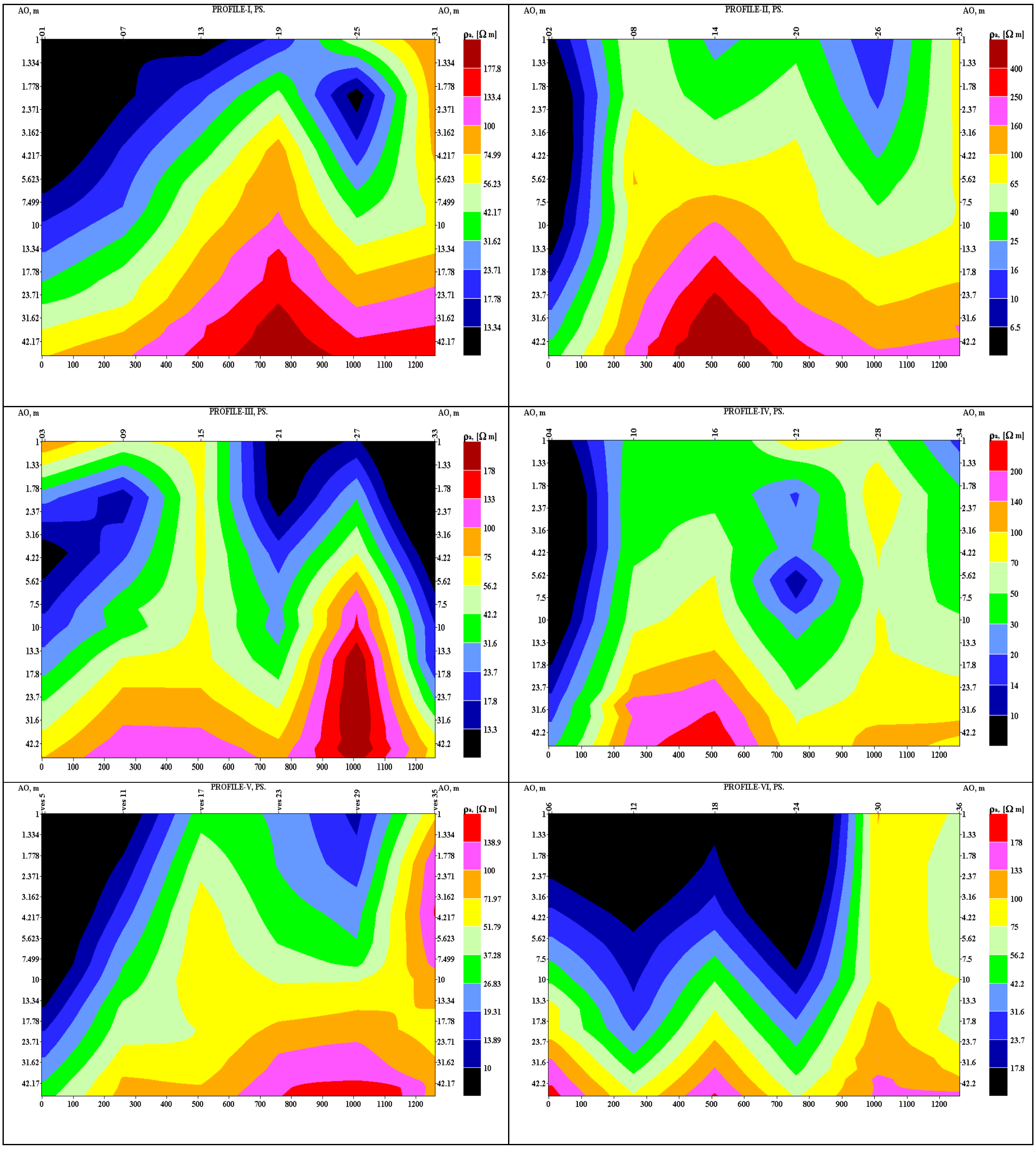
The main objective of the quantitative interpretation of VES curve is to obtain the geoelectrical parameters. A geoelectric layer is called by its fundamental characters, resistivity ‘ρ’ and thickness ‘h’. These two parameters are called the primary geoelectrical parameters. The secondary geoelctrical are also important to describe the geoelectric section consisting of several layers. The longitudinal (S) and the total transverse (T), transverse resistivity (T/h) an – isotropy (λ) are called the secondary geoelectrical parameters. The (Fig.2) Shows columnar prism used in defining geoelectric parameters.



P	**=**	**RESISTIVITY**
h	**=**	**THICKNESS**
S	**=**	**LONGITUDINAL CONDUCTANCE**
T	**=**	**TRANSVERSE RESISTANCE**

Fig.2. Columnar prism defining geoelectrical parameters

Fig.3.Pseudosections of the profiles I to VI



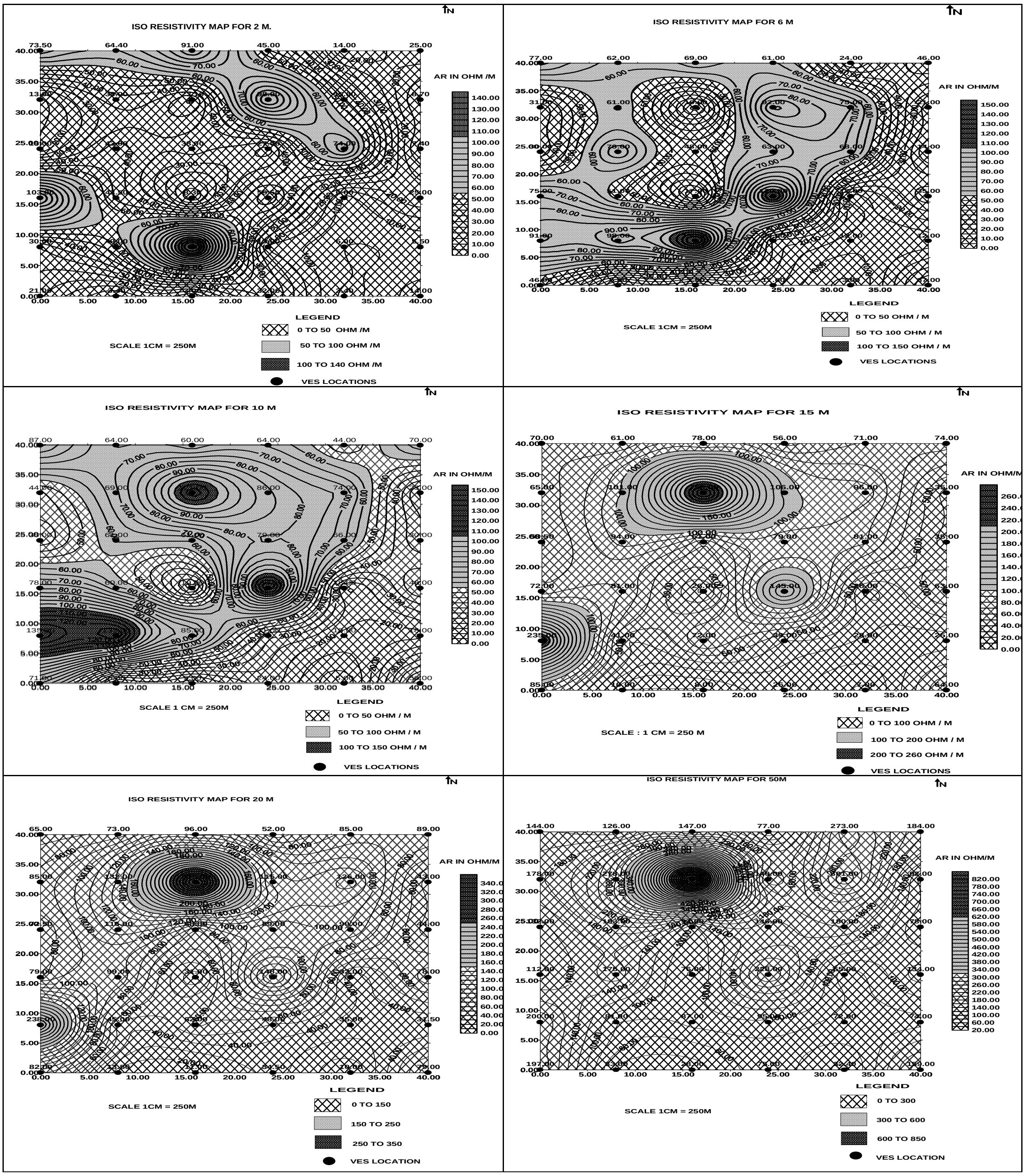


Fig.4.Isoresistivity maps for the depth of 2, 6, 10, 15, 20 and 50 m

Quality and Quantitative method

In the qualitative method the shape of the field curve is critically observed to get an idea qualitatively about the number of layers and the order of resistivities. The thirty six VES curves have been prepared by IPI2 Win software Program and studied in-depth VES curves of the study area. Majority of the curve types are 'A' and 'AA' types of the study area, the other curve types are 'H', combination of 'HA' and 'KH' types.

In the quantitative method geoelectrical parameter i.e., true resistivities and layer thickness are obtained. There are two types of quantitative analysis i) indirect method and ii) direct method. The field curve is compared with album of theoretical curves to get the geoelectrical parameters and this technique is known as curve matching technique.

To obtain initial model parameters by indirect method the field curve is matched with standard curves and also by auxiliary point technique [4]. In the direct method the inverse slope technique which is a semi empirical method proposed by [6].

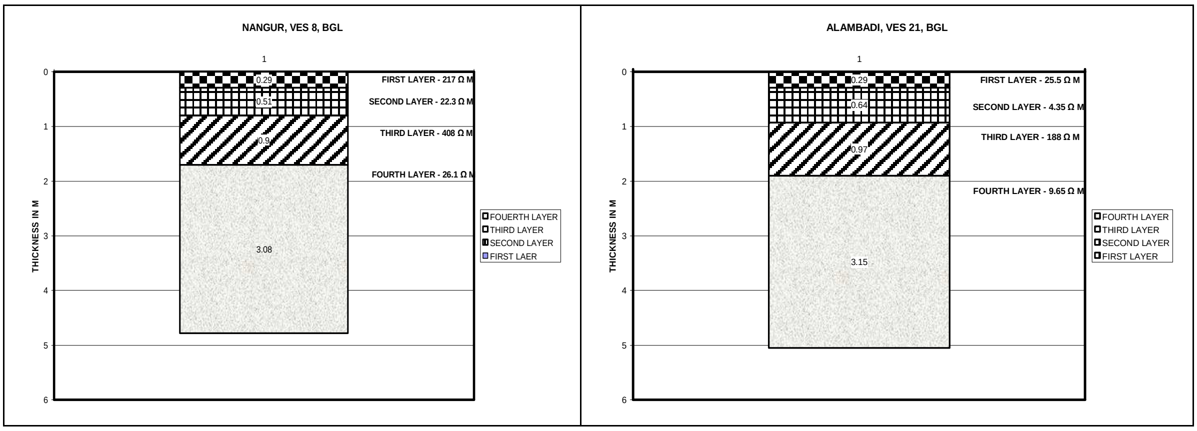


Fig.5. Geoelectrical sections

RESULT AND DISCUSION

The pseudosection profiles (Fig.3.) shows that the southern part of the profiles (station 25 & 31) having high resistivity indicating poor weathering. The low resistivity anomaly extends down to a depth of 31 m. Another low resistivity anomaly is not prominently observed at the southern part i.e. at station 26. Along the station 27 a prominent high resistivity anomaly is observed from the depth of 7m, indicating the massive nature of the rock (Fig.4 & 5). Another low resistivity anomaly is exhibited at station.23, where the low anomaly is sandwitched. Another lower resistivity anomaly is observed between the stations. 23 and 29, the weathering thickness is restricted upto a depth of 5m. There are two high resistivity anomalies observed at station.06 (7.5m) and 18 (7.5m).

Isoresistivity contour map showing the high resistivity anomalies at station the prominent low resistivity anomalies observed at stations 21, 15 and 09 indicating a weaker zone along N – S direction (Fig.4- 6m map). The prominent low resistivity anomaly exhibited in 2 m and 6 m contour maps indicating a prominent weaker zone. From the low resistivity anomalies at a station 21, 35, 36, 24, 12, 13 and 05 indicating a NW – SE oriented weaker zone, the high resistivity anomalies at a station 25, 26, 22, 09, 01 and 06 indicates a massive rock formation (Fig. 4- 10m map). The prominent low resistivity anomalies at stations are 21, 36, 12 and 18 indicating a weaker zone along N – S direction. High resistivity anomalies at a station 09, 22, and 25 indicate a poorly weathered rock (Fig.4- 15m map). The prominent low resistivity anomalies at stations 21, 22, 36, 12, 18 and 05 indicate N – S trending weaker zone and E - W trending weaker zones along station. 21 and 22 (Fig.4- 20m map). Figure 4 i.e. 50m map shows the prominent low resistivity anomalies at stations 36, 22, 18, 12, 11, 05, and 04 indicting a fractured zone along N – S direction.

VES.08 is 'KH' type curve and VES.21 is 'AA' type curve both are five layered nature, through VES. 21 have very least resistivity, indicating more weathered nature of formation (Fig.5).

CONCLUSION

Electrical resistivity survey has been carried out at every 2Km interval in a grid pattern and totally 36 VES were conducted. Pseudosections and isoresistivity maps were generated. Both low and high resistivity anomalies have been demarcated in pseudosection and isoresistivity map. Majority of the VES curves are 'A' and 'AA' types. With multi layered geoelectrical sections. From the pseudosections it may be revealed that the N, NW and NE are comparatively more weathered than the other parts. A prominent low resistivity anomaly has been exhibited at VES.21 in all the six maps indicating more weathered nature of the formation. Based on the hydrogeological condition and geoelectrical resistivity survey findings VES.21 (Alambadi) may be the prospective zone for groundwater development.

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