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Electrical Resistivity Method for Groundwater Exploration: A Case Study of Ganori Village Area, Aurangabad District, Maharashtra, India

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Abstract

An attempt is made by geophysical surveys involving VES to depict the fracture zones. A total of twelve VES were established in the part of Ganori village of Aurangabad district, Maharashtra to identify the groundwater potential zones. The quantitative interpretation of the VES curves involves the IX1D technique. The resistivity values and subsurface thickness of first layer is represents the top soil and has a mean resistivity value of 10 meters with mean thickness 0.5 ohm-m. The second layer has a mean resistivity of 21ohm-m to 30 ohm-m with means thickness 5 to 10 meters. This layer represents a murumatic, weathered/fractured rock basement. The third layer has means resistivity of30 ohm-m to 35ohm-m and a mean thickness 30m to 50 meters. This layer represents the Amygdaloidal basalt/zeolitic rocks. Four layers were obtained in three vertical electrical soundings and only VES with a resistivity value 0f 50 ohm-m to 105ohm-m and mean thickness 35 m and below hard Trap devoid of joints and fractures rock in the study area.

Keywords: Groundwater, Basaltic terrain, VES, Schlumberger, IX1D Software.

1. Introduction

Water is one of the most essential commodities for mankind and the largest available source of fresh water lays underground1. It is one of the most significant natural resources which support both human needs and economic development. Tremendous increase in the agricultural, industrial and domestic activities in recent years has increased the demand for good quality water to meet the growing needs. Groundwater is mostly preferred to meet this growing demand because of its lower level of contamination and wider distribution (Arkoprovo et al, 2012). Water is an important agent in the formation of landforms (Scheidegger,1973, Sreedevi et al,2005). The occurrence and movement of groundwater in an area is governed by several factors such as topography, lithology, geological structures, depth of weathering, extent of fractures, secondary porosity, slope, drainage pattern, landforms, land use/land cover, climatic conditions and interrelationship between these factors (Roy 1991, Greenbaum 1992, Mukherjee 1996, Jaiswal et al, 2003). Groundwater plays an important role in augmenting water supply for domestic, industrial and irrigation uses. Groundwater in hard rock occurs mainly in weathered, fracture, faults and joints. Electrical resistivity method is the most suitable method among all geophysical method for the delineation of groundwater resources because of a good contrast between the resistivity of the water saturated formation and the formation devoid of water. Electrical resistivity surveys have been successfully carried out by many workers to delineate aquifers in different geological vicinities. Bose and Ramkrishna (1978) have carried out Electrical resistivity survey us to guide the tube well drilling programs aimed at alleviating the drinking water scarcity in the drought-stricken village in part of Sangli District of Maharashtra. Rao et al. (1983) have carried out integrated geophysical surveys consisting of geo-electric survey and magnetic survey for groundwater exploration in Deccan trap covered Godavari Purna basin in Aurangabad district of Maharashtra. Murthy et al. (1986) have carried out geophysical investigations of the delineation of Gondwana formation below the Deccan traps in umrer, bander, Kamathi and Katol troughs in Nagpur district. Yadav and Singh (2007) have carried out integrated gradient profiling and electric sounding to delineate fracture saturated with water in hard rock areas of Gurdevnagar in Mirzapur district, U.P. Electric sounding have been carried out to access ground water availability in the Salboni block of the west Midinapore district, West Bengal (Jha et al, 2008). Kumar et al. (2010) have carried out geo-electrical survey to decipher potential groundwater zones around Aurangabad. Electrical resistivity survey has been conducted for delineation of deeper aquifer in part of Katol taluka (Rai et al 2011).

The ever-increasing demand of groundwater in typical hard rock terrains leads to more intensive and integrated hydrogeological studies incorporating the results of hydrogeomorphological, hydro chemical and geophysical analysis. However, electrical resistivity techniques are mostly considered to be the best suited methods for developing groundwater resources as they surficially decipher the concealed aquifer characteristics. There have been a number of studies carried out in different parts of the world for groundwater exploration using geophysical techniques (Keller and Frichnecht,1966; Zohdy et.al,1974; Deshpande and Aher 2012).

The electrical resistivity survey involved VES is based on measuring the potentials between one electrode pair while transmitting direct current (DC) between another electrode pair. The depth of penetration is proportional to the separation between the electrodes, in homogeneous ground, and varying the electrode separation provides information about the stratification of the ground (Dahlin, 2000, Lashkaripour, 2003). In hard rock areas, groundwater is found in the cracks and fractures of the local rock. Groundwater yield depends on the size of fractures and their interconnectivity. Use of Schlumberger sounding is well known for determining the resistivity variation with depth. However, it is very difficult to perform resistivity soundings everywhere without a priori information. The VLF method has been applied successfully to map the resistivity contrast at boundaries of fractured zones having a high degree of connectivity (Parasnis, 1973; Sharma and Baranwal,2005). The present work describes result of vertical electrical sounding (VES) carried out in part of Ganori village of Phulambri taluka of Aurangabad district of delineation of groundwater source within and below the traps to meet the ever-increasing demand of water for irrigation and domestic uses.

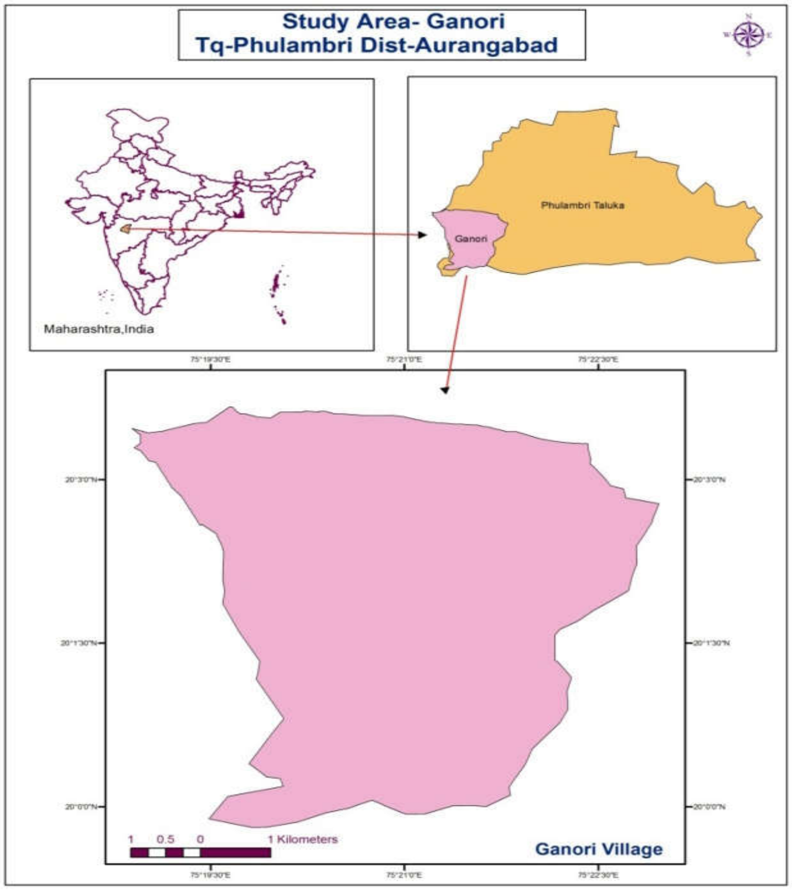

Fig. 1:

2. Study Area

The study area (latitudes 20° 03′ 00″ to 20° 00′ 00″ N and longitudes 75° 19′ 30″ to 75° 22′ 30″ E) covers an area of about 35.44 km^2 (Fig. 1). The Girija River is an ephemeral stream and culminates in the east of the study area. The Girija River basin enjoys a semi-arid climate with temperatures between 24 and 43^0 C and an average annual rainfall of 720 mm. The entire area is underlain and surrounded mainly by basaltic lava flows belonging to the Deccan volcanic province that flooded during upper Cretaceous to Eocene age in the Deccan Plateau. The Deccan Traps sequence consists of multiple layers of solidified lava flows. The prominent geological units observed in study area are the horizontally disposed basaltic lava of dark grey in color. The lava flows are horizontal and each flow has distinct two units. The upper layers consist of vesicular and amygdule zeolitic basalt whiles the bottom layer consists of massive basalt. The soil is mostly of black, medium black, shallow and calcareous types having different depths and profiles (CGWB, 2013). Te hydrogeological condition of the study area is controlled by the lithology, structure and geomorphology. The groundwater in all the rock formations occurs in unconfined and semi-confined aquifers. Groundwater occurs in a limited quantity in unevenly distributed aquifers with secondary porosity caused by weathering, faulting and fracturing of the trap rocks. The permeabilities of all the formations depend on secondary porosity, except for alluvium where the porous material is highly permeable. Alluvium mainly occurs along the stream courses.

3. Materials and Methodology

The earth subsurface layer resistivity is related to various geological parameters of the subsurface formation such as the mineral and fluid content, porosity and degree of water saturation, as well as the salinity of the water in the rocks (Grant and West, 1965). The electrical resistivity method in generals involves passing current (I) into ground through (V) a pair of current electrodes and measuring the potential drop through a pair of potential electrode. The apparent resistivity of the model earth formation is related to the potential difference and the current by the equation. Electrical resistivity data were acquired through vertical electrical sounding (VES) using the computerized Resistivity meter (CRM, 20) fabricated by Sparconix, Pune. Twelve VES were conducted by employing schlumberger electrode array method with maximum current electrode separation (AB/2) of 100 m. The aim to be determines the resistivity variation with depth. In addition to these bore well inventory is carried out during the field work which is help full in the interpretation work. The data was interpreted by IX1D software and goe-electrical layers are prepared.

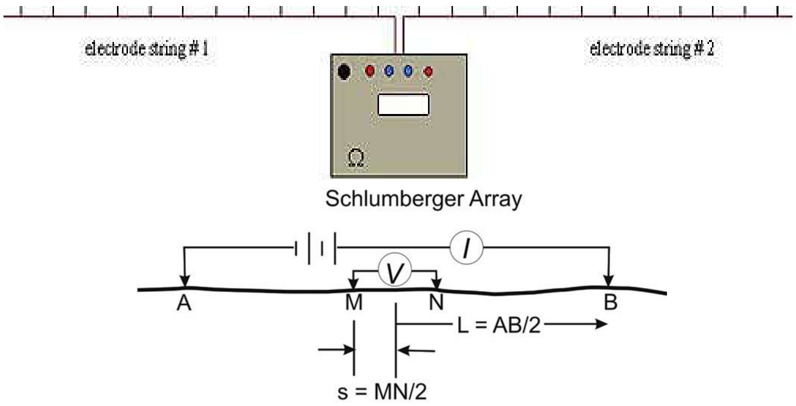

Fig. 2:

4. Interpretation

Twelve VES data using schlumberger array were carried out from the field. The (VES) date were collected and their corresponding borehole logs were also collected for quantitative analysis in order to basically determine the subsurface layering, thickness of the surface layers, and thickness of the saturated groundwater layer beneath each of the studied VES sites. The field resistivity data was interpreted using the IX1D programme. The resistivity of the different layers and the corresponding thickness were reproduced by number of iteration unit the model parameters of all the VES curves were totally resolved with minimum RMS error (7%) exception G5 and G10. Out of 12 VES sounding location no. G1 to G9 and G11shows three layers earth section, location no. G10 show two layers earth section and location no. G12 shows four layers section. The number of two and three layers sequence was maximum in the study area.

Table 1: Ranges of Resistivity layer and thickness value

Thickness	Lithology	Apparent Resistivity	Suitability
0-5m	Soil	10	------
5-10m	Weathered zone	21 Ω m to 30 Ω m	Good yield High yield Dug well cum Bore well
10-35m	Amygdaloidal basalt/zeolitic trap	30 Ω m to 50 Ω m	Medium to good yield Low yield Bore well
35m and below	Hard trap devoid of joints and fractures	50 Ω m to 105 Ω m	Poor yield to Dry Unsuitable for Bore well and Dug well

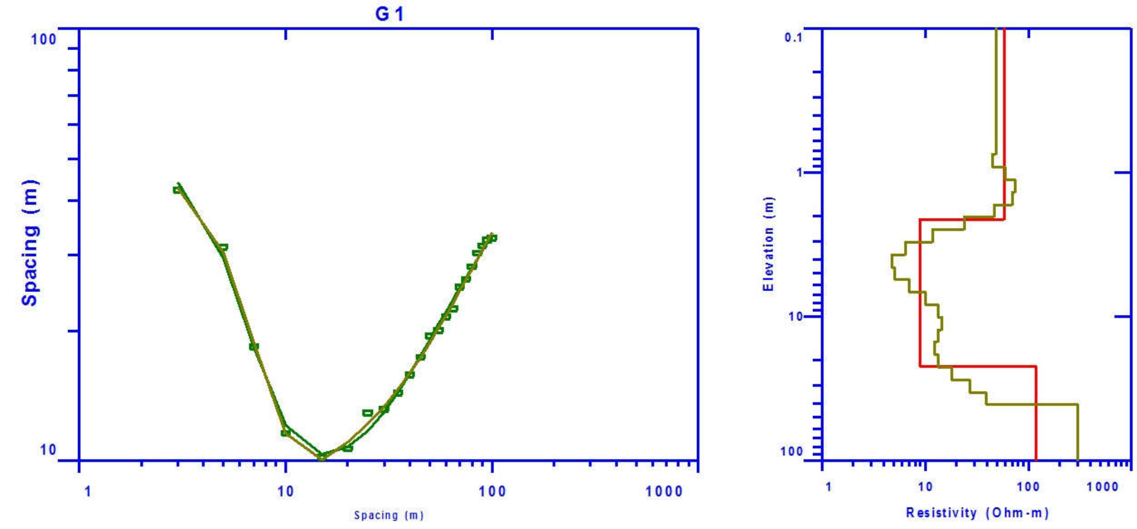

Fig. 3a: VES sounding curve of location G1

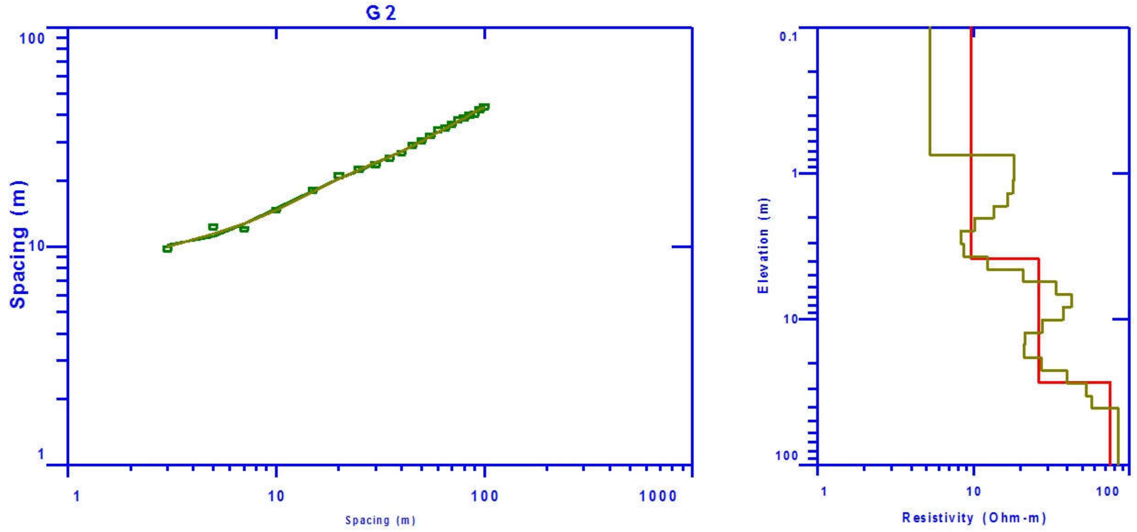

Fig. 3b: VES sounding curve of location G2

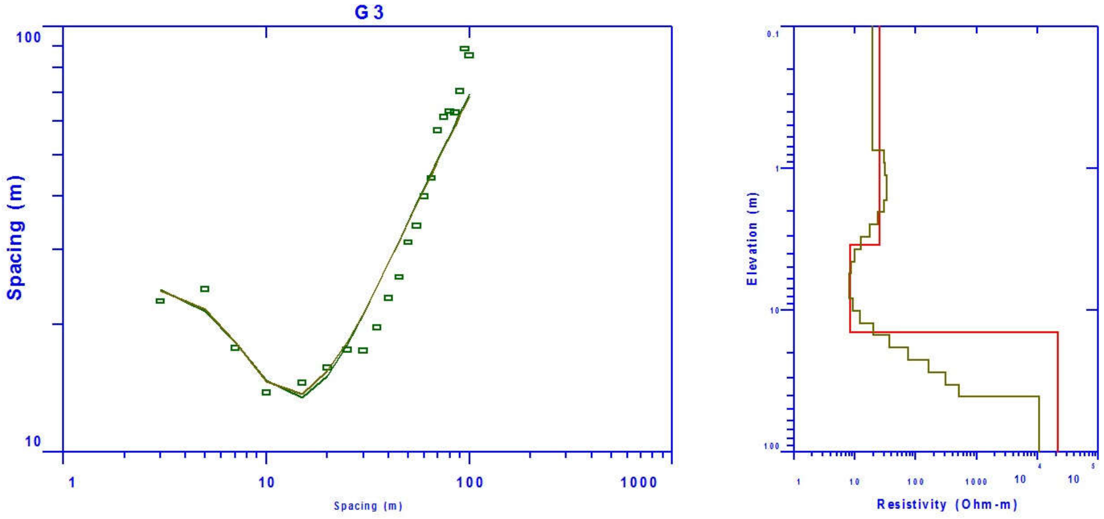

Fig. 3c: VES sounding curve of location G3

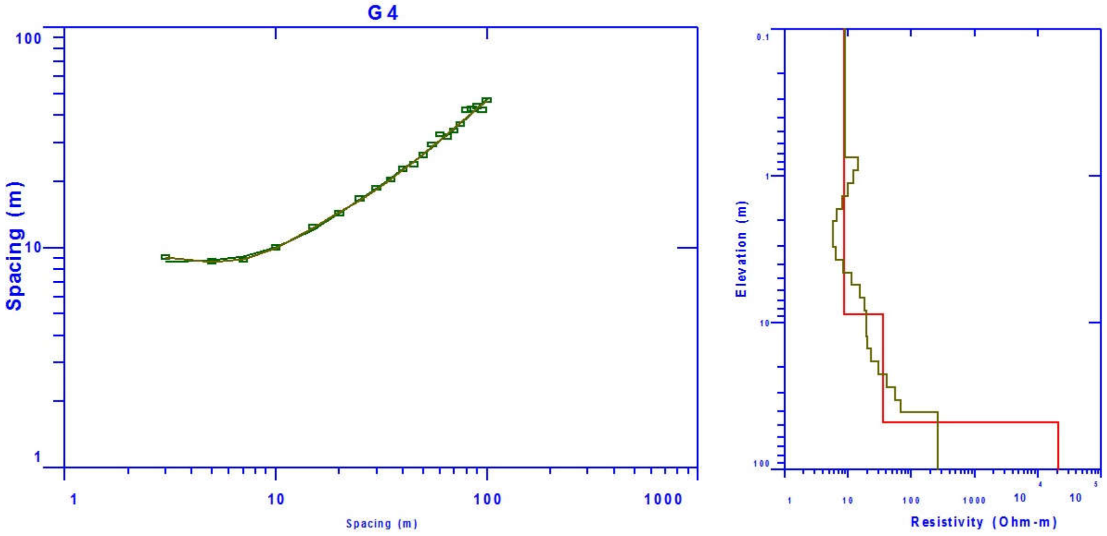

Fig. 3d: VES sounding curve of location G4

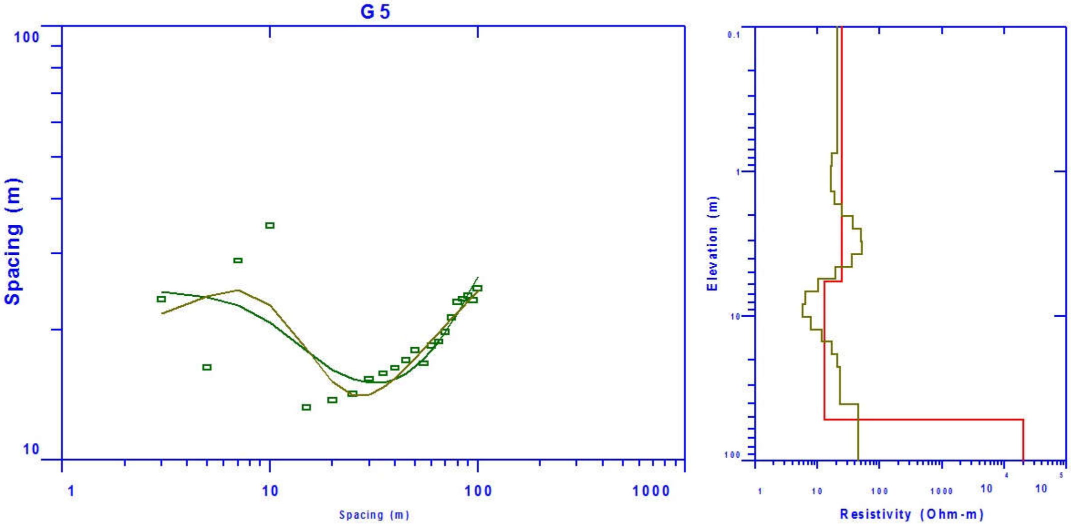

Fig. 3e: VES sounding curve of location G5

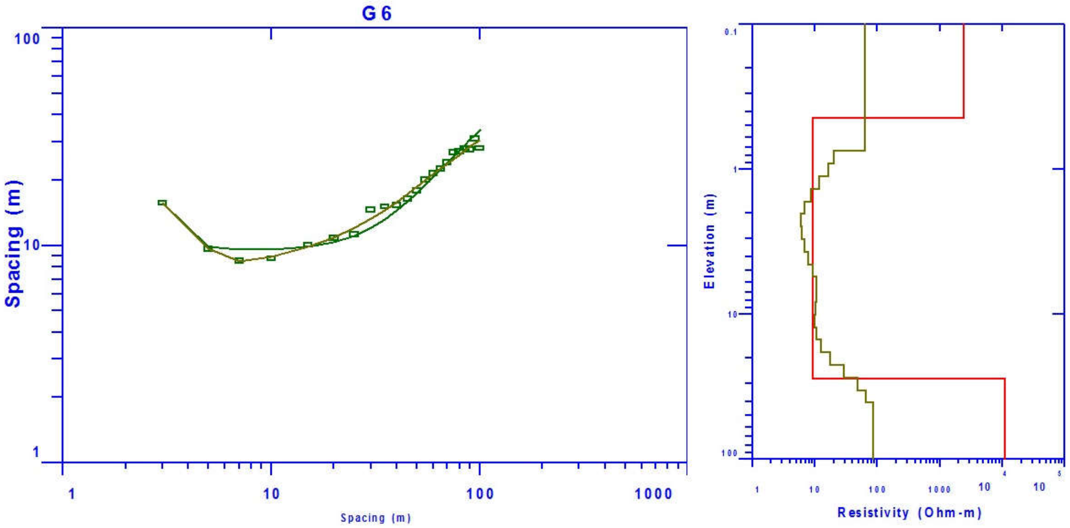

Fig. 3f: VES sounding curve of location G6

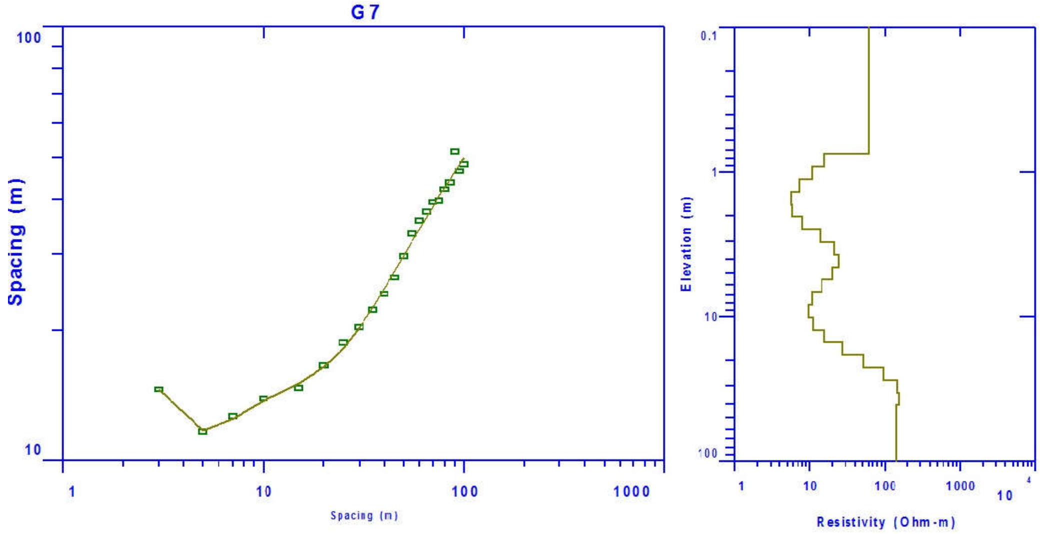

Fig. 3g: VES sounding curve of location G7

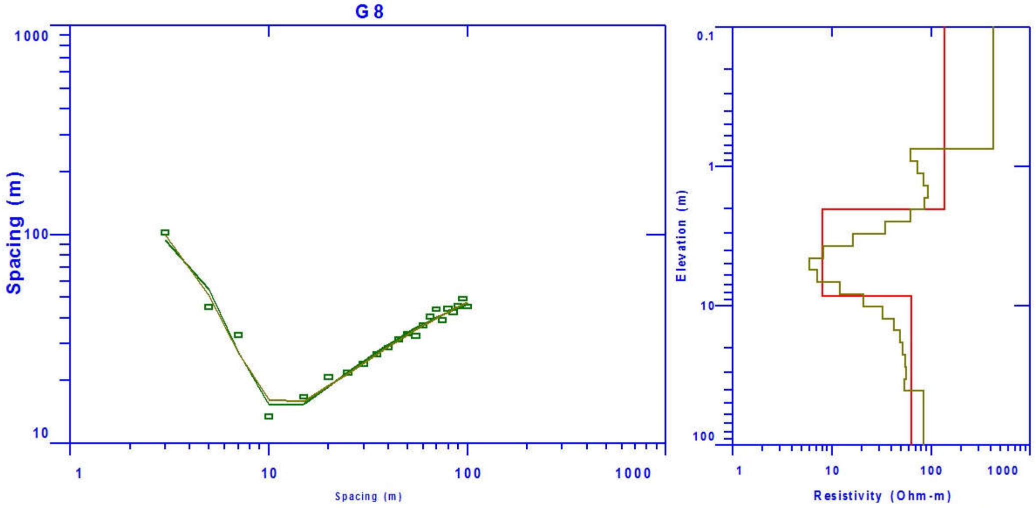

Fig. 4h: VES sounding curve of location G8

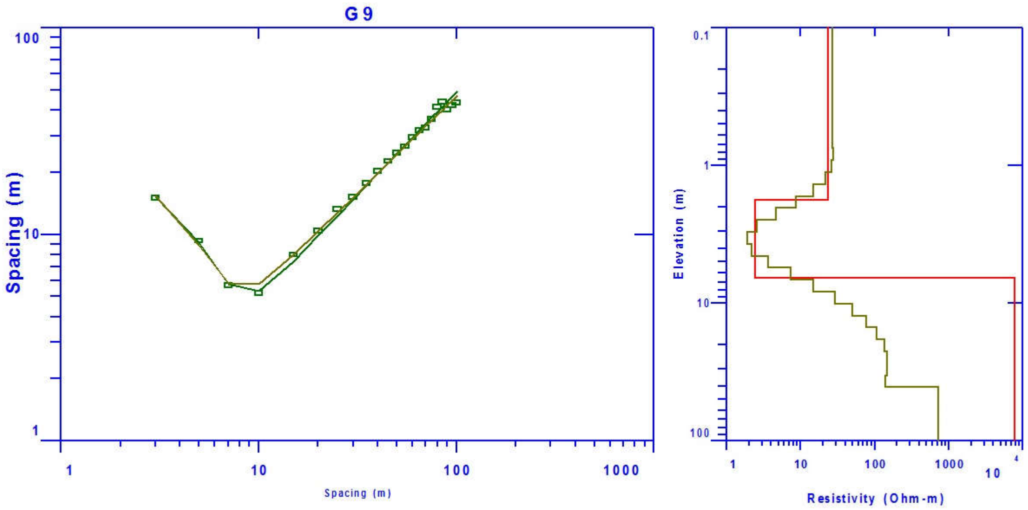

Fig. 3i: VES sounding curve of location G9

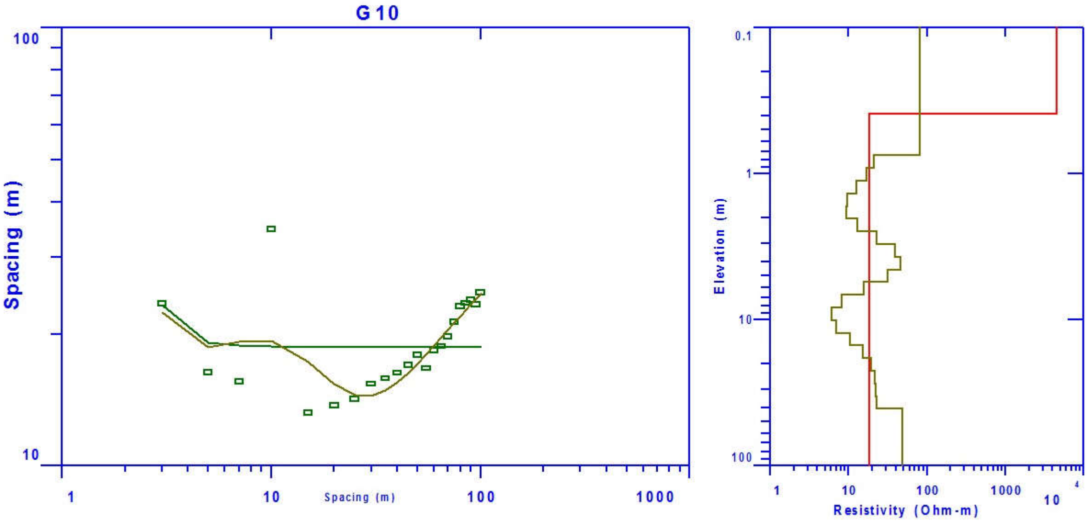

Fig. 3j: VES sounding curve of location G10

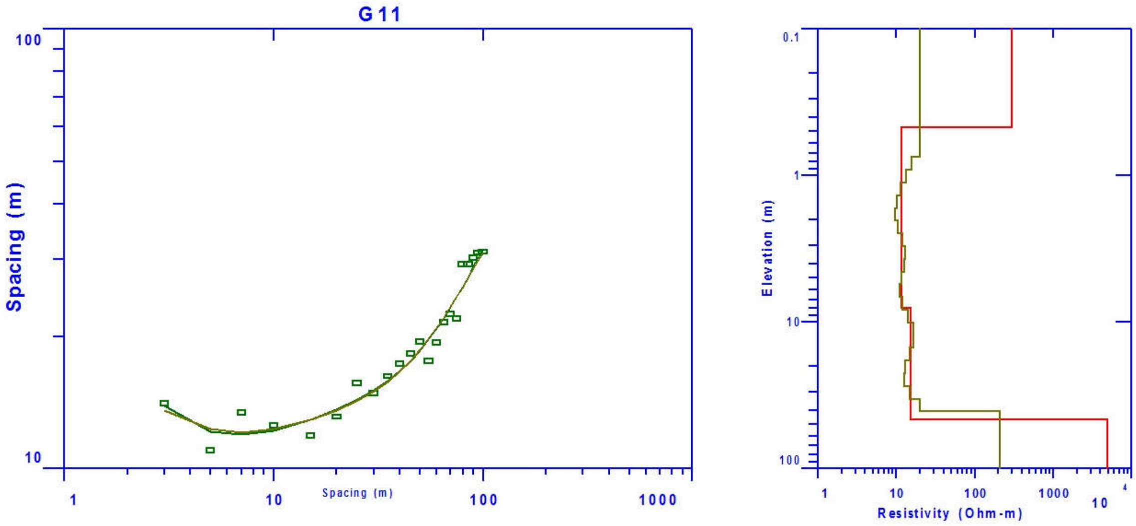

Fig. 3k: VES sounding curve of location G11

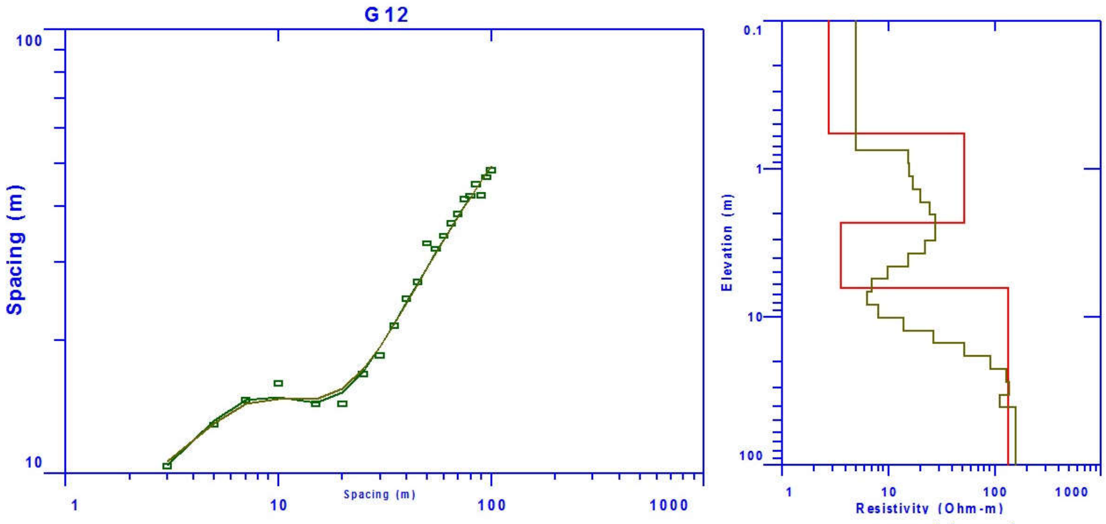

Fig. 3l: VES sounding curve of location G12

Table 2: Resistivity layer and thickness value of G1 to G12

Curve No	Resistivity	Thickness	Curve No	Resistivity	Thickness	Curve No	Resistivity	Thickness
G1	58.1	2.1	G5	2294.9	0.4	G9	23.2	1.5
	8.9	20		1	0.1		1.5	2.7
	120			198.9	0.9		251.4	
G2	6	0.6		33.2		G10	17.4	3.9
	1108	4.2	G6	66.6	0.9		8.6	3.5
	28.1	25.3		7.4	5.1		16.5	49.8
	79.2			11.4	17.6		180.9	
G3	25.5	3.5		81.5		G11	13	3.7
	28.4	10.9	G7	1056.3	0.4		9.6	3.4
	27693.1			12.4	16.4		15.8	39.6
G4	8.6	3.7		122.4			4443.1	
	35	37.8	G8	115.1	2	G12	2.4	0.4
	3395.7			2.8	1.7		61.9	1.4
				38.4	21.6		3.2	3.7
				81			130.1	

5. Discussion

These sites are distributed according to geomorphic units in the study area. Using the layer parameter so obtained from various resistivity sounding data in all 12 sounding values were interpreted starting from simple two-layer earth section and complex five-layer earth section were obtained. Total 12 VES conducted in the study area. The interpretation of these VES data reveals 4-5 layers. These geoelectrical layers comprises of top soil, weathered basement, partly weathered / fractured basement and fresh basement.

Subsurface layer indication low resistivity and enough saturated thickness are up to 30m depth. Soil cover in the study area is varies from place to place at some places weathered or murumatic rocks exposures are present, thickness of murumatic weathered rocks varies from 5m to 10m. The vesicular as well as amygdaloidal basalt occurring below the fractured and weathered zone having thickness of 10m to 35m.

The compact basalt is hard in nature and devoid of primary porosity and permeability. Based on Vertical Electrical Soundings suggestions like Roof Water Harvesting, traditional and advanced waterconservation methods if employed deficiency of water may be overcome.

6. Conclusion

The use of geoelectrical soundings provides an inexpensive method for characterizing on the groundwater conditions of the region as well as electrical resistivity is the main tool for groundwater exploration using the data obtained from electrical resistivity measurements and their good correlation with the borehole lithology in different parts of the study areas. The VES curves have brought out of three and four types of curves which are typical of Deccan trap formation.

Vertical electrical sounding technique of the electrical resistivity method has proven to be successful and highly effective in the identification and delineation of subsurface structures that are favorable for groundwater accumulation in a Deccan trap complex area. The electrical resistivity survey method used in this project necessitates locating favorable dug well and boreholes of the area.

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