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Studies on subsurface resistivity structures for groundwater harvesting in Dhubdhubi Basin, Solapur District, Maharashtra, India

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ABSTRACT

Measurements of electrical soundings in grid have been taken at 40 observation points, covering the entire Dhubdhubi basin, a sub basin of Bhima river in the Solapur District Maharashtra. The results of the sounding data revealed two-, three- and multi-layered earth sections. The resistivity distribution for a= 10 m, in the Wenner configuration, the pre monsoon water level contour map and structure contour map at the base of the first layer, interestingly correlate with each other for most part of the basin. The structure contour maps for five layers and structure profiling along three directions have been drawn and sites for groundwater development and groundwater harvesting are suggested.

INTRODUCTION

Resistivity sounding provides very useful subsurface information regarding subsurface resistivity distribution and the thickness of various layers which can be correlated with the local geology for the present investigations in Dhubdhubi basin, 40 electrical soundings Wenner electrode configuration have been taken with in a grid pattern and processed.

The resistivity sounding curves were first interpreted by the curve matching technique (Bahttacharya & Patra1968). Using these layer parameter so obtained, the interpretation was further refined by computer-aided technique (Koefoed 1979) by changing layer parameter in an interactive manner to archive better match between the observed and the computed curves.

However, in situations where 2-D coverage of the soundings has been made over the over the survey area, it is possible to prepare contour maps for the subsurface interfaces of different layers obtained from resistivity soundings. These contour maps on different layer interfaces, called structure contour maps (Twiss & Moores 1992), provide qualitative regional correlation between the subsurface geology and the electrical resistivity. The electrical resistivity in turn can delineate possible aquifers. In structure contouring, the interfaces of different layers are conceptually visualized by progressively stripping the top or the first layer, then the combined first and the second layer and so on. As the surfaces of the deeper horizons are exposed one after another, the interpreter progressively gets nearer to the groundwater table, unconfined aquifers, the impervious layers and the confined aquifers. The flow systems or patterns for each of the aquifers in a multiple aquifer system are also visualized. That is to say one moves to deeper horizons in stages. This useful approach has been proposed by Narayanpethkar, Vasanthi & Mallick (2006). The favorable horizons for groundwater accumulation, under the unsaturated situation can be utilized for groundwater harvesting.

This technique has been attempted in the present investigations in the Dhubdhubi Basin, it is in South Solapur and Akkalkot Taluka of Solapur District Maharashtra, and is located on Survey of India toposheet no 47 0/14, 47 0/15, 56 C/2, 56 C/3 on the scale of 1:50000. It lies between Latitudes 17° 21' to 17° 41' N and longitudes 76° 00' to 76°11' E in fig. 1. The total area is 450 sq km.

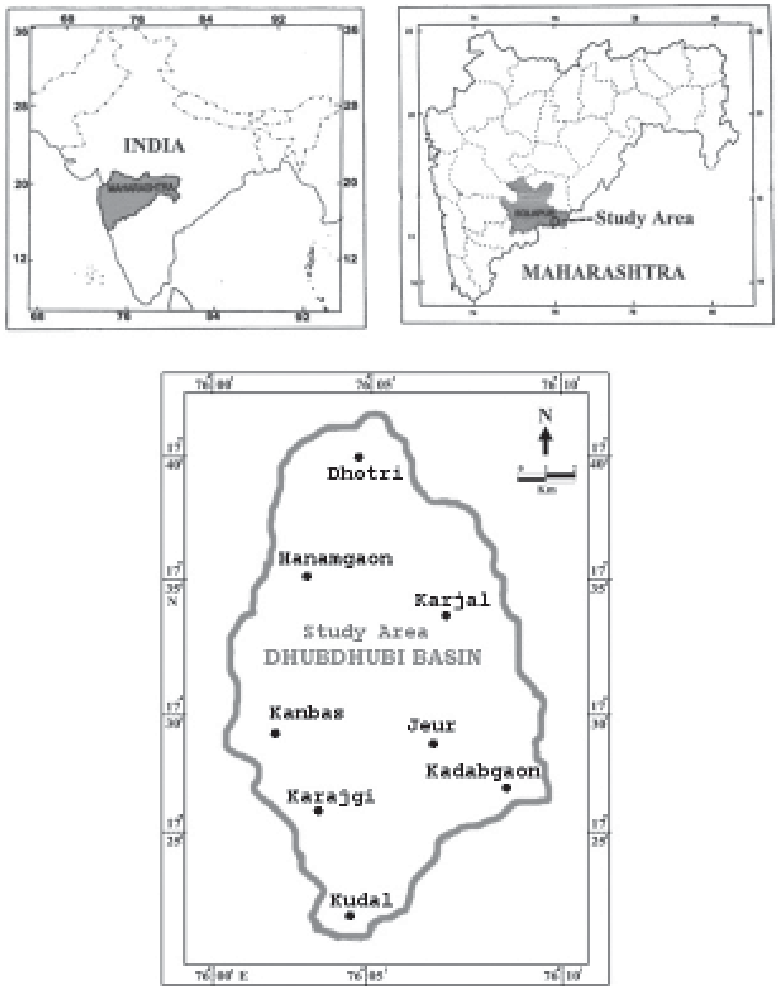

Figure 1. Location map of Dhubdhubi Basin, Solapur District,Maharashtra.

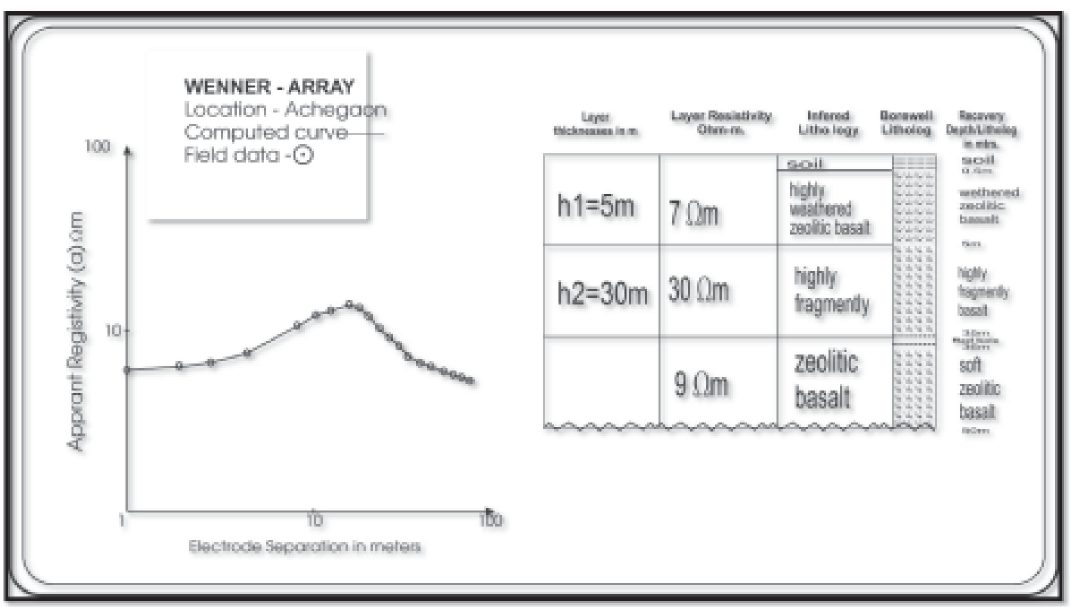

Figure 2. Resistivity sounding results and the borewell litholog correlation at Achegaon.

GEOLOGY

The geological formations in the Dhubdhubi Basin belong to Indrayani Stratigraphic unit of Sahyadri group of Deccan trap Formations of upper Cretaceous to lower Eocene age. There are four "aa" Flows of 21m, 21m, 46m and 22m thicknesses respectively. The flows consist of basal clinker, massive basalt, vesicular/ Zeolitic basalts and red boles. This forms complete succession of one lava flow. Upper and lower lava flows represent part of it, as a section is weathered and eroded.

RESULTS OF RESISTIVITY SURVEY

Wenner configuration has been used to carry out resistivity sounding. Interpretation of resistivity sounding data has been done using curve matching technique mostly in the field with the help of the standard master curves (Rakesh Kumar 1970) and later with the help of computer – aided techniques. The results of the sounding data revealed two, three and multi layer earth – sections. The majority of the soundings showed three- layer and four- layer earth-sections. The resolution gets poorer with the increase in the number of layers, particularly at depths. A representative sounding result has been shown in the fig. 2 at Achegaon. This shows resistivities 7, 30, 9 ohm m and layer thicknesses of 5, 30 m and the basement. However, borehole litholog shows recovery of soil 0.5 m, then 4.5 m weathered zeolitic, 30 m of highly fragmentary basalt,1m red bole and then up to total 50 m depth i.e. 14 m thick soft zeolitic basalt. The soil and redbole layers could not be resolved because of very thin layers.

STRUCTURE CONTOURS

The structure contour maps have been prepared for the Dhubdhubi basin. If one imagines that the entire top first layer material is removed, the surface of the second layer is exposed. This pseudo-surface has the form as that of elevation contour map at the base of removed layer, as shown in fig. 3(a). It is interesting to note that these elevation contours nearly resemble those of the observed groundwater table, fig No. 4, in the northern and southern portion of the basin. However, in the central portion of the basin the contours show different shape because of the higher thickness of the layer. This portion represents a trough like structure which is clear in the 3-D surface map showing a depression in that zone fig. 3 (b). If we compare the Ist horizon resistivity contour map for a = 10m fig. 5 with that of the base of the Ist layer structure map the resistivities in the central portion are of the order of 100 ohm-m representing hard rock. The resistivities between 30 and 40 ohm-m in the NE portion shows weathered rock. The central trough like structure shows higher resistivities ranging between 50 and 90 ohm-m. The basin in the south and west-central portion show low resistivities representing thick weathered zone. It is also interesting to note that the groundwater flow directions can also be visualized from the structure contour maps and apparent resistivity contour maps.

Fig. 6(a) shows the surface structure at the base of second layer. It has contour closures almost aligned in NS direction and shows depressions in the NW. The central and the southern parts of the basin are elevated giving a necklace appearance, in the eastern basin boundary in Fig. 6 (b). The3-D surface map at the base of second layer shows elevated central part.

The structure contour map of the basin at the base of third layer is completely different from the previous one, and shows closed contours extending NE-SW with a deep depression in the central part of the basin, grooving towards SW. The basin boundaries show high ground surface with a peak near Karajgi as shown in fig. 7 (a) and a 3-D synoptic view in fig. 7 (b). Such a depression will facilitate accumulation of groundwater or this can be the site for artificial recharge at a larger depth.

The base of fourth layer surface shows prominent step like depression from the eastern part of the basin to the central zone. However, the slope of the surface decreases in the central zone. This is represented by wider contours. Two moderately high peaks, one in the NW portion and another in the south central zone are also prominent as seen in fig. 8 (a) for 2-D and 8 (b) for 3-D surface maps.

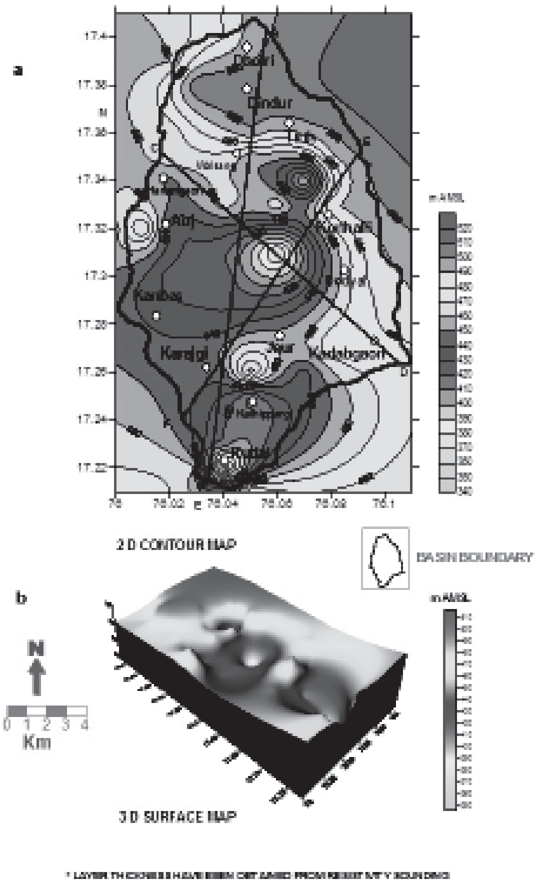

Figure 3. a) Subsurface contour map at the base of first layer in Dhubdhubi Basin. Solapur Dist., Maharashtra, Contour Interval: 10m. b) 3D Subsurface map at the basin of first layer in Bhubdhubi Basin.

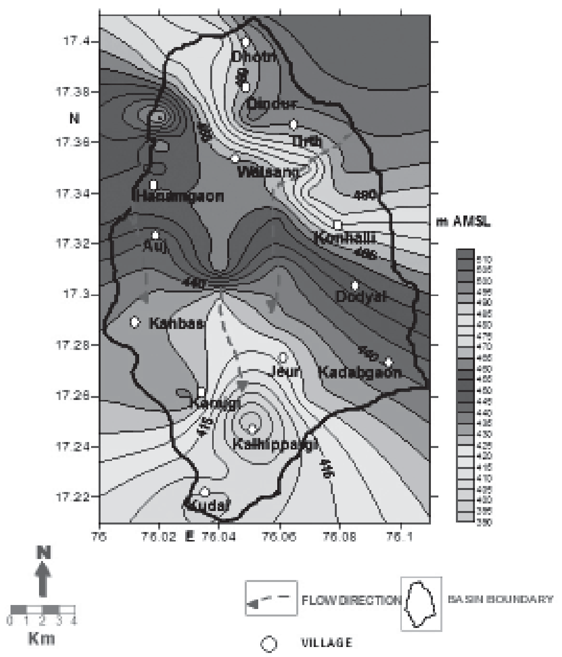

Figure 4. Pre-monsoon groundwater level contour map with flow direction for May 2003 in Dhubdhubi Basin, Solapur Dist. Maharashtra Contour Interval: 5 m.

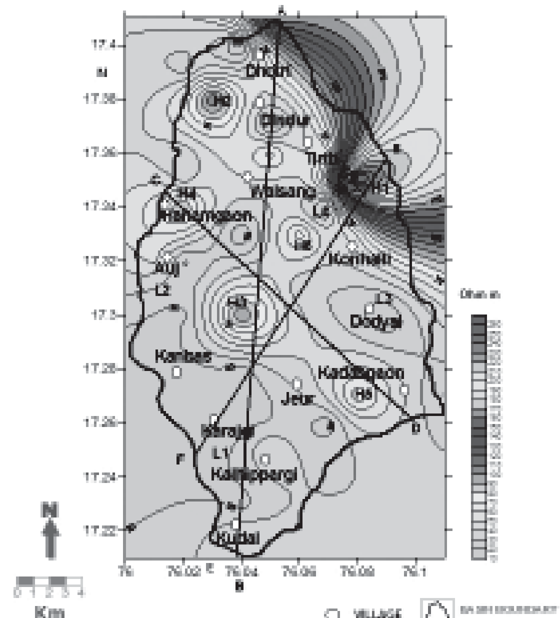

Figure 5. Apparent resistivity contour map in Dhubdhubi Basin, Solapur Dist. Maharashtra Contour Interval: 10 m.

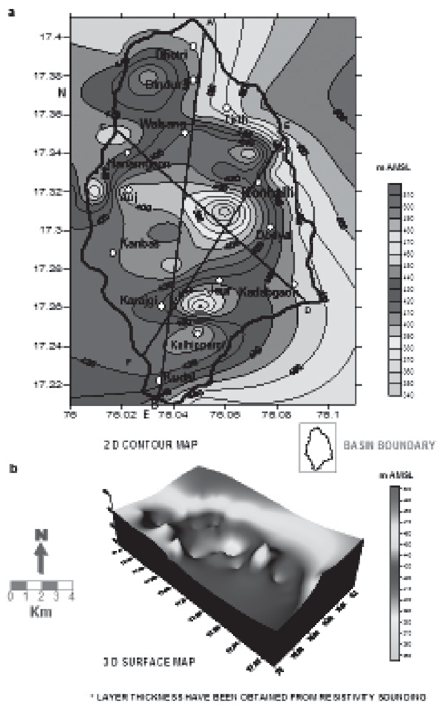

Figure 6. a) Subsurface contour map at the base of second layer in Dhubdhubi Basin. Solapur Dist., Maharashtra, Contour Interval: 10m. b) 3D Subsurface map at the basin of second layer in Dhubdhubi Basin.

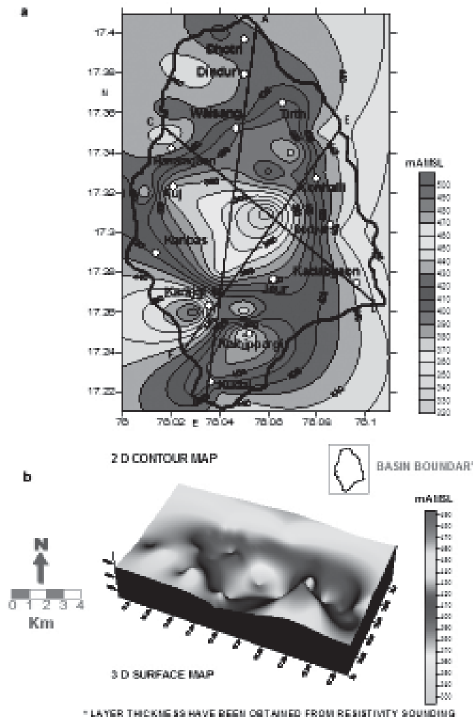

Figure 7. a) Subsurface contour map at the base of third layer in Dhubdhubi Basin. Solapur Dist., Maharashtra, Contour Interval: 10m. b) 3D Subsurface map at the basin of third layer in Dhubdhubi Basin.

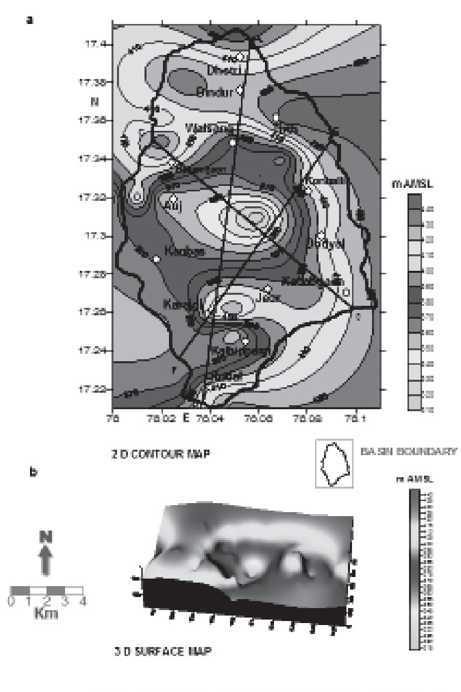

Figure 8. a) Subsurface contour map at the base of fourth layer in Dhubdhubi Basin. Solapur Dist., Maharashtra, Contour Interval: 10m. b) 3D Subsurface map at the basin of fourth layer in Dhubdhubi Basin.

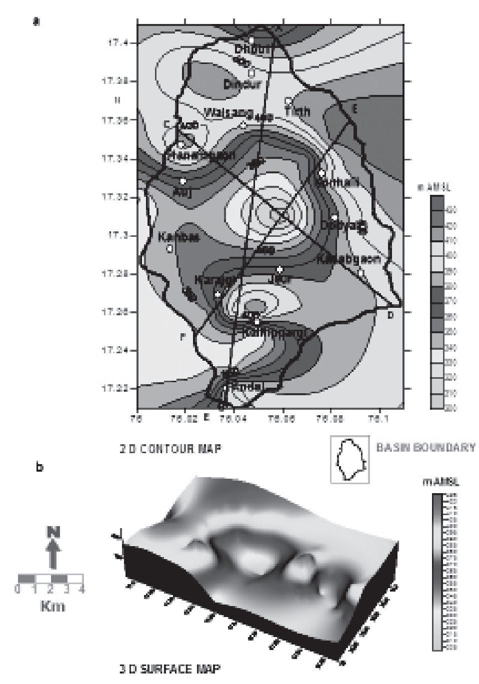

Figure 9. a) Subsurface contour map at the base of fifth layer in Dhubdhubi Basin. Solapur Dist., Maharashtra, Contour Interval: 10m. b) 3D Subsurface map at the basin of fifth layer in Dhubdhubi Basin.

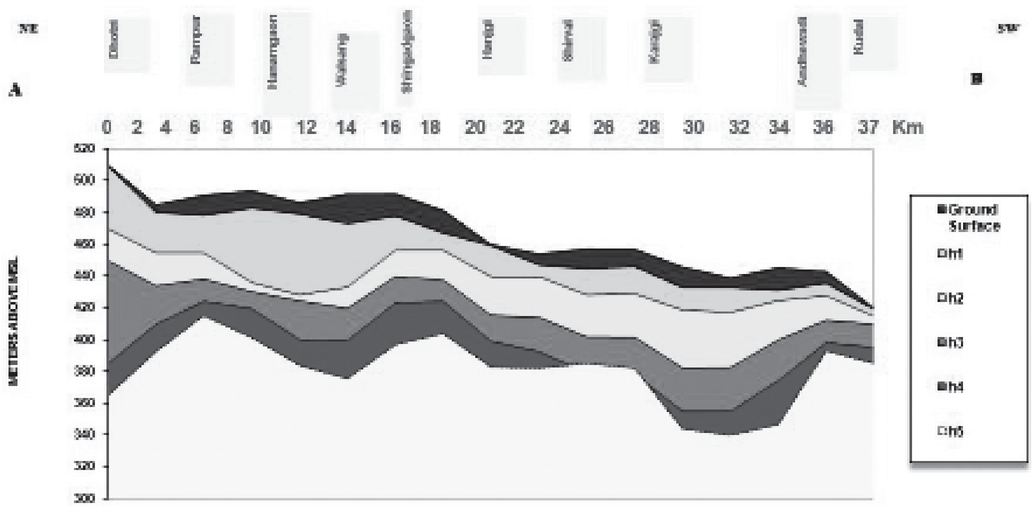

Figure 10. Depth profile along AB

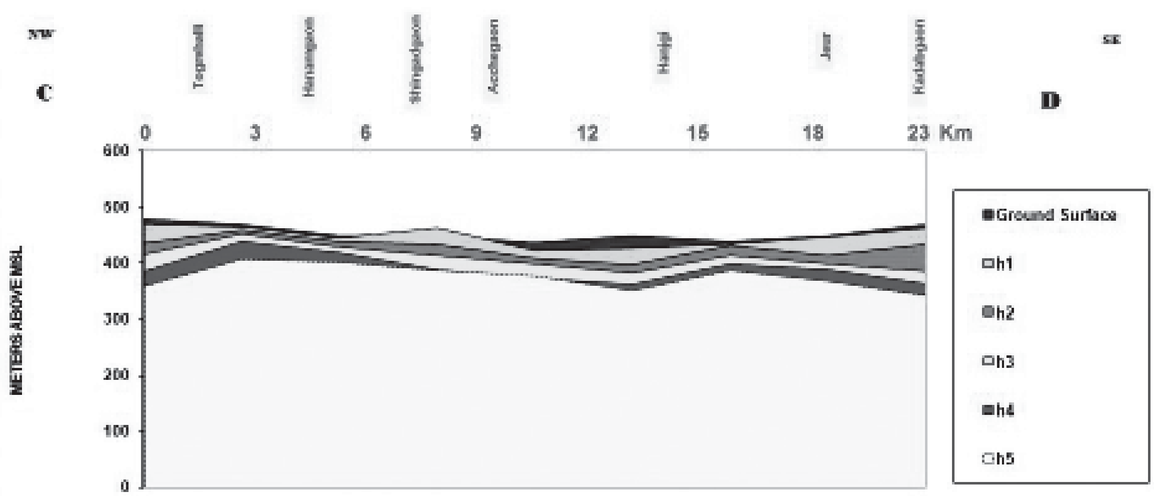

Figure 11. Depth profiling along CD

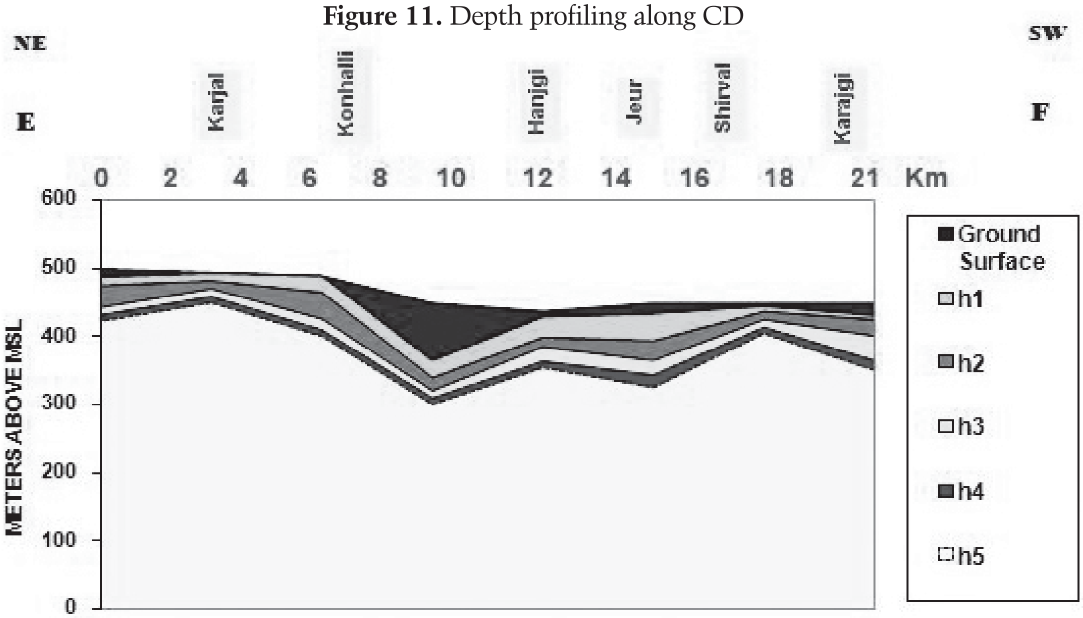

Figure 12. Depth profile along EF

Fig. 9 (a) and 9 (b) represent the structure contours and 3-D Surface at the base of fifth layer showing the same general trend of step like appearance having slope towards west and south west. The structure more or less coincides with the present day stream channel in general. The topography gets flattened in the west-central and southwest areas of the basin.

Vertical Structure Sections

The vertical section, obtained from the interpretation of the sounding data helps to have a quick look into the validity of the interpretation of the resistivity measurements in terms of the subsurface geology and possible sites for artificial recharge. The profile along AB runs NS. The following features have been observed in fig. 10.

1) The top layer is comparatively thin, maximum thickness of approximately 25m is observed near Shirval followed by 18 to 20m thick first layer below Rampur and Andhewadi.

2) The second layer is thickest (75m) between Hanamgaon and Walsang, followed by subsurface of Shingadgaon and area between Karajgi and Andhewadi. The thinnest layer of 10m is observed near Shirval and Andhewadi.

3) The thickness of the third layer varies between 10m and 30m in general. The area between Hanamgaon and Walsang shows large thickness. This is because of the depth of penetration of current is not sufficient for the electrode separation to resolve the thickness of the third layer.

4) The fourth layer thickness varies between 10 and 30m.

5) The fifth layer is comparatively thinner and the thickness could not be resolved under the surface between Shirval and Karajgi and Andhewadi.

6) Generally it is observed that the hard massive units of the lava flows prevent current penetration and the resolution of layer resistivity and thickness become poor.

The depth profile obtained along CD running in NW-SE direction, fig. 11 is also shows thin parallel five layers. The topography is almost flat and the layers are parallel to the present day topography. However, the subsurface between Shingadgaon, Achegaon, Jeur and Kadabgaon shows only three layers probably because the electrode spacings were not sufficient to resolve the thickness of the thick third layer. The subsurface below Achegaon and Jeur shows five layers.

The third section of subsurface structure EF obtained from the structure contours of different layers along NE – SW profile shown in the fig. 12 shows five layers of thin to moderately thick earth layers almost running parallel to the surface. However, under Jeur the fifth layer thickness could not be resolved.

DISCUSSION AND CONCLUSIONS

From the structure contours which provide pseudo surfaces of elevation contours at the bases of five successive layers the following information is drawn:

1) The elevation contours at the base of first layers nearly resemble the observed pre monsoon groundwater table map, broadly in the northern and southern portion of the basin. This map also resembles shallow depth apparent resistivity distribution map. Hence groundwater flow directions can be visualized from the contour maps at the base of first layer and apparent resistivity distribution map for a = 10m.

2) The resistivities in the NE, central west and southern portion represent the weathered zone, which is a favorable site for groundwater development. This also provides the information that the surface artificial recharge structures will be helpful for groundwater harvesting in these regions.

3) The structure contours at the base of the second layer have NS alignment of thicker formations having depression in the NW and elevated central portions, with higher resistivities

4) The pseudo topography at the base of the third layer shows a deep depression in the central part, grooving towards SW. Such a depression will facilitate accumulation of groundwater and suitable for artificial recharge at that depth

5) The base of the fourth and fifth layer shows same general trend with a step like appearance having slope towards SW. The structures more or less coincide with the present day stream channels. It is also clear that deeper borewell structures are necessary for artificial recharge in these areas.

Thus it is concluded that the studies on subsurface resistivity distribution reflect the overall nature of the lava flows and give an idea about nature of palaeotopography. This is also useful to delineate basaltic flow units and therefore to differentiate the flow contacts which act as permeable zones for groundwater accumulation and movement and are also possible sites for artificial recharge.

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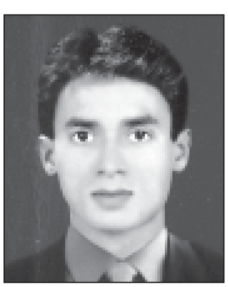

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