Geoelectrical Exploration for Groundwater in Shooroo Basin, Southwest of Zahedan, Iran

Hadi Tahmasbi nejad, Gholam R. Lashkaripour

Islamic Azad University, Behbahan branch, Tel: 09163720786, hdtahmasbi@yahoo.com

Department of Geology, University of Mashhad

Abstract

A geophysical survey using the Vertical Electrical Soundings (VES) techniques has been used to investigate the sub-surface layering in Shooroo basin, Southwest of Zahedan in order to determine the nature, characteristics and spatial extent of the components of the aquifer underlying the region, the field data was interpreted using the Russian software IPI7.63. The results of the interpreted VES data suggest that the region consists of four to five layers of topsoil, unsaturated aquifer, saturated aquifer and bed rock. From the viewpoint of geoelectric, aquifer is divided into two separated parts. One with high resistivity in the west especially southwest of basin which thanks to good water quality and coarse grain size (existing alluvial fan) and another with low resistivity specially in the central part, as a result of bad water quality inputted from adjust basin. The average resistivity of top soil, alluvium, aquifer and bedrock calculated in the entire basin are respectively as 110, 87, 27 and 110 Ohm-m, in the east as 70, 74, 12 and 103 ohm- m and in the west as 175, 116, 46 and 106 ohm-m. The depth and thickness of the aquifer were measured in the entire basin as 30 and 30 m, in the east as 23 and 24 m and in the west as 40 and 41 m. In the case study, the relationship between the depth of current penetration and length of current electrodes is obtained. Limitation of aquifer, depth of aquifer in entire basin, and isopize groundwater map to be obtained from geoelectrical survey, also zones with high yield potential have been determined.

Key Words: *exploration, Groundwater, Vertical Electrical Soundings (VES), Shooroo basin.*

Introduction

Shooroo basin is located in Southwest of Zahedan and between longitudes of 60˚50´ to 20˚12´ (fig. 1). Average of annual rainfall in Shooroo basin is 84 millimeter and its climate is dry (using Demarton method), and intense hot (using Amberger method).

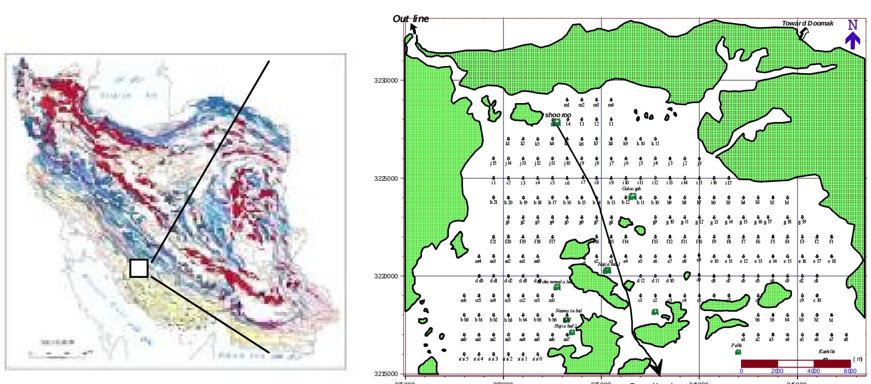

Fig.1. Location of investigation and sounding data

Geological Setting

From the view point of geology and structural geology, Shooroo basin is located in Flysch zone of Eastern Iran. In this zone, sediments of older than cretaceous are absent, mountains direction is north-south and more numerous Flyshes were metamorphic (McCall, 1997).

Approximately entire area has been covered by Slats mainly green as upper Cretaceous age and partly, Eocene too.

In west part of watershed were observed intermediate of Phylit and Sandstone. Quaternary alluviums that has covered plain surface were involve to fine grain alluvium of Shooroo river and drainage's, gravel to pebble of alluvial fan and too sand to gravel's of near the mountains.

Introduction

Surface geophysical survey as a veritable tool in groundwater exploration, has the basic advantage of saving cost in borehole construction by locating target aquifer before drilling is embarked upon (Obiora and Ownuka, 2005).

Vertical electrical sounding (VES) is a geoelectrical common method to measure vertical alterations of electrical resistivity (Heilan, 1940).

Also, schlumberger array is found to be more suitable and common in groundwater exploration. It is well known that resistivity methods can be successfully employed for ground water investigations, where a good electrical resistivity contrast exists between the water-bearing formation and the underlying rocks (Zohdy et al., 1974)

In general, VES method with Schlumberger array assumes considerable importance in the field of ground water exploration because of its ease of operation, low cost and its capability to distinguish between saturated and unsaturated layers. Thus this technique has been used in case study. This method is generally used to solve a wide variety of groundwater problems. such as determination of depth, thickness and boundary of a aquifer (Bello and Makinde, 2007; Omosuyi, 2007; Ismail Mohamaden, 2005), determination of zones with high yield potential in a aquifer (Akaolisa, 2006; OSEJI, 2005), determination of the boundary between saline and fresh water zones (El-Waheidi, 1992; Khalil, 2006), delineation groundwater contamination (Kelly, 1976; Park et al., 2007), Exploration of geothermal reservoirs (El-Qady. 2006), estimation of porosity of aquifer(Jackson et al., 1978), estimation of hydraulic conductivity of aquifer (Asfahan, 2007; Yadav, 1995) estimation of aquifer transmissivty (Kosinski and Kelly, 1981) and estimation of aquifer specific yield(Frohlich and Kelly, 1988). The electrical resistivity technique enables the determination subsurface resistivity by sending an electric current into the ground and measuring the potential field generated by the current. The depth of penetration is proportional to the Schlumberger array uses closely spaced potential electrodes and widely spaced current electrodes.

Separation between the electrodes in homogeneous ground and varying the electrodes separation provides information about the stratification of the ground (Dahlin, 2001). However, in general, the depth of infiltration is small in this method, and only shallow subsurface layers have been surveyed (Danielsen et al., 2007). For soundings, the apparent resistivity values (ρ_a) were plotted against half current electrode separation on a log-log graph and a smooth curve was drawn for each of the soundings. Then, the sounding curves were interpreted to determine the true resistivities and thicknesses of the subsurface layers.

Geoelectrical resistivity survey

Geoelectrical survey of Shooroo basin was involve 207 vertical electrical sounding by Schlumberger array and 19 profiles (profile spacing was 1 kilometer) that sounding spacing was 750 m and direction of total profiles was East-West (Fig. 1).

For Schlumberger soundings, the apparent resistivity values were plotted against half current electrode separation (AB/2) on transparent double log graph paper and a smooth field curve was drawn for each of the soundings. The field curves were interpreted by the well-known method of curve matching with the aid Russian software IPI7.63.

The key to success of any geophysical survey is the calibration of the geophysical data with hydro geological and geological ground truth information. Therefore, a number of geoelectric stations were purposely located near about 70 wells so that litologic information obtained from log could be used to calibrate the V.E.S field curves. Where test hole-log information was available, the solution to automatic interpretation procedure was constrained by keeping known layer thickness constant during the program computations.

The result of Schlumberger soundings have been compared with the geoelectrical sections obtained from 13 Pizometer. These results are in good agreement whit the geological sections.

Results and discussion

At the test sites, one type of sounding curve was observed that a four-layer curve resulted from a four-layer section consisting of topsoil, unsaturated aquifer, saturated aquifer and bed rock. In some cases more than one layer was evident in the saturated zone but these cases were also treated in this analysis as single layers. Depth and thickness of subsurface layers were identified and dimension of the aquifer and type of bedrock were indicated. Bedrock of area is generally Slat but in some parts is appeared as Shale. Geoelectrical section of profile a`a` has been shown in figure 2, for example**.**

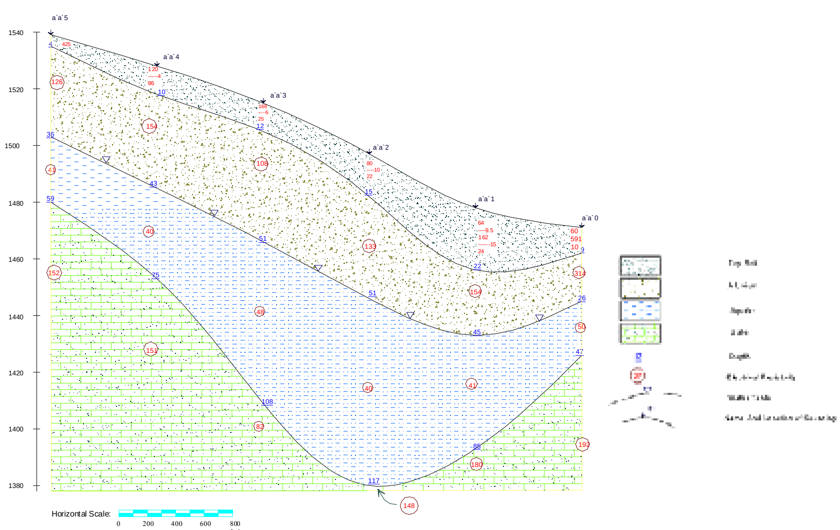

Fig. 2. The geoelectrical section of profile a`a`

Two separate parts is identifiable in the east and the west parts of basin. The average resistivity of top soil, alluvium, aquifer and bedrock respectively calculated in the total basin as 110, 87, 27 and 110 Ohm-m, in the east as 70, 74, 12 and 103 ohm- m and in the west as

175, 116, 46 and 106 ohm-m. Depth and thickness of the aquifer were measured in entire basin as 30 and 30 m, in the east as 23 and 24 m and in the west as 40 and 41 m.

These are obtained in the west part due to existence alluvial fan and in the other due to bad water quality inputted from adjust basin.

Yield potential in the west part of basin is more than another part and profile ee has the most of yield potential and the best of water quality with respect to high thickness and resistivity.

The geoelectrical model of subsurface layers indicates average of resistivity and thickness of layers is shown in Fig.3.

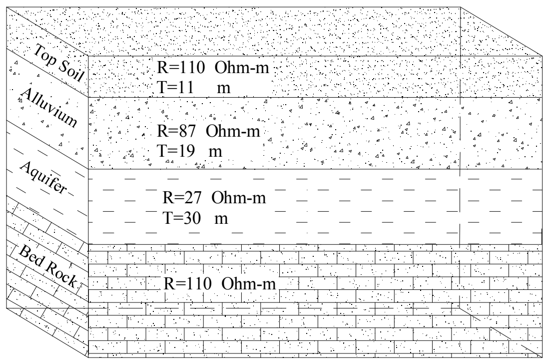

Fig.3. The geoelectrical model of subsurface layers.

Also, for example, interpreted curve of sounding aa_5 by software IPI7.63 is shown in Fig.4.

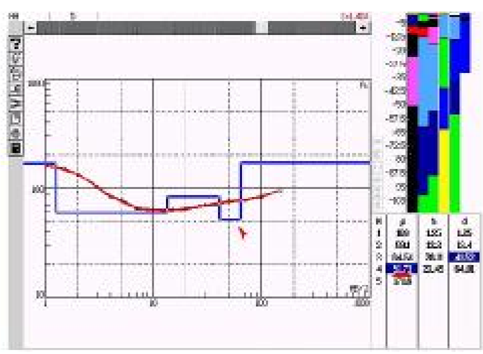

Fig.4. Typical interpreted VES curve from study area (sounding aa_5).

After the interpretation, depth of current penetration in plain was calculated (Fig.5), as:

$$Depth = 0.57(\frac{AB}{2})^{0.97}$$

This relation present current penetration depth in plain equal Approximately $\frac{AB}{4}$.

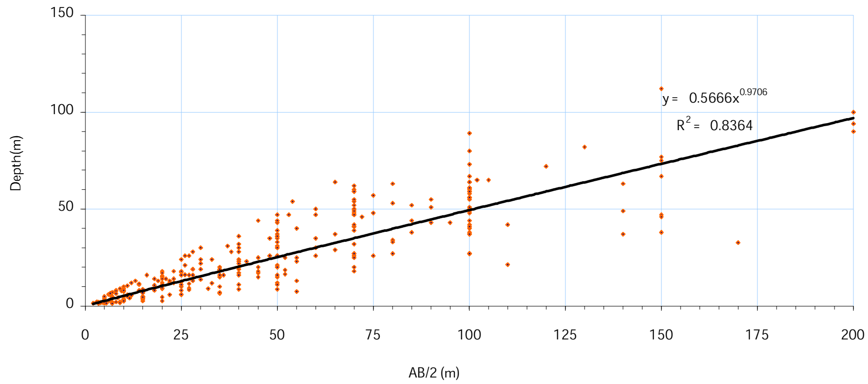

Fig.5. relation of depth of current penetration with length of current electrodes

Fig. 6 shows isopize groundwater map to be obtained from geoelectrical survey that represents inflow and outflow of aquifer. Limitation of aquifer and type of bedrock were indicated. Bedrock of area is generally Slat and at some points has appeared as Shale.

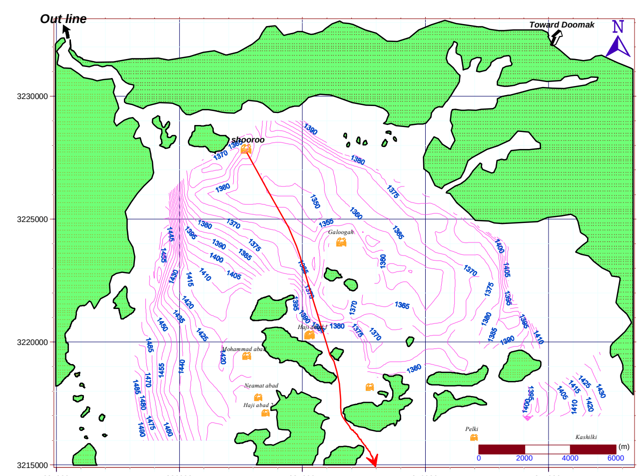

Fig. 6 Isopize groundwater map (obtained of geoelectrical survey)

Conclusions

The geoelectric investigations showed that there are four geoelectric layers correspond to near-surface layers, dry alluvium, aquifer and bedrock. Aquifer has different resistivity values that respect to its water quality and its component grain size. Also bedrock show different resistivity values with respect to degree of saturation and values of fracture. In the west part of plain, yield potential and water quality is more than another part.Limitation of plain has been estimated profile e in Sought-East profile a`a` in Northwest and mountains in North.

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