Modern Applied Science; Vol. 10, No. 1; 2016
ISSN 1913-1844 E-ISSN 1913-1852
Published by Canadian Center of Science and Education

Determining Aquifers and Bedrock of Qaen Plain by the Resistance Measurement Method

Farnusch Hajizadeh[1] & Saeed Reza Akhondi[2]

[1] Assistant Professor, Urmia University, Iran

[2] Graduate Student, Urmia University, Iran

Correspondence: Farnusch Hajizadeh, Assistant Professor, Urmia University, Iran. E-mail: f.hajizadeh@mail.urmia.ac.ir

Received: November 2, 2015 Accepted: November 19, 2015 Online Published: January 5, 2016

doi:10.5539/mas.v10n1p200 URL: http://dx.doi.org/10.5539/mas.v10n1p200

Abstract

The aim of this study is to determine aquifers and bedrock of Qaen plain by the resistance measurement method. Using symmetrical Schlumberger electrode array, the most common method to detect underground water, Qaen plain was located in the west of Khanik village situated in the North East of drainage basinto the West of Aliabad village situated in the West of drainage basinat 159 electric sounding stations along 13 profiles under the geoelectrical operation. Profiles were along the south East-North West. At most, the half of the Electrode distance was 500 meters in the Schlumberger array. Interpretation of geoelectric sounding was done using the Partial and computer compliancemethod (using ipi2win Software). The obtained results of the Geoelectrical operation were interpreted and drawn by resistivity section, resistivity profiles, the apparent resistivity maps of the different flow lines (AB including 200, 600, and 1000 meters), and isobath map of the rock.

Keywords: vertical electrical sounding, Schlumberger array, apparent resistivity

1. Introduction

Geo Electric is one of the important branches of geophysics, which are often used to track metal and conductive minerals. This method is largely used for water exploration and engineering works (to determine the depth of the bedrock). In general, electrical grounding techniques are less used in the oil fields because they are useful in low depth and can't provide useful information aboutthe subsurface forms greater than 500 meters. Measuring the electrical resistivity is considered as the basis for the detection of layering and the internal structure of the ground. The method of the electrical resistivity harvest is performed by creating a direct current (low-frequency alternating current) inside the ground between the electrodes. This method is the best tool for the accuracy of the sections on the ground. This method is considered as the best tool for distinguishing and separating subsurface layers in terms of the resistivity and thickness as well as the location and exploration of underground water. One of the most important issues in this regard is locating groundwater and quantitative studies and qualitative analysesfor them. According to this method, the vertical electrical sounding data are used for the quantitative interpretation and the data processing of profiles are used for the qualitative interpretation. Furthermore, resistivity sections are drawn for studying and detecting thesubsurface layers.Vertical electrical sounding method is used for studying vertical and deep changes of the resistivity and thickness of the layers (Heiln, 1940). This method is suitable for the study of hydrology of the sedimentary basins (Kelly & Stanislav, 1993). One dimensional modeling is used to study and detect subsurface structures (Zohdy, 1989). Vertical electrical sounding method is used for groundwater exploration in sedimentary environments (Emenike, 2000). This method is used to determine the depth, thickness and boundaries of aquifers (Bello & Makinde, 2007; Ismail mohamaden, 2005)zones with high potential in a aqueous layer (Akaolisa, 2006; Oseiji et al., 2006) the boundary between fresh and salt water zones (El Waheidi et al., 1992) and groundwater pollution (Park et al., 2007).

2. Geography, Geology and Sounding of the Studied Area

The city of Qaenat is located in the East of Iran and the north of Southern Khorasan Province between 15 and 33 to 12 and 34, latitude and 38 and 56 to 56 and 60, longitude. This city is limited to Khaf and Gonabad from the north and to Ferdows and Sarayan from the West and to Birjand and Darmian from the south and has a

130km-long border with Afghanistan from the East. To access Ghaen Plain through the Asian road of Mashhad to Zahedanat a distance of approximately 105 kilometers of the south of Gonabad city,we reach Qaen city which is located in the western part of the plain center. Formation of Ghaen Plain related to Precambrian is made of granites, gneisses and metamorphic rocks. This formation is located in Zoul Mountain situated in the south of Rakhnamon basin. Formation of Mesozoic Era which is largely spread in the area is made of lime "Jurassic and Cretaceous" and alternation of shale and sandstone. Deposits of the Cenozoic era aremade of igneous rocks "andesite, tuff" sandstone and conglomerate. Most of them are in the North East and South Eastof Ghaen Plain. Quaternary sediments are made of the terraces, alluvial fans, loess and sand. They are seen in the range of heights in this plain.

3. Methodology

In order to determine the depth of aquifers and the bedrock, 13 resistivity profiles were designed and implemented along the South East-North West with Schlumberger array in Qaen plain. Given the number of sounding and the topographical region, the length of the profileswas varied. In this study, AB/2 including 100, 300, and 500 meters was used to draw and compare the results the geoelectrical sections and maps. IPI2win software was used for the interpretation of vertical electrical sounding curves and one dimensional modeling. Res2dinv software was used for two-dimensional modeling and the preparation of electrical resistivity sections. The apparent resistivity maps were prepared to investigate electric apparent resistivity changes in different horizons. Surfer software was used to counter data related to the depth of the bedrock and determine the direction of groundwater in the region. Three-dimensional model of the bedrock was drawn using the interpretation of the vertical electrical sounding curves.

4. Discussion

Although the electrical resistance was harvested on 9 profiles and then they were modeled and interpreted, in this study, the results of modeling and interpretation for one profile are discussed.

The respective profile is located in the west of Khanik village situated in the North East of drainage basin of Qaen plain. Four sounding stations are located in order of sounding 1 to 4 (Table 1) from South East to North West along the profile A. Underground layers in this stretch can be divided into 4 different types.

Table 1. Height values, UTM and number of the sounding stations in profiles A

station	**X**	**Y**	**Z**
1	713651	3738371	1469
2	713466	3738788	1445
3	713215	3739218	1448
4	711413	3745122	1366

1-According to the field curve for sounding 1 (Figure 1), it can be said that the first layer with the electrical resistivity of 15 ohm meters is evaluated as a thickness of 5 meters consisting of sand and clay particles and detected only in the location of sounding 1. Thesecond layer is detected by the electrical resistivity of 56 ohm meters and this layer is mainly composed of coarse particles of debris. The thickness of this layer is 17 meters at its greatest extent in sounding 1. Thethird layer is detected by the electrical resistivity of 8 ohm meters and is mainly composed ofclay particles. Thefourth layer is detected by the electrical resistivity of 100 ohm meters and is mainly composed ofseverely crushed limestone.

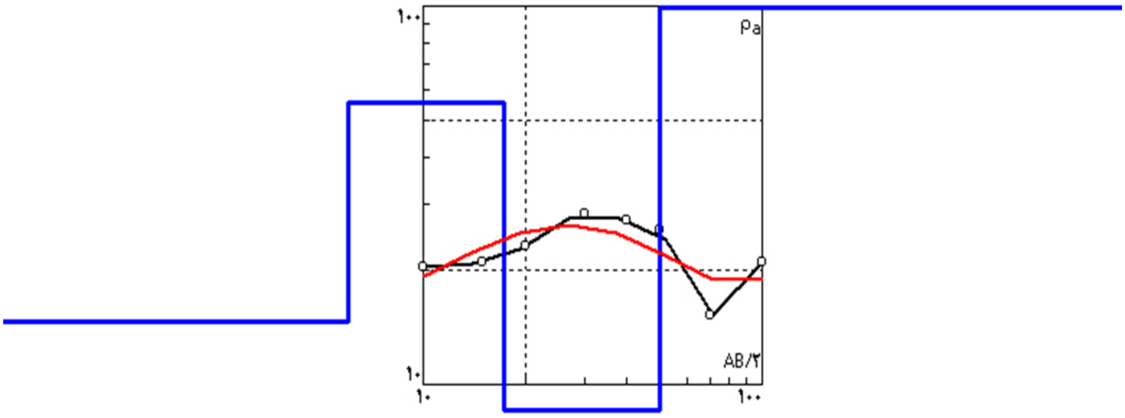

Figure 1. The calculated field curve forsounding 1

2-Three layers are detected in the location of sounding 2 (Figure 2). They are detectedby68, 8, and 100 ohm meter resistance.

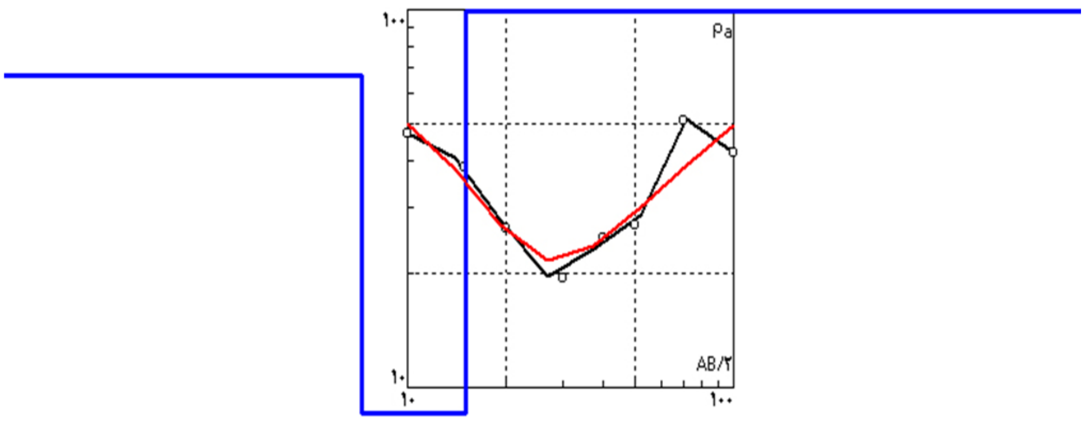

Figure 2. The calculated field curve for sounding 2

3-According to the field curve for sounding 3 (Figure 3), three layers are detected in the location. They are detectedby100, 12, and 80 ohm meter resistance, respectively.

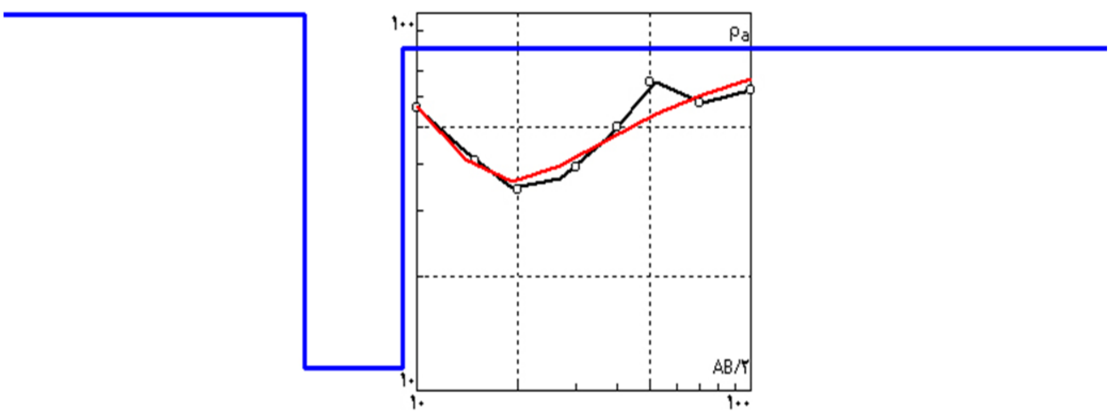

Figure 3. The calculated field curve for sounding 3

Drawing the cross-section of the profile A (figure 4), the layers are composed of four sections along the profile.

1. The first layer is only seen in the location of sounding 1.

2. The second layer with 56-100 ohm meter resistance is seen along the respective profile other than sounding station 4. This layer is mainly composed of coarse particles of debris.

3. The third layer is mainly composed ofclay particles. This layer also includes sand and gravel particles in the lower section of sounding 4. It is detected by 8-30 ohm meter resistance. The thickness of this layer is 40 meters at its greatest extent in sounding 4.

4. The fourth layer is considered as the bedrock and is mainly composed ofseverely crushed limestone. It is detected by 80-100 ohm meter resistance. According to the provided section, the depth of reaching water is predicted by 20-25 meters along the profile A.

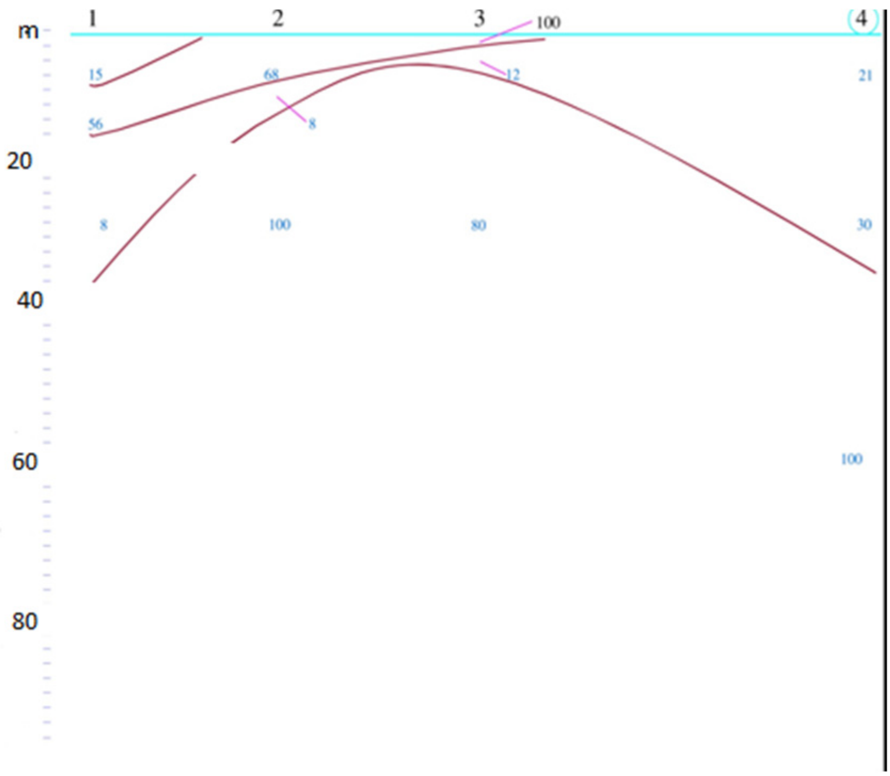

Figure 4. Geoelectric section of the profile

Map of the thickness for the alluvium (Figure 5) which can be considered as theisobath map of the bedrock represents changes in the thickness of the alluvial deposits in the different regions of the plain. In general, the thickness of alluvium in the North East of the basin (the location of the output) is lower than the other regions. The thickness of the alluvialreduces from West to East and from the plains to the mountain range. Most thickness of the alluvial deposits can be seen in southern and southwestern of the plain. The thickness of the alluvial was calculated from 65 to 190 meters in the region of Qaen city. In many points of sounding, the thickness of the alluvium was beyond the respective depth and the bedrock was not detected by the final depth. If we want to examine the general situation for the topography of thebedrock, the thickness of the alluvium reduces from the south to the north. Steep topography of the bedrock is from the North, North East towards the South, South West. The process of the bedrock is drawn according to the obtained depth. It is composed of Limestone, igneous rock, sandstone, conglomerate and shale.

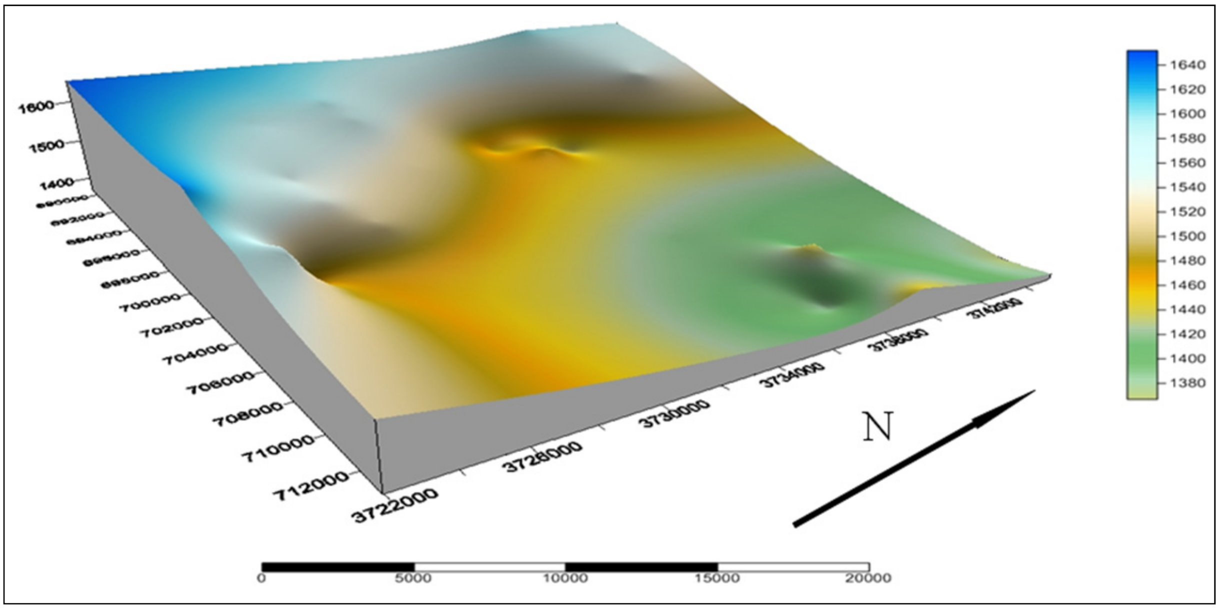

Figure 5. The three-dimensional view of the bedrock in the respective region

Forasmuch as the steep topography of the bedrock is from the North, North East towards the South, South West, the process of the groundwater movement is towards the North East of the plain because the plain region was less tectonized. The reports about the piezometers wells by the soil mechanics in Razavi Khorasan Province confirm this issue (Figure 6).

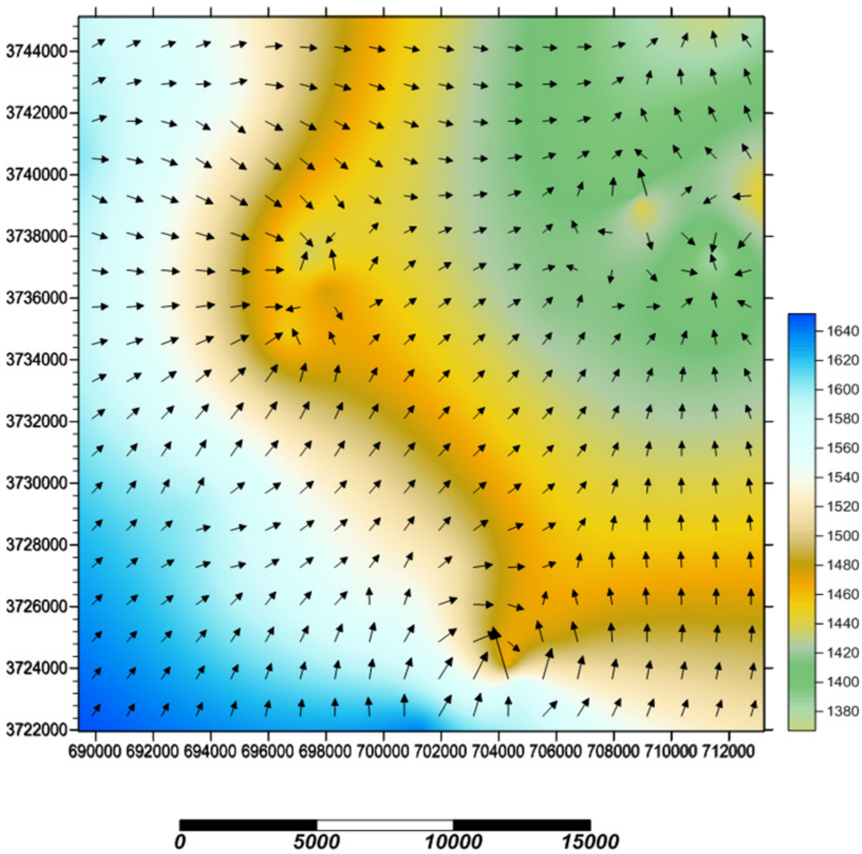

Figure 6. The process of the flow on the bedrock in the respective region

Table 1 shows the scale of the electric resistivity, the changes for the electric range in the underground layers, and their sedimentary features in the studies region. According to the description of geoelectric sections and resistance curves, Appropriate locations are presented for the extraction of underground water in terms of quantity and quality along with the proposed depth for drilling (see Table 2).

Table 1. Scale of electrical resistivity

Sedimentary layer	Scale of electrical resistivity (ohm-m)	Geological description
The first layer	6 - 500	Agricultural soil, clay, silt, sand Debris and dense particles
The second layer (aqueous)	2 - 25	Clay and silt containing water
The third layer (aqueous)	40 - 400	Sand, gravel, river rubble containing water
The fourth layer (bedrock)	6 - 1000	limestone, igneous rock, sandstone, conglomerate and shale

Table 2. Suggested points for drilling

station	X	Y	Z	Profile	depth
3	713215	3739218	1448	A	100
4	711413	3745122	1366	A	100
9	711471	3737331	1383	P	80
14	708896	3739044	1442	T	200
15	708664	3739415	1397	T	180
36	704681	3723476	1575	D	80
42	702467	3727563	1511	D	210
48	705603	3735824	1416	D	160
76	706176	3724830	1483	K	100
81	704328	3724141	1464	D	100
84	702641	3727327	1511	D	210
85	702197	3728274	1505	D	210
93	698019	3736225	1477	D	150
94	697437	3737360	1433	D	210
99	694724	3742433	1546	D	150
102	698792	3730625	1513	Z	200
103	701074	3726177	1545	Z	200
114	696653	3734791	1453	Z	100
123	701230	3721954	1641	R	150
128	699182	3726026	1550	R	100
129	698758	3726464	1552	R	100
141	695155	3730017	1570	Z	80

5. Conclusion

Data and the obtained results of geoelectric tests showed that thickness of the alluvial in the center and West of plain is more than East and North East of the basin. Furthermore, the depth of encountering with the bedrock decreases from south to north and West to East. Particles of alluvial deposits on the northern edge of the plain are affected by quaternary(including clay layer) composed of clay and silt. In addition, it is predicted that the mentioned sediments have an adverse impact on the quality of water. As also can be seen along the geoelectric sections, the spread of the grained deposits with 2 to 20 ohm-m resistivity can be observed more in the end of the profiles. The wide and deep spread of thecoarse-grained depositsis observedon the edge of the southern heights and central areas of the basin in Qaen plain. The aquifer is appropriately evaluated in the central part of the plain in the East and West of Qaen city.

References

Akaolisa, C. (2006). Aquifer transmissivity and basement structure determination using resistivity sounding at Jos Plateau state Nigeria. *Environmental monitoring and assessment, 114*, 1-3.

Bello, A. A., & Makinde, V. (2007). Delineation of the Aquifer in the South-Western Part of the Nupe Basin, Kwara State, Nigeria. *Journal of American Science, 3*(2), 36-44.

El Waheidi, M. M., Merlanti, F., & Pavan, M. (1992). Geoelectrical resistivity survey of the central part of Azraq basin (Jordan) for identifying saltwater/freshwater interface. *Journal of Applied geophysics, 29*, 125–133.

Emenike, E. A. (2000). Geophysical Exploration for Groundwaterin a Sedimentary Environment: A Case Study from Nanka Over Nanka Formation in Anambra Basin, Southeastern Nigeria. *Global Journal of Pure and Applied Sciences, 7*(1), 97–10.

Heiln, C. A. (1940). *Geophysical exploration*. Prentice Hall, Newyork, N.Y.

Ismail mohamaden, M. I. (2005). Electric resistivity investigation at Nuweiba Harbour Gulf of Aqaba, south Sinal, Egypt. *Egyptian journal of aquatic research Issn, 31*, 1110-0354.

Kelly, W. E., & Stanislav, M. (1993). *Applied geophysics in hydro geological and engineering practice*. Elsevier, Amesterdam.

Kelly, W. E. (1976). Geoelectric sounding for delineating ground water contamination. *Ground Water, 14*(1), 6-11.

Omosuyi, G. O., Adeyemo, A., & Adegoke, A. O. (2007). Investigation of Groundwater Prospect Using Electromagnetic and Geoelectric Sounding at Afunbiowo, near Akure, Southwestern Nigeria. *The pacific journal of science and technology, 8*(2), 172-182.

Oseiji, J. O., & Askhia, M. B. (2006). Determination of groundwater potential in obiaruku and environs using surface geoelectric sounding. *Environmentalist, 26*, 301–308. http://dx.doi.org/ 10.1007/s10669-006-0159-x

Park, Y., Doh, S., & Yun, S. (2007). Geoelectric resistivity sounding of riverside alluvial aquifer in an agricultural area at Buyeo, Geum river watershed, Korea: an application to groundwater contamination study. *Environmental geology journal, 53*(4), 849-859.

Telford, W. M., Geldart, L. P., & Sheriff, R. E. (1990). *Applied Geophysics* (2nd ed.). Cambridge university press.

Zohdy, A. A. R. (1989). A new method for the automatic interpretation of Schlumberger and Wenner sounding curves. *Geophysics, 54*, 245–253.