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Determine the Groundwater Aquifers in Southwest of Samawah City, (Al Muthannā Governorate), Southern Iraq, by using 2-D Resistivity imaging survey

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Abstract

The 2-D Resistivity imaging survey conducted within the desert area to meet the region's need of groundwater, due to the absence of any surface water, in addition, there are no any geophysical studies carried out previously. Ten point survey was performed to study the ground water aquifers in the southwest of Samawah city, Iraq. The length of the survey line in each point survey is 1200 meters by using 120 electrodes with 10 meters electrode spacing by applying Wenner-Schlumberger array. There are three main resistivity zones in the study area. The first resistivity zone ranging between 2.00-10.1 ohm.m, locate at shallow depth, represented Quaternary deposits. The second resistivity zone ranging between 22.8-51.3 ohm.m, it represents bearing-groundwater zone, located within middle Dammam Formation. The third resistivity zone was ranging between 115-584 ohm.m, it represents the impermeability zone of lower Dammam Formation.

Keywords: 2-D resistivity imaging, aquifer, Dammam Formation, Wenner-Schlumberger array, Samawah city.

تحديد خزانات المياه الجوفية جنوب غرب مدينة السماوة (محافظة المثنى) جنوب العراق، باستخدام مسح المقاومة التصويري ثنائي البعد

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الخلاصة:

تم اجراء مسح المقاومة النوعية ثنائي البعد ضمن منطقة صحراوية لتلبية حاجة المنطقة للمياه الجوفية ولعدم توفر أي مصادر للمياه السطحية بالإضافة الى عدم وجود أي دراسات جيوفيزيائية سابقة فيها. تم تنفيذ عشر نقاط مسح لدراسة خزانات المياه الجوفية جنوب غرب مدينة السماوة، العراق. يبلغ طول خط المسح لكل نقطة مسح 1200 متر، باستخدام 120 قطب كهربائي، والمسافة الفاصلة بين الأقطاب 10 متر باستخدام ترتيب فنر–شلمبرجر للأقطاب. أظهرت النتائج وجود ثلاث أنطقه رئيسية للمقاومة النوعية التحت سطحية. النطاق الأول هو النطاق الضحل والذي تتراوح فيه قيم المقاومة الكهربائية بين 2.00–10.1 اوم.متر، والذي يمثل نطاق ترسبات العصر الرباعي. النطاق الثاني تتراوح فيه قيم المقاومة الكهربائية بين 22.8–51.3 اوم.متر، والذي يمثل النطاق الحامل للمياه الجوفية ضمن الجزء الوسطي لتكوين الدمام. النطاق الثالث تتراوح فيه قيم المقاومة الكهربائية بين 115–584 اوم.متر والذي يمثل النطاق غير نفاذ للجزء الأسفل لتكوين الدمام.

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Introduction

Many of ancient civilizations are founded in Mesopotamia territory as a result of abundant water surfaces. Nevertheless, at present these water sources are limited in location and inefficient to meet the life requirements. The geophysical methods consider as the most important to give good solution to resolve these problems. The electrical imaging survey is the most useful and widespread technique [1-4]. The two-dimensional (2-D) resistivity imaging survey is one of heading electrical techniques to determining the bearing-groundwater zones [5- 7]. The study area is located about 100 km southwest of Samawah city, locally called Shghateia (SH), in Al Muthannā Governorate. It restricted between the longitude (E 45º 05' – 45º 16') and (N 30º 48' - 30º 43') at southeaster part of western desert, Iraq, as be shown in Figure-1. It considered as a part of the Al Salman zone [8- 10]. The study area is dominated by deserts climate, lacks vegetation covers, absence any surface water, except some surface runoff comes from the west at winter season by many valleys [6, 8]. The surface of the study area characterized by outcrops of Dammam Formation alternating with depressions and flat areas. These depressions and flat areas consist of clay and silt with secondary gypsum (Quaternary deposits) [8, 11]. It extends from several hundred meters squires to many kilometres squires [6, 12].

Hydrogeological study area

The study area located within Shbecha-Al Salman basin, as one of the hydrogeological basins in the southwestern desert of Iraq [13]. The Dammam Formation considered as one most important of geological formations that contain abundant of groundwater (unconfined aquifers type) in Samawah desert [9, 14]. There are many wells are drilled by General Commission for Groundwater close to the survey point 2-D SH 1and 2-D SH 10. These wells give information about lithologic section and the water level of the survey area, as be shown in Figure-2. The electrical conductivity of groundwater ranging between 6000-3150 micro Mohs\cm according to wells registration. The Dammam Formation consists mainly of changeable carbonate rocks (limestone, dolomite and dolomitic limestone) [6, 9]. It characterizes by the presence of cavities, karstified canals and fractures make it has the highest permeability [8].

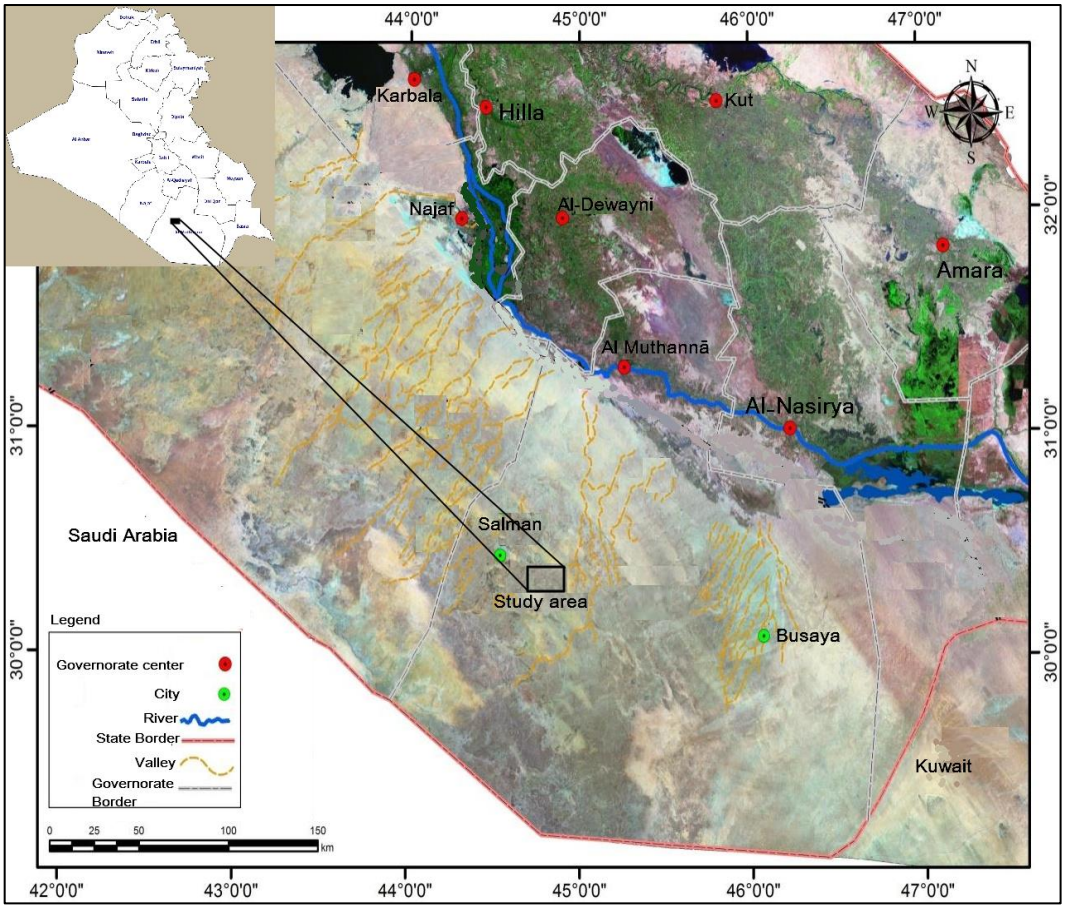


Figure 1 - Location of the study area.

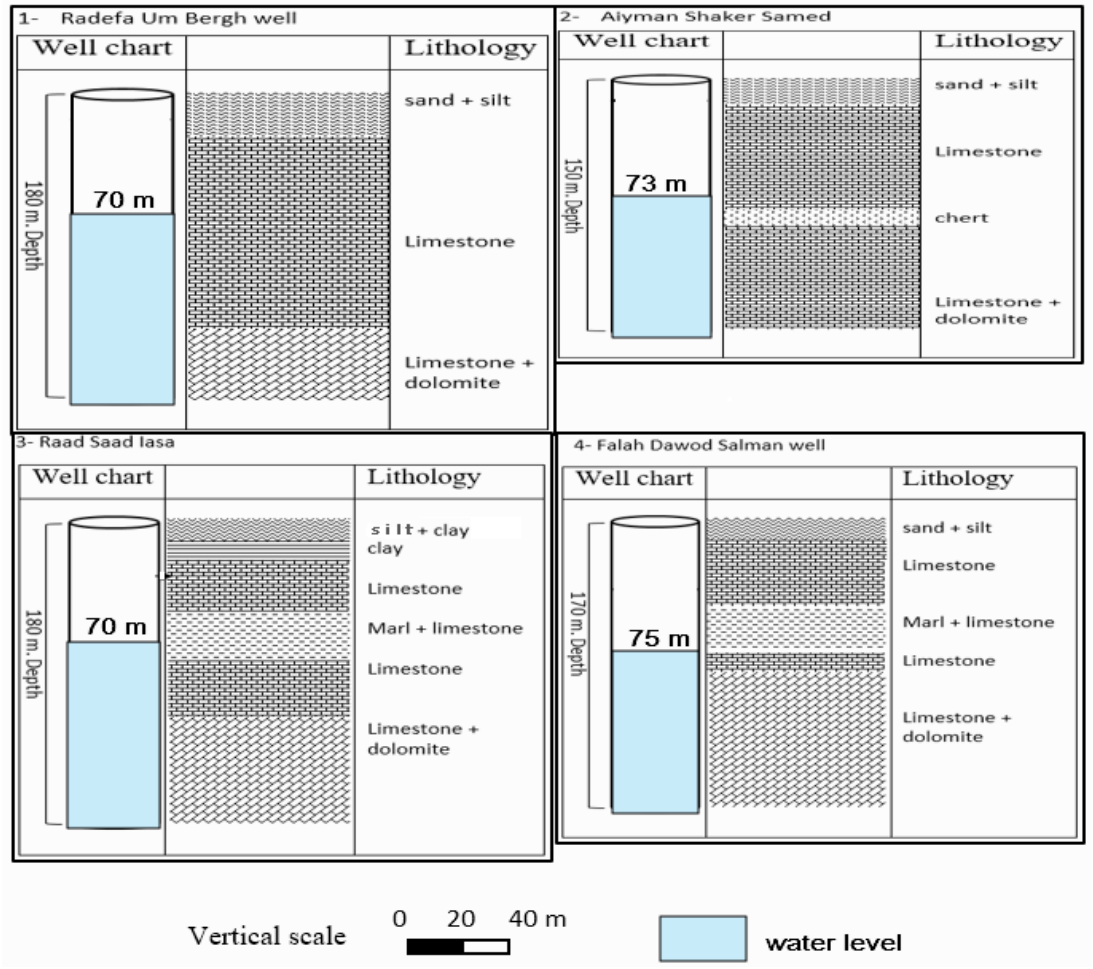


Figure 2 - wells section**.**

Methodology

This study performed in four stages;

- The first stage is collecting of geological information, choose the suitable area to carry out the 2-D survey points and determine the number of survey points that covers this study.
- The second stage is creating the sequence of measurement by using ELECTRE PRO program, which determines the array type and depth of investigation [14], and the fieldwork to carrying out 2-D resistivity imaging surveys.
- The third stage is processing and interpretation of the field data by using PROSYSI II and RES2DINV programs [5, 14].
- The fourth stage is a discussion of results to get batter conclusions and recommendations.

To complete any stage, it should be planned and prepare the suitable and possible types of equipment, with taking in our consideration the required cost to achieve this aim. The good preparations make the field data measurements be highly accurate and give the best results about the distribution of true resistivity [2, 15]. In the current study, ten 2-D survey points performed by using Wenner-Schlumberger array [16, 17]. The length of array line in each point survey is 1200 meters by using 120 electrodes with 10 meters electrode spacing. The maximum estimated depth of investigation to each survey line reaches to 225 m. Except for the survey point 2-D SH 4, which performed by using only 100 electrodes, with the maximum depth of investigation about 190 meters. Because it located within the very narrow flat area, which restricted by Dammam Formation outcrops. The direction of the line array to each point survey is northeast-southwest, perpendicular to the slope of the layers [8] to obtain the true thickness and depth of these layers [6].

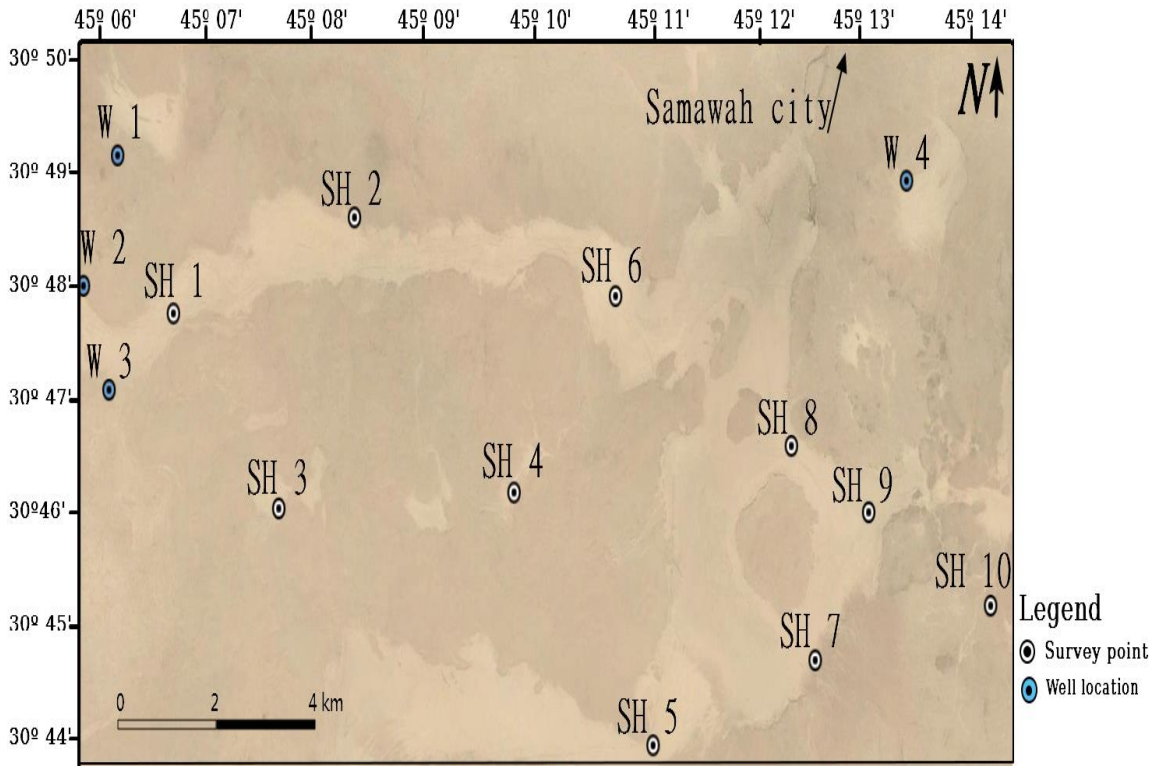


Figure 3- Satellite image shows the location of survey points and wells.

Data processing

The field data was processed by several stage, the first stage by using PROSYS II program. This program allows to removing bad data by the manual filter, if it was a little number of the bad data, or by using the automatic filter if the field data contained a large number of bad data [14, 18]. The second stage performed by using RES2DINV program into two practices, first practice by picking the bad data from field data in profile form, second practice by removing the percent of bad data from the bar chart before repeated the iteration of the inversion subroutine to reduce the RMS error ratio [15, 19].

Interpretation the field data.

The RES2DINV program designed to invert a large number of field data produced by a large number of electrodes (more than 25 electrodes). After finishing all process and remove of bad data, the field data becomes high quality and can give inverse models that reflect the real distribution of resistivity subsurface [2, 3]. The least-square inverse method was used to interpret the field data.

Interpretation survey point 2-D SH 1.

The 2-D survey point locates at the coordinate (30 46 52.8 N) (45 07 37.1 E), 108 meters above sea level. The inverse model shows three main resistivity zones, as shown in Figure-4. The first zone locates at a shallow depth that characterizes by low resistivity, which range between 2.00 - 4.5 ohm.m. It represents the Quaternary deposits, which consist mainly of clay and silt with secondary gypsum. This zone extends along of survey point, which varies in thickness between 10 m southwest side and reaches to 70 m at northeaster side of survey point, depending on the thickness of Quaternary sediments. The second zone has a resistivity ranging between 10.2-51 ohm.m, which believed to be groundwater-bearing zone. This zone varies in depth and located beneath low resistivity zone has a thickness ranging between 50-70 m, within middle Dammam Formation. It extends toward the right side of the inverse model with an increase of its depth reach to 160 m. The third zone characterizes by high resistivity zone (more than 115 ohm.m) represented the lower Dammam Formation, which consists mainly of dolomite with dolomitic limestone.

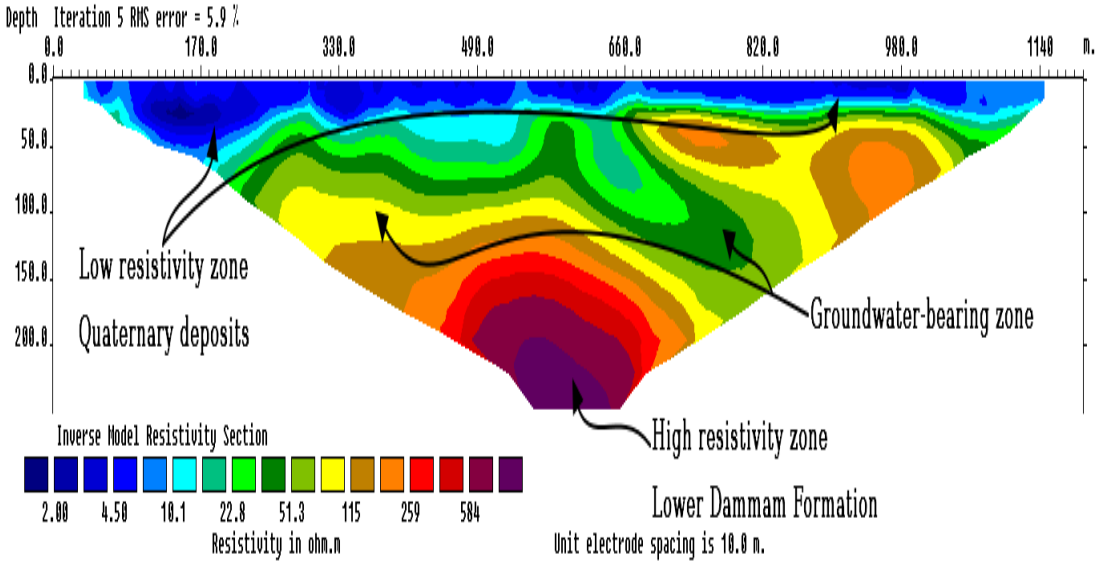


Figure 4- the Inverse model of the survey point 2-D SH 1.

Interpretation survey point 2-D SH 2.

The point survey is located at coordinate (E 30° 45′ 15.9″) (N 45° 08′ 56.7″), 109 meters above sea level. The inverse model shows there are three main resistivity zones (Figure-5). The first zone ranging between 2.00 - 4.5 ohm.m, locate at shallow depth extend along with the inverse model reach to 70 m depth, represents the quaternary deposits. The second zone rangs between 10.2-51 ohm.m, which belief to be groundwater-bearing zone. It located mainly under low resistivity zone. The depth of this zone is varies and rangs between 65-150 m depth. The groundwater-bearing zone locates mainly at

the right side of the inverse model, it considers as the most encourage area to drilling wells. The third zone ranges about 115 ohm.m and above. locate at the center of survey point at depth extend from 100 m, and continue to lower end of the inverse model (more than 200 m depth), represents the lower Dammam Formation.

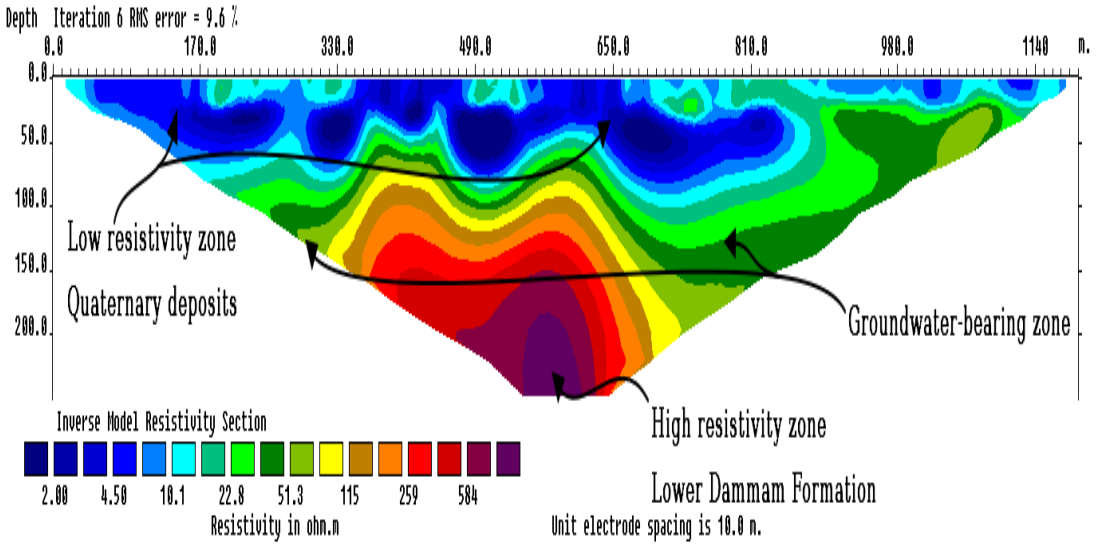
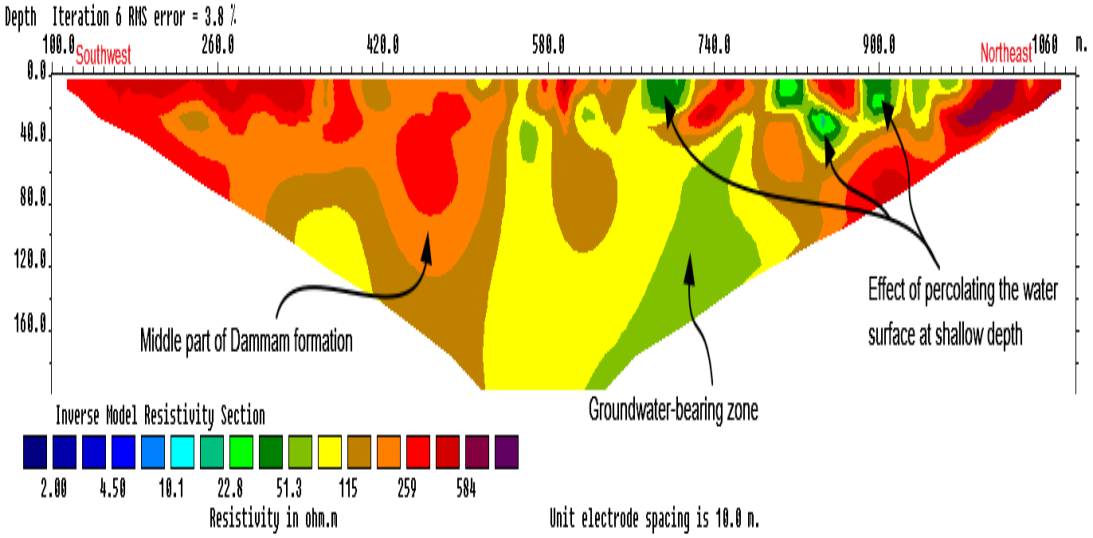


Figure 5- an Inverse model of the survey point 2-D SH 2.

Interpretation survey point 2-D SH 3.

The point survey is located at coordinates (E 30° 46′ 18.6″) (N 45° 09′ 9.7″), 117 meters above sea level. The inverse model shows what believe to be fault plane (requires carry out more survey points and other geological studies to detect and track the effects of fault plan), because it divided the high

resistivity zone (115 ohm.m and more) at the right side of the inverse model into two part as shown in Figure-6. The groundwater-bearing zone (ranging between 10.2-51 ohm.m) located at 100 m depth and continue down more than 200 m, it founded mainly within fault plane. The high resistivity zone exists at shallow depth, which extends from ground surface to 150 m depth. It represents middle



Dammam Formation.

Figure 6- Inverse model of the survey point 2-D SH 3.

Interpretation survey point 2-D SH 4.

The point survey is located at coordinates (E 30° 46′ 04.8″) (N 45° 15′ 31.8″), 123 meters above sea level. The survey point performed by using only 100 electrodes, with an estimated depth of investigation reach to 190 m, as shown in Figure-7. Because of the survey point 2-D SH 4 located within a very narrow flat area (surrounding by outcrops of Dammam Formation). The inverse model shows there are three main resistivity zones. The high resistivity zone (about 115 ohm.m and above) locates at both side of the inverse model, extend from the ground surface and continue down to the lower edge of the inverse model, represented the middle Dammam Formation. The groundwater-bearing zone (ranging between 10.2-51 ohm.m) locate at centre of the inverse model, extend from 65 m depth and continue down to the lower edge of the inverse model. The low resistivity zone (ranging between 2.00 - 4.5 ohm.m) locate at shallow depth, represented the effect of water surface percolating

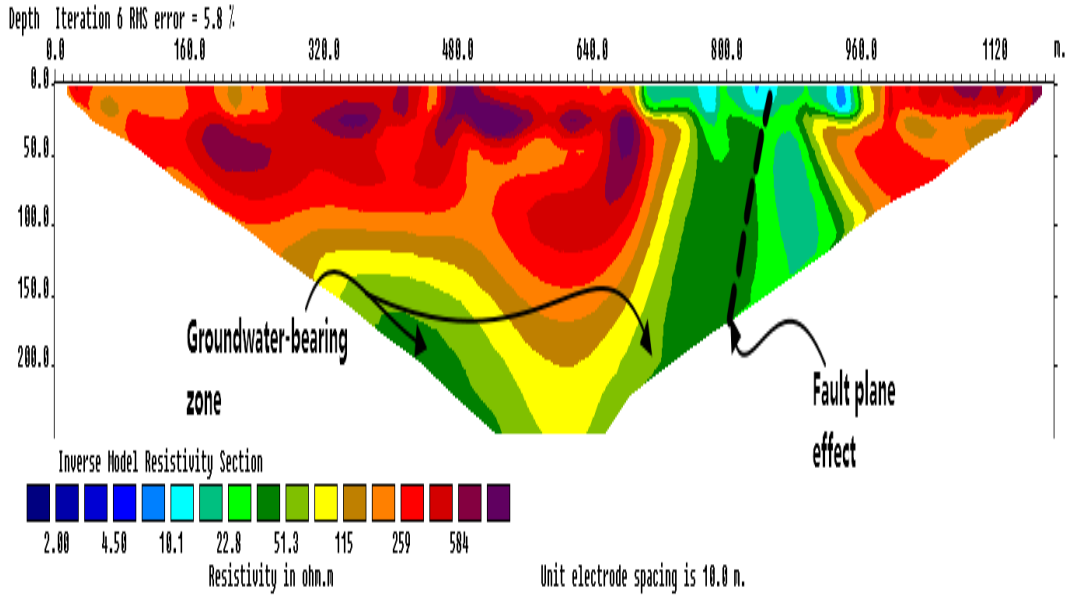


Figure 7- Inverse model of the survey point 2-D SH 4.

Interpretation survey point 2-D SH 5.

The point survey is located at coordinate (E 30° 44′ 57.0″) (N 45° 11′ 42.6″), 112 meters above sea level. The point survey contains three resistivity zones as be shown in the inverse model (Figure-8). The first zone ranging between 2.00 - 4.5 ohm.m, located in right side at a shallow depth of the inverse model, represent the effect of Quaternary deposits. The second zones rangs between 10.2-51 ohm.m located at both side of the inverse model within middle Dammam Formation, at depth extend from 70 m and continue to lower edge. The centre of the survey point character by high resistivity zone (115 ohm.m, and above) locate into two levels. The shallow zone extends from the ground surface and reach to 50 m depth, represent the middle Dammam Formation. The deepest zone extends from 110 m and continue to the lower end of the inverse model, represent the lower Dammam Formation. The most abundant of groundwater founded at both side of the inverse model, which consider the encourage area to drilling wells.

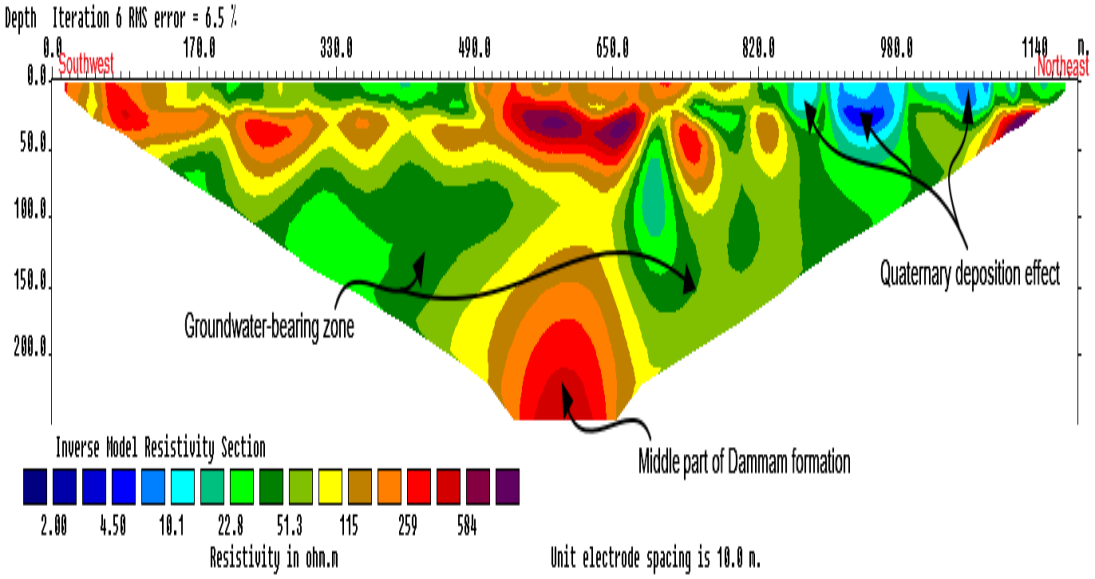


Figure 8- Inverse model of the survey point 2-D SH 5.

Interpretation survey point 2-D SH 6.

The point survey is located at coordinates (E 30° 46′ 57.5″) (N 45° 11′ 23.4″), 113 meters above sea level, as shown in Figure-9. There are three main resistivity zones. The first zone characters by low resistivity ranging between 2.00 - 4.5 ohm.m. It located at the shallow depth of the inverse model (extend from ground surface to 50 m depth), represented the quaternary deposits effect. The low resistivity that founded at depth reach to 60 m, at the left side of the inverse model represents the effect of percolating water surface. The second resistivity zone rangs between 10.2-51 ohm.m, represented the groundwater-bearing zone, locate mainly in centre of the survey point at depth extend from 75 m to lower edge of the inverse model. Third resistivity zone (about 115 ohm.m and above) founded in very restricted area, located mainly at the left edge of the inverse model, extend from ground surface to 50 m depth. The most abundant of groundwater locate at the centre of the survey point, which consider encourage area to drilling wells.

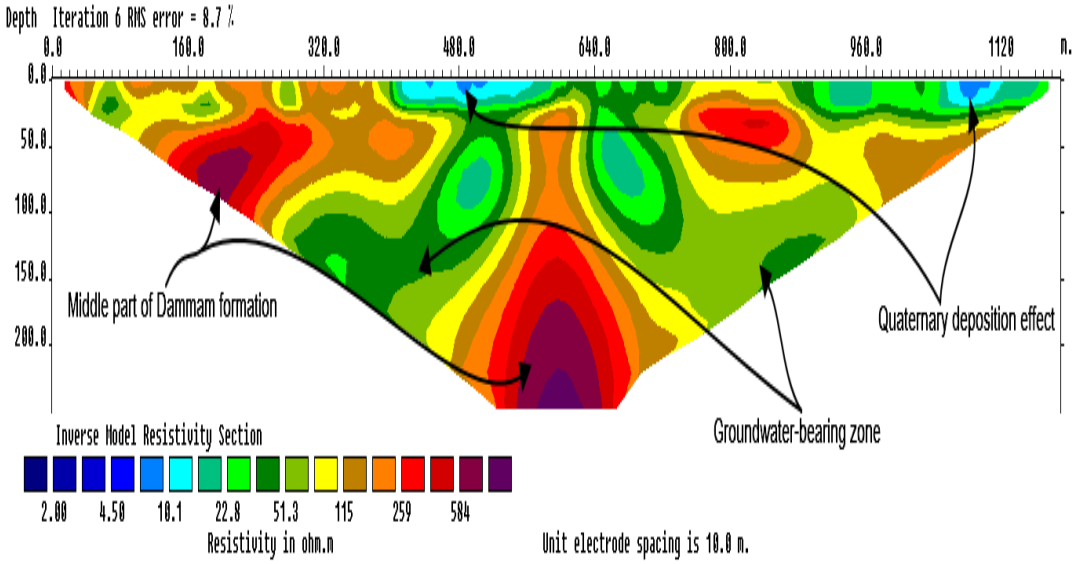


Figure 9- Inverse model of the survey point 2-D SH 6.

Interpretation survey point 2-D SH 7.

The survey point is located at coordinates (E 30° 45′ 31.6″) (N 45° 12′ 06.0″), 106 meters above sea level. The inverse model shows there are three main resistivity zones. The first zone characters by low resistivity ranging between 2.00 - 4.5 ohm.m. It locates at shallow depth; extend from ground surface to the 30 m depth represent the effect of quaternary deposits. The second zone has a resistivity ranging between 10.2-51 ohm.m. It located in both side of the inverse model, at depth extend from 70 m and continue to lower edge. Third zone characters by high resistivity (about 115 ohm.m and above). It located into three positions as shown in Figure-10. The shallow depth represents middle Dammam Formation and the deepest zone represent lower Dammam Formation. The most founded of groundwater exist at both side of survey point centre, which consider encouraging area to drill wells.

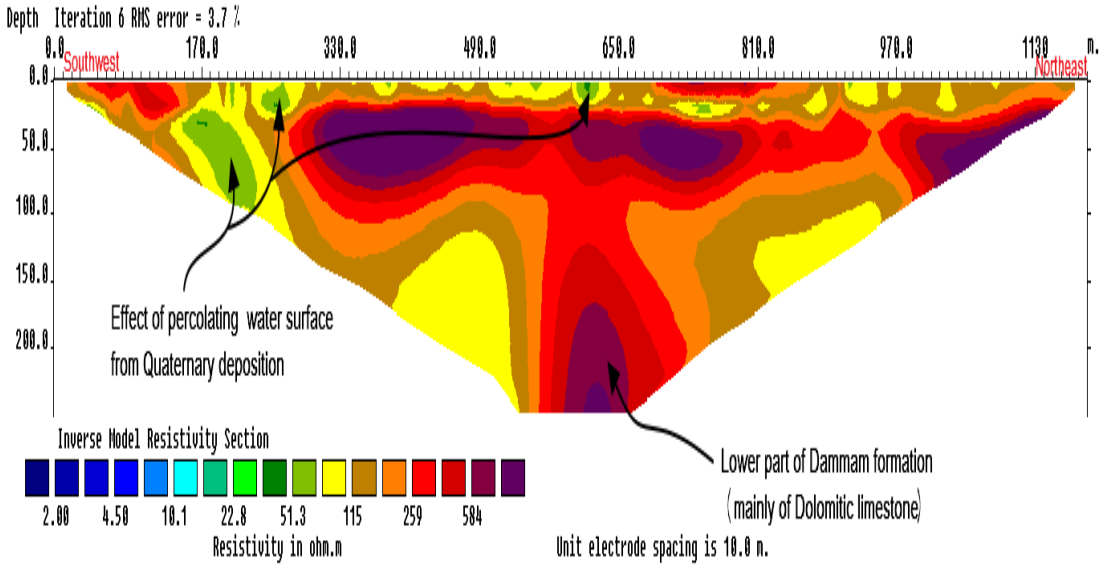


Figure 10- the Inverse model of the survey point 2-D SH 7.

Interpretation survey point 2-D SH 8.

The point survey is located at coordinates (E 30° 45′ 19.8″) (N 45° 13′ 5.6″), 117 meters above sea level. The inverse model appears there is not exist any evidence of groundwater-bearing zones. Because of lower Dammam Formation (resistivity ranging between 115 ohm.m, and above) existed at shallow depth and rises middle Dammam Formation above water level. The low resistivity zone (22.8-51 ohm.m) located into two level zones. The first level locates at shallow depth, represented the Quaternary deposits (clay, silt, and secondary gypsum), the second level locate at left side of the inverse model and restricted between 20-100 m depth, represent effect of percolating water surface.

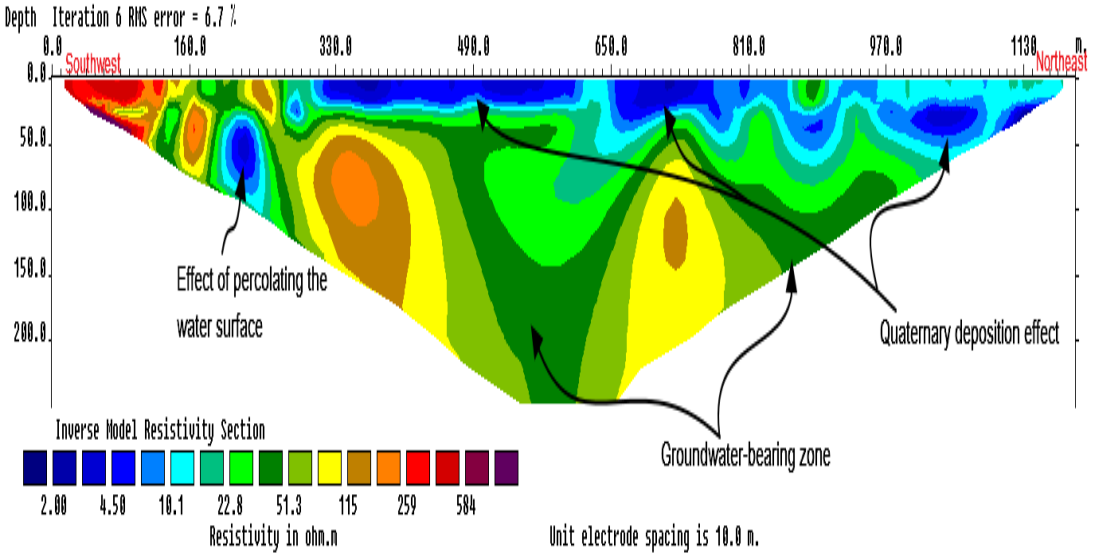


Figure 11- the Inverse model of the survey point 2-D SH 8.

Interpretation survey point 2-D SH 9

The point survey is located at coordinate (E 30° 45′ 59.5″) (N 45° 13′ 33.0″), 116 meters above sea level. The inverse model appears high resistivity compare with the previous inverse models as shown in Figure-12. The high resistivity zone founded about wholly the inverse model, except at shallow depth, where the existence of thin layers of quaternary deposits. The high resistivity represents the lower Dammam Formation, which consists mainly of dolomitic limestone and dolomite (the resistivity of limestone and dolomite ranging between 60-5000 ohm.m, according to the table of resistivity rocks in look 2016). There is no evidence of existence any groundwater-bearing zone in the inverse model

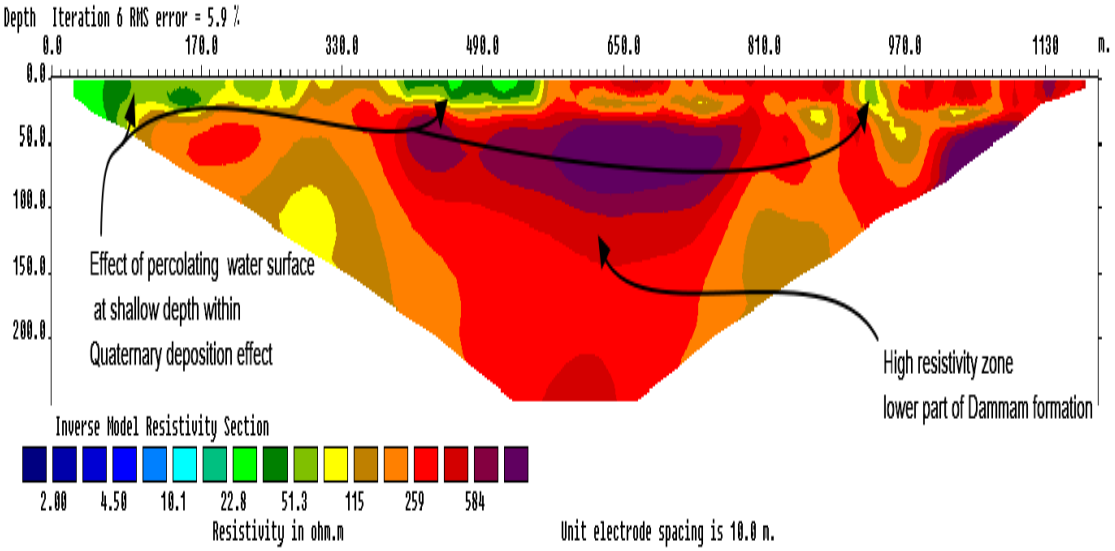


Figure 12- Inverse model of the survey point 2-D SH 9.

Interpretation survey point 2-D SH 10.

The point survey is located at coordinate (E 30° 45′ 34.4″) (N 45° 14′ 35.4″), 112 meters above sea level. The inverse model shows it completely higher resistivity than the other inverse models. maybe results from raising the lower Dammam Formation (consist mainly of dolomitic limestone and dolomite) and the middle Dammam Formation located above water level. The inverse model shows there is no evidence of existence any groundwater-bearing zone, except effect the percolting surfac water at northeast side.

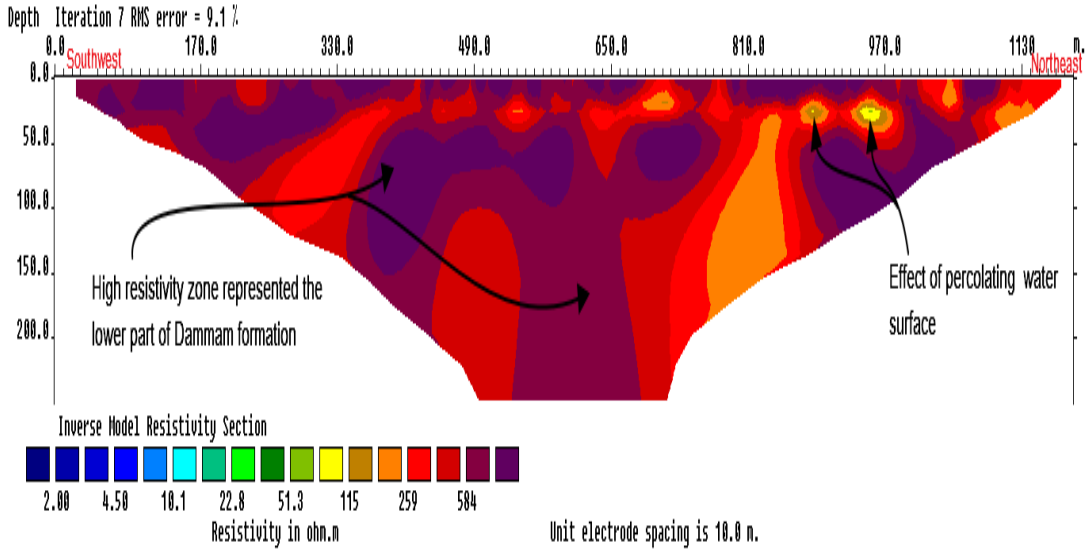


Figure 13- the Inverse model of the survey point 2-D SH 10.

Conclusions

The 2-D resistivity imaging survey considered as the best technique for defining the groundwater-bearing zones from the other zones and detecting the extension with the lateral change of the groundwater-bearing zone. Many conclusions can give by this study.

1- Generally, the inverse models of 2-D survey points show vertical gradients in resistivity (increases the resistivity with the depth).

2- The inverse models of the survey points show there are three main resistivity zones in the survey area. The first zone characterizes by low resistivity (ranging between 2.00 - 4.5 ohm.m), represents the Quaternary deposits (because of clay mineral contain with secondary gypsum that makes these deposits has high conductivity). The second zone characterizes by resistivity ranging between 10.2-51 ohm.m, represents the groundwater-bearing zone. It locates mainly under low resistivity zone within middle Dammam Formation because it characterizes by fissures with fracture zones, cavities and canal. The third zone characterizes by high resistivity (115 ohm.m and above) represents lower Dammam Formation, located under groundwater-bearing zone.

3- The southwest of the study area characterizes by high resistivity, as a result of raises the lower Dammam Formation, in addition, the middle Dammam Formation locates above the water level of the survey area.

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