(Review Article)

Groundwater and its detection by geophysical methods (Review)

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- Date of research received 14/11/2023 and accepted 31/12/2023.

Abstract

The world, including Iraq, suffer from the opportunity to obtain water sources, involves groundwater which is necessary for daily uses, agriculture and industry, it face many problems of environmental pollution, climate changes and the increasing in demand due to growth in population .Groundwater is a source that present inside the voids and fractures in the rocks and various soils under the surface of the earth forming water reservoirs which can be investigated and detected to be used later to satisfy the needs of humanity. Geophysics is a branch of geological science, it based on the theories of physics and their applications to detect the materials that make up the earth, including groundwater, so it is necessary to explain the foundations of the different methods necessary for those working in this field, geophysical research representation especially those who conducted electromagnetic, electrical and self-potential methods have proven that they are good and effective in detecting the locations, distribution and depth of groundwater.

Key words: Geophysics, Groundwater, investigation, Kirkuk/ Iraq
Citation: Ali, D. (2023). Groundwater and its detection by geophysical methods (Review). *Kirkuk University Journal For Agricultural Sciences*,14(4), 243-253. doi: 10.58928/ku23.14422.
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Introduction

Groundwater has important role in the countries at many parts of the world, it is an important source of daily life, agriculture, industry and the environment , according to (UNICEF,2000) 1.1 billion people did not have access to adequate water. According to[1], 67 percent of village dwellers did not receive water, but rather depended on surface water from lakes, streams and rivers. It is not possible to rely on surface water due to the evaporation and various climatic problems, including global warming and its consequences, population increasing, technological development and pollution of various diseases that need treatment which are not Ease. Groundwater in voids and fractures, rocks and soils relatively is far from the sources of pollution and loss by evaporation, in addition to being the source which can control the withdrawal of water according to demand, gives it a preference as a source of water for local demand for agriculture and industry. The groundwater is not present every location in the world so it need multiple techniques provides to find out its location and depth. Geophysics is science used to search for groundwater, namely, gravitational, magnetic, seismic, electrical and electromagnetic methods[2]. The effective methods in the study of groundwater are the electrical and electromagnetic method because it is Sensitive in detecting hydraulic properties of rock formations such as porosity and permeability compared to electrical conductivity, as it proved successful in this direction[3].

Basic concepts in groundwater

Groundwater: - Groundwater is defined as a water source located under the surface within sediments and rocks, [4] defines groundwater as the water located below the water level and usually fills the voids in the saturated rock system, which is the most distributed water sources in the earth.

Among the factors affecting groundwater are geological rock, geological structure, provision of water drainage sources and geomorphology of the earth[5]. Groundwater plays an important role in the hydrological cycle of the global system and the movement of water known as the hydrological cycle as in Figure (1)

The cycle begins with rainfall from the atmosphere descending on the surface of the earth as running water as access of, part of it penetrates the ground down to the groundwater and the remain filters and saturates close to the surface of the earth where plants benefit from it and return to the atmosphere by the process of evaporation-transpiration or evaporates directly from the surface of the earth .

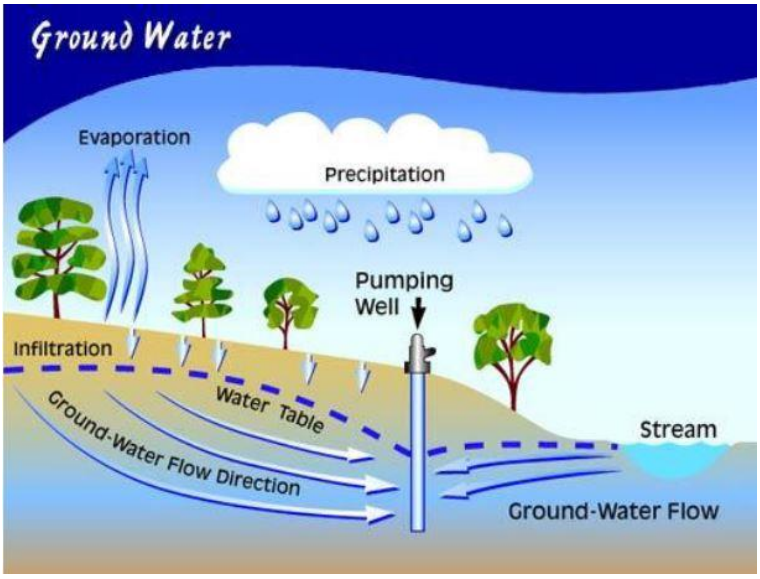

Figure 1. Groundwater is part of the hydrological cycle

Water below the surface of the earth is found in different areas in rocks and soils, which are the saturated sector and the unsaturated sector , in the saturated sector the water fills all the voids of rocks and the movement of water is due to gravity the water descends towards the bottom and the pressure where the water rises upwards.

In the unsaturated sector, the voids are filled with air and moisture as a result of this sector is divided into three different varieties, which are the upper topsoil with moisture and different thicknesses, from which plants benefit for growth and the movement of water is towards the top or bottom depending on gravity, the middle layer, which is located below the upper layer, holds the water with the force of internal particles against gravity , The capillary layer, as it is called, holds the capillary property against the pull force of gravity, and this layer is present over the saturated layer.

Water level

Simply defined as the saturated level of groundwater, which we can say is the the surface under which the voids inside the rocks and sediments are filled with water, groundwater is located below this level, which does not intersect with the surface of the earth except in rare cases on water streams and lakes (Figure 2), the groundwater level changes according to geology, geomorphology and seasons.

Groundwater reservoir and its types: It is defined as a rock formation that stores groundwater or a geological formation that has the ability to store and provide significant amounts of water and depends on the components of soil and rocks with their porosity and permeability[6]. Among the good geological reservoirs that store water are unconsolidated sand, sandstone, gravel with conglomerate and jointed limestone rocks.

There are reservoir are bounded from the top and bottom by impermeable layers, and others the reservoir is covered only from the bottom with an impermeable layer and the upper layer is permeable or semi-permeable and connects to the surface of the earth.

In the light of these relationships of the constituent layers of the aquifer is divided into

A - confined reservoir: in which the reservoir is covered from the bottom and top layer of low permeability such as mud where it restricts the movement of water and keeps water away from pollution and the pressure of water is greater than the pressure of the atmosphere and if penetrated by drilling, the water level reaches the top of the aquifer [7] (Figure 2).

B- Unconfined reservoir: It is the opposite of the confined reservoir, where there is no impermeable layer between the surface of the earth and the groundwater level, which is directly connected to atmospheric pressure through the voids in the soil or rocks of the upper layer that covers the reservoir, and that the water comes from the filtration of rainwater or running water from the upper layers.

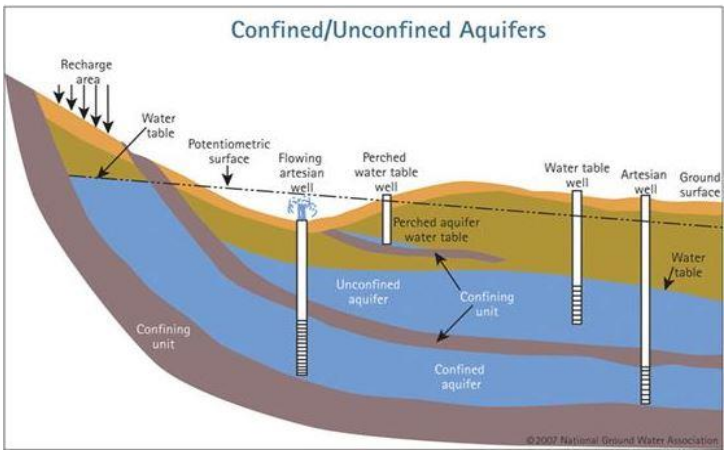

Figure 2. The two types of water reservoirs

C - Suspended reservoir: It is similar to the confined reservoir, which consists of two layers of low permeability with a permeable layer and is located under groundwater, but above the main groundwater level and this type of reservoir exists when the groundwater above the rock formation is unsaturated as a result of the characteristic of lack of continuity in the permeability of the layer(fig 3).

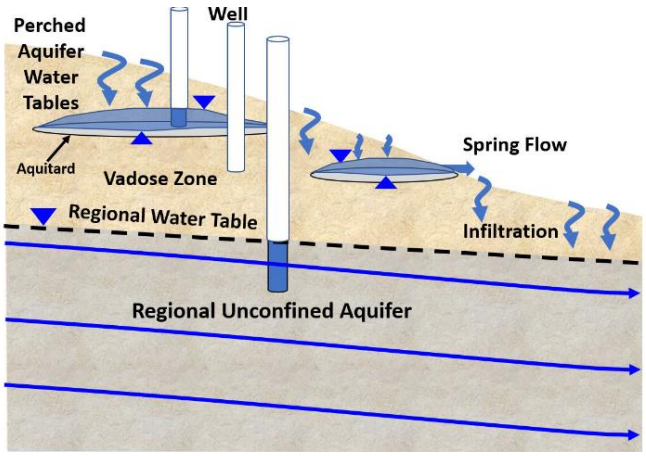

Figure3. Perched aquifer

Principles of Geophysics Methods

Geophysics is a science that applies the principles of physics to the study of the Earth [2].There are many geophysical techniques used to investigate the components of the Earth, including known source and unknown source.In a known (effective) method, it sends artificial signals such as the electric and electromagnetic field into the Earth and then measures the Earth's response to these signals. Examples of this method are electrical, electromagnetic, seismic and georadar.

The method is unknown source (ineffective) depends on a natural field found in the earth where the Earth's response to these signals is measured and this method is used easily and the detection of depths is greater than the previous method and examples of this method are magnetism, gravity, self-potential and radioactive.

Electromagnetic method

In this method, the Earth's response to the electromagnetic field induced entering the earth is measured and does not need direct contact with the surface of the earth, such as the electric method, but the signals are sent from a distance through radar, which facilitates the scanning process and produces preliminary information. Where signals (Figure 4) are sent electromagnetic primary to the inside of the earth and pass through the materials of the earth and according to the electrical conductivity generate vortex currents and in turn generate secondary electromagnetic waves, which are measured and recorded from the surface of the earth, and in scientific ways and using different software(GPR) analyzes information and gives an image of objects inside the earth and geophysicist and according to his experience can distinguish these materials, including the presence of groundwater and where water is a good conductor of electric current and can distinguish clearly in the final section resulting from the process Survey.

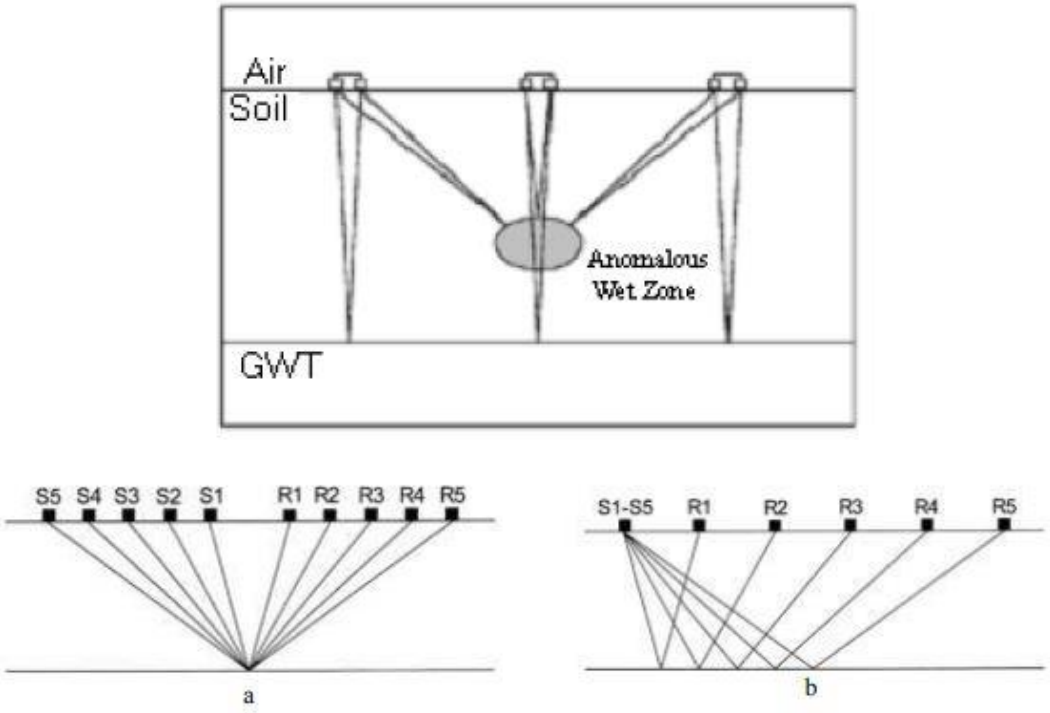

Figure 4. Georadar mode in the survey process and survey methods (A&B)

Electric method

In this method, the electrical resistance of materials inside the earth is measured by passing the electric current coming out of the device(fig 5) to the underground surface using two electrodes (Figure 6), then measuring the potential difference generated by two other electrodes and according to Ohm's law in electrical resistance is extracted.

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Figure 5. SAS 4000 Tetrameter

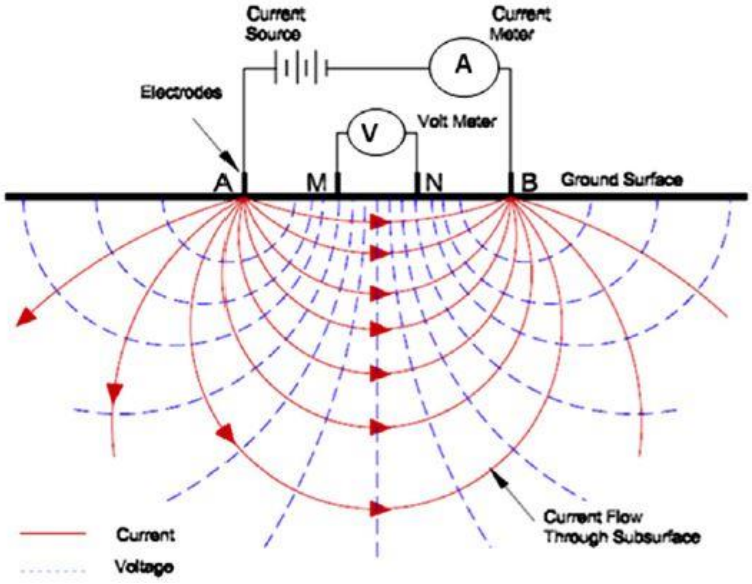

Figure 6. Picture of the electrical scan showing the current electrodes (A&B) and the voltage difference electrodes (M&N))

There are types of survey depends on how the electrodes of the electric current are distributed with measuring electrodes in the characteristic of electrical conductivity, the output of the survey and using information analysis software turned into an image of the distribution of electrical resistance to underground materials, and since water has high electrical conductivity, so it can be clearly distinguished and detected.

Self-potential method

This method was old and neglected for a while, but recently research and software have developed so that it has become effective in detecting groundwater. This method depends on the presence of an autonomous potential (electric potential difference) resulting from the passage of water inside the spaces of rocks and soils, where it produces negative charges on the grains of rock or soil and a positive charge in running water, and by measuring the electric potential difference resulting from the flow of water under the surface of the earth by two electrodes on the surface of the earth and by converting recordings from Information into curves, sections or maps can distinguish and detect groundwater.

Case studies

1- Conducted [8] geophysical electromagnetic method (Georadar) to detect the behavior of the groundwater table near the wells in the city of Tikrit, where the device was installed near the well of water withdrawal for experimental purposes at different times during the process of pumping groundwater outside the well and the data were measured and analyzed and concluded that the depth of groundwater is between 2.9-3.2 m and between the results that this method is useful and accurate High in investigating the behavior of groundwater stored in shallow layers and also showed that Georadar signals determined the depth of the range of capillary property. Figure (7) represents the pictorial section of the survey and the red line indicates the groundwater level of the reservoir.

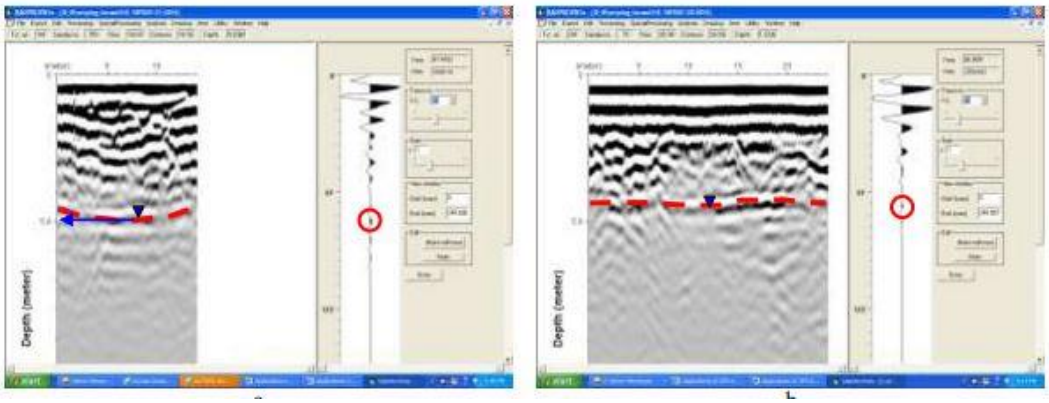

Figure 7 Georadar section showing groundwater level (red line)

2- In a study carried out by [9] used georadar devices to estimate the depth of groundwater in the area of Yusufiyah, south of Baghdad, where he made longitudinal sections through electromagnetic scanning in addition to drilling traditional test wells in order to compare the two methods, the results showed that this method is effective in detecting the presence of groundwater and that its depth is 8 m. Figure (8) shows the final result of interpreting the results of the survey data and clearly shows the groundwater level (bottom red arrow).

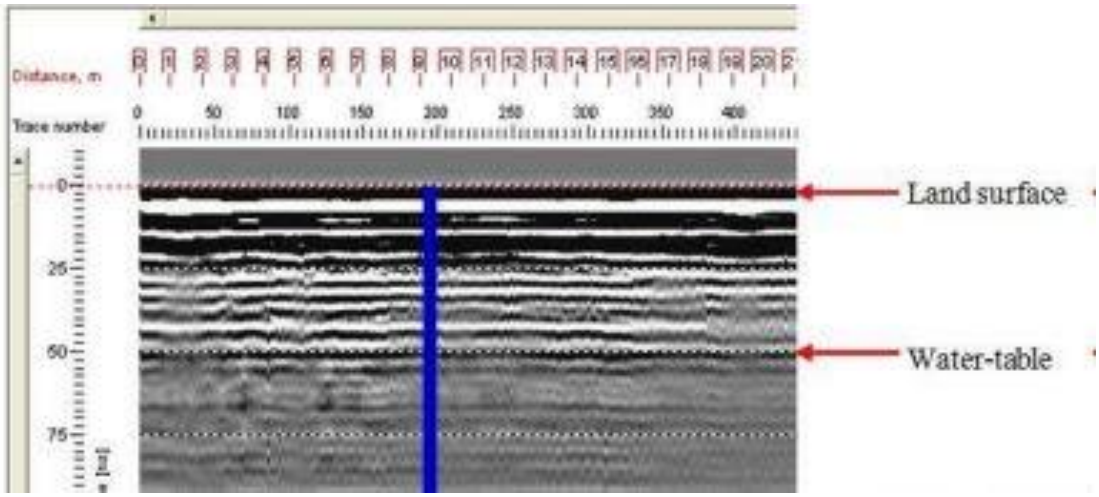

Figure (8) A section of the georadar showing the groundwater level (red arrow down)

3- In a study using the electrophysical method, [10] by surveying electrical geophysics and geographic information systems (GIS) in Halabja area in order to determine the places of good storage and groundwater productivity in the Sayed Sadiq basin with the help of a lot of information from hydrology, land cover, topography, drainage density, soil type, slope and rainfall maps. Present within the quaternary era sediments. GIS has contributed effectively to locating reservoirs, and Figure (9) is a geoelectric section and the blue color are areas with low electrical resistance, which geophysically interprets are groundwater catchment areas.

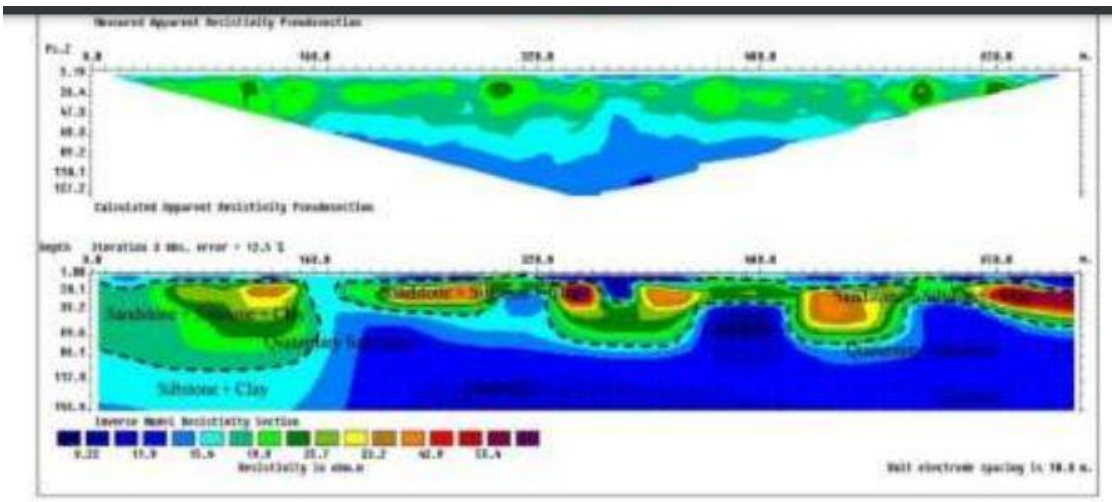

Figure (9) A section of geoelectric and shows the locations of groundwater (reduced resistance in blue color)

4- [11] investigated groundwater in the Najaf Sea to obtain the hydraulic specifications of the aquifer from the Dammam rock formation, which is characterized by its possession of gaps and voids by applying a geoelectric survey with three axes. The hydrogeophysical model showed that the main reservoir consists of carbonate rocks and is highly saturated with groundwater, which is of the confined type and at a depth of 100 m and a thickness of 160 m. Figure (10) is a geoelectric section and appears below and in blue with resistance Low electric, which indicates the presence of groundwater.

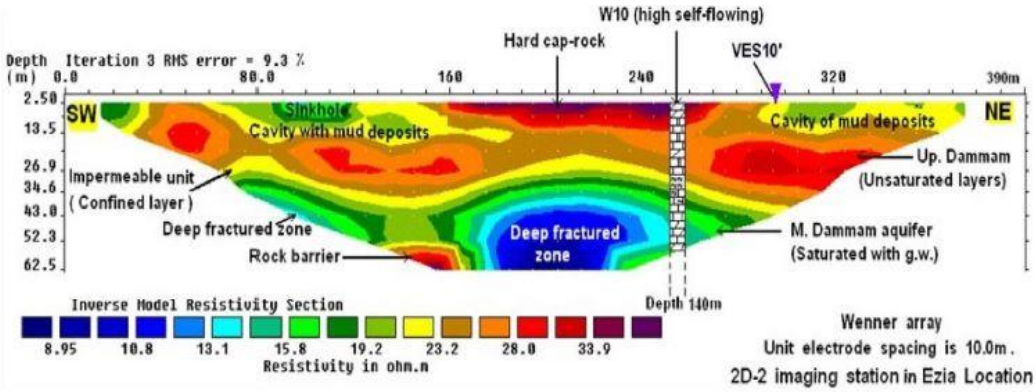

Figure (10) Geoelectric section and indicates the places of groundwater accumulation (low resistance in blue)

Figure (11) represents the geohydrological section of the study area, which was built on the basis of converting the geophysical results to this section, the green and blue colors represent the two parts of the groundwater reservoirs in the rocks of the Dammam formation.

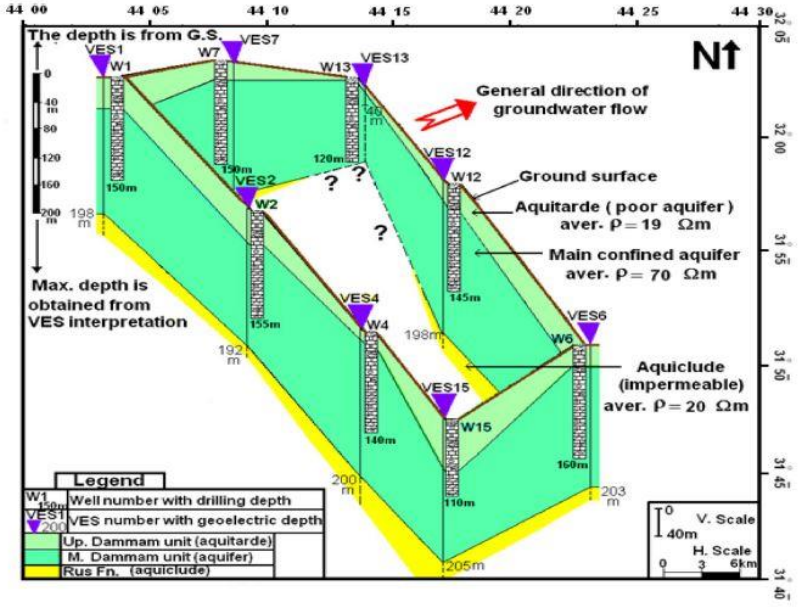

Figure (11) Geohydrological section shows the extension of water

Reservoirs in the rocks of Dammam (green and blue)

5- The self-potential geophysical method (SP) is one of the important and effective methods in the investigation of groundwater and is currently widely used in the world, especially after conducting multiple researches Software innovation and scientific methods for quantitative, not only qualitative, interpretation of the data produced from field surveys. [12] carried out a survey in the Laylan area in Kirkuk with 40 measurement points, in addition to six survey lines on the basis of which single sections and a map with self-voltage values were established. Lower values represent the feeding area near the highlands in the region (Fig.12).

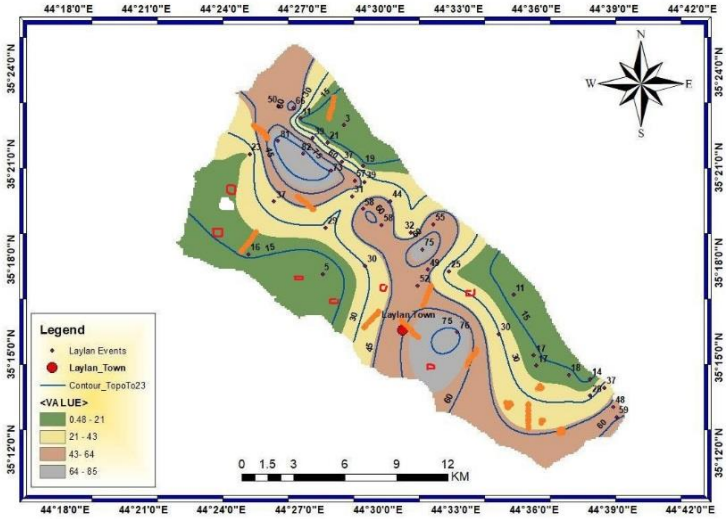

Figure12. Self-potential contour for Lilan area self-voltage values

Conclusions

Water is indispensable in the life of humanity and its great importance to the need for it in daily uses, agriculture, industry and the environment, the existence of a shortage of water sources and the presence of various environmental problems with the increasing in the population in the world and Iraq in particular, so the search for water sources such as groundwater has became a necessary matter that must be taken care of by governments, society and specialized

scientists and needs to know how to exist, types and components in addition to methods of detecting groundwater and using geophysical methods Various important topics, these methods are the electromagnetic and electrical method, self-potential, seismic, magnetic, gravitational radioactive, and electromagnetic. Electrical, Electromagnetic and Self-potential geophysical methods have proven their worth in investigating and detecting the locations of groundwater and determining its depth and behavior.

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المياه الجوفية والكشف عنها بالطرق الجيوفيزيائية (مراجعة)

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• تاريخ استلام البحث 2023/11/14 وقبوله 2023/12/31.

الملخص

يعاني العالم ومنها العراق من فرصة الحصول على مصادر المياه ومنها الجوفية الضرورية لاستعمالات اليومية والزراعة والصناعة والتي تواجه مشاكل كثيرة من تلوث البيئي وتغيرات المناخية وزيادة الطلب عليها بسبب زيادة عدد السكان، والمياه الجوفية مصدر تتواجد داخل الفراغات والكسور في الصخور والترب المختلفة تحت سطح الأرض مكونة الخزانات المائية والذي يمكن التحري والكشف عنها ليستعمل لاحقا في اشباع حاجيات البشرية. اصبح التطرق الى فهم ماهية وكيفية تواجد وأنواع الخزنات للمياه الجوفية والكشف بطرق العلمية ضرورة ملحة. الجيوفيزياء هو فرع من علوم الجيولوجية الذي يستند الى نظريات الفيزياء وتطبيقها للكشف عن مواد المكونة للأرض ومن ضمنها المياه الجوفية وعليه شرح الأسس الطرق المختلفة ضروري للعاملين عليها في هذا المضمار، اثبتت عروض البحوث الجيوفيزياء وخاصة الذين اجروا الطرق الكهرومغناطيسية والكهربائية والجهد الذاتي انها جيدة وفعالة في الكشف عن أماكن تواجد وتوزيعا وعمق الماه الجوفية.

الكلمات المفتاحية: جيوفيزيا، المياه الجوفية، التحري، كركوك/ العراق.