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Electrical Prospecting for Structural Setting in North-East Al-Umarah City / Iraq

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Abstract

An electrical resistivity investigation as vertical electrical sounding technique was utilized to measure and detect the vertical changes in resistivity of the geologic section even the subsurface structure in North-East Al-Umarah city / Iraq."27" VES'S were carried out using schlumberger conFigure ure uration with maximum current electrode spacing of (950m). It is believed that such spacing can give enough penetration in which it then yields and reflects sufficient information about the subsurface condition. The purpose of this study is how can find an approach to exploit the present measurements in order to give more obvious picture about the subsurface condition which then main task of the work can be reached. This approach is abbreviated by using the horizontal resistivity data extracted and discriminated from the schlumberger VES'S field data, where horizontal resistivity contour maps "as an earth slices" for all usable spacing were constructed and space section as well. More information can also be invented and obtained with the aid of available geophysical information. Two intersected vertical contacts as fault like structure were concluded, could be with various age, the older one trending NW-SE while the younger one trending NE-SW which are in well conforming with available surface geological information .

Keywords: Geophysics; Electric; Structural setting; Iraq.

1. Introduction

One of the most important and widely used methods of geological exploration is the electrical resistivity methods that use the electrical conducting properties of the rocks and minerals to investigate the prevailing geological situation.

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Such electrical principles are used mainly for geological mapping of concealed structures, hydro geological investigation, oil prospecting, and mineral exploration, archeological and engineering studies [1].The electrical resistivity technique basically involves a controlled D. C or low frequency alternating current into the group by means of two electrodes namely current electrodes and measuring the potential difference or resistance between two points chosen with respect to the current electrodes. Any subsurface variation in conductivity alters the form of the current flow within the earth and thus effects the electric potential distribution, the degree of effect depending on the size, shape, location and electrical resistivity of the subsurface layers or bodies [1]. Well, for steeply dipping contacts, or for studying lateral changes in the resistivity of a particular horizon, the resistivity profiling method is used. In resistivity profiling, the spacing between the electrodes is held constant, and the array is moved as a whole along a traverse line [1]. The electrical traversing procedure has carried out in the site of investigation. The spacing of the electrode arrays as a fixed value along the traverse line at each measuring station position. Basically, the apparent resistivity determined in this procedure will be a function of the position, spacing and orientation. However, since the traverse line was oriented perpendicular to the strike of the general structure, the resultant apparent resistivity will be a function of the position and spacing only [1]. One application of resistivity profiling which usually leads to quantitative results is its use in measuring the conductance of a conductive overburden. The problem consists of determining the depth of soil over bed rock, the sort of problem frequently encountered in engineering geology and occasionally in mining geology. Instead of using vertical sounding measurements, a resistivity profile may be run using two or more fixed electrode separations. These separations are selected in the way to be sufficient for solving the problem under consideration [1 &2]. Commonly, the resistivity profiling technique is used as a semi-reconnaissance tool in the search for vertical structures which are likely to be identified with large resistivity contrasts, such as faults, contacts, dykes, shear zones and veins [6]. Any of the electrode arrays used in sounding may also be used in profiling, but the data obtained with some types of arrays are more readily interpretable than data obtained with other arrays. Interpretation of resistivity profiles is usually qualitative in nature. The electrical structure being sought is located by the change in apparent resistivity associated the structure [1 & 6]

2. Location of the study area

The area under study is located in the Northeast of Al-Umarah Governorate, bounded by latitudes (32° 15' – 32° 30') and longitudes (47° 15' – 47° 30'), belongs Ali Al-Gharby plate and is a part of the sedimentary plain. It covers an area of (584.37 km^2), (Figure ure ure 1). The eastern and north-eastern parts of such plate form Hamrin Mountains, which are composed of low folds that include the rocks of the Muqdadiya and Bai Hassan formations [2].

2.1 The Purpose of the Study

How we can use the conventional electric approach for the present measurements to be useful and give more obvious picture about the subsurface structural condition.

2.2 Geology of the Study Area

Generally, two types of sediments can be recognized from the surface geology in the area under investigation are the Quaternary represented by the Pleistocene and recent sediments and the Tertiary deposits represented by Bai Hassan formation. The most north-eastern and eastern part of Al-Umarah area is covered by Bai-Hassan formation of upper Pliocene age which is composed almost purely of terrigeneous clastics from silt size and sandstone of continental sediments to boulder conglomerates with some Lst and chert, underlain by Al-Muqdadiyah formation of lower Pliocene age composed of red sandstone and some marl with thin bed of secondary gypsum (continental and marine deposits) while the north-western and western part is covered by Quaternary deposits including, older alluvium of Pleistocene age, consists laucostrine, silt and sand appeared as a limited lenses, and younger alluvium of recent age composed of gravel, sand, silt and clay associated with little secondary gypsum [4]. However, this recent sediments may represent as sand dunes covered the flood plain valleys, (Figure ure ure 2).

2.3 Structural setting of the study area

The study area is a part of Ali-AlGharbi plate and these in turn are a part of the sedimentary plain, located on its eastern edge, where it is bounded by minor low folds from the east and north-east belongs to the Hamrin mountain which extends north-northwest to the south-southeast. The sedimentary plain is characterized by the presence of wide concave folds and narrow convex folds having northwest - southeast direction, accompanied by normal longitudinal faults [4 & 5], (Figure ure ure 3).

2.4 Hydrogeology of the study area

Pliocene deposits that including both (Bai- Hassan and Al-Maqdadiyah), form the main upper aquifer within the border areas, while the Quaternary deposits constitute the main upper aquifer of the general Ali – Algharbi plate. In general, the sediments of the Quaternary period consist the succession of clay, silt, sand and gravel layers. It should be noted that the sand and gravel sediments form the aquifer, while the clay and silt deposits form the un-porous sediments or aquitared layers. The thickness of this aquifer reaches a few tens of meters and such sand deposits can be found at a depth of 10-20 meters below the ground surface. The static water level varies between (2.5-21 m). The Tertiary age (Pliocene period), on the other hand, which represented by Bai-Hassan and Al-mugqadyia formations are revealed and exposed at the border regions and over-lained by the Quaternary deposits in the most areas of the plate. These deposits consist mainly of sand and gravel with thickness reached more than 100 meters. The values of transmisivity have ranged (12-290 m^2/day), permeability (0.5-15.5 m/day), specific yield of (115-1782 m^3/day) and static water level having range (1-64 m). The general trend of groundwater movement is in line with the topography of the region, which is from the north and north-east towards the south and southwest. Water quality, on the other hand, is heterogeneous which mostly contained sulphate in the eastern highlands while chloride is predominantly in the sedimentary plain [3].

3. Field Operation and Data Presentation

The measurements were made along two long profiles, namely (A & B), totaling about (43kms), (14 & 29 kms) respectively. Measuring stations were pegged along these profiles and some in near area with total of (23) points. Profile (A) is oriented (NW) to (W) and terminated at profile (B) which almost oriented (N-S), (Figure ure ure 4). Full schlumberger conFigure ure uration was employed to carry out the sounding-profiling measurements with half space (AB/2) = 3, 5, 8, 101, 20, 30, 50, 80, 100, 150, 200, 250, 300, 400 and 475m. All these measurements were made using (SYSCLR1) instrument. The elaborated resistivity measurements are presented in two various modes, the 1st mode of horizontal resistivity maps whereas the second mode was appeared as a space section (Pseudo section) and resistivity profiles [6 & 7].

4. Analysis and Interpretation

As mentioned before, the analysis of the measured horizontal resistivity data is usually leads to qualitative results [6]. Basically, the most useful approach in contacts exploration is to locate the high gradients of either resistivity or conductivity within a certain depth of penetration, i.e. the lateral variation in apparent resistivity due to the presence of a vertical contact [1 & 2]. To get a clear picture about the location, trend and other geological characteristic features of such a zone, a grid of traverse lines should be constructed in which the traverse characteristic as (length, interval, orientation and station interval) should be determined with respect to the suspected subsurface structure. All station measurements with the same apparent resistivity values are joined by contour lines called iso-resistivity contour lines, and the final form of these contour lines is called an iso-resistivity contour map [1 & 2]. (15) Maps on the same scale have been constructed for the mentioned spacing revealing the lateral variation in their resistivity values, (Figure ure s 5-19). In addition, two space sections as pseudo sections were constructed, revealing the vertical changes in the resistivity column, (Figure ure s 20-21), more over resistivity profiles were constructed as well, (Figure ure ure 22). On the basis of electrical resistivity maps, space sections and resistivity profile, the relief of the subsurface structure has been mapped and its trend has been delineated. In general and by inspection these resistivity maps, all clearly shown a great similarity and agreement in the pattern of the contour shape of two intersected major anomalous zones represented by a well defined high resistivity anomalies with their axes trending NW-SE and NE-SW in respect to the map coordinates respectively. Obviously, these two major intersected anomalous zones indicate the presence of concealed subsurface fault or vertical contact structures and their strike direction. Noticeably, these anomalies revealed two zones of contour behavior, the first one represented by high density contour lines with maximum apparent resistivity of (415 ohm.m) characterized by steep gradient and displayed clearly in shallow depth or short space interval, spacing (3-100m), (Figure ure ure 5-12) whilst the second zone was represented by low density contour lines with maximum apparent resistivity value of (40 ohm.m), spacing (150-475m), characterized by gentle gradient, (Figure ure ure 13-19). From geological information available in the area, such behavior contrast is mainly attributed to the presence of ground water level, where the lateral contrast in depth between both sides of the vertical contacts or the fault structure was diminished; the contrast was clear in shallow depth because it was far enough and away from the presence of ground water. Well, the general shape of these major fault or vertical contact anomalies in all maps indicate a continued anomalies which reflects the presence of fault like structure or contact outside the investigated area, since the anomalies are characterized by open contour lines. For further investigation, the apparent resistivity values were displayed in the form of apparent resistivity space section (pseudo section), where the observed apparent resistivities were plotted at their sounding position, horizontal axis, and electrode spacing, vertical axis [1]. These values were contoured along lines of iso-resistivity representing a two dimensional resistivity distribution, (Figure ure ure 17-22).

Although a semi-quantitative technique was available to interpret such space sections [6], qualitative analysis was only conducted. Principally, both Figure ure ures show an indication of high correlation between the apparent resistivity distributions with surface geology. The high resistivity zone positioned below stations (4, 5, 6, 12, 13, 16 & 17), is easily recognized as being associated with the vertical contact or fault like structure. However, it can be clearly seen, that the contour line values decreased with increasing space, i.e. apparent resistivity decreased with depth. This behavior is due to the presence of ground water that reduced the lateral contrast in both sides of the contact structure. The resistivity profiles, on the other hand, revealed similar behavior to that vertical contact (fault) behavior given by [6 & 1], (Figure ure s 23-25). These profiles are characterized by the intersection of sharp drops in apparent resistivities which then confirmed the results given from the maps and pseudo sections. In addition, an iso-true resistivity map and depth of the aquifer were constructed as well, (Figure ure s 26 & 27) to give more obvious picture about the geologic condition. Again, confirmation with previous result was indicated.

5. Conclusion

With regard to the anomaly shape, magnitude and position given in different spacing maps, pseudo section, resistivity profiling, panel diagram and iso-true rersistivity map, all these indicating clearly the existence of two major anomalous zones. On the basis of anomaly behavior (in comparison with ideal one), resistivity contrast and depth of the aquifer, these two major anomalies gave an evidence and reflected the presence of two intersected vertical contacts (fault like structure) with their axes trending (NW-SE) and (NE-SW) respectively. Moreover, evidence is also given from the geological information, in which many springs were existed and scattered along the intersected part of the structure. Finally, a solid and efficient result from the discrimination of schlumberger VES'S as profiling approach can be obtained.

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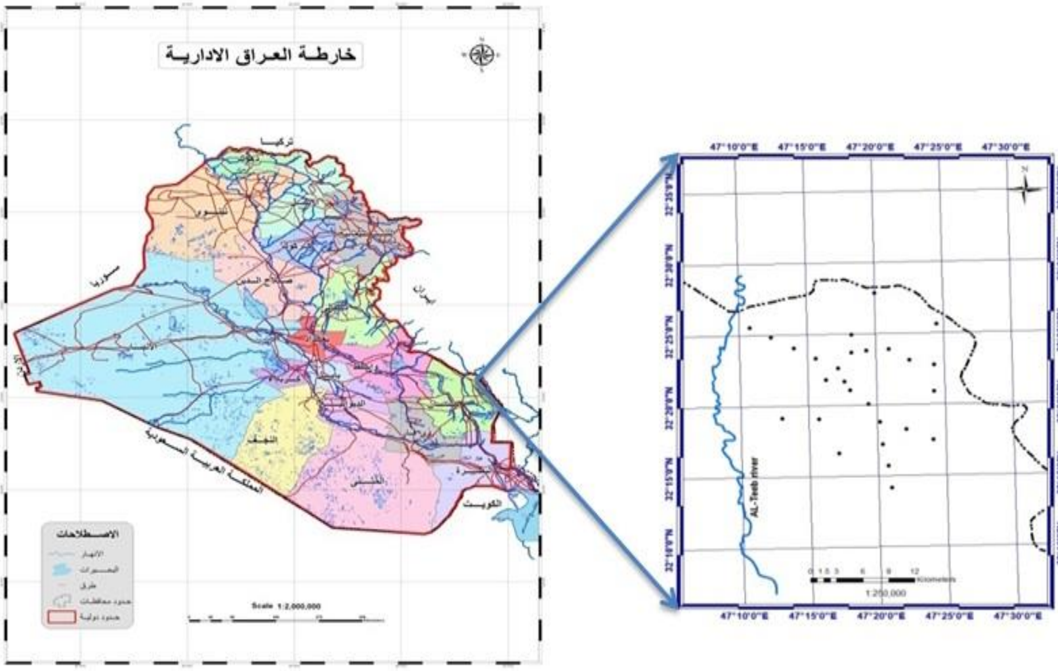


Figure 1: Location of the Study Area

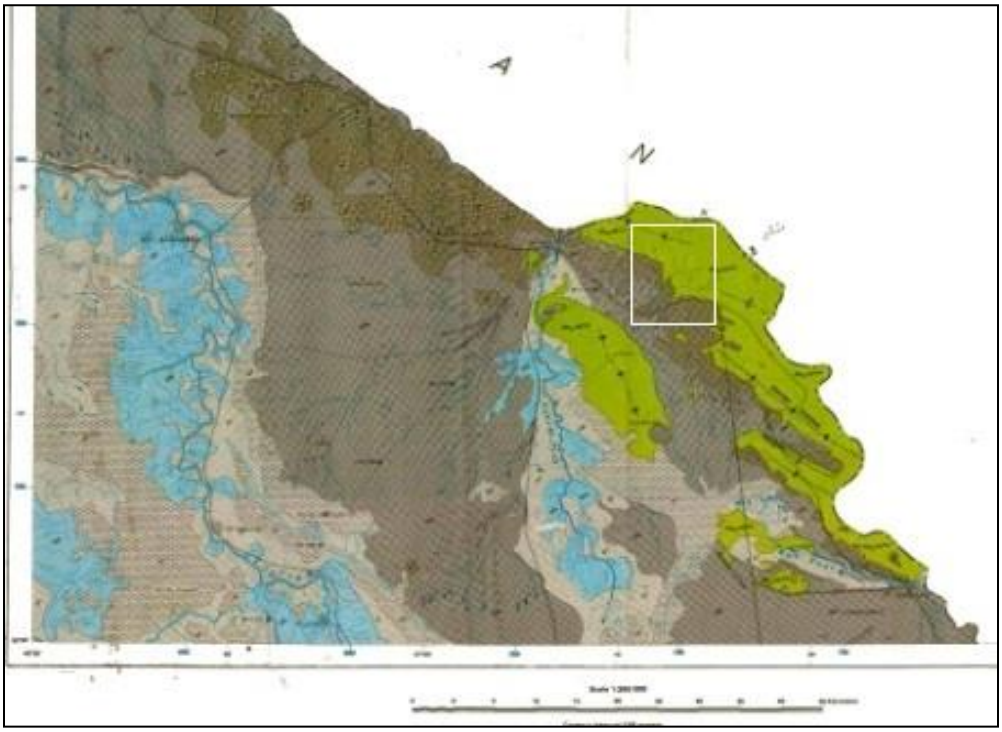


Figure 2: Geological map of the study area and its surroundings

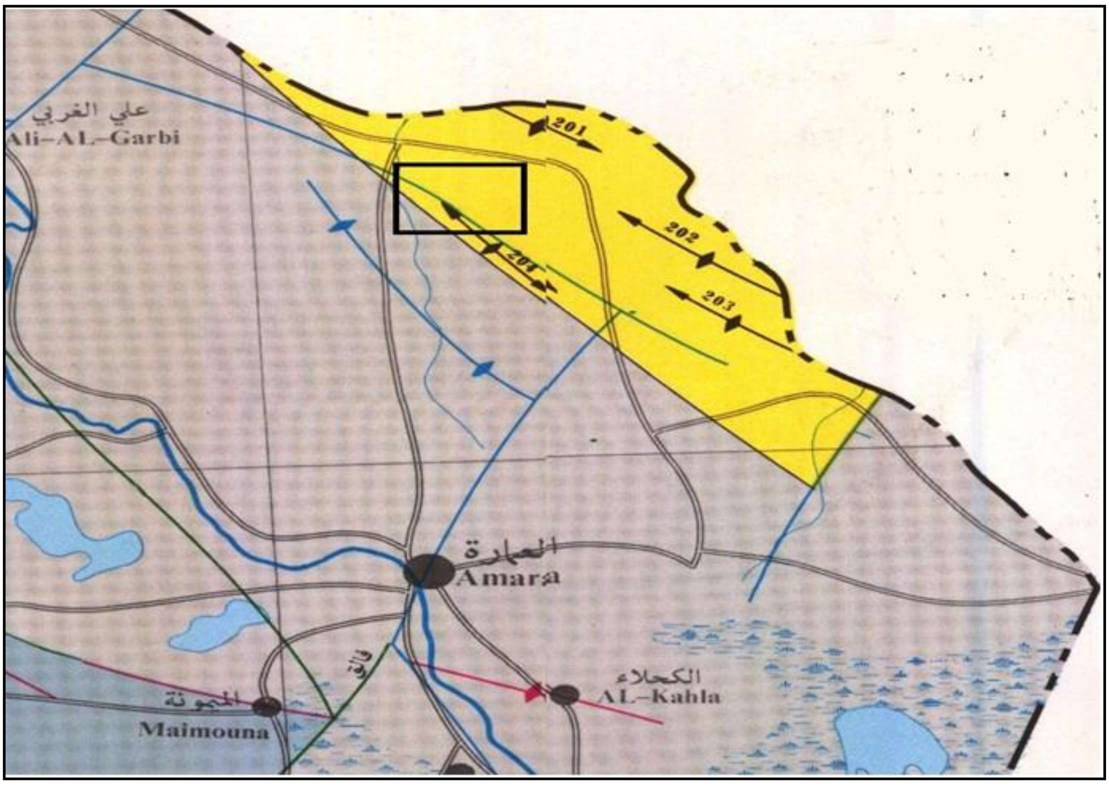


Figure 3: Tectonic map of the study area and its surroundings

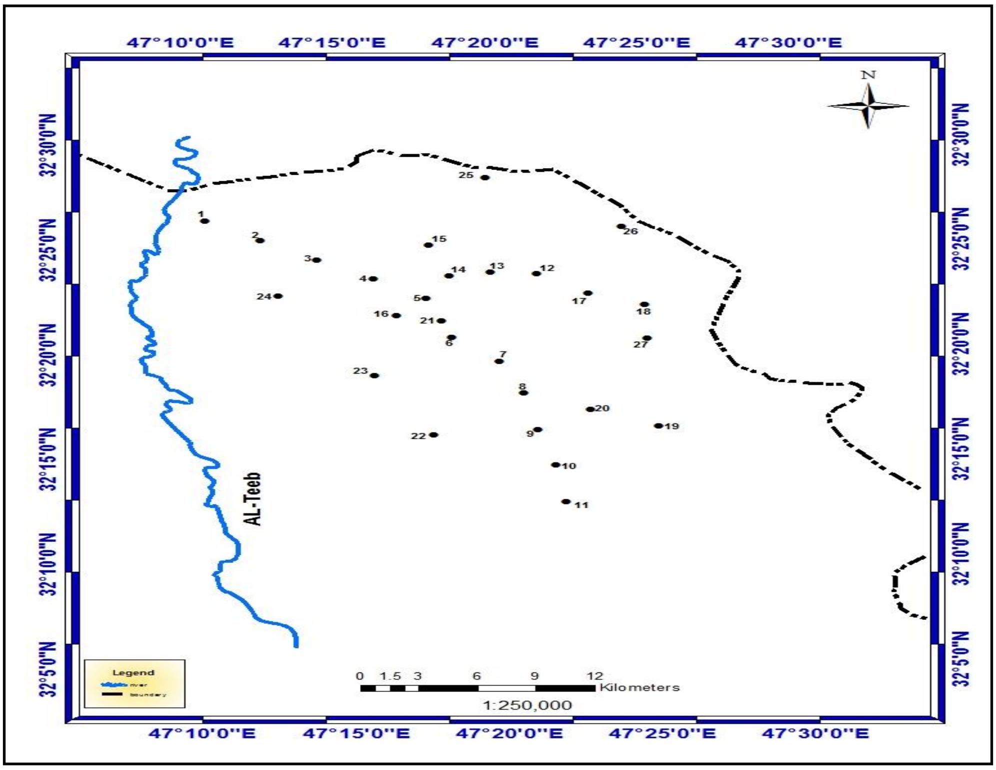


Figure 4: Electric traverses and measuring points

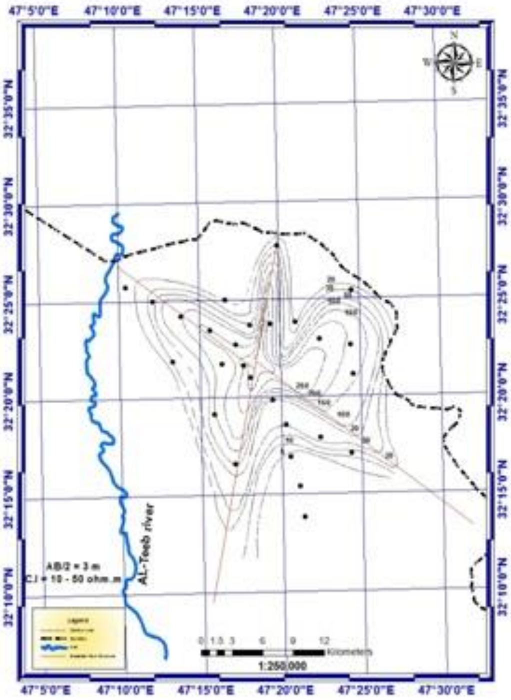


Figure 5: Horizontal electric map, AB/2=3m

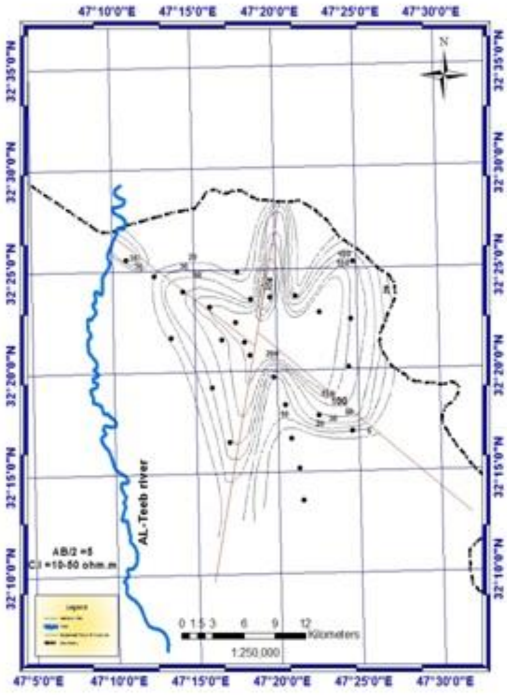


Figure 6: Horizontal electric map, AB/2=5m

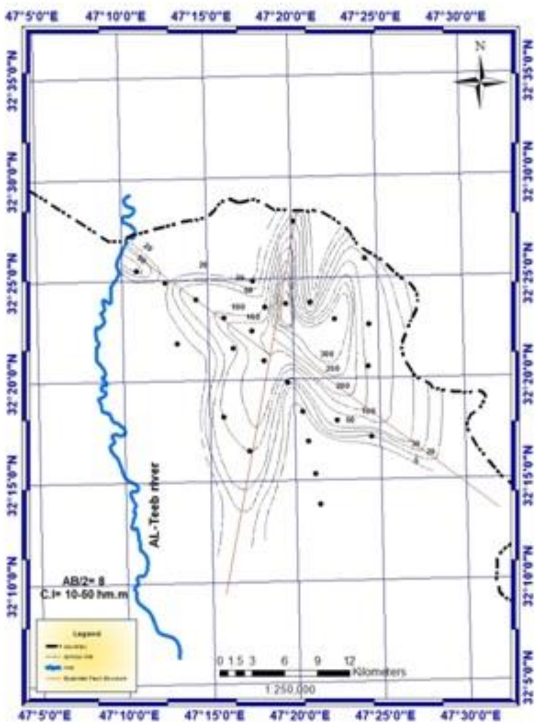


Figure 7: Horizontal electric map, AB/2=8m

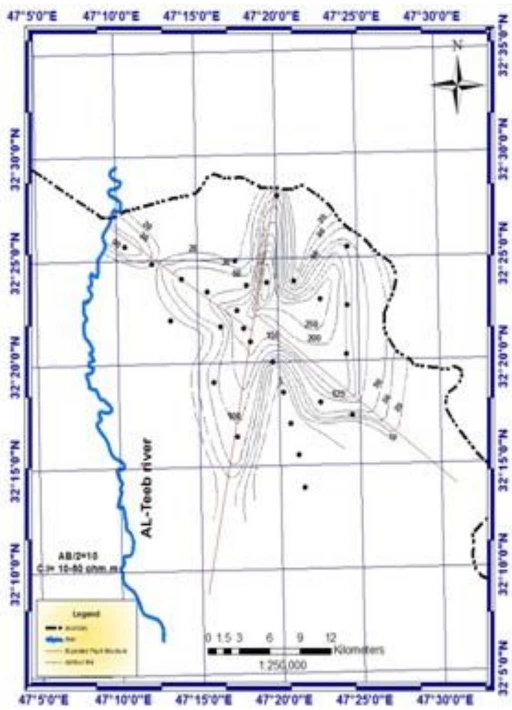


Figure 8: Horizontal electric map, AB/2=10m

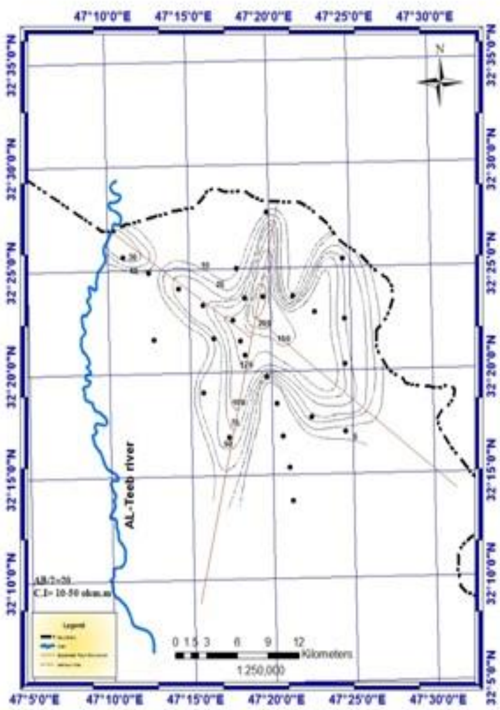


Figure 9: Horizontal electric map, AB/2=20m

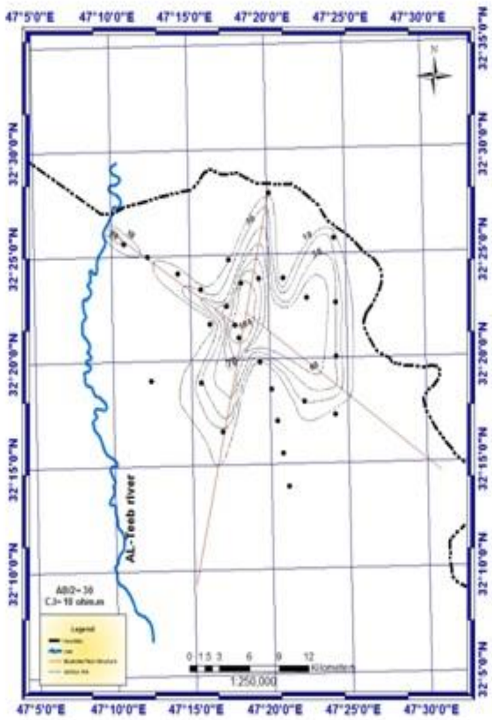


Figure 10: Horizontal electric map, AB/2=30m

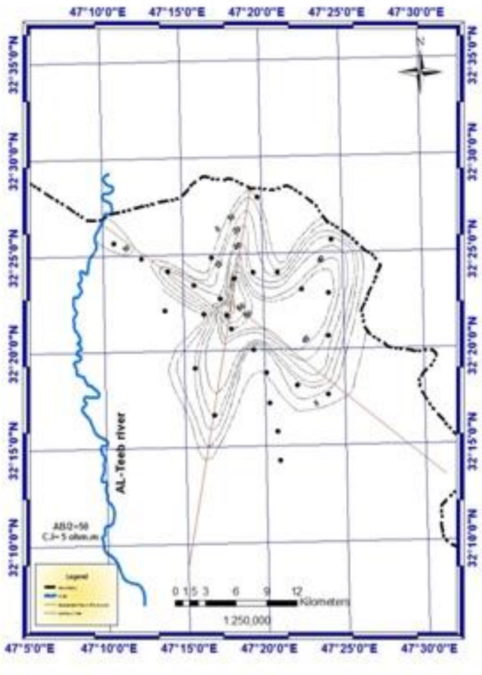


Figure 11: Horizontal electric map, AB/2=50m

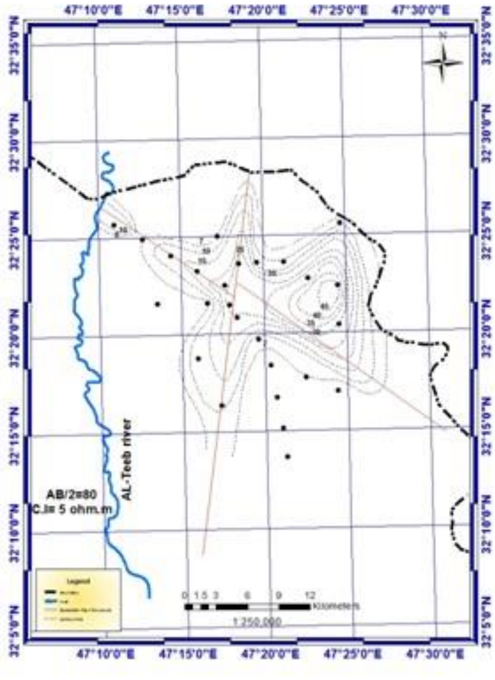


Figure 12: Horizontal electric map, AB/2=80m

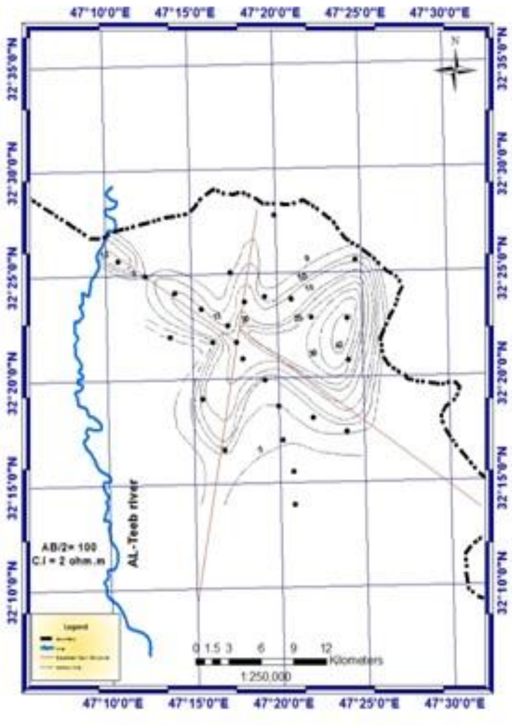


Figure 13: Horizontal electric map, AB/2=100 m

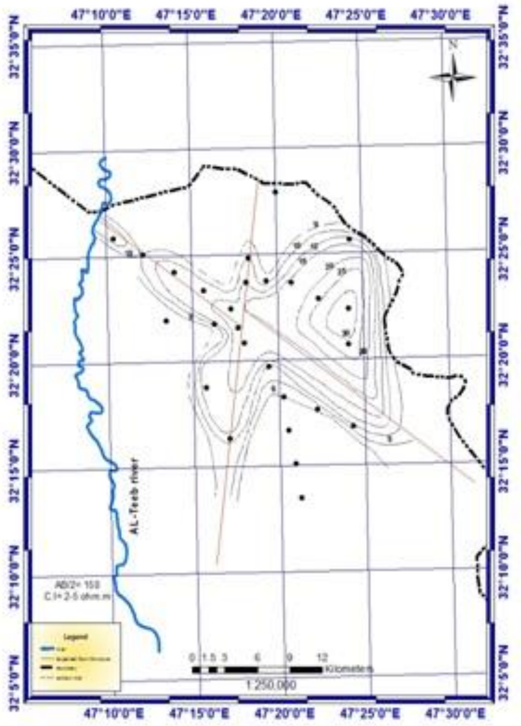


Figure 14: Horizontal electric map, AB/2=150 m

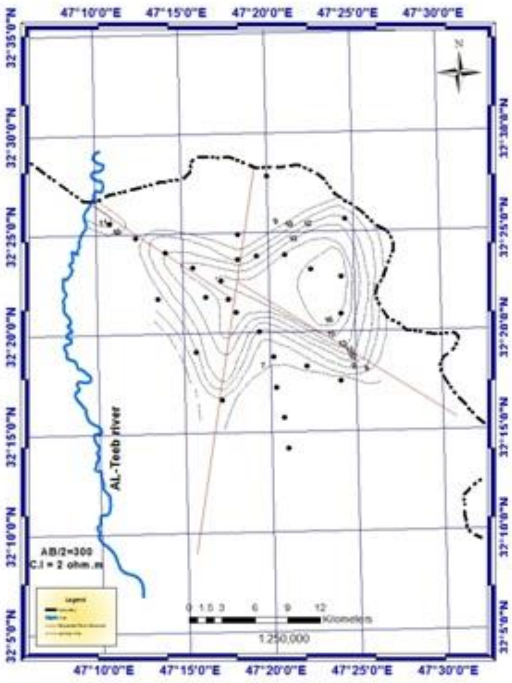


Figure 15: Horizontal electric map, AB/2=300 m

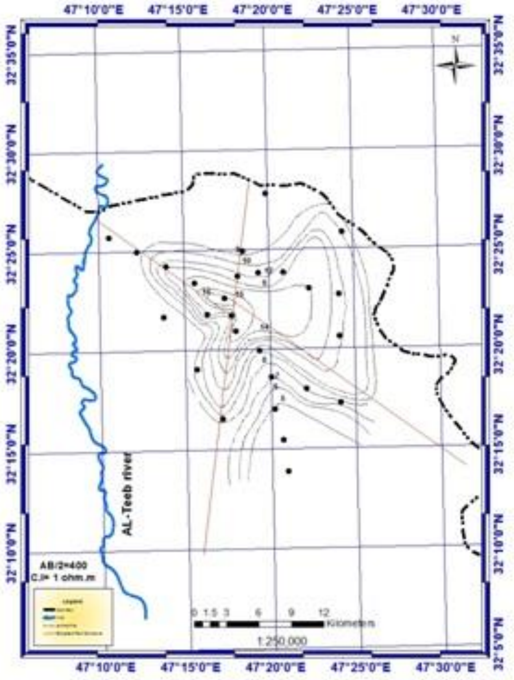


Figure 16: Horizontal electric map, AB/2=400 m

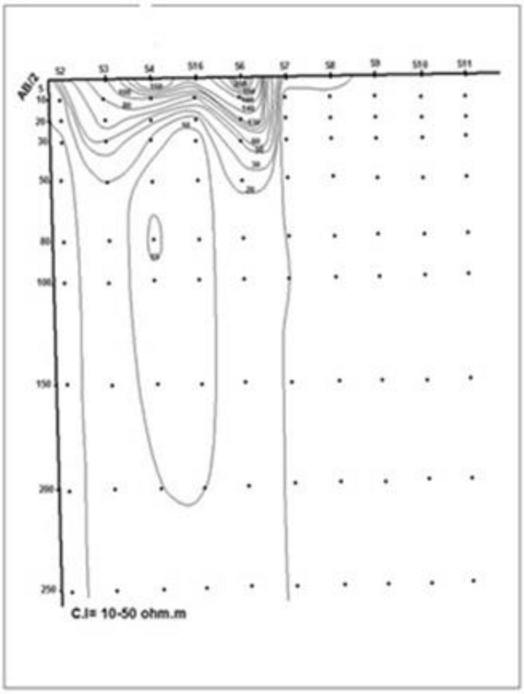


Figure 17: Space Section along profile A

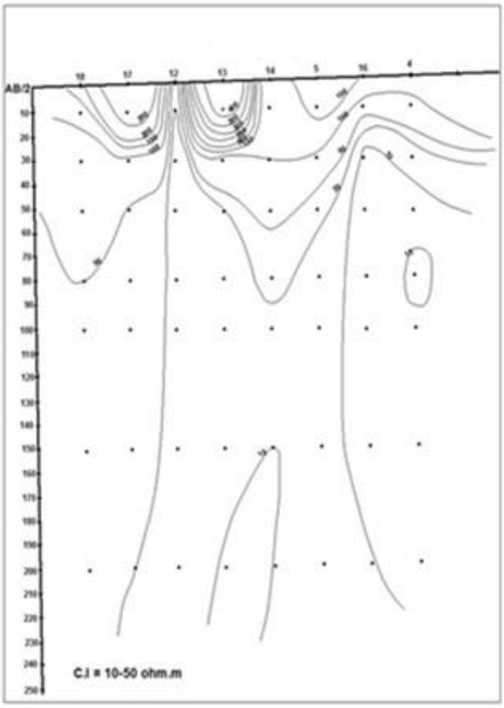


Figure 18: Space Section along profile B

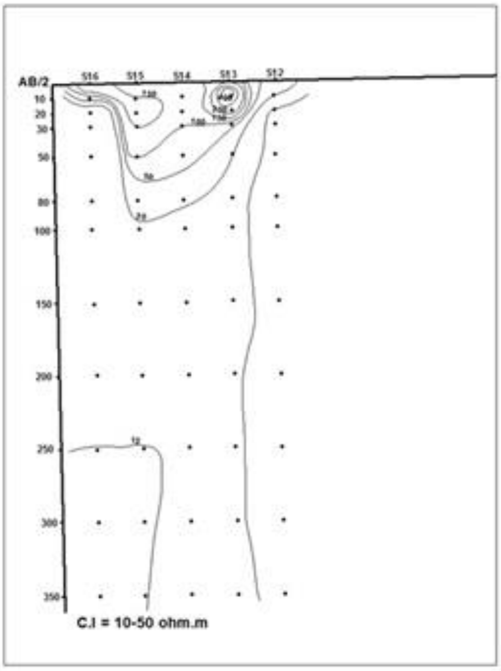


Figure 19: Space Section along profile C

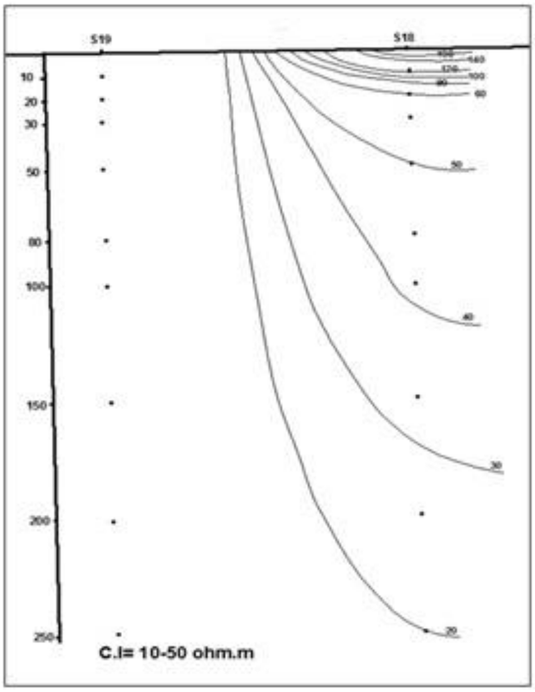


Figure 20: Space Section along profile E

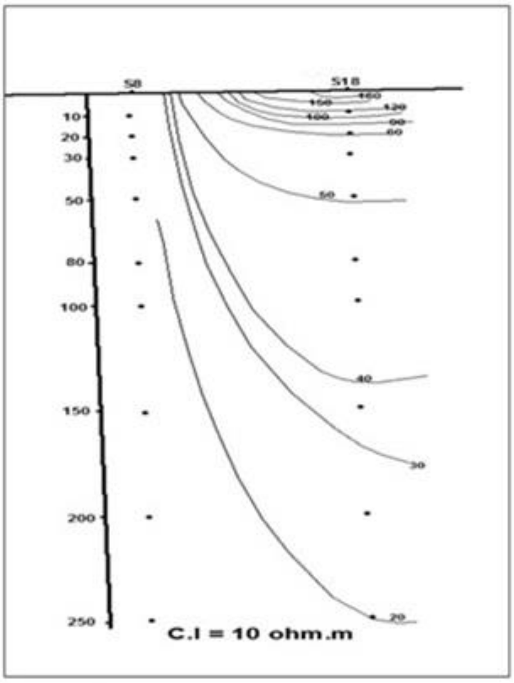


Figure 21: Space Section along profile H

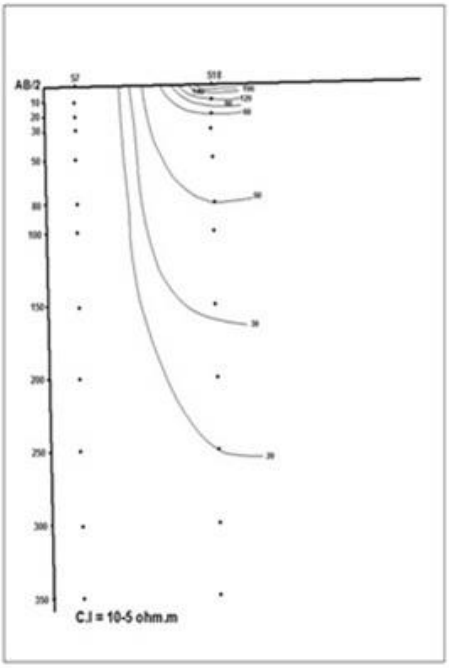


Figure 22: Space Section along profile I

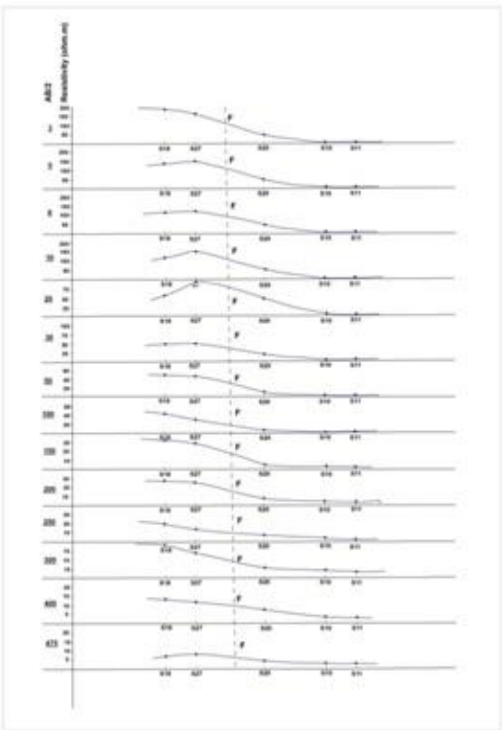


Figure 23: Horizontal electrical resistivity profile 1

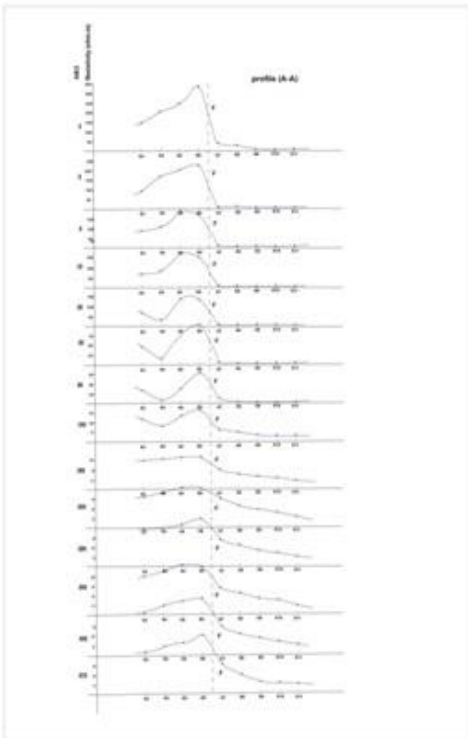


Figure 24: Horizontal electrical resistivity profile 2

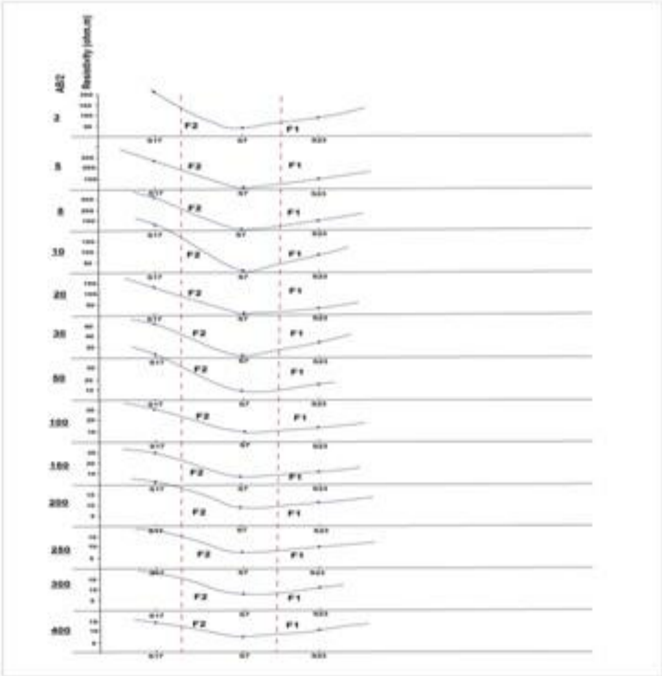
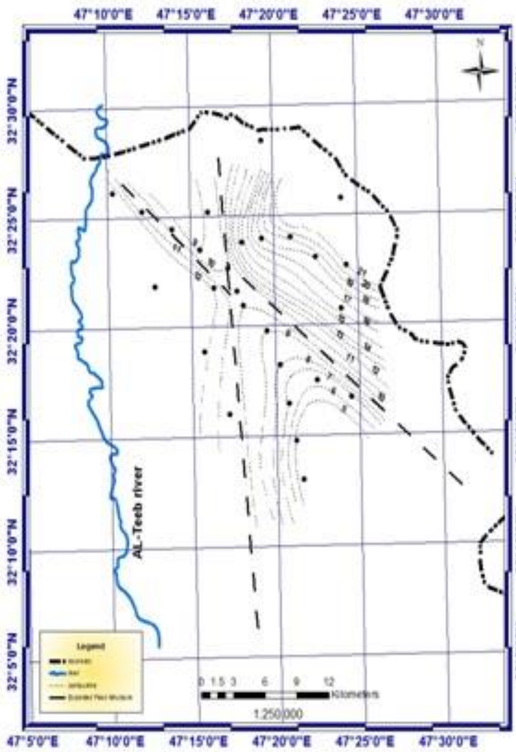


Figure 25: Horizontal electrical resistivity profile 3



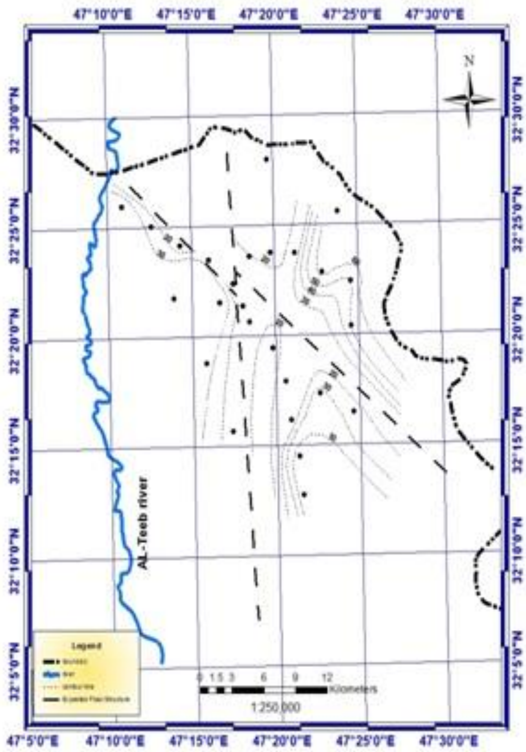


Figure 26: Iso-True Resistivity Map of the studyarea **Figure 27:** Depth of Aquifer Map