CONTRIBUTION TO THE RECOGNITION OF THE STRUCTURE OF TASSAOUT DOWNSTREAM OF TADLA BASIN THROUGH THE APPLICATION OF GEOELECTRIC METHODS

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Abstract

Geoelectric study is used in determining the image of the structure of the aquiferous system of the Tadla plain (Tessaout aval) through the measure of electric soundings. The treatment processing of these measures, their correlation with the data of certain drilling, the well existing in the canvassed area, and the analysis of all the results, shows that the study area of the profiles and the maps of the established electrics resistivities and clear geoelectric cups gives a general looks. This put the superimposing of several variables as evidence. Roughly speaking, grounds draws a structure of monoclonal wrinkle sometimes tectonised, which dives the Northwest towards the Southeast. This structure is affected by a series of flaws which are causing the collapse of compartments which are located in the South.

Keywords: Geoelectric, aquiferous, structure, Tessaoutaval

Introduction

Regular water supply is one of the greatest challenges of humanity in this millennium. The scarcity of this resource is not an exceptional concept. It stems from the peculiarities of the geographical context and the climate condition of the region. In the coming decades, the uncertainty of climate changes, population growth, increased socio-economic needs, and the risk of pollution, exacerbates the problems of the availability of this resource in quantity and quality. Faced with these problems, it is necessary to put in place mechanisms and actions to operate the use of available water resources particularly groundwater. Also, it is important that the available water resources should be recognized, preserved, and safeguarded.

Therefore, the main objective of this research is to improve the recognition of Tadla basin through geo-electric method. This helps in determining the structure of these aquifers, their extensions, depths, and their thicknesses in order to establish resistivity cards, cards thickness, and depth maps. Furthermore, it also assists in monitoring the lateral and vertical development of apparent resistivity, generate geo-electrical sections juxtaposed training, and meet the need of the physical characteristics of the basement in TessaoutAval area.

Presentation of the Study Area

The study area is the Tassaout downstream which is part of the plain of Tadla. Thus, it is mainly found in the western part between the wadis Al Abid and Tassaout. Natural conditions are characterized by the appearance of semi-arid climate, the regularity of the topography, and the existence of a major river system that is organized around the Oum-er-Rbia (Figure1a).

Geologically, the study area has an extensive asymmetrical depression covered by deposits of heterogeneous Mio-Pliocene-Quaternary (Choubert, 1956). This is a syncline whose axis is located near the southern edge of the Atlas and where powerful series from the Triassic to Quaternary were deposited (Figure 1b). Consequently, these deposits are generally made by alternating clay marl, calcareous marl, lacustrine limestones, and conglomerates. In fact, it is complex having a multitude of alluvial aquifer horizons and countless facies variations (Boucart, 1942). In miocene epoch, rough conglomerate involved in Atlas deformation phase is individualized in that the lower part of the groove is in contact with the thick portion in the Atlas of sedimentary prism. Elsewhere, it speaks especially of Plio-Quaternary in which fluvio lacustrine facies Villafranchian take an important place, especially near the OumEr-Rbia. Near the Atlas, large deposits thicknesses are partly due to large cone formed at the foothills of the chain dismantling products (Bouchaou, 1995).

Rainfall usually occurs between the months of October and May. However, it falls irregularly in time and space from an annual average of 210 mm/year in BeniMoussa. Also, it has an annual average of about 230mm/year in Beni Amir. The special distribution of precipitation over all stations of the downstream Tassaout (average 1967-2012) was marked by a decrease from the South to the North, as well as going Southeast to the northwest i.e. the Atlas Jbilet (380mm/year in El Kelaa of Sraghna), and to the OumEr-Rbia. Consequently, temperatures have very significant seasonal variations with its peak in August and its minimum in the month of January. Winter is temperate, and the average daily minima do not descend to less than 5 ° C. In the downstream Tassaout, temperatures are on an average of 7 ° C in January to near 26 ° C in August.

Figure 1

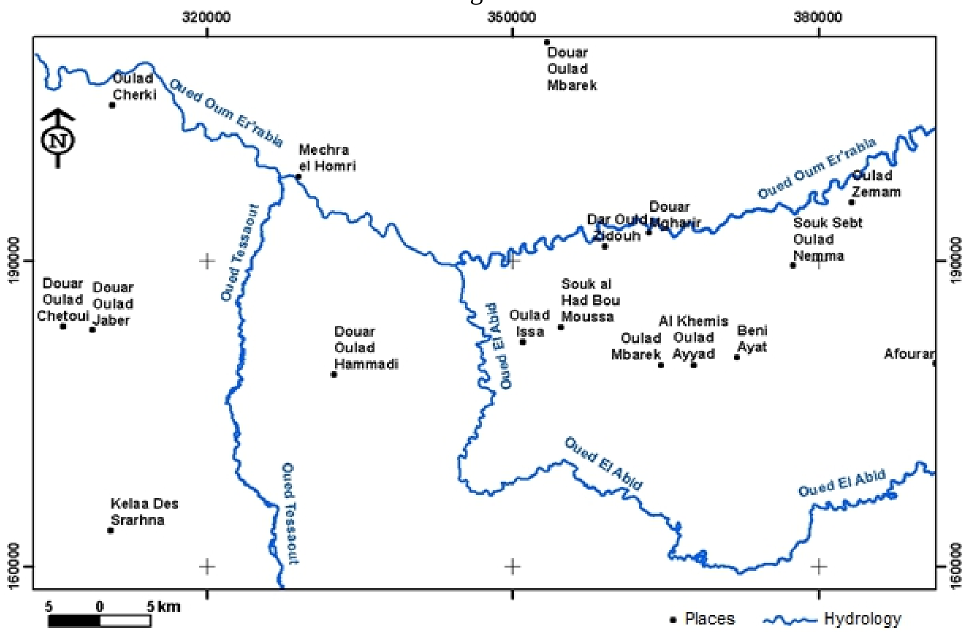


Figure 1a. Presentation of the study area.

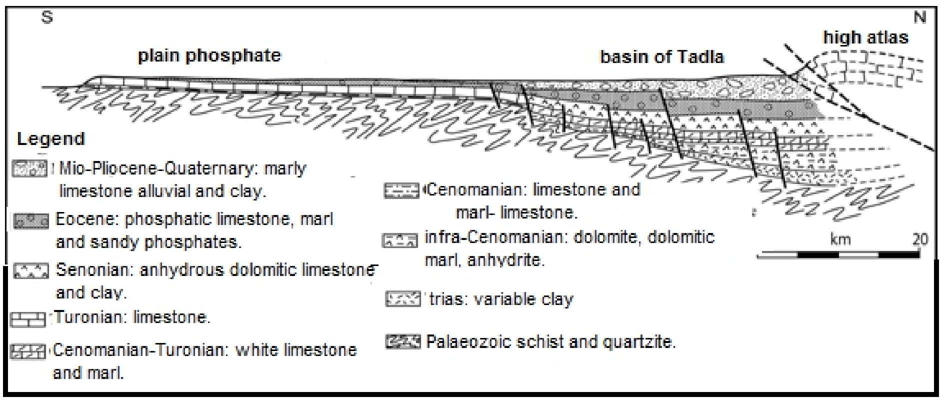
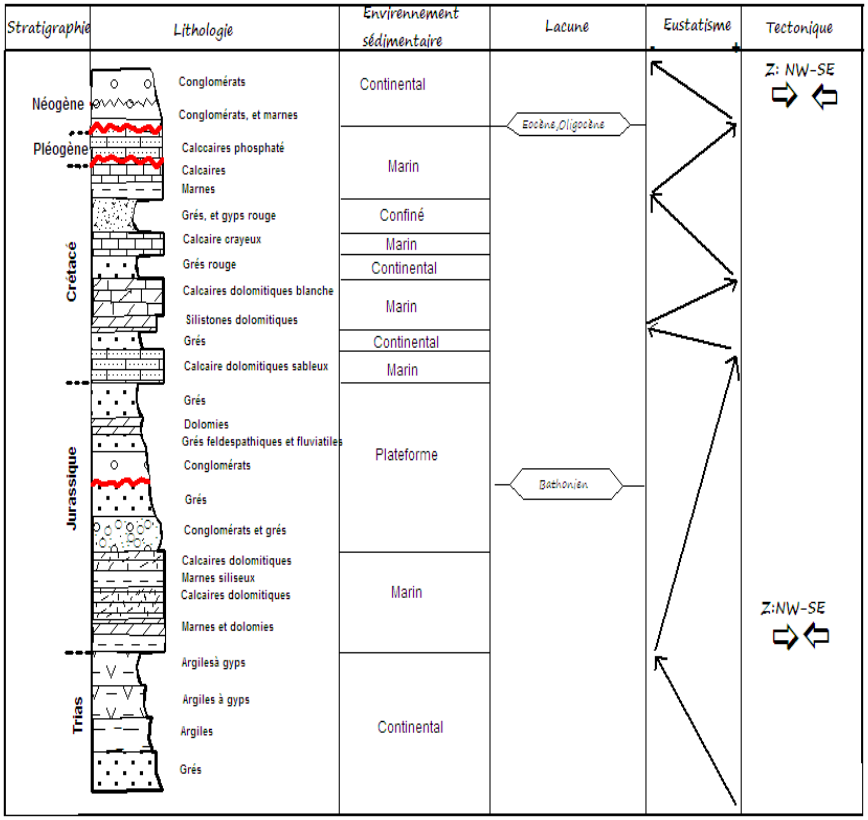


Figure 1b.Geological section showing the structure of the Tadla basin aquiferous system (Hsissou, 1991).

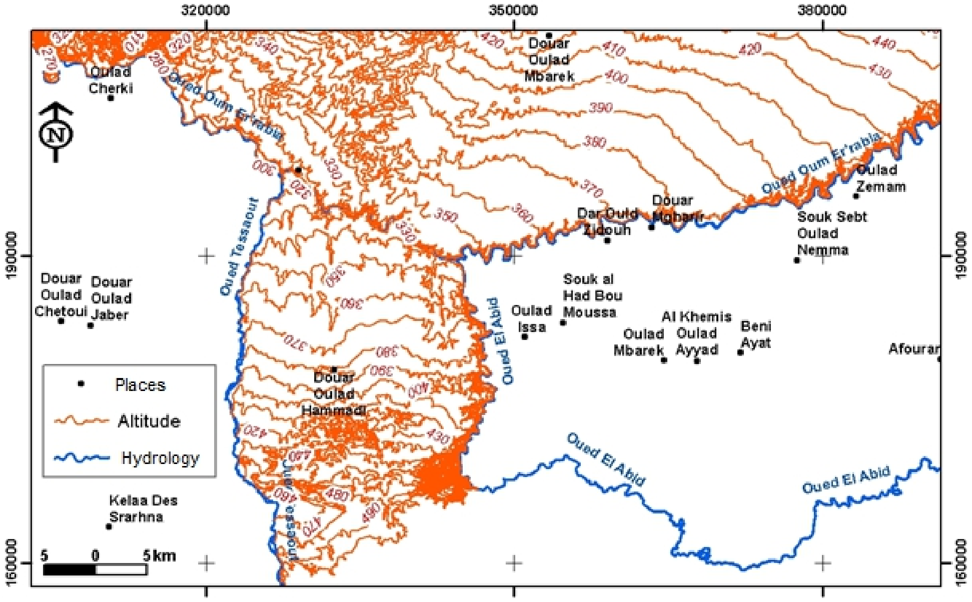
(c)



Methods

The choice of a geophysical method and technical program should be established after examining the problem of geological and environmental conditions. This choice leads to retain the physical parameters that may be a sufficient contrast in meeting the objective of this study. However, the sequence of different tasks scheduled in the present study had respected some rules to cover a systematic way throughout the Tessaout Aval. Thus, it makes every step to become more efficient. During the initial phase, geological reconnaissance was well placed in advance. It aims to get all the information on the characteristics and basement of the soil. The geological information collected also facilitates the selection of the most appropriate measurement devices in the context of this study. In addition, it is used for implementing the best data acquisition profiles. In parallel with this first phase of the study, all data relating to the hydrogeology of the study area was taken. These data were collected moderately which raised a piezoelectric companion and lithological identification of aquifer levels. Thus, it is essential to look beyond the existing wells in the study area, but to take into account all water points in the vicinity. It is also essential to provide guidance on the flow of groundwater and the lateral evolution of the different facies. It consists of a picket and materialization on the ground of different profiles and measurement stations. This was followed by surveying and leveling the originating altitudes i.e. the average sea level. A synthetic topographical map of the study area has been established with a constant equidistance (Figure 2). However, the spatial configuration of the measuring stations has been chosen so as to obtain the maximum amount of information while considering terrain conditions.

Figure 2.Synthetic topographic map of Tessaoutaval area.



The recognition program included the completion of 124 electrical surveys distributed over twelve profiles (1TB, 3TB, 5TB, 7TB, 9TB, 11TB, 13TB, 15TB, 17TB, 19TB, 21TB, 23TB and) which differ from each other through the number of electric polls. The inter-profile is 5km, while the distance between the holes centers is 2.5km (Figure 3). Electrical polls types Schlumberger were aligned in the direction NS, and geological data have revealed five families of electrical soundings curves (A, B, C, D, and E) corresponding to the different successions of soil layers (Figure 4). Thus, the processing of the acquired data was performed using a IPI2W in modeling program developed by the University of Moscow. This program helps to determine the number of layers involved, and the thicknesses and resistivities of each of these layers. Subsequently, 124 Geoelectric curves were constructed from the data of the resistivity and the length of the line AB. From the data of apparent resistivity, four cards iso-resistivity corresponding to four different lengths of line AB (200, 500,1000, and 2000), that is to say at increasing depths, was established. The juxtaposition and interpolation between different electrical levels highlighted on electrical polls and achievement of resistivity maps, thick cards and depth maps, allowed us to follow the lateral and vertical development of apparent resistivity. Thus, this assists us in generating geo-electrical sections juxtaposed training, and also to meet the physical characteristics of the basement in TessaoutAval area.

Figure 3. Area concerned by the geophysical measurements and mechanical survey.

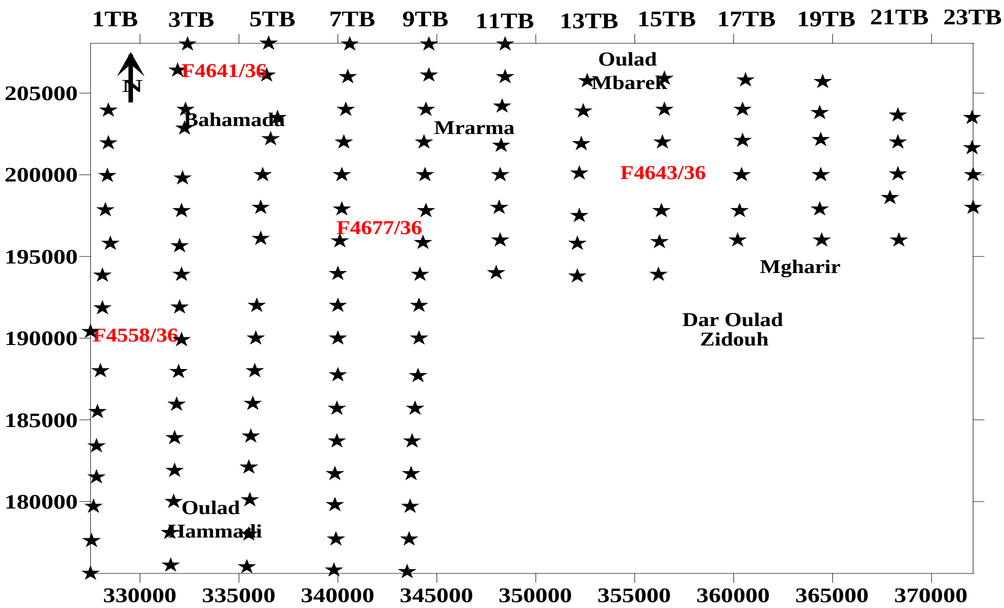
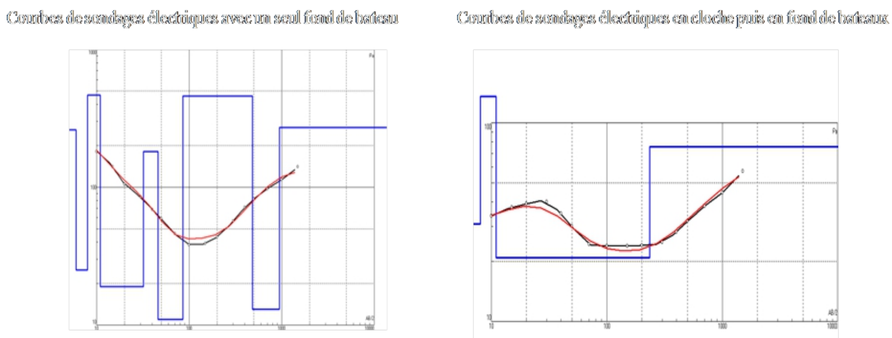
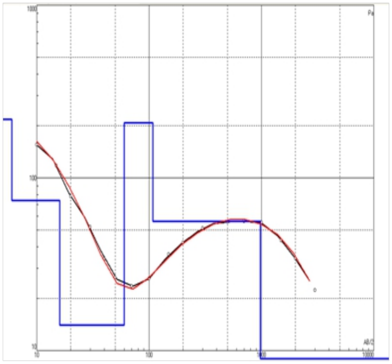


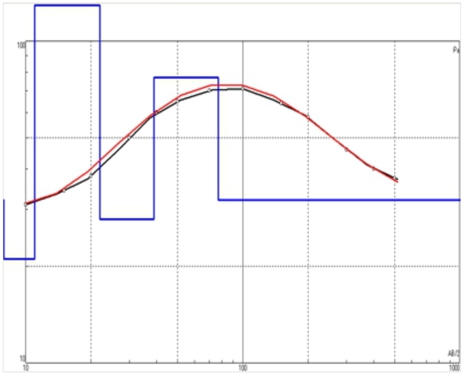
Figure 4. Interpreted curves of electrical soundings (A, B, C, D, E).



Courbes de sondages électriques à deux fonds de bateaux consécutifs



Courbes de sondages électriques à une seule cloche



Courbes de sondages électriques avec deux cloches consécutives puis en fond de bateaux

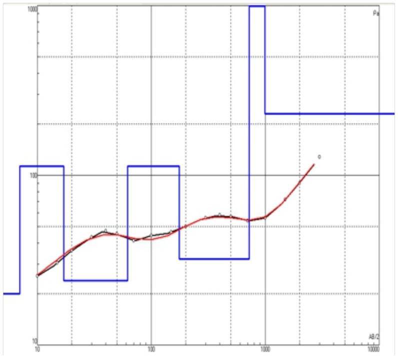


Figure 5. Lithology of the mechanical survey 3868/36

F 3868/36 X= 357145 Y= 208260

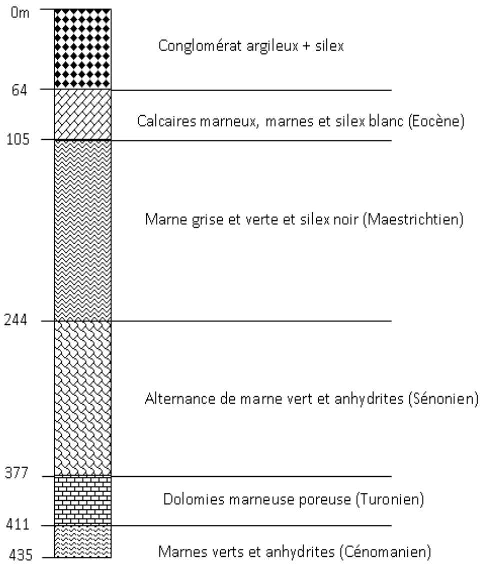
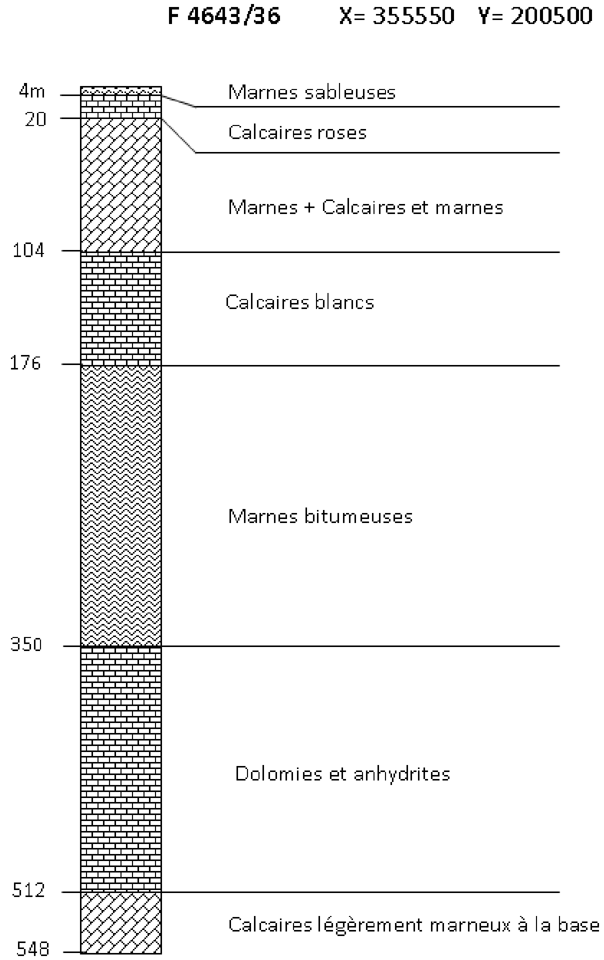


Figure 6. Lithology of the mechanical survey 4643/36



Interpretation of Results

The analysis of the overall results of the profiles established in the resistivity maps and the synthetic sections shows that one end to the other of the surveyed area generally have gaits. Hence, this shows the superposition of several grounds of different electrical resistivity. These lands monoclinale draws a structure that plunges the Northwest to the Southeast with the following levels:

• A heterogeneous collection of variable resistivity ranging from 3 to about 290 ohm.m;

• A strong training (260-500 ohm.m) and thick variable depth;

• A thick conductor level (400 to 860m) and resistivity of between 65 and 250 ohm.m;

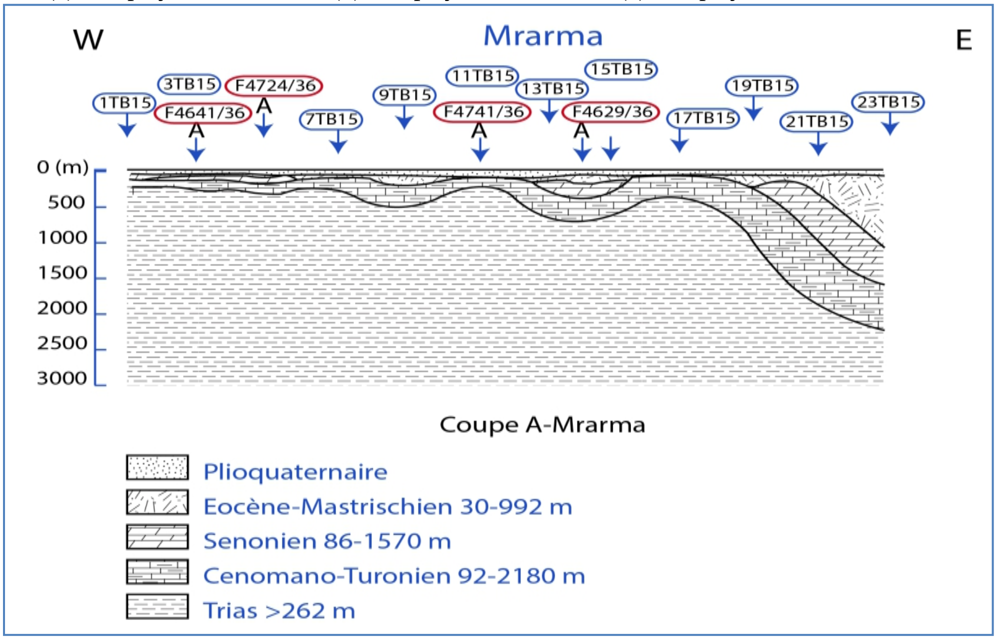
• A very strong training component bedrock geological series; hence, its resistivity exceeds 350 Ohm.m.

The heterogeneous complex corresponds to the filling Mio-Pliocene-Quaternary. Its thickness is variable and it increases considerably from north to south (Figure 7a) (15m to the north and northwest, and over 300m to the south and southeast). Very low resistivity (less than 10 ohm.m) encountered in some stations are of significant past impermeable clay or high salinity of the water table. The high resistivity includes limestone lens features incorporated in the mass alluvial (Bolelli, 1942). The basis of this complex is formed from a thin conductive horizon constituting the impermeable wall of the Mio-Pliocene-Quaternary aquifer. The consultation with technical sheets core drilling F4741\36, F4768\36 and F3868\36 (Figure5), show that this is a clay level identical to that observed in the Mrarma area. However, re-resistant superficial level corresponds to the limestone of Maastrichtian-Eocene which is present throughout the survey area. It shows a dip from North to South, from the North West to the South East, and the West to the East. In addition, its thickness is variable. Indeed, the most depressed areas are located in the North East of Dar OuledZidouh near the OumEr-Rbia where the roof of the resistant level achieved a rating of 250m (electric survey 17TB11) and a rating of + 120 m in the place of confluence of Oued Oumer-Rbia and Al Abid (electric survey 9TB8). To the north of the study area, the highest points are located in the area of OuladMbarek to the nearby electric 15TB16 survey (Figure 7b). Synthetic cut 1TB and 9TB show that the level of resistant bedrock attributed to the Eocene-Maastrichtian horizon rises to a rating of 50m to the North, West, and South directions between the wadis of Tessaout and Al Abid. Consequently, the contours of the steep gradient observed in the northern part and the low gradient of contours is marked in the western and south western parts of the study area (TessaoutAval). This area is more or less tectonized. Thus, it is affected by two faults (between 1TB6 and 1TB7, and between 1TB5 and 1TB6) that are responsible for the collapse of the compartments located in the South of electrical sounding 1TB7. These flaws are well separated by the offset of the structure. It reached a depth of 250m to 1TB6 and 700 m to 1TB7.

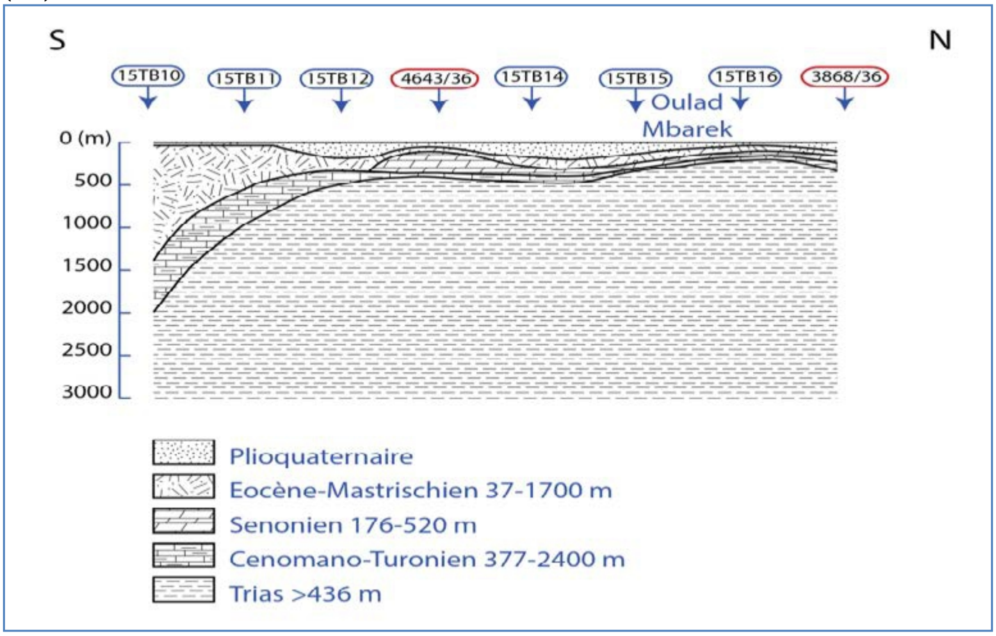
The level assigned to the Senonian (phosphate Area) is limited to the North between drilling F4643 / F3868 and drilling 36/36 with a depth not exceeding 520 m (Figure 6) and uniform electrical resistivity. It is located in the south zone Tassaked (F563 / 45) and north to the right of the drill F4642 / 36 (Sidi Bel Abbas) in the area of El Azzaba between electric and electric survey 3TB8 7TB8 survey. It disappears to the south from the survey Electric 15TB12 of the right drilling F4779 / 36 to the vicinity of BirKaddour and to the southern part of the East NNW-SSE synthetic cut (Figure 7c) between the drill F4686 / 36 and the electrical survey, 9TB10. This results in Senonian erosion in these areas, such as suggesting lithological series F4676 drilling / 36 and F4686 / 36. The Senonian formation is pleated with a variable thickness in TessaoutAval. Therefore, it is more or less conductive. The values of electrical resistivity are also very low (7-23 ohm.m). The facies of this tank is formed essentially as marls gray dolomite, Senonian Marin, clay, and sandy clay of evaporite anhydrite Senonian.

The deep level resistant Rt was awarded to Turonian which constitutes the largest reservoir of Tadla basin by its storage capacity and the quality of its waters (NAJINE, 2004). The nature of this reservoir facies carbonate type is mainly formed from limestone, dolomitic limestone, and ooliticlimestones. These facies are characterized by relatively high values of resistivity. They are relatively conductive in places of interbedded marl and clay, materialized by local drops in electrical 15TB15 and 19TB15 resistivity. However, we noted a rise in the bedrock Rt resistant roof between the electric 1TB15 survey and drilling F4629/36 (a depth of approximately 103 m) on the synthetic cut B near the DouarOuladNifaoui (a depth of 240m approximately), the South from the DouarOuledRegraga (1TB2), and the south between Oued Al Abid and Tassaout. The appearance of resistant bedrock Roof Rt was attributed to Cenomanian-Turonian limestone which draws successive synclines along the NW-SE coupe. A local depression between the mechanical survey F1053/45 and the electric survey 1TB5, and the maximum depth of the roof of Turonian attributed to resistant bedrock reached the right 1TB3 electrical sounding (1300 m), as we met another depression. However, this depression is more or less important than the first between the electric 1TB6 survey and the drilling F4558/36. Consequently, the lowest point of the Turonian bedrock is located directly above the electrical sounding 1TB14 (+ 800m). An increase in resistivity values of resistant bedrock is attributed to Turonian towards the Southeast from the electrical survey 7TB12 (444 and 1549 ohm.m), heading south from the electrical survey 9TB3 (447 and 746 Ohm. m) and northbound from the electrical survey 9TB14 (ohm.m 375 and 706). However, the level could be less cracked or harder at that place or simply influenced by the underlying formations which is very resistant.

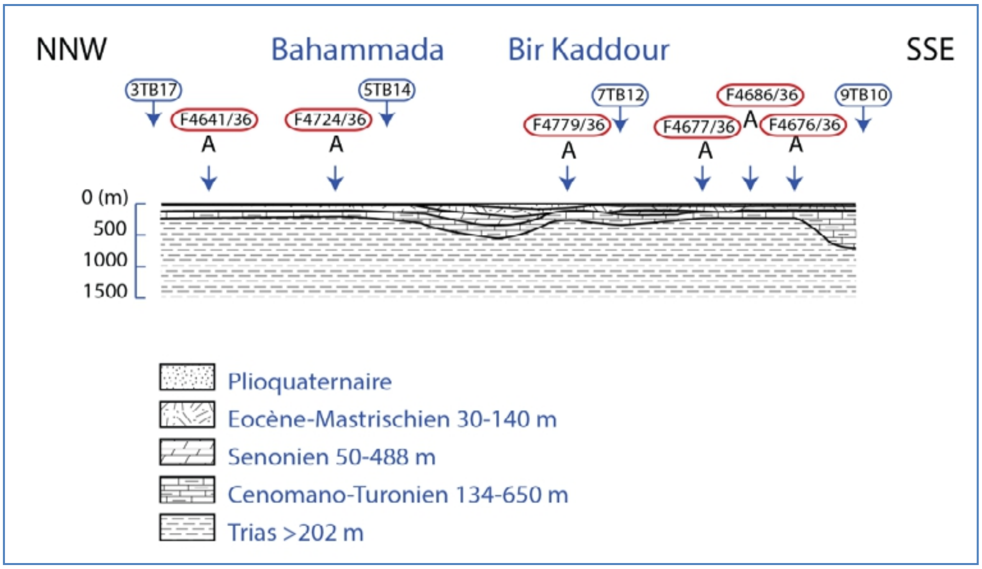
Figure 7.Cups synthetics electrics geography of the juxtaposed formations.
(a) : Cup synthetic 11TB. (b) : Cup synthetic 15TB. (c) : Cup synthetic NNW-SSE.



(a)



(b)



(c)

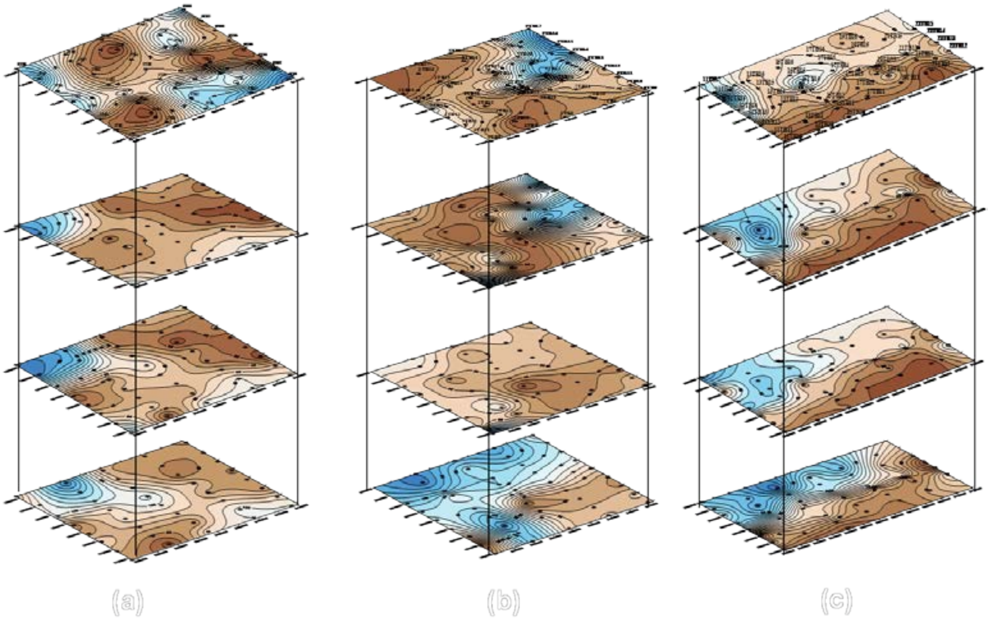
Furthermore, we therefore deduce that the secondary and tertiary series are the same as those of the Plateau des Phosphates, but thicker and invaded at the Middle and Lower Cretaceous clastic and lagoon with abundant evaporite sediments. Thus, this is added to complement an oligo-Miocene marl and thick Pliocene-Quaternary continental and lacustrine series.

The resistivity maps established for tablecloths Senonian Eocene and Cenomanian-Turonian show very wide variations of the measured values between the eastern part and the western part of the basin. Indeed, in the area of OuladHammadi (Western part of the downstream Tessaout), the superposition of resistivity maps depending on the depth (Figure 8a), shows the existence of three moderately resistant beaches having resistivities range from 30 Ohm. m and 50 Ohm.m. The rest of the survey area has conductive formations. Vertically, according to these overlays, there is a shift of the conductive pad (15 ohm.m - 55 ohm.m) to the electrical profile 9TB. Also, there is a displacement of highly resistant pads (55 ohm.m - 170 Ohm. m) electric 1TB4 survey at a depth of 200 m to the electrical survey 5TB8 at the depth 2000 m.

Analysis of the assumption of resistivity maps depending on the depth of the Bahamada sector (central Tessaout downstream) shows the presence of the resistivity of three different zones (Figure 8b). The first is a very small mass resistant to a resistivity of 135 ohm.m and a depth of 200 m (next to the F4642 / 36), which moves vertically to the electrical survey 9TB12 at 500m. The second proofs a mass that is very limited, with a resistivity between 95 and 115 ohm.m, which is taken to be the electric center 1TB9 survey. However, it is located on a depth of 500m and 1000m. The third which is conductive have an electrical resistivity between 35 and 65 ohm.m. It is very broad and is shifted vertically to the electrical profile, 9TB9-9TB13.

The area of OuladBouHarrou (eastern part of Tessaout downstream) has three geological formations (Figure 8c). The prospected sector which is 200m deep shows a strong formation of an electrical resistivity which ranged from 60 to 90 ohm.m. However, this is taken to be the center 15TB14 electrical sounding (F4629 / 36), which is another very strong training (65 ohm.m - 135 ohm.m) Limited 11TB13-11TB17 profile between the electric and the electric survey 13TB15, and a conducting training that expanded the study area. Vertically, it is noted in this area that moving detected geological formations, and resistant training shifts to the electric 19TB15-19TB17 profile (in depth of 2000m), while conducting training (<50 ohm.m) is usually limited between the electrics profiles 11TB10-11TB12 and 23TB.

Figure 8.Superimposing of the maps of resistivities according to the depth.
(a) : The OuladHammadi Sector. (b): The Bahamada Sector. (c):The OuladBouHarrou Sector.



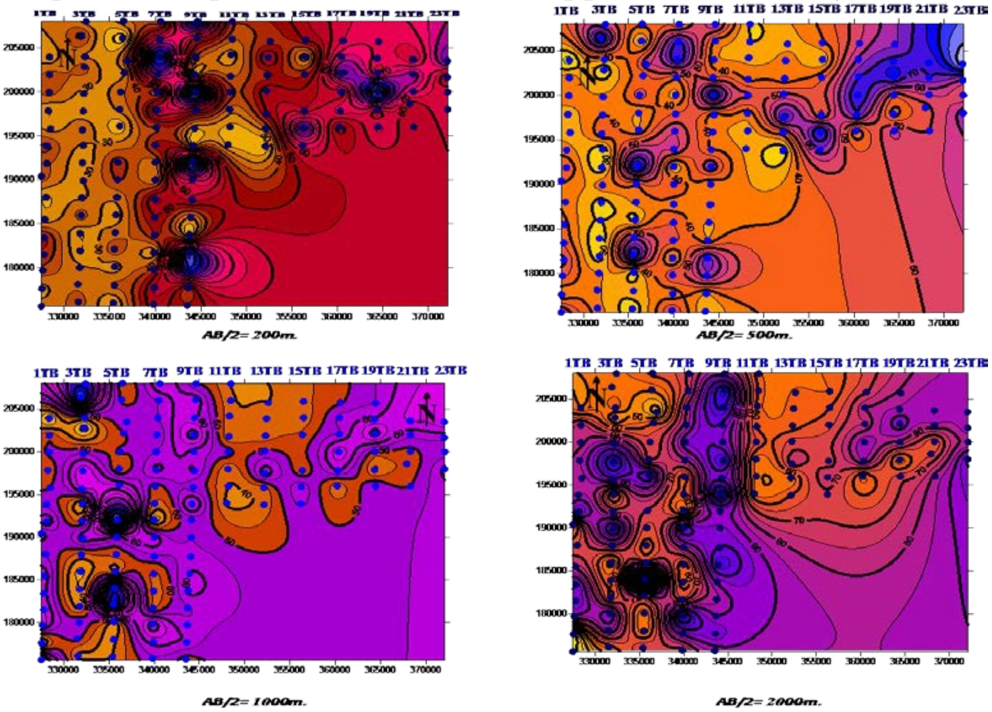
Generally, limestone has very good hydrodynamic characteristics which are Cenomanian-Turonian for the tank according to the state of the water table or captive. This is explained by the importance and hydrogeological interest of this sheet at the TessaoutAval area. This area is more or less tectonized. It is affected by faults that are causing sagging compartments located in the eastern 13TB15 survey. Generally, the study area is affected by several vulnerabilities. However, the most important are those located in the plains of Beni Amir where the pelvic structure plunges rapidly (collapsed Zone). Other faults are highlighted in the western part of the electrical profiles 1TB and 3TB. Thus, they result in the shift of the structure. Consequently, Turonian bedrock of the roof reached a depth of + 1800m at the electrical survey 3TB11, while at + 1000m in Bled El Abiod (13TB11).

Conclusion

Geoelectric studies focused on the realization of 124 electrical surveys distributed over twelve profiles which differ among themselves by the number of electrical surveys. Thus, they are aligned in the direction NS. Geoelectric curves were generated from data of the resistivity and the length of the line AB. These types Schlumberger electrical soundings made Tessaout downstream; and geological data have revealed five families of electrical soundings curves (A, B, C, D, and E) corresponding to the different successions of soil layers. The achievement of resistivity maps, thick cards, and depth maps, allowed us to follow the lateral and vertical development of apparent resistivity. It also help us to determine facies surveyed land, explains the geological and hydrogeological context tablecloth studied, identify the geo-electrical sections juxtaposed training, and meet the physical characteristics of the basement in TessaoutAval area. Thus, analysis of East-West synthetic cups together, shows folding and a dip of the structure to the east. These lands roughly speaking of monoclinale, draws a pleated structure which is sometimes tectonized (section A and B cut). The NW-SE section shows an increase in resistivity values of resistant bedrock attributed to Turonian from the electrical survey 9TB15 (151 and 678 ohm.m).

The pace of the Roof of resistant bedrock attributed to Cenomanian-Turonian limestone draws successive synclines along the cut, from which this bedrock rises to the Northwest. Analysis of the North South sections shows that most of the cuts situated west of 11TB cut, showed rise formations to the north and south, except 9TB section showing a slight deepening in the South drilling law 563/45. Therefore, the rest of the cuts (15TB to 23TB) show a dip of the structure with a southward development of different geological horizons (Turonian and Cenomanian) in that direction.

Maps of the spatial distribution of apparent resistivity.



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