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ORIGINAL ARTICLE

HYDROGEOLOGICAL RECOGNITION BY GEO ELECTRICAL METHOD IN THE BASIN OF SAIS-MOROCCO

| Salahddine didi[1] | EL mouatassime sabri [2] | Abdessamad najine [3] | Amina wafik [4] |and | Fatima Ezzahra housni [5] |

1. Sultan Moulay Slimane University | Department of Geology | Beni Mellal | Morocco|
2. Sultan Moulay Slimane University | Department of Geology | Beni Mellal | Morocco|
3. Sultan Moulay Slimane University | Department of Geology | Beni Mellal | Morocco|
4. Cadi Ayyad University | Department of Geology | Marrakech | Morocco|
5. University of Guadalajara| Department of Geology | Guadalajara| Mexico |

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ABSTRACT

Background: This geophysical study has conducted in the plateau of Meknes which presents the median part of Saïs basin, with a total surface of 12Km^2.The study focused on the upper aquifer in the right side of the plateau, which presents the reservoir of the Plio-quaternary above the deep layer of the Lias. **Objective**: The study aimed to recognize the aquifer depth, and to localise the hydro geologically interesting areas. **Methods**: To meet our objective we have used a geoelectrical method based on Schlumberger vertical sounding, where the distance between the electrodes reaches 1000 meters to detect a resistivity layer in the depth of 113 meters, then after a quantitative interpretation of Vertical Electric Sounding (VES) based on the geological data and dataset of the existing drillings, we came out with an iso-resistivity, iso-paque, and iso-hypse maps which give a clear view and then help to better understand the hydrogeological and geological structure of the region. **Results**: The results show the existence of four geo electricals levels where the depth of Plio-quaternary layer has found varies between 9 to 19 m, which is recommended as favourable area where the drilling could be carried out and then helping thereby the local population to meet their needs for potable water. **Conclusion**: These finding support the ability of geoelectrical methods in the hydrological recognition of the underground also to define the vertical succession of the existing aquifers.
Keywords: *Basin, Plateau of Meknes, geophysics, Plio-Quaternary, isoresistivite,* isopaque.

1. INTRODUCTION

The Water shortfall presents a serious problem in south Mediterranean countries which affects the sustainable development, and has a direct impact on the quality of life [1]. Then the management of groundwater and surface water resources has become a necessity, given that the water supply has increased, also view the water quality degradation during last decades, the treatment of the crucial situation becomes urgent.

The study area exists in the southwest part of the sedimentary basin of Saïss which is known with an important agricultural activity [2-3]. The region is under semi-arid climate where the water resources are not sufficient to cover the human and agricultural activities [4].

In the last twenty years, the population has been increasing and food supply has augmented, which make the provision of water resources takes place, and push the decision makers to take actions in order to prospect, develop, and use others aquifers to cover the increasing water supply [5]. The geo electrical prospection is one of non-destructive technics widely used in Morocco. Many studies have done by private companies in several basins across Morocco using this type of surveys which provides a large dataset [6-7].

The aim of this work is to interpret the Vertical Electric Sounding (VES) in efficient way, and later to form an open database to explore others aquifers in the basin of Saiss which constitutes the median part of the southern Rifain furrow. This last presents a depression oriented East-West significantly and extents from the West of the Atlantic Ocean to the East of the Mediterranean through the corridor of Taza-Oujda (Fig. 1) [8]. The basin is filled with deposits from Miocene to Quaternary age and covers a Mesozoic-Paleozoic bedrock as presented in the lithostratigraphic log (Fig. 2) **[9]**.

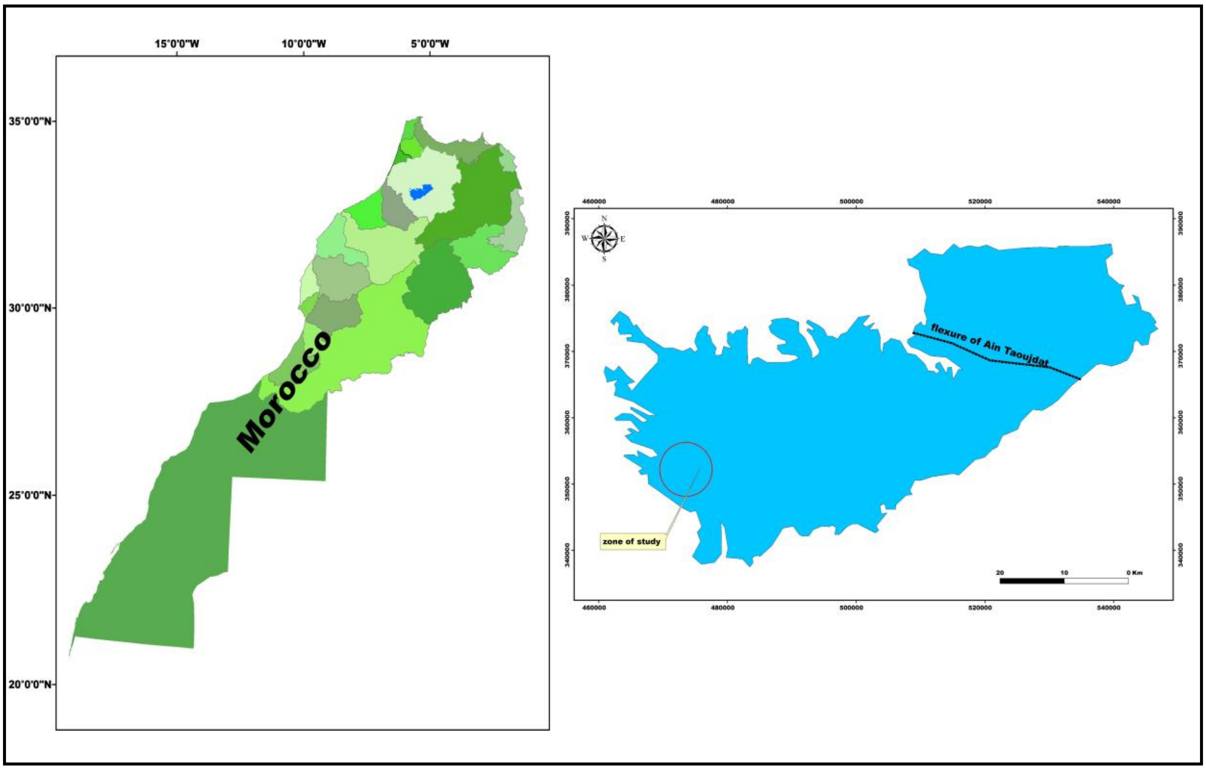

Figure 1: The figure show the map of location of the study area.

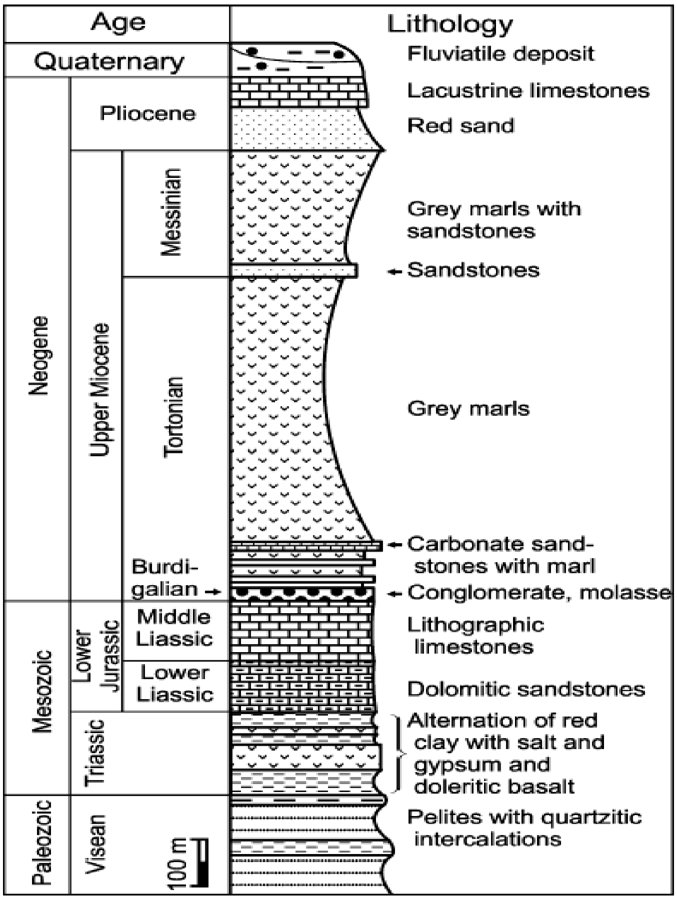

Figure 2: Synthetic lithostratigraphic log (Essahlaoui, 2001 and Harmouzi, 2009).

The altitude in the plateau of Meknes varies from 900 m in the region of El Hajeb South to 550 m in Meknes city North with an average slope of 12% (Fig. 3) [10].

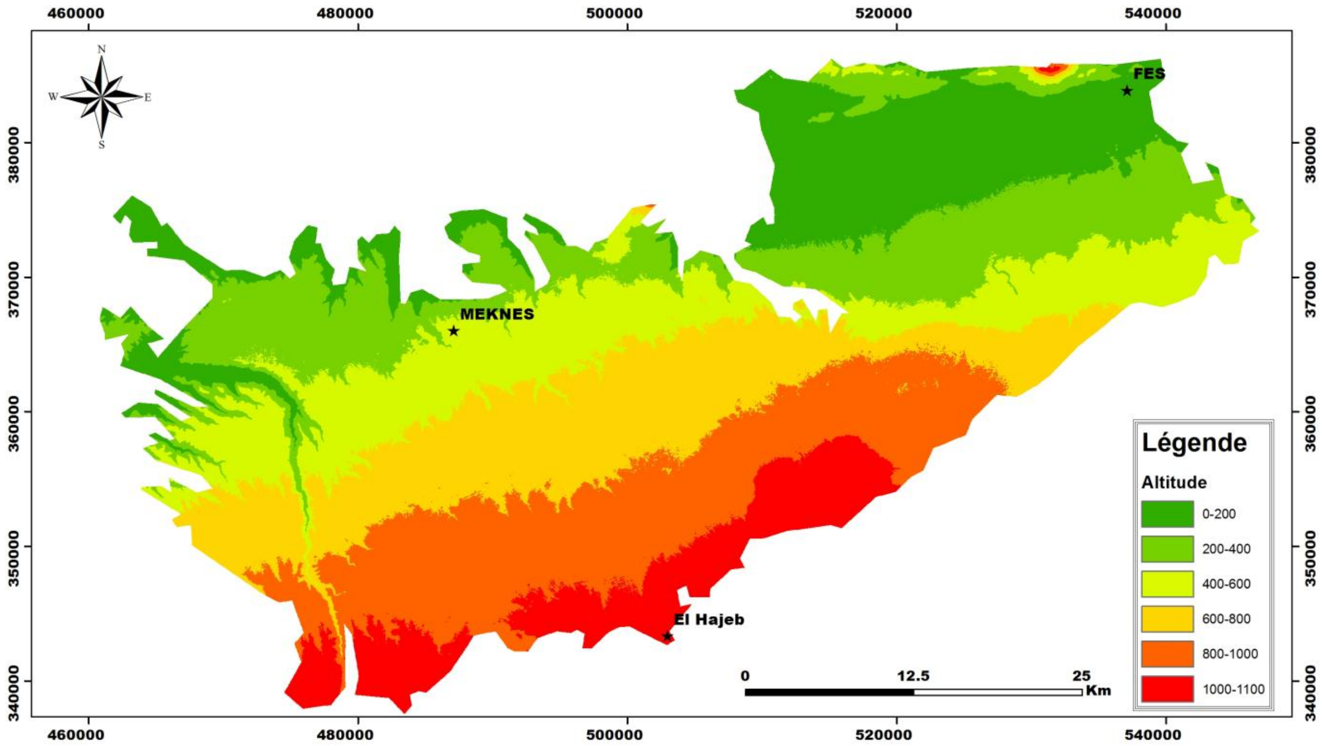

Figure 3: The figure show the map of altitude in the basin of saïss.

The main rivers crossing the basin between its southern and northern boundaries are (from west to east) oued El Kell, oued R'Dom and oued Mikkes. These Oueds generally have an SSE-NNW direction and drain the plateau of Meknes (Fig.4). The average slope of drainage line is between 2% and 3% downstream and less than 0,5 % upstream the plateau.

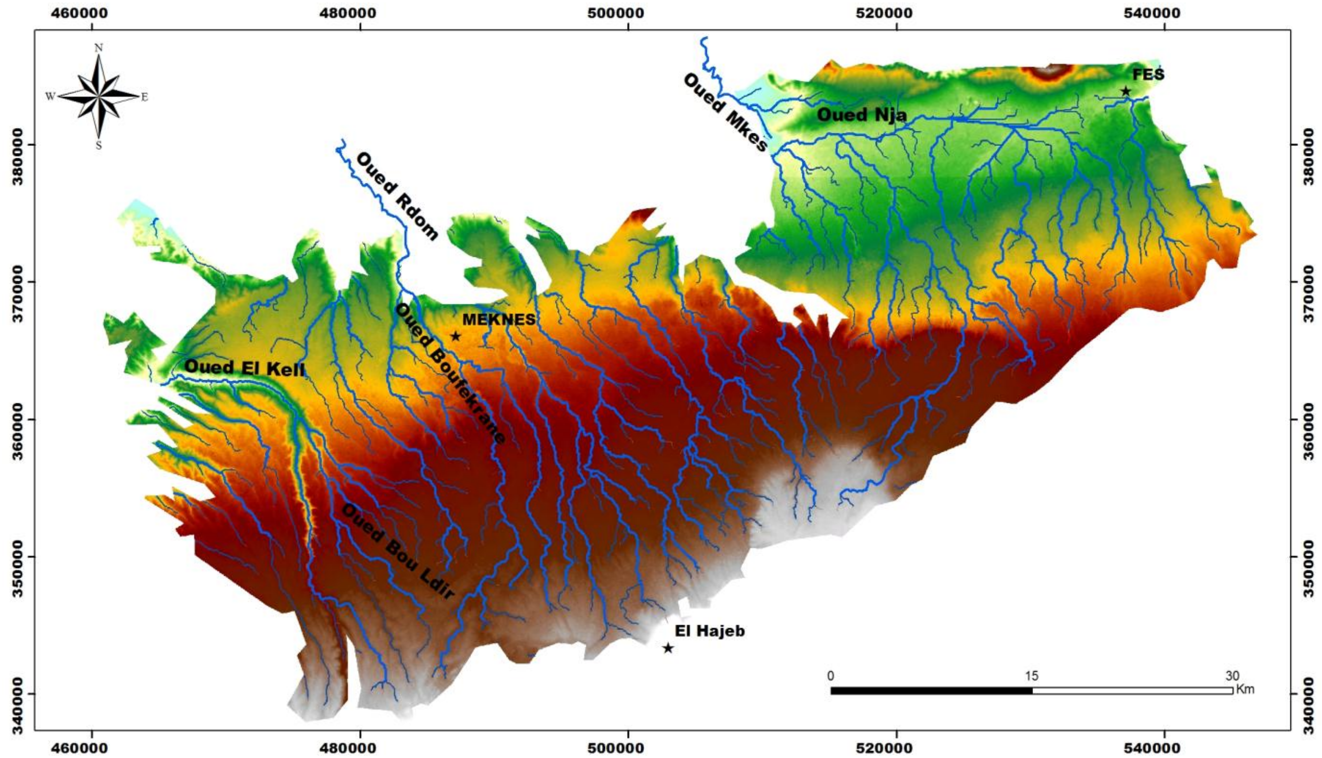

Figure 4: The figure show main rivers in the basin of Sais.

Hydrologically the basin of Meknes embodies two major aquifers: the water table of Plio-Quaternary age and the confined groundwater flow system of Lias age (Fig. 5) [11].

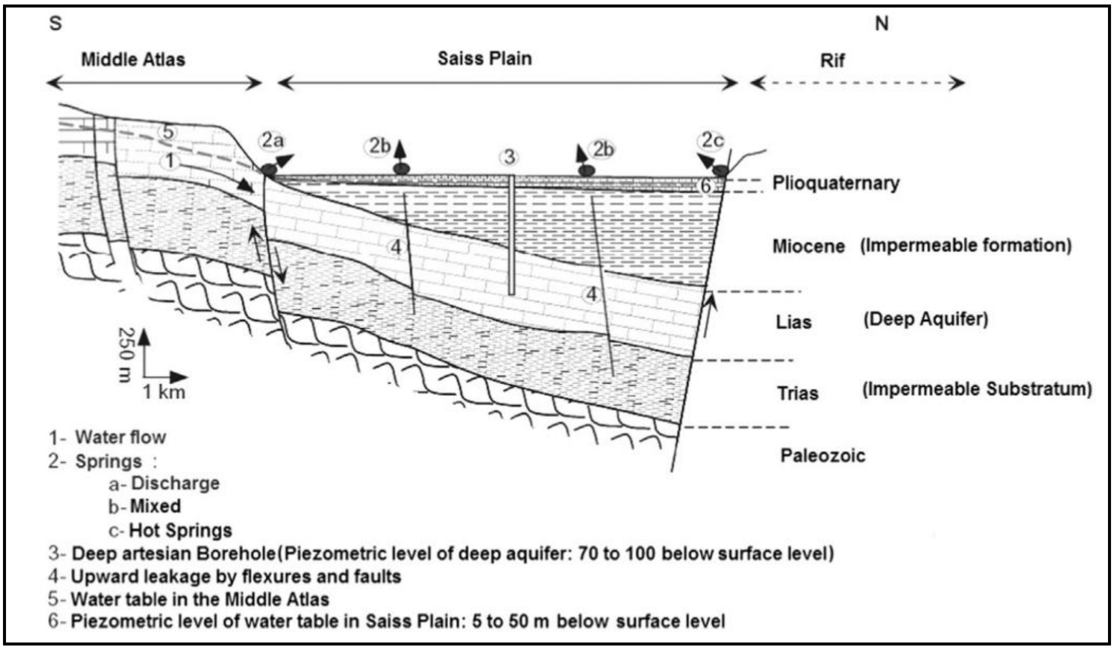

Figure 5: The figure show the Aquifers in the basin of Sais (Siham Laraichi, 2016 and Belhassan et al., 2010).

The water table is alimented by rain infiltration, bottom-up drainage from confined groundwater flow system and by the feedback of irrigation water [12-13-14]. Where the Plio-Quaternary aquifer thickness is varying from a few dozen meters on the southern border to 60 m in the north of the plain where the transmissivity and permeability are highly variable due to the porosity of the aquifer system crack [12-13-14].

2. MATERIALS AND METHODS

The general methodology involves the use of electrical methods in hydrogeology which are based on resistivity measurements of geological formations to study the structure of the aquifer and produce the geo electrical carts, also for precise analyse of surface and subsurface aquifers an acquisition of the most relevant data had done.
To acquire the data in the field we used verticals electricals surveys (VES) which allow following the variation of the vertical resistivity through the deep ground, the distance AB reached 1000 meters to take measurements in a deep of 113 meters as presented in the figure Below (Fig. 6).

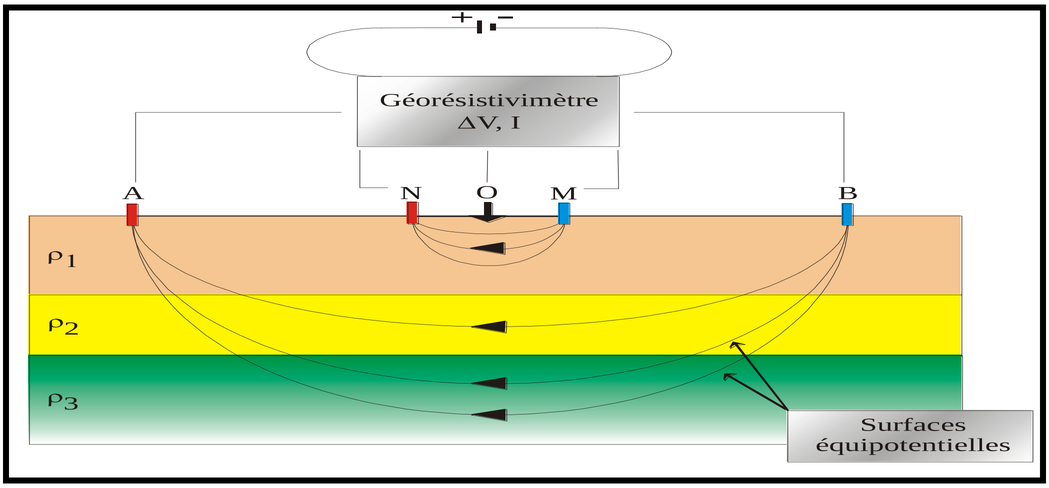

Figure 6: The figure show eelectrical resistivity method.

We send through the electrodes A and B, a current with an intensity (I) to measure, using a potentiometer or a recorder, the difference of potential ΔV (d.d.p.) between the electrodes M and N every time we increase the distance AB.
To calculate the apparent resistivity the ohm's law has used (Formula.1) [15].

$$\sigma = K \bullet \Delta V / I \qquad (1)$$

Where K is a coefficient that depends on the geometry of the ABMN devices (Fig. 7).
In this study, we used the Schlumberger method, the electrodes are posed symmetrically (OA=OB) and aligned with M and N where the distance AB is longer much more than the distance MN. Later the apparent resistivity values measured for different distances AB represented on curves using the formula below (Formula.2) and interpreted manually [16].

$$\sigma a = f(AB/2) \qquad (2)$$

Figure 7: The figure show the equipment used.

The Materials of acquisition used consists:

- A Geo-Trade resistivimeter
- A current generator
- 1,000 m of cables on portable reels
- stakes of iron and copper electrodes
- maintenance materials
- GPS

3. RESULTS

The interpretation of all VES (Fig. 9), permits to point only one family of VES represented by 4A (Fig. 8), which shows a similarity in term of electrical level succession, with a difference in resistivity values due the difference in the thickness of its electrical horizons.
Based on the analysis of the VES (4A) and historic data from the exist drill the structure is made of 4 layers (a, b, c, d) as presented in the figure below.

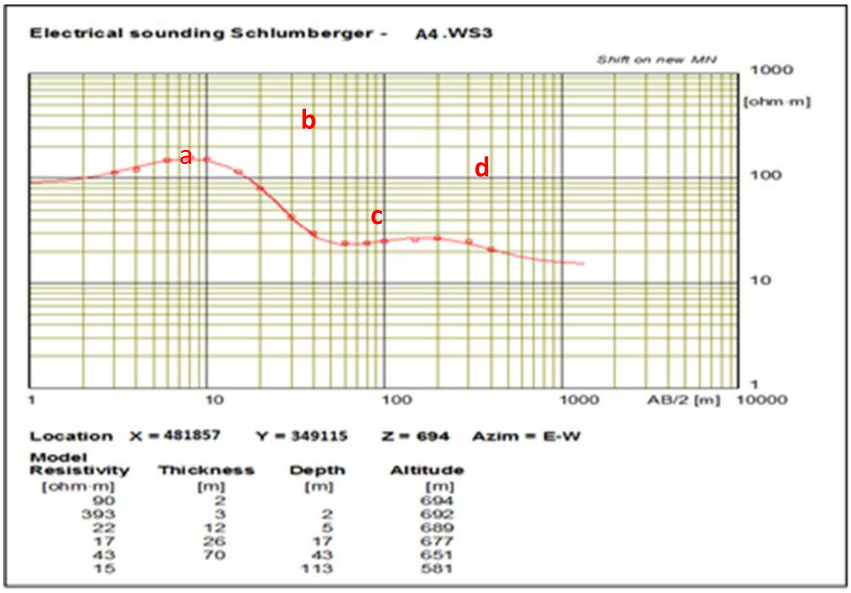

Figure 8: VES A4: (a) Sand; (b) Marl; (c) Sandy Marls; (d) Honest Marls.

Also for a correct interpretation on underground layers, an Isoresistivity map (Fig. 9), Isohypse map (Fig. 10) and Isopaque map (Fig. 11) corresponding to a depth of 25 m has produced and showed the existence of marl layer with low electrical resistivity in the south-East also a decrease of the Isohypse (Marl layer altitude) from the East to the West with an increase in the marl layer thickness in the opposite direction.

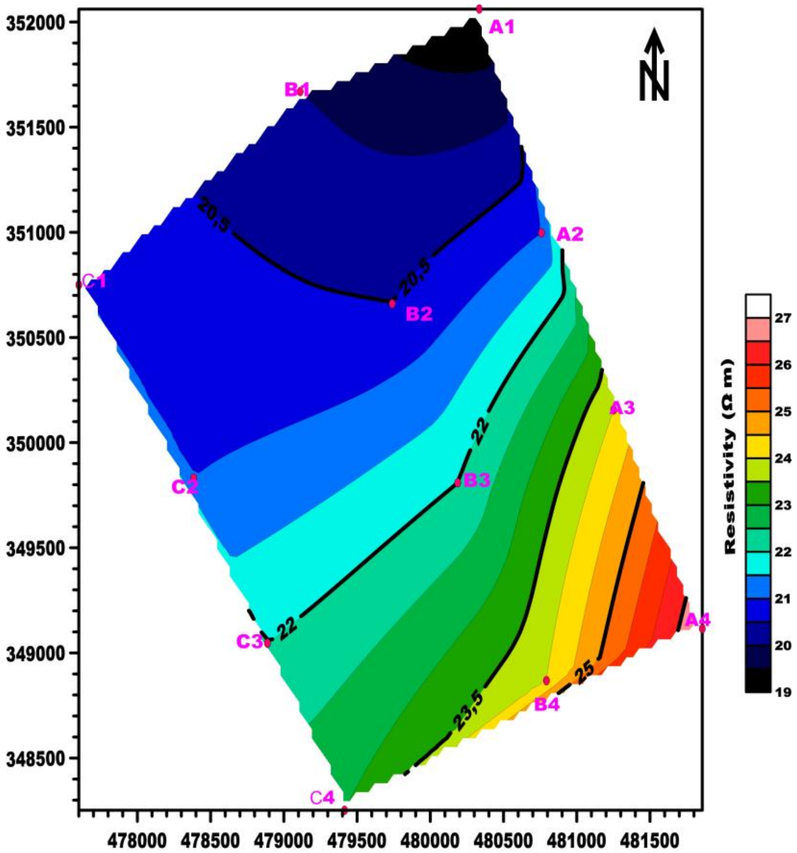

Figure 9: The figure show the isoresistivity map and VES.

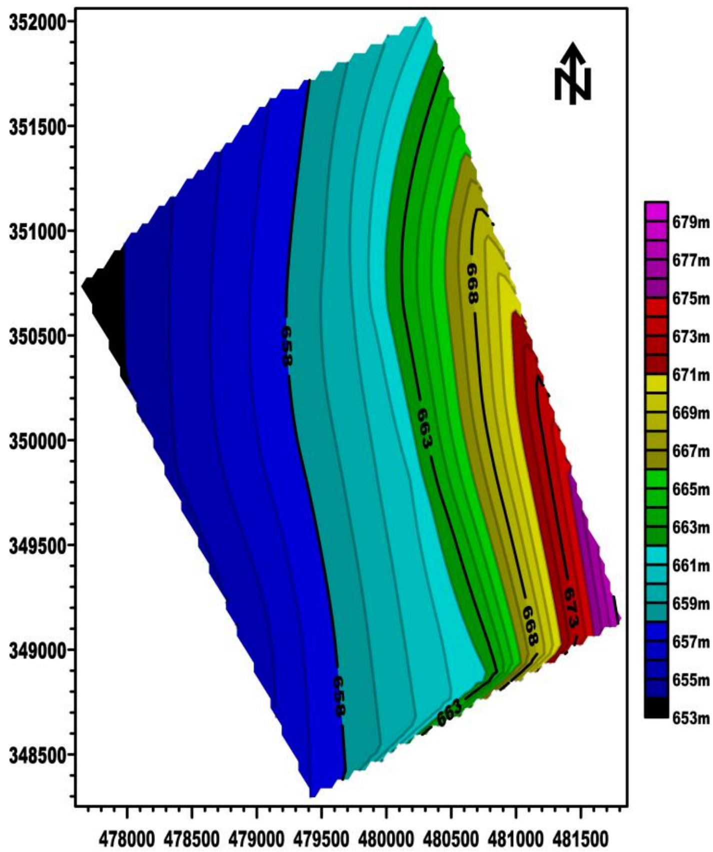

Figure 10: The figure show the isohypse map.

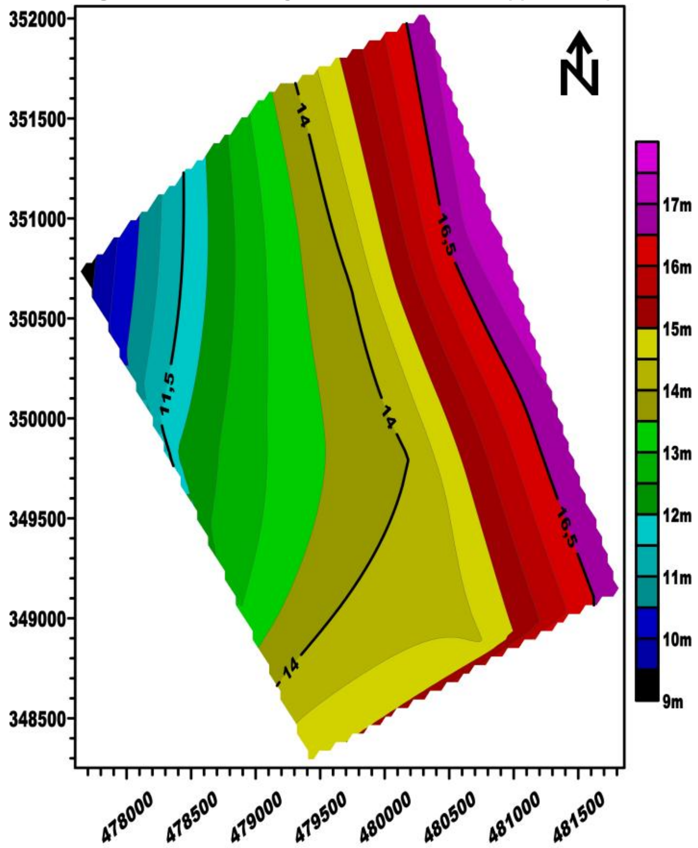

Figure 11: The figure show the isopaque map.

The Cut N1(SE-NW) (Fig. 12), Cut N2 (SE-NW) (Fig. 13) and cut N3 (SW-NE) (Fig. 14) including the geo electricals surveys (B1, B2, B3,B4), (A1, A2,A3 and A4) and (A1, B1 and C1) respectively, shows the existence of 4 geo electricals levels which retain the same thickness along the cut with a sandy-marly level characterized by a high thickness compare to others levels with a low electrical resistivity and with smooth inclination noticed in the cuts number 2 and 3 .

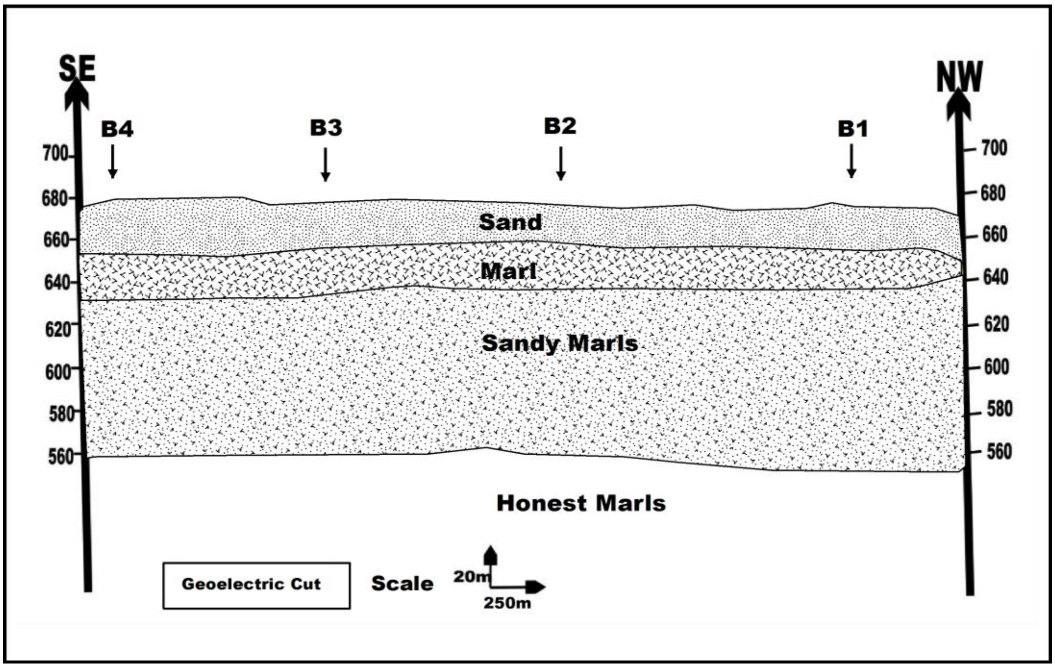

Figure 12: The figure show the cut geoelectric 1.

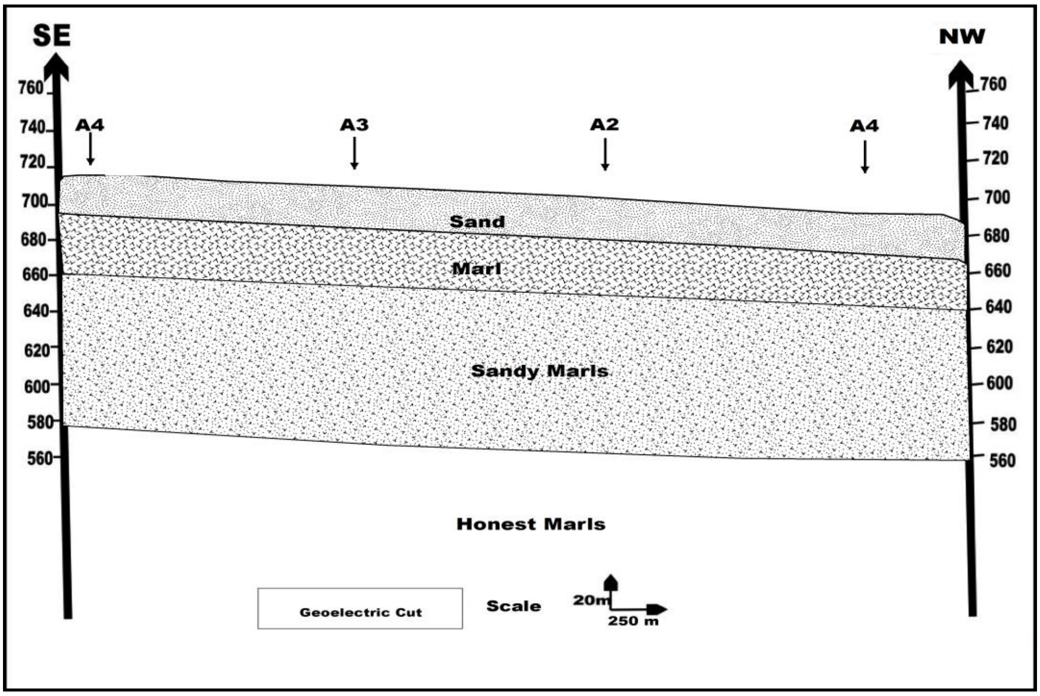

Figure 13: The figure show the cut geoelectric 2.

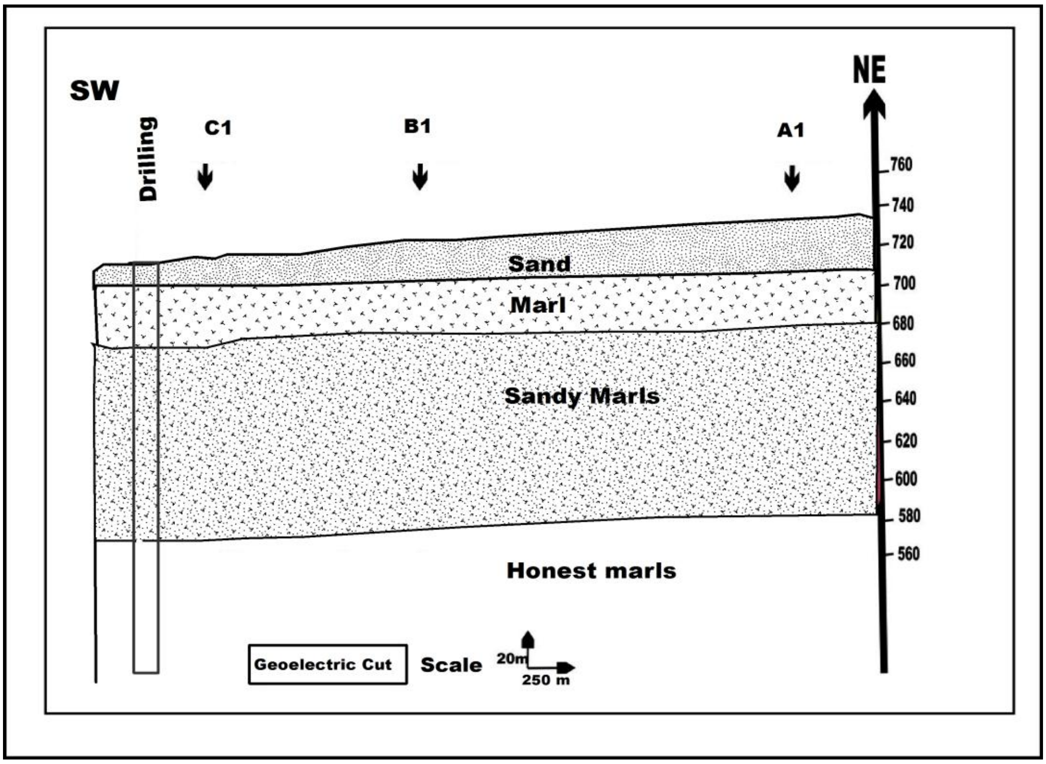

Figure 14: The figure show the cut geoelectric 3.

4. DISCUSSION

The present geo electrical study has done to recognize the depth of Plio-quaternary layer using vertical electric sounding based on Schlumberger method and cover 12 km^2 in south west part of basin of sais, as result the depth of the aquifer has found varies from 9 to 19 m.

A study has done by Mr. Amraoui [17] based on data of 153 surveys across the entire basin of Sais within a surface of 6000 km^2 and showed that the marls is divided into four classes with the same size while the depth varies from 0 (flush) to 137 m, with an average of 56 meters. In the other side, the centre of the basin along the axis Boufekrane - Haj kaddour - Ain Taoujdate present the sector where the depth of the marl is higher and decreases as long as we approach the Prerifaines or Atlantic bounded. The carte (Fig. 15) shows also the presence of the Plio-quaternary in the west and in the south west of Meknes city with a depth under 37 m as shown in the present study.

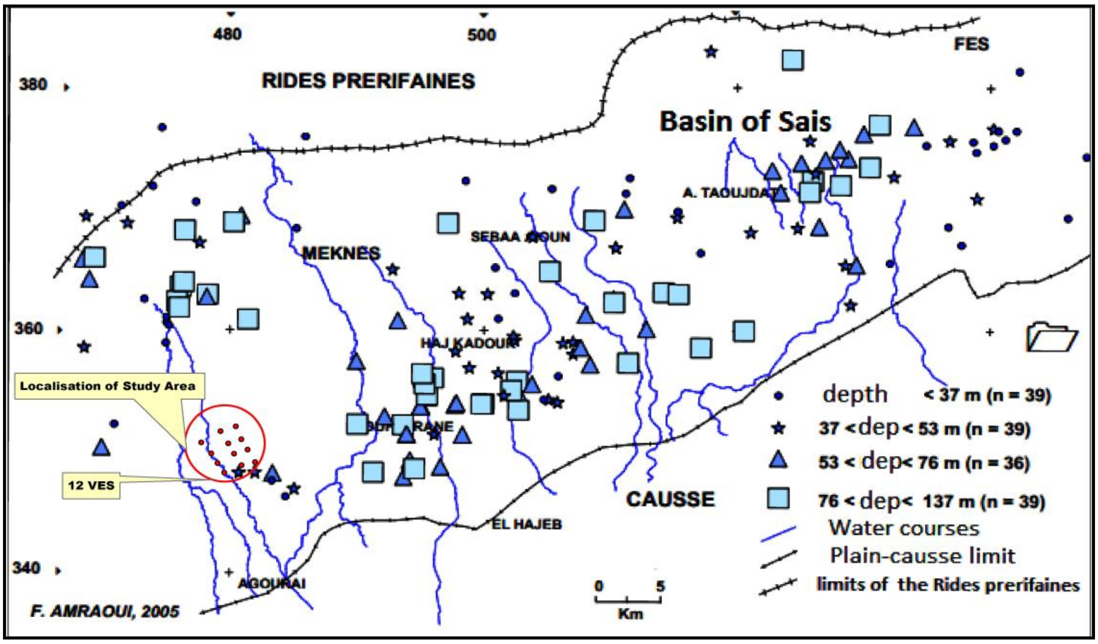

Figure 15: The figure show the depths of the marl thickness of the Plio-Quaternary (Amraoui, 2005).

Therefore, this study comes as a complement of Amraoui's (2005) study and validate its results concern the south west and provides more accurate results in the concerned study area and shows that the geological formations in the region has an important hydrogeological interest.

Indeed, the interpretation of the VES has its limits by lack of historical datasets and unpublished studies concern the study area which could be helpful to understand accurately the geological formation, adding some difficulties related to the implementation of VES, as topographic limitation which restrict our mobility and sometimes obligate us to change the directions, the things which could affect the accuracy of the results.

5. CONCLUSION

The method of electrical resistivity applied to the recognition of underground aquifers is a method that can be adapted to both regional and local study projects. Indeed, in the regional case, it allows to follow the evolution of petro-physical, geometric, etc. in addition to the fact that it makes it possible to locate zones with potential water. In the case of local prospecting, it allows at least to define the vertical succession of the existing aquifers in addition to the local petro-physical characteristics which can be compared with those of the closest calibration holes.

Based of this study of hydrogeological reconnaissance by geophysical prospecting using the geoelectric method and as a recommendation, the hydro geologically interesting areas are in the southern part of the study area view the greatest thickness of the water table.

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