Quantification of Hydrogeological potential through Geoelectrical prospecting: Application in Jahjouka village (Central north of morocco)

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Abstract- In order to ensure drinking water supply to the inhabitants of Jahjouka village located in the central north of Morocco, a geophysical Geo-electric study has been performed in order to evaluate the water potential of the land in question. The area being studied has from the top up to 20m depth a clay-marl formation containing large blocks of sandstone rocks. This very permeable formation cannot be linked to the characteristic clay formation of the geological unity of Tangier. The main reservoir has a capacity of approximately 50m before turning to true clay of external Tangier. It is at this horizon where the water has been located, trapped and stored.

Index Terms- Geophysical, Geo-electric, Hydrogeological, Jahjouka, Resistivity.

I. INTRODUCTION

1. Geographical, geological and hydrogeological context of the study area

Our study area is located in the village called Jahjouka. The latter is accessible by the national road of Ksar el Kebir through Tataft towards the Chefchaouen city.

Between the main entrance of the village at 200m above sea level and the great mountain peaks rising altitudes of around 500 m, the village of Jahjouka is perched at an average altitude of about 300m.

From geological point of view, and in the absence of a published geological map, information collected in the field show the following characteristics:

On the path from the main road to the village, we notice the presence of a clay- schist series, topped by a series of sandstone levels intercalated in clay and marl before moving on to a powerful formation consisting of sandstone layers that cap peaks. This layers succession recalls the geological structural unit of the Numidien Post Nappe with its sandstone character; based, following an abnormal contact, on the Structural Unit of External Tangier with a clayey nature.

If Numidian sandstones are considered good potential groundwater reservoirs, the clay- schist series of the unity of external Tangier has no water potential and is forming instead a screen and a sub-horizontal impermeable horizon preventing any infiltrations in the bedrock.

Since the village Jahjouka is at an altitude of 300m, and the true clay of the structural unit of External Tangier crop out at around 250m, so we have a thickness of 50m (value derived from cartographic equidistance mentioned on the extract of the topographic map of Sebt El Kolla) of favorable ground for the hydrogeological study. So this zone must be scanned to identify the nature of soil and subsoil in the studied field.

2. Study objective :

This study aims at evaluating water potential of the land in question. In order to optimize groundwater searching we attempts to:
On the one hand to identify the nature of the soil and subsoil and also to detect any faults or fractures that may correspond to the main drains. Knowing that Numidian sandstones are not a generalized aquifers but water that may be therein is localized in these drains.

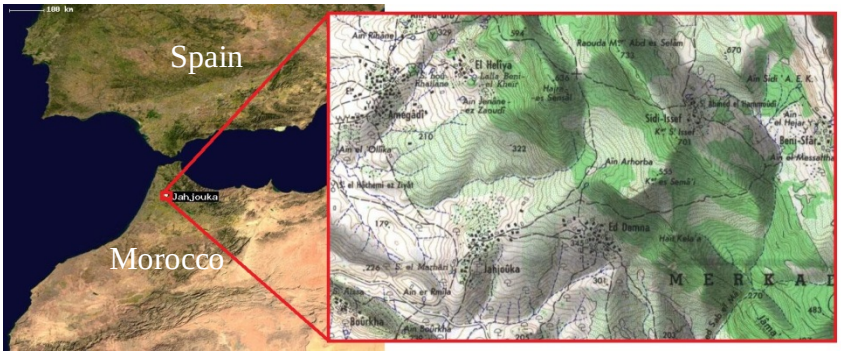

Figure 1: Geographical location of the studied area

II. MATERIALS AND METHODS:

Electrical prospecting is one of the oldest geophysical prospecting methods. Its implementation is relatively simple. We inject Direct Current (Often slots) using two injection electrodes and we measure the resulting potential difference using two measuring electrodes (Figure.2) which depends on the electrical resistance of the subsoil.

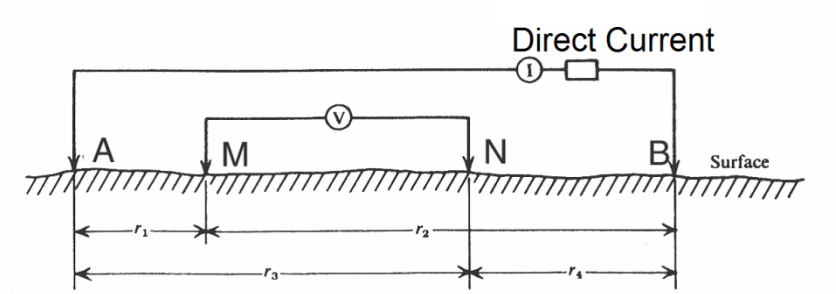

Figure2: Device installation and the principle of operation of the geoelectric method

During our campaign a Geotrade resistivimeter and its accessories has been used.
To meet the above objectives we proceeded as follows: Along the track between the two sites in this study we have performed:

- A Schlumberger electrical survey to study the nature of soil to a maximum depth.

The electrical survey was conducted according to the following characteristics; ABmax = 200m along the south-west --- North-east direction.

- Four Electric profiles to look for possible wetlands according to the following characteristics:
- Profile 1; AB = 40m; MN = 8m Azimuth SW NE
- Profile 2; AB = 120m; MN = 20m; Azimuth SW NE.
- Profile 3; AB = 40m; MN = 8m; Azimuth SE NW.
- Profile 4; AB = 60m; MN = 8m; Azimuth SE NW.

For all profiles spacing was set at 5m.

III. RESULTS AND DISCUSSION:

1. Electrical survey :

After data capture and processing, the result of the electrical survey is shown on the table below:

Table 1: Electrical survey results

N° station	MN/2	AB/2	K	Delta V	I	Resistivity
1	0,3	3	46,65	1,36	10,02	**6,36**
2	0,3	4	83,3	0,56	7,61	**6,57**
3	0,3	6	188	0,6	33,9	**3,37**
4	0,3	8	334,63	0,21	35,65	**2,30**
5	1	6	54,97	4,84	72,73	**3,63**
6	1	8	98,96	1,43	37,78	**3,76**
7	1	10	155,5	0,95	36,02	**3,92**
8	1	12	224,64	1,24	77,96	**3,59**
9	1	16	400,55	0,88	106,19	**3,34**
10	1	20	626,74	0,33	39,42	**5,35**
11	4	16	94,24	4,43	102,19	**4,08**
12	4	20	150,79	0,65	22,03	**4,45**
13	4	30	347	0,77	59,21	**5,02**
14	4	40	622	0,35	23,52	**7,08**
15	4	60	1407	0,3	101,62	**4,16**
16	4	80	2507	0,2	127,08	**3**
17	10	60	550	1,2	70,89	**3,2**
18	10	80	990	0,9	36,5	**4,01**
19	10	100	1555	4,3	70,5	**3,52**

The comparison of the resistivity obtained throughout this electric survey indicates values varied between 4 and 7 ohm.m/ S. These values are characteristic of the clay-marl soil and subsoil in which large boulders are packed, as it can be assumed through direct field observation. This formation is homogeneous, at least, to 20m depth.

2. Electrical profiles :

After data capture and processing, results are plotted on resistivity graphs (Ω.m / S) according to the measurements stations (spread over 5m).

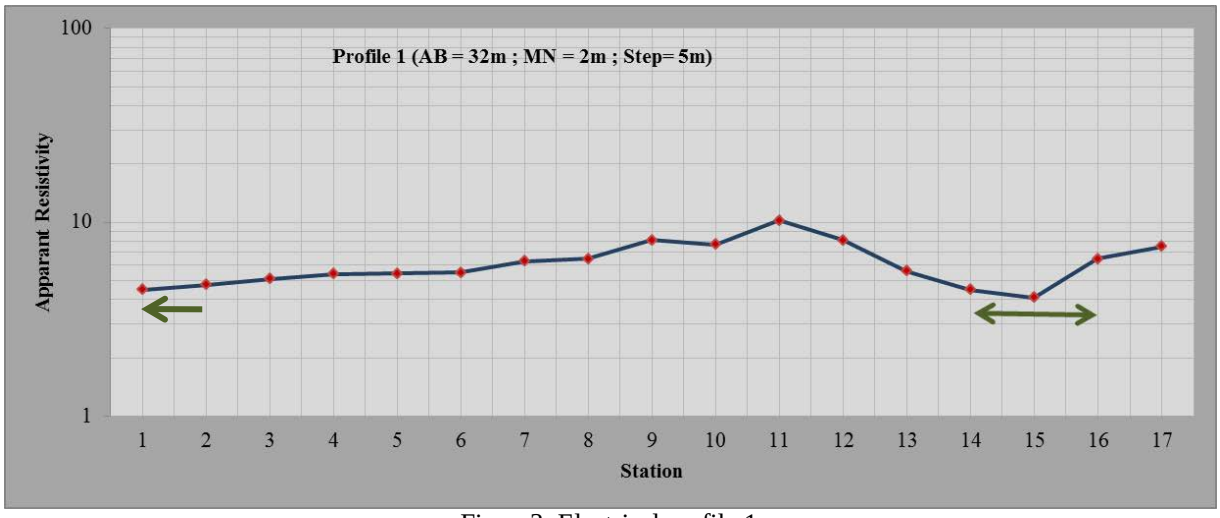

Figure3: Electrical profile 1

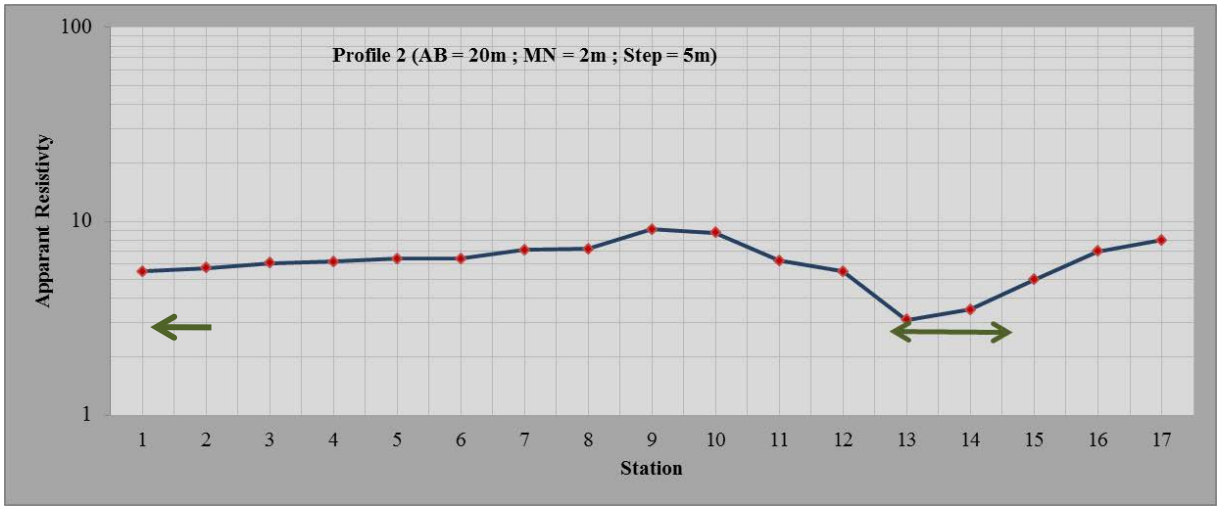

Figure 4: Electrical profile2

The two electrical profiles 1 and 2 (see profile above) made according to the South west-- North East direction allow investigation to 20m and 10m depth respectively. They show two negative anomalies (at stations 1 and 14) where the resistivity values are low. This result is corroborated by the two profiles and interpreted as wetlands compared to the rest of the land.

Profiles 3 and 4 (see profile below) are made according to the South East - North West direction, perpendicular to the preceding profiles, to test the lateral equivalent of the previous anomalies.

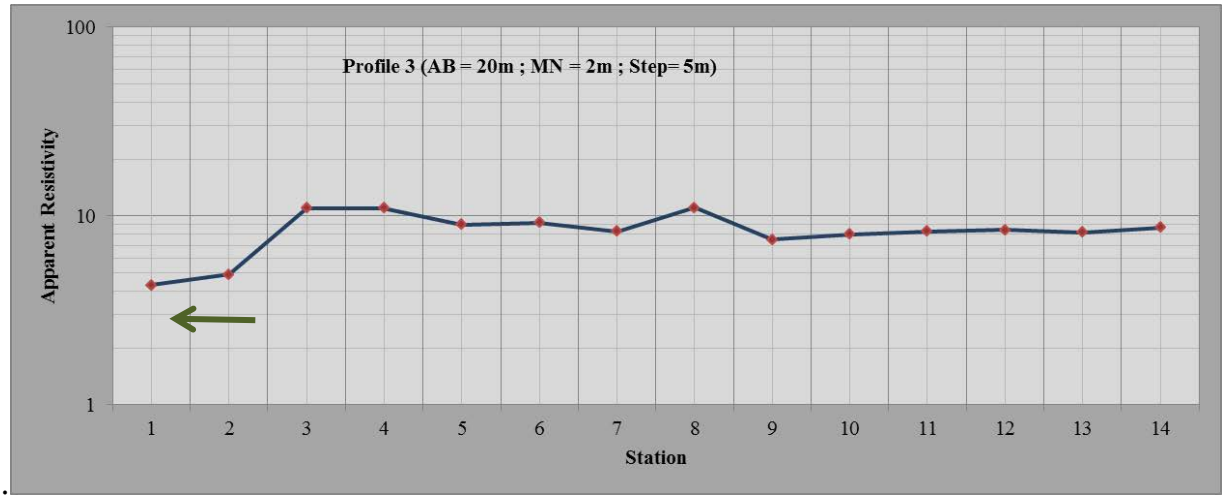

Figure 5: Electrical profile 3

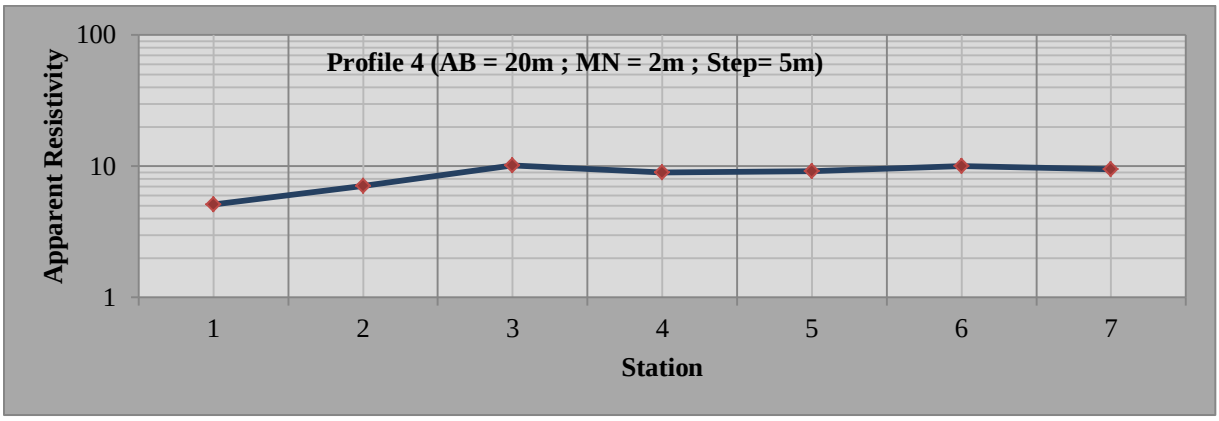

Figure 6: Electrical profile 4

These electrical profiles allow an investigation to10mdepth. They also confirm the existence of a negative anomaly clearly visible at stations1of the two profiles.

Based on this information, the scanned area has 2 anomalies characterized by resistivity falls which are interpreted as wetlands.

IV. GENERAL CONCLUSION AND RECOMMENDATION

After this study and following the application of geo-electric prospecting it's concluded that:

- The studied land has from its surface up to 20 m depth a clayey marl formation containing large blocks of sandstone rocks. This very permeable formation cannot be linked to the characteristic clay formation of the Tangier unity.
- Even if the formation; in the indicated wetlands; is potentially favorable to trap groundwater, it remains very limited as a potential producer. It cannot meet the needs during summer periods.
- The potential reservoir has a capacity of approximately 50m before turning to free clays of external Tangier. It's at this horizon where groundwater was trapped and stored.
- Wells location is dictated by the position of the identified anomalies on the electrical profiles which corresponds to the water circulation areas; It is at these levels where best water flows can be found.

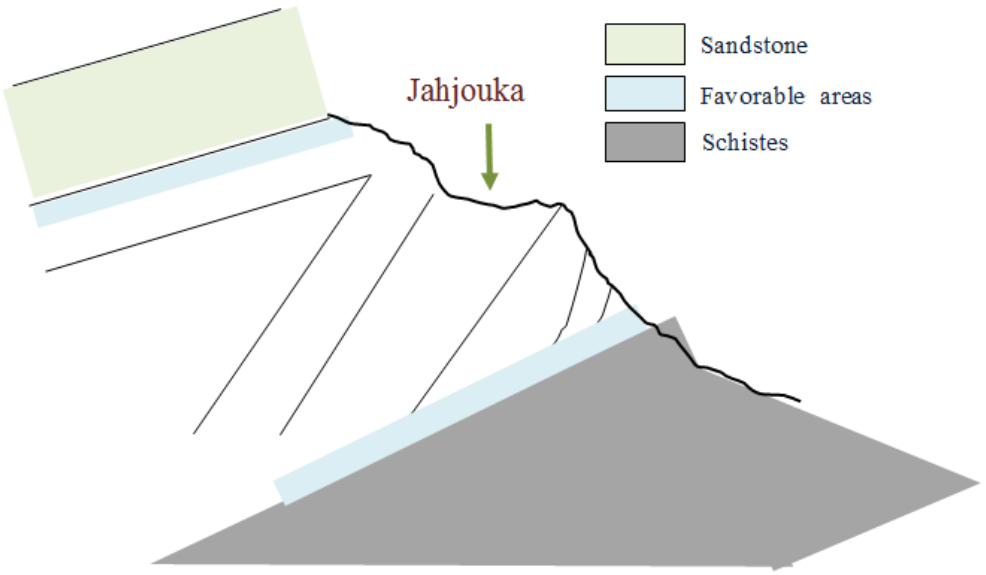

Figure 7: Synoptic scheme of the studied area

- Given the importance of this geological formation powers and the existence of large rocks blocks in this area, it is advisable to use the drilling machine or probe.

RISKS:

- The handmade (artisanal) well will not touch the potential horizon as is still far from 30 meters (See scheme below)
- Large rocks blocks can be encountered during the digging process. When this happens, we call on other stakeholders; technician, jackhammer and a compressor
- Unless meet a good flow, the artisanal well may not meet the need during the summer period.
- It is imperative to pay for a digging risk insurance to cover workers and avoid any nasty surprise.

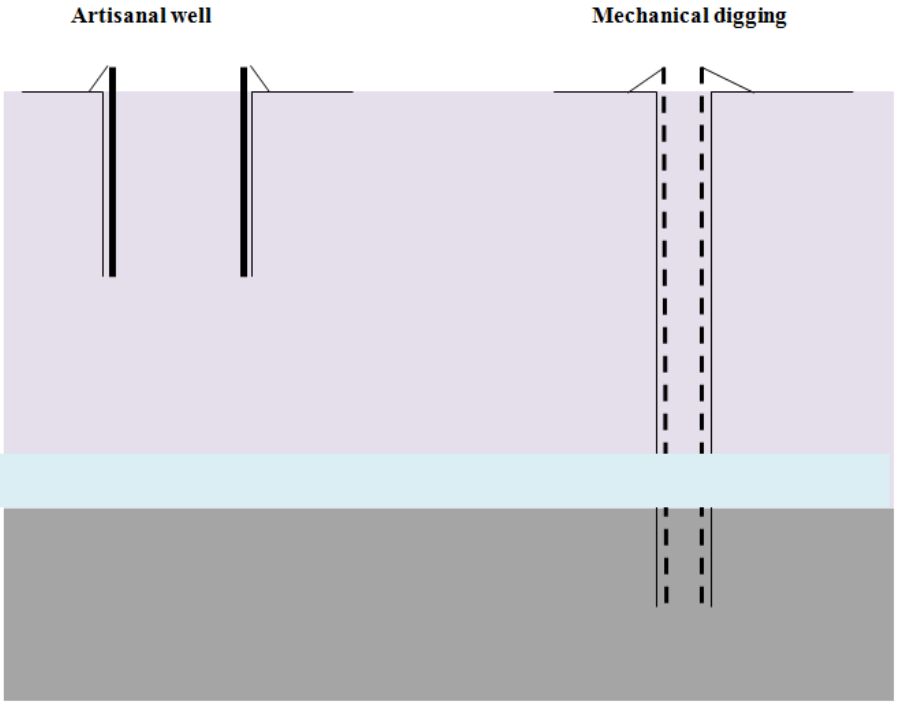

Figure 8: Comparison between two groundwater exploitation methods

REFERENCES

[1] A. Michard. F Negro., O. Saddiqi., M.l. Bouybaouene., Chalouan A., Montigny R., Goff´e B., " Pressure-temperature-time constraints on the maghrebide mountain building: evidence from the Rif-Betic transect (Morocco, Spain), Algerian correlations, and geodynamic implications", c. r. géoscience. 338, 92–114, 2006.

[2] Kouakou, E. G. K., Sombo, B. C., Dgbéhi, Z. B., Kouassi, F. W., Sombo, A. P., & Kouamé, L. N. (2012). Utilisation de la Prospection Géophysique par Résistivité Électrique Pour la Recherche d'eau Souterraine Dans le Département de TANDA (Est de la Cote D'IVOIRE). European Journal of Scientific Research, 83(2), 230-244.

[3] J. Stitou El Messari , S García-lópez , A Emran, "hydrogeological, hydrochemical and isotopic survey of the groundwater of the haouz karstic massif (northern Rif, Morocco)", geogaceta 50: 95-98, 2011.

[4] Hilal, I., Azouagh, A., El Messari, J. S., Mansour, M. R. A., & Draoui, M. (2015). Cartographie de la vulnérabilité à la contamination des eaux du barrage 9 Avril 1947 (Maroc, Septentrional)[Mapping vulnerability to contamination of waters in the 9 April 1947 dam (Morocco, North)]. International Journal of Innovation and Applied Studies, 10(1), 250.

[5] Bakkali, S., & Bouyalaoui, J. (2005). Contribution de La prospection geoelectrique à la Connaissance des ressources en eau du village d Anergui (Tafraoute, Anti-Atlas marocain). e-Gnose , (3), 0.

[6] G. Marquis, "Prospection électrique", EOST , Strasbourg, 19April 2005.

[7] National Agency of the Land Conservation, Cadaster and Cartography : Topographic data from the study area.

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