Application of the Electromagnetic VLF Method for the Detection of Fracture Areas in Cause of El Hajeb (Morocco)

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Abstract: ***The renowned Causse d'El Hajeb study area is located in northern Morocco; it is bounded to the north by the Saiss basin, to the south by means of the pleated atlas, to the west by the Causse of Agouray and the East by the Bsabis's Causse. The results obtained from these profiles have revealed at the anomalies corresponding to faults and / or fractures, which serve the flow of groundwater at the Causse to the plain of Saiss, using the electromagnetic VLF Low Frequency). This study consisted of four (04) profiles in the N-S directions for the VLF1 profil and E-O for the VLF 2, VLF 3 and VLF4 profiles, with a length distance of 300 to 470m with 10m steps.***

Keywords: Middle Atlas Causse, faults, underground waters, VLF electromagnetic

1. Introduction

The Causse of El Hajeb is formed mainly by calcareous carbonate formations affected by intense fracturing, which allows the preferential circulation of groundwater from the upstream part of the Causse to the plain of Saiss.

Geophysical prospecting, using the electromagnetic VLF method, has become very important in various fields, namely, hydrogeological, archaeological and geotechnical research (cavity detection) (Mcneill and Labson 1991; Sharma and Baranwal 2005; Stampolidis et al., 2005).

There are two modes of acquisition, the resistivity mode (VLF-R) which gives an apparent electrical resistivity variation and the inclination mode (T-VLF) which makes it possible to detect the presence of conductive structures (faults, dykes, geological contacts, etc.) by measuring the inclination and ellipticity of the ellipsoid from the polarization of the primary field in contact with the detected structure (Paterson and Ronka, 1971 and Smith and Ward, 1974). This mode was adopted for our study.

The results of a VLF prospecting can be presented in the form of maps and profiles of resistivity or the inclination and ellipticity of the resulting magnetic field. These conductive structures are marked on the profiles by a sudden change and are located directly above the inflection point (Telford et al., 1977, Monteiro Santos et al., 2006). The only processing done for this type of data is a derivation by the "Fraser filter" which locates the anomaly on the maximum of the curve.

2. The Study Area

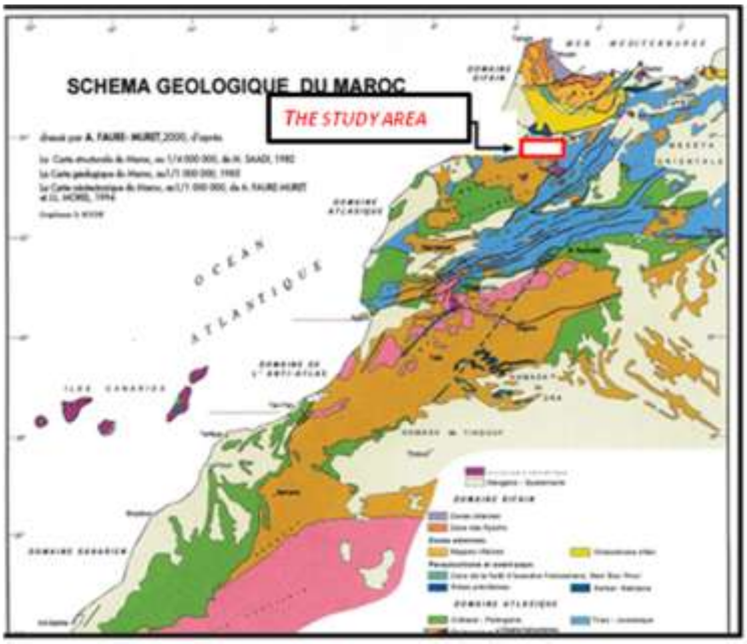
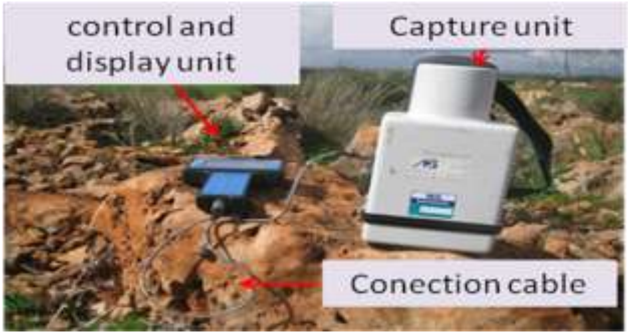


Figure 1: Situation of study area

3. Implementation of the VLF

In order to carry out the present study, we have mobilized a device "T-VLF" of Iris instrument (Photo 1), presenting the advantages of automatic correction of the effect of apparent anisotropy due to the polarization of the field which deforms the anomalies and responds only to the initially fixed frequencies, which eliminates the disturbance due to the metallic objects carried by the operator. The frequency used for our study is of the order of 15 kHz emitted by the station "FUO" in France (T-VLF User's manual, 2006).



Picture 1: Used VLF equipment

4. Situation of Measurement Profiles

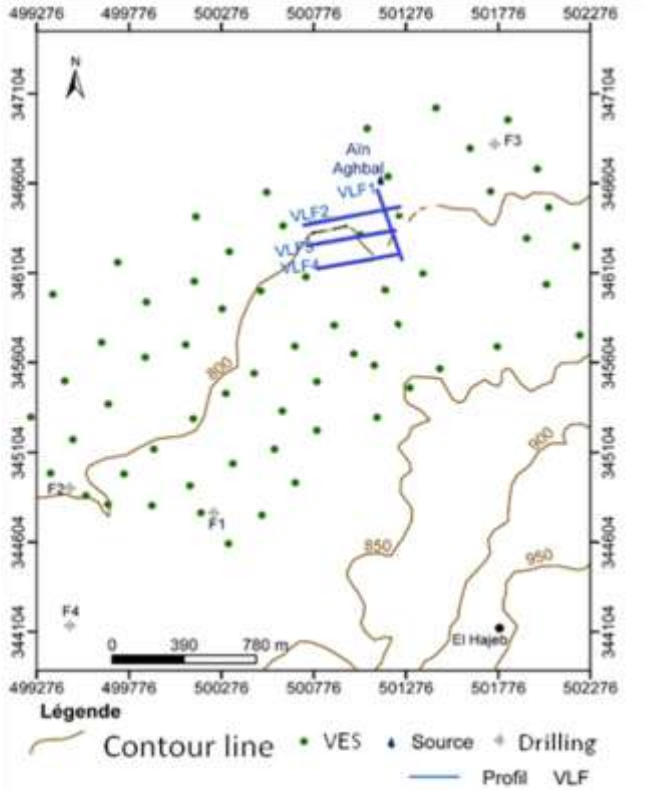


Figure 2: Location of VLF profiles

5. Discussion and Interpretation of Results

The results are presented in graphs representing the variation of the inclination (noted Tilt) and the ellipticity as a function of the distance traveled.

5.1 VLF 1 profile

The graph below shows the presence of a set of peaks of the two components reflecting an heterogeneity and also an intense fracturing of the prospected terrain. At a distance of about 360m to 370m from the beginning of the profile we notice an intense decrease of the Tilt component of the order of -12%. On the other hand, the imaginary component that corresponds to the ellipticity has a very important value of the order of 12%, which indicates the presence of a highly conductive anomaly at this level, which may correspond to a fault.

This profile also shows that the two components studied are close together, this could be explained by the wet and rainy period during which the measurement campaign was carried out.

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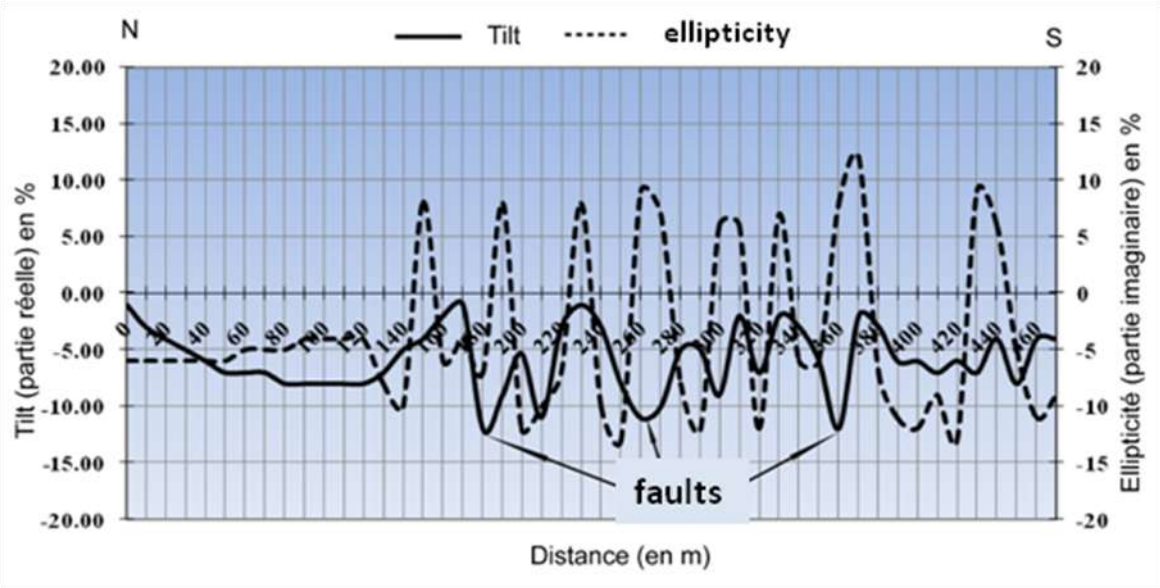

Figure 3: Variation of inclination and ellipticity as a function of the distance of the VLF 1 profile

5.2 VLF 2 profil

It shows important variations of the two components. Along the profile, the real component is negative (between -20% and -45%), while the imaginary component is positive over most of the surveyed terrain (between 0% and 20%). The anomaly zone corresponding to the presence of a fracturing is observed at a distance of approximately 175 m from the beginning of the profile (Tilt = -45%, and ellipticity = 15%). On both sides of this anomaly zone, variations in the two observed components can be attributed to moisture accumulations and in situ mineralization of near-surface lands.

This profile also shows that the two components studied are remote, this could be explained by the dry period during which the measurement campaign was carried out.

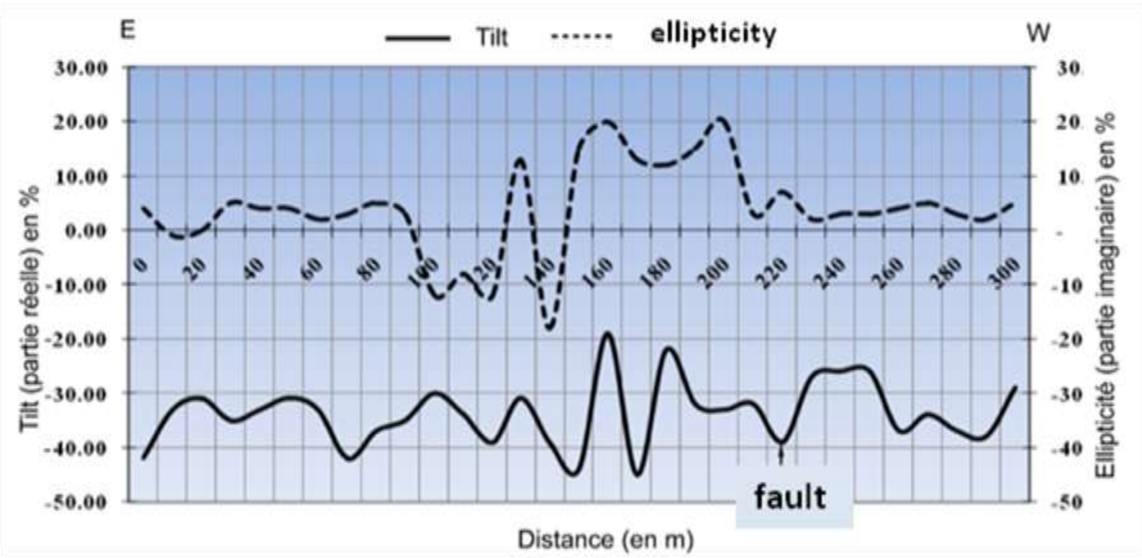

Figure 4: Variation of inclination and ellipticity as a function of the distance of the VLF 2 profile

5.3 VLF 3 profile

The results obtained from the zones studied (FIG. 4), the graph shows the presence of different observed peaks (ellipticity), which reflects the existence of a relatively intense fracturing. Both components had low values. Three fracturing zones are identified, the first at a distance of x = 75m (Tilt = -28% and Ellipticity = -5%), the second at x = 150m (Tilt = -25% and Ellipticity = 5%) and third at x = 245 m (Tilt = -30% and Ellipticity = 4%).

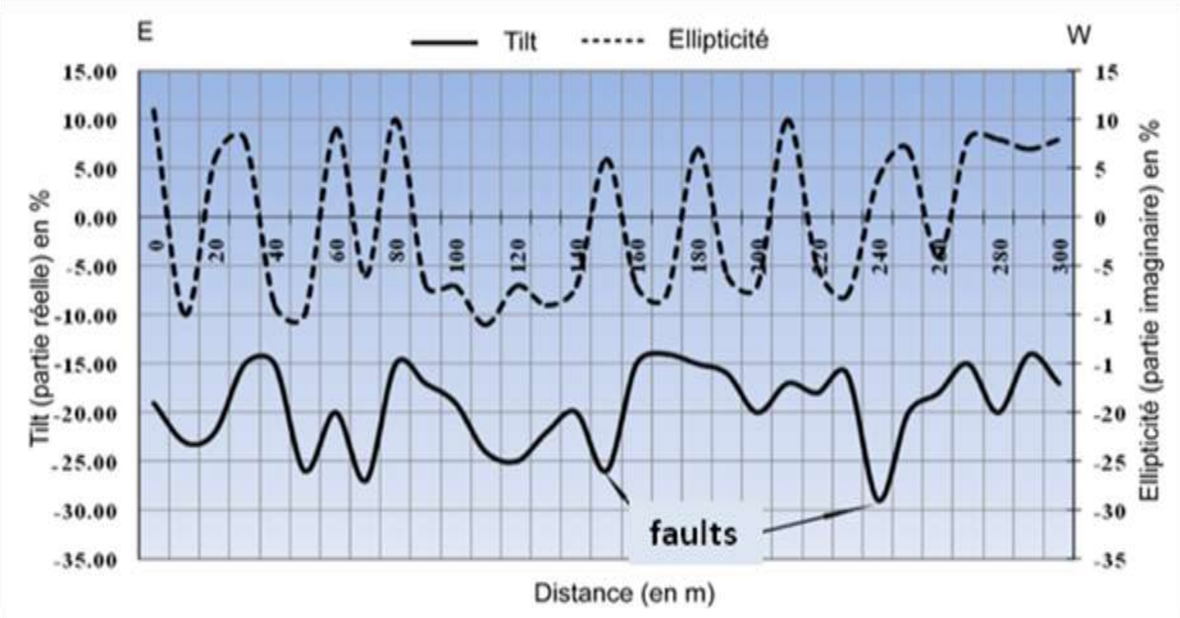

Figure 5: Variation of inclination and ellipticity as a function of the distance of the VLF 3 profile

5.4 VLF 4 profile

The graph of the two components (Figure 6) indicates that the medium is relatively humid during the geophysical acquisition. They show a heterogeneity of the ground prospected due to the presence of the intensity of the peaks of the curves of the two measured components. The Tilt component always exhibits negative behavior throughout the profile at fault locations and has reached the minimum value of about -20% to locations x = [150m; 205m and 255m]. At the same locations, corresponds the maximum value of the ellipticity which is of the order of 10%. Another fault was detected at the point x = 185 with values of the order of -15% and 7% respectively corresponding to Tilt and Ellipticity.

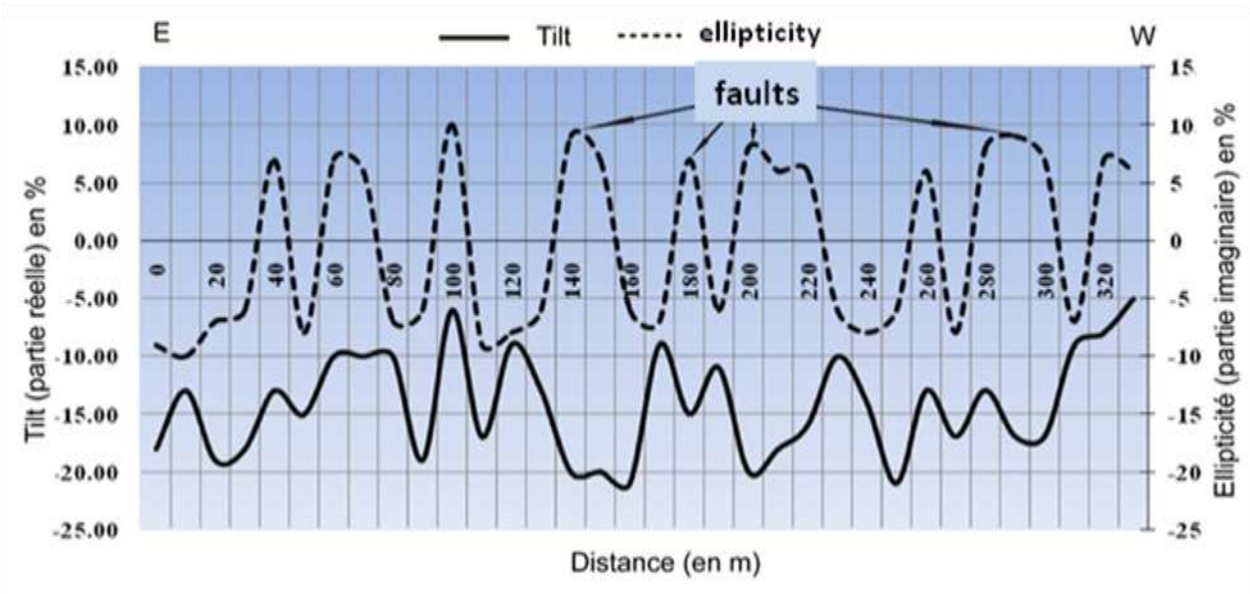

Figure 6: Variation of inclination and ellipticity as a function of the distance of the VLF profile 4

6. Conclusions

The electromagnetism method VLF is considered among the very interesting techniques in hydrogeological research, is mainly in the karstic and fractured media as in our case. From the results obtained from the four profiles, we have found that the apparently prospective terrain is very heterogeneous from the first profile to the fourth profile at the southern end. Indeed we can deduce the following points:

- The heterogeneity of the terrain surveyed results in the fluctuation of the two measured components (tilt and ellipticity);
- The effect of the humidity and the chemical composition of the subsoil on the measured parameters;
- The correlation of the anomalies between the profiles a makes it possible to locate a fault or fracture denoted fault 5 (figure 7);

- The combination of some anomalies detected at the three profiles VLF2, VLF3 and VLF4, which could possibly correspond to the south-north fault 6 (figure 7).

The present VLF method is very useful for the detection of possible anomalies (faults and / or fractures) serving as the flow of groundwater from the Causse to the plain of Saïss.

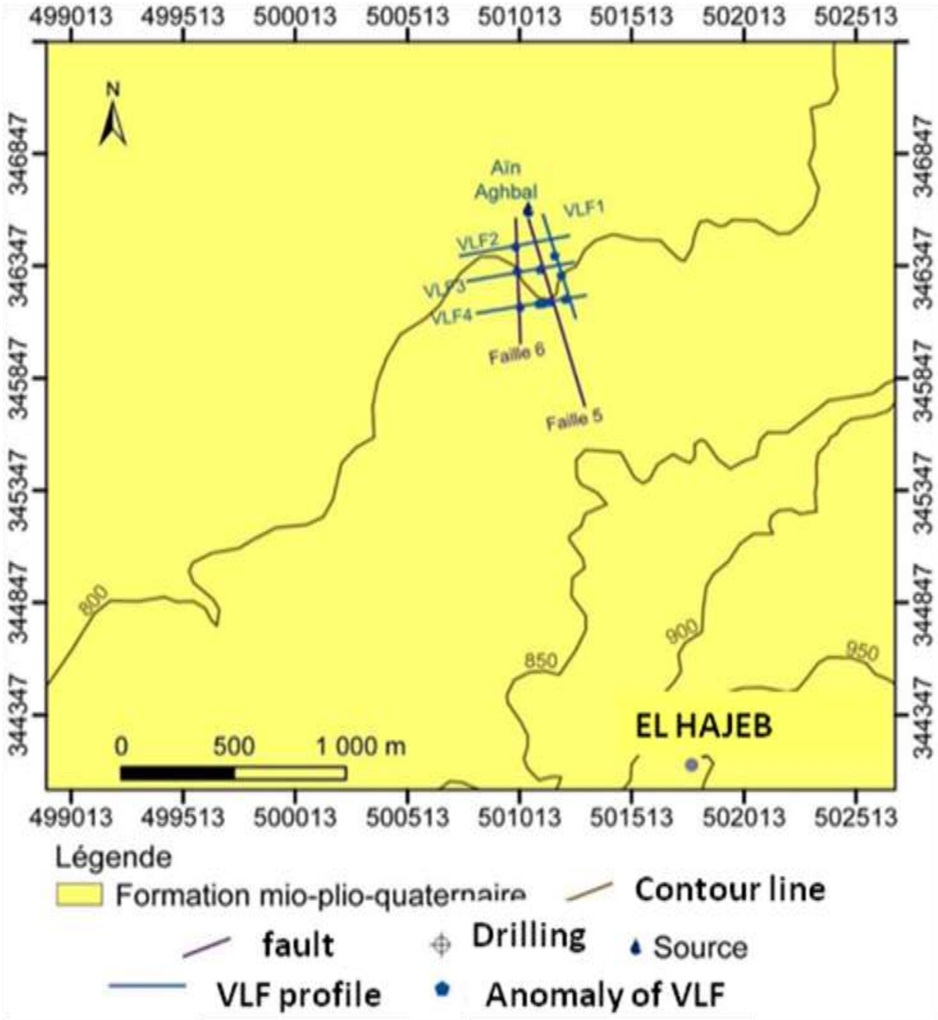

Figure 7: Synthesis map of the results obtained from the electromagnetic VLF method

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